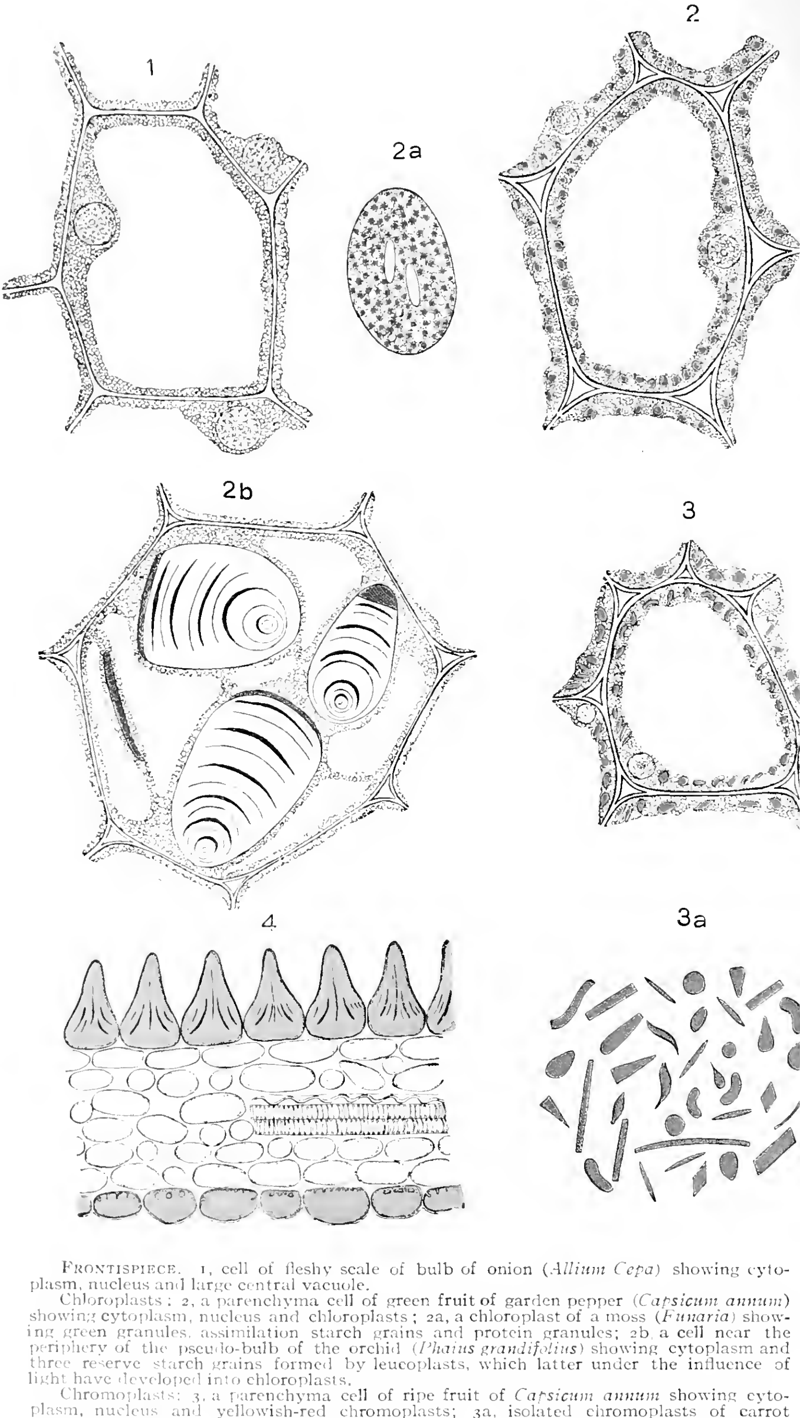

FRONTISPIECE. 1, cell of fleshy scale of bulb of onion (*Allium Cepa*) showing cytoplasm, nucleus and large central vacuole.

Chloroplasts: 2, a parenchyma cell of green fruit of garden pepper (*Capsicum annum*) showing cytoplasm, nucleus and chloroplasts; 2a, a chloroplast of a moss (*Funaria*) showing green granules, assimilation starch grains and protein granules; 2b, a cell near the periphery of the pseudo-bulb of the orchid (*Phaius grandifolius*) showing cytoplasm and three reserve starch grains formed by leucoplasts, which latter under the influence of light have developed into chloroplasts.

Chromoplasts: 3, a parenchyma cell of ripe fruit of *Capsicum annum* showing cytoplasm, nucleus and yellowish-red chromoplasts; 3a, isolated chromoplasts of carrot (*Daucus Carota*).

4, transverse section of petal of wild pansy (*Viola tricolor*) showing colored cell-sap in epidermal cells.

A

TEXT-BOOK OF BOTANY AND PHARMACOGNOSY

INTENDED FOR THE USE OF STUDENTS OF PHARMACY, AS A REFERENCE BOOK FOR PHARMACISTS, AND AS A HAND-BOOK FOR FOOD AND DRUG ANALYSTS

By

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Illustrated with over 300 plates comprising about 2000 figures

FOURTH REVISED AND ENLARGED EDITION

PHILADELPHIA & LONDON
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PREFACE TO FOURTH EDITION.

WITH each edition of this book the author has found it desirable to make certain changes and additions, not only with the object of increasing its usefulness as a text-book for the student, but also for the purpose of making it still more valuable as an aid and guide in practice. In the present edition a number of improvements have been made in the text as well as in the illustrations. The botanical portion of the book has been revised, the author having been fortunate in securing the coöperation of Dr. Theo. Holm, of Brookland, D. C., who has critically gone over certain portions of the morphology and classification of the Angiosperms and re-written a number of the articles. While there are some teachers who naturally prefer their students to have an independent course in botany before taking up pharmacognosy, the treatment of this subject in this book is such as to be directly applicable to pharmaceutical work, and will be found useful to the student of pharmacy in the college course, as well as of assistance to the pharmacist and analyst who engages in practical pharmacognostical work.

Up until the present time, the anatomical or histological method has received the sole attention of pharmacognosists. By this method, based for the most part upon the study of tissues, the identity and general quality of drugs and foods are ascertained, and the results thus obtained, when taken in conjunction with those of chemical analysis, have been of great value in determining the purity of the products examined. For some years it has seemed to the author important that the pharmacognosist study the active and other constituents of drugs, such as may be obtained in crystalline form from sections, from extractions of small quantities of powders, or from a few drops of an extracted solution as obtained in assay work. While there are a number of books treating of micro-chemistry, yet the treatment of the microscopic crystals in these is of a general character. The only satisfactory way to study these crystals is by means of the petrographical microscope. In Part IV about forty pages have been included treating of the micro-analysis of some of the important plant constituents, and it is believed that this portion will be especially useful in the detection and accurate study of these substances. In the preparation of this part the author had the hearty coöperation of Dr. Charles Travis, of the University of Pennsylvania, who not only made careful studies of the crystals described, but read the proof very carefully.

The new illustrations include some thirty-five photographs of microscopic crystals; a four-color plate, made from Lumiére autochrome photographs, showing salicin and cocaine hydrochloride under the micro-polariscope, with crossed nicols; and a number of half-tone illustrations and drawings of medicinal plants. In addition, the work has been brought up to date by including the results of the researches published during the past two years.

Acknowledgment is cheerfully made to the editor of *Merck's Report* for permission to use some of the excellent drawings from Dr. Theo. Holm's articles on "Medicinal Plants of North America."

H. K.

September, 1910.

PREFACE.

Owing to the rôle played by vegetable substances in the treatment of disease, pharmacognosy takes rank as one of the most important divisions of applied botany. It is generally understood to treat of the external characters, gross structure, histology, and chemical constituents of the plant parts used in medicine. In a broader sense it also implies the study of plants themselves, of systematic botany, and of plant chemistry (phyto-chemistry). Furthermore, when the factors which influence the formation of the active principles in plants are taken into consideration, the subject is seen to have a relation to plant physiology on the one hand and to plant culture on the other.

This work is divided into three parts. Part I comprises five chapters, and is devoted to a consideration of the distinguishing characters of the main groups of plants, from the lowest to the highest; (2) the anatomy or outer structure of the Angiosperms (or so-called Flowering Plants); (3) the inner structure or histology of the higher plants, including the cell-contents; (4) a classification of the Angiosperms yielding vegetable drugs and other useful products, together with concise descriptions of the plants, as also of the non-official drugs derived from them, and (5) the subject of the cultivation of medicinal plants.

Part II comprises two chapters, one devoted to the crude drugs official in the United States Pharmacopœia, including a few non-official drugs, and another which treats of the subject of powdered drugs and foods. The latter is designed not only for the use of students but also to furnish assistance to food and drug analysts in identifying and estimating the quality of vegetable powders, and includes a description of the distinguishing histological elements of over two hundred food, spice and drug products, together with directions for making examinations of materials of this kind.

In Part III are given the various classes of reagents, together with the technique involved in sectioning and the mounting of specimens. In addition various tests are given in connection with different subjects in other parts of the book.

The work is illustrated throughout, and the student is advised to consult the illustrations freely, not only on account of their value in elucidating the descriptions, but also because the legends contain information which in some instances supplements that given in the text.

It should be stated that a large proportion of the illustrations are reproductions of photographs and drawings made by the author, and that in all cases where illustrations are borrowed, credit is given each author in connection with the reproduction.

One of the most difficult questions which arises in writing a work of this kind is that relating to nomenclature. Owing to the desirability of maintaining a stable nomenclature, particularly for medicinal plants, the author has adopted a rather conservative course and has been largely guided by Engler & Prantl and Index Kewensis, or, in the case of plants growing in the United States, the names given in Britton's Flora may have been employed.

Among the works consulted by the author, and of which special mention should be made, are the following: Organography of Plants by K. Goebel (English translation by Isaac Bayley Balfour); The Physiology of Plants by W. Pfeffer (second revised English edition by Alfred J. Ewart); Die Heilpflanzen by Georg Dragendorff; The Volatile Oils by Gildemeister & Hoffmann (English translation by Edward Kremers); Die Pflanzen-Alkaloide by Jul. Wilh. Brühl, E. Hjelt and O. Aschan.

Grateful acknowledgment is also made to the following publishers for permission to reproduce illustrations from the works mentioned. Wilhelm Engelmann, of Leipzig: Die naturlichen Pflanzen-familien by Engler & Prantl. Gebrüder Borntraeger, of Berlin: Handbuch der systematische Botanik by E. Warming. Weidmannsche Buchhandlung, of Berlin: Wissenschaftliche Drogenkunde by Arthur Meyer. Gustav Fischer, of Jena: Lehrbuch der Botanik by Strasburger, Noll, Schenck and Schimper.

The author desires fully to acknowledge the services of Miss Florence Yaple, without whose painstaking and constant assistance during the course of revision, this book could not have appeared in its present enlarged form.

H. K.

April, 1907.

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PART I.—BOTANY.

CHAPTER I.

PRINCIPAL GROUPS OF PLANTS.

INTRODUCTORY.

THERE are four main lines of botanical work now recognized, —namely, Morphology, Histology, Physiology, and Ecology. MORPHOLOGY treats of the form and structure of plants and the subject is sometimes divided into (1) external morphology or organography and (2) internal morphology or anatomy (histology). The former deals with external characters of plant parts and the latter with their minute inner structure. PHYSIOLOGY may be defined as the study which considers life processes and the conditions which influence these. ECOLOGY is the study of the adaptation of plants and their parts to external conditions. It is important to bear in mind, however, that these several departments are more or less interdependent, and that one of them cannot be intelligently considered without encroaching on the territory of the others. For instance, as Goebel states, we cannot understand the relation of the external forms of organs without reference to their functions. In other words, form and function have a direct relation; one influences the other. So, too, in the study of ecology we study the influence of external conditions on plants and these, as indicated above, have a direct influence on physiological processes, and thus the study of ecology merges into the study of physiology on the one hand and into morphology on the other.

While this book will deal chiefly with the structure of plants and their parts, still it will be necessary occasionally to refer to some of the characters of plants which properly belong to other departments of botanical study.

Basis of Plant Structure.—In order to understand the significance and relation of the various parts of plants it is necessary to know something of their functions and habits of life as well as of their internal structure.

If we make a section of a plant and examine it by means of the microscope, the cut surface presents the appearance of a network indicating that the tissue is made up of small compartments or chambers. One of these compartments together with its contents constitutes the structure known as the CELL (see Frontispiece).

The cell contents vary greatly in appearance and composition, but in all active or living cells there is always present the substance known as PROTOPLASM. The protoplasm is the basis of all plant structures whether they belong to the lowest or highest forms; for by its aid or from it all parts of the plant are developed. Even the cell wall is a product of protoplasmic activity. The protoplasmic content of the cell consists of several intimately related but more or less distinct portions,—namely, a somewhat thin, semi-liquid, granular portion known as the CYTOPLASM; a more or less spherical body embedded in the cytoplasm called the NUCLEUS; and frequently, but not always, certain small bodies which are more or less variable in shape called PLASTIDS, these being also embedded in the cytoplasm (see Frontispiece). The cytoplasm and nucleus are sometimes considered together as a unit, which is known as the PROTOPLAST. A fuller discussion of the differentiated portions of the protoplasm will be found in Chapter III. (See page 156.)

The lowest organisms, as the slime molds, do not have an enclosing membrane but consist of a naked mass of protoplasm. With this exception plants have an outer wall or membrane. They may consist of a single cell, as in the Bacteria, or a chain of cells, as in the filamentous Algæ, or a mass of cells, as in the majority of plants, and are accordingly designated as unicellular or multicellular. The cell wall is composed for the most part of cellulose, but may be modified in various ways.

Nomenclature.—The names for describing plants have been derived for the most part from studies of the higher plants, they having exclusively attracted the attention of botanists at first.

But with the light which has been thrown on the relationship of the higher and lower groups of plants by the more recent study of the lower forms the older terminology has been somewhat modified. Thus, for example, we speak of the root and shoot, with its leaves, as the vegetative organs of the higher plants, and in describing the corresponding organs (where they exist) in the lower plants, we either apply these terms directly, or indirectly by saying that the latter are root-like, stem-like, etc. On the other hand, we now speak of the sexual organs of the higher plants as antheridia and oögonia (or archegonia) instead of classifying them roughly as stamens and pistils, the latter names being retained but with a different signification.

Factors Influencing Growth.—Plants have certain inherent or inherited tendencies or characters which make up the inner constitution, and this can not be modified by external agencies except within more or less narrow limits. Depending upon this character we find plants as different in kind as the apple tree and pine growing under precisely the same conditions. In other words, the character of the structure is determined in the main by the nature of the organism. It is true that an apple tree may grow better in one locality than another, but it is still an apple tree whether it be dwarfed or attain to the full measure of its growth. These slight changes in the character are known as accidental variations. Frequently they are the result of temporary conditions and are not repeated in the succeeding generation. On the other hand, if the special conditions remain these individual variations may be repeated in generation after generation and finally become permanent characters.

The gradual change in the structure and nature of organisms which takes place through long periods of time is spoken of as EVOLUTION. In some cases specific changes in the characters of plants arise rather suddenly without any known cause and such changes are spoken of as saltations or MUTATIONS.

The factors essential for growth in all cases are food, water and a certain temperature. Among the food elements we may mention as of chief importance, carbon, hydrogen, oxygen and nitrogen. Some of the other elements are also essential to most plants although they occur in relatively small proportion in the plant, as potassium, magnesium, phosphorus, sulphur, iron and calcium. The latter element does not seem to be necessary to the normal development of some of the Fungi and certain Algæ.

Water permeates all parts of the plant and when the cells are in the normal turgescent state it contains more than half its weight of water. When the supply of water falls below the normal the plants begin to droop and finally die. The need of plants varies greatly in this particular; some are aquatic in their habits and live wholly in the water; others can live only on the land; and still others are adapted to desert regions.

The degree of temperature necessary for growth varies within certain limits for each kind of plant, but as is stated by Pfeffer, the greatest extremes are shown by Fungi, Bacteria and the lower Algæ. Generally speaking the most favorable temperature for growth is between 24° and 34° C.

Besides the factors enumerated there are other factors which influence growth. They include light (p. 106), gravity (p. 94), mechanical agencies, etc., and are sometimes spoken of as external stimuli.

It is difficult to separate those factors which act solely as external stimuli from those which are essential to the normal growth of the plant and which may be considered as physiological factors. For example, light under certain conditions may be regarded as in the nature of an external stimulus and not essential to the growth of the plant, while in other cases it has a direct influence on normal growth and is essential to the life of the plant, as in all plants or parts of plants where photosynthesis (p. 109) takes place.

In addition to the essential food elements, there are many substances which affect the growth of plants which may be grouped as chemical stimuli, such as (*a*) the substances secreted by gall-forming insects, (*b*) in a certain measure some of the substances produced by Fungi, (*c*) and numerous substances not found as normal constituents of the plant. Depending upon the amount of the substance present and the conditions under which it is supplied, the substance may act as a poison and injure the plant, or it may accelerate growth, or cause abnormal developments.

This subject has an important bearing on the physiological testing of drugs. Kobert states that in determining the qualities of a new chemical, preliminary experiments should be conducted on lower plants and animals before trying it on man. Of the plants which have been used in the testing of poisons the following may be mentioned: Oscillaria, Spirulina, Nostoc, Zygnema, Spirogyra, Saccharomyces, Mucor, Elodea, Lemna, Pistia, Potamogeton, Myriophyllum, Ceratophyllum, Tradescantia, seedlings of grasses, lupine, bean, pea, corn, etc.

Plant Organs.—Depending upon the fact that the plant requires nourishment for its growth and development and that it has also to carry on the work of reproduction or propagation, —*i.e.*, the production of new plants,—we distinguish between vegetative or nutritive organs and propagative or reproductive organs. The vegetative organs, such as the root, stem and leaves in higher plants, manufacture the food necessary for the life of the plant, while certain other more or less specialized organs or cells carry on the work of reproduction.

In the lower plants, however, the whole structure is much simpler, and in some instances a cell which performs the work of a nutritive cell at one stage may become a reproductive cell at another, or, as in the case of the unicellular Algæ, all the various functions of the plant may be carried on by a single cell.

Generally speaking, there are two principal ways in which plants are multiplied or reproduced: (1) By CELL DIVISION or cell fission, and (2) by the formation of special cells known as SPORES. In cell division (Fig. 94) the nucleus and cytoplasm of a cell divide to form two new cells or protoplasts, which become distinct by the formation of a wall or cell-plate between the two halves. All growth in plants is dependent upon this method, and in growing parts the cells are said to be in a state of division. Owing to the plasticity of the plant organism, detached portions will often grow and give rise to new plants, as in the case of cuttings. Growth here as in the parent plant is accompanied by cell division. In some of the lower Algæ (Fig. 6) cell division is the only method of propagation, and as only the ordinary vegetative or nutritive cells of the plant are involved in the process it is sometimes spoken of as vegetative multiplication.

In both lower and higher plants, with the exceptions just noted, reproduction is also carried on by means of spores.

Depending upon their origin two classes of spores are distinguished, namely, (*a*) asexual spores, and (*b*) sexual spores. In the production of asexual spores the contents of a certain cell

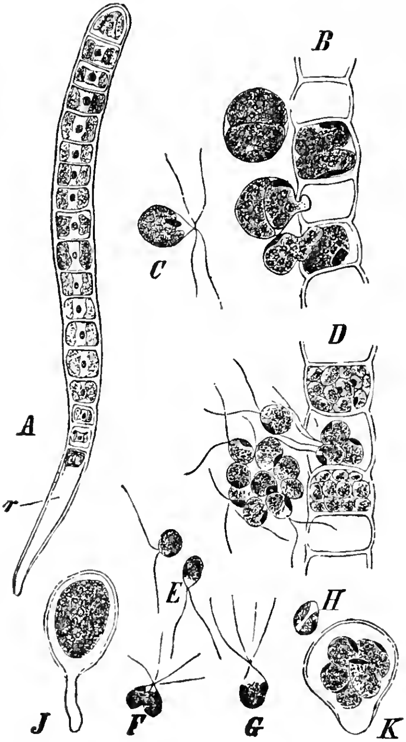

FIG. 5. *Ulothrix zonata*. A, young filament with rhizoid cell (r); B, piece of filament showing escape of swarm spores; C, a swarm spore or zoöspore with 4 cilia; D, biciliate gametes escaping from a filament; E, F, G, showing different stages of union of two gametes; H, young zygote or zygospore in which the cilia have been absorbed; J, 1-celled plant developed from zygote; K, young plant organizing zoöspores.—After Dodel-Port.

called a mother cell or SPORANGIUM break up into a number of new cells sometimes called daughter cells, which escape through the cell wall. In the lower plants, particularly those growing in water or in moist places, these cells are provided with short thread-like appendages known as cilia, which enable them to move about in the water. They are known as ZOÖSPORES or swarm spores (Fig. 5, *B*, *C*), and each individual zoöspore is able to produce a new plant.

The number of zoöspores formed in a sporangium is usually 2 to 8, as in *Ulothrix*, but the number may be larger. The method of cell formation which gives rise to zoöspores is sometimes spoken of as INTERNAL DIVISION from the fact that they arise within the old cell and retain no relation to the old wall as is the case in cell fission. The zoöspores are at first naked protoplasts, but later, on coming to rest, may form a wall. Sexual spores, on the other hand, are formed by the union of two cells known as GAMETES. When the gametes are similar the resulting spore is known as a ZYGOSPORE or zygote (Fig. 5, *E*, *F*, *G*). When the gametes are unlike, the spore produced by their union is known as an OÖSPORE. In the latter case one of the gametes is larger than the other, is less active, and is spoken of as the female gamete, oösphere, or egg (Figs. 11, 12). The other more active cell is known as the male gamete, antherozoid or sperm (Fig. 34, *III*). The cell giving rise to the oösphere is known as the oögonium (Figs. 8, 11, 12), while the one in which the antherozoid or sperm originates is called the antheridium (Figs. 8, 11, 12, 34).

PLANT GROUPS.

Botanists earlier divided the plant kingdom into flowering plants or Phenogams (Phanerogams), and non-flowering plants, or Cryptogams. It was formerly the custom to devote attention chiefly to the more prominent groups of plants, or those that produce seeds, but more recently the results of the studies on the less prominent groups, as ferns, mosses, etc., have modified our views and made it imperative that the botanist have a general knowledge at least of all the great groups of plants.

The most general classification of plants is that which divides them into three great groups,—namely, (1) Thallophytes (Thallophyta), (2) Archegoniates (Archegoniatæ), and (3) Spermophytes (Spermophyta).

THALLOPHYTES.

The Thallophytes include the lowest orders of plants,—*i.e.*, those simplest in form and structure. They are supposed also to represent more or less primitive types. In these plants the plant body does not show a differentiation into root, stem and leaf, as in the higher plants, and is termed a THALLUS. The thallus may branch in various ways, but the structure remains more or less uniform throughout. It should be understood, however, that even in this group of plants certain cells or groups of cells may become specialized, *i.e.*, set apart for a particular function, as, for example, the reproductive cells. The Thallophytes vary in size and general appearance from minute unicellular organisms and those which are filamentous and delicately branched to large leaf-like organisms many feet in length (Figs. 6, 9, 13).

The Thallophytes are divided into the two groups of plants known as (1) Algæ and (2) Fungi. The Algæ produce chloroplasts, and hence are capable of manufacturing food from the inorganic substances air and water (see page 108), which fact constitutes a fundamental difference between them and the Fungi.

ALGÆ.

Algæ are also characterized by their habit of living in water or in moist places, and they are sometimes classified as "fresh water algæ" and "salt water algæ" (Fig. 9). In the first group are included the common pond-scums and certain forms living on trees, moist rocks, fences and elsewhere, and in the second group the sea-weeds.

In addition to the chlorophyll (see page 159) of the chloroplasts other color substances are found in Algæ, which mask the green color to a considerable extent. On the basis of their color Algæ are subdivided into (1) Blue-green Algæ or Cyanophyceæ, (2) Green Algæ or Chlorophyceæ, (3) Brown Algæ or Phæophyceæ, and (4) Red Algæ or Rhodophyceæ. While no attempt will be made to consider these groups in detail, it should be stated that they not only vary in color, but they also vary greatly in structure and general appearance. A few type forms will be considered in order to illustrate their habits of life.

Pleurococcus.—One of the commonest of the Green Algæ as well as one of the simplest is Pleurococcus (*Pleurococcus vulgaris*) (Fig. 6). It occurs as a green coating, in both winter and summer on the moist bark of trees, moist ground, and stone walls, and is a component of some lichens. The plant is one-celled, more or less spherical, and at one stage contains a number of chlorophyll grains which finally unite to form a single plate which lies against the wall and is known as a CHROMATOPHORE. Besides it contains a considerable amount of oil. An allied species (*Pleurococcus viridis*) contains the sugar erythrite. The plant usually reproduces by simple division, that is, one cell or plant divides to form two. The division may continue by the production of another cross wall, so that four cells result. Under favorable conditions, division may take place by the formation

FIG. 6. *Pleurococcus vulgaris*. Different stages of division of the cell.—After Wille

of still another wall at right angles to the other two. In this way two, four and finally eight individuals arise which adhere more or less to one another, thus forming colonies. The number of individuals in a colony depends upon the number of individuals in the colony when division begins and the extent to which division is carried. Thus if there were four cells in a colony to begin with and division took place in three planes, there would be thirty-two cells in the colony at the end of the period.

Spirogyra.—Another one of the common Green Algæ is Spirogyra (Fig. 7), one of the pond-scums, which forms floating green masses on ponds and shallow water in the spring. The plant-body consists of a chain of cylindrical cells forming long threads or filaments. The transverse walls are sometimes peculiarly thickened. The chromatophores occur in one or more spiral bands (Fig. 7, *II*), which extend from one end of the cell to the other. In these bands are embedded protein bodies known as pyrenoids. The nucleus lies in the center of the cell and is connected with the cytoplasmic layer lining the walls of the cell by delicate threads of cytoplasm.

Spirogyra may be propagated vegetatively by one or more cells of a filament breaking off and forming new individuals by cell division. The plant is also reproduced by means of zygo-

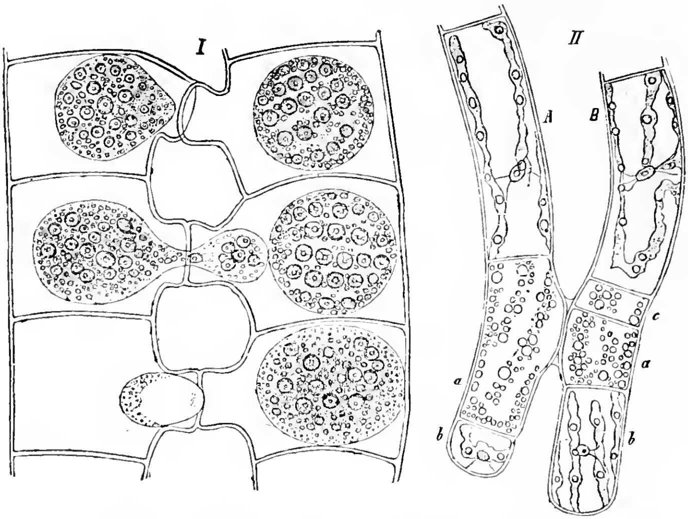

FIG. 7. II. *Spirogyra stictica*, showing parts of two filaments with band-like chromatophores (chloroplasts), in which are embedded spherical pyrenoids. Nuclei are shown in some of the cells with delicate threads of cytoplasm radiating from them. Two of the cells (a,a,) of the adjoining filaments (A, B) are beginning conjugation. I, *S. Heeriana*, showing different stages of conjugation. In the upper cells, the contents have rounded off previous to the rupture of the adjoining walls of the two filaments. The two middle cells show the contents passing from one cell into the opposite cell. In the lower cell to the right the zygospore is shown.—After De Bary.

spores, as follows: The cells of two adjoining filaments each send out processes (Fig. 7, *II*, *a*, *a*), which meet; the end walls are absorbed, forming a tube through which the contents from one cell pass over into the other (Fig. 7, *I*); the contents of the two cells then fuse, after which the mass becomes surrounded by a cellulose wall. The spore thus formed may remain dormant over winter, and the following spring germinate and form a new Spyrogyra filament or plant. This method of reproduction is known as CONJUGATION, and the zygospore is called a resting spore. It should be explained that certain cells, as well as spores, may lie dormant for a period, as during the winter season or at other times, when the conditions are unfavorable to growth, and then renew their activities, these being known as "resting cells."

Vaucheria (Fig. 8) is another common green alga which may also be selected as showing the habits of this group of plants. The plant has a branching thallus and lives in shallow

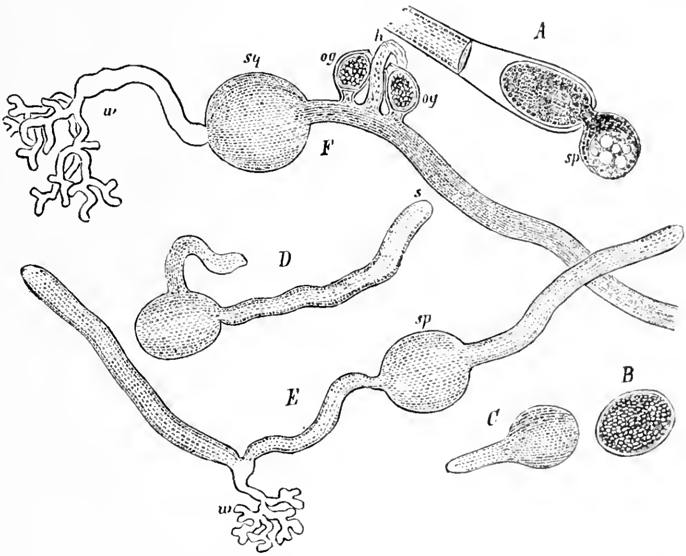

FIG. 8. *Vaucheria sessilis.* A, sporangium from which the multiciliate zoöspore is escaping; B, resting zoöspore; C, D, germinating zoöspores with growing point (s); E, plant showing root-like organ of attachment (w), spore from which the plant is developing (sp), F, showing in addition two oögonia (og) and an antheridium (h).—After Sachs.

water or on moist earth, being attached to the substratum by means of delicate root-like processes sometimes spoken of as rhizoids (Fig. 8, *w*). In the thin layer of protoplasm lying near the wall are numerous nuclei and small oval chromatophores. Numerous oil globules are also found in the protoplasm, and calcium oxalate crystals may occur in the cell-sap.

Vaucheria furnishes an example of a plant whose interior is not segmented by cell walls. In other words, the cavity within the outer or enclosing membrane is continuous, and such a plant is said to be cœnocytic, *i.e.*, like a syphon. But it should be borne in mind that the plant contains a great many nuclei, and as we have seen (page 2) a nucleus with its associated cytoplasm constitutes a unit of work. Hence such a plant as Vaucheria is in a certain sense equivalent to a plant having as many uninucleate cells as it has nuclei. It would probably be better to call such a plant multinucleate rather than unicellular.

Reproduction by means of asexual spores is brought about as follows (Fig. 8, *A*): A cross wall is formed near the end of one of the branches, the end portion constituting a sporangium. The contents, including numerous nuclei group themselves into one large zoöspore, which escapes through an opening in the sporangial wall, and after swimming about for a time comes to rest and germinates, giving rise to a new plant (Fig. 8, *C, D*). This large zoöspore is multinucleate and multiciliate, there being two cilia for each nucleus, and by some botanists is considered to be an aggregation of numerous biciliate zoöspores. It is also of interest to note that the zoöspores of Vaucheria appear to arise by a grouping of the cytoplasm and the nuclei already existing in the sporangium rather than by repeated divisions of a single nucleus.

Another method of reproduction in Vaucheria (Fig. 8, *F*) is that by means of oöspores, or spores formed by the union of egg and sperm cells. Two special branches are formed on the thallus as short side shoots. One of these branches, known as the oögonium (Fig. 8, *og*), is somewhat egg-shaped and separated from the thallus by means of a cross wall. It contains a great many chromatophores and considerable oil, and has a comparatively thick wall. The apex is somewhat beaked and contains colorless protoplasm. The second branch, which is known as an antheridium (Fig. 8, *h*), is smaller, somewhat cylindrical and curved towards the oögonium. It is also cut off from the thallus by means of a cross wall. The antheridium contains very little chlorophyll, but a great many sperm cells. These are oval or egg-shaped and have two cilia, one at each end. The sperms escape from the apex of the antheridium and enter an opening at the apex of the oögonium, one of them uniting with the egg cell, which then develops a thick membrane, the resulting oöspore being a resting spore.

Diatoms constitute a large group of unicellular plants, occurring in both fresh and salt waters. They form the plankton or floating microscopic life found in oceans and lakes, which is the

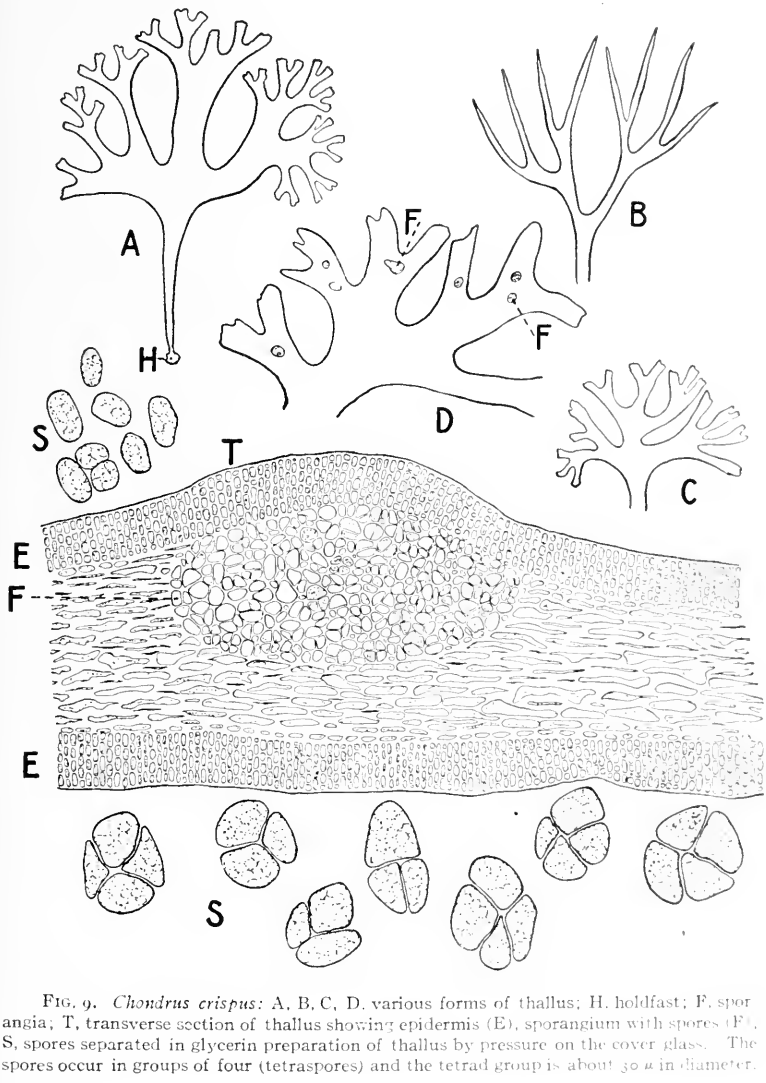

FIG. 9. *Chondrus crispus:* A, B, C, D, various forms of thallus; H, holdfast; F, sporangia; T, transverse section of thallus showing epidermis (E), sporangium with spores (F), S, spores separated in glycerin preparation of thallus by pressure on the cover glass. The spores occur in groups of four (tetraspores) and the tetrad group is about 30 μ in diameter.

source of food of small animal forms inhabiting these waters. One of the distinguishing characters of the group is that the cell wall is incrusted with silica. For this reason they are practically indestructible and form marls and strata in the earth. They occur either singly or grouped in bands or chains. They are very variable in shape, being boat-shaped,

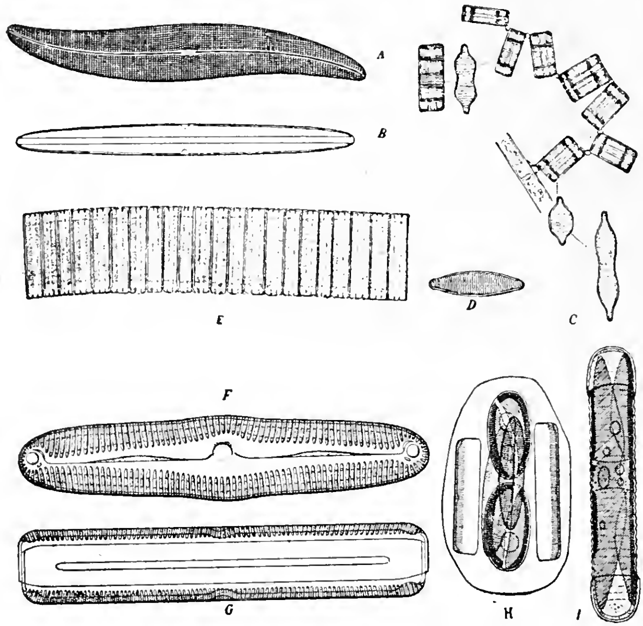

FIG. 10. Diatoms: A, *Pleurosigma attenuatum* as seen from above; B, *Pleurosigma balticum* as seen from the girdle side; C, D, E, *Fragilaria virescens* showing colonies attached to an alga in C, a view of a single diatom from above at D, and a chain of diatoms viewed from the girdle side at E; F, G, two views of *Navicula viridis;* H, I, the formation of auxospores in *Navicula firma*, H showing the exit of the protoplasts and the throwing off of the original valves.—A, B, D, after Van Heurck; C, E, after W. Smith; F–I, after Pfitzer.

ellipsoidal, spherical, or peculiarly curved in some forms. They are either free or attached to a substratum, as stones, water plants, etc., those which are free having an active movement (Fig. 10).

The cell-wall of Diatoms practically consists of two halves, one fitting over the other like the lid of a box. These are known as "valves" or "theca." The manner in which the two valves are joined results in the formation of a "girdle" or "pleura." The girdle is provided with a series of pores connecting with canals at either end and in the middle, through which food from without is supplied to the protoplast. The valves are very often beautifully marked by a series of parallel cross lines, dots, circles, or polygons, which are characteristic of the different groups. Some forms are used in testing the definition of objectives, as *Pleurosigma angulatum*, in which the lines are one-half micron wide (Fig. 10, *A*).[1]

In the Diatoms the protoplasm lies as a thin layer close to the wall surrounding a large central vacuole. The nucleus is surrounded by a relatively dense mass of cytoplasm, and occurs in definite positions according to the species. The chromatophores frequently occur in plates which are typical for certain species. They are sometimes greenish-yellow, the color being generally masked by the presence of a brown substance known as diatomin. They frequently contain pyrenoids, which are sometimes associated with granules of starch.

Reproduction takes place by simple division or fission, the two valves separating and a new valve forming on each half to replace the old one. In each case the valve formed fits into the old one and hence in the case of the smaller valve the new cell or plant becomes smaller than the parent plant, the walls not being able to expand on account of the siliceous composition. In this way the cells of one series gradually become smaller and smaller until a certain minimum is reached, when the plant rejuvenates itself by the production of spores (auxospores). These are formed in two ways: In one case the valves separate from each other, the protoplast escapes, grows larger and develops a new wall; in the other case, of which there are several types, two individuals come together, and envelop themselves in a mucilaginous covering. They then throw off their siliceous walls and the protoplasts unite to form a zygospore which grows until it is three times the original size, after which it develops a new wall, the larger valve forming first (Fig. 10, *H*, *I*).

Economic Uses of Algæ.—Diatomaceous earth, which is

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[1] The micron (μ) is the $\frac{1}{1000}$ of a millimeter.

made up of the valves of diatoms, is used chiefly as an absorbent agent for storing nitroglycerin, as in the production of dynamite. Being a non-conductor of heat the material also finds use in the manufacture of the so-called isolation plates for machinery. Another use is as a tooth powder. Among the Chinese and Laplanders diatomaceous earth has also been used as an edible earth known as "mountain meal" or "bread-stone." It has been used in India as a rubefacient.

Many of the Algæ are of use as food, of which the following may be mentioned: *Vaucheria fastigiata*, *Griffithsia coralina*, *Ceramium Loureirii*, *Chondrus crispus* (Fig. 9), *Gigartina mamillosa* (Fig. 278a), *Gelidium cartilagineum*, *Gelidium crinale* (yielding agar-agar), *Rhodymenia palmata* (yielding dulse), and several species of Gracilaria (which also yield agar-agar).

Some of the sea-weeds are used in the production of iodine, as *Durvillæa utilis*, *Ascophyllum nodosum*, *Fucus vesiculosus* (bladder-wrack), *Sargassum linifolium*, *Laminaria saccharina*, *Laminaria digitata*, *Alaria esculenta*, *Rhodymenia palmata*, *Phyllophora membranifolia*, *Macrocystis pyrifera*, and *Fastigiaria furcellata*.

A number of the Algæ are also used in medicine, particularly for phthisis, as *Fucus cartilagineus*, *Stilophora rhizodes* and *Dictyopteris polypodioides*. *Alaria esculenta* and *Laminaria digitata* are used in the making of bougies and tents used in surgery. Owing to the toughness of some of the Algæ on drying, the material is used in the manufacture of various articles, as handles for tools from the thick stem of *Lessonia fucescens*, fishing lines from *Chordaria filum*, etc.

FUNGI.

The Fungi form a large group of plants which do not produce chloroplasts or any bodies having a similar function. They have not the power of carbon dioxide assimilation, that is, unlike the Algæ they are unable to manufacture food materials, such as carbohydrates (starches, sugars, etc.), from carbon dioxide and water. Hence they are dependent upon previously formed food products, and may derive their food from living plants or animals, when they are known as PARASITES, or from decaying animal or vegetable matter, when they are known as SAPROPHYTES. The living plant or animal attacked by a fungus is known as the host.

Fungi are especially characterized by the habit of arising from spores and of producing thread-like cells the growing point of which is at the apex. These threads are known as HYPHÆ (singular hypha). They branch and become interwoven, forming a mass or mat known as the MYCELIUM (Fig. 13). The mycelium constitutes the plant body proper, and absorbs the food material from the substratum, which it ramifies, often causing decay. The mycelium is frequently not visible, and the presence of the fungus is not recognized until the so-called fruit bodies are developed, as sometimes seen in the case of moldy oranges, mildewed linen, and as illustrated by the common mushroom. The mycelium has a cellulose wall which in some cases is modified to chitin, a nitrogenous substance related to animal cellulose and found in crabs and other lower animals. The protoplasm either occurs in a more or less delicate form lining the hyphæ and enclosing large vacuoles, or is comparatively dense enclosing numerous small vacuoles. Many fungi contain color substances which are dissolved in the cell-sap and are of a quite brilliant hue. One of the most interesting classes of substances produced by fungi is that of the ferments, including the oxidizing ferment allied to laccase. They contain also amido-substances related to lecithin; fats; carbohydrates, as trehalose and mannitol; organic acids, as oxalic, tartaric, malic, etc.; and calcium oxalate may be present in some cases.

Reproduction in the Fungi is chiefly by means of asexual spores, which arise in two ways. In the one case they are developed in a special cell or sporangium at the end of a mycelial thread and are known as ENDOSPORES. In the other case they arise on special hyphæ, or directly from the mycelium and are known as EXOSPORES or conidia. There are also several modifications of these two types of spores, which may be referred to later.

Groups of Fungi.—There are two principal groups of Fungi, namely, (1) the Phycomycetes, or Alga-fungi, so called because they show a resemblance to certain of the Algæ, and (2) the Eumycetes, or true Fungi. The Eumycetes have two subdivisions, namely, (1) Ascomycetes and (2) Basidiomycetes.

The Ascomycetes are distinguished by having a sporangium of a definite shape and size, which is called an ASCUS, and which contains a definite number of spores, which is two or some multiple thereof. The Basidiomycetes are the most highly developed Fungi, producing large fruit bodies, such as are seen in mushrooms, toadstools and puffballs. They are characterized by producing spores (basidiospores) on special hyphæ. The spores are usually four in number and the spore-producing organ is known as a BASIDIUM.

PHYCOMYCETES: ALGA-FUNGI.—The plant body of the Phycomycetes consists of a mycelium which is unsegmented, more or less thread-like and sometimes considerably branched. Reproduction takes place by means of several kinds of spores, and by reason of the production of two kinds of sexual spores they are subdivided into two important groups. These are (1) the Oömycetes which produce oöspores, and (2) the Zygomycetes which produce zygospores.

Saprolegnia.—Probably one of the best representatives of the Oömycetes is the group of water molds known as Saprolegnia, which are aquatic in their habits and are both parasitic and saprophytic, occurring on living fish, insects, crayfish and decaying plants and animals as well. The plant body consists of a mycelium which may be simple or branched, sometimes forming a dense mass (Fig. 11, *A*). Like the alga Vaucheria, it produces both swarm spores (zoöspores) and oöspores. The swarm spores (Fig. 11, *B*, *C*) are produced in sporangia formed by the production of a partition wall at the end of a hypha. The sporangia are either cylindrical or spherical, and contain numerous zoöspores which have two cilia at one end. These spores are peculiar in that after their escape from the sporangium they swim about, then come to rest and take on a wall, after which resting period they develop two cilia on the side, again move about, and germinate when they find a suitable host.

The oögonia and antheridia (Fig. 11, *D–F*) are also formed at the ends of hyphæ. The oögonia are usually spherical and the wall contains a number of small pores. The contents which are at first more or less uniform, later develop egg-cells, of which there may be as many as fifty in a single oögonium. The antheridium is more or less cylindrical and contains a somewhat uniform mass of protoplasm. The antheridium bends toward the oögonium and comes in contact with it, but apparently does not in all cases penetrate it. Nevertheless the egg-cells develop walls and become resting oöspores.

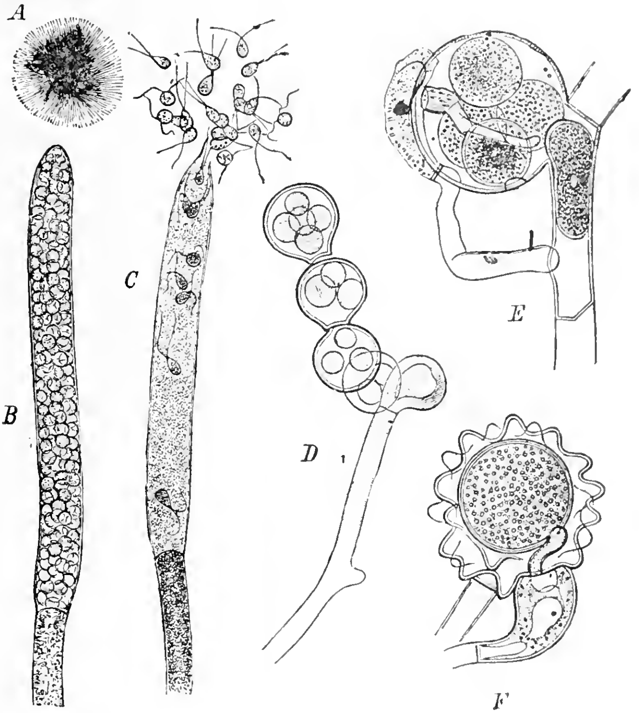


FIG. 11. Species of *Saprolegnia*. A, mycelium growing out from and surrounding a dead house-fly in a water culture; B, C, sporangia with biciliate swarm spores; D, a number of oögonia containing oöspheres; E, F, oögonia and antheridia, in F the tube of the antheridium having penetrated the oögonium.—A–C, after Thuret; D–F, after De Bary.

In **Peronospora**, one of the Oömycetes, the antheridium (Fig. 12, *n*) develops a tube which pierces the wall of the oögonium (Fig. 12, *o*); the contents unite with the egg-cell, after which a heavy membrane develops forming an oöspore which germinates when it finds a suitable host. The plants belonging to Peronospora as well as related genera are destructive to many cultivated plants, constituting mildews or blights, as those occurring on the leaves of hyoscyamus, tobacco, anthemis, matricaria, aconite, grape vine, lima bean, potato, etc. The group has received the name "downy mildews" because of the

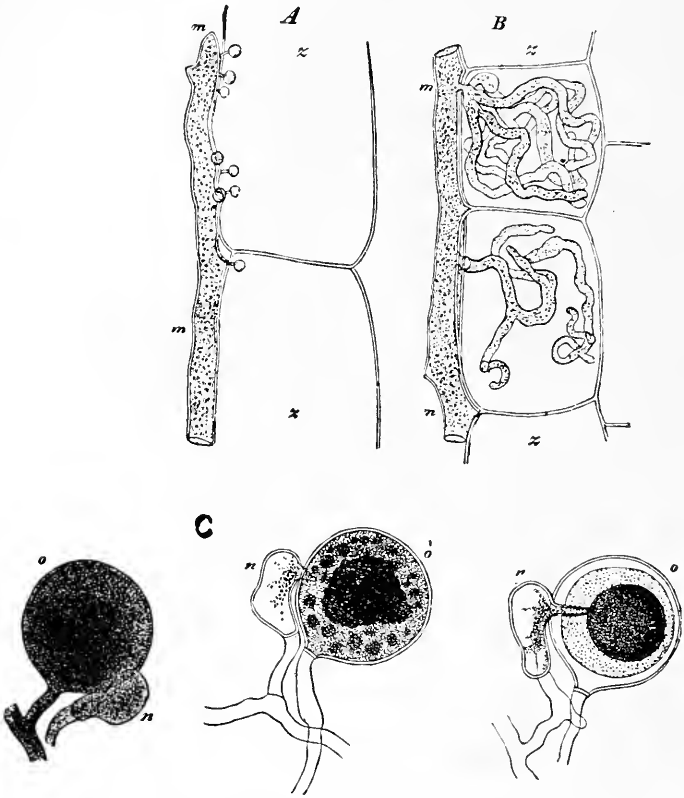


FIG. 12. A, *Cystopus candidus;* B, *Peronospora calotheca.* Mycelia (m) with haustoria penetrating cells (z) of hosts. C, Oöspore formation in *Peronospora:* o, oögonium; n, antheridium. At the left the antheridium is in contact with oögonium; the next stage shows the antheridium penetrating oögonium and discharging its contents; at the right the resulting oöspore is shown.—After De Bary.

fact that the conidiophores rise to the surface of the leaves where the spores are discharged, forming powdery patches.

Black Mold.—A common example of the Zygomycetes is furnished by the "black mold," *Mucor mucedo.* The mycelium of this plant is cœnocytic, thread-like, very much branched, and profusely developed much like that of *Phycomyces nitens* (Fig. 13, *B*). This mold is widely distributed, causing trouble in the spoiling of many sugar- and starch-containing substances in the household, including preserves, syrups, fruits, etc. In

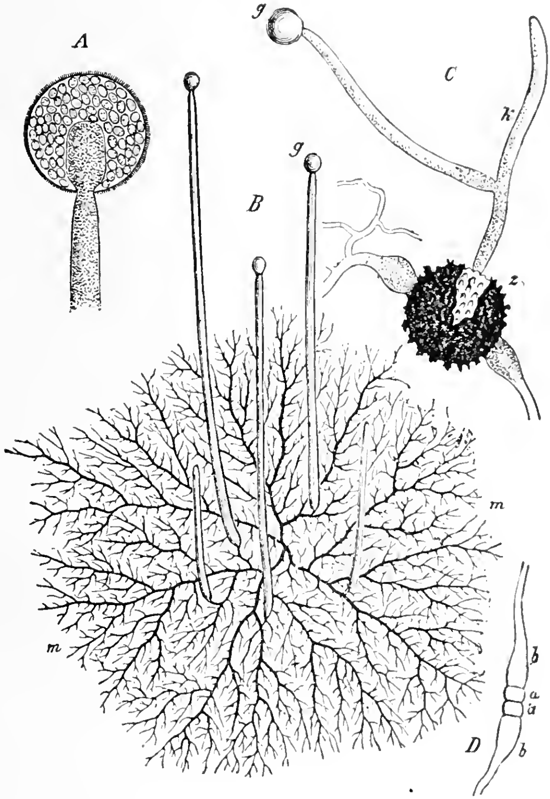


FIG. 13. B, richly branching mycelium (m) of the mold *Phycomyces nitens* showing upright hyphæ bearing sporangia (g). A, C, D, the common black mold *Mucor mucedo*. A, sporangium with columella; C, germination of zygospore (z), with formation of hypha (k), and sporangium (g); D, earliest stages in the development of a zygospore the hyphal branches (b) showing adjoining ends (a) cut off by cross walls.—After Sachs.

fact, a number of species of Mucor have the power of inducing alcoholic fermentation in glucose-containing solutions. They are also commonly found in many aqueous solutions of inorganic chemicals as well as organic substances. Asexual spores are formed at the ends of hyphæ which rise into the air. The sporangia are spherical and are cut off from the hyphæ by means of a transverse wall which projects upward into the sporangium and which is technically known as the columella (Fig. 13, *A*). The contents by simultaneous division form numerous one-celled spores, which are discharged by the bursting of the sporangium wall and distributed by air-currents or the wind. As the name

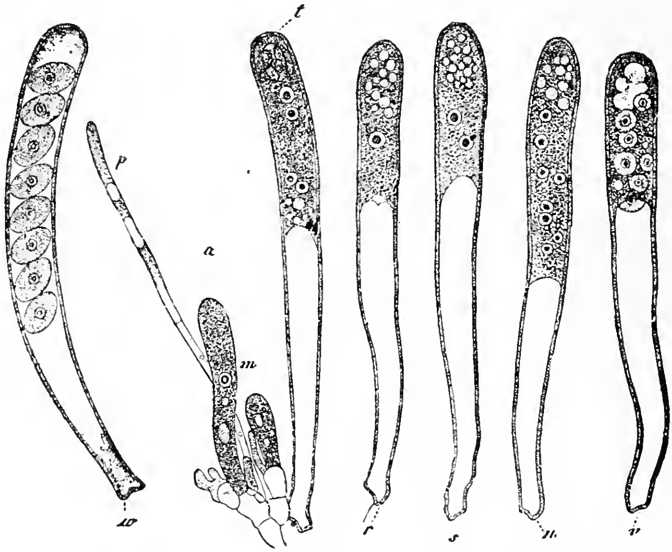


FIG. 14. *Peziza confluens* showing stages in the development of ascospores. In the youngest asci (m, r) there is only one nucleus; this divides into two (s); the division is repeated, so that there are 4 nuclei in (t) and 8 in (n). These surround themselves with protoplasm and a cell wall (v, w) but the protoplasm of the mother cell or ascus is not entirely used up.—After De Bary.

of the group to which this plant belongs indicates, it also produces zygospores (Fig. 13, *D*). These are formed by hyphal branches which ascend from the substratum. The ends of two branches come together, a transverse wall is formed in each branch, the walls in contact are absorbed, the contents unite, and a spore is formed with three membranes, two belonging to the spore proper and the third being formed by the united hyphæ. As would be expected, these spores are quite resistant, being able to withstand unfavorable conditions, and germinate (Fig. 13, *C*) only after a period of rest.

EUMYCETES: TRUE FUNGI.—ASCOMYCETES.—The Ascomycetes are distinguished for the most part, like the other higher Fungi, in having a septate mycelium, *i.e.*, one cellular in structure, and in producing asci (sacs), which latter are formed at the ends of the branches of the mycelia. Two main sub-groups are recognized, the one producing an indefinite number of spores in asci which are not well developed, and known as the HEMIASCI; the other producing a definite number of spores, which number is

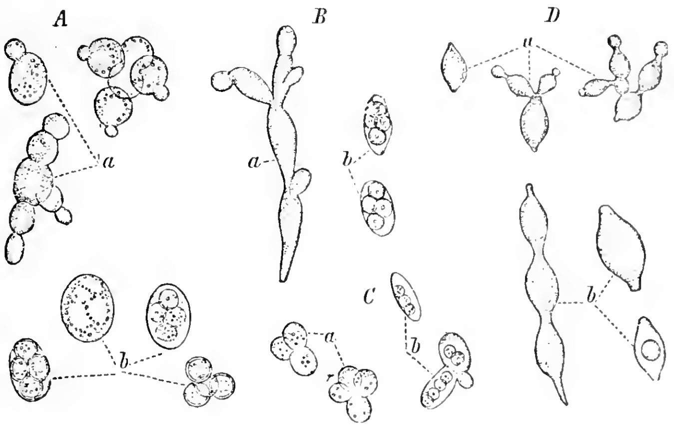


FIG. 15. Species of Saccharomyces (Yeasts). A, *S. cerevisiæ* or beer yeast; B, *S. Pastorianus*; C, *S. glomeratus*; D, *S. Piculatus*: a, vegetative cells reproducing by budding; b, formation of ascospores.—After Reesz.

characteristic for each species, in a well-developed ascus, and known as the EUASCI. In the latter group the spores arise by successive divisions of the primary nucleus into two, as shown in *Peziza confluens* (Fig. 14).

Yeasts.—The simplest of the Ascomycetes is the sub-group known as the Saccharomyces, or Yeasts. The Yeasts do not produce a mycelium, but the plant body consists of a single cell, or a chain of cells, and multiplies by a peculiar process known as "yeast budding" (Fig. 15, *a*). From either end of the cell a wart-like process develops, which enlarges until about the size of the original cell, from which it is then separated by the formation of a transverse wall. The cells are spherical, ellipsoidal, or egg-shaped, and in some cases somewhat elongated and hypha-like. In the protoplasm are one or more large vacuoles. In certain of the cells, which may be considered to be asci, two to eight spherical or ellipsoidal spores are produced (Fig. 16). There are a number of different species of Yeasts, some of which

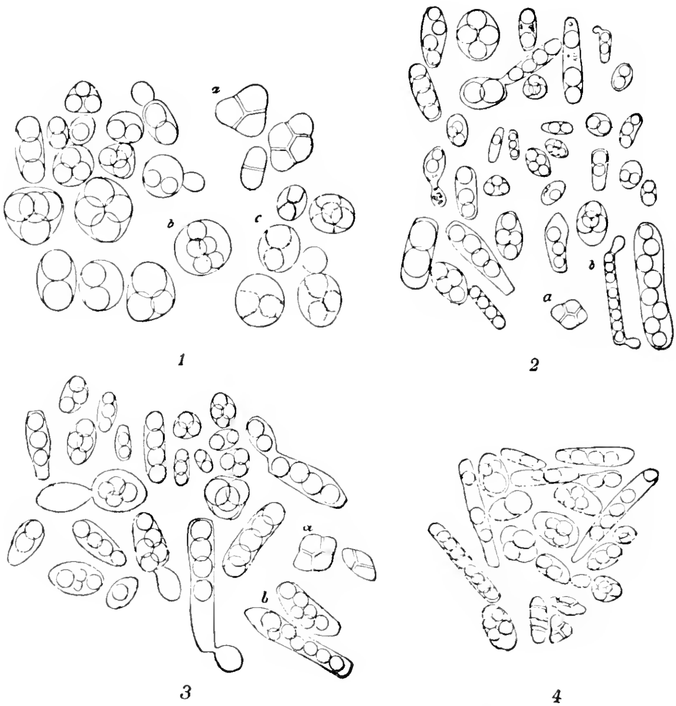


FIG. 16. Formation of ascospores in a number of different species of Yeasts. 1. *Saccharomyces cerevisiæ*; 2, *S. Pastorianus*; 3, *S. intermedius*; 4, *S. validus*.—After Hansen.

are cultivated; and these latter are of great economic importance on account of their property of inducing alcoholic fermentation. They are also of use in the making of bread, changing the carbohydrates in part into carbon dioxide and alcohol, both of which are driven off in the baking. Yeasts are used in the treatment of certain skin diseases, their action being attributed to a fatty substance, ceridine. Other principles found in yeasts as well as extracts are used in the treatment of cancer.

Green and Yellow Mildews.—To the Ascomycetes also belong the green and yellow Mildews, Penicillium and Asper-

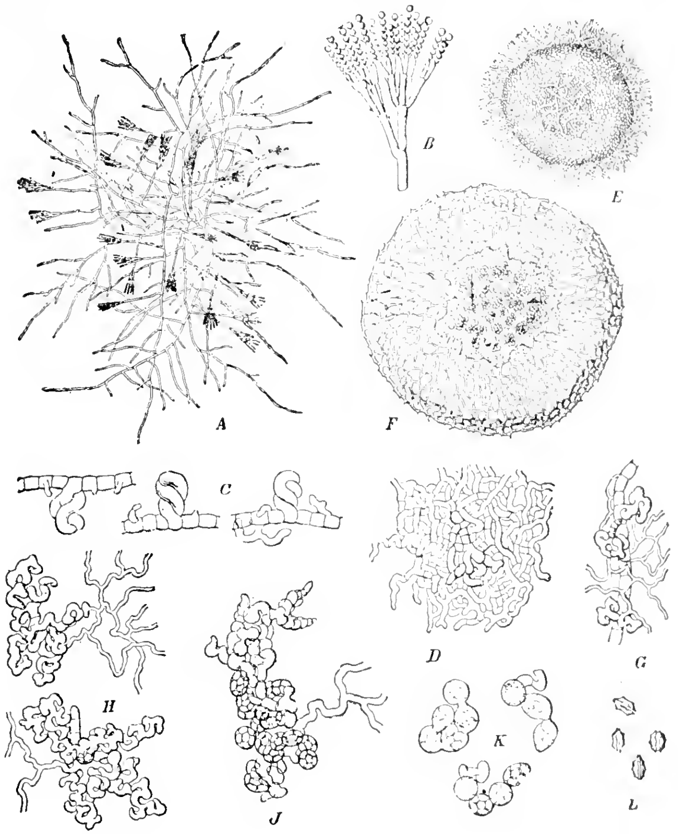


Fig. 17. Penicillium, a green mildew. A, richly branching mycelium with conidiophores; B, enlarged view of conidiophore showing chains of conidia; C, D, E, F, successive stages in the development of a perithecium; G, H, J, development of asci; K, groups of asci containing from 4 to 8 ascospores; L, ascospores seen from the side and showing characteristic markings.—After Brefeld.

gillus, so common in the household, the dairy, and the granary. These plants produce profusely branching mycelia which form patches upon or just under the surface of the materials upon which they grow. These areas become soft and spongy and are always white at first. After a time hyphal branches, which are more or less flask-shaped, rise above the substratum, and by a process of division at the end of the branch, or conidiophore, a spore called a conidiospore is formed (Fig. 17, *A*; Fig. 18, *A*). The process of division at the end of the conidiophore continues

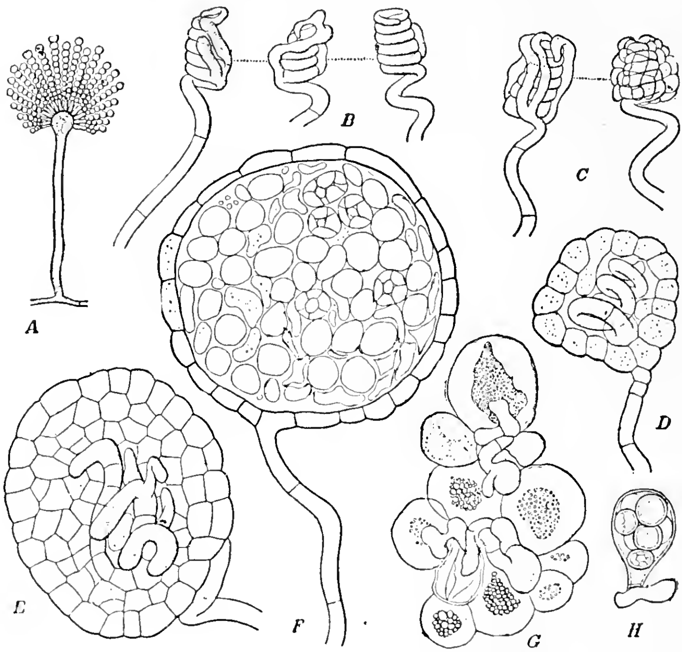


Fig. 18. Aspergillus, a yellow mildew. A, conidiophore with enlarged, more or less spherical end, from which the fan-like series of chains of conidia arise; B–E, successive stages in the development of perithecium; F, section through a nearly ripe perithecium; G, groups of young asci; H, a ripe ascus with 8 spores.—A, after Kny; B–H, after De Bary.

from below until a chain of conidiospores is formed. The conidiophore frequently branches, so that a fan-like series or group of conidia or conidiospores is produced (Fig. 17, *B*; Fig. 18, *A*). The conidia are usually some shade of green, but finally they may become more or less brown. They are thin-walled, quite small, and so light that they float freely in the air. If a colony is inhaled it gives the sensation commonly called the "smell of mold."

They are capable of germinating on almost everything, as old shoes, old paper, as well as on bread and other articles of the household, and are commonly found on "moldy drugs," in a number of pharmaceutical preparations, as syrups and infusions, and even in solutions of inorganic as well as organic chemicals.

Aspergillus (Fig. 18) is distinguished from Penicillium (Fig. 17) by the fact that the upper end of the hyphal branch or conidiophore is somewhat enlarged and more or less spherical.

In addition to the conidiospores these fungi sometimes produce in the fall of the year, particularly when grown upon bread, asci fruits (Fig. 17, *C–F;* Fig. 18, *B–E*). In this case two fertile initial hyphæ wind themselves around each other, after which they become surrounded with sterile branches which form a kind of loose tissue, more or less cellular in structure, that finally develops into a yellowish leathery wall. This body, which may be regarded as a closed ascocarp, is known as a perithecium (Fig. 17, *F;* Fig. 18, *F*). As a result of the conjugation of the fertile cells, asci (Fig. 17,*G, H, J;* Fig. 18, *G, H*) develop within the perithecium, which are more or less spherical or ellipsoidal and contain from four to eight spores (ascospores) (Fig. 17, *K;* Fig. 18, *H*). After maturity the cellular tissue around the asci dries up and disintegrates, the walls of the asci dissolve, and the ascospores are liberated from the perithecium by slight pressure. The spores lie over winter and then germinate, producing a mycelium from which conidia first develop and afterwards the perithecia, thus repeating the life history of the plant.

Ergot.—Another Ascomycete of special interest is the fungus known as ergot (*Claviceps purpurea*). The spores of this fungus germinate on the flowers of certain grasses. The mycelium penetrates the walls of the ovary, absorbing the nutriment. After a time the mycelium develops on the surface, and from this short conidiophores arise bearing small ovoid conidia (conidiospores) (Fig. 19, *A*). The mycelium secretes a sweet fluid, the so-called honey dew which attracts insects, and thus the conidia are carried to other plants. As the conidia are capable of immediate germination the so-called "ergot disease" rapidly spreads during the flowering season of the host plants. After the formation of conidia ceases, the mycelium forms a dense mass which is surrounded by a dark layer, and this, if developed upon rye, constitutes the ergot grains (Fig. 19, *B*) used in medicine, these grains being a number of times larger than the rye grains which

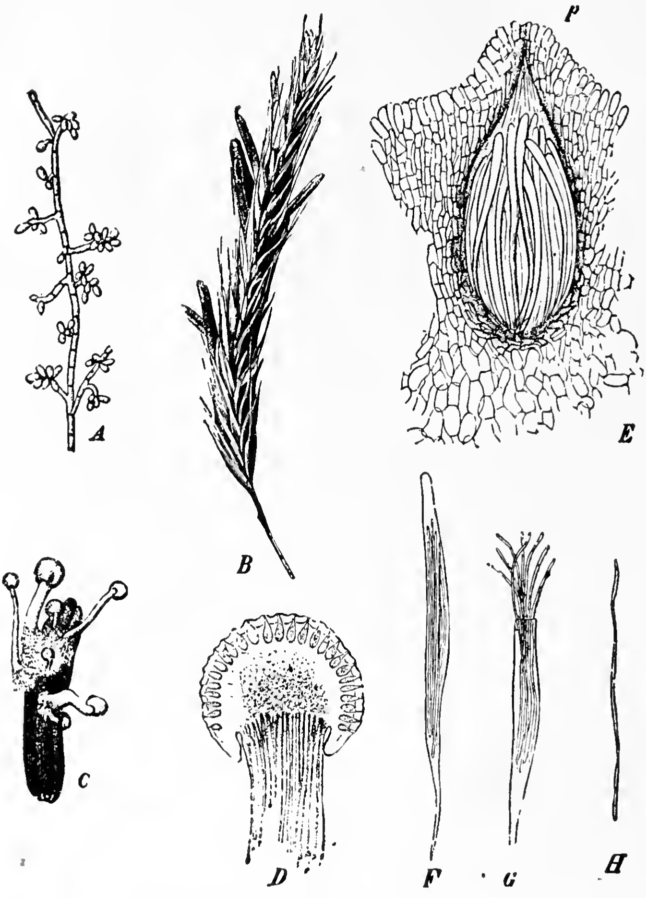


FIG. 19. *Claviceps purpurea.* A, mycelium developing conidia; B, an ear of rye with a number of ripe sclerotia replacing grains of rye, and known as ergot; C, sclerotium developing spherical fruit bodies; D, fruit body in longitudinal section showing numerous flask-shaped perithecia at the periphery; E, enlarged perithecium with numerous cylindrical asci; F, closed ascus with 8 ascospores; G, discharge of ascospores; H, single thread-like ascospore.—A, after Brefeld; B, after Schenck; C–H, after Tulasne.

they replace. The mycelial tissues connected with the host plant die, and the ergot drops to the ground. At this stage the ergot mass is more or less cellular in structure and is known as the SCLEROTIUM. It is quite resistant and usually remains dormant until the following spring when the grasses are in flower again. The sclerotium then shows signs of renewed activity by the development of small, reddish, spherical bodies with a fair-sized stalk (Fig. 19, *C*). Within the periphery of these spherical heads

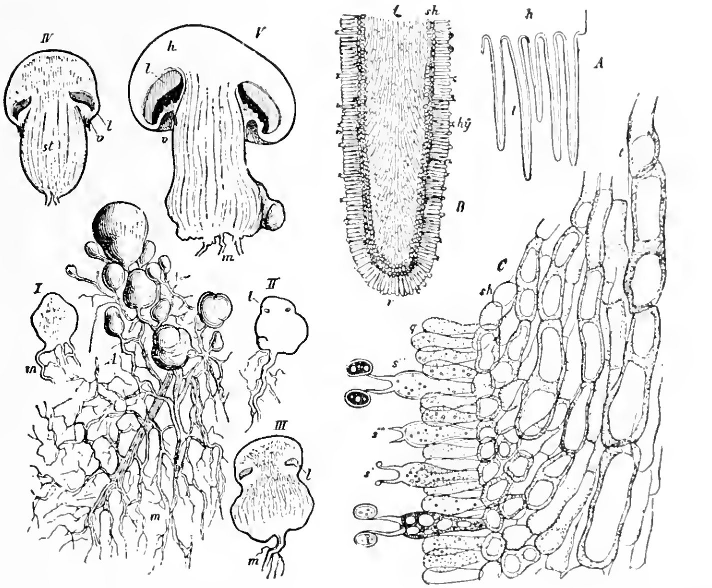


FIG. 20. *Agaricus campestris*, the common edible mushroom, showing at A on the left mycelium (m) and development of buttons or young mushrooms; I to V, longitudinal sections showing successive stages in development of fruit body; m, mycelium; st, stipe; l, portion between veil (v) and spore-bearing portion (h).

The illustration to the right (A, B, C) shows the structure of the hymenium in different degrees of magnification: A, section through portion of pileus showing five of the gills; B, section of a gill somewhat magnified; C, section of gill still more magnified and showing sterile cells or paraphyses (q), and the fertile cells or basidia (s), from each of which arise two basidiospores.—After Sachs.

are produced flask-shaped perithecia or ascocarps (Fig. 19, *D*) containing numerous cylindrical asci (Fig. 19, *E*), each of which contains eight spores (Fig. 19, *F*); the latter are one-celled, hyaline and thread-like (Fig. 19, *H*). These spores are carried by the wind to the flowers of certain of the grasses, as already stated, and the life history or cycle of growth begins again.

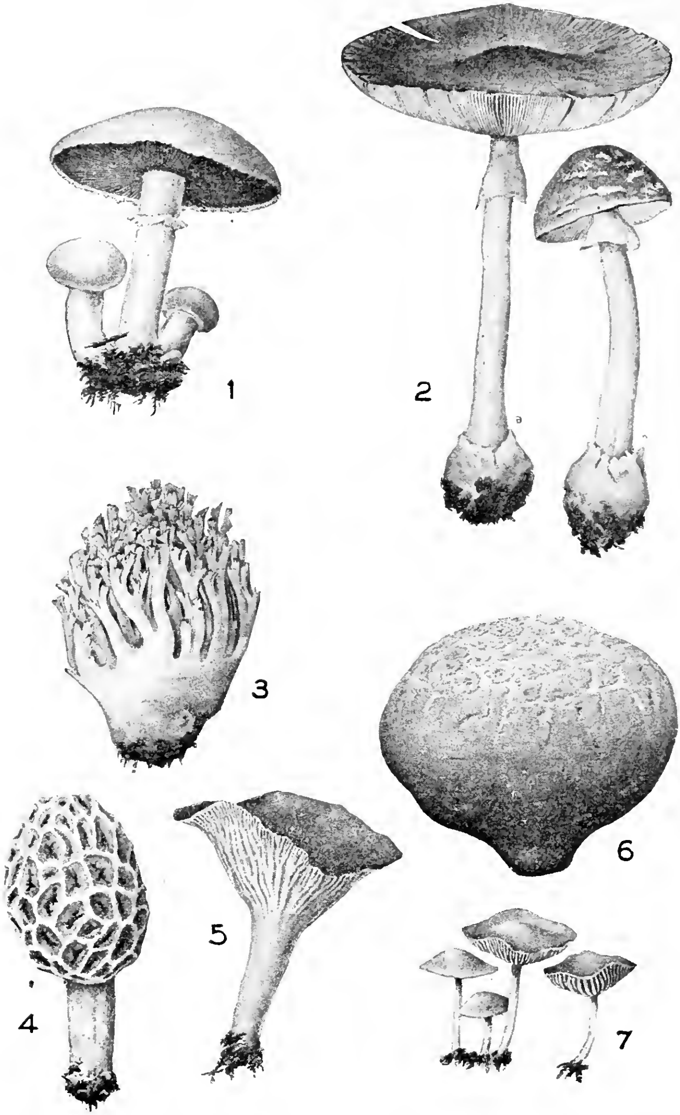


FIG. 21. Some common *edible* mushrooms and a common poisonous one. The following are edible: 1, Common Field mushroom (*Agaricus campestris*); 3, *Clavaria flava*, young plant; 6, Puffball (*Lycoperdon cyathiforme*); 4, Morel (*Morchella esculenta*); 5, Chanterelle (*Cantharellus cibarius*); 7, Fairy-ring Fungus (*Marasmius oreades*).

Only one *poisonous* species is shown, namely, 2, the deadly Agaric (*Amanita phalloides*). —Adapted from Farlow.

Basidiomycetes.—The Basidiomycetes are the most highly organized of the Fungi. The mycelium consists of white branching threads and is usually concealed in the substratum. In the cultivation of the edible mushrooms propagation is by means of the mycelium which is known commercially as "spawn." It is recognized, however, that mushrooms can not be propagated in this way exclusively for more than two or three years. The mycelium is really the plant body, and the part which rises above the surface and is commonly regarded as the toadstool or mushroom (Figs. 20 and 21) is a fruit branch, or spore-producing organ. When these branches first make their appearance they are in the form of small solid bodies known as "buttons" (Fig. 20, *I-V*). As growth proceeds these bodies differentiate into a stalk-like portion known as the stipe (Fig. 20, *st*), which is directly connected with the mycelium, and an umbrella-like portion borne at the summit of the stalk, called a pileus, which at first is closed down over the stalk, but later expands or opens more or less widely according to the species. On the under surface of the pileus, known as the hymenium, the spores are borne (Fig. 20, *A, B, C*). In some cases the under surface is composed of a series of narrow, radiating, knife-like plates, or gills, as in the common edible mushroom Agaricus. On the surface of the gills the basidia or spore-bearing organs arise. The basidia are somewhat swollen terminal cells of the closely arranged hyphæ composing the gills, which bear a group of spores on short stalks (Fig. 20, *C*). Both the basidia and spores (basidiospores) are of a characteristic size and number for the different species.

In some of the other members of the group the gills are replaced by pores, as in the "pore-fungi," which are parasites on trees and destructive to timber. In still other cases the under surface is furnished with teeth, as in the "teeth-bearing Fungi," some of which, as *Hydnum repandum*, form the "fairy-rings" in the woods. The latter are also formed by *Marasmius oreades* (Fig. 21, illus. 7), in which the gills are comparatively few and bulge out at the middle.

One or two types will be considered, namely, the common edible mushroom and two of the poisonous group, Amanita.

Edible Fungi.—*Agaricus campestris* (common mushroom) (Fig. 21, illus. 1) is practically the only edible species cultivated in this country. The plant grows wild in open grassy fields during August and September. It is not found in the mountains to any extent, and is never found in the woods or on trees or fallen trunks. The color of the stipe and the upper surface of the pileus varies from whitish to a drab color, but the color of the gills is at first pinkish and then of a brownish-purple, which is an important character, the color being due to the spores. The stipe is cylindrical and solid, and a little more than half way up is furnished with a membranous band known as the ring. There are no appendages at the base of the stipe, which appears to rise directly out of the ground. Before the pileus is fully expanded a veil extends from its border to the stipe, which when ruptured leaves a portion attached to the stipe, and it is this which constitutes the ring. The ring shrinks more or less in older specimens but usually leaves a mark indicating where it has been formed.

Poisonous Fungi.—There are two of the poisonous group of fungi which are very common and which have some resemblance to the edible mushroom just described, namely, the fly agaric (*Amanita muscaria*) and the deadly agaric (*Amanita phalloides*) (Fig. 21, illus. 2). The fly agaric, while more abundant in some localities than the common edible mushroom, is seldom found in grassy pastures, but more generally in poor soil, especially in groves of coniferous trees. It occurs singly and not in groups. The gills are always white; the stipe is white, hollow and provided with a ring at the top, and the base is bulbous, having fringy scales at the lower part. The pileus is yellow or orange and sometimes reddish; the surface is smooth, with prominent, angular, warty scales, which can be easily scraped off.

The deadly agaric (Fig. 21, illus. 2) somewhat resembles the fly agaric and also differs from the common mushroom in not usually growing in pastures. It occurs singly but not in groups, in woods and borders of fields. The gills and stipe are white, the latter, when young, having a number of mycelial threads running through it. The base is quite bulbous, the upper part of the bulb having a sac-like membrane called the volva. The pileus may vary from any shade of dull yellow to olive, although sometimes it is shiny and white. While it does not possess the warty scales found in the fly agaric, it has occasionally a few membranous patches.

The Toxic Principles in Poisonous Fungi.—The deadly agaric (*Amanita phalloides*) is the cause of the greatest number of cases of mushroom poisoning. According to Abel and Ford it contains two toxic principles: (1) *Amanita-hemolysin* a blood-laking principle, which is a very sensitive glucoside, that is, precipitated by alcohol and destroyed by heating to 70° C. and by the action of digestive ferments; (2) *Amanita-toxin* which is soluble in alcohol and not destroyed by the action of heat or ferments. The latter principle is the important poisonous principle in mushroom poisoning and is probably the most toxic principle known, 0.4 of a milligramme killing a guinea pig within 24 hours. "The majority of individuals poisoned by the "deadly amanita" die, but recovery is not impossible when small amounts of the fungus are eaten, especially if the stomach be very promptly emptied, either naturally or artificially."

The fly agaric (*Amanita muscaria*) owes its toxicity to *muscarine*, an alcohol-soluble crystalline substance. It is supposed by Ford that the fly agaric may contain another poisonous constituent. In cases of poisoning atropine has been successfully administered hypodermically in doses of $\frac{1}{100}$ to $\frac{1}{50}$ of a grain.

It is stated that the *A. muscaria* used by the peasants of the Caucasus in the preparation of an intoxicating beverage is deficient in muscarine.

The question as to whether the ordinary edible mushrooms, as distinguished from the poisonous toadstools, may not in certain localities or at certain periods of the year be the cause of fatal intoxication is answered by Ford in the negative. He states (*Science*, 30, p. 105, July 23, 1909) that there are no authentic cases of poisoning from the black or brown spored agarics, although old and badly decomposed specimens may cause transient illness.

Economic Uses of Fungi.—A large number of the Fungi, particularly of the Basidiomycetes, are used for food. There are, however, only a few of these which enter the market. These are derived chiefly from *Agaricus campestris* (Fig. 21, illus. 1) and *Agaricus arvenis*, although some other species of Agaricu as well as *Morchella esculenta* (Fig. 21, illus. 4) furnish excellent products and are cultivated to a limited extent. The "truffles" of the market are tuber-like masses formed under ground, which consist of the ascocarps of certain Tuberaceæ, one of the sub-groups of the Ascomycetes, and which are used as a condiment and sometimes roasted like potatoes. Tuckahoe or "Indian bread" is also produced under ground and consists apparently of the fungus *Pachyma Cocos* and the roots of Liquidambar, the tissues of which have been changed into a compound resembling pectic acid by the fungus. Quite a number of Fungi have been used in medicine, as *Claviceps purpurea* (Fig. 19), *Polyporus officinalis* and other species, and various species of Lycoperdon. A number of species are used in making surgeon's agaric (Fungus chirurgorum) formerly used as a hemostatic, including *Lycoperdon bovista* and *Polyporus fomentarius*. Many of them yield very toxic principles, as (1) several species of Amanita which contain several toxic principles; (2) *Lactarius piperatus* and others which yield highly poisonous resinous principles. Other uses of Fungi have been mentioned under the several groups.

USTILAGINEÆ and UREDINEÆ.—There are two groups of Fungi of considerable economic interest which by some writers are classed by themselves, and by others placed with the Basidiomycetes. These are the Ustilagineæ, or Smut Fungi, and the Uredineæ, or Rust Fungi.

The Smut Fungi are parasitic on higher plants. The mycelium penetrates the tissues of the host, but does not seem to cause either disease or malformation of the plant. Injury to the host results only after the development of resting spores. The mycelia are hyaline, more or less branched, and finally become septate. They send short branches, called haustoria, into the cells of the host, from which they obtain nourishment. Eventually the mycelium becomes much branched, compact and more or less gelatinous through a transformation of the hyphal walls, forming gall-like swellings or blisters on the host. Spores are formed within this gelatinous mass at the ends of the branches of the mycelium. At a later stage the smut loses its gelatinous character, the mass breaks up, and the spores are freed and distributed as a dry, dusty powder. The spores (primary conidia) are somewhat spherical or ellipsoidal, and are generally separate, but are sometimes united into a mass forming the so-called "spore balls." These are resting spores and upon germination (Fig. 23) produce a promycelium or basidium which becomes septate and from each cell of which conidia called sporidia arise. The sporidia are formed in succession one after another and the process continues for some time. On germination they bud like

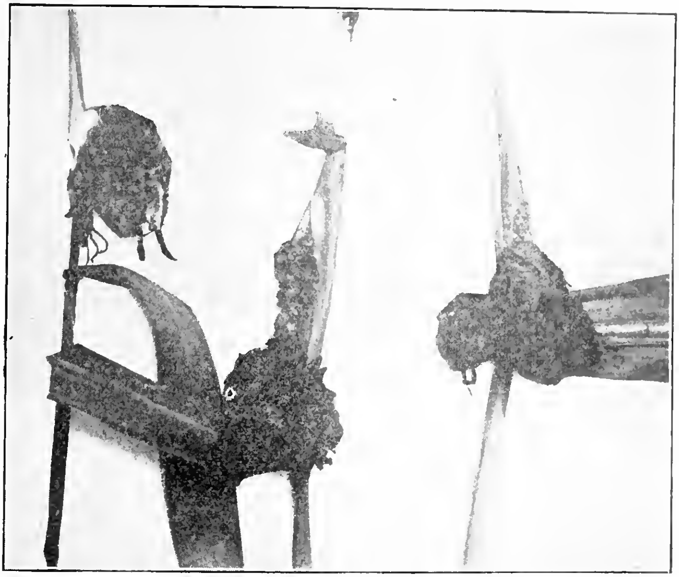


FIG. 22. Corn smut (*Ustilago Maydis*) showing several gall-like masses of smut full of spores.

yeast, forming new conidia, or when nutrition is not abundant they may form a mycelium, which is usually the case when they germinate on a host plant.

Corn Smut.—One of the Smut Fungi, namely, *Ustilago Maydis*, which develops on Indian corn (Fig. 22), is used in medicine. It forms rather large gall-like masses on all parts of the plant, including the root, stem and leaves, and both staminate and pistillate flowers. The spores (Fig. 23) are at first a dark olive-green, but on maturity are dark brown. They are sub-spherical, have prominent spines, and vary from 8 to 15 microns in diameter.

They do not germinate at once, but on keeping them for six months to a year they germinate readily on a culture medium of potato, and retain their power of germination for years.

Rust Fungi.—The Rust Fungi are parasitic on higher plants and produce a thread-like, branching, cellular mycelium, which develops in the tissues of the host. They differ especially

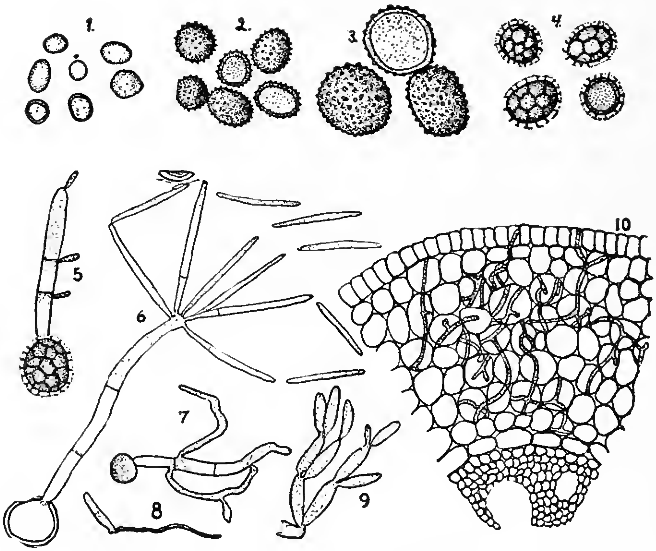


FIG. 23. Spores of various Smuts. 1, *Ustilago longissima* growing on the reed meadow-grass (*Panicularia americana*); 2, *Ustilago Maydis* from Indian corn (*Zea Mays*); 3, *Ustilago Oxalidis* on the yellow wood-sorrel (*Oxalis stricta*); 4, *Ustilago utriculosa* on the Pennsylvania persicaria (*Polygonum pennsylvanicum*).

FIG. 24. Germination of spores. 5, *Ustilago utriculosa*, in water, showing promycelium and sporidia; 6, *Doassansia opaca* from the broad-leaved arrow-head (*Sagittaria latifolia*) in water, showing promycelium, sporidia, and secondary sporidia which are falling off; 7, *Ustilago avenæ* from oat (*Avena sativa*) in horse dung, showing promycelium, and lateral "infection threads" or hyphæ; 8, germination of a sporidium of *Ustilago Sorghi* into an infection thread; 9, small portion of a group of sporidia developed from promycelium of *Tolyposporium ericcauli* in potato agar; 10, cross-section of epicotyl of broom-corn infected by *Ustilago Sorghi* showing mycelium ramifying through parenchyma cells of the cortex.—After Clinton.

from the other Fungi in producing resting spores known as TELEUTOSPORES. These spores consist of one or more cells surrounded by a thick black wall, and they produce the "black rust" seen on foliage at the end of the season.

LICHENS.

General Characters.—The Lichens are a peculiar group of plants in that an individual lichen consists of both an alga called a GONIDIUM and a fungus. These are so intimately associated that they appear to be mutually beneficial, and such a relation is known as SYMBIOSIS (Fig. 25). The Algæ which may be thus associated in the Lichens are those members of the Blue and Green Algæ which grow in damp places, as Pleurococcus, Nostoc, Lyng-

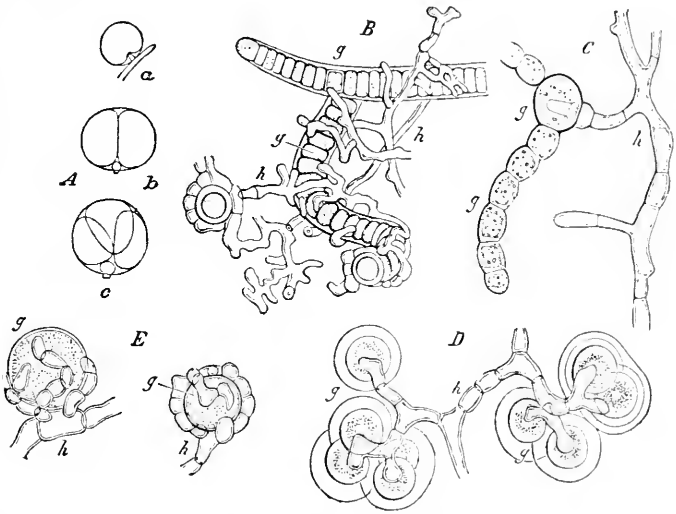


FIG. 25. Lichens showing manner of union of algæ or gonidia (g) and hyphæ (h) of Fungi. A, *Pleurococcus*, showing the manner in which hyphæ penetrate the cell and influence cell division; B, *Scytonema*, an alga surrounded by richly branching hyphæ; C, chain of *Nostoc* showing hypha of fungus penetrating a large cell known as a heterocyst; D, fungal hyphæ have penetrated the cells of *Glœocapsa* a blue-green, unicellular alga; E, *Chlorococcum*, a reddish or yellowish alga found in *Cladonia furcata*, the cells of which are surrounded by the short hyphæ of the fungus.—A, after Hedlund; B–E, after Bornet.

bya, etc. (Fig. 25). The Fungi which occur in this relation belong both to the Ascomycetes and Basidiomycetes and it is on the characters of the fruit bodies of these particular Fungi that the main divisions of Lichens are based. The Fungi, however, are not known to exist independently of the Algæ with which they are associated, that is, the mycelia of the fungi will not live for any length of time unless they come in contact with a suitable alga. In its development the fungus forms a mycelium which encloses the alga, the growth of which latter is not hindered. The two organisms then continue to grow simultaneously forming lichen patches. A section of a lichen shows a differentiation into several parts, namely, a more or less compact row of cells on both surfaces forming two epidermal layers; and an inner portion made up of the hyphal tissue of the fungus in which the alga is embedded either in a single layer or throughout the mycelium. The mode of growth and branching is influenced largely by the fungus, although in some cases the alga may exert the most influence. In some cases the lichen consists of a thallus which is irregular in outline, growth taking place at no definite point, and in other cases branches which are more or less regular are formed, growth taking place at the apex.

Groups of Lichens.—According to the manner of growth and the manner of attachment to the substratum three principal groups (Fig. 26) of lichens are distinguished: namely, (1) Crustaceous Lichens, where the thallus adheres closely to the stones and barks of trees and practically can not be removed without injury; (2) Foliose Lichens, or those which are more or less flattened, somewhat leaf-like and attached at different points; (3) Fruticose Lichens, or those which are attached at a particular part of the thallus, and form diffusely branching clumps. To this latter group belongs *Cetraria islandica* or Iceland moss (Fig. 26), which is used in medicine (p. 690), *Usnea barbata* and the red-fruiting Cladonias which are so common.

Reproduction in the Lichens takes place in several ways. In all of them there is a vegetative mode by means of what are known as SOREDIA. These are small spherical bodies consisting of a group of algal cells, which are surrounded by a mass of hyphæ, and which when cut off from the main body are able to grow. Lichens also produce spores of a number of kinds. In the largest group, the one to which *Cetraria islandica* (Fig. 26) belongs, the spores are found in special spherical receptacles, known as PYCNIDIA, which are formed on the teeth of the margin of the thallus. The spores arise from the ends of hyphæ at the base of the pycnidia and are in the nature of conidiospores. To these spores the name PYCNOCONIDIA has been applied. Cetraria also produces, like many other Lichens, disk-like or cup-shaped bodies at various places on the surface of the thallus, which are known as APOTHECIA and which may be regarded as exposed or open ascocarps. The inner surface of the apothecia is lined with a number of asci as well as sterile cells, the former giving rise to ascospores.

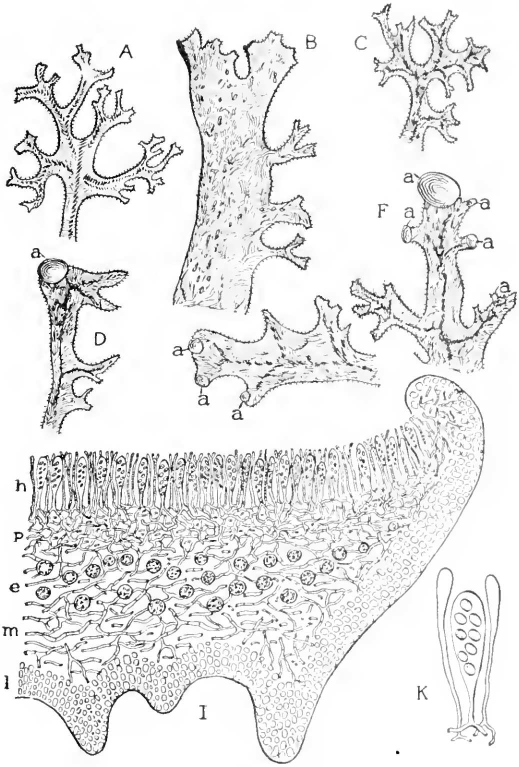


Fig. 26. Iceland Moss (*Cetraria islandica*). A–F, various forms of thalli showing apothecia (a); I, cross-section of an apothecium showing the hymenium (h), the hypothecium (p), the algal layer (e), the medullary layer (m), and lower or ventral surface (l); K, an ascus with eight ascospores and two paraphyses from the hymenium (h of I).

Economic Uses of Lichens.—A number of the Lichens are used in medicine, as several species of *Cetraria*, *Pertusaria communis*, *Physcia parietina*, *Sticta pulmonacea*, *Evernia furfuracea*.

Some of those used in medicine, are also used as foods on account of the gelatinous carbohydrate lichenin which they contain. Besides those given the following may be mentioned: *Cladonia rangiferina* (reindeer moss), *Lecanora esculenta* (supposed to be the manna of the Israelites. The Lichens are, however, chiefly of interest because of the coloring principles which they contain. *Roccella tinctoria*, *Lecanora tartarea*, and other species of *Lecanora*, yield upon fermentation the dyes orcein and LITMUS, the latter of which finds such general use as an indicator in volumetric analysis. Cudbear, a purplish-red powder, is prepared by treating the same lichens with ammonia water; while in the preparation of orchil, a purplish-red pasty mass, sulphuric acid and salt are subsequently added. A number of species contain a yellow coloring principle, as *Zeora sulphurea*, *Zeora sordida*, *Lecidea geographica* and *Opegrapha epigæa*.

BACTERIA.

The Bacteria, or Fission Fungi, occupy rather an anomalous position, some writers classifying them with Fungi and some with Algæ. They are 1-celled plants, microscopic in size, and of various shape. The contents consist of protoplasm and a central body in some cases, which is looked upon as a rudimentary nucleus. They are more or less colorless, but sometimes produce a distinct pigment called bacteriopurpurin which is rose-red or violet, and occasionally a chlorophyll-green color substance. They are capable of multiplying by division in one, two, or three directions, and under favorable conditions increase very rapidly in number. The wall is more or less albuminous in character, in this respect resembling the wall of the animal cell, and is provided with one to many cilia, or flagella, the number and position of which have been used as a basis of classification. Sometimes the walls of the cells become mucilaginous, so that the bacteria hold together forming a mass known as a zoöglœa. Bacteria may form resting spores which arise in two ways. In one case the contents round off and take on a membrane forming a so-called ENDOSPORE; in the other case the plant body is transformed directly into a spore known as an ARTHROSPORE, as in some of the Blue-green Algæ. This body is not strictly a spore but is in the nature of a resting cell (Fig. 26a).

Occurrence.—Bacteria occur everywhere in nature, and play a most important part in decay and putrefaction in that they change dead animal and plant tissues back again into simple inorganic substances, as carbon dioxide, water, ammonia, etc. They

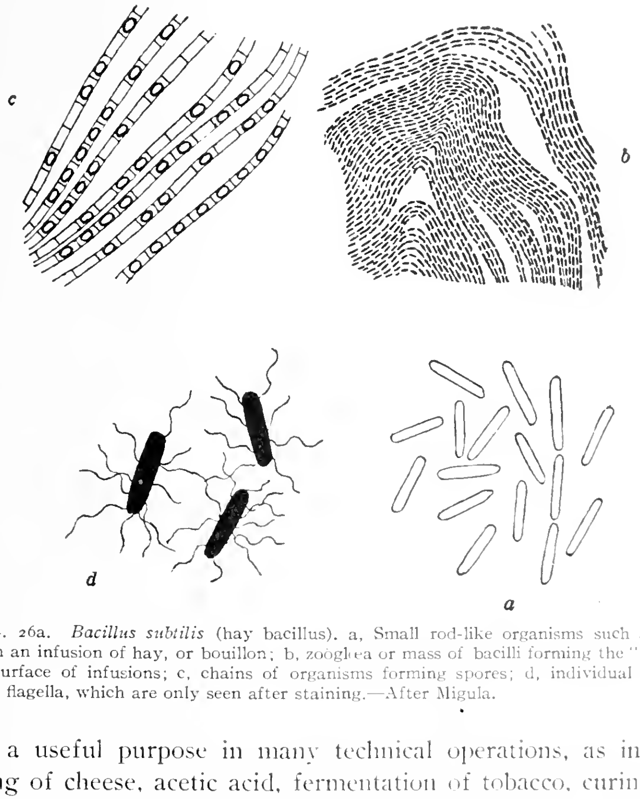


FIG. 26a. *Bacillus subtilis* (hay bacillus). a, Small rod-like organisms such as are found in an infusion of hay, or bouillon; b, zoöglœa or mass of bacilli forming the "skin" on the surface of infusions; c, chains of organisms forming spores; d, individual bacilli showing flagella, which are only seen after staining.—After Migula.

serve a useful purpose in many technical operations, as in the making of cheese, acetic acid, fermentation of tobacco, curing of vanilla and many vegetable drugs, and in soil nitrification, helping to change ammonia into nitrates—one of the sources of the nitrogen used by plants (see page 98). Many of them are disease-producing, or pathogenic, and are the cause of a number of infectious diseases in man and the lower animals, and plants as well. They are injurious in two ways, in one case they consume the tissues of the host, as in tuberculosis, and in the other they produce powerful poisonous substances, or toxins, as in diphtheria.

Classes of Bacteria.—In order to study Bacteria they are grown upon nutrient media, such as sterile bouillon, potato, milk, etc. They are divided into a number of classes, depending for the most part on the shape of the cell: (1) The Sphærobacteria, or Cocci, are those whose cells are spherical or spheroid, and in which division takes place in one, two or three directions of space. Very few of the group are provided with cilia. According to the number of cells in a colony they are distinguished as Micrococci, Diplococci, etc. (2) Bacteria proper are elongated, rod-shaped organisms in which division occurs in only one direction, namely, transversely to the long axis, and only after a preliminary elongation of the bacterium. The Bacteria are subdivided into two important groups, namely, Bacterium and Bacillus. The Bacilli are motile organisms and produce endospores (Fig. 26a), whereas the Bacteria are non-motile and do not usually produce endospores. (3) Spiral bacteria constitute the third principal group and are characterized by the cells being spirally coiled. Division is in only one direction. These bacteria are usually motile, and seldom produce endospores. (4) There is another important group which includes the Sulphur Bacteria, of which the most common one is *Beggiatoa*. These occur in long threads, and move in an undulating manner much like *Oscillaria*, one of the Blue-green Algæ. They are found in sulphur waters, as in sulphur springs, and contain sulphur granules.

Bacteriological Technique.—Principally because of the minuteness in size of micro-organisms a different technique is required in their study from that required in the study of the higher plants. In the first place it is difficult to isolate them so as to be able to study individual forms. Another difficulty is to prevent contamination after they are isolated. And even though a pure culture is obtained it is difficult on purely morphological grounds to differentiate the various forms, as they are all so much alike.

I. While it is comparatively easy to prepare a sterile solution, that is, one in which all life is absent, it is very difficult to prevent subsequent contamination under ordinary conditions. Even when a cork or glass-stoppered bottle for keeping liquids is used it is difficult to prevent the entrance into and development of micro-organisms in the liquids. The use of stoppers consisting of plugs of absorbent cotton was first suggested by Schroeder and von Dusch in 1854. They found that if flasks containing liquids, which under ordinary conditions were likely to decompose, as beef broth, etc., were stoppered with plugs of absorbent cotton and the liquid then boiled for some time that it would keep indefinitely.

II. It remained for Koch and Pasteur to show what took place in the boiling of the liquid, who at the same time developed the principles of sterilization in bacteriological work. These authors discovered that micro-organisms have two stages of development, one of which is active and the other resting, the latter being known as the egg or spore condition. They found that the organisms in the active condition were completely destroyed on heating the solution containing them for 30 minutes at 100° C. If this solution was allowed to stand for 24 hours or longer there would be evidences of decomposition, which was due to the fact that the spores representing the resting stage of the organisms were unaffected by the first heating and developed into the active stage. As a result of further experiments they found that if the solution were heated on the second day for 30 minutes at a temperature of 100° C. the second growth of organisms was destroyed but it was found that the solution might still undergo decomposition in the course of time, owing to the later development of a few remaining spores. It was however found that heating the liquid again on the third day was sufficient to kill all of the spores as well as the organisms in the active stage. By repeating these experiments the authors confirmed their observations and established the process known as *discontinuous sterilization*, which simply means that if a solution of a putrescent or fermentative substance is heated on three consecutive days for 30 minutes at a temperature of 100° C., the flask or bottle being stoppered with absorbent cotton, it will keep indefinitely. Instead of using a plug of absorbent cotton the neck of the flask can be drawn out into a narrow tube and directed downwards (see Fig.

323). The time required for producing a sterile solution, that is one free from micro-organisms or their spores, can however be much reduced by increasing the temperature, or pressure, or both. By use of the autoclave in which the pressure can be increased from 10 to 20 pounds, sterilization can be accomplished in 30 minutes by using a temperature of 110° C.

As already indicated one of the greatest difficulties is to isolate the organisms. In a cubic centimetre of water there may be a million organisms representing various groups of bacteria. In trying to solve the problem of their separation it occurred to Koch that if he could secure a medium which was solid at the ordinary temperature and liquid at a slightly higher temperature, he could mix a certain quantity of liquid containing micro-organisms with the medium in a sterile condition, and then by solidifying the mixture the organisms would be fixed, and thus from each organism a colony would be developed which could be isolated and further studied. We are indebted to Koch for the use of solid culture media like nutrient gelatin and nutrient agar in the study of these organisms.

The application of stains for differentiating the various organisms was introduced by Weigert in 1877. Staining is of use in the determination of the number of flagella of certain organisms, in the study of spores, and the identification of certain pathogenic organisms, which occur in mucus and pus, as tubercle bacilli, etc. Gram's method of staining is of great use in differentiating many pathogenic as well as non-pathogenic organisms, and is of importance in classifying bacteria.

ARCHEGONIATES.

The two main features which distinguish the Archegoniates from the Thallophytes are the structure of the sexual organs and the distinct manner in which the peculiar phases known as alternation of generations is shown. The antheridium or male sexual organ is a well differentiated multicellular body which is either sunk in the adjacent tissues of the plant or is provided with a stalk. Within it are organized the sperms or spermatozoids, which are ciliate and swim freely in water. Corresponding to the oögonium of the Thallophytes is the ARCHEGONIUM or female sexual organ which gives name to the group. The archegonium is a flask-shaped cellular body consisting of a basal portion or venter, which contains a single egg, and a neck through which the sperms enter (Figs. 32, 34).

In the life history of this group of plants there are two generations or phases of development. During one stage the archegonium and antheridium are developed and this is known as the sexual generation, and as these organs give rise to gametes or sexual cells it is also spoken of as the GAMETOPHYTE. By the union of the sex cells (sperm and egg) an oöspore is formed which germinates at once within the archegonium. That portion of the plant which develops from the oöspore gives rise to asexual spores and hence this phase is called the asexual generation. It is also spoken of as the SPOROPHYTE from the fact that it gives rise to spores. These spores are in the nature of resting spores and do not germinate on the plant as does the oöspore. They are distributed and on germination give rise to the gametophyte stage.

In some of the Archegoniates these two phases are combined in one plant as in the Bryophytes, whereas in other members of the group the two phases are represented by two distinct plants, that is, the gametophyte and sporophyte become independent of each other, as in the Ferns.

The following table shows the main divisions and subdivisions of the Archegoniates:

Archegoniates	Bryophytes	Hepaticæ (Liverworts). Musci (Mosses).
	Pteridophytes	Filicales (Ferns). Equisetales (Horsetails). Lycopodiales (Club Mosses).

BRYOPHYTES.

The structure of the sexual organs in the Liverworts (Fig. 27) and Mosses (Fig. 32) is essentially the same, but the vegetative organs are more or less dissimilar. In the Liverworts the plant body or thallus lies more or less close to the substratum or rises somewhat obliquely, whereas in the Mosses the part we designate as the plant is in all cases an upright leafy branch. The moss plant is said to have a radial structure from the fact that the leaves radiate from a central axis, while in the Liverworts the thallus is dorsiventral, that is, as a result of its habits of growth, it is characterized by having a distinct upper and lower surface.

The Life History of this group of plants may probably be best illustrated by following that of a moss plant. Beginning with the germination of an asexual spore which is microscopic in

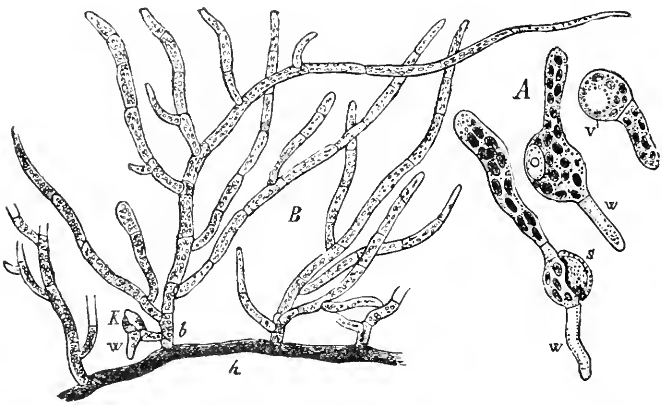


FIG. 27. A common moss (*Funaria*). A, germinating spores: v, vacuole; w, root-hair; s, exospore. B, protonema about three weeks after germination: h, procumbent primary shoot; b, ascending branch of limited growth; K, bud or rudiment of a leaf-bearing axis with root-hair (w).—After Sachs.

size and which germinates on damp earth, there is produced an alga-like body consisting of branching septate filaments, which is known as the PROTONEMA, or prothallus (Fig. 27). The Protonema lies close to the surface of the ground and is more or less inconspicuous except for the green color. From the lower portion thread-like processes, or rhizoids consisting of a row of cells, are developed, which penetrate the ground. Sooner or later lateral buds arise from some of the lower cells. Growth continues from an apical cell which divides and gives rise to cells that differentiate into stem and leaves, forming an upright branch, which constitutes the structure commonly regarded as the "moss-plant"

(Fig. 28, *A*). The leaf-bearing axis varies considerably in size, in some cases it is but a millimeter high whereas in some species, as *Polytrichum* (Fig. 28), it may be several hundred millimeters

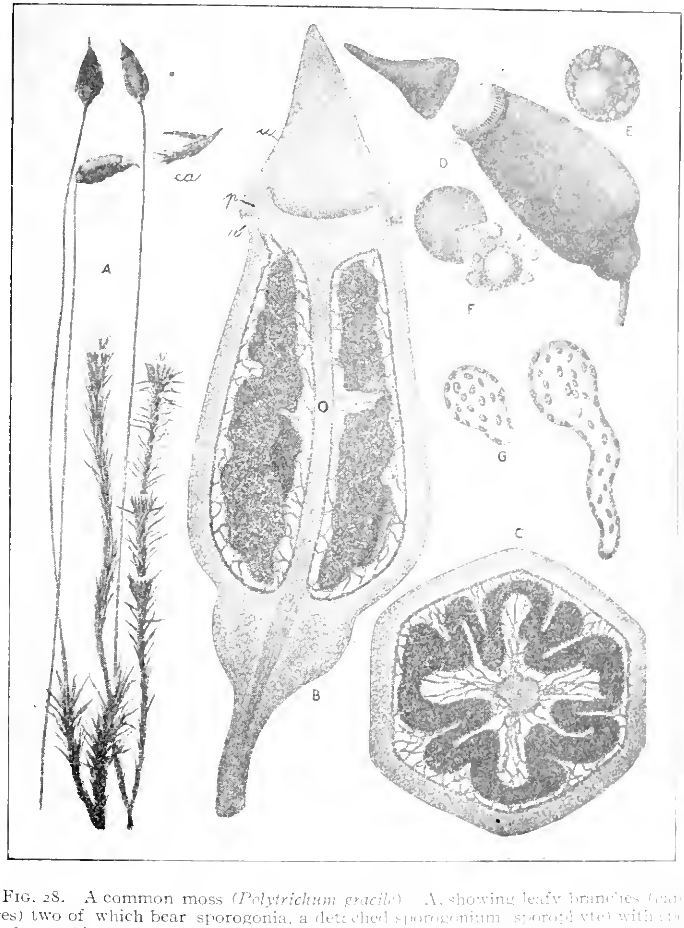


FIG. 28. A common moss (*Polytrichum gracile*). A, showing leafy branches (gametophores) two of which bear sporogonia, a detached sporogonium (sporophyte) with sporangium from which the calyptra (ca) has been detached. B, longitudinal section through a nearly ripe sporangium showing columella (o), the elongated area of sporogenous tissue (archesporium) on either side, annulus (n), peristome (p), lid or operculum (d); C, transverse section of sporangium showing columella in center and dark layer of sporogenous tissue (archesporium); D, ripe sporangium (capsule) showing the escape of spores after detachment of lid; E, ripe spore containing large oil globules; F, ruptured spore showing separated protoplasm and oil globules; G, two germinating spores 14 [illegible] after being sown, showing beginning of protonema in which are a number of ellipsoidal [illegible]. —After Dodel-Port.

in height. At the tip of the branch the antheridium (Fig. 32, *A*) and archegonium (Fig. 32, *B*) are formed. These organs are developed in among the leaves and certain hairy processes, known as paraphyses (Fig. 32, *p*). They may both occur at the end of one branch (Fig. 32, *C*) or they may occur on separate branches (Fig. 32, *D*), when the plants are said to be monœcious, whereas when these organs occur on separate plants (Fig. 32, *A*, *B*) the plants are called diœcious. In the case of diœcious plants the plant bearing the antheridium is frequently smaller and less complex than the one producing the archegonium. As already stated the archegonium produces the egg-cell or female gamete (egg) and the antheridium, the sperm cell or male gamete (sperm).

The sperms in the Bryophytes are more or less filiform and are provided with a pair of cilia at one end. The antheridia owing to the peculiar mucilaginous character of the cells only open when there is an abundance of moisture, when the sperms are discharged and move about in the water, some being carried to the archegonium, which likewise opens only in the presence of moisture. With the transferral of the sperms to the archegonium and the union of one of these with the egg which remains stationary, the work of the gametophyte may be said to be completed. The act of union of the egg and sperm is known as FERTILIZATION, and when this is effected the next phase of the life history begins.

The egg after fertilization divides and re-divides within the archegonium which becomes somewhat extended until finally it is ruptured. The dividing cells differentiate into a stalk and a spore case or sporangium which is borne at the summit, the whole structure being known as the SPOROGONIUM (Fig. 28). The base of the stalk is embedded in the apex of the moss plant, and is known as the foot, it being in the nature of a haustorium or nourishing organ. As the sporogonium develops and rises upward it carries with it the ruptured archegonium which forms a kind of covering over the top, called the calyptra (Fig. 28, *ca*). At first the sporangium is more or less uniform but eventually differentiates into two kinds of tissues, the one being sterile and the other fertile (producing spores), which latter is known as the ARCHESPORIUM (Fig. 28, *B, C*). The fertile tissue in both the Liverworts and Mosses is variously disposed; sometimes it forms a single area and is dome shaped, spherical, or in the form of a half sphere. In other cases it is separated into two areas by sterile tissue. The sterile tissue which extends up into the dome-shaped archesporium, or which in other cases separates the fertile tissue into two parts, is known as the columella (Fig. 28, *B, C*). The sporangium in the mosses is capsule-like and the spores are distributed in three ways: (1) In some cases the capsule does not open, but when it decays the spores are liberated. (2) In other cases the capsule dehisces longitudinally in dry weather and thus the spores are freed. (3) There is a third method in which the capsule is provided with a lid or operculum which comes off and permits the spores to escape, this being the most common method for the escape of the spores (Fig. 28, *D*). In the latter instance the mouth of the capsule is usually marked by one or two series of cells, constituting the PERISTOME, which are teeth-like and characteristic for some of the groups of mosses. These teeth bend inward or outward according to the degree of moisture and assist in regulating the dispersal of the spores. In the sphagnum mosses there is no peristome, but, owing to unequal tension of the lid and capsule on drying, the lid is thrown off, and the spores are sometimes discharged with considerable force and sent to quite a distance (as much as 10 centimeters), in this way insuring their dispersal.

The spores (Fig. 28, *E*) vary in diameter from 10 to 20 microns, being sometimes larger. They occur in groups of four in a mother-cell, and the spore-group is known as a tetrad, which is characteristic for the Bryophytes and the higher groups of plants. The spores therefore vary in shape from spherical tetrahedrons to more or less spherical bodies, depending upon the degree of separation. The contents are rich in protoplasm and oil (Fig. 28, *F*). The wall consists of two layers, the outer of which is either yellowish or brown and is usually finely sculptured. At the time of germination the outer wall is thrown off, and the protonema develops (Fig. 28, *G*). The spores may germinate almost immediately, or only after a considerable period. These spores are asexual and each one is capable of giving rise to a new plant. With the formation and dispersal of the spores the work of this generation terminates, and this phase is called the sporophyte or asexual generation, from the fact that it produces spores.

Having thus followed the stages of development in the life-history of a mŏss, we see that it is composed of the following

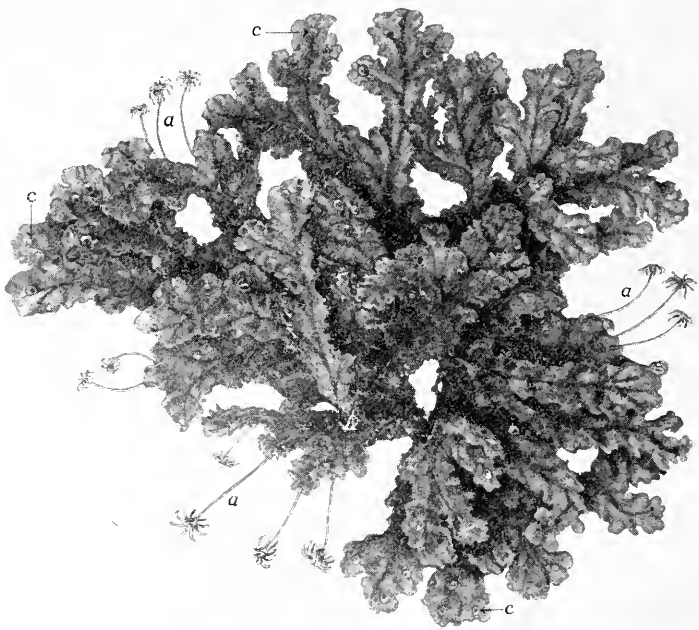


FIG. 29. Dichotomously branching thallus of the common liverwort (*Marchantia polymorpha*) showing near some of the margins the cup-like depressions in which gemmæ are borne (c), and several archegoniophores (a).

parts: (1) The alga-like protonema; (2) the leafy branch which gives rise to an oöspore (sexual spore), and (3) the sporogonium which produces asexual spores. The leafy branch is sometimes spoken of as the gametophore (gamete-bearer), and it and the protonema together constitute the gametophyte or sexual generation, while the sporogonium represents the sporophyte or asexual generation.

The protonema sooner or later dies off in most plants, but in other cases it persists, forming a conspicuous portion of the gametophyte.

HEPATICÆ.

General Structure.—The Hepaticæ or Liverworts (Fig. 29) are usually found in moist situations. The protonema formed on germination of a spore is filiform, and the plant body which develops from it consists of a flat, dichotomously-

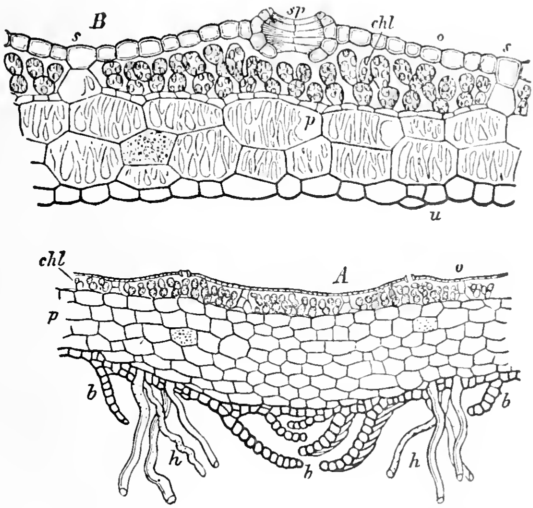


FIG. 30. Transverse section through the thallus of *Marchantia polymorpha*. A, middle portion with scales (b) and rhizoids (h) on the under side; B, margin of the thallus more highly magnified, showing colorless reticulately thickened parenchyma (p), epidermis of the upper side (o), cells containing chlorophyll (chl), air pore (sp), lower epidermis (u). —After Goebel.

branching thallus, or it may in some of the higher forms differentiate into a leafy branch as in the leafy liverworts. The thallus, owing to its position, has an upper and an under surface which are somewhat different, as in Marchantia (Fig. 29), hence it is said to be DORSIVENTRAL. From the lower colorless surface unicellular rhizoids arise (Fig. 30, *h*). The upper surface consists of several layers of cells containing chlorophyll which give the green color to the plant.

Vegetative propagation may ensue by the lower portion of a branch dying and the upper portion continuing as an independent plant. Or special shoots known as GEMMÆ, may arise either on the margin of the thallus or in peculiar cupules, which when detached by rain or other means, are capable of growing and producing a new plant.

In addition the thallus body produces both antheridia and archegonia (Fig. 29) which may rise on special stalks above the surface. After fertilization of the egg-cell which completes the work of the sexual generation or gametophyte, the sporophyte develops producing a sporogonium consisting of a short stalk which is embedded in the tissues of the gametophyte, and a capsule (sporangium). The latter at maturity dehisces or splits and sets free the spores, which are assisted in their ejection by spirally banded cells called "elaters" (Fig. 31, *C–F*). The spores on germination give rise to a protonema which then develops a thallus bearing the sexual organs. As in the mosses the sporogonium represents the asexual generation known as the sporophyte.

Liverwort Groups.—There are three important groups of Liverworts: (1) The MARCHANTIA group (Fig. 29) in which the thallus is differentiated into several layers and so somewhat thickened. Another character is the diversity in form of the sexual organs which range from those which are quite simple to those which are highly differentiated. In Riccia the sexual organs are embedded on the dorsal (upper) side of the thallus, while in Marchantia they are borne upon special shoots, one, which has a disk at the apex that bears the antheridia, known as the antheridiophore, and one, the apex of which consists of a number of radiate divisions and bears the archegonia (Fig. 29) on the lower surface, known as the archegoniophore; these being borne on separate plants. In Riccia, the simplest of the Liverworts, the sporangium is enclosed by the thallus and the spores are not liberated until the decay of the plant.

(2) The JUNGERMANNIA Group, known as "Leafy Liverworts" or "scale mosses," includes those forms which are more or less moss-like and develop stems and small leaves. The sporogonium has a long stalk and the capsule is 4-valved, *i.e.*, separates into four longitudinal sections at maturity.

(3) In the ANTHOCEROS Group (Fig. 31) the gametophyte is thallus-like and very simple in structure, the sexual organs being embedded in the thallus. The sporogonium is characterized by a bulbous foot and an elongated, 2-valved capsule. Like the thallus it develops chlorophyll and possesses stomata resembling those found in certain groups of mosses and higher plants.

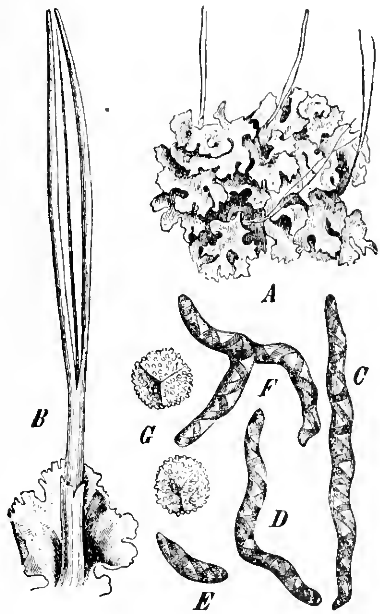


FIG. 31. *Anthoceros gracilis*, one of the liverworts. A, thallus with 4 sporogonia; B, a ripe elongated sporogonium, dehiscing longitudinally and showing two valves between which is the slender columella; C, D, E, F, various forms of elaters; G, spores.—After Schiffner.

MUSCI.

In the Mosses the archegonia always form the end of the axis of a shoot, whether this be a main one or a lateral one. As has already been stated (p. 48) the sexual organs are surrounded by leaves or leaf-like structures, known as perichætia or perichætal leaves, and by hair-like structures or paraphyses, both of which are considered to act as protective organs. Sometimes the groups of sexual organs together with the protective organs are spoken of as the "moss flower." As already stated the Mosses are both monœcious (Fig. 32, *C, D*) and diœcious (Fig. 32, *A, B*), hence a moss flower may contain only one of the sexual

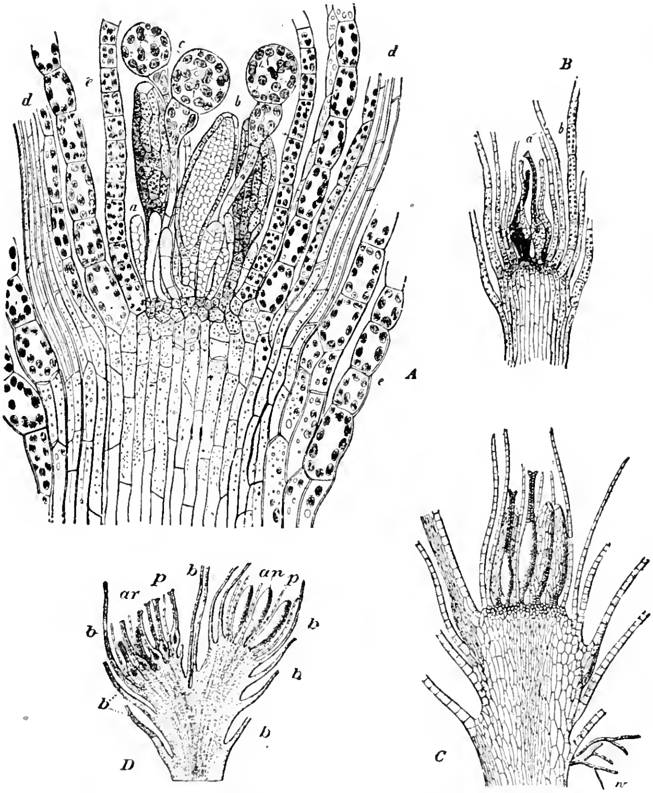


FIG. 32. Longitudinal sections through tips of leafy branches of mosses. A, showing antheridia (a, b) in different stages of development and paraphyses or cell-threads (e), the apical cell of which is spherical and contains chlorophyll, and leaves (d, e); B, showing archegonia (a) and leaves (b); C, section of Bryum showing both archegonia, and antheridia, paraphyses and leaves; D, section of Phascum showing archegonia (ar), antheridia (an), thread-like paraphyses (p), and leaves (b).—A, and B, after Sachs; C, after Limpricht; D, after Hofmeister.

organs or it may contain both. Mosses are also characterized by an abundant vegetative propagation. New branches are developed from the old. "Almost every living cell of a moss can grow out into protonema, and many produce gemmæ of the most different kinds." Entire shoots provided with reserve material are cut off and form new plants. In this way moss carpets are frequently formed in the woods, or masses in bogs.

Moss Groups.—There are two general classes of mosses: (1) SPHAGNUM forms are those which produce leaves without nerves, and in which the sporogonium does not possess a long stalk or seta. What appears to be the stalk is the prolongation of the gametophyte stem which is known as the pseudopodium or "false stalk." These forms are characteristic of wet places. Some of the group as Sphagnum proper form "sphagnum bogs." New plants develop on top of the old which latter gradually die and finally pass into sphagnum peat, which forms thick masses and finds use as a fuel. (2) The TRUE MOSSES are especially distinguished by the differentiated character of the sporogonium, which not only produces a stalk but also the peristome (Fig. 28, *p*) which when present is of great importance in distinguishing the different species.

Economic Uses of Bryophytes.—The investigations on the chemistry of the Liverworts and Mosses have not been very numerous. The constituents which have been found are in the nature of tannin, resins, ethereal oils, glucosides, alkaloids, coloring compounds and organic acids like citric, oxalic, tartaric and aconitic. In the mosses starch and silicon salts are found in addition. Several species of Marchantia and Jungermannia are used in medicine. Of the mosses the following have been found to have medicinal properties; *Sphagnum cuspidatum*, *Grimmia pulvinata*, *Funaria hygrometrica*, *Fontinalis antipyretica*, and several species of *Polytrichum* and *Hypnum*.

PTERIDOPHYTES.

The Pteridophytes were formerly known as the VASCULAR CRYPTOGAMS. Like the Bryophytes these plants show a distinct alternation of generations, *i.e.*, the gametophyte or sexual generation alternates with the sporophyte or asexual generation. Their relation is, however, somewhat changed. In the Bryophytes the gametophyte is the most conspicuous and is looked upon as constituting the plant proper, whereas in the Pteridophytes the gametophyte is rather insignificant in size, while the sporophyte constitutes the generation or phase which is ordinarily regarded as the plant. In the higher members of the Pteridophytes the sporophyte is entirely detached from the gametophyte and is able to lead an independent existence. This group also shows a distinct advance in structure. There is a differentiation into root, stem and leaves, and the development of a system of conducting tissue known as the VASCULAR SYSTEM.

The Pteridophytes include three principal groups, namely, (1) Filicales or Ferns, (2) Equisetales or Scouring Rushes, and (3) Lycopodiales or Club Mosses, which differ considerably in general appearance and general morphological characters.

With the exception of the sperms in the Club Mosses, which are biciliate and somewhat resemble those in the Bryophytes, the sperms in the Pteridophytes are spirally coiled and multiciliate, and according to the number of cilia of the sperms some writers divide the Pteridophytes into two classes, namely, biciliate and pluriciliate (Figs. 34, *C*; 43, *F*).

Some of the Pteridophytes, as *Selaginella* (Fig. 41), are distinguished by the fact that they produce two kinds of asexual spores, which are known respectively as MICROSPORES (Fig. 41, *F*) and MEGASPORES (Fig. 41, *E*). The two kinds of spores are formed in separate sporangia which organs may occur on the same plant or on different plants. The sporangia have the corresponding names, microsporangia (Fig. 41) and megasporangia (Fig. 41). This differentiation in sporangia and spores also leads to a differentiation in the resulting gametophytes, the microspores giving rise to gametophytes which produce antheridia, and hence called male gametophytes; and the megaspores to gametophytes which give rise to archegonia, and hence called female gametophytes. When a plant produces both microspores and megaspores it is said to be HETEROSPOROUS, as in *Selaginella* (Figs. 41, 43, 44); while one that produces but one kind of sporangium and one kind of asexual spores is said to be ISOSPOROUS. In this connection attention should be called to the fact that the spores from a single sporangium of an isosporous plant may give rise to male and female gametophytes, which shows that a certain degree of differentiation in the spores has already taken place. The causes leading to the differentiation of the spores seem to be connected with nutrition, those nuclei which are in more favorable positions giving rise to larger and better nourished spores which eventually lead to the formation of the megaspores, and those which are less favorably placed leading to the microspores.

The subject of heterospory is one of great interest, and when it is pointed out that all of the higher plants are heterosporous the subject has even more interest.

FILICALES.

General Characters.—On germination the asexual spore in the Filicales or Ferns gives rise to a thallus-like body known as the prothallus which is frequently dorsiventral and in a number

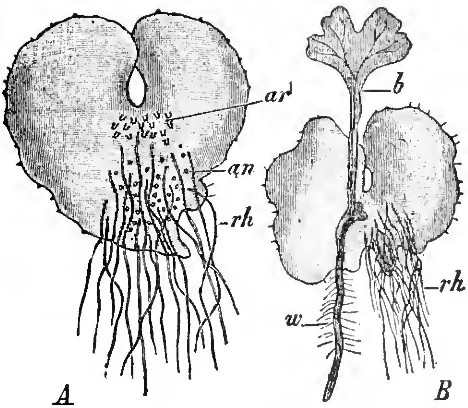


FIG. 33. Male fern [*Aspidium* (*Nephrodium* or *Dryopteris*) *Filix mas*]. A, prothallus of gametophyte as seen from the under (ventral) side showing archegonia (ar), antheridia (an), and rhizoids (rh); B, prothallus showing young plant (sporophyte) which has developed from an oöspore and is still connected with the gametophyte, roots (w), and the first leaf (b).—After Schenck.

of cases somewhat heart-shaped, but varies considerably in outline, being sometimes more or less tuberous. The prothallus is frequently but a few millimeters in diameter and the cells usually contain chloroplasts. On the under or ventral surface rhizoids are usually present (Fig. 33, *rh*). The sexual organs usually arise on the lower surface (Fig. 33) but they may develop on the upper or dorsal surface or even laterally. A single prothallus gives rise to both kinds of organs unless stunted in its growth, when it produces antheridia only.

The antheridia either develop upon or are sunk in the tissues of the prothallus. The archegonia (Fig. 34) are not flask-shaped as in the Bryophytes. The venter containing the oösphere or egg-cell (Fig. 34, *e*) is embedded in the thallus, the structure being surmounted by a few-celled neck (Fig. 34, *h*). The inner cells of the neck are known as canal cells (Fig. 34, *k*) and these at the time of ripening of the egg swell and exit through the opening of

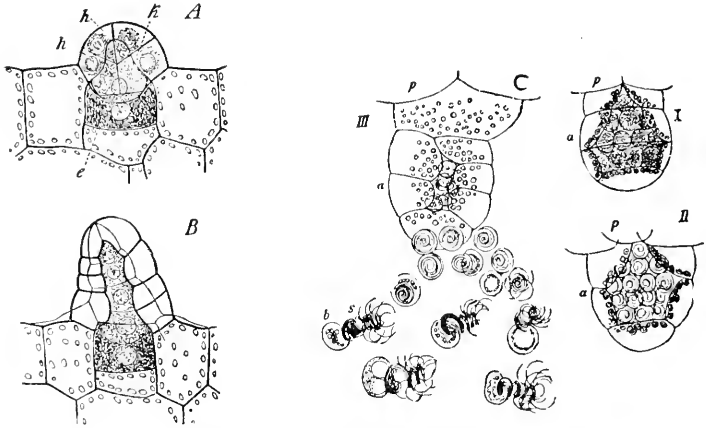


FIG. 34. A, B, development of archegonia of a fern (*Pteris*) showing the neck (h), the neck-canal cell (k) and oösphere (e).—After Strasburger.

C, development of antheridium in the Venus-hair fern (*Adiantum Capillus-Veneris*): prothallus (p), antheridium (a), sperm (s), sperm mother cell with starch grains (b); I, immature state of antheridium, II, sperms developed, and III, discharge of sperm mother cells and escape of coiled and pluriciliate sperms.—After Sachs.

the archegonium, through which then the sperms enter, one of which unites with the egg, thus effecting fertilization. The fertilized egg or oöspore takes on a cellulose membrane.

The oöspore which is held in the venter of the archegonium is not a resting spore but germinates immediately and early differentiates into the several organs (Fig. 35). These arise independently and include a stem-bud (Fig. 35, *s*); a first leaf or cotyledon (Fig. 35, *b*) so called because it does not arise out of the stem as the later leaves do; a first or primary root (Fig. 35, *w*); and a foot or haustorial organ (Fig. 35, *f*) whereby it obtains nutriment from the prothallus (Fig. 35, *pr*). This latter organ is, however, only a temporary provision, for as soon as the root grows out and penetrates the soil, it dies off and the sporophyte thus becomes independent. The stems are frequently more or less condensed and lie prostrate in the soil, developing roots from the under surface and leaves from the sides and upper surfaces. The leaves which constitute the conspicuous part of the ordinary ferns consist of a stalk and lamina or blade on which are borne the sporangia (Figs. 277; 36, *A*). The sporangia usually occur on the under surface of the leaf in groups or clusters known as SORI (Fig. 36, *A*). The sori are of characteristic shape and in certain

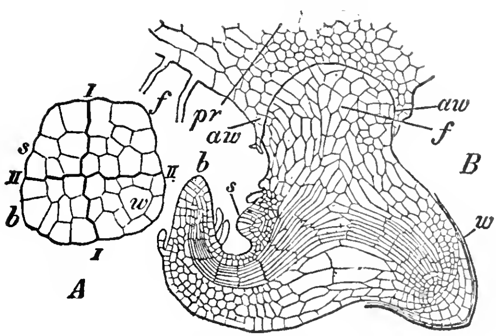


FIG. 35. The brake fern (*Pteris*). A, differentiation of cells in germinating oöspores; B, later stage showing development of embryo: pr, prothallus; f, foot embedded in the archegonium (aw); w, root; s, young stem; b, young leaf.—A, after Kienitz Gerloff; B, after Hofmeister.

species are covered by a plate called the INDUSIUM (Fig. 36, *B*) which rises from the epidermis. In some species the entire leaf becomes a spore-bearing organ, and is then known as a SPOROPHYLL (Figs. 36, 37, 38), to distinguish it from the foliage leaves. The sporangia develop a row of cells around the margin constituting what is known as the ANNULUS (Fig. 36, *n*). The form of the annulus determines the manner of dehiscence of the sporangia, which occurs on drying. The spores are ejected with considerable force (Fig. 36, *D*). They (Fig. 36, *E*; Fig. 39) are either bilateral or tetrahedral and require a short period to elapse before they germinate. They retain their vitality for a long time except those which are green, *i.e.*, contain chlorophyll. The spores are greenish or yellowish in color, variously sculptured and vary from 0.025 mm. to 0.158 mm. in diameter.

Fern Groups.—There are a number of distinct groups of ferns which vary considerably in appearance. (1) In the Tropics

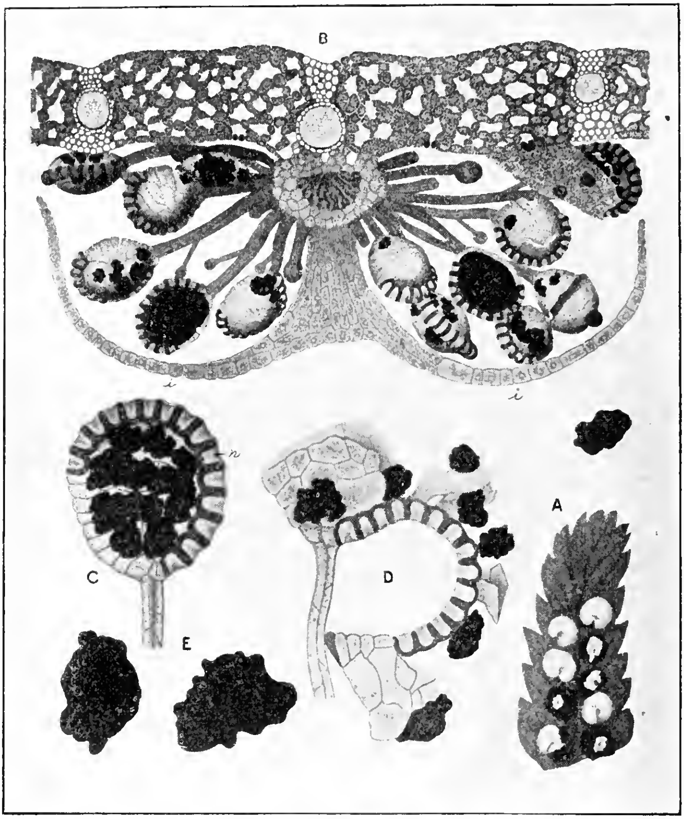


FIG. 36. Male fern [*Aspidium* (*Nephrodium* or *Dryopteris*) *Filix mas*]. A, portion of leaflet showing a number of more or less reniform sori near the mid-vein; B, transverse section through a ripe sori showing clusters of stalked sporangia, which are covered by the indusium (i), an outgrowth of the leaflet; C, a closed but ripe sporangium showing the annulus or ring (n), and the irregular-shaped spores within; D, showing the manner of opening of the mature sporangium and the dispersal of the spores; E, two spores much magnified.—After Dodel-Port.

as well as in greenhouses TREE FERNS, characterized by an overground stem, occur. The leaves arise at the summit of the stem or trunk and form a crown.

(2) The TRUE FERNS include by far the largest number of species which inhabit temperate regions. These vary considerably in size ranging from quite diminutive plants 5 to 12 cm.

FIG. 37. Several Osmundas. 1, the royal fern (*O. regalis*) showing fertile tip of branch and sterile bipinnate leaflets below; 2, Clayton's fern (*O. Claytoniana*) showing three pairs of fertile leaflets in the middle and a number of sterile leaflets above and below; 3, cinnamon fern (*O. cinnamomea*) showing a fertile leaf (sporophyll) to the left and a sterile leaf (foliage leaf) to the right.

high, as the slender Cliff Brake (*Pellæa atropurpurea* and the variety *cristata*) and maiden hair spleenwort (*Asplenium Trichomanes*), to plants several feet high, as in the several species of

Osmunda (Fig. 37), *Aspidium* (Fig. 227), etc. This group is chiefly characterized by the underground or prostrate stems, known as rhizomes, the part of the plant that is seen above ground being the leaf.

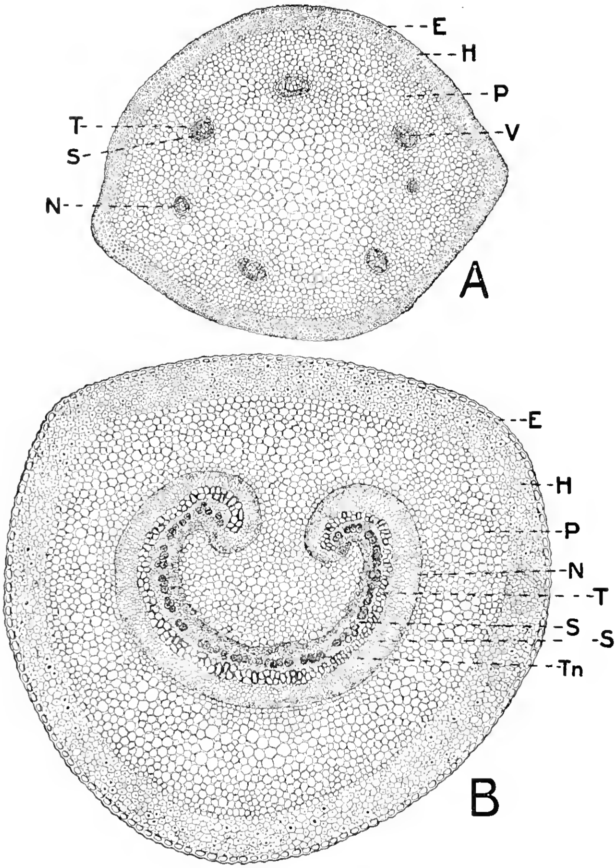


Fig. 38. A, transverse section of stipe of *Aspidium marginale:* E, epidermis; H, hypodermis of collenchymatic cells; P, parenchyma containing starch; V, fibrovascular bundle; S, sieve; T, tracheæ; N, endodermis surrounding each bundle. B, transverse section of stipe of *Osmunda Claytoniana:* H, hypodermis of lignified sclerenchymatous fibers; N, endodermis of large central fibrovascular bundle; Tn, tannin cells.

(3) There is also a group of ferns known as WATER FERNS which are aquatic in habit, that is, they live in marshy places or float on water. As representatives of this group may be mentioned *Marsilia,* which has a slender rhizome that is buried in the muddy bottom of streams, and 4-parted, clover-like leaves that float on the water; and *Salvinia* (Fig. 40) which is a small floating plant that develops two kinds of leaves, one which floats on the surface of the water and are more or less oblong, and another which are filiform, branching, root-like and submerged. The water ferns are further distinguished by the production of megaspores and microspores.

(4) The ADDER'S TONGUE FAMILY, to which *Ophioglossum* and *Botrychium* belong, develops a subterranean prothallus which is destitute of chlorophyll. The prothallus is in some cases

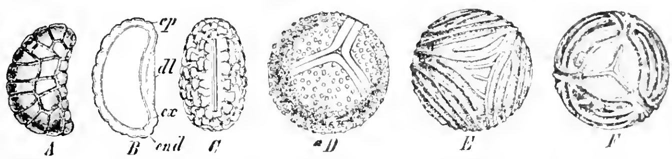


FIG. 39. Some fern spores. A, B, C, different views of the bilateral spores of the common polypody (*Polypodium vulgare*) showing outer wall (ep), middle wall (ex), inner wall (end) and line of dehiscence (dl); D, a tetrahedral spore of the royal fern (*Osmunda regalis*); E, F, spores of *Ceratopteris thalictroides* seen in two views.—A–D, after Sadebeck; E–F, after Kny.

tuberous, and the sporophyte produces two kinds of leaves, namely, foliage leaves, and fertile leaves or those which bear the sporangia. The sporangia occur on lateral branches of the sporophyll and open at maturity by means of a horizontal slit.

Ferns Used in Medicine and as Foods.—Many of the ferns contain tannin, a brownish coloring principle and in addition an anthelmintic principle. They may also contain ethereal oils, starch, coumarin, aconitic acid and other principles. A large number have been used in medicine, of which the following may be mentioned: *Aspidium* (*Dryopteris* or *Nephrodium*) *marginale* (Fig. 277) and *A. Filix-mas,* yielding the official Aspidium. A number of other species of *Aspidium,* as well as species of *Adiantum, Asplenium* and *Polypodium* are also used in various parts of the world. The rhizomes of some of the ferns contain considerable starch and are used to some extent as foods, as *Pteris esculenta* of China; *Pteridium aquilinum* var. *lanuginosa* of the Canary Islands; *Aspidium varium* and *Asplenium bulbosum* of Cochin China. *Polypodium vulgare* contains a substance related to glycyrrhizin. *Adiantum pedatum* and *Polypodium Phymatodes* are said to contain coumarin, the latter plant being used in perfumery.

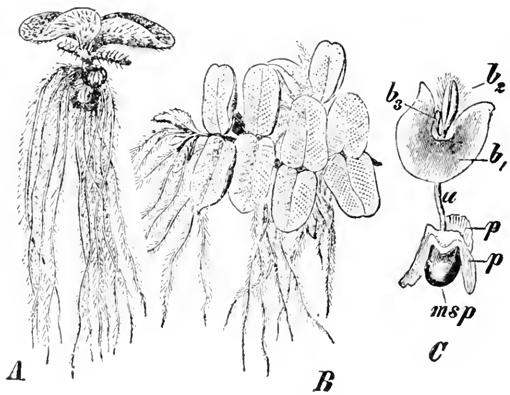


FIG. 40. A water fern (*Salvinia natans*). A, a plant seen from side and showing floating leaves at top attached to the horizontal stem, root-like finely divided leaves beneath, and a cluster of globose sporocarps; B, a view from above showing especially the character of the upper leaves; C, young plant developing from a megaspore (msp).—A, and B, after Bischoff; C, after Pringsheim.

EQUISETALES.

The Horsetails, or scouring rushes (Fig. 45, *B*) are perennial plants containing a large amount of silicon in their tissues. Like in the ferns the more or less branching, creeping rhizome persists from year to year, sending out each year new shoots. As in some of the ferns it develops two kinds of leaf-shoots, a fertile and a sterile one (Fig. 45, *B*), each of which are distinctly jointed. The scale-like leaves are arranged in circles about the joints or nodes, the work of photosynthesis being carried on by the green stems. The fertile branch develops at the apex a group of sporophylls known as a cone or strobilus. The archesporium, or initial spore-producing zone is unilocular. In *Equisetum*, the only representative of the group, the spores are spherical and each is furnished with two spiral bands or elaters which assist in its dispersal. Some of the Equisetums contain aconitic acid and are used in medicine. Common scouring rush (*Equisetum hyemale*) is used for polishing woods, and *Equisetum arvense* is used for scouring tin ware.

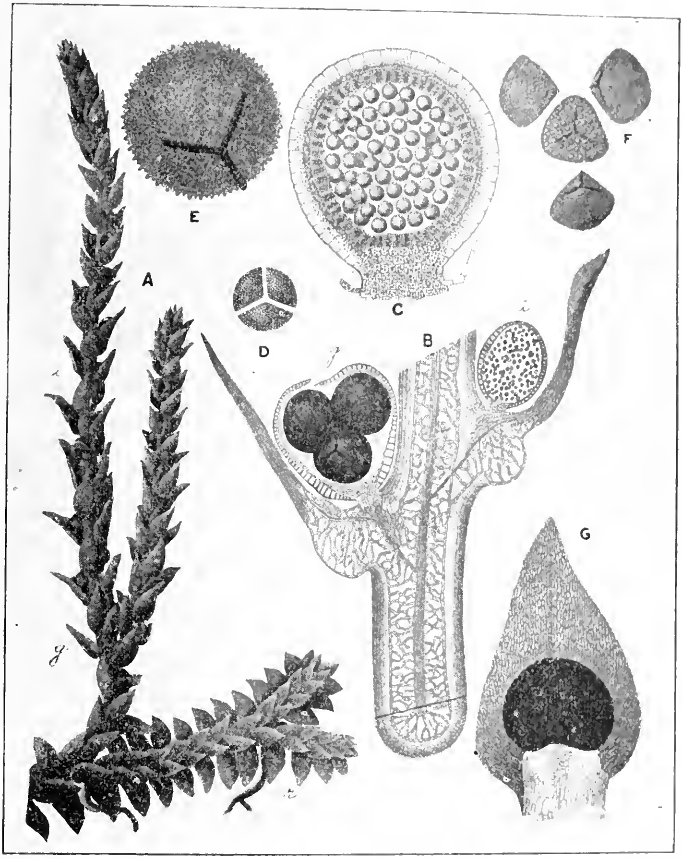


FIG. 41. *Selaginella helvetica*. A, sporophyte consisting of leafy branches giving rise to microsporangia (i), megasporangia (g) and rhizoids (r); B, longitudinal section of portion of branch showing a megasporangium (g) with 3 megaspores in view, a microsporangium (i) containing microspores; C, a young microsporangium showing free mother cells before formation of tetrads; D, tetrahedral division of spore mother cell; E, ripe megaspore; F, four microspores of tetrad separated; G, microsporophyll seen from above showing ripe microsporangium.—After Dodel-Port.

LYCOPODIALES.

The Lycopodiales, or Club Mosses (Fig. 46), are perennial moss-like plants, with more or less erect or creeping and branching stems, on which are borne numerous small simple leaves. The sporangia arise either at the base of the upper surface of the leaves or occur in terminal cones. They have short stalks, are unilocular and 2-valved. The asexual spores are of one kind in *Lycopodium* (Fig. 278b) and in the form of spherical tetrahedrons resulting from the manner in which division has taken place. In *Selaginella* (Fig. 41) two kinds of asexual spores are produced,

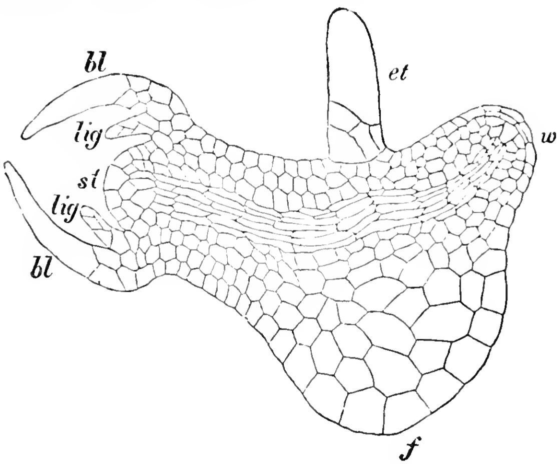


FIG. 42. Longitudinal section of young embryo of a Selaginella before separation from the prothallus: et, suspensor; w, root; f, foot; bl, cotyledons; lig, ligules or bud scales.—After Pfeffer.

that is, both microspores and megaspores, which in turn give rise to male and female prothalli respectively. The microspore develops a male gametophyte (Fig. 43) which remains entirely within the spore, and consists of a few-celled prothallus and a number of mother cells which produce sperms that eventually escape by the breaking of the wall.

The megaspore frequently begins to develop the gametophyte (Fig. 44) while still within the sporangium. The prothallus consists of a number of cells and partly protrudes through the ruptured spore wall. On the upper part of the prothallus or nutritive layer a few archegonia are borne. It should be stated that sometimes the archegonia are developed very early on the prothallus tissue, but usually they are developed after the spores have escaped from the sporangium. After fertilization of the egg a multicellular embryo develops which shows the following parts (Fig. 42): (1) An elongated cell or row of cells which extends into the tissues of the prothallus for the purpose of obtaining nutriment; (2) a root; and (3) a stem bearing at its tip (4) two leaves, or cotyledons. One of the specially notable

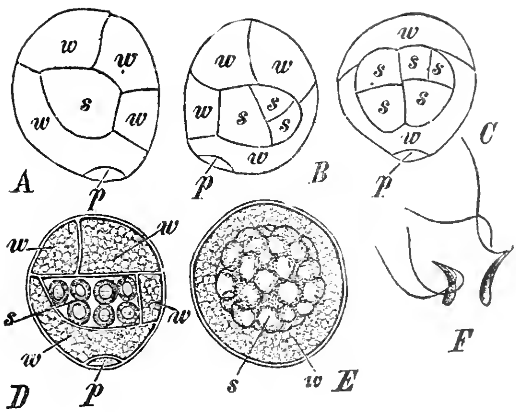


FIG. 43. Successive stages in the germination of the microspores of a *Selaginella:* p and w, cells of the prothallus; s, cells giving rise to sperms. A, B, D, views of spores from the side; C, view from the back; in E the cells surrounding the sperm mother cell are disorganized; F, two biciliate sperms.—After Belajeff.

characters of the plants of the *Selaginella* group is, as we have seen, the great reduction in size of the gametophyte which in the case of the microspore does not enlarge beyond the wall of the spore, and in the case of the megaspore only partly protrudes beyond the wall of the spore.

Isoetes.—This is a genus of aquatic or marsh plants known as quillworts. The plants produce a number of filiform roots which penetrate the mud, and a compact tuft of rush-like leaves. The plants are heterosporous, as in Selaginella. The sporangia are borne in the axils of the leaves, the outer leaves bearing the megasporangia and the inner leaves the microsporangia. The gametophytes consist of but a few cells. While the group is heterosporous and the gametophytes resemble those in Selaginella, the sperms are multiciliate and coiled as in the Ferns.

Distribution and Uses of Lycopodiales.—A number of the Lycopodiums are common on rocks, damp woods, sandy bogs, and illustrations of several of these are shown in Fig. 46. Some tropical species are used in medicine; the spores particularly of *Lycopodium clavatum* (Fig. 46, illus. 3) are used as a dusting powder (Fig. 278b), and for burning in the production of flash

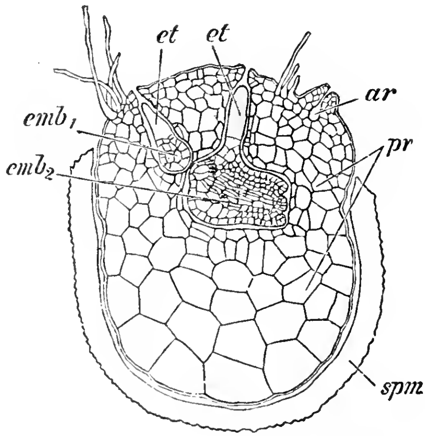


Fig. 44. The female gametophyte of a *Selaginella;* prothallus (pr) projecting through the ruptured wall (spm) of the megaspore; ar, sterile archegonium; emb¹, emb², two embryos embedded in the tissue of the prothallus; et, et, suspensors.—After Pfeffer.

lights. The Selaginellas, of which there are several native species, are commonly used for decorative purposes. Some species are, however, also used in medicine, and it is interesting to note that the spores of one species (*Selaginella selaginoides*) are used like those of *Lycopodium*.

While the Pteridophytes do not form a very conspicuous portion of the flora at the present time and yield but few products of use to man, it may be pointed out that in former ages they formed the dominant vegetation of the earth. Many of the ancestral forms of this group attained the size of trees and made up the forest vegetation during the Devonian and Carboniferous Ages, the latter being sometimes spoken of as the age of Pteridophytes. It is also called the Coal Age from the fact that the coal measures were chiefly laid down during this period. By some it is thought that the deposits of coal of this age were probably

Fig. 45. A piece of slate from the coal formation in Shenandoah County, Pennsylvania, showing a fossil fern which is probably a species of Neuropteris.

principally formed from the remains of certain marsh plants including two extinct groups of huge, tree-like club mosses (Lepidodendron and Sigillaria) and the Calamites, representatives of the scouring rushes.

SPERMOPHYTES.

The Spermophytes, or Seed Plants, constitute the third of the great divisions into which plants are divided. The plants belonging to this division not only form the most conspicuous feature of

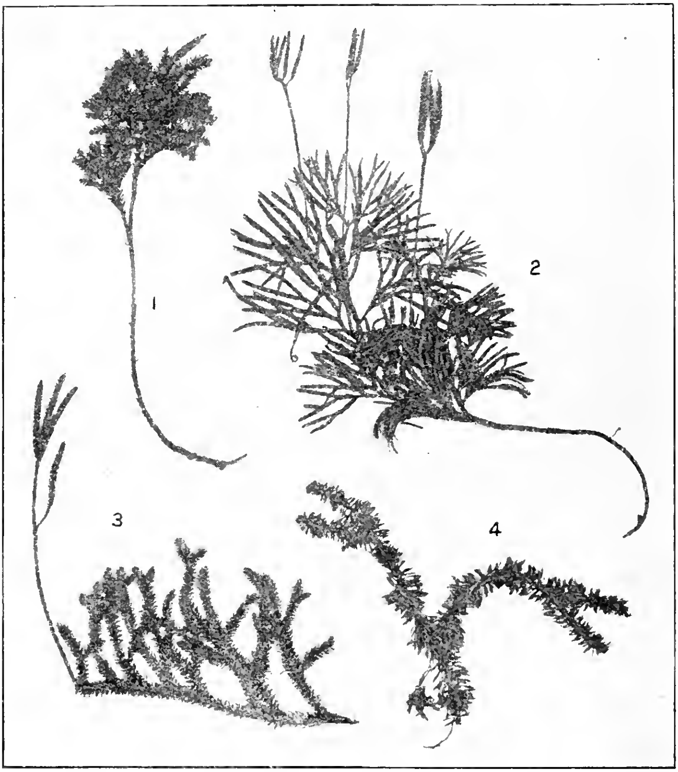


FIG. 46. Several species of *Lycopodium*. 1, Ground pine (*L. obscurum*) showing a leafy branch with one strobile at the apex; 2, a branch of trailing Christmas green (*L. Complanatum*) bearing four or five strobiles at the apex of long dichotomously branching stalks; 3, club moss or running pine (*L. clavatum*) with a branch bearing four strobiles; 4, shining club moss (*L. lucidulum*) with small sporangia borne in the axils of the leaves.

the flora because of their size and general distribution, but also because of the fact that the flowering plants render a large number of them especially attractive. The plants of this group are also of great importance from an economic point of view. They furnish a large part of the food of man and other animals, as well as materials for clothing, shelter, fuel and divers other purposes. In this group of plants there is the highest differentiation of tissues and the most complicated structure. The one character which especially distinguishes them from the lower groups of plants is that of the production of seeds.

The plants have for the most part well differentiated stems and leaves, and represent the sporophyte or asexual generation. The sporophyte produces sporophylls which are of two kinds, namely, megasporophylls and microsporophylls. The megasporophylls bear small ellipsoidal bodies known as ovules, which develop into seeds. The megasporangium is not separate and distinct in the spermophytes as it is in Selaginella, but is embedded within an ovule and corresponds to that part of the ovule known as the nucellus. The nucellus encloses the embryo-sac, which is regarded as a megaspore (Figs. 49, 50, 56, 85). Each megasporangium (nucellus) therefore contains but a single megaspore, whereas in Selaginella the megasporangia contain from 1 to 8 megaspores. The microsporophyll bears microsporangia (pollen sacs) which contain microspores (pollen grains). The female gametophyte in the Spermophytes is still more limited in its development than even in the highest Pteridophytes (as *Selaginella* and *Isoetes*) and remains wholly within the megaspore or embryo-sac. As a result of fertilization of the egg-cell an embryo is produced which consists of root, stem and one or more cotyledons and which with the integuments covering it constitutes the seed.

Spermophytes embrace two well defined groups, namely, (1) Gymnosperms or naked-seeded plants and (2) Angiosperms, or enclosed-seeded plants.

GYMNOSPERMS.

In the Gymnosperms the ovules, each of which contains a megasporangium (nucellus), are borne on an open sporophyll (carpel), and thus are exposed, as are also the seeds developed from them. In the Angiosperms the ovules are borne within closed sporophylls, and are thus protected or covered until the seeds, which develop from them, mature.

The Gymnosperms represent an ancient group of plants and were more numerous during the Triassic period than now. They are mostly shrubs and trees, and do not shed their leaves periodically as the Angiosperms do, and hence are known as "evergreens." As in some of the Pteridophytes (*Lycopodium, Equisetum*) the sporophylls occur in groups forming cones or strobiles (Fig. 47). They not only differ in external appearance from the Angiosperms but also in the anatomical structure of the stem, which is without large conducting vessels. In order to understand the relation of the Gymnosperms to the Pteridophytes on the one hand and to the Angiosperms on the other, it will be necessary to consider briefly the life history of a representative group, such as the Coniferæ.

General Characters.—The seed consists essentially of three parts, namely, a woody or leathery seed-coat, a nutritive layer rich in oil known as the endosperm, and a straight embryo. The latter is a more or less differentiated plantlet, consisting of a stem with a varying number of cotyledons or first leaves (2 to 16), and a small root which is attached to a suspensor, as is the embryo in *Selaginella* (Fig. 44). When the embryo begins its development into the plant it uses up the nourishment with which it is surrounded in the endosperm, and as it increases in size the seed-coat is split. The root then protrudes and the cotyledons to some of which the seed-coat is still attached are carried upward by the stem through the surface of the soil, when the seed-coat is cast off and the plant begins an independent existence. The first root is the primary or tap root and from this are sent out numerous branches known as secondary roots, constituting a well developed root system which serves the double purpose of absorbing nutriment from the substratum or soil and of holding or fixing the plant in its upright position. The embryonal stem grows vertically upwards continuing its growth indefinitely. Lateral branches arise at more or less regular intervals which extend from near the ground to the apex, the younger branches continually succeeding the older ones from the ground upward, thus giving the trees a cone-like outline. The leaves arise on the branches and are of two kinds, primary leaves which are more or less scale-like and deciduous, and secondary leaves which are true foliage leaves, and are usually quite simple in structure. The leaves vary in form but are usually narrow and somewhat thickened giving them a needle-like appearance.

In addition sporophylls (spore-bearing leaves) are formed at the ends of the young shoots or in the axils of more mature ones

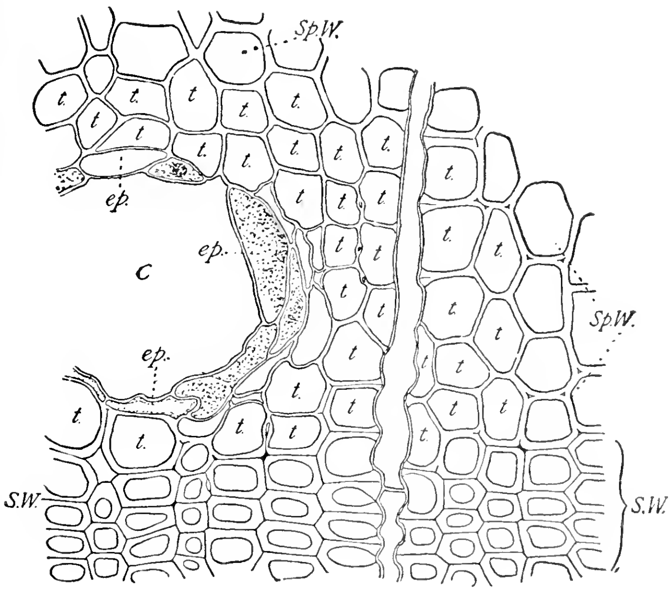


FIG. 47. *Pinus reflexa.* Transverse section of a portion from the inner face of the spring wood showing a schizogenous resin duct or passage with the central canal (C) and the thin-walled and resinous epithelium (ep); with parenchyma tracheids (t), the spring wood (Sp. W.) and the summer wood (S. W.).—After Penhallow.

The Coniferæ represent the most ancient group in which resin passages or reservoirs are found. While these passages show certain important variations in structure and origin, and while even in certain genera of the group, as in the genus Pinus, they exhibit considerable variation in detail, yet in this genus they are all of the same structural type as in *Pinus reflexa*, the white pine of the high mountainous regions of New Mexico and Arizona. The epithelial tissues are thin-walled and readily broken in making sections except in the hard pines as the Loblolly pine (*P. tæda*), where the cells often become strongly resinous. (See Penhallow's "Manual of the North American Gymnosperms.")

(Fig. 51). These are compactly arranged forming cones or strobili which are always of two kinds and borne on different twigs of the same plant or on different plants. The staminate cones consisting of microsporophylls (stamens) are more or less elongated and cylindrical or ovoid (Fig. 48, *A*). The carpellate cones consisting of megasporophylls (carpels) have a shorter longitudinal axis, and the cones vary considerably in the different groups.

The Microsporophylls (Fig. 48) are usually of a yellowish-brown color, and consist of a slender stalk and a lamina which

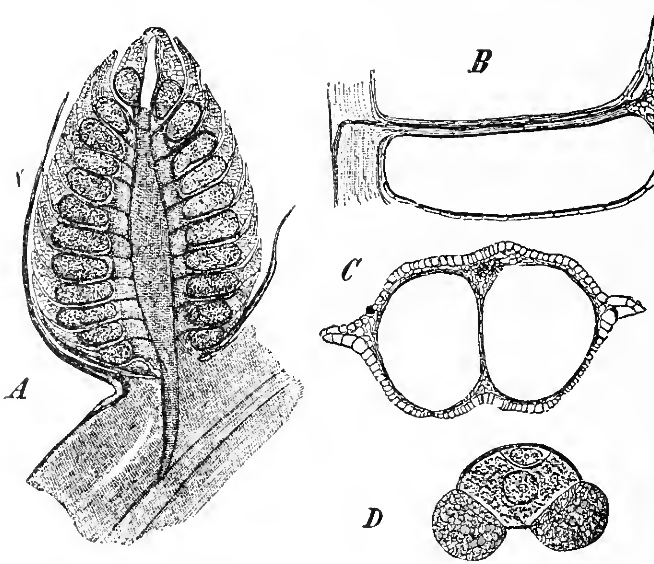


FIG. 48. A, longitudinal section of cone composed of microsporophylls, of one of the pines; B, longitudinal section of microsporophyll showing microsporangium (pollen sac); C, the same in transverse section showing both microsporangia; D, winged microspore (pollen grain), with a two-celled male gametophyte, the upper cell being the generative cell, the remaining nucleated cell giving rise to the pollen tube.—After Schimper.

bears the microsporangia (pollen sacs) on the lower or dorsal surface (Fig. 48, *B*, *C*). In this they show a resemblance to ferns where the sori are borne on the under surface of the leaves. The microsporangia vary in number from 2 to 15, and are protected in various ways, either being sunk in the tissues of the sporophyll, as in *Pinus* and *Abies* or they are, as in *Juniperus* and *Thuja*, provided with a covering resembling the indusium of the sori of the ferns. The walls are variously thickened and on drying, owing to unequal tension, the sacs are ruptured longitudinally and the spores scattered. The microspores are very numerous, sometimes forming powdery deposits. They are either 1-celled or 3-celled. In the latter case two lateral cells act as wings for the dispersal of the spores by the wind (Fig. 48, *D*).

The Megasporophylls consist of sessile carpels (leaves) on which are borne one or two naked ovules containing the spor-

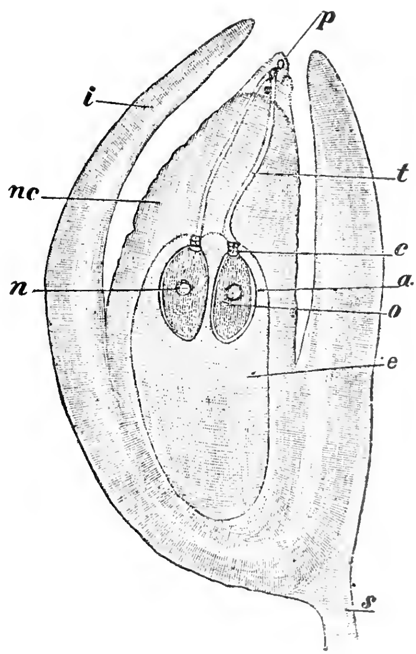


Fig 49. Longitudinal section of an ovule of a spruce (*Picea*): i, integument; nc nucellus (megasporangium); e, embryo-sac (megaspore) which has developed the female gametophyte consisting of endosperm (e), two archegonia (a), which show the neck (c), and the egg (n); p, germinating pollen grains (microspores) with pollen tubes (t) which have penetrated the nucellus (nc) and reached the neck cells of the archegonia.—After Schimper.

angia (nucelli). In certain groups, as in the pines, balsams, etc., a scale is formed at the base of the carpel which bears the ovules, and this scale is called the seminiferous scale. The ovules consist of several parts (Figs. 49 and 50): a stalk; an integument or wall which has an opening at the apex known as the micropyle;

a nucellus (megasporangium), being that portion next within the integument; and embedded within the nucellus a portion known as the megaspore or embryo-sac.

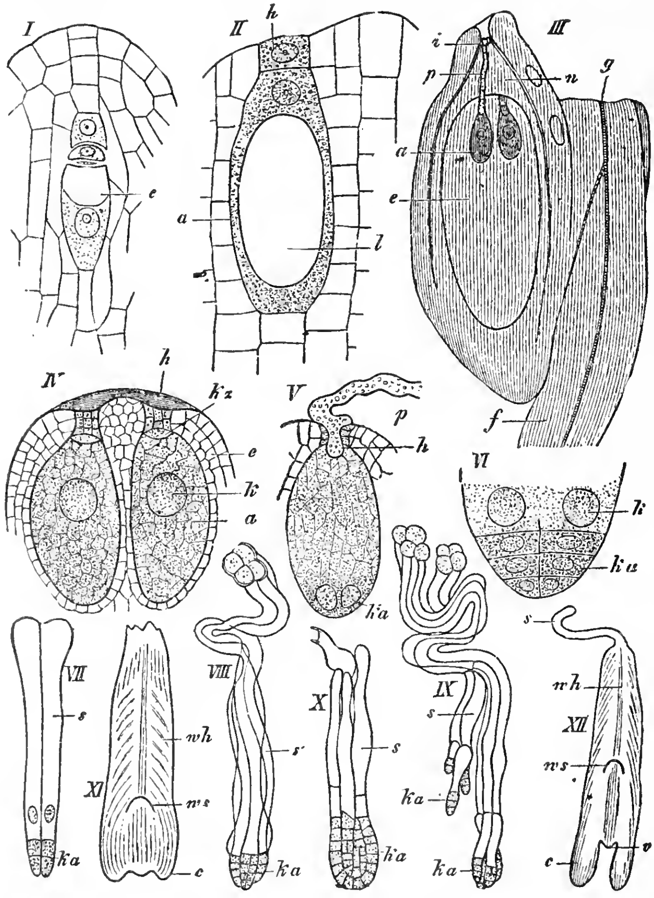


FIG. 50. Development of gametophyte and embryo in one of the Coniferæ. e, embryo-sac (megaspore); a, archegonium; h, neck of archegonium; i, integument; p, pollen tube; n, nucellus; f, wing of seed; g, fibrovascular tissue; kz, canal cells of archegonium; ka, beginning of embryo; k, nuclei; ws, tip of root; wh, root-cap; c, cotyledons; v, point of growth of stem; s, suspensor.

I, early stages of embryo-sac (e); II, young archegonium (a) after development of neck cells (h), cell lumen (l); III, section of ovule with portion of attached seminiferous scale(f) showing entrance of pollen tube; IV, embryo-sac with two developed archegonia; V, archegonium after fertilization there being four nuclei at the lower part only two of which are seen; VI, further development of embryo; VII, VIII, IX, X, showing development of large tortuous suspensor, to which is attached the young embryo (ka); XI, XII, mature embryo.—After Strasburger.

Gametophytes.—The development of the gametophytes from the asexual spores, namely, the microspore or pollen grain, and the megaspore or embryo-sac, is as follows: The nucleus of the megaspore divides repeatedly (Fig. 50), cell walls are formed and a multicellular structure known as the ENDOSPERM is produced. This structure constitutes the prothallus of the female gametophyte (Fig. 49, *E*; Fig. 50). In the upper portion of the prothallus (that is, at the micropylar end), three to five archegonia are formed (Fig. 49, *a*; Fig. 50), which are separated from one another by cells of the endosperm or prothallus which are rich in protoplasm. The structure of the archegonium is much like that of the preceding group, consisting of a venter which contains the egg, and a short neck composed of 4 to 8 cells.

The male gametophyte begins to develop while the pollen is still in the sporangium. At this stage it consists of a generative cell and a wall-cell, which constitute the antheridium, the cells of the prothallus being usually suppressed (Fig. 48, *D*).

In addition to the extreme minuteness of the gametophytes we have also to note the character of the male gamete or sperm. With the exception of the Cycads and Ginkgo, motile sperms are not found in the Gymnosperms, but these are represented by two male nuclei which are transferred directly to the archegonium from the male gametophyte, formed through germination of the microspore (pollen grain). It may be recalled that in the Pteridophytes the motile sperms are discharged from the antheridium and carried by the agency of water to the archegonium, but in the Gymnosperms water is no longer a medium of transferral. The microspores themselves are carried to the ovules usually through the agency of wind after which they germinate developing a tube which carries the male nuclei directly to the archegonium without their ever having been free.

The transferral of the microspores or pollen grains to the ovule is known as pollination. After pollination the wall-cell develops a tube, the *pollen tube*, and the generative cell gives rise to two male nuclei, which, with the remaining protoplasmic contents of the antheridium, are carried by the pollen tube to the micropyle, which it enters, penetrating the tissue of the nucellus (Fig. 49, *t*). On reaching the neck of an archegonium the pollen tube pushes its way down into the venter, where it discharges one of the sperm nuclei which unites with the egg, forming an oöspore. Cessation in growth does not yet take place and the oöspore develops into the embryo already described. The developing embryo obtains its nourishment by means of a suspensor (Fig. 50, *s*), which also places the embryo in a favorable position.

There being several archegonia in an ovule (Figs. 49, 50), a corresponding number of embryos may be formed, but rarely more than one survives. While the embryo is developing, the other tissues of the megaspore are likewise undergoing changes leading to the maturity of the seed. The carpels and seminiferous scales also continue to grow, and they usually become more or less woody, forming the characteristic cones of the pines (Fig. 51), but may coalesce and become fleshy, producing the berry-like fruits of Juniper (Fig. 52). The seed on germination gives rise to the sporophyte (tree).

Groups of Gymnosperms.—There are two principal groups of Gymnosperms, (1) one of which includes the Cycads or Fern Palms, which are characteristic of tropical and sub-tropical countries. The trunk does not branch as in the ordinary evergreens, and the leaves form a crown at the summit of the stem or trunk. An important character of some of the Cycads is the production of multiciliate sperms, as in the ferns, *Equisetum* and *Isoetes.* (2) To the Coniferæ belong the pines, hemlocks, balsams, arbor vitæ, junipers (Fig. 51) and cedars, this being by far the largest group of Gymnosperms.

Economic Uses of the Coniferæ.—From an economic point of view the Coniferæ are by far the most important group of plants thus far considered. In fact they may be ranked first in the production of valuable timber. Of those yielding timber the following species may be mentioned: White pine (*Pinus strobus*); long-leaved, yellow, or Georgia pine (*Pinus palustris* Mill.); spruce pine (*Pinus echinata*); the Redwood of Upper California (*Sequoia sempervirens*); pitch pine of New Mexico (*Pinus Ponderosa*); the Scotch fir, the common pine of Europe (*Pinus sylvestris*). Some of the woods are adapted for special purposes: as that of *Pinus Cembra* of the high mountains of Europe and Northern Siberia, which is excellent for wood-carving; Red cedar (*Juniperus virginiana*) (Fig. 52) used in the making of cigar boxes and lead pencils; balsam fir (*Abies balsamea*) used in the manufacture of wood pulp.

By reason of the oleo-resinous constituents the woods of some of the Coniferæ are among the most durable known. A few years ago Jeffrey examined a specimen of *Sequoia Penhallowii* which was obtained from auriferous gravels of the Miocene in the Sierra Nevada Mountains and found it to be in a very perfect

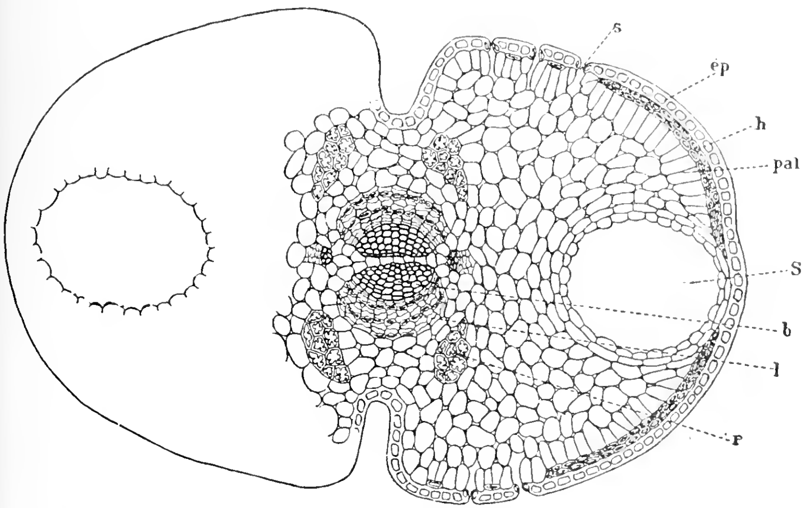


FIG. 51. Transverse section of the stalk of *Juniperus Sabina* at the point of attachment of two leaves. ep, epidermis; s, stomata; h, hypodermis; pal, palisade cells; l, bast fibers; b, xylem; r, mechanical tissue; S, oil secreting gland or reservoir. After Mongin.

state of preservation. Penhallow (*loc. cit.*) considers this to be the most ancient record of an uninfiltrated and unaltered wood. Coleman, in 1898, found in the Pleistocene clays of the Don Valley a specimen of red cedar (*Juniperus virginiana*) which not only possessed all of the external characteristics of this species but when sawed emitted the aromatic odor of the bark. In the Pleistocene deposits of the western United States and Canada are found more or less unaltered specimens of various species of Juniperus, Pseudotsuga, Picea, and Larix.

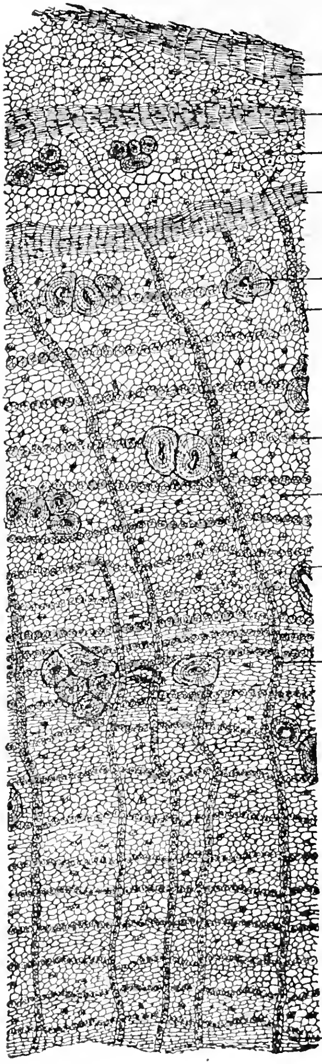


FIG. 52. Cross-section of bark of *Tsuga Canadensis*. c, c, c, secondary cork formation; a, dead phloem tissues rich in coloring, resinous and tannin-like substances; s, s, stone cells; m, m, medullary rays; cr, cells containing long prisms of calcium oxalate; ca, cambium; st, bands of starch-bearing parenchyma cells.—After Bastin.

Some of the pines yield edible seeds which have been used by the Indians of Western America: as the edible or "nut pine" of California and New Mexico (*Pinus edulis*); *Pinus monophylla*, discovered by Colonel Fremont in Northern California; *Pinus Jeffreyi* of Northern California; and *Pinus Pinea* of Europe, the seeds of the latter being used like almonds and known as "pignone." The seeds of *Pinus Lambertiana* (Fig. 51, *C*) of California are baked before being used as food. This latter species is also known as the sugar pine as it yields a manna-like product. A manna is also yielded by *Cedrus Libani* and *Larix decidua*. The latter is known as "Briancon Manna," and contains melizitose. The bark of some species furnishes valuable tanning material, as that of the hemlock spruce (*Tsuga canadensis*).

The Coniferæ yield large quantities of volatile oils, resins and allied products which are used both in medicine and the arts. A number of them yield turpentine (see pp. 675–677 and p. 653), as *Pinus palustris*, *Pinus glabra*, *Pinus Tæda*, *Pinus heterophylla* and *Pinus echinata*. *Larix decidua* of the Alps and Carpathian mountains yields Venice turpentine. *Abies balsamea* is the source of Canada turpentine or balsam of fir; *Picea Mariana* or black spruce yields spruce gum largely used in the manufacture of chewing gum, and is also the source of spruce beer. *Picea excelsa* or Norway spruce yields Burgundy pitch (see p. 670). *Abies alba* or white fir tree yields the Strasburger turpentine. Canada pitch is the resinous exudation from the common hemlock (*Tsuga canadensis*). Sandarac is yielded by *Callitris quadrivalvis* found growing in Northwestern Africa. Volatile oils are yielded by a number of the Coniferæ, of which the following may be mentioned: *Juniperus Sabina* yielding oil of savin; *Juniperus communis* yielding oil of juniper, both of which are used in medicine. The remains of Coniferæ (*Picea*, etc.) are often found as fossils, as the fossil resin amber, which is used in the arts, and on distillation yields a volatile oil having medicinal properties.

ANGIOSPERMS.

General Characters.—The Angiosperms constitute the most conspicuous portion of the flora, embrace the greatest variety of forms, and are the most highly organized members of the plant kingdom. They vary in size from diminutive plants like the windflower to the giant oak which shelters it. They may accomplish their life work in a few months, as the common stramonium, or they may persist for several hundred years, as the trees of our primitive forests. They may inhabit dry desert regions, as the Cacti and Chenopodiaceæ, or they may live wholly in water, as the water lilies. In short they show the greatest adaptability to their surroundings. But no matter how diversified they may seem in form and structure, they agree in this with possibly one exception, namely, mignonette, that the seeds are produced in a closed carpel. This has been considered, as already indicated, to be the chief difference between the Gymnosperms and Angiosperms.

The two groups are further distinguished by several other important characters: (1) the carpel or carpels (megasporophyll) is developed into an organ commonly known as a pistil (Figs. 83 and 85). This organ consists of three parts, namely, ovary, style and stigma, the ovary enclosing the ovules (Figs. 83, 85). In the Angiosperms the megaspore (embryo-sac) develops a gametophyte which does not give rise to archegonia, but the egg arises directly from the megaspore nucleus by a series of divisions.

(3) The Microsporophyll (stamen) differs considerably in structure and appearance from that of the Gymnosperms. The stamen may be defined as a leaf which bears sporangia (spore cases). It usually consists of the following differentiated parts: filament and anther, the latter consisting of pollen sacs (microsporangia) in which the pollen grains (microspores) are developed (Figs. 81, 83 and 85). (4) In a large number of cases in the Angiosperms there is developed in addition to the sporophylls or sporangial leaves (stamens and pistils) another series of leaves known as floral leaves (Fig. 83). The latter usually are of two kinds, known as sepals and petals.

The Development of the Two Generations, namely, the sporophyte and gametophyte, is much the same in the Angiosperms as in the Gymnosperms. That is, the sporophyte constitutes the plant body and what is commonly considered to be the plant. The gametophytes are still more reduced than was the case in the Gymnosperms, the male gametophyte consisting of but two cells.

Beginning with the germination of the seed we may outline the life history of the plant as was done under Gymnosperms. The seeds in the two groups are much alike with the exception that in the Angiosperms they usually have two integuments. Within the Angiosperms two classes of embryos are distin-

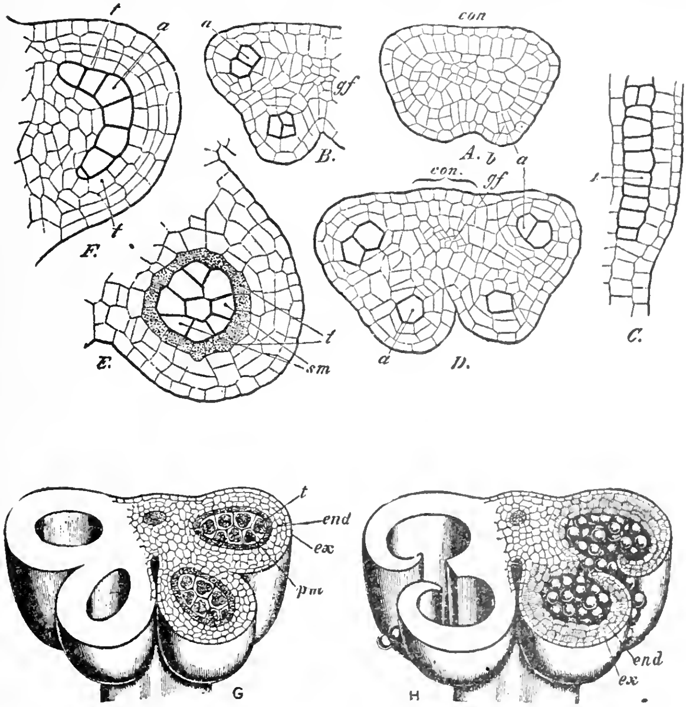


FIG. 53. Development of pollen sacs (microsporangia) in several of the Angiosperms: A, showing beginning of archesporium (a), an outer sterile layer (b), position of connective (con); B, later stage showing development of fibrovascular tissue (gf); C, longitudinal section of archesporium; D, E, F, successive later stages showing in addition pollen mother cells (sm) and tapetum layer (t). G, H, diagrammatic sections of mature pollen sacs showing pollen mother cells (pm), tapetum (t), endothecium (end), exothecium (ex), and in H longitudinal dehiscence with formation of what appears to be a unilocular pollen sac on either side of the connective.—A–F, after Warming; G–H, after Baillon and Luerssen.

guished, which give rise to the most important division of this group of plants. In the one case a single cotyledon is formed at the apex of the stem, and all plants having an embryo of this kind are known as MONOCOTYLEDONS, that is, plants having one seed leaf. In the other case two cotyledons arise laterally on the stem and opposite each other, and those plants having an embryo of this type are grouped together as DICOTYLEDONS, or plants having two seed leaves. In the monocotyledons the cotyledon is limited to one, but in the dicotyledons the seed leaves are not limited in number and there may sometimes be three or more.

The sporophyte which develops from the germinating seed consists of the essential parts already given, *i.e.*, root, stem and leaves. The leaves are of four kinds: (1) Foliage leaves, (2) scale leaves or bud scales, (3) floral leaves, which in some cases are wanting, and (4) sporangial leaves or sporophylls. Inasmuch as the latter give rise to the gametophytes (male and female) the development of the sporangia in each will be considered in detail.

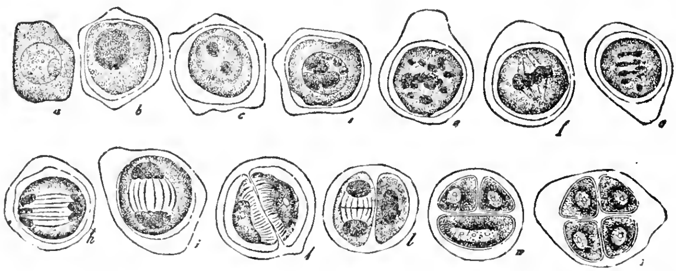


FIG. 54. Development of pollen grains (microspores) of garlic (*Allium narcissiflorum*): a, pollen mother cell with nucleus; b, the same with homogeneous nucleus and a thicker wall; c–e, changes in nucleus prior to division; f, formation of spindle with nuclear masses in the center from which nuclear threads extend to the poles of the spindle; g, division of nuclear substance and receding of it from the center of the cell; h–i, further stages in the organization of the nuclear substance at the poles; k, formation of a wall between two daughter cells; l, beginning of division of one daughter cell; m–n, final divisions resulting in the formation of a tetrad (group of 4 cells).—After Strasburger.

The Microsporangia (pollen sacs) arise by the division of certain cells under the epidermis of the anther (Fig. 53). This process of division continues until four regions of fertile tissue (sporangia) are produced (Fig. 53, *D*). The sporangia are directly surrounded by a continuous layer of cells which constitutes the tapetum or tapetal cells (Fig. 53, *t*), these being in the nature of secretion cells and containing considerable oil. The tapetum is in turn surrounded by a layer of cells which are peculiarly thickened and which on drying assist in the opening of the anther and the discharge of the pollen, and this layer is called the endothecium (Fig. 53, *end*). There is still a third or external layer of cells, which constitutes the exothecium (Fig. 53, *ex*). These four sporangial regions may remain more or less distinct and separate at maturity, or the two on either side may coalesce. This latter usually occurs at maturity, when dehiscence takes place, forming apparently a single pollen sac on either side of the connective or axis (Fig. 53, *H*).

The Microspores (pollen grains) are developed somewhat differently in Monocotyledons and Dicotyledons. In most monocotyledons the nucleus of each cell (pollen mother cell) making up the archesporium divides into two nuclei, each of which takes on a wall of cellulose. Each of these (daughter cells) in turn divides giving rise to four pollen grains. In dicotyledons (Fig. 54) the nucleus of a mother cell divides into four nuclei before the walls are formed which separate the nuclei, thus giving rise

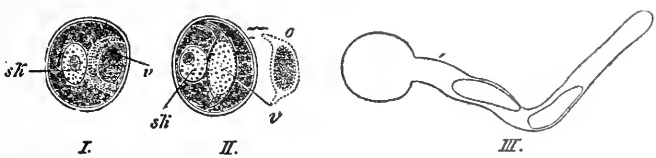


FIG. 55. Development of male gametophyte in an Angiosperm. I, pollen grain (microspore) which has divided into the mother or generative cell (v) and a larger tube-cell with nucleus (sk); II, appearance of pollen grain on treatment with osmic acid showing the separation of the generative cell (v) from the wall of the pollen grain; o, at the right giving a view of the generative cell with the nucleus embedded in the hyaline protoplasm; III, showing the development of the tube-cell into the pollen tube which contains the two male cells (nuclei) or gametes formed by the generative cell.—After Elfving.

to the tetrad group of spores to which attention has already been called (page 49) under Bryophytes. The wall of each spore is divided into two layers, an inner layer consisting of cellulose known as the intine, which gives rise to the pollen tube on germination of the spore; and an outer layer somewhat different in composition and variously sculptured, known as the exine. When the spores are mature the original walls of the cells of the archesporium dissolve and the ripe pollen grains are set free, forming a yellowish powdery mass filling the pollen sac. In some cases the spores of the tetrads hang together or even the whole mass of pollen tetrads may be more or less agglutinated, as in the orchids and milkweeds, these masses being known as pollinia.

Male Gametophyte.—Before the dispersal of the pollen grains or microspores, certain changes leading to the development of the gametophyte have taken place (Fig. 55). The spore as we have seen is unicellular. This divides into two cells, one, which is relatively small, known as the mother cell of the antheridium (Fig. 55, *v*), and another, which, composed of the remaining nucleus with the surrounding cell-contents, constitutes the tube- or wall-cell of the antheridium.

Development of Ovule and Megasporangium (nucellus).—The ovule at first develops as a small protuberance on the inner surface of the ovary, after which it differentiates into (*a*) a stalk or funiculus by which it is attached to the ovary, the tissue to which it is attached being called the placenta; and (*b*) an upper portion which becomes the ovule proper. The differentiation of the tissues is in a general way as follows: (1) The cells beneath the epidermis in the apical portion of the ovule go to make up the megasporangium (nucellus); (2) the peripheral cells from below the nucellus give rise to the integuments; and (3) while the integuments are developing the archesporium or mother cell of the embryo-sac (megaspore) is being formed within the nucellus near the apex.

Female Gametophyte.—The archesporium divides into two cells, the lower one of which repeatedly divides, finally giving rise to the embryo-sac which is sunk in the tissues of the nucellus. The nucleus of the embryo-sac divides and redivides until 8 cells are produced (Figs. 56 and 85), which are separated into the following groups: (1) Three of the cells form a group lying at the apex, the lower cell of the group being the egg or egg-cell, the other two cells being known as synergids or helping cells. (2) At the opposite end of the sac are three cells, known as antipodal cells, which usually develop a wall of cellulose and do not seem to have any special function. (3) Near the center of the sac are the two remaining nuclei, which unite to form a single nucleus, from which after fertilization the endosperm is derived. The embryo-sac, as it is organized at this stage, constitutes what is regarded as the female gametophyte (Fig. 56). The undifferentiated embryo-sac constitutes the megaspore, which latter after germination or differentiation into egg-cell and other cells, con-

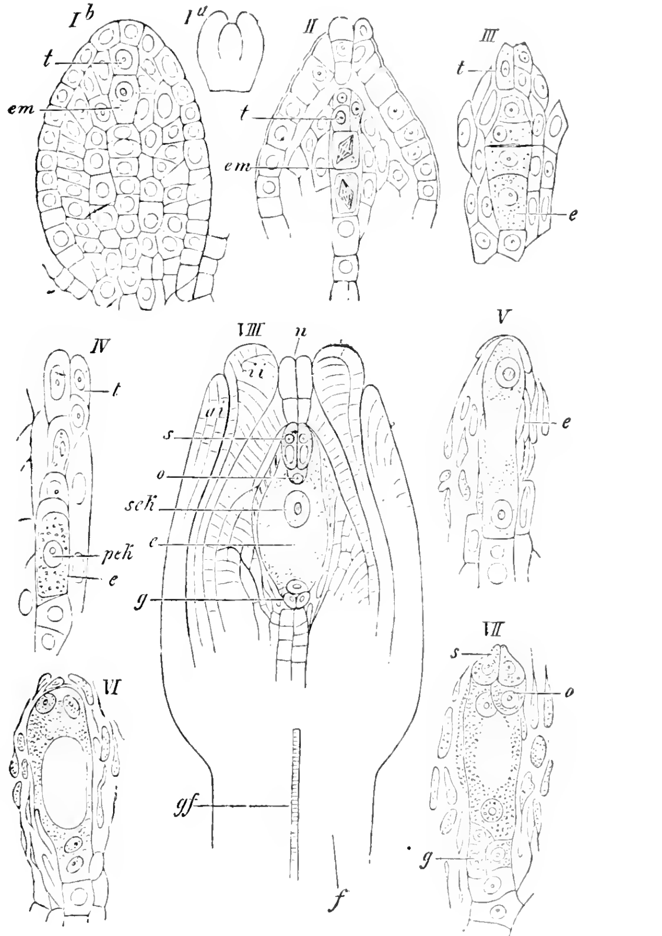


FIG. 56. Development of embryo-sac or megaspore in an Angiosperm. Ia, longitudinal section through a young ovule. Ib, longitudinal section through a rudimentary ovule before the formation of the integument, showing mother cell of the embryo-sac (megaspore) (em) and primary tapetal cell (t). II, later stage showing the two cells into which the mother cell has divided, the nuclei of which are in the act of dividing. III, mother-cell of the embryo-sac divided into four cells (sporogenous mass of cells); the lowest of these cells (e) displaces the rest and becomes the embryo-sac in IV. IV, pek. is the primary nucleus of the embryo-sac. V, two daughter cells resulting from the division of the nucleus of the embryo-sac. VI, VII, show egg apparatus composed of two synergids (s) and the oösphere (o), and antipodal cells (g). VIII, longitudinal section through a mature ovule with the inner integument (ii), the outer integument (ai), the nucellus (n), the vascular bundle (gf) entering the funiculus (f), and secondary nucleus in the embryo-sac (ek.). After Strasburger.

stitutes the gametophyte. It is thus seen that in the female gametophyte of the Angiosperms archegonia are apparently not formed. The gametophyte, then, consists of the cell group containing the egg and the remaining portion of the embryo-sac, which latter may be compared to a prothallus. This comparison is not difficult to understand if we bear in mind the structure of the gametophyte in the Gymnosperms and particularly if we recall the structure in the higher Pteridophytes.

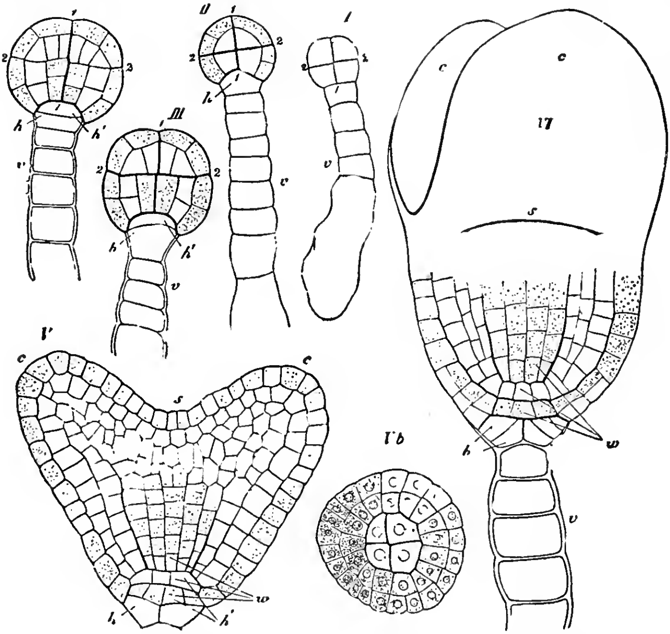


FIG. 57. Development of embryo in the shepherd's purse (*Capsella Bursa-pastoris*). I–VI, various stages of development: Vb, apex of the root seen from below. 1, 1, 2, 2, the first divisions of the apical cell of the pro-embryo (suspensor); h, h, cells from which the primary root and root-cap are derived; v, the pro-embryo; c, cotyledons; s, apex of the axis; w, root.—After Hanstein.

Fertilization.—While in the gymnosperms the pollen grains are usually provided with wings so as to bring about their transferral to the carpel by the agency of the wind, in the angiosperms, on the other hand, the grains are not provided with wings, but are adapted to transferral by insects. Pollination, however, may be also effected by the wind as is the case with many of our forest trees. After the deposition of the pollen grain on the stigma, the tube-cell begins to form a tubular process (pollen tube) which carries the male nuclei to the egg-cell (Fig. 85, *i*). It pierces the tissue of the stigma (Fig. 85, *h*) and traverses the style (Fig.

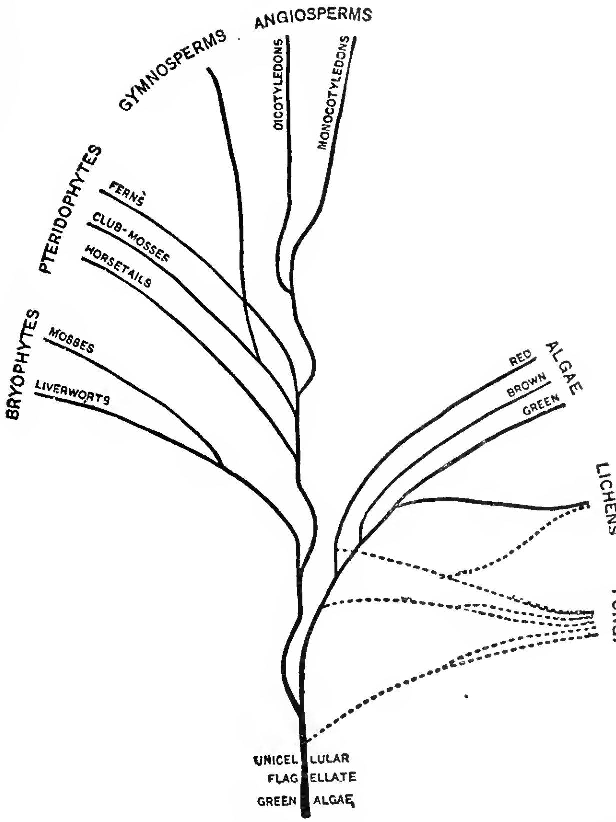


Fig. 58. Hypothetical tree of relationship and descent of the leading groups of plants.—After Ganong.

85, *g*) until it reaches the micropyle of the ovule, which it enters (Fig. 85, *m*), then reaching the nucellus it penetrates this, entering the embryo-sac. The tip of the tube breaks and one of the generative nuclei which has been carried downward unites with the egg, after which a wall is formed, giving rise to an oöspore. The oöspore develops at once into the embryo or plantlet as seen in the seed, this stage being followed by a period of rest. In fact the young plant may lie dormant in the seed for years.

Development of Seed.—The steps in the development of the mature seed occur in the following order (Fig. 57): The oöspore divides into two parts, an upper portion which gives rise to the embryo, and a lower portion which by transverse segmentation gives rise to a short suspensor (Fig. 57, *v*) which practically serves the same purpose as in the Gymnosperms (page 78). The embryonal cell develops the embryo which consists of: (1) a root portion which is connected with the suspensor (Fig. 57, *w*); (2) one or two cotyledons (Fig. 57, *c*) which are attached to the stem; (3) a little bud at the apex of the stem which is known as the plumule.

While the embryo is developing, the nucleus of the embryo-sac, either after fusing with the prothallial cell of the pollen grain, or in the absence of such union, begins active division, forming a highly nutritive tissue rich in starch, oil, or proteins, known as the endosperm (Figs. 121 and 122). Simultaneously with the development of the endosperm the nucellus may give rise to a nutritive layer called the perisperm, or the tissues of the nucellus may be modified and form with the altered integuments or coats of the ovule, the seed-coat.

Inasmuch as the Angiosperms furnish by far the larger proportion of plants and plant products used in medicine, it is desirable to give particular attention to the morphology of the plant as also to the distinguishing characters of a number of the important groups or families.

Economic Importance.—As indicating the great usefulness to mankind of the products obtained from the Angiosperms it will be sufficient to merely mention that all of our garden vegetables as well as the great crops of cereals like wheat, corn, rye, etc.; edible fruits and seeds; textile products, such as cotton, flax, etc.; medicinal products; timbers of various kinds, as oak, mahogany, walnut, chestnut, cherry, etc., are furnished by this great group of plants.

CHAPTER II.

THE OUTER MORPHOLOGY OF ANGIOSPERMS.

INTRODUCTORY.

It may be well to repeat at this point that on germination of the megaspore the female gametophyte bearing the egg-cell is formed, and that on germination of a microspore the male gametophyte bearing male nuclei is organized. The union of egg-cell and a male nucleus gives rise to the sporophyte embryo contained in the seed, which develops into the plant we see, namely, the sporophyte. The female gametophyte always remains concealed within the embryo-sac and the male gametophyte may be said to embody the protoplasmic contents of the pollen tube.

A complete flower is made up of floral leaves and sporophylls, the latter being essential for the reason that they give rise to the spores. While the flower belongs to the sporophyte generation the propagative organs may be said to be derived from both the sporophyte and gametophyte, and hence may be distinguished as asexual and sexual. The following outline illustrates their derivation:

- Propagative Organs
  - Sexual, derived from gametophytes (sexual generation)
    - Egg-apparatus, containing egg-cell
    - Male Generative-cell, giving rise to male nuclei or male gametes
  - Asexual, derived from sporophyte (asexual generation)
    - Microsporangium, giving rise to microspores (pollen grains)
    - Megasporangium, giving rise to megaspore (embryo-sac)

The vegetative organs comprise the root and shoot, the latter being usually differentiated into shoot axis or stem, and leaves. The usual type of shoot is one which bears leaves and is exposed to the light. The work of carbon dioxide assimilation (photosynthesis) being carried on for the most part by the leaves, it is sometimes spoken of as the "assimilation shoot."

I. THE ROOT.

True Roots are found only among plants having a vascular system, as the Spermophytes and the higher Pteridophytes,

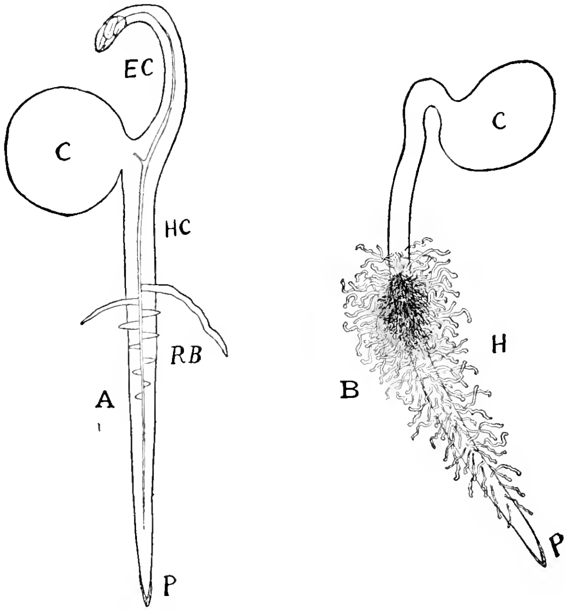


FIG. 59. A, advanced stage of germination of the common garden pea (*Pisum sativum*) showing growing point of root protected by root-cap (p); root branches or secondary roots (rb); hypocotyl (hc); epicotyl or stem above the cotyledons (ec); cotyledons (one in view) (c). B, plantlet of white or yellow mustard (*Sinapis alba*) showing copious development of root-hairs (h).

although on the other hand some of the higher plants do not possess them, as certain of the saprophytic orchids and some of the aquatic plants as Utricularia, Lemna, etc. If we take a germinating plant and mark the root into ten equal divisions, beginning at the apex, and place the plant in a moist chamber, it will be found in the course of one or two days that the marks between 1 and 5 have become much further apart, and that the growth in this region is about three times that between 5 and 10. This experi-

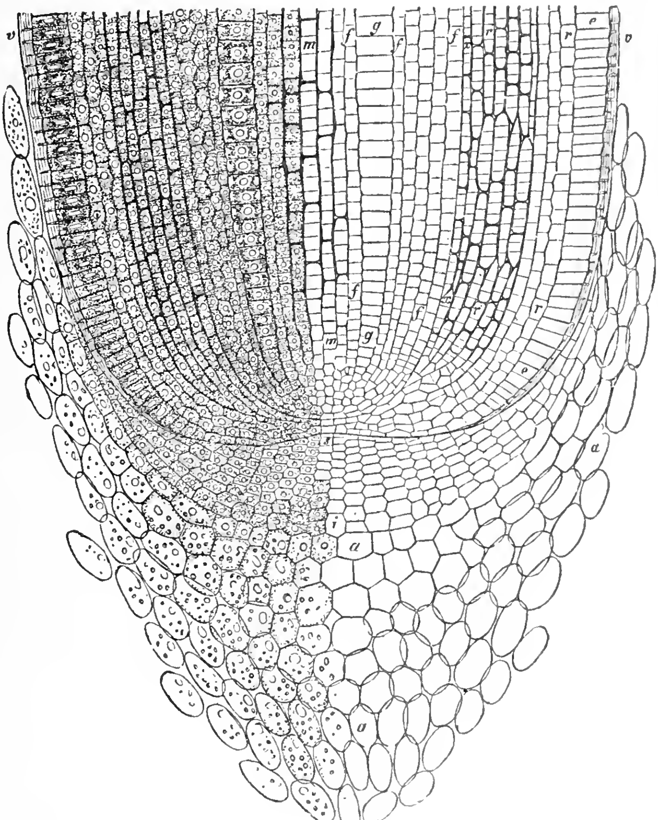


Fig. 60. Longitudinal section through the tip of the root of Indian corn (*Zea Mays*) showing root-cap: a, outer layer; i, inner layer.—After Sachs.

ment indicates that the growth of the root takes place at or near the apex, this region being known as the point of growth, or point of vegetation (Fig. 60).

Upon examining the tip of a very young root by means of the microscope, it will be seen that the growing point is protected by a cup-shaped body of a more or less solid structure and frequently mucilaginous; its function is to protect the growing point, and exists in all roots of terrestrial, epiphytic and aquatic plants except the parasites.

Just above the root-cap there is developed a narrow zone of delicate hairs, which arise from the surface cells and are usually thin-walled and unicellular. These are known as ROOT-HAIRS (Fig. 59, *B*) and their function is twofold: (1) They secrete an acid which renders the inorganic substances of the earth soluble, and (2) they absorb these and other substances for the nourishment of the plant. It should be stated that there are a number of plants which for various reasons do not possess root-hairs, such as water-plants, marsh-plants, certain Coniferæ, etc.

When the primary root persists (as in Gymnosperms and Dicotyledons) it increases considerably in length and becomes ramified; if at the same time, it increases in thickness, and much more so than its branches, then it is called a TAP-ROOT (as in Daucus, Beta, etc.).

In the vascular cryptogams (Pteridophytes) and the monocotyledons the primary root is generally thin and weak, frequently but little ramified, and disappears at an early stage, being replaced by SECONDARY ROOTS, as in Zea. Secondary roots may arise not only upon the stem but even upon leaves as in Begonia and Bryophyllum. The term LATERAL ROOTS is restricted to those that develop from the root alone.

The development of roots upon shoots or of so-called "ADVENTITIOUS ROOTS" occurs in nearly all of the woody plants of the Spermophyta. Many annual herbaceous plants do not possess this capacity at all. The adventitious roots arise from "root-primordia" which are formed under the cortex of the shoots. While ordinarily they do not develop upon the shoots, yet if cuttings are made, as of Coleus, Geranium, Rosa, etc., we find "either singly or on both sides of the axillary buds" the development of adventitious roots from the latent root-primordia.

Influence of Gravity.—The root is popularly supposed to grow downward, in order to avoid the light. On the other hand, the theory has been established (as a result of Knight's experiments) that the root grows downward by reason of the influence of gravity. In addition it may be said that the principal functions of the root, namely, those of absorbing inorganic food materials, and of fixing the plant to the soil, determine in a measure the direction of its growth. The tendency of the root to grow downward is a characteristic which distinguishes it from other parts of the plant and it is said to be POSITIVELY GEOTROPIC (Fig. 61, *A*).

The influence which gravity has on plants may be best understood by bearing in mind that gravity is a constant force which acts perpendicularly to the surface of the earth, and that all parts of the plant are subject to its influence. The organs of plants

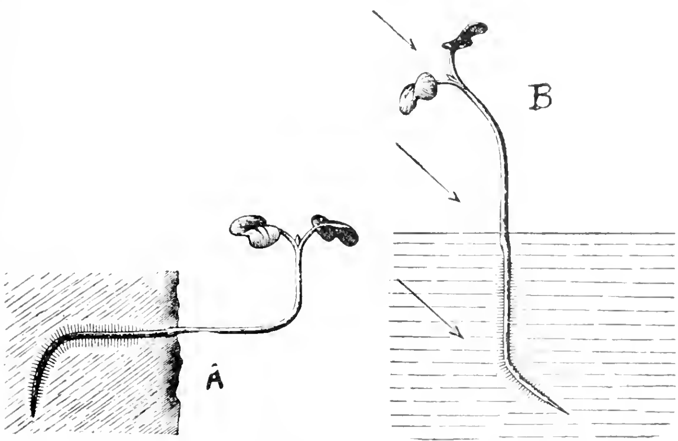


FIG. 61. A, seedling of *Brassica nigra* in which root and stem have curved into a vertical position after being laid horizontally. B, seedling of *Sinapis alba*, the hypocotyl showing a positive, the root in water a negative heliotropic curvature. The arrows show the direction of the incident rays of light.—After Pfeffer.

respond in different ways to the action of gravity, but a clear distinction should be made between mere mass attraction or that manifestation of the force of gravity whereby the heavily laden branch of a fruit tree *bends* downward and the stimulus which causes the primary root of a plant to *grow* downward and the shoot to grow upward. While all parts of the plant are subject to the influence of gravity not all the organs of plants respond in an equal degree. This is well illustrated by roots themselves. It is well known that whatever the position of the seed at the time of germination the young radicle begins to grow perpendicularly downward (Fig. 61, *A*). The branches, however, which arise on the primary root are less positively geotropic and instead of growing downward parallel with the primary or tap root, diverge at an angle from it (Fig. 88). The secondary branches are still less affected by gravity and diverge still more from the perpendicular, or grow out horizontally, while still others do not appear to be in the least affected by gravity and grow freely in any direction. In the case of large trees we frequently find that the lateral

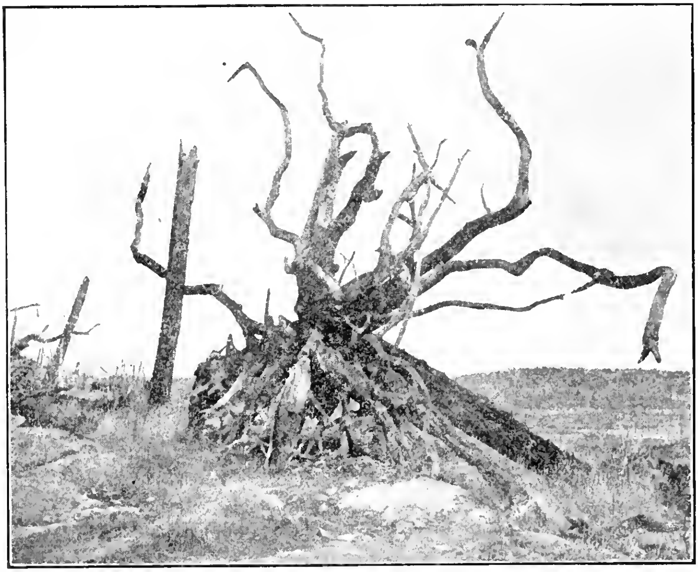


FIG. 62. Over-turned tree trunk showing spreading root-system, the main or tap root having died away.

roots spread out in a more or less horizontal plane near the surface of the earth, and if the main root has died the influence of gravity is not very evident (Fig. 62). But here it must be remembered that gravity was instrumental in determining the direction of growth at an earlier stage. This spreading of the roots near the surface of the earth is of decided advantage to plants, for it enables them to avail themselves of the better soil of the surface layers. As indicated, gravity also determines the upward perpendicular direction of the shoot, which is therefore said to be

NEGATIVELY GEOTROPIC, but, as in the case of the root, the branches are less influenced by it and hence diverge at various angles from the main axis.

Some of the other effects of gravity may be noted. If the end of a shoot be cut off the branches next to the top will grow perpendicularly upward and thus assume the work of the main axis. Likewise in the case of roots, if the apex of the main or tap root be cut off the branches near the end will assume a perpendicular direction. It will frequently be noticed in the case of trees which have been uprooted or where branches have been bent over horizontally that the new branches which arise grow perpendicularly upward. Creeping shoots furnish another good example showing the influence of gravity, the branches growing upward and the roots downward.

Modified Roots.—Roots which arise from the nodes of the stem or other parts of the plant are known as secondary or adventitious roots. These include the aerial roots of the banyan tree, which are for the purpose of support; the roots of the ivy, which are both for support and climbing, and the roots of Indian corn and many palms which serve both for support and the absorption of nourishment. Under this head may also be included the aerial roots of orchids and the root-like structures, or haustoria, of parasites, as of mistletoe and dodder, which penetrate the tissues of their host plants.

Of special interest also are the breathing roots of certain marsh-plants which serve to convey oxygen to the submerged parts; and the assimilation roots of certain water-plants and epiphytes, which are unique in that they produce chlorophyll. In certain plants the roots give rise to adventitious shoots as in Prunus, Rubus, Ailanthus, etc., and in this way these plants sometimes form small groves.

Root Tubercles.—The roots of the plants belonging to the Leguminosæ are characterized by the production of tubercles, nodules or swellings (Fig. 64) which have been shown to have a direct relation to the assimilation of nitrogen by the plants of this family. Like carbon, nitrogen is one of the elements essential to plant-life, being one of the constituents of protoplasm and present in various nitrogenous (protein) compounds which occur as normal constituents of the plant. The nitrogen required by plants is derived either from nitrogen salts contained in the soil,

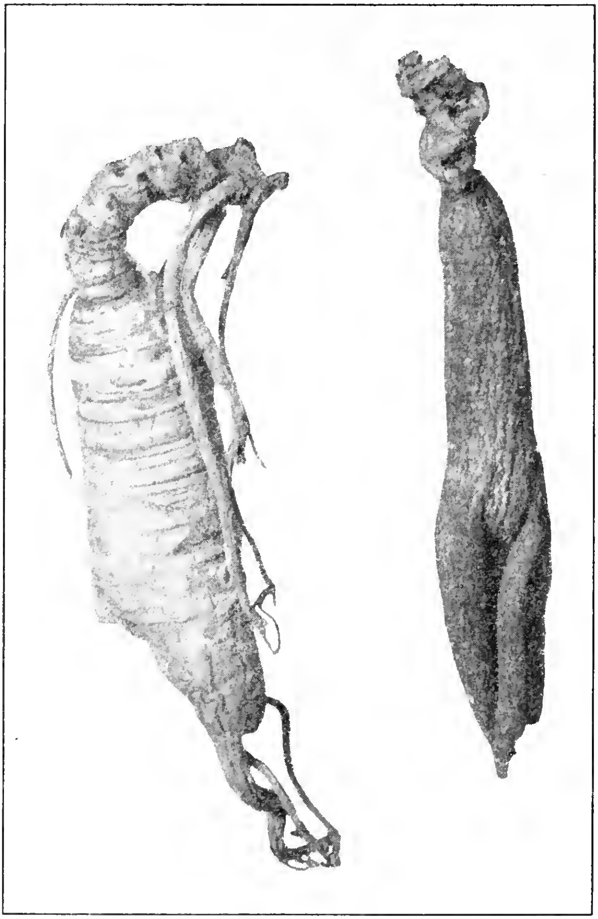


FIG. 63. Tuberous root of ginseng (*Panax quinquefolium*). The root on the left is a fresh specimen and was grown in the United States. The one to the right was purchased at a Chinese bazaar and cost 75 cents. It is translucent, of a yellowish-brown color, and has the characteristic shape considered desirable by the Chinese. The markings on the upper segment of the specimen are stem scars which are usually found on old roots. The translucent appearance is no doubt due to the manner of treatment. While the method is not generally known, similar specimens may be prepared by treating the recently gathered roots with freshly slaked lime.

as nitrates and ammonium salts, or from the free nitrogen of the atmosphere. While most of the higher plants are able to assimilate nitrogen compounds existing in the soil, only the

Leguminosæ, with possibly a few exceptions, are able to assimilate atmospheric nitrogen, and in this respect the majority of the Leguminosæ stand as a class by themselves. Apparently in direct relation to this character stands the fact that the seeds of these plants contain a high percentage of nitrogen. This special ability of the Leguminosæ to fix atmospheric nitrogen in the plants depends upon the presence of the nodules, which are due to the

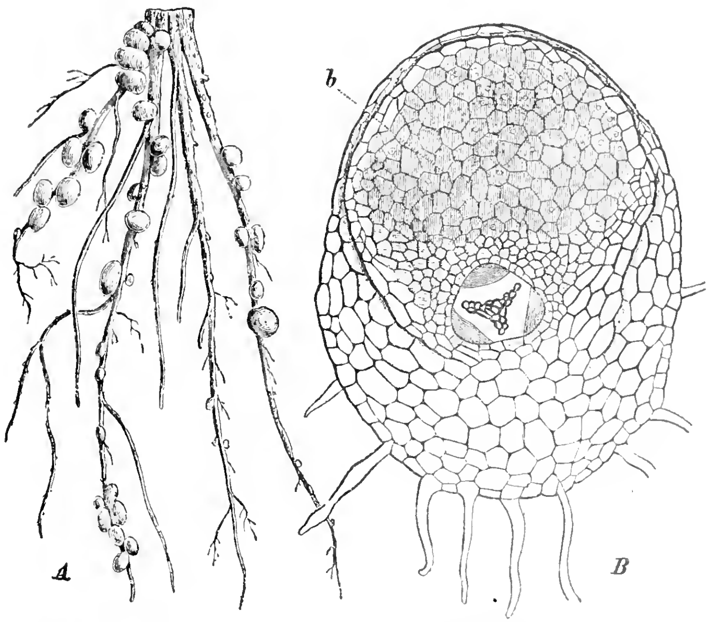


FIG. 64. Root tubercles on Lupinus, one of the *Leguminosæ:* A, roots with tubercles; B, transverse section of root showing the cells (b) which contain the nitrogen bacteria.—A, after Taubert; B, after Frank.

infection of the roots by a soil-bacterium (*Pseudomonas radicicola*), although the precise mode of fixing the nitrogen is not known. The bacteria seem to be localized in the nodules and are not found in any other part of the plant.

It has been shown that when the roots of leguminous plants are free from nodules they do not have the power of assimilating free nitrogen. On the other hand when the nodules produced by the bacteria are developed, the plants will grow in soil practically free from nitrogen salts. Because of this power the plants of this family are useful in restoring worn-out land, *i.e.*, land in which the supply of nitrogen is exhausted, and they thus play an important rôle in agricultural pursuits.

The enriching of the soil is accomplished by ploughing under the leguminous crops, as of clover or alfalfa, or allowing the nodule-producing roots to decay, when the nitrogen compounds are distributed in the soil.

II. THE STEM.

The stem, or ascending axis of the plant, usually grows in a direction opposite to that of the root, seeking the light and air. The tendency of the stem to grow upward is characteristic of the majority of plants, and is spoken of as NEGATIVE GEOTROPISM. The growing point of the stem is at the apex, and it is protected by a layer of bud scales (Fig. 108, *B*).

Stems are further characterized by bearing leaves, or modifications of them. The leaves occur at regular intervals in the same species, and that portion of the stem from which they arise is spoken of as a NODE, while the intervening portion is called an internode.

Stem Branches usually arise in the axils of the leaves, first appearing as little protuberances, sometimes spoken of as primordia, on the stem. Their origin differs from that of the root branches, in that they arise from meristematic or embryonic tissue (p. 181) developed just beneath the epidermis. The branches, like the main axis, manifest negative geotropism, although to a lesser degree. They likewise possess a growing point at the apex, covered with embryonic leaves (Fig. 108). Not infrequently more than one branch arises in the leaf axil.

Buds may be defined as undeveloped shoots in which the foliage is yet rudimentary. The buds at the ends of stems or branches are known as APICAL, or TERMINAL BUDS, and those situated in the axils of the leaves, as AXILLARY BUDS. In some cases they are protected by scales, as in hickory, when they are known as scaly buds; while buds which are not thus protected, are called naked buds. They are further distinguished as leaf, flower, and mixed buds, as they develop into leaves, or flowers, or both.

We have to distinguish between overground shoots and underground shoots. The former are sometimes designated as epigeous (upon the earth) and the latter as hypogeous (under the earth).

Epigeous Shoots.—As would be supposed these two kinds of shoots vary to a certain extent. In epigeous shoots a number

FIG. 65.

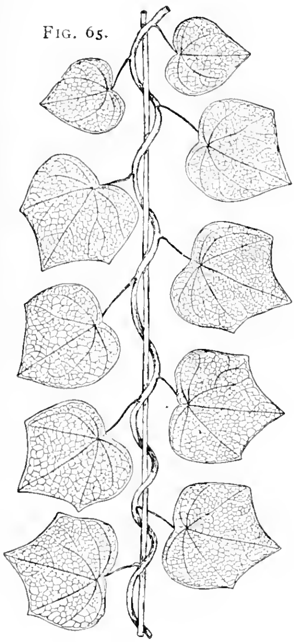


FIG. 66.

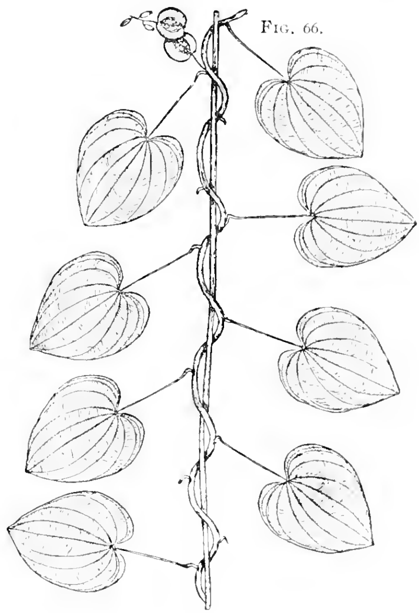


FIG. 65. Woody vine of Canada moonseed (*Menispermum canadense*), which ascends by twining to the right.

FIG. 66. Stem of wild yamroot (*Dioscorea villosa*), which ascends by twining to the left, and several of the characteristic 3-winged capsules at the top.

The twining movements of stem climbers are due to the stimulus of gravity rather than to contact stimulus, and in the majority of twining plants the revolving movements, as seen from the side, are from the left to the right, *i.e.*, in a direction opposite to that of the hands of a watch if represented diagrammatically.

of features may be noted. If the internodes are long the leaves do not usually interfere with one another so far as exposure to light is concerned, but if the internodes are short, the leaves are all brought close together on the axis, and hence were it not for various modifications, their relation to light would be very unequal. Sometimes the shoot-axis may share with the leaves the work of assimilation, as in the case of certain green stems. Then again there are cases in which the leaves are reduced, and the work of assimilation is carried on exclusively by the shoot-

FIG. 67. *Bryonia dioica.* a, young, spirally coiled tendril; b, expanded and irritable tendril; c, tendril which has grasped a support; d, tendril which has not grasped a support, and has undergone the old-age coiling.—After Pfeffer.

axes, as in most Cactaceæ, certain marsh-plants and others. On the other hand the shoot-axis may be modified so as to increase the assimilating surface, as by a flattening of the axis, as in some of the Cacti, the leaves being suppressed or considerably reduced. Branches are not infrequently modified to hard, pointed and spiny structures, as in the Japanese quince, when they are spoken of as thorns. Leaves and even flowers may arise upon thorns, which shows that they are modified branches.

A number of plants ascend into the air on other plants, or other objects which serve as supports, either by attaching themselves to them or by twining around them, when they are distinguished as twiners and climbers. TWINERS ascend by a special

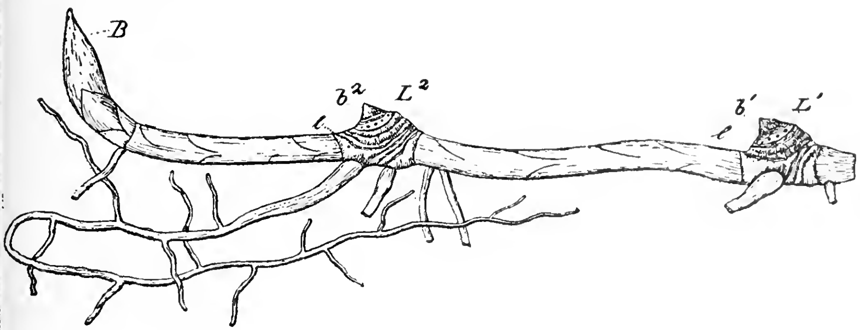


FIG. 68. Rhizome of Podophyllum representing three years' growth: b¹, the terminal bud of last year; b², the corresponding one of the present year; B, the terminal one of the entire rhizome will develop in the spring of next year. L¹ and L² indicate the scars of aerial leaves of the two preceeding years' growth; b^1 and b^2, latent buds.—After Holm.

circumnutating movement of the stem, as in the morning glory, Menispermum (Fig. 65), etc. CLIMBERS, however, ascend by means of special structures, as the aerial roots of the ivy (root climbers); or they may climb by means of leaves, as in Clematis (leaf climbers): still others climb by means of tendrils, as in the grape and Bryonia (tendril climbers) (Fig. 66); and again plants may climb by means of hooked hairs or spines as in Rubus, Rosa, etc. The tendrils, which are thread-like modifications of the stem, are in some cases provided with disk-like attachments for holding the plant in position, as in the Virginia creeper. Twiners and climbers are sometimes spoken of as LIANES (lianas), particularly those of tropical regions, where they form a prominent feature of the forest vegetation. The lianes usually have rope-like, woody stems, the formation of leaves being either suppressed or retarded, and they often run for long distances over the ground and climb to the tops of the tallest trees. They are also frequently characterized by an anomalous stem-structure, the tracheæ being very large.

Stems vary furthermore in size and form. While most stems are more or less cylindrical or terete, other forms also occur, as the flattened stems in the Cactaceæ; triangular in the Cyperaceæ, and quadrangular in the Labiatæ and Scrophulariaceæ.

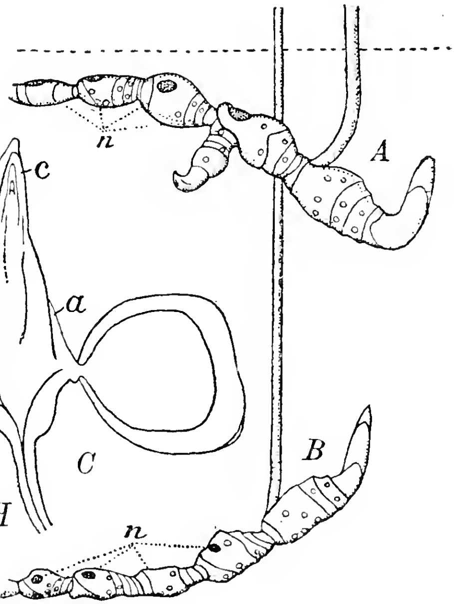


FIG. 69. *Polygonatum multiflorum*, a plant growing in the Northern Hemispheres and Japan and producing a rhizome resembling our Solomon's Seal (*Polygonatum biflorum*). A, rhizome placed artificially higher in the soil than the normal depth; its continuation shoot has grown downwards. B, rhizome placed deeper than the normal depth; its continuation shoot has grown upwards. The dotted lines at n indicate the amount of annual growth in the rhizomes A and B. C, a seedling rhizome. At the right is the seed, which encloses the haustorial end of the cotyledon; H, primary root; n, lateral roots arising within the axis of the shoot; a, posterior side of cotylar sheath; v, anterior side of the same; b, c, katophyls (or leaves on hypogeous shoots) on the axis of the seedling.—A and B, after Rimbach; C, after Irmisch. (From Goebel's "Organography of Plants.")

Hypogeous Shoots.—While most stems attain a more or less erect position as in trees and shrubs there are others which bend over to one side, or lie prostrate on the ground, and in some cases produce roots from the nodes, as in *Mentha spicata*. These latter are known as STOLONS or runners.

Furthermore the stems of a number of plants grow underground and these are known as RHIZOMES or ROOT-STOCKS; from the upper portion of the nodes overground branches arise which bear leaves (so that the work of assimilation may be carried on) as well as flowers, and from the lower surface, roots (Fig. 68).

While most rhizomes are perceptibly thickened, and more or less fleshy when fresh, as *Sanguinaria*, in other instances they are of the ordinary thickness of the overground stem.

There are some rhizomes that are excessively thickened, as in the common white potato, and these are called TUBERS. The so-called "eyes" are small buds covered with small scale-like leaves which develop into shoots. Tubers should not be confounded with tuberous roots, as those of the sweet potato and jalap, for these latter have the morphological characters of roots.

Instead of the node, or internode, or both, becoming excessively thickened, they may be reduced in size and crowded upon each other, the leaves at the same time becoming thickened and filled with nutriment. Such a modified stem and leaves, as in the onion, is called a BULB. Bulbs are sometimes produced in the axils of the leaves of overground stems, as in some lilies, and are then called bulbils or bublets. They are also found in Allium, forming what are commonly known as "onion sets." Bulbs and tubers serve not only as storage-organs and carry the life of the plant over from one season to another but may form, as in bulblets, an important means of distributing the plants. The thickened fleshy stems of Cactaceæ are also regarded as storage organs.

A CORM is intermediate between a true tuber and a bulb; it is more in the nature of a thickened internode, being surrounded in some cases by thin membranous scales, as in Crocus and Colchicum.

The function of the vegetative shoot is to absorb nutrition from the earth as well as from the air. The shoot may be AERIAL or SUBTERRANEAN. Some plants possess only aerial shoots or LIGHT-SHOOTS, as for instance trees, shrubs and herbs that flower but once. Other plants possess both aerial and subterranean shoots and of these the subterranean shoot may exhibit some of the peculiarities of roots, in that they do not develop chlorophyl and produce secondary roots for the purpose of obtaining nutritive substances from the soil. The SUBTERRANEAN SHOOTS are generally destitute of true leaves and are furnished only with membranous or sometimes thick, fleshy leaves which are bladeless, pale, scale-like or tubular.

Depending upon the duration of the shoot (or better the stem), plants are divided into HERBS, SHRUBS and TREES. In herbs the aerial shoots are herbaceous, while in shrubs and trees they become woody and persist throughout many years.

Many of the herbs have subterranean shoots, but these are generally absent from woody plants, excepting in Sambucus, Ailanthus, Calycanthus, etc. The herbs may be further subdivided as annual, biennial and perennial.

In ANNUAL herbs the individual possesses only aerial shoots and the plant sets fruit the same year that the individual has developed from the seed. In BIENNIAL herbs the plant does not produce flowers until the second season. The PERENNIAL herbs on the other hand develop flowers continuously for many (or at least several) years and also produce subterranean shoots, such as creeping rhizomes, tubers, bulbs, etc.

The roots of annuals, biennials and perennials differ in a number of particulars. In the annuals, belonging to the monocotyledons, the roots are fibrous, possessing numerous lateral branches, whereas in the annuals belonging to the dicotyledons only the primary roots develop. The biennials are nearly all dicotyledons and have a persistent primary root which while usually slender may become fleshy, as in Beta. In the perennials, on the other hand, we find a number of different types of roots varying from the slender aerial roots of epiphytes, to the smaller tuberous, fleshy roots of many terrestrial plants, and the peculiar roots of parasites.

III. THE LEAF.

Leaves are lateral formations upon the stem and their growth is definite. They never occur on other portions of the plant than stems from the surface of which they are developed. Leaves appear in acropetal succession, so that the youngest leaves occur nearest the apex of the stem. Terminal leaves are extremely rare but arise in some instances from the flowers of certain Euphorbiaceæ.

A Simple Leaf consists of a LAMINA or blade, which is usually membranous and of a green color, and a PETIOLE or stalk, which, however, may be wanting when the leaf is said to be sessile. Leaves may also possess a pair of leaf-like structures at the base, known as STIPULES (Figs. 70, 74). The principal function of the latter appears to be that of protecting the buds, as in the tulip poplar (*Liriodendron*) (Fig. 74), although they may

FIG. 70.

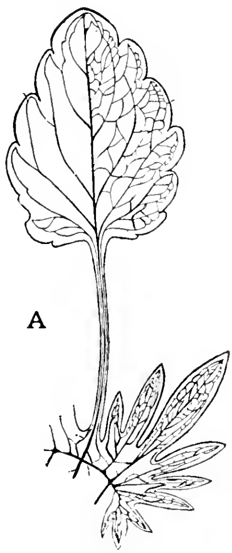


FIG. 71.

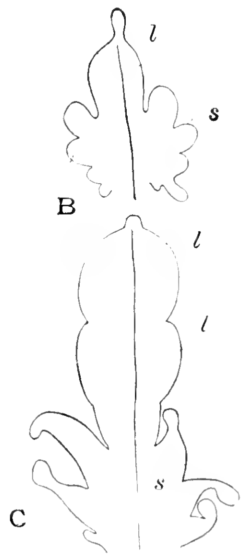


FIG. 70. A, leaf of violet (*Viola tricolor*) showing broad lamina, long petiole, and one of the palmately-lobed stipules at the base of the petiole.
FIG. 71. B, C, stages in the development of the leaf. The lobes of the stipules (s) develop before the lamina (l).

become leaf-like and assist in the functions of the lamina, as in the pansy (*Viola tricolor*) (Fig. 70).

Right Relation of Leaves.—While the lamina of the leaf appears to assume a more or less horizontal position, it usually inclines at such an angle as to receive the greatest amount of diffused daylight. Wiesner has shown, for instance, that when plants are so situated that they receive direct sunlight only for a time in the morning, and diffused daylight during the rest of the day, the position of the upper surface is at right angles to the incident rays of daylight, and not to that of the rays of the morning sun. This phenomenon may be studied in the house geranium and other window plants. In endeavoring to explain this behavior of the leaves, Frank assumes it to be due to a kind of heliotropic irritability peculiar to dorsiventral organs, and terms it TRANSVERSE HELIOTROPISM.

The stem, as well as the petiole or stalk of the leaf, is also influenced by the light, and is said to manifest positive heliotropism. Those parts of plants that turn away from the light, as the aerial roots of the ivy, are said to possess negative heliotropism.

Depending upon their relation to external agents, several forms of leaves are distinguished. In those which assume a more or less horizontal position the two surfaces of the lamina are quite different, and the leaves are said to be DORSIVENTRAL, or bifacial. Usually there is a more compact arrangement or stronger development of chlorophyll tissue on the upper or ventral surface, while on the lower or dorsal surface the veins stand out more prominently, and there is a greater number of stomata.

In contrast with this type of leaf may be mentioned those which grow edgewise and in which both surfaces of the leaf are more or less alike, as in the Eucalypts and Acacias of Australia. In Iris and Calamus, the leaf-like organ is actually not the blade, but merely a part of the dorsal face, which, in the bud, has already pushed out so as to exceed the apex. Such leaves are called SWORD-SHAPED and are frequently referred to as EQUITANT. The leaves of certain species of Juncus, Carex and some of the grasses are commonly spoken of as CYLINDRIC. Such leaves are, however, only apparently cylindrical, since the ventral surface is often distinct, though much narrower than the dorsal. They are also frequently hollow.

Functions of the Leaf.—When we speak of the leaves of the plant we usually have in mind the foliage leaves or green chlorophyll leaves.

Under the influence of sunlight the chloroplasts are able to rearrange the elements in carbon dioxide and water, which are looked upon as inorganic substances, into starch or related compounds which are of an organic nature. This process is known as carbon dioxide assimilation, or PHOTOSYNTHESIS, which latter term means the building up of a compound under the influence of light. In this process, which is sometimes expressed by the following formula, oxygen is given off:

$$\underset{\text{Carbon Dioxide}}{6CO_2} + \underset{\text{Water}}{5H_2O} = \underset{\text{Starch}}{C_6H_{10}O_5} + \underset{\text{Oxygen}}{6O_2}$$

The importance of this function can be best appreciated by bearing in mind that all of the organic products built up by the plant are derived almost entirely from the carbon dioxide of the air which is taken in through the leaves.

Transpiration and respiration are also functions of the leaf. TRANSPIRATION is the giving off of water (through water-pores), or watery vapor (through the stomata), which has been absorbed by the root hairs and transported through the tissues of the root, stem and leaf; the process of breathing, or RESPIRATION, consists in the taking in of oxygen and giving off of carbon dioxide, the exchange being just the reverse of what it is in photosynthesis. These several functions are, however, not confined to the leaf alone, but are carried on by all the green parts of the plant.

Leaf Venation.—The foliage leaves of higher plants are traversed by vascular bundles, which enter the blade through the petiole and diverge at the base, or, as in the case of Dicotyledons, branch in various ways; and it will be seen that the form of the leaves corresponds to the distribution of the bundles. These bundles are known as veins or nerves, and they have two functions, namely, (1) that of a mechanical support, and (2) that of carrying nutritive materials to and from the leaves.

The mode of venation in Monocotyledons and Dicotyledons differs somewhat, but it will be found that in a number of instances the venation of leaves of plants belonging to one of these great groups will resemble that of the leaves of certain plants in the other group. However, there are certain general types belonging to each group (Fig. 72).

VENATION IN MONOCOTYLEDONS.—An examination of the leaf of lily-of-the-valley shows that the primary veins run more or less parallel to the apex with short though distinct anastomoses. Such a leaf is said to be PARALLEL-VEINED or NERVED. It will moreover be noticed that the distribution of the veins in this manner produces a lamina with an even, or entire margin, and such a system of venation is known as a closed system of venation (Fig. 72, A). The leaves of Veratrum (Fig. 129) and *Zea Mays,* furnish other examples of parallel-nerved leaves.

In palms (Fig. 251) the venation is somewhat different. The veins instead of converging toward the apex as they do in the more or less lanceolate leaf of lily-of-the valley, radiate from the base to the margin of the more or less round leaf, and a leaf of this type is said to be PALMI-NERVED.

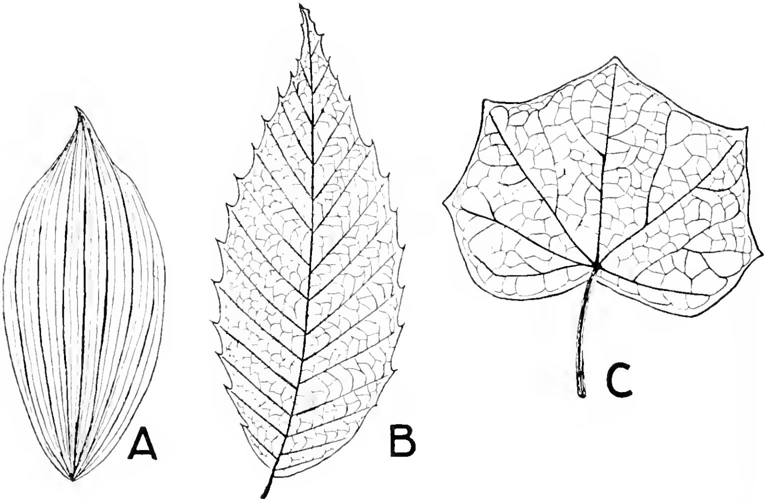


FIG. 72. Leaf venation: A, parallel-veined leaf of Solomon's seal (*Vagnera racemosa*); B, pinnately-reticulate leaf of chestnut; C, palmately-veined leaf of *Menispermum canadense.*

There is still a third type of venation in Monocotyledons. In this instance one principal vein runs from the base to the apex of the leaf, and from this branches run parallel to the margin. The banana furnishes an example of this type, and is said to be PINNI-NERVED.

VENATION IN DICOTYLEDONS.—Here the veins are characterized by their habit of repeatedly branching and anastomosing, whatever the general type of venation may be and thus form a net-work or reticulum, hence the leaves are said to be RETICULATE or NETTED-VEINED. The principal types are as follows: A chest-

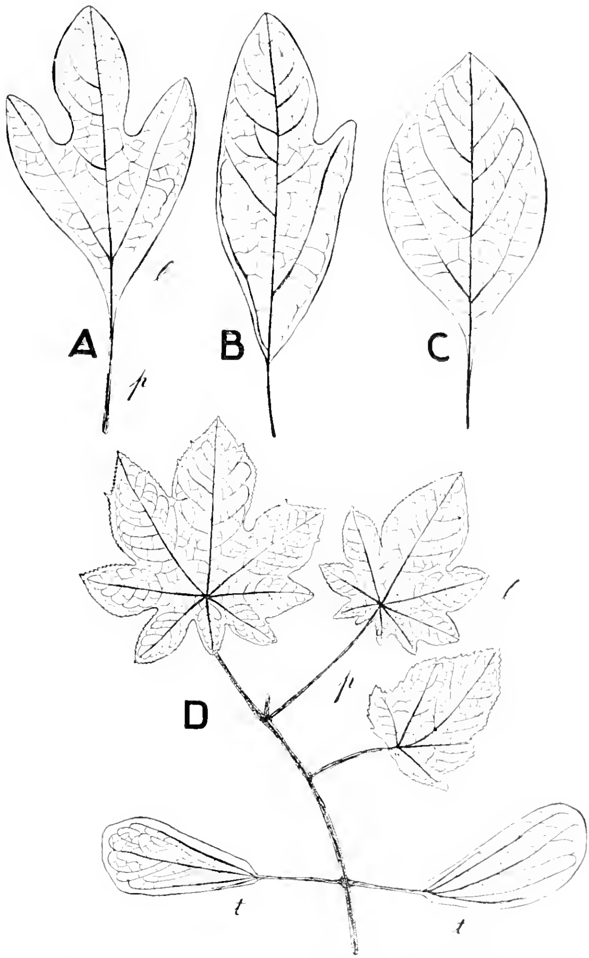


FIG. 73. Variation in the form of leaves on the same plant. A, B, C. Leaves of sassafras; D, young castor oil plant showing cotyledons (t) and variously lobed foliage leaves. l, lamina; p, petiole.

nut or chinquapin leaf (Fig. 72) furnishes a good illustration of a pinnately-reticulate leaf. The principal vein which runs from the base to the apex is called the MIDRIB, while the secondary veins which arise from it and run more or less parallel to the margin are sometimes spoken of as ribs and may be likened to the plumes on the shaft of a feather.

In other cases several large veins arise at the base and diverge toward the margin, giving rise to PALMATELY-VEINED leaves, as in the leaf of maple. There are still other types, as in cinnamon (Fig. 146) which is said to be *rib-netted*, etc.

Surface of Leaves.—In addition to the markings of leaves due to veining there are certain other characters which serve to distinguish them. Hairs are of frequent occurrence on leaves, being generally most abundant on the dorsal surface, especially the veins, and various terms having reference to the kinds of hairs have been applied to leaves (page 210; Figs. 283, 284, 285).

Texture of Leaves.—Leaves also vary in texture. A thin pliable leaf is called membranous; one which is thick and leathery, coriaceous; and one which is thick and fleshy, succulent, as that of the century plant and Aloe (Fig. 130).

Forms of Leaves.—The leaves of plants exhibit an almost innumerable variety of forms (Fig. 78); even on the same plant there are not infrequently several forms, as in *Viola tricolor* and sassafras (Fig. 73); even the two sides of the same leaf may vary, as in *Hamamelis* (Fig. 264) and *Begonia,* when it is known as an inequilateral or asymmetric leaf. It frequently happens that the lower leaves on a shoot are lobed while the upper ones are entire, or some of the leaves may be sessile and others petiolate. Many of the terms used in ordinary language in describing the forms of objects are applied here also, as linear, lanceolate, oblong, elliptical, spatulate, wedge-shaped, etc.

APEX OF LEAF.—A number of descriptive terms are employed in describing the apex of the lamina, as ACUTE, when the form is that of an acute angle; OBTUSE, when the angle is blunt; ACUMINATE, when the angle is prolonged; TRUNCATE, when the end of the leaf appears to be cut off; RETUSE, when it is slightly notched at the apex; OBCORDATE, when the notch is pronounced; EMARGINATE, when the degree of notching is between retuse and obcordate. Sometimes the apex appears like the continuation of the midrib, when it is termed CUSPIDATE or mucronate.

BASE OF LEAF.—Some of the terms used in describing the general outline, as well as the apex of the leaf, are also applied to the

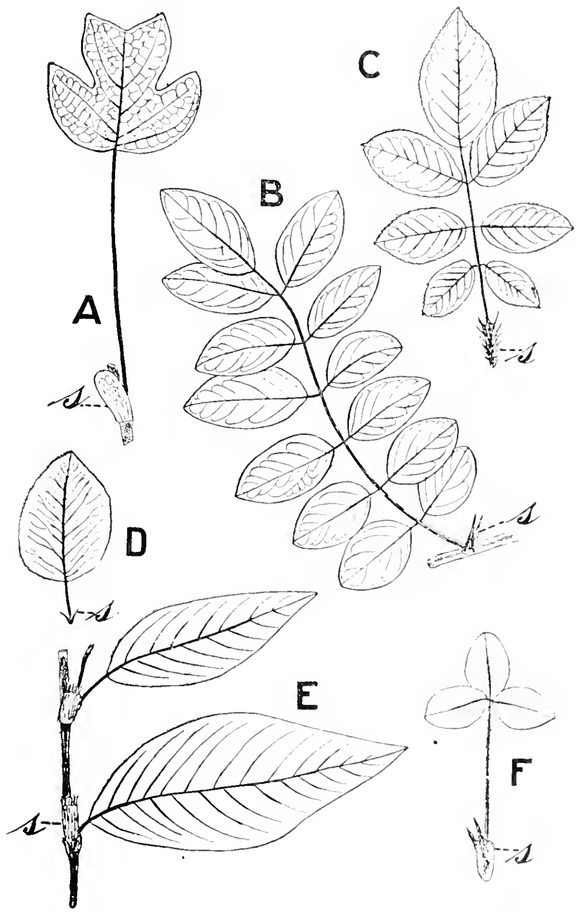


FIG. 74. Leaves having different forms of stipules (*s*): A, bud-scale stipules of *Liriodendron tulipifera;* B, thorny stipules and odd-pinnate compound leaf of the locust tree (*Robinia Pseudacacia*); C, adnate stipules of rose; D, filiform stipules of the pear; E, fringed clasping stipules (ocrea) characteristic of all of the Polygonums; F, adnate stipules of clover.

base, as obtuse, truncate, cordate, reniform, etc. Other terms, however, especially apply to the base, as CUNEATE or wedge-shaped; CONNATE-PERFOLIATE, when opposite leaves are connected at the base and surround the stem; PERFOLIATE, when the leaf simply clasps the stem. In Monocotyledons the base of the leaf is frequently developed as a closed or open sheath, sometimes provided with a membranous protuberance between the sheath and the blade, as in the LIGULE of grasses and sedges.

MARGIN OF LEAF.—The leaves of many woody dicotyledonous plants of temperate regions possess an even margin. The others according to the degree and character of the incisions or indentations, are described as SERRATE, when the apex of the divisions or teeth is sharp and directed forward like the teeth of a saw; DENTATE, when the divisions project outward; CRENATE, when the teeth are more or less rounded; REPAND, when the margin is somewhat wavy; SINUATE, when the wavy character is pronounced; LOBED, when the incisions extend not more than halfway into the lamina, and the sinus (or hollow) and the lobe are more or less rounded; CLEFT, when the incisions are still deeper and the sinuses and lobes are somewhat acute; and DIVIDED (Figs. 75 and 76), when the incisions extend almost to the midrib.

Compound Leaves.—The divisions of a parted leaf may assume the form of a simple leaf, when the divisions are known as LEAFLETS and the whole as a compound leaf. The distinction between a simple leaf and a leaflet is, that the former has a bud in the axil. The difference between the divisions of a simple leaf and those of a compound leaf is this,—in the former they never become detached from the petiole or midrib, whereas in the compound leaf they are articulated and drop off individually. Compound leaves may be divided into PINNATELY-compound (Fig. 74) or PALMATELY-compound (Fig. 78, *E*), this distinction depending upon whether the leaflets are arranged pinnately or palmately. A number of forms of pinnately-compound leaves are recognized. When the leaflets are all lateral (Fig. 71) the leaf is said to be PARI-PINNATE; when there is an odd or terminal leaflet as in the locust (Fig. 74) the leaf is IMPARI-PINNATE; when the midrib is prolonged into a tendril as in the garden-pea (*Pisum*) the leaf is said to be CIRRHIFEROUS-PINNATE.

Movements of Leaves.—The leaves as well as other organs of plants exhibit a variety of movements or curvatures in response to stimuli of different kinds, and are said to possess the property of irritability. Movements of organs are of two general classes:

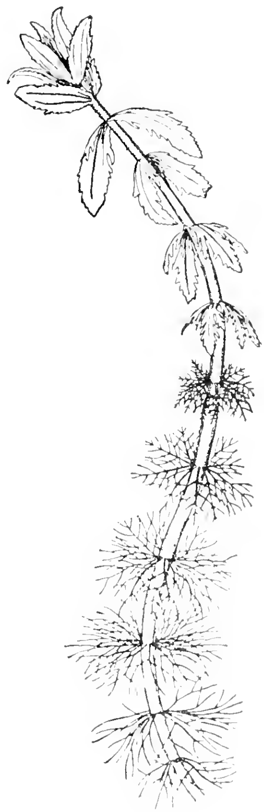


FIG. 75. *Limnophila heterophila*, a marsh-plant belonging to the Scrophulariaceæ and growing in tropical Asia. The submerged or water leaves, below, are much divided and arranged in apparent whorls; while the leaves at the end of the shoot above water are entire and arranged in decussate dimerous whorls. In between occur transition forms, which are divided and variously lobed and arranged in decussate whorls.—After Goebel.

(1) Those due to stimuli which originate in the plant and (2) those due to the influence of external factors. To the former class belong all those movements which occur during the course of

FIG. 76. 1. Leaf, fruits and flowers of *Anemone Pulsatilla*. 2, Leaf, flower and fruit of *Anemone pratense*. The leaves are pinnately divided, the divisions being further incised or dissected.

development from the young to the mature stage. These are known as growth movements or NUTATION. They are especially noticeable in tips of growing branches, which instead of growing in a straight line, move either from one side to the other, or coil or curve about an imaginary axis. This spiral movement is known as circumnutation and is characteristic of twining stems and tendrils, as the hop vine (Fig. 136) and tendrils of Bryonia (Fig. 66). Nutation curvatures are due to unequal growth on two sides of the organ and cease when there is a cessation in growth or when the plant has reached maturity.

The movements of organs due to external stimuli are usually in a direction which shows a relation to the direction of the stimulus, as those produced by gravity and light (Fig. 61), and these movements are of use in bringing the organs into more favorable positions for growth. Stimuli of this kind are spoken of as orienting or TROPIC. The compound leaves of a number of plants exhibit in addition certain variable and periodic movements, which have their origin in a special mechanism known as the PULVINIS. The pulvinis appears as a swelling on the petiole and consists of parenchymatous tissue which is highly turgid, *i.e.*, full of water. Any stimulus, such as mechanical shock, which causes a difference in the degree of turgidity on two sides, will result in a movement of the leaves in such plants as Mimosa, Oxalis and locust. The leaves of *Mimosa pudica*, a common cultivated sensitive plant, show a very rapid response to such stimuli, the leaflets folding together and the petiole and petiolules drooping. In other cases there is a change in the position of the leaves following the alternations of day and night. During the day the leaflets are spread out freely, but at night or in darkness they droop and fold together. These are spoken of as nyctinastic (nyctitropic) or "sleep movements," and are exhibited by a number of leguminous plants, as clover, bean, *Cassia* (Fig. 71), and by wood-sorrel (*Oxalis Acetosella*) and various cultivated species of *Oxalis*. The leaves of *Oxalis* as well as of some other plants fold together under the influence of intense light as well as at night or when the amount of light is reduced. Of special interest also are the lateral leaflets of *Desmodium gyrans* (telegraph plant) which describe curvatures at more or less regular intervals day and night when the temperature is favorable. The leaves of the sundew (*Drosera*) are remarkable for their sensitiveness to touch. The upper surface and margin are provided with peculiar hairs or tentacles (Fig. 77, *II*) which when touched, as by an insect, gradually curve inward. Not only this, the stimulus may be transmitted to other tentacles and sometimes even the blade itself may roll inward to some extent, thus entrapping small insects which serve as food to the plant. The leaves of a related plant *Dionæa*

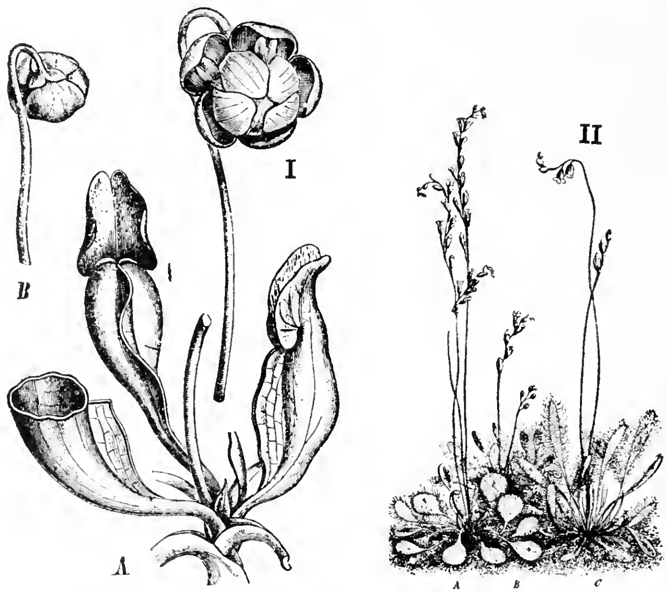


FIG. 77. So-called carnivorous plants. I, the pitcher plant (*Sarracenia purpurea*) showing the modified pitcher-like leaves (A) with inflated portion which narrows into the petiole, and a terminal, more or less spreading winged portion; and a flower and flower-bud (B). II, Three species of sundew: A, *Drosera rotundifolia;* B, *D. intermedia;* C, *D. ongifolia.*—I, after Gray; II, after Drude.

are even more sensitive and when special hairs on the blade are touched that part of the lamina bearing these hairs closes with a quick, trap-like movement imprisoning its insect prey.

Phyllotaxy, or phyllotaxis, is the study of the distribution of leaves upon the stem, and of the laws which govern it. If we examine germinating plants of the beech, the elm, or the oak, we observe that, while the seed-leaves are opposite to each other, the subsequent leaves are arranged according to a different order in these several plants, but in a definite manner in each. In the elm, the distribution of the leaves is such that the third leaf is directly above the first; in the beech, the fourth leaf is above the first, and in the oak, the sixth leaf is above the first. If these leaves are connected in the order of their development, it will be seen that they describe a spiral in their arrangement, and it will also be found that one or more circuits of the stem are made between the superimposed leaves. Furthermore, it will be found that this arrangement constitutes a mathematical series which may be expressed in degrees, or the parts of a circle that the leaves are from each other, this measure being known as DIVERGENCE; or by the number of perpendicular rows of leaves on the stem, which are known as ORTHOSTICHIES.

The following may serve to illustrate the terms used:

LEAVES.	DIVERGENCE.		ORTHOSTICHIES.
	Degrees.	Parts of a Circle.	
Elm	180	$\frac{1}{2}$	Distichous
Beech	120	$\frac{1}{3}$	Tristichous
Oak	144	$\frac{2}{5}$	Pentastichous

If we examine the fractions used, we will find that the numerator indicates the number of turns around the stem before encountering a superimposed leaf, and that the denominator indicates the number of leaves found; the latter also expresses the number of orthostichies. On adding the numerators and denominators of any two successive fractions, a fraction is obtained which expresses the next highest arrangement, as

$$\frac{1}{2} + \frac{1}{3} = \frac{2}{5};\ \frac{1}{3} + \frac{2}{5} = \frac{3}{8}.$$

In quite a number of plants two leaves arise at the nodes, as in the Labiatæ. These are invariably situated opposite each other on the stem, and the successive pairs alternate with one another, forming the decussate arrangement of leaves (Figs. 67, 136, 168, 172).

Modified Leaves.—Leaves are variously modified and serve for other purposes than those already described. They may be fleshy in character and serve as storehouses for nutritive material, as the seed-leaves of the oak, or they may serve for the storage of water, as in Agave and Aloe (Fig. 130). In some instances, particularly when situated near the flowers, they lose

FIG. 78. Group of transplanted wild plants showing variation in form of leaves. A, Cinnamon fern (*Osmunda cinnamomea*) showing sporophylls (fertile leaves) and a cluster of pinnatifid sterile leaves, the pinnæ being linear-lanceolate and deeply pinnatifid; B, wild ginger (*Asarum canadense*) showing basal, reniform, long-petiolate leaves with cordate base and slightly pointed apex; C, young hickory (*Hicoria ovata*) showing the odd-pinnate (imparipinnate), 5- to 7-foliate leaves; D, ternate, decompound leaf of Virginia grape fern (*Botrychium virginianum*); E, digitately compound leaves of cinquefoil (*Potentilla*).

their green color, as in the dogwood, skunk cabbage and others. In other cases they are modified so that they serve as a trap for insects, as in species of *Sarracenia* and *Drosera* (Fig. 77). The petiole may become enlarged and perform the functions of the leaf, as in the acacias, of Australia; or it may become bladder-like and serve as a means for floating the plant, as in the water hyacinth. The stipules may likewise be modified, becoming leaf-like, as in the pansy (Fig. 70); or metamorphosed into thorns, as in the locust; or clasping, as in Polygonum. In some cases the leaves are very much reduced, their functions being performed by the stem, as in Cactaceæ, or even by the roots, as in some orchids which have assimilating roots.

Prefoliation or vernation is the disposition of leaves in the bud. The terms used to describe the folding of the leaves in the bud are derived from an examination of transverse sections of the bud. The following are some of the terms which are employed: CONDUPLICATE, when the lamina of the leaf is folded lengthwise along the midrib so that the two halves of the upper surface lie together, as in the *Magnoliaceæ;* PLICATE or plaited, when the lamina is folded along the veins, like a closed fan, as in the maples; CONVOLUTE, when rolled lengthwise and forming a coil in cross section, as in the *Rosaceæ;* INVOLUTE, when both margins are inrolled lengthwise on the upper surface, as in the violets; REVOLUTE, when both margins are inrolled lengthwise on the lower surface, as in Azalea.

In addition, there are several terms used which are derived from the appearance of the bud, as RECLINATE or inflexed, when the upper part is bent on the lower, as in Liriodendron; and CIRCINATE, when the upper part is coiled on the lower so that the tip of the leaf is in the center of the coil, as in the ferns.

IV. THE FLOWER.

THE FLOWER is a shoot which has undergone a metamorphosis so as to serve as a means of propagating the individual. It is an unbranched and definite shoot, or an apex of a shoot. It might be termed a "dwarf-branch" that dies and drops off the plant after the maturation of the fruit. The most complete flower has four kinds of leaves: sepals, petals, stamens and carpels.

While the flower is a very complicated structure in many cases, the definition given it by some writers is very simple. It is defined as a branch which bears sporophylls. As we have seen, a sporophyll is a leaf which bears sporangia. According to the definition given, the strobiles or cones of the Gymnosperms and certain Pteridophytes, as the horsetails and club mosses, are entitled to rank as flowers. In Angiosperms other leaves may be present, and these are known as the FLORAL LEAVES. The flower then in Angiosperms is made up of sporophylls which are essential, and floral leaves which may or may not be present. But in speaking of the sporophylls of the flower in Angiosperms it is customary to use terms which were applied to them before their relation to the similar organs in the Gmynosperms and Pteridophytes was understood. Thus the microsporophylls as already pointed out, are known as STAMENS, and the megasporophylls as CARPELS.

For a great many years botanists taught that the stamens and carpels are transformed foliage leaves,—in other words that they are derived from foliage leaves, but in more recent years the view has been established that they arise as independent members, are in fact as independent as the foliage leaves themselves. Various transformations or modifications may and do occur, but these are not confined to the foliage leaves alone for under certain conditions the sporophylls may assume the character of floral leaves.

It is true that in the case of some ferns, the sporophylls bear a strong resemblance to foliage leaves, as in *Aspidium Felix mas* (Fig. 277), but this does not necessarily prove that the sporophylls of Angiosperms are transformed leaves, but only that the further back we go, the less the degree of differentiation of parts until we reach the unicellular algæ.

The flowers of the Angiosperms differ from those of the Gymnosperms in that the ovules (megasporangia) are enclosed, before pollination, in an ovary which has developed a special organ—the stigma—for the reception of the pollen grains (microspores) and the floral envelopes are much more conspicuous.

The several parts of the flower are arranged more or less compactly at the terminus of an axis known as the flower branch, the special portion bearing these parts being known as the TORUS (sometimes spoken of as the receptacle), and that portion below the flower proper as the flower stalk (Fig. 83, *PE*). The carpel or carpels occupy the terminal portion of the branch while the stamens and floral leaves occur in circles or whorls below.

Pistil.—There may be only one carpel present in a flower or there may be more. In the latter case the carpels may remain distinct or they may be united, but whatever the number or the degree of union, it is the carpel or carpels which constitute the closed structure known as the pistil. The pistil is usually differentiated into three quite distinct regions: (1) A lower bulbous portion which contains the ovules, known as the OVARY; (2) a neck-like portion known as the STYLE; and (3) at the top of the style a specialized portion which receives the pollen, known as the STIGMA (Figs. 83 and 85). When the pistil is made up of a single carpel it is said to be SIMPLE, and when composed of more than one carpel it is called COMPOUND.

The carpels in the compound pistil appear to be united in different ways. Sometimes they appear to have coalesced or grown together at the margins, thus forming an ovary with but one chamber or compartment (Fig. 84, *B*). In other cases the carpels appear as though they were incurved or folded together at the margins along the line of union, thus forming septa or walls which divide the inner cavity into several compartments or *locules* (Fig. 84, *A*, *C*).

When the carpels are not united but remain separate, there are as many pistils as carpels, as in the flowers of buttercup (Fig. 84, *D*). Thus a unilocular ovary may belong to a simple or compound pistil.

GYNÆCIUM.—The aggregate of pistils in a flower constitutes the gynæcium. If the gynæcium is made up of a number of simple pistils, as in the flower of buttercup (Fig. 84, *D*), it is said to be APOCARPOUS. But if the carpels are united into one structure, then the gynæcium is said to be SYNCARPOUS, as in the orange flower, which is in reality equivalent to a compound pistil. Inasmuch as the styles and stigmas are frequently not united the expression compound ovary is usually employed. According as the gynæcium consists of one, two, three or many carpels, it is said to be monocarpellary, dicarpellary, tricarpellary or polycarpellary.

The pistil of the flower of the pea is simple and has an elongated ovary, and upon dissecting the ovary and also making a transverse section of it, it is observed that the ovules are borne upon the part which projects from the concrescent margins into the cavity, this part being known as the PLACENTA, and the united margins of the carpel forming the "inner" or VENTRAL SUTURE. In the syncarpous gynæcium the ventral suture of the carpels is directed toward the axis of the flower; in some cases that portion

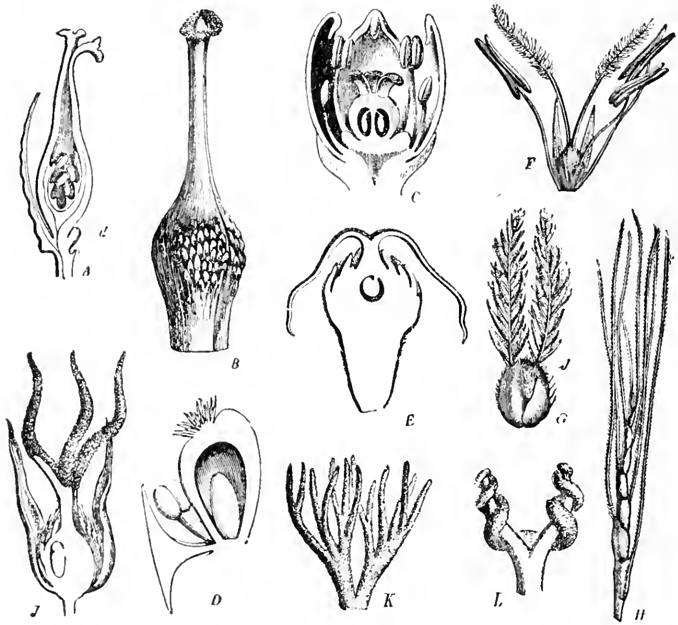


FIG. 79. Pistils and different kinds of stigmas. A, simple (monocarpellary) pistil of willow with lobed stigma; B, compound pistil of *Fourcroya* with head-like stigma; C, longitudinal section through flower of *Spondias* with five separate styles and stigmas, only three of which are shown; D, flower of *Peperomia* showing bristly stigma; E, recurved, thread-like stigmas of the Upas-tree (*Antiaris*); F, flower of a Canary grass showing the two simple plumose stigmas; G, pistillate flower of couch grass showing the two compound plumose stigmas; H, thread-like stigmas of pistillate inflorescence of *Euchlæna* one of the grasses; J, tri-parted stigmas of the pistillate flower of the castor-oil plant; K, L, two forms of stigmas of *Begonia*.—After Engler.

of the carpel corresponding to the midrib is very prominent, as in the Papilionatæ, and has received the name of "outer" or DORSAL SUTURE.

There are as many locules in the ovary as there are carpels, and the walls or partitions between the locules of a syncarpous gynæcium are known as DISSEPIMENTS; when three or more carpels are united the number of dissepiments corresponds to the number of carpels. It sometimes happens that a partition or wall is intruded from the mid-vein of the carpel, dividing a unilocular ovary into one that is bi-locular, as in species of *Astragalus*, and such a partition is termed a FALSE DISSEPIMENT.

When no other than the true dissepiments exist in the syncarpous gynæcium the placentas are borne along the axis of the flower and are termed axial placentas. In the Caryophyllaceæ the ovules are borne upon a central axis, and the dissepiments having been absorbed the gynæcium is said to possess a free central placenta. In other cases the placentas grow backward from the central axis toward the mid-vein of the carpel, carrying the ovules with them, when they are spoken of as parietal placentas, as in colocynth fruit (Fig. 254).

The STYLE not only varies in shape and size but in the manner of attachment to the ovary (Fig. 79); it may be very short, as in the clove; long and filiform, as in *Œnothera;* club-shaped (clavate) as in the orange; or broad and petalloid, as in *Iris*. It is usually situated at the summit of the ovary when it is said to be apical or terminal; it may, however, be laterally attached, as in the strawberry, or, as in a few instances, attached to the base of the ovary. It is usually smooth, but may be hairy, as in the Compositæ. The styles like the carpels may be separate or united, and in the latter case may have a central canal connecting the stigma with the ovary, as in the violets. While usually deciduous, the style may be more or less persistent—forming a part of the fruit—or even become much elongated, as in the dandelion.

The STIGMA is an essential part of the pistil in that it is the germinating ground of the pollen grains, it being viscid and especially adapted for this purpose (Fig. 79). The stigmas may be separate, as in the Compositæ, or they may be united into a more or less club-shaped or globular head, consisting of as many lobes as there are stigmas, as in the poppy. The stigma, while usually solid, may have an opening, as in the violets, which sometimes has a lid-like appendage, as in *Viola tricolor*.

The OVULES (Fig. 85), as we have already seen, are small bodies which are borne on the placentas, and which, after fertilization develop into seeds. The number of ovules varies considerably

—there may be but one, as in the almond, or there may be a large number, as in the watermelon.

There are several principal forms of ovules (Fig. 80) recognized, of which the following may be mentioned: (1) ATROPOUS, in which the ovule is straight and erect on its stalk, as in the Urticaceæ; (2) ANATROPOUS, in which the ovule is bent over on to the stalk so as to be in an inverted position, the line of attachment of the ovule and stalk being known as the raphe (Fig. 85, *n*); (3) CAMPYLOTROPOUS, in which the ovule is bent upon itself, as in *Stramonium*, this form being less frequent than the other two. Most of the ovules of flowering plants are anatropous.

Stamen.—As already indicated the stamen consists of a stalk-like portion called the FILAMENT, and a specialized portion

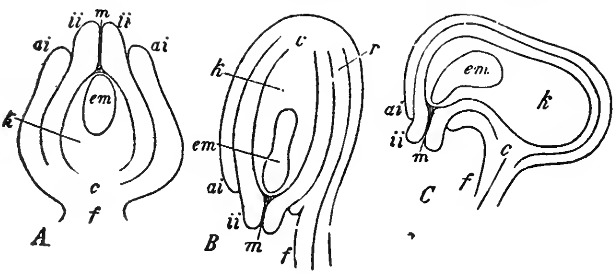


FIG. 80. Three positions of ovules. A, atropous; B, anatropous; C, campylotropous. (f) funiculus or stalk; (c) chalaza, or point of union of nucellus and integuments; (k) nucellus or megasporangium; (em) embryo-sac or megaspore; (ai) outer integument; (ii) inner integument; (m) foramen or orifice for entrance of pollen tube, known as the micropyle in the seed; (r) raphe.—After Prantl.

which bears the sporangia, called the ANTHER (Fig. 81). The filament may be long or short or wanting. It is commonly thread-like, but varies considerably, and is sometimes leaf-like.

The ANTHER is the essential part of the stamen (Figs. 81, 85) and consists of two lobes, each of which is composed of two divisions or pollen sacs (Fig. 53). These sacs contain the pollen which is commonly discharged either through a longitudinal suture or line of dehiscence, or through an opening at the tip. The anthers may be variously attached to the filament (Fig. 81). When they face the axis of the flower they are said to be INTRORSE, as in the Violaceæ, and when they face the perianth they are said to be EXTRORSE, as in the Magnoliaceæ; when they lie horizontally on the tip of the filament, so that they swing as on a pivot, as in the tiger lily, they are said to be VERSATILE; when they adhere longitudinally to the sides of the filament and the dehiscence is

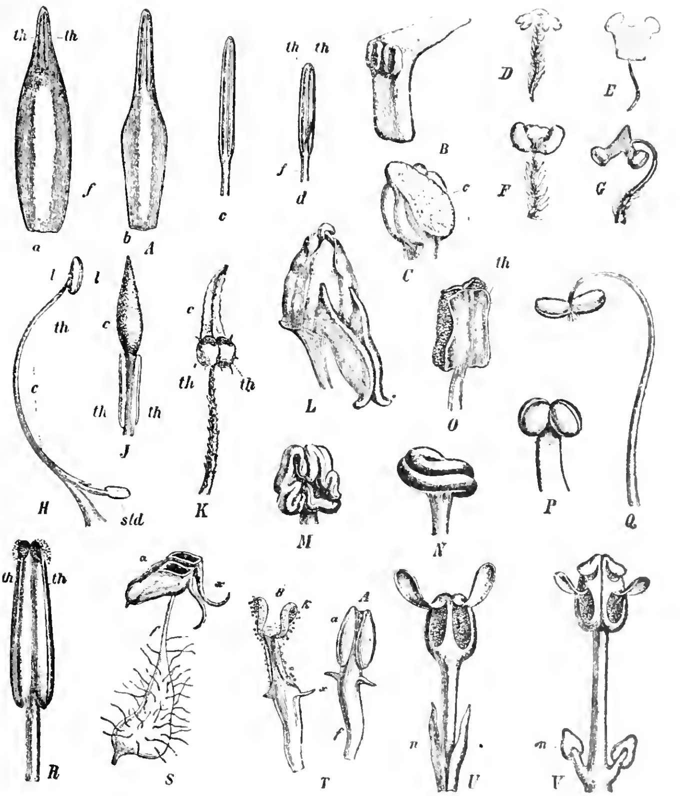


FIG. 81. Different types of stamens. Abbreviations: filament (f), pollen sacs or theca (sporangia) (th), connective (c). A, stamens of a water lily (*Nymphæa*) showing variation in the stamens (a–d); B, theca near middle of the stamen of *Popowia;* C, anther of another species of *Popowia* with fleshy connective and pollen sacs on either side; D, stamen of *Tradescantia* with transverse connective; E, F, G, stamens of several *Commelinaceæ* with broad connectives; H, stamen of *Salvia* with peculiar swinging connective and an aborted pollen sac or staminodium (std) at the lower end and the fertile pollen sac above; J, peculiar elongated connective of *Unona;* K, elongated connective of *Humiri;* L, andrœcium of violet showing two spurred sessile stamens; M, stamen of *Columelia* with sinuous confluent anthers, broad connective and short filament; N, confluent transverse pollen sacs of *Arisarum;* O, united pollen sacs of Columbine showing small connective; P, spherical pollen sacs of *Calla*, with slightly developed connective; Q, versatile anther and long, slender filament of dead nettle (*Lamium album*); R, dehiscence of anther of *Solanum* by means of terminal pores; S, spurred anther of *Arbutus* with terminal pores; various kinds of valvular dehiscence, as in *Berberis* (T), *Atherosperma* (U) and *Persea* (V).—A, after Caspary; B, H–R, U, V, after Baillon; S, T, after Sachs; D–G, after Schonland.

marginal, they are said to be INNATE; when they adhere longitudinally to the filament and the latter extends slightly beyond them, they are said to be ADNATE, in which case they may be extrorse or introrse. In some of the Labiatæ the lobes of the anther are united at the apex of the filament, but diverge from the point of attachment and are said to be connate, coherent or CONFLUENT.

The CONNECTIVE is that portion of the filament to which the lobes of the anther are attached or which connects them (Fig. 81); usually, it is not very prominent; but in some of the Labiatæ, as

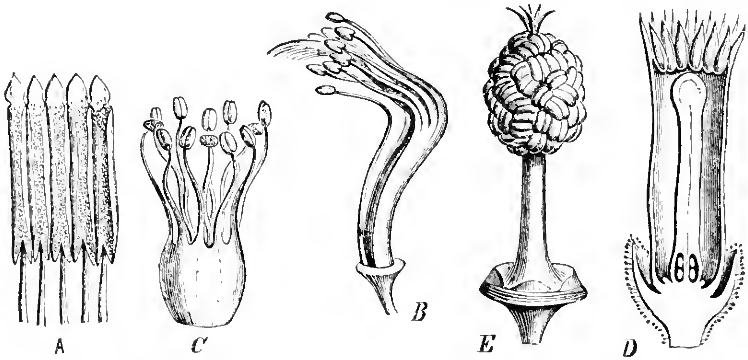


FIG. 82. Union of stamens. A, united anthers of flower of Compositæ; B, diadelphous stamens of *Pisum* with 1 free stamen and 9 united; several types of monadelphous stamens, as in *Erythroxylon* (C), *Melia Azedarach* (D), and common mallow (E).—After Baillon.

in *Salvia*, it is rather broad; in some of the Malvaceæ it is entirely wanting, the two lobes being confluent; in other cases it may be extended beyond the lobes of the anther, as in species of *Asarum*.

APPENDAGES OF ANTHER.—In certain instances the anthers are appendaged (Fig. 81): In the violets there is a triangular growth at the apex; in the oleander the apex is plumose; in deer berry (*Polycodium stamineum*) there are two awn-like appendages upon the back of the anther; in the violets the two stamens that project into the spurred petal are also spurred and secrete a nectar; in the Asclepiadaceæ the anthers possess wing-like appendages, each sack or division of which contains a pear-shaped coherent mass of pollen grains (pollinium).

When a flower has but one stamen it is termed MONANDROUS; and when there are two, three or many stamens, it is said to be diandrous, triandrous or polyandrous (Fig. 84). The aggregate of stamens in the flower is called the ANDRŒCIUM. In the Labiatæ there are four stamens arranged in a longer and shorter pair and the stamens are said to be DIDYNAMOUS; in the Cruciferæ the flowers possess six stamens, four of which are longer than the other two, and the stamens are described as TETRADYNAMOUS; in some plants, as in the Lobeliaceæ, Papilionatæ, etc., the filaments cohere, forming groups (Fig. 82) which are termed monadelphous, diadelphous, etc.; in the flowers of the potato the anthers lie close together but are not united, forming apparently a continuous ring or band around the pistil, when they are said to be connivent; in the tubular flowers of the Compositæ the anthers are united, forming a closed ring, and the stamens are spoken of as SYNGENESIOUS (Fig. 82, *A*); in many of the *Cucurbitaceæ* the filaments and anthers both are confluent; in the flowers of the Orchidaceæ the stamens are borne upon the pistil and are said to be GYNANDROUS (Fig. 133).

Floral Envelopes.—As their name indicates the floral envelopes occupy the outermost or lowest position in the arrangement of the parts of the flower. In the bud condition they protect the essential elements, and in the expanded flower are considered to play an important rôle in securing pollination through the visitation of insects. The floral envelopes are made up generally of two kinds of leaves, *petals* and *sepals* (Fig. 83).

The PETALS form a spiral which surrounds the adrœcium. They are as a rule quite bright and attractive, being frequently highly colored, as in the rose, *Fuchsia*, violet, etc., and are known collectively as the COROLLA.

The SEPALS form the next and lowermost spiral. They are usually green and leaf-like, as in the rose and carnation, and together constitute the CALYX. Sometimes the corolla and calyx are spoken of together as the PERIANTH, although strictly speaking the term has a more special application, and is used mostly in speaking of the sepals and petals of monocotyledonous flowers, these parts being much alike and not distinguishable, save in position, as in certain lilies.

When the divisions of the calyx and corolla remain separate and distinct the latter are spoken of as CHORISEPALOUS and CHORIPETALOUS, respectively; but when the divisions are united or coalesced the calyx and corolla are called GAMOSEPALOUS (synsepalous) and GAMOPETALOUS (sympetalous), respectively.

When the divisions of the calyx or corolla are entirely united these elements are said to be ENTIRE, and when the divisions are partly united they are spoken of as "toothed," "lobed" or "parted," according to the degree of union.

In the flowers of the Cruciferæ and Caryophyllaceæ there is a conspicuous stalk to each of the separate petals, which is known as the UNGUIS or CLAW; while the upper outspreading portion is

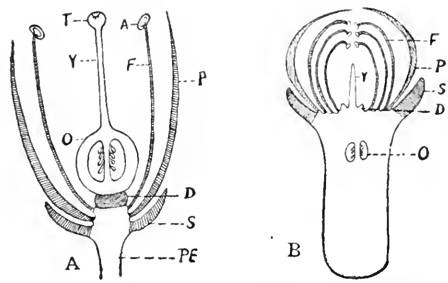


FIG. 83. A, longitudinal section through orange flower (*Citrus Aurantium*) showing stalk (PE); sepals (s); petals (p); stamen with filament (F) and anther (A); compound pistil (composed of united carpels) with stigma (T), style (Y) and superior ovary (O) with ovules; disk or nectary (D). B, longitudinal section of a bud of clove (Caryophyllus) showing inferior ovary (O), style (Y), stamens (F), petals (P), sepals (S), nectary (D).

known as the LAMINA or blade. In the gamosepalous calyx and the gamopetalous corolla the lower united portion is known as the TUBE, and the upper outspreading portion as the LIMB or "border."

The form of the calyx and corolla is quite characteristic for a number of important families. In the Compositæ there are two characteristic forms of corolla, namely, the tubular in the disk flowers and the ligulate in the ray flowers; in the Papilionatæ the corolla, from its fancied resemblance to a butterfly, is described as PAPILIONACEOUS (Figs. 88; 134, *L*); in the Labiatæ the petals are united into two lip-like divisions, and the corolla is said to be BILABIATE (Fig. 84, *F*). There are two kinds of bilabiate corollas—one, as in lavender, where the mouth of the tube is open, known as RINGENT; and another, where the mouth is closed, as in *Linaria*, called PERSONATE.

There are a number of other special forms of calyx and corolla, particularly the latter, and of these may be mentioned the following: A corolla, like that of the harebell, which is more or less bell-shaped, is termed CAMPANULATE; a more or less campanulate corolla contracted near the opening, as in *Gaultheria*, is spoken of as URCEOLATE or urn-shaped; in the morning glory and other Convolvulaceæ the corolla is said to be INFUNDIBULIFORM or *funnel-shaped* (Fig. 174); a corolla, in which the limb spreads abruptly from the tube, as in *Phlox*, is termed HYPOCRATERIFORM or salver-shaped; a corolla with a short tube and outspreading limb, as in potato, is said to be ROTATE or wheel-shaped; a rotate corolla with the margin more or less upturned is called CRATERIFORM or saucer-shaped; in aconite the upper petal is hood- or helmet-shaped, the corolla is spoken of as GALEATE; in the violets one of the petals has a spurred appendage and the corolla is described as SACCATE or calcarate, while the modified petal in the orchids is known as the LABELLUM.

DURATION OF CALYX AND COROLLA.—There is considerable difference in the length of time that the calyx and corolla persist, not only with reference to each other but in different plants. The parts are said to be CADUCOUS when they drop from the flower as soon as it opens, as the calyx of the poppy; when they remain for a day or so, they are said to be EPHEMERAL or fugacious, as in the petals of the poppy; in the rose and apple the petals fall away soon after the pollen reaches the stigma and they are said to be DECIDUOUS; in some flowers the petals wither but persist until the maturing of the fruit, as in the Droseraceæ, and are known as MARCESCENT; the calyx may remain unaffected until the maturing of the fruit, as in the *Labiatæ*, when it is said to be PERSISTENT.

Bracts.—In addition to the floral envelopes other more or less modified leaves are borne on the flower branch below the flower, frequently at the base of the flower stalk, and these have received the name BRACTS. The bracts closely resemble the foliage leaves but usually are smaller and frequently are mere scales, without chlorophyll. In some cases, however, they are large and showy, looking like petals (petaloid), as in the water arum (Fig. 128), the common dogwood; Bougainvillea and Poinsettia seen in greenhouses.

The Torus constitutes the terminal portion of the flower axis or stalk, and is usually more or less conical and somewhat enlarged. When the torus is of this shape the parts of the flower are inserted upon it in serial succession, all of the other parts arising below the pistil. It may, however, be modified into a hollow or cup-like structure which grows up around the ovary carrying the other parts of the flower (sepals, petals and stamens) with it, thus changing the relative position of the parts, although it should be understood that the ovary occupies practically the same position in the two cases.

When the torus is of the first type and the other parts of the flower are inserted below the ovary, the flower is said to be HYPOGYNOUS, as in the orange flower (Fig. 83, *A*) and the ovary superior; but when the torus forms a cup-shaped receptacle and the other parts of the flower arise on its margin above the ovary, the flower is called EPIGYNOUS, as in the clove (Fig. 83, *B*; 84, *C*) and the ovary inferior. In other cases a ring of leaf-like tissue arises from the torus, forming a cup-like receptacle or tube which is known as the perianth tube, the sepals, petals and stamens being inserted on its margin. The perianth tube may be free from the ovary, when the flower is said to be PERIGYNOUS and the ovary half inferior or half superior, as in cherry (Fig. 84, *B*); or in the case of an epigynous flower it may form a prolongation of the cup-shaped torus.

Prefloration or estivation is the arrangement of the parts of the flower—more especially the calyx and corolla—in the bud. Some of the terms used in this connection are also employed in the study of vernation. The following are some of the terms which are employed: VALVATE, when the sepals or petals meet each other at the edges, as in Malvaceæ; IMBRICATED, when the sepals or petals overlap each other, as in the Magnoliaceæ; PLICATE or PLAITED, when the divisions are united and folded together, as in the petals of *Convolvulus* and *Datura*.

The sepals and petals do not necessarily possess the same arrangement, as in the Onagraceæ, where the sepals are valvate and the petals are convolute. Furthermore, in addition to the principal types of estivation and vernation already given, there are a number of special modifications of these, depending upon the number and arrangement as well as direction of the overlapping parts of the flower- or leaf-bud.

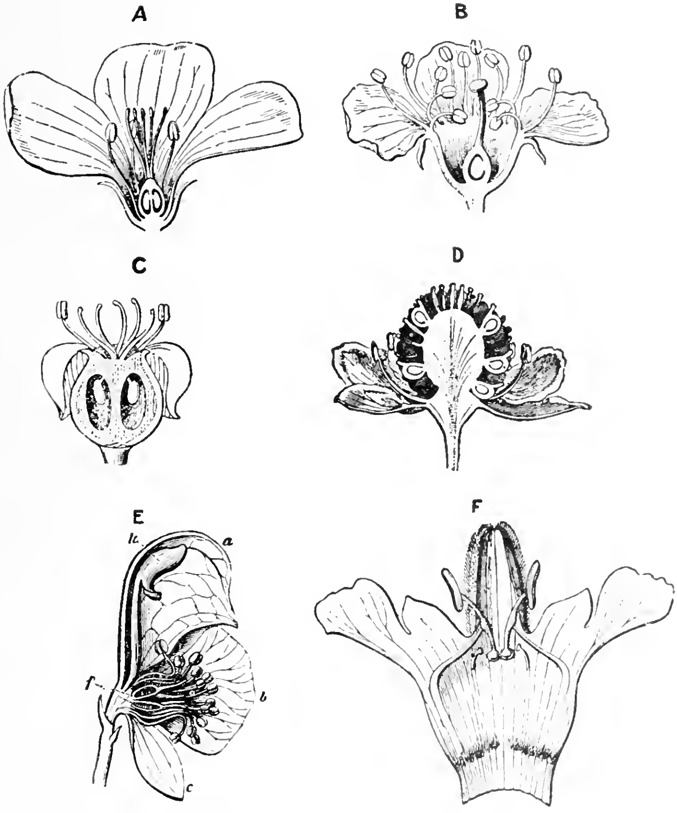


FIG. 84. Types of flowers: A, hypogynous flower of flax; B, perigynous flower of cherry, showing perianth tube with sepals, petals and stamens on its border; C, epigynous flower of American sarsaparilla; D, flower of buttercup showing apocarpous gynæcium and large conical torus; E, irregular (bilateral or zygomorphic) flower of aconite showing half of helmet-like sepal (a), other sepals (b, c), long-clawed nectary (k) developed from one of the posterior petals, separate pistils (f); F, corolla of *Salvia* spread open and showing the two rudimentary stamens and two fertile stamens. The connectives in the latter are long and filamentous and each bears at the upper part a normal pollen sac and at the lower end a non-fertile enlarged portion which the insect pushes against in entering the flower and thus causes the pollen to be deposited on its back.—A–C, after Gray; D–F, after Warming.

Coalescence and Adhesion.—Not only may the divisions of the same circle or whorl of the flower be united but even those of different circles, and a number of terms are used to describe these modifications.

When the divisions of the same circle are united there is said to be a COHESION or COALESCENCE of the parts. When the divisions of different circles are united, as of stamens with corolla, the union is spoken of as ADHESION or adnation, as in Convolvulus.

Chorisis and Multiplication of Parts.—In contrast with the reduction in number of parts of the flower due to union, there may be an increase in the number of parts due to simple division or splitting of the parts, and this is known as chorisis or deduplication. An illustration of this is furnished by the stamens of the orange flower, where from a single initial stamen or primordium a group of from 3 to 11 stamens may be produced. In other cases there may be a multiplication in the number of parts from the beginning, each part arising independently on the torus, as in the stamens of rose. This of course would not be termed chorisis, as no splitting or branching takes place.

Double Flowers.—In double flowers there is an increase in the number of petals, which is considered to be due to the methods of cultivation and the stimulus of an increased food-supply. This results in several ways: (1) By transformation of the sporophylls, more particularly the stamens, into petals; (2) by division or chorisis of the stamens or carpels with subsequent transformation into petals; (3) by division or branching of the petals; and (4) by the production of new series of petals. The extra petals in double carnations and double roses trace their origin to the stamens, while in *Fuchsia* they are the result of chorisis of the petals.

In the snow-ball (*Viburnum opulus*) and hydrangea the essential elements have undergone a complete transformation, and the flowers, while large and showy, are sterile. In the white water lily (*Nymphæa*) there is a series of parts ranging from stamens with narrow filaments and stamens with broad petaloid filaments to petals tipped with a small anther and regular petals (Fig. 81, *A*). In this case the stamens are considered to result from the transformation of the petals. In the case of green roses and green strawberry flowers the petals become green and leaf-like, and the change is spoken of as CHLOROSIS or CHLORANTHY. In some flowers even the ovules are replaced by leaf-like processes or appendages, as in *Drosera* and clover.

Arrested Development.—The arrest or suppression of parts of the plant, particularly of the flower, is of very common occurrence. Just as there are millions of seeds that never find suitable conditions for germination, so in the flowers of a large number of plants a very large proportion of the ovules never develop into seeds, the plants in many instances not furnishing sufficient nutriment for all of the ovules to mature. Under leaves it was stated that in the axil of each leaf there is a bud. This is not always apparent, but if the plant be subjected to some special stimulus, some of the latent buds will become evident. For example, the rubber plant (*Ficus*), so commonly cultivated as an ornamental plant, shows a tendency to develop a straight, unbranched shoot, but if the tip of the shoot be cut off, the buds in the axils of the upper leaves will develop into branches, while some of those lower down will form small protuberances, but develop no further. In other cases there is a loss of parts which seems to be due to loss of function. When there is a partial loss of the element, as of the anthers in the flower of catalpa, it is said to be imperfectly developed or ABORTIVE. When the entire element remains undeveloped as in some of the stamens of the Labiatæ, it is said to be SUPPRESSED (Fig. 84, *F*). In flax the stamens of the outer whorl are reduced to thread-like processes. Such sterile or aborted stamens are called STAMINODES (staminodia). In other plants the parts are not apparently arrested, but have not yet been differentiated, as is the case in the Lily family where the perianth is composed of segments which are more or less alike (Fig. 123). In other cases, however, there seems to be a suppression or arrest of the floral envelopes.

Cleistogamous Flowers.—In addition to the regular flowers some plants produce cleistogamous or closed flowers. In these flowers the corolla is usually suppressed. The flowers develop stamens and pistils but remain closed, and thus there is no chance for cross-pollination. The cleistogamous flowers appear later than the regular flowers and are more or less inconspicuous developing under the leaves and sometimes underground. Of the plants producing cleistogamous flowers, the following may be mentioned: various species of Viola, Polygala, etc.

Classes of Flowers.—As we have seen the megasporophylls and microsporophylls in the Gymnosperms are borne on separate branches, thus giving rise to two kinds of flowers or cones. While the separation of the stamens and pistils is exemplified in a number of plants in the Angiosperms, still it is not the rule and these two elements are usually borne close together on the same axis, *i.e.*, they both enter into a single flower structure. Such a flower is said to be HERMAPHRODITE or bisexual, and most of the conspicuous flowers are of this kind, as roses, buttercups, lilies, etc. Inasmuch as the stamens and pistils constitute the essential elements of the flower, hermaphrodite flowers are also spoken of as PERFECT providing the stamens and pistils are capable of exercising their generative functions. When the stamens and pistils occur in separate flowers the flowers are said to be UNISEXUAL or IMPERFECT, as in willow, oak, hickory, etc. A flower having only a pistil or pistils is called PISTILLATE (Fig. 79, *A*), while one having only a stamen or stamens is STAMINATE (Fig. 135). The staminate and pistillate flowers may be borne on the same plant, when it is said to be MONŒCIOUS, as in castor bean, chestnut, hickory, alder; or they may be borne on separate plants, when the plant is called DIŒCIOUS, as in willows and poplars. Plants bearing hermaphrodite and unisexual flowers on the same individual plant or on different individuals are called POLYGAMOUS, as in Ailanthus.

A COMPLETE flower is one which possesses both kinds of essential elements and both kinds of floral envelopes, and is SYMMETRICAL when a plane can be laid in all directions, the parts being alike and when the number of parts in each circle is the same or when the number in one circle is a multiple of that in the others; as a rule the number of stamens is some multiple of one of the other parts, as in geranium (Fig. 155), where we find five sepals, five petals, ten stamens and five pistils.

Flowers are also spoken of as REGULAR or IRREGULAR, according to whether all the parts of a circle are uniform in shape or not; the flowers of geranium are regular while those of violets are irregular. Regular flowers are also spoken of as ACTINOMORPHIC or RADIAL, and irregular flowers as ZYGOMORPHIC. The latter are also spoken of as DORSIVENTRAL. Dorsiventral flowers either arise as such, as in some of the Leguminosæ (Fig. 88), or they may arise as radial flowers and become dorsiventral during the course of development, as in willow herb (Epilobium).

In some flowers the floral envelopes are wanting, and the flowers are said to be NAKED, as in the willows and grasses.

ANTHOTAXY.—The study of the arrangement of flowers on the stem is known as anthotaxy. The flowering axis may bear only a single terminal flower, as in Tulipa; or the flowers may occur singly in the axils of the leaves, as in *Viola canadensis.* When, on the other hand, the flowers are borne upon a branch shoot, the internodes of which are more or less condensed, and the leaves smaller and of a more simple structure than the foliaceous leaves, the whole shoot is known as an INFLORESCENCE, and the leaves are called BRACTS. The flower thus represents a single unbranched shoot, while the inflorescence represents a branched or ramified shoot.

The so-called bracts besides being generally smaller than the leaves proper are mostly sessile; they may, however, be green, or membranaceous, or they may exhibit a bright coloration, as in Monarda.

The stalk of the individual flower is called a PEDICEL, and may be naked, or bear one or two small bracts, which are called FORE-LEAVES or PROPHYLLA. In the monocotyledons there is usually only one fore-leaf, which turns its back to the mother-axis and is frequently two-nerved and two-keeled. In the dicotyledons there are generally two fore-leaves, which are placed to the right and left of the flower, as in the violets.

The position of the floral leaves (the sepals, the petals and those of the perianth) depends upon the arrangement of the fore-leaves, so that in most of the monocotyledons, where there is one mediane prophyllon, the first leaf of the perianth is placed on the front, while the two succeeding leaves of the perianth occupy a position of 120° from this (Fig. 124). When, on the other hand, as in the dicotyledons with pentamerous flowers two fore-leaves are developed, the first floral leaf (sepal) is situated obliquely above the last fore-leaf, usually on the frontal part of the flower; the second sepal is directly behind the first or diagonally opposite to it, the remaining three leaves (sepals) occurring in a spiral of two-fifths (Fig. 134). Several deviations from this type occur, as in Lobelia (Fig. 272), Polyala, etc.

Two types of inflorescence are distinguished: (1) The INDEFINITE, in which the flowers open or develop in acropetalous or centripetal succession, and (2) the DEFINITE, in which the flowers open in basipetalous or centrifugal succession. The indefinite type of inflorescence is seldom terminated by an expanded flower, and two classes of this type are distinguished: (a) Those in which the flowers are pedicelled, as in the raceme (Fig. 139) and umbel (Fig. 169); and (b) in which the flowers are sessile, as in the spike (Fig. 250) and head (Fig. 242).

The RACEME is a long inflorescence with pedicelled flowers, which are frequently subtended by bracts (Figs. 139, 150, and 207). The CORYMB is a modified raceme in which the pedicels of the basal flowers are much longer than those of the apical, and thus the inflorescence looks like an umbel. In the milkweed the flowers have pedicels of the same length which arise from the apex of the shoot or peduncle, and this form of inflorescence is known as an UMBEL. In the Umbelliferæ a flower cluster or umbellets takes the place of the individual flowers of the umbel, and is known as a COMPOUND UMBEL (Fig. 169).

The SPIKE is also generally a long inflorescence, the flowers being sessile (Fig. 87, illus. 3), the secondary spikes in grasses being known as SPIKELETS. The SPADIX is a form of spike, which is readily distinguished by the fleshy stem, in which the flowers are frequently deeply imbedded, and which is frequently surrounded by a large bract, the so-called SPATHE, as in Arisema. The CATKIN is a kind of spike with small, often imperfect flowers, which falls off as a whole, as in the staminate catkins of the oak. The catkins are mostly decompound, and in some species of Populus the single flowers are pedicelled, and hence are actually racemose rather than spicate inflorescences.

In the head and the umbel the main inflorescential axis is exceedingly short and the innermost flowers are often destitute of bracts, in contrast with the external, which are frequently provided with bracts that are of quite considerable size. Sterile bracts also occur in these two types, and are called involucral leaves, as in *Cornus florida* where they are white or pink. There is also a difference in sex of the outer and inner flowers (see page 391). While the head occurs as typical inflorescence in the Compositæ, it also exists in some of the Umbelliferæ.

Two types of definite inflorescence are distinguished: (1) the DIBRACHIOUS (bifurcate) CYME in which the inflorescence represents a series of very regularly arranged lateral axes, one on each side of the terminal or median flower, as in the Caryophyllaceæ; and (2) the MONOBRACHIOUS (simple) CYME, of which there are several modifications, but common to all of them is the development of only one lateral branch to each terminal flower. In the SCORPIOID cyme the lateral axes are arranged alternately to the right and left, while in the HELICOID cyme the lateral axes are all on the same side of the main axis, as in Hypericum. The so-called flower-cluster is a cymose inflorescence of either the definite or indefinite type in which the flowers are almost sessile or very short pedicelled, as in Chenopodium, Juncus, etc. Sometimes the inflorescences may be decompound or complex, as in several Compositæ, where the heads may be arranged in cymes or racemes; or, as in the Gramineæ, where the spikelets, which are spikes, may be arranged in panicles, *i.e.*, branched racemes; or finally, as in Cryptotænia (Umbelliferæ), where the umbels are arranged in cymes.

Pollination and Fertilization.—Fertilization represents the final stage in the work of the flower as a whole, and has already been defined as the union of the egg-cell and a male nucleus. Pollination may be considered to include the transferral of the pollen grains from the anther to stigma and their subsequent germination thereon, this latter process resulting in the production of the male nuclei. Pollination thus represents but one series of changes or processes which precede fertilization, for, while the pollen grain is going through the various stages in development which lead to the formation of the male nuclei, a series of complex changes are going on in the embryo-sac leading to the development of the egg-cell.

Our special interest in pollination arises from the fact that the pollen grains are not retained in the pollen-sacs and are dependent upon various agencies for transferral to the stigma. This is a matter of great biological significance, for it is claimed that many of the special characters of flowers have a direct relation to pollination.

The various ways in which the anthers open for the discharge of the pollen when it is ripe have already been considered (Fig. 81), but it may be added that the manner in which this is done usually appears to have a relation to the manner in which the pollen is to be carried to the stigma. In order that pollination may be effected, the stigma must be ripe or mature, when it is said to be receptive. It then usually secretes a sticky, sugary liquid which causes the pollen grains to adhere to the stigmatic surface (Fig. 85), and which at the same time serves as a nutrient to them. Usually the pollen grains begin to germinate in a short time after reaching the stigma, which is made evident by the protrusion of the pollen tubes. The stigma seems also to have the power of selection, for in many cases the pollen does not germinate as readily on the stigma of the same flower as on that of another flower provided it be of the same or a nearly related species.

When a flower possesses both stamens and pistils, that is, is bisexual or hermaphrodite, and its pollen germinates upon its own stigma, the process is known as close or SELF-POLLINATION, and if fertilization follows this is known as SELF-FERTILIZATION. While most hermaphrodite flowers are self-pollinated there are some that are not, and this is brought about in several ways: (1) As already pointed out the pollen may germinate better on the stigma of another flower than on the stigma of the same flower; (2) the anthers and pistils of the same flower may mature at different times, and this is one of the commonest ways of preventing self-pollination. Usually in such cases the stamens mature first. The common plantain (*Plantago*) furnishes an example of the maturing of the stigma before the anther. The flowers of this plant are arranged in spikes (Fig. 87, illus. 3 and 4) which belong to the indefinite class, and hence the lower flowers on the spike expand first. As stated, the pistil of each flower matures first, and after it withers the stamens protrude and discharge their pollen. It is evident that the flowers can not be self-pollinated, nor is it likely that one flower will be pollinated by another of the same spike. (3) The stamens and pistils of the same flower may vary in length, as in Polygonum (Fig. 86, illus. 1 and 2) and Lythrum (Fig. 87, illus. 5), or stand in such other relation to each other that self-pollination will not be effected, as in some of the irregular or zygomorphic flowers, like those of Orchids. In these several cases the pollen grains either fall upon

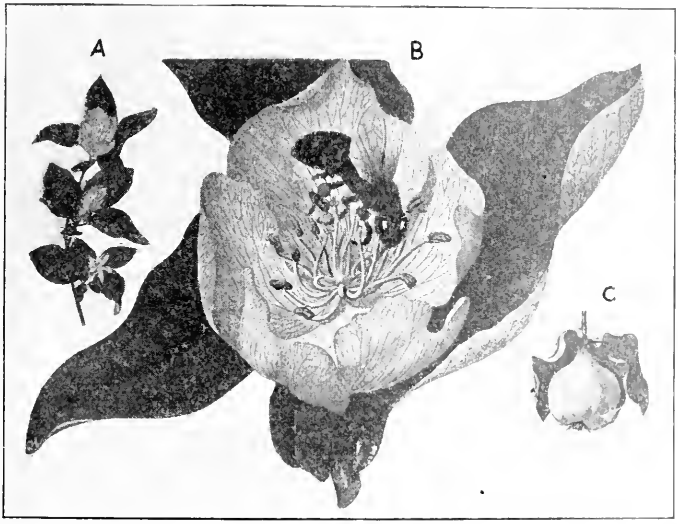


FIG. 85. Cross-pollination through the agency of a bee, in flower of quince (*Cydonia vulgaris*). A, flowering branch; B, flower showing bee extracting nectar, and masses of pollen adhering to its legs, some of which will fall upon the stigmas of other flowers when it visits them; C, ripe inferior fleshy fruit (pome) of quince.—After Dodel-Port.

or are carried by various agents to the stigmas of other flowers, and this is known as CROSS-POLLINATION, and the fertilization which follows as CROSS-FERTILIZATION.

Cross-fertilization is an advantage to the species for usually the seeds which result from this process give rise to plants which are more vigorous and otherwise superior to those which result from self-fertilization. In some cases in order to insure the production of fruit, hand-pollination is practiced, as by the growers of vanilla and some other tropical plants of economic importance.

In the case of unisexual flowers, or those in which the stamens and pistils are in separate flowers, there is of course no chance for self-pollination. Here, as in the case of cross-pollinated hermaphrodite flowers, pollination may be more or less close or it may be remote, as between flowers of the same cluster or inflorescence, between flowers of different clusters or inflorescences on the same plant, or between flowers on different plants.

In buckwheat (Fig. 86, illus. 1 and 2) and partridge berry (*Mitchella repens*) two kinds of flowers are produced, viz.: (*a*) one with short styles and long filaments, and another (*b*) with long styles and short filaments, and thus the flowers appear to be especially adapted for insect cross-pollination and are called DIMORPHIC. In still other cases one species gives rise to three kinds of flowers, depending upon the difference in the relative lengths of the styles and filaments, as in the purple loosestrife (*Lythrum Salicaria*), and such flowers are called TRIMORPHIC.

The external agents which are instrumental in carrying pollen from one flower to another and thereby promoting cross-pollination are the wind, water currents, insects, small animals and birds, such as humming-birds, which are, even in temperate regions, to be observed visiting the garden nasturtium.

In many of the early-flowering trees, as well as pines, Indian corn, etc., the flowers are devoid of showy, attractive features, but produce large quantities of pollen which is more or less dry and powdery and carried by the wind to other flowers. Flowers which are wind-pollinated are classed as ANEMOPHILOUS and it is estimated that about one-tenth of all the flower-producing plants belong to this class.

Plants which are pollinated by the aid of water-currents are known as HYDROPHILOUS, and under this head are included those plants which live under the water and those that produce flowers at or near the surface of the water.

Those plants which depend upon the visitation of insects for the transferral of the pollen in cross-pollination are called ENTOMOPHILOUS (Fig. 85). They frequently possess bright, highly colored flowers and it is considered that these serve as an attrac-

Fig. 86.

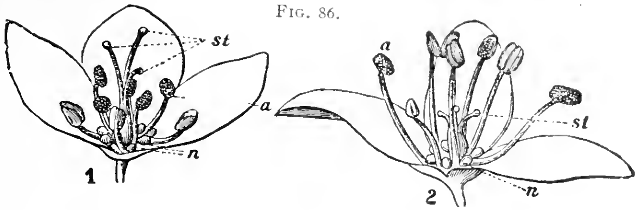
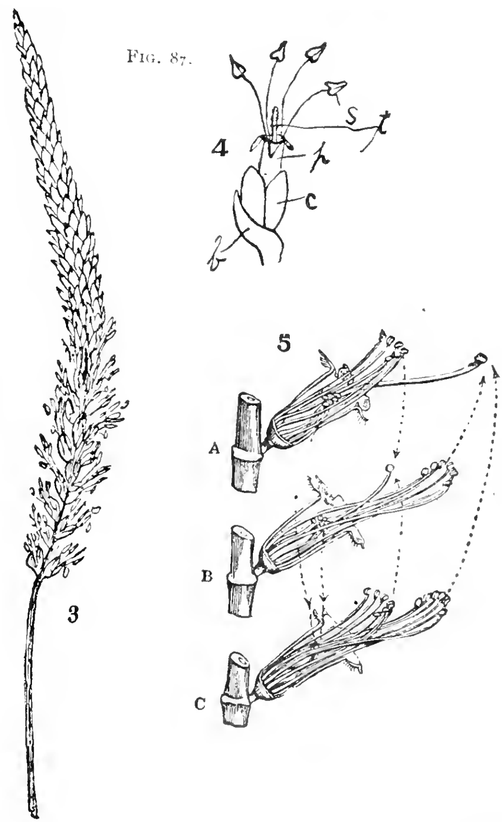


Fig. 87.



Figs. 86 and 87. Manner of cross-pollination in some hermaphrodite flowers. 1, 2, Flowers of buckwheat, showing long style and short filaments in 1, and short styles and long filaments in 2: a, anthers; st, stigmas; n, nectaries. 3, Spike of plantain showing maturing of stamens below and pistils above. 4, Dissected flower of plantain: b, bract, c, calyx; p, corolla tube; s, stamens; t, protruding withered style. 5, Flowers of Purple willow-herb (*Lythrum Salicaria*), one side of the perianth removed from each. A is long-styled, B, medium-styled, and C, short-styled. The direction of the arrows and dotted lines indicates the best methods of crossing.—1, 2, 5, adapted from Warming.

tion to the insects which visit them. The insects are, however, probably more attracted by the odor and food products which they obtain, such as the nectar. The nectar is secreted by

FIG. 88. A, flowering and fruiting plant of peanut (*Arachis hypogæa*). After fertilization the carpophore (or stalk between calyx and ovary) grows in length, sometimes 4 to 8 cm., and curves downward penetrating the soil (el), after which the fruit develops. B. longitudinal section through the papilionaceous (bilateral) flower; C. longitudinal section through the pod (peanut).—After Taubert.

glands known as nectaries which are variously located; frequently they are on the torus either between the ovary and stamens (Fig. 83) or between the stamens and petals. Sometimes the stamen is modified to a nectar-secreting spur as in the violets. In aconite the nectary is developed from one of the posterior petals (Fig. 84, *E*). In seeking the nectar the pollen of the ripe anther may fall upon or adhere to the insects and thus be carried from one flower to another (Fig. 86).

HONEY is a product formed through transformation of the plant nectar by honey bees. The nectar is supposed to be acted upon by certain salivary secretions of the bee and changed into a fruit-sugar, the so-called honey, consisting of a mixture of dextrose and levulose. The nectar of buckwheat and clover (particularly white clover) is the principal source of the commercial article. The nectar of some plants is poisonous and may furnish a poisonous honey (see p. 357).

V. THE FRUIT.

After the fertilization of the ovule or ovules, the parts of the flower that play no further part either in protecting the seed or aiding in its dispersal soon wither and are cast off; in most flowers the petals lose their color and, together with the stamens, style and stigma, wither and fall away shortly after fertilization. The stigma may, however, persist, as in the poppy; the style may likewise remain, as in *Ranunculus*, or even continue to grow or lengthen, as in *Taraxacum;* in other cases the calyx persists, as in orange and belladonna; in still other cases the torus may become fleshy and form a part of the fruit, as in pimenta and apple. The fruit may consist, therefore, not only of the ripened pistil, but also of other parts of the flower and torus which persist or develop with it.

The wall of the fruit is called the PERICARP, and, like the leaf, it consists of three distinct layers, viz.: (1) the outer layer corresponding to the outer epidermis of the ovary is called the EPICARP or EXOCARP; (2) the inner layer corresponding to the inner epidermis of the ovary is called the ENDOCARP, or, from the fact that it is sometimes hard and stone-like, it is called the PUTA-

MEN, as in the prune; and (3) the middle layer situated between the epicarp and endocarp is called the MESOCARP;

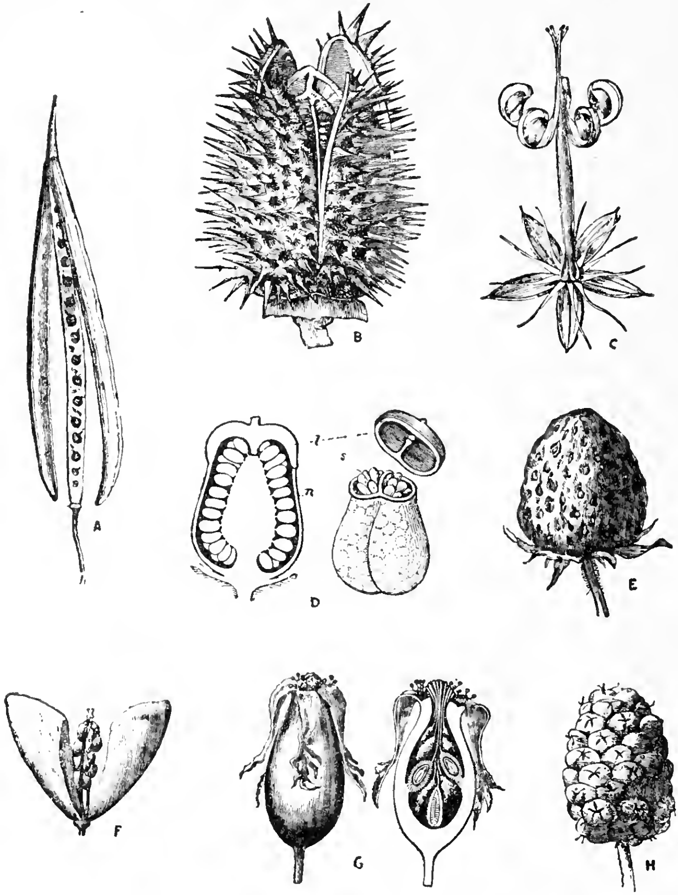


FIG. 89. Different types of fruits. A, silique of mustard showing the separation of the two valves leaving the seeds attached to the central axis; B, spinous capsule of Stramonium showing septifragal dehiscence into four valves, the capsule being strictly 2-locular but apparently 4-locular owing to the formation of false dissepiments; C, 5-valved capsule of Geranium in which the carpels become detached from one another and roll upwards remaining attached to the beak-like compound style; D, capsule of Hyoscyamus showing transverse dehiscence by means of a lid (1) and the two loculi containing numerous small seeds; E, fruit of strawberry showing fleshy torus and numerous embedded akenes; F, silicula of shepherd's-purse showing seeds attached to central axis and longitudinal dehiscence of the valves which remain attached below; G, fruit of rose, so-called rose "hip," the akenes being enclosed by the hollow oval torus which shows remains of calyx at the apex; H, multiple fruit of mulberry composed of small drupes, the pulpy portion of each consisting of the fleshy perianth.—Adapted from Warming.

and from the fact that it is sometimes succulent or fleshy, as in the prune, it is also called the SARCOCARP.

There are a number of distinctive and descriptive names applied to fruits. Some of the more important are as follows:

An **Akene** is a non-fleshy, or so-called dry, unilocular and one-seeded, indehiscent fruit, in which the pericarp is more or less firm, and may or may not be united with the seed. Akenes may be inferior, as in the Compositæ (Fig. 241) where they develop from inferior ovaries, being frequently surmounted by the pappus or calyx; or half inferior, as in the rose (Fig. 89, *G*) where they develop from half inferior ovaries; or superior, as in the buttercup (Fig. 84, *D*).

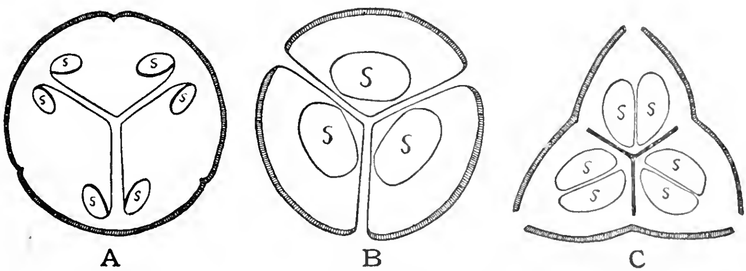


FIG. 90. A, transverse section of colocynth showing seeds (s) borne on parietal placentas; B, transverse section of fruit of *Ricinus communis* showing septicidal dehiscence of capsule, the seeds (s) being borne on axial placentas; C, transverse section of cardamom showing loculicidal dehiscence, the seeds (s), as in B, being borne on axial placentas.

A **Berry** is a fleshy, indehiscent fruit, the seeds of which are embedded in the sarcocarp; berries are superior when they develop free from the torus, as in belladonna (Fig. 268), capsicum, grape, etc., and inferior when the torus forms a part of the fruit, as in banana, cranberry and gooseberry.

A **Capsule** is a dry, dehiscent fruit, consisting of two or more united carpels. Dehiscence in capsules may occur in five different ways: In the castor-bean (Fig. 90, *B*) the carpels separate from each other along the walls or septa (dissepiments), the seeds being discharged along the ventral suture of the separated carpels, and this mode of dehiscence is called SEPTICIDAL. In mustard (Fig. 89, *A*) the dissepiments remain intact and dehiscence occurs along the margin of the capsule, and is therefore called MARGINICIDAL;

but as the partial carpels, or valves as they are termed, separate from the walls or septa, the dehiscence is also known as SEPTIFRAGAL. In cardamom (Fig. 90, *C*) the septa as well as valves are united, and at maturity the latter separate and dehisce at points in the margin corresponding to the mid-vein of the carpel, and this form of dehiscence is known as LOCULICIDAL. In poppy capsules (Fig. 91) there are a few openings beneath the united

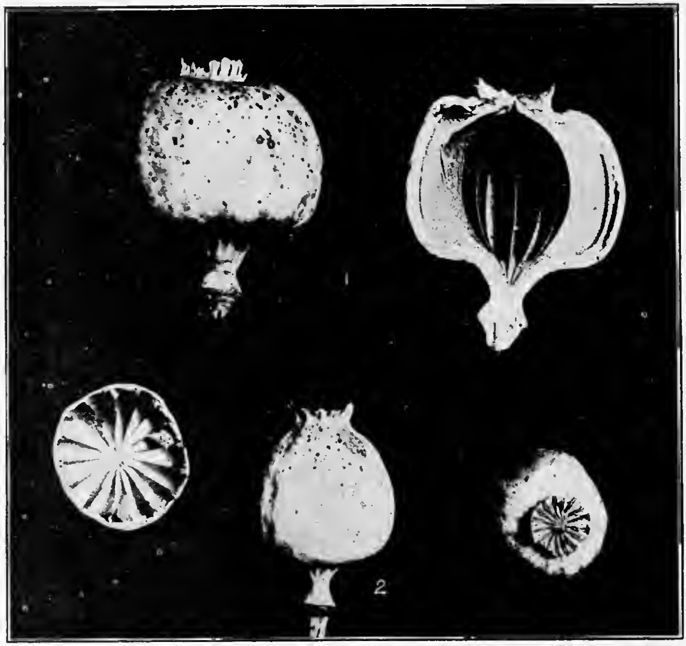


FIG. 91. Capsules of poppy (*Papaver somniferum*), whole and in transverse and longitudinal sections, showing dissepiments and remains of radiate stigmas at the apex, which are porous and through which the seeds are discharged. 1, French capsules; 2, German capsules.

stigmas through which the seeds are expelled, and this form of dehiscence is known as POROUS. In hyoscyamus (Fig. 89, *D*) a portion of the capsule comes off from the remainder like a lid, and this form of dehiscence being circular or transverse to the sutures of the carpel, it is called CIRCUMCISSILE. A capsule of this kind is known as a Pyxis or Pyxidium.

A **Caryopsis**, or Grain, is an indehiscent, non-fleshy fruit possessing a thin pericarp, which is closely adherent to the thin seed-coats, as in wheat, corn and other Gramineæ (Figs. 120, 125).

A **Cremocarp** is a dry, indehiscent fruit which consists of two inferior akenes, known as MERICARPS; these are separated from each other by means of a stalk known as a CARPOPHORE. This fruit is characteristic of the *Umbelliferæ* (Figs. 245, 248).

A **Drupe** is a fleshy, indehiscent fruit with a more or less succulent and well-developed sarcocarp and an indurated endocarp. Drupes are superior when they are free from the torus, as in prune; inferior when the torus forms a part of the fruit, as in pimenta. Drupes are also spoken of as "dry" when the sarcocarp is less succulent, as in *Rhus glabra* (Fig. 249) or when they are collected unripe, as in pepper and cubeb (Fig. 250). The fruits of the raspberry and blackberry consist of a collection of little drupes, the whole being known as an ETÆRIO. In the blackberry the drupelets cohere with the fleshy torus, while in the raspberry the drupelets cohere with one another, forming a cap which is separable from the cone-shaped torus.

A **Follicle** is a dry, dehiscent fruit which consists of one or more separate carpels, the dehiscence being usually along the ventral suture; in *Delphinium* the carpels are single; in aconite there are from three to five carpels, and in star-anise (*Illicium*) from seven to eight; in magnolia the carpels are numerous, forming a kind of succulent cone and dehisce along the dorsal suture.

A **Galbalus** is a berry-like fruit, formed by the coalescence of fleshy, open scales, as in juniper (Fig. 52).

Hesperidium.—The fleshy, indehiscent, superior fruit of citrus, as lemon and orange, is known as a hesperidium. The pericarp is more or less coriaceous, and from the inner walls secretion hairs develop, which contain sugar and an acid cell-sap, these constituting the fleshy portion in which the seeds are embedded.

A **Legume** is an elongated, monocarpellary, usually dry, dehiscent fruit, in which dehiscence takes place along both sutures, the carpel thus dividing into two halves, or valves, as in the garden pea (*Pisum*) and other members of the Leguminosæ (Fig. 153). In some cases legumes are jointed or articulated and indehiscent, breaking up at maturity into a number of parts which are dispersed in much the same manner as samara-fruits, as in *Meibomia*. Legumes may be not only indehiscent but fleshy, as in *Cassia fistula*.

A **Nut** is an akene-like fruit, the pericarp of which is more or less indurated. Nuts are sometimes subtended (as in acorns) or enclosed (as in chestnuts) by a kind of involucre, forming what is technically known as a cupule; and a fruit consisting of a nut and cupule is known as a GLANS. The akene-like fruit of the Labiatæ is spoken of as a *Nutlet*.

A **Pepo** is an inferior berry, in which the placentas have become developed into succulent layers, as in the watermelon, cucumber and colocynth (Fig. 254).

A **Pod** is a general term used to designate all dry, dehiscent, apocarpous or syncarpous fruits, as capsules, follicles and legumes.

A **Pome** is an indehiscent, half-inferior, fleshy, syncarpous fruit, as in the apple. The carpels constitute the core and the fleshy part is developed from the torus (Fig. 86, *C*).

A **Samara** is a winged, akene-like fruit. The winged appendage may be at the apex, as in white ash, or around the edge, as in elm. Two samaras may be united into one fruit, which is called a "double samara" as in maple.

A **Silique** is a narrow, elongated, 2-valved capsule which is separated by the formation of a false dissepiment into two locules, as in the Cruciferæ (Fig. 89, *A*).

A **Sorosis** is a fleshy fruit resulting from the aggregation of the carpels of several flowers, as in mulberry (Fig. 89, *H*) and pineapple.

A **Strobile** or cone is a scaly fruit, at the base of each scale of which there is either a seed, as in the *Coniferæ*, or an akene-like body, as in hop (Fig. 136).

A **Syconium** consists of a succulent hollow torus, which encloses a number of akene-like bodies, as in the fig (Ficus).

An **Utricle** is an inferior akene with a thin and loose pericarp, as in *Chenopodium*.

Classification of Fruits.—More or less artificial classifications of fruits have been made. They may be grouped either according to structure or according to their manner of protection or dispersal, the following classification being based on the structure:

- From a number of flowers
  - Strobile or Cone
  - Sorosis
  - Syconium
- From a single flower
  - *A.* With a compound pistil
    - *a.* Indehiscent
      - Dry
        - Akene
        - Caryopsis
        - Cremocarp
        - Nut
        - Samara
        - Utricle
      - Fleshy
        - Berry
        - Drupe
        - Etærio
        - Hesperidium
        - Pepo
        - Pome
    - *b.* Dehiscent
      - Dry
        - Capsule
        - Follicle
  - *B.* With a simple pistil
    - *a.* Indehiscent
      - Fleshy
        - Drupe
    - *b.* Dehiscent
      - Dry
        - Follicle
        - Legume

VI. THE SEED.

The seed may be defined as the fertilized and developed ovule. The seeds of different fruits vary in number as well as in size and shape. In form they correspond to the ovules; in size they vary from about 1 millimeter, as in the poppy, to 10 or 15 centimeters in diameter, as in the cocoanut palm. Seldom are all of the ovules of the pistil fertilized, hence the number of seeds is usually less than the number of ovules.

Structure of Seed.—After the fertilization of the egg-cell certain changes take place in the embryo-sac: At one end the developing embryo is attached to the wall by a short stalk or suspensor (Fig. 57); the nuclei, lying in a mass of cytoplasm around the wall of the embryo-sac, divide and re-divide; the large vacuole in the center becomes filled with a watery or milky fluid, and later the nuclei, with portions of the cytoplasm, may be enclosed by a cellulose wall and become permanent cells, in which the embryo is embedded. Likewise in the nucellus, changes are also taking place; the cells are found to be dividing, and storing starch, oil, aleurone and other food materials, like the cells of the embryo-sac. The cells in which these materials are stored are known as reserve cells and in the nucellus they constitute the PERISPERM, while those formed in the embryo-sac make up the ENDOSPERM. Usually the endosperm of seeds is prominently developed while the perisperm occurs as a thin layer; in cardamom, however, the endosperm and perisperm are both well developed (Fig. 253). In some instances the embryo may not fill the embryo-sac, as in cocoanut, and sometimes, as in the almond, both of the reserve layers are consumed in the development of the embryo when the seed is said to be without endosperm (Fig. 187).

The perisperm and endosperm are sometimes spoken of together as the albumen of the seed, but as the cells comprised in these layers contain not only protoplasmic contents and aleurone grains, but starches, oils and other substances, the term is misleading. On this basis, seeds containing either endosperm or perisperm, or both, have been designated as albuminous, but on account of these layers containing larger proportions of other substances than proteins it would be better to speak of them as RESERVE LAYERS (Figs. 121, 122).

While these changes in the nucellus and embryo-sac have been going on there have been equally great changes in the coats of the ovules, which later constitute the seed-coats. In the seed the two coats are generally readily distinguishable. The inner, as in *Ricinus*, *Pepo*, etc., is thin, light in color, of a delicate structure, and is known as the TEGMEN; the outer is more or less thickened, of a darker color and firmer in structure, and is known as the TESTA. In some instances the perisperm, or both perisperm and endosperm, may be reduced to a thin layer when it is considered to form a part of the seed-coat, as in mustard. In other cases the two coats are so closely united that they are not easily distinguished, as in stramonium.

The terms used in describing the kinds of ovules (atropous, anatropous, campylotropous, etc.), are retained in the description of the seeds; and in describing the different parts of the seed some of the terms which were applied to the ovule are also retained, as chalaza and raphe; the seed when ripe usually becomes detached from its stalk and the resulting scar is called the HILUM; that part of the seed corresponding to the foramen of the ovule is more or less closed and is known as the MICROPYLE; the embryo

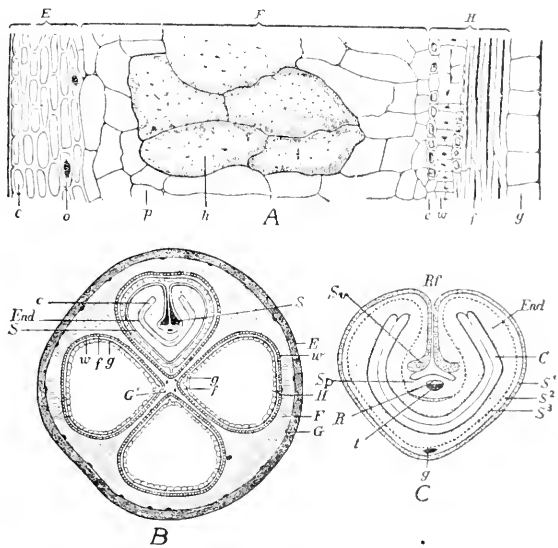


FIG. 92. *Rhamnus cathartica.* A, *cross-section through wall of the pericarp.* E, epicarp; F, sarcocarp; H, endocarp; e, epidermis; o, calcium oxalate in cells of hypodermis; p parenchyma; h, secretion cells containing a substance which is insoluble in alcohol or chloral solutions, soluble in solutions of potassium hydroxide, and colored reddish brown or greenish with ferric chloride solutions; c, calcium oxalate cells of endocarp; w, sclerotic cells; f, stereome cells. B, *cross-section of entire fruit,* showing one seed; E, F, H, g, f, w, as in A. S, seed-coat; S^1, outer wall of seed-coat; End, endosperm; c, cotyledons; g, vascular bundle C, *cross-section of a seed:* S^1, S^2, S^3, different layers of the seed-coat; R, vascular bundle of raphe; t, position of vessels of mestome strand; g, mestome strand; Rf, cleft in which raphe is situated; End, endosperm; C cotyledons; Sv, cells with thick walls; Sp, parenchymatic cells.—After Meyer.

develops in such a way that the tip of the young root always points in the direction of the micropyle.

In the fully developed embryo three distinct parts may be differentiated (Fig. 59): (1) The COTYLEDONS; (2) the part below the cotyledons, known as the HYPOCOTYL, the apical portion of which constitutes the young root or RADICLE; (3) the part above the cotyledons, known as the EPICOTYL, the apex of which consists of a more or less developed bud spoken of as the PLUMULE.

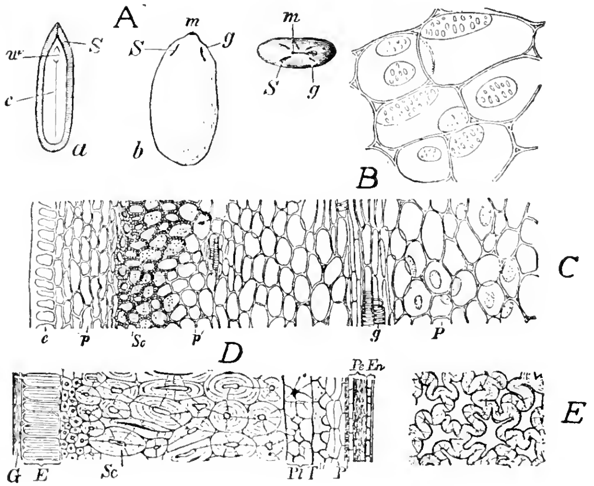


FIG. 93. *Citrullus Colocynthis.* A, *seed:* a, in longitudinal section, and b, surface view; S, deep clefts or fissures; m, micropyle; g, hilum; w, radicle; c, cotyledons. B, parenchyma cells of ripe fruit showing simple pores, the walls are colored blue with chlor-zinc-iodide. C, longitudinal section of wall of pericarp of ripe fruit showing e, epidermis; p, parenchyma; Sc, sclerotic cells which gradually pass into a thick-walled parenchyma consisting of small cells (p′); g, spiral vessels; P, isodiametric, porous parenchyma cells, containing air and of which the fruit for the most part consists. D, cross-section of seed-coat showing, G, an outer layer which is more or less easily separable from the rest of the seed and the walls of which are somewhat mucilaginous; E, epidermis of palisade-like cells; Sc, sclerotic cells; Pl, a layer of tabular cells with undulate walls; T, a layer of small somewhat branching cells, the walls of which are not strongly thickened and either porous or reticulate; P, several layers of parenchyma and the collapsed epidermis; Pe, perisperm; En, endosperm. E, tangential section of tabular sclerotic cells of seed-coat shown in Pl in Fig. D.—After Meyer.

The position of the embryo (Figs. 121, 122) in the seed varies somewhat: in most seeds it lies in the center, as in strophanthus and linum: it may, however, be excentral, as in colchicum and nutmeg. The cotyledons are usually situated above the hypocotyl, but in the Cruciferæ, either their edges lie against the hypocotyl, as in the mustards, when they are said to be ACCUMBENT or conduplicate, or they lie so that the back of one is against the hypocotyl, as in *Lepidium*, which position is known as INCUMBENT.

Externally, the seed-coats vary considerably: they may be nearly smooth, as in ricinus; finely pitted, as in the mustards; prominently reticulate, as in staphisagria; hairy, as in cotton (Fig. 166) and strophanthus (Fig. 185), or winged, as in the seeds of the catalpa. There are also a number of other appendages, these having received special names: the wart-like development at the micropyle or hilum of some seeds, as in castor-bean and violet, is known as the CARUNCLE; in the case of sanguinaria, a wing-like development extends along the raphe, and this is known as the STROPHIOLE; in some cases the appendage may completely envelop the seed, when it is termed an ARILLUS; when such an envelope arises at or near the micropyle of the seed, as the mace in nutmeg, it is known as a "false arillus," or ARILLODE.

Seed Dispersal.—Seeds and fruits are distributed in various ways, and so are often found growing in localities far from their native habitat. In some instances seeds are adapted for distribution by the wind, being winged, as in *Paulownia*, *Catalpa* and *Bignonia*, or plumed and awned, as in *Strophanthus* (Fig. 185); *Asclepias* and *Apocynum* (Fig. 201). As examples of fruits having special parts which aid in their distribution may be mentioned the akene of Arnica which is provided with a pappus (Fig. 241), the bladder-like pericarp of Chenopodium, the winged fruit or samara of maple. The hooked or barbed appendages on some fruits serve to attach them to animals and thus they may be widely distributed, as in the burdock and Spanish needles (*Bidens bipinnata*). In still other cases fruits may be carried long distances by water currents, or even by ocean currents, as those of the Double-cocoanut palm (*Lodoïcea Seychellarum*), which while native of the Seychelles Islands is now found on many of the islands in the Pacific and Indian Oceans. It may also be mentioned in this connection that a number of fruits, as the garden balsam, castor-oil plant, violets (pansy, etc.), *Wistaria*, etc., are elastically dehiscent and discharge the seeds with considerable force.

CHAPTER III.

INNER MORPHOLOGY OF THE HIGHER PLANTS.

CELL AND CELL-CONTENTS.

A TYPICAL living cell may be said to consist of a wall and a protoplast (a unit of protoplasm), although it is often customary to refer to the protoplast alone as constituting the cell. This is in view of the fact that the protoplasm which makes up the substance of the protoplast is the living substance of the plant.

Besides the protoplasm other substances are also found in the cell, hence in a general way the cell may be said to be composed of a wall and contents (cell-contents). The wall, as well as the cell-contents, consists of a number of substances, and, as the cell-contents are of primary importance in the development of the plant, their nature and composition will be considered first.

Cell-contents.—With the distinction already made the cell-contents may be grouped into two classes: (1) Protoplasmic, or those in which the life-processes of the plant, or cell, are manifested, and (2) non-protoplasmic, or those which are the direct or indirect products of the protoplast. The first class includes the protoplasm with its various differentiated parts, and the second, the various carbohydrates (starches and sugars), calcium oxalate, aleurone, tannin, oil, and a number of other substances.

PROTOPLASMIC CELL-CONTENTS.

Protoplasm.—Protoplasm occurs as a more or less semi-fluid, slimy, granular, or foam-like substance, which lies close to the walls of the cell as a relatively thin layer and surrounding a large central cavity or vacuole filled with cell-sap, or it may be distributed in the form of threads or bands forming a kind of network enclosing smaller vacuoles. Protoplasm consists of two comparatively well differentiated portions: (1) Certain more or less distinct bodies which appear to have particular functions and to which a great deal of study has been given, as the nucleus and plastids, and (2) a less dense portion which may be looked upon as the ground substance of the protoplast and which is now commonly referred to as the CYTOPLASM (see Frontispiece). These differentiated bodies and the cytoplasm are intimately associated and interdependent. The nucleus and cytoplasm are present in

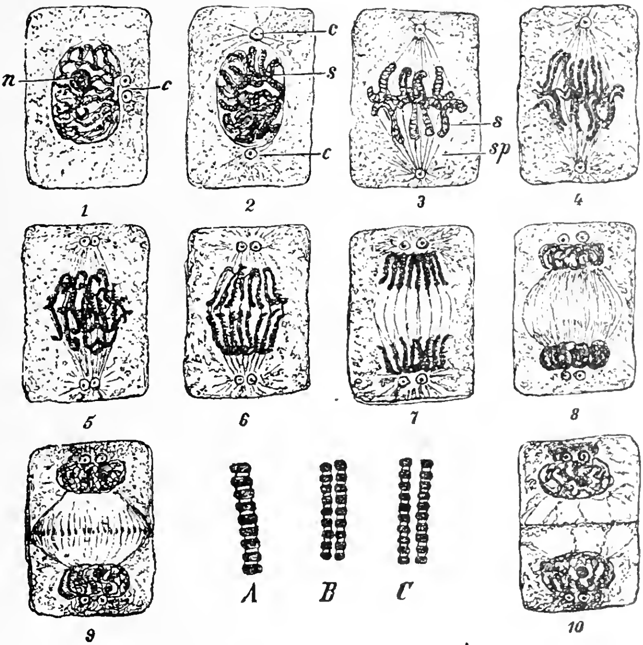


FIG. 94. Successive stages in nuclear and cell division. n, nucleolus; c, centrospheres s, chromosomes; sp, spindle fibers; A, B, C, division of chromosomes. 1, cell with nucleus containing nucleolus (n), and two centrospheres (c); 2, showing separation of nucleus into distinct chromosomes (s) and the centrospheres at either pole of the nucleus; 3, formation of spindle fibers (sp); 4, longitudinal division of chromosomes; 5, division of the centrospheres; 6, 7, 8, further stages in the development of the daughter nuclei; 9, formation of cell-wall which is completed in 10 giving rise to two new cells.—After Strasburger.

all living cells and it is through their special activities that cell division takes place. When in addition plastids are present, constructive metabolism takes place, whereby complex substances are formed from simpler ones (p. 222).

Besides the nucleus and plastids other protoplasmic structures are sometimes found embedded in the cytoplasm. These are the

CENTROSPHERES (Fig. 94, *c*), small spherical bodies that are associated with the nucleus and appear to be concerned in cell division. There are in fact quite a number of minute bodies in the cytoplasm which may be always present or only under certain conditions, and which are grouped under the general name of MICROSOMES or MICROSOMATA.

Chemically protoplasm is an extremely complex substance, but does not appear to have a definite molecular structure of its own, being composed in large measure of proteins, a class of organic compounds which always contain nitrogen, and frequently phosphorus and sulphur. The molecule of the proteins is large and more or less unstable, and hence subject to rapid changes and a variety of combinations, and it is to these interactions that the vital activities of the plant are attributed.

Nucleus.—The nucleus consists of (1) a ground substance in which is embedded (2) a network composed of threads containing a granular material known as CHROMATIN, and (3) generally one or more spherical bodies called NUCLEOLES, the whole being enclosed by (4) a delicate membrane (Fig. 94). The chromatin threads are readily stained by some of the aniline dyes, and are mainly composed of nucleins (proteins) rich in phosphorus, which by some writers are supposed to be essential constituents of the nucleus and necessary to the life of the protoplast. Chromatin is constant in the nucleus and prior to cell division the threads become organized into bodies of a definite number and shape known as CHROMOSOMES (Fig. 94, *s*).

Plastids.—The plastids or chromatophores form a group of differentiated protoplasmic bodies found in the cytoplasm (Frontispiece) and are associated with it in the building up of complex organic compounds, as starch, oil and proteins. The term chromatophore means color-bearer, but applies also to those plastids which may be colorless at one stage and pigmented at another. Hence we may speak of colorless chromatophores. According to the position of the cells in which these bodies occur and the functions they perform, they vary in color—three distinct kinds being recognized. (1) In the egg-cell and in the cells of roots, rhizomes and seeds the plastids are colorless and are called LEUCOPLASTIDS. (2) When they occur in cells which are more or less exposed to light and produce the green pigment called chlorophyll, they are known as CHLOROPLASTIDS or chloroplasts. (3) In other cases, independently of the position of the cells as to light or darkness, the plastids develop a yellowish or orange-colored principle, which may be termed chromophyll, and are known as CHROMOPLASTIDS. Chloroplastids are found in all plants except Fungi and non-chlorophyllous flowering plants, and chromoplastids in all plants except Fungi. Plastids vary in form from more or less spherical to polygonal or irregular-shaped bodies, and they increase in number by simple fission. They suffer decomposition much more readily than the nucleus, and are found in dried material in a more or less altered condition.

Leucoplastids.—The chief function of the leucoplastids is that of building up reserve starches or those stored by the plant for food, and they may be best studied in the common potato tuber, rhizome of iris, and the overground tubers of *Phaius* (Fig. 2, *b*). The reserve starches are formed by the leucoplastids from sugar and other soluble carbohydrates.

The chloroplastids occur in all the green parts of plants (see Frontispiece). They vary from 3 to 11 μ in diameter and are more or less spherical or lenticular in shape, except in the Algæ, where they are large and in the shape of bands or disks (Figs. 6, 7), and generally spoken of as chromatophores. Chloroplastids are found in greater abundance in the cells near the upper surface of the leaf than upon the under surface, the proportion being about five to one. These grains upon close examination are found to consist of (1) a colorless stroma, or liquid, in which are embedded (2) green granules; (3) colorless granules; (4) protein masses; (5) starch grains; and (6) a membrane which surrounds the whole. The green granules are looked upon as the CO_2 assimilation bodies; the colorless grains are supposed to assist in the storing of starch or in the production of diastase, the conditions for these processes being directly opposite, *i.e.*, when CO_2 assimilation is active, starch is stored, and when this process is not going on, as at night, diastase is produced and the starch is dissolved. The protein grains may be in the nature of a reserve material of the plastid and are also probably formed as a result of CO_2 assimilation.

While the protoplasm has been termed by Huxley "The physical basis of life," the chloroplastid has been spoken of as the mill which supplies the world with its food, for it is by the process of photosynthesis that the energy of the sun is converted into vital energy, and starch and other products formed, which become not only the source of food for the plant itself, but also the source of the food-supply of the animals which feed upon plants. In other words, horse-power is derived from the energy of the sun which is stored by the chloroplastids in the plant.

Chromoplastids.—In many cases, as in roots, like those of carrot, or flowers and fruits, which are yellowish or orange-colored, there is present a corresponding yellow pigment, and to this class of pigments the name chromophyll may be applied. Some of these pigments, as the carotin in carrot, have been isolated in a crystalline condition (see Frontispiece).

Chromoplastids usually contain, as first pointed out by Schimper and Meyer, protein substances in the form of crystal-like bodies; starch-grains may also be present. The chromoplastids are very variable in shape and in other ways are markedly different from the chloroplastids. They are more unstable than the chloroplastids, and are formed in underground parts of the plant, as in roots, as well as in parts exposed to the light, as in the flower. Their formation frequently follows that of the chloroplastids, as in the ripening of certain yellow fruits, such as apples, oranges, persimmons, etc.

The PLASTID PIGMENTS are distinguished from all other color-substances in the plant by the fact that they are insoluble in water and soluble in ether, chloroform and similar solvents. In fact they are but little affected by the usual chemical reagents under ordinary conditions.

Apart from the difference in color, the yellow pigment (chromophyll) is distinguished from the green (chlorophyll) by the fact that the latter is said to contain nitrogen, and also by their difference in behavior when examined spectroscopically, chlorophyll giving several distinct bands in the yellow and orange portion of the spectrum, which are wanting in the spectrum of the yellow principle.

NON-PROTOPLASMIC CELL-CONTENTS.

The non-protoplasmic constituents of plants may be said to differ from the protoplasmic cell-contents in two important particulars, namely, structure and function. For convenience in considering them here, they may be grouped as follows:

(1) Those of definite form including (a) those which are colloidal or crystalloidal, as starch and inulin; (b) those which are crystalline, as the sugars, alkaloids, glucosides, calcium oxalate; (c) composite bodies, as aleurone grains, which are made up of a number of different substances.

(2) Those of more or less indefinite form, including tannin, gums and mucilages, fixed and volatile oils, resins, gum-resins, oleo-resins, balsams, caoutchouc, and also silica and calcium carbonate.

I. SUBSTANCES DEFINITE IN FORM.

COLLOIDAL OR CRYSTALLOIDAL.

Starch is the first visible product of photosynthesis although it is probable that simpler intermediate products are first formed. This substance is formed in the chloroplastid (see Frontispiece) and is known as ASSIMILATION STARCH. Starch grains are usually found in the interior of the chloroplastid, but may attain such a size that they burst through the boundary wall of the plastid, which latter in the final stage of the growth of the starch grain forms a crescent-shaped disk attached to one end of the grain, as in Pellionia. Starch is changed into soluble carbohydrates by the aid of ferments and probably other substances, and in this form is transported to those portions of the plant requiring food. The starch in the medullary rays and in other cells of the wood and bark of plants is distinguished by being in the form of rather small and nearly spherical grains. In rhizomes, tubers, bulbs and seeds the grains are, as a rule, quite large, and possess more or less distinct characteristics for the plant in which they are found. Starch of this kind is usually spoken of as RESERVE STARCH.

Occurrence of Starch.—Starch is found in most of the algæ and many of the mosses, as well as in the ferns and higher plants. The amount of starch present in the tissues of plants varies. In the root of manihot as much as 70 per cent. has been found. This constituent also varies in amount according to the season of the year. Rosenberg has observed that in certain perennial plants there is an increase in the amount of starch during the winter months, whereas in other plants it decreases or may entirely disappear during this period. In the latter case, from six weeks to two months in the spring are required for its re-formation, and about an equal period is consumed in the fall in effecting its solution.

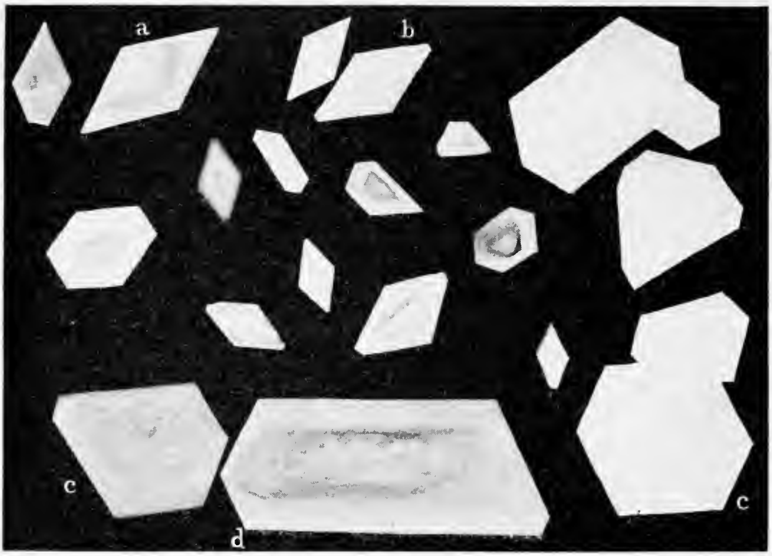


FIG. 95. Microphotograph of the rhombic prisms of Asparagin (amido-succinamic acid) which occurs in Althæa, glycyrrhiza, the roots of *Robinia pseudacacia* and is rather widely distributed in the vegetable kingdom. (See Part IV.)

Structure and Composition of Starch Grains.—The formula which is generally accepted for starch is $(C_6H_{10}O_5)_n$, this being recognized by Pfeffer, Tollens and Mylius. It is supposed that the molecule of starch is quite complex, it being composed of different single groups of $C_6H_{10}O_5$ or multiples of the same. While this formula may be accepted in a general way, still it has been shown that there are at least two substances which enter into the composition of the starch grain, and more recent studies tend to show that it is in the nature of a sphero-crystalloid, resembling inulin in some respects. Starch grains have an interesting structure. They vary in shape from ovoid or spherical to polygonal, and have a more or less distinct marking known as the "hilum," "nucleus" or the POINT OF ORIGIN OF GROWTH. The substances of which the grains are composed are arranged in concentric layers or lamellæ which are more or less characteristic and which sometimes become more distinct on the application of certain

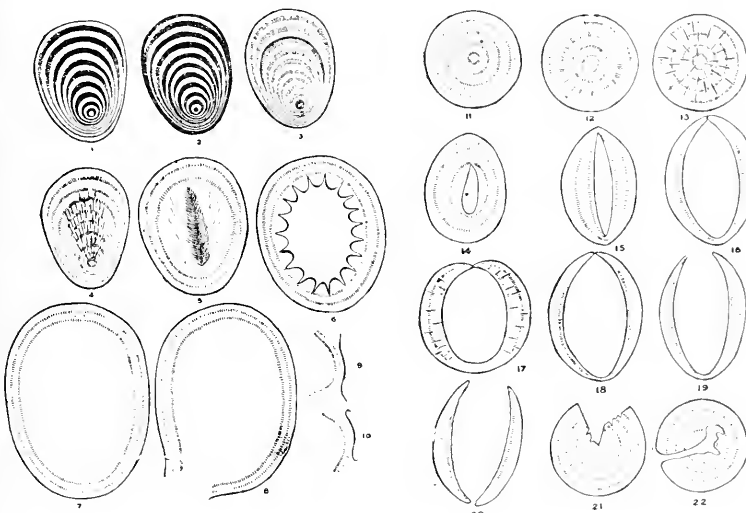


FIG. 96. Successive stages in the swelling and disintegration of starch grains in the presence of water on the application of heat (60°–70° C.) or certain chemicals. Potato starch 1-10; wheat starch 11-22.

reagents (Figs. 96, 97). The point of origin of growth and alternate lamellæ are stained by the use of gentian violet and other aniline dyes, which may be taken to indicate that these layers contain a colloidal substance somewhat resembling a mucilage, while the alternating layers are stained with dilute iodine solutions and are probably composed of soluble starch, this latter corresponding to the α-amylose of Arthur Meyer or the granulose described by Nägeli. The peripheral layer of the grain appears to be a distinct membrane. It is quite elastic, more or less porous, and takes up stains readily.

While starch grains usually occur singly, they are not infrequently found in groups of two, three or four grains, when they are spoken of as two-, three-, or four-compound. In some of the cereals, as rice and oat, they are 100-compound or more. The individuals in compound grains are in some cases easily separated from one another. This occurs frequently in microscopical preparations, and is especially noticeable in the commercial starches.

The various commercial starches belong to the class of reserve starches and may be distinguished by the following characteristics:

(1) The shape of the grain, which may be spherical, ellipsoidal, ovoid, polygonal, or of some other characteristic form (Figs. 316, 317).

(2) The size of the grain, which varies from 1 or 2 μ to about 100 μ in diameter.

(3) The position of the point of origin of growth, which may be central (Fig. 316, *C, D*) or excentral (Fig. 316, *A, B*). In some cases there are apparently two points of origin of growth in a single grain, and it is then spoken of as "half-compound," as in potato (Fig. 316, *A*).

(4) The shape of the point of origin of growth, which may be spherical, as in potato (Fig. 316, *A*); cross-shaped, as in maranta (Fig. 316, *B*); a three- or five-angled fissure or cleft, as in corn (Fig. 316, *D*), or indistinct or wanting, as in wheat (Fig. 316, *C*).

(5) The convergence of the lamellæ, which may be either toward the broad end of the grain, as in maranta (Fig. 316, *B*), or toward the narrow end, as in potato (Fig. 316, *A*). In most grains the lamellæ are indistinct or wanting, as in wheat and corn (Fig. 316, *C, D*).

(6) Behavior toward dilute iodine solutions, the color produced varying from a deep blue in most starches to a red or yellowish red, as in the amylodextrin grains of mace.

(7) The temperature (45°–77° C.) at which the "kleister" or paste is formed, and its consistency.

(8) The appearance as viewed by polarized light, the distinctness of the cross, as well as the degree of color produced, varying considerably as Nichol's prism is revolved (Figs. 175a, 322).

(9) Behavior toward various reagents, as chromic acid, calcium nitrate, chlor-zinc-iodide, diastase and various aniline stains, showing peculiarities of both structure and composition (Fig. 96).

General Properties of Starch.—If starch is triturated with water and the mixture filtered, the filtrate does not give a reaction with iodine solution; if, on the other hand, the starch is previously triturated with sand and then with water, the filtrate becomes blue on the addition of iodine solution. It appears that in the latter operation the wall of the grain is broken and the soluble starch present in the grain is liberated.

If dry starch and iodine are triturated together no color or, at the most, a faint blue color is produced; whereas, if a little water is added and the trituration repeated, a deep blue color is immediately produced.

The blue color of starch solution and iodine disappears on the application of heat, but slowly returns on cooling the solution, but not with the same degree of intensity, part of the iodine being volatilized.

When starch is heated with glycerin it dissolves, and if alcohol is added to the solution, a granular precipitate is formed which is soluble in water, the solution giving a blue reaction with iodine.

When starch is heated with an excess of water at 100° C. for even several weeks, dextrinization of the starch does not take place, *i.e.*, the solution still gives a blue color with iodine. If, however, a mineral acid be added, it is quickly dextrinized, turning violet-red, reddish and yellowish with iodine; finally, maltose and dextrose are produced, these giving no reaction with iodine, but reducing Fehling's solution. The ferments and other chemicals have a similar effect on starch.

When dry starch is heated at about 50°C. from 15 to 30 minutes the lamellæ and crystalloidal structure become better defined and the polarizing effects produced by the grains also become more pronounced. When starch is mounted in a fixed oil, as almond, the polarizing effects are more pronounced than when it is mounted in water, but the inner structure is not usually apparent, unless the starch has been previously heated.

Inulin appears to be an isomer of starch and occurs in solution in the cell-sap of various members of the Compositæ and several other families, being found in the lower orders of plants only in isolated cases.

It is stored chiefly in the parenchyma cells of the wood and bark of rhizomes, tubers and roots, being also found in the medullary-ray cells. It occurs in the form of a colorless, or yellowish, highly refractive, concentrated solution, about 30 per cent. being present in plants during the early fall and spring, when it exists in greatest amount. During winter and also during summer it is changed to levulose.

According to Dragendorff there are two forms of inulin; one of which is amorphous and easily soluble in water, and another which is crystalline and difficultly soluble in water. The latter is probably, however, a modification of the former, and it is not unlikely that the various principles known as pseudoinulin, inulenin, helianthenin and synantherin are all modifications of inulin.

If inulin-containing plants are preserved in alcohol and examined by aid of the microscope, the inulin will be found to have separated in the form of sphere-crystalloids, which are attached to the cell wall (Fig. 101, *E;* Fig. 105); but if the material is first allowed to dry out, the inulin will be found in irregular, almost gum-like lumps, which are with more or less difficulty dissolved in water.

Drugs Containing Inulin.—Inulin, in the form of irregular, strongly refractive masses, is found in the following drugs: Inula, lappa, pyrethrum and taraxacum.

CRYSTALLINE SUBSTANCES.

The **sugars** constitute a group of crystalline principles of wide distribution. They occur in the cell-sap, from which by evaporation or on treatment with alcohol they may be crystallized out. Quite a large number of distinct principles belonging to this class have been recognized, of which the following may be mentioned:

Dextrose (grape-sugar or dextro-glucose) is found in sweet fruits, the nectaries of the flowers, and stems and leaves of various plants. It crystallizes in needles and varies in amount from 1 to 2 per cent. (in peaches), to 30 per cent. in certain varieties of grapes. It also occurs in combination with other principles, forming the glucosides.

Levulose (fructose, fruit-sugar or levo-glucose) is associated with dextrose, occurring in some instances even in larger quantities than the latter.

Sucrose (saccharose or cane-sugar) is found rather widely distributed, as in the stems of corn, sorghum and the sugar-cane; in roots, as the sugar-beet; in the sap of certain trees, as sugar-maple and some of the palms; in the nectaries and sap of certain flowers as fuchsia, caryophyllus and some of the Cactaceæ; in seeds, as almond and chestnut, and in various fruits, as figs, melons, apples, cherries. In some plants, as in sugar-cane, the yield is as high as 20 per cent. It crystallizes in monoclinic prisms or pyramids and forms insoluble compounds with calcium and strontium.

Maltose is found in the germinating grains of cereals (see malt); it forms colorless, needle-shaped crystals resembling those of dextrose, and forms compounds with calcium, strontium, barium and acetic acid.

Trehalose occurs in some fungi, as ergot and *Agaricus muscarius*—the latter containing as much as 10 per cent. in the dried plant.

Mannitol occurs in the form of needles or prisms and is found in the manna of *Fraxinus ornus* to the extent of 90 per cent. It is also found in some of the Umbelliferæ, as *Apium graveolens*, some of the Fungi and seaweeds, and is rather widely distributed.

Dulcitol, which is closely related to mannitol, is found in *Euonymus europæus* and in most of the plants of the Scrophulariaceæ.

Gentianose occurs in the root of *Gentiana lutea*.

The **alkaloids** probably arise in the protoplasm. Later they appear in the cell-sap in combination with various plant acids, as malic, tannic and others, and may be precipitated by the so-called alkaloidal reagents. They occur in greatest amount in those cells which are in a potential, rather than an active condition, being associated with starch, fixed oils, aleurone grains, and other reserve products, in the roots, rhizomes and seeds. They are found in fruits in greatest amount during the development of the seed, but after the maturing of the latter they slowly disappear, as in poppy and conium. The occurrence of alkaloids in the walls of the cells of certain plants, as in nux vomica, is probably due to their imbibition by the wall as a result of pathological changes in the cell (p. 437).

Many of the alkaloids which have been isolated by chemical means are in the nature of decomposition products of those naturally occurring in the plant, as certain of the alkaloids of tobacco, tea, coffee, cinchona, opium, etc. The alkaloids are of more frequent occurrence in the dicotyledons than in the monocotyledons, and are rather characteristic for certain groups, as those of the genera Strychnos, Cinchona, Erythroxylon, Papaver, etc.

While the microchemical study of the alkaloids requires considerable technic, still, in certain drugs, their detection is quite simple, as in nux vomica, strophanthus and hydrastis (Fig. 292).

The **glucosides,** like the alkaloids, are also probably formed in the protoplasm. They are compounds of glucose and other principles and may be classed as reserve products. In some instances they readily separate out in the plant cell, as hesperidin; while others give characteristic color-reactions, as crocin, salicin and coniferin, but in most instances they are with difficulty detected by microchemical means.

Gluco-alkaloids represent a class of compounds intermediate between the alkaloids and glucosides, possessing characteristics of each. To this class belongs achilleine, found in various species of Achillea, and also solanine, found in a number of species of Solanum. (See pages 373–375.)

Cell-sap Colors.—The majority of the other color-substances found in the higher plants besides the green and yellow principles previously mentioned occur in solution in the cell-sap, and may be in the nature of secondary substances derived from the plastid pigments, or they may be produced directly by the protoplasm. Upon making sections of the tissues containing cell-sap color-substances, not infrequently strikingly contrasting colors are observed in contiguous cells; as in the petals of the poppy and petals of certain lilies, where we find some cells of a deep purple color, others of a deep red and still others of intermediate shades.

These substances are easily extracted with water or dilute alcohol and are all more or less affected by certain chemicals (many of which occur naturally in the plant), such as citric acid, oxalic acid, salts of calcium, iron, aluminum, etc.

A number of plant pigments of this class are used as indicators in volumetric chemical analysis, their use in this connection being dependent upon their sensitiveness to acids and alkalies. The fact that they respond to iron salts, that is, give a blue or green reaction with these salts, would indicate that they are associated with tannin or that they are tannin-like compounds, as has been supposed by some writers, but they behave very differently from tannin toward other reagents, such as organic acids, alkalies, lime water and solution of alum.

An examination of the color-substances of a large number of plants shows that the flower color-substances are distributed in all parts of the plant. For example, the flower color-substance of the rose occurs in the leaves and prickles as well as in the petals.

The color-substance in the root of the radish closely corresponds to that in the flowers, while the one in the grains of black Mexican corn corresponds to that in corn silk.

The cell-sap color-substances are usually found in greatest amount at the tips of the branches, this being well marked in the foliage of the rose, and may be said to be rather characteristic of spring foliage. Not infrequently in the purple beech the young leaves will be of a distinct purplish-red color and almost entirely free from chlorophyll, suggesting a correspondence in position and color to a flower.

Color in Autumn Leaves.—The coloring matters in both spring and autumn leaves closely resemble the cell-sap color-substances of flowers, although it is the spring leaves which give the most satisfactory results when examined. The fact that in the autumn leaves there is little or none of the plastid pigment present would point to the conclusion that the color-substances occurring in these leaves are in the nature of by-products and of no further use to the plant. Of course in the case of autumn leaves we know that these products cannot be further utilized by the plant, and for this reason we are justified in regarding them as waste products.

So-called White Colors.—The so-called white colors in plants do not properly belong to either class, but may be said to be appearances due rather to the absence of color, and depending upon the reflection of light from transparent cells separated by relatively large intercellular spaces containing air. In other words the effect produced by these cells may be likened to that produced by the globules in an emulsion. The white appearance is most pronounced in the pith cells of certain stems, where on the death of the cells the size of the intercellular spaces is increased and the colorless bodies in the cells as well as the walls reflect the light like snow crystals.

Calcium oxalate is found in many of the higher plants, and in the algæ and fungi as well; while in the mosses, ferns, grasses and sedges it is seldom found. It occurs in plants in crystals of either the monoclinic or tetragonal system (Figs. 281, 282). The crystals dissolve in any of the mineral acids without effervescence and their identity is usually confirmed by the use of dilute hydrochloric acid. The crystals of the monoclinic system are rather widely distributed, while those of the tetragonal system are less frequent in their occurrence, being found in species of Allium, Tradescantia and Begonia, in *Paulownia imperialis* and in the Cactaceæ. The crystals belonging to the monoclinic system include a number of forms, as follows: (1) Rosette aggregates, or what are commonly termed rosette-shaped crystals; (2) prisms, pyramids and elongated or irregular polygonal-shaped crystals: (3) crystal-fibers; (4) raphides; (5) sphenoid micro-crystals and (6) membrane crystals.

Rosette aggregates of calcium oxalate consist of numerous small prisms and pyramids, or hemihedral crystals more or less regularly arranged around a central axis, and have the appearance of a rosette or star (Fig. 281, *A*). The development of these aggregates may be readily observed in the stem of *Datura stramonium*. Crystals of this class are more widely distributed than any of the others, and are found in a number of drugs. (See chapter on Powdered Drugs.)

Monoclinic prisms and pyramids are also widely distributed and are frequently so modified in form that they are of an elongated or irregular polygonal shape (Fig. 281, *C*, *E*). The crystals of this group are sometimes mistaken for silica, owing to the fact that in some instances the lumen of the cell is completely filled by the crystal, and the inner wall having the contour of the crystal, it is impossible to determine whether the crystal is affected by the use of hydrochloric acid. It should be stated in this connection that silica never occurs as a cell-content in sharp, angular crystals, but either in more or less ellipsoidal or irregular hollow masses, or in somewhat solid, irregularly branching masses.

Crystal Fibers.—In quite a number of drugs a single monoclinic prism occurs in each of the parenchyma cells adjoining the sclerenchymatous fibers, and to this single longitudinal row of superimposed cells the name crystal fiber has been applied (Fig. 282, *B*).

Raphides are groups of needle-shaped crystals which are found in various plants (Fig. 281, *B*). These have been mistaken by several observers for calcium phosphate. Calcium phosphate, however, occurs in plants either in solution or in combination with protein substance. The cells containing raphides are long, thin-walled and contain sooner or later a mucilage, which arises from the cell-sap and behaves with reagents much like cherry-gum. The cells are either isolated or occur in groups placed end to end, as in *Veratrum viride.*

Micro-crystals are exceedingly small (about 0.2 to 10 μ in diameter), apparently deltoid or arrow-shaped, and so numerous as to entirely fill the parenchyma cells in which they occur, giving the cells a grayish-black appearance which readily distinguishes them from other plant cells (Figs. 175a, 281, *D*). It has been supposed that they are tetrahedrons, but they are probably sphenoids in the monoclinic system, inasmuch as monoclinic prisms occur in neighboring cells in the same plant or drug, as in stramonium, quassia, etc.

Membrane Crystals.—There are several forms of crystals which may be included in this group. The so-called Rosanoff crystals consist of rosette aggregates attached to inward-protruding walls of the plant cell. These, however, do not concern us so much as the large monoclinic crystals which have a membrane surrounding them. The crystal first appears in the cell-sap and then numerous oil globules appear in the protoplasm around it; later some of the walls of the cell thicken and grow around the crystal, which they finally completely envelop, as in Moraceæ.

PLANT PROTEINS.

The proteins are nitrogenous compounds, most of which contain sulphur and some of which contain phosphorus. Their constitution or the molecular structure of their molecules has not been determined, but they are very large, and are built up of amino-acids, the simplest of which is glycocoll (amino-acetic acid).

Apart from the protoplasm found in living cells, the proportion of proteins in plants is relatively small, except in seeds, where they serve as nutriment during the germinating period, being made available by the action of proteolytic enzymes. Most of the plant proteins are GLOBULINS, and collectively have been termed phyto-globulins. (1) The globulins are insoluble in *pure* water and in dilute acids, but are soluble in dilute solutions of sodium chloride (1 to 20 per cent.), ammonium chloride, sodium sulphate and dilute solution of potassium hydrate, from which solutions they may be precipitated by dilution, dialysis, or acidification with CO_2 or dilute acids, or by "salting out" by the use of strong or saturated solutions of ammonium sulphate, magnesium sulphate or sodium chloride. (2) The proteins which contain phosphorus are sometimes called phyto-vitellins, as legumin in peas, which contains 0.35 per cent. of phosphorus. A third class of plant proteins, which are alcohol-soluble, are found in cereals, as the gliadin of wheat and rye and the zein of maize. The cohesive and doughing properties of wheat flour are attributed to the association of gliadin and another protein called glutenin.

Some of the plant proteins occur naturally in the crystalline form, either free in the cytoplasm, as in the potato tuber (Fig. 97, *A*), or as components of aleurone grains, as in the seeds of *Ricinus communis* and Brazil nuts (Figs. 97, *D*; 122, *D*). Phyto-globulins in the form of crystals and spheroids have been obtained from extracts of flax-seed, hemp-seed, Brazil-nut, castor-oil seeds and others. Protein crystals are, according to Wichmann, isomorphic, and probably belong to the hexagonal system.

Aleurone grains are made up of protein-crystalloids, globoids and a ground mass, the whole being enclosed by a membrane-like material. They may be studied by taking advantage of the difference in solubility of the substances composing them. The membrane is a protoplasmic membrane and, while soluble in water, remains intact on examining sections in any of the

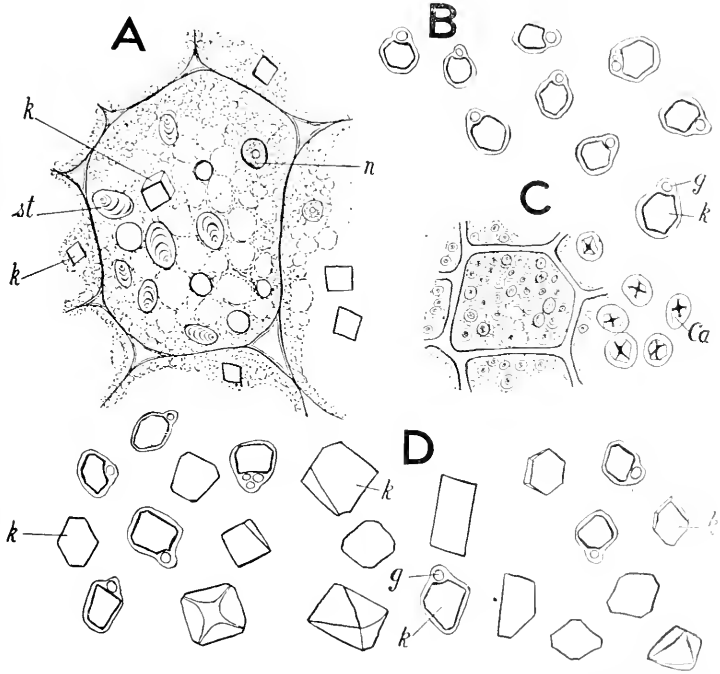


FIG. 97. Protein crystalloids: A, cell of tuber of white potato (*Solanum tuberosum*) showing protein crystalloids (k), starch grains (st), nucleus (n); B, aleurone grains of the seed of the castor-oil plant (*Ricinus communis*); C, aleurone grains of fruit of fennel (*Fœniculum vulgare*) containing large calcium oxalate crystals (Ca) which are strongly polarizing as shown in the isolated grains; D, aleurone grains of Brazil nut (*Bertholletia excelsa*). g, globoids; k, protein crystalloids.

fixed oils, as cotton-seed oil. Usually seeds which contain aleurone are rich in fixed oils, and if this oil is first removed by placing fresh sections in alcohol, or alcohol and ether, the subsequent study is facilitated. If the sections thus treated are mounted in water, the membrane gradually dissolves, leaving the crystalloids, globoids and calcium oxalate. On adding a 0.1 to 1 per cent. solution of either sodium or potassium hydrate, the crystalloids dissolve, the globoids and calcium oxalate crystals remaining unaffected. The globoids may be dissolved by the use of a 1 per cent. acetic acid solution, or concentrated solutions of ammonium sulphate or monopotassium phosphate. The calcium oxalate remaining may then be treated with hydrochloric acid in the usual way.

II. AMORPHOUS SUBSTANCES.

Cystoliths.—Occasionally cells are found among the parenchyma or in the inner row of the epidermal cells on the upper side of the leaf, the walls of which form an inward protrusion into the cell and become impregnated with and encrusted by calcium carbonate, giving rise to more or less stalked bodies known as cystoliths (Fig. 221). The calcium carbonate dissolves on the application of acetic acid, leaving a core which responds to the tests for cellulose. Cystoliths are not of common occurrence, being found with but few exceptions in the two families Acanthaceæ and Moraceæ, and in a few species of the Cucurbitaceæ. In the leaves of the cultivated rubber plant the cystoliths have long stalks, whereas in cannabis indica (Fig. 279), they are sessile.

Tannin and Tannoids.—Tannins are astringent principles which belong to the class of phenol acids and give blue or green precipitates with iron salts. The tannoids, in addition, precipitate albuminous compounds, and when applied to animal hides convert them into leather. These principles are widely distributed, occurring dissolved in the cell-sap, in parenchyma cells or in distinct reservoirs or vessels, and vary in amount from 1 per cent. or less to as high as 70 per cent. in Chinese galls. Tannin may be precipitated in the plant cells by copper acetate.

Mucilages and Gums.—By the terms mucilages and gums are meant those substances which are soluble in water, or swell very perceptibly in it, and which, upon the addition of alcohol, are precipitated in the form of a more or less amorphous or granular mass. Mucilage originates in the plant as a cell-content, or as a modification of the wall. In the former case it arises as a product of the protoplasm, or it may be a disorganization product of some of the carbohydrates of the cell-contents. When it arises through modification of the wall it is spoken of as "membrane mucilage" (Fig. 99), and owes its origin to several causes: either to a secondary thickening of or an addition to the cell wall, or a metamorphosis of it, at least in part. In the latter case it

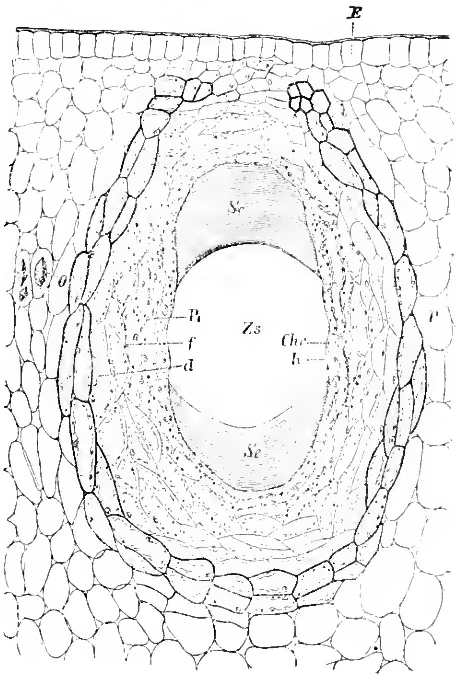


Fig. 98. *Citrus vulgaris.* Longitudinal section of a young fresh fruit showing a lysigenous oil canal or duct. Se, oil; Zs, cell sap; Pl, cells in which the walls have been dissolved; f, thin-walled cells; D, thick-walled cells; K, nucleus; Chr, chromoplasts; o, crystals of calcium oxalate; e, epidermis.—After Meyer.

may arise either as a disorganization product of the primary wall, or of the subsequent lamellæ making up the walls of the cells of the pith, medullary rays, parenchyma and other tissues, as in *Astragalus gummifer* (Fig. 274), or it may arise as an intercellular substance.

The following is a classification of some plants, based upon the origin of the mucilage which they contain:

A. Cell-content Mucilage: Tuber of Orchis sp. (salep); rhizome of *Agropyron repens;* bulb of *Urginea maritima;* bulb of Allium sp. (onion, garlic); stem, leaf and elements of flower,

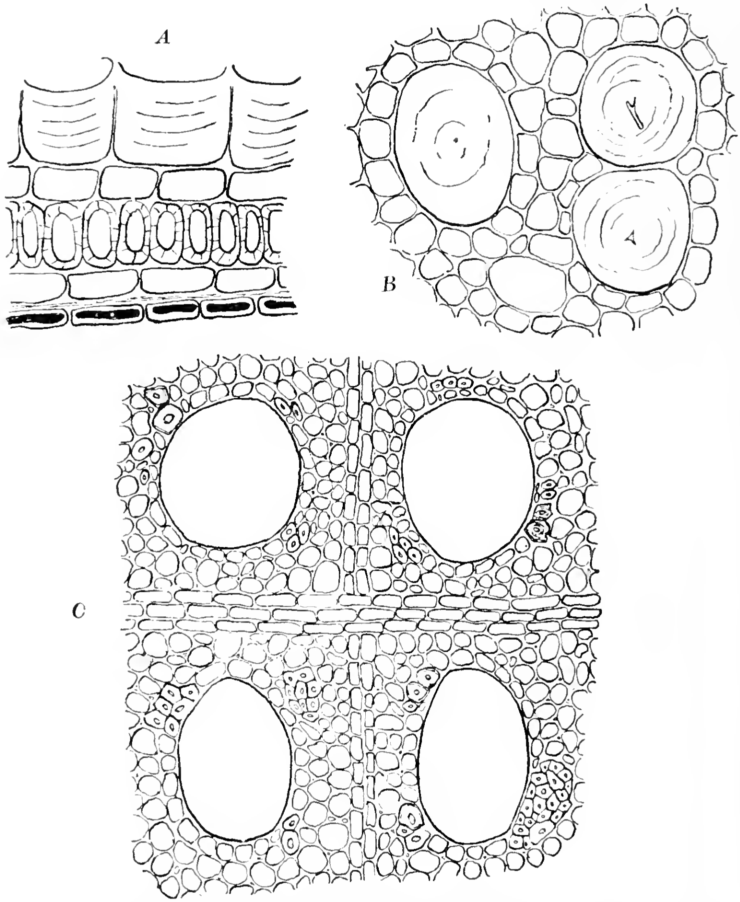


Fig. 99. Cell-wall mucilage. A, transverse section of seed-coat of flaxseed treated with water, showing the swelling of the mucilaginous layer beneath the cutin; B, section of Althæa root showing three large mucilage-cells; C, transverse section of elm bark showing four large mucilage-cells.

excepting stamens, of *Viola tricolor;* flower-stalks of *Hagenia abyssinica;* pulp of fruit of *Musa paradisiaca* (banana); succulent plants, as aloe, etc. (See Fig. 98.)

B. Cell-membrane Mucilage. *a.* Secondary thickening of wall: Root of *Althæa officinalis;* bark of Cinnamomum sp.; bark of *Rhamnus Frangula;* bark of root of *Sassafras officinale;* inner bark of *Ulmus fulva;* leaves of *Barosma betulina,* and *B. crenulata;* seed-coat of *Cydonia vulgaris;* seed-coat of *Linum usitatissimum;* seed-coat of *Sinapis alba,* and *Brassica nigra.* *b.* Metamorphosis of Cell wall: 1. Pith and medullary-ray cells: Astragalus sp., yielding tragacanth. 2. Parenchyma cells of wood and bark; cherry gum, yielded by some of the Amygdal-

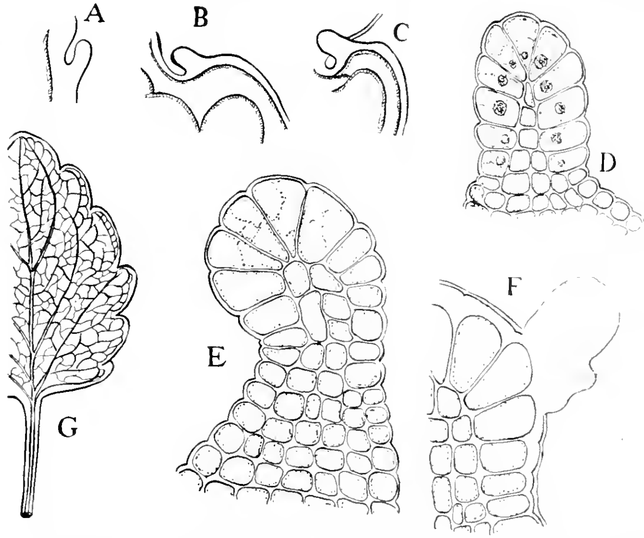


FIG. 100. A, B, C, successive stages in the development of the mucilage hairs or glands on the lobes of the leaves of *Viola tricolor:* D, young secretion hair showing some of the cells with large nuclei and several vacuoles; E, mature hair; F, gland showing mucilaginous layer beneath the cutin and the protrusion of a portion of the mucilage through the broken wall.

aceæ. 3. Various cells of the bark; *Acacia Senegal,* yielding gum arabic. 4. Primary wall as intercellular substance; thallus of *Chondrus crispus* (Irish moss). (See Figs. 99, 100, 274.)

C. Glandular Hairs (Drüzenzotten): Leaf and calyx of *Viola tricolor* (Fig. 100) and leaves of *Coffea arabica* (coffee) and of *Prunus avium.*

The origin of mucilage may be satisfactorily studied in the fresh tuber of salep and in the root of althæa—in the former as a cell-content mucilage, and in the latter as a cell-wall mucilage.

The mucilages are further distinguished by their behavior toward reagents; those which are colored blue by chlor-zinc-iodide, and are soluble in ammoniacal solution of cupric oxide, are known as cellulose mucilages. To this class belong the mucilages of the tuber of salep and the seeds of cydonium. Most of the other mucilages, particularly the pectose-mucilages, are colored by alcoholic and glycerin solutions of the basic aniline dyes.

Mucilage which occurs in cells containing raphides is stained by corallin, which is not usually the case with the other mucilages.

Oils, resins and their associated products, like the mucilages and tannins, are formed in the plant either as a result of the activities of the protoplasm, or by reason of abnormal or pathological changes in some of the constituents of the cell. The oils may be divided into two principal classes, namely, the reserve or fixed oils, which are more or less intimately associated with the protoplasm in fruits and seeds; and the volatile oils which occur in special secretion cells or special canals. The former are large parenchyma cells, the walls of which are not infrequently suberized, and are found in rhizomes, as of calamus (Fig. 101, *B*) and ginger; in barks, as sassafras (Fig. 236) and cascarilla; in fruits, as capsicum, cubeba (Fig. 250), piper and cardamomum. Oil secretion canals are formed either as a result of the enlargement of the intercellular spaces (Fig. 182), due to the separation of the cells, or as a result of the disintegration of a number of cells. The former are spoken of as being SCHIZOGENOUS in origin, and the latter as LYSIGENOUS. These terms are also used to designate similar reservoirs holding mucilage, gum-resins and other products. The schizogenous ducts are of more common occurrence and are always surrounded by a layer of epithelial cells (Figs. 47, 182, 257, 244, etc.), while the lysigenous ducts are generally surrounded by remnants of the cell-walls (Fig. 98). The latter are also found in other plants of the Rutaceæ and in Acacia, Prunus, etc., where they contain gum.

The oils, both fixed and volatile, are insoluble, or nearly so, in water; but are soluble in ether, carbon disulphide, chloroform, benzin, benzol and acetone. Most of the volatile oils and a few of the fixed oils are more or less soluble in alcohol. They are colored brownish or brownish-black with osmic acid. The volatile oils are stained red by alcoholic solutions of alkanet, and some of them by certain of the aniline dyes, as fuchsin. The distinctive test for the resins is that when treated with concentrated aqueous solutions of copper acetate they acquire a green color. They are likewise stained by many of the aniline dyes. The reserve or fixed oils are liberated as oily globules on treatment of sections with sulphuric acid or concentrated chloral solution.

The volatile oils are not infrequently associated with other substances of the plant cell in varying proportions, as resins, gums, cinnamic and benzoic acids. Those products which consist chiefly of oil and resin are known as OLEO-RESINS, and include turpentine and copaiba; those consisting chiefly of gum and resin and containing but little volatile oil, are known as GUM-RESINS, and include ammoniac, asafetida, galbanum and myrrh; oleo-resins associated with aromatic acids are known as BALSAMS, as balsam of tolu, balsam of Peru, storax and benzoin, which latter is usually called a balsamic resin.

The **enzymes** or ferments are probably derived from proteins, and bring about certain decompositions in the food substances in plants previous to their assimilation, and are of quite general distribution in both lower and higher plants. They have received different names according to the class of substances which they decompose. Thus, those acting upon starch in changing it to sugar are known as DIASTASES. Those which change cane sugar into dextrose are known as INVERTASES (or invertins), while those which act on proteids are called PROTEOLYTIC.

One of the interesting properties of the ferments is that in comparison with the amount of ferment employed the product formed through its influence is very large. Thus it is stated that diastase is able to hydrolize 10,000 times its own bulk of starch. Results of this kind are considered to be due to a catalytic action of the ferments, *i.e.*, their power of inducing chemical reactions by their mere presence without themselves entering into the products formed. The ferments require specific temperatures for their action, as, for example, emulsin or sinaptase, which decomposes a number of the glucosides at a temperature of 35° to 40° C., while diastase, the ferment of germinating seeds, requires a somewhat higher temperature, namely, 50° to 70° C.

While some of the vegetable ferments have been isolated and are prepared on a commercial scale, as diastase and the peptic enzyme papain found in the latex of *Carica papaya,* in other cases the ferment-producing organisms themselves are used in a number of industries involving fermentation processes, as the yeast-plants and certain of the molds and bacteria.

The microchemical study of the ferments is attended with certain difficulty on account of the lack of specific reagents for their detection. The most that can be done is to study the products formed by their action upon certain other constituents of the cell.

Enzymes may be divided into two classes according to whether they introduce oxygen or the elements of water substances. (1) The former are called oxidase enzymes, and are rather limited in number, and include laccase, found in the lacquer trees, and those which produce nitric fermentation in nature. (2) The latter or hydrolytic enzymes include diastase, which acts on starch, changing it into dextrose; inulase, which acts on inulin, producing levulose; pectase, acting on pectin, producing vegetable jellies; emulsin or sinaptase, which decomposes amygdalin, arbutin, salicin and other glucosides; myrosin, which acts on the glucoside sinigrin (potassium myronate), producing the essential oil of mustard, and papain the proteolytic enzyme of *Carica papaya.*

EXAMINATION OF CELL-CONTENTS.

PROTOPLASMIC.	NON-PROTOPLASMIC.		
	Crystalline.	Crystalloidal.	Amorphous.
1 Cytoplasm 2 Nucleus 3 Plastids	4 Calcium Oxalate 5 Sugars 6 Alkaloids	7 Starch 8 Inulin 9 Protein Crystalloids	10 Mucilage 11 Tannin 12 Resin 13 Oil

1, 2 and 3 have characteristic appearance (see Frontispiece). 4. Crystals of characteristic shape, soluble in hydrochloric and insoluble in acetic acid. 5. Crystalline in fresh material treated with alcohol. The glucoses give a reddish precipitate with Fehling's solution. 6. Concentrated sulphuric acid gives either a distinct color reaction, as with strophanthus (p. 431), or the separation of crystals, as in hydrastis (Fig. 292). 7. Blue with dilute iodine solution, except the dextrin starches, as in mace, which are colored red. 8. Sphere-crystalloids in fresh material treated with alcohol. 9. (See page 172.) 10. Colored blue with alcoholic solutions of methylene blue. 11. Reddish-brown with copper acetate solutions. 12. Green with copper acetate solutions. 13. Separation in the form of large globules on the application of sulphuric acid or solution of chloral hydrate. The essential oils are more soluble in alcohol than the fixed oils, which are usually only completely removed from the cells by the use of ether or a similar solvent.

THE CELL WALL.

Origin and Composition.—The cell wall is formed by the protoplasm, and varies in composition at different stages of the growth of the cell, and according to the various functions it has to perform.

In order to thoroughly understand the nature and composition of the cell wall, it is necessary to study the origin and formation of new cells. Growth of the plant is attended not only by an increase in the size of the cells, but by the division of these new cells are also formed. Cells that have the property to divide and form new cells are known as meristematic cells and constitute the MERISTEM. The new and dividing walls resulting from the division of the cells consist of a number of substances. When a cell divides the two daughter protoplasts which result from the division of the nucleus and cytoplasm are separated by the formation of a new wall between them (Fig. 94, 10). The first layer formed is apparently different from the subsequent layers and is known as the middle plate or MIDDLE LAMELLA. This layer is soluble in, or readily attacked by, solutions of the alkalies or solutions containing free chlorine. It is insoluble in sulphuric acid, and readily stained by the aniline dyes. While usually more or less permanent, this middle plate may be finally absorbed, as in the glandular hairs of kamala, or it may be changed into mucilage, as in chondrus, or transformed into pectin compounds, as in fleshy roots and fruits.

To this middle plate is added on either side by the newly formed protoplasts a layer of substance closely resembling cellulose, this constituting the PRIMARY MEMBRANE or primary lamella.

Still other layers may be added, consisting of one or more of the following substances: cellulose, or some modification of it; wax, silica or calcium oxalate, these layers constituting what may be termed the SECONDARY LAMELLA.

Cellulose in its various modifications constitutes the greater proportion of the cell wall. The cellulose making up the cotton fiber may be said to be the typical cellulose, and is known as "cotton cellulose." It is soluble in copper ammonium sulphate solution; is colored blue with chlor-zinc-iodide solution or iodine and sulphuric acid, and is stained by acid phenolic dyes, as alizarin, if previously treated with basic mordants, as basic salts of aluminum, etc.

According to their origin in the plant, or their behavior toward reagents, the cellulose walls may be divided into the following groups: (1) Lignocellulose walls; (2) protective cellulose walls; (3) reserve cellulose walls; (4) mucilage cellulose walls, and (5) mineral cellulose walls.

Lignocellulose walls are composed of true cellulose and a non-cellulose (the so-called lignin or lignone), these constituting the woody (so-called lignified) portion of plants and, in some instances, also the bast portion of the bark. The lignocelluloses are colored yellow with chlor-zinc-iodide, or iodine and sulphuric acid. On account of their containing in some instances furfurol, coniferin, vanillin, cinnamic aldehyde, benzaldehyde or other aldehydic substances, they give definite color-reactions with certain reagents. They are also stained by the aniline dyes, as fuchsin, safranin, gentian violet, aniline blue, methylene blue, etc.

A 2 per cent. phloroglucin solution, used in conjunction with hydrochloric acid, gives a reddish-violet color with the lignocelluloses, although there are some celluloses of this class which do not respond to this test, as flax (the bast fibers of Linum); while in other plants phloroglucin may occur as a constituent of the cells.

Aniline hydrochloride with hydrochloric acid and aniline sulphate with sulphuric acid produce a golden-yellow color in cell walls containing lignocelluloses.

Protective cellulose walls are composed of mixtures of lignocellulose and oils and waxes, and frequently contain in addition tannin, vanillin and other compounds. In the cuticle or epidermis of leaves and green stems, the cellulose is associated with a fatty compound known as cutin (or cutose), while in the cork of stems and roots it is combined with suberin (or suberose). This class of celluloses is distinguished from cotton cellulose and lignocellulose by being insoluble in sulphuric acid.

Reserve cellulose walls are those found in various seeds, as in coffee, date, nux vomica, etc. They behave toward reagents much like the true celluloses (Fig. 173).

Mucilage cellulose walls consist of cellulose and mucilage and are found in all parts of the plant, and in the case of seeds are associated with the protective celluloses. They dissolve or swell in water, are colored blue or yellowish with iodine, and are stained with alcoholic or glycerin solutions of methylene blue.

Mineral cellulose walls are composed of cellulose and various inorganic substances, as silica, calcium oxalate or calcium carbonate. These are more commonly found in the cell wall of the lower plants, as Algæ, Fungi and Equisetaceæ. Calcium carbonate also occurs in the cystoliths of the various genera of the Moraceæ and Acanthaceæ (Fig. 221).

From what has just been said of the chemical composition and structure of the cell wall, it is seen that it consists of lamellæ or layers of different substances, and in no case does it consist of but a single substance; but for convenience we speak of a wall as consisting of cellulose, lignin, or suberin, meaning thereby that the wall gives characteristic reactions for these substances.

LAMELLÆ.—In some cells, as in lignified cells, the lamellæ are quite apparent. In other cases the use of reagents, as chromic acid, or chlor-zinc-iodide, is necessary to bring out this structure. The layering which is observed in transverse sections of the cell wall is spoken of as stratification of the wall (Fig. 173), whereas the layering observed in longitudinal or tangential sections is referred to as striation of the wall (Figs. 166, 299, *B*).

Thickening or Marking of Walls.—In the formation of the cell wall each appears to work in unison with its neighbors for the building up of the plant. The thickening of the walls of the cell is primarily for the purpose of strengthening the walls, but if the walls were uniformly thickened, osmosis, or the transferral of cell-sap from one cell to another, would be hindered. Thus we find that the contiguous walls of the cells are thickened at definite places opposite each other, leaving pores or canals which permit rapid osmosis. The pores thus formed are known as simple pores, and when seen in surface view are somewhat elliptical or circular in outline, and may be mistaken for some of the cell-contents. These thickenings assume a number of forms, which are quite characteristic for the plants in which they are found. They may have the form of transverse or oblique rings, longitudinal spirals, or be ladder-like or reticulate in appearance (Fig. 102). In other instances the thickening of the wall is quite complex, as in the wood of the pines and other Coniferæ (Fig. 103). The thickening, or sculpturing, as it is sometimes called, may not only occur on the inner surface of the wall, when it is spoken of as CENTRIPETAL, but may also take place on the outer surface, when it is known as CENTRIFUGAL; as examples of the latter, may be mentioned the spores of lycopodium (Fig. 278b) and the pollen grains of the Compositæ (Fig. 280).

FORMS OF CELLS.

Upon examining sections of various portions of the plant, it is observed that not only do the cell-contents and cell wall vary in composition, but that the cells are of different forms, depending more or less upon their functions. Groups of cells which are similar in form and function constitute the various tissues of the plant; and they may be classified, for convenience of study, as follows: (1) parenchyma cells, (2) mechanical cells, (3) conducting cells and (4) protective cells.

Parenchyma.—Under the head of parenchyma are included those cells which are nearly isodiametric and thin-walled, the walls consisting of cellulose lamellæ (Fig. 101, *A*). They may contain both protoplasmic and non-protoplasmic cell-contents. According to the function and nature of contents, three kinds of parenchyma cells are recognized: (*a*) CHLOROPHYLL-PARENCHYMA or assimilation parenchyma contains numerous chloroplastids and occurs in leaves and all green parts of the plant. (*b*) Reserve parenchyma occurs in seeds, roots, rhizomes, leaves, and contains starch, aleurone grains, fixed oils and other reserve materials. The parenchyma in stems and leaves of various of the orchids,

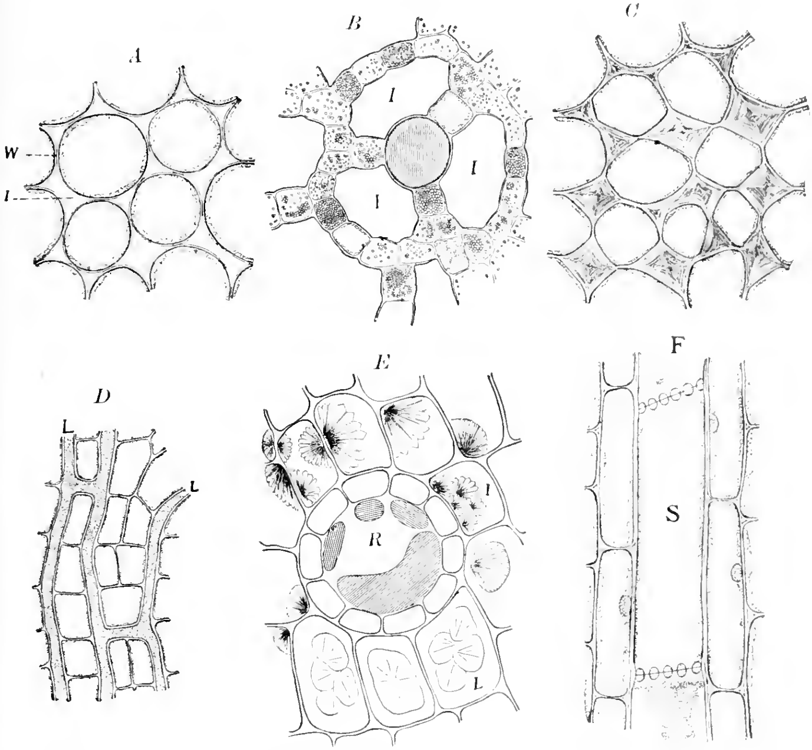


Fig. 101. Forms of cells. A.—Transverse section of the pith of *Tradescantia virginica:* I, intercellular space; W, cell wall. B.—Transverse section of calamus rhizome showing a large oil-secretion cell, smaller cells containing starch, and large intercellular spaces (I). C.—Transverse section of the stem of *Phytolacca decandra* showing collenchymatous cells beneath the epidermis. D.—Longitudinal section of taraxacum root showing branched laticiferous tissue (L). E.—Transverse section of pyrethrum root: R, oil-secretion reservoir with oil globules; I, cells with sphere-crystals of inulin, such as separate in alcoholic material; L, cells containing irregular masses of inulin, as found in dried material. F.—Longitudinal section of stem of *Cucurbita Pepo:* S, sieve-cell with protoplasm-like contents, and transverse walls (sieve plates) showing simple pores.

as well as that of plants of arid regions, which store water, may be included in this group. (*c*) Conducting parenchyma assists in the transferral of food from one part of the plant to another.

Besides these forms of parenchyma there are some special kinds which may be mentioned, as the somewhat branching cells in leaves, and in the stems of various marsh plants, as in species of Juncus and Pontederia. In calamus, large intercellular spaces are formed (Fig. 101, *B*).

The **Mechanical Tissue** comprises four types of cells: sclerotic, collenchymatic, stereomatic and libriform. Of these the libriform cells are scarcely to be distinguished from the stereomatic cells except by their position, being developed in the inner part of the mestome-strands (or vascular bundle), inside the cambium ring, hence the libriform cells accompany the vessels or tracheæ (Fig. 104, WF).

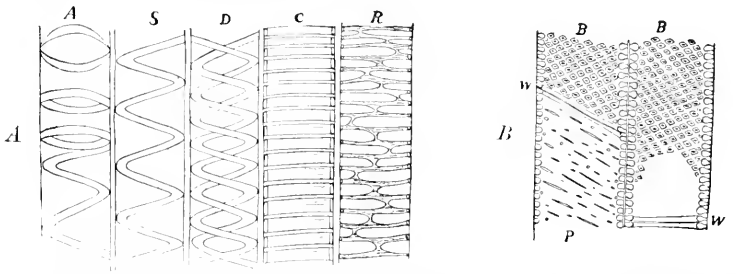


Fig. 102. Forms of ducts. A.—Longitudinal section of stem of *Cucurbita Pepo* showing various forms of ducts: A, annular; S, spiral; D, double spiral; C, close annular; R, reticulate. B.—Ducts of glycyrrhiza rhizome: W, wall; B, bordered pores; P, oblique simple pores.

The **sclerotic cell** is of the parenchymatic type but with very thick, lignified walls having many layers and simple pores which are spherical in surface sections. This type of cells contains only air or an aqueous liquid, but never nutritive matters, as in Cocoanut, Walnut shells, Vanilla (Fig. 313), poppy capsule (Fig. 314). Sclerotic cells are also referred to as "Stone cells" (Figs. 301, 302).

The **Collenchyma cell** is elongated, prismatic, with soft walls consisting mainly of cellulose and never lignified; the contents being rich in water. In transverse section it is readily distinguished by the local thickening of the walls, *i.e.*, at the angles of the cells (Fig. 101, c). Pores are rare, but when present they are annular or slit-like. Collenchyma occurs near the surface of plant organs, as herbaceous stems, when they form ribs, as in the Umbelliferæ. They are also found in leaves (Figs. 141, 142, 266, 271) and in fruits, as in the Umbelliferæ (Fig. 246).

The **Stereome cell** is very long, spindle-shaped, with more or less thick walls provided with narrow oblique pores. The walls consist of cellulose but may also become lignified; the lumen is narrow and mainly contains air. The stereome represents the skeleton of plants and is the most important mechanical tissue, being much firmer than the collenchyma. The stereome or

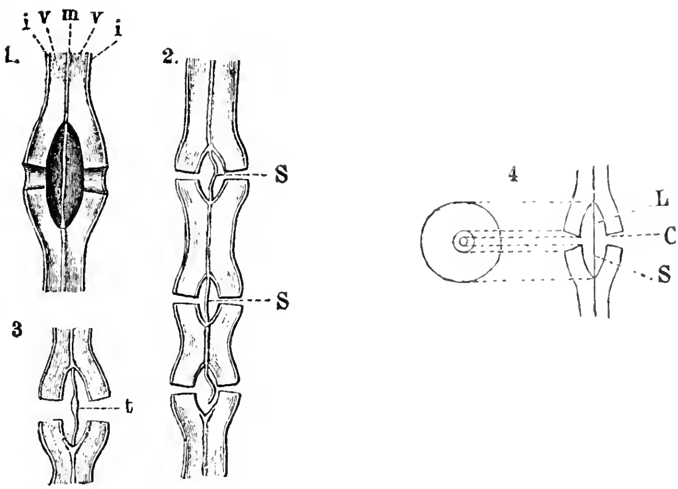


FIG. 103. Bordered pores of the tracheids of the wood of *Abies alba* as viewed in longitudinal section: m, middle lamella; v, i, middle and inner layers of walls of contiguous cells; C, pore-canal through which sap passes from one cell to another; L, dome-shaped cavity of pore; S, separating wall or closing membrane which is usually thickened in the middle as shown at t. In older cells the separating membrane is broken as shown in the lower pore in figure 2. At the right in figure 4 is shown a surface view of a bordered pore, the dotted lines indicating the relation of the circles to the structure of the pore.—After Vogl.

strengthening cells of the cortex are commonly spoken of as "bast fibers" (Figs. 104, WF, 299, 300).

The **Libriform cell** is the strengthening cell of the xylem and as has already been stated accompanies the tracheæ. Libriform cells are also spoken of as "wood fibers" (Figs. 104, BF, 299, 300). While the stereome cell is frequently not lignified, the libriform cell is usually more or less lignified, giving strong reactions for lignin with anilin sulphate or phloroglucin solutions.

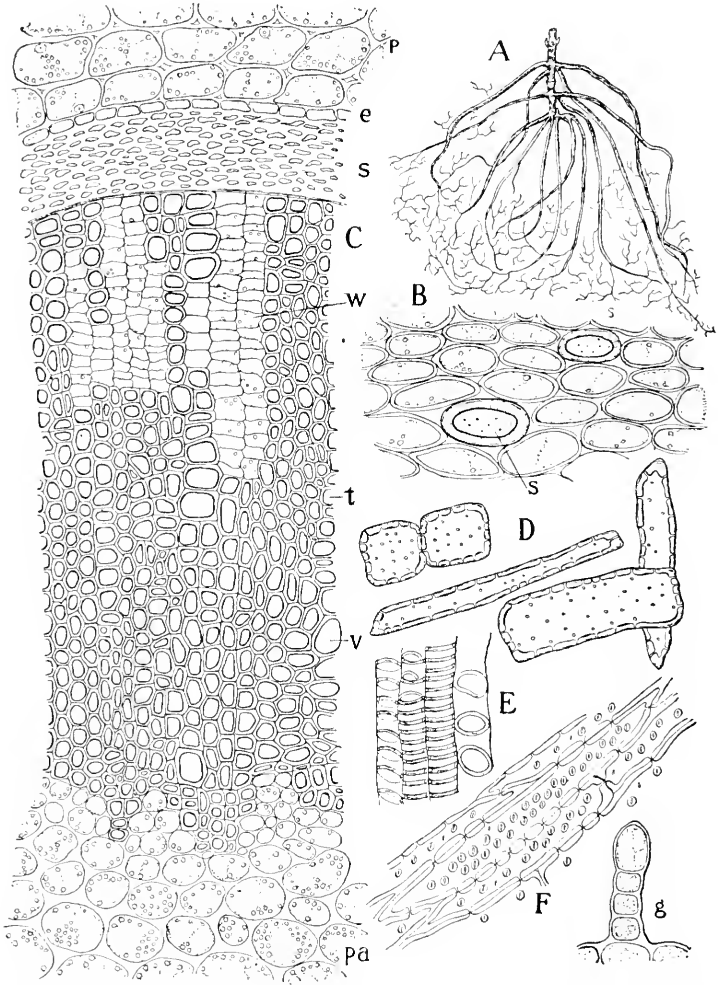


FIG. 103a. *Phlox carolina:* A, lower portion of plant showing long roots with numerous rootlets at the ends; B, parenchyma from cortex of rhizome showing two sclerotic cells (s); C, cross-section of portion of rhizome showing parenchyma of cortex (p) which contains protoplasm and starch grains, endodermis (e), leptome (s), tracheæ (v), libriform (t), wood parenchyma (w), parenchyma of pith containing starch grains and protoplasm; D, isolated sclerotic cells from cortex; E, vessels with annular and spiral thickenings; F, libriform cells; G, glandular hair from the leaf.

Conducting cells or **mestome** include those cells which are chiefly concerned in the transferral of either crude or assimilable food materials. The more or less crude inorganic materials are carried from the root through the woody portion of the stem to the leaves, and from the leaves the products of CO_2 assimilation, as well as other plastic substances, are distributed through some

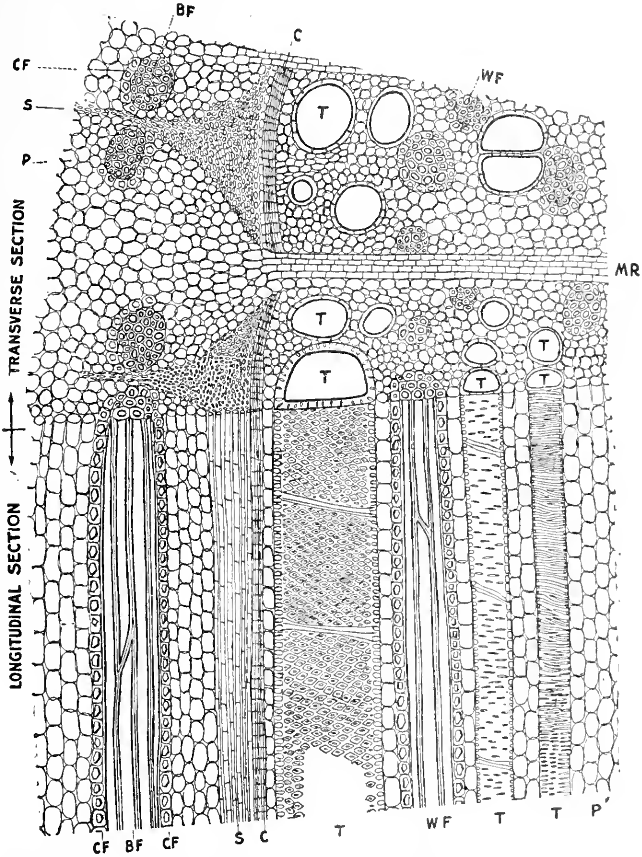


FIG. 104. Longitudinal-transverse section of licorice rhizome including the cambium: P, parenchyma; T, tracheæ or ducts; WF, wood fibers; C, cambium. S, sieve; CF, crystal fibers; BF, bast fibers; MR, medullary ray.

of the tissues of the bark to other parts of the plant. The tissues or elements of the wood which conduct food materials are of several forms and include tracheæ or ducts, tracheids and conducting parenchyma; and the elements of the bark which transport the assimilable materials, comprise the leptome and conducting parenchyma (Fig. 104). Water conducting elements, TRACHEAL ELEMENTS, comprise the vessels (tracheæ) and the tracheids, which resemble each other except that the latter are single cells of prosenchymatic shape, while the former are very long tubes, varying from cylindrical to prismatic in shape and are arranged in long rows in which they are superimposed lengthwise.

The **tracheæ** or **vessels** are formed by the disintegration and removal of the transverse walls between certain superimposed cells, forming an elongated cell or tube, which occasionally retains some of the transverse walls (Fig. 102, *A, B*). The longitudinal

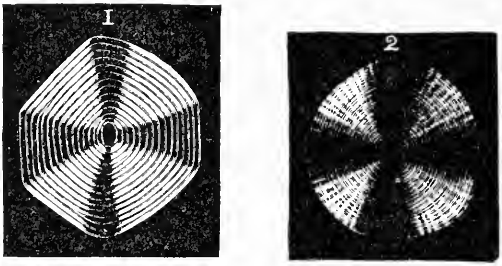


FIG. 105. 1, cross-section of a bast fiber of Begonia as seen by the micropolariscope. 2, polariscopic view of a sphero-crystal of inulin in *Helianthus tuberosus*.—After Dippel.

walls are relatively thin and consist of lignocellulose, giving more or less pronounced reactions with phloroglucin or aniline sulphate.

Four types of vessels or tracheæ are known: annular, spiral, reticulate and porous. Those having the thickenings in the form of horizontal or oblique rings are known as ANNULAR TRACHEÆ; those having the thickenings in the form of spirals, which usually run from right to left, are known as SPIRAL TRACHEÆ; those having the thickenings in the form of a reticulation are known as RETICULATED TRACHEÆ (Figs. 102, 175a, 191), and those with spherical or oblique slit pores known as POROUS TRACHEÆ or vessels (Figs. 104, 220, 287, 303).

In those vessels in which but few of the transverse walls are obliterated, the walls are marked by both simple and bordered pores, which latter are described under tracheids. Vessels contain water, water-vapor and air; in some cases they contain sugar, tannin, mucilage or resin.

The **tracheids** are intermediate in character between tracheæ and libriform, resembling the former in possessing bordered pores (Fig. 103) and scalariform thickenings; and the latter in being true cells, which are usually elongated and quite thick-walled, the walls giving distinct reactions for lignocellulose with phloroglucin or aniline sulphate.

One of the chief characteristics of tracheids are the BORDERED PORES (Fig. 103). These differ from simple pores in that the wall surrounding the pore forms a dome-shaped or blister-like protrusion into the cell. On surface view the pores are either circular or elliptical in outline, the dome being circular or, if the pores are numerous and arranged close together, more or less polygonal (Fig. 102, *B*).

The number and distribution of bordered pores in the Coniferæ are quite characteristic for some of the genera, and may be studied in any of the pines, the pores being most numerous in the radial walls (Fig. 47).

The **leptome** or **sieve** is distinguished from the other conducting elements in that the walls are thin and are composed of cellulose (Fig. 101, *F*). It consists of superimposed elongated cells, the transverse walls of which possess numerous pores which are supposed to be in the nature of openings, permitting of the direct passage of the contents from one cell to the other. This transverse wall, which may be either horizontal or oblique, is known as the SIEVE PLATE, and the thin places, as pores of the sieve. The sieve plates are sometimes also formed on the longitudinal walls. When the activities of plants are suspended during the winter, there is formed on either side of the sieve plates a layer of a colorless, mucilaginous substance, known as callus, which has somewhat the appearance of collenchyma, but is colored brownish by chlor-zinc-iodide.

The sieve cells contain an albuminous substance somewhat resembling protoplasm; in some instances starch grains have also been found.

When the activities of the sieve tubes have ceased, they become altered in shape, and are then known as obliterated sieve. In the drying of plants a similar alteration is produced, and for this reason the sieve of vegetable drugs is of this character.

Protecting cells include those cells which are located on the outer parts of the plant. The function of these cells is to lessen the rate of transpiration, or the giving off of water; to furnish protection against changes of temperature, and to protect the inner tissues against the attack of insects; they also have a mechanical function (Figs. 106; 111, *E*).

Depending principally upon their composition, these cells may be divided into two classes, namely, epidermal cells and cork cells.

The **epidermal cells** constitute the outermost layer of the plant. They contain cytoplasm but the plastids in some instances are wanting; in some instances they also contain dissolved coloring principles; and on account of the relatively large amount of water which they contain, they are classed among the important water-reservoirs of the plant.

The outer walls are principally characterized by one or more lamellæ of cutin, these uniting to form a continuous wall. The cutin is often associated with wax, this constituting the bloom of fruits; less frequently such inorganic substances as calcium carbonate, calcium oxalate and silica are present, and not infrequently mucilage is present, as in the walls of certain seeds (Fig. 99, *A*).

On surface view the form of these cells varies from nearly isodiametric to oblong; they may also be polygonal or branched. In transverse section their radial diameter is much the shorter. In some instances the inner and side walls are considerably thickened, as in the seeds of a number of the Solanaceæ (Fig. 302, *A*).

The epidermis usually consists of a single layer of cells, but may have additional layers underneath forming the HYPODERMIS, as in the upper surface of the leaves of species of Ficus; in some instances the hypodermis undergoes a mucilage modification, as in the leaves of buchu. (See also Figs. 99, *A*; 100.)

Plant Hairs.—The epidermal cells are sometimes specially modified centrifugally, giving rise to papillæ, to which the velvety appearance of the petals of flowers is due; in other cases this modification is in the form of hairs or trichomes (Figs. 110, 118, 283, 284). These may be unicellular or multicellular, and in addition the latter may be glandular or non-glandular. Glandular hairs possess a head-like apex, consisting of one or more cells, and they secrete oil, mucilage and other substances (Fig. 285).

Stomata.—Distributed among the epidermal cells are pairs of crescent-shaped cells having an opening between them, known as a pore or STOMA, which leads to a cavity beneath it. The two

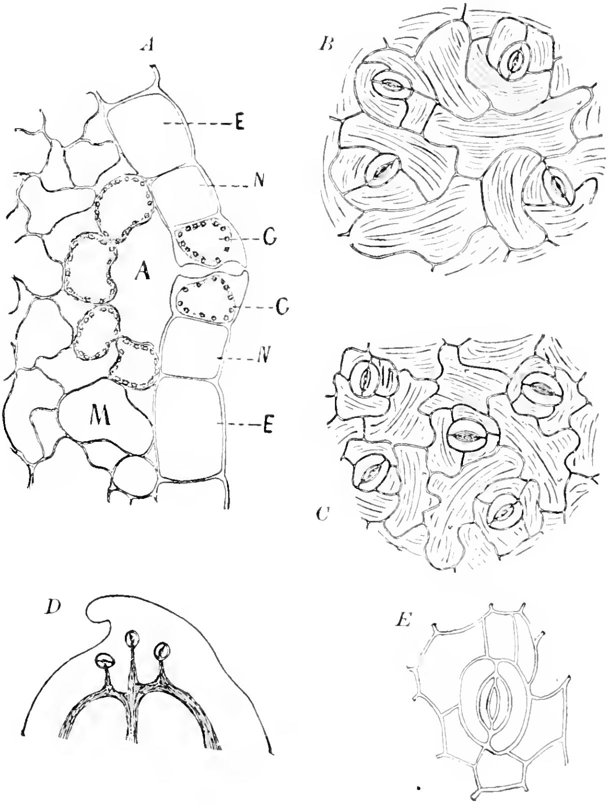


FIG. 106. Stomata and water-pores. A.—Transverse section through lower surface of leaf of stramonium: stoma, with guard cells (G), containing cytoplasm, nucleus and chloroplastids; N, surrounding cells; A, intercellular cavity usually filled with cell-sap or watery vapor; E, epidermal cells; M, mesophyll. B.—Surface section of upper surface of leaf of *Viola tricolor* showing four stomata. C.—Surface section of under surface of leaf of *Viola tricolor* showing five stomata. D.—A section through the margin of the leaf of *Viola tricolor* showing a tooth with three water-pores. E.—A water-pore of *Viola tricolor* in surface section.

contiguous cells are known as GUARD CELLS (Fig. 106, *G*). The adjoining walls of the guard cells are alike in transverse section, but the cells vary in shape in different plants; they are more or less elastic, and when the cells are turgescent, as when there is an abundance of water and root pressure is strongest, the contiguous walls of the guard cells recede from each other, forming an opening between the cells, thus permitting the exit of the excess of water taken up by the plant and the exhalation of the oxygen given off during assimilation, as well as the intake of the carbon dioxide used in photosynthesis. The cells beneath the stomata are loosely arranged, there being large intercellular spaces so that carbon dioxide soon finds its way to the cells containing the chloroplastids. On the other hand when the amount of water in the plant is reduced below the normal and the plant shows signs of wilting the guard cells flatten and the stoma or pore is closed.

The guard cells may be slightly raised above or sunk below the surrounding epidermal cells, the number of the latter being characteristic for certain plants. (Compare Figs. 106, 263, 286.)

Stomata occur in the largest numbers on the blades of foliage leaves, being more numerous on the under surface, except in aquatic plants where they occur only upon the upper surface.

Water Pores.—Near the margin of the leaf and directly over the ends of conducting cells, not infrequently occur stomata, in which the function of opening and closing is wanting, and which contain in the cavity below the opening water and not air, thus differing from true stomata (Fig. 106, *D*, *E*). These are known as WATER PORES, and they give off water in the liquid form, the drops being visible on the edges of the leaves of nasturtiums, fuchsias, roses, etc., at certain times.

Periderm.—The epidermis is not adapted for the protection of the perennial plant organs on account of its thin, frequently delicate structure and its inability to continue with the increase in thickness of stems and roots. Hence it becomes replaced by the periderm, which consists of a lasting tissue, the CORK and of a meristematic tissue, the PHELLOGEN, which reproduces the cork when it becomes torn or destroyed by the continued growth in thickness of stems or roots. Cork is not only of sub-epidermal origin, but may occur deeper in the cortex, or even inside the endodermis. In the latter case, as in roots, it owes its existence to the activity of the pericambium. Superficial, *i.e.*, hypodermal cork, is extremely rare in roots.

Cork not only occurs as a secondary protective layer, but may also arise in other parts of the plant as a result of injury, as in leaves, fruits, stems and tubers. It also arises as a result of the disarticulation of the leaf in autumn.

Lenticels may be described as biconvex fissures in the cork which permit of the easy access of air to the intercellular spaces of the rather loosely arranged cells lying beneath them (Fig. 107). They usually arise as the product of a meristem situated beneath the stomata of the epidermis, the stomata being replaced by them when cork is developed. Several types of lenti-

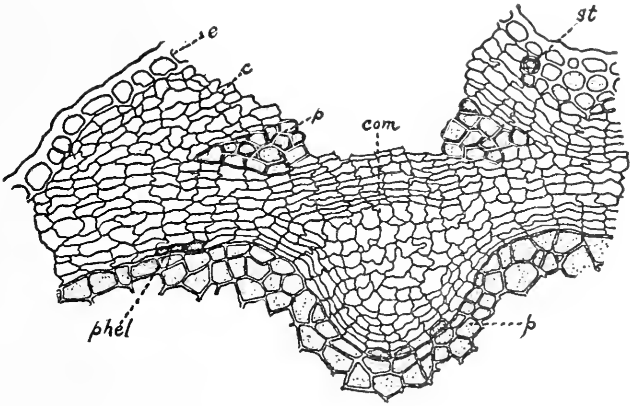


FIG. 107. Section through a secondary lenticel in the bark of Sassafras; e, epidermis, st, stone cells; phel, phelloderm derived from secondary phellogen and having thick lignified wall; p, parenchyma; c, cork; com, complementary cells.—After Weiss.

cels are distinguished. They are quite characteristic and prominent in a number of barks, as those of species of Betula, Prunus, Rhamnus (Fig. 229), etc.

Laticiferous or **milk tissue** occurs in all those plants which emit a milk-juice on being cut or otherwise wounded. The juice may be colorless, as in the oleander: whitish, as in the Asclepiadaceæ and Apocynaceæ (Fig. 202); or yellowish, as in the Papaveraceæ. It contains caoutchouc, oils, resins, mucilage, starch, calcium oxalate and alkaloids as well. The walls are relatively thin and consist chiefly of cellulose. The tissue consists either of single cells of indefinite length, as in the Asclepiadaceæ, or it may consist of a more or less branching net work formed by the anastomosing of a number of cells, as in Taraxacum (Fig. 101, *D*).

Special Secretion Cells.—In Sanguinaria there occurs a rudimentary laticiferous tissue, most of the juice being contained, however, in special parenchymatous cells, which may be more or less isolated, or arranged in irregular longitudinal rows. Cells of this character are known as secretion cells and usually contain oil, resin, tannin, calcium oxalate, mucilage (Figs. 98; 101, *B*), etc., instead of substances which form an emulsion or milk-juice; these cells are distributed in all parts of the plant, and include the epidermal cells and glandular hairs. The walls usually consist of cellulose but may have lamellæ of cutin and suberin, the latter being found particularly in the oil-secretion cells of rhizomes, roots, barks and fruits (Figs. 101, *B;* 212; 236; 250).

In some instances mucilage cells containing raphides occur in longitudinal rows resembling the secretion cells of Sanguinaria; in some of the ferns, the barks of elder and locust, and leaves of the Crassulaceæ, the tannin-cells are very much elongated, resembling the simple laticiferous cells in the Asclepiadaceæ.

Oils, resins, mucilage, gum-resins and allied products occur quite frequently in special reservoirs or cavities formed as already described (p. 178).

INNER STRUCTURE OF MEMBERS OR ORGANS.

THE STRUCTURE OF THE ROOT.

Primary Structure.—If we make a transverse section of the young portion of a root (Vascular Cryptogam, Gymnosperm or Phenogam), we notice the following tissues (Figs. 109–111). The outermost tissue is EPIDERMIS (E), it being generally thin walled and destitute of cuticle; it is as a rule hairy, and these hairs, which are relatively long, but always unicellular, are known as ROOT-HAIRS (Fig. 110, H); they ramify but very seldom. Inside the epidermis there is frequently present an EXODERMIS (commonly referred to as hypodermis) composed of a single layer of cells or at the most of but several layers, the cells of which differ in shape and size from those of the epidermis and the adjoining cortical parenchyma. The exodermis takes the place of the epidermis when the latter is worn off, except in the few cases where hypodermal cork becomes developed, as in Cephalanthus, Solidago, and Bignoniaceæ. The root bark is parenchymatic; being commonly referred to as the CORTEX, and is either homogeneous or divided into two zones, the outer or peripheral being composed of thick-walled cells which naturally belong to the exodermis and an inner or internal strata made up of thin-walled cells. The cells of the cortical parenchyma may contain starch, calcium oxalate, calcium carbonate and there may be associated with them secretory cells, frequently referred to as "ducts," as "resin ducts," etc. The innermost layer of cells of the cortex is quite distinct and known as the ENDODERMIS (EN). It consists always of a single layer of cells, without any intercellular spaces, and the radial walls show in transverse section Casparyan spots,[1] depending upon a local folding of the cell-wall, which is here suberized. In the course of time the cell-walls of the endodermis frequently become thickened, either all around, or only on the inner or radial walls, so that we might speak of an O-endodermis as in Honduras sarsaparilla (Fig. 194) or an U-endodermis as in Mexican sarsaparilla (Fig. 194), according to the manner of thickening. This is especially the case in the monocotyledons where the walls of the endodermal cells become completely suberized and impermeable to water. In some roots the cells of the endodermis may be uniformly thick-walled throughout, while in others some of the cells may remain thin-walled, and these cells, the so-called "transition cells" or "passage cells," form channels of communication between the cortical parenchyma and the vessels of the stele; they are therefore located just outside the peripheral vessels of each ray of the hadrome (or xylem).

Inside the endodermis is the STELE, formerly called the central-cylinder. In this the peripheral stratum, sometimes composed of two or three layers of cells, represents the PERI-CAMBIUM. The cells are generally thin-walled and in Dicotyledons and Gymnosperms are able by cell-division to form cork and secondary cortex, but in all vascular plants it is capable of giving rise to

[1] Physiologische Pflanzenanatomie. By Dr. G. Haberlandt, p. 245.

"lateral branches" or "lateral roots" (Fig. 109), hence it is frequently referred to as the "RHIZOGENOUS LAYER."

Inside the pericambium (by some authors compared with the pericycle of the stem) we find strands of leptome (P) alternating radially with a corresponding number of strands of hadrome (X). The number of these strands vary in the different groups of plants (Figs. 109, 193, 217, 220), being highest in the monocotyledons where a pith is developed, as in sarsaparilla (Fig. 193), several grasses, palms, etc. This peculiar arrangement of the leptome and hadrome, as separate strands alternating with each other,

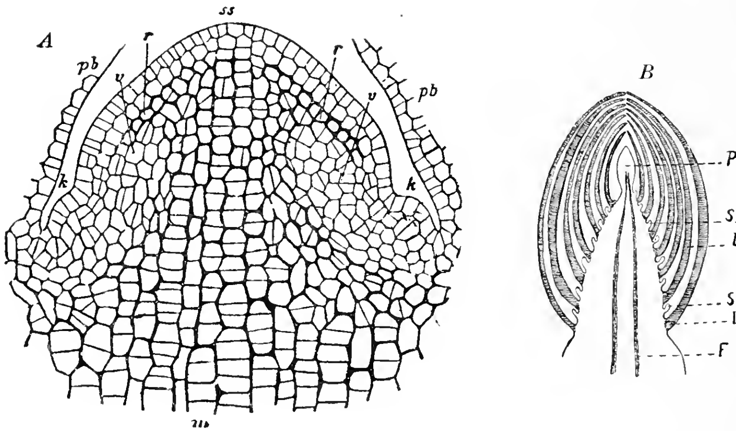


FIG. 108. A, longitudinal section through the apical region of the stem of the embryo of a bean (*Phascolus multiflorus*); ss, apex; pb, parts of the two first leaves, and their axillary buds (k, k,); r, periblem or primary cortex. B, diagram of longitudinal section through winter bud of *Quercus coccinea:* P, growing point; L, young leaves; SB, stem branches; F, fibrovascular bundle.—A, after Sachs.

and not being located, as in stems, in the same radii, has given rise to several adverse views. Some authors have considered the root-stele as one single mestome-strand (or fibrovascular strand), while others especially of recent date compose the structure with that of several MESTOME STRANDS, and of the HADROCENTRIC TYPE where the leptome partly surrounds the hadrome.[1]

[1] Compare Kattein: Der Morphol. Werth d. Centralcylind. d. Wurzel. Cassel, 1897.

The hadrome contains tracheæ or vessels, the peripheral being spiral and narrower than the inner, which are scalariform or reticulate. The tissue in the center of the stele in monocotyledons is not uncommonly made up of parenchyma cells, and corresponds exactly with the pith of the stem. In roots it is often called CONJUNCTIVE TISSUE and the cells may contain starch and crystals of calcium oxalate.

Secondary Structure.—In roots that are able to increase in thickness (as in Gymnosperms and Dicotyledons), the increase depends upon the activity of the pericambium, which develops cork outwardly and secondary cortex inwardly, and on the development of a cambium. The latter develops on the inner face

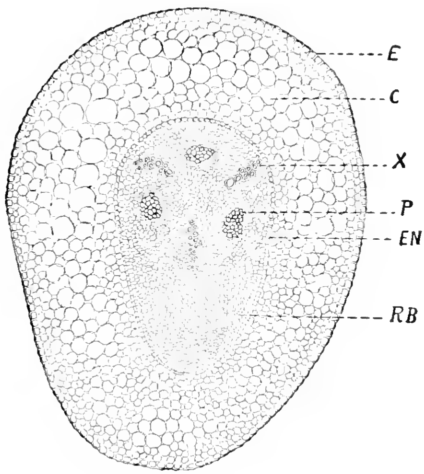


FIG. 109. A transverse section through the root of a germinating pea-plant (Pisum) about 40 mm. from the tip, showing the origin of a root-branch (RB); E, epidermis; C, primary cortex; X, hadrome (vessels); P, leptome (sieve); EN, endodermis.

of the leptome and extends from there to the outside of the peripheral vessels of the hadrome (Fig. 111), thus a continuous cambial zone gradually arises. From this zone secondary tracheæ or vessels become developed on the inner face of the primary leptome, while secondary leptome becomes differentiated outside the primary rays of hadrome; or only parenchyma develops outside the primary hadrome, resulting in the formation of secondary PARENCHYMA-RAYS (or medullary rays). In other words, the original radial structure of the stele changes to the collateral type (Fig. 112). Owing to this increase within the stele, the peripheral tissues from the endodermis to the epidermis, naturally become broken and are subsequently thrown off, but are replaced by the pericambial cork and secondary cortex. The older roots, then of Gymnosperms and Dicotyledons thus resemble the structure of stems, except that no pith exists in these roots, at least not usually. Some differences are, however, quite notice-

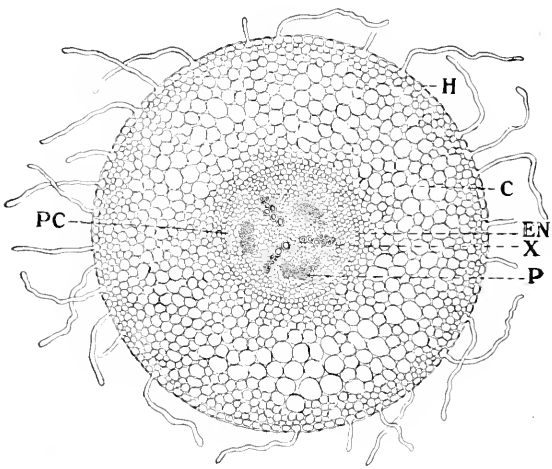


FIG. 110. Primary structure in the root. Transverse section of root of pea (Pisum) about 40 mm. from the root-cap: H, epidermal cells, some of which are developed into root hairs; C, primary cortex; EN, endodermis; PC, pericambium; X, ladrome, composed of tracheæ; P, leptome, composed of sieve cells, the hadrome (vessels) and leptome (sieve) forming a triarch radial fibrovascular bundle.

able in some instances as in the thick roots of Beta, Radish, etc., where the wood parenchyma is usually abundant, thin-walled and not lignified, the annual rings also being mostly indistinct.

The characteristics distinguishing the primary and secondary structures of dicotyledonous roots may be summarized as follows:

PRIMARY STRUCTURE: Epidermis and root hairs. Hypodermis. Primary cortex consisting of parenchyma. Endodermis, pericambium, hadrome arranged in radial rays which alternate with leptome or sieve strands, constituting a radial fibrovascular bundle (Fig. 110).

SECONDARY STRUCTURE: Cork cells. Phellogen. Secondary cortex consisting of parenchyma. Leptome, cambium and hadrome, arranged in radial groups, forming open collateral fibrovascular bundles. Medullary rays separating the fibrovascular bundles.

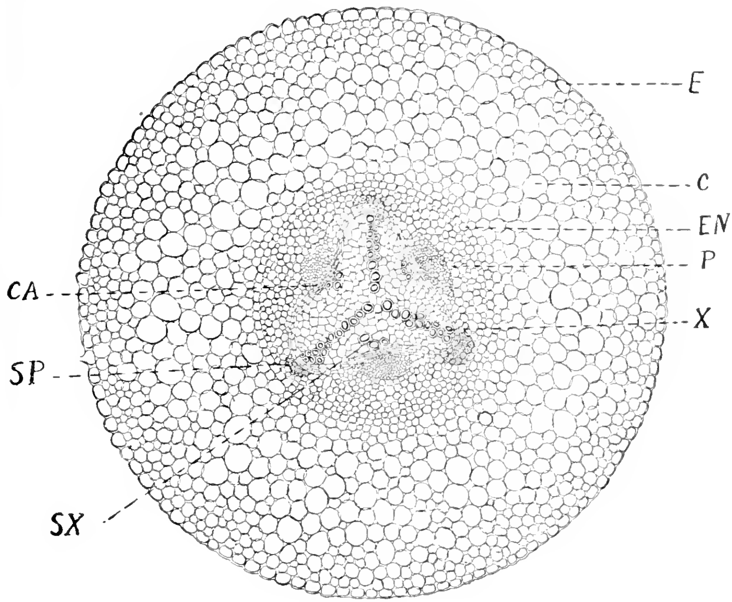


FIG. 111. Section in the older part, higher up on the root of pea (Pisum) showing in addition to what has been observed in Fig. 110, the beginning of the change from primary to secondary structure: CA, the development of a cambium; SX, secondary hadrome (or vessels) and SP, secondary leptome (or sieve).

Sometimes, as in glycyrrhiza and valerian, a number of parenchyma cells are found in the center of the root, these constituting the PITH (Fig. 115) or medulla; but they are usually wanting in dicotyledonous roots.

Wood and bark are terms used to distinguish those portions of the root or stem separated by the cambium; all that portion inside of the cambium, including hadrome, medullary rays and pith, being known as the WOOD. The BARK includes the leptome, the medullary rays outside of the cambium, and the tissue formed by the phellogen.

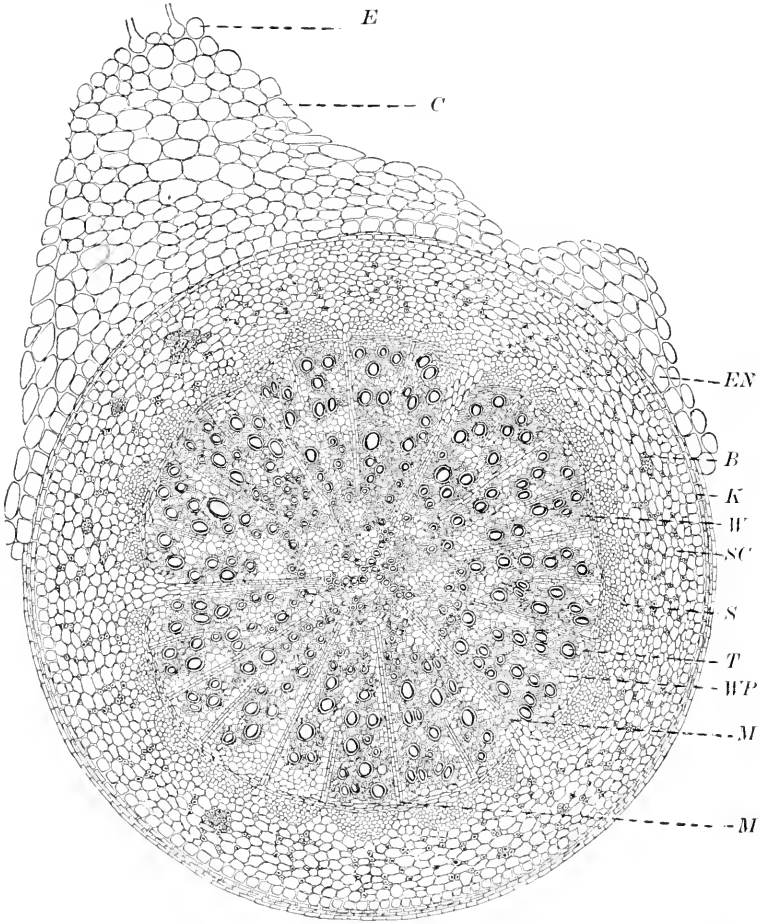


FIG. 112. Fully developed secondary structure in root. Transverse section of root of pea (Pisum) at the end of the summer's growth: E, some epidermal cells with fragments of root hairs; C, primary cortex; EN, endodermis; K, cork; B, bast fibers; SC, secondary cortex; S, leptome; T, hadrome; W, wood fibers; WP, wood parenchyma; M, medullary rays; the hadrome (or vessels) and leptome (or sieve) forming open collateral fibrovascular bundles, these being found in dicotyledons with but few exceptions.

The following diagram of the secondary structure of a dicotyledonous root may be of assistance in understanding the origin and relation of the tissues comprising it:

- Wood made up of ....
  - Pith, which may be wanting.
  - Xylem ... Composed of vessels, wood parenchyma and wood fibers; or tracheids may replace these cells, or be associated with them. These are arranged in groups forming radial rows which are separated by medullary rays.
- Cambium produces
  - Xylem
  - Phloem
- Bark made up of ....
  - Phloem .. Consisting of leptome and companion cells; bast fibers may also be present. These are arranged in collateral groups and form radial rows which are separated by medullary rays.
  - Pericambium, producing parenchyma and cork.

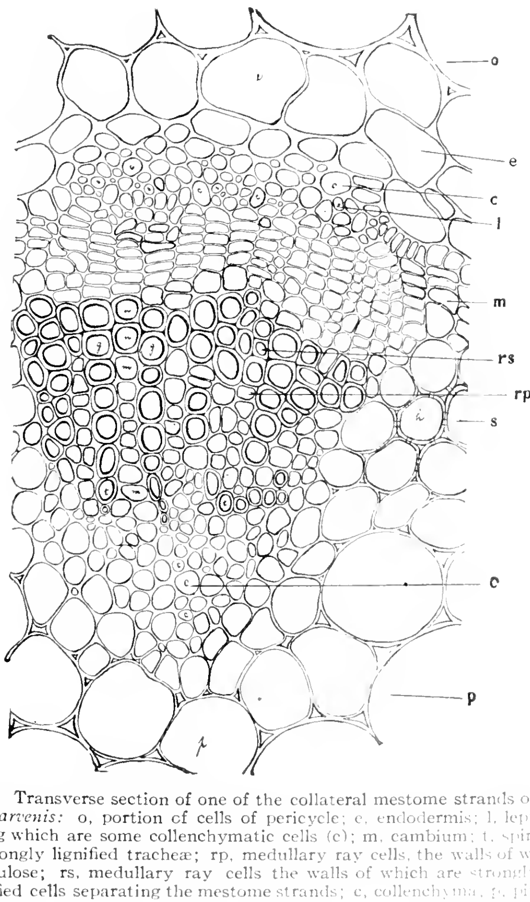


FIG. 113. Transverse section of one of the collateral mestome strands of the stem of *Viola tricolor arvenis:* o, portion of cells of pericycle; e, endodermis; l, leptome or sieve cells, in among which are some collenchymatic cells (c); m, cambium; t, spiral tracheæ or vessels; g, strongly lignified tracheæ; rp, medullary ray cells, the walls of which are composed of cellulose; rs, medullary ray cells the walls of which are strongly lignified; s, strongly lignified cells separating the mestome strands; c, collenchyma; p, pith.

The root branches arise as the product of a meristem, known as the PERICAMBIUM, situated beneath the endodermis (Figs. 59, *RB*; 109). The tissues forming the branches are directly connected with the fibrovascular tissues of the root and protrude through the overlying tissues without having any connection with them. The structure of the branches thus formed

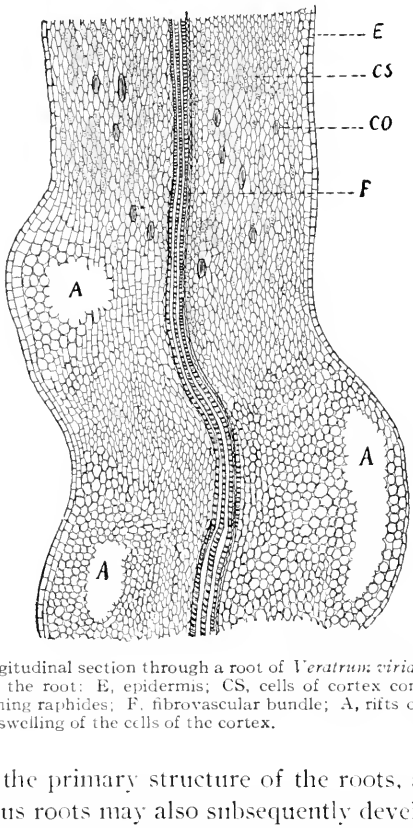


FIG. 113a. Longitudinal section through a root of *Veratrum viride* showing the nature of the contraction of the root: E, epidermis; CS, cells of cortex containing starch; CO, cells of cortex containing raphides; F, fibrovascular bundle; A, rifts or cavities formed as a result of the radial swelling of the cells of the cortex.

corresponds to the primary structure of the roots, and in the case of dicotyledonous roots may also subsequently develop a secondary structure. Goebel states that in plants which grow in moist soil, or whose roots function only for a short time, the branches may be altogether suppressed as in Colchicum, Arisæma, etc.

Contraction of roots is observed in both monocotyledons and dicotyledons, it being most apparent in the former, as in the roots of *Veratrum viride* (Fig. 113a). The uneven or corkscrew-like appearance is due to a contraction, which arises as follows: Some of the longitudinally elongated cells beneath the epidermis as well as cells extending to and including the endodermis absorb large quantities of water, which causes them to assume a spherical form (as the cells of a potato are altered on boiling), the result being a longitudinal contraction of the root at this point. In this way the plant is fastened more securely to the earth, and at the end of the season's growth the apical buds of plants, with upright rhizomes, as of *Veratrum viride*, Dracontium, etc., are drawn into the earth and thus protected during the winter season.

Abnormal Structure of Roots.—It is often difficult to recognize the type-structure of dicotyledonous roots in drugs, owing to the anomalous and abnormal secondary structure. Sclerenchymatous fibers, while present in glycyrrhiza (Fig. 104) and althæa, are not infrequently wanting. Wood fibers may be sparingly developed, as in young belladonna roots or even wanting, as in gentian. In other cases the medullary rays are abnormal, being replaced in calumba (Fig. 198) by wood parenchyma, and in ipecac (Fig. 203) and taraxacum by sclerenchymatous cells (Fig. 197a). In asclepias and calumba (Fig. 198) a layer of stone cells occurs near the periphery; in gentian, sieve cells develop in the xylem (Fig. 210); in senega the xylem is not uniformly developed (Fig. 197), and in still other cases, as in jalap (Fig. 195), pareira (Fig. 199) and phytolacca (Fig. 200), successive cambiums develop, producing concentric series of open collateral fibrovascular bundles.

THE STRUCTURE OF THE STEM.

If we make a transverse section of a young herbaceous stem, we observe a differentiation of the tissues, which in several respects agrees with that of the root, described in the preceding chapter. In the primary structure of the stem the following tissues are to be noticed: The outermost tissue is the epidermis with a more or less distinct cuticle: the second is the cortical parenchyma, frequently with strands of collenchyma near the epidermis, often containing secreting ducts or cells, and not infrequently with the innermost layer differentiated as an endodermis. The latter surrounds the so-called pericycle, a sheath consisting of more or less distinct stereomatic strands, either forming a closed sheath or merely representing isolated arches outside the leptome of the stele. Inside the pericycle we observe the mestome strands constituting mostly one circular band (in cross section) in the Dicotyledons and Gymnosperms, or several more or less concentric bands in the Monocotyledons. The mestome-strands may be collateral (Fig. 115), bicollateral or concentric, the last of which being found only in the Monocotyledons (Fig. 212) and Ferns (Fig. 278).

In the DICOTYLEDONS the collateral mestome-strands which are the most frequent, contain leptome, *i.e.*, sieve tubes, companion-cells and cambiform, furthermore cambium, and inside this follows the hadrome, *i.e.*, vessels, tracheids, mestome, parenchyma and libriform. When the collateral mestome-strand increases in thickness, the increase is due to the activity of the cambium, here called the INTRAFASICULAR CAMBIUM, which then develops leptome outwardly and hadrome inwardly. Between the primary mestome strands there is frequently a procambium, which connects these strands with each other, and which generally gives rise to secondary mestome strands, or the connection may be effected by means of the intrafasicular cambium, which often extends itself from one strand to another and develops leptome and hadrome, as in the primary strands, such cambium is distinguished as INTERFASICULAR CAMBIUM and is commonly referred to as the CAMBIUM RING.

The BICOLLATERAL mestome strands, characteristic of some Dicotyledons (Labiatæ, Solaneæ, Cucurbitaceæ, etc.) differ from the COLLATERAL type by having a leptome strand developed on the inner face of the hadrome, thus each mestome strand carries two strands of leptome (Figs. 208, 220). In the CONCENTRIC mestome strands, the leptome may encircle the hadrome, as in the Ferns (Fig. 278), or the hadrome may partly (Fig. 212), as in the rhizomes of many Monocotyledons, surround the ieptome. While thus the collateral type of strand or bundle occurs in both Monocotyledons (Fig. 114) and Dicotyledons (Figs. 104, 115,

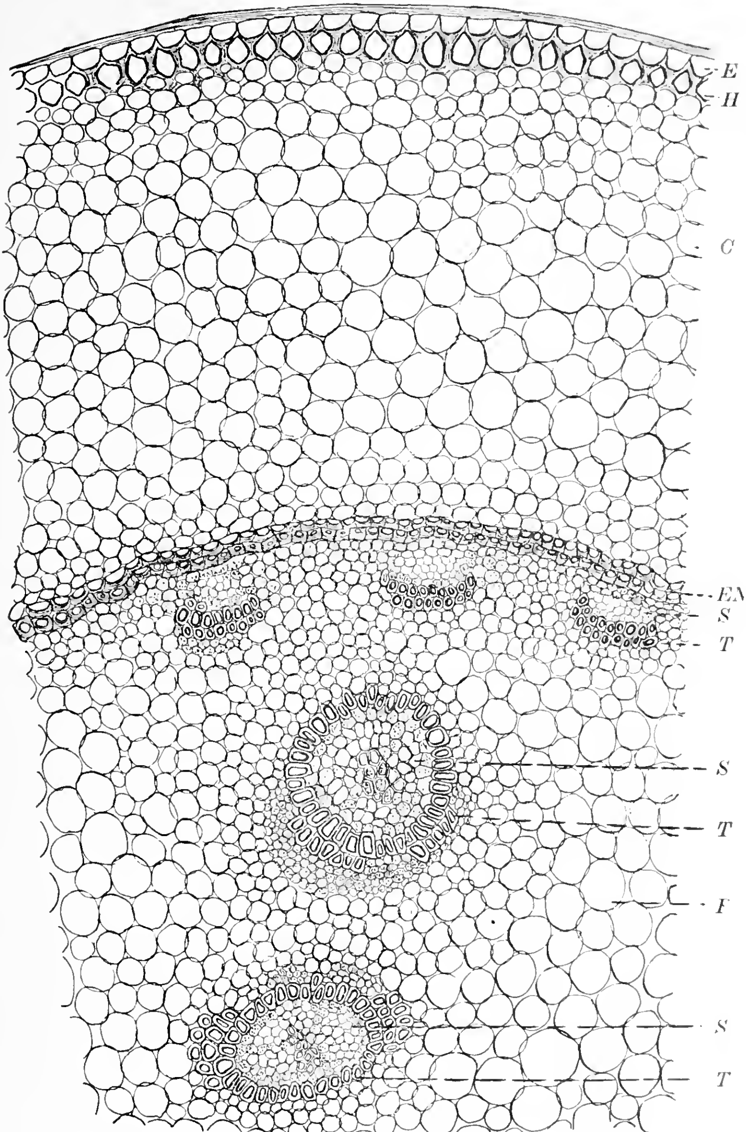


FIG. 114. Monocotyledonous stem structure. Transverse section of convallaria rhizome: E, epidermis; H, hypodermis composed of collenchyma; C, cortex; EN, endodermis; S, perihadromatic sieve; T, tracheæ or vessels; P, parenchyma. The bundles are of the collateral and concentric types.

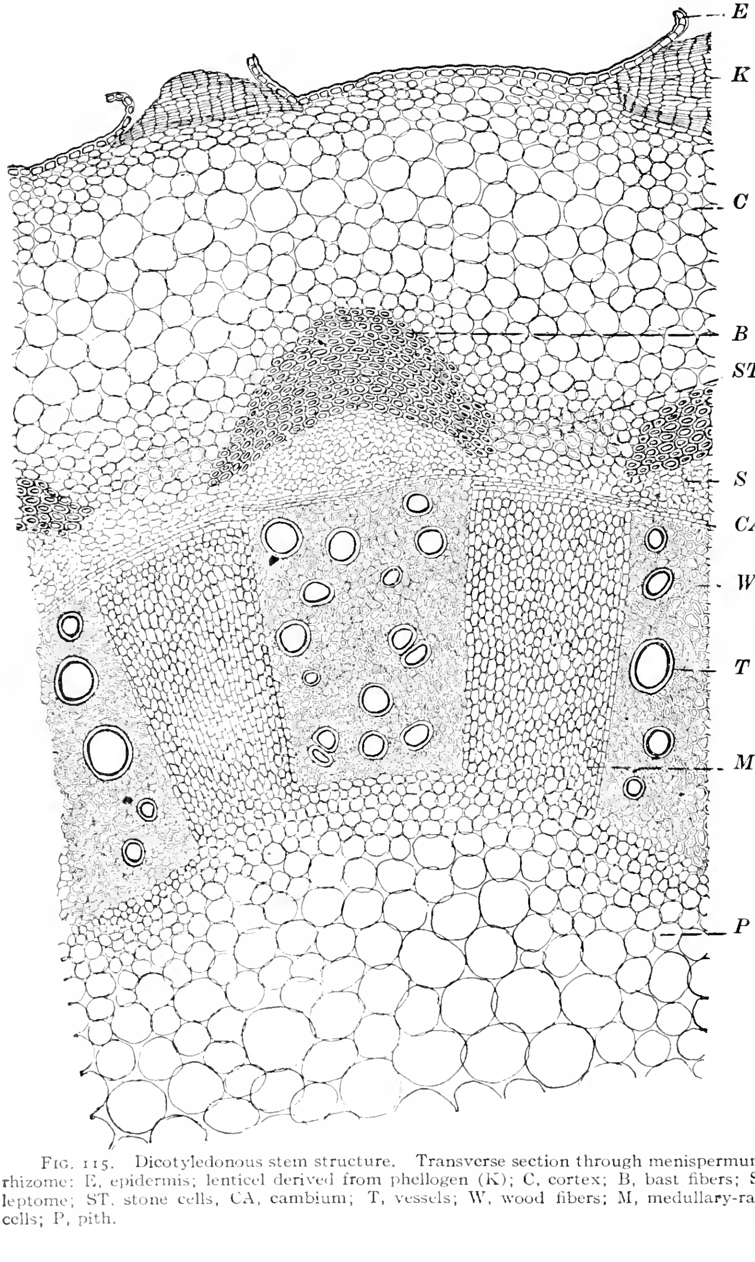


Fig. 115. Dicotyledonous stem structure. Transverse section through menispermum rhizome: E, epidermis; lenticel derived from phellogen (K); C, cortex; B, bast fibers; S, leptome; ST, stone cells, CA, cambium; T, vessels; W, wood fibers; M, medullary-ray cells; P, pith.

etc.) the presence of a cambium is found only in the Dicotyledons and extremely seldom in the Monocotyledons. The central portion of the stele is frequently differentiated into a PITH of parenchymatic structure, the cells of which often contain large quantities of starch (Figs. 220, 223). In addition in the pith, we often find the same types of secreting ducts or cells as occur

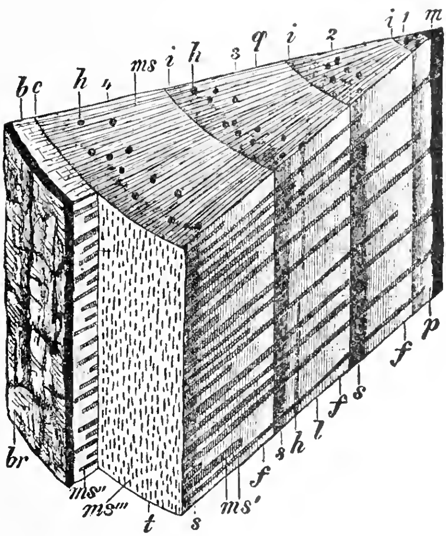


FIG. 116. Section of a four-year-old stem of a pine cut in winter; q, view in transverse section; l, radial-longitudinal section; t, tangential-longitudinal section; f, spring wood; s, fall wood; m, pith; 1, 2, 3, 4, successive years' rings of growth in which i shows the dividing line; ms, medullary rays in transverse section; ms^{1}, ms^{11}, medullary rays in radial-longitudinal section; ms^{111}, medullary rays in tangential-longitudinal section; c, cambium; b, bast; h, resin-canals; br, bork.—After Strasburger.

in the cortex (as in Apocynum). The pith may constitute a homogeneous tissue or be broken, as in Phytolacca (Fig. 139, A), Carya, Halesia, etc., where a longitudinal section shows the pith divided into a row of broad cavities that are separated by thin transverse walls of parenchyma.

Finally it may be mentioned that cork is of frequent occurrence, especially upon stems that persist more than one year. The cork may arise in the epidermis itself, or it may develop in the hypodermal strata of the cortex or in still other cases we find its development much deeper, even within the pericycle.

In regard to the increase in thickness, the stem behaves much like the root, as in the throwing off the peripheral tissues extending from the epidermis to the endodermis, or only of the epidermis and adjoining cortex, which then becomes replaced by strata of

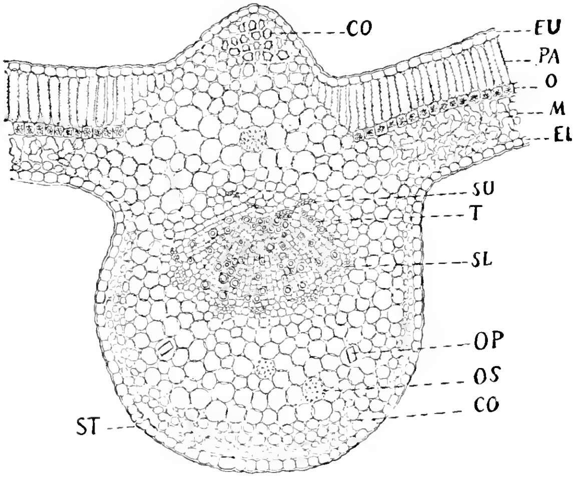


FIG. 117. Transverse section of midrib of leaf of stramonium: EU, upper epidermis; CO, collenchyma; PA, palisade cells; O, layer of cells containing rosette aggregates of calcium oxalate; M, loose mesophyll; EL, lower epidermis; OP, prisms of calcium oxalate; OS, cryptocrystalline crystals of calcium oxalate; ST, stoma; T, ducts; SU, sieve on upper side of ducts; SL, sieve on lower side of ducts, this arrangement of sieve and ducts forming bicollateral fibrovascular bundles.

cork and secondary cortex. The mestome strands in the stem, however, grow in a more regular manner than is the case with those of the root, as is seen in the very distinct and frequently very regular layering of the tissues of woody stems, forming the so-called "Annual Rings," where each ring represents the growth that occurs during a single year. The development of these annual rings depends especially upon the fact that the growth of the perennial stem does not take place continuously, but is interrupted during certain periods of the season, for instance during the winter or during the dry seasons of tropical climates. And since the tissues, which are formed at the beginning of each season's growth are distinct from those already formed during the previous season in both color and structure of the wood (especially in the thickness of cell-walls and the width of the tracheæ or vessels), we perceive in this manner distinct zones of wood, or the "annual rings" as they are called, the larger vessels with thin walls being produced in the spring and early summer.

Various abnormal stem-structures are known which are due to certain peculiarities in the growth in thickness of stems. These are especially noticeable in lianes. In some of the Monocotyledons, as in Dracæna, Yucca, Agave and Aloe we find a secondary increase in growth of the stems.

Plant Hairs.—When the surface of the plant (either of stems or leaves) is covered with short, fine hairs, which are not very dense and *not matted*, the surface is described as PUBESCENT; when the hairs are relatively long but scattered the surface is said to be VILLOUS; or when the hairs cover each other in one direction it is described as SERICEOUS or silky. When the hairs are stiff though slender we speak of a HIRSUTE covering; when the hairs are vernate, thickish and stiff, as in Borago, the surface is spoken of as being HISPID. If the hairs are bristle-like the surface is described as STRIGOSE; or if they are terminated by a globular, glandular head (Figs. 285, 287), as GLANDULAR. Again, when the hairs *are matted* the surface is described as LANATE; when they are long it is said to be WOOLLY; or when they are short and soft as in Mullein it is said to be TOMENTOSE.

When the hairs are hard and prickle-like the surface is described as HISPID or STRIGOSE; when they are modified to spines it is said to be SPINOSE; and when they are hooked it is described as ECHINATE.

In still other cases the epidermal cells, particularly of leaves, are uneven, forming depressions and protuberances which if slight give the surface the appearance described as RUGOSE: or if wart-like, give the appearance known as VERRUCOSE. Furthermore, the veins of leaves may be quite prominent, particularly in the lower surface, and if they are much reticulated in addition, the surface is described as RETICULATE.

STRUCTURE OF THE LEAF.

In all green leaves the typical structure is as follows: A cuticle covers the outer cell-wall of the epidermis, while the epidermis itself shows much of the same modifications as exist in the stem; frequently the lumen of the cells of the epidermis is wider on the ventral face than on the dorsal. Hairs abound on the leaves in many plants and stomata are especially frequent on the dorsal surface. The upper epidermis may further be characterized by the presence of water-pores, the origin and function of which have already been described (p. 193).

The green chlorophyl-bearing tissue is called CHLORENCHYMA (frequently spoken of as mesophyll), and is frequently differentiated into a ventral PALISADE TISSUE, composed of long cells which are placed vertically to those of the epidermis; and a DORSAL PNEUMATIC TISSUE, made up of irregularly branched or lobed cells with very large intercellular spaces. Secreting ducts or cells occur in the chlorenchyma of many plants and correspond with those found in the cortex of the stem. When the palisade tissue is distributed on both faces of the leaf blade, the pneumatic tissue is thus located in the center, the leaf is called "bifacial," otherwise the leaf is said to be "unifacial" or "dorsiventral." (See Figs. 117, 139, 141, 158, 175, 257, 261, etc.)

Mechanical tissues, as collenchyma and stereome, are frequent and these accompany the veins as hypodermal strands, being best developed usually on the dorsal face of the latter, as underneath the leptome. The mestome-strands of the leaf blade generally lie in a single plane. They are collateral and have the leptome situated towards the dorsal face. They are nearly always surrounded by thin-walled PARENCHYMA-SHEATHS, or as in several grasses and sedges by thick-walled mestome-sheaths. In some plants of various families, the midrib is not only stronger developed than the lateral veins, but it may be composed of several, instead of only one, mestome-strand, sometimes representing a true stele.

The petiole generally shows the structure of the midrib as far as concerns the mestome-strands, but possesses furthermore a more or less strongly developed parenchyma, the cells of which are colorless, thin-walled and which may often be traced to the leaf-blade itself, where it surrounds the stronger veins, causing them to project as ribs and to be much thicker in cross-section than the adjoining chlorenchyma.

From a histological point of view the leaf structure of Dicotyledons resembles very closely that of the Monocotyledons, except that in the latter the palisade-cells often radiate towards the center of the mestome strands. There are, however, many instances of a similar development in the leaves of Dicotyledons.

Abnormal structures are common in leaves, especially in such as are not held in a horizontal position, but vertical, as those of Eucalyptus, the Irideæ, etc.

The **Epidermis** forms the surface of the leaf and may consist of one or more layers of cells. The outer walls are cutinized, and when nearly smooth the leaf is said to be GLABROUS. They may be covered or whitened with a bloom, as in magnolia, when the leaves are spoken of as GLAUCOUS. In other cases the outer walls of the epidermal cells are modified to hairs (Figs. 283–285).

INNER MORPHOLOGY OF THE FLOWER.

The inner structure of the flower bears a close resemblance to that of the stem and leaf. The BRACTS in almost all particulars are like the foliage leaf of the same plant and the FLOWER STALK closely resembles the foliage stem. The CALYX, while resembling the foliage leaf, usually contains calcium oxalate in greater amount, and the chlorenchyma consists wholly of rather loose chlorophyll parenchyma; the outer or under epidermis contains the stomata, and if hairs are present, they also arise from this surface; the fibrovascular bundles are generally simple in structure, although in some cases, as in lavender, sclerenchymatous fibers are strongly developed.

In the COROLLA the epidermal cells are generally more or less centrifugally developed, forming prominent papillæ (Fig. 118, *A*, *B*), which give the petals a velvety or satiny appearance, as in the rose; glandular and non-glandular hairs are also developed which are peculiar to the corollas of irregular flowers, as in *La-*

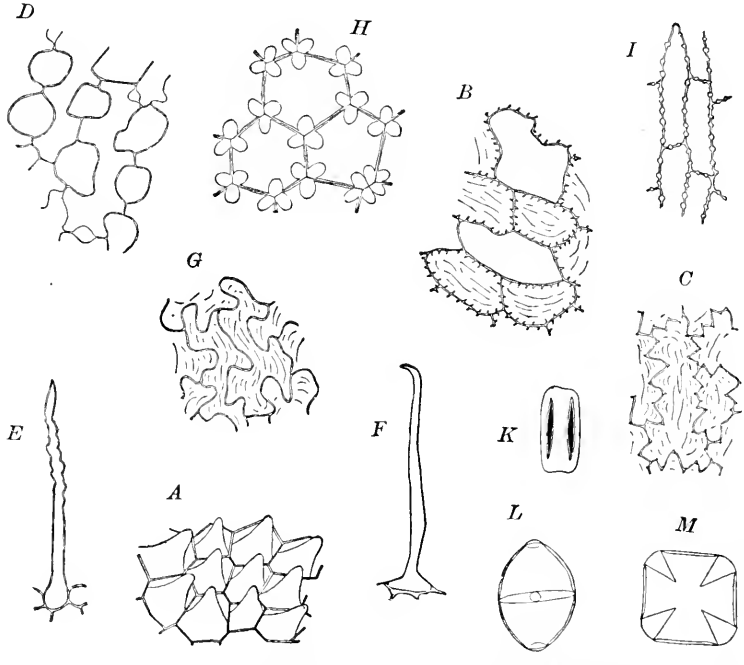


FIG. 118. Inner morphology of the flower as illustrated in *Viola tricolor*. A, epidermal cells from the outer surface of the spurred petal showing papillæ; B, epidermal cells from the under surface of the petals, some of the cells showing centripetal thickenings, the two without thickenings covering sub-epidermal mucilage-cells; C, epidermal cells from the under surface of the petals showing a zigzag outline and short centripetal thickenings; D, surface view of the mesophyll of the petals; E, corkscrew-like hair from the inner surface of the spurred corolla near the throat; F, a hair from the edge of an anther; G, epidermal cells of the anthers; H, surface view of the mesophyll cells from the spurred stamen showing collenchymatous thickening; I, surface view of cells of endothecium; K, pollen grain viewed from the side; L, pollen grain examined in water; M, pollen grain observed in chloral solution.

vandula vera (Fig. 285, *A*) and *Viola tricolor* (Fig. 118, *E*); stomata are comparatively few in number. The epidermal cells are but slightly cutinized, and in surface view are strongly undulate and appear striate owing to the papillose development (Fig.

106, *B*, *C*). The chlorenchym is made up of rather loose, branching parenchyma cells (Fig. 118, *D*), with large intercellular spaces. The cells are free from chloroplastids, may contain chromoplastids, or, like the epidermal cells, a colored sap; in some instances, as in the buttercups, starch grains are also found in the mesophyll. Calcium oxalate crystals are usually present, and milk vessels are sometimes found, as in the Papavaraceæ.

The FILAMENT and connective possess a central fibrovascular bundle, around which are arranged comparatively small parenchyma cells and among which secretion cells are sometimes scattered, as in Tilia. The pollen sacs consist of but two layers of cells—an outer layer called the "exothecium," which resembles the epidermis of the corolla, and an inner layer called the "endo-

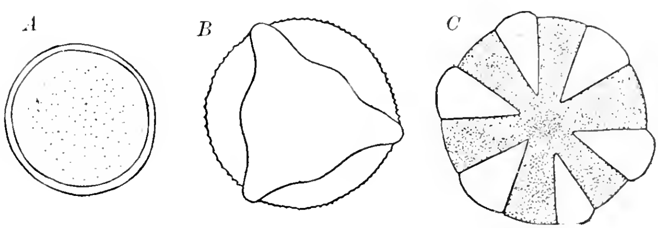


FIG. 119. Several forms of pollen grains: A, crocus; B, arnica, with three thin places in the wall through one of which the pollen tube may protrude; C, lavender showing six thin places in the wall.

thecium," the cells of which are contractile and peculiarly thickened, this feature being rather characteristic for certain species (Fig. 118, *I*). Lining the pollen sacs during their development, there is a layer of cells, called the "tapetal cells;" but these are usually sooner or later absorbed.

The POLLEN GRAINS vary greatly in number, as well as in size and shape. They are usually more or less ellipsoidal but may be spherical, as in Crocus (Fig. 119, *A*); more or less three-sided, as in the Compositæ and in cloves; four or five-sided, as in *Viola tricolor* (Fig. 118, *K*, *L*, *M*), and in some cases, as in the Coniferæ, they may be winged. In addition to protoplasm and one or more nuclei, pollen grains contain considerable oil and starch. The outer or enclosing membrane (Fig. 119) consists of two parts: an inner one known as the "intine" and consisting of cellulose, and an outer, known as the "exine," apparently consisting chiefly of cutin; in some cases the exine also contains an oil which is colorless, as in Salvia, or yellowish, as in lavender, and in some instances it may contain a viscid substance, causing the pollen grains to adhere, as in Œnothera. The grains may be smooth or variously sculptured; in most instances the exine is unevenly developed, leaving thin places through which the pollen tubes protrude in germination; these give the appearance of grooves when the grains are dry, and the number of grooves is characteristic for different species; in most of the Compositæ they are three in number; in the Labiatæ there are six, while in Crocus they are wanting (Fig. 119).

The epidermal cells of the STIGMA are quite characteristic. The cells of the epidermis, or so-called "stigma-epithel," may be palisade-like, forming a more or less wart-like mass, as in the viscous stigmas of the Umbelliferæ, or the outer walls may be modified to rather broad papillæ, as in matricaria and arnica, or they may be developed into hair-like processes, as in Crocus. The pollen tubes either enter the style through an open canal, as in the violets, or they penetrate into the conducting tissues of the style, either through the papillæ, as in Malva, or through the middle lamella of two neighboring papillæ, as in *Atropa Belladonna.*

The important tissue of the STYLE is the conducting tissue; in styles which are hollow it forms the lining of the canal, the cells resembling those of the stigma-epithel; in styles that are solid the conducting tissue occupies the central axis and consists of somewhat elongated cells, the walls of which are generally thick, frequently strongly refractive and possess the property of swelling, being furthermore separated by large intercellular spaces. Surrounding the conducting tissue are thin-walled parenchyma cells, in which the fibrovascular bundles are distributed, the number of groups of the latter corresponding to the number of carpels that compose the gynæcium. There may also occur secretion cells, containing mucilage, as in Malva, or oil and resin, as in matricaria. Occasionally, the parenchyma is replaced either in part or entirely by mechanical cells, and the epidermal cells may be modified to hairs.

The tissues of the OVARY are, as a rule, in a very rudimentary condition; in fact, so rudimentary that it is difficult to distinguish the ovaries of two flowers that develop into quite different fruits. In some instances it is said that notwithstanding the subsequent changes, each cell of the fruit is already indicated in the ovary. The ovary possesses an outer and an inner epidermis; the outer is provided with stomata and may also possess hairs; the inner may also have stomata and after fertilization may develop secretion hairs, as in the orange. Between the epidermal layers occur thin-walled parenchyma cells which contain leucoplastids and chloroplastids, and in which the fibrovascular bundles are distributed, these being usually simple, or complex, as in the pea. The number of fibrovascular bundles is more or less dependent upon the number of carpels that make up the gynæcium; as a rule, there is a strong fibrovascular bundle which corresponds to the midvein of each carpel.

The PLACENTA is a development from the inner epidermis. It is traversed by a fibrovascular bundle from which branches are given off to the individual ovules; it may have a conducting tissue similar to that found in the style, and in some cases the epidermis of the stalk of the ovule may be developed to a stigma-epithel.

The OVULE not only possesses a distinct form as already given, but the internal structure, by reason of the changes associated with fertilization, is more or less characteristic for certain species and genera. It has an epidermal layer, the outer walls of which are more or less cutinized, and it consists for the most part of parenchyma cells rich in protoplasm and food-materials; in addition the embryo-sac contains a number of nuclei. The stalk and raphe are connected with the placenta by means of a fibrovascular bundle.

The NECTAR may be secreted by certain of the epidermal cells of various parts of the flower; these may resemble the ordinary epidermal cells or they may be modified to papillæ, as in the spurred stamens of the violets, or to hair-like processes, as in Malva. The cells which secrete nectar constitute the "nectar-apparatus," and the walls are usually thin and more or less cutinized. The nectar-apparatus is found more generally upon some part of the stamen, but the sepals and petals are not infrequently saccate or spurred, which adapts them for holding the nectar.

INNER MORPHOLOGY OF FRUITS.

The inner structure of fruits is quite variable and it is difficult to treat of this in a general way. In the simplest fruits there are

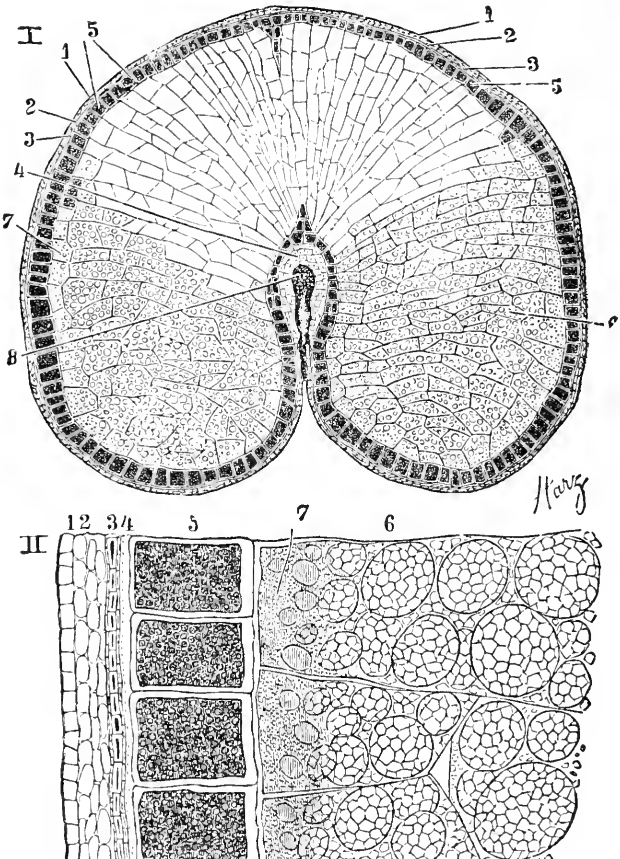


FIG. 120. Transverse (I) and longitudinal (II) sections of oat grain (*Avena sativa*): 1, 2, cells of pericarp; 3, seed-coat; 4, remains of perisperm; 5, cells containing gluten; 7, endosperm cells containing considerable proteins and some starch; 6, endosperm cells with polygonal compound starch grains; 8, fibrovascular bundle of the pericarp.—After Harz.

three distinct layers, as in the capsule of cardamom, in which there is an outer epidermis of isodiametric or polygonal cells, an inner epidermis of more or less obliterated and elongated cells, between which is a thin-walled parenchyma traversed by a number of fibrovascular bundles (See also Figs. 246, 250, 252).

In some cases the outer epidermis contains numerous stomata, as in poppy capsules, or is developed into hairs and other outgrowths or appendages, as in anise (Fig. 244), arnica, rhus glabra and raspberry.

The inner epidermis may also contain stomata, as in the poppy, or be developed into hairs, as in vanilla (Fig. 256) and orange, or more or less obliterated, as in akene-like fruits, or modified to sclerenchymatous elements, as in drupes.

The middle layer, which is composed of parenchyma, may contain protoplasm, starch, sugars, calcium oxalate, coloring principles, alkaloids and other principles, and it may also have oil-secretion cells, as in cubeb (Fig. 250) or oil-secretion canals, as in orange and the fruits of the Umbelliferæ, in the latter of which they are known as vittæ (Figs. 244 to 248); milk vessels sometimes occur, as in poppy; a collenchymatous layer is sometimes developed beneath the epidermis, as in capsicum (Fig. 252), in some cases sclerenchymatous cells may be present, as in pimenta and cubeb (Fig. 250); and in still other instances the entire pericarp may be made up of stone cells.

INNER MORPHOLOGY OF THE SEED.

The SEED-COAT usually consists of from two to six layers of cells: (1) an outer layer or so-called epidermis, (2) a layer of sclerenchymatous cells or stone cells, (3) a pigment layer, (4, 5) one or two rows of parenchymatous cells, (6) a row of more or less obliterated parenchyma cells.

The EPIDERMAL CELLS vary considerably in different species, both as regards the form of the cells and the composition of the walls (Fig. 302). The cells may be more or less isodiametric in cross-section, as in cardamom (Fig. 253); elliptical, as in almond (Fig. 302, *D*); palisade-like, as in *Abrus precatorius*, or more or less irregular, as in Delphinium. While the outer and side walls are usually thickened, in hyoscyamus (Fig. 302, *A*) it is the inner and side walls which are thickened, the outer wall remaining thin. The outer wall may be in part modified to mucilage, as in mustard and flaxseed (Fig. 184); or to non-glandular hairs which consist either of cellulose, as in cotton (Fig. 166), or lignocellulose, as in nux vomica (Fig. 283, *B*).

The PERISPERM and ENDOSPERM (Fig. 121) consist chiefly of parenchyma cells, which contain, besides protoplasm, starch, as in physostigma; oil, as in strophanthus (Fig. 186); aleurone

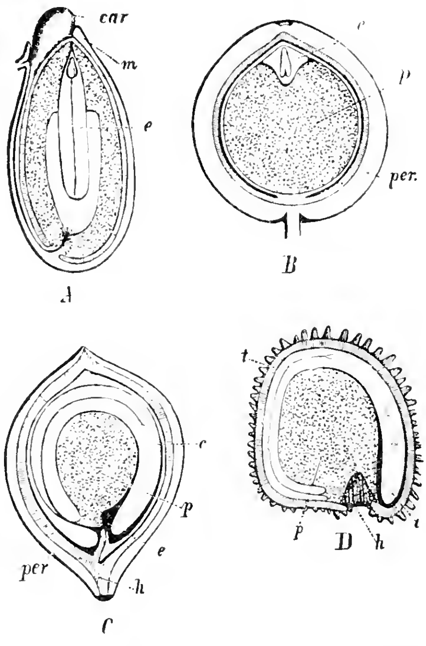


FIG. 121. Form of embryo and distribution of endosperm in various seeds and fruits. A, Ricinus seed: car, caruncle; m, micropyle; e, embryo. B, superior drupe of Piper: per, pericarp; e, endosperm; p, perisperm. C, spinach fruit and D, corn cockle seed (*Agrostemma Githago*): per, pericarp; t, seed-coat; h, hilum; p, perisperm; e, endosperm c, curved embryo.—A, C, D, after Harz; B, after Baillon.

grains, as in ricinus (Fig. 122); glucosides, as in almond; alkaloids, as in stramonium. The walls are usually thin, but may in some instances be considerably thickened, as in coffee, colchicum and nux vomica (Fig. 122, *C*).

The embryo consists chiefly of parenchyma cells with a few fibrovascular bundles; the cotyledons may be thin and leaf-like, as in ricinus and nux vomica, or thick and fleshy, as in almond

(Fig. 188) and cola, or partly developed as in strophanthus (Fig. 186); the hypocotyl is usually small, but in the Umbelliferæ it is as large as the cotyledons.

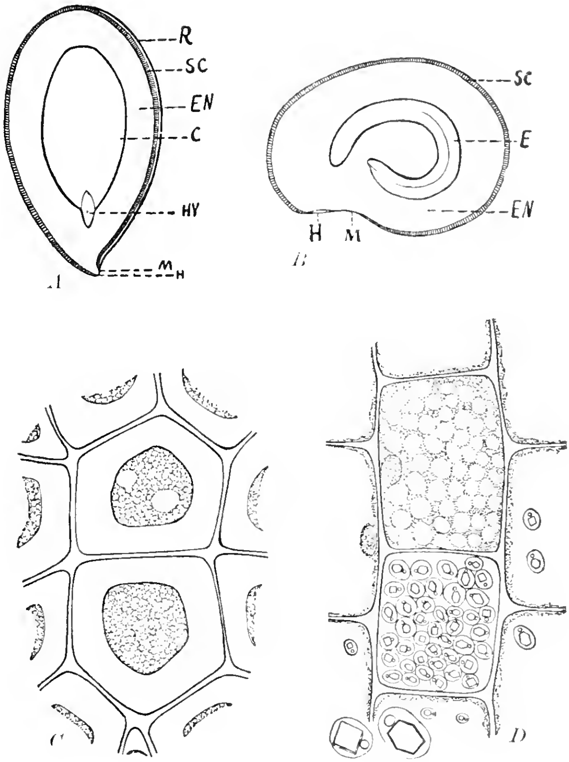


Fig. 122. A.—Longitudinal section through anatropous seed of linum: R, raphe; SC, seed-coat; M, hilum; H, micropyle; EN, endosperm; C, cotyledon; HY, hypocotyl. B.—Longitudinal section through stramonium seed: SC, seed-coat; H, micropyle; M, hilum; EN, endosperm; E, curved embryo. C.—Transverse section through endosperm of nux vomica showing thick-walled parenchyma, the cells containing oil and protoplasm. D.—Transverse section through endosperm of seed of *Ricinus communis*, one cell filled with aleurone grains containing a crystalloid and globoid, and another in which the aleurone grains have been dissolved, the cytoplasm and nucleus remaining.

PLANT METABOLISM.

Food of Plants.—It has already been pointed out that certain of the chemical elements are necessary for the growth of plants (p. 3), and that these are derived partly from the surrounding atmosphere and partly from the soil. Those elements derived from the air are either themselves gases or exist in combination in the form of gas, and include oxygen, nitrogen in exceptional cases (p. 99), and carbon dioxide, the source of the carbon entering into the carbon compounds formed by plants.

The elements obtained by plants from the soil exist in combination with other elements and must be in the form of solution to be absorbed. The soil consists largely of mineral substances, together with certain organic products (humus). The water held in the soil not only acts as a medium for carrying the soluble constituents in the soil to the plant, but is itself an important food product, being the source of the hydrogen used by plants, as also of assimilable oxygen. Among the mineral constituents of the soil that are useful to plants are ammonium salts and nitrates, sulphates, phosphates, chlorides, silicates and carbonates. When plants are collected and subjected to a temperature of about 110° C. the water is driven off, and then if heat sufficient to incinerate the material be applied the organic matter is driven off in the form of gases, leaving the mineral constituents in the form of ash, as calcium, magnesium, iron, potassium, sodium and a few other elements.

Root Absorption.—Notwithstanding the various agents which are at work tending to break down and dissolve the substances contained in the soil, as soil bacteria, the liquids given to the soil by the roots of the plants themselves, the presence of the so-called humic acids, and the action of water and air, it has been shown that the soil water is an exceedingly weak solution. This is largely due to the peculiar absorptive and fixing power of the soil itself.

The dilution of the aqueous solution of the soil constituents is a matter of very great significance, for upon this depends its absorption by the root hairs. While other parts of roots have certain absorptive powers, the root hairs have been defined as the organs of absorption of the plant. They are very delicate in structure and contain protoplasm. Their absorbent function depends upon the principle that when a membrane (animal or vegetable) is interposed between two liquids of unequal density, the less dense liquid will pass through the membrane and mix with the denser liquid. This process is known as OSMOSIS, and when a liquid passes outward through a membrane or cell-wall it is called exosmosis, and when inward it is called endosmosis. The soil is made up of minute earth particles, each of which is surrounded by a thin film or envelope of water, and it is this portion of the soil liquid that is absorbed by the root hairs. The root hairs come into close contact with these soil particles; in fact, appear to grow fast to them, and the cell-liquid in the root hairs being denser than that surrounding the soil particles, the latter passes through the wall into the root hairs.

If, on the other hand, the water supplied to the roots of plants should contain an excess of soluble material, the plant will be injured. In this case exosmosis ensues and the plant loses some of its own liquids or cell-sap and will show signs of wilting. It is well known that if cultivated plants are supplied with strong solutions of fertilizer the plants will be injured rather than benefited.

ROOT PRESSURE.—The distribution of the water absorbed by the roots to other parts of the plant is influenced by a number of factors, which are commonly spoken of together as root-pressure. Among these are osmosis within the plant, due to unequal density of the liquids in different cells; the changes in the equilibrium of the cell-liquids, due to chemical changes, and the transpiration of water from the leaves, thus establishing a flow of liquids from the roots upward, which is usually spoken of as the ASCENT OF SAP. The cell-sap passes upward through the xylem for the most part carrying constituents obtained from the soil to the growing parts, where they are combined with the products of photosynthesis, and through a series of reactions protoplasm is finally built up.

OXIDATION.—The free oxygen taken in by plants through the stomata and lenticels serves the same purpose in plants as that inhaled by animals, namely, the oxidation of certain compounds, whereby part of the energy necessary for vital activity is liberated. Oxygen is required by all parts of the plant. When the roots of plants, such as those of *Zea Mays*, are surrounded by water so as to exclude the air the plants will become yellow. Germinating seeds consume a large amount of oxygen, but not all the energy formed is used by the plantlet, much of it escaping as heat, as in the germination of barley in the preparation of malt (p. 575). Those plants dependent upon the presence of free atmospheric oxygen are called AEROBES, while those which are not thus dependent, as certain fungi and bacteria, are called ANAEROBES.

METABOLISM.—Processes of construction and destruction are going on simultaneously in the plant, and these are all grouped under the general name of metabolism. The processes whereby complex substances are built up from simpler ones, as in photosynthesis, are together spoken of as CONSTRUCTIVE METABOLISM (anabolism), while those which involve the breaking down of complex compounds into simpler ones, either through oxidation or other chemical action, as when sugar is changed into carbon dioxide and water, are grouped under the head of DESTRUCTIVE METABOLISM (catabolism).

Inasmuch as the carbon dioxide of the atmosphere and the water taken up by the roots together with the mineral salts which it holds in solution are the only sources of the food supply of green plants, it follows that the highly complex proteins trace their origin to these comparatively simple substances. By some it is supposed that the final stages in the building up or synthesis of the proteins take place in the leaves, but it is probable that they take place in all the growing parts of the plant. It has already been stated in the paragraph on proteins that seeds contain reserve materials which are broken up into simpler compounds through the action of certain enzymes, and thus made available for the seedling. It is claimed that these compounds are principally amino acids, and that of these aspartic and glutaminic acids occur in largest amount and that these two acids are found in different relative amounts in different plants. It is furthermore claimed by some authors that by certain syntheses these compounds are respectively converted into asparagin and glutamin, both of which occur as reserve materials in seeds and in other parts of plants as well. Yet other syntheses take place whereby asparagin and similar bodies are converted into albumin and other proteins. In the Coniferæ the part played by asparagin and glutamin in protein syntheses is taken by arginin, which substance is found in considerable amount in the seeds of the plants of this group.

CHAPTER IV.

CLASSIFICATION OF ANGIOSPERMS YIELDING VEGETABLE DRUGS.

INTRODUCTORY.

INASMUCH as the plants yielding drugs and proximate principles, represent a large number of families it will be found that the study of the important characters of these groups will give a rather comprehensive view of the important groups of the Angiosperms. Reference will also be made to other economic products yielded by the angiosperms, as food-products, fibers, coloring principles, woods and timbers, as well as to the plants commonly cultivated for ornamental purposes.

Drugs which are recognized by the pharmacopœias are said to be official. It should be understood that those referred to in this book as being official are those recognized by the United States Pharmacopœia.

Nomenclature.—The names first given to plants consisted of a single Latin name, as Quercus, Rubus, Rosa, etc. Later some of the names applied to plants were obtained from the Greeks through Latin literature, as Aristolochia, Colchicum. The list of classical names was added to from time to time from both the Latin and Greek, as Convallaria, Glycyrrhiza, etc. Later the names applied to plants in other countries were Latinized, as Datura from the Arabic, Guaiacum from America. Since very early times the names of distinguished men have been applied to plants, as Asclepias which was dedicated to Æsculapius, and Linnæa which was named after the great Swedish botanist Linnæus. When it was found that there were different kinds of plants in what had been considered a single type these were distinguished by the addition of other names indicating their specific characters, and in this way plant names became quite long and cumbersome. Botanical science is indebted to the Swedish botanist Linnæus for proposing names for plants separate from their description. He reduced plant names to two: a generic name and a specific name. The specific name is the name applied to plants which are of one kind, and these constitute a SPECIES; and the generic name is that applied to a group of nearly related species, each group constituting a GENUS. Thus the oaks make up a genus of plants to which the Latin name Quercus signifying "beautiful tree" is applied. But we know that the oaks are not all alike and different names are applied to the different kinds, as the white oak which has the specific name *alba;* the plant therefore is known scientifically as *Quercus alba;* while the black oak is known as *Quercus velutina.*

Nearly related genera are brought together in groups known as FAMILIES. Thus we have the Mint Family known as the Labiatæ, which comprises a number of related genera, such as Mentha, Hedeoma, Salvia, etc. Still larger groups of related families make up ORDERS, as the Graminales, including the Gramineæ or Grass Family and the Cyperaceæ or Sedge Family. Orders make up classes and sub-classes, as the Monocotyledons and Dicotyledons.

The names of genera consist of one word which is a singular Latin noun, and are derived in various ways, as Sanguinaria, so named because of the red or sanguine character of the juice; Castanea which is named from Castanea in Thessaly the home of the chestnut; Ricinus from the Latin word meaning "bug," because of the resemblance of the seed to a bug; Digitalis, so named from the finger-shaped corolla.

Specific names are generally adjectives and must agree in gender with the generic name. Thus we have *Medicago virginica* in which the endings are feminine; *Lepidium virginicum* in which the endings are neuter, and *Sporobolus virginicus* which has masculine endings. Like the generic name the specific name is derived in various ways, but it usually indicates some peculiarity of the plant. Thus the specific name in *Gentiana lutea,* refers to the golden-yellow flowers; in *Conium maculatum,* the specific name has reference to the brownish-purple spots on the stem; in *Brassica nigra,* the word *nigra* has reference to the black seeds; in *Aristolochia reticulata,* the specific name refers to the reticulated leaves; and in *Phytolacca decandra,* the word *decandra* has reference to the ten stamens.

A. CLASS MONOCOTYLEDONS.

The Monocotyledons are mainly distinguished as follows: The embryo has only one cotyledon; the leaves are mostly scattered and parallel-veined; the fibro-vascular bundles of the stem are of the closed type, and the flowers are typically trimerous.

I. ORDER GRAMINALES OR GLUMIFLORÆ.

This order is composed of the two families, grasses (Gramineæ) and sedges (Cyperaceæ).

a. GRAMINEÆ OR GRASS FAMILY.—The plants of this family are nearly all herbs having cylindric, generally hollow culms with swollen nodes. The leaves are exactly alternate, and have long sheaths which are split or seldom closed, tubular, and nearly always with a distinct ligule. The flowers are mostly hermaphrodite and borne in spikelets with alternate floral-leaves, the spikelets themselves being borne in spicate or paniculate inflorescences. Each spikelet (Figs. 125, 126) consists of two (seldom more) empty glumes, which are the lowest floral-leaves in each spikelet; a varied number of flowering glumes, frequently awned or toothed, which follow inside the empty glumes, and each of which subtends a short branch (the rhachilla), the latter bearing an adorsed fore leaf (the pale), which is generally two-keeled and two-toothed, enclosing two minute scales (lodicules) and the flower. The flower has mostly three stamens (there being six stamens in Oryza and Bambusa), with the anthers versatile, and a simple gynæcium consisting of one carpel having two styles and a plumose stigma. The ovary is unilocular with one ascending or pendulous ovule. The fruit is a nut (grain caryopsis), the seed being always firmly united with the thin pericarp (except in Sporobolus, Eleusine, etc.). The embryo is situated at the base, on the outer convex surface of the seed, outside the endosperm. On germination the cotyledons remain in the seed.

The endosperm contains numerous starch grains and oil, while the gluten layer around the endosperm contains proteins. The number of layers of gluten- or aleurone-containing cells varies in the different cereals. In corn, wheat and rye it consists of but a single layer; in oat and rice, of 1 or 2 layers; while in barley it is made up of 2 to 4 layers.

The Grasses comprise about 3500 species and are distributed in all parts of the world. While most of the plants are grass-like still some of them, as the bamboos of the Tropics, become quite tall, having woody silicious stems and bearing many branches in the axils of the leaves. They yield the cereal grains forming so

FIG. 123. FIG. 124.

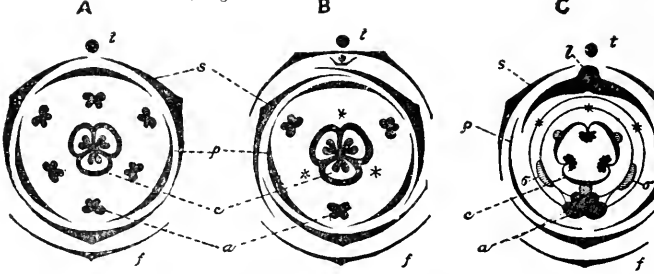


FIG. 123. Diagrams of cross-sections of monocotyledonous flowers: t, stem of plant; f, bract; s, sepals or outer circle of perianth; p, petals or inner circle of perianth; a, stamens; c, ovary. A, regular flower of the lily; B, irregular flower of iris. FIG. 124. C, flower of an orchid, in which l is the lip and δδ the two staminodes.—After Warming.

large a proportion of the food of man, and forage constituting the food of many of the lower animals. The following are some of the important cereals: Wheat (*Triticum sativum* and its varieties), corn (*Zea Mays*), oat (*Avena sativa*), rice (*Oryza sativa*), barley (*Hordeum sativum* and its varieties), rye (*Secale cereale*). A number of the species yield a sweet cell-sap from which cane sugar is made, of which the most important are the sugar cane (*Saccharum officinarum*) and sorghum (*Andropogon arundinaceus saccharatus* and other varieties).

A large number of the grasses are used in medicine, one of which, couch-grass (*Agropyron repens*), is official (p. 490).

Agropyron repens is a common perennial grass, forming slender jointed rhizomes, by means of which the plant is extensively propagated; the culms vary from one to four feet in height, the spikelets are 3- to 7-flowered; and the empty glumes, 5- to 7-nerved, acute or with an awn-like apex.

Hordeum sativum is an annual grass with the flowers in terminal cylindrical spikes resembling wheat. The spikelets are sessile, 1-flowered, and usually in clusters of three on opposite sides of the notched rachis. The empty glumes are long and narrow,

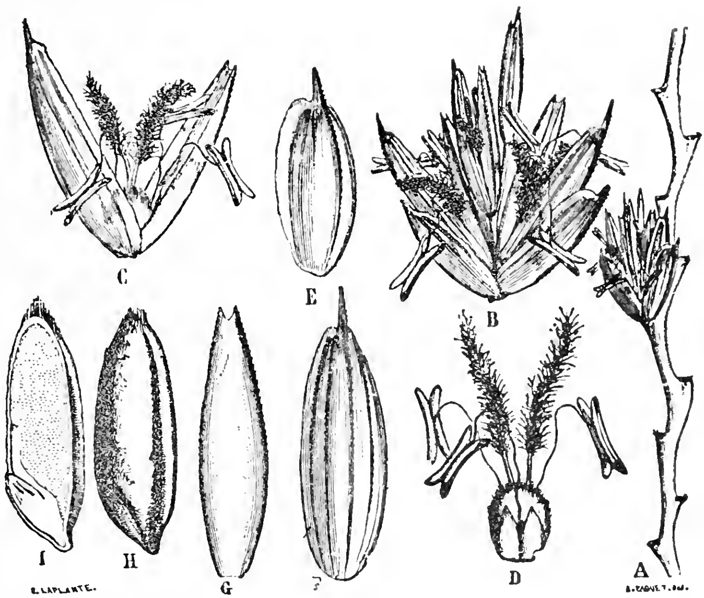


FIG. 125. Wheat (*Triticum*): A, zigzag axis or rachis of ear showing the notches where the spikelets were inserted; B, an entire spikelet; C, a flower with the pales; D, a flower without the pales, showing the lodicules at the base; E, glume; F, outer pale; G, inner pale; H, fruit (*caryopsis*); I, longitudinal section of fruit.—After Warming.

forming a kind of involucre around the spikelet. It is supposed that *Hordeum sativum* is a cultivated form of *H. spontaneum* growing in the countries between Asia Minor and other parts of Western and Southwestern Asia. Three important varieties are distinguished depending upon the number of rows of grains in the ear. *H. sativum distichon* includes the plants having 2-rowed ears and these are chiefly grown in Middle Europe and England.

H. sativum hexastichon includes the plants having the grains in six rows, these having been cultivated since prehistoric times and now cultivated in Southern Europe. *H. sativum vulgare* includes the plants in which the grains are in four irregular rows, and these are cultivated in northern temperate regions. The latter plant is cultivated in the United States and furnishes the grain used in the preparation of malt (p. 575).

Zea Mays (Indian Corn) is a cereal plant probably indigenous to Central Mexico. It is extensively cultivated in the United States and other parts of the world for its grain. From a multiple, primary, somewhat fibrous root arise one or more erect simple

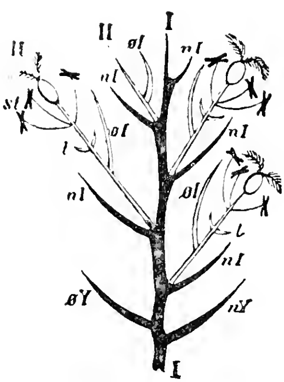


Fig. 126. Diagrammatic outline of a spikelet: nY, lower glume; ϕ Y, upper glume; nI, outer pale; ϕ I, inner pale; l, l, lodicules; st, stamens; I–I, main axis; II, lateral axes or branches.—After Warming.

culms, which are grooved on alternate sides in the successive internodes and from the nodes of which arise aerial secondary roots. The leaves are alternate and consist of three parts: (a) a blade, which is long, broadly-linear and tapering toward the apex, the tip being pendulous; (b) a lower sheathing portion which is open; and (c) a short, translucent, somewhat hairy ligule, situated between the sheath and the blade. The flowers are monœcious, the staminate, which are arranged in a terminal panicle, maturing first: the pistillate occur in axillary spikes, the axes of which constitute the corn cob. They are enclosed in spathe-like bracts or husks, from which the long filiform styles

(p. 558) protrude. The grain is somewhat ovate or triangular, flattened, pointed at the base, grooved on one side, indicating the position of the embryo, from 10 to 15 mm. long and about 10 mm. broad, more or less translucent, and varies in color in the different varieties. The constituents of the corn grain are 50 to 75 per cent. of starch; about 10 per cent. of proteins; 4.29 per cent. of a fixed oil; about five per cent. of sugar, and 1.29 per cent. of ash.

There are a large number of varieties and sub-varieties of *Zea Mays*, some of the former being ranked as species. The following well defined varieties may be mentioned:

(1) *Zea Mays everta*, to which belong the POP-CORNS. The size of the ears and grains is about one half or less that of the other corns; the grains have a more or less translucent and horny endosperm, the cells of the latter containing numerous compactly arranged polygonal starch grains, which are from 7 to 10 μ in diameter and have a central rarified area from 2 to 7 μ in diameter. It is owing to the structure of the starch grains that the peculiar popping of the corn grains results when they are heated. Heating the corn grains at 145° to 160° C. for from 4 to 10 minutes causes the bursting of the starch grains, and at the same time a rupture of the cells and splitting of the pericarp into 4 parts. The white appearance of the popped grains in due to the inclusion of air in the bursted cells. During the heating the starch is converted into a soluble form and this gives popped corn its nutritive value. Some of the flint and dent corns show a similar tendency to pop when heated, but it is only in those parts of the endosperm that are horny and the cells of which contain compactly arranged polygonal starch grains in which the rarified area is at least from one-tenth to one-fifth the diameter of the entire grain. Pieces of the pop-corn, as well as the horny portions of some of the flint and dent corns, will pop as readily as the whole grains.

(2) *Zea Mays indentata* yields the DENT OR FLINT CORNS, the grains of which have a corneous (horny) endosperm on the sides and are indented at the summit, owing to the shrinking of the cells which contain more cell-sap and less compactly arranged starch grains.

The starch grains in the cells of the horny endosperm resemble those of pop-corn, but the starch grains in the other cells are more or less rounded or slightly polygonal, and vary from 5 to 25 μ in diameter; the central rarified area is either wanting or usually not more than 2 μ in diameter.

(3) *Zea Mays saccharata* yields the SUGAR CORNS. While the grains are more or less translucent and horny, they have a wrinkled or shrivelled surface. The cells of the endosperm contain gum-like substances and a relatively small number of nearly spherical starch grains from 4 to 10 μ in diameter.

BROOM CORN (*Andropogon arundinaceus vulgare*) is a plant which is cultivated for the panicles or seed heads, which are used in the manufacture of brooms. This plant differs from the other species of Andropogon in that the branches of the panicles are longer, straighter and stronger, forming a so-called "brush."

Quite a number of the grasses contain odorous principles, as *Andropogon citratus* which yields lemon-grass oil; *A. Schœnanthus* which yields gingergrass or geranium-grass oil; *A. squarrosus* the rhizome of which is known as Vetiver. Coumarin is found in Vanilla grass (*Anthoxanthum odoratum*) and white or Dutch clover (*Hierochlœ odorata*). Some species of Stipa are used in the manufacture of paper (Alfa or Esparto) in North Africa and Spain.

b. CYPERACEÆ OR SEDGE FAMILY.—These plants are all herbaceous, the majority being perennial (seldom annual). The rhizomes are mostly sympodial (being monopodial, however, in certain Carices), and the stems are mostly solid and triangular, without swollen nodes. The leaves are grass-like, generally arranged in three rows, and the sheath is closed, being mostly without ligules. The flowers may be hermaphrodite or unisexual, sometimes diœcious, and arranged in spikes or racemes. The perianth is wanting or only represented by six bristles, or by an indefinite number of hairs. The number of stamens is three, with the anthers attached by their bases to the filament. The gynæcium consists of 2 to 3 carpels, with one style divided into 2 or 3 branches, and provided with papillæ. The fruit is a nut, whose seed is generally united with the pericarp. The embryo is small and lies at the base of the seed in the central line, surrounded by the endosperm. On germination, the cotyledon is freed from the seed.

A number of the sedges yield food products, as the rhizomes of *Cyperus esculentus* and *Eleocharis tuberosa*, the latter of which is used in the manufacture of starch in China and India. Quite a number of species of Scirpus, Cyperus, Carex, etc., are used in medicine. Various species of Cyperus (*C. scariosus*, of the East Indies, and *C. pertenuis*, of India) yield ethereal oils and are used in making perfumery. *Cyperus Papyrus* is also used in medicine and furnished the paper of the Ancients.

II. ORDER PRINCIPES.

In this order is included that interesting group of tropical and sub-tropical plants the PALMS (Palmæ). They are arborescent, having simple unbranched trunks which are terminated by clusters of leaves, in the axils of which flowers are produced. The leaves are pinnate (Feather Palms) or palmate (Fan Palms) and often very large. The petiole is well developed with an amplexicaul, more or less fibrous sheath. The inflorescence is usually lateral, in some cases forming a large spadix with a woody, boat-shaped spathe. In comparison the individual flowers are very small. The fruit is either a berry, as in the Date palm, or a drupe, as in the Cocoa-nut palm, generally 1-seeded and with a large horny or bony endosperm, as in the Date palm (p. 233) and *Phytelephas macrocarpa*, the latter of which yields vegetable ivory, used in the making of buttons (Fig. 173).

The fruit of the saw palmetto [*Serenoa (Sabal) serrulata*], one of the fan palms, is official (p. 578). The saw palmetto is characterized by having a creeping root-stock or rhizome one end of which rises a short distance above ground, this portion being surmounted by a dense crown of leaves. The petioles are slender and spinose on the edges; the blade is fan-shaped and consists of a number of palmate divisions which are slightly cleft at the apex. The inflorescence is densely tomentose and shorter than the leaves. The fruit is a 1-seeded drupe (Fig. 251).

The palms yield a number of useful products. The Betel-nut palm (*Areca Catechu*) produces a seed having medicinal properties (Fig. 127). The seeds, known as ARECA NUT, are 20 to 25 mm. long, conical, grayish-brown, with numerous spiral, reddish veins, heavy, hard, somewhat aromatic, astringent and slightly acrid. They contain about 0.1 per cent. of an oily liquid alkaloid, arecoline, which chemically and in its physiological action resembles pelletierine; 14 per cent. of tannin, resembling catechutannic acid; gallic acid; a red coloring principle; and 14 per cent. of a fixed oil. They also contain 3 other alkaloids: arecaine, arecaidine and guvacine, but these do not seem to give the drug its properties.

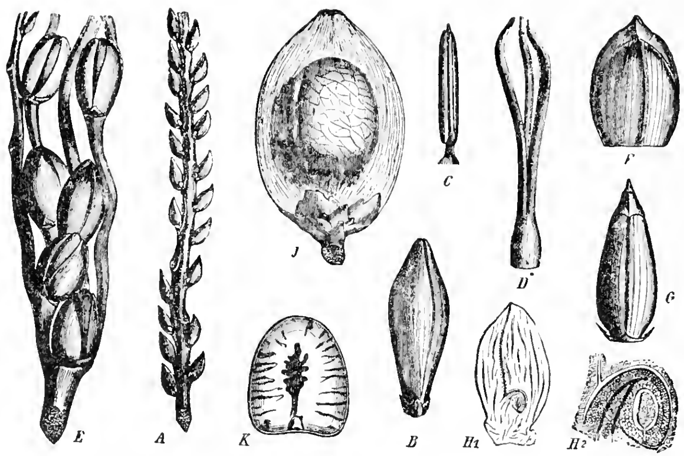


FIG. 127. *Areca Catechu* (Betel-nut palm). A, upper portion of an inflorescence bearing staminate flowers; B, enlarged view of staminate flower; C, 3 stamens; D, upper part of ovary with 3 styles; E, a branch bearing 4 pistillate flowers in the lower portion and 2 staminate flowers above; F, a pistillate flower with bracts removed showing the calyx; G, an ovary with rudimentary stamen; H1, longitudinal section through ovary; H2, the same giving a magnified view of the ovule; J, section through a berry showing the fibrous sarcocarp and the seed covered by reticulated branches of the raphe; K, section of seed showing the ruminating endosperm with small embryo near the base.—After Drude.

CARNAUBA-WAX is obtained from the Carnauba-palm of Brazil (*Copernicia cerifera*). The wax exudes from the surface of the young leaves and is obtained by boiling them with water. DRAGON'S BLOOD, a bright red resinous substance, is obtained from the juice of the fleshy fruit of *Calamus Draco*. It consists chiefly of resin, some tannin and about 3 per cent. of benzoic acid.

The Oil palm (*Elæis guineensis*) of equatorial West Africa yields a drupe with an oily sarcocarp, from which by means of pressure or boiling with water, PALM OIL is obtained. The Cocoa-nut palm (*Cocus nucifera*) yields the COCOA NUT of the market and is probably one of the most useful palms to the natives, furnishing as it does, food, clothing, utensils of all kinds, building materials, etc. The Sago-palms (*Metroxylon Rumphii* and *M. læve*) yield SAGO, which is prepared by washing out the starch from the cut stems and subsequently heating it. A tree 15 years old yields from three to four hundred kilograms of sago starch. The Date palm (*Phœnix dactylifera*) yields the DATES of the market, and it is interesting to note that since very early times the fruits produced by the growers in the Orient have been the result of artificial or hand-pollination.

III. ORDER ARALES OR SPATHIFLORÆ.

This order includes two families which are markedly different in their habits: (1) The Araceæ which are rather large herbs with an inflorescence known as a spadix and consisting of a fleshy spike, which is subtended or enclosed by a large bract known as a spathe, as in the Calla-lily where it is large and white, and (2) the Lemnaceæ or duckweed family, which is composed of minute, floating, thalloid plants that develop one or more flowers on the margin or upper surface of the thallus.

ARACEÆ OR ARUM FAMILY.—The plants belonging to this family are perennial herbs with tuberous or fleshy rhizomes and simple or compound leaves which are usually long-petioled. The spadix is densely flowered, the staminate flowers being above and the pistillate below on the same axis, or the plants are wholly diœcious. The perianth when present consists of 4 to 6 scale-like segments. Frequently the spadix is subtended or enclosed by a more or less showy spathe. The fruit is usually a berry, sometimes a utricle.

A number of the plants of this family have medicinal properties and one of them yields the official drug CALAMUS (p. 496). The drug is derived from sweet flag (*Acorus Calamus*) a plant common in swamps and along streams in the Eastern United States, and characterized by its long, narrow, linear, bilateral leaves which are from two to six feet high and one inch wide or less. The inflorescence is a spike-like spadix having greenish-yellow flowers.

Many of the Araceæ possess an acrid juice. The acridity is probably due either to saponin or an acrid volatile principle rather than to raphides of calcium oxalate. Frequently these principles are dissipated or destroyed on cooking and the plants are then used as food, as the WATER ARUM (*Calla palustris*),

FIG. 128. Vanillin, orthorhombic crystals obtained from saturated aqueous solutions.

which on account of its acrid principles is used as a remedy for snake bites when in the fresh condition, but which on drying loses its acridity and being rich in starch is used as a food (Fig. 128). To this family also belong Jack-in-the-pulpit, or INDIAN TURNIP (*Arisæma triphyllum*), the acrid corm of which is used in medicine; SKUNK CABBAGE (*Symplocarpus fœtidus*), the fetid rhizome of which has medicinal properties. A number of plants of the Arum family are rich in starch, as the tubers of *Xanthosome edule* of Surinam which contain 62 per cent. of starch.

IV. ORDER XYRIDALES OR FARINOSÆ.

The plants are mostly perennial herbs of tropical and subtropical America. The order includes a number of families among which is BROMELIACEÆ, to which the pineapple (*Ananas sativus*) belongs. PINEAPPLE is a native of Brazil and is now cultivated in warm countries of the eastern and western hemispheres. The fruit contains a proteolytic enzyme resembling trypsin and also a milk-curdling ferment. The bast fibers of the leaves are used for textile purposes. Some of the Bromeliaceæ are epiphytic (air-plants), the best known member being probably the FLORIDA MOSS (*Tillandsia usneoides*) which is used in upholstery.

The family Commelinaceæ is represented in the United States by Commelina or day-flower, some species of which have medicinal properties. The roots of some tropical species contain saponin, as *C. deficiens,* of Brazil. The rhizomes of a number of species of Commelina contain notable quantities of starch and are edible. The spiderworts (Tradescantia) common in rich soil in the United States, and the Wandering Jew (*Tradescantia Zebrina*) commonly cultivated as an ornamental plant, also belong to this family.

V. ORDER LILIALES OR LILIIFLORÆ.

The plants of this order are mostly perennial herbs with rhizomes, tubers, bulbs, or fibrous roots. The leaves are parallel-veined.

a. LILIACEÆ OR LILY FAMILY.—The plants are the most typical of the Monocotyledons. They are scape-like herbs with bulbs; the flowers are symmetrical, and the perianth is parted into six more or less distinct segments (Fig. 123): the anthers are introse (123, *A*). The ovary is free, 3-locular, with a single style, and the fruit is a 3-locular, loculicidal dehiscent capsule. The following plants yield official drugs:

Veratrum viride is a plant two to eight feet high, which is characterized by the broad, clasping, strongly plicate leaves, and by having the flowers in large terminal panicles (Fig. 129). The plant is found in swamps and wet woods in the United States in spring and early summer. The rhizome is upright, and is the part used in medicine (p. 492). The plant including the rhizome closely resembles the *Veratrum album* of Europe.

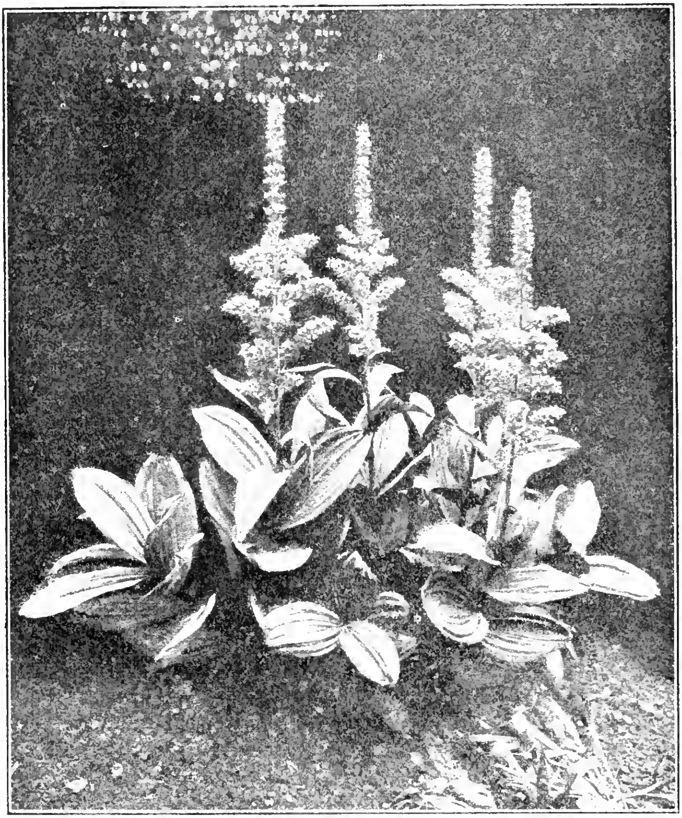


FIG. 129. Plants of *Veratrum viride* growing in the Royal Botanic Society's Gardens (London) and showing the parallel veined (or nerved) leaves with entire margin, and the large terminal panicles of flowers.—After Perredès.

Colchicum autumnale.—This is the autumnal-flowering colchicum, a perennial herb but a few inches high which arises from a corm and bears proportionately large lilac-colored flowers. The fruit consists of three follicles containing numerous seeds. The corm (p. 509) and seeds (p. 426) of this and other species of Colchicum are the parts used in medicine.

Aloe species.—The stems are about a meter high and bear at the summit a cluster of thick succulent leaves which are lanceolate and spinous-toothed. The inflorescences are in long spikes

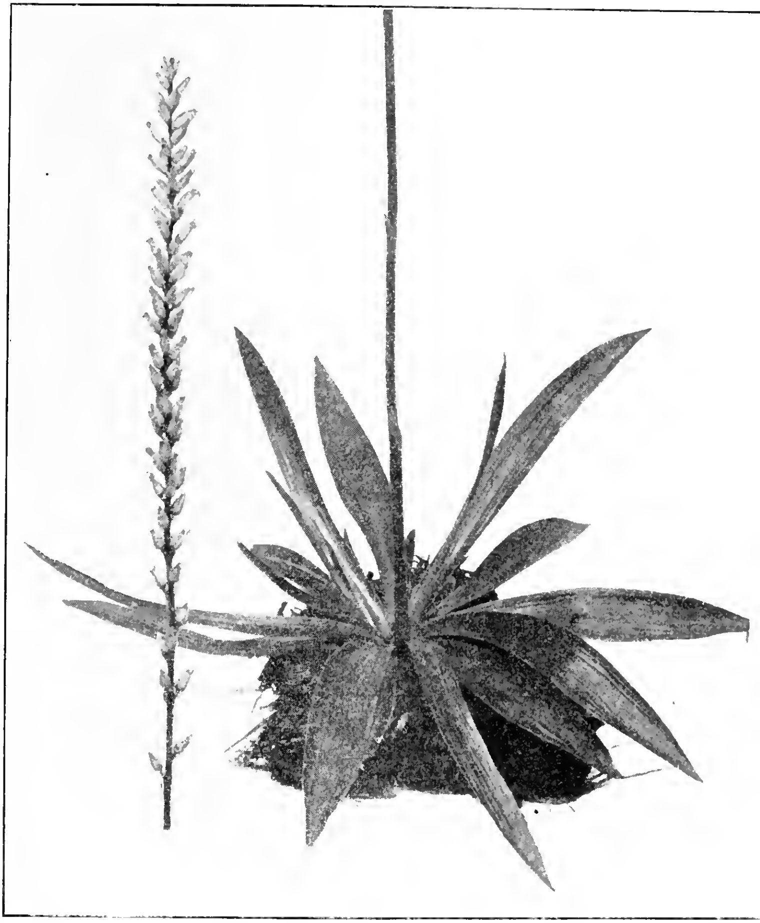


FIG. 130. Plant of *Aletris farinosa* showing characteristic rosette of lanceolate leaves at the base and portion of long slender scape with numerous tubular flowers. The plant is common in dry coniferous woods in the eastern part of the United States.

which are quite showy and characteristic for the different species. *Aloe Perryi* which yields the SOCOTRINE ALOES possesses leaves with white spines and flowers that are orange-red or scarlet at the base, the stamens being unequal; *Aloe vera* which yields the Barbadoes or Curaçao aloes has leaves with yellow or reddish spines and yellow flowers in which the stamens are as long as the corolla (Fig. 130); *Aloe spicata* and some other African species which yield Cape aloes, have flowers in close spikes, the petals being white and marked by green lines, and the stamens much longer than the corolla. The inspissated juice is official in all the pharmacopœias (p. 661).

Urginea maritima, which yields the drug squill, is characterized by its large onion-like bulb, from which arise ten to twenty broadly lanceolate, grayish-green leaves; and by having the inflorescence in long spikes consisting of whitish flowers which have a distinctly purple stripe on each division of the perianth (p. 510).

Convallaria majalis or Lily-of-the-valley is a plant which is well known. It produces a raceme of delicately odorous white flowers and beautiful oblong leaves with prominent parallel veins. The rhizome and roots are official (p. 488).

Smilax species.—The drug sarsaparilla (p. 446) is yielded by a number of species of Smilax. These are mostly vines with woody or herbaceous, often prickly stems and leaves with petioles which have a pair of persistent tendril-like appendages. The flowers are small, mostly greenish, diœcious and in axillary umbels. The fruit is a globose berry. Not a great deal is known of the species which yield the drug, with the exception of *Smilax medica* which yields the Mexican sarsaparilla. In *Smilax medica* the leaves vary from more or less cordate to auriculate-hastate; in *Smilax officinalis* which yields the Jamaica sarsaparilla they are ovate, as they are also in *Smilax papyracea* which yields Para sarsaparilla. Nothing is known of the plant yielding Honduras sarsaparilla, although this drug has been in use for nearly four centuries. The plants have short rhizomes which give rise to long roots which are the part used in medicine.

A dragon's blood, resembling that derived from *Calamus Draco* (p. 232) is obtained from *Dracæna Draco,* a tree growing in the Canary Islands. Some of the trees of this species are of historic interest, as the dragon tree of Orotava which is 46 feet in circumference at the base.

A number of the plants of this family contain saponin, as the species of Smilax. Some contain coniferin and vanillin, as *Asparagus officinalis.* Some of the group contain glucosidal principles which under the influence of ferments yield ethereal oils containing sulphur, as the various species of Allium.

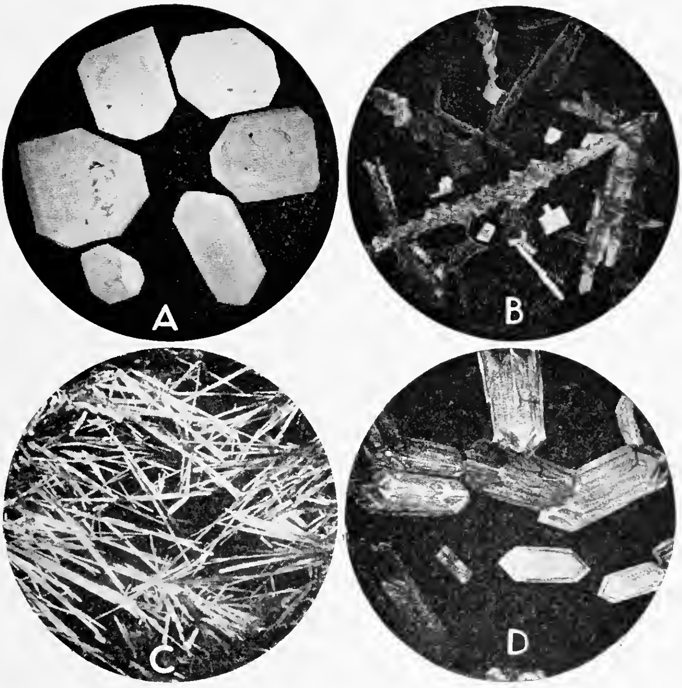


Fig. 131. Coumarin. Type A, tabular crystals obtained by cooling melted coumarin to 54°–56° C.; type B, aggregates of tabular crystals; type C, needles; type D, short prisms obtained from hot aqueous solutions.

A number of plants of the Liliaceæ are used as vegetables as the onion and asparagus. Garlic (*Allium sativum*) contains a glucoside, alliin, which on hydrolysis with an oxydase (allisin) forms the essential oil of garlic. A number also are quite poisonous when fresh but edible when cooked.

b. AMARYLLIDACEÆ OR AMARYLLIS FAMILY.—This group is of special interest because it includes the Agave or Century plant. This is a characteristic genus of plants of the hot and arid regions of North America. The best known of these is the CENTURY PLANT (*Agave americana*) which is one of the most important economic plants of Mexico. The stem axis of the plant is very short and the thick fleshy leaves form a tuft at the tip. The leaves are lanceolate, with spinose margins, and furnished with stout terminal spines. The leaves as well as the roots contain a large amount of mucilage which retains water and thus helps to adapt the plants to these arid regions. The plants grow slowly and may flower when they are ten or twelve years old.

The Agaves contain saponin and other principles of medicinal value. They yield a number of other products as follows: PULQUE a fermented drink of the Mexicans, MEZCAL a distilled drink resembling rum; various fibers, as SISAL HEMP, "Henequen" or "Sacci," etc. Other members of the Amaryllidaceæ likewise find use as medicines and as foods, many of them being cultivated as ornamental plants, as Narcissus, Hymenocallis, Crinum and Amaryllis.

c. DIOSCOREACEÆ OR YAM FAMILY.—The plants belonging to this family are twining shrubs or herbs with tubers either above or below ground. The general characters of the plants are shown in the wild yam-root (*Dioscorea villosa*) of the United States. Several species, notably, *D. Batatas*, yield the YAMS or Chinese potatoes of commerce.

Many of the species of Dioscorea, as well as other members of this family contain active principles which like those of the Araceæ and Liliaceæ are destroyed on heating. The rhizome of *Tamus communis* contains saponin and *Rajania subamarata* contains tannin.

d. IRIDACEÆ OR IRIS FAMILY.—The plants of this family are perennial herbs with mostly equitant (bilateral) leaves and horizontal rhizomes, or corms. The flowers are regular or irregular and with a petalloid stigma (Fig. 124, *B*).

Iris versicolor is a flag-like plant commonly known as the LARGER BLUE FLAG and found abundantly in the marshes and wet meadows of the Eastern United States. It is distinguished by its tall stems and sword-shaped, somewhat glaucous leaves. The flowers are violet-blue. The rhizome somewhat resembles that of calamus, but is of a dark brown color and contains 25 per cent. of acrid resins, a volatile oil, starch and tannin.

Iris florentina, which yields the ORRIS ROOT of commerce (p. 795), is a plant cultivated in Middle and Southern Europe, and closely resembles the above mentioned species. The rhizome contains a volatile oil resembling that found in violets, and is used in perfumery. Orris root is also obtained from *Iris germanica* and *I. pallida*. The violet odor is developed on keeping the rhizome a year or two.

Crocus sativus, the orange-red stigmas of which have been used in medicine since ancient times, is an autumnal-flowering plant. The flowers are lilac-purple, somewhat like those of Colchicum, and occur at the tip of a scape rising 15 to 20 centimeters above ground. The leaves are linear and rise directly from a more or less globular corm. The plant is cultivated in Spain and other parts of Europe and in the United States as well. The stigmas constitute the drug SAFFRON (Crocus) which was formerly official, and contain a coloring principle, 1 part of which will impart a distinct yellow color to 100,000 parts of water. Saffron contains a yellow glucoside, CROCIN, which is soluble in alcohol but not in water, and is colored blue by sulphuric acid. The drug also contains 7.5 to 10 per cent. of a volatile oil, which appears to be derived from a coloring principle that resembles carotin; and the bitter principle picro-crocin.

e. JUNCACEÆ OR RUSH FAMILY.—These are grass-like marsh plants, which are distinguished by the fact that the flowers are small, with 6-parted glumaceous perianth, and the fruit is a loculicidally dehiscent capsule. The stems are mostly solid, slender, usually arise in tufts from the rhizome and are characterized by stellate parenchyma cells, among which are large intercellular spaces, the latter also being characteristic of the leaves. The rushes are principally found in cold and temperate regions.

Several species of Juncus and Luzula have been used in medicine, particularly in Europe. The seeds of *Luzula campestris*, a common wood rush of the United States naturalized from Europe, are edible. Soft rush (*Juncus effusus*) and Hard rush (*J. conglomeratus*) are used in Japan in the manufacture of rush matting. In Holland the rush is grown on the embankments along the coast to prevent the action of the tides.

VI. ORDER SCITAMINALES OR SCITAMINEÆ.

The plants of this order are mostly found in the Tropics and are perennial herbs with fleshy rhizomes. The leaves are large, more or less elliptical and pinnately veined. The leaf sheaths close tightly around each other and form a kind of false stem. The flowers are epigynous, unsymmetrical or zygomorphic, and frequently only one stamen is completely developed.

a. THE ZINGIBERACEÆ OR GINGER FAMILY is distinguished from the other Scitamineæ by the fact that the seeds have endosperm as well as perisperm. The plants are rich in volatile oils and a number are used in medicine and perfumery.

Zingiber officinale yields the official ginger (p. 486). From a creeping, fleshy, branching and laterally compressed rhizome arises a stem about 1 M. high bearing numerous lanceolate leaves. The flowering stalk arises directly from the rhizome, terminating in a spike which bears flowers having greenish-yellow petals with violet or purple stripes (Fig. 132).

Elettaria Cardamomum (*E. repens*) yields the cardamom of the several pharmacopœias (p. 581). The plant has a leafy as well as floral stem which rises from a tuberous rhizome. The leaves are broadly lanceolate. The flowers are greenish-white, the labellum (consisting of two petal-like staminodes) being bluish. The fruit is a capsule, and the seeds are the part used in medicine.

The so-called PARADISE GRAINS are the seeds of *Amomum Melegueta* growing in Western Africa. They are about 3 mm. in diameter, dark brown, nearly smooth, friable and contain a volatile oil.

GALANGAL, which is used in perfumery, is the rhizome of *Alpinia Galanga* growing in the East Indies and cultivated in China and Bengal. It is frequently referred to as "Galangal major" to distinguish it from the rhizome of *Alpinia officinarum* growing in China near Hainan. Galangal occurs in short, branched pieces of a reddish-brown color, with numerous circular scars and has an aromatic and pungent taste. It contains 0.5 per cent. of a volatile oil, the principal constituent of which is cineol; a

FIG. 132. *Zingiber officinale*, the rhizome of which constitutes the ginger of the market. Entire plant showing rhizome and roots, a leaf-branch and a flower-branch, as also scars of previous year's growth after decay of leaf- and flower-branches. A, entire flower; B, section of flower showing beak-like appendage at the apex of the fertile stamen, which encloses the style; C, three-parted labellum or irregular segment of corolla showing 2 tooth-like staminodes (rudiments of stamens) at the base; D, the ovary with lower portion of style and two epigynous, filiform processes which secrete nectar; E, apex of funnel-shaped, fringed stigma.—After Berg and Schmidt.

pungent principle, galangol; an acrid, pungent resin; 25 per cent. of starch; and three crystalline principles.

CURCUMA OF TURMERIC is the rhizome of *Curcuma longa*, a reed-like plant which is largely cultivated in India and other tropical countries. In preparing the rhizome for market it is subjected to a scalding or par-boiling process which agglutinates the starch in the cells. While turmeric is used as a condiment it is also used on account of its color as an adulterant of mustard and other articles, but is very easily detected (Fig. 290). Several forms of curcuma are found in commerce, as "round curcuma," consisting of the main rhizome, and "long curcuma," composed of the short branches. They occur in cylindrical or ovoid pieces, 2 to 5 cm. long, of a yellowish-brown color externally, bright yellow internally, and aromatic odor and taste. Curcuma contains 1 per cent. of volatile oil containing phellandrene and turmerol; 0.3 per cent. of a yellow crystalline principle, CURCUMIN, which is soluble in alcohol, sparingly soluble in water, forms reddish-brown solutions with alkalies and is converted into vanillin with weak oxidizing agents. It also contains considerable starch and a small quantity of an alkaloid.

Other families of the Scitamineæ are of great importance on account of the food-products obtained from them, as the *Musaceæ* which contains the group of plants to which the BANANA (*Musa paradisiaca* and *M. Sapientum*) belongs. To the *Cannaceæ* belong the cultivated Cannas, one of them, *Canna edulis*, being grown extensively in the West Indies and Australia as a vegetable, and another, *Canna coccinea*, which grows in the West Indies and South America furnishing "Tous les mois," the arrow-root starch of the English and French. To the *Marantaceæ* belongs *Maranta arundinacea*, which is cultivated in tropical America, and the rhizome of which yields the starch, MARANTA ARROWROOT (Fig. 316, *B*).

VII. ORDER ORCHIDALES OR MICROSPERMÆ.

The most important family of this order is the ORCHIDACEÆ or ORCHID FAMILY. The orchids are the most highly specialized of the Monocotyledons. They are perennial herbs with diverse habits, many tropical species being epiphytes, and varying morphological structure which is particularly evident in the zygomorphic flowers. The perianth consists of six segments. The three outer correspond to sepals and are similar. Two segments of the inner circle correspond to petals and are alike, while the third, which is known as the LIP, is remarkably modified, being usually larger, often spurred, and frequently reversed, being turned forwards and downwards by the twisting or torsion of the ovary. Only one of the stamens—the anterior of the external whorl—is developed and bears an anther. The other stamens are entirely wanting or present as staminodes (except in Cypripedium and the Apostasieæ). The filament is united with the style to form a column, the so-called "stylar column" and the anther is thus placed on its apex, and behind the stigma. The 3 carpels form a unilocular ovary with 3 parietal, deeply bifid placentæ. The fruit (Fig. 256) is a capsule, which dehisces mostly by means of 6 valves, and contains numerous minute seeds, which are without endosperm, and the embryo of which lacks frequently any trace of external organs. The seed coat is membranous and loose.

Vanilla planifolia, which yields the official vanilla, is a high-climbing plant with long internodes and distinct nodes from which arise more or less oval or broadly lanceolate, somewhat fleshy leaves and also commonly a single aerial root. The long stem is terminated by a raceme, flowers also arising in the axils of the leaves for some distance back on the stem. The flowers are yellowish-green and the segments of the perianth are similar, and erect or spreading. The lip is united with the column, forming a cylindrical body which is strongly concave on one side and spreading at the upper portion. The pollinia are granular. Pollination may be effected by insects but is usually brought about by artificial means (hand-pollination). The fruits require several months to become fully grown and an equal period of time is necessary for their maturity which is indicated by their yellow color. They are then gathered and cured by alternately steaming and drying them when they acquire the dark brown color and the odor of the commercial article. Vanilla is cultivated in all tropical countries where the temperature does not fall below 18° C., and the humidity is considerable. Usually vanilla culture is combined with that of Cacao. The plants begin to yield fruits the third year and continue bearing for thirty or forty years (p. 585).

The yellow-flowering Cypripediums of the United States (*C. parviflorum* and *C. parviflorum pubescens*) yield the cypripedium of the Pharmacopœia (p. 490). The plants are a foot or two high. The leaves are oval or elliptical (in the latter) or

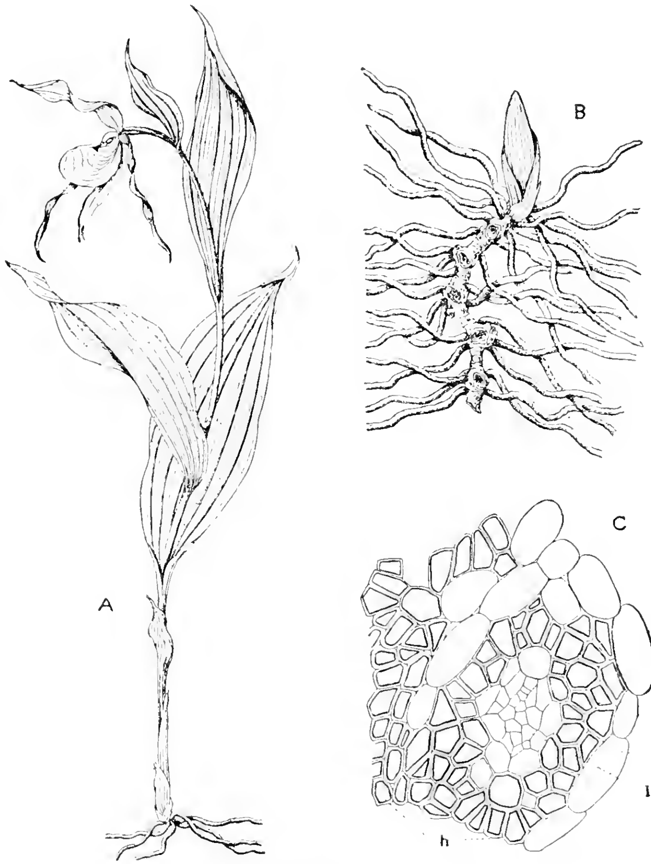


FIG. 133. *Cypripedium parviflorum pubescens.* A, flowering plant; B, rhizome seen from above; C, cross-section of a leptocentric mestome strand from the rhizome showing parenchyma (p), hadrome (h), and leptome (l).—After Holm.

elliptical or lanceolate (*C. parviflorum*). In *C. pubescens* the lip is pale yellow with purple veins, 25 to 50 millimeters long, and possesses a tuft of white, jointed hairs at the throat. In *C. parviflorum* the lip is smaller and non-hairy.

The root-stocks of a number of Orchids are rich in mucilage and yield the drug salep or a product resembling it. Salep occurs in the form of globular or somewhat flattened, more or less translucent, light yellowish-brown tubers, 2 to 4 cm. long, of a horny texture and a mucilaginous taste. The principal constituent is mucilage which originates in the cell-contents. It may contain in addition either starch or sugar.

B. CLASS DICOTYLEDONS.

The following are some of the prominent features of the Dicotyledons: (1) The leaves are reticulately (open) veined and usually with an irregular margin, being sometimes deeply lobed; (2) the parts of the flower are usually in circles of 2 to 5 each; (3) the stems and roots generally increase in thickness by means of a cambium, and the vascular bundles are open, varying from simple collateral to bi-collateral; annular rings are formed in the perennial stems; (4) the germinating plant usually has two cotyledons which are opposite each other. The Dicotyledons are divided into two series or sub-classes, depending upon whether the parts of the corolla are distinct or are united, namely, the Archichlamydeæ and Metachlamydeæ.

ARCHICHLAMYDEÆ OR CHORIPETALÆ.

The Archichlamydeæ or Choripetalæ comprise those dicotyledonous plants in which the petals are separate and distinct from one another or are entirely wanting.

I. ORDER PIPERALES.

The plants of this order are mostly tropical herbs and shrubs and possess very small flowers which have neither petals nor sepals. The leaves are simple and without stipules, the most important family medicinally as well as in other ways being the PIPERACEÆ, to which the following medicinal plants belong.

Piper nigrum is a woody climber that has leathery, grayish-green, ovate, cordate or ovate-elliptical leaves, with three prom-

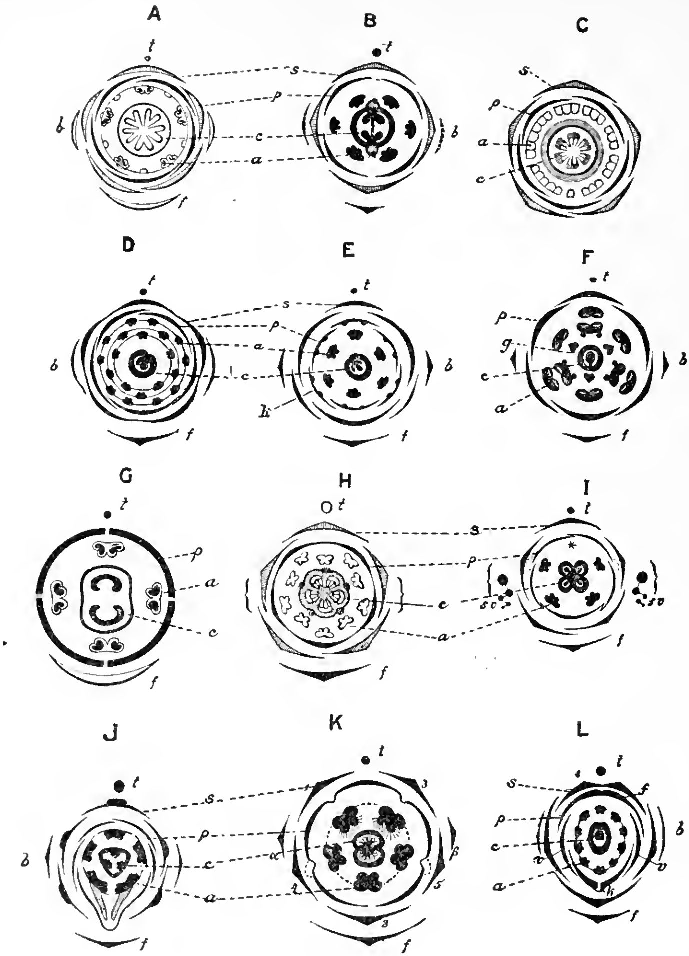


FIG. 134. Diagrams of cross sections of the flowers of a number of families of dicotyledonous plants showing the number and position of the parts with reference to each other: t, stem of plant; f, foliage leaf; b, bracts or leaves on the flower-stalk; s, sepals; p, petals; a, stamens; c, ovary; per, perianth. A, Linaceæ; B, Cruciferæ; C, genus Citrus; D, Rosaceæ; E, Berberidaceæ, showing nectaries (k) on the petals; F, Lauraceæ, showing staminodes (g); G, epigynous flower of Rubiaceæ; H, Ericaceæ; I, Labiatæ, showing position of other flowers (sv) in the cymes; J, Violaceæ showing spurred stamens; K, Campanulaceæ, showing bracts (α, β) the relation of the sepals (1, 2, 3, 4 and 5), and two posterior hairy stamens; L, Leguminosæ, showing the large posterior petal (p) known as the vexillum or standard, the two lateral petals (v) situated under the standard known as alæ or wings, and the two anterior petals which are covered by the wings and partly cohering to form a prow-shaped body called the carina or keel (k).—Adapted from Warming.

inent middle nerves and two side nerves; the flowers are perfect, sessile and form an elongated fleshy spike; the fruit is a berry which is yellowish-red when ripe. The unripe fruit constitutes the BLACK PEPPER of commerce (p. 571). WHITE PEPPER (p. 573) is the ripe berry from which the epicarp is removed, while "LONG PEPPER" (p. 573) is obtained from *Piper longum*, an entirely different plant.

Piper Cubeba is a climbing perennial with leathery elliptical-ovate or long elliptical leaves; the flowers are diœcious and arranged in spikes; the fruit is a berry, the pedicel becoming much elongated after fertilization. The unripe fruit is the part used in medicine and is official as cubeb (p. 569; Fig. 250).

Piper angustifolium yields the official MATICO (p. 617). The plant is a shrub growing in Central and South America and is characterized by its long, oblong-lanceolate, deeply reticulate, very hairy leaves. The flowers and fruits are very small and arranged in long, slender spikes, which are frequently found in the drug. Matico contains 2 to 3 per cent. of a volatile oil, containing a stearoptene matico camphor, which appears to be the most important constituent. It also contains an acrid resin, a bitter principle and a crystalline principle artanthic acid. Other related species of Piper are used in tropical America similarly to *Piper angustifolium*.

The leaves of a number of species of Piper (known as "betel leaves") are mixed with the Areca nut and lime and constitute what is known as "BETEL," which compound is used for chewing, in India and other countries, chiefly on account of its astringency. The root of *Piper methysticum* is also chewed, and when mixed with the milk of the Cocoanut yields an intoxicating drink which is used by the inhabitants of the Sandwich Islands. The dried root has been used in medicine under the name of METHYSTICUM or KAVA-KAVA. It consists of large, branching, soft, spongy, dark brown pieces, which are tough, fibrous and with a pungent, somewhat bitter taste. Kava-kava contains 3 resins, one of which has marked anæsthetic properties; an alkaloid, kavaine; a neutral body, methysticin; and about 50 per cent. of starch. The drug is free from calcium oxalate crystals, these being usually wanting in the Piperaceæ.

II. ORDER SALICALES.

This order comprises but a single family, namely, the SALICACEÆ or Willow Family, to which belong the willows and poplars. The plants are diœcious shrubs and trees; the flowers being in *aments* or *catkins* and without petals or sepals. The fruit is a capsule containing many seeds which are small and with long silky hairs at the base.

The barks of a number of the members of this group contain glucosides, as *salicin* which is found in *Salix alba* the white willow of Europe and the United States, and the brittle willow *Salix fragilis;* and populin which is found in the white or silver-leaf poplar (*Populus alba*) of Europe, Asia and the United States and *Populus pyramidalis* of Italy. These principles are also found in other species of willow and poplar. A number of the barks contain a yellow coloring principle allied to quercitrin, as *Salix daphnoides* of Europe and *Salix alba.* Tannin is a common constituent in both the willows and poplars. The buds of many of the poplars contain in addition a volatile oil which is in the nature of a di-terpene, as those of *Populus pyramidalis. Populus balsamifera,* the tacamahac or balsam poplar of the United States and Canada, furnishes the BALM OF GILEAD buds which are coated with an oleo-resin that gives them their aromatic properties. *Populus nigra* yields a volatile oil of which the important constituent is humulene.

The charcoal used medicinally is prepared by burning the wood of the young shoots of the white and black willow, poplar, beech or linden without access of air.

III. ORDER MYRICALES.

This group somewhat resembles the Salicales in that the flowers are in aments. The flowers are either pistillate or staminate and mostly diœcious in our native species. The most important family is the MYRICACEÆ or Bayberry Family. The genus Myrica is especially characterized by the fact that the outer layer of the drupe is waxy. This is particularly true of the following species: *Myrica cerifera* the wax myrtle of the sandy swamps of the United States contains a volatile oil. The fruit of sweet gale (*M. Gale*) yields a volatile oil containing a camphor. The sweet fern (*Comptonia peregrina*) found in the United States, yields a volatile oil resembling that of cinnamon. The rhizome of this plant contains also tannin and possibly gallic and benzoic acids.

IV. ORDER JUGLANDALES.

The plants are trees with alternate, pinnately-compound leaves. The staminate flowers are in drooping aments, the pistillate being solitary or several together. The flowers are monœcious and have a more or less distinct perianth consisting of three to six lobes. The fruit is a kind of drupe formed by the union of the torus with the wall of the ovary. There is but one family in this order, namely, the JUGLANDACEÆ (Walnut family), which includes the hickory (Hicoria) and walnut. The black walnut (*Juglans nigra*) of the United States yields a valuable timber and an edible nut; the white walnut or butternut (*J. cinerea*) of the United States yields the butternuts which are edible, and a bark which has medicinal properties and was formerly official under the name of JUGLANS. Butternut bark occurs in quills or channelled pieces of variable length, 2 to 10 mm. thick; it is dark brown externally; has a short, fibrous fracture, characteristic odor and bitter, pungent and acrid taste. It contains about 7 per cent. of a yellow, crystalline acrid principle which is colored purple with alkalies; 2 to 2.5 per cent. of a crystalline resin; volatile oil, tannin, sugar and a fixed oil.

J. regia native of Persia and cultivated in various parts of Europe and California, yields the edible ENGLISH WALNUT.

The following species of hickory yield edible nuts: The shell-bark hickory (*Hicoria ovata*); the pecan (*H. pecan*) common from Illinois southward; and western shell-bark hickory (*H. sulcata*). The wood of these as well as *H. glabra* and other species of hickory is used where strength and elasticity are required.

Coloring principles are found in the barks of a number of species and are used for technical purposes. The following contain yellow coloring principles: *Hicoria ovata, H. sulcata,* and *H. glabra* (pig-nut hickory); green coloring principles are found in *H. tomentosa,* and yellowish-brown principles in *Juglans nigra, J. cinerea* and *J. regia.*

The fatty oils from the cotyledons (kernels) of both hickory-nuts and walnuts are articles of commerce, and they have been used in medicine.

V. ORDER FAGALES.

The plants are trees or shrubs with alternate, petiolate, simple, pinnately veined leaves. The flowers are in aments, monœcious, and with a more or less distinct perianth. The fruit is a nut which is subtended by the mature involucre (bur or cup) or samara, the seeds being without endosperm (Fig. 135).

a. BETULACEÆ OR BIRCH FAMILY.—The plants are aromatic trees or shrubs and are represented in the United States by such trees as hornbeam (Carpinus), ironwood (Ostrya), and birch (Betula); and by such shrubs as the hazelnut (Corylus) and alder (Alnus). The plants yield a volatile oil consisting largely of methyl salicylate. The bark of the sweet birch (*Betula lenta*) yields the oil of betula which is official and closely resembles the oil of wintergreen. The bark of a number of plants of this family yields tannin and yellow coloring principles. A number of species of Betula yield a sweet sap, as *B. lenta,* and *B. Bhojpattra* of Russia. The nuts of some species are edible, as the filbert or hazelnut of Europe (*Corylus Avellana*), the hazelnut of the Orient (*C. Colurna*), the American hazelnut (*C. americana*).

b. FAGACEÆ OR BEECH FAMILY.—This family includes some of our largest forest trees, these being rather characteristic of temperate regions. They are all highly valued for their timber and yield other valuable products besides. One notable characteristic is that all of the chestnuts and oaks and some of the beeches contain tannin in the wood, bark and leaves. The oaks are further notable in being prone to the attack of gall-producing insects (various species of Cynips) whereby the peculiar excrescences known as galls are formed on the leaves and young shoots. Among the oaks which yield galls rich in tannin are the following: *Quercus infectoria* of the Mediterranean, which yields the Turkish or Aleppo galls which are official (p. 646); *Quercus Robur*, which is sometimes divided into *Q. pubescens* and *Q. pedunculata*, yields a European gall; the live oak (*Q. virginiana*) of Texas; and *Q. lobata* of California. Various oaks of the Southern States also produce "ink balls" or "ink galls," as *Q. coc-*

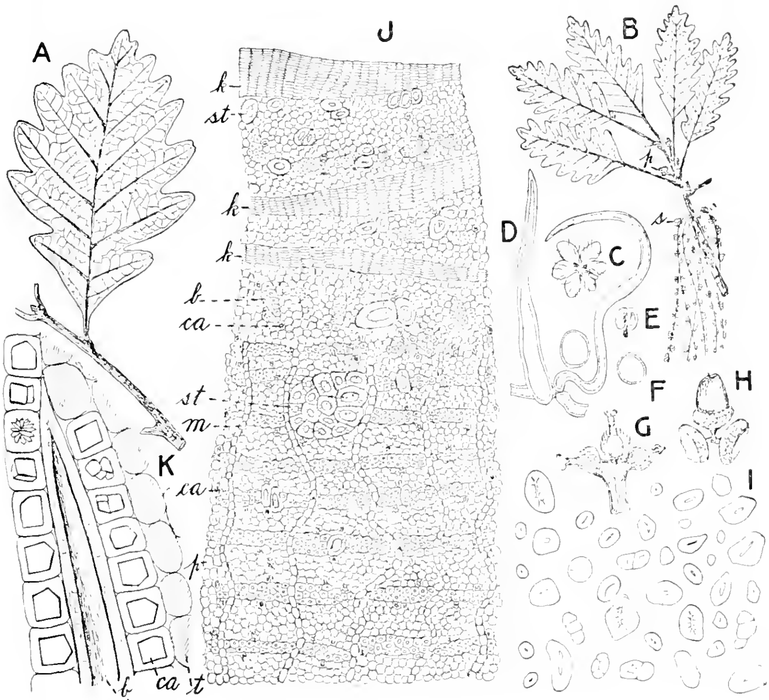


FIG. 135. White oak (*Quercus alba*): A, characteristic, lobed leaf; B, young branch showing pistillate (p) and staminate (s) flowers; C, hairy bracts of a staminate flower; D, group of hairs from bract; E, stamen; F pollen grains; G, cluster of pistillate flowers; H, acorn with cupule; I, starch grains from acorn, which vary from 10 to 25 μ long; J, transverse section of bark showing cork (k), stone cells (st), bast fibers (b), crystal fibers (ca), medullary rays (m), parenchyma (p); K, longitudinal section of bark showing end of bast fiber (b) crystal fibers (ca) and parenchyma cells (t) containing tannin.

cinea and *Q. imbricaria.* Several species of oak are used in the tanning industry, as that of white oak (*Quercus alba*), red oak (*Q. rubra*), Spanish oak (*Q. digitata*), and black oak (*Q. velutina*), all of North America; *Q. pedunculata* and *sessiliflora* of Germany, and *Q. dentata* of Japan.

The glucosidal coloring principle quercitrin is found in the bark of Quercitron or black oak (*Q. velutina*). *Q. coccifera* of Southern Europe yields a red coloring principle which is used in dyeing.

The wood of the American beech (*Fagus americana*) and of the European red beech (*F. sylvatica*) yields a tar from which on distillation the official CEOSOTE is obtained (p. 678).

The cork of commerce which is used for a variety of purposes is derived from the bark of several species of Quercus, namely, *Q. Suber* and *Q. occidentalis* growing in Spain, Southern France and Algiers.

The cotyledons of the seeds of the Beech family are rich in proteins, starch and oil, and some of the nuts are edible, as the Spanish CHESTNUTS obtained from *Castanea vulgaris*, American chestnut from *C. dentata* and CHINQUAPIN from *C. pumila* (Fig. 72).

VI. ORDER URTICALES.

This order embraces three families which, while they agree in certain characters, are quite distinct in other ways.

a. ULMACEÆ OR ELM FAMILY.—The plants are trees or shrubs with alternate, simple, serrate, petiolate leaves. The flowers are monœcious or diœcious, with a 4- to 6-divided perianth. The fruit is a 1-seeded drupe, samara or nut. The typical group of this family is that of the elms, of which the American or white elm (*Ulmus americana*) is the most prized for ornamental purposes. The elms yield valuable timber and the bark of *Ulmus campestris* of Europe is used for tanning and dyeing because of the presence of tannin and a yellow coloring principle.

The inner bark of the red or slippery elm (*Ulmus fulva*) is used in medicine on account of its mucilaginous character (p. 544; Fig. 99, *C*). The tree has a gray, fragrant bark; leaves which are very rough above and become fragrant on drying, and the wood is reddish-brown. The samara is not hairy as in some of the other species.

b. MORACEÆ OR MULBERRY FAMILY.—The members of this family are herbs, shrubs or trees, many of them containing a milk-juice or latex. There are many representatives in the tropical regions and some in temperate regions. The flowers are unisexual, with a 4- to 5-parted perianth and occur in spikes or ament-like clusters.

Cannabis sativa.—This is the plant yielding hemp and the drug Cannabis Indica (p. 635). The plant is an annual branching herb from 1 to 3 M. high. The leaves are alternate above, opposite below, digitate with 5 to 11 linear-lanceolate, serrate lobes (Fig. 273). The flowers are diœcious, the staminate occurring in panicles and the pistillate in erect simple spikes. The inner bark of the stem is fibrous and it is from this that the HEMP FIBER is prepared.

Humulus Lupulus or hop is a twining perennial plant, curving to the right, with opposite, palmately 3- to 7-lobed (or simply dentate above) rough leaves (Fig. 136). The flowers are diœcious, the staminate ones occurring in panicles and the pistillate in ament-like spikes. On the inner surface of each scale of the ament occur two flowers consisting of a membranous perianth and a bicarpellary ovary with two long styles. After fertilization the aments become cone-like and this compound fruit constitutes the hop of commerce. This fruit differs essentially from the true strobiles or cones of the Gymnosperms in that the seed in the latter is replaced by an akene. "Hops" are used in medicine (p. 582) and in brewing.

Ficus Carica, which yields the official fig, is a deciduous tree from 3 to 7 M. high, and with large, 5-lobed, petiolate leaves. The flowers are situated in a hollow torus, the walls of which after fertilization become thick and fleshy constituting the fruit (p. 590).

A large number of the plants belonging to the Moraceæ yield economic products, some of which, as the drug Cannabis indica obtained from *Cannabis sativa*, are extremely poisonous. HASHISH or BHANG is a preparation made from the dried leaves, stems and flowers of the pistillate plants and is smoked either alone or with tobacco, or chewed in combination with other substances, or an intoxicating drink is made from it, it being extensively used by the inhabitants of Arabia, Persia, India and other oriental countries. The leaves of *Ficus Ribes* of the Philippine and Molucca Islands are smoked like opium. The milk-juice of a number of plants belonging to the Moraceæ is the source of arrow poisons. The URARI POISON of Brazil is obtained from *Ficus atrox;* the IPOH ARROW POISON of Java and Borneo is derived from the Upas-tree, *Antiaris toxicaria.* Many of the plants of the group

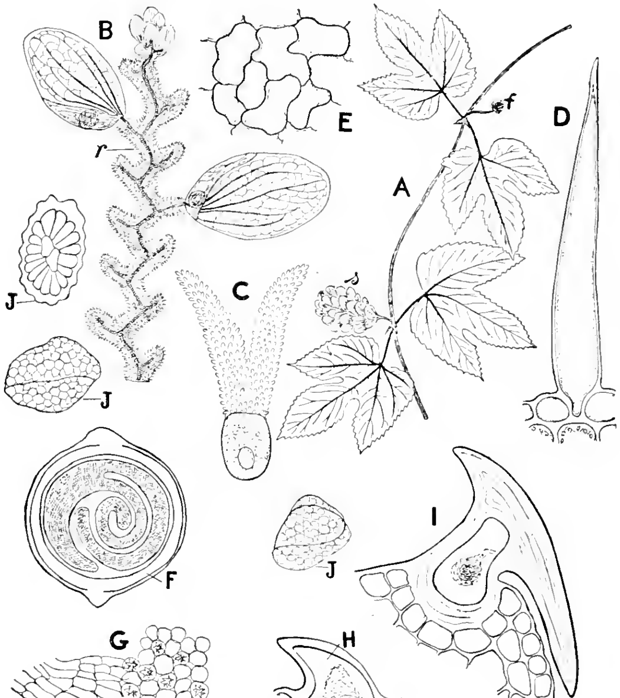


FIG. 136. Hop vine (*Humulus Lupulus*): A, portion of branch with pistillate flowers (f) and cone-like fruit (s); B, portion of rachis of strobile with two scales enclosing akenes; C, pistil; D, hair from rachis; E, epidermis of scale; F, longitudinal section of akene showing coiled embryo; G, surface view of bract showing epidermis and cells containing calcium oxalate; H, cystolith of leaf; I, cystolith of stem; J, glandular hairs (lupulin).

contain emetic principles, as the COCILLANA BARK of *Guarea Rusbyi,* a tree of Bolivia.

The milk-juice of quite a number of species of Ficus yields India-rubber or caoutchouc (p. 667), as *Ficus elastica* of the East Indies, *F. toxicaria* of South America, *F. elliptica* and *F. pri-*

noides of New Granada and several other species of Brazil, *Brosimum spurium* of Jamaica, *Cecropia peltata* of the West Indies and South America, and *Castilloa elastica* of Mexico and the West Indies. *Ficus benghalensis* of India and tropical Africa, and *Ficus Tsiela* of India, yield gum-lac. *Ficus altissima* and *F. religiosa* of tropical Asia yield shellac on puncture of the stems by a hemipterous insect (*Coccus lacca*).

A yellow coloring principle is found in *Cudrania javanensis* of tropical Asia and Africa, *Chlorophora tinctoria* of Mexico, *Maclura aurantiaca* (*Toxylon pomiferum*) or osage orange, a hedge plant of North America; *Ficus tinctoria* of the Friendly Islands and *F. asperrima* of India. A fixed oil is obtained from *Artocarpus Blumei* of Java.

A large number of the plants of the Moraceæ yield edible fruits besides the fig tree already described, as the BREAD-FRUIT trees (*Artocarpus incisa*) of the Sunda Islands and the JACK-TREE (*A. integrifolia*) of the East Indies, the WHITE MULBERRY (*Morus alba*) and the BLACK MULBERRY (*Morus nigra*).

The leaves of the white mulberry (*Morus alba*) indigenous to China and cultivated since the twelfth century in Europe and now in cultivation to a limited extent in the United States, are the chief food of the silkworm.

c. FAMILY URTICACEÆ.—The plants belonging to the Urticaceæ or Nettle Family are chiefly herbs with mostly petiolate, stipulate, simple leaves. The flowers are small and with 2 to 5 distinct or more or less united sepals. The fruit is an akene; the embryo is straight and surrounded by an oily endosperm. The stems and leaves of several of the genera are characterized by stinging hairs, this being especially true of the sub-group to which the genus Urtica or stinging nettle belongs. Of the stinging nettles the following are used in medicine: *Urtica dioica* of Europe and naturalized in the United States, *U. spatulata* of Timor, *Laportea crenulata* of tropical Asia, *L. moroides* of Queensland, and *Girardinia palmata* of India. In the small nettle (*Urtica urens*) of Europe and the United States an alkaloid has been found, and *Laportea stimulans* has been used as a fish poison. *Boehmeria cordata* of Brazil is used as a substitute for Arnica. The fibers of a number of the Urticaceæ have been found useful, of which the following may be mentioned: *Urtica cannabina* of Asia, *U. dioica*, *U. urens* and *Boehmeria nivea* of the Sunda Islands and China, the latter of which yields RAMIE. The akene of *Debregeasia edulis* of Japan and the rhizome of *Pouzolzia tuberosa* of China and Japan are edible.

VII. ORDER PROTEALES.

The members of this group are mostly shrubs and found principally in the Tropics and southern hemisphere, several species being cultivated in greenhouses for the sake of the beautifully colored flowers which are in crowded inflorescences. The order is represented by but a single family, namely, the Proteaceæ. The leaves are leathery and vary even on the same plant from simple to compound. The glucoside proteacin and a bitter principle are found in *Leucadendron argenteum* and *L. concinnum*, both of Africa. A gum-resin is found in *Grevillea robusta* of Australia, and a tannin in the bark of *Lomatia obliqua* of Chile.

A golden-yellow coloring principle is obtained from the flowers of *Persoonia saccata* of Australia. The wood of *Protea grandiflora* of Abyssinia is used in wagon building, and *Leucospermum conocarpum* of Cape Colony yields a valuable red wood and a tan bark.

Banskia æmula of Australia and the sugar-bush (*Protea mellifera*) of Australia and *P. speciosa* have a sugary cell-sap. The oily seeds of the Chilean hazelnut (*Guevina Avellana*) are highly prized as food by the inhabitants. The seeds of *Brabeium stellatifolium* or wild chestnut of Cape Colony are poisonous when fresh, but on roasting they become edible and are used as a substitute for coffee.

VIII. ORDER SANTALALES.

This order embraces a number of families which are quite distinct in several respects.

a. LORANTHACEÆ OR MISTLETOE FAMILY.—The plants are half-parasites with well developed leaves containing chloroplastids. They live on trees by means of haustoria. To this family belongs the American mistletoe (*Phoradendron flavescens*) parasitic on oaks, elms, the tupelo (Nyssa), red maple and other deciduous trees. The white, globose berries of this plant are quite poisonous, as are also those of the European mistletoe (*Viscum album*) and the oak mistletoe of Southern Europe (*Loranthus europæus.*) *Viscum album* contains a volatile alkaloid, VISCINE, a glucoside and a resinous principle. This substance serves to attach the seeds to the barks of trees, where they germinate, and it is used in the manufacture of BIRD-LIME, which owing to its viscid character is used to catch small birds.

b. SANTALACEÆ OR SANDALWOOD FAMILY.—The plants are chlorophyllous herbs or shrubs which are common in warm countries, and many of which are parasitic on the roots of other plants. A number of them contain volatile oils, as the wood of various species of Santalum. The official oil of santal is obtained from the scented wood of the white sandalwood (*Santalum album*) a small tree growing wild and also cultivated in India and the East Indian Archipelago. The wood from the East Indies is known as Macassar sandalwood and yields 1.6 to 3 per cent. of oil, while the Indian wood yields 3 to 5 per cent. The oil consists of 90 to 98 per cent. of santalol. Fiji oil of santal is obtained from *S. Yasi;* and Australian oil of santal from *Fusanus acuminatus* and *F. spicatus.* The Chinese oil is obtained from *Santalum Freycinetianum* and *S. Preisei.*

c. FAMILY BALANOPHORACEÆ.—The plants of this group are indigenous to tropical and sub-tropical regions. They are root-parasites and develop tuberous rhizomes and fleshy shoots which are yellow and without foliage leaves. *Balanophora elongata* of Java grows on the roots of Ficus and other plants, and contains a large quantity of wax and resin. *Sarcophyte sanguinea* of Cape Colony, which lives on the roots of certain Acacias, contains a principle with the odor of scatol. *Cynomorium coccineum*, found in the countries bordering the Mediterranean, has a blood-red, astringent sap. The torus of the flower of *Langsdorffia hypogæa* of tropical America is edible. The plant is also rich in wax and in New Granada it is sold under the name of "Siejas" and burnt like a candle.

IX. ORDER ARISTOLOCHIALES.

This order includes two families which are very different in their general habits. (a) The Rafflesiaceæ are parasitic herbs that are almost devoid of chlorophyll. The reddish vegetative parts penetrate into the tissues of the host and from these arise almost mushroom-like flowers which in the case of *Rafflesia Arnoldii* of Sumatra are 1 M. in diameter, being probably the largest flowers known. The plants of this family are rich in astringent substances.

b. ARISTOLOCHIACEÆ OR BIRTHWORT FAMILY. The plants are non-parasitic herbs or shrubs, some of which are twining. The leaves are simple and in many of the plants more or less cordate and reniform. The flowers are perfect and the perianth is 3- to 6-lobed. While the flowers of our native species are rather small and insignificant those of the tropical plants are extremely curious, being generally of some striking color and of various odd forms.

Aristolochia reticulata is one of the plants that furnishes the official drug serpentaria (p. 501). From a slender rhizome with numerous hair-like roots, arise one or more short, leafy branches which are more or less simple, somewhat hairy, and bear oblong-cordate, prominent-reticulate, hairy leaves (Fig. 137). The flowers are borne on slender, scaly, basal branches; the calyx tube is purplish and curved like the letter "s," being enlarged around the ovary and at its throat. The fruit is a capsule containing numerous flat or concave seeds. An allied species *Aristolochia Serpentaria* furnishes the drug Virginia snakeroot. It is a more delicate plant, the leaves being ovate-lanceolate, acuminate; the flowers are solitary, and in some cases cleistogamous. This species is found growing in the United States, more especially east of the Mississippi, while *Aristolochia reticulata* is found west of the Mississippi from Arkansas to Texas. The plants of this genus contain volatile oils and in addition to the two species mentioned forty-five other species are used in medicine in varous parts of the world.

Asarum canadense (Canada snakeroot or wild ginger) is a plant common in the Northern United States and Canada (Fig.

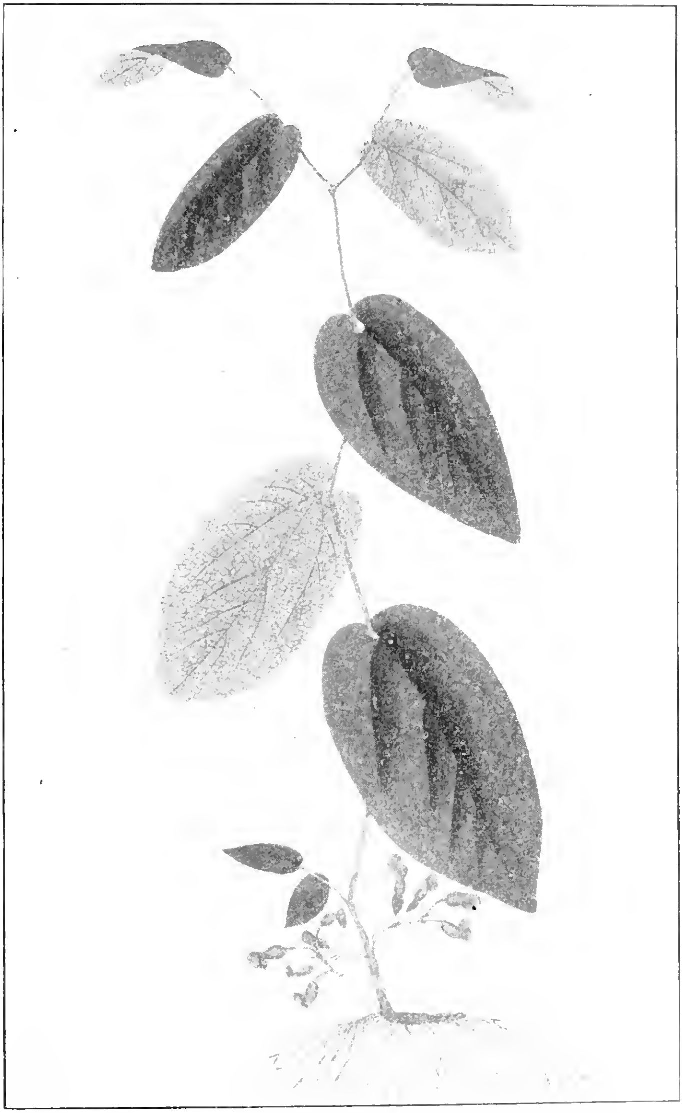


FIG. 137. Southern serpentaria (*Aristolochia reticulata*) showing the cordate, reticulately-veined leaves, and the clusters of irregular flowers on the lower part of the stem. —After Carson.

78, *B*). The long and slender rhizomes are used in medicine. They are 5 to 15 cm. long, about 2 mm. thick, more or less bent and curved, purplish-brown externally; whitish internally; the bark is thick, wood with about 12 fibrovascular bundles, pith large; the odor is aromatic; the taste pungent and bitter. The drug contains 2 to 3 per cent. of a volatile oil containing a fragrant body, asarol; a pungent, fragrant resin; a yellow coloring principle which is colored dark green with ferric salts; and starch. The volatile oil obtained from *A. europæum* contains a principle (asarone) which forms irritating vapors on heating.

X. ORDER POLYGONALES.

This order is represented by a single family, the POLYGONACEÆ or Buckwheat family. The plants are mostly herbs but include some twining vines and shrubs. The leaves are simple, mostly entire, and characterized by having a stipulate appendage (ocrea) which sheaths the stem. The flowers are small, perfect and with a 2- to 6-parted perianth. The fruit is a 3- to 4-angled akene. The embryo is either straight or curved, and the endosperm is mealy.

Rheum officinale is the source of the "South China" rhubarb from Szetschuan (p. 474). The plant is a perennial herb resembling the garden rhubarb (Fig. 205). The rhizome is vertical and gives rise to a leafy branch terminated by the inflorescence which is a panicle. The leaves are large, with a sub-cylindrical petiole, a cordate or orbicular lamina which is either entire or coarsely and irregularly dentate. There are several nearly related species which also yield the drug. *Rheum palmatum* of Northern China has leaves which are lobed or deeply incised, which character is especially marked in the variety *tanguticum*. *Rheum Rhaponticum*, which yields English rhubarb, has leaves which are heart-shaped at the base and with a more or less irregularly undulate margin. All of these species are more or less common in cultivation in botanical gardens in Europe.

Rumex crispus or curled dock is a perennial herb growing in fields and waste places in the United States and parts of Canada. The leaves are oblong-lanceolate, with an undulate margin and rather long petiole. The flowers have a 6-parted, dark green

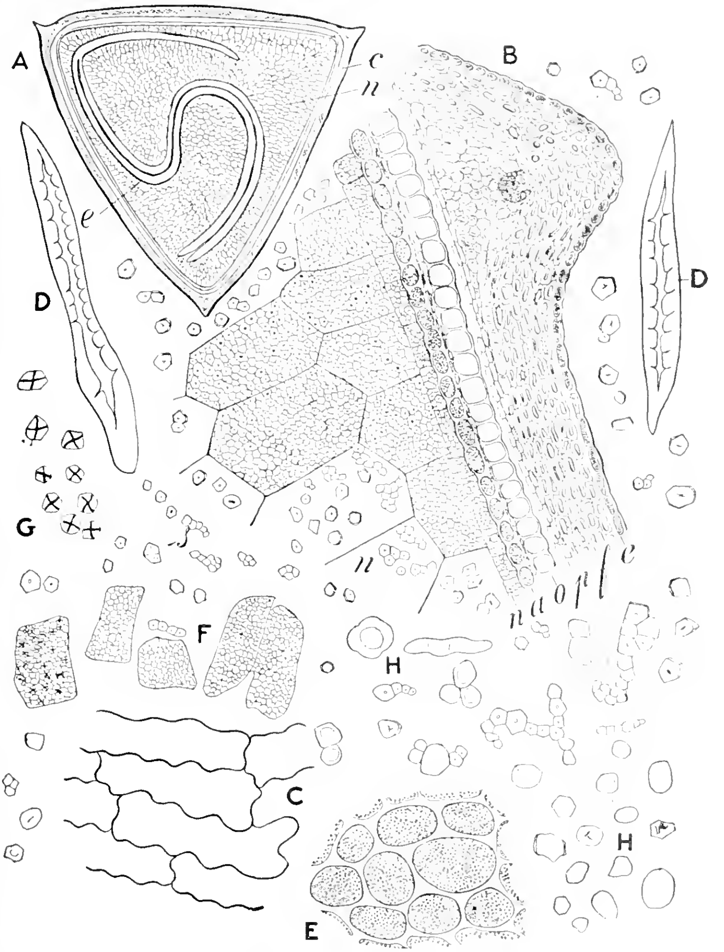


FIG. 138. Buckwheat (*Fagopyrum esculentum*): A, transverse section of grain showing pericarp (c), endosperm (n) and slender coiled embryo (e); B, transverse section of portion of grain showing epicarp (e), fibrous layer (f), pigment layer (p), outer epidermis of spermoderm (o), aleurone cells (a), endosperm cells containing starch (n); C, surface view of cells of epicarp; D, isolated fibers of pericarp; E, surface view of aleurone cells; F, isolated parenchyma cells of endosperm filled with starch grains as seen in buckwheat flour; G, appearance of starch grains when mounted in oil and viewed with polarized light; H, swollen and altered starch grains which are two to three times the size of the normal grains.

perianth, and are perfect or polygamo-diœcious. The fruit is a dark brown, cordate-winged, 3-angled akene. The dried root is somewhat fusiform, reddish-brown and with a bitter, astringent taste. It contains chrysophanic acid, tannin, calcium oxalate and some of the other constituents found in rhubarb.

Rumex Acetosella (field or sheep sorrel) is a slender annual herb with hastate leaves, having flowers in compound racemes. The leaves contain oxalic acid, both free and in combination with calcium and potassium.

Tannin is obtained from a number of the plants belonging to the Polygonaceæ, as the root of *Rumex hymenosepalus* of Texas which is known as CANAIGRE; the rhizome of *Polygonum bistorta* of Europe which yields the drug BISTORTA.

Polygonum cuspidatum of the gardens contains emodin; polygonin, a glucoside yielding emodin; and probably emodin methyl ether. *Rumex ecklonianus* of South Africa contains emodin, a volatile oil and a resin. The latter consists of emodin monomethyl ether; chrysophanic acid, physosterol (resembling rhamnol), etc. *Polygonum Hydropiper* and *P. aviculare*, both common in the United States, are poisonous to sheep.

A number of the plants of this family yield food products. Buckwheat is the fruit of *Fagopyrum esculentum* indigenous to Central Asia and cultivated in many parts of the world.

Some are also cultivated as ornamental plants, as the Prince's feather (*Polygonum orientale*).

XI. ORDER CHENOPODIALES OR CENTROSPERMÆ.

This order includes seven families, in all of which the embryo is curved or coiled, and the reserve consists chiefly of perisperm.

a. CHENOPODIACEÆ OR GOOSEFOOT FAMILY.—The plants are annual or perennial herbs with simple leaves and small perfect flowers, the fruit being a utricle. The fruits of a number of the group contain volatile oil, and are used in medicine, as the common wormseed (*Chenopodium anthelminticum*), which is found in waste places in the United States, an allied species *C. ambrosioides*, and other species of Chenopodium as well. Spanish wormseed is obtained from *Anabasis tamariscifolia*.

Chenopodium mexicanum yields saponin. *Atriplex hortensis* of Tartary yields indigo. The ash of very many species of

Atriplex as well as genera of the Chenopodiaceæ yields soda. The seeds of several species are edible, as of *Chenopodium viride* of Europe and Asia, *C. Quinoa* of Chile, etc. Seeds of *Spinacia tetrandra* of the Orient are used in bread-making.

A number of species are used as garden vegetables, as spinach (*Spinacia oleracea*) (Fig. 121, *C*) and beet (*Beta vulgaris*).

The SUGAR BEET (*Beta vulgaris Rapa*) which contains from 4 to 15 per cent. of cane sugar (sucrose) is largely cultivated in Germany, as well as to some extent in the United States, and is an important source of cane sugar. While the juice of the beet contains a larger amount of nitrogenous substances than that of the sugar cane it is practically free from invert sugar.

b. AMARANTACEÆ.—The plants are weed-like and much resemble the Chenopodiaceæ. They yield anthelmintic principles, edible seeds, and the leaves of a number of species are used as vegetables. The ash yielded by some species contains potash, as *Achyranthes aspera* and *Amaranthus ruber*. Some are ornamental plants having a fasciated inflorescence, as the Cock's-comb (*Celosia cristata*).

c. NYCTAGINACEÆ OR FOUR-O'CLOCK FAMILY.—The plants are mostly herbs growing in America. The leaves are entire and simple, and the flowers are regular and in terminal or axillary clusters. The perianth consists of a 4- to 5-lobed corolla-like calyx. The most common representative of this family is the Marvel-of-Peru or four-o'clock (*Mirabilis Jalapa*). While this plant is an annual in the United States, in the Tropics the tuberous root is used as a substitute for jalap, and is sometimes sold for it. The seeds of this plant are edible, as are also the leaves of several species, as of *Bœrhavia erecta*, which are used as green vegetables. Some members of the group, as *Bougainvillea spectabilis*, are handsome plants with bright rose-colored bracts which envelop the small greenish flowers.

d. PHYTOLACCACEÆ.—The plants of this family are mostly tropical and are represented in this region by only one species, namely, the common poke (*Phytolacca decandra*), the root (p. 465) and fruit (p. 466) of which are used in medicine. This is a succulent, branching herb 1 to 4 M. high, having a large perennial root. The stem is hollow except for the thin, papery partitions.

The leaves are simple, ovate-lanceolate (Fig. 139). The flowers are in racemes and characterized by having ten stamens. The fruit is a dark purple, juicy berry.

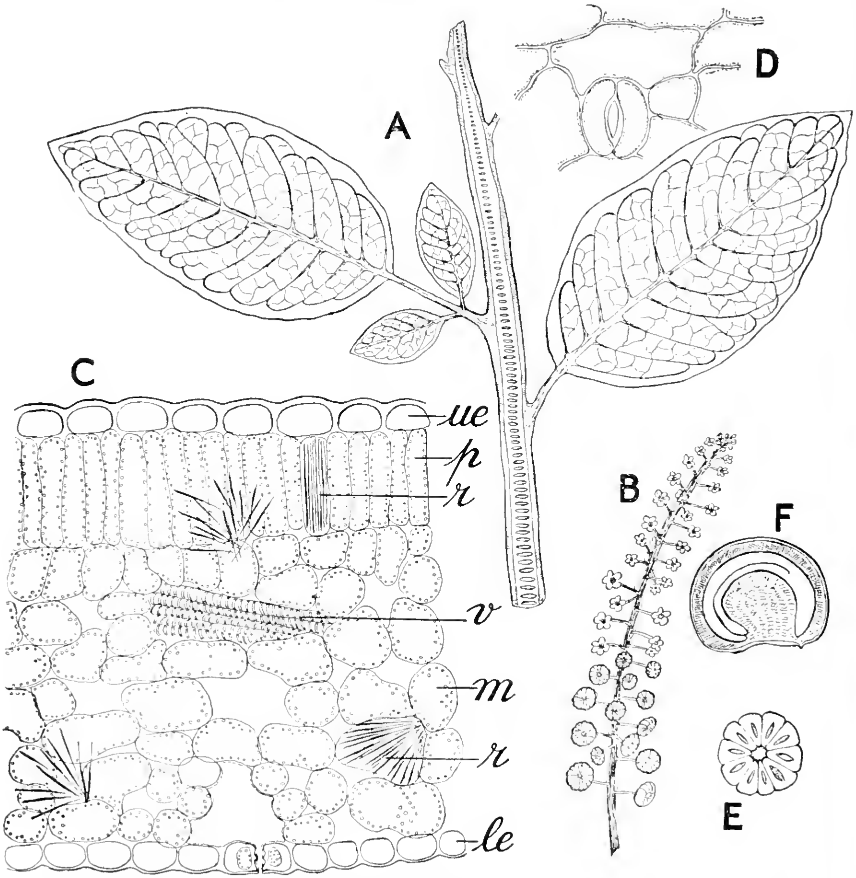


FIG. 139. Poke weed (*Phytolacca decandra*): A portion of shoot showing leaves and stem which has a large pith with bi-convex cavities resembling the pith of certain xerophytic *Compositæ*, as *Senecio præcox* of Mexico; B, raceme showing fruits at the lower end and flowers at the upper end; C, transverse section of leaf showing upper epidermis (ue), palisade cells (p), raphides (r), spiral tracheæ (v), parenchyma (m) with large intercellular spaces, lower epidermis (le); D, stoma of lower surface of leaf; E, transverse section of fruit; F, longitudinal section of seed, the embryo being curved and the endosperm containing starch.

The roots of this species as well as others contain powerful drastic principles, as *Pircunia littoralis* and *Anisomeria drastica* of Chile. *Phytolacca abyssinica* contains saponin, and a red coloring principle is found in the berries of *Phytolacca decandra* and *Rivinia tinctoria* of Venezuela. The leaves of some species of Phytolacca are used as greens.

e. AIZOACEÆ.—This is a group of mostly tropical plants, very many of them having fleshy leaves and adapted to arid regions. Many of the plants, particularly those belonging to the genus *Mesembryanthemum*, are much prized on account of their beautiful flowers, which expand only in the sunshine. The common ice-plant of the gardens, so called because of the numerous glistening globules of water which cover the leaves, is *M. crystallinum*. This plant as well as other species of Mesembryanthemum are used in medicine. The ashes yielded by the plants of this family also contain soda. The seeds of some species of Mesembryanthemum as well as other members of this family are edible, and the leaves of some species are used as vegetables like lettuce.

f. PORTULACACEÆ.—The plants are fleshy or succulent herbs mostly indigenous to America. The two common representatives are the spring beauty (*Claytonia virginica*), the tubers of which are rich in starch, and purslane (*Portulaca oleracea*) sometimes used as a green vegetable. The seeds of the latter plant as well as of other species of Portulaca are used in medicine.

g. CARYOPHYLLACEÆ.—The plants are annual or perennial herbs often swollen at the nodes, with opposite, entire leaves, and usually perfect regular flowers. The perianth has a distinct corolla of 4 or 5 petals. The fruit is a capsule and the seeds are half anatropous. The plants are most abundant in the northern hemisphere; and some of them are quite showy, as the CARNATION (*Dianthus caryophyllus*) and pinks (*Dianthus* species) and the cultivated pink or Sweet William (*D. barbatus*). A number of the members of this group contain saponin, as bouncing bet (*Saponaria officinalis*), which is naturalized in the United States from Europe, *Gypsophila Struthium* of Spain and other species of this genus, as well as species of *Lychnis* and *Herniaria*. The leaves of *Paronychia argentea* are used in Morocco as a substitute for tea. The roots of *Scleranthus perennis* of Eastern Europe are inhabited by an insect (*Coccus polonica*) which is used in the preparation of a red dye. The fleshy stitchwort (*Alsine crassifolia*) of Europe and the United States is poisonous to horses.

XII. ORDER RANALES.

The plants are mostly herbs but include some shrubs and trees, and comprise eight families of economic importance.

a. NYMPHLEACEÆ OR WATER LILY FAMILY.—These are aquatic perennial herbs with thick root-stocks and floating, peltate leaves. The flowers are perfect and have large petals. The seeds are enclosed in an aril and the embryo has fleshy cotyledons.

Nuphar luteum of Europe and Middle Asia contains the alkaloid nupharine and tannin, the latter of which splits into ellagic and gallic acids. The yellow pond lily (*Nymphæa advena*) of the United States contains similar principles. The seeds and rhizomes are rich in starch and are used as food, in some cases starch being manufactured from them, as of various species of *Nymphæa*, *Nelumbo* (Lotus) and *Victoria*, and *Euryale ferox*.

b. RANUNCULACEÆ OR CROWFOOT FAMILY.—These are annual or perennial herbs with simple or compound leaves, regular or irregular flowers, and fruits which are akenes, follicles, or berries.

Hydrastis canadensis yields the drug hydrastis (p. 498). From a short, thick, horizontal rhizome with numerous slender roots rises a short stalk with a few palmately lobed, reniform, petiolate, pubescent leaves. The flowers are small, solitary and greenish-white, and the fruit is a head of crimson berries somewhat resembling the raspberry (Fig. 218).

Cimicifuga racemosa (black cohosh or black snakeroot) yields the drug cimicifuga (p. 497). This is a tall perennial herb with large knotty rhizome, large decompound leaves and a long raceme of white flowers (Fig. 140).

Aconitum Napellus yields the official drug aconite (p. 477). This is a perennial herbaceous plant indigenous to Europe and extensively cultivated. From a tuberous root arises a simple leafy stem with palmately lobed or divided leaves, and large, irregular, blue flowers which form a rather loose panicle (Fig.

141). The sepals are five in number, the posterior upper one being large and helmet-shaped. The petals are 2 to 5 and rather

FIG. 140. A group of transplanted wild plants with a plant of *Cimicifuga racemosa* in the foreground, showing the characteristic, large, decompound leaves and long raceme of flowers.

small, the two posterior or upper ones which are hooded and concealed in the helmet-shaped sepal are nectar-secreting (Fig. 84, *E*). The fruit is a follicle and contains numerous small seeds.

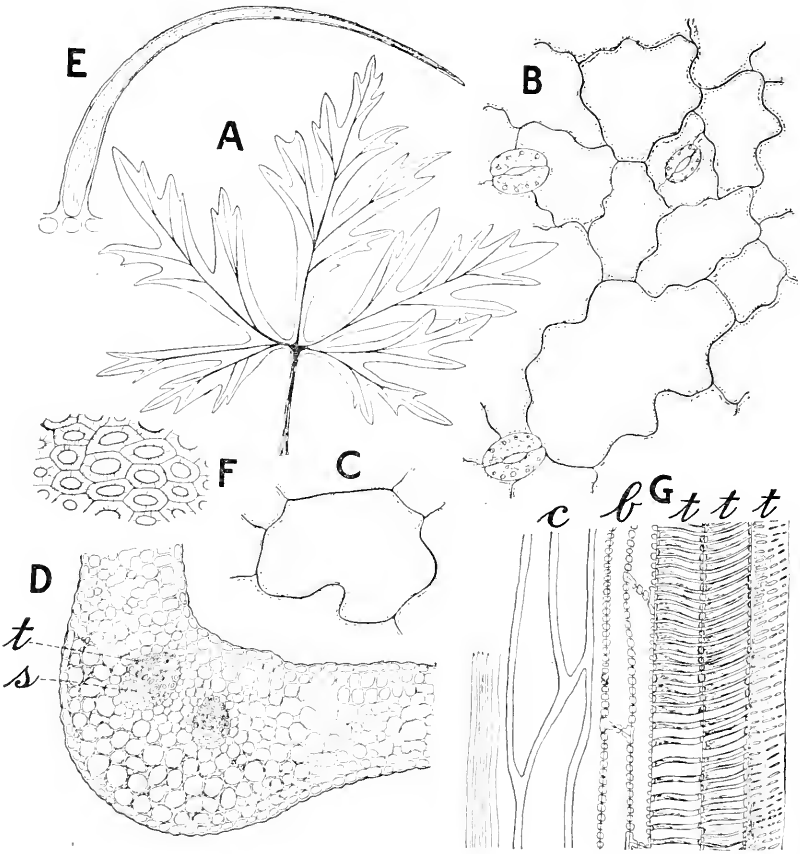


FIG. 141. *Aconitum Napellus*. A, one of the long-petiolate, divided leaves; B, epidermal cells of lower surface; c, an epidermal cell of the upper surface; D, transverse section through one of the principal veins showing two fibrovascular bundles, and strongly collenchymatic cells beneath the lower epidermis, E, one of the few hairs from the petiole; F, lignified bast fibers surrounding the sieve in the petiole; G, longitudinal section through fibrovascular bundle showing spiral and reticulate tracheæ (t), bast fibers (b) and some of the collenchyma cells (c), those at the left exhibiting longitudinal pores which give a crystal-like effect.

Delphinium Staphisagria, which yields staphisagria (p. 427) or stavesacre, is a handsome, tall, biennial larkspur, with dark green, palmate, 5- or 7-lobed leaves, and blue or purplish flowers in racemes. The flowers are zygomorphic and somewhat resemble those of Aconite.

PULSATILLA, which was formerly official, is obtained from several species of Anemone growing in Europe. These are perennial herbs (Fig. 76) with basal leaves which are deeply lobed or dissected, those of the stem forming a kind of involucre near the flower. The flowers are rather large and with numerous petaloid sepals. The fruit is a densely woolly akene in those

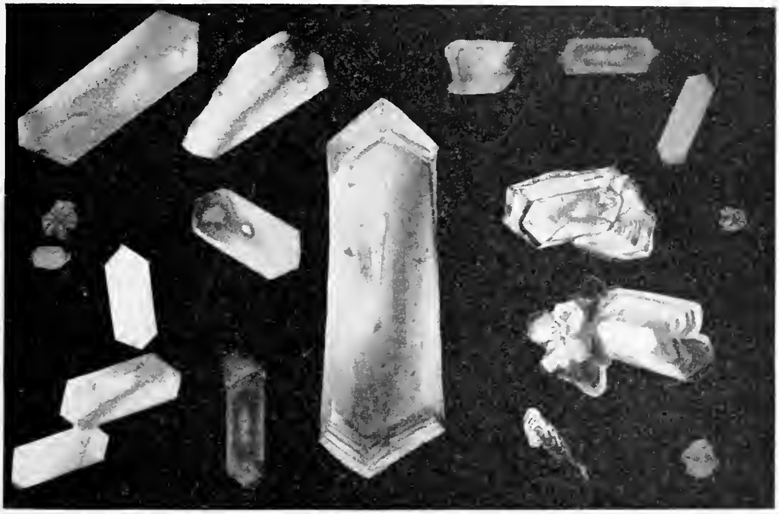


FIG. 142. Aconitine: orthorhombic crystals, crystallized from alcoholic solutions.

species which are used in medicine. The entire plant is used and contains an acrid volatile oil the principal constituent of which is an anemone camphor (anemonol). The latter is easily decomposed into anemonin, which on fusion becomes exceedingly acrid. Similar principles are found in other species of Anemone as well as in certain species of Ranunculus (buttercup) and *Clematis vitalba* of Europe.

Very many of the other Ranunculaceæ contain active principles. The glucoside helleborein, which resembles digitalin in its medicinal properties, is found in *Helleborus niger* the BLACK HEL-

LEBORE of Europe, and probably in other species of Helleborus, as well as in *Actæa spicata* the baneberry of Europe and *Adonis vernalis* the false hellebore of Europe and Asia.

c. BERBERIDACEÆ OR BARBERRY FAMILY.—The plants of this family are herbs or shrubs with simple or compound

FIG. 143. A group of transplanted plants, showing in the upper portion a fruiting plant of blue cohosh (*Caulophyllum thalictroides*).

leaves, and flowers either single or in racemes (Figs. 134, *E*; 81, *T*). The fruit is a berry or capsule.

Berberis Aquifolium (trailing mahonia) yields the official drug berberis (p. 482). It is a low, trailing shrub with 3- to 7-compound, scattered leaves. The leaflets vary from oval to nearly orbicular, are obtuse at the apex, slightly cordate at the base, finely reticulate, and spinose-dentate. The flowers are yellow and in dense terminal racemes. The fruit is a blue or purplish berry.

Caulophyllum thalictroides or blue cohosh of the Eastern United States is a perennial herb with a thick rhizome and large ternately compound leaves (Fig. 143). The flowers are small and greenish-purple. The fruit is peculiar in that it resembles a berry and consists only of blue, globular, naked seeds, the pericarp being ruptured and falling away soon after fertilization. The rhizome and roots were formerly official. It is a horizontal, much branched rhizome with broad, concave stem-scars, and numerous roots; it is grayish-brown externally, sweetish, slightly bitter and somewhat acrid. The drug contains an acrid, saponin-like glucoside, leontin; a crystalline alkaloid, caulophylline; two resins; and starch. For analysis of the seeds see *Chem. News,* 1908, p. 180.

Podophyllum peltatum or May apple is the source of the official podophyllum (p. 506). This is an early, herbaceous, perennial plant forming large patches by reason of its long dichotomously branching rhizome (Fig. 222). It forms two kinds of branches, one bearing a single, peltate, 5- to 7-lobed leaf; and another bearing in the axil of two similar leaves a white flower which gives rise to a large, yellowish, ovoid berry which is edible.

d. MENISPERMACEÆ OR MOONSEED FAMILY.—The plants are climbing or twining, herbaceous or woody vines with simple, entire or lobed leaves and small, greenish-white diœcious flowers. The fruit is a drupe and contains a characteristic crescent-shaped seed.

Menispermum canadense or Canada moonseed yields the drug menispermum which was formerly official. It grows in the Northern United States and Canada and is a high-climbing vine with broadly ovate, cordate and 3- to 7-lobed leaves (Fig. 65). The flowers are in panicles giving rise to a characteristic cluster of bluish-black berries.

The rhizome occurs in pieces which are 5 to 7 dm. long and 2 to 5 mm. in diameter; externally it is longitudinally wrinkled, of a yellowish-brown color and somewhat resembles Sarsaparilla. In transverse section, however, it is very distinct (Fig. 115). The drug has a bitter taste and contains a bitter alkaloid menispine, berberine and starch. In addition it contains the alkaloid oxyacanthine which is also found in *Berberis vulgaris* of Europe and the West Indies.

Jateorhiza palmata yields the official drug calumba (p. 459). The plant is a herbaceous climber somewhat resembling Menispermum, the leaves being more decidedly lobed. The flowers form long racemes.

Chondrodendron tomentosum, the source of the official drug pareira (p. 460), is a high woody twiner. The leaves are large, petiolate, broadly ovate or rounded, slightly cordate, and densely tomentose on the lower surface.

Anamirta paniculata is a woody climber of the East Indies. The fruits, known as fishberries or COCCULUS, are used as a fish poison by the natives and contain the neutral principle picrotoxin.

Very many other plants of the Menispermaceæ contain powerful toxic principles and are used as fish poisons and as antidotes to snake poison. Several species of Abuta are used in the preparation of curare poison.

e. MAGNOLIACEÆ OR MAGNOLIA FAMILY.—The plants are mostly trees or shrubs and are represented in the United States by the magnolias and tulip tree (*Liriodendron tulipifera*). The latter is a magnificent tree with characteristic leaves (Fig. 74) and large, fragrant, orange-colored, tulip-like flowers.

The plants of this family contain a variety of constituents. Ethereal oils containing anethol and resembling those of anise are found in the fruit of *Illicium anisatum* (*I. verum*) or STAR ANISE, a small evergreen tree growing in the mountains of Southern China. A volatile oil with a disagreeable odor is found in a closely related species *I. religiosum* (Shikimi) of Japan. The fruit of the latter plant is known as JAPANESE STAR ANISE and contains in addition a poisonous neutral principle. The fruits of both star anise (Illicium) and the Japanese star anise are made up of 6 to 8 radially arranged follicles, which are dark brown, dehiscent on the upper (ventral) surface and each contains a single, brown, shiny seed. Star anise has an odor and taste resembling anise. Japanese star anise has a bitter taste and in addition is brownish-black, very woody and strongly beaked.

Volatile oils are also found in the flowers of the various species of Magnolia and in *Michelia Champaca* found in the Malay Archipelago and cultivated in India and Brazil, and in *M. nilagirica* of India, the latter being used in perfumery.

Winter's bark is derived from *Drimys Winteri*, a shrub of South America. It occurs in quills which are from 5 to 10 mm. thick; externally it is grayish-brown and covered with numerous lichens; the fracture is short, the broken surface being marked by stone cells and resin canals; the odor is fragrant; taste aromatic, pungent and bitter. The drug contains a volatile oil which consists essentially of a hydrocarbon known as winterin; it also contains a resin.

A crystalline principle magnolin, a glucoside and a volatile oil are found in *Magnolia macrophylla* (or cucumber-tree of the

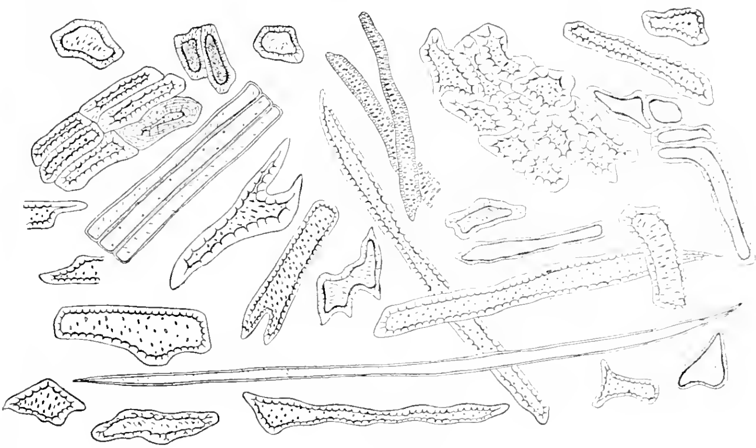


FIG. 144. Various forms of stone cells in star anise, the fruit of *Illicium anisatum*.

Southern States) and *M. tripetala* or umbrella tree growing southward from Pennsylvania. A bitter principle liriodendrin, a volatile oil, an alkaloid, and a glucoside are found in the tulip poplar or tulip tree.

The bitter and aromatic bark of *Michelia montana* of Java is used like cascarilla (Euphorbiaceæ). A bitter resin is found in the fruit of *Talauma Plumieri* of the Antilles.

A glucoside which dissolves the blood corpuscles is found in *Talauma macrocarpa* of Mexico. A red coloring principle soluble in water occurs in the leaves of *Michelia tsiampaca* of Java. The fruits of *Schizandra propinqua* of Nepal and *Kadsura Rox-*

burghiana of Japan contain considerable mucilage and are edible. The latter plant is also used as a hair-restorer. From the ash of *Schizandra chinensis* of China and Japan sodium chloride is obtained.

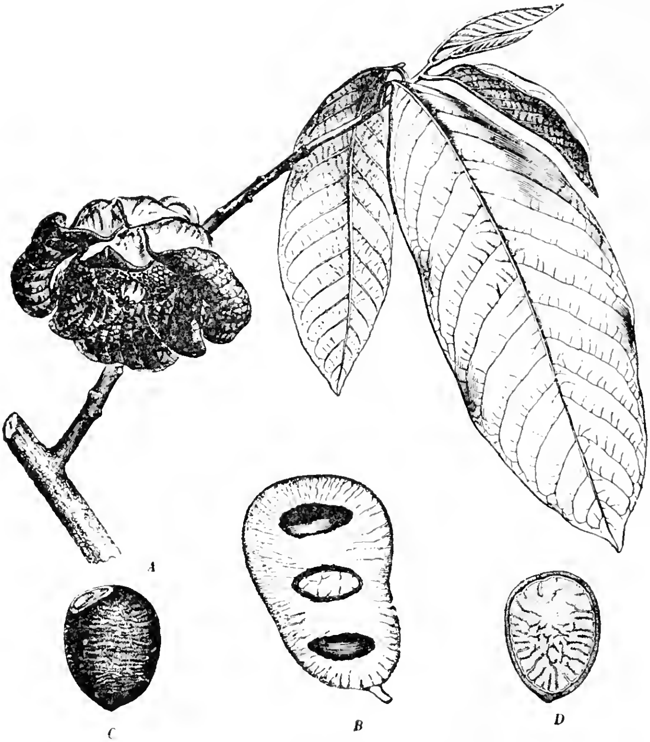


FIG. 145. North American papaw (*Asimina triloba*): A, branch showing lateral nodding flower and the large, pinnately-veined, entire leaf; B, section of the oblong, 3-seeded berry; C, D, seeds, the one in longitudinal section.—After Baillon.

The flowers of *Magnolia Juglans* are used to flavor tea and the leaves of *Talauma ovata* are used as a substitute for tea in Brazil.

f. ANONACEÆ OR CUSTARD-APPLE FAMILY.—These are shrubs or small trees chiefly inhabiting warm-temperate and tropical regions. They yield very many economic products. The fruit of *Xylopia brasilensis* is used as a substitute for cubeb. Some yield fruits having an aroma similar to that of nutmeg, as *Monocarpia Blancoi* of Africa and Jamaica. The flowers of *Cananga odorata* of tropical countries are used in the preparation of a pomade from which the perfume Ylang-ylang is made. Ethereal oils are also found in other species, as *Unona ligularis* of Amboyna, the seeds of which are used in perfumery. The bark of *Popowia pisocarpa* of Java contains an alkaloid.

The seeds of *Xylopia salicifolia* of Trinidad and *X. muricata* of Jamaica are very bitter, as are also the wood and bark of *X. glabra* of the West Indies.

The seeds of *Asimina triloba* the North American papaw (Fig. 145), contain an emetic principle. This plant should not be confounded with *Carica Papaya* (Caricaceæ) which contains the ferment papain.

Many of the Anonaceæ yield large succulent fruits, some of which are edible, as the sugar apple obtained from *Anona squamosa* and custard apple from *A. reticulata* both abundant in the Tropics. The fruit of *A. muricata* sometimes weighs as much as two Kilograms.

g. MYRISTICACEÆ OR NUTMEG FAMILY.—This family is represented by the single genus Myristica. Nutmeg (p. 439) and mace are obtained from *Myristica fragrans*, an evergreen tree with ovate, petiolate, coriaceous, entire and pinnately-veined leaves. The flowers are small, yellow and diœcious. The fruit is a berry having somewhat the shape and size of the green fruit of black walnut. It has a line of dehiscence, and when ripe is yellow. The arillode of the seed constitutes mace while the kernel is the nutmeg, the pericarp of the fruit and coat of the seed being rejected.

h. LAURACEÆ OR LAUREL FAMILY.—The members of this family are chiefly shrubs and trees which are distributed mostly in the Tropics although a few are found in the temperate zones (Fig. 134, *F*).

Sassafras officinale.—This is a tree common in the eastern and central portion of the United States and is characterized by its rough bark and its 1- to 3-lobed leaves, from whence it received its former name *Sassafras variifolium* (Fig. 73). The flowers are yellow, diœcious and appear in the spring before the leaves. The fruit is an oblong, blue drupe (p. 539).

Cinnamomum zeylanicum, which is the source of the Ceylon cinnamon (p. 513), is a small, handsome, evergreen tree with opposite, coriaceous, broadly lanceolate, 3- to 5-nerved leaves (Fig. 146). The flowers are yellowish-white, hermaphrodite, or both

FIG. 146. Young plant of *Cinnamomum zeylanicum* grown from cutting.

pistillate and staminate. The fruit is a black, ovoid berry. The oil of Ceylon cinnamon from the bark and branches is characterized by its content of cinnamic aldehyde; from the leaves by eugenol; and from the root bark by camphor. *C. Cassia* which yields Cassia cinnamon is a tree growing in China, Sumatra, and cultivated in Java. It has long, oblong-lanceolate leaves which are pubescent on the lower surface. Cassia cinnamon (bark) is also obtained from *Cassia Burmanni*. Saigon cinnamon (p. 513) is derived apparently from wild trees growing in the mountainous regions of Anam, the botanical origin of which has not been determined.

The volatile oils of the members of the Lauraceæ vary considerably in composition. In addition to the oils of Sassafras and Cinnamon the following may be mentioned: A CINNEOL-containing oil is found in *Cinnamomum Oliveri* of Australia, *Umbellularia californica* of Western North America and *Laurus nobilis* the noble laurel of the Mediterranean and Mexico. A BORNEOL-containing oil is obtained from the root of *Dicypellium caryophyllatum* of Guiana, the wood of which is known in Cayenne as rose-wood. An oil containing a notable amount of METHYL SALICYLATE is obtained from the spice-bush (*Lindera Benzoin*) of the United States.

Cinnamomum Camphora, or the camphor tree, is indigenous to China, Japan and Formosa, and is now cultivated in many warm countries as a shade and ornamental tree, growing very well in Southern California and the Southeastern States. All parts of the tree contain a volatile oil which on oxidation yields camphor which latter is obtained by distillation and sublimation. Camphor of poor quality is obtained from *C. Parthenoxylon* of Burmah, Malaya and China, and *C. glanduliferum* of the Himalayas. Camphor is also a constituent of other ethereal oils of this same family, as the Massoy bark oil obtained from the root bark of *C. zeylanicum* and *C. Burmanni* of Java.

A EUGENOL-containing volatile oil is obtained from *Ravensara aromatica* of Madagascar, and *Machilus Thunbergii* of Japan. Eugenol is also found in oil of laurel leaves (*L. nobilis*), Massoy bark oil, the oil of the leaves of Ceylon cinnamon, and the oils obtained from *Cinnamomum Culilawan* of the Malay Peninsula and China, and *C. Wightii* of East India, and possibly is also found in *Dicypellium caryophyllatum*.

The wood and the bark of Nectandra or Beeberu (*Nectandra Rodiæi*) of Guiana and Brazil contain several alkaloids, one of which is known as beeberine and is supposed to be identical with the alkaloids in *Buxus sempervirens* (Fam. Buxaceæ); pelosine found in Pareira; and paricine found in the bark of the cultivated cinchonas of Java. Coto bark which is used in medicine, is obtained from an unknown tree in Northern Bolivia belonging to this family. The bark contains a volatile oil having a pungent taste, and a volatile alkaloid.

Fatty oils are obtained from *Ravensara aromatica* of Madagascar, *Litsea glauca* of Japan and other species of *Litsea* found growing in Cochin China and India. A red sap with a very fetid odor is obtained from *Ocotea fœtens* of tropical and sub-tropical America, and the stink-wood of South Africa (*O. bullata*).

XIII. ORDER RHŒADALES OR PAPAVERALES.

These are mostly herbaceous, seldom woody, plants. The flowers are perfect and the fruit capsular. This order includes two families of importance medicinally.

a. PAPAVERACEÆ OR POPPY FAMILY.—These are herbs with a milky or colored latex.

Papaver somniferum or opium poppy is an annual herb 1 to 2 M. high. The stem is sparingly branched, with alternate, deeply lobed, pubescent, clasping (by a cordate base), dull green leaves (Fig. 147, *A*). The flowers in the variety *album*, from which opium is obtained, are white or silver-gray, and in many cultivated varieties are large and extremely showy. The two sepals drop away with the expansion of the corolla; the ovary is smooth, more or less globular and subtends the radiate stigma; the fruit is a capsule (Fig. 91), dehiscing by means of terminal pores, and contains a large number of extremely small white seeds, the latter being known as MAW-SEED and which on expression yield a fixed oil known as poppy-oil. (For opium see p. 658.)

Other allied members of the Papaveraceæ possess narcotic properties, but the alkaloid morphine has not been isolated from any of them, as the California poppy (*Eschscholtzia californica*) (Fig. 147, *B*); the Mexican poppy (*Argemone mexicana*): *Hypecoum procumbens*, and *Fumaria plicata* both of Southern Europe. These latter plants probably contain also the alkaloid protopine which is apparently identical with fumarine.

Sanguinaria canadensis or bloodroot, the rhizome of which is official (p. 508), is a small, herbaceous, perennial herb with a red latex. The rhizome is horizontal, short and thick, and gives rise to a single, petiolate, palmately 5- to 9-lobed leaf and a single white flower with a long peduncle (Fig. 148). The capsule is oblong, 2-valved and contains a number of smooth but crested seeds.

Chelidonium majus (celandine) is the source of the herb CHELIDONIUM which was formerly official. The plant is a delicate branching herb about 0.5 M. high; with alternate, deeply pinnati-

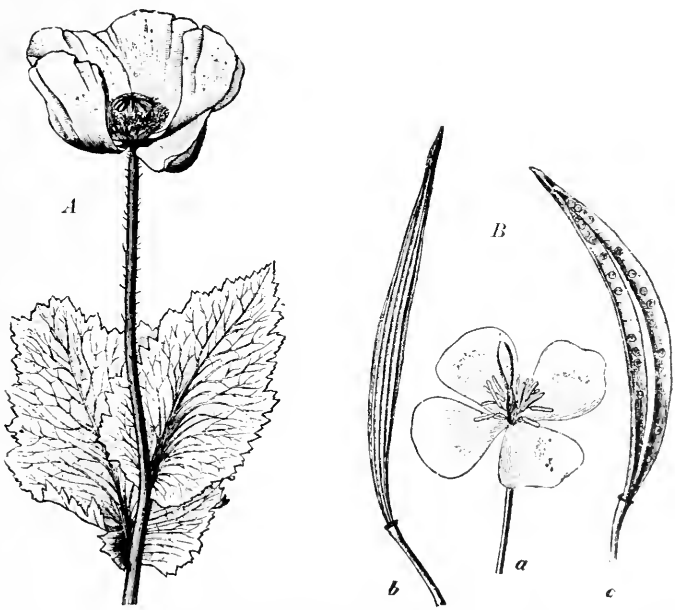


FIG. 147. A, Opium poppy (*Papaver somniferum*); B, California poppy (*Eschscholtzia californica*) showing flower (a), and capsules (b, c), one of which (c) is dehiscent.—After Schimper.

fid leaves; yellow flowers; slender elongated capsule resembling that of the mustards, and a yellow latex in every part. Celandine is indigenous to Europe and Asia and is common in waste places in the United States. The drug contains the following alkaloids: Chelidonine (identical with stylophorine), chelerythrine (which is fluorescent), and protopine (found also in opium and sanguinaria). It also contains a bitter neutral principle chelidoxanthin and several organic acids.

To this family belong a number of other plants which contain principles similar to or identical with those found in Sanguinaria and Chelidonium, and of these the following are common in the United States: Yellow or celandine poppy (*Stylophorum diphyllum*) and the Dutchman's breeches (*Bicuculla Cucullaria*).

The alkaloid PROTOPINE (fumarine) is found in the following plants of this family: *Sanguinaria canadensis; Chelidonium majus; Stylophorum diphyllum; Eschscholtzia californica; Glaucium corniculatum* of Middle Europe; *Bicuculla Cucullaria; Adlumia fungosa*, the climbing fumitory of the United States and Canada; *Fumaria officinalis*, the fumitory of Europe, which is naturalized in the United States and Canada; *Bocconia cordata* of China and Japan, and *B. frutescens* of the West Indies, Mexico and Paraguay; *Dicentra pusilla* of Japan and several species of corydalis. The tubers of squirrel corn or corydalis (*Bicuculla canadensis*) contain the alkaloidal corydaline.

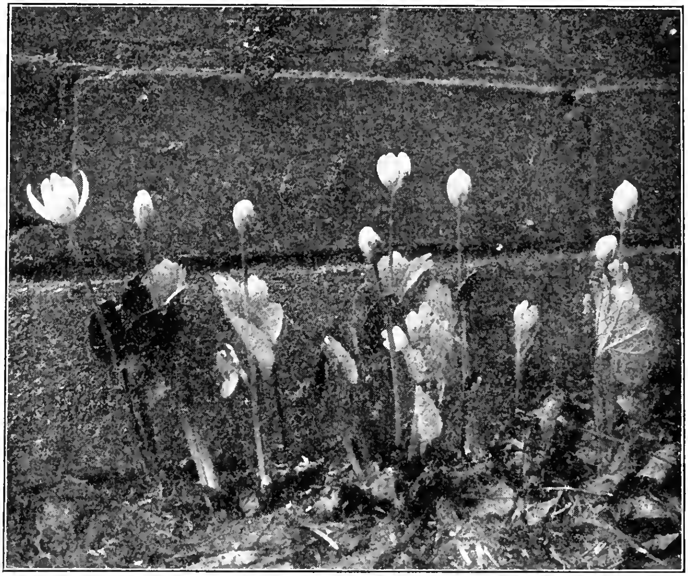


FIG. 148. A group of transplanted bloodroot plants (*Sanguinaria canadensis*) showing 1-flowered scapes, and the palmately veined and lobed leaves.

b. CRUCIFERÆ OR MUSTARD FAMILY.—These are herbaceous plants with characteristic flowers and fruits. The flowers have four sepals in two sets, four petals which are more or less spreading and clawed at the base, and six stamens which are tetradynamous (Fig. 134, *B*). The fruit is a 2-celled silique or silicle, which varies in shape in the different genera (Fig. 89).

Sinapis alba (white mustard).—The plant is a slender, branching, more or less hispid (bristly hairy) annual or biennial herb usually less than 0.5 M. high, with deeply pinnatifid lower leaves and lanceolate, dentate upper leaves. The flowers are yellow, and the silique is densely hispid, constricted between the seeds and terminated by a long, flat, sword-like beak. The seeds are official as white mustard (p. 428) but are known in commerce as yellow mustard.

Brassica nigra or black mustard, the seeds of which constitute the official black mustard (p. 429), is a larger, more branching plant than *Sinapis alba*, being from 1 to 3 M. high. The silique is shorter, more cylindrical and with a slender, filiform beak.

Glucosides similar to those which occur in SINAPIS ALBA and BRASSICA NIGRA, are also found in other species of SINAPIS and BRASSICA, as well as in the following plants, but the oils produced are not identical: Horseradish (*Roripa Armoracea*), the oil being similar to volatile oil of mustard; water cress (*R. Nasturtium*); garden radish (*Raphanus sativus*); *Sisymbrium Alliaria* of Europe, and the hedge mustard (*S. officinale*) naturalized in the United States; TURNIP (*Brassica rapa*) of Europe; field pennycress (*Thlaspi arvense*) of Asia and found in waste places in the Eastern and Middle United States; the narrow leaved peppergrass (*Lepidium ruderale*) naturalized from Europe; scurvy-grass (*Cochlearia officinalis*) of Northern and Middle Europe, the herb of which, known as HERBA COCHLEARIÆ, is used in medicine; "HONESTY" (*Lunaria annua*) common in cultivation on account of the ornamental use of the dry pods; *Parrya macrocarpa* of Southern Europe; treacle mustard (*Erysimum cheiranthoides*) of Northern Europe and the United States, and garlic mustard (*E. Alliaria*).

The seeds of most of the Cruciferæ are also rich in fixed oils, and the commercial oils are obtained from the following species:

Wild mustard or charlock (*Brassica arvensis*) naturalized in the United States from Europe; *Hesperis tristis* of Southern Europe; cabbage (*Brassica oleracea*). An INDIGO-forming glucoside is found in *Isatis tinctoria* of Europe and *I. indigotica* of China; *Neslia paniculata* of Europe and the Orient; and *Lepidium owaihiense* of the Hawaiian Islands. Shepherd's purse (*Capsella Bursa-pastoris*) contains an alkaloid (bursine) and tannin. The leaves and roots of many of the Cruciferæ are used as garden vegetables, and some are cultivated as ornamental plants. The seeds of *Lunaria biennis* (or "honesty") contain an orange red crystalline alkaloid, or possibly a mixture of alkaloids.

c. There are several other families of the Rhœadales which yield economic products. The RESEDACEÆ include the mignonette (*Reseda odorata*) the flowers of which yield a fragrant volatile oil; and *R. luteola* of Europe which contains a yellow coloring principle and also an anthelmintic principle. The MORINGACEÆ comprise a single genus, Moringa. The root of *M. olifera* of tropical and sub-tropical countries contains a volatile oil resembling the volatile oil of mustard, and the stem yields an astringent gum resembling that of *Bombax malabaricum* (Bombaceæ).

XIV. ORDER SARRACENIALES.

This order includes several families which are of special interest because of the fact that the leaves are of peculiar construction and adapted to the catching and digestion of insects (Fig. 77).

Probably all of the plants of this order produce proteolytic ferments resembling those in the pine-apple and are capable of acting upon and digesting animal substance. Some writers have supposed that the properties of these plants might be due to bacteria present in the liquid contained in the pitchers of the leaves, but there seems to be no question that a distinct enzyme resembling trypsin is formed in those plants which have been studied.

(a) The genus Sarracenia of the family SARRACENIACEÆ or pitcher-plant family, is represented in the United States by a number of species. The rhizome and roots of *Sarracenia purpurea* contain several alkaloids, one of which, sarracenine, seems to have some resemblance to veratrine. (b) The DROSERACEÆ or sundew family includes the Droseras or sundew plants and *Dionæa muscipula* the Venus's flytrap of North Carolina. A number of species of Drosera probably contain the red coloring principle which has been isolated from the rhizomes of *D. Whittakerii* of Australia and is a derivative of methylnaphthoquinone. Citric acid has been found in *D. longifolia*, a sundew common in the United States as well as in Europe and Asia. (c) The family Nepenthaceæ contains the single genus *Nepenthes*, several species of which are extensively cultivated in greenhouses. The leaves and roots of *N. Boschiana* of Borneo contain an astringent principle.

XV. ORDER ROSALES.

The plants range from herbs to shrubs and trees and have complete flowers which are mostly perigynous. The carpels are solitary, or several either distinct or united.

a. PODOSTEMACEÆ OR RIVER-WEED FAMILY.—The plants are aquatic and more or less alga-like, and are represented in the United States by the river-weed (*Podostemon ceratophyllum*) which is a densely tufted plant found in running water attached to stones. The ash of these plants contains a considerable amount of sodium chloride, the ash of *Mourera Weddelliana* of Brazil containing 50 per cent. of salt and being used as a source of table salt.

b. CRASSULACEÆ OR ORPINE FAMILY.—The plants are chiefly succulent herbs and represented by such plants as houseleek (*Sempervivum tectorum*), which is cultivated largely as an ornamental plant, and the common sedums, of which there are numerous species in temperate regions. The common mossy stonecrop or wall-pepper (*Sedum acre*) naturalized in the Northern United States contains a ferment capable of dissolving the membrane formed in diphtheria and croup; *Sempervivum balsamiferum* of the Canary Islands contains a substance resembling the viscine found in certain Loranthaceæ. Ditch or Virginia stonecrop (*Penthorum sedoides*) contains tannin.

c. SAXIFRAGACEÆ OR SAXIFRAGE FAMILY.—The plants are mostly found in temperate regions and among the important members are mitrewort (*Mitella*), false mitrewort

(*Tiarella cordifolia*), alum root (*Heuchera americana*), golden saxifrage (*Chrysosplenium*), grass of Parnassus (*Parnassia*), mock orange (*Philadelphus coronarius*) and the wild hydrangea (*Hydrangea arborescens*).

The plants are rich in tannin, as the alum root of Eastern and Central North America, which contains 10 to 20 per cent. of tannin. A glucoside hydrangin, a volatile oil, and possibly also a saponin are found in "SEVEN BARKS" or wild hydrangea (*H. arborescens*); a glucoside is also found in the root of garden hydrangea (*H. paniculata grandiflora*).

d. GROSSULARIACEÆ OR GOOSEBERRY FAMILY.—The family includes the single genus *Ribes*. These are more or less spinous shrubs with alternate or fascicled, more or less pubescent, 3- to 7-lobed petiolate leaves. The flowers are solitary, as in gooseberry or in racemes, as in the currants. The fruit is an inferior globular berry. The cultivated CURRANTS are varieties of *Ribes rubrum:* the cultivated GOOSEBERRIES are varieties of *R. Uva-crispa*. Both of these plants are natives of Europe and Asia and have escaped from cultivation in the United States and Canada. The fruits contain fruit-acids and fruit-sugars and are used in a variety of ways. The fetid currant (*Ribes prostratum*) has a very fetid odor and it is said that the flowers of the buffalo currant (*Ribes aureum*) contain hydrocyanic acid.

e. HAMAMELIDACEÆ OR WITCHHAZEL FAMILY. The plants are shrubs or trees and are most abundant in subtropical countries.

Hamamelis virginiana, or witchhazel, the leaves (p. 610) and bark (p. 527) of which are official, is a shrub which is especially characterized by its asymmetric, undulate leaves and by its producing flowers in the autumn when the leaves are falling and the mature, but not ripe, capsules of the preceding year are still present (Fig. 264).

Liquidambar Styraciflua or sweet gum-tree of the Atlantic coast of the United States and Mexico, is a tall tree with characteristic cork-wings on the branches; 3- to 7-lobed, petiolate, finely serrate leaves; monœcious flowers, and a spiny, globular, capsular fruit. The tree yields a balsam allied to the official styrax (p. 679), which is obtained from a very similar tree (*L. orientalis*).

f. ROSACEÆ OR ROSE FAMILY.—The plants are herbs, shrubs or trees usually with alternate, stipulate, simple or compound leaves, and regular perfect flowers with or without petals, and numerous stamens (Fig. 134, *D*). The fruit is a pome, drupe, follicle or akene (Fig. 89).

Prunus serotina or wild black cherry is a tree varying from 10 to 30 M. in height, with a more or less smooth bark marked by prominent transverse lenticels, and showing a tendency to peel off in semicircular pieces, which gives the older bark, which is more or less black, a roughened appearance. The leaves and inner bark have an agreeable aromatic odor; the leaves are oval- or oblong-lanceolate, acute or acuminate, serrate, the teeth being glandular; the flowers are white and in racemes; the fruit is a dark purple or blackish, globular drupe (Fig. 235). The nearly related species wild cherry or choke cherry (*Prunus virginiana*) is a shrub or small tree with broadly oval, acuminate leaves, red or nearly black drupes, and flowers and fruits several weeks earlier than *P. serotina* (p. 538).

Prunus Amygdalus is a small tree resembling somewhat the peach tree. The leaves are lanceolate, serrate; the flowers are rose-colored, and the fruit is a dehiscent drupe in which the leathery sarcocarp separates from the endocarp, which latter, with the seed which it encloses, constitutes the almond of the market (Fig. 187). The kernels of some of the seeds are bitter (bitter almonds, p. 433), and some are bland and free from bitterness. By a process of selection plants yielding the latter are now extensively cultivated in sub-tropical and warm-temperate regions, and yield the sweet almond (p. 434) of the market. In Turkestan some of the almonds have a smooth endocarp.

A glucosidal substance having the properties of amygdalin is found in the buds, leaves, bark and seeds, more especially the latter, of some members of the following genera: Prunus, Sorbus (mountain ash), Cotoneaster, Amelanchier, and Eriobotyra (*E. japonica* or Japanese medlar).

Prunus domestica yields the French plum or prune of commerce (p. 576). The leaves are ovate or ovate-lanceolate, dentate, and pubescent on the lower surface. The flowers are greenish-white, with a hairy peduncle. The fruit is a drupe.

The bark of *Pyrus toringo* yields a yellow coloring principle known in Japan as "dzaini." The bark contains a white, crystalline glucoside (toringin), and pyrus-quercitrin, which forms yellow needles and on hydrolysis yields quercetin and rhamnose. The bark is also used to adulterate licorice, gentian and other drugs in the powdered form.

The apple (*Pyrus malus*), the pear (*Pyrus communis*), and the quince (*Cydonia vulgaris*) are inferior fruits known as pomes, the fleshy part developing from the torus and persistent calyx, the core being composed of the united carpels. The edible fruits of the Rosaceæ contain a number of FRUIT-ACIDS, such as malic, citric, tartaric, and FRUIT-SUGARS, as dextrose and levulose. The acids vary from 0.20 per cent. in pears to 1.50 per cent. in plums; and the sugars from 4.48 per cent. in peaches to 8.26 per cent. in pears. The carbohydrates mannit and sorbit are found in the fruit of *Prunus Lauro-cerasus* of Europe. In the unripe fruits there is more or less tannin and also a principle known as PECTOSE. This latter during the ripening of the fruit is converted into PECTIN, a viscid principle which is further changed into pectic and pectosic acids, the solutions of which gelatinize on cooling, so that these fruits are adapted to jelly making.

Rubus nigrobaccus, or high bush-blackberry, is a branching shrub 1 to 2 M. high with reddish, prickly, erect or recurved stems. The leaves are 3- to 5-foliate, the leaflets being ovate, coarsely and unequally serrate, and midrib and petiolules with stout, recurved prickles. The flowers are white, in terminal racemes and with hairy and prickly stalks. The fruit is broadly ovoid and consists of an aggregate of drupelets which ripen in August and September (Fig. 232).

Rubus villosus Ait. (*Rubus canadensis L.*) or low-blackberry (Northern dewberry), is a trailing, shrubby, prickly plant the leaves of which are 3- to 7-foliate, the leaflets being oval or ovate-lanceolate, serrate and nearly smooth. The flowers are in racemes and the fruit resembles that of *R. nigrobaccus*, but is smaller.

Rubus cuneifolius or sand-blackberry of the Eastern and Southern States is a small shrub less than 1 M. high, much branched, and with straight or recurved, stout prickles. The leaflets are ovate or cuneate, and densely pubescent, as are also the young shoots. The inflorescence consists of two to five flowers, the petals of which are white or pinkish. The fruit is oblong, more or less cylindrical, and sometimes 20 mm. long.

Rubus Idæus or the cultivated European red-raspberry is a shrub with a glaucous, bristly stem and with 3- to 7-foliate leaves. The flowers are white and the red fruit consists of a cap-like collection of hairy drupelets which is easily detached from the non-fleshy receptacle. The fruit is used in the preparation of syrup of raspberry which is used for flavoring. There are a number of varieties of this species of raspberry in cultivation, the fruits of which vary in color from crimson, brown, or yellow to nearly white. The fine flavored but watery fruit of the wild red-raspberry (*R. strigosus*) is sometimes substituted for the fruit of *Rubus Idæus.*

Rosa gallica which yields the red rose-petals, official in a number of the pharmacopœias (p. 557), is a native of Southern Europe and is extensively cultivated.

Rosa centifolia which is now known only in cultivation, and of which there are a large number of varieties, is distinguished by its glandular leaflets, and its pale red or pink petals. The cone-like collection of petals of the flower-bud is the part which is used in medicine, but it is deficient in coloring principles and fragrance as compared to *Rosa gallica.*

Rosa damascena, the petals of which yield the oil of rose or attar of rose, is extensively cultivated in Bulgaria and to some extent in France and Germany. It flowers very profusely, and the yield of oil is about 0.02 per cent. The oil consists of a crystallizable hydrocarbon known as rose-camphor which is odorless, and a liquid portion consisting of geraniol, l-citronellol, l-linalool, citral, n-nonyllic aldehyde and phenyl ethyl alcohol. Similar oils are obtained from other species of Rosa growing in Northern Africa, Abyssinia and Northern India, as *R. moschata*, and *R. sempervirens.*

The fruits of wild brier (*Rosa canina*) naturalized from Europe as well as of other species of Rosa (*R. pomifera* and *R. rugosa*), contain considerable malic and citric acids and fruit-sugars, and are made into a confection by boiling with syrup.

In addition to the fruit-ethers found in the common edible fruits of this family and the volatile oil of rose, it should be mentioned that oils containing salicylic acid are also present. A number of species of *Spiræa* contain salicylic aldehyde and methyl salicylate.

Quillaja Saponaria is a large tree having a thick bark and hard wood. The leaves are oval, coriaceous, slightly dentate and evergreen (Fig. 149). The flowers are monœcious or diœcious, white, apetalous, and axillary in groups of one to four. The ovary

FIG. 149. Orthorhombic crystals of Mannitol (Mannit) obtained from aqueous solutions: A, large crystals; B, feathery aggregates of needles.

consists of 4 to 5 carpels and on ripening forms a star-like, spreading group of follicles. The inner bark is the part used in medicine (p. 541).

A spurious quillaja bark (*Q. Pœppigii*) differs from the official in being thinner, darker and in having the surface covered with a coarse network of whitish lines. Another bark, occurring in quilled pieces, from 8–15 cm. long, and 1–5 cm. wide, has also been found in commerce.

Hagenia abyssinica is an ornamental tree with 7- to 13-foliate leaves. The flowers are monœcious and occur in panicles; the staminate being greenish-yellow and with 20 stamens; and the pistillate fragrant, bicarpellary, and with a reddish calyx (Fig. 243). The fruit is a nutlet. The pistillate flowers are official under the name of Cusso (p. 556).

Various species of Prunus yield GUMS, as cherry, peach, apricot, etc. MUCILAGE is found in the testa of certain seeds, as of quince. The manna of Luristan is obtained from *Pyrus glabra* of Persia. Tannin and gallic acid are found in TORMENTILLA

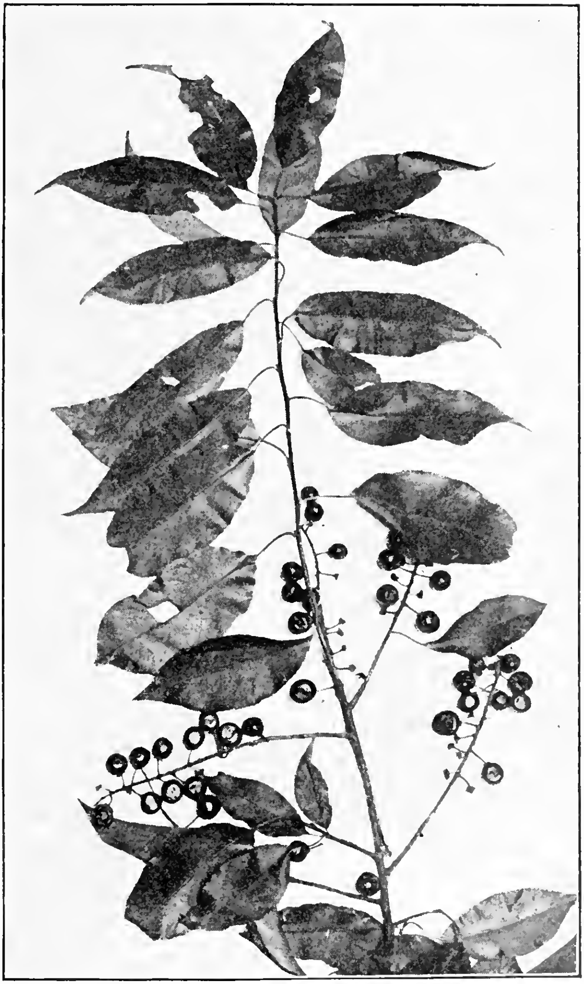


FIG. 150. Fruiting branch of wild black cherry (*Prunus serotina*).

rhizome which is obtained from *Potentilla silvestris*, a perennial herb of Europe, and other species of Potentilla. The fruit of the hawthorn (*Cratægus oxyacantha*) contains quercitrin. A bitter principle and tannin are found in *Purshia tridentata* of the Rocky Mountains. Phlorizin is found in the root bark of a number of species of *Pyrus* and *Prunus.*

In the genus Fragaria to which the strawberry belongs, the torus becomes large and fleshy and is the edible part of the fruit. The garden strawberry (*F. Chilænsis*) has a large, dark-colored fruit, the akenes being sunken in the periphery of the torus. In the wild strawberries the fruit is smaller, usually somewhat flesh-colored and the akenes are either embedded in the torus as in *F. virginiana* or borne on the surface as in *F. vesca.* The strawberry fruit contains about 87 per cent. of water; 6 per cent. of cane sugar; 5 per cent. of invert sugar (a mixture of dextrose and levulose); 1 per cent. of free fruit-acids; and about 2 per cent. of nitrogenous substances.

g. LEGUMINOSÆ OR PULSE FAMILY.—The plants are herbs, shrubs, trees, or vines with alternate, stipulate and usually compound leaves. The flowers are complete, and the corolla is either regular or irregular; the stamens are usually united, and the pistil is simple and free, becoming in fruit a legume. The plants are widely distributed, many of them being found in the Tropics. Three principal sub-groups, which have been ranked as families by some botanists, are recognized.

1. PAPILIONATÆ.—Those species with papilionaceous flowers are separated into a group called the Papilionatæ. This sub-group has a number of representatives in the United States, as clover, locust, and Baptisia (Fig. 134, *L*).

2. CÆSALPINIOIDEÆ include the sennas and have flowers which are nearly regular, or imperfectly, or not at all papilionaceous.

3. The MIMOSOIDEÆ include the acacias and have flowers that are regular.

Cassia acutifolia is a small shrub with leaves that are 8- to 10-foliate. The leaflets are official as Alexandria senna (p. 607); the flowers are yellowish and in axillary racemes; the fruit is a smooth, flat, dehiscent pod, with 6 to 8 seeds (Fig. 262).

Cassia angustifolia is a shrub which is cultivated in Southern India and resembles *Cassia acutifolia.* The leaflets which constitute India or Tinnevelly senna (p. 607) are longer and narrow-lanceolate, and the pods are longer, and slightly crescent shaped, as compared to those of *C. acutifolia* (Fig. 262).

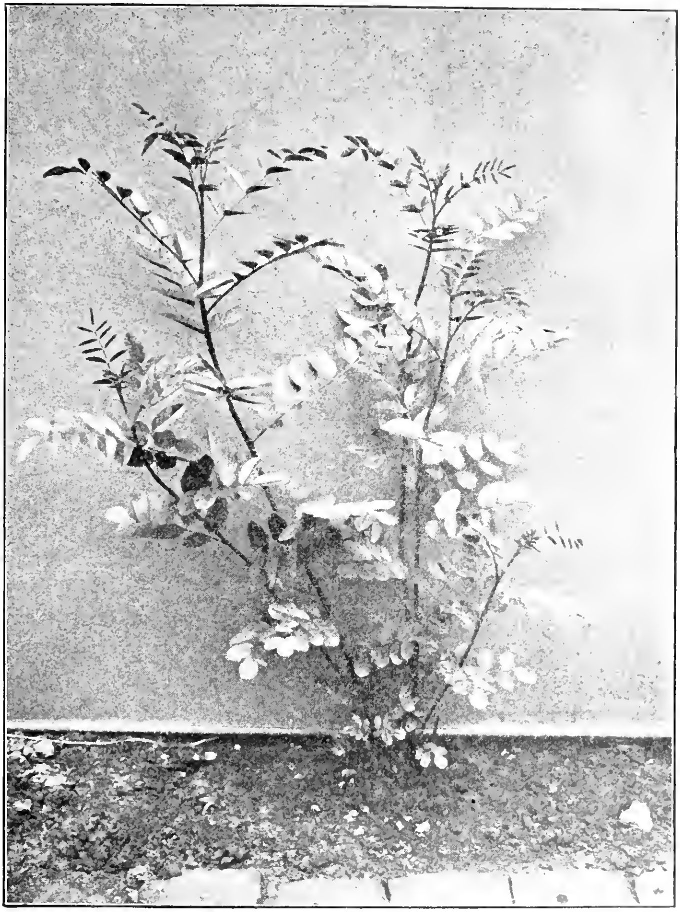


FIG. 151. Spanish licorice (*Glycyrrhiza glabra*) plant grown from a cutting by the late Henry N. Rittenhouse of Philadelphia.

Cassia fistula or purging cassia, the pods of which are official (p. 585), is a tree about 15 M. high. The leaves are 10- to 12-foliate; the flowers golden-yellow and in racemes; and the fruit is a very long, cylindrical, indehiscent legume. The leaves of quite a number of species of Cassia are used in medicine and the following are the source of FOLIA MALABATHRI: *C. Tamala* of Assam and *C. javanica.*

Glycyrrhiza glabra is a perennial herb, with 8- to 14-foliate leaves (Fig. 151), the leaflets being glandular in the variety *glandulifera;* the flowers have a violet-colored, papilionaceous corolla, and the fruit is a flat, dehiscent legume. The rhizome and roots are the parts used in medicine (p. 472).

Cytisus Scoparius or green or Scotch broom is a shrub naturalized from Europe. The branches are numerous, slender, erect and grow close together adapting them for use as brooms. The tops are used in medicine (p. 637).

Tamarindus indica is a tree attaining a height of 25 M. The leaves are pinnately compound having numerous sessile, entire leaflets (Fig. 256a); the flowers are in terminal racemes and the petals are yellow with reddish veins; the fruit is a curved, indehiscent legume which has a thin epicarp and a pulpy sarcocarp with numerous fibers, and contains a number of flat, quadrangular seeds. The pulp is the part used in medicine and is official as tamarind (p. 593).

Astragalus gummifer is a tomentose shrub less than 1 M. high. The leaves are pinnately compound, the leaflets being narrow and elliptical; the flowers are pale yellow, sessile and axillary; the fruit is a small, somewhat cylindrical, hairy pod or legume. The gummy exudation constitutes the Tragacanth of commerce (p. 650).

Acacia Senegal, which yields gum Arabic or acacia (p. 643), is a small tree with bipinnate leaves which are subtended by curved spines; the flowers are yellow and in dense spikes; the fruit is a broad pod containing five or six seeds (Fig. 153).

Acacia Catechu is a small tree which resembles *Acacia Senegal* and furnishes Black Catechu (p. 666).

Pterocarpus Marsupium is a fine timber tree with spreading branches. The leaves are 5- to 7-foliate, the leaflets being coriaceous, obovate, and emarginate; the flowers are pale yellow, and the fruit is an indehiscent, orbicular pod with a single reniform seed. The official Kino is prepared from the juice (p. 654).

The trees yielding kino are under State control in Madras. According to v. Höhnel the kino is present in special cells in the bark, which are arranged in radial rows in the region of the leptome. The cells are from 50 to 100 μ wide and from 100 to 500 μ long, the walls consisting of cellulose. The term "kino" is applied to a number of red astringent plant juices (see pp. 654–656). "AMERICAN KINO" is a synonym sometimes applied to the extract of *geranium maculatum* (Fam. Geraniaceæ).

Pterocarpus santalinus is a small tree with trifoliate leaves, and flowers and fruits resembling those of *P. Marsupium*. The heart-wood is official (p. 547).

FIG. 152. American senna (*Cassia marilandica*). The figure at the left shows the pinnately-compound leaves in the day position when under the influence of light, and the one to the right the drooping position of the leaflets at night.

Hæmatoxylon campechianum is a small tree with irregular spinous branches. The leaves are 8- to 10-foliate, the leaflets being sessile and obcordate. The flowers are fragrant, have a purple calyx and yellow corolla, and are in racemes. The fruit is a slender, lanceolate, flat pod, which dehisces laterally instead of along the sutures. The heart-wood of this tree constitutes the official Logwood which is recognized in nearly all the pharmacopœias (p. 546).

Krameria triandra is a shrub with simple, ovate-lanceolate, sessile, silver-white, glistening leaves (Fig. 154). The flowers are complete, having two purple petals and three stamens. The fruit is a 1-seeded, globular, prickly, indehiscent pod. *K. Ixina* found growing from Mexico to Northern South America, and *K. argentea* of Northern Brazil, are distinguished by having flowers with three petals and four stamens. The root is the part used in medicine (p. 453).

Copaiba Langsdorffii is a small tree found growing in Brazil. The leaves are 6- to 10-foliate, the leaflets being ovate-lanceolate,

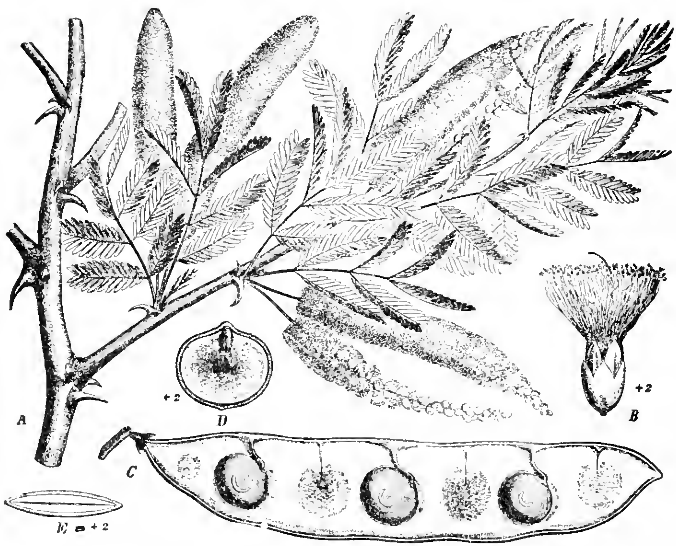


FIG. 153. *Acacia Senegal:* A, flowering branch; B, a single flower showing numerous stamens; C, part of legume showing attachment of seeds; D, E, sections of seeds.—After Taubert.

glabrous, coriaceous, and glandular punctate. The flowers are apetalous, and the fruit is an ellipsoidal, coriaceous, 2-valved pod having a single glandular seed with an arillus. An oleo-resin collects in longitudinal cavities in the trunk of the tree, often amounting to many liters, and sometimes the pressure thus produced is sufficient to burst the trunk in places. The oleo-resin is official as COPAIBA. The latter consists of 30 to 75 per cent. of a volatile oil from which the sesquiterpene caryophyllene has been isolated; a bitter acrid resin and a bitter principle. A similar product is obtained from a number of other species of Copaiba growing in South America as well as *C. copallifera* of Western Africa, and *Hardwickia Mannii* of tropical Africa, and *H. pinnata* of India.

An oleoresin known by the natives in the province of Velasco in Bolivia as "Copaiba" is obtained from *Copaiba paupera*. It is thick, like Maracaibo balsam but lighter in color and resembles in odor and taste true copaiba. It is distinguished from the other specimens of American copaiba by its dextro-rotation

FIG. 154. Hematoxylin: monoclinic tabular crystals from aqueous solution.

$[a]_D + 36°$. On the addition of one to two volumes of petroleum ether it forms a clear solution, giving a white precipitate on the addition of more ether.

Toluifera Balsamum is a tree about 25 M. high, with a straight trunk, on which the branches first appear at a height of from 15 to 20 M., and is found growing in Northern South America. The leaves are compound and with seven to eleven alternate, oblong, acuminate, glandular-punctuate leaflets; the flowers are white and in simple axillary racemes; the fruit is a winged, indehiscent, 1-seeded legume. The plants yield a balsam (official in all the pharmacopœias and known as BALSAM OF TOLU) which occurs in schizogenous cavities in the bark of young twigs, and is obtained by incising the bark, it being usually collected in gourds. The balsam consists of 75 to 80 per cent. of resin, which is a compound of tolu-resinotannol, cinnamic and benzoic acids; 18 to 20 per cent. of free cinnamic acid; 0.2 to 1 per cent. of a volatile oil; and 0.05 per cent. of vanillin. A good tolu balsam is also obtained from *T. peruifera* growing in the northeastern part of South America.

Toluifera Pereiræ is a tree about 15 M. high, which has a short trunk and begins to branch at a height of 2 or 3 M. It otherwise resembles *T. Balsamum*. It is found over the whole of Northern South America, extending through Central America to Mexico, and is cultivated in Singapore. The balsam, which is formed as a result of injury to the trunk, consists chiefly of esters of benzoic and cinnamic acids, some free cinnamic acid, and vanillin. A very fragrant vanilla-like balsam is obtained from the fruit of this same plant, and in San Salvador it is known as white Peru balsam to distinguish it from the black Peru balsam obtained from the trunk.

Physostigma venenosum is a woody climber. The leaves are 3-foliate, the leaflets being ovate-acuminate; the flowers are violet in color and in axillary racemes; the fruit is a broadly linear, somewhat flattened, distinctly veined, dehiscent pod which tapers at both ends, and usually contains two or three seeds. The seeds are official as Physostigma (p. 438).

The blue coloring principle INDIGO is mostly obtained from the herbs *Indigofera tinctoria* and *I. Anil* which are indigenous to, and cultivated in tropical and sub-tropical countries. It is prepared by extracting the leaves with water. The glucosidal principle indican (or mother-substance of indigo blue) undergoes oxidation and the insoluble indigo blue separates out. This is the commercial indigo. A similar principle is found in the wild indigo (*Baptisia tinctoria*) of the United States and Canada; the leaves of *Robinia Pseudacacia* of North America; several species of Psoralea and Amorpha, as well as some other Leguminosæ. It is also found in other families, as in Polygonaceæ, Cruciferæ, Asclepiadaceæ, and Apocynaceæ.

A yellow coloring principle is found in the dyer's broom (*Genista tinctoria*) of Europe and Asia and naturalized in the New England States. *G. ovata* of Europe yields a similar dye.

COPAL RESINS are derived from a number of the Leguminosæ: American copal from *Hymenæa Coubaril* of the West Indies and South America; Brazilian copal from *H. Martiana* of Rio Negro; Zanzibar or Chakazzi-copal from *Trachylobium mozambicensis* of Western Africa; Sierra Leone copal (yellow gum, red gum) from *Copaiba Guibourtia* of Sierra Leone; Inhambane copal from *Copaiba conjugata* and *C. Gorskiana* of Singapore, Jamaica and Australia.

Probably the majority of the LOCO-WEEDS or plants containing principles poisonous to cattle belong to the Leguminosæ, and of these the following may be mentioned: California loco-weed (*Astragalus crotalariæ*), Texas or woolly loco-weed (*A. mollissimus*), rattle-box (*Crotalaria sagittalis*) found in the Eastern United States and Canada. The poisonous action of these plants is apparently due in some cases to the presence of barium salts. *Clitoria glycinoides* of Brazil, *Phaca ochroleucaca* of Chile and *Oxytropis Lambertii* of Mexico are poisonous to horses and should probably be included with the loco-weeds.

A large number of the plants belonging to the Leguminosæ contain toxic principles and those which have not already been considered might be grouped according to the principles which they contain.

1. ARROW-POISON group, including the genera Erythrophlœum, Afzelia and Pithecolobium.

2. FISH-POISON group, including the genera Albizzia, Afzelia, Bauhinia, Barbiera, Enterolobium, Leucæna, Millettia, Tephrosia, Acacia, Abrus, Clitoria, Mundulea, Derris, Lonchocarpus, Piscidia (*P. Erythrina* or Jamaica dogwood, which contains a curare-like alkaloid).

3. SAPONIN-containing plants, as the genera Acacia, Albizzia, Entada (*E. scandens* or the sea bean of the East and West Indies), Enterolobium, Gleditschia and Gymnocladus (*G. dioica* or Kentucky coffee-tree growing in the United States and Canada).

4. CYTISINE-containing plants; the alkaloid cytisine is found in *Laburnum vulgare* and *L. alpinum* growing wild in Southern

Europe and also cultivated, and in one or more species of the following genera: Anagyris, Baptisia, Coronilla, Crotalaria, Genista, and Ulex.

Abrin, composed of a globulin and albumose and whose properties are affected at a temperature of 50° C. or over, is found in the seeds of JEQUIRITY (*Abrus precatorius*) and *Cassia hispidula* of Mexico; two alkaloids (lupinine and lupinidine) and a bitter glucoside (lupinin) are found in the white lupine (*Lupinus albus*) of Europe and in other species of Lupinus; a glucoside (wistarin) and a poisonous resin are found in WISTARIA (*Kraunhia floribunda*) a common woody climber in cultivation as an ornamental plant; the glucoside ononin is found in RADIX ONONIDIS the root of *Ononis spinosa* of Europe; the glandular hairs on the pods of *Mucuna pruriens* and *M. urens* growing in the Tropics of both hemispheres constitute the COWHAGE of medicine; butyric acid is found in ST. JOHN'S BREAD the fruit of *Ceratonia Siliqua* which grows in European countries bordering the Mediterranean, and also in *Eperua falcata* of Guiana.

A bitter principle, bondicine, known as poor man's quinine, is found in *Cæsalpinia Bonducella* and other species of *Cæsalpinia* growing in Sumatra, Borneo, New Zealand and Brazil; the seeds of *Phaseolus lunatus* of the East Indies contain a principle from which hydrocyanic acid is derived.

The seeds of many of the plants belonging to the Leguminosæ are rich in starch and proteins and hence are used as foods. The protein LEGUMIN is characteristic of this family. The following are some of the important food plants: the garden pea (*Pisum sativum*), the garden bean (*Phaseolus vulgaris*); lentil (*Lens esculenta*), Japanese Soy bean (*Glycine hispida*). The peanut (*Arachis hypogæa*) indigenous to Brazil and extensively cultivated in most of the Southern States and in Southern Europe, belongs to the group of plants which have geocarpic fruits, that is, fruits which penetrate the soil during their development and ripen under ground (Fig. 88). In peanuts the starch is replaced by a fixed oil which is present to the extent of about 45 per cent. and which is an article of commerce. In addition to the seeds mentioned those of a number of other plants as well as some fruits, roots and leaves are used as foods in various parts of the world, particularly in the Tropics. The plants of a number of species are used as forage, as those of clover (*Trifolium*); some are cultivated as ornamental plants, as sweet pea (*Lathyrus odoratus*), and some yield valuable timber, as the locust (*Robinia*).

XVI. ORDER GERANIALES.

This order includes a number of families of economic importance. The sepals are mostly distinct; the stamens are few; the carpels are united, and the ovules are pendulous (epitropous).

a. GERANIACEÆ OR GERANIUM FAMILY.—The plants are herbs with alternate or opposite, usually stipulate leaves, regular and perfect flowers, and capsular fruit (Fig. 89, *C*).

Geranium maculatum is a perennial herb (Fig. 155) with a short, thick, horizontal rhizome, from which arises a simple, somewhat branching, hairy stem, with 3- to 5-parted, variously toothed and cleft, petiolate leaves, those on the upper part of the stem being opposite; the flowers are regular and 5-merous, occurring singly or in twos in the axils of the leaves; the petals are rose-purple and hairy at the base; the fruit is a dehiscent capsule; the five carpels when ripe separate and roll upwards remaining attached to a central column by means of a slender carpophore, the individual carpels being in the nature of akenes. The rhizome constitutes the official geranium (p. 505).

The cultivated geraniums belong to the genera Pelargonium, and some of the species furnish oil of rose geranium, as *P. odoratissimum*, *P. capitatum* and *P. radula*, all of which are cultivated in France, Spain, Germany, Algiers and Reunion for the oil, which is largely used in perfumery. The oil contains geraniol, citronellol, and various esters. The leaves of *Pelargonium peltatum*, growing in certain parts of Africa and Australia, contain oxalic acid and acid oxalates.

b. OXALIDACEÆ OR WOOD-SORREL FAMILY.—To this family belongs the genus *Oxalis*, some species of which have leaves that are quite sensitive to light as well as mechanical stimuli, which applies especially to the cultivated forms of South Africa, and to the common wood-sorrel (*Oxalis Acetosella*) of the United States and Canada, as well. The leaves contain oxalic acid and acid oxalates.

c. THE TROPÆOLACEÆ OR NASTURTIUM FAMILY comprises but a single genus, Tropæolum. Some species

FIG. 155. *Geranium maculatum* showing typical dicotyledonous flowers and the 5-parted, reticulately-veined leaves.

are cultivated for ornamental purposes and are the nasturtiums of the gardens. The young shoots are succulent and taste like some of the cresses, hence they have received the name "Indian cress." They contain volatile constituents resembling those of the Cruciferæ, and in the leaves of *Tropæolum majus* benzyl mustard-oil is found. The flower-buds and young fruits of this species are used for pickling like capers.

d. LINACEÆ OR FLAX FAMILY.—The most important plant of this family is the common flax (*Linum usitatissimum*). This is an erect, slightly branching annual herb with alternate, lanceolate and 3-nerved leaves. The flowers are in terminal, leafy panicles, the pedicels being slender, the calyx non-glandular, and the petals blue (Fig. 134, *A*). The fruit is a 10-locular, 10-seeded capsule. The seeds are official (p. 426). There are a number of cultivated varieties and the seeds of the *var. Humile* contain a glucoside which yields, under the influence of ferments, hydrocyanic acid. A cathartic principle has been found in *L. catharticum* growing in Europe. The bast fibers of *Linum usitatissimum* are used in the manufacture of linen. These fibers are distinguished from many other vegetable fibers in not containing lignin.

e. ERYTHROXYLACEÆ OR COCA FAMILY.—This family contains but two genera, one of which is Erythroxylon. The official coca leaves (p. 604) are obtained from *Erythroxylon Coca*. The plant is a shrub and requires a very humid atmosphere and a comparatively high elevation. The leaves are alternate, petiolate and entire; the flowers are white and very small; the fruit is a 1-seeded, reddish drupe resembling that of dogwood (Fig. 260).

Other species of Erythroxylon also yield useful products. An aromatic oil is found in the wood of *E. monogynum* of Ceylon and India, and the wood is known as "bastard cedar" or "bastard santal." A brownish-red coloring principle is found in the red-wood (*E. œrolatum*) of Jamaica and in *E. suberosum* and *E. tortuosum*. Purgative and anthelmintic principles are found in some species of this genus.

f. ZYGOPHYLLACEÆ OR CALTROP FAMILY.—The plants are mostly herbs and shrubs which are widely distributed in warm-tropical regions. The leaves are mostly opposite, pinnate and stipulate. The genus *Guaiacum* is of interest on account of the wood containing considerable resin, which is used in medicine.

Guaiacum officinale is a small tree with 4- to 6-foliate leaves, the leaflets being ovate, entire and sessile; the flowers are large, blue, and in axillary clusters; and the fruit is a 2-valved capsule (Fig. 156). *G. sanctum* is a tree resembling *G. officinale,* but is distinguished by having leaves which are 8-foliate and with smaller leaflets, and a 4- to 5-valved capsule. The resin of both species is official (p. 668).

A resin having an odor resembling that of creosote occurs in the CREOSOTE BUSH (*Covillea tridentata*) of Mexico and Texas.

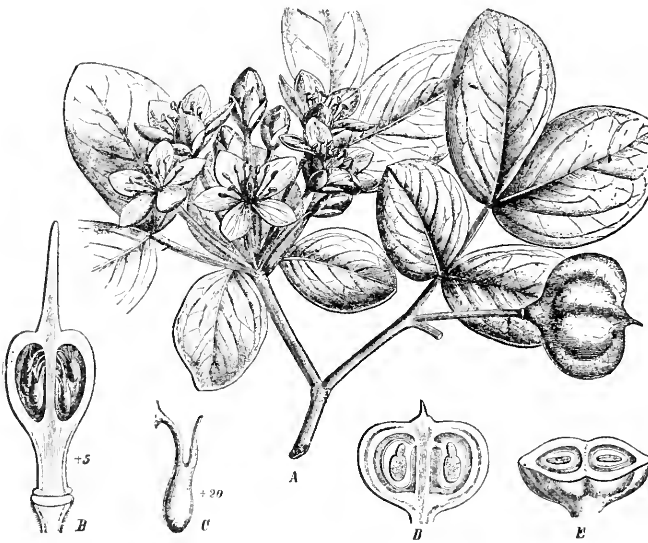


FIG. 156. *Guaiacum officinale:* A, flowering and fruiting branch; B, gynæcium in longitudinal section showing the pendulous ovules; C, a seed; D, E, the fruit in longitudinal and transverse sections.—After Berg and Schmidt.

The juice of *Peganum Harmala* contains a yellow coloring principle used in dyeing. A number of the plants of this family contain powerful poisonous principles.

g. RUTACEÆ OR RUE FAMILY.—The plants are shrubs or trees, seldom herbs, with lysigenous oil-secretion cells. The leaves are usually alternate, simple or compound and glandular-punctuate (Fig. 134, C).

Xanthoxylum americanum or northern prickly ash, is a shrub or small tree with 5- to 11-compound leaves, the leaflets being ovate and nearly sessile; the flowers are diœcious, greenish, and in axillary cymes; the fruit is a black, 2-valved capsule. *X. Clava-Herculis* or the southern prickly ash is a very prickly shrub, which is characterized by having cork-wings on the bark. The leaves are 5- to 17-foliate, the leaflets being ovate and crenulate; the flowers are in terminal racemes and have a calyx of 4 or 5 sepals,

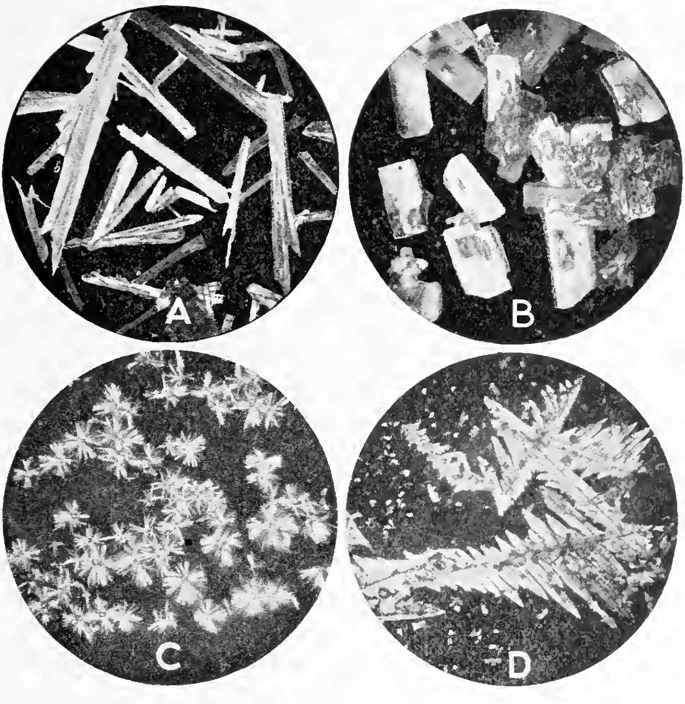


Fig. 157. Cocaine: A, monoclinic crystals of cocaine; B, orthorhombic crystals of cocaine hydrochloride; C, monoclinic crystals of cocaine hydrochloride and palladous chloride; D, skeleton aggregates of cocaine hydrochloride and palladous chloride.

the calyx being wanting in *X. americanum.* The bark of these two species is official (p. 532).

Pilocarpus.—To this genus belong a number of species which are shrubs or small trees and indigenous to tropical America. The leaves are mostly pinnately-compound, the leaflets being coriaceous and entire; the flowers are small, greenish and in axillary or terminal racemes; the fruit is a 1-seeded, 2-valved capsule (Fig. 257). The leaves of three species are official as Pilocarpus or Jaborandi (p. 596).

Barosma.—The buchu leaves of medicine are obtained from several species of Barosma (see Buchu). The plants are branching shrubs with opposite, coriaceous, serrate or dentate leaves with glandular margins; the flowers are white or red and occur, 1 to 3, in the axils of the leaves: the fruit is a 5-valved capsule. The leaves contain a volatile oil, one of the constituents of which is diosphenol (Figs. 158, 259).

Citrus.—The fruits of a number of species of this genus are edible, and the plants are also valued for their volatile oils. They are aromatic, glandular, mostly thorny shrubs or small trees indigenous to tropical and sub-tropical Asia, and now extensively cultivated in tropical, sub-tropical and warm-temperate regions. The leaves are more or less winged-petiolate, glaucous, coriaceous, mainly unifoliate (or trifoliate); the flowers are complete, with 3- to 6-toothed gamosepalous calyx, and 4 to 8 glandular petals; the stamens are 20 to 60, in groups of 1 to 9; the ovary is subtended by a cushion-shaped disk, and the fruit is a spherical, oblong or pear-shaped berry, having a coriaceous pericarp with numerous lysigenous oil-glands, a juicy pulp made up of peculiar hair-structures which arise from the endocarp, and in which are embedded white polyembryonic seeds (Fig. 134, *C*).

Botanists have divided this genus into two sub-groups: (a) the Pseudo-Ægle group is represented by the trifoliate orange (*Citrus trifoliata*), cultivated widely in the United States as a hedge. The leaves are trifoliate and deciduous, the petals spatulate and the ovary and disk hairy. (b) In the Eucitrus group the leaves are unifoliate and evergreen, the petals oblong, and the ovary and disk glabrous. This latter group includes the two species which yield most of the edible Citrus fruits.

Citrus Aurantium includes a number of sub-species and varieties. The plants are small trees with leaves having winged petioles (Fig. 158); white flowers; and a more or less globular fruit. The Sweet Orange (Malta, Portugal) is derived from the sub-species *sinensis*. The Bitter Orange (Seville, Curaçao) is derived from the sub-species *amara*. The flowers of both the

Sweet and Bitter Orange tree contain a volatile oil known as OIL OF NEROLI, and composed of limonene, geraniol, linalool, etc. The oil from the rind of the fruit is known as OIL OF ORANGE PEEL, and is obtained chiefly from Italy and Sicily. It is composed of limonene, citral, citronellol, etc. The oil from the Bitter Orange peel has a superior flavor and is known as BIGARADIA OIL. The Bergamot Orange is the fruit of the sub-species *Bergamia*, cultivated in Europe, but only rarely in the United States. The oil of the rind of the fruit is known as BERGAMOT OIL and consists

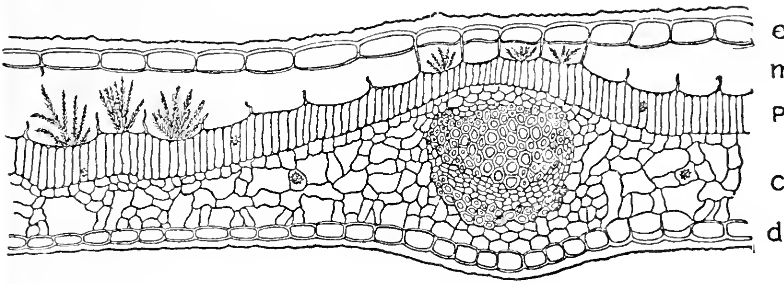


FIG. 158. Transverse section through the leaf of *Barosma serratifolia* Willd: e, epidermal cells of upper surface, the inner walls of which are mucilaginous. The mucilage (m) frequently includes dendritic excretions of hesperidin, which dissolve in solutions of potassium hydroxide, giving a yellow color; p, palisade cells, some of which contain rosette aggregates of calcium oxalate; c, chlorenchyma, some of the cells containing rosette aggregates of calcium oxalate, also a large vascular bundle (mestome strand) with a stereomatic pericycle forming an arch on the dorsal face; d, epidermis of lower (or dorsal) face of the leaf. —After Solereder.

largely of linalyl acetate. In the group of MANDARIN or Kid-glove oranges (*Citrus nobilis*) the fruit is compressed, spherical, 5–6 cm. in diameter and with an orange-yellow, loose and easily removable rind. The SHADDOCK or grape-fruit is derived from the sub-species *sinensis* var. *decumana*, a tree indigenous to the Malay Archipelago and extensively cultivated in India, Florida, California and elsewhere. The fruits are quite large, sometimes weighing several kilograms, and those which are round are the most valuable commercially, being known as Pomelos or GRAPE-FRUITS. The BLOOD ORANGE is the fruit of the sub-species *sinensis* var. *sanguinea*. The OTAHEITE ORANGE which is extensively cultivated as a dwarf pot plant and the foliage and flowers of which resemble those of lemon, is probably a variety of the sub-species *sinensis*, or it may be a hybrid of lemon and orange. The Navel Orange is a sweet orange in which an additional compound ovary is developed within the fruit.

Lemon and lime fruits are derived from sub-species of *Citrus medica*, which are mostly shrubs with simple, petiolate leaves, reddish twigs and flowers, and more or less ellipsoidal fruits. Lemons are derived from the sub-species *Limonum*. The rind of the fruit yields the oil of lemon, which consists of limonene, citral, etc. Most of the commercial article comes from Sicily and Calabria. Lime fruits or limes are derived from the sub-species *acida*, a shrub cultivated in the West Indies and Florida. The Citron fruit, the rind of which is used in the making of preserves and confections, is derived from the sub-species *genuina*. The fruit is large and lemon-like but with a thick rind, the plant being cultivated to some extent in Florida and California.

The Kumquat Orange is obtained from *Citrus japonica*, a thornless tree with spreading dwarf habit extensively cultivated in China and Japan and very hardy even in Northern Florida. The fruit is round or oblong, from 3 to 5 cm. long and 2 to 3 cm. in diameter, and of an orange-yellow color; the rind is sweet while the pulp is acid, and usually free from seeds, although from 1 to 4 slightly beaked seeds may be present.

The inner white portion of the rind of the Citrus fruits contains a crystalline, tasteless glucoside known as hesperidin. Those which are bitter contain in addition several bitter glucosides, namely, aurantiamarin and naringin. (See Aurantii Amari Cortex, p. 592, and Aurantii Dulcis Cortex, p. 591.)

Volatile oils are also found in other members of the Rutaceæ. The garden rue (*Ruta graveolens*), the leaves of which are used in medicine, contains a volatile oil consisting of several ketones. It also contains a glucoside known as rutin which resembles the barosmin of buchu; and quercetin, which is said to be derived from rutin. The Hop tree (*Ptelea trifoliata*) of Eastern North America contains besides a volatile oil, a resin and an alkaloid. The volatile oil of pepper-moor (*Xanthoxylum piperitum*) of China and Japan is known as Japanese oil of pepper.

Angustura bark obtained from *Cusparia trifoliata* or *C. officinalis*, plants growing in the region of the Orinoco River, contains a volatile oil, resin, a bitter principle and four alkaloids. The wood of *Amyris balsamifera* of Guiana and Jamaica, yields on distillation a volatile oil resembling Oleum Rhodii.

h. SIMARUBACEÆ OR AILANTHUS FAMILY.—The plants are chiefly shrubs or trees with alternate and pinnately-compound leaves. The flowers are regular, diœcious or polygamous and in axillary racemes. The plants are natives of tropical countries and are distinguished from the Rutaceæ, which they somewhat resemble, by the absence of oil ducts or reservoirs.

FIG. 150. Caffeine gold chloride; crystals formed on the addition of a solution of gold chloride to a dilute aqueous solution of caffeine.

They are widely employed particularly in the tropics, on account of their bitter principles and are considered valuable tonics, febrifuges and remedies for dysentery.

Picrasma excelsa is a small tree with 9- to 17-foliate leaves, the leaflets being ovate and more or less tomentose, particularly in the bud; the flowers are yellow, polygamous and in axillary panicles; the fruit is a large, spherical drupe. The wood of the plant constitutes Jamaica quassia (p. 544).

Quassia amara is a small tree or shrub with 4- to 5-foliate leaves; the leaflets are narrow, obovate and acuminate, and the rachis and petiole or stalk are winged; the flowers are hermaphrodite, with 10 stamens, bright red corolla, and in terminal racemes; the fruit is a 5-valved indehiscent pod or nutlet. The wood constitutes Surinam quassia (p. 544).

A red coloring principle is found in *Samadera indica* of India, Ceylon and Java. The alkaloid cedronin is found in the seeds of *Simaba Cedron* of New Granada, the seeds being used as an antidote for the bites of poisonous animals. A similar principle may exist in the bark of *Simaruba versicolor* of Brazil, the plant being used for a similar purpose. The alkaloid brucamarine is found in the fruit of *Brucea sumatrana*. A tragacanth-like gum is obtained from *Ailanthus excelsa* of India. DIKA or GABUN CHOCOLATE is obtained from the seeds of *Irvingia gabonensis* of tropical West Africa. Cay-Cay-Butter is obtained from the seeds of *Irvingia Oliveri* and *I. Malayana* of Malacca and Cochin China.

A gum resembling acacia is also obtained from the bark, petioles and seeds of the species of *Irvingia*.

i. BURSERACEÆ OR MYRRH FAMILY.—The plants are shrubs or trees, the latter being sometimes quite large, with resin-canals in the bark, and alternate compound leaves; the flowers are small, occurring in racemes. The members of this family are found in tropical countries.

Commiphora abyssinica is a shrub 10 M. high, the branches being modified to thorns; the leaves are trifoliate, the leaflets being oblong, dentate, sessile and the terminal one much larger than the other two; the flowers are diœcious, and the fruit is a drupe with fleshy, resinous sarcocarp (Fig. 160). The official Myrrh is obtained from this plant (p. 673).

A number of other resinous products are yielded by plants of this family. West India ELEMI resin or Elemi Occidentale (Anime) is obtained from the stems of *Protium Icicariba* of Brazil. The resin is greenish-yellow, soft, with a bitter taste and dill-like odor. Manila Elemi is a soft, granular, lemon-yellow or grayish-white resin derived from *Canarium commune* of the Philippine Islands. Bengal Elemi is derived from *Commiphora Agallocha* of the East Indies and Madagascar. The TACAMAHAC RESINS are balsamic resins, of which there are several commercial varieties: Mauritius tacamahaca is obtained from *Protium hepta-*

phyllum of Columbia, and Mexican or West Indian tacamahaca from *Bursera tomentosa* of Mexico, West Indies, and South America. INDIA BDELLIUM is a resin obtained from the bark of *Commiphora Roxburghiana* of Northwestern India and Beluchistan. COPAL-like resins are obtained from *Canarium Bengalense* (East Indian Copal) and possibly several species of

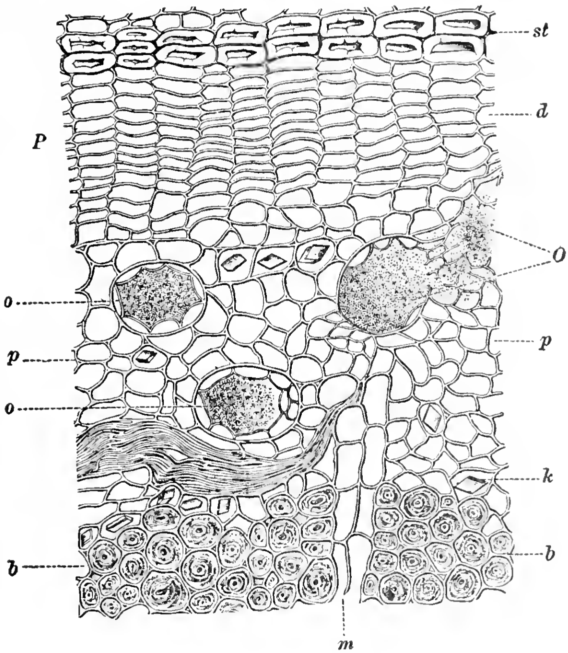


FIG. 160. Cross-section of the bark of one of the Burseraceæ probably *Commiphora Myrrha:* P, bark made up of sclerotic cells (st) and cork (d); o, more or less regular secretion canals, one of which (o) shows the irregular spreading of the gum-resin; m, medullary rays; b, bast fibers; k, crystals of calcium oxalate; p, parenchyma.—After Vogl.

Bursera. BLACK DAMMAR resin is obtained from *Canarium rostratum* of the Molucca Islands. OLIBANUM or Frankincense is a gum-resin obtained from several species of *Boswellia* of Asia and Somali Land. AMERICAN OLIBANUM or Soft Resin of Cayenne exudes spontaneously from the stems of *Protium heptaphyllum* and *P. guianense*. GILEAD BALSAM is obtained from *Protium altissimum* and *P. carana* of Guiana and Brazil. MEXICAN LIN-

ALŒ OIL is obtained from *Bursera graveolens*, and several species of *Bursera* of Mexico are used as a substitute for Aloe wood.

j. MELIACEÆ OR MAHOGANY FAMILY.—This is a large family of tropical trees and shrubs with mostly alternate, compound and exstipulate leaves, the leaflets being entire, with secretion cells, but not glandular-punctate (Fig. 161). The flowers are complete, the filaments being united into a tube; and

FIG. 161. Pride of China (*Melia Azedarach*): A, flowering branch; B, a part of the inflorescence.—After Harms.

they occur in axillary clusters or racemes; the fruit is a capsule, berry or drupe; the seeds are sometimes winged and with fleshy or leaf-like cotyledons.

The bitter principle mangrovin is found in the bark of the China Tree or Pride of China (*Melia Azedarach*) indigenous to Asia, and extensively cultivated in tropical and warm-temperate regions, and naturalized in the southern part of the United States (Fig. 161). A similar principle is found in other plants of this family.

Carapa Oil, which has a characteristic odor and bitter taste and is toxic to insects, is obtained from the seeds of *Carapa procera* and *C. guianensis*, of tropical West Africa and tropical America, and also from *Swietenia Mahagoni* (Mahogany Tree). Cedar-wood oil ("Oleum Cedrelæ") is obtained from several species of Cedrela growing in tropical America. The most important constituent of the oils is cadinine. Oils with a garlic-like odor are found in the seeds of *Melia Azedarach*, the bark of *Cedrela australis* of Australia and the fruit of *Dysoxylum binectariferum* of Java. Besides the Mahogany tree there are other trees of this family which yield valuable woods. Cigar boxes and sugar boxes are made from the wood of *Cedrela odorata* of the West Indies and Guiana, and from other species of Cedrela.

k. MALPIGHIACEÆ is a rather large family of shrubs, small trees, or lianes with anomalous stem-structure, found in the Tropics, principally in South America. The leaves are usually opposite, the sepals are glandular, and the fruit is a winged samara somewhat like that of maple (*Acer*).

The plants contain a notable amount of tannin and the woods of some species contain a red coloring principle.

l. POLYGALACEÆ OR MILKWORT FAMILY.—The members of this family are herbs or shrubs, occurring in all parts of the world except in the Arctic regions.

Polygala Senega is a perennial about ⅓ M. high. It has a fleshy root, producing at the crown a large number of buds and giving rise to a cluster of stems or so-called plants (Fig. 197). The leaves are alternate, lanceolate or oblong-lanceolate and sessile; the flowers are faintly greenish-white and in cylindrical spikes; the capsule is loculicidally dehiscent, and the seed is hairy and slightly longer than the lobes of the caruncle. The root is official (p. 456).

Polygala alba or White Milkwort yields the White or Texas senega. The stems are numerous and taller than those of *P. Senega*; the leaves are narrow-lanceolate or linear with revolute margin; the flowers are white and in elongated conic spikes; the caruncle lobes are about half as long as the seed. The plant is found west of the Mississippi River extending as far south as Texas and Mexico and west as far as Arizona and New Mexico.

m. EUPHORBIACEÆ OR SPURGE FAMILY.—The plants are herbs, shrubs or trees with acrid and often milky latex. The fruit is mostly a trilocular, dehiscent capsule; the seeds are anatropous and have an oily endosperm.

Stillingia sylvatica or Queen's-Root yields the official Stillingia (p. 462). The plant is a perennial herb about 1 M. high and diffusely branched. The leaves are obovate, short-petiolate, with glandular-serrate margin; the flowers are in terminal spikes, light yellow, monœcious, the staminate being above and the pistillate below, the latter solitary in the axils of the lower bractlets (Fig. 162).

Ricinus communis or Castor-Oil Plant is an annual herb in the temperate regions but is shrub-like and perennial in tropical and sub-tropical countries. In temperate regions the plant is from 1 to 5 M. high; the leaves are peltate and 6- to 11-palmately-lobed; the flowers are greenish, apetalous, monœcious and in racemes, the pistillate being above the staminate on the flower-axis; the fruit is a 3-locular, oval, spinous capsule, which dehisces septicidally (Fig. 90, *B*). The seeds are anatropous, somewhat flattened-oblong; 10 to 16 mm. long and 4 to 8 mm. in diameter; smooth, mottled grayish-brown or yellowish-red, with a prominent caruncle; hard but brittle testa, thin white tegmen, large oily endosperm, and thin foliaceous cotyledons at the center. The seeds contain 45 to 50 per cent. of oil which constitutes the Castor Oil of medicine and a large amount of proteins in the form of aleurone grains (Fig. 122, *D*). The cake from which the oil is expressed contains a poisonous principle known as ricin which is apparently poisonous to cattle, but not to poultry.

Croton Tiglium is a shrub or small tree indigenous to tropical Asia and extensively cultivated in tropical countries; the leaves are alternate, oblong-lanceolate with petioles which are glandular at the base, but wanting in the star-shaped hairs so characteristic of other species of this genus; the flowers are small, monœcious and in terminal racemes, the pistillate being above and the staminate below; the fruit is a 3-locular, septicidally dehiscent capsule. The seeds resemble those of Ricinus in size and structure, except that they are less smooth, more brownish in color and the caruncle is quite small.

They contain a fixed oil which is obtained by expression and which is poisonous and a powerful cathartic. The seeds of a number of the other members of the Euphorbiaceæ contain fixed oils resembling those of Croton and Ricinus, as CURCAS the seeds of *Jatropha Curcas* of tropical America. MEXICAN CROTON OIL

FIG. 162. *Stillingia sylvatica:* showing the more or less closely arranged leaves and the terminal spike of flowers.—After Bentley and Trimen.

is obtained from the seeds of *Euphorbia calyculata.* The seeds of the Caper Spurge or Wild Caper (*Euphorbia Lathyris*) naturalized in the United States from Europe, also contain a fixed oil resembling that of Croton. The seeds of *Joannesia princeps* of the maritime provinces of Brazil are also powerful purgatives.

Mallotus philippinensis is a shrub or small tree found in tropical countries of the Eastern Hemisphere. The leaves are alternate, petiolate, ovate, acuminate, coriaceous and evergreen; the flowers are small, diœcious, and in racemes; the fruit is a 3-locular, glandular-hairy capsule. The hairs of the capsule are official in a number of pharmacopœias under the name of KAMALA and occur as a reddish-brown, granular powder, consisting of two kinds of hairs, the one colorless and occurring in branching clusters (Fig. 284, *B*) and the other with yellowish-red, multicellular, glandular heads. The important constituent is about 80 per cent. of a dark brownish-red resin composed of a crystalline principle rottlerin; isorottlerin; two reddish-yellow resins; a coloring principle and wax. It also contains a trace of volatile oil, starch, sugar, tannin, oxalic and citric acids.

A red coloring principle is found in the bark of *Aleurites triloba* of the Polynesian Islands, *Euphorbia parviflora* of Ceylon, *E. pulcherrima* of Mexico and Brazil and the other species of Euphorbia.

CASCARILLA BARK is obtained from *Croton eluteria* and other species of Croton growing in the Bahama Islands and other parts of the West Indies and Florida. Cascarilla bark is official in a number of pharmacopœias. It occurs in small curved pieces or quills, 1 to 3 mm. thick, externally brownish-gray; inner surface is reddish-brown, the fracture short, resinous; odor aromatic; particularly on burning; taste aromatic and bitter. Cascarilla contains 1 to 1.5 per cent. of a volatile oil, containing eugenol, limonene, an oxygenated portion, and some other constituents; 15 per cent. of resin; a bitter principle, cascarillin; tannin and vanillin.

COPALCHI BARK or Quina blanca which is derived from *Croton niveus* of Mexico contains a bitter principle, copalchin, which is also found in other species of Croton. Malambo bark is derived from *Croton Malambo* of Venezuela, the latter two barks being sometimes substituted for Cascarilla bark.

ELASTICA or India Rubber (Caoutchouc) is the prepared milk-juice obtained from one or more species of the following genera: Hevea, Mabea, Euphorbia and Excœcaria. The fresh latex of a number of species is a powerful irritant, as that of the Sand-box tree (*Hura crepitans*) of tropical America, which contains a highly toxic albuminoid; the Blinding-tree (*Excœcaria Agallocha*) of Southern Asia and Australia, the juice of which produces blindness.

The gum-resin EUPHORBIUM is obtained from *Euphorbia resinifera*, a cactus-like plant of Morocco, and is also found in other species of Euphorbia. It contains, among other constituents, 38 per cent. of an acrid resin, and 22 per cent. of a crystalline principle euphorbon.

The milk-juice of several species of *Euphorbia* is used in the preparation of arrow poisons in Brazil. One or more species of the following genera are used as fish poisons: Flueggea, Phyllanthus, Bridelia, Excœcaria and Euphorbia. A number of plants are used as remedies for the bites of serpents, as the bark of *Phyllanthus mollis* of Java and *Euphorbia pilulifera* of South America and India. *Euphorbia pilulifera*, common in tropical countries, contains an alkaloid, a wax-like substance, several resins and tannin. (*Ph. Jour.*, 29, July 31, 1909, p. 141.)

A camphor-containing oil is found in the bark of *Pentalostigma quadriloculare* of Australia; the aromatic wood of *Colliguaya odorifera* of Chile is used as a substitute for santal and on burning emits a rose-like odor; the leaf of *Croton menthodorus* of Peru contains an oil with an odor of mentha; a balsam resembling Copaiba is derived from the bark of *Croton origanifolius* of the West Indies; methylamine is found in *Mercurialis annua* of Europe and other species of Mercurialis. Tannin is found in the following genera: Macaranga, Phyllanthus and Bridelia; Brazil kino is obtained from a species of Croton (*C. erythrœus?*) of Brazil. A gum-lac is formed on the stems of *Aleurites laccifera* of the Antilles and Ceylon as a result of the sting of an insect, and contains among other substances a large amount of melyl- and ceryl-alcohols, and a substance resembling abietic acid. The sap of *Euphorbia cyparissias* of Europe yields a resin which is sometimes substituted for scammony.

A reddish resinous substance resembling dragon's blood is obtained from *Croton erythrema* of Brazil; a yellow coloring principle is found in the seed of *Croton tinctorius* of Mexico; poncetin, a violet coloring principle, occurs in *Euphorbia heterophylla* of Brazil; a blue coloring principle is found in *Chrozo-*

phora tinctoria of Southern Europe and Africa and in *Argithamnia tricuspidata lanceolata* of Chile; an indigo-like principle is obtained from *Mercurialis perennis* of Europe. The fresh latex of *Euphorbia phosphorea* of Brazil is phosphorescent.

Quite a number of the seeds of this family contain fatty oils. The Chinese Tallow tree (*Sapium sebiferum*) yields a fat which is used for burning and for technical purposes; a similar fat is obtained from the seeds of several species of Aleurites and Euphorbia.

Tapioca starch is derived from the tuberous roots of *Manihot utilissima*, extensively cultivated in tropical countries; other species of Manihot also yield starchy food products.

Edible fruits are obtained from the following genera: Phyllanthus, Baccaurea and Antidesma; the seeds of *Hevea brasiliana* are edible; a sweet sap is found in *Baccaurea ramiflora* of Cochin China and Brazil; a peptone-like ferment is found in *Euphorbia heterodoxa* of South America and other species of Euphorbia.

XVII. ORDER SAPINDALES.

The plants of this order are chiefly trees and shrubs. The flowers are mostly regular and the seeds usually without endosperm. The order has a number of representatives in both tropical and temperate regions.

a. FAMILY CORIARACEÆ.—This family is represented by but a single genus, Coriaria. The plants are shrubs found in Europe, Asia and South America, and yield several important economic products. The leaves and bark of *C. myrtifolia* of Southern Europe and Northern Africa are rich in tannin and used in dyeing. This plant also contains a narcotic principle, resembling picrotoxin, known as coriamyrtin, which is also found probably in *C. atropurpurea* of Mexico. The leaves of *Coriaria myrtifolia* or TANNER'S SUMAC are coriaceous, distinctly 3-nerved, astringent and bitter and were at one time substituted for senna leaves. A black dye is obtained from *C. ruscifolia* of New Zealand and Chile. While the fruits of some species are quite poisonous the sap of the fleshy leaves is used in New Zealand in making an intoxicating drink

b. BUXACEÆ OR BOX TREE FAMILY.—The plants are shrubs with alternate or opposite, evergreen leaves, and usually axillary monœcious or diœcious flowers. The most important plant of this family is the Box tree (*Buxus sempervirens*) which is extensively cultivated. The wood is used for making musical instruments and for other purposes, and the twigs have been used in medicine. The latter contain several alkaloids, the most important being buxine which resembles beberine; a volatile oil containing butyric acid and a wax containing myricyl alcohol and myricin.

c. ANACARDIACEÆ OR SUMAC FAMILY.—The plants are trees or shrubs with an acrid, resinous or milky latex, and alternate leaves.

Rhus radicans, POISON IVY or Poison Oak, is a woody vine, climbing by means of aerial roots and sometimes becoming quite shrub-like, which is common along roadsides in the United States. The leaves are 3-foliate, the leaflets being ovate, acuminate, nearly entire, inequilateral and with short stalks; the flowers are green and in loose axillary panicles; the fruit is a globular, glabrous, grayish drupe (Fig. 163). The poisonous properties of this plant are due to a brownish-red resin which is soluble in alcohol. A vesicating principle CARDOL is found in the CASHEW NUT. The latter is the fruit of *Anacardium occidentale*, a shrub growing in tropical America. A principle resembling cardol is found in the East India Marking tree or Ink tree (*Semecarpus Anacardium*) and *Holigarna ferruginea* of India.

The POISON SUMAC or Poison Elder (*Rhus vernix*) is a shrub or small tree found in swamps in the United States and Canada. The leaves are 7- to 13-foliate, with obovate or oval, acuminate, entire leaflets; the flowers are small, green, and in axillary panicles; the fruit resembles that of *R. radicans* (Fig. 163). The plant is poisonous like *R. radicans* and probably contains the same principle. Other species of Rhus are also poisonous, as the western Poison Oak (*R. diversiloba*) of the Pacific Coast, and the Japanese Lacquer or Varnish tree (*R. vernicifera* and *R. succedanea*). The lacquer trees grow wild in both China and Japan where they are also cultivated. The lac is obtained by incising the bark and removing it with a pointed spatula. The grayish-white emulsion is strained and on exposure to air it changes to brown becoming finally black. This change

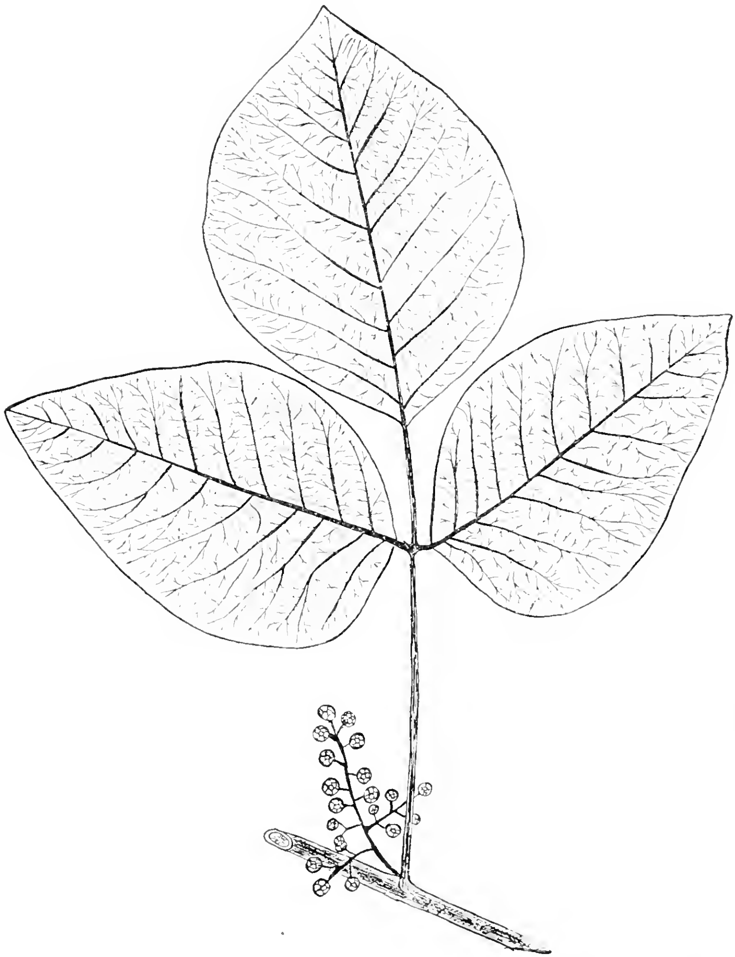


Fig. 163. Leaves and fruit of the poison ivy (*Rhus radicans*). This is a 3-foliate compound leaf, the leaflets being ovate and having veins which bifurcate and end free.

is due to the oxidizing enxyme laccase. The natural lac (Ki-urushi) contains a non-volatile poisonous resin-like principle and is closely associated with other resinous substances. Japanese lac is thinned with camphor, or mixed with linseed oil and on drying in a moist atmosphere forms the most indestructible varnish known. Various pigments are used, as vermillion, gamboge, acetate of iron and other substances. The best glossy black colors are obtained by the addition of iron.

Rhus glabra or the Scarlet Sumac is a smooth shrub. The leaves are 11- to 31-foliate, the leaflets being lanceolate, acuminate, sharply serrate, dark green above and tomentose below; the flowers are greenish, polygamous and in terminal panicles; the fruit is official (p. 569).

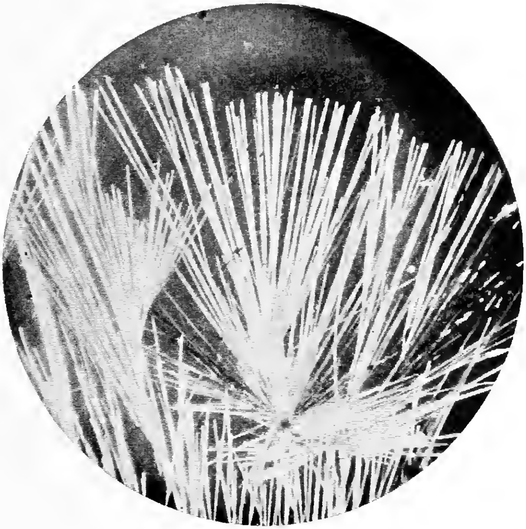


FIG. 164. Gallic acid: long orthorhombic crystals obtained from an aqueous solution.

CHINESE GALLS are excrescences produced on *Rhus semialata* as a result of the stings of an Aphis. JAPANESE GALLS are similar formations occurring on *Rhus japonica*. (See Galla.)

Pistacia Lentiscus is a shrub or tree, which is found growing in the Grecian Archipelago. The leaves are pinnately compound and with winged axis, the leaflets being alternate, oblong, entire, sessile; the flowers are small, diœcious, and in axillary clusters. In the bark of this plant there are large cavities which contain an oleo-resin that is official as Mastic in a number of pharmacopœias (p. 645). The wood of *Schinopsis Lorentzii* and *S. Balansæ*, growing in Argentine and Paraguay, is known in commerce as QUEBRACHO COLORADO. It is red, very hard and contains tannin, gallic and ellagic acids.

The PISTACIO nuts or Pistacia almonds are obtained from *Pistacia vera* indigenous to Syria and Mesopotamia and extensively cultivated in the countries bordering the Mediterranean. The kernels are used extensively in confectionery. The nuts are about 20 mm. long, somewhat quadrangular in cross-section, and the seed consists of two fleshy, green cotyledons. The seeds of *Buchania latifolia* and other species of *Buchania* are used in India much like almonds.

Gums are found in several species of *Anacardium* and *Sclerocarya*. ACAJOU GUM is obtained from *Anacardium occidentale*. Considerable sugar and citric acid are found in MANGOS, the fruit of *Mangifera indica* native of Farther India and Ceylon and cultivated in the Tropics. A fruit used like lemons is obtained from *Dracontomelum mangiferum* of Malacca and the Sunda Islands.

d. AQUIFOLIACEÆ (ILICACEÆ) OR HOLLY FAMILY.—The plants are mostly shrubs or trees with alternate, petiolate, simple leaves and small, white, regular flowers. The fruit is a berry-like drupe containing several nutlets. The most important genus of this family is Ilex, a number of species of which are found in the United States.

The European holly (*Ilex Aquifolium*) contains a bitter glucosidal principle, ilicin, which is found in the bark as well as the drupes. The drupes contain a principle which is a homologue of benzyl alcohol, and a glutinous substance which renders them useful in the manufacture of birdlime. The American holly (*I. opaca*) growing in the Eastern United States, probably contains similar constituents to the European holly. This is the plant which furnishes the CHRISTMAS HOLLY.

MATÉ, Paraguay or Brazilian tea, consists of the leaves of *Ilex paraguayensis* found in Southern Brazil, Argentine and

Paraguay. They contain about 2 per cent. of caffeine, 11 per cent. of tannin and some volatile oil, and are used like tea in the making of a beverage. Cassine or Appalachian tea consists of the leaves of the Dahoon holly (*Ilex Cassine*) growing in the Southern United States. These leaves contain about half as much caffeine and tannin as Maté.

e. CELASTRACEÆ OR STAFF-TREE FAMILY.—These are shrubs, as *Euonymus*, or woody climbers, as the climbing bittersweet (*Celastrus scandens*). The plants are especially characterized by their dehiscent fruits and scarlet or reddish arilled seeds.

Euonymus atropurpureus (Wahoo or Burning Bush) is a shrub or small tree. The twigs have four distinct cork-wings making them somewhat 4-angled. The leaves are opposite, petiolate, ovate-oblong, acuminate, crenulate-serrulate and hairy beneath. The flowers are purplish and in axillary cymes. The fruit is a 3- to 4-lobed, persistent, loculicidally dehiscent capsule with 6 to 8 scarlet seeds. The bark of the root is official (p. 531).

The leaves of *Catha edulis* growing in Arabia and Abyssinia are chewed and also used like tea. They contain the alkaloids cathine and celastrine which are supposed to have similar properties to cocaine, as well as tannin and an ethereal oil. A yellow coloring principle is found in the bark of *Euonymus tingens* of the East Indies. The yellow coloring principle in the arils of the seeds of *Celastrus* and *Euonymus* appears to closely resemble carotin. The seeds of a number of plants of this family contain a considerable quantity of fixed oil, as *Celastrus macrocarpus* of Peru, and *Maytenus Boaria* of Chile.

f. ACERACEÆ OR MAPLE FAMILY.—The plants of this family are trees or shrubs, the most widely distributed representative of which is the maple (Acer). The most distinguishing character of this family is the fruit, which is a double samara. The sap of a number of species of Acer contains cane sugar or sucrose, and the sap of the sugar maple (*Acer saccharinum*) which grows in the United States and Canada contains from 3 to 4 per cent. The making of maple syrup and maple sugar is quite an industry in some localities. Maple sugar is also obtained from the black sugar maple (*Acer nigrum*) and the ash-leaved maple

(*A. Negundo*). The bark of the latter species is used to some extent in medicine. Valuable timber is yielded by the maple trees.

g. HIPPOCASTANACEÆ OR BUCKEYE FAMILY.—The plants are shrubs or trees with opposite, petiolate, and 3- to 9-digitately-foliate leaves. The flowers are in terminal panicles and the fruit is a 3-lobed capsule, which usually contains one large, shiny seed.

The horse-chestnut (*Æsculus Hippocastanum*) contains in the bark two fluorescent bitter principles, æsculin and paviin, the former of which is in the nature of a glucoside, and in the bark, leaves and flowers the coloring principle, quercitrin is present; in the seed-coat saponin is supposed to occur, and the glucoside æsculin as well. The cotyledons contain considerable starch, some proteins and sugar, a small quantity of a fixed oil, and argyresin to which the antihemorrhoidal action appears to be due. A narcotic principle is present in the bark, twigs and leaves of the red buckeye (*Æsculus Pavia*) of the Southern United States.

h. SAPINDACEÆ OR SOAPBERRY FAMILY.—The plants are mostly trees or shrubs indigenous to the Tropics. In some genera there are herbaceous or woody vines (lianes). The plants of this family usually have either a milky sap or contain saponin, and it seems strange that a plant yielding caffeine, namely, *Paullinia Cupana*, which furnishes the official Guarana (p. 441), should belong to this group.

The fruit shells of *Nephelium lappaceum* contain a toxic saponin (*Ph. Weekblad.*, 45, 1, 156, 1908). Four or five per cent. of SAPONIN is found in the fruit of *Sapindus trifoliatus* of India. A principle related to saponin is found in *Sapindus Saponaria* of tropical America. Saponin is also found in the fruits of other species of *Sapindus*, the bark of *Pometia pinnata* of the Sunda and South Sea Islands, and the kernels of the seeds of the two species of *Magonia* indigenous to Brazil. The latter plants also yield a poisonous nectar and the root-bark is used in the poisoning of fish. A shellac is obtained from *Schleichera trijuga* of India and the seeds of this plant yield "*marcassa oil*."

Paullinia Cupana is a woody climber indigenous to and cultivated in Northern and Western Brazil. The leaves are alternate and 5-foliate, the leaflets being oblong, acuminate, coarsely, irregularly dentate, and with short stalks; the flowers are yellow and in axillary panicles; the fruit is a 3-locular, 3-seeded sub-drupose capsule (Fig. 165).

FIG. 165. Flowering and fruiting branch of Brazilian cocoa (*Paullinia Cupana*).—After Radlkofer.

i. BALSAMINACEÆ OR JEWEL-WEED FAMILY.—The plants are succulent herbs with alternate, petiolate leaves and conspicuous axillary flowers; the fruit is a capsule which at maturity breaks into five valves, discharging the seeds with considerable force.

The balsam of the gardens (*Impatiens Balsamina*), which flowers all summer, belongs to this family. Other species of Impatiens are also cultivated.

The stem sap as well as that of the flowers of a number of species of Impatiens is used on account of its red and yellow coloring matters, to color the skin of the hands and feet as also the nails by the people of India, Tartary and Japan. The seeds of some species of Impatiens yield an oil which is used for burning.

XVIII. ORDER RHAMNALES.

This order includes two large families which are characterized by having 4 or 5 stamens which are either alternate with the sepals or opposite the petals when the latter are present. The ovules are atropous.

a. RHAMNACEÆ OR BUCKTHORN FAMILY.—The plants are woody climbers, shrubs or small trees.

Rhamnus Purshiana is a large shrub or small tree. The leaves are petiolate, oblong, elliptical, acuminate, finely serrate and pubescent beneath; the flowers are small and in axillary umbellate cymes, and the fruit is 3-lobed, black, ovoid, and drupaceous. The bark constitutes the official Cascara sagrada (p. 523).

Rhamnus Frangula or Alder Buckthorn, is a shrub the botanical characters of which closely resemble those of *R. Purshiana*. The bark of this plant is also official (p. 521).

The leaves of the shrub known as New Jersey Tea (*Ceanothus americanus*) are said to have been used as a substitute for tea during the Revolutionary times. This plant is found in the Eastern United States and Canada and the root, which contains considerable tannin and possibly an alkaloid, has been used in medicine. The leaves of *Sageretia theezans* of Asia have also been used as a substitute for tea. A number of plants of this family have been SUBSTITUTED FOR HOPS in the fermentation industry, as *Ceanothus reclinatus* of the West Indies; *Colubrina fermenta* of Guiana, and *Gouania domingensis* of Martinique and Hayti. Saponin is found in the bark of *Gouania tomentosa* of Mexico. A crystalline bitter principle, colletin, occurs in the wood of *Colletia spinosa* of South America. The bark of *Discaria febrifuga* of Brazil has been used as a substitute for cinchona. A number of genera furnish fish poisons, as Zizyphus, Tapura, and Gouania. Gum-lac is formed on the twigs of *Zizyphus Jujuba* of Asia as the result of the sting of an insect (*Coccus lacca*).

The fruits of several species of Zizyphus, thorny shrubs found growing in South America, are edible and enter into the French or Spanish confection known as JUJUBE-PASTE.

b. VITACEÆ OR GRAPE FAMILY.—The plants of this family are woody climbers or erect shrubs with alternate, petiolate leaves, and small, greenish, regular flowers, the fruit being a berry.

The most important genus, economically, is Vitis to which belong the cultivated grapes, the fruits of which furnish raisins, wine and brandy. The GRAPE-VINE indigenous to Europe (*Vitis vinifera*) is cultivated in all temperate and sub-tropical countries, and the variety *silvestris* which is found distributed in the Mediterranean countries as far east as the Caucasus Mountains is supposed to have furnished the cultivated wine grape. The CONCORD and CATAWBA GRAPES are cultivated varieties of the northern Fox- or Plum-grape (*Vitis Labrusca*) indigenous to the Northern United States east of Minnesota. The DELAWARE GRAPES are cultivated varieties of the frost-grape (*V. cordifolia*) and the sweet-scented grape (*V. vulpina*) of the Eastern United States. The pulpy part of the grape contains from 9 to 18 per cent. of grape-sugar and 0.5 to 1.36 per cent. of tartaric acid. In unfavorable seasons the tartaric acid is replaced in part by malic acid. The soil has a marked influence on the quality of grapes, a sandy soil producing a light colored wine, a soil rich in calcium a sweet wine, and a clay soil a fine boquet, etc.

WINES are made by fermenting the grape juice, and contain from 5 to 20 per cent. of alcohol, from 1 or 2 to 12 per cent. of sugar, about 0.5 per cent. of tartaric, acetic and other fruit-acids, tannin and coloring matter from a trace to 0.3 per cent., and various compound ethers, giving them their characteristic flavors or boquets. WHITE WINES are made from the juice of the pulp of the white or colored grapes after separation from the epicarp and seeds. In the manufacture of RED WINE no care is taken to separate the seeds and skins of colored grapes or even the stems on which the fruits are borne. PORT WINE is made from a grape grown in Portugal, the wine being chiefly exported from Oporto. The term CLARET is applied to a red wine containing a small amount of alcohol. BRANDY is obtained by the distillation of the fermented juice of the grape. CHAMPAGNE is a product obtained by fermenting grape juice to which other substances have been added, and contains about 10 per cent. of alcohol and 67 per cent. of carbon dioxide. RAISINS are obtained from a variety of *Vitis vinifera* containing a high percentage of sugar. In the preparation of raisins the ripe grapes are dried either by exposure to the sun or artificial heat. In grape preserves in addition to the indistinguishable cells of sarcocarp, raphides of calcium oxalate occur.

A principle resembling toxicodendrol is found in *Vitis inconstans* of Japan. A greenish-blue coloring principle occurs in *Vitis sicyoides* of South America. The leaves and twigs of VIRGINIA CREEPER or American ivy (*Parthenocissus quinquefolia*) contain tartaric acid, glycollic acid, paracatechin and inosit.

XIX. ORDER MALVALES.

This order includes several families having rather diversified characters. The stamens are numerous, the sepals are valvate and the placentas are axillary.

a. FAMILY ELÆOCARPACEÆ.—The members of this family are shrubs or trees mostly indigenous to the Tropics. They are distinguished from the plants of the other families of this order in not containing lysigenous mucilage canals. A principle yielding hydrocyanic acid is found in *Echinocarpus Sigun* of Java. A yellow coloring principle is found in the leaves of *Vallea cordifolia* of Peru. A fatty oil is found in the seeds of several species of *Elæocarpus.* A number of fruits of this family are edible. Maqui Fruit is obtained from *Aristotelia Maqui* of Chile and is used to color wine. The seeds of *Sloanea dentata* are eaten like chestnuts in Guiana.

b. TILIACEÆ OR LINDEN FAMILY.—The plants are shrubs or trees with alternate, simple leaves, and with white flowers in cymes or panicles. In the Linden or Basswood (*Tilia*) the peduncles are partly adnate with the long, leaf-like bracts. The fruits are dry drupes.

The flowers of the European Linden (*Tilia europæa*) contain a fragrant volatile oil and are used in medicine. The flowers of other species of *Tilia* also contain volatile oils, and the flowers of *Tilia tomentosa* of Southern Europe are used to flavor champagne. The leaves of *Tilia europæa* contain the glucoside tiliacin. Several species of *Grewia* are used as fish poisons. A purgative principle is found in the seeds of *Corchorus olitorius* of Southern Asia, Africa and South America. A bitter principle occurs in the seeds of *Corchorus tridens* of Arabia, India and Egypt. A reddish-colored, fatty oil known as Apeiba oil is obtained from the seeds of *Apeiba Tibourbon* of Guiana. The root of *Grewia scabrophylla* is used as a substitute for Althæa in India. Mucilage is found in the flowers and fruits of a number of genera. The leaves of *Corchorus siliquosus* are used in Panama as a substitute for tea. A number of the fruits of this family are edible, as of *Muntingia* and *Apeiba*. The bast fibers of several species of *Corchorus*, particularly *C. capsularis* of China and India, constitute *jute*, which is used in the making of cordage. The fiber is separated by cold retting in stagnant water.

c. MALVACEÆ OR MALLOW FAMILY.—The plants are mostly herbs or shrubs with alternate, simple leaves, and regular, perfect, large flowers, with the stamens united into a column which encloses the styles (Fig. 82, *E*), and a capsular fruit. The cultivated ornamental Hollyhock and Althæa belong to this family.

Althæa officinalis or marshmallow is a perennial herb about 1 M. high with broadly ovate, petiolate, acute, dentate and lobed, pubescent leaves; the flowers are 2 to 4 in number in the axils of the leaves and have rose-colored petals. The bractlets are linear and the fruit consists of 15 to 20 indehiscent carpels. The root is official (p. 450).

Gossypium species.—The plants are herbs or shrubs with 3- to 5-lobed leaves, and large axillary flowers; the fruit is a 5-locular, dehiscent capsule or pod; the seeds are spherical or somewhat angular and covered with long 1-celled hairs, which latter constitute cotton (p. 440).

There are three important cultivated species. (1) Sea Island Cotton is obtained from *Gossypium barbadense*, a plant which is principally cultivated in the Southern United States and also in Northern Africa, Brazil, Peru and Queensland. This species is distinguished by the fact that after removal of the hairs from the seeds they are smooth. (2) *G. arboreum* has purplish-red flowers, yields a particularly white cotton, and is cultivated in Egypt, Arabia and India. (3) *G. herbaceum* is distinguished by its broadly lobed leaves and yellowish flowers. The plant has

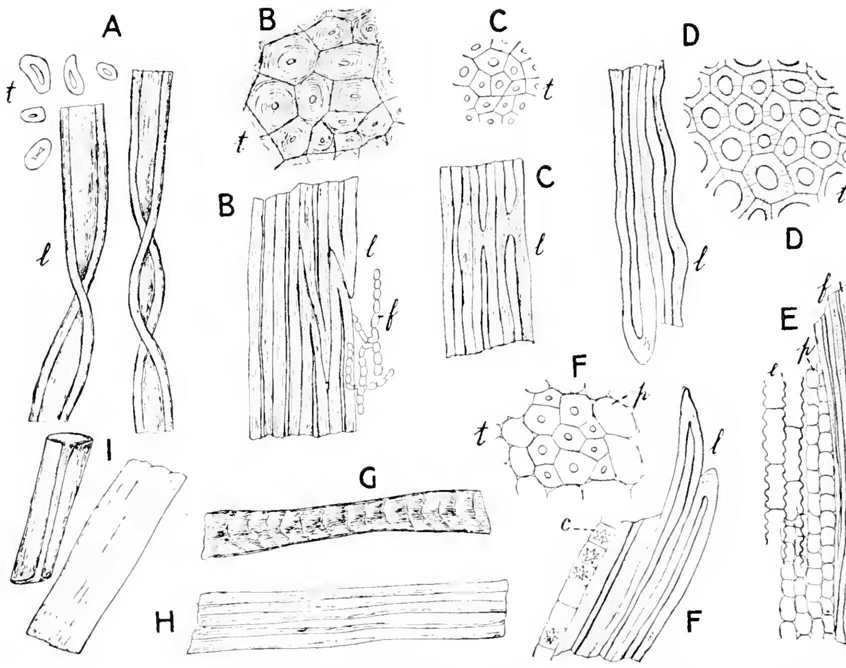


Fig. 166. Transverse (t) and longitudinal (l) sections of commercial fibers: A, long staple cotton from the seeds of *Gossypium*; B, Kentucky hemp, the bast of *Cannabis sativa;* C, jute, the bast of *Corchorus;* D, sisal, the fibers from the leaves of the Century plant (*Agave rigida Sisalana*); E, raphia, the outer layers of leaflets of *Raphia pedunculata;* F, ramie, the fibers from a Formosa nettle; G, Merino wool; H, silk; I, artificial silk, the figure on the left showing a false lumen due to the infolding of the edges. f, fungal hyphæ; c, rosette aggregates of calcium oxalate; p, parenchyma cells.

been cultivated for over 26 centuries in Arabia and the East Indies, and since 1774 in the United States. Of this latter species there are a number of cultivated varieties. The bark of the root constitutes the cotton-root bark of medicine (p. 527).

The seeds of the genus Gossypium contain a large percentage of fixed oil, which is obtained by expression and is official as

COTTON SEED OIL. The residue is known as cotton seed oil-cake, and contains a considerable amount of proteins with a small quantity of oil and a poisonous principle, ricin. A fat resembling that of Cacao is obtained from the seeds of *Pachira macrocarpa* of Brazil; Kapak oil is derived from the seeds of *Eriodendron anfractuosum caribæum* of the West Indies.

The flowers of some of the members of the Malvaceæ contain coloring principles, and have been used for dyeing, as Hollyhock (*Althæa rosa*) and Mallow (*Malva sylvestris*). MUSK SEED or Amber seed, which is used in perfumery as a substitute for musk, is obtained from *Abelmoschus moschatus* indigenous to the East Indies and now cultivated in other tropical countries. *Malva moschata* also has the odor of musk, and is found in Middle and Southern Europe.

Saponin is found in the roots of *Sida jamaicensis* and *Hibiscus Sabdariffa* of the East and West Indies; *Sida paniculata* of Peru is used as an anthelmintic and the action is supposed to be due to the secreting hairs. The seeds of several members of this family are used as substitutes for coffee, as *Abutilon muticum* of Egypt, and Okra or Gumbo (*Hibiscus esculentus*). The leaves of *Sida canariensis* and *S. retusa*, the latter of India, have been substituted for tea leaves. The fruits of several of the members of this family are edible, as *Hibiscus esculentus*, which yields the vegetable okra, and *H. ficulneus* of Ceylon and Egypt which are used like beans.

Fibers are obtained from a number of the other members of this family, as the bast fibers of *Hibiscus tiliaceus* of the Tropics, *H. cannabinus* of the East Indies, *Urena lobata*, *Abutilon indicum*, *Sida retusa*, and *Napæa lævis*, all cultivated more or less in tropical countries.

d. FAMILY BOMBACEÆ.—This is a group of tropical trees yielding a variety of useful products. A gum is obtained from *Bombax malabaricum*, and mucilage is contained in the genus Ochroma and several species of Bombax. The root of *Bombax malabaricum* contains tannin in addition. The bast fibers of a number of the plants of this family are used like cotton in making fabrics, as species of Bombax, Chorisia and Adansonia. The fruits of several of the Bombaceæ contain tartaric acid, as the

Sour Cucumber tree or CREAM-OF-TARTAR TREE (*Adansonia Gregorii*) of Northern Australia; and the MONKEY-BREAD TREE or BAOBÁB (*Adansonia digitata*) of India and South America, which attains a diameter of 9 M. The green fruit of *Matisia cordata* of the Andes region is edible. The seeds of *Bombax insigne* and *Matisia Castonon* of South America yield a product on roasting which is used like cacao bean. The seeds of *Cavanillesia umbellata* of Peru are edible and contain a considerable quantity of fixed oil.

e. STERCULIACEÆ OR COLA FAMILY.—The plants are herbs, shrubs or trees, sometimes lianes, with mostly simple, petiolate, alternate leaves; the flowers are small and form a rather complex inflorescence.

Theobroma Cacao is a small tree 5 to 10 M. high, with coriaceous, glaucous, entire leaves, and clusters of brownish 5-merous flowers arising from the older branches or stem; the fruit is large, fleshy, ovoid, 10-furrowed longitudinally, yellow or reddish, and contains five rows of seeds, 10 or 12 in each row (Fig. 167). The seeds are ovoid, somewhat flattened, and with large, convoluted cotyledons which break up into more or less angular fragments on drying. The seeds contain 35 to 50 per cent. of a fixed oil known as CACO BUTTER and official as Oleum Theobromatis; 15 per cent. of starch; 15 per cent. of proteins; 1 to 4 per cent. of theobromine; 0.07 to 0.36 per cent. of caffeine, about 0.5 per cent. of sugar, and also a small amount of tannin. The red color of the seed is due to a principle known as cacao-red which is formed by the action of a ferment on a glucoside.

The Cacao tree is indigenous to the countries bordering the Gulf of Mexico and is now cultivated in many tropical countries. Most of the cacao of the market is obtained from Ecuador (the Guayaquil variety being especially valued), Curaçao, Mexico, Trinidad, and the Philippine Islands. The seeds of the wild plants contain a bitter principle, the quantity of which is found to be greatly reduced in the plants when under cultivation. The bitter principles in the raw product are more or less destroyed by the process of fermentation to which the seeds are subjected in preparing them for use, which at the same time develops the aroma.

Cola acuminata is a tree with lanceolate or obovate, acuminate, entire, petiolate leaves. The flowers are yellowish, unisexual, and in small axillary clusters, frequently arising from the old wood; the fruit consists of five follicles, each containing 4 to 8 seeds. The seed is made up of two large, fleshy cotyledons. They have much the same constituents as Cacao, but the proportions of these differ. (See Cola.) The leaves of *Waltheria glomerata* are used as a hemostatic in Panama like matico, as are also the

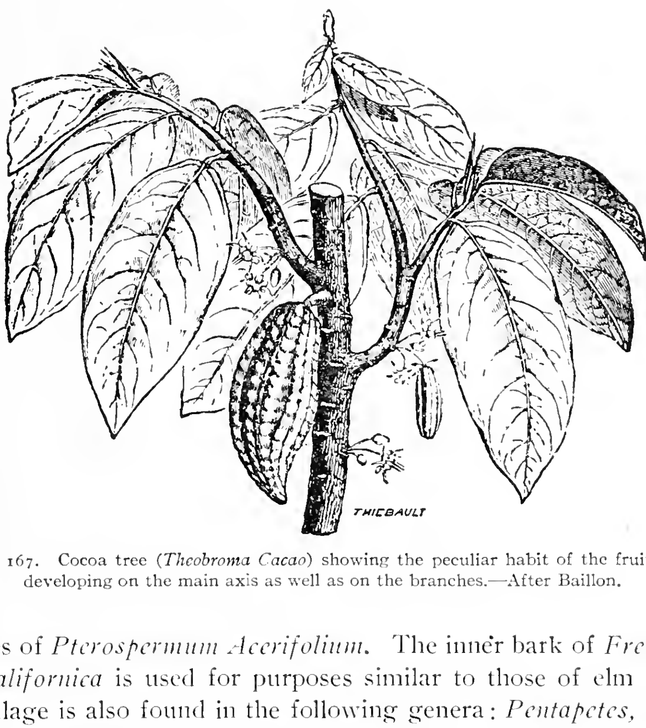


FIG. 167. Cocoa tree (*Theobroma Cacao*) showing the peculiar habit of the fruits in developing on the main axis as well as on the branches.—After Baillon.

leaves of *Pterospermum Acerifolium.* The inner bark of *Fremontia californica* is used for purposes similar to those of elm bark. Mucilage is also found in the following genera: *Pentapetes, Waltheria, Guazuma, Helicteres,* and *Sterculia.* Tannin is found in the bark of *Guazuma ulmifolia* of South America. An oil is manufactured from the seeds of *Sterculia fœtida* of the East Indies and Cochin China. The seeds of a number of species of Sterculia are edible. *Abroma augusta* of India yields a fiber which has been suggested as a substitute for silk.

XX. ORDER PARIETALES.

This is a group of plants of rather wide distribution, and includes perennial herbs like the violets; evergreen shrubs, such as the Tea plant; and vines like the Passion flower. As the name indicates the plants of this order are characterized by the flowers having, for the most part, ovaries with parietal placentas.

a. FAMILY DILLENIACEÆ.—The plants are mostly tropical trees which yield valuable timber. The wood of a species of Dillenia growing in the East Indies also contains red coloring substances. The fruits of *Dillenia indica* contain citric acid and are used like lemons. The leaves of *Curatella americana* contain considerable silicon and are used to polish wood. *Dillenia speciosa* of India contains a large percentage of tannin. Some species of *Dillenia* are cultivated and the foliage and flowers combine to make the plants the most beautiful in the plant kingdom.

b. MARCGRAVIACEÆ.—The members of this family are partly epiphytic, and have dimorphic leaves, the smaller ones being pitcher-like. The plant which is cultivated in greenhouses, *Marcgravia umbellata*, is used in the Antilles in medicine.

c. THEACEÆ OR TEA FAMILY.—The plants are shrubs or trees with alternate, evergreen leaves, and perfect, regular flowers with numerous stamens, occurring one or more in the axils of the leaves. The fruit is a 3- to 5-locular, dehiscent capsule. The most important member of this family is *Thea sinensis*, the two varieties *viridis* and *Bohea* furnishing the leaves known as TEA. The Tea tree is indigenous to Eastern Asia, and is now extensively cultivated in China, Japan, India, Java, Brazil, Sicily, Portugal and France, and to some extent in the Southern United States.

The fresh leaves of Thea do not have the properties which characterize the commercial article, the aroma and other qualities being developed after special treatment. Two general classes of tea are found in commerce, these depending on the mode of treatment. Those which are rapidly dried by means of artificial heat constitute GREEN TEA. The leaves which are slowly dried, permitting fermentation to set in, furnish BLACK TEA. Tea leaves contain 1.5 to 3.5 per cent. of caffeine; theobromine and theophylline (an isomer of theobromine); 10 to 20 per cent. of gallotannic acid; quercitrin, and a volatile oil containing among other components, methyl salicylate. The seeds contain about 30 per cent. of fixed oil, 1 per cent. of caffeine, and saponin. The leaves furnish one of the sources of the official caffeine. Saponin is found in the seeds of *Thea Sassanqua* of China and Japan. Two saponin-like substances (assamin and assaminic acid) are found in the seeds of *Thea assamica*. The flowers of *T. Sassanqua* are used in China and Japan to flavor teas. The flowers and leaves of *Thea kissi* are used as an insecticide. The red colored sap of *Laplacea Hæmatoxylon* of New Granada is used in medicine.

d. GUTTIFERÆ OR GAMBOGE FAMILY.—The plants are principally shrubs and trees of the Tropics, that is, if we exclude the Hypericaceæ which are now put in a group by themselves.

Garcinia Hanburyi is a tree with ovate, petiolate, coriaceous, opposite leaves. The flowers are small, yellow, diœcious, occurring in small clusters in the axils of the leaves. The fruit is a pome-like berry, with a papery endocarp and an oily sarcocarp, and 3 or 4 seeds, 1 in each loculus (Fig. 168). The trees are chiefly valued on account of the gum-resin known as gamboge (p. 648), which they contain.

A resin used in making plasters is obtained from *Calophyllum brasiliense* of Brazil. Balsams resembling Copaiba have been obtained from *Calophyllum Calaba* of the West Indies. Balsams known as TACAMAHAC are also derived from the following plants: Bourbon Tacamahac from *Calophyllum Tacamahaca*, India Tacamahac from *C. apetalum* and Brazilian Tacamahac from *Rheedia Madrunno*. Balsams are also obtained from *Caraipa grandiflora* of Brazil, and *Rheedia acuminata* of Peru. Resins and balsams are obtained from a number of species of *Clusia*.

A yellow coloring principle, mangostin, is obtained from the bark and fruit of Mangosteen (*Garcinia Mangostana*) of the East Indies. Yellow coloring principles are found in *Ochrocarpus longifolius* of India and *Vismia acuminata* of South America. Tannin occurs in *Mahurea palustris* of Brazil, *Mesua ferrea* of the East Indies, the flower-buds of *Ochrocarpus longifolius* of India, and several species of *Cratoxylum* of China and Java.

A butter-like fat is obtained from the seeds of *Garcinia indica.* A fixed oil known as LAUREL-NUT OIL is derived from the seeds of *Calophyllum Inophyllum* and other species of *Calophyllum* growing in the East Indies, Cochin China and Brazil, as well as the seeds of *Symphonia fasiculata* of Brazil.

FIG. 168. Gamboge plant (*Garcinia Hanburyi*). A branch showing the axillary pistillate flowers and pome-like fruits.—After Baillon.

The bark of *Clusia Pseudo-china* is used in Peru as a substitute for cinchona. An alkaloid is found in *Vismia robusta* of Java. A gum is obtained from *Calophyllum tomentosum* of India and *Vismia acuminata*, that of the latter being purgative. The flower buds of the India Suringi (*Ochrocarpus longifolius*) have an aromatic odor resembling cloves. Aromatic principles are also found in other plants of this family.

Edible fruits are yielded by the following plants: MANGO FRUIT from *Garcinia Mangostana* and other species of Garcinia; MAMMEI APPLE or Apricot of St. Domingo from *Mammea americana* of tropical America, the latter being used in the preparation of Mammey wine or "Toddy" and a liquor known as "Eau de Creole." The seeds of *Platonia insignis* are used like almonds in Brazil and Paraguay; the fruit of the latter plant is quite acid and is eaten with sugar.

e. HYPERICACEÆ OR ST. JOHN'S-WORT FAMILY.—The plants are herbs or shrubs of the temperate regions, and are represented in the United States by the Hypericums, which are quite common. The flowers are characterized by the numerous stamens which are united into distinct groups or clusters. The flowers of *Hypericum perforatum* or Common St. John's-wort contain yellow and red coloring principles. Yellow coloring principles have also been isolated from *Hypericum laricifolium* of Ecuador and *H. elodes* of Northern Europe. The entire plant of *H. perforatum* is used in medicine and contains considerable resin, and a small amount of volatile oil.

f. FAMILY DIPTEROCARPACEÆ.—The plants of this family are principally trees and indigenous to tropical Asia. The family derives its name from the winged fruits of the principal genus Dipterocarpus. A number of economic products are furnished by this group of plants. BORNEO CAMPHOR is obtained from *Dryobalanops aromatica.* The camphor separates in canals in the older parts of the wood and between the wood and bark, and is obtained by felling the trees, splitting the wood, and then removing the camphor by hand. Owing to the fact that some of the trees do not contain camphor, it is sometimes necessary to fell a hundred trees in order to obtain 6 or 8 K. of the product. The young twigs of this plant as well as the older wood yield a volatile oil known as Oil of Borneo camphor.

GURJUN BALSAM or Wood oil is obtained from a number of species of Dipterocarpus growing in the East Indies by incising the stems as in the collection of turpentine. The balsam is used as a substitute for copaiba and contains an ethereal oil which consists chiefly of a sesquiterpene, an indifferent resin, and gurjunic acid. SINDOR BALSAM is obtained from *Dipterocarpus mar-*

ginatus of Borneo. A resin known as "PINEY RESIN," which is used as a substitute for Dammar, is obtained from a number of species of *Vateria* growing in India. CHAIA RESIN is obtained from *Shorea rubifolia* of Cochin China. The bark of *Shorea robusta* of Northern India contains 32 per cent. of tannin. The seeds of species of *Shorea, Pinanga, Gysbertsiana* and *Isoptera* yield the fatty oil known in Java as TANGKAWANG. The seeds of a number of plants of this family contain considerable starch, as Vateria, Vatica and Doona. The woods of the following genera are extensively used: Vatica, Shorea, and Hopea.

g. FAMILY TAMARICACEÆ.—The plants are halophytic shrubs found in the desert regions of Central Asia and Mediterranean countries and one genus (*Fouquieria*) is found in Mexico. *Fouquieria splendens* is cultivated to some extent, and is known as Ocotilla or Coach-whip Cactus. The bark contains gum, resin and wax; the latter is known as OCOTILLA WAX and resembles beeswax. The twigs of *Myricaria germanica* of Europe are used as a substitute for hops. A manna-like sugar is formed on the stems of *Tamarix mannifera* growing in Egypt, Arabia and Afghanistan, as the result of the sting of an insect (*Coccus manniparus*). Tannin is found in a number of species of Tamarix as well as in the galls formed on the plants, the tannin being used for dyeing. A table salt is prepared from the ash of several species of *Reaumuria* found in Northern Africa and the East Mediterranean region.

h. FAMILY BIXACEÆ.—These are shrubs or trees found in the Tropics, and are of interest chiefly on account of the seeds of *Bixa Orellana* which furnish the coloring matter known as ANNATTO (Orlean, Arnotta). The plant is found in tropical America and also in Polynesia and Madagascar. The seeds are covered with a fleshy arillus from which the coloring matter is prepared by means of water. The insoluble matter is collected, made into cakes and chiefly used for dyeing and coloring. Annatto contains a red crystalline principle, bixin, a yellow coloring principle, orellin, and an ethereal oil. The root of this plant also contains some coloring matter. A yellow coloring principle is found in *Cochlospermum tinctorium* of Senegambia and an aromatic resin is obtained from *Cochlospermum Gossypium* of Ceylon and Malabar.

i. FAMILY WINTERANACEÆ OR CANELLACEÆ.—These are trees with aromatic barks having an odor of cinnamon; pellucid-punctate leaves; and golden-yellow flowers. The most important member of this family is *Winterana Canella* growing in the Antilles and in Southern Florida, which furnishes the CANELLA BARK or False Winter's bark used in medicine. The bark occurs in large quills or broken pieces, from 3 to 10 mm. thick, with the periderm nearly entirely removed, the outer surface yellowish or orange-red with transversely elongated patches of cork and shallow, whitish depressions; the fracture is short with numerous resin canals; the odor aromatic; taste aromatic, bitter and pungent. It contains mannitol, resin and 0.5 to 1.28 per cent. of a volatile oil containing eugenol, cinneol, caryophyllene and pinene. The bark of one or more species of Cinnamodendron of tropical America is sometimes substituted for Canella bark, but it is distinguished by containing tannin, which constituent is not found in Canella.

j. VIOLACEÆ OR VIOLET FAMILY.—The plants are herbs or shrubs with basal or alternate leaves, perfect, irregular flowers, and 3-valved dehiscent capsules (Fig. 134, *J*). The best known representatives of this group are the cultivated species of the genus Viola, including the English or sweet violet (*Viola odorata*), which produces a volatile oil containing ionon; and the varieties of *Viola tricolor vulgaris* which furnish the pansies of the garden. The entire herb of *Viola tricolor* has been used in medicine and contains the yellow coloring principle viola-quercitrin, salicylic acid and methyl salicylate (Figs. 70, 100, 118).

k. FAMILY FLACOURTIACEÆ.—These are tropical shrubs and trees, and are chiefly of interest because of their valuable woods and acid, juicy fruits. A number of them are of medicinal interest. CHAULMUGRA OIL is said to be obtained from the seeds of *Gynocardia odorata* of Farther India. The seeds also contain gynocardic acid and hydrocyanic acid. The latter is also present in the seeds of *Hydnocarpus venenata* of Southern India and Ceylon and the leaves of *Kiggelaria africana*.

A number of species of *Lætia* growing in Cuba yield a resin resembling sandarac. The Coccos oil which is used in perfumery is obtained from several species of *Myroxylon* growing in Polynesia. The fixed oils from the seeds of *Gynocardia odorata* and of several species of *Pangium* are used in cooking. A bitter principle occurs in the bark of *Casearia adstringens* of Brazil. A purgative principle is found in *C. esculenta* of tropical Asia and Australia. The root of *Homalium racemosum* of Guiana contains an astringent principle.

l. FAMILY TURNERACEÆ.—These plants are herbs, shrubs and trees mostly found in tropical America, and are of interest on account of the leaves of *Turnera diffusa,* particularly the variety *aphrodisiaca,* which yield the DAMIANA of medicine esteemed as a tonic laxative like Rhamnus Purshiana. The drug usually consists of leaves although the reddish stems, yellowish flowers and globular capsules may be present. The leaves are about 25 mm. long, varying from oblanceolate to obovate; the margin is serrate-dentate; the color, light-green (older leaves somewhat coriaceous and pubescent); the odor aromatic; taste aromatic and bitter. Damiana contains a volatile oil, resin, and the bitter principle damianin. Ethereal oils are found in other species of Turnera, and *T. angustifolia* of Mexico contains considerable mucilage.

m. PASSIFLORACEÆ OR PASSION-FLOWER FAMILY.—The plants are mostly herbaceous or woody vines climbing by means of tendrils, with alternate, palmately-lobed, petiolate leaves and solitary, perfect, regular flowers. The flowers are peculiar in that between the corolla and stamens there are numerous, frequently petaloid, colored, sterile, filamentous bodies which are known collectively as the "corona." The fruit is a berry or dehiscent capsule. The genus Passiflora is known as the Passion-flower because the flowers are considered to be emblematic of the Crucifixion, the corona representing the crown of thorns, the stamens the nails, and the gynæcium with its three styles, the three thieves. The rhizomes of the Passion-flowers of the Southern States (*Passiflora incarnata* and *P. lutea*) have been used in medicine. Not much is known with regard to the active principles of these two plants or of the thirty other species of Passiflora which are used in medicine. The fruits of several species of Passiflora are edible, and a number of them are cultivated on account of their beautiful as well as odorous flowers.

n. CARICACEÆ OR PAPAW FAMILY.—This family is composed of two genera of latex-containing trees growing in tropical America, the best known of which is the genus Carica. The Papaw or Melon tree (*Carica Papaya*) is a small tree with a straight, slender, usually unbranched trunk which bears at the summit a cluster of long-petiolate, deeply-lobed leaves. The flowers are diœcious, and the fruit is a large, melon-like berry. The green fruits as well as the leaves contain a milk-juice which is obtained by incising them. The material is dried and is used in medicine on account of its containing a proteolytic ferment, papain or papayotin, which is active in the presence of both acids and alkalies. The leaves and fruit also contain the alkaloid carpaine, and in addition the leaves contain the glucoside carposid. The root contains a glucoside somewhat resembling potassium myronate and a ferment which has a decomposing action upon it. A proteolytic ferment is also present in the leaves of *Carica quercifolia* of Argentina. The melon tree is cultivated on account of the fruits, which are edible.

o. BEGONIACEÆ.—This is a family of tropical plants which are extensively cultivated. They are herbs or shrubs frequently with tuberous rhizomes and with characteristic, asymmetric, variegated leaves. They are easily propagated by cuttings providing they have sufficient moisture, even the leaves giving rise to new plants. The roots of *Begonia anemonoides* of South America and *B. gracilis* of Mexico contain purgative principles. Calcium oxalate and acid oxalates are found in the leaves of probably all of the species of *Begonia*. The roots of a number of species of this genus are astringent.

p. DATISCACEÆ.—The plants are trees or shrubs found principally in the Tropics. A bitter principle is found in the Yellow hemp (*Datisca cannabina*) of Southern Europe and the Orient. The root contains a yellow coloring principle, datiscin, which is used in the dyeing of silk. The wood of *Octomeles* and *Tetrameles* is used in the making of tea-chests.

XXI. ORDER OPUNTIALES.

The plants of this order are succulent, with much reduced leaves, and with flowers characterized by having a perianth with numerous segments and an inferior ovary.

a. CACTACEÆ OR CACTUS FAMILY.—This is a remarkable family of succulent plants growing largely in the arid regions of Mexico, Brazil and other parts of America. The stems are more or less flattened, terete or tuberculated, in some cases becoming branched and woody. The leaves are reduced to scales, but are sometimes larger, more or less cylindrical or dorsiventral, and usually drop off sooner or later. In the axils of the leaves or leaf-scars there are usually groups of hairs and spines. The flowers are mostly solitary, sessile, perfect, regular and conspicuous. The fruit is usually a fleshy berry, the fruits of a number of species being edible.

Quite a number of the Cacti have been used in medicine, the one most commonly employed being the NIGHT-BLOOMING CEREUS (*Cereus grandiflorus*), which is extensively cultivated on account of its flowers. The flowers and fresh stems are the parts used. They contain several acrid principles including probably an alkaloid and a glucoside, the drug resembling in its action digitalis.

MESCAL BUTTONS (*Anhalonium*), are the dried tops of several species of *Lophophora* growing in Northern Mexico. The main axis of the plant is under the ground and produces at certain points small aerial shoots which are more or less button-shaped or disk-like, being about 20 to 50 mm. in diameter. In the center of the disk occur tufts of hairs which vary in the different species, and among which are usually found one or more pinkish flowers. The drug has been used like Night-blooming Cereus, and contains several alkaloids, namely, anhalonine (similar to pellotine), mescaline, anhalonidine and lophophorine. Alkaloidal principles are also found in other members of this family.

The sap of several species of *Cereus* of the Antilles has anthelmintic properties, as also that of certain species of *Rhipsalis* and *Opuntia*. A caoutchouc-like exudation is obtained from *Opuntia vulgaris* and other species of Opuntia growing in the West Indies. An astringent principle is found in the root and bark of *Opuntia Karwinskiana* of Mexico. A tragacanth-like gum is found in *Peireskia Guacamacho* of Venezuela, *Opuntia rubescens* of Brazil and *O. Tuna* of the West Indies, Mexico and South America. An alcoholic beverage is made by the Indians of Sonora from the fruit-juice of *Cereus Thunbergii*.

A number of species of Opuntia yield edible fruits. The PRICKLY PEAR is the fruit of *Opuntia Tuna* growing in the West Indies and tropical America; INDIAN FIG is derived from *Opuntia Ficus-Indica* growing in Southern Europe, particularly Sicily; a fruit also known as Prickly pear or Indian fig is derived from *Opuntia vulgaris*, a common Cactus growing in sandy soil in the Eastern United States. The COCHINEAL INSECT which is official under the name of coccus in a number of pharmacopœias (*Pseudo-coccus Cacti*) lives on the following Cacti: *Nopalea coccinellifera* of Jamaica and South America, *Opuntia Tuna* and *O. Dillenii* both of tropical America, and *Peireskia aculeata* of the Antilles.

XXII. ORDER MYRTALES OR MYRTIFLORÆ.

The plants are herbs or shrubs with complete flowers, rarely apetalous, producing one or more ovules in each loculus.

a. THYMELÆACEÆ OR MEZEREUM FAMILY.—The characters of this family are illustrated by the Spurge laurel or Mezereon (*Daphne Mezereum*) which is a small shrub about 1 M. high, with oblong-lanceolate, acute, entire, sessile leaves, and small groups of fragrant flowers, the perianth tube of which is purplish-red or white. The fruit is an ovoid, reddish drupe. The bark of *Daphne Mezereum* and other species of *Daphne* is used in medicine (p. 536).

The bark of *Funifera utilis* of Brazil contains a vesicating principle. A principle with similar properties is found in the bark of Leather wood (*Dirca palustris*) of the Eastern United States and Canada. The fruit and leaves of *Gnidia carinata* of Cape Colony contain emetic and drastic principles. A poisonous principle is found in *Pimelea trichostachya* of Australia. A yellow coloring principle is found in several species of *Daphne* and *Thymelæa*. The wood of *Aquilaria Agallocha* of India and China is aromatic and resembles the "Aloe wood." A balsam is obtained from the wood of *Pimelea oleosa* of Cochin China. The bast fibers of quite a number of plants are used in the making of paper, as of *Daphne* in India, *Gnidia* of Madagascar, *Lagetta* (*L. lintearia* or Lace-tree) of Jamaica and St. Domingo, *Thymelæa* of the Mediterranean countries and *Linodendron* of Cuba. The fibers of Leather wood (*Dirca palustris*) of the Eastern United States and Canada are said to be used in a similar manner.

b. FAMILY ELÆAGNACEÆ.—This is a small family represented in the United States by several genera, among which is the Buffalo berry (*Lepargyræa argentea*), a thorny shrub found in the western part of the United States and the Northwest Territory. The fruit is a reddish drupe-like berry which contains a small amount of citric and malic acids, 5 per cent. of sugar, and in composition is much like the currant. It is eaten by the Indians, and used to a great extent in the Western States in the making of jellies. The leaves and flowers of a number of species of Elæagnus are used in medicine.

c. LYTHRACEÆ OR LOOSESTRIFE FAMILY.—The members of this family are herbs, shrubs and trees usually with opposite, entire leaves. The flowers are in racemes and the fruit is a capsule. Quite a number of the plants yield valuable woods and a number are cultivated as ornamental plants.

The flowers of *Woodfordia floribunda* of India contain a red coloring principle, and the bark and leaves of *Lafœnsia Pacari* of Brazil contain a yellow coloring principle. Considerable tannin is found in the root of the Purple loosestrife (*Lythrum Salicaria*) of the Northern United States and Canada, and widely distributed in the Old World; and also in the fruit of *Woodfordia floribunda*, a plant which is extensively cultivated in greenhouses. A bitter principle, nessin, is found in the leaves of *Nesæa syphilitica* of Mexico and probably other species of this genus. *Cuphea viscosa* of Mexico is said to resemble digitalis in its physiological action. A vesicating principle, resembling cantharidin in its action, is obtained from the fresh leaves of *Ammanni baccifera* of India. A narcotic principle is found in the seeds of *Lagerstrœmia Flos reginæ* of India. The flowers of *Lawsonia inermis*, native to and cultivated in the Orient, have an odor resembling that of the Tea rose. The shrub is also cultivated to some extent in the West Indies and is known in the Orient as the HENNA PLANT. The leaves are used in the preparation of the cosmetic Hinna. They contain an orange or brownish-yellow dye which is used in the dyeing of the skin and hair.

d. PUNICACEÆ OR POMEGRANATE FAMILY includes a single genus of two species. The Pomegranate (*Punica granatum*) indigenous to the Levant and now extensively cultivated is of chief interest. The plants are small trees, the young twigs of which are 4-angled and frequently thorn-like. The leaves are opposite, ovate-lanceolate, entire, short-petiolate. The torus, calyx and corolla are scarlet, and the gynæcium consists of two whorls of carpels. The fruit is an inferior edible berry with hard pericarp or rind. The pulpy portion is formed from the outer layer of the seed-coat. The bark of the root and stem is used in medicine. (See Granatum, p. 534.) The rind of the fruit is used as an astringent because of the tannin which it contains. It does not appear, however, to contain the alkaloids found in the official bark.

e. FAMILY LECYTHIDACEÆ.—The plants are mostly shrubs and trees indigenous to the Tropics. They are of chief interest on account of the BRAZIL-NUT or Para-nut obtained from *Bertholletia excelsa*, and the Sapucaya-nut obtained from the Monkey-pot tree (one or more species of Lecythis), both genera of South America. The seeds (so-called nuts) are rich in oil and proteins and are edible. The fruit of *Careya arborea* is drupaceous and is also edible, the seeds being considered, however, to be poisonous. Bitter narcotic or poisonous principles are also found in the fruit of *Planchonia valida* of the Molucca Islands and the seeds of a number of species of *Lecythis*. The fruits and roots of a number of species of *Barringtonia* are used in China and Java to stupefy fish. The pericarp of the fruit of *Fœtida moschata* of Guiana contains considerable quantities of an ethereal oil. The flowers of *Grias cauliflora* of the Antilles are used like tea. A cooling drink is made from the sarcocarp of *Couroupita guianensis* of the West Indies and Guiana.

f. RHIZOPHORACEÆ OR MANGROVE FAMILY.—These are tropical shrubs or small trees with evergreen, coriaceous leaves, small cymose and axillary flowers, and seeds which germinate while the fruit is still attached to the plant. The best known genus of this family is Rhizophora (Mangrove tree), of which there are three species, the AMERICAN MANGROVE being *R. mangle*. This tree produces aerial roots on the stems and branches, and leaves which are characterized by a number of layers of water-containing cells. The plants grow in muddy swamps, or along the sea-coast where the water is brackish, a number together forming the so-called "Mangrove swamps."

The root and bark of the Mangrove, as well as other species of Rhizophora and several species of Bruguiera, contain a large quantity of tannin which resembles catechu. The aerial roots of Rhizophora are used by the natives of Polynesia in the making of bows, and the woods of several genera are used in carpentry.

g. MYRTACEÆ OR MYRTLE FAMILY.—This is a group chiefly of shrubs and trees, some, as of species of Eucalyptus, being the loftiest trees known, attaining a height in some instances of 105 M. The plants are indigenous to Australia and tropical America and some are extensively cultivated.

EUCALYPTUS species.—The leaves frequently vary in shape and in arrangement on the young and older branches of the same plant. On the young branches they may be, as in *Eucalyptus Globulus*, ovate or broadly elliptical, opposite and sessile, while on older branches they are scythe-shaped, glandular-punctate, petiolate and alternate (Fig. 258). In the latter case the petioles are twisted and the leaves stand edgewise so that both surfaces are equally exposed to the light and hence of similar structure. The flowers are solitary, or in cymes or umbels, occurring in the axils of the leaves. Petals are wanting and the whitish stamens, which are numerous and inflexed in the bud, are covered by an operculum or lid which is considered to be formed by the union of the sepals, and which dehisces on the maturing of the stamens, this being one of the most characteristic features of the genus. The fruit is a 3- to 6-locular truncated capsule or pyxis.

This is a very important genus from an economic point of view, among the products being the volatile oil (oil of eucalyptus), and eucalyptol, both of which are official, and the tannin or so-called "gum," known as Eucalyptus kino (p. 655).

Jambosa Caryophyllus (*Eugenia Caryophyllata*).—This is a small tree indigenous to the Molucca Islands and now extensively cultivated in the Tropics. The leaves are opposite, ovate-lanceolate, acuminate, petiolate, entire and evergreen. The flowers are rose-colored and in cymes; the fruit is berry-like and constitutes the Anthophylli or Mother-clove. The unexpanded flower-buds constitute the drug or spice known as Cloves. (See Caryophyllus.)

Pimenta officinalis is a tree with opposite, lanceolate, acute, petiolate, pellucid-punctate and evergreen leaves. The flowers are small, white and in axillary racemes. The fruit is used for flavoring and in medicine. (See Pimenta.)

Not only are ethereal oils obtained from the genera Eucalyptus, Jambosa and Pimenta already described, but also from other members of the Myrtaceæ. Oil of Bay or oil of Myrcia is distilled from the leaves of *Pimenta acris* of the West Indies. The oil consists largely of eugenol, methyl-eugenol, chavicol, methyl-chavicol, citral, phellandrene and myrcene, and is used in the preparation of Bay rum. The fruits of *P. acris* yield 3.3 per cent. of an oil resembling the leaf oil.

Cheken leaves are obtained from *Eugenia Cheken*. They are about 25 mm. long, ovate or rectangular, with entire, somewhat revolute margin, light green, pellucid punctate, aromatic, astringent and bitter. Cheken leaves yield about 1 per cent. of a volatile oil containing cineol and pinene; 4 per cent. of tannin; a volatile alkaloid and a glucoside.

Oil of Cajeput is obtained from the leaves and twigs of *Melaleuca Leucadendron*, particularly the varieties *Cajeputi* and *minor* of the East Indies. The principal constituents of this oil are cineol, terpineol, pinene, and a number of aldehydes and acid esters. An oil resembling Cajeput oil is obtained from the leaves and flowers of *Myrceugenia camphorata* of Chile.

The leaves of *Myrtus communis*, a plant extensively cultivated in the Mediterranean countries of Europe, yield a distillate with water known as Eau d'ange and used as a toilet article.

The leaves of the following plants are used as substitutes for tea leaves: *Myrtus Molinæ* of Chile, *Melaleuca genistæfolia* of Australia, and *Leptospermum scoparium* and other species of this genus growing in New Zealand. The seeds of *Eugenia disticha* are known in the Antilles as Wild coffee. Quite a number of the genera of this family yield edible fruits. Guava or Guayava fruit is obtained from *Psidium Guayava* of tropical America. Rose apple is the fruit of *Jambosa malaccensis*, growing in the East Indies and Oceanica. Jambuse berries are derived from

Jambosa vulgaris which is extensively cultivated in the Tropics. The lemon-like fruit of *Myrcia coriacea* is used in medicine, the bark in tanning, and the wood in dyeing. The fibrous bark of *Eugenia ligustrina* is used like oakum.

h. FAMILY COMBRETACEÆ.—The members of this family are shrubs or trees, sometimes climbing, with usually alternate, petiolate, simple leaves; sessile flowers in racemes; somewhat fleshy, winged, 1-seeded fruits, and are mostly found in the Tropics.

Like the Fagaceæ the plants of this family contain a tannin, similar to gallotannic acid, in nearly all parts of the plant. The MYROBALANS of the East Indies are the young fruits of *Terminalia Chebula*. The pericarp contains from 5 to 45 per cent. of tannin, the latter amount being found in the fruits known as Long or Chebula Myrobalans. The fruits also contain ellagic and chebulinic acids. The fruits of *Terminalia belerica* constitute the Beleric Myrobalans. The galls of *Terminalia macroptera* of Africa and other species of Terminalia as well as of *Bucida Buceras* of tropical America are particularly rich in tannin. A yellow coloring principle is found in *Terminalia Brownii* of Africa and is used in dyeing leather. The bark of *T. Catappa* of Asia and Africa is used to dye leather black.

A gum-resin with cathartic properties is obtained from *Terminalia fagifolia* of Brazil. An aromatic resin is found in *Terminalia angustifolium* of the East Indies. The fruits of one or more of the Combretaceæ are said to be used in the preparation of the arrow-poison of the Negritos. The seeds of *Terminalia Catappa* and *Combretum butyrosum* contain about 50 per cent. of fixed oil. These seeds as well as those of other species of *Terminalia* and *Quisqualis indica* of Farther India and tropical Africa are edible. The seeds of the latter plant when unripe are said to be used like mustard. The woods of a number of the plants of the Combretaceæ are valuable for building purposes, and some of the genera furnish ornamental plants which are cultivated in greenhouses.

i. FAMILY MELASTOMACEÆ.—This is a large family of herbs, shrubs and trees with opposite, 3- to 9-nerved leaves and regular, perfect, often showy flowers. They are chiefly found in South America and are represented in temperate regions by the Meadow beauty (Rhexia). Quite a number of the plants are cultivated and a large number yield edible fruits. The fruits, barks and leaves frequently contain COLORING PRINCIPLES. A yellow coloring principle is found in the leaves of a number of species of Memecylon of the East Indies and Africa, which resembles that of saffron and curcuma. Red coloring principles are found in the berries of a number of species of Blakea of South America. A black coloring principle is obtained from the fruit of several species of Tamonea of tropical America, *Melastoma malabathricum* of the East Indies and *Tococa guianensis* of Northern South America and *Tibouchina Maximiliana* of Brazil. Tannin is found in considerable quantity in the barks of Tibouchina, Dissotis and Rhynchanthera.

The leaves of *Tamonea theæzans* are used in Peru as a substitute for tea. A mucilage is found in the bark of *Medinilla crispata* of the Molucca Islands. The flowers of the latter plant as well as of *M. macrocarpa* are used as a remedy for the bite of poisonous serpents.

j. ONAGRACEÆ OR EVENING PRIMROSE FAMILY. These are mostly annual or perennial herbs with usually entire or toothed, simple leaves. The flowers are perfect, regular or irregular, epigynous, variously colored, solitary in the axils of the leaves or in somewhat leafy spikes. The fruit is a dehiscent capsule, berry, drupe, or nut. This family is represented in temperate regions by such plants as the Willow herb (Epilobium), Evening primrose (Œnothera), on which de Vries has carried on his famous mutation experiments, and Enchanter's nightshade (Circæa). The cultivated FUCHSIA also belongs to this family. The subterranean parts of *Primula officinalis* contain two crystalline glucosides, primeverin and primulaverin, which by the action of the ferment, primeverase, produce an anise-like odor. The odors of the other species of Primula are probably due to distinct glucosides: (a) one producing an anise-like odor as in *P. officinalis, P. capitata* and *P. denticulata;* (b) one producing the odor of methyl salicylate, as in *P. longiflora, P. elatior* and *P. vulgaris;* (c) one producing the odor of coriander, as in *P. auricula, P. panonica* and *P. palinuri.* The flowers of a number of genera are light in color and somewhat luminous in the dark.

A yellow coloring principle is obtained from the herb and unripe fruits of *Jussieua pilosa* of Brazil. The roots of *Œnothera biennus, O. muricata* and other species of this genus are edible.

k. HYDROCARYACEÆ OR TRAPACEÆ.—These are aquatic plants comprising a single genus, one of which *Trapa natans* or Water chestnut is naturalized to some extent in the ponds of Massachusetts and New York. The fruit is coriaceous, 2- to 4-spinose, and 1-seeded. The cotyledons are unequal, rich in starch, and are edible, sometimes being ground and made into bread by the people of Europe and Northern Asia.

XXIII. ORDER UMBELLALES OR UMBELLIFLORÆ.

The plants of this order are widely distributed in northern temperate regions although there are some representatives in the Tropics. The flowers are small, 4- or 5-merous and epigynous.

a. ARALIACEÆ OR GINSENG FAMILY.—The plants are mostly trees or shrubs with alternate, petiolate, simple or 3- to 7-compound leaves. The flowers are either in umbels or panicles. The fruit is a drupe or berry. The best known representatives of this family are the English ivy (*Hedera helix*) of Europe, and Ginseng (*Panax quinquefolium*) (Fig. 169) growing in the Eastern and Central United States. This plant is the source of the ginseng root of commerce, considerable quantities of which are exported to China where it is used like the root of *Panax Ginseng*, a plant growing wild in Manchuria and Korea. Both plants are also cultivated in the United States, the roots from the wild plants being preferred. The root contains a volatile oil, and considerable starch. Several species of Aralia are used in medicine (p. 450).

The leaves of the English ivy contain the glucoside helixin, and a carbohydrate, inosit. They also contain formic, oxalic, malic, tannic and hederic acids, besides the yellow principle carotin. The fruits of the ivy contain a purplish-red coloring substance and are said to be poisonous.

The Chinese RICE PAPER is made from the pith of *Tetrapanax papyrifer* which grows wild in Formosa and is extensively cultivated in China. The pith is cut spirally into thin strips which are spread out flat and then cut into pieces varying from 15 to

30 cm. long and 10 to 12 cm. broad. This paper differs from other papers in that it is a natural product.

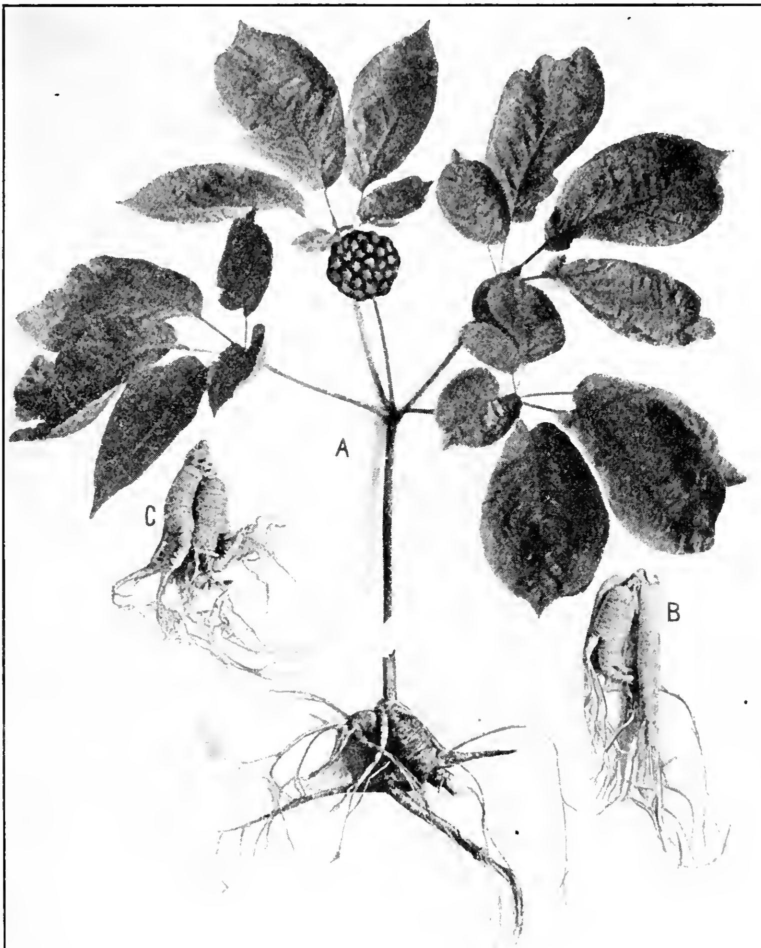


FIG. 169. *Panax quinquefolium* (Ginseng): A, upper portion of plant showing palmately-compound leaves with long-stalked leaflets, the berry-like drupes; B, fusiform root; C, roots showing characteristic stem scars at the upper portion.—From a photograph by Wyss. (See also Fig. 63, p. 98.)

The rhizome of *Panax repens* growing in Japan, contains 20.8 per cent. of a non-toxic saponin with hemolytic properties.

b. UMBELLIFERÆ OR CARROT FAMILY.—The plants are herbs, frequently with hollow stems; alternate, simple or compound leaves, the base of the petiole often forming an inflated sheath; and small white, yellowish, greenish or somewhat purplish flowers occurring in simple or compound umbels. The fruit is a cremocarp, having characters which are of important taxonomic value, as the presence or absence of secondary ribs, number and position of the vittæ, etc.

Coriandrum sativum is an annual herb the fruits of which are official (p. 562). The leaves are bi-or tri-pinnate, the leaflets being narrow linear-lanceolate; and the flowers are white or rose-colored.

Conium maculatum or Poison Hemlock is a tall, erect, branching, biennial plant, with purplish spotted stems, large pinnately decompound leaves and small, white flowers. The fruit is official (p. 567).

Carum Carvi (Caraway) is a biennial herb with bi- or tri-pinnate, deeply incised leaves, and white flowers. The fruit is official (p. 565) and the leaves are also used in medicine.

Pimpinella Anisum is a small, hairy, annual herb. The leaves are variable, the lower being somewhat cordate and serrate, the middle distinctly lobed, and the upper ones trifid; the flowers are white. The fruit is official (p. 560) and is also used for flavoring.

Fœniculum vulgare is an annual or perennial, glabrous herb with very finely dissected leaves, the divisions being narrow-linear. The flowers are yellow, and the involucre and involucels are wanting. The fruit is official (p. 563).

Ferula fœtida is a stout, perennial herb with few, ternately compound leaves and small, polygamous, light yellow flowers. The root is rather large and yields the gum-resin asafetida (p. 671). Asafetida is also derived from other species of *Ferula*.

Ferula Sumbul is a tall perennial herb with purplish latex-containing stems. The basal leaves are ternately compound and with amplexicaul base. The leaves decrease in size from the base upward, becoming bract-like near the inflorescence. The flowers are polygamous, resembling those of *F. fœtida*. The root is official (p. 462) and is probably also obtained from other closely related species of *Ferula*.

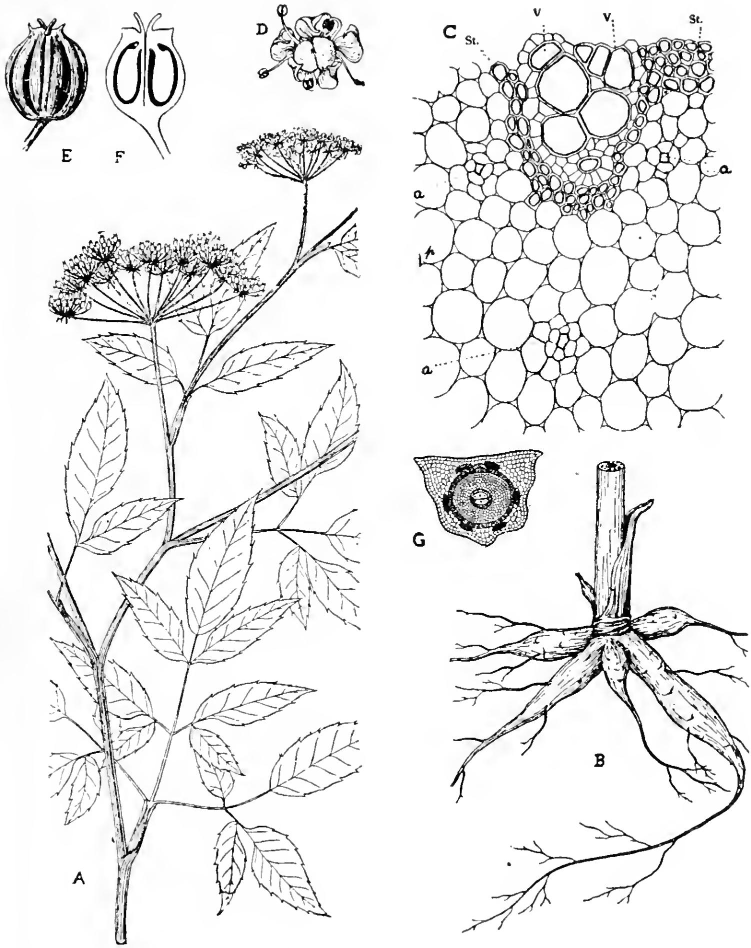


FIG. 170. *Cicuta maculata* (Water Hemlock): A, upper part of stem with leaves and compound umbels; B, base of the stem and the thick tuberous roots; C, cross-section of stem showing part of a mestome strand and the pith with three oil-ducts (a), vessels (v), libriform (St), pith (p); D, a flower showing petals with long inflexed apex and the five stamens inserted on the disk that crowns the ovary; E, the fruit; F, fruit in longitudinal section showing the two ovules; G, cross-section of a mericarp showing the six vittæ or oil-tubes.—After Holm.

A large number of the plants belonging to the Umbelliferæ contain essential oils, resins, gum-resins and related substances. The gum-resin AMMONIAC is an exudation found on the stem and branches of *Dorema Ammoniacum* and other species of Dorema as a result of the sting of an insect. The plant is found in Western Asia. The gum-resin occurs in yellowish-brown, globular, or somewhat flattened tears which are brittle, milky-white internally, with a distinct balsamic odor and bitter, acrid, nauseous taste. It contains a small quantity of volatile oil having the odor of Angelica. AFRICAN AMMONIAC is obtained from *Ferula tingitana* growing in Northern Africa and Western Asia.

The gum-resin GALBANUM is obtained by incising the root of *Ferula galbanifula* and other species of Ferula growing in the Levant. Galbanum occurs in pale yellowish-brown agglutinated tears, forming a more or less hard mass, which is brittle when cold but soft and sticky at 37° C.; the odor is distinct, balsamic; the taste bitter and acrid. It contains from 10 to 20 per cent. of a volatile oil composed of d-pinene, cadinene, and other principles.

A volatile oil, known as AJOWAN OIL, and containing thymol, is obtained from the fruit of *Carum Ajowan* of Europe, Asia and Africa. A volatile oil containing APIOL is found in the fruit and leaves of the garden parsley (*Petroselinum sativum*). DILL OIL is obtained from the garden Dill (*Anethum graveolens*). The fruit of Sweet cicely (*Washingtonia longistylis*) yields a volatile oil known as sweet anise oil, which contains anethol. The oil of water fennel (*Œnanthe Phellandri*) contains about 80 per cent. of phellandrene. CUMIN OIL is obtained from *Cuminum Cyminum* of Turkestan and Egypt, and contains cymene.

The roots of a number of the plants of this family contain volatile oils, as Lovage (*Levisticum officinale*) of Southern Europe; European angelica or garden angelica (*Angelica Archangelica*); American angelica or the purple-stemmed angelica (*A. atropurpurea*) found in the Northern and Eastern United States and Canada; Wild angelica (*A. sylvestris*) of Europe.

c. CORNACEÆ OR DOGWOOD FAMILY.—The plants are shrubs or trees with simple, opposite leaves, and flowers in cymes or heads, which in the case of the Flowering dogwood

(*Cornus florida*) are subtended by four large, petal-like, white, or pinkish bracts.

The bark of *Cornus florida*, a shrub or small tree growing in the United States, contains a bitter principle, cornin; and a small quantity of gallic and tannic acids.

Aucuba japonica, a plant indigenous to the Himalayas, China and Japan and extensively cultivated on account of its crimson berries, contains a glucoside aucubin. It is found in the different varieties and varies in amount from 0.31 to 1.96 per cent.

METACHLAMYDEÆ OR SYMPETALÆ.

This is the highest group of plants and is marked by the following characters: The corolla is sympetalous; the flowers are mostly perigynous or epigynous and both the corolla and stamens are borne on the perianth tube. The number of parts is definite, there being 5 sepals, 5 petals, 5 or 10 stamens and 2 or 5 carpels. This sub-class includes but six orders, to which, however, belong a large number of medicinal and economic plants.

I. ORDER ERICALES.

The plants of this order are distinguished by the fact that the stamens are mostly free from the perianth tube.

a. PYROLACEÆ.—The plants are small, mostly evergreen perennials, and are represented in the United States by several genera.

Chimaphila umbellata (Prince's pine or Pipsissewa) is a small trailing or creeping plant producing distinct flower- and leaf-branches. The leaves are official (p. 603). The flowers are in small corymbs and the petals are white or pinkish. In *Chimaphila maculata* the leaves are lanceolate, mottled with white along the veins and the flowers are considerably larger.

With the Pyrolaceæ are sometimes grouped the saprophytic plants of the genus Monotropa. There are two representatives of this genus which are common in the United States, namely, Indian pipe (*Monotropa uniflora*) and false beech-drops (*M. Hypopitys*) The latter contains a glucoside or an ester of methyl salicylate, and a ferment gaultherase.

b. ERICACEÆ OR HEATH FAMILY.—This is a large family and the plants are widely distributed, especially in the northern mountainous parts of both the Eastern and Western Continent. They vary from perennial herbs to trees. The flowers are usually regular, the stamens being mostly 2-spurred (Fig. 81, *S*), and the fruit is either a superior or inferior drupe or berry (Fig. 134, *H*).

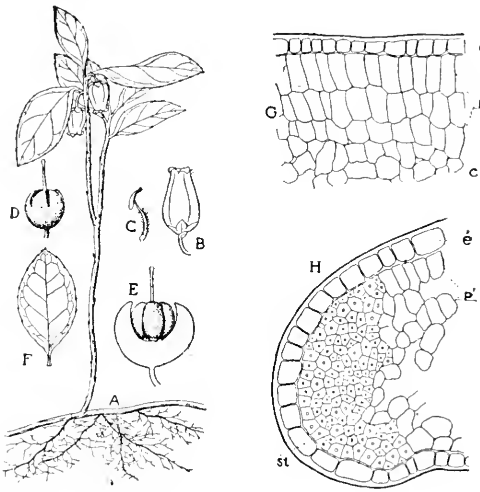


FIG. 171. *Gaultheria procumbens:* A, entire plant showing horizontally creeping stolons and solitary axillary flowers; B, flower showing hypocrateriform corolla; C, stamen; D, young fruit; E, section of fruit showing the baccate or berry-like calyx which encloses the real fruit or capsule; F, leaf showing venation; G, cross-section of leaf showing epidermis (e), three layers of palisade cells (p), and chlorenchyma (c); H, cross-section of margin of leaf showing in addition a large group of sterome cells.—After Holm.

Arctostaphylos Uva-Ursi is a low branching shrub which trails or spreads on the ground. The leaves are used in medicine (p. 601). The flowers are small, white or pink, few and in short racemes. The fruit is a red, globular drupe.

Trailing arbutus (*Epigæa repens*) is a trailing, shrubby, hairy plant with broadly elliptical or ovate, coriaceous, evergreen leaves and white or rose-colored, fragrant flowers which are either perfect, with styles and filaments of varying length, or diœcious. The leaves contain similar constituents to those in Uva Ursi and Chimaphila.

The leaves of wintergreen (*Gaultheria procumbens*) are the source of true oil of wintergreen, which consists almost entirely of methyl salicylate. It contains a small quantity of an alcohol and an ester giving the characteristic odor. The same principles probably also occur in several other species of Gaultheria (Fig. 171).

The poisonous principle andromedotoxin is found in a number of species of Rhododendron, Leucothœ, and Pieris. This principle is a powerful emetic and one of the most toxic principles known. It probably occurs in the nectar of the flowers of Kalmia and Rhododendron, being the cause of the poisonous properties of the honey from this source. The leaves of several species of laurel (Kalmia) contain considerable quantities of this principle, and are poisonous to cattle.

The plants of the genus Gaylusaccia are small shrubs distinguished by having an inferior, berry-like drupe with ten loculi. To this genus belong the huckleberries, as black huckleberry (*G. resinosa*); blue huckleberry (*G. frondosa*); and dwarf huckleberry (*G. dumosa*). The latter plant grows in sandy swamps in both the United States and Canada and the fruit ripens in May and June. The fruits of the other two species ripen in July and August.

The plants belonging to the genus Vaccinium vary from very small shrubs to tree-like shrubs and the fruit is an inferior, 5-locular berry with numerous seeds. The blueberries or bilberries (whortleberries) are the fruits of several species of Vaccinium. The low bush blueberry (*V. pennsylvanicum*) yields the berries which ripen in June and July, while the high bush blueberry (*V. corymbosum*) furnishes the fruits which are found in the market in July and August.

The bilberry of Europe, *Vaccinium Myrtillus*, a plant growing in Northern Europe and Asia and the Western United States and Canada, is said to destroy *Bacillus typhosus* and *B. Coli*, an infusion of the dried berries being used for this purpose. The leaves of this plant contain ericolin and kinic acid.

Cranberry is the fruit of several species of Vaccinium which are sometimes grouped in a separate genus, Oxycoccus. There are two principal species: The large or American Cranberry (*V. macrocarpum*) in which the berries are ovoid or oblong and the small or European Cranberry (*V. Oxycoccus*) in which the berries are globose. The berries contain from 1.4 to 2.8 per cent. of citric acid; and a bitter glucoside, oxycoccin.

II. ORDER EBENALES.

This order includes three families which are chiefly indigenous to the Tropics. The leaves are alternate, and the flowers vary in the different families, the fruit being a berry or drupe.

a. SAPOTACEÆ OR SAPODILLA FAMILY.—The plants usually have a milky latex, and many of them yield GUTTA-PERCHA, of which the following may be mentioned: *Palaquium Gutta, P. oblongifolium, P. borneense* and *P. Treubii,* all growing in the East Indies. The latex is obtained by incising the trees and collecting the exuding juice in suitable vessels. It soon coagulates and forms grayish or reddish-yellow hard masses, which are plastic at 65° to 70° C. Owing to the fact that the material is plastic when heated and firm and tenacious when cold, it is used for a variety of purposes, as in the manufacture of surgical instruments and as a material for filling teeth. Gutta-percha as it exudes from the tree is supposed to consist of a terpene-like hydrocarbon, which on coagulation is oxidized, forming a number of resinous compounds. The plants of other genera of this family also yield gutta-percha, as *Mimusops Balata, M. Elengi* and about fifteen species of *Payena* growing in the East Indies.

GUM BALATA is obtained from *Mimusops Balata,* a tree of Guiana. The gum is more resinous and flexible than gutta-percha. It contains β-amyrin acetate and probably lupeol acetate.

A gum resembling gutta-percha is obtained from the Sabodilla tree (*Achras Sapota*). This gum is known in commerce as GUM CHICLE and is obtained from Yucatan. It is whitish, brittle, and yet somewhat elastic, aromatic, and contains 45 per cent. of a colorless crystallizable resin, soluble in alcohol and ether; and 18 per cent. of caoutchouc. It is used in large quantities in the making of chewing gum.

The seeds of *Illipe butyracea* yield a fixed oil which is known as VEGETABLE BUTTER. A fixed oil is also obtained from other species of Illipe as well as various species of Bassia, Argania and

Butyrospermum, that from the latter being known as "shea butter."

The family is notable on account of the hard woods, known as IRONWOODS, which it furnishes, these being yielded by *Mimusops Kauki* of Farther India and tropical Australia and *Argania Sideroxylon* of Southwestern Morocco.

A number of species also yield highly prized edible fruits, as the SAPOTILLA yielded by *Achras Sapota* indigenous to the Antilles and cultivated in tropical countries, and STAR APPLE yielded by *Chrysophyllum Cainito* of tropical America.

b. EBENACEÆ OR EBONY FAMILY.—The plants differ from those of the preceding family in not containing a latex. The flowers are monœcious or diœcious and they usually have from two to eight styles. The chief interest is in the genus *Diospyros*, which yields the wood known as EBONY. Black ebony is obtained from various species of Diospyros growing in tropical Africa, and Asia, and the Philippine Islands. White ebony is obtained from several species of Diospyros growing in the Philippines. A red ebony is obtained from *D. rubra* of Mauritius, a green ebony from *D. chloroxylon* of Farther India, and a striped ebony from several species growing in the Philippines.

PERSIMMON fruit is obtained from *Diospyros virginiana*, a tree growing from Rhode Island south to Texas. The astringency of the unripe fruit is due to the tannin which it contains. When it is ripe, which is not until after the appearance of frost, it is palatable and contains considerable malic acid and sugars. The Japanese persimmon is a cultivated variety of *D. Kaki* and produces a large orange-colored fruit which is not uncommon in the fruit markets in many parts of the world. At the present time the plant is cultivated in California.

The bark of our native persimmon is used in medicine. It contains considerable tannin which resembles gallotannic acid, and a crystalline resinous principle with a peculiar odor and slightly astringent taste.

c. STYRACEÆ OR STORAX FAMILY.—The flowers of this family somewhat resemble those of the Ebenaceæ, but the filaments of the stamens are united in a single series, and there is a single slender style.

Styrax Benzoin is a medium-sized tree with long, ovate, acuminate leaves which are very hairy on the under surface. The flowers occur in terminal racemes, and are silvery white on the outer surface and reddish-brown on the inner surface. The balsamic resin yielded by this plant is official as benzoin (p. 672).

III. ORDER GENTIANALES OR CONTORTÆ.

The plants of this order have opposite leaves, the flowers are regular and the gynæcium consists of two separate carpels. The order includes five families all of which furnish medicinal plants.

a. OLEACEÆ OR OLIVE FAMILY.—This family is chiefly of interest because of the olive and manna trees.

The olive tree (*Olea europæa*) is indigenous to the Orient and is now cultivated extensively in Southern Europe, Northern Africa, the islands of the Mediterranean, tropical America, including the Southern United States, and in California. The leaves are narrow-lanceolate, entire, coriaceous and evergreen. The flowers are small, white, diandrous and in axillary racemes. The fruit is a drupe, the sarcocarp of which is rich in a fixed oil known as olive oil. The oil is obtained by expression, and is official. Depending upon the character of the fruits and the amount of oil which they yield, over forty varieties are recognized. The fresh green olives contain a glucoside oleuropein, which disappears on the maturation of the fruit.

Fraxinus Ornus is a tree resembling the ash, with 7-foliate leaves, and polygamous flowers occurring in compound racemes. The fruit is a flat samara with the wing at the apex. The saccharine exudation from this plant is official as manna (p. 649).

The white ash (*Fraxinus americana*) is a valuable tree on account of the timber which it yields. The bark contains a bitter glucoside, fraxin, the solutions of which are fluorescent; a bitter substance, fraxetin; an ethereal oil of a butter-like consistency, and tannin. Some of these principles are also found in other species of Fraxinus growing in the United States and Europe.

The bark of the fringe tree (*Chionanthus virginica*) of the Southern United States, contains an intensely bitter glucosidal principle, chionanthin, and possibly also saponin.

The leaves of the garden lilac (*Syringa vulgaris*) contain a crystalline glucoside, syringin, and syringopicrin, both of which

Fig. 172. Carolina pink (*Spigelia marilandica*) showing the rhizome bearing two branches with opposite leaves and flowers in terminal scorpioid cymes.

are probably also found in other species of Syringa as well as the bark and leaves of privet (*Ligustrum vulgare*) which latter plant is extensively used for hedges.

b. LOGANIACEÆ OR LOGANIA FAMILY.—The plants are variable in character, being herbs, shrubs, trees or vines.

Yellow jessamine (*Gelsemium sempervirens*) is a twining woody vine, sometimes trailing on the ground for a considerable distance. The leaves are oblong-lanceolate and evergreen. The flowers are bright yellow and dimorphic. The fruit is a septicidally dehiscent capsule. The rhizome and roots are official (p. 480).

Carolina pink (*Spigelia marilandica*) is a perennial herb with ovate-lanceolate, more or less acute and nearly sessile leaves. The flowers are yellow on the inner and scarlet on the outer surface, and occur in a 1-sided spike or scorpioid cyme. The fruit is a circumscissile, 2-valved capsule (Fig. 172). The rhizome and roots are official (p. 503).

Strychnos Nux-vomica is a small tree with broadly elliptical, 3- to 5-nerved, reticulately-veined, somewhat acuminate, coriaceous leaves. The flowers are whitish and in terminal cymes. The fruit is a berry of varying size and contains several seeds, the seeds being official (p. 436).

CURARE which is used by the Indians of South America as an arrow-poison is supposed to be made from the bark of *Strychnos toxifera* growing in Guiana, and probably other species of this genus. The active principle of this poison is the alkaloid curarine, which when administered hypodermically has a powerful action resembling that of digitalis.

c. GENTIANACEÆ OR GENTIAN FAMILY.—The plants are mostly herbs with regular, perfect, showy flowers occurring usually in small cymes or racemes.

Yellow gentian (*Gentiana lutea*) is a large, perennial herb (Fig. 209) with large, 5- to 7-nerved, broadly elliptical leaves. The flowers are yellow and occur in axillary cymes. The fruit is a 2-valved, ovoid capsule. The rhizome and roots are official (p. 483).

Sweertia Chirata.—The entire plant is official (p. 637).

HERBA CENTAURII MINORIS, the entire plant of *Erythræa Centaureum* of Europe, contains a glucoside, erytaurin, which forms small colorless prismatic and bitter crystals and is slowly hydrolyzed by emulsin. *Sabbatia Elliottii* occurring in the pine barrens of the Southern States is known as the "quinine herb."

d. APOCYNACEÆ OR DOGBANE FAMILY.—The plants vary from perennial herbs to shrubs and trees, contain an acrid latex, and have flowers with the stigmas and styles united and the stamens distinct. They are mostly found in the Tropics.

Apocynum cannabinum is a perennial herb with erect or ascending branches. The leaves are oblong-lanceolate, opposite, nearly sessile or with short petioles (Fig. 201, *C*, *D*). The flowers are greenish-white, the lobes of the corolla being nearly erect and the tube about as long as the calyx. The fruit is a slender, terete follicle containing numerous seeds tipped at the micropylar end with a tuft of hairs. The root is official (p. 467).

The root of a closely related species, namely, spreading dogbane (*Apocynum androsæmifolium*) is sometimes substituted for the official drug. The plant is distinguished by being more spreading in its habit. The leaves are ovate (Fig. 201, *A*, *B*), the flowers are pinkish, the lobes being revolute and the tube several times as long as the calyx.

Strophanthus Kombe.—The plant is a woody climber with elliptical-acuminate, hairy leaves. The flowers are few, characterized by long styles, and occur in axillary racemes. The fruit consists of two long follicles containing numerous awned seeds (Fig. 185), which are official (p. 430). In the closely related plant *S. hispidus* the flowers are numerous and occur in terminal cymes.

QUEBRACHO OR ASPIDOSPERMA is the bark of *Aspidosperma Quebracho-blanco,* a tree growing in Argentine. It occurs in nearly flat pieces which are 1 to 3 cm. thick; the outer surface is yellowish-gray and deeply fissured, the inner bark being very hard and tough. It is aromatic and bitter and contains six alkaloids, all of which are present in the commercial aspidospermine. They are aspidospermine, which is colored brown, then cherry-red or purplish by sulphuric acid and potassium dichromate; aspidosamine, which is colored blue by sulphuric acid and potassium dichromate; aspidospermatine, which is colored deep red by perchloric acid like the two preceding alkaloids, but not by sulphuric acid and potassium dichromate; quebrachine, which is colored yellow by perchloric acid; and quebrachinamine, which resembles quebrachine but has a much lower melting point. The bark is used for tanning leather and yields a commercial extract.

The leaves and bark of the cultivated oleander (*Nerium Oleander*) contain the glucoside oleandrin, resembling digitalin in its action; a fluorescent principle, and probably several other principles.

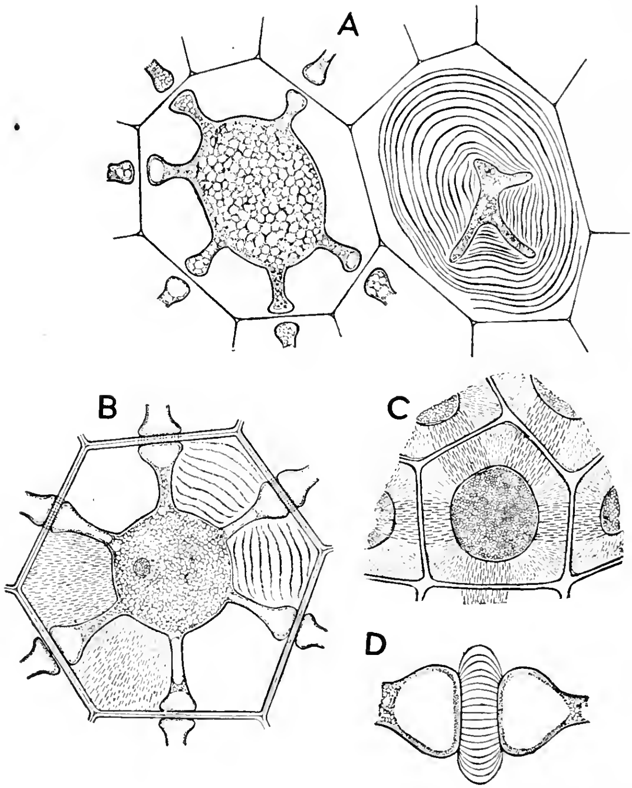


FIG. 173. A, cells of endosperm of the seed of the date palm (*Phœnix dactylifera*), the one normal and the other showing the stratification of the wall after treatment with chlor-zinc-iodide.
B, cell of endosperm of *Phytelephas macrocarpa* (vegetable ivory) showing lamellation and spherite structure in the wall after treatment with chlor-zinc-iodide, clove oil, chromic acid or certain other reagents.
C, cell of endosperm of *Strychnos Nux-vomica* after treatment with iodine and potassium iodide solution.
D, opposite pores in the walls in contiguous cells of vegetable ivory showing striæ between them after treatment with iodine solution.

The common periwinkle (*Vinca minor*) contains the principle vincin which is supposed to be a glucoside and which probably occurs in other species of Vinca.

e. ASCLEPIADACEÆ OR MILKWEED FAMILY.—The plants somewhat resemble those of the Apocynaceæ. The flower, however, is distinguished by having distinct styles, a 5-lobed corona connecting the corolla and stamens, which latter are mostly monadelphous, and pollen grains that are coherent, forming characteristic pairs of pollinia. It may be noted that while this family contains a large number of plants that are used in medicine none of them are official. PLEURISY ROOT, which was formerly official, is obtained from *Asclepias tuberosa*, a plant growing in the Eastern United States and one of the two members of this genus that have orange-colored flowers. The root is more or less fusiform, wrinkled, about 1 or 2 cm. thick, and is usually cut into longitudinal pieces. In the dried condition it is light brown externally, more or less irregular, with a tough fracture and a bitter, slightly acrid taste. The active principle is the glucoside asclepiadin. A similar principle is found in the root of other species of Asclepias.

CONDURANGO is the bark of *Marsdenia Cundurango*, a liane of Ecuador and Columbia. It occurs in quilled pieces, the bark being from 2 to 6 mm. thick. Externally it is brownish-gray and with a more or less scaly cork. The taste is bitter, acrid and aromatic. The drug contains an amorphous glucoside; an unsaturated alcohol occurring in large prisms; and a volatile oil (0.3 per cent.).

IV. ORDER POLEMONIALES OR TUBIFLORÆ.

This is a large order of plants, which are mostly herbaceous. The leaves are either opposite or alternate; the flowers are regular or irregular, the stamens being usually adnate to the corolla.

a. CONVOLVULACEÆ OR MORNING-GLORY FAMILY.—The plants are mostly herbs or shrubs, frequently twining (to the left). They are found mostly in the Tropics, but quite a number of genera occur in temperate regions (Fig. 174).

Exogonium Purga is a perennial twining herb with distinctly veined, cordate leaves; purple flowers with the stamens exserted, and occurring in cymes. The fruit is a 2-locular capsule. The plants produce slender rhizomes with tuber-like roots, these being used in medicine (p. 451).

Convolvulus Scammonia is a perennial twining herb, with a large tap root, containing a resinous latex, and is the source of the official scammony (p. 656). The leaves are sagittate; the flowers are large, yellowish-white and funnel-form, as in the morning-glory, and occur in the axils of the leaves, either solitary or in clusters. The fruit is a 4-seeded, 4-locular, dehiscent capsule.

FIG. 174. Great bind weed (*Convolvulus sepium*) showing trailing or twining habit, the hastate leaves and funnel-shaped corolla. The plant is very resistant to noxious fumes and is usually found in smelter regions.

A number of the plants of the Convolvulaceæ are cultivated, probably the most important of which is the SWEET POTATO vine (*Ipomœa Batatas*), a plant extensively cultivated in tropical and sub-tropical countries on account of the edible tuberous roots. The roots contain from 3 to 10 per cent. of sugar and 9 to 15 per cent. of starch, which occurs in larger proportion in plants grown in sub-tropical countries. The starch is a commercial product and is known as sweet-potato starch or BRAZILIAN ARROW-ROOT.

The grains are more or less bell-shaped and 2- or 3-compound, about the size of wheat-starch grains, and in other ways resemble those of tapioca.

To this family also belongs rather an interesting group of parasitic plants, namely, dodder (Cuscuta). They contain the principle cuscutin, and quite a number have been used in medicine.

b. HYDROPHYLLACEÆ OR WATERLEAF FAMILY. The plants are herbs or shrubs which are indigenous to Western North America. Very few of the plants of this family are of use medicinally, although quite a number are ornamental plants.

Eriodictyon californicum (*E. glutinosum*) or Yerba Santa is a shrub growing in Northern Mexico and California. The leaves are official (p. 612). The flowers are funnel-form, white or purple, occurring in cymes. The fruit is a dehiscent capsule and the seeds are small and few.

c. BORAGINACEÆ OR BORAGE FAMILY.—The plants are mostly herbs with regular blue flowers, occurring in scorpioid inflorescence. The best examples of the group are the forget-me-not (*Myosotis*), the roots of several species of which have been used in medicine; and the garden heliotrope (*Heliotropum peruvianum*), the fragrance of the flowers being due to a volatile oil. This plant, as well as other species of Heliotropum, contains a poisonous volatile alkaloid.

At one time considerable interest attached to ALKANET, the root of *Alkanna tinctoria* of Southern Europe and Asia, on account of the red coloring principle alkannin, which is soluble in alcohol, ether, fixed and ethereal oils, but insoluble in water. COMFREY or SYMPHYTUM is the root of *Symphytum officinale* and other species of this genus naturalized from Europe in waste places in the United States. It occurs on the market in small, purplish-black, more or less curved pieces, which are quite mucilaginous and astringent to the taste. The drug contains a gluco-alkaloid, consolidin, and an alkaloid, cynoglossine. It also contains a small amount of dextrin-starch, *i.e.*, one which is not colored blue with iodine, and tannin. The root and herb of HOUND'S TONGUE (*Cynoglossum officinale*) are both used in medicine. The drug contains the powerful alkaloid cynoglossine, which resembles curarine in its action; and the gluco-alkaloid, consolidin.

d. VERBENACEÆ OR VERVAIN FAMILY.—The plants are chiefly herbs or shrubs with usually opposite or verticillate leaves and more or less irregular flowers.

To this family belongs the group of verbenas, some of which are used in medicine, as blue vervain (*Verbena hastata*), which resembles eupatorium in its medicinal properties; nettle-leaved vervain (*V. urticifolia*) which contains a bitter glucoside. The drug LIPPIA MEXICANA consists of the leaves of *Lippia dulcis mexicana*, and contains a volatile oil, the camphor lippiol, tannin and quercetin. *Lippia citriodora*, found growing in the central part of South America, contains a volatile oil, of which citral is a constituent. TEAK-WOOD, which is one of the hardest and most valuable of woods, is derived from the teak tree (*Tectona grandis*), a large tree indigenous to Farther India and the East Indies.

e. LABIATÆ OR MINT FAMILY.—The plants are mostly aromatic herbs or shrubs, with square stems, simple, opposite leaves, bilabiate flowers and a fruit consisting of four nutlets. The calyx is persistent, regular or 2-lipped and mostly nerved. The corolla is mostly 2-lipped, the upper lip being 2-lobed or entire, and the lower mostly 3-lobed. The stamens are adnate to the corolla tube, and are either 4 and didynamous, or 2 perfect and 2 aborted. The ovary is deeply 4-lobed (Fig. 134, *I*).

The Labiatæ are especially distinguished on account of the volatile oils which they yield and a few contain bitter or glucosidal principles.

1. The following PLANTS ARE OFFICIAL:

Scutellaria lateriflora (skullcap). The entire plant is official. (See page 638.) The plant is a perennial herb producing slender stolons somewhat resembling those of peppermint and spearmint. The stems are erect or ascending, commonly branching and from 22 to 55 cm. high.

Marrubium vulgare (white hoarhound) is a perennial woolly herb with ascending branches, the leaves and flowering tops being official (p. 628).

Salvia officinalis or garden sage is a perennial, somewhat shrubby, pubescent herb. The leaves are official (p. 612). The flowers are bluish, somewhat variegated, the calyx and corolla both being deeply bilabiate. Only the two anterior stamens are fertile (bear anthers); the connective is transverse, the upper

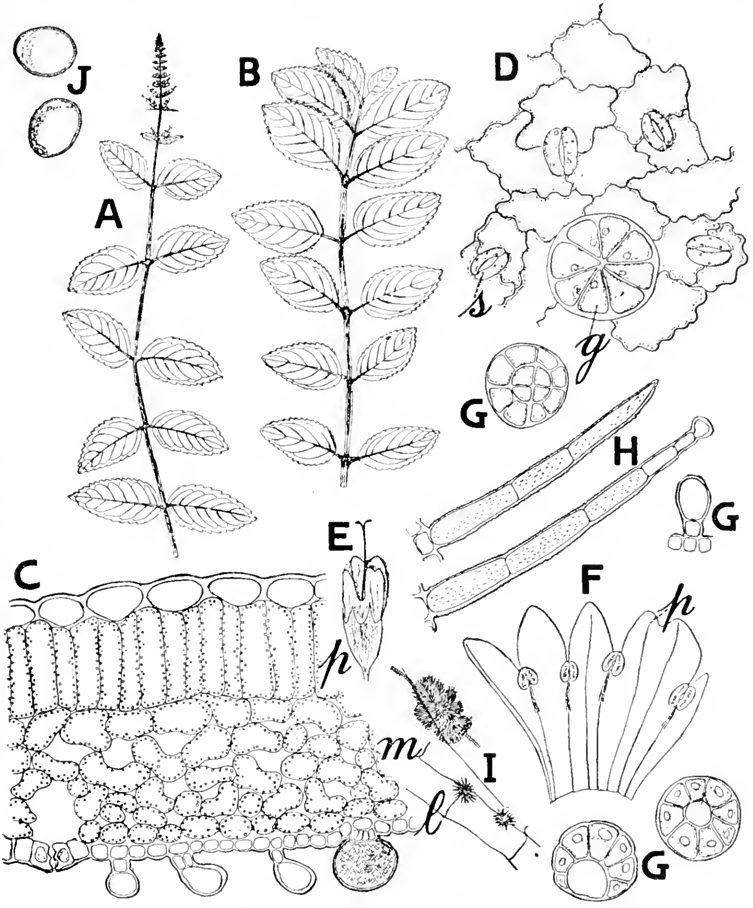


FIG. 175. Peppermint (*Mentha piperita*): B, portion of shoot showing petiolate leaves; C, transverse section of leaf showing several forms of glandular hairs on lower surface, loose parenchyma (m) and palisade cells (p); D, lower surface of leaf showing stoma (s) and glandular hair (g). Spearmint (*Mentha spicata*): A, portion of shoot showing flowers and nearly sessile leaves; E, flower; F, outspread corolla showing cleft posterior lobe (p) and the four adnate, included stamens; G, H, hairs from calyx; I, sphere crystals (sphærites) of a carbohydrate found in the corolla and style; J, pollen grains.

end bearing a perfect pollen-sac and the lower, a somewhat enlarged rudimentary pollen-sac (Fig. 84, *F*).

Hedeoma pulegioides (American pennyroyal) (see p. 628).

MENTHA species.—The plants are nearly glabrous, diffusely branching herbs, which form leafy stolons that are perennial (Fig. 175). The leaves and flowering tops of both *Mentha piperita* (p. 631) and *Mentha spicata* (p. 632) are official.

2. VOLATILE OILS of the following plants are official:

Rosmarinus officinalis is a shrub growing in the Mediterranean countries. The plant has linear, coriaceous leaves, and bluish, bilabiate flowers, the middle lobe of the lower lip of the corolla being large, concave, and toothed on the margin. The flowering tops yield from 1 to 1.5 per cent. of oil which is composed of 15 to 18 per cent. of borneol; about 5 per cent. of bornyl acetate; and pinene, camphene, camphor and cinneol. There are two commercial varieties of the oil, the Italian and French, the latter having the finer odor.

Lavandula officinalis (garden lavender) is a shrub growing in the Northern Mediterranean countries, as well as in England. The leaves are linear, coriaceous; the flowers are small, light blue, bilabiate, with a tubular calyx, and occur in opposite cymes (verticillasters).

The oil is derived from the fresh flowering tops, the flowers yielding about 0.5 per cent. Two kinds of oil are on the market, namely, French and English. The French oil contains 30 to 45 per cent. of l-linalyl acetate; linalool; geraniol, both of which latter constituents occur free and as esters. The English oil contains about 5 to 10 per cent. of linalyl acetate and a slight amount of cineol. Spike lavender (*Lavandula spica*) is sometimes distilled with true lavender (p. 371).

Thymus vulgaris (garden thyme) is a small shrub having linear or linear-lanceolate leaves, and pale blue flowers with strongly bilabiate, hairy calyx that occur in axillary cymes. The plant grows in the mountains of Southern France. The herb contains from 0.3 to 0.9 per cent. of volatile oil, which is of a dark reddish-brown color, and contains from 20 to 25 per cent. of thymol; and cymene, l-pinene, borneol and linalool. The Spanish oil of thyme contains from 50 to 70 per cent. of carvacrol, but no thymol.

3. Of OTHER PLANTS OF THE LABIATÆ which are of interest, the following may be mentioned:

Lavandula spica yields oil of spike, which has an odor of lavender and rosemary. The oil contains camphor, borneol, cineol, linalool and camphene.

Origanum majorana (Sweet marjoram) is an annual cultivated herb that has more or less oval, entire leaves, white flowers and an aromatic odor and taste. It produces a volatile oil which contains terpinene and d-terpineol. *Origanum vulgare* (Wild marjoram) grows in fields and waste places in the Eastern United States and Canada. The calyx is equally 5-toothed and the corolla varies from white to pink or purple. It contains a volatile oil having an odor somewhat like that of the oil of *O. majorana*. *Origanum hirtum* and *O. Onites* yield an origanum oil containing carvacrol and cymene. The oils obtained from Cretian Origanum are the source of commercial carvacrol.

Pogostemon Patchouli, a plant cultivated in Southern China and the East and West Indies, furnishes the oil of PATCHOULI used in perfumery. Patchouly camphor and cadinene have been isolated from the oil, but nothing, however, appears to be known of the nature of the odorous principle.

Hyssopus officinalis (Garden hyssop) contains about 0.5 per cent. of a volatile oil to which the characteristic odor of the plant is due. *Satureja hortensis* (summer savory) yields a volatile oil containing carvacrol, cymene and terpene. *Ocimum basilicum* (Sweet basil) is an herb growing in Europe, and yields an oil which is used in the preparation of Chartreuse and similar liquors. The oil contains methyl chavicol, linalool, cineol, camphor, pinene and terpin hydrate.

Melissa officinalis (Sweet balm) is a perennial herb indigenous to Europe and Asia and also cultivated. The leaves are ovate, dentate, and the flowers are bilabiate, the calyx being bell-shaped and 13-nerved. The taste is bitter, this being due to a bitter principle. The fresh leaves are quite aromatic and produce from 0.1 to 0.25 per cent. of a volatile oil containing a stearoptene.

Several species of Monarda known as HORSEMINT or wild bergamot are used in medicine. The oil was at one time official. The oil of *Monarda punctata*, a perennial herb found growing from New York to Texas, contains thymol, thymoquinone, hydrothymoquinone, carvacrol, cymene and limonene.

Nepeta Cataria (catnip) is a perennial herb naturalized in the United States from Europe (Fig. 74). It contains a bitter principle, tannin, and an oxygenated volatile oil. *Glecoma hederacea* or GROUND IVY is a creeping perennial herb with blue bilabiate flowers and reniform, crenate leaves. It contains a bitter principle and volatile oil. *Cunila origanoides* or American DITTANY, is a small perennial herb growing from New York to Florida, and characterized by its pungent aromatic properties.

Leonurus Cardiaca or MOTHERWORT is a perennial herb naturalized in the United States and Canada from Europe. The leaves are 3-lobed; the calyx is 5-nerved and with 5 prickly teeth; the corolla varies from white to pink or purple. The plant contains a volatile oil of rather an unpleasant odor; a bitter principle; two resins and several organic acids, namely, malic, citric and tartaric.

f. SOLANACEÆ OR POTATO FAMILY.—The family includes herbs, shrubs, trees and vines, which are most abundant in tropical regions. The leaves are alternate and vary from entire to dissected. The flowers are mostly regular, except in hyoscyamus. The stamens are adnate to the corolla tube, the anthers connivent and the pollen-sacs apically or longitudinally dehiscent. The fruit is a berry or capsule in which the sepals mostly persist and sometimes become enlarged or inflated. The seeds have a large reserve layer and the embryo is frequently curved.

Datura Stramonium (Jimson weed) is a large, annual, branching herb (Fig. 269), found in waste places in the United States and parts of Canada, being naturalized from Asia. The leaves and flowering tops are official (p. 622). The large, spiny capsule is shown at Fig. 89, *B*. The seeds are described on page 624.

Atropa Belladonna (Deadly nightshade) is a perennial herb producing a large fleshy root, which is used in medicine (p. 463), as are also the leaves and flowering tops (Fig. 268, p. 620).

Scopolia carniolica is a perennial herb with nearly entire or somewhat irregularly toothed leaves. The flowers are campanulate and dark purple. The fruit is a globular, transversely dehiscent capsule (pyxidium). The rhizome is official (p. 509).

Hyoscyamus niger or henbane is a biennial herb (Fig. 267), the leaves and flowering tops of which are official (p. 617).

Pichi is the dried leafy twigs of *Fabiana imbricata*, a shrub with small, scale-like leaves, indigenous to Chile. It contains a volatile oil; 0.1 per cent. of a bitter alkaloid; a glucoside resembling æsculin; and a bitter resin.

Solanum Dulcamara (Bitter sweet) is a perennial, climbing herbaceous plant, indigenous to Europe and Asia and naturalized

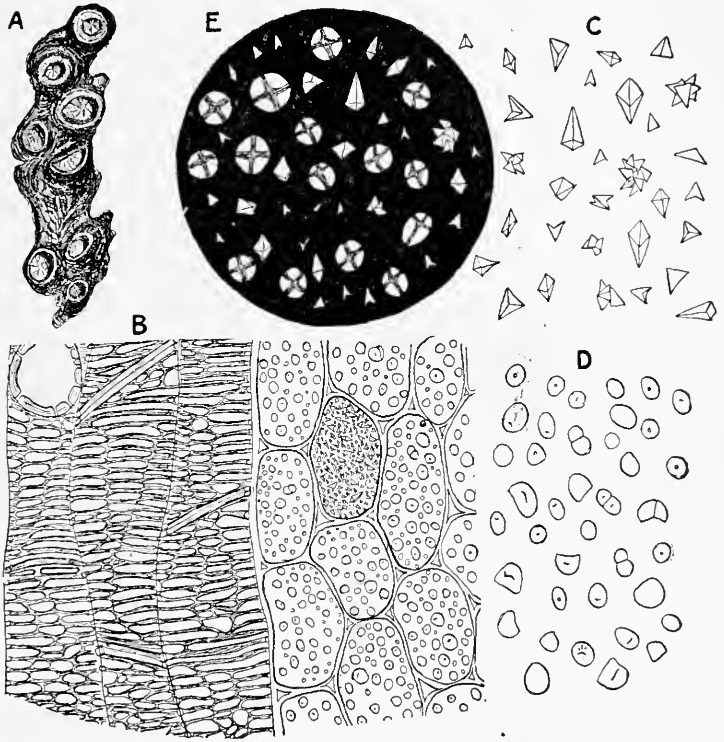


Fig. 175 a. Scopola (*Scopolia carniolica*); A, rhizome showing prominent stem scars; B, longitudinal section showing reticulate tracheæ, parenchyma cells containing starch and one with sphenoidal micro-crystals of calcium oxalate; C, individual crystals which separate from sections or in the powder, the single crystals being from 5 to 10 μ in diameter and the aggregates being 15 μ in diameter; D, isolated starch grains, which are 5 to 20 μ in diameter; E, field showing starch grains and crystals of calcium oxalate under polarized light.

in the Northern United States. The branches which have begun to develop periderm are collected, and were formerly official as Dulcamara. They are cut into pieces 10 to 20 mm. long which are greenish-brown, hollow, with a sweetish, bitter taste and contain a glucoside, dulcamarin, and the gluco-alkaloid solanine.

Solanum carolinense (Horse nettle) is a perennial herb having numerous yellow prickles on the branches and leaves. The leaves are oblong or ovate, irregularly lobed (Fig. 176). The flowers

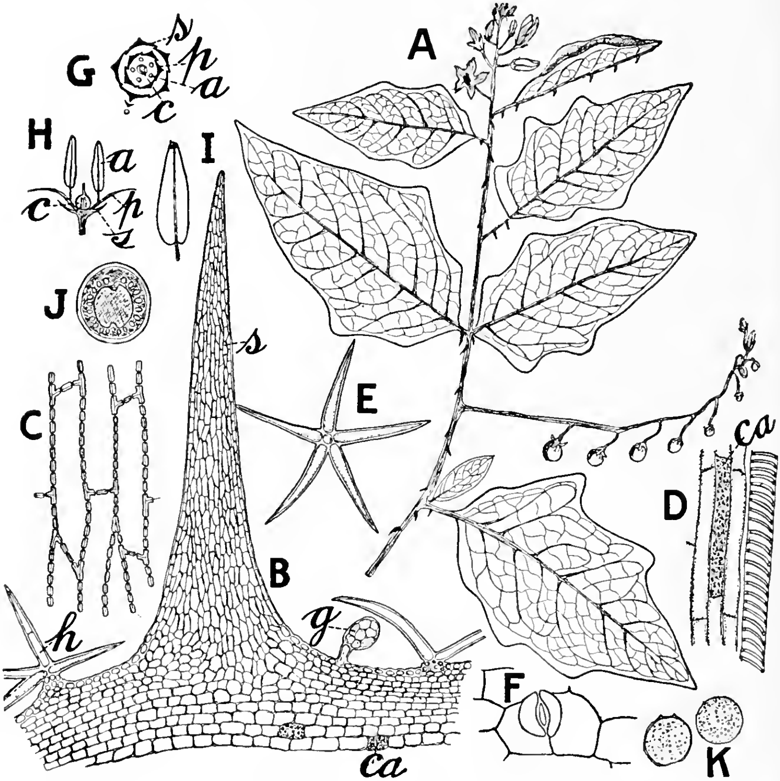


FIG. 176. Horse nettle (Solanum carolinense): A, portion of shoot showing flowers and fruits and spines on leaves and stem; B, longitudinal section of spine (s) and portion of stem showing glandular (g) and non-glandular (h) hairs, and cells containing cryptocrystalline crystals (ca); C, thick-walled, strongly lignified cells of spine; D, portion of fibrovascular bundle showing cryptocrystalline crystals (ca) of calcium oxalate in the cells accompanying the sieve; E, stellate, non-glandular hair; F, stoma of stem; G, diagram of cross section of flower showing sepals (s), petals (p), stamens (a), ovary (c); H, longitudinal section of flower; I, stamen showing terminal pores; J, cross section of 2-locular berry; K, pollen grains, 30 μ in diameter.

are white or light blue and occur in lateral cymes. The fruit is an orange-yellow, glabrous berry. The plant is common in waste places in Canada and the United States east of the Mississippi.

The root and berries are used in medicine. The root is simple and quite long, 5 to 10 mm. in diameter, yellowish-brown, the bark readily separating from the wood. It has a narcotic odor and a sweetish, bitter, somewhat acrid taste. Both the root and berries contain the gluco-alkaloid solanine, which varies from 0.15 (in the root) to 0.8 per cent. (in the berries).

Capsicum fastigiatum (Cayenne pepper) is a perennial, smooth, herbaceous, or somewhat shrubby plant, with ovate, acuminate, petiolate, entire leaves; the flowers are greenish-white, and solitary in the axils of the leaves. The fruit is official and is known in commerce as African pepper (p. 578). This plant and a number of other species of Capsicum are indigenous to tropical America, where they are extensively cultivated, as also in Africa and India.

Nicotiana Tabacum (Virginia Tobacco plant) is a tall annual herb indigenous to tropical America and widely cultivated. The stem is simple, giving rise to large, pubescent, ovate, entire, decurrent leaves, the veins of which are prominent and more or less hairy. The flowers are long, tubular, pink or reddish, and occur in terminal spreading cymes. The various forms of tobacco are made from the leaves, which are hung in barns, whereby they undergo a slow drying or process of curing. Other species of Nicotiana are also cultivated, as *N. persica*, which yields Persian tobacco; and *N. rustica*, the source of Turkey tobacco. Tobacco leaves contain from 0.6 to 9 per cent. of the alkaloid nicotine; an aromatic principle nicotianin or tobacco camphor, to which the characteristic flavor is due and which is formed during the curing of the leaves. The dried leaves yield from 14 to 15 per cent. of ash, consisting in large part of potassium nitrate.

Solanum tuberosum (Potato plant) is indigenous to the Andes region of South America and is extensively cultivated on account of the edible tubers. The tubers (potatoes) contain about 75 per cent. of water, 20 per cent. of starch, and nearly 2 per cent. of proteins in the form of large protein crystalloids. The fruits and young shoots contain the gluco-alkaloid solanine and the alkaloid solanidine. The tubers contain a small amount of solanine, which is increased when they are attacked by certain fungi or exposed to light.

Besides the potato plant, several other plants belonging to the Solanaceæ yield vegetables, as the Tomato plant (*Solanum Lycopersicum*) and the Egg plant (*Solanum Melongena*). Various cultivated species of *Capsicum annuum* furnish the common red peppers of the market.

g. SCROPHULARIACEÆ OR FIGWORT FAMILY.—The plants are herbs, shrubs or trees with opposite or alternate leaves and perfect, mostly complete and irregular flowers. The corolla and stamens show some resemblance to those of the Labiatæ in that the corolla is frequently more or less 2-lipped and the stamens are didynamous. The fruit is a dehiscent capsule and the seeds have a reserve layer and a straight or slightly curved embryo.

Leptandra virginica (*Veronica virginica*) or Culver's root, is a perennial herb with leaves in whorls of 3 to 9, those on the upper part of the stem being opposite. They are lanceolate, serrate, and pinnately veined; the flowers are white or bluish, tubular, and in dense racemes. The rhizome and roots are official (p. 501).

Digitalis purpurea (Foxglove) is a tall, biennial, pubescent herb, producing the first year a large number of basal leaves (Fig. 265), and the second, a long raceme of drooping, tubular, slightly irregular, purplish flowers; the inner surface of the corolla is spotted, the stamens are didynamous and the upper calyx segment is narrower than the others. The leaves are official in all the pharmacopœias (p. 613).

The Scrophulariaceæ are well represented in the United States, and a number of the plants have medicinal properties. The common MULLEIN (*Verbascum Thapsus*) contains a volatile oil, two resins and a bitter principle. The flowers of mullein contain the same principles and in addition a yellow coloring principle. Other species of Verbascum are used in medicine in different parts of the world.

BUTTER-AND-EGGS (*Linaria vulgaris*) contains a crystalline principle, linariin, antirrhinic acid, a volatile oil, resin and tannin. Several species of Scrophularia, as *S. nodosa* of Europe and *S. marilandica* of the Eastern United States, contain a pungent resin and a trace of an alkaloid. TURTLE-HEAD (*Chelone glabra*) contains a bitter principle and gallic acid. The entire plant of

HYSSOP (*Gratiola officinalis*) of Europe contains gratiolin, a bitter glucoside, and gratiosolin. The leaves of *Curanga amara* of the East Indies contain a glucoside, curanjiin, which resembles digitalin in its action.

h. BIGNONIACEÆ OR TRUMPET-CREEPER FAMILY.—The plants are shrubs, trees or woody vines, and are represented in the United States by the catalpa tree (*Catalpa bignonioides*) and the trumpet creeper (*Tecoma radicans*). The bark, pods and seeds of CATALPA have been used in medicine and contain a bitter principle, catalpin, a glucoside and several crystalline principles. The TRUMPET CREEPER contains narcotic poisonous principles. The leaflets of CAROBA (*Jacaranda Copaia*), and other species of Jacaranda contain the alkaloid carobine, an aromatic resin, carobone and a principle having the odor of coumarin.

i. PEDALIACEÆ.—The plants are herbs indigenous to the Tropics of the Old World, some of which are now cultivated in the Tropics of both hemispheres. Benne oil (oil of sesame) is obtained from the seeds of *Sesamum indicum* by expression. It consists chiefly of a glycerite of oleic acid, a glycerite of linoleic acid, and myristin, palmitin and stearin. It is a bland, non-drying oil and is used like olive oil.

j. ACANTHACEÆ OR ACANTHUS FAMILY.—The plants are mostly tropical perennial herbs, or shrubs with opposite leaves, in the mesophyll or epidermal cells of which cystoliths usually occur (Fig. 221). Several genera are represented in the United States, one of which, Ruellia (*Ruellia ciliosa*), is the source of the spurious spigelia which has been on the market for some years past (p. 504).

Ruellia ciliosa is a perennial herb which is distinguished from the other species of the genus Ruellia by the leaves, stems and calyx being distinctly pubescent. The leaves are ovate-lanceolate, nearly sessile and entire; the flowers are blue, sessile, solitary, or two or three in a cluster, in the axils of the leaves; the stamens are 4, and exserted. The fruit is an oblong, terete capsule containing from 6 to 20 orbicular seeds. The plant is found from New Jersey and Pennsylvania to Michigan and as far south as Florida and Louisiana. Long cystoliths are found in some of the epidermal cells of both surfaces of the leaf.

Quite a number of the plants of the Acanthaceæ are used in the Tropics in medicine. One of these, *Adhatoda vasica* of tropical Asia, contains the alkaloid vasicine, and is said to have the property of destroying algæ which grow in the rice swamps.

k. PLANTAGINACEÆ OR PLANTAIN FAMILY.—The plants are annual or perennial herbs, represented by but few genera, but numerous species. The principal genus is Plantago, which includes 200 species that are widely distributed. Several species of Plantago are used in medicine. The common plantain (*Plantago major*) contains a glucoside, acubin; emulsin; and invertin, and the short rhizome, considerable starch. The seed-coat has an outer mucilaginous layer, and the mucilage of the seeds of *Plantago psyllium*, *P. arenaria* (both of Europe) and *P. ispaghul* (of the East Indies) is used as a sizing material. The seeds of a number of the species of Plantago are used as bird food, particularly for canaries.

V. ORDER RUBIALES.

The plants of this order are distinguished from all of the preceding Sympetalæ by having flowers which are distinctly epigynous. The leaves are opposite or verticillate.

a. RUBIACEÆ OR MADDER FAMILY.—The plants are herbs, shrubs or trees, and of the representatives found in the United States the following may be mentioned: Bluets (*Houstonia* species), Partridge-berry (*Mitchella repens*) and Bedstraw (*Galium* species). In Mitchella and Houstonia the flowers are dimorphic.

CINCHONA species.—The plants are mostly trees, or rarely shrubs, with elliptical or lanceolate, entire, evergreen, petiolate, opposite leaves (Fig. 177). The flowers are tubular, rose-colored or yellowish-white, and occur in terminal racemes. The fruit is a capsule, which dehisces into two valves from below upward, the valves being held above by the persistent calyx. The seeds are numerous and winged. There are from 30 to 40 species of Cinchona found growing in the Andes of South America at an elevation above 800 M. and in a restricted area about 500 miles in length extending from Venezuela to Bolivia. The plants are cultivated in Java, Ceylon, New Zealand and Australia, as well as in Jamaica.

There are two species which furnish the Cinchona bark (p. 517) of medicine: (1) *Cinchona Ledgeriana* (*C. Calisaya Ledgeriana*), which has small, elliptical, coriaceous leaves, the under surface of which is reddish; small, yellowish, inodorous flowers, and a short capsule; (2) *C. succirubra* which has large, thin, broadly-elliptical leaves, purplish-red calyx, rose-colored petals and

FIG. 177. *Cinchona Ledgeriana:* A, flowering branch; B, bud and open flower; C, fruiting branch.—After Schumann.

a very long capsule. While *C. Ledgeriana* yields barks containing the highest amount of alkaloids, *C. succirubra* is most cultivated.

Uragoga (*Cephaëlis*) *Ipecacuanha*.—The plants are perennial herbs 10 to 20 cm. high, with a creeping, woody, hypogeous stem. The roots are official in all of the pharmacopœias (p. 467). The leaves are elliptical, entire, short-petiolate, and with divided stipules (Fig. 178). The flowers are white and form small terminal heads. The fruit is a blue berry, with characteristic spiral arrangement of the carpels.

Coffea arabica is a small evergreen tree or shrub with lanceolate, acuminate, entire, slightly coriaceous, dark green, short-petiolate leaves, which are partly united with the short interpetiolar stipules at the base. The flowers are white, fragrant, and occur in axillary clusters. The fruit is a small, spherical or ellip-

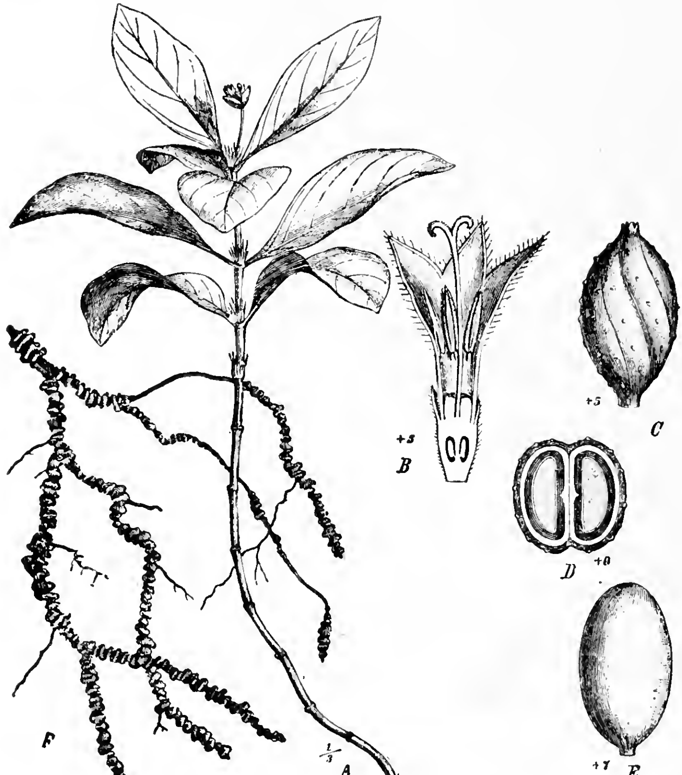


FIG. 178. Ipecac plant [*Cephaëlis* (*Uragoga*) *Ipecacuanha*]: A, flowering shoot; B, flower in longitudinal section; C, fruit; D, fruit in transverse section; E, seed; F, annulate root.—After Schumann.

soidal drupe with two locules, each containing one seed, or COFFEE GRAIN. The coffee plant is indigenous to Abyssinia and other parts of Eastern Africa, and is widely cultivated in tropical countries, notably in Java, Sumatra, Ceylon and Central and South America, particularly Brazil, over 600,000 tons being produced annually in the latter country. The yield of one tree is between 1 and 12 pounds. There are two methods of freeing the seeds from the parchment-like endocarp: In the one case the fruits are allowed to dry and are then broken; in the other case, which is known as the wet method, the sarcocarp is removed by means of a machine, and the two seeds with the parchment-like endocarp are allowed to dry in such a manner as to undergo a fermentation, and after drying the endocarp is removed. Coffee seeds contain from 1 to 2 per cent. of CAFFEINE; from 3 to 5 per cent. of tannin; about 15 per cent. of glucose and dextrin; 10 to 13 per cent. of a fatty oil consisting chiefly of olein and palmitin; 10 to 13 per cent. of proteins; and yield 4 to 7 per cent. of ash. The official caffeine is derived in part from coffee seeds.

In the ROASTING of coffee there is a change in the physical character of the seeds, as well as a change in some of the constituents. The AROMA is supposed to be due to an oil known as coffeol, which is said to be a methyl ether of saligenin.

YOHIMBI (Yohimbihi) bark is obtained from *Corynanthe Yohimbi,* a tree growing in the Cameroon region of Africa. The pieces of bark are 25 cm. or more in length, 5 to 8 mm. thick, externally dark brown or grayish-brown, and somewhat bitter. Numerous bast fibers are present but no sclerotic cells. It yields 4 alkaloids (0.3 to 1.5 per cent.), the principal one being yohimbine (corymbine or corynine), which forms white prismatic needles, soluble in alcohol and almost insoluble in water, and on treatment with nitric acid becomes first deep green and then yellowish, changing to a cherry-red if followed with an alcoholic solution of potassium hydroxide (distinction from cocaine).

A number of the Rubiaceæ contain valuable coloring principles, as the madder plant (*Rubia tinctorum*), which is a perennial herb occurring wild in Southern Europe and formerly cultivated in France and Germany on account of the coloring principle in its roots. The root is known commercially as MADDER, and contains when fresh a yellow coloring principle, which on the drying of the root breaks up into several glucosides, one of which on further decomposition yields ALIZARIN, the principle to which the red color of the dried root is due. At present alizarin is made artificially from anthracene, a coal-tar derivative.

Morinda citrifolia, a shrub widely distributed in tropical countries, contains a red coloring principle in the flowers and a yellow coloring principle in the roots, the latter being known as morindin and resembling the color principle in madder.

The pulp of the fruit of Cape jasmine (*Gardenia jasminoides*) contains a yellow coloring principle resembling crocin, found in Crocus.

The stem and root barks of Button-bush (*Cephalanthus occidentalis*) common in swampy regions in the United States, are sometimes used in medicine. The barks contain a bitter glucoside, cephalanthin, and a tasteless glucoside which is fluorescent in solution. *Mitchella repens* contains a saponin-like body in the fruit and a tannin and bitter principle in the leaves. Quite a number of species of Galium (bedstraw) are used in medicine and for other purposes. A principle resembling glycyrrhizin is found in wild licorice (*Galium circæzans*), a perennial herb growing in dry woods in the United States, and also in *Galium lanceolatum,* which is found from Virginia northward to Ontario. The yellow bedstraw (*Galium verum*), naturalized from Europe, contains a milk-curdling ferment.

b. CAPRIFOLIACEÆ OR HONEYSUCKLE FAMILY.—The plants are perennial herbs, shrubs, trees, or woody climbers with opposite, simple or pinnately compound leaves. The flowers are perfect, epigynous, regular, or bilabiate, and arranged in corymbs. The fruit is a berry, drupe or capsule. They are mostly indigenous to the northern hemisphere.

Viburnum prunifolium (Black haw) is a shrub or small tree 25 cm. in diameter. The winter buds are acute and reddish-pubescent; the leaves are ovate, elliptical, obtuse or acute at the apex, somewhat rounded at the base, finely serrulate, glabrous and short-petiolate (Fig. 179); the flowers are white and in nearly sessile cymes; the fruit is a small, oval, bluish-black, glaucous, inferior drupe. The root-bark is official (p. 525).

Viburnum Opulus (Wild guelder-rose or cranberry-tree) is a shrub about half the height of *V. prunifolium,* with broadly ovate, deeply 3-lobed and coarsely dentate pubescent leaves. The flowers are white and in compound cymes, the outer being sterile and large and showy. The fruit is a reddish, globular, very acid drupe. The bark is official (p. 532). The Snow-ball or guelder-rose of the gardens is a sterile variety of this species. Another variety (*edule*) is also cultivated on account of its edible fruits, particularly in Canada and the Northern United States.

A number of species of Viburnum are rather common in various parts of the United States, as the Maple-leaved arrow-

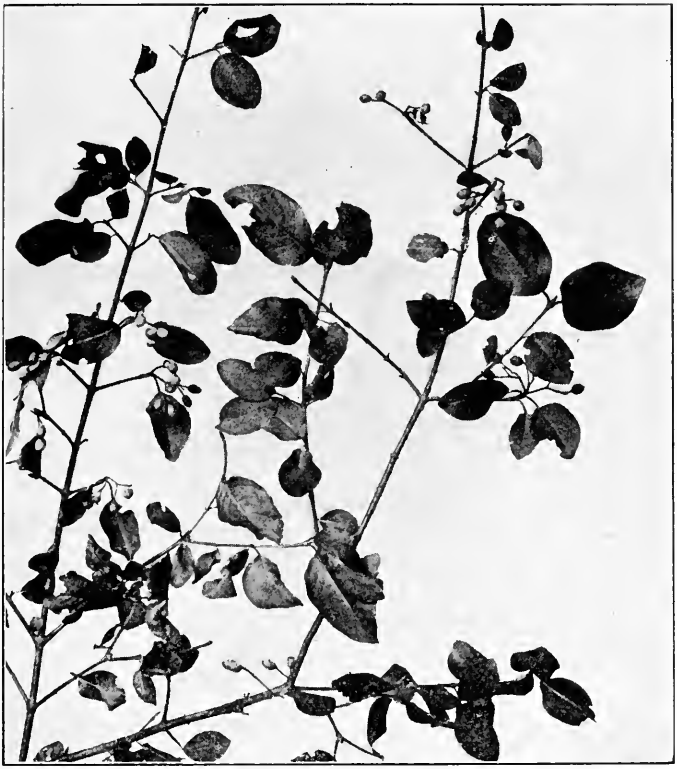


Fig. 179. Fruiting branch of *Viburnum prunifolium.*

wood (*V. Acerifolium*), which is a small shrub with deeply 3-lobed, coarsely dentate leaves and small, nearly black drupes; Arrow-wood (*V. dentatum*), with broadly ovate, coarsely dentate leaves and blue drupes, which become nearly black when ripe; Soft-leaved arrow-wood (*V. molle*), which somewhat resembles *V. dentatum*, but has larger leaves that are crenate or dentate and stellate-pubescent on the lower surface; Larger withe-rod (*V. nudum*), having nearly entire leaves and a pink drupe, which becomes dark blue.

Sambucus canadensis (American elder) is a shrub growing in moist places in the United States as far west as Arizona and in Canada. The leaves are 5- to 7-foliate, the leaflets being ovate, elliptical, acuminate, sharply serrate and with a short stalk; the flowers are small, white and in convex cymes. The fruit is a deep purple or black berry-like drupe. The dried flowers are used in medicine. They are about 5 mm. broad, with a 5-toothed, turbinate calyx, and a 5-lobed, rotate corolla, to which the 5 stamens are adnate. The odor is peculiar and the taste is mucilaginous and somewhat aromatic and bitter.

The active principles have not been determined, but are probably similar to those of *S. nigra*. The inner bark is also used in medicine and contains a volatile oil, a crystallizable resin and valerianic acid. It does not appear to contain either tannin or starch. The roots of elder contain a volatile principle somewhat resembling coniine. The pith consists chiefly of cellulose, is delicate in texture and has a variety of uses.

The Black elder (*Sambucus nigra*), which is a shrub common in Europe, is characterized by narrower leaflets, a 3-locular ovary and black berries. The flowers are official in some of the European pharmacopœias. They contain about 0.4 per cent. of a greenish-yellow, semi-solid volatile oil, which when diluted has the odor of the flowers. They also contain an acrid resin.

The Red-berried elder or mountain elder (*S. pubens*) somewhat resembles the common elder, but the stems are woody, and the younger branches have a reddish pith. The flowers are in paniculate cymes, and the fruits are scarlet or red.

Other plants of the Caprifoliaceæ are also used in medicine. Horse gentian (*Triosteum perfoliatum*), a perennial herb with connate-perfoliate leaves and small, orange-red, globular drupes, growing in Canada and the United States as far west as Kansas, furnishes the drug (rhizome) known as WILD IPECAC or Triosteum. The rhizome is yellowish-brown, somewhat branched, cylindrical, 10 to 20 cm. long, 10 to 15 mm. in diameter, with numerous cup-shaped stem-scars, and coarse, spreading roots; it is rather hard and tough, and has a bitter, nauseous taste. Triosteum contains an emetic alkaloid, triosteine, and considerable starch. The seeds of *Triosteum perfoliatum* are sometimes roasted and employed like coffee, the plant being known as Wild coffee.

The roots and stems of the following plants are sometimes employed: The Snowberry (*Symphoricarpos racemosus*), the Bush honeysuckle (*Diervilla Lonicera*) and various species of Lonicera, these being also known as honeysuckles.

VI. ORDER VALERIANALES OR AGGREGATÆ.

The plants are mostly herbs with an inferior ovary, which is either unilocular with a single pendulous ovule, or tri-locular with frequently but a single anatropous ovule.

a. VALERIANACEÆ OR VALERIAN FAMILY.—The plants are herbs with opposite, exstipulate leaves, small, perfect, or polygamo-diœcious flowers, occurring in corymbs. The fruit is dry, indehiscent and akene-like. The calyx is persistent, becoming elongated and plumose, and resembling the pappus in the Compositæ.

Valeriana officinalis (Garden or Wild valerian) is a tall, perennial herb, more or less pubescent at the nodes. The leaves are mostly basal, pinnately parted into seven or more segments, which are lanceolate, entire or dentate. The flowers are white or pink and arranged in corymbed cymes. The calyx is much reduced, consisting of 5 to 15 pinnately branched teeth (pappus); the corolla is tubular, somewhat sac-like on one side, but not spurred as in other members of this family; the stamens are 3 in number and adnate to the corolla tube; the stigma is 3-lobed. The fruit is ovoid, glabrous, and with a conspicuous plumose pappus. The rhizome and roots are official (p. 504).

The young leaves of several species of Valerianella are used as a salad and are cultivated like spinach, as the European corn-salad (*V. olitoria*), which is also cultivated to some extent in the United States.

b. DIPSACACEÆ OR TEASEL FAMILY.—The plants are annual or perennial herbs, chiefly indigenous to the Old

World. The flowers are arranged in heads on a common torus, resembling in some cases those of the Compositæ.

Some of the plants are used in medicine, as the roots, leaves, flowers and seeds of Fuller's teasel (*Dipsacus fullonum*), the roots of *Succisa pratensis* of Europe, and several species of Scabiosa and Cephalaria. The seeds of *Cephalaria syriaca* when admixed with cereals give a bread that is dark in color and bitter. This family is, however, chiefly of interest on account of Fuller's teasel, which is a cultivated form of *Dipsacus ferox,* indigenous to Southwestern Asia, the plant being cultivated in Europe and New York State. The elongated, globular heads, with their firm, spiny and hooked bracts, are used in the fulling of cloth.

VII. ORDER CAMPANULATÆ.

This order differs from the two preceding by having the anthers united into a tube (syngenesious). It includes three principal families, which are distinguished by differences in the character of the andrœcium: (a) Cucurbitaceæ, in which there are three stamens, having not only the anthers united but the filaments also (monadelphous); (b) Campanulaceæ, in which there are five stamens, both the filaments and anthers being united into a tube; (c) Compositæ, in which there are five stamens, but the anthers only are united, the filaments being separate (Fig. 82, *A*).

a. CUCURBITACEÆ OR GOURD FAMILY.—The plants are mostly annual, tendril-climbing or trailing herbs (Fig. 66), mainly indigenous to tropical regions. The leaves are alternate, being opposite the tendrils, petiolate, and entire, palmately lobed or dissected. The flowers are epigynous; the petals are borne on the calyx tube and frequently are united (campanulate); the ovary is 1- to 3-locular and with few or many anatropous ovules. The fruit is a pepo, which is indehiscent but may burst somewhat irregularly.

Citrullus Colocynthis is a trailing herb with deeply lobed leaves. The flowers are yellow, axillary and monœcious, the staminate being with short filaments and glandular pistillodes (aborted pistils), and the pistillate having a 3-locular, globose ovary and three short staminodes. The fruit is globular, 5 to 10 cm. in diameter, smooth, greenish and mottled (Fig. 254). The fruit deprived of the epicarp (Fig. 254) is official (p. 583).

Cucurbita Pepo (pumpkin-vine) is an extensively trailing hispid vine, with large, nearly entire, cordate leaves with long petioles. The tendrils are branching. The flowers are large, deep yellow and monœcious; the staminate ones being in groups and the pistillate single. The fruit is a large, yellowish berry, sometimes weighing from 10 to 72 K. The seeds are numerous and are official as Pepo (p. 429).

Ecballium Elaterium (Squirting cucumber) is a bristly-hairy, trailing perennial herb with thick, rough-hairy, cordate, somewhat undulate leaves. The flowers are yellow, monœcious. The fruit is ellipsoidal, about 4 cm. long, rough-hairy or prickly, pendulous, and at maturity separates from the stalk, when the seeds are discharged upward through a basal pore. The plant is indigenous to the European countries bordering the Mediterranean, the Caucasus region, Northern Africa and the Azores. The juice of the fruit yields the drug ELATERIUM, which is official in the British Pharmacopœia. Elaterium yields 30 per cent. of the ELATERIN of the Pharmacopœias. From the latter by fractional crystallization from 60 to 80 per cent. of α-elaterin, a lævo-rotatory crystalline substance is separated, which is completely devoid of purgative action; and varying amounts of β-elaterin, a dextrorotatory crystalline compound which possesses a very high degree of physiological activity. (Power and Moore, *Ph. Jour.*, 29, Oct. 23, 1909, p. 501; and *Proc. Chem. Soc.*, No. 362, 1909, p. 1985).

Bryonia or BRYONY is the dried root of *Bryonia alba* (White bryony), a climbing herb indigenous to Southern Sweden, Eastern and Central Europe, including Southern Russia, and Northern Persia (Fig. 66). Bryony occurs in the market in nearly circular disks, which are 2 to 10 cm. in diameter, 5 to 10 mm. thick, white or yellowish-white, with concentric zones of collateral fibrovascular bundles; short, mealy fracture; slight odor, and bitter, nauseous taste. The drug contains two bitter glucosides, bryonin and bryonidin; two resinous principles and considerable starch. *Bryonia dioica* (Red bryony) also has medicinal properties and is a source of the drug. *B. dioica* has red berries, while the fruit of *B. alba* is black. The latter plant is sometimes known as Black bryony, but this plant should not be confounded with *Tamus communis* (Fam. Dioscoreaceæ), of Southern Europe, the rhizome of which is known commercially as Black bryony.

The fruits and seeds of various members of the Cucurbitaceæ contain powerful drastic and anthelmintic principles. A number of the plants, however, are cultivated on account of the fruits, which are used as food, as the pumpkin already mentioned, the WATER MELON (*Citrullus vulgaris*), indigenous to Southern Africa and cultivated in Egypt and the Orient since very early times; CANTALOUPE or musk-melon, derived from cultivated varieties of *Cucumis melo*, indigenous to tropical Africa and Asia, also cultivated since early times. The common CUCUMBER is obtained from *Cucumis sativus*, which is probably indigenous to the East Indies. These fruits contain from 90 to 95 per cent. of water, and the water melon contains 3.75 per cent. of dextrose, 5.34 per cent. of saccharose and yields 0.9 per cent. of ash.

Luffa cylindrica is an annual plant indigenous to the Tropics of the Old World. It is cultivated to some extent in America, but especially in the Mediterranean region. The fruit is more or less cylindrical and 20 cm. or more long. The pulp is edible and the fibrovascular tissue forms a tough network, which, when the seeds, epicarp and pulpy matter are removed, constitutes the LUFFA-SPONGE.

The fruits of *Luffa operculata* and *L. echinata*, both found in Brazil, contain a bitter principle resembling colocynthitin.

b. CAMPANULACEÆ OR BELL-FLOWER FAMILY.—The plants are mostly annual or perennial herbs, but are sometimes shrubby, with an acrid juice containing powerful alkaloids. The rhizomes and roots of about twelve of the genera contain inulin. The leaves are alternate; the corolla is regular, campanulate and rotate, or irregular, as in Lobelia. The fruit is a capsule or berry containing numerous small seeds.

Lobelia inflata (Indian or Wild tobacco) is an annual pubescent, branching herb (Fig. 272), the dried leaves and tops of which are official (p. 633). About 15 different species of Lobelia are used in medicine. The most important of those growing in the United States is the Cardinal flower or Red lobelia (*Lobelia cardinalis*), a plant found in moist soil from Canada to Texas, and characterized by its long, compound racemes of bright scarlet or red flowers. The Blue cardinal flower or Blue lobelia (*L.*

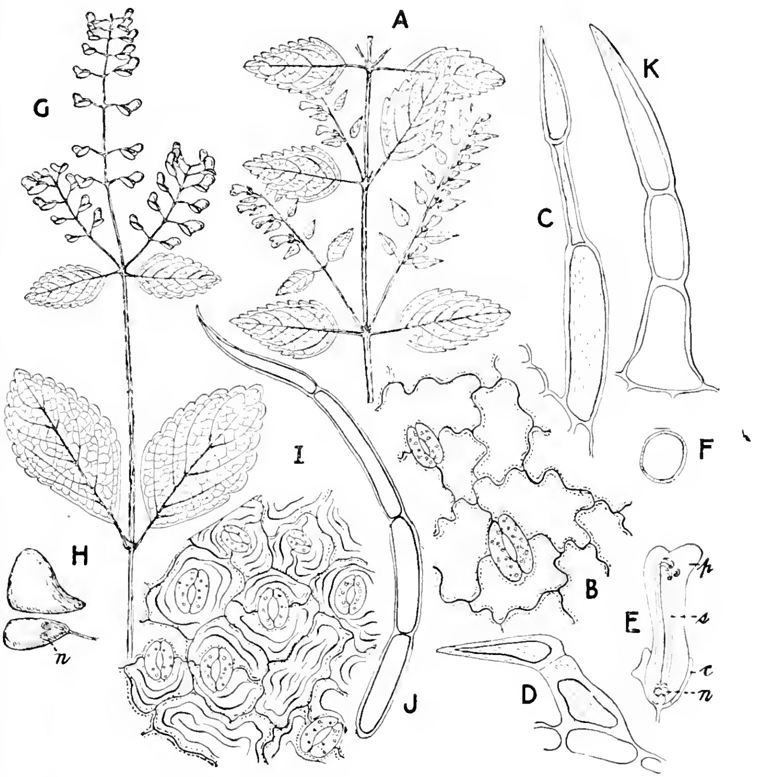


FIG. 180. *Scutellaria lateriflora:* A, portion of branch showing the ovate, serrate leaves and the axillary one-sided racemes; B, lower surface of leaf showing elliptical stomata; C, D, hairs from the stem and lower surface of leaf; E, section of flower showing calyx (c) with crest on one side, 2-lipped corolla (p), the didynamous stamens (s), and 4-locular ovary (n); F, pollen grain 18 μ in diameter. Hairy skullcap (*Scutellaria pilosa*): G, branch showing crenate leaves and helmet-shaped capsular fruits; H, capsule after dehiscence showing nutlets (n). *Scutellaria canescens:* I, view of lower surface of leaf showing numerous broadly elliptical stomata and wavy cuticle; J, K, hairs from the leaf.

syphilitica) is a plant of nearly the same habit and same general character, except that the flowers are of a bright dark blue color or occasionally white.

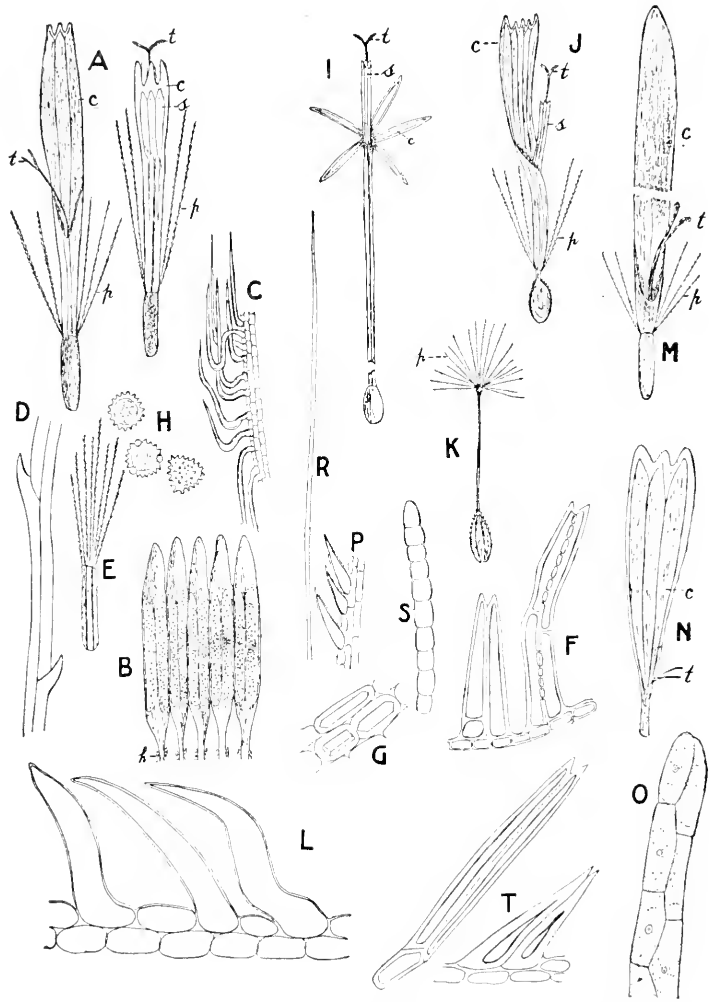


FIG. 181. Flowers of the Compositæ: A, ligulate and tubular florets of *Inula Helenium*; B, united anthers of same showing hairs (h) on the filaments; C, hairs of filaments magnified; D, portion of barbed hair of pappus; E, akene; F, double hairs of akene; G, cells of epidermis of akene containing prisms of calcium oxalate about 25 μ long; H, pollen grains in different views. I, tubular floret of safflower (*Carthamus tinctorius*). J, ligulate floret of dandelion (*Taraxacum officinale*); K, one of the akenes showing spreading pappus on long stalk which developes after fertilization; L, hairs of corolla. M, ligulate floret of coltsfoot (*Tussilago Farfara*). N, ligulate floret of marigold (*Calendula officinalis*); O, one of the hairs of corolla. P, pappus of yellow goat's-beard (*Tragopogon pratensis*); R, one of the long slender hairs in the pappus; S, hair from akene. T, two double hairs from akene of *Tagetes tennifolia*. c, corolla; t, stigma; s, stamens; p, pappus.

c. FAMILY COMPOSITÆ.—This is a large group of plants, which are annual, biennial or perennial herbs, undershrubs, shrubs, trees and twiners or even climbers, a few being aquatic. They contain inulin, a constituent peculiar to this group of plants. The most distinguishing character is the inflorescence, which is a head or capitulum (Figs. 181, 242), consisting of 1 or 2 kinds of flowers, arranged on a common torus, and subtended by a number of bracts, forming an involucre. The flowers are epigynous and the fruit is an akene, usually surmounted by the persistent calyx, which consists of hairs, bristles, teeth or scales, which are known collectively as the PAPPUS (Fig. 241).

The individual flowers are called florets (Figs. 241, 242), and may be hermaphrodite or pistillate, monœcious, diœcious or neutral. Depending upon the shape of the corolla, two kinds of flowers are recognized, one in which the corolla forms a tube, which is 5-lobed or 5-cleft, known as TUBULAR FLOWERS (Figs. 241, *C*; 242, *C*); and one in which the petals are united into a short tube, with an upper part that forms a large, strap-shaped, usually 5-toothed limb, known as LIGULATE FLOWERS (Figs. 241, *B*; 242, *D*).

In some of the plants of the Compositæ the head consists of ligulate flowers only, but in the larger number of plants the head is composed of both tubular and ligulate flowers or tubular flowers alone and accordingly two main groups or sub-families are distinguished. The sub-family in which all of the flowers are ligulate is known as LIGULIFLORÆ, or CICHORIACEÆ, by those who give the group the rank of a family. This group includes plants like dandelion, chicory, lettuce and Hieracium. The group or sub-family in which the flowers are all tubular or ligulate on the margin only, is known as the TUBULIFLORÆ. When the head consists only of tubular flowers it is called DISCOID, but when ligulate flowers are also present it is called RADIATE. When the heads are radiate, as in the common daisy, the tubular flowers are spoken of as DISK-FLOWERS, and the ligulate flowers as RAY-FLOWERS. The disk-flowers are usually perfect, while the ray-flowers are pistillate or neutral (without either stamens or pistils). By some systematists the Tubulifloræ are divided into groups which have been given the rank of families. This division is based especially on the characters of the stamens. In a small group represented by the ragweed and known as the AMBROSIACEÆ, the anthers, while close together (connivent) are not united, and the corolla in the marginal or pistillate flowers is reduced to a short tube or ring. In a large group, which includes probably 10,000 species and which is considered to be the COMPOSITÆ proper, the stamens in the tubular flowers are syngenesious and the marginal or ray flowers are distinctly ligulate. This group includes the daisy, sunflower, golden-rod, aster, thistle and most of the plants which yield official drugs.

It may also be added that the Compositæ is considered to be the highest and youngest group of plants.

Taraxacum officinale (Dandelion) is a perennial, acaulescent herb with milky latex; oblong-spatulate, pinnatifid or runcinate, decurrent leaves, and with a 1-headed scape, the stalk of which is hollow. The flowers are ligulate, golden-yellow and numerous; the involucre consists of two series of bracts, the inner one of which closes over the head while the fruit is maturing, afterward becoming reflexed. The fruit consists of a loose, globular head of akenes, each one of which is oblong-ovate and with a slender beak at the apex which is prolonged into a stalk bearing a radiate tuft of silky hairs, which constitute the pappus. The root is fusiform and usually bears at the crown a number of branches 2 to 5 cm. long, having a small pith and other characters of a rhizome. The root is official (p. 458).

Lactuca virosa (Poison lettuce) is a biennial prickly herb, with milky latex and oblong-obovate, spinose-toothed, runcinate basal leaves and with alternate, somewhat sessile or auriculate, scattered stem leaves, the apex and margin being spinose. The flowers are pale yellow and occur in heads forming terminal panicles. The involucre is cylindrical and consists of several series of bracts. The flowers are all ligulate and the anthers are sagittate at the base. The akenes are flattish-oblong, and the pappus, which is raised on a stalk, is soft-capillary, as in Taraxacum. The prepared milk-juice is official as Lactucarium (p. 649).

Eupatorium perfoliatum (Boneset or Common thoroughwort) (see Fig. 270). The leaves and flowers are official (p. 625).

Eupatorium rebaudianum, which is added to Maté as a sweetening agent, contains two sweet glucosides; eupatorin and rebandin; a bitter principle, and a resin.

GRINDELIA species.—The plants are perennial, greenish-yellow, resinous herbs, sometimes being under-shrubs, with alternate, sessile or clasping, oblong to lanceolate, spinulose-dentate leaves, and large, terminal, yellowish heads, consisting of both ligulate and tubular flowers. The leaves and flowering tops of *Grindelia robusta* and *G. squarrosa* are official (p. 626).

Erigeron canadensis (*Leptilon canadense*) (Canada fleabane) is an annual or biennial, hispid-pubescent herb found growing in fields and waste places in nearly all parts of the world. The stems are simple, with numerous crowded leaves and numerous flowers occurring in terminal panicles. The plants are sometimes branched and 1 to 3 M. high. The leaves are linear, nearly entire, of a pale green color, the lower and basal ones being spatulate, petiolate and dentate or incised. The flowers are white and the heads are composed of both ligulate and tubular florets, the former being pistillate and not longer than the diameter of the disk. The pappus consists of numerous capillary bristles and the involucre, which is campanulate, consists of five or six series of narrow, erect bracts. The fresh flowering herb contains 0.3 to 0.4 per cent. of a volatile oil which is official, tannin, and a small amount of gallic acid. The oil is obtained by distillation and consists chiefly of d-limonene.

The genus Erigeron includes a number of species which have medicinal properties. *E. annuus* (Sweet scabious or Daisy fleabane) is a low, branching, annual herb, characterized by its linear-lanceolate or ovate-lanceolate leaves and its conspicuous flowers, which resemble those of the common daisy, the ray-flowers often being tinged with purple (Fig. 181). It contains a volatile oil resembling that of Canada fleabane, and tannin. The Philadelphia fleabane (*Erigeron philadelphicus*) is a perennial herb producing stolons, and has clasping or cordate leaves, the basal being spatulate, and is further distinguished by its light purplish-red ray-flowers.

Anthemis nobilis (Roman chamomile) is an annual or perennial, procumbent, branched herb, with numerous 2- to 3-pinnately divided leaves, the ultimate segments being narrow-linear. The flowers occur in terminal heads with long peduncles, a conical torus and few white pistillate ray-flowers. The flowers of cultivated plants are official (p. 554), the heads consisting mostly of ligulate flowers, forming so-called "double flowers," as in the cultivated chrysanthemums.

Anacyclus Pyrethrum (Pellitory) is a perennial herb resembling *Anthemis nobilis* in its general characters. The ray-flowers, however, are white or purplish, and the pappus consists of a ring or scale. The root is official (p. 455).

Matricaria Chamomilla (German chamomile) is an annual, diffusely branched herb, with pinnately divided leaves, consisting of few, linear segments. The flowers are official (p. 553).

Arnica montana is a perennial herb with small rhizome; nearly simple stem; opposite, somewhat connate, entire, spatulate, hairy leaves, and yellow flowers in large heads with long peduncles. The flowers are official (p. 551).

Arctium Lappa (Burdock) is a coarse, branched, biennial or perennial herb, with alternate, broadly ovate, repand, entire, tomentose, mostly cordate leaves, the basal ones being from 30 to 45 cm. long. The flowers are purplish-red or white, tubular and form rather large corymbose heads; the involucre consists of numerous lanceolate, rigid, nearly glabrous bracts, which are tipped with hooked, spreading bristles. The akenes are oblong and somewhat 3-angled, and the pappus consists of numerous short bristles. The root is official (p. 465).

The common burdock (*Arctium minus*) resembles *A. Lappa*, but is a smaller plant and is more common in the United States. The heads are smaller and the inner bracts are shorter than the tubular flowers, the bristles of this series being erect and with the outer spreading.

Calendula officinalis (Marigold) is an annual herb, with alternate, spatulate, oblanceolate, entire or serrate leaves. The flowers are yellow and form solitary heads, consisting of both ray and tubular florets. In the cultivated varieties most of the tubular florets are changed to ligulate, the latter being official (p. 555).

While the Compositæ include a large number of genera and species, the plants do not yield many important drugs, although a number are used in medicine and for other purposes.

The so-called INSECT FLOWERS (*Pyrethri Flores*) are the partly expanded flower-heads of several species of Chrysanthemum, and are used in the preparation of a powder which is a powerful insecticide. The plants are perennial herbs resembling

FIG. 181a. Daisy-fleabane (*Erigeron annuus*).

in their habits the common white daisy (*C. Leucanthemum*). The DALMATIAN Insect Flowers are obtained from *C. cinerariifolium*, growing in Dalmatia, and cultivated in Northern Africa, California and New York. The heads as they occur in the market are about 12 mm. broad, light yellowish-brown and have a slightly rounded or conical torus, which is about 12 mm. in diameter and 2 or 3 series of lanceolate, obtuse, involucral scales. The ray-florets are pistillate, the corolla varying in length from 1 to 2 cm. and having numerous delicate veins and 3 short, obtuse or rounded teeth. The tubular flowers are perfect and about 6 mm. long. The ovary is 5-ribbed and the pappus forms a short, toothed crown. The odor is distinct and the taste bitter.

PERSIAN Insect Flowers are derived from *C. roseum* and *C. Marshallii,* growing in the Caucasus region, Armenia and Northern Persia. The heads are about the same size as those of *C. cinerariifolium;* the torus is dark brown; the involucral scales and ray-florets are purplish-red; the ovary is 10-ribbed.

Insect flowers contain from a trace to 0.5 per cent. of a volatile oil, the Persian flowers containing the larger proportion, and the amount decreasing with the maturing of the flowers. They also contain two resins, varying from 4 to 7 per cent., the larger amount being found in the Dalmatian flowers; a small quantity of a glucoside and a volatile acid.

The principle toxic to insects is PYRETHRON, an amber-yellow, syrupy substance which is the ester of certain unidentified acids, and on saponification yields the alcohol pyrethrol which crystallizes in fine needles. The acids combined in the ester pyrethron do not give crystalline salts.

WORMWOOD or Absinthium consists of the dried leaves and flowering tops of *Artemisia Absinthium,* a perennial, somewhat woody, branching herb, indigenous to Europe and Northern Africa, cultivated in New York, Michigan, Nebraska and Wisconsin and naturalized in the United States from plants that have escaped from cultivation. The leaves are grayish-green, glandular-hairy, 1- to 3-pinnately divided, the segments being obovate, entire, or lobed; the flowers are yellowish-green, the heads being about 4 mm. broad and occurring in raceme-like panicles; the torus is hemispherical and the involucre consists of several series of linear bracts, the inner being scale-like; the florets are all tubular, the outer ones sometimes being neutral. The herb is aromatic and very bitter.

The fresh drug contains about 0.5 per cent. of a VOLATILE OIL which is of a dark green or blue color, has a bitter, persistent taste but not the pleasant odor of the plant, and consists of d-thujone (absinthol), thujyl alcohol free and combined with acetic, iso-valerianic and palmitic acids, phellandrene and cadinene. The other constituents of the drug include a bitter glucosidal principle, ABSINTHIIN, which forms white prisms and yields on hydrolysis a volatile oil; a resin; starch; tannin; succinic acid, potassium succinate, and about 7 per cent. of ash. The plant is used in the preparation of the French liquor known as ABSINTHE.

Artemisia Cina furnishes the official Santonica (p. 350).

Other species of Absinthium also yield volatile oils, as the COMMON MUGWORT (*Artemisia vulgaris*), which yields from 0.1 to 0.2 per cent. of an oil containing cineol; *Artemisia Barrelieri,* which contains an oil consisting almost entirely of thujone, and said to be used in the preparation of Algerian absinthe.

SAFFLOWER consists of the dried florets of *Carthamus tinctorius,* an annual herb which is known only in cultivation. The florets are tubular, yellowish-red, the corolla tube being about 2 cm. long and with 5 small, linear lobes; the stamens are exserted. The ovary with the long, slender style is usually not present in the drug (Fig. 296, *C*). Safflower contains a small percentage of a yellow coloring principle (safflower-yellow), which is soluble in water, and 0.3 to 0.6 per cent. of a red coloring principle (carthamin or carthamic acid), which is insoluble in water but soluble in alcohol, the solution having a purplish-red color. A volatile oil is also present. Carthamin is used in conjunction with French chalk in the preparation of a rouge.

TANSY is the dried leaves and tops of *Chrysanthemum* (*Tanacetum*) *vulgare* (Fig. 75), a perennial herb indigenous to Europe, extensively cultivated and naturalized in the United States. The leaves are large and pinnately divided, and the flowers, both tubular and ligulate, are yellow, the heads being in terminal corymbs.

The plant yields from 0.1 to 0.3 per cent. of a volatile oil, consisting of thujone, borneol and camphor; and 3 resins.

ELECAMPANE (*Inula Helenium*) is a large, perennial, densely pubescent herb with alternate leaves and large, solitary terminal heads, consisting of yellow tubular and ligulate florets (Fig. 182). The plant is indigenous to Central Europe and Asia, and naturalized in North America from Canada to North Carolina. The root is used in medicine and was formerly official as INULA. It is cylindrical, tapering, and in preparing the drug it is usually cut into longitudinal pieces, which after drying are grayish-brown or dark brown and longitudinally wrinkled on the outer surface,

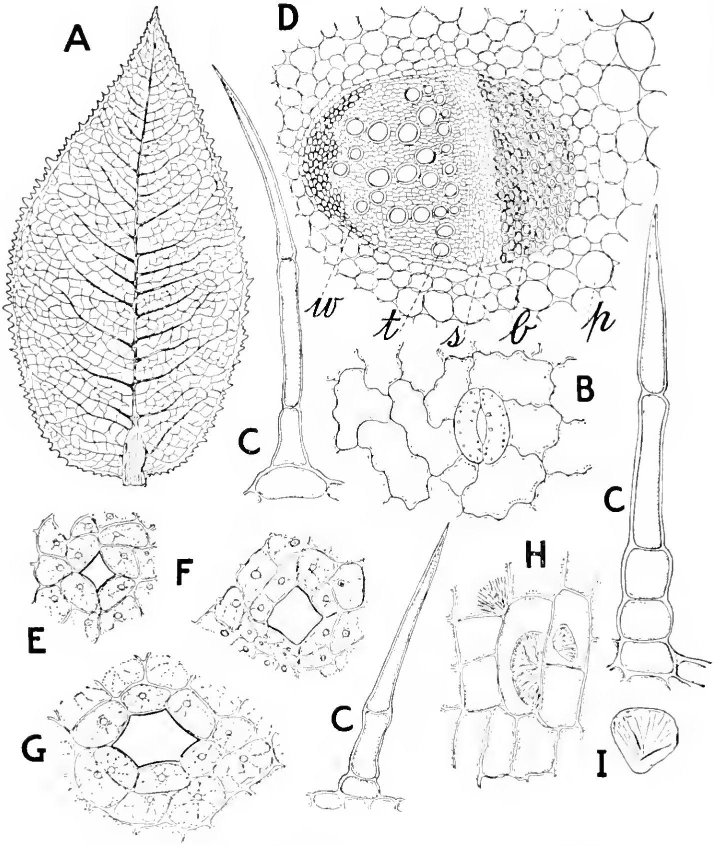


FIG. 182. Elecampane (*Inula Helenium*): A, one of the smaller leaves near the inflorescence; B, under surface of the leaf; C, hairs of leaf; D, transverse section of petiole showing parenchyma (p), lignified bast fibers (b), sieve (s), tracheæ (t), and somewhat thickened cells of wood (w); E, F, G, successive stages in the development of the intercellular or schizogenous oleo-resin canals of very young roots; H, sphere-crystals of inulin as seen in the root after treatment with alcohol; I, single sphere-crystal.

somewhat lighter in color on the cut surface; the fracture of thicker pieces is tough, of thinner pieces, short when dry; it is pale yellow internally, with numerous radiate resin canals; the odor is aromatic; the taste bitter and acrid. It is distinguished from belladonna root (Fig. 200), which has been sometimes substituted for it, by the latter having a characteristic odor and taste and containing starch (p. 463) (Fig. 182).

Inula contains about 44 per cent. of inulin, which on hydrolysis yields levulose, which latter replaces inulin in the roots gathered in spring. From 1 to 2 per cent. of a crystalline substance is obtained by distillation with water, which consists of a colorless, crystalline principle, alantolactone, that is insoluble in sodium carbonate solution, and alantolic acid, which crystallizes in fine needles, is soluble in sodium carbonate solution and is largely decomposed on heating with water. The drug also contains helenin, which crystallizes in 4-sided prisms and is not affected by ordinary reagents; and alantol, a yellowish liquid isomeric with common camphor and apparently occurring only in the fresh root.

The root of *Polymnia Uvedalia,* a plant closely related to Inula, but indigenous to the United States east of the Mississippi, contains a volatile oil, a glucoside, tannin, and a resinous substance consisting of two resins, one of which is pale yellow and soft, the other dark brown and hard.

The following Compositæ, while not of very great importance, are used in some localities:

Yarrow (*Achillea Millefolium*) is a common weed naturalized from Europe and Asia, and contains about 0.1 per cent. of a dark blue volatile oil with a strongly aromatic odor and a small amount of a bitter alkaloid, achilleine. The roots of yarrow, on the other hand, yield a volatile oil with a valerian-like odor. *Achillea nobilis* of Europe contains an oil resembling that of yarrow, but it is of finer quality and has a spice-like taste. *Achillea moschata*, an alpine plant of Europe, yields three alkaloids and a volatile oil containing cineol, and is used in Italy in the preparation of the liquor, "Esprit d' Iva." *Achillea tanacetifolia* yields a blue volatile oil having the odor of tansy.

The High Golden-rod (*Solidago canadensis*) yields 0.63 per cent. of a volatile oil, consisting chiefly of pinene, with some phellandrene and dipentene, and containing about 9 per cent. of borneol, 3 per cent. of bornyl acetate and some cadinene. The True or Anise-scented Golden-rod (*Solidago odorata*) yields an aromatic volatile oil and a small amount of tannin.

The rhizome of the large Button-snakeroot (*Lacinaria scariosa*), growing in the eastern and central portion of the United States and Canada, contains 0.1 per cent. of volatile oil, about 5 per cent. of resin, and 2 per cent. of a caoutchouc-like substance.

COLTSFOOT (*Tussilago Farfara*) is a plant indigenous to Europe and naturalized in the Northern United States and Canada. It is an acaulescent herb with a slender rhizome 30 to 40 cm. long; nearly orbicular, somewhat lobed and tomentose leaves, and large, solitary, yellow flowers appearing before the leaves. The plant contains an acrid volatile oil, a bitter glucoside, resin and tannin.

ECHINACEA is the root of *Brauneria* (*Rudbeckia*) *purpurea*, a plant growing in rich soil from Virginia to Illinois and southward, and of *B. pallida*, growing from the Northwest Territory to Texas. It occurs in pieces from 5 to 10 cm. long and 5 to 15 mm. in diameter; it is grayish-brown or reddish-brown externally, longitudinally wrinkled, sometimes spirally twisted; the fracture is short, the fractured surface exhibiting a number of resin cells and a greenish-yellow wood. The odor is distinct and the taste is aromatic, acrid and pungent. The drug contains an alkaloid and 0.5 to 1 per cent. of an acrid resinous substance to which the medical properties are due.

ROSIN WEED or COMPASS PLANT (*Silphium laciniatum*), found growing from Ohio to South Dakota and south to Texas, produces an oleo-resin which exudes either spontaneously or from the punctures of insects, and contains about 19 per cent. of volatile oil, and 37 per cent. of acid resin.

The THISTLE (*Cnicus benedictus*) contains a crystalline bitter principle, cnicin, which is colored red with sulphuric acid.

The Mexican drug PIPITZAHOAC is the rhizome of *Perezia Wrightii*, *P. nana* and *P. adnata*, plants found in Southwestern Texas and Mexico. It contains about 3.6 per cent. of a golden-yellow crystalline principle, pipitzahoic acid, which appears to be related to oxythymoquinone and is colored an intense purple with alkalies and alkaline earths.

LION'S FOOT, the root of *Nabalus Serpentaria*, *N. alba* and other species of Nabalus growing in the United States, contains bitter principles, resin and tannin. MIO MIO (*Baccharis cordi-

folia), of South America, is poisonous to sheep and cattle and contains an alkaloid, baccharine, and a bitter principle. SPINY CLOTBUR (*Xanthium spinosum*) contains a bitter resin and possibly a volatile alkaloid. The fruit of *Xanthium strumarium*, a common weed naturalized from Europe, contains an amorphous, non-glucosidal substance, xanthostrumarin, which forms precipitates with a number of the alkaloidal reagents. SNEEZE-WEED (*Helenium autumnale*) contains a volatile oil, a bitter glucoside and tannin. *Helenium tenuifolium*, of the Southern United States, is a narcotic poison. PARA CRESS (*Spilanthes oleracea*), of tropical America, contains a soft pungent resin and a crystallizable principle, spilanthin. The common white daisy (*Chrysanthemum Leucanthemum*) yields about 0.15 per cent. of a greenish volatile oil with the odor of chamomile and mint.

CHICORY, the root of *Cichorium Intybus*, a perennial herb with blue ligulate florets, indigenous to and cultivated in Europe and naturalized in certain localities in the United States, is used in medicine as well as in the preparation of a coffee substitute. The root is spindle-shaped, somewhat resembling Taraxacum, but is of a light brown color and the laticiferous vessels are arranged in radial rows in the somewhat thinner bark. It contains a bitter principle and a large amount of inulin. In the preparation of a coffee substitute the root is cut into rather large, equal pieces and roasted, after which it is ground to a yellowish-brown, coarse powder. The grains are heavier than water, imparting to it a yellowish-brown color. Under the microscope it is distinguished by the branching latex-tubes and rather short, oblique tracheæ with rather large, simple pores.

The SUNFLOWER (*Helianthus annuus*) is an annual herb indigenous to tropical America and extensively cultivated. The plant is grown on a large scale in Russia, Hungary, Italy and India for its fruits, which yield a fixed oil resembling that of cotton seed. The akenes (so-called seeds) are obovate, flattened, externally black or with alternate white and black stripes, the pappus consisting of two deciduous, chaffy scales. Sunflower seed-cake is readily distinguished by a few of the fragments of the epicarp, with the characteristic twin, unicellular, non-glandular hairs and large, oblique, but rather short, sclerenchymatous fibers. Besides

40 per cent. of a fixed oil, the seeds contain a peculiar glucosidal tannin, helianthic acid, which is colored deep green with ferric chloride and yellow with alkalies. The root contains inulin; the shoot asparagin, and the fresh pith about 1.5 per cent. of potassium nitrate. The latter has been used in the preparation of MOXA, a combustible vegetable material which burns without fusing and is used by the Portuguese to destroy any deep-seated inflammation. The pith of various species of Artemisia, which also contains considerable potassium nitrate, furnishes the Chinese Moxa.

JERUSALEM ARTICHOKE (*Helianthus tuberosus*) is a large, coarse, pubescent herb with yellow ray-florets, which is indigenous to the Middle United States and sometimes cultivated. The tubers, which resemble artichokes, are more or less elongated or pear-shaped, reddish-brown, somewhat annulate, and internally white or reddish. They have been used as a substitute for potatoes and contain about 16 per cent. of the following carbohydrates: Inulin, pseudo-inulin, inulenin, saccharose, helianthenin, and synantherin. In early spring with the development of the tubers there is formed a small quantity of dextrose and levulose.

The Globe artichoke of the gardens (*Cynara Scolymus*) is a hardy perennial and is valued on account of the fleshy involucral scales and torus, which are edible.

The POLLEN of a number of plants of the Compositæ, as ragweed (Ambrosia), goldenrod (Solidago), aster and chrysanthemum, is said to be responsible for the autumnal cold, known as HAY FEVER. A similar disease is produced in spring and early summer by the pollen of certain grasses. It has been found that the pollen grains of these plants contain a highly toxic substance, belonging to the toxalbumins, which is the cause of the disease. By inoculation of rabbits, goats and horses with this toxalbumin a serum containing an antitoxin is obtained which neutralizes the pollen toxin and protects those who are susceptible to hay fever from its attacks. In practice the serum is prepared by injecting the toxalbumin subcutaneously into horses, the serum being known in commerce as POLLANTIN.

The flowers of the Japanese chrysanthemum "Riuno-kiku" (*Chrysanthemum Sinense Japonicum*) yield 0.8 per cent. of a volatile oil containing an optically inactive crystalline iso-camphor.

CHAPTER V.

CULTIVATION OF MEDICINAL PLANTS.

THERE is a growing scarcity of many of the native medicinal plants in the United States, due both to the destruction of the woodlands where they grow and to the direct extermination of the plants themselves by drug collectors, and it seems not improbable that if the collecting of vegetable drugs continues at the present rate it will not be many years before a number of the most important drug-yielding plants will be exterminated, unless some measures are taken to conserve them in their native localities or to propagate them by cultivation. There seems, however, to be little chance for their conservation unless by cultivation, for already the demand is far greater than the supply and in some cases the drugs are scarcely to be had at all. Of the important medicinal plants which are becoming markedly limited in their area of growth may be mentioned those yielding the drugs serpentaria, senega, cypripedium, hydrastis, spigelia and cascara sagrada.

Not only is there a necessity for the cultivation of medicinal plants on account of the scarcity of the drugs yielded by them, but experiment has shown that in some instances the drug has been improved by giving attention to cultural conditions. The possibilities of what can be done in this direction are shown in the case of coca and cinchona, where by selection and cultivation the plants have not only been conserved but the yield of the medicinal products has been greatly increased. It is true also that very many of our economic plants have been improved by selection and cultivation, as corn, wheat, potatoes, fruits of various kinds, and there is reason to believe that like results would follow the cultivation of medicinal plants. The fact should not, however, be overlooked that in some instances the wild plants, as those of the solanaceous-drug group, are said to give a better yield of the active principles than the cultivated ones; but this would probably not result if the nature of the plants were better understood and the methods of cultivation improved accordingly.

It is well known that when growth is very rapid the plant will produce few or no flowers, whereas if growth is slower the production of flowers and seed will be increased. So in the case of some of the medicinal plants it is probable that the yield of active principles would be less in a very vigorous plant than in one less thrifty. The conditions must, therefore, be studied in relation to the object to be attained.

In undertaking the cultivation of native medicinal plants they should first be studied in their natural surroundings until a knowledge is gained of the peculiar requirements and habits of each, including the composition and physical condition of the soil, the climatic conditions, their relation to other plants, etc. It should at the same time be borne in mind that most plants can in time adapt themselves to surroundings differing from those of their original habitat. Still, notwithstanding this general law of adaptation, in order to be sure of results we must take into consideration the particular conditions under which a given species will thrive best, or yield the largest percentage of active principles. For example, some plants appear to prefer a dry soil, as *Sassafras officinale;* others, a damp location, as *Veratrum viride;* some, a rich soil, as *Asarum canadense,* while still others grow in waste places and on ballast, as *Matricaria Chamomilla.* Some prefer shade, as *Arisæma triphyllum,* and others exposure to direct sunlight, as *Datura Stramonium.* Among the other factors which must also be taken into consideration is that of altitude, some plants appearing to thrive best high up on hills and mountains, while others are found in the lowlands and marshes. The question of latitude must also be considered owing to the extremes in our country in this particular.

PROPAGATION.—The methods of propagation used in the cultivation of other useful plants apply also to medicinal plants. These include propagation from seeds, from cuttings, and from grafts. A CUTTING is a severed portion of a plant having one or more nodes or buds. A GRAFT is a severed twig or branch which is embedded in a branch of another plant in such a way that the cambiums or growing regions of the two branches are brought into such intimate contact that they fuse or grow together. This method is largely followed in fruit culture, the branch of a more desirable fruit tree being frequently engrafted on one which produces an inferior grade of fruit; besides, the process consumes much less time than would be required for a fruit-bearing tree to develop from seed.

Most annuals and biennials are propagated from seeds. Considerable care is necessary in the buying of seeds in order to obtain those that will germinate and are true to name. Frequently some of the seeds are immature, and in some cases many of them are sterile, as those of Eucalyptus (Fig. 258, *H*). This latter fact may explain why it is so difficult to grow the eucalypts from seeds. In some instances the seeds may be sown where the plants are to be grown, but probably in most cases it would be better to germinate them under glass or in seed boxes and then transplant the young plants when the conditions are most favorable. It may be pointed out that there is much variation in seeds in regard to the length of time required for germination. This applies not only to seeds of different species, but even to seeds of the same plant. With many plants, as corn, wheat, beet and others, it has been found that by selecting the best seeds or those produced by plants having some specially desirable quality, as a large percentage of oils, proteins, or sugar, and repeating the selection from year to year, decided improvements have been brought about and maintained. It is reported that in the cinchona plantations in Java methods of selection have largely superseded the system of "mossing" (p. 518) for increasing the alkaloidal percentage.

Cuttings are extensively employed in the propagation of plants, particularly by florists. They are derived either from over-ground shoots, as in carnation, rose, geranium and coleus, or, where the plant produces root-stocks or rhizomes, they are made from these rather than from the over-ground shoots. Not all plants can be propagated equally well from cuttings. Some plants are readily propagated in this way, as the willows, the twigs of which when they fall off or are broken off frequently take root in the moist soil. Other plants, like the oak, are very difficult to grow from cuttings. In propagating plants from rhizomes the latter are cut into pieces, each of which has one or two buds, and these pieces are planted. Among the medicinal plants which have been grown from cuttings of rhizomes are licorice and ginger, but it is likely that all plants which produce rhizomes can be readily propagated from cuttings. Cuttings of overground stems are made from the growing parts of branches, and it is necessary to have them of such a length that at least one node may be placed in the soil. These are at first planted in micaceous soil or river sand, which should be kept well moistened. It is desirable that the leaves be as few as possible, so as to reduce the transpiring surface until the young roots have been formed, which may take several weeks or several months. Usually the lower leaves should be cut off entirely, while the others may be partially trimmed. The cuttings should also be protected from strong light, as this tends to increase transpiration, and also against a dry atmosphere, which may be accomplished by covering them with glass, particularly during the day, when the weather is dry. Cuttings of hard wood plants intended for outdoor culture should be made in the fall. They should be 6 or 8 inches in length, kept covered with sand in a suitable place during the winter, and planted in the spring.

One of the methods for producing new varieties is by hybridization, or cross-pollination, of different related species or varieties. The offspring is known as a HYBRID, and has a blending of the qualities or characters of the two parent plants. This method is mostly employed by florists who desire to produce some new or striking flower, or by horticulturists who desire to establish some new quality or transfer a desirable quality from a foreign plant to one which is adapted to a given locality. The method has not been largely employed in the cultivation of medicinal plants, except in the case of cinchona, where it is claimed that the barks richest in alkaloids are the direct result of hybridization and selection. By transplanting and special methods of treatment, as that of mossing, the alkaloidal percentage has been increased from 8 per cent. to 10, whereas by hybridization the amount of total alkaloids has reached as high as 16 per cent., about three-fourths being quinine.

THE COLLECTION, CURING AND YIELD OF DRUGS. On page 418 are given some general rules for the collection of vegetable drugs, and attention is directed to the importance of properly drying them and preparing them for the market. When not only the nature of the plant but the diversity of the constituents of vegetable drugs is taken into consideration, it will be seen that the collection and preparation of them for the market is really a fine art, requiring extended knowledge and experience, and a keen appreciation of the difference in quality due to factors of this kind. The large crude-drug collectors give instruction to their employes as to the methods to be followed in the preparation of the drug, this knowledge having been acquired as the result of years of experience. We are apt to think that the only drugs that require particular care are those like tobacco, vanilla and gentian, in which in addition to drying there is a curing process that takes place; but this is true also of digitalis, the solanaceous leaves and many of the other important drugs. While the quality thus acquired, like that of teas and wines, etc., cannot readily be determined by any assay process, the therapeutist is able to detect the difference between the drug that has been carefully collected and prepared and the one that has been carelessly handled.

It has already been pointed out that plants consist in large proportion of water, and when they are collected and dried there is necessarily considerable loss. The loss is greater in the case of herbaceous plants, where the yield of crude drug is only about 10 per cent., as in eupatorium and stramonium. Roots and rhizomes yield on an average from 20 to 30 per cent. of dried drug. In some cases, as in hops, the yield of dried drug is over 60 per cent., and in fruits and seeds there is very little loss.

CULTIVATED MEDICINAL PLANTS.—Of the strictly medicinal plants which are under successful cultivation in the United States attention may be called to the following: *Mentha piperita, Crocus sativus, Digitalis purpurea; Atropa Belladonna, Conium maculatum, Matricaria Chamomilla, Calendula officinalis, Valeriana officinalis, Inula Helenium, Ricinus communis, Panax quinquefolium,* and *Urtica urens.* In addition, a number of medicinal plants are cultivated as garden herbs for domestic use, some of them since colonial times, as anise, balm, sweet basil, bene, boneset, borage, caraway, catnip, coltsfoot, coriander, cumin, dill, sweet fennel, hoarhound, lavender, pennyroyal, rosemary, rue, sage, summer and winter savory, sweet marjoram, symphytum, tansy, tarragon, thyme, and wormwood. A number of other plants have been successfully grown in an experimental way, as *Glycyrrhiza glabra, Hyoscyamus niger, Papaver somniferum, Cinnamomum Camphora, Citrullus Colocynthis, Capsicum fastigiatum, Datura Tatula, Scopolia Carniolica, Cassia angustifolia, Convallaria majalis, Anacyclus Pyrethrum, Chrysanthemum cinerariifolium, Aristolochia Serpentaria,* and *Althæa officinalis.*

CULTIVATED ECONOMIC PLANTS WHICH ARE ALSO OF MEDICINAL VALUE.—Several hundred of the plants cultivated in the United States either for the food products which they yield or for ornamental or other purposes, are more or less esteemed for their medicinal properties. To this class belong the following plants, both the name of the drug, or the part of the plant used in medicine, and the botanical name of the plant being given. The name of the drug is sometimes synonymous with the common name of the plant.

DECIDUOUS AND EVERGREEN TREES.—The buckeye or American horse-chestnut (*Æsculus glabra*); the European horse-chestnut (*Æsculus Hippocastanum*); tree of heaven (*Ailanthus glandulosa*); black birch bark (*Betula lenta*); chestnut (*Castanea dentata*); Judas tree (*Cercis canadensis*); orange and lemon (*Citrus* species); dogwood (*Cornus florida*); persimmon bark (*Diospyros virginiana*); eucalyptus (*Eucalyptus Globulus*); red gum (*Eucalyptus rostrata*); American or white ash bark (*Fraxinus americana*); black ash bark (*Fraxinus nigra*); butternut (*Juglans cinerea*); black walnut (*Juglans nigra*); juniper (*Juniperus communis*); savine (*Juniperus Sabina*); tamarac bark or American larch (*Larix americana*); spice bush or fever bush (*Lindera Benzoin*); sweet gum bark (*Liquidambar Styraciflua*); tulip tree bark (*Liriodendron Tulipifera*); sweet bay or magnolia bark (*Magnolia glauca*); pride of China (*Melia Azedarach*); ironwood (*Ostrya virginiana*); white pine (*Pinus Strobus*); balsam poplar (*Populus candicans*); white poplar (*Populus tremuloides*); wild cherry (*Prunus serotina*); hop tree or wafer ash (*Ptelea trifoliata*); mountain ash (*Sorbus americana*); apple tree bark (*Pyrus Malus*); white oak bark (*Quercus alba*); red oak bark (*Quercus rubra*); black oak bark (*Quercus velutina*); white willow (*Salix alba*); black willow (*Salix nigra*); sassafras (*Sas-

safras officinale); hemlock spruce (*Tsuga canadensis*); elm bark (*Ulmus fulva*); prickly ash (*Xanthoxylum americanum*).

Deciduous and Evergreen Shrubs.—Swamp-, bush- or tag-alder (*Alnus serrulata*); barberry bark (*Berberis vulgaris*); boxwood (*Buxus sempervirens*); Jersey tea (*Ceanothus americanus*); fringe tree (*Chionanthus virginica*); sweet fern (*Comptonia peregrina*); red osier bark (*Cornus stolonifera*); English hawthorn (*Cratægus oxyacantha*); mezereum (*Daphne Mezereum*); American burning bush or wahoo (*Euonymus atropurpureus*); broom tops (*Cytisus Scoparius*); witchhazel (*Hamamelis virginiana*); hydrangea (*Hydrangea arborescens*); black alder (*Ilex verticillata*); mountain laurel (*Kalmia latifolia*); sweet bay (*Laurus nobilis*); wax myrtle or bayberry (*Myrica cerifera*); peach (*Amygdalus persica*); buckthorn berries (*Rhamnus cathartica*); buckthorn bark (*Rhamnus Frangula*); cascara sagrada (*Rhamnus Purshiana*); sumac (*Rhus glabra*); rose flowers (*Rosa gallica* and *Rosa centifolia*); rosemary (*Rosmarinus officinalis*); elder flowers and bark (*Sambucus canadensis*); European elder (*Sambucus nigra*); hardhack (*Spiræa tomentosa*); common arbor vitæ (*Thuja occidentalis*); cramp bark (*Viburnum opulus*); black haw (*Viburnum prunifolium*).

Twining and Climbing Plants.—American ivy or Virginia creeper (*Parthenocissus quinquefolia*); staff vine or false bitter-sweet (*Celastrus scandens*); Carolina jasmine (*Gelsemium sempervirens*); hops (*Humulus Lupulus*); yellow parilla or moon-seed (*Menispermum canadense*); passion-flower (*Passiflora incarnata*); bittersweet (*Solanum Dulcamara*).

Herbaceous Perennials.—Yarrow (*Achillea Millefolium*); aconite (*Aconitum Napellus*); sweet flag (*Acorus Calamus*); star grass (*Aletris farinosa*); garlic (*Alliüm sativum*); hollyhock (*Althæa rosea*); pulsatilla (*Anemone* species); chamomile (*Anthemis nobilis*); pleurisy root (*Asclepias tuberosa*); wild indigo (*Baptisia tinctoria*); wood betony (*Betonica officinalis*); American senna (*Cassia marilandica*); helonias or blazing star (*Chamælirium luteum*); black snake root (*Cimicifuga racemosa*); bitter apple (*Citrullus Colocynthis*); lily-of-the-valley (*Convallaria majalis*); foxglove (*Digitalis purpurea*); echinacea (*Echinacea angustifolia*); water eryngo (*Eryngium aquaticum*); fennel

(*Fœniculum vulgare*); cranesbill (*Geranium maculatum*); Indian physic (*Gillenia trifoliata*); blazing star (*Lacinaria spicata*); ground ivy (*Glecoma hederacea*); liverwort (*Hepatica triloba*); lavender (*Lavandula vera*); peppermint (*Mentha piperita*); peony (*Pæonia officinalis*); ginseng (*Panax quinquefolium*); anise (*Pimpinella Anisum*); solomon's seal (*Polygonatum biflorum*); abscess root (*Polemonium reptans*); thimbleweed (*Rudbeckia laciniata*); East Tennessee pink root (*Ruellia ciliosa*); rue (*Ruta graveolens*); sage (*Salvia officinalis*); rosinweed or compass plant (*Silphium laciniatum*); garden thyme (*Thymus vulgaris*); blood root (*Sanguinaria canadensis*); comfrey (*Symphytum officinale*); beth-root (*Trillium erectum*); white and red squill (*Urginea maritima* and its varieties).

The Cacti.—Night-blooming cereus (*Cereus grandiflorus*); and mescale (*Lophophora Lewinii*).

Annuals.—Broom corn seed (*Andropogon arundinaceus vulgare*); hemp (*Cannabis sativa*); cayenne pepper (*Capsicum fastigiatum*); common or garden parsley (*Petroselinum sativum*); caraway (*Carum Carvi*); coriander (*Coriandrum sativum*); watermelon (*Citrullus vulgaris*); pumpkin (*Cucurbita Pepo*); larkspur seed (*Delphinium Consolida*); cotton (*Gossypium* species) henbane (*Hyoscyamus niger*); lactucarium (*Lactuca virosa* and other species of *Lactuca*); garden marigold (*Calendula officinalis*); tobacco (*Nicotiana Tabacum*); sweet basil (*Ocimum Basilicum*); sweet marjoram (*Origanum Majorana*); poppy (*Papaver somniferum*); horseradish (*Roripa Armoracia*); summer savory (*Saturia hortensis*); red clover (*Trifolium pratense*); white clover (*Trifolium repens*); corn silk (*Zea Mays*).

The following orchids may be obtained through nurserymen: Small yellow lady's slipper (*Cypripedium parviflorum*); yellow lady's slipper (*Cypripedium hirsutum*).

The following ferns may likewise be procured: Male fern (*Aspidium marginale*); polypody leaves (*Polypodium vulgare*); maiden hair (*Adiantum hirsutum*).

INDIGENOUS OR NATURALIZED MEDICINAL PLANTS.—The following medicinal plants, not mentioned in the preceding lists, grow in such numbers in this country that it ought not to be difficult to procure them or their seeds for purposes of cultivation. Possibly the cheapest way to procure both American and foreign plants for purposes of cultivation would be to purchase the fresh or green drug, as of roots, rhizomes, etc., gathered at the resting period of the plant. The recently gathered drug will in some instances contain mature fruits and seeds from which plants may be successfully grown, as the leaf- and herb-drugs of the Compositæ, Labiatæ, Solanaceæ, etc.

Balsam fir or spruce (*Abies balsamea*); calamus (*Acorus Calamus*); European agrimony (*Agrimonia Eupatoria*); couch grass or dog grass (*Agropyron repens*); tree of heaven (*Ailanthus glandulosa*); common chickweed (*Alsine media*); marshmallow (*Althæa officinalis*); scarlet pimpernel (*Anagallis arvensis*); angelica seed (*Angelica Archangelica*); mayweed (*Anthemis cotula*); bitter root (*Apocynum androsæmifolium*); Canadian hemp (*Apocynum cannabinum*); dwarf elder (*Aralia hispida*); American sarsaparilla (*Aralia nudicaulis*); Uva Ursi (*Arctostaphylos Uva-Ursi*); mescale (*Anhalonium Lewinii*); burdock (*Arctium Lappa*); manzanita (*Arctostaphylos glauca*); Indian turnip (*Arisæma triphyllum*); serpentaria (*Aristolochia Serpentaria*); southern wood (*Artemisia Abrotanum*); common wormwood (*Artemisia Absinthium*); wormwood, mountain sage, or Sierra salvia (*Artemisia frigida*); common mugwort (*Artemisia vulgaris*); Canada snake root (*Asarum canadense*); white Indian hemp (*Asclepias incarnata*); silkweed (*Asclepias syriaca*); pawpaw seed (*Asimina triloba*); spice bush (*Lindera Benzoin*); Oregon grape (*Berberis Aquifolium*); black sampson or purple cone flower (*Echinacea angustifolia*, syn. *Brauneria purpurea*); borage (*Borago officinalis*); Indian hemp (*Cannabis sativa*); shepherd's purse (*Capsella Bursa-pastoris*); blessed thistle (*Cnicus benedictus*); pond-lily or sweet-scented white water-lily (*Castalia odorata*); blue cohosh (*Caulophyllum thalictroides*); red root or New Jersey tea (*Ceanothus americanus*); true unicorn root, star grass (*Chamælirium luteum*); celandine (*Chelidonium majus*); turtle head or snake head (*Chelone glabra*); American wormseed (*Chenopodium anthelminticum*); pipsissewa (*Chimaphila umbellata*); common feverfew (*Chrysanthemum Parthenium*); Canada thistle (*Carduus arvensis*); black cohosh (*Cimicifuga racemosa*); stone root (*Collinsonia canadensis*); sweet fern (*Comptonia pere-*

grina, syn. *Myrica asplenifolia*); gold thread (*Coptis trifolia*); coral root or crawley root (*Corallorhiza odontorhiza*); green osier bark (*Cornus circinata*); red osier dogwood (*Cornus stolonifera*); American dittany (*Cunila origanoides*); broom tops (*Cytisus Scoparius*); stramonium leaf and seed (*Datura Stramonium*); turkey corn or squirrel corn (*Bicuculla canadensis*); wild yam root (*Dioscorea villosa*); sundew (*Drosera rotundifolia*); male fern (*Aspidium marginalis* and *A. Filix mas*); bittersweet (*Solanum Dulcamara*); scouring rush (*Equisetum hyemale*); fireweed (*Erechtites hieracifolia*); fleabane (*Erigeron canadense*); yerba santa (*Eriodictyon californicum*); European centaury (*Erythræa Centaurium*); boneset (*Eupatorium perfoliatum*); joe-pye weed (*Eupatorium purpureum*); yerba reuma or flux herb (*Frankenia grandifolia*); European wood-strawberry leaves (*Fragaria vesca*); American columbo (*Frasera carolinensis*); cleavers (*Galium aparine*); California fever-bush (*Garrya Fremontii*); wintergreen (*Gaultheria procumbens*); 5-flowered gentian (*Gentiana quinquefolia*); purple or water-avens (*Geum rivale*); sweet or fragrant life-everlasting (*Gnaphalium obtusifolium*); grindelia (*Grindelia robusta* and *G. squarrosa*); pennyroyal (*Hedeoma pulegioides*); frostwort (*Helianthemum canadensis*); false unicorn root (*Helonias bullata*); masterwort, cow parsnip (*Heracleum lanatum*); hydrastis (*Hydrastis canadensis*); common St. John's wort (*Hypericum perforatum*); hyssop (*Hyssopus officinalis*); wild celandine, pale touch-me-not (*Impatiens aurea*); twin leaf (*Jeffersonia diphylla*); mountain or sheep laurel (*Kalmia latifolia*); mountain mint (*Koellia incana* and *K. virginiana*); lactucarium (*Lactuca virosa*); motherwort (*Leonurus cardiaca*); cancer root or beech drop (*Leptamnium virginianum*); Culver's root (*Leptandra virginica*); lovage (*Levisticum officinale*); deer tongue, vanilla plant, vanilla leaf (*Liatris odoratissima*, syn. *Trilisa odoratissima*); lobelia (*Lobelia inflata*); bitter bugle-weed, water or marsh horehound (*Lycopus europæus*); purple bugleweed (*Lycopus virginicus*); low, dwarf or running mallow (*Malva rotundifolia*); horehound (*Marrubium vulgare*); wild or German chamomile (*Matricaria Chamomilla*); yellow sweet clover, yellow melilot (*Melilotus officinalis*); spearmint (*Mentha spicata*); buckbean, marsh or bean trefoil (*Menyanthes trifoli-

ata); yerba buena (*Micromeria Douglasii*); squaw-vine, partridge berry (*Mitchella repens*); horsemint leaves (*Monarda punctata*); catnip (*Nepeta Cataria*); large yellow pond lily (*Nymphæa advena*); common evening primrose (*Œnothera biennis*); sourwood leaves (*Oxydendrum arboreum*); field, red or corn poppy flowers (*Papaver Rhœas*); American ivy or Virginia creeper (*Parthenocissus quinquefolia*); ditch or Virginia stonecrop (*Penthorum sedoides*); American mistletoe (*Phoradendron flavescens*); poke root and berries (*Phytolacca decandra*); small burnet saxifrage, small pimpernel (*Pimpinella Saxifraga*); common or greater plantain leaves (*Plantago major*); mandrake (*Podophyllum peltatum*); poison-ivy (*Rhus toxicodendron*); senega (*Polygala Senega*); American, dotted or water smartweed (*Polygonum punctatum*); bearsfoot (*Polymnia Uvedalia*); hair cap moss (*Polytrichum juniperinum*); balm of gilead buds or balsam poplar buds (*Populus candicans*); Indian black-root (*Pterocaulon pychnostachyum*); dewberry, low running blackberry (*Rubus canadensis*); wild red raspberry leaves (*Rubus strigosus*); high bush blackberry root (*Rubus nigrobaccus*); sheep sorrel (*Rumex Acetosella*); yellow dock (*Rumex crispus*); saw palmetto (*Serenoa serrulata*); red or American centaury (*Sabbatia angularis*); quinine flower (*Sabbatia Elliottii*); blood root (*Sanguinaria canadensis*); soapwort (*Saponaria officinalis*); trumpet plant (*Sarracenia flava*); pitcher plant (*Sarracenia purpurea*); Maryland figwort, heal-all or pilewort (*Scrophularia marilandica*); mad-dog skullcap (*Scutellaria lateriflora*); uncum or liferoot (*Senecio aureus*); button snake-root, rosin weed (*Silphium terebinthaceum*); carrion flower (*Smilax herbacea*); bamboo-brier root (*Smilax Pseudo-china*); horsenettle (*Solanum carolinense*); sweet or anise-scented goldenrod (*Solidago odora*); European goldenrod (*Solidago Virgaurea*); pink-root (*Spigelia marilandica*); marsh-rosemary (*Limonium carolinanum*); queen's root (*Stillingia sylvatica*); pencil flower (*Stylosanthes biflora*); skunk cabbage (*Spathyema fœtida*); tansy (*Tanacetum vulgare*); dandelion (*Taraxacum officinale*); cancer root or beech drop (*Thelesia uniflora*); vanilla leaf, deer-tongue (*Trilisa odoratissima*); hemlock (*Tsuga canadensis*); coltsfoot (*Tussilago Farfara*); California laurel (*Umbellularia californica*); stinging or great nettle

(*Urtica dioica*); American hellebore (*Veratrum viride*); mullein (*Verbascum Thapsus*); blue vervain (*Verbena hastata*); common speedwell (*Veronica officinalis*).

FOREIGN MEDICINAL PLANTS.—The following are some of the

FIG. 182, A. A seedling plant of Digitalis about six months old.

foreign plants that have been profitably cultivated in this country: safflower or American saffron (*Carthamus tinctorius*); angelica root (*Angelica Archangelica*); Roman chamomile (*Anthemis nobilis*); arnica (*Arnica montana*); belladonna (*Atropa Belladonna*); borage (*Borago officinalis*); cayenne pepper (several species of *Capsicum,* see p. 578); senna (*Cassia acutifolia* and *C. angustifolia*); lippia Mexicana (*Cedronella mexicana*); colocynth (*Citrullus Colocynthis*); colchicum corm and seed (*Colchicum autumnale*); conium (*Conium maculatum*); stavesacre

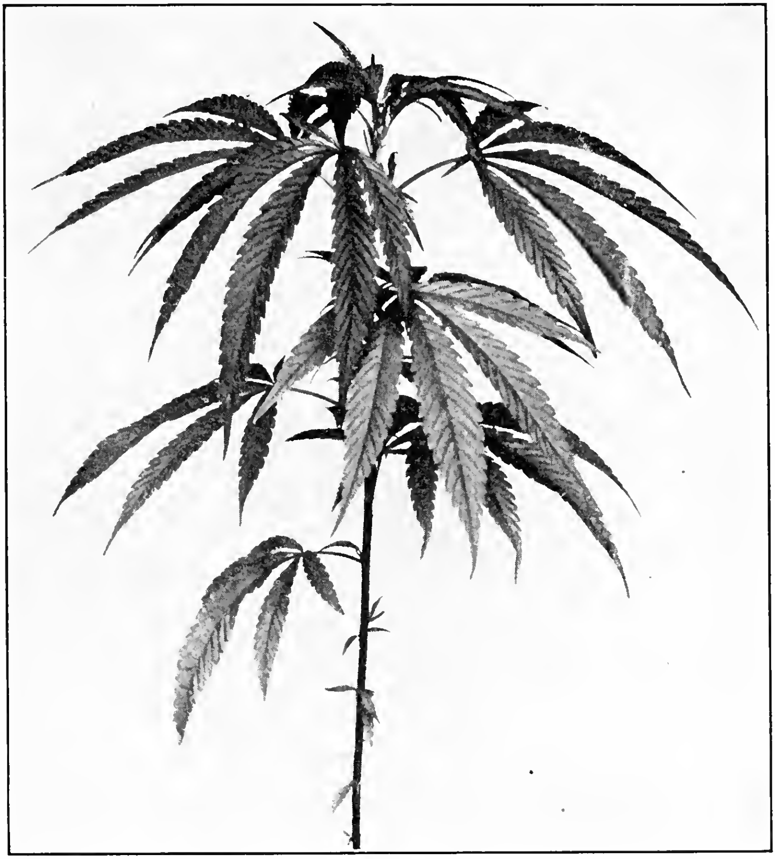


FIG. 182, B. *Cannabis sativa:* Young plant grown from seed found in the drug Cannabis indica.

seed (*Delphinium Staphisagria*); licorice (*Glycyrrhiza glabra* and the var. *glandulifera*); black hellebore (*Helleborus niger*); henbane (*Hyoscyamus niger*); elecampane (*Inula Helenium*); Florentine orris root (*Iris florentina*); laurel, sweet bay (*Laurus* *nobilis*); wild or German chamomile (*Matricaria Chamomilla*): poppy (*Papaver somniferum*); rhubarb (*Rheum officinale*); sco-

FIG. 182, C. Seedling plants of *Erythroxylon Coca* (A) and *Eucalyptus globulus* (B).

pola (*Scopolia carniolica*); squill (*Urginea maritima*); valerian (*Valeriana officinalis*); pansy (*Viola tricolor*).

PART II.—PHARMACOGNOSY.

CHAPTER I.

CRUDE DRUGS.

INTRODUCTORY.

PHARMACOGNOSY is a term derived from two Greek words which, together, mean a knowledge of drugs. According to modern usage it is generally understood to mean the study of the structure and chemical constituents of crude drugs.

The word drug is derived from the Arabic word "dowa," meaning "cure," and was transformed into the Latin "dogua, doga," with the euphonic intercalation of "r."

The NATURAL ORIGIN is the scientific name (generic and specific names) of the plant or animal yielding the drug. In the case of vegetable drugs the natural origin is spoken of as the BOTANICAL ORIGIN. A vegetable drug usually represents some special part of the plant, but in some instances the entire plant is employed, as chirata.

The habitat of plants is the region where they grow. Sometimes this term is applied erroneously to the drugs themselves. Neither the scientific name of the plant nor the commercial name of the drug may be relied upon as indicating the true habitat of medicinal plants. For example, the specific name of *Spigelia marilandica* indicates that the plant is found in greatest abundance in Maryland, whereas it is only occasionally met with in that State. In other cases plants are common to a much larger territory than the specific name would indicate, as *Prunus virginiana*. The geographical names associated with drugs frequently apply to the places from which they are exported, rather than to the habitat of the plant yielding the drug, as, for example, Para sarsaparilla, which is obtained from a plant growing in the upper Amazon region, is shipped to Para, from whence it is exported.

Plants which yield drugs may grow wild, as is most usually the case, or they may be cultivated, as those yielding anthemis, cannabis indica and the solanaceous leaves. Plants growing in their native countries are said to be INDIGENOUS to those regions, as *Stillingia sylvatica,* of the Southern United States; *Aconitum Napellus,* of the mountainous regions of Europe, etc. Plants are said to be NATURALIZED when they grow in foreign land or in another locality than their native home. Some of these may have been distributed by natural agencies, or they may have escaped from cultivation, or they may have been introduced with the seeds of cultivated plants or with the ballast of ships.

The term COMMERCIAL ORIGIN applies solely to the drugs themselves, and indicates their commercial source, which may be either the country where the plant yielding the drug is grown, or the port from which the drug is sent into the marts of the world. English hyoscyamus leaves are gathered from plants grown in England; Canton rhubarb is the product of plants grown in various parts of China, but shipped by way of Canton.

The official or PHARMACOPŒIAL TITLES of vegetable drugs are derived from either the generic name of the plant, as gelsemium, or the specific name, as ipecacuanha, or they may include both the generic and specific names, as viburnum prunifolium, or they may be derived from other sources, as opium and sarsaparilla.

In addition to the botanical names of plants and the pharmacopœial titles of drugs, a number of vernacular names and synonyms are also applied to vegetable drugs, as licorice root for glycyrrhiza, prickly ash for xanthoxylum.

The official or PHARMACOPŒIAL DEFINITION of drugs is given in the leading paragraph under each drug in the different pharmacopœias, and includes the botanical origin as well as the name of the part of the plant yielding the drug; and in some cases other special features or requirements are given, as the habitat of the plant yielding the drug, the time of collection, mode of preservation, etc.

The time of the COLLECTION of vegetable drugs is of prime importance, and, while we may not be able to make extended generalizations, still, the following general rules for the collection of various drugs may be given:

(1) Roots, rhizomes and barks should be collected immediately before the vegetative processes begin in the spring, or immediately after these processes cease, which is usually in the fall.

(2) Leaves should be collected when the CO_2 assimilation process is most active, which is usually about the time of the development of the flowers and before the maturing of fruit and seed.

(3) Flowers should be collected prior to or just about the time of pollination.

(4) Fruits should be collected near the ripening period, *i.e.*, full grown but unripe.

(5) Seeds should be collected when fully matured.

The PRESERVATION of vegetable drugs is likewise deserving of careful consideration, and attention should be given to the influence of temperature, moisture, air and light, and the attacks of insects. The temperature of the room or part of the store devoted to the storage of dry drugs should not be more than about 25° C., and nearly uniform throughout the year.

Drugs containing volatile principles require to be kept in air-tight containers, as the herbs of the Labiatæ and Compositæ, and wild-cherry bark. Air-tight tin cans are probably the most economical and satisfactory containers for the purpose, and the suggestion has been made to paint the edges of the cans with melted beeswax. Drugs are sometimes stored in wooden boxes or in drawers. This method is objectionable, not only because they are more liable to deteriorate, but because the odors are communicable from one to the other. The storage of drugs in parcels is the most objectionable, particularly, as is usually the case, when the different parcels are stored together.

Those drugs that are difficult to dry, as the inulin-containing drugs, and some fleshy roots and rhizomes, as Veratrum, are liable to become moldy and should be thoroughly dried before placing them permanently in containers.

The preservation of drugs against the attacks of insects is, unfortunately, generally overlooked. Most drugs are subject to their depredations, and are usually attacked by the insects in the larval stage. The insects which infest vegetable drugs belong chiefly to the Lepidoptera, Coleoptera and Diptera. The Lepidoptera are the most destructive, and include the cornmeal moth (*Tinea zea*), which, during its larval (the caterpillar or grub) stage, is known to attack aconite, capsicum, ergot, lappa, linseed, rhubarb, taraxacum and many other drugs. Among the Coleoptera are various members of the Ptinedæ, as *Ptinus brunneus, Anobium paniceum* and *Lasioderma serricorne,* which attack the spices chiefly, as capsicum, cinnamon and pimenta. Chief among the Diptera is *Trypeta arnicivora,* which is sometimes found in arnica flowers.

For the destruction of these insects and prevention of their attacks a number of substances and methods have been employed, the simplest method of all being to expose the drug to a temperature of about 100° C. This method is, however, open to objection, as there is liability either to decomposition or loss of active principle. Camphor and tar-camphor have been employed, but it is doubtful if they should be used, unless in the case of animal drugs. In some instances, as with nutmeg and ginger, the drug is sprinkled in the drying-room, and when packed for market, with quicklime. Benzin and carbon disulphide have been proposed, but these are of a disagreeable odor as well as inflammable. Ether has been suggested, but it is very volatile and inflammable. Formaldehyde has been proposed for the preservation of orris root. The use of chloroform as a preservative was formerly sanctioned by the U.S.P. in the case of ergot, and is probably the best preservative that has been proposed. A few drops of chloroform added to a drug on placing it in the container will usually prevent it from becoming "*wormy.*" Some drugs, however, as taraxacum and glycyrrhiza, may require inspection from time to time and the addition of a little more chloroform.

Commercial Forms of Drugs.—Vegetable drugs are brought into market in various forms; they may be crude, that is, more or less entire, or in a powdered condition. Crude drugs may be nearly entire, as seeds, flowers, fruits, leaves, and some roots and rhizomes; or they may be cut or sliced, as in woods, barks, many roots and a few rhizomes. They may be more or less matted together, as in chondrus and the solanaceous leaves; or they may be pressed together by means of hydraulic pressure, giving the so-called pressed drugs; or they are first powdered and then molded into forms, as "rhubarb fingers." In some cases the periderm is removed, as in a number of roots (althæa) rhizomes (zingiber) and barks (ulmus).

The QUALITY of vegetable drugs is injured by a number of factors, of which the following may be mentioned: (1) lack of knowledge or want of care in collecting them; (2) carelessness in drying and keeping them; (3) insufficient care in garbling and preparing them for the market; (4) inattention in preserving them and storing them; (5) accidental admixture in the store, and (6) adulteration and substitution.

The influence which the TIME OF COLLECTION has on the quality of vegetable drugs may be best shown by a few illustrations. It is well known that when the fruits of conium are green they will yield over 3 per cent. of coniine, but when they become yellow the alkaloid diminishes rapidly in quantity, and, therefore, much of the commercial drug will not yield 1 per cent. of coniine. The same thing may be said of santonica: when the flower heads are unexpanded they will yield over 3 per cent. of santonin, but just so soon as the flower matures there is a rapid disappearance of the anthelmintic principle. Dealers in insect powder (Flores pyrethri) know that the flowers gathered when they are closed produce the finest and most powerful insect powder, worth nearly twice as much as that made from the half-closed or open flowers. It may be that the variation in quality of some of the commercial aconite is due to improper drying, or to the extraction of the active principles; still, there is no doubt but that much of the trouble with this drug is due to the variation in the time of collection in different countries, as well as to its being collected from different species.

Another factor affecting the quality of vegetable drugs is carelessness in drying them and caring for them after they are gathered. In some cases the Pharmacopœia specifies that the drug shall be kept a certain length of time before being used, as in the case of frangula. A similar specification should be made in regard to rhamnus purshiana; but since the results of the changes on keeping are now ascertained, and since a similar effect may be obtained by heating the bark at 100° C. for forty-eight hours, this specification seems no longer necessary.

In some drugs a sort of ripening process takes place in the drying, as in gentian, guarana, vanilla and the solanaceous leaf drugs. In still others a marked deterioration takes place if they are placed in heaps and allowed to ferment, as in the case of lavender and most other drugs yielding essential oils. In the preparation of oil of peppermint, the yield of oil is greater and the quality better if the plants are allowed to dry and are distilled immediately or soon after. On the other hand, the yield of methyl salicylate is greater in the leaves of *Gaultheria procumbens* or the bark of *Betula lenta* if they are first macerated in water for about 12 hours.

Quite a number of drugs are not infrequently observed in commerce in a moldy condition, as taraxacum, veratrum, aconite, maranta starch, etc. The question as to what influence this mold has on the quality of the drug has not been decided.

A third cause of inferiority of vegetable drugs is lack of sufficient care in GARBLING. This applies to a number of drugs, as leaves, with which may be admixed a large number of stems and roots; rhizomes and tubers, in which the proportion of stem-remnants may be excessive, or, as in other cases, the proportion of roots to rhizomes may be large. The roots contain much less of the active principles, and have been found in cypripedium and hydrastis to the extent of 50 per cent.

A fourth factor influencing the quality of drugs is the MANNER OF PRESERVATION. While it is generally conceded that most drugs deteriorate on keeping, still this depends largely upon the manner in which they are kept. Thus, the Pharmacopœia limits the time of keeping of ergot and states how it shall be preserved; yet a number of writers call attention to the fact that, if properly prepared and preserved, the time of keeping may be very much extended. In order to preserve ergot, Grover proposed the removal of the oil, and Moss found the drug thus treated to retain its therapeutic value for six and a half years. Zanon suggests placing the drug in alternate layers with sand and keeping it in a closely sealed jar. Others grind the fresh ergot and preserve with chloroform in paraffin paper, while some first extract the oil from the powder with alcohol or ether.

Accidental admixture in the store or warehouse depends upon the care of the individual, and need not receive attention here.

The adulterations, substitutions and sophistications will be considered under the respective drugs.

The Valuation of Drugs.—In the identification of vegetable drugs certain characters are taken into account, such as color, odor, general appearance, structure, texture, etc., these at the same time indicating in a greater or less degree the qualitative value of the drug. While these characters may enable the expert to detect very slight variations in quality, and to estimate approximately the value of a given drug, still the true value is based upon the amount of the medicinal principles or so-called active constituents. The methods employed in the valuation of drugs may be grouped as follows: (1) Chemical, (2) Physical, (3) Microscopical, and (4) Biological.

(1) Chemical methods are more generally employed and usually involve the isolation and estimation of the active principles.

(2) Physical methods involve such processes as the determination of specific gravity of the drug, as of jalap, or the determination of the elasticity or measurement of the fibers, as of cotton, and still other special methods which apply to individual drugs, showing indirectly their quality.

(3) Microscopical methods of valuation may oftentimes be employed when other methods fail, as, for example, when foreign starches are added to starchy products, as the cereals and spices. Microchemical reactions may also be depended upon in some instances to indicate the value of a drug, as in strophanthus, where the quality of the drug appears to bear a direct relation to the number of seeds giving a green coloration with sulphuric acid. The separation of the salts of the alkaloids in hydrastis on the addition of sulphuric acid is also of value in determining the quality of this drug.

(4) Biological methods involve the consideration of the effects of drugs upon animals or plants. They may be conveniently grouped as follows: 1. Effects or influence upon animals, including (*a*) those dependent upon the perceptions or senses of the experimenter or tester, as color, taste and odor; (*b*) those which are physiological or pathological. These are usually determined by experiments upon lower animals, as insects, frogs, rabbits, guinea pigs, fowls, and even upon man. 2. The effect or influence

produced upon plants by drugs, or solutions of their active principles. For experiments of this kind seedlings are usually employed and the effects are based upon the amount of growth of the root of the plant in a given time when placed in the solution. Some of the lower plants (p. 5) are also used in testing the properties of chemicals, which may have a toxic action on the protoplast or a plasmolytic action on the protoplasm (Fig. 55, *II*).

Fig. 183. Case for drug specimens.

Drug Collections.—It is important that the student, pharmacist and analyst possess a collection of typical drug specimens. It is necessary in the study of drugs and also for purposes of identification and comparison. Specimens may be kept in various kinds of boxes and bottles, but one of the most satisfactory ways is to keep them in type cases (Fig. 183) such as are used by printers, the top being covered with glass which can be removed.

The glass can be kept in place by means of long, broad-headed tacks or can be fastened permanently by means of hinges. The frames may be hung on the wall or held by means of molding.

DRUGS DERIVED FROM ANGIOSPERMS.

I. SEEDS.

Seeds should, as a rule, be collected when they are ripe and carefully preserved against the attacks of insects and changes of various kinds, as those incident to germination. They may, or may not, be dried before using.

The medicinal seeds may be classified as follows:

I. ENTIRE SEEDS.

I. Not more than 5 to 6 mm. long.

1. With an appendage (*caruncle*):
   - Ovoid or irregularly globular, dark brown ....Colchici Semen
2. Without an appendage:
   - *A. Anatropous.*
     - *a.* Ovate, flattened, smooth........................Linum
     - *b.* Triangular or quadrangular, reticulate....Staphisagria
   - *B. Campylotropous.*
     - Yellowish-brown ....Sinapis Alba
     - Reddish-brown ....Sinapis Nigra

II. From 10 to 20 mm. long.

- Whitish, smooth..Pepo
- Yellowish-green or light brown, hairy..............Strophanthus

III. From 20 to 30 mm. long.

1. More or less flattened:
   - *a.* Ovate or oblong-lanceolate.
     - Taste bitter...........................Amygdala Amara
     - Taste bland..........................Amygdala Dulcis
   - *b.* Plano-convex or 3- to 6-sided......................Cola
   - *c.* Orbicular, hairy............................Nux Vomica
   - *d.* Reniform, brownish-red ....Physostigma
2. Ellipsoidal ....Myristica

II. PRODUCTS OF OR PARTS OF SEEDS.

- Hairs ....Gossypium Purificatum
- A paste of the crushed seeds..............................Guarana
- The arillode of Myristica......................................Macis

COLCHICI SEMEN.—COLCHICUM SEED.—The dried, ripe seeds of *Colchicum autumnale* (Fam. Liliaceæ), a perennial bulbous plant, native of and growing in moist meadows in Southern and Middle Europe and Northern Africa (p. 236). The commercial supplies come chiefly from England and Germany.

DESCRIPTION.—Hemi-anatropous, ovoid or irregularly globular, more or less beaked, with an easily detachable strophiole, 2 to 3 mm. in diameter; externally dark brown, becoming darker with age, minutely pitted, the epidermis detached in irregular patches in older seeds; frequently agglutinated when fresh, due to the presence of a saccharine exudation; very hard when dry, tough when damp, internally whitish, endosperm hard, embryo

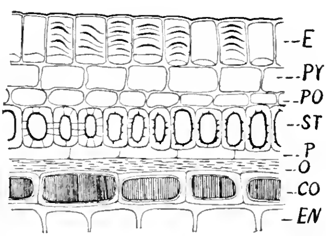


FIG. 184. Transverse section of flaxseed; E, epidermal cells with small lumen and very thick outer wall showing mucilage lamellæ; PY, PO, parenchyma cells; ST, stone cells; P, parenchyma below stone cells; O, obliterated cells; CO, cells with reddish-brown contents; EN, endosperm.

0.5 mm. long and situated at end opposite the strophiole; nearly inodorous; taste feeble, bitter and somewhat acrid.

CONSTITUENTS.—Proteins; fixed oil about 6 per cent.; a tannin-like substance in the seed-coat; starch grains in the caruncle; an alkaloid colchicine 0.4 to 0.6 per cent. (0.55 per cent. required by the U.S.P.); a resinous principle colchicoresin; ash about 2.5 per cent. (See also Colchici Cormus.)

LINUM.—LINSEED OR FLAXSEED.—The seed of *Linum usitatissimum* (Fam. Linaceæ), an annual, which is cultivated in nearly all temperate and tropical regions, either for the fiber (flax) or seed (p. 303).

DESCRIPTION.—Anatropous, ovoid or oblong-lanceolate, flattened, somewhat less rounded on one side and on one margin, apex acute or beaked, chalazal end rounded, plano-convex in transverse section, 4 to 5 mm. long, 2 to 2.5 mm. broad, 0.5 to 0.75 mm. thick; externally light brown, very smooth and glossy, the raphe extending as a distinct, light-yellow ridge along one edge, outer wall of epidermal cells transparent, mucilaginous and swelling in water; easily cut; endosperm white, adhering to the seed-coat, embryo light green, straight, 3 to 4 mm. long, 1 to 2 mm. broad, cotyledons plano-convex; odor slight; taste mucilaginous and slightly unpleasant.

INNER STRUCTURE.—See Figs. 99, *A*; 184; 293.

CONSTITUENTS.—Fixed oil 30 to 40 per cent.; proteins about 25 per cent.; mucilage in outer walls of the epidermal cells; ash 1 to 4 per cent.

GROUND FLAXSEED (flaxseed meal or crushed linseed) is not infrequently deficient in oil on account of its being admixed with "oil-cake" or "cake-meal." The latter is the residue after expressing about 20 to 30 per cent. of the oil naturally occurring in the crushed linseed, and the deficiency is sometimes made up by the addition of mineral oils. Ground flaxseed sometimes contains fragments of the cereals rye and wheat, which is partly due to the fact that these cereals grow in with the flax, and partly because it is sometimes shipped in meal or flour sacks.

STAPHISAGRIA.—STAVESACRE.—The ripe seed of *Delphinium Staphisagria* (Fam. Ranunculaceæ), an annual or biennial native of Southern Europe and Asia Minor, and cultivated in Austria (Trieste), Italy and Southern France, from which latter countries the commercial supplies are obtained (p. 270).

DESCRIPTION.—Anatropous, irregularly triangular or somewhat tetrahedral, one side convex, the others plane, the micropylar end acute or obtuse, 5 to 6 mm. long, 3 to 6 mm. broad; externally dark brown, becoming lighter and duller with age, more or less uniformly reticulate, the pits being about 0.5 mm. in diameter, raphe forming a more or less distinct ridge on the largest of the plane surfaces or on the edge of two united sides, epidermis modified to distinct papillæ; inner seed-coat yellowish-brown, adhering to the endosperm when moistened, the latter white or yellowish, and enclosing at the pointed end a small, straight embryo 1 mm. long and with a relatively large hypocotyl; slightly odorous; taste of endosperm intensely bitter and acrid.

Constituents.—Two alkaloids, about one per cent. These are delphinine, which crystallizes in rhombic prisms and resembles aconitine in its physiological action; and staphisagroine, which is amorphous and insoluble in chloroform. The alkaloids delphisine and delphinoidine are probably decomposition products of delphinine. The seeds also contain 25 to 30 per cent. of a fixed oil; an equal amount of proteins; 8 or 9 per cent. of ash; and several resins.

Allied Plants.—A number of other species of Delphinium have been investigated and found to have poisonous properties. The seeds of *Delphinium consolida* resemble stavesacre, but are only about one-fifth the size.

SINAPIS ALBA.—WHITE MUSTARD.—The dried, ripe seeds of *Sinapis alba* (Fam. Cruciferæ), an annual native of Europe and Southwestern Asia and naturalized and extensively cultivated in many countries. The commercial supply of the drug is obtained from plants grown in England, Germany, Holland and Italy (p. 283).

Description.—Campylotropous, irregularly spherical, somewhat compressed, 1 to 2 mm. in diameter, externally yellowish-brown, seed-coat membranaceous, and minutely pitted, marked on one side by a distinct ridge and two parallel furrows formed by the hypocotyl and cotyledons; internally light yellow, without a reserve layer, hypocotyl curved, cotyledons conduplicate; inodorous; taste pungent and acrid.

Inner Structure.—See Figs. 294; 302, *E, F*.

Constituents.—Fixed oil 20 to 25 per cent.; mucilage in the outer wall of the epidermal cells; proteids about 30 per cent.; a glucoside sinalbin ($C_{30}H_{44}N_2S_2O_{16}$), and a ferment myrosin, which yield on interaction a yellowish non-volatile oil (acrinyl sulphocyanide) which is pungent to the taste, but owing to its non-volatile character, does not affect the eyes or nose. In the reaction there is also formed glucose and acid sinapine sulphate. Sinapine is an alkaloid which is decomposed, on heating its solutions with alkalies, into choline and sinapic acid.

Adulterants.—While the whole mustard is seldom, if ever, adulterated, ground mustard may contain wheat middlings or shorts, and occasionally rice or pea flour; when these flours are employed, turmeric is also added to bring up the color, which latter may be detected by means of the microscope (Fig. 290) and by its becoming deep red with sulphuric acid and blue with iodine.

Allied Plants.—The seed of Turnip (*Brassica campestris*) is supposed to be the white mustard of Sanscrit writers.

SINAPIS NIGRA.—BLACK MUSTARD.—The dried, ripe seeds of *Brassica nigra* (Fam. Cruciferæ), an annual occurring much the same as Sinapis alba (p. 283).

Description.—Campylotropous, ellipsoidal or irregularly spherical, 1 to 1.5 mm. in diameter; externally brownish-red, seed-coat membranaceous, finely pitted, hilum whitish, forming a conical projection, micropyle occurring as a slight depression; without a reserve layer, hypocotyl curved, cotyledons conduplicate; inodorous; taste pungent and acrid.

Inner Structure.—See Fig. 295.

Constituents.—Black mustard contains the same constituents as white mustard, save that it contains more fixed oil (30 to 35 per cent); less of the ferment, myrosin; and the sinalbin is replaced by the glucoside, sinigrin (potassium myronate), which is present to the extent of about 1 per cent. and yields on interaction with the myrosin a light yellowish volatile oil (allyl isosulphocyanide or volatile oil of mustard), which has an acrid, burning taste, pungent odor, and also affects the eyes. In the reaction there is also formed glucose and potassium acid sulphate.

Allied Products.—Of the seeds of the other Cruciferæ which somewhat resemble black mustard, the following may be mentioned: The seeds of Field mustard or *Sinapis arvensis*, which are almost black and perfectly smooth; the seeds of Sarepta mustard, (*Brassica Besseriana*), which are larger and distinctly reticulate; Rape or colza seeds (*Brassica Napus*), which are larger, not reticulate and of a bluish-black color; Turnip seeds yielded by *Brassica campestris*, which are somewhat larger but less acrid, and are used in India in place of black mustard; and *Brassica juncea*, which is cultivated in tropical Asia for the same purpose.

PEPO.—PUMPKIN SEED.—The ripe seeds of *Cucurbita Pepo* (Fam. Cucurbitaceæ), a procumbent herb native of tropical America and possibly tropical Asia, and long cultivated in tropical and temperate zones (p. 387).

DESCRIPTION.—Anatropous, broadly elliptical, acute, acuminate or truncate, flattened, about 20 mm. long, 10 mm. broad, about 2 mm. thick; externally white or light yellow, very smooth or somewhat rough from adhering fruit pulp, marked by a shallow groove or slight ridge parallel to and within 1 mm. of the margin; raphe not conspicuous, hilum characterized by a minute depression; seed-coat consisting of two distinct layers—the outer white and coriaceous and the inner dark green and membranaceous; embryo white, straight, with a small hypocotyl and two plano-convex cotyledons; slightly odorous when contused; taste bland.

CONSTITUENTS.—Fixed oil about 40 per cent.; starch about 30 per cent.; proteins; a resin. There is no indication of the presence of any principle possessing anthelmintic properties. Any therapeutic value must be attributed solely to mechanical action.

ALLIED PLANTS.—The seeds of other species of Cucurbita are also used in medicine; in Italy *C. maxima* and in the West Indies *C. occidentalis* are the sources of the drug.

The seeds of other members of the Cucurbitaceæ are also employed in medicine; they include the seeds of watermelon (*Citrullus vulgaris*), cucumber (*Cucumis sativus*), muskmelon (*Cucumis melo*) and lagenaria (*Cucurbita Lagenaria*).

STROPHANTHUS.—The ripe seeds of *Strophanthus Kombe* (Fam. Apocynaceæ), a twining shrub found in Zambesi and other parts of Eastern Africa (p. 363). The plumose awns at the apex of the seeds are usually removed before exportation (Fig. 185).

DESCRIPTION.—Hemi-anatropous, oblong-lanceolate or spatulate, acute or acuminate, unevenly flattened and in transverse section deltoid or plano-convex, 8 to 15 mm. long, 3 to 5 mm. broad, 1 to 1.5 mm. thick; externally yellowish-green, covered with long hairs giving a silky appearance to the seed, the raphe extending as a distinct ridge from the hilum about half the length of the seed; fracture short; internally whitish, endosperm about 0.2 mm. thick, embryo 6 to 12 mm. long and 1 to 2 mm. broad, cotyledons plano-convex, about 1 mm. thick, hypocotyl conical, 2 mm. long; inodorous except when broken; taste very bitter.

When treated with concentrated sulphuric acid the endosperm, in about 65 per cent. of the seeds, becomes green; the cotyledons red or purple and finally green, in some instances.

Inner Structure.—See Figs. 186; 284, *A*; 306.

Constituents.—Strophanthin, a crystalline principle occurring chiefly in the endosperm and varying from 0.95 to 3 per cent.; strophanthin is colored greenish with sulphuric acid, and yields on decomposition a crystalline body called strophanthidin; the other constituents are kombic acid and about 30 per cent. of a fixed oil.

Allied Plants.—The seeds of a number of other species and varieties of Strophanthus find their way into the market, but

Fig. 185. A dehiscent follicle of strophanthus showing plumose seeds.

these are usually more or less deficient in strophanthin and hence do not give a greenish color with sulphuric acid. The most important of these are the seeds of *Strophanthus hispidus,* a plant growing in Upper Guinea and other parts of Western Africa. These are smaller, thicker and less hairy than those of *S. Kombe* and yield less than 1 per cent. of strophanthin. The commercial drug may contain other Strophanthus seeds, some of which contain calcium oxalate prisms.

Another principle, pseudo-strophanthin, has been isolated from the seeds of some undetermined species of Strophanthus. This

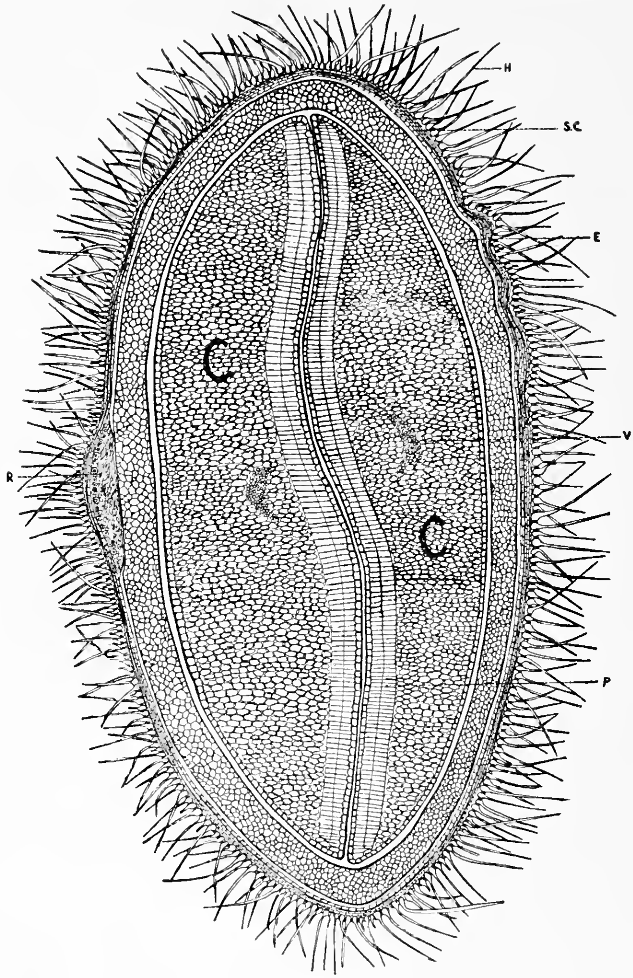


FIG. 186. Transverse section of strophanthus seed; SC, seed-coat with unicellular non-glandular hairs (H); R, raphe; E, endosperm; C,C, cotyledons with fibrovascular bundle (V) and palisade cells (P).

principle appears to be more powerful than strophanthin, but is less satisfactory as a heart tonic.

AMYGDALA AMARA.—BITTER ALMOND.—The ripe seed of *Prunus Amygdalus amara* (Fam. Rosaceæ), a tree native of Asia Minor, Persia and Syria, and cultivated and naturalized in tropical and warm-temperate regions (p. 287). The commercial product is obtained mostly from Sicily, Southern France, Southern Italy and Northern Africa. In commercial almonds the yellowish, more or less porous, fibrous and brittle endocarp is frequently present, and this should be removed (Fig. 187).

DESCRIPTION.—Anatropous, ovate or oblong-lanceolate, flattened, more rounded on one margin, apex acute or beaked, chalazal end rounded or obliquely truncate, 20 to 30 mm. long, 11 to 17

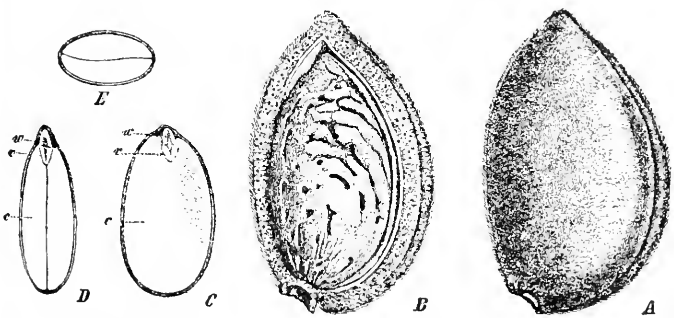


FIG. 187. Drupe-like fruit of almond (*Prunus Amygdalus*): A, whole fruit with distinct suture; B, longitudinal section showing fibrous sarcocarp, and thin shell-endocarp; C, D, E, sections of the seed; c, cotyledons; w, hypocotyl; v, epicotyl or plumule.—After Focke.

mm. broad, 7 to 9 mm. thick; externally light brown, with numerous parallel veins extending from the chalaza to the micropyle, outer walls of epidermal cells modified to distinct papillæ, seed-coat thin, membranaceous, easily removed on soaking the seed in water, the raphe extending on the more rounded edge as a more or less distinct ridge from the hilum to or near the chalaza; fracture short; without reserve layers, embryo straight, whitish, hypocotyl conical, 2 to 3 mm. long, cotyledons plano-convex, sometimes slightly unequal, plumule 1 mm. long; odorless, except on treatment with water, when an odor of hydrocyanic acid is emitted, or of benzaldehyde when old; taste bitter.

INNER STRUCTURE.—See Figs. 188; 302, *D*; 319.

CONSTITUENTS.—Fixed oil 45 per cent.; proteins 25 to 30 per cent.; a glucoside, amygdalin, 1 to 3 per cent.; and a ferment, emulsin, which acts upon amygdalin, decomposing it into a volatile oil (benzaldehyde or oil of bitter almond) and hydrocyanic acid. In addition to the protein emulsin, there is another casein-like protein present, amandin, both of which act as emulsifying agents in the preparation of emulsion of almonds.

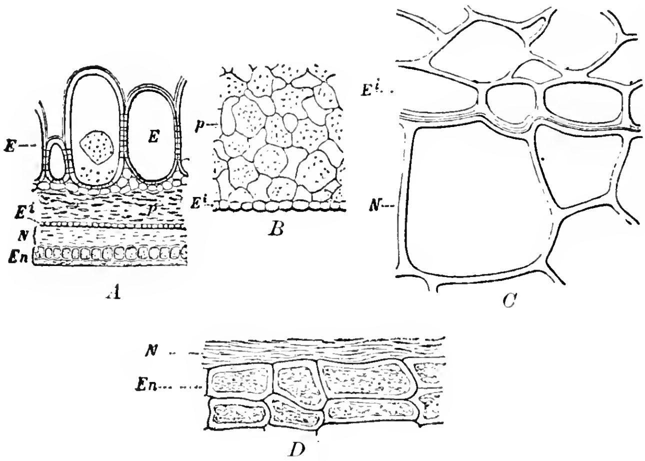


FIG. 188. Sections of almond seed: A, cross section of seed-coat treated with cold potassium hydrate solution and showing outer epidermis (E), inner epidermis (Ei), between which is rather loose parenchyma (p), tissues of nucellus (N) and endosperm (En). B, parenchyma (p) with large intercellular spaces and the inner epidermis of the seed-coat (Ei). C, transverse section of inner epidermis (Ei) and the outer cells of the nucellus (N). D, more or less obliterated cells of nucellus (N) and two layers of the endosperm (En), which remain intact in the ripe seed.—After Meyer.

Amygdalin, or a similar principle, is found in the young shoots and flower-buds, as well as seeds, of apricot, peach, plum, cherry and cherry laurel. (See Wild Black-cherry Bark.)

AMYGDALA DULCIS.—SWEET ALMOND.—The ripe seeds of *Prunus Amygdalus dulcis* (Fam. Rosaceæ), a tree like the bitter almond but more extensively cultivated. The commercial supply is obtained from Northern Africa, Southern France, Italy and Spain, the choicest seeds being imported from Malaga and known as "Jordan almonds" (p. 287).

Description.—Closely resembling the Bitter Almond but giving no odor of hydrocyanic acid when treated with water, or of benzaldehyde when old; taste bland and sweet.

Constituents.—Resembling bitter almond, but containing slightly more fixed oil (about 50 per cent.), and being free from amygdalin.

COLA.—KOLA.—The kernel of the seed of *Cola acuminata* (Fam. Sterculiaceæ), a tree indigenous to Guinea, and now extensively cultivated in the West Indies and South America. The commercial supplies come principally from Western Africa and the West Indies. The seed obtained from the West Indies is known commercially as Bichy or Bissy-bissy nut. The kernels are used in a fresh condition or the cotyledons are separated and dried (p. 333).

Description.—Anatropous, plano-convex, polygonal, three to six-sided, 18 to 35 mm. long and 5 to 20 mm. in diameter; externally yellowish or yellowish-red when fresh, but becoming darker with age and on drying, with a shallow furrow indicating the line of union of the two cotyledons, micropyle forming a distinct cleft at one end, otherwise nearly smooth; easily cut when fresh, but hard when dry; without reserve layers, cotyledons unequal and varying from two to five in number, the hypocotyl small; odor distinct; taste astringent, somewhat sweet.

Constituents.—Starch 35 to 40 per cent., the grains resembling those of potato starch but uniformly smaller; caffeine 1.5 to 3.6 per cent.; theobromine 0.02 to 0.09 per cent.; 1.5 to 4 per cent. of a tannin; an enzyme similar to the lipase found in nutmeg and black pepper which decomposes fats.

Caffeine or theine (trimethyl xanthine or methyl theobromine) also occurs in coffee (p. 380), tea (p. 334), cacao (p. 332) and Paraguay tea (p. 322). It separates in the form of acicular crystals having a bitter taste, is soluble in water and alcohol, the solutions being neutral; and may be sublimed without decomposition on heating. On treating a small quantity of caffeine with a few drops of nitric acid or chlorine water and evaporating the solution to dryness on a water bath the reddish-yellow residue is colored purplish by ammonia. A similar reaction is also obtained by treating the alkaloid with hydrochloric acid and a crystal of potassium chlorate, evaporating the solution and adding a drop of ammonia water to the residue. (See also Fig. 159.)

THEOBROMINE (dimethyl xanthine) also occurs in cacao (p. 332) and crystallizes in rhombic prisms, which are sparingly soluble in water and alcohol, the solutions being slightly acid. It sublimes on heating without decomposition, and forms crystallizable salts with mineral acids, which are readily decomposed with water. Theobromine on treatment with methyl iodide yields caffeine. Both caffeine and theobromine are also prepared synthetically.

Fresh kola nuts also yield from 0.3 to 0.4 per cent. of a crystalline tannin-containing substance, KOLATIN, which is combined with the caffeine as kolatin-caffeine. The latter is unstable and is easily decomposed on curing or drying the drug. Kolatin resembles pyrocatechin in its reactions and appears to neutralize the physiological action of caffeine, and hence the dried kola nuts are more active than the fresh nuts.

The red color in dried kola seeds is due to an oxydase similar to that which causes the darkening of apples when freshly cut and exposed to the air. If the seeds are first heated in boiling water for 30 minutes and then dried they do not darken.

ALLIED PLANTS.—The seeds of a number of other plants are said to be sometimes admixed with kola, and of these the following may be mentioned: *Cola Ballayi,* a plant growing in the Gaboon, the seeds of which contain six cotyledons and are deficient in alkaloids. The seeds of *Garcinia Cola* (Fam. Guttiferæ) have been substituted for Cola under the name of "Staminate Cola." These seeds do not contain caffeine, but two resins which seem to have a physiological effect similar to Cola. The seeds of *Pentadesma butyraceum*, of Sierra Leone, have also been used as a substitute for Cola; they contain a fat, having a turpentine-like odor, which is used by the natives in place of butter, and hence the tree is known as the "Butter or Tallow tree."

NUX VOMICA.—The dried, ripe seeds of *Strychnos Nux-vomica* (Fam. Loganiaceæ), a small tree native of the East Indies and also found growing in the forests of Ceylon, on the Malabar Coast and in Northern Australia. The fruit is a kind of berry with from three to five seeds, which are freed from the bitter pulp by washing, and dried before exportation (p. 362).

DESCRIPTION.—Orbicular, compressed, concavo-convex, sometimes irregularly bent, margin acute or rounded, 17 to 30 mm. in diameter, 3 to 5 mm. thick; externally grayish-yellow or grayish-green, covered with long hairs giving the seed a satiny luster, sometimes with adhering dark-brown fragments of the fruit pulp, hilum near the center of one side, and a more or less distinct ridge resembling a raphe extending from it to the micropyle; very hard when dry, tough when damp; internally whitish, horny, endosperm in two more or less regular concavo-convex halves, embryo small, situated near the micropyle, and with two heart-shaped cotyledons; inodorous; taste intensely and persistently bitter.

INNER STRUCTURE.—See Figs. 173, 283, *B;* 318.

CONSTITUENTS.—Ash 1 to 4 per cent.; chlorogenic (formerly called igasuric acid), which is a dibasic acid and crystallizes in needles, the solutions giving a green color with ferric chloride; 1.5 to 5 per cent. of alkaloids consisting of strychnine and brucine, the former comprising from one-third to one-half of the total amount. Strychnine crystallizes in rhombic prisms and gives with concentrated sulphuric acid, in connection with potassium dichromate, a blue or violet color. Brucine forms rectangular octohedra and gives a deep-red color with nitric acid. A glucoside, loganin, is present in the seeds in small amount, but it is found in the pulp of the fruit to the extent of 5 per cent. The alkaloids are probably distributed in both the cell-contents and cell wall. Their presence in the wall is shown by the use of iodine solution and in the contents by the use of potassium dichromate and sulphuric acid. The thick cellulose walls give the hard, horny character to these seeds (Fig. 173), as also the date seed. A small amount of starch is found in the fragments of adhering pulp. The seeds are sometimes made to look fresh by the use of a blue dye which is soluble in dilute alcohol.

ALLIED PLANTS.—The seeds of *Strychnos Ignatii,* a woody climber of the Philippine Islands, contain about the same amount of total alkaloids as nux vomica, of which one-third to two-thirds is strychnine. The seeds are irregular, somewhat oblong or ovoid, pebble-like, 20 to 30 mm. long, grayish or brownish-black, more or less translucent, and are nearly free from lignified hairs, such as are found in nux vomica.

PHYSOSTIGMA.—CALABAR BEAN.—The ripe seeds of *Physostigma venenosum* (Fam. Leguminosæ), a woody climber growing in the region of the Gulf of Guinea on the western coast of Africa (p. 298). The seeds are also known as "the ordeal bean of Calabar" (Fig. 189).

DESCRIPTION.—Anatropous, somewhat reniform or irregularly oblong or ellipsoidal, 25 to 30 mm. long, 15 to 18 mm. in diameter, 10 to 15 mm. thick, with a brownish-black groove from 1 to 2 mm. in diameter extending about half-way around the edge, containing the raphe as a narrow line, and in which is frequently found the remains of the white membranaceous funiculus, the micropyle occurring near one end of the groove as a slight depression; seed-coat brownish-red, hard, thick, smooth, but somewhat rough near the groove; reserve layers wanting, embryo large, white, with short hypocotyl and two concavo-convex cotyledons: inodorous; taste starchy.

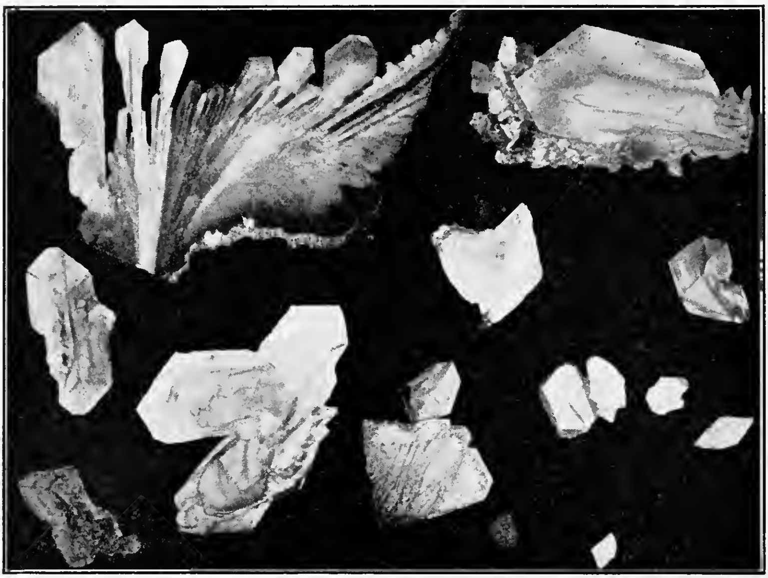


FIG. 189. Physostigmine salicylate: orthorhombic crystals from a solution in chloroform.

Constituents.—Starch about 45 per cent.; proteins about 20 per cent.; fixed oil about 2 per cent.; ash about 3 per cent. Several alkaloids have been isolated, the most important of which is physostigmine (eserine), which occurs in the embryo to the extent of 0.1 to .25 per cent. It crystallizes in rhomboidal plates; has a strong alkaline reaction, is colored red with alkalies and yellow with sulphuric or nitric acid. With the latter reagent the solution changes to olive-green. The aqueous solutions of physostigmine are easily decomposed and a reddish colored substance, rubreserine, separates. The salicylate and sulphate of physostigmine are official, the solutions of the former being more stable. Physostigma also contains eseridine (isophysostigmine), an alkaloid resembling physostigmine in its physiological action; a liquid alkaloid, calabarine, which is physiologically antagonistic to physostigmine, and a crystalline alkaloid, eseramine, which is inactive.

Allied Plants.—The seeds of *P. cylindrospermum* have been substituted for Calabar bean; they are nearly cylindrical and are said also to contain physostigmine.

The lenticular, brown, glossy seeds of *Entada scandens* have been offered as a substitute for physostigma. *Canavalia obtusifolia,* of the East Indies, is also said to have been used as an adulterant of physostigma.

MYRISTICA.—NUTMEG.—The kernel of the seed of *Myristica fragrans* (Fam. Myristicaceæ), a tree indigenous to the Molucca and neighboring islands, and now extensively cultivated in other tropical regions, including the West Indies. The commercial supply is largely derived from the Malay Archipelago, from whence it is shipped to Amsterdam and London. The testa and arillode are removed, the latter constituting mace. With the exception of those from Penang, nutmegs are not infrequently partially coated with lime to protect them from the attacks of insects (p. 277).

Description.—Ellipsoidal, 20 to 30 mm. long, 15 to 20 mm. in diameter; externally light brown, usually whitish from a dressing of lime, reticulately furrowed, at one end a white, smooth projection 3 to 5 mm. in diameter, in the center of which is the micropyle, the chalaza indicated near the other end by a slight, dark depression, from which there extends a more or less distinct furrow indicating the position of the raphe; easily cut, the surface having a waxy luster, and mottled by reason of the light-brown perisperm penetrating into the yellowish-brown endosperm, the shrunken embryo lying in an irregular cavity about 4 or 5 mm. long, near the micropyle; odor and taste aromatic and pleasant.

CONSTITUENTS.—Fixed oil, sometimes occurring in prismatic crystals, 25 to 40 per cent.; volatile oil 8 to 15 per cent. The oil is official as oleum myristicæ and contains myristicin and a number of terpenes. Nutmegs also contain considerable proteins and starch, the latter being colored blue by iodine solutions.

ALLIED PLANTS.—Other species of Myristica yield nutmegs which are used by the natives, as *M. succedanea* of Timor, *M. fatua* of the Indian Archipelago, and *M. Kombo* of Guinea. The kernels of the seeds of *M. fatua* constitute the LONG, WILD, OR MALE NUTMEG. They are narrow-ellipsoidal, feebly aromatic and have a more or less disagreeable taste. The seeds of *M. officinalis* and *M. Bicuhyba* of Brazil have medicinal properties, a balsam being obtained from the latter, which is used as a substitute for copaiba. The so-called African nutmegs derived from *M. surinamensis* of the West Indies soon lose their odorous properties. *M. sebifera* of Guiana yields a fatty oil which has but little odor of nutmeg. Fatty and ethereal oils resembling those of nutmeg are found in the "American nutmegs" obtained from *Cryptocarya moschata* (Fam. Lauraceæ) of Brazil.

ADULTERANTS.—False nutmegs consist of exhausted powdered nutmegs or defective nutmegs and mineral matter.

GOSSYPIUM PURIFICATUM.—PURIFIED COTTON. The hairs of the seeds of *Gossypium hirsutum, G. barbadense,* and other species of Gossypium (Fam. Malvaceæ), biennial or triennial shrubs indigenous to sub-tropical Asia and Africa, and cultivated in all tropical and sub-tropical countries (Fig. 166). The seeds are hand-picked, freed from dust by screens or drums, and the cotton removed in the cotton-gin. It is then freed from mechanical impurities, deprived of fatty and other substances and finally bleached. It is estimated that 1000 million K. of cotton are produced annually. Long staple or sea-island cotton is obtained from *G. hirsutum,* while short staple or upland cotton is derived from *G. barbadense* (p. 329).

DESCRIPTION.—A white, soft tufted mass, consisting of somewhat flattened, twisted and spirally striate, 1-celled, non-glandular hairs, from 2.5 to 4.5 cm. long; inodorous and tasteless.

Absorbent cotton is soluble in ammoniacal solution of cupric oxide, yields less than 1 per cent. of ash, and on treating it with water the solution should have a neutral reaction and not give any reaction with ammonium carbonate, barium chloride, mercuric chloride or silver nitrate.

ADULTERANTS.—Various substances may be added to absorbent cotton to increase the rate of absorption of water, as chlorides of calcium, magnesium and zinc, glycerin and glucose; as loading materials, barium and calcium salts, and clay are added to inferior grades of the article.

The hairs from immature seeds are known as "dead cotton" and are distinguished by having very thin walls, a thin outer layer of cutin, but lack the essential properties for technical uses.

GUARANA.—A dried paste consisting of the crushed seeds of *Paullinia Cupana* (Fam. Sapindaceæ), a climbing shrub native of Brazil and Uruguay. The commercial product is obtained from cultivated plants. The ripe seeds are deprived of the appendage or aril, crushed, made into a doughy mass with water, sometimes tapioca being added to increase the adhesiveness, molded into forms and dried at a gentle heat. During the drying the mass undergoes a kind of curing. Considerable skill is required in supervising the operation, which is performed by special workmen. In addition to its use in medicine, Guarana is used in the preparation of a beverage which is used like tea and coffee by the people of Brazil (p. 324).

DESCRIPTION.—Cylindrical sticks, 15 to 30 cm. long, 35 to 50 mm. in diameter; externally blackish-brown, surface marked by depressions, but otherwise smooth; hard, heavy and brittle, the fracture being uneven; internally light brown to reddish-brown, somewhat variegated from the fragments of contused seeds; odor slight; taste astringent, bitter.

CONSTITUENTS.—Caffeine 2.5 to 5 per cent.; tannin (catechutannic acid) about 25 per cent.; ash about 2 per cent. Guarana also contains considerable starch, a small amount of catechin, a volatile oil, an acrid, green fixed oil, and saponin. (Also see Cola.)

MACIS.—MACE.—The arillode of the seed of *Myristica fragrans* (Fam. Myristicaceæ). (See Nutmeg.) According to Warburg the arillode arises in the region of the hilum before the flower opens and fertilization is effected (p. 277).

DESCRIPTION.—In coarsely reticulate bands about 1 mm. thick, the whole having the outline of the nutmeg, the basal portion

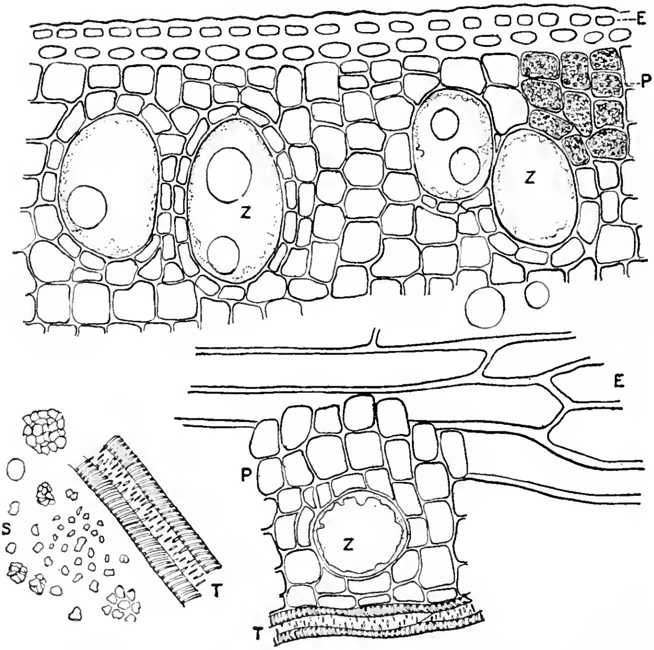


FIG. 190. Mace: E, epidermal cells, which in transverse section are nearly isodiametric, but in longitudinal section are elongated, sometimes being 1 mm. in length; P, parenchyma cells with small starch grains which are colored reddish with iodine; Z, large oil cells showing oil globules and protoplasmic contents lining the walls; T, tracheæ; S, small, irregular starch grains.

united, but with a small, irregular opening; usually in compressed, nearly entire pieces, reddish or orange-brown, somewhat translucent, brittle when dry; odor and taste aromatic.

INNER STRUCTURE.—See Fig. 190.

CONSTITUENTS.—An aromatic balsam 24.5 per cent.; volatile oil 4 to 7 per cent. and resembling that obtained from nutmegs but containing a larger percentage of terpenes; fixed oil, and considerable starch, which is colored red by iodine solution, distinguishing it from nutmeg starch. Mace also contains from 2 to 4 per cent. of a dextrogyrate sugar.

True mace should yield from 20 to 30 per cent. of non-volatile ether extract, from 20 to 30 per cent. of starch, and not more than 3 per cent. of ash.

ALLIED PLANTS.—Macassar or Papua mace, derived from *Myristica argentea*, is somewhat darker and with broader segments than true mace. It gives a cherry-red color with concentrated sulphuric acid, is very pungent and yields over 50 per cent. of non-volatile ether extract, and less than 10 per cent. of starch.

Bombay mace, or wild mace, is the product of *Myristica malabarica;* it is distinguished from true mace in that the entire mace is narrow-ellipsoidal, the reticulations are not so coarse, the apex is divided into numerous narrow lobes, and it is darker in color. With alkalies or sulphuric acid wild mace assumes a darker color than the true mace does. It is slightly aromatic, but has little value as a spice, and yields nearly 60 per cent. of non-volatile ether extract.

II. ROOTS AND RHIZOMES.

Roots and rhizomes represent those parts of plants which develop under ground, the latter having all of the characteristics of stems except their manner of growth. Most drugs derived from roots and rhizomes possess the typical characteristics of these plant parts, the commercial products being readily distinguishable as such. There are some, however, that are more or less intermediate in character, and, while commonly spoken of as roots, they are in reality modifications of the stem, at least in part, as aconite, gelsemium, glycyrrhiza and rhubarb. For this reason, and in order to facilitate their study, roots and rhizomes are here considered in one class, which is subdivided as follows: (1) True Roots; (2) Rhizomes that are root-like, at least in part; (3) True Rhizomes; (4) Corms; (5) Bulbs.

Some of the roots and rhizomes that are employed in medicine are prepared for market by removing a part of the periderm; in a general way this treatment is objectionable, particularly in the case of those drugs containing volatile principles, as these exist in greatest amount in the cortical portion, and the periderm serves to prevent the volatilization as well as deterioration of these principles.

Rhizomes are distinguished as upright. horizontal or oblique, depending upon their manner of growth, and this may be determined in the drug by placing the rhizome in such a position that the stem-scars are horizontal.

I. True Roots.

1. Monocotyledons ....Sarsaparilla
2. Dicotyledons.
   A. Periderm removed ....Althæa
   B. Periderm present.
      a. Roots nearly entire.
         Tuber-like ....Jalapa
         Long, thin and of a reddish color.........Krameria
         Fusiform, very acrid....................Pyrethrum
         Keeled, crown knotty......................Senega
         Fusiform, small, yellowish central wood..Taraxacum
      b. Roots cut into transverse pieces.
         Yellowish-green disks ....Calumba
         Concentric zones of collateral fibrovascular bundles ....Pareira
         Bark soft, spongy and finely fibrous.......Stillingia
         Very light in weight, wood large with fibers interlacing ....Sumbul
      c. Roots cut into longitudinal pieces.
         Characteristic odor and taste.....Belladonnæ Radix
         Horny, tough, pith white....................Lappa
         Ribbon-like slices, very fibrous..........Phytolacca
      d. Roots more or less broken into pieces.
         Bark transversely fissured and easily separable from the wood..............Apocynum
         Somewhat tortuous, bark irregularly annulate and sometimes transversely fissured ....Ipecacuanha

II. Rhizomes that are Root-like.

A. Periderm removed.

Yellowish, fibrous, taste sweetish......Glycyrrhiza (Russian)
Reddish-brown, heavy, granular.....................Rheum

II. Rhizomes that are Root-like.—*Continued.*

B. Periderm present.

Tuber-like .... Aconitum
Cylindrical, fracture tough, wood whitish.......... Gelsemium
Cylindrical pieces, tough, wood yellowish........... Berberis
Annulate above, odor characteristic.................. Gentiana
Fibrous, taste sweetish................ Glycyrrhiza (Spanish)

III. True Rhizomes.

1. Filices .... See Aspidium
2. Monocotyledons.
   A. Periderm removed .... Zingiber
   B. Periderm present.
   a. Rhizome and roots.
   α Horizontal in growth.
   Light brown, few roots............. Convallaria
   Dark brown with densely matted roots .... Cypripedium
   Small pieces, grass-like, hollow in the center .... Triticum
   β Rhizome upright................ Veratrum Viride
   b. Rhizome without roots..................... Calamus
3. Dicotyledons.
   a. Rhizome with roots.
   α Rhizome horizontal.
   Numerous upright or curved branches and few roots....................... Cimicifuga
   Internally deep yellow................... Hydrastis
   Light brown and with numerous coarse roots .... Leptandra
   β Rhizome oblique.
   Odor terebinthinate .... Serpentaria
   Odor aromatic .... Spigelia
   γ Rhizome upright .... Valeriana
   b. Rhizome without roots.
   α Entire rhizomes.
   Tuberculate .... Geranium
   Prominent seal-like stem-scars........ Podophyllum
   Internally with reddish resin cells...... Sanguinaria
   β Longitudinal pieces .... Scopola

IV. Corm.

Transverse reniform disks .... Colchici Cormus

V. Bulb.

Narrow, light yellow pieces............................... Scilla

SARSAPARILLA.—The dried root of various species of Smilax (Fam. Liliaceæ), perennial climbers indigenous from Mexico to Brazil (p. 238). There are four principal commercial varieties: (1) HONDURAS sarsaparilla yielded by *Smilax offici-*

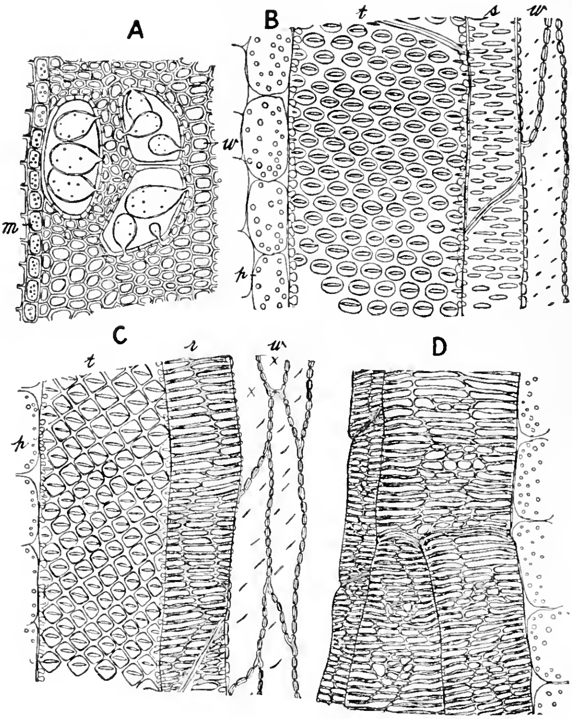


FIG. 191. Different kinds of tracheæ. A, transverse section of stem of grape-vine (*Vitis vinifera*) showing three tracheæ from the older wood containing tyloses. w, wood fibers; m medullary rays. The tyloses or thyllen, are in the nature of ingrowths from the wood fibers and protrude through the adjoining pores, at the end of the season's growth closing the cavities of the tracheæ. B, longitudinal section of belladonna root showing a large trachea with bordered pores (t), a trachea with simple pores (s), wood fiber with oblique pores (w) and parenchyma (p) containing starch. C, longitudinal section of phytolacca root showing a trachea with bordered pores (t), trachea with reticulate thickening (r), wood fibers (w) and parenchyma (p) containing starch. D, longitudinal section of scopola rhizome showing reticulate tracheæ and parenchyma containing starch.

nalis, growing in Guatemala, Honduras and Nicaragua, and exported from Honduras and Belize; (2) PARA sarsaparilla, yielded by *Smilax papyracea*, growing in the upper Amazon region, and exported from Para; (3) MEXICAN sarsaparilla, yielded by *Smilax medica* (Fig. 131), growing in Mexico, and exported from Vera Cruz and Tampico, and (4) Jamaica or Central American sarsaparilla, derived from *Smilax ornata,* growing in the United States of Colombia, Costa Rica and Nicaragua, and shipped to Jamaica, from whence it is exported—chiefly to London. There is also a native Jamaica sarsaparilla which is obtained from plants cultivated in Jamaica. The Honduras and Mexican varieties are chiefly used in this country, although Para sarsaparilla has been employed to a certain extent for years.

Description.—Honduras Sarsaparilla.—In bundles about 1 M. in length and from 8 to 15 cm. in diameter, consisting of

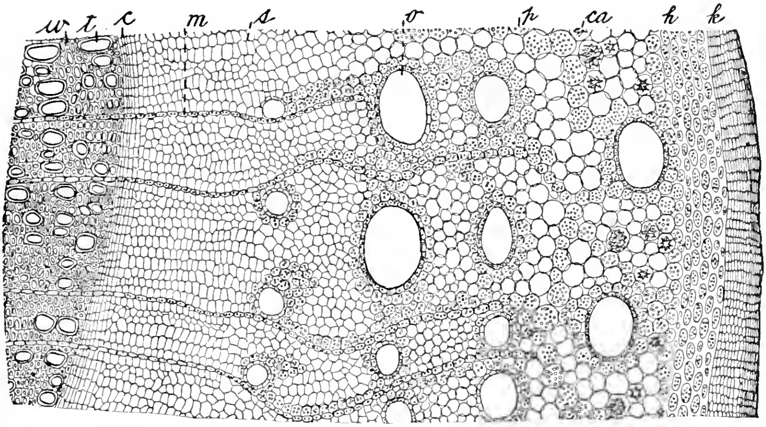


Fig. 192. Transverse section of American sarsaparilla (rhizome of *Aralia nudicaulis*) showing cork (k), hypodermis (h), rosette aggregates (ca) of calcium oxalate (75 μ in diameter), parenchyma (p) containing angular starch grains (3 to 10 μ in diameter), oil secretion reservoirs (o), sieve (s), medullary rays (m), cambium (c), tracheæ (t), wood fibers (w).

the long, folded roots, and rhizomes, bound together by roots of the same plant or stems of some other plant, the ends of the bundles rarely being trimmed at the present time: roots about 2 M. long and uniformly about 2 to 6 mm. in diameter; externally dark or reddish-brown, longitudinally furrowed, minutely hairy and having slender rootlets, the furrows usually free from soil; fracture fibrous; internally consisting of a white pith, a light-yellow, porous, central cylinder and a grayish-white or dark-brown cortex, the latter being lighter and more starchy near the growing end, and darker (more resinous) near the union with the rhizome; odor slight; taste slightly acrid (Fig. 193).

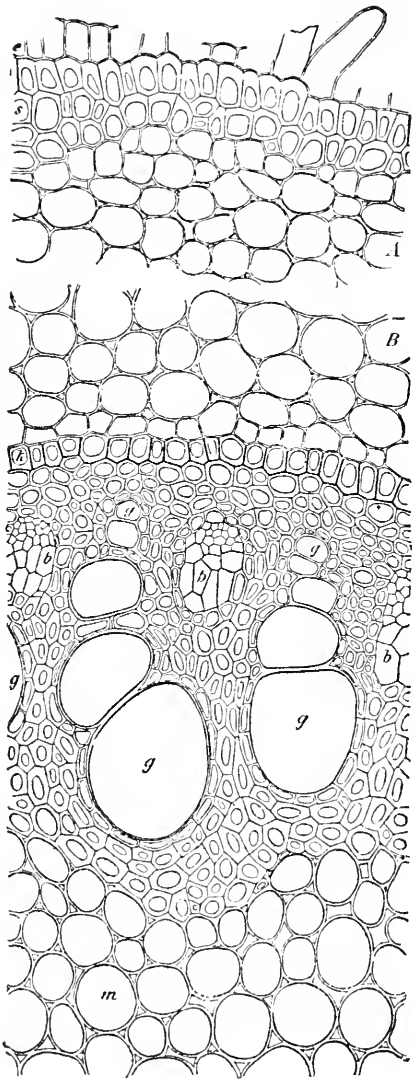


FIG. 193. Transverse section of Honduras sarsaparilla in which the middle portion of the cortex is omitted; e, epidermis with root hairs; s, hypodermis; A, outer portion of cortex; B, inner portion of cortex; k, endodermis; g, trachea; b, sieve cells; m, parenchyma at the center of the root. The thick-walled cells around the tracheæ and sieve cells are sclerenchyma fibers.—After Luerssen.

The cells of the endodermis and hypodermis are oblong in transverse section and nearly uniformly thickened (Fig. 194).

MEXICAN SARSAPARILLA.—In bundles, with the roots usually more or less free; the latter grayish-brown, somewhat shrunken, the furrows containing larger or smaller amounts of

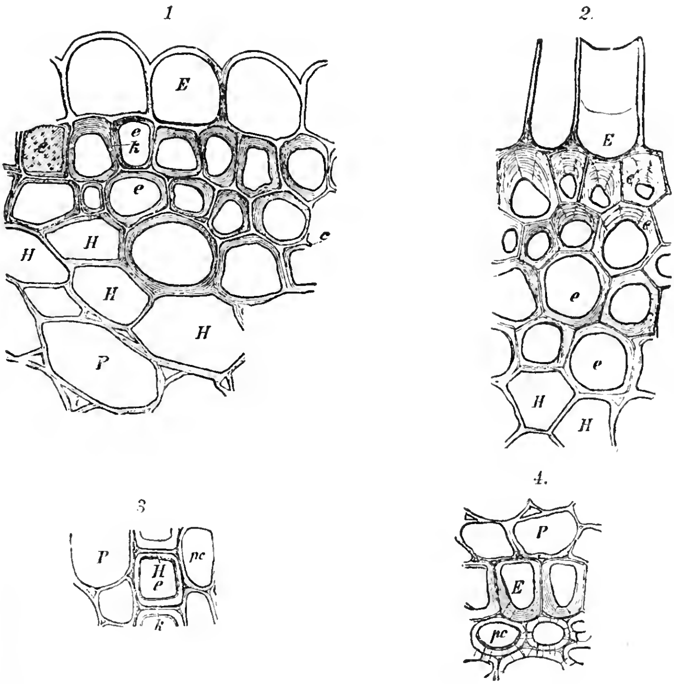


FIG. 194. 1, transverse section of Honduras sarsaparilla showing the hypodermal cells (e) with cork lamellæ (k); 2, similar section of Mexican sarsaparilla; 3, transverse section of Honduras sarsaparilla showing endodermal cells (e) with cork lamellæ (k) and lignified walls (H); 4, similar section of Mexican sarsaparilla showing endodermal cells (E).—After Meyer.

soil. The outer walls of the cells of the hypodermis and the inner walls of the cells of the endodermis are considerably thickened (Fig. 194.)

PARA SARSAPARILLA.—Closely resembling Honduras sarsaparilla in structure, but coming into market in the form of rather large bundles, closely bound by means of the stem of a vine, and the ends evenly trimmed.

Jamaica Sarsaparilla occurs in rather loose bundles. The roots are especially marked by the numerous coarse rootlets. The cells of the hypodermis and endodermis somewhat resemble those of Mexican sarsaparilla.

Constituents.—Sarsaparilla contains three glucosidal principles, which are present to the extent of about 3 per cent.—parillin, saponin and sarsosaponin, of which the latter is the most active; it also contains about 15 per cent. of starch; raphides of calcium oxalate; volatile oil, and resin.

Allied Products.—American Sarsaparilla is the rhizome of wild or Virginia sarsaparilla (*Aralia nudicaulis,* Fam. Araliaceæ), a perennial acaulescent herb, indigenous to Canada and the Northern United States as far west as Nebraska. The rhizome is of variable length, from 5 to 15 mm. thick; externally brownish-gray and somewhat annulate; internally light brown, more or less spongy, and having an aromatic odor and taste. It contains about 0.33 per cent. of a volatile oil, which is bitter and pungent; 3 per cent. of resin; tannin, starch and rosette aggregates of calcium oxalate (Fig. 192).

The rhizome and roots of American spikenard (*Aralia racemosa*), growing in the Eastern and Central United States, have constituents similar to those of *A. nudicaulis,* but are more aromatic. The bark of Hercules' Club (*Aralia spinosa*), of the Eastern and Central United States, contains the glucoside araliin and possibly also saponin.

The roots of *Cocculus villosus* (Fam. Menispermaceæ) are used in the East Indies like sarsaparilla.

ALTHÆA.—MARSHMALLOW.—The dried root of *Althæa officinalis* (Fam. Malvaceæ), a perennial herb (p. 329) native of Central and Southern Europe, and naturalized in the United States in the marshes from Massachusetts to Pennsylvania. The commercial supply is obtained from plants cultivated in Germany, France and Holland. The roots are collected from plants of the second year's growth, and the periderm and rootlets are removed.

Description.—Nearly entire, cylindrical, tapering, 10 to 20 cm. long, 5 to 20 mm. in diameter; externally very light brown, obscurely 4- to 6-angled, deeply furrowed longitudinally, covered with detachable bast fibers, with few circular root-scars; fracture of bark tough, fibrous, of wood short and granular; internally light brown, finely radiate, bark 0.5 to 2 mm. thick, and easily separable from the wood, cambium zone marked by a distinct brown line, wood porous; odor faint, aromatic; taste sweetish, mucilaginous (Fig. 99, *B*).

Constituents.—Mucilage 25 to 35 per cent.; asparagin (amido-succinamide) 1 to 2 per cent., which occurs in hard crystals with an acid reaction, insoluble in alcohol but soluble in 50 parts of cold water; starch about 35 per cent.; pectin about 10 per cent.; sugar about 10 per cent.; ash about 5 per cent. An infusion of althæa is colored bright yellow with dilute solutions of the alkalies.

Allied Plants.—The roots of a number of other genera of this family are used for similar purposes, as those of *Kosteletzyka pentacarpa* of Southern Europe; *Hibiscus Bancroftianus* of the West Indies; *Malvaviscus pentacarpus* of Mexico; *H. Rosa Sinensis* of tropical Asia and cultivated; *Althæa rosea* of the Levant and cultivated; and *Sida ovalis* of Peru. Mucilage is also found in the flowers and leaves of one or more species of *Malva, Sida, Pavonia, Hibiscus, Pachira* and *Eriodendron.*

JALAPA.—JALAP.—The tuberous root or tubercle of *Exogonium Purga* (Fam. Convolvulaceæ), a perennial twining herb (p. 365) native of the eastern slopes of the Mexican Andes, and cultivated in Jamaica and India. The roots are collected in the fall and dried by artificial means, the larger ones being first cut into longitudinal pieces. Mexico furnishes the principal part of the commercial supply, which is exported from Vera Cruz.

Description.—Fusiform, irregularly ovoid or pyriform, upper end more or less rounded, lower end obtuse or slightly acuminate; 3 to 8 cm. long, 1 to 5 cm. in diameter; externally dark brown, deeply and irregularly furrowed longitudinally, otherwise nearly smooth or wrinkled, with numerous lenticels 2 to 4 mm. long and few circular rootlet-scars; fracture horny and resinous; internally dark brown and marked by more or less distinct, secondary, concentric cambium zones; odor fruity; taste starchy and slightly acrid.

Tubercles which have a specific gravity less than 1.275 and are white internally should be rejected.

Inner Structure.—See Fig. 195.

CONSTITUENTS.—Resin 8 to 12 per cent., 85 to 90 per cent. of which is insoluble in ether. Power and Rogerson (*J. Am. Chem. Soc.*, 32, 1910, p. 80) isolated from the ethereal extract of the resin a new dihydric alcohol (ipurganol) which crystallizes in colorless needles and yields color reactions similar to those given by the phytosterols. From the chloroform extract they isolated a small amount of β-methylæsculetin. The petroleum ether extracts showed the presence of palmitic and stearic acids in the free state. On treatment with alkalies and dilute sulphuric acid some of the extracts of the resins yield a number of acids and there are indications that a portion of the chloroform extract of the resins is

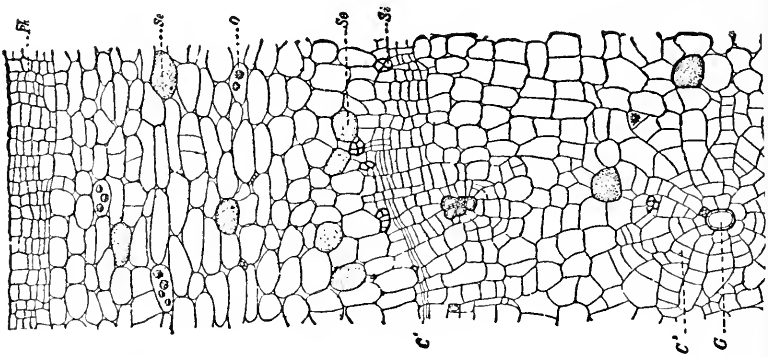


FIG. 195. Transverse section of jalap: Ph, cork cells; Se, resin cells; O, rosette aggregates of calcium oxalate; Si, sieve cells; G, tracheæ; C[1], primary cambium; C[2], secondary cambium.—After Meyer.

of a glucosidal nature. The alcohol extract of the resin, which represented 38.8 per cent. of the total resin, was obtained, after treatment with animal charcoal, in the form of a nearly white powder. When subjected to alkaline hydrolysis with baryta, this alcohol extract yielded a number of organic acids together with a hydrolyzed resin of very complex composition. Jalap also contains a volatile oil, calcium oxalate, starch, gum and sugar.

ALLIED PLANTS.—Turpeth root or Indian Jalap is the root of *Operculina Turpethum*, a plant growing in the East Indies. It contains a resin consisting chiefly of turpethin and turpethein, a glucosidal, ether-soluble resinoid substance.

Male Jalap or Orizaba is the root of *Ipomœa orizabensis*, a plant indigenous to Mexico. The drug consists of the entire, spindle-shaped roots, or of more or less rectangular pieces, and contains about 10 per cent. of scammonin.

Ipomœa simulans, indigenous to the eastern slope of the Mexican Andes, yields the Tampico jalap, which is more or less uniform in thickness, somewhat tortuous, and without any lenticels; it contains about 10 per cent. of resin, which is completely soluble in ether and resembles scammonin.

Wild jalap is the tuberous root of *Ipomœa pandurata,* a plant growing in the Eastern and Southern United States. It contains 1.5 per cent. of an active resin.

From the aerial stems of the common morning glory (*Ipomœa purpurea* Roth) Power and Rogerson (*Am. Jour. Pharm.*, 80, 251, 1908) isolated a volatile oil and 4.8 per cent. of a soft resin of which 15.5 per cent. is soluble in ether.

The roots and stems of *Ipomœa fistulosa,* of South America, yield 0.2 per cent. of jalapin (orizabin), a hexose, wax and tannin.

KRAMERIA.—RHATANY.—The dried root of various species of *Krameria* (Fam. Leguminosæ), small shrubs indigenous to South America, Mexico and the West Indies (p. 295). There are three principal commercial varieties: (1) Peruvian Rhatany, which is derived from plants of *Krameria triandra,* growing in Peru and Bolivia; (2) Savanilla Rhatany, which is derived from more or less disputed species of Krameria (*K. Ixina*), growing in the United States of Colombia, British Guiana and Brazil, and (3) Para or Brazilian Rhatany, which is supposed to be derived from *Krameria argentea,* growing in Brazil.

Peruvian Rhatany.—Consisting of a more or less cylindrical crown 50 mm. long and 15 to 20 mm. in diameter, and numerous cylindrical, somewhat tapering, branching roots 10 to 40 cm. long and 1 to 7 mm. thick; externally brownish-red; crown with rugged and scaly bark; roots smooth or slightly wrinkled longitudinally; fracture of bark slightly fibrous, of wood, tough and splintery; internally reddish, bark 1 to 2 mm. thick, somewhat easily separable from the lighter colored, slightly radiate wood; odor slight; wood nearly tasteless, bark astringent (Fig. 196).

Savanilla Rhatany.—Crown more or less cylindrical or spherical, rough, knotty; root externally dark reddish-brown, somewhat purplish, with numerous transverse fissures at more or

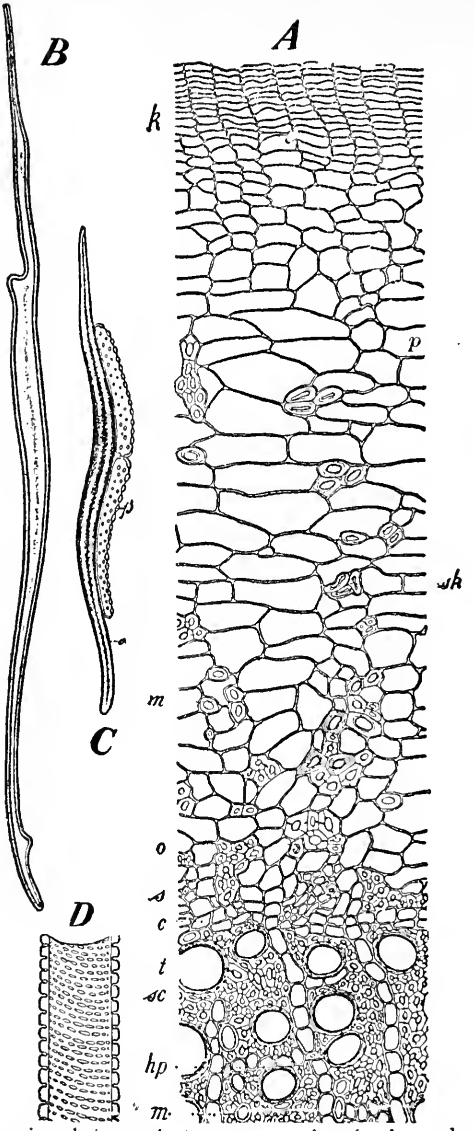


FIG. 196. Peruvian rhatany: A, transverse section showing cork (k), a group of bast fibers (sk), parenchyma of cortex (p), one cell near the middle containing a monoclinic prism of calcium oxalate (o), medullary-ray cells of bark (m), cambium (c), tracheæ (t), wood fibers (sc), wood parenchyma (hp), medullary-ray cells (m); B, bast fiber; C, wood fiber with neighboring parenchyma cells which are somewhat elongated and have somewhat thickened, porous walls; D, trachea.—After Meyer.

less regular intervals; periderm not scaly; bark about twice as thick as that of Peruvian rhatany.

PARA RHATANY closely resembles the Savanilla variety.

CONSTITUENTS.—Tannin from 8 to 20 per cent., krameric acid, starch, an uncrystallizable sugar, and calcium oxalate. The tannin is colored dark green with ferric salts and is in the nature of a glucoside resembling the one found in *Potentilla Tormentilla* (Fam. Rosaceæ) and *Æsculus Hippocastanum* (Fam. Hippocastanaceæ). The tannin also yields phloroglucin and protocatechuic acid.

The tincture of Savanilla rhatany forms a clear solution with water, which gives with alcoholic lead acetate test-solution a purplish precipitate and a colorless filtrate; the tincture of Peruvian rhatany forms a cloudy mixture with water, and gives with alcoholic lead acetate test-solution a reddish-brown precipitate and a light-brown filtrate.

ALLIED PLANTS.—*Krameria lanceolata* of the Southern United States furnishes the TEXAS krameria, and *K. cistoides* of Chile is the source of the PAYTA krameria. The root of *Leea speciosa* (Fam. Vitaceæ) of India has been used as a substitute for Krameria.

PYRETHRUM.—PELLITORY.—The root of *Anacyclus Pyrethrum* (Fam. Compositæ), a perennial herb indigenous to Northern Africa and Southern Europe (p. 394), the commercial article coming from Algeria. The root is collected in autumn and dried.

DESCRIPTION.—Nearly cylindrical, slightly tapering, or broken into irregular pieces, 2.5 to 10 cm. long, 3 to 20 mm. in diameter; externally dark brown, wrinkled and somewhat furrowed longitudinally, with few rootlets or rootlet-scars; crown somewhat annulate from scars of bud-scales, and sometimes tufted with coarse fibers of fibrovascular tissue or with long, soft-woolly, nearly straight, one-celled hairs; fracture short and horny when dry, tough when damp; bark dark brown internally, with two circular rows of secretion reservoirs, 0.5 to 1 mm. thick, and closely adhering to the light-yellow, radiate, porous wood, in the medullary rays of which secretion reservoirs are also found; odor distinct, penetrating; taste pungent, acrid.

Inner Structure.—See Fig. 101, *E*.

Constituents.—An alkaloid pyrethrine, which occurs in colorless, acicular crystals, has an intense pungent taste, and which is decomposed by alkalies into piperidine (a pungent principle occurring in black pepper) and pyrethric acid, a principle resembling piperic acid. Pyrethrum also contains a brown acrid resin, two other acrid resins, a volatile oil and about 50 per cent. of inulin.

Allied Plants.—German pellitory, the root of *Anacyclus officinarum*, is smaller; the bark contains but one row of secretion reservoirs, which are wanting in the medullary rays; and the roots contain tannin in addition to the constituents found in Pyrethrum.

SENEGA.—SENEGA ROOT.—The dried root of *Polygala Senega* (Fam. Polygalaceæ), a perennial herb (p. 313) found in Canada and the Eastern United States as far south as North Carolina and as far west as Minnesota and Missouri (Fig. 197). There are two representative commercial varieties—the northern, collected in Manitoba and in the State of Minnesota; the southern, from Virginia to Texas.

Description.—Southern Senega.—Nearly entire, with broken and detached rootlets, crowned with numerous buds and short stem-remnants, slenderly conical, more or less tortuous, somewhat branched, 3 to 8 cm. long, 2 to 6 mm. thick; externally dark yellow, the crown being rose-tinted, longitudinally wrinkled, slightly annulate, marked with circular scars of detached rootlets and in some cases by a keel which is more prominent near the crown and in perfectly dry roots; side opposite keel more or less flattened; cross-section elliptical or triangular; fracture short when dry, tough when damp; internally, wood lemon-yellow, 2 to 5 mm. in diameter, usually excentral, bark dark yellow, much thickened on one side, forming the keel on drying; odor slight, penetrating; taste sweetish and acrid (Fig. 197).

Manitoba Senega is 8 to 15 cm. long, 6 to 12 mm. thick, externally dark brown and somewhat purplish near the crown.

Constituents.—The principal constituents are about 5 or 6 per cent. of two glucosides: senegin, which resembles saponin, and polygalic acid, which is sternutatory. The root also contains 0.12 per cent. of a volatile oil which is chiefly methyl salicylate; resin, pectin, sugar and considerable proteins.

Allied Plants.—Saponin-like substances and methyl salicylate are found to a greater or less extent in other species of Polygala, of which at least forty have been used in medicine. Other genera of the Polygalaceæ seem to have constituents similar to Senega, as Comesperma of Australia and Monnina of South America.

Adulterants.—The rhizomes and roots of *Cypripedium hirsutum* and *C. spectabile* of the United States are said to be sometimes used as adulterants of Senega (Fig. 213).

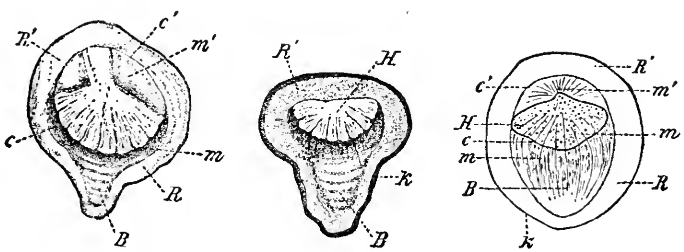


Fig. 197. Transverse sections of senega, the two on the left being of the dry drug, and the one on the right showing the appearance after soaking the material in water: R, outer bark; R^1, bark on the side having abnormal development of wood; B, inner bark, which gives gives rise to the "keel" on the drying of the root; H, wood; C, C^1, cambium; m, medullary rays; m^1, parenchyma developed in place of wood on one side.—After Meyer.

TARAXACUM.—DANDELION.—The root of *Taraxacum officinale* (Fam. Compositæ), a perennial herb indigenous to Europe and Asia, but now naturalized in all civilized parts of the world (p. 392). The root should be collected in spring or in autumn either directly before or directly after the vegetative activity of the plant. It is used in either the fresh or dried condition, the principal supply of the dried root coming from Europe. The pith of the rhizome portion is liable to be attacked by insects.

Description.—Somewhat cylindrical, tapering, more or less flattened, slightly branched or broken into irregular pieces 6 to 15 cm. long, 5 to 15 mm. in diameter; externally light brown, wrinkled, with numerous rootlet-scars; crown simple or branched, slightly annulate from numerous leaf-bases; fracture short, horny when dry, tough when damp; internally, bark light brown, 2 to 6 mm. thick, made up of concentric layers of laticiferous vessels and sieve alternating with white parenchyma, wood lemon-yellow, 1 to 4 mm. thick, porous and non-radiate; odor slight; taste bitter.

INNER STRUCTURE.—See Figs. 101, *D;* 197a.

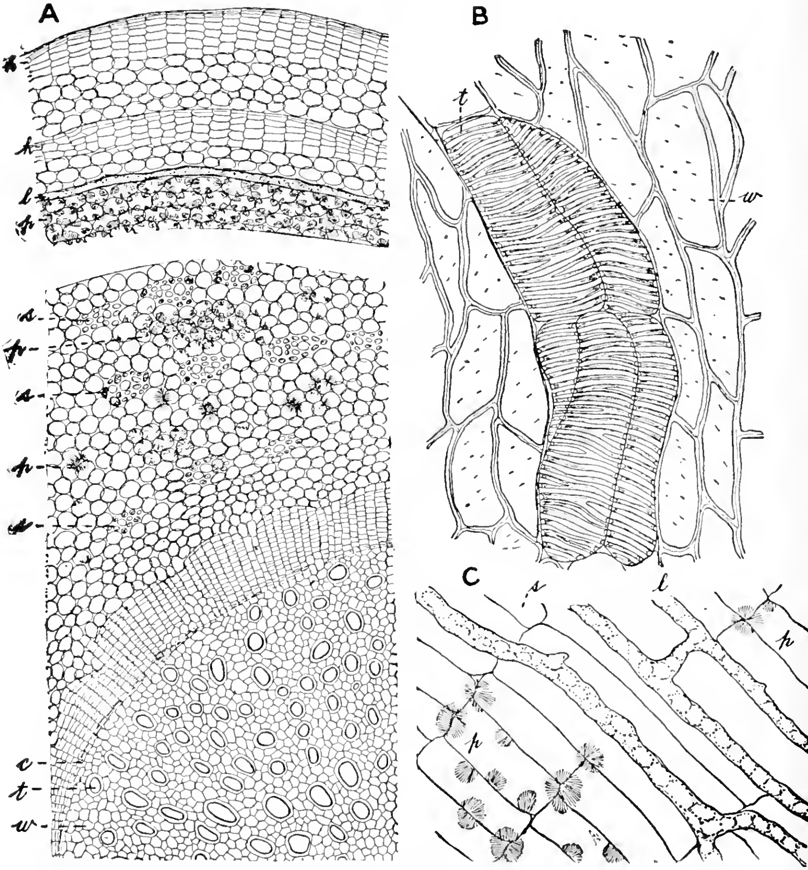


FIG. 197a, Taraxacum: A, transverse section of root showing cork (k), parenchyma containing inulin (p), laticiferous vessels (l), phloem groups (s) composed of sieve and laticiferous vessels, cambium (c), tracheæ (t), modified, non-lignified wood-fibers (Ersatzfasern) (w); B, longitudinal section of xylem showing several of the reticulate tracheæ and the modified wood-fibers with oblique pores that are apparent in preparations made with chlor-zinc-iodide; C, longitudinal section of a phloem group showing branching laticiferous vessels (l), sieve cells (s), containing sphere crystals of inulin.

CONSTITUENTS.—The drug contains about 0.05 per cent. of a bitter principle, taraxacin, which gives reactions with certain of the alkaloidal reagents; it also contains two resins, one soluble in alcohol and the other in chloroform; a waxy substance, taraxacerin; 24 per cent. of inulin; and about 5 per cent. of ash.

CALUMBA.—COLUMBO.—The root of *Jateorhiza palmata* (Fam. Menispermaceæ), a perennial herbaceous climber, native of

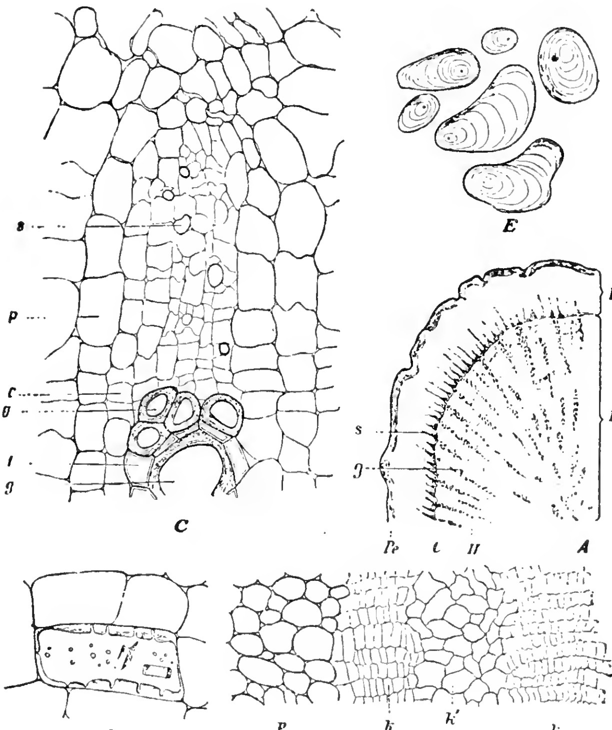


FIG. 198. Calumba: A, transverse section showing bark (R), cambium (C), and wood (H), wood fibers (II), tracheæ (g), periderm (Pe) and sieve (s); B, longitudinal section of periderm showing parenchyma (p), small-celled cork (k) and large-celled cork (k^1); C, transverse section near cambium showing tracheæ (g, g), intermediate fiber (f) cambium (c), parenchyma (p) and sieve cell (s); D, stone cell from the periderm containing calcium oxalate.—After Meyer.

the forests of Eastern Africa (p. 274). The large, fleshy roots are collected in the dry season, cut into transverse pieces, dried and exported by way of Zanzibar and Bombay.

DESCRIPTION.—In nearly circular or elliptical disks, sometimes irregularly bent, 2 to 5 cm. in diameter, 2 to 10 mm. thick;

bark externally yellowish-green or dark brown, wrinkled; fracture short, mealy; internally, radiate, yellowish-green, collateral wood bundles forming a concentric zone, bark 4 to 6 mm. thick. cambium zone distinct, center either depressed or more or less prominent; odor slight; taste bitter and aromatic.

INNER STRUCTURE.—See Fig. 198.

CONSTITUENTS.—Two yellowish alkaloids, closely resembling berberine and varying from 0.98 to 1.38 per cent. in the bark and 1.02 to 2.05 in the wood. To one of these bases the name columbamine has been given. Calumba also contains a volatile oil 0.0056 per cent., starch about 35 per cent, pectin 17 per cent., resin 5 per cent., calumbic acid, calcium oxalate, mucilage, and yields 6 per cent. of ash.

SUBSTITUTES.—Various substitutes for calumba have been offered, but these are free from starch, or they may contain tannin, as American columbo, the root of *Frasera carolinensis* (Fam. Gentianaceæ), an herb indigenous to the Eastern United States. This root formerly occurred in the market in transverse disks somewhat resembling calumba, but without the radiate structure. It contains a larger amount of a yellow coloring principle and less gentiopicrin than gentian.

ADULTERANTS.—Calumba has been adulterated with the roots of *Tinospora Bakis* of tropical Africa and *Coscinum fenestratum* (both of the Fam. Menispermaceæ), the latter growing in India. The disks are woody, the center being prominent and not depressed, and the ash varies from 11.9 to 16.6 per cent.

PAREIRA.—PAREIRA BRAVA.—The root of *Chondrodendron tomentosum* (Fam. Menispermaceæ), a perennial climber indigenous to Brazil and Peru (p. 274). The commercial article is exported from Rio Janeiro.

DESCRIPTION.—Nearly cylindrical, more or less tortuous, cut into pieces of various lengths, usually from 10 to 20 cm. long and 10 to 30 mm. in diameter, rootlets few; externally brownish-black, longitudinally furrowed and transversely ridged and fissured, with numerous rootlet-scars and occasional grayish patches of lichens; fracture fibrous, lustrous when cut; internally dark brown, with three or more irregular, excentral and distinctly radiate, concentric zones of secondary fibrovascular bundles, each 2 to 3 mm. wide, and separated by distinct, concentric zones of parenchyma and stone cells; odor slight; taste slightly bitter.

CONSTITUENTS.—An alkaloid pelosine (cissampeline) about 1 per cent., somewhat resembling beberine in bebeeru bark (*Nectandra Rodiæi*, one of the Lauraceæ) and buxine in box wood (*Buxus sempervirens*, one of the Sapindaceæ); starch, tannin, wax, ash 4 to 5 per cent.

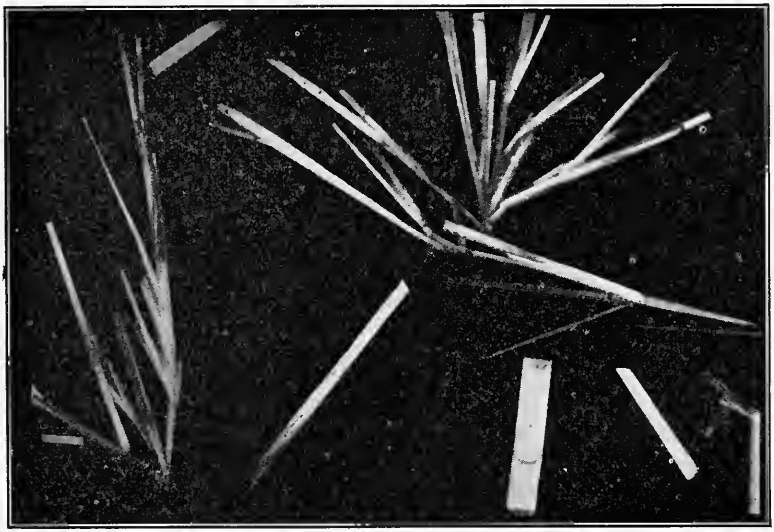


FIG. 199. Atropine: long orthorhombic prismatic crystals from an alcoholic solution.

SUBSTITUTES.—Other roots are frequently substituted for genuine pareira brava, which are no doubt derived from other menispermaceous plants; these roots are of a brownish color, possess numerous concentric zones of fibrovascular bundles, and do not have a waxy luster when cut.

FALSE PAREIRA is obtained from a related species (*Cissampelos Pareira*), growing in South America, West Indies and East Indies. The root is somewhat flattened, externally dark brown, internally yellowish-brown, free from the concentric zones of wood bundles, and contains about 0.5 per cent. of pelosine.

The stems of *Chondrodendron tomentosum* are also sometimes found in the drug; these are more woody, possess a distinct pith and are marked externally by the apothecia of lichens.

The roots of several other plants of this family are used as substitutes for pareira, among which may be mentioned *Chondrodendron platyphyllum* of Brazil and Paraguay, and *Stephania discolor* of India. White Pareira is obtained from *Abuta rufescens,* the roots of which are whitish or pale yellow and very starchy. Yellow Pareira is obtained from *A. amara.* The root is bright yellow internally, very bitter and apparently contains alkaloids resembling beberine and berberine.

STILLINGIA.—QUEEN'S ROOT.—The root of *Stillingia sylvatica* (Fam. Euphorbiaceæ), a perennial herb (Fig. 162) indigenous to the Southern United States (p. 314). The root is collected in August; it is deprived of its rootlets, cut into transverse pieces and carefully dried.

DESCRIPTION.—Cylindrical, tapering, and slightly branched, about 40 cm. long; usually cut into pieces 2 to 10 cm. long, 5 to 30 mm. in diameter; externally dark brown, longitudinally wrinkled, rootlets or rootlet-scars few; fracture of bark fibrous; internally, bark light reddish-brown, 0.5 to 4 mm. thick, soft, spongy, with numerous resin cells and easily separable from the porous, radiate wood; odor faint; taste bitter, acrid and pungent.

CONSTITUENTS.—A volatile oil with the odor and taste of the root from 3 to 4 per cent.; an acrid resin sylvacrol; an acrid fixed oil; 10 to 12 per cent. of tannin; starch; calcium oxalate; ash about 5 per cent.

SUMBUL.—The dried rhizome and root of *Ferula Sumbul* (Fam. Umbelliferæ), a perennial herb indigenous to Turkestan (p. 352). The drug is exported by way of St. Petersburg, and is commonly known as musk-root.

DESCRIPTION.—In cylindrical, sometimes branched, transverse segments, 3 to 10 cm. long and 1.5 to 7 cm. in diameter, very light; externally light to dark brown, distinctly annulate, periderm easily separable; the upper part of the rhizome with occasional circular scars and leaf-remnants consisting of stout fibers; fracture short, fibrous but irregular; internally, light yellow, resinous, spongy, porous, arrangement of wood irregular, due to anomalous secondary cambiums, bark dark brown, about 0.5 mm. thick; odor musk-like; taste bitter, pungent.

CONSTITUENTS.—Volatile oil having the taste of peppermint, from 0.3 to 1 per cent.; two balsamic resins, one soluble in alcohol and having the odor and taste of the root, the other soluble in ether; fixed oil 17 per cent.; ash about 8 per cent.; starch and several acids, as angelic, valerianic and methyl-crotonic.

BELLADONNÆ RADIX.—BELLADONNA ROOT.—The root of *Atropa Belladonna* (Fam. Solanaceæ), a perennial herb (p. 372), native of Central and Southern Europe, and cultivated in England and Germany, from which countries most of the commercial supply is obtained (Fig. 268). The roots are collected in autumn from plants three to four years old and carefully dried.

DESCRIPTION.—Cylindrical, slightly tapering, somewhat twisted, or split into longitudinal pieces 5 to 15 cm. long, 4 to 25 mm. in diameter; externally light brown, smooth, longitudinally wrinkled or fissured, sometimes with transverse ridges and with rootlet-scars or fragments of rootlets; fracture short, mealy when dry and emitting a dust consisting of starch grains and fragments of cells, tough when damp; internally light yellow, slightly radiate, bark 0.5 to 2 mm. thick, not fibrous, and adhering closely to the wood, cambium zone distinct; odor narcotic; taste sweetish, acrid.

Roots that are shrunken, spongy, dark brown and free from starch should be rejected, as also old woody roots and stem-remnants.

Phytolacca root and Althæa are distinguished from belladonna root by having numerous sclerenchymatous fibers, while inula has neither starch nor cryptocrystalline crystals of calcium oxalate.

INNER STRUCTURE.—See Figs 199, 200, 281, 303.

CONSTITUENTS.—There are two principal alkaloids—hyoscyamine and atropine—which together amount to 0.2 to 1. per cent., the proportions of these varying according to the age of the root, the hyoscyamine, however, usually being in excess. The atropine appears to be derived from its isomer hyoscyamine and not to preëxist in the root; a small amount of scopolamine (hyoscine) is also present. Other alkaloids, as belladonnine, apoatropine, etc., have been isolated, but these are decomposition products of hyoscyamine. The drug also contains a fluorescent

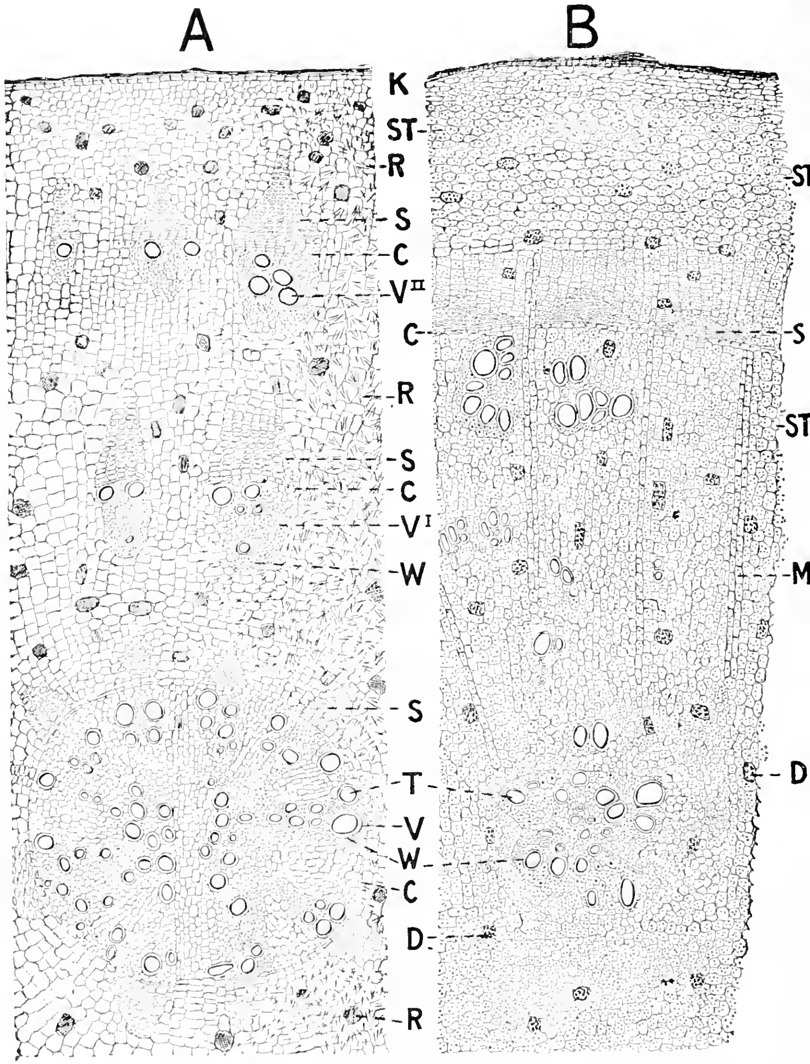


FIG. 200. A, transverse section of Phytolacca root, showing the fibrovascular bundles (V, V′, V″,) which are produced by distinct cambiums (C). The parenchyma contains little starch, and some of the cells (R) show short raphides of calcium oxalate, many of the crystal being distributed in the section.

B. Transverse section of Belladonna root which is two or three years old. There is but one cambium zone (C). Most of the parenchyma contains starch (St), the remaining cells containing cryptocrystalline crystals of calcium oxalate.

K cork; S, sieve; W, wood fibers and T, tracheæ, both of which are strongly lignified in Belladonna root; M. medullary rays.

principle, B-methyl æsculetin, considerable starch and calcium oxalate in the form of sphenoidal micro-crystals. See also Hyoscyamus (p. 619), Belladonnæ Folia (p. 620) and Stramonium (p. 622). (For atropine crystals see Fig. 199.)

ALLIED PLANTS.—Mandragora or European mandrake is the root of *Atropa Mandragora*. The drug occurs in fusiform, somewhat bifurcated pieces and contains two mydriatic alkaloids: mandragorine (isomeric with atropine) and an alkaloid resembling hyoscyamine.

LAPPA.—BURDOCK.—The root of *Arctium Lappa* and of other species of Arctium (Fam. Compositæ), biennial herbs (p. 394) indigenous to Europe and Northern Asia, and naturalized in waste places in the United States and Canada. The fleshy root is collected in autumn from plants of the first year's growth, and carefully dried.

DESCRIPTION.—Nearly cylindrical, slightly tapering, or broken and split longitudinally into pieces, 10 to 20 cm. long, 5 to 20 mm. in diameter; externally, bark dark brown, longitudinally wrinkled, with few rootlets or rootlet-scars, crown somewhat annulate from scars of bud-scales and sometimes surmounted by a soft, woolly tuft of leaf-remains with 1-celled, twisted hairs; fracture short, horny when dry, tough when damp; internally light brown, radiate, bark 2 to 3 mm. thick, wood porous, cambium zone distinct; odor feeble; taste mucilaginous, slightly bitter.

Old woody roots in which the pith is more or less obliterated and which have been collected from the fruiting plant should be rejected.

CONSTITUENTS.—Inulin about 45 per cent.; a glucoside probably identical with that found in the seed, to which the name lappin has been applied; and about 0.4 per cent. of a fixed oil.

PHYTOLACCA.—POKE ROOT.—The root of *Phytolacca decandra* (Fam. Phytolaccaceæ), a perennial herb (p. 265) indigenous to Eastern North America, and naturalized in the West Indies and Southern Europe (Fig. 139). The root is collected in autumn and, after removal of the rootlets, cut into transverse and longitudinal pieces and dried.

DESCRIPTION.—Fusiform or nearly cylindrical, tapering, usually in longitudinal ribbon-like slices, 8 to 16 cm. long, 5 to 15 mm. in diameter, 2 to 10 mm. thick; externally, bark dark brown, more or less wrinkled; fracture fibrous, tough; internally light brown, characterized by alternating zones of collateral fibrovascular bundles and parenchyma formed by secondary cambiums; odor slight; taste acrid. (Fig. 200).

CONSTITUENTS.—A bitter, acrid glucoside resembling saponin; a crystalline alkaloid phytolaccine, which is soluble in alcohol and

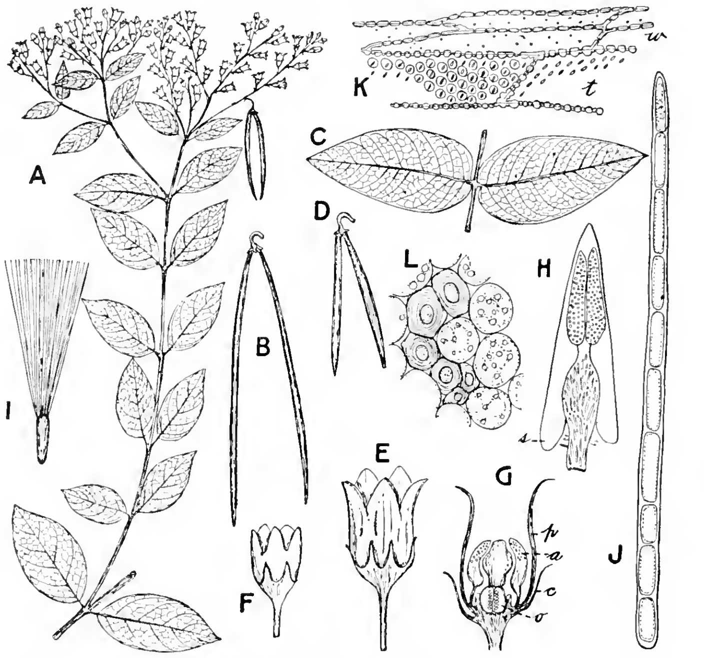


FIG. 201. *Apocynum androsæmifolium:* A, flowering branch; B, a fruit consisting of 2 follicles; E, flower; G, longitudinal section of flower; H, single stamen with long spurs (s); J, multicellular hair from leaf; K, tracheæ with bordered pores (t) and wood fibers (w); L, a few bast fibers and adjoining parenchyma cells containing starch. *Apocynum cannabinum:* C, two of the opposite, nearly sessile leaves; D, fruit; F, flower; I, seed with coma of long, 1-celled, hyaline hairs.

sparingly soluble in water; sugars 10 per cent.; starch 10 per cent.; phytolaccic acid; formic acid; potassium formate 2 per cent.; calcium oxalate 6 per cent.; and ash 13 per cent., of which about one-half is potassium oxide.

PHYTOLACCÆ FRUCTUS or Phytolacca Fruit occurs in agglutinated masses of a purplish-black color, and consisting of the compound berries, which are about 8 mm. in diameter and composed of 10 loculi, each of which contains a single, lenticular, black seed. The sarcocarp is fleshy, sweet and slightly acrid and contains a purplish-red coloring principle which is soluble in water but not in alcohol, and which is decomposed on heating the aqueous solution. The fruit also contains phytolaccic acid, several fruit-acids and phytolaccin, a substance resembling tannin.

APOCYNUM.—CANADIAN HEMP.—The dried root of *Apocynum cannabinum* (Fam. Apocynaceæ), a perennial herb (p. 363) growing in fields and thickets in the United States and Southern Canada (Fig. 201).

Description.—Cylindrical, somewhat branched, usually broken into pieces 4 to 10 cm. long, 5 to 10 mm. in diameter; externally light brown, longitudinally wrinkled and transversely fissured, with few rootlets or rootlet-scars; fracture short; internally, bark light brown, 1 mm. thick, easily separable from the lemon-yellow, porous, slightly radiate wood; odor slight; taste of bark bitter and acrid, of wood slightly bitter.

Stem fragments are distinguished by having a comparatively thin, finely fibrous bark and a hollow center.

Inner Structure.—See Fig. 202.

Constituents.—Cynotoxin (apocynamarin), a dilactone of Kiliani's oxydigitogenic acid, or of an isomeride, forms small rhombic pyramids, which are sparingly soluble in water and the usual organic solvents, and is extremely bitter. Apocynin (0.2 per cent.) occurs in slender colorless prisms with a slight odor of vanillin. There are also present a volatile oil, resin, tannin, starch and about 10 per cent. of ash.

Allied Plants.—The commercial article frequently contains the root of *A. androsæmifolium* (p. 363, Figs. 201 and 202).

IPECACUANHA.—IPECAC.—The dried root of *Cephaëlis Ipecacuanha* (*Uragoga Ipecacuanha*) (Fam. Rubiaceæ), a shrub indigenous to Brazil, and sparingly cultivated near Singapore (Fig. 178). The commercial supply is obtained from Matta Grosso, Brazil, and is known as Rio, Brazilian or Para Ipecac. The roots of *Cephaëlis acuminata*, a plant closely related to *Cephaëlis Ipecacuanha* and indigenous to the northern and central portion of the United States of Colombia, are exported from Carthagena and Savanilla, and are known commercially as Carthagena Ipecac. Two commercial sub-varieties of Ipecac are also recognized, depending upon the proportion of wood and bark in

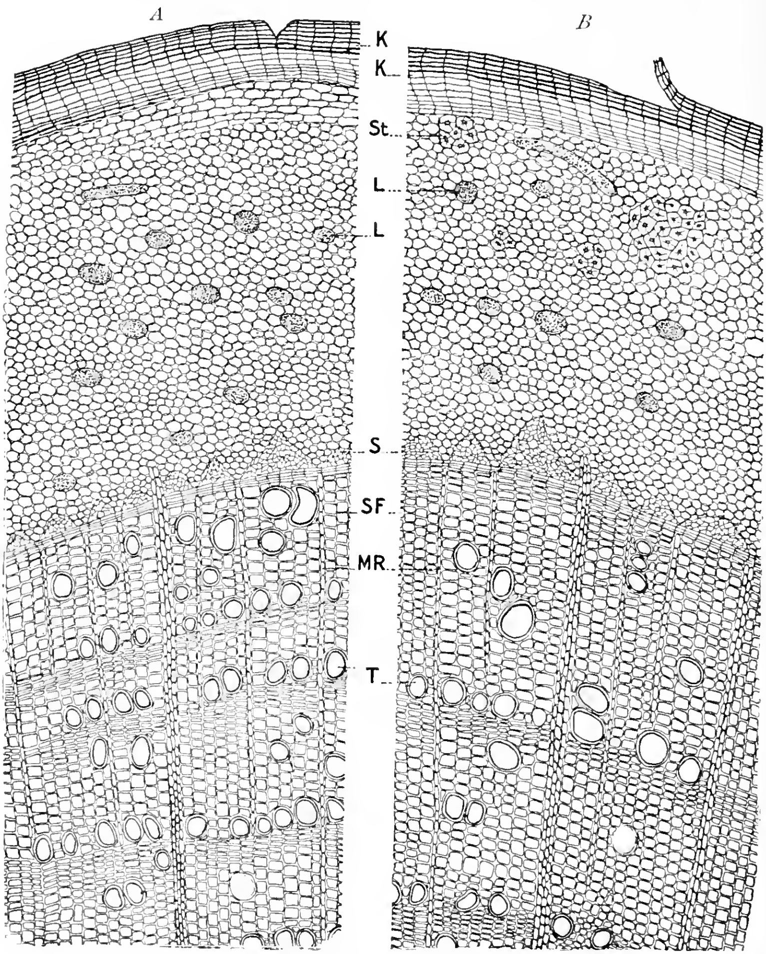


FIG. 202. A, transverse section of the root of *Apocynum cannabinum* showing cork (K); latex cells (L) in the cortex; sieve (S), beneath which is the cambium zone; wood fibers (SF), tracheæ (T), and medullary rays (MR). B, transverse section of the root of *Apocynum androsæmifolium* showing in addition groups of stone cells (St) in the cortex.

the drug. Specimens in which the wood is more pronounced are known as "WIRY ROOTS," while those which are characterized by a thicker bark are called "FANCY" or "Bold" roots (p. 379).

Rio or Brazilian Ipecac.—Cylindrical, more or less tortuous, 5 to 15 cm. long, 1 to 5 mm. in diameter; externally dark brown, irregularly annulate, sometimes transversely fissured, with occasional rootlets or rootlet-scars; fracture of bark brittle, of the wood tough; internally, bark light brown, 0.5 to 1 mm. thick, easily separable from the dark-yellow, non-porous wood; odor slight; taste bitter, acrid.

An aqueous infusion of ipecac gives a copious precipitate with potassio-mercuric iodide solution; a hydro-alcoholic infusion gives a yellow precipitate with picric acid, or if hydrochloric acid and potassium chlorate are added the solution becomes orange-red with a reddish fluorescence.

Inner Structure.—See Figs. 203, 291.

Carthagena Ipecac closely resembles the Rio or Brazilian ipecac, but the roots are uniformly thicker (4 to 7 mm. in diameter), of a brownish-gray color, and the annulations are less pronounced.

The stems are usually more slender, 5 to 10 cm. long, 1 to 1.5 mm. in diameter, nearly smooth or longitudinally wrinkled; bark 0.1 mm. thick, with bast fibers either single or in groups; pith distinct, 0.5 mm. in diameter.

Constituents.—Ipecac contains three alkaloids (2 to 3 per cent.)—emetine, cephaëline and psychotrine, that are said to be contained chiefly in the bark, which makes up about 90 per cent. of the drug.

Emetine (methyl-cephaëline) is white, amorphous, forms crystalline salts, becomes darker on exposure to light, and with Frœhde's alkaloidal reagent (consisting of 0.01 Gm. of sodium molybdate in 1 c.c. of concentrated sulphuric acid) becomes dirty green, changing to a bright green on the addition of hydrochloric acid. Cephaëline occurs in silky needles, forms amorphous salts and is quite unstable, becoming yellow even in the dark. With Frœhde's reagent, cephaëline changes to purple, becoming deep blue on the addition of hydrochloric acid. Psychotrine is amorphous, quite unstable, and becomes purplish with Frœhde's reagent, changing to green on the addition of hydrochloric acid. Ipecac also contains 2.25 per cent. of ipecacuanhic acid, with which the alkaloids are combined; a glucoside resembling saponin;

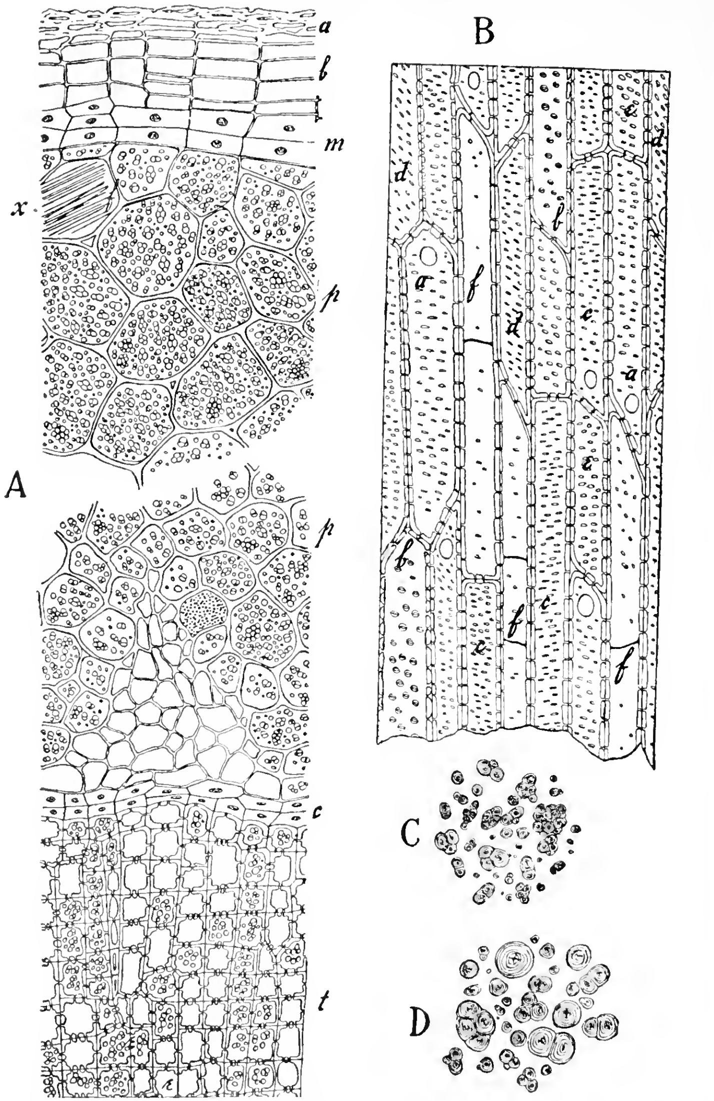


FIG. 203. Ipecac. A, transverse section of Rio ipecac showing outer layers of cork (a); cork cells (b); phellogen (m); parenchyma containing starch (p); raphides (x); cambium (c); tracheids (t). B, longitudinal section of a portion of the wood showing duct-like tracheids (a); tracheids with bordered pores (b), linear pores (c) and oblique linear pores (d); transition tracheids (e); tracheids with delicate pores (f). C, starch grains of Rio ipecac. D, slightly larger starch grains of Carthagena ipecac.—After Schneider.

about 40 per cent. of starch; and calcium oxalate in the form of raphides.

The total amount of alkaloids in Rio and Carthagena ipecac not only varies but there is a difference in the proportions of emetine (the expectorant alkaloid) and cephaëline (the emetic alkaloid); in Rio ipecac the proportion is one-third cephaëline to two-thirds emetine, while in Carthagena ipecac there are four-fifths cephaëline to one-fifth emetine.

ALLIED PLANTS.—A number of drugs, some of which resemble ipecac, sometimes find their way into commerce, and, while they all possess emetic properties, none of them contain emetine. The following drugs obtained from plants of the RUBIACEÆ have been substituted for Ipecac. UNDULATED (or Farinaceous) IPECAC from *Richardsonia scabra,* a plant growing in tropical and sub-tropical America, is an undulate, annulate root, the bark of which is nearly as thick as the yellowish, soft wood. STRIATED IPECAC from *Cephaëlis emetica,* a plant growing in South America, is a dark purplish-brown root, with a few transverse fissures and a thick bark in which starch is absent. Several members of the ROSACEÆ contain emetic principles and the roots of the following plants growing in the United States have been substituted for Ipecac: AMERICAN IPECAC (*Porteranthus Gillenia Stipulatus*); the root is annulate, and somewhat resembles ipecac, but has a thinner bark with numerous resin cells; and Indian Physic (*P. trifoliatus*), the roots of which resemble those of American Ipecac but are not annulate.

The roots of several of the plants of the EUPHORBIACEÆ are used as emetics. IPECAC SPURGE is the root of *Euphorbia Ipecacuanha,* a plant common in sandy soil of the Eastern United States. The roots are 30 cm. or more long, about 1 cm. thick, nearly cylindrical, light brown; internally the wood is yellow and the bark white and with numerous latex vessels. The taste is sweet, somewhat acrid and bitter. Ipecac spurge contains a crystalline resin, euphorbon; probably a glucoside, and starch. Purging or EMETIC ROOT is obtained from the large flowering spurge (*Euphorbia corollata*), a plant found in sandy soil east of the Mississippi. The root resembles the Ipecac spurge but is dark brown or brownish-black externally, and the constituents are similar.

The following emetic drugs are obtained from plants belonging to the VIOLACEÆ: Ionidium or the so-called WHITE IPECAC is obtained from the root of *Hybanthus Ipecacuanha* of Brazil. It is easily distinguished from ipecac by being somewhat branched, larger and with a thin bark. An emetic principle is also present in the roots of other species of *Hybanthus*, the root of *Anchieta salutaris* of Brazil, and possibly also in the rhizome of *Viola odorata*.

A few emetic drugs are also obtained from plants belonging to the MELIACEÆ. The alkaloid naregamine is found in the Goanese Ipecac derived from *Naregamia alata* of the East Indies. The alkaloid rusbyine is found in the bark of COCILLANA (*Guarea Rusbyi*) of Bolivia, a drug having properties similar to those of Ipecac. The roots of several of the Polygalas (Fam. POLYGALACEÆ) possess emetic properties, viz.: *P. scoparia* of Mexico and *P. angulata* of Brazil. The root of the latter plant, which is also known as WHITE IPECAC (*Poaya blanca*) resembles senega, is free from starch and contains considerable saponin.

GLYCYRRHIZA.—LICORICE ROOT.—The dried rhizome and root of *Glycyrrhiza glabra*, and of the var. *glandulifera* (Fam. Leguminosæ), perennial herbs (Fig. 151), found growing in the countries of the Eastern Mediterranean region and Eastern Asia and cultivated in Spain, Russia, other parts of Europe and to a limited extent in the United States (p. 294). There are two principal commercial varieties: (1) Spanish Licorice, yielded by cultivated plants of *G. glabra*, and chiefly exported from Spain and Southern France, and (2) Russian Licorice, obtained from wild plants of *G. glabra glandulifera* or *G. echinata*, growing in Southern Russia. The latter consists more largely of roots which are deprived of the periderm, whereas the Spanish variety consists mostly of rhizomes.

SPANISH LICORICE.—Nearly cylindrical, more or less tortuous, cut or broken into pieces 14 to 20 cm. long, 5 to 25 mm. in diameter; crown knotty; externally dark brown, longitudinally wrinkled or furrowed, with few rootlet-scars, rhizome with corky patches and numerous small conical buds; fracture coarsely fibrous; internally lemon-yellow, radiate, bark 1 to 3 mm. thick, wood porous, rhizome with small pith; odor distinct; taste sweetish, slightly acrid.

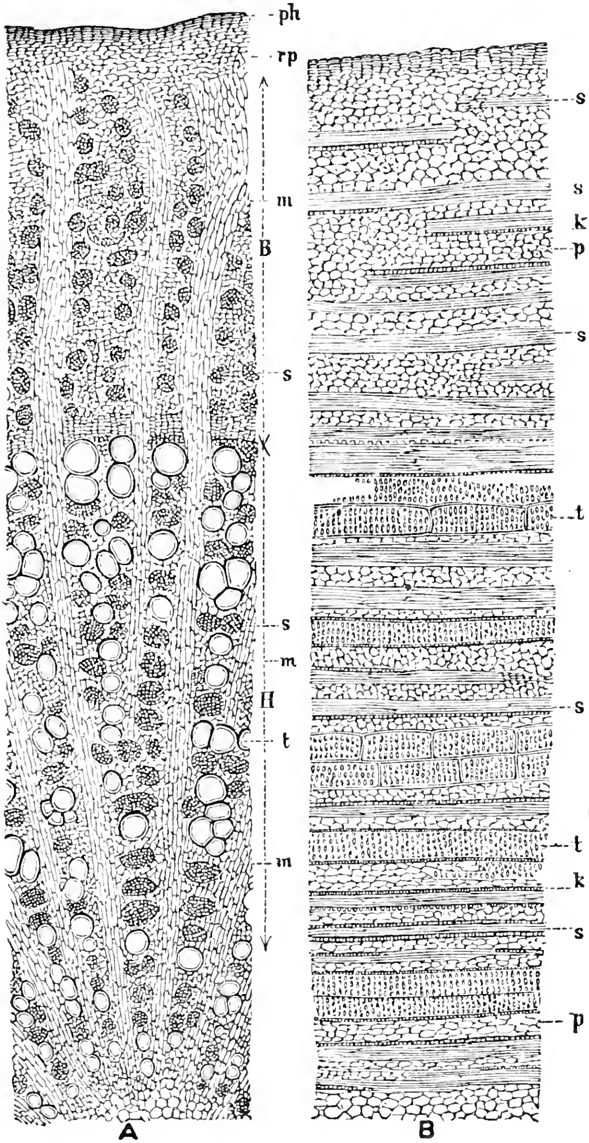


Fig. 204. Glycyrrhiza: A, transverse section; B, longitudinal section. B, bark; H, wood; X, cambium zone; ph, cork cells; rp, cortex; p, parenchyma; k crystal fibers; s, sclerenchyma fibers; t, tracheæ; m, medullary rays.—After Meyer.

INNER STRUCTURE.—See Figs. 104; 204; 282, B.

RUSSIAN LICORICE.—Nearly cylindrical, tapering, sometimes split longitudinally, 15 to 30 cm. long, 10 to 30 mm. in diameter; externally lemon-yellow, nearly smooth, porous, with detachable bast fibers and circular rootlet-scars, cork, if present, more or less easily detachable; internally lemon-yellow, bark, coarsely fibrous, wood radially cleft, not so fibrous as the Spanish variety.

CONSTITUENTS.—About 3 per cent. of GLYCYRRHIZIN, a crystalline, intensely sweet substance consisting of the calcium and potassium salts of glycyrrhizinic acid, which latter is an ester of glycyrrhetinic acid; asparagin 2 to 4 per cent. (see Althæa); a bitter principle glycyramarin, which occurs principally in the bark and hence is less abundant in the Russian licorice; a volatile oil 0.03 per cent.; mannit; considerable starch and calcium oxalate chiefly in crystal fibers.

ALLIED PLANTS.—The root of wild or American licorice, *Glycyrrhiza lepidota,* a perennial herb indigenous to Western North America, is somewhat similar to Spanish licorice. It contains 6 per cent. of glycyrrhizin and considerable glycyramarin.

A number of plants of this family contain principles similar to glycyrrhizin, as the root and leaves of Indian or Jamaica licorice (*Abrus precatorius*) of India and the West Indies; the root of *Ononis spinosa,* a perennial herb of Europe, and other species of *Ononis* as well; the locust (*Robinia Pseudacacia*) of the United States and Canada; *Caragana pygmæa* of Siberia and Northern China; *Hedysarum americanum* of the Northern United States and Canada; *Periandra mediterranea,* and *P. dulcis* of Brazil and Paraguay; the rhizome of *Polypodium vulgare* (Filices). (See also *Galium,* p. 382.)

The root of *G. uralensis* of Siberia is said to be only slightly inferior to the best kind of Russian licorice.

RHEUM.—RHUBARB.—The rhizome of *Rheum officinale, Rheum palmatum, Rheum palmatum tanguticum,* and probably other species of Rheum (Fam. Polygonaceæ), perennial herbs (Fig. 205) indigenous to Northwestern China and Eastern Thibet, and sparingly cultivated in other parts of the world (p. 262). The rhizomes are collected in autumn from plants that are eight to ten years old, most of the bark is removed, and they are then

FIG. 205. *Rheum officinale*, growing in the Chelsea Physic Garden (London).—After Pérrédès.

perforated, strung on ropes and dried either in the sun or by artificial heat. The drug is exported chiefly from Shanghai. The principal commercial varieties are known as Chinese rhubarb, Canton rhubarb and Shensi rhubarb, the latter being preferred.

Description.—Cut into irregular plano-convex and oblong pieces, frequently with a large perforation, hard and moderately heavy, 5 to 15 cm. long, 5 to 8 cm. broad and 3 to 6 cm. thick; externally mottled from alternating striæ of light-brown parenchyma cells and dark-brown medullary rays, occasionally with reddish-brown cork patches and small radiate scars of fibro-vascular tissue, smooth and sometimes covered with a light-brown powder; fracture somewhat granular; internally light brown; odor distinct; taste bitter, astringent and gritty.

Light and spongy rhizomes should be rejected.

Inner Structure.—See Figs. 281, *A*; 289.

Constituents.—The principal constituent appears to be a glucoside (possibly the chrysophan of some authors) or an undetermined substance which yields successive oxidation products, viz.: chrysophanic acid (di-oxy-methyl-anthraquinone), emodin (tri-oxy-methyl-anthraquinone), and rhein (tetra-oxy-methyl-anthraquinone). Chrysophanic acid crystallizes in golden-yellow, clinorhombic prisms and dissolves in alkalies and in concentrated sulphuric acid, the solutions having a deep-red color. It is re-formed in rhubarb after extracting it by exposing the moistened root to air. Emodin occurs to the extent of 1.5 per cent. and forms orange-red needles which are soluble in hot toluene and give with alkalies and alkali carbonates purplish colored solutions. Rhein forms yellowish-brown scales which are insoluble in hot toluene, soluble in hot acetic acid and produce purplish-red solutions with the alkalies or alkali carbonates. Recently another oxymethylanthraquinone-yielding substance, rheopurgarin, has been isolated from Shensi rhubarb. It forms yellow needles, and appears to be composed of four glucosides: (a) one related to emodin, (b) one related to rhein, (c) chrysophanein, which yields chrysophanic acid, and (d) rheochrysin, which yields a yellow crystalline body, rheochrysidine, considered to be identical with Hesse's rhabarberon or iso-emodin. The following glucosidal tannoid constituents are also present: glucogallin, yielding gallic acid, and tetrarin, yielding in addition to gallic acid, cinnamic acid and rheosmin, an aldehyde having the odor of rhubarb. A catechin resembling the catechin of gambir has also been found. Rhubarb also contains considerable starch; calcium oxalate; and yields about 15 per cent. of ash.

Allied Plants.—The rhizomes of other species of Rheum are also used to a limited extent, as English or Austrian rhubarb from *Rheum rhaponticum;* they are more or less cylindrical, distinctly radiate, and contains, besides chrysophanic acid, rhapontin. *Rheum palmatum* which is cultivated in France, Germany and Russia, produces rhizomes that are lighter in color and less valuable than the Chinese rhubarb, the constituents being similar to those of Austrian rhubarb.

ACONITUM.—ACONITE.—The tuberous root of *Aconitum Napellus* (Fam. Ranunculaceæ), a perennial herb (Figs. 84, 141), growing in the mountainous districts of Europe, Asia and Western North America. It is also cultivated in temperate regions (p. 268). The commercial supplies are obtained from England and Germany, and in England the root is collected in autumn from cultivated plants after the overground parts have died down, whereas in Germany the roots are collected from wild plants during the flowering period, this being done to distinguish the particular species yielding the drug. The root should be carefully dried.

Description.—More or less conical or fusiform, 4 to 10 cm. long, 5 to 20 mm. in diameter; externally dark brown, smooth or somewhat wrinkled, the upper portion with a bud, remains of bud-scales or stem-scars, with numerous root-scars or short roots; fracture horny, somewhat mealy; internally, bark light or dark brown, 1 to 2 mm. thick, cambium irregular, 5- to 7-angled, wood yellowish, in small bundles at the angles, pith light brown, about 2 to 6 mm. in diameter; odor very slight; taste sweetish, acrid, pungent, accompanied by a sensation of numbness and tingling.

The shrunken, hollow, older tubers, together with the overground stem-remnants, should be rejected.

Inner Structure.—See Figs 206, 309.

Constituents.—A number of alkaloids have been isolated, of which aconitine is the most important; it occurs to the extent of about 0.75 per cent., and forms prisms (Fig. 142), which are not colored by concentrated sulphuric or nitric acid. An aqueous solution of the alkaloid, after acidulating with acetic acid, gives on the addition of a solution of potassium permanganate a red crystalline precipitate. Aconitine decomposes quite readily and several of its derivatives have been isolated: benzaconine, an inert alkaloid and aconine which produces apparently contrary physio-

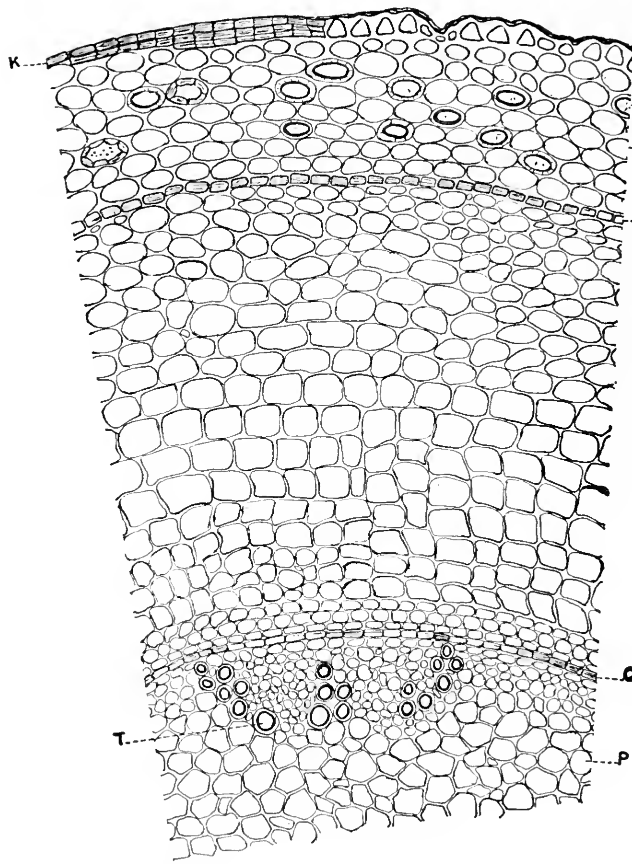


FIG. 206. Transverse section of aconite: K, cork; E, epidermis; ST, stone cells; EN, endodermis; C, cambium; T, tracheæ; P, parenchyma.

logical effects to aconitine. The alkaloid napelline may be isomeric with aconine. Aconite also contains considerable aconitic acid which is chiefly combined with calcium and occurs in other genera of the Fam. Ranunculaceæ, viz.: Delphinium and Adonis;

considerable starch; a little mannitol and a resin. The other alkaloids are amorphous and non-toxic, and of these isaconitine (napelline) has been employed medicinally.

FIG. 207. Culver's-root (*Leptandra virginica*) showing the verticillate leaves and the long spike-like terminal racemes.

ALLIED PLANTS.—Japanese aconite is obtained from *Aconitum Fischeri;* the root is smaller, conical, nearly smooth and with starch grains that are much larger than those of the official drug (Fig. 309). Indian aconite, the product of *Aconitum ferox,* is a much larger root and somewhat horny, owing to the gelatinization of the starch in its preparation for market.

A very large number of species of Aconitum are used medicinally. These may be brought into five groups: (1) Those containing the alkaloid aconitine, as *Aconitum Napellus;* (2) those containing pseudaconitine, which, while it resembles in some of its properties aconitine, is not chemically identical with it, and is found in the Indian aconite obtained from *A. ferox, A. luridum* and *A. palmatum;* (3) those containing the alkaloid, japaconitine, which closely resembles pseudaconitine and is found in Japanese aconite, obtained from *A. Fischeri;* (4) those which contain the narcotic bases, lycaconitine and myoctonine, found in *A. lycoctonum* of Asia and Europe; (5) those yielding lappaconitine, a powerful alkaloid occurring in *A. septentrionale,* a nearly related species to *A. lycoctonum.*

Aconite leaves, the dried leaves (Fig. 141) of *Aconitum Napellus,* are extensively used (p. 268). The constituents resemble those of the tuber and the amount of aconitine varies from 0.25 to 0.50 per cent. The ash is about 16 per cent. In Great Britain the fresh or recently dried leaves are largely employed.

GELSEMIUM.—YELLOW JESSAMINE, YELLOW JASMINE.—The dried rhizome and roots of *Gelsemium sempervirens* (Fam. Loganiaceæ), a smooth, perennial climber of the Southern United States and Guatemala (p. 362). The drug should be collected in autumn.

Description.—Rhizome horizontal, cylindrical, usually cut into pieces 9 to 20 cm. long, 4 to 15 mm. in diameter; externally light brown, longitudinally wrinkled, transversely fissured; upper surface with few stem-scars; under and side portions with numerous roots and root-scars; fracture tough, wiry; internally light brown or pale yellow, bark about 1 mm. thick, wood distinctly radiate, excentral, with four groups of internal phloem, pith disintegrated; odor slight; taste bitter.

Inner Structure.—See Figs. 208, 208a.

Roots light brown, 3 to 20 cm. long, 2 to 8 mm. thick; internally light yellow, bark about 0.5 mm. thick, wood distinctly radiate.

The overground stem is dark or reddish-brown, longitudinally wrinkled and has numerous lenticels and few, somewhat elliptical branch-scars; the bark is about 0.2 mm. thick and somewhat greenish.

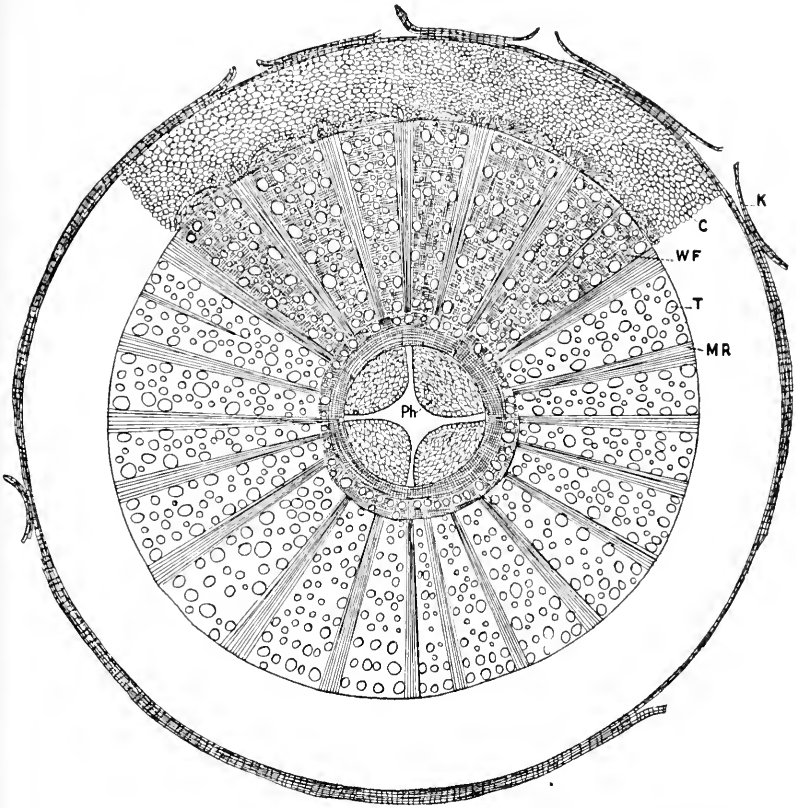


Fig. 208. Transverse section of rhizome of gelsemium: K, cork; C, cortex; WF, wood fibers; T, tracheæ; MR, medullary rays; Ph, internal phloem.

CONSTITUENTS.—Two alkaloids of great toxicity, the one known as GELSEMINE, crystallizes in silky needles and on the addition of concentrated nitric acid and heating the solution is colored reddish and then dark green; the other GELSEMININE, occurring in amorphous masses and forming yellowish amorphous salts, is colored greenish on the addition of nitric acid. In addition the drug contains 0.2 to 0.5 per cent. of B-methyl-æsculetin (gelsemic acid), which also occurs in scopola and other plants, and which gives with solutions of the alkalies, a bluish fluorescence; 0.5 per cent. of a volatile oil; about 4 per cent. of resins, one of which is acrid; starch; and calcium oxalate in the form of monoclinic prisms.

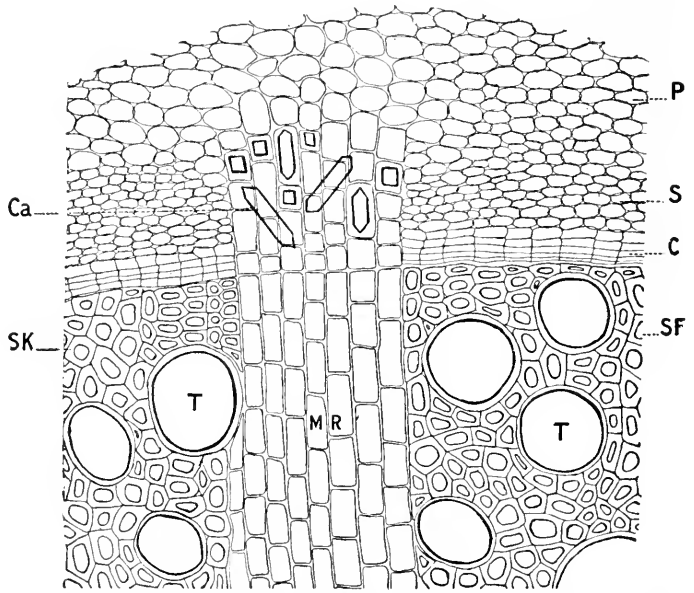


Fig. 208a. Transverse section of gelsemium near the cambium: P, parenchyma; S, sieve; C, cambium; Ca, calcium oxalate crystals; SK, SF, wood fibers; T, tracheæ; MR, medullary rays.

BERBERIS.—OREGON GRAPE-ROOT.—The rhizome and roots of *Berberis Aquifolium* (Fam. Berberidaceæ), a low trailing shrub (p. 272), which is indigenous to the Rocky Mountain region of the United States, extending into British Columbia and as far east as Nebraska.

Description.—In cylindrical pieces which vary from 8 to 12 cm. long and 1.5 to 3.5 cm. in diameter; externally pale yellowish-brown to dark yellowish-brown, longitudinally wrinkled, with few root branches and occasionally rootlets; hard and tough. Internally, bark dark brown, less than 1 mm. thick and rather soft;

wood lemon-yellow, distinctly radiate, with narrow medullary rays; pith bright yellow, 2 or 3 mm. in diameter. Slightly odorous. Taste bitter.

CONSTITUENTS.—Four alkaloids, namely, berberine; oxyacanthine, which acquires a yellow color in sunlight; berbamine, which is distinguished from the above-mentioned alkaloids by being soluble in water; and another alkaloid whose properties have not been investigated. The drug also contains resin and considerable starch.

ALLIED PLANTS.—*Berberis vulgaris* (European barberry), naturalized in the United States, furnishes a drug which has similar properties. Not only the rhizomes and roots but also the stem and root barks are employed, the root bark containing a larger amount of alkaloids than that of the stem.

The bark and root of *Berberis asiatica* of the Himalaya region and *B. aristata* of India are similarly employed, the latter containing about 2 per cent. of berberine.

The flowers and berries of *Berberis Aquifolium* and *B. vulgaris* contain berberine, oxyacanthine, volatile oil, about 6 per cent. of malic acid and 3.5 to 4.7 per cent. of sugar.

The alkaloid berberine is also found in *Argemone mexicana* (Fam. Papaveraceæ) and in the following members of the Ranunculaceæ: *Hydrastis canadensis, Coptis trifolia* and *Xanthorrhiza apiifolia.*

GENTIANA.—GENTIAN.—The rhizome and roots of *Gentiana lutea* (Fam. Gentianaceæ), a perennial herb (Fig. 209) indigenous to Central and Southern Europe and Asia Minor (p. 362). The fleshy rhizomes and roots are collected in autumn and frequently cut into longitudinal pieces and slowly dried, during which latter process they develop a distinctive color and odor, losing thereby some of the gentiopicrin. The commercial supplies are obtained from France, Germany, Spain and Switzerland.

DESCRIPTION.—Nearly cylindrical and sometimes branched, split longitudinally or broken into irregular pieces, 3 to 15 cm. long, 5 to 40 mm. in diameter; externally light brown, the upper or rhizome portion annulate from scars of bud-scales, longitudinally wrinkled, and with few buds, stem- and root-scars, roots longitudinally wrinkled; fracture short when dry, tough and flexible when damp; internally dark yellow, bark 0.5 to 2 mm. thick, porous, cambium zone distinct; odor heavy; taste bitter.

INNER STRUCTURE.—See Fig. 210.

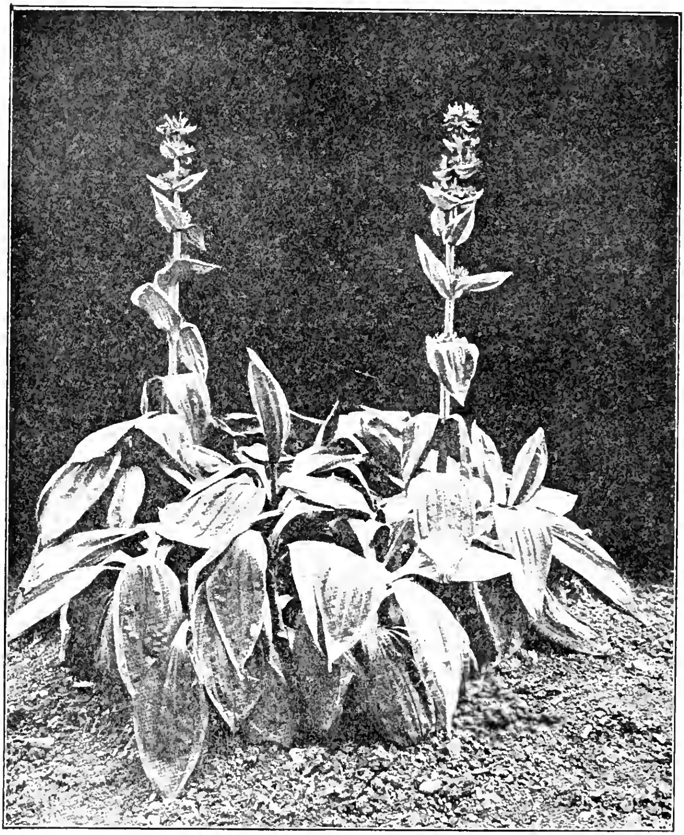


FIG. 209. *Gentiana lutea*, growing in the Royal Botanic Society's Gardens (London). —After Pérrédès.

CONSTITUENTS.—A bitter glucoside gentiopicrin, about 0.1 per cent., occurring in yellow needles which are readily soluble in water but less so in alcohol and to which the drug owes its peculiar bitterness and odor; a coloring principle gentisin (gentianin or gentisic acid), occurring in yellowish prisms which are soluble in alcohol but nearly insoluble in water, and becoming greenish-brown with ferric salts, whence some consider it to be a kind of tannin and have named it gentiotannic acid; quercitrin,

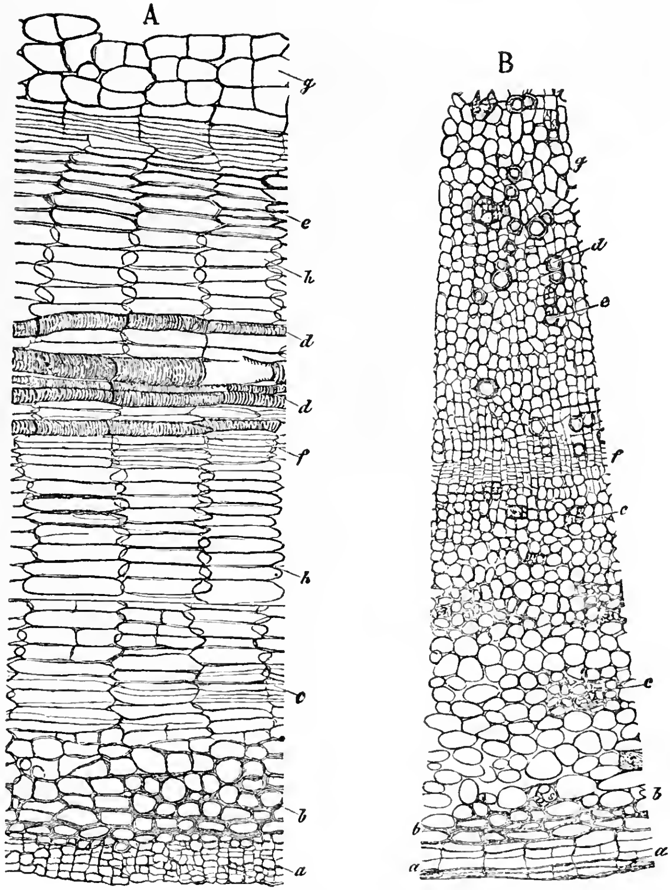


FIG. 210. Longitudinal (A) and transverse (B) sections of gentian: a, cork; b, a kind of hypodermal layer; c, sieve; f, cambium; e, elongated fiber-like cells; h, somewhat elongated parenchyma cells; g, short parenchyma cells.—After Meyer.

or an allied product, crystallizing in yellowish needles; gentianose, a crystalline carbohydrate which occurs in the fresh root and which does not reduce Fehling's solution; 12 to 15 per cent. of glucose; and pectin. Gentian also contains two other glucosides:

gentiamarin, which is amorphous, has a disagreeable bitter taste and gives a slight darkening with iron salts; and gentianin, which occurs in yellowish needles, gives a greenish-black color with ferric salts and on hydrolysis yields gentienin, xylose and glucose.

ALLIED PLANTS.—The rhizomes and roots of various other European species of Gentiana are sometimes collected and employed medicinally, as of *Gentiana purpurea*, collected in Switzerland, and *G. Pannonica* and *G. Punctata*, collected in Austria. The rhizome and roots of Elliott's gentian, *Gentiana Elliottii*, indigenous to the southeastern part of the United States, was at one time official in this country.

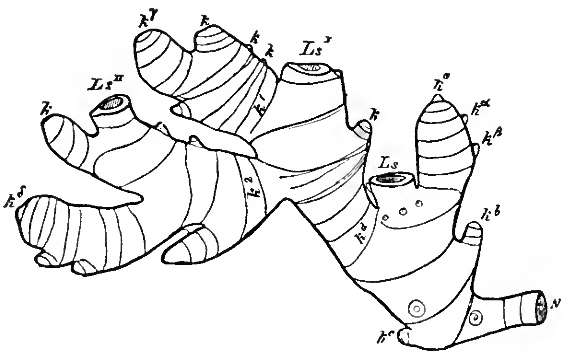


FIG. 211. Rhizome of African ginger showing scars of overground branch (Ls) and buds (k). The more or less parallel lines represent leaf-scars and scars of bud-scales, and the small circles, root-scars.—After Meyer.

The root of American Columbo, also known as yellow gentian (*Frasera carolinensis*), a perennial herb growing in the Eastern United States and Canada, resembles in the whole condition the official gentian, but is of a lighter color (p. 460).

ZINGIBER.—GINGER.—The rhizome of *Zingiber officinale* (Fam. Zingiberaceæ), a perennial herb (Fig. 132) indigenous to Asia, and cultivated in tropical countries, notably in the West Indies, India, and Africa (p. 242). The rhizomes are collected between December and March; they are cleaned by washing, peeled, again washed in water, sometimes containing juice of the lime fruit, and dried in the sun. There are several kinds of the drug, depending upon the manner of treatment. That from

Africa has the periderm removed from the vertical sides only, and is known as "coated" ginger; in the Jamaica variety the periderm is completely removed and the product is known as "peeled" or "uncoated" or "scraped" ginger. The latter is sometimes steeped in milk of lime to protect it against the attacks of insects. The Jamaica variety is the official ginger.

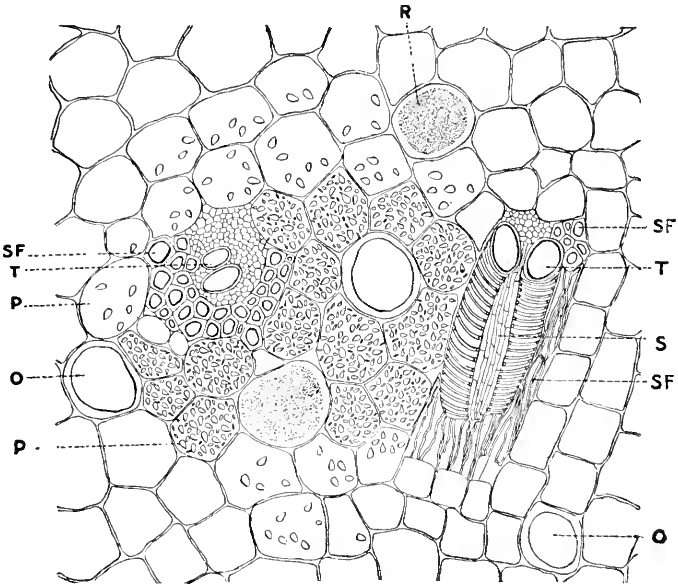


FIG. 212. Transverse section of portion of rhizome of ginger: P, parenchyma containing ovoid starch grains; O, oil cells; R, cells containing resin; SF, sclerenchymatic fiber; T, tracheæ; S, sieve.

JAMAICA GINGER.—Horizontal, laterally compressed, irregularly branched pieces (Fig. 211), 4 to 10 cm. long, 4 to 20 mm. broad, 5 to 10 mm. thick; externally light brown, longitudinally wrinkled, with somewhat elliptical, depressed stem-scars, with few fibers of fibrovascular tissue or adhering fragments of periderm; fracture mealy and with short projecting fibrovascular bundles; internally, cortex light brown, 0.1 to 0.4 mm. thick; central cylinder with numerous circular groups of fibrovascular tissue and yellowish secretion cells; odor strongly aromatic; taste pungent.

INNER STRUCTURE.—See Figs. 212, 214.

Ginger which is bleached by means of sulphur fumes or bleaching powder (chlorinated lime) or that is coated with lime should not be used.

CONSTITUENTS.—VOLATILE OIL, possessing the aromatic odor of the drug, 1 to 3 per cent., and consisting chiefly of a sesquiterpene, some dextro-camphene and phellandrene; a colorless, viscid principle GINGEROL, which has the pungent taste of the drug, 0.5 to 1.5 per cent.; two resins, one of which is acid in character; starch, 20 per cent.

COMMERCIAL VARIETIES.—The following are derived from *Zingiber officinale:* (1) NATURAL JAMAICA ginger occurs in long, slender, flattish, branching, light yellowish-brown pieces, the periderm being completely removed. (2) BLEACHED JAMAICA ginger is the natural Jamaica rhizome frequently coated with lime. (3) AFRICAN ginger consists of grayish-brown pieces which are partly peeled on the flattened sides, in section exhibit garnet resin dots, and the taste is intensely acrid. (4) CALCUTTA ginger resembles African ginger, but has a greater proportion of cork, and yields a higher percentage of ash than the other commercial gingers. (5) CALICUT ginger also resembles African ginger. (6) COCHIN ginger is a scraped ginger, internally is of a light cream color and exhibits numerous black resin dots. (7) JAPAN ginger is probably derived from *Z. Zerumbet.* It belongs to the class of scraped and limed gingers, and has a short and mealy fracture. The resin dots are reddish, and it differs from all the other gingers in having numerous compound starch grains varying from 4 to 25 μ in diameter.

In fresh ginger and in the confection "crystallized ginger" the contents of the secretion cells are oily and of a yellow color, but in old dried rhizomes the contents are darker and insoluble in alcohol, ether, glacial acetic acid, potassium hydrate and chloral hydrate.

CONVALLARIA.—LILY-OF-THE-VALLEY.—The dried rhizome and roots of *Convallaria majalis* (Fam. Liliaceæ), a perennial herb (p. 238) indigenous to Europe, Asia and the higher mountains of Virginia, North Carolina and South Carolina and extensively cultivated for its flowers. The rhizome and roots should be collected late in summer and carefully dried. The leaves and flowers have also been used in medicine.

Description.—Rhizome horizontal, cylindrical, and sometimes branched, jointed, in pieces from 3 to 17 cm. long, internodes 10 to 50 mm. long, 1 to 3 mm. in diameter, nodes with a circular scar, not much thickened; externally light or dark brown, longitudinally wrinkled, somewhat annulate from scars of bud-scales, mostly smooth between the nodes, upper surface of nodes marked by

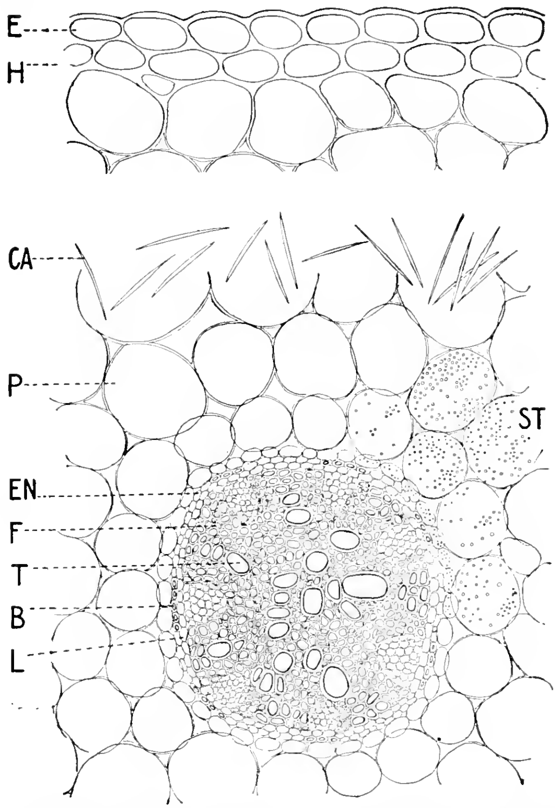


Fig. 213. Transverse section of central cylinder and portion of cortex of root of *Cypripedium hirsutum*: E, epidermis; H, hypodermis; Ca, Raphides of calcium oxalate; P, parenchyma containing starch (St); En, endodermis; F, lignified sclerenchymatous fibers; T, tracheæ; B, non-lignified, thick-walled fibers exterior to sieve groups; L, peripheral layer of central cylinder. The latter usually consists of 6 to 8 radial fibrovascular bundles.

stem-scars, side and under surface with root-scars, or usually with three to five roots, fracture short or fibrous; internally light or dark brown, cortex 0.5 mm. thick, separable from the central cylinder; odor faint; taste bitter, slightly acrid.

Roots somewhat tortuous, 5 to 6 cm. long, about 0.3 to 0.5 mm. in diameter, rootlets few.

Inner Structure.—See Fig. 114.

Constituents.—A bitter, somewhat crystalline glucoside, convallamarin, about 0.6 per cent., which is soluble in water, alcohol and ether and has a physiological action similar to digitalin. An acrid glucoside, convallarin, forming rectangular prisms which are insoluble in ether and sparingly soluble in water, the solution foaming on shaking like a saponin solution.

The flowers of Lily-of-the-valley contain a volatile crystalline principle which is fragrant in even dilute solutions.

CYPRIPEDIUM.—LADY'S SLIPPER.—The dried rhizome and roots of *Cypripedium pubescens* (*C. hirsutum*), and *Cypripedium parviflorum* (Fam. Orchidaceæ), perennial herbs (Fig. 133) native in woods and thickets of the Eastern and Central United States and Canada (p. 245).

Description.—Rhizome horizontal, somewhat tortuous and bent, 3 to 7 cm. long, 2 to 4 mm. in diameter; externally dark brown, annulate from scars of bud-scales, upper surface with numerous large, sometimes depressed scars, under and side portions with numerous roots and few root-scars; fracture short; internally light brown, cortex about 0.5 mm. thick, central cylinder somewhat porous, and with numerous scattered fibrovascular bundles; odor heavy, distinct; taste bitter, somewhat pungent. The walls of the endodermal cells are slightly cutinized (Figs. 133, 213).

Roots 3 to 11 cm. long, 0.5 to 1.5 mm. in diameter; externally light or dark brown, longitudinally wrinkled; fracture somewhat fibrous; internally, cortex white, central cylinder yellowish.

Constituents.—Volatile oil, several resins, a bitter glucosidal principle, tannin, gallic acid, starch, calcium oxalate in the form of raphides, and ash about 6 per cent.

TRITICUM.—COUCH GRASS.—The rhizome of *Agropyron* (*Triticum*) *repens* (Fam. Gramineæ), a perennial grass indigenous to Europe and Asia, and naturalized in North America, except in the Arctic region (p. 227). The rhizome is gathered in spring, deprived of the rootlets, cut into pieces and carefully dried. Our commercial supplies come chiefly from Central Europe.

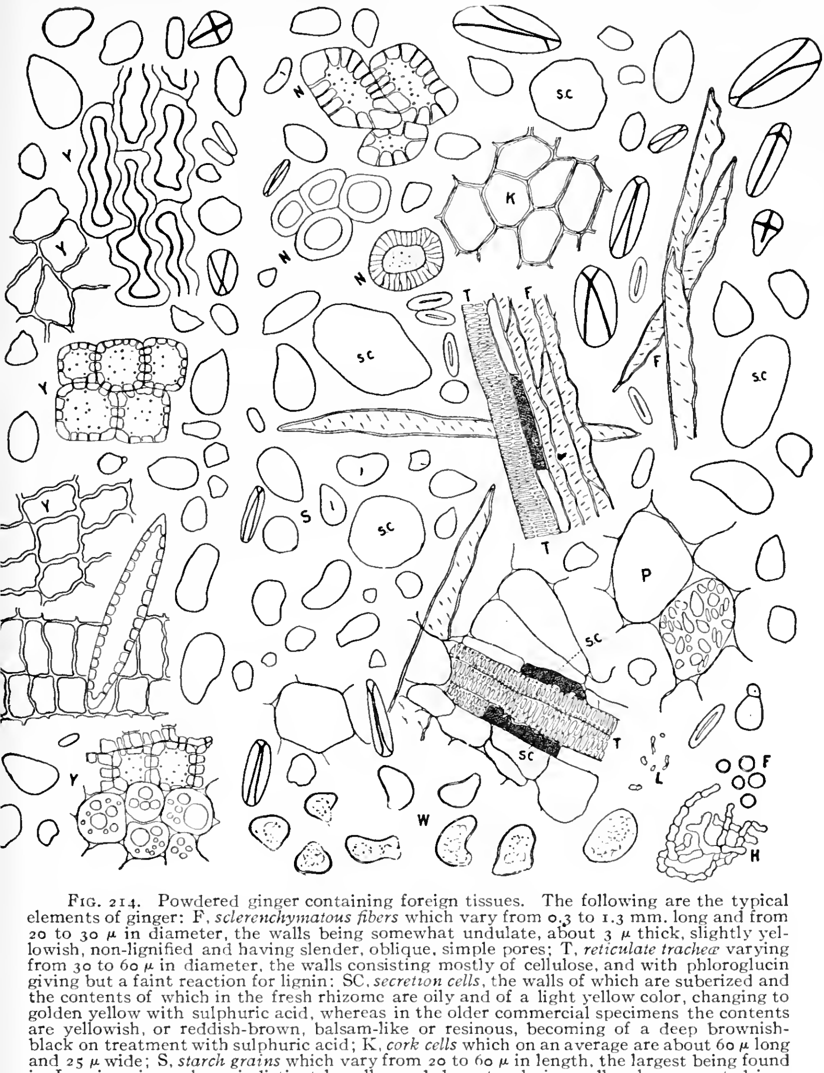


FIG. 214. Powdered ginger containing foreign tissues. The following are the typical elements of ginger: F, *sclerenchymatous fibers* which vary from 0.3 to 1.3 mm. long and from 20 to 30 μ in diameter, the walls being somewhat undulate, about 3 μ thick, slightly yellowish, non-lignified and having slender, oblique, simple pores; T, *reticulate tracheæ* varying from 30 to 60 μ in diameter, the walls consisting mostly of cellulose, and with phloroglucin giving but a faint reaction for lignin; SC, *secretion cells*, the walls of which are suberized and the contents of which in the fresh rhizome are oily and of a light yellow color, changing to golden yellow with sulphuric acid, whereas in the older commercial specimens the contents are yellowish, or reddish-brown, balsam-like or resinous, becoming of a deep brownish-black on treatment with sulphuric acid; K, *cork cells* which on an average are about 60 μ long and 25 μ wide; S, *starch grains* which vary from 20 to 60 μ in length, the largest being found in Jamaica ginger, have indistinct lamellæ, and do not polarize well unless mounted in a fixed oil, as almond or olive; W, swollen starch grains; L, small, swollen, altered starch grains; P, *parenchyma* cells; H, F, hyphæ and spores of a fungus, which are usually present in African ginger and easily detected in mounts prepared with sulphuric acid. In Calcutta ginger occur a large number of spherical starch grains resembling those of wheat, whereas in Japan ginger there are numerous compound grains. Adulterated ginger may contain fragments of tissues of Capsicum (Y), stone cells of endocarp of olive (N), or tissues of soap bark (Fig. 315).

Description.—Horizontal, somewhat cylindrical or 4- to 6-angled, usually cut into pieces 5 to 8 mm. long, 1 to 2 mm. in diameter; externally light yellow, longitudinally furrowed, smooth, shiny, nodes with circular leaf-scars and few root-scars; fracture tough, fibrous; internally, bark light brown, about 0.5 mm. thick, wood light yellow and porous, center hollow; odor slight, taste sweetish, slightly acrid.

Constituents.—Triticin, a lævo-rotatory carbohydrate resembling inulin, 8 per cent.; dextrose and levulose 2.5 to 3.3 per cent.; a nitrogenous, gummy substance, 11 per cent.; acid malates; and about 4.5 per cent. of ash containing much silica. The rhizome is free from starch and calcium oxalate, and the lactic acid found in the extract is apparently a fermentation product.

VERATRUM.—The rhizome and roots of *Veratrum viride* (Fam. Liliaceæ), a perennial herb (Fig. 129) found growing in wet meadows usually associated with skunk cabbage (*Spathyema fœtida*), and indigenous to the Eastern and Central United States and naturalized in Canada, British Columbia and Alaska; and *Veratrum album*, a similar plant, indigenous to Central and Southern Europe, the former being known as American or green hellebore and the latter as European or white hellebore. The plant dies down early in the summer and the rhizome may be collected soon thereafter. It is cut longitudinally and dried. Much of the drug used in this country is derived from *Veratrum album* and imported from Germany (p. 235).

American or Green Hellebore.—Rhizome upright, obconical, usually cut longitudinally into halves or quarters, 2.5 to 5 cm. long, 1.5 to 3 cm. in diameter; externally dark brown or brownish-black, rough and wrinkled, somewhat annulate from scars of bud-scales, top truncate, lower part more or less decayed, with numerous roots and few root-scars; fracture hard and horny; internally light yellow, cortex 2 to 3 mm. thick, endodermis distinct, central cylinder with scattered yellow fibrovascular bundles; odor slight; taste bitter and acrid.

Roots yellowish-brown, nearly cylindrical, 3 to 8 cm. long, 2 to 3 mm. in diameter; externally yellowish-brown, longitudinally or transversely wrinkled (Fig. 113); internally, bark white, 1 to 2 mm. thick; wood porous, cylindrical; fracture short.

EUROPEAN OR WHITE HELLEBORE closely resembles the American Hellebore, but the color varies from whitish to yellowish-brown and usually the rootlets are removed.

The drug should be kept in well closed vessels, and the leaf and stem bases, if present, should be removed.

INNER STRUCTURE.—See Figs. 215, 216.

CONSTITUENTS OF VERATRUM ALBUM.—The drug contains a number of alkaloids, of which the most important is PROTOVERATRINE, which occurs to the extent of 0.03 per cent. and forms monoclinic prisms which are insoluble in water, soluble in strong alcohol, and with concentrated sulphuric acid give a greenish-colored solution which gradually changes to blue and finally to violet. It also contains the following alkaloids which are physiologically inactive or but feebly toxic: JERVINE (0.10 to 0.13 per cent.) forms satiny, lustrous prisms which are colored yellow with hydrochloric acid, the solution afterwards changing to green;

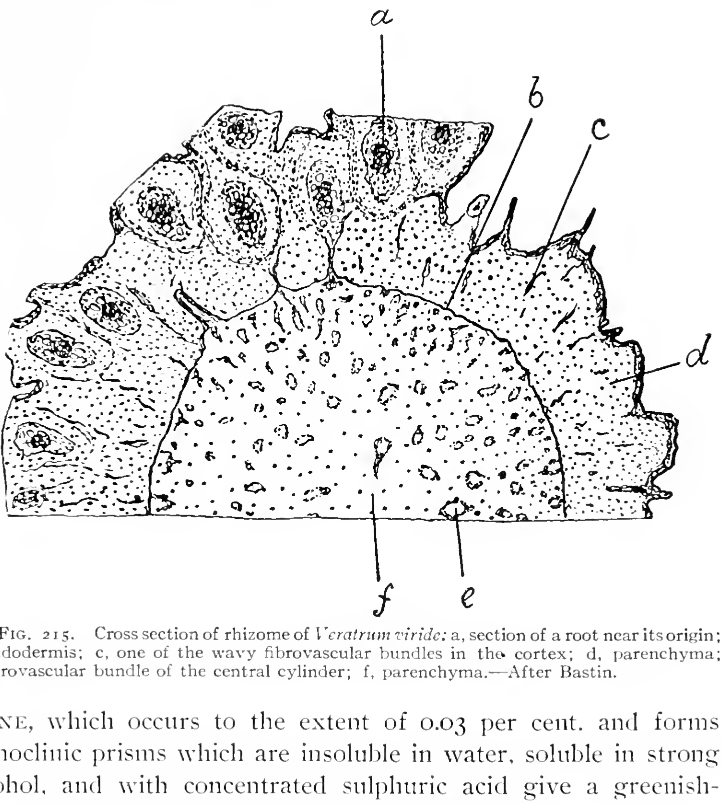


FIG. 215. Cross section of rhizome of *Veratrum viride:* a, section of a root near its origin; b, endodermis; c, one of the wavy fibrovascular bundles in the cortex; d, parenchyma; e, fibrovascular bundle of the central cylinder; f, parenchyma.—After Bastin.

RUBIJERVINE (about 0.005 per cent.) forms long prisms which are colored yellow with concentrated sulphuric acid, the solution becoming orange and finally red; PSEUDOJERVINE forms hexagonal prisms which are colored yellow with concentrated sulphuric acid; PROTOVERATRIDINE is a decomposition product of protoveratrine and forms cubical prisms which are colored violet with concentrated sulphuric acid, the solution afterward becoming cherry-red. Veratrum also contains a bitter glucoside veratramarin; jervic

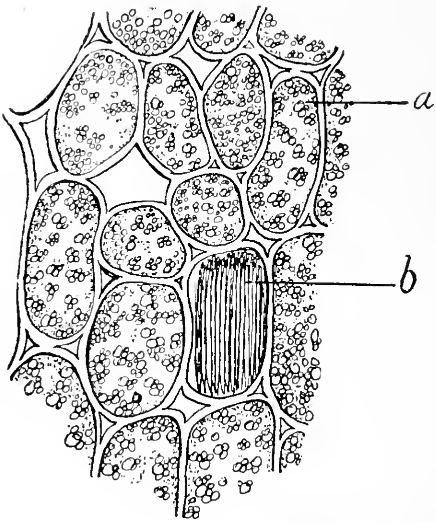


FIG. 216. Several parenchyma cells from rhizome of *Veratrum viride:* a, cells containing starch grains; b, cell containing raphides of calcium oxalate.—After Bastin.

acid, which is identical with chelidonic acid, and crystallizes in silky needles; considerable starch; ash 3 to 4 per cent.; and calcium oxalate in the form of raphides.

CONSTITUENTS OF VERATRUM VIRIDE.—Green hellebore contains about 0.08 per cent. of total alkaloids. Of these about one-half consists of CEVADINE, an exceedingly toxic ether-soluble alkaloid, also found in Sabadilla seeds, which crystallizes in needles and gives a violet color on warming with nitric acid, the solution changing to scarlet-red on boiling. The remainder consists chiefly of the ether-insoluble alkaloids JERVINE and PSEUDOJER-

VINE, both of which are found in *Veratrum album;* a small quantity of VERATRINE, that occurs as an amorphous, resinous mass which is colored yellow with concentrated sulphuric acid, the solution becoming deep red (thus resembling protoveratrine); and VERATALBINE, an amorphous alkaloid. VERATROIDINE is now considered to be a mixture of amorphous bases.

ALLIED PLANTS.—The rhizome of *Veratrum viridifolium,* a plant with greenish flowers growing in the mountainous districts of Europe and Northern Asia, contains jervine and veratroidine. The rhizome of *Veratrum nigrum,* a plant with purplish-red flowers, indigenous to Middle and Eastern Europe, Siberia, Manchuria and Japan, contains jervine.

SABADILLA SEEDS are the source of the official veratrine. They are obtained from *Schœnocaulon officinale* (Fam. Liliaceæ), a bulbous plant indigenous to Mexico and the West Indies. The seeds are brownish-black, 5 to 8 mm. long, narrow, angular, flat, beaked and have a very bitter and acrid taste. They are frequently exported from Mexico in the small trilocular dehiscent capsules there being 3 to 6 seeds in each loculus. They contain about 1 per cent. of a mixture of alkaloids known as VERATRINE. This consists of cevadine and veratrine (veratridine), both of which are found in the rhizome of *Veratrum viride,* and three other alkaloids: cevadilline, sabadine and sabadinine, the two latter being crystalline.

The bulbs of DEATH CAMAS (*Zygadenus venenosus*), known to the Nez Perce Indians as "Wa-i-mas," contain the alkaloids veratalbine, sabadine and sabadinine.

BLACK HELLEBORE consists of the rhizome and roots of *Helleborus niger* (Fam. Ranunculaceæ), a perennial herb indigenous to the Eastern and Southern Alps and also cultivated. The rhizome is 2.5 to 7.5 cm. long, 6 to 12 mm. in diameter; with numerous short, knotty branches and short, brittle roots; externally, of a grayish-black color; internally, with a characteristic dicotyledonous structure; odor slight; taste sweet, somewhat bitter and acrid. The drug contains two crystalline glucosides: helleborin, a narcotic poison with a burning taste, and helleborein, a cardiac stimulant and having a sweetish taste. The former gives a violet-red color with concentrated sulphuric acid and the latter a deep violet color with the same reagent. The drug also contains a volatile oil, two acrid resins, an acrid fixed oil, aconitic acid and gallates of calcium and potassium.

The rhizome of *Helleborus viridis* (so-called "GREEN HELLEBORE"), a plant found in Middle and Southern Europe, has been used similarly to that of *H. niger*. It contains the same principles as *H. niger*, the helleborein apparently predominating.

FALSE HELLEBORE is the entire herb of *Adonis vernalis* (Fam. Ranunculaceæ) and other species of Adonis indigenous to Europe and Asia. The drug contains adonidin, a mixture of several principles, the most important being the amorphous glucoside picradonidin, a principle resembling digitalin in its physiologic action.

CALAMUS.—SWEET FLAG.—The dried, unpeeled rhizome of *Acorus Calamus* (Fam. Araceæ), a perennial herb widely distributed in all north-temperate regions (p. 233). The commercial supplies are obtained from the United States, Germany, England, Russia and India. The rhizomes are collected in autumn, the drug from India being the more aromatic, whereas the German product, on account of the removal of the outer portion of the rhizome, is probably the least aromatic. A confection was at one time made by "candying" the fresh rhizome.

DESCRIPTION.—Horizontal, cylindrical, slightly compressed, usually split longitudinally into pieces 5 to 15 cm. long, 5 to 12 mm. in diameter; externally light brown or yellowish green, annulate from remnants of circular bud-scales, upper surface with triangular leaf-scars or hair-like fibers of fibrovascular tissue, the sides with large circular branch-scars, and the under and side portions with root-scars or short fragments of roots; fracture short; internally light brown, distinctly porous, with numerous intercellular spaces, endodermis distinct; odor aromatic; taste strongly aromatic (Fig. 101, *B*).

CONSTITUENTS.—Volatile oil 1.5 to 3.5 per cent., having the odor and taste of the drug; acorin, a bitter, viscid, aromatic glucosidal principle, which when hydrolized in a current of hydrogen yields oil of calamus; choline (trimethyl-oxyethyl ammonium hydrate), a strong, non-poisonous base, and formerly known as calamine; a soft resin about 2.3 per cent.; tannin; mucilage; starch and calcium oxalate.

An Indian variety contains from 1 to 2.5 per cent. of oil and is mostly preferred.

CIMICIFUGA.—BLACK SNAKEROOT, BLACK COHOSH.—The dried rhizome and roots of *Cimicifuga racemosa*

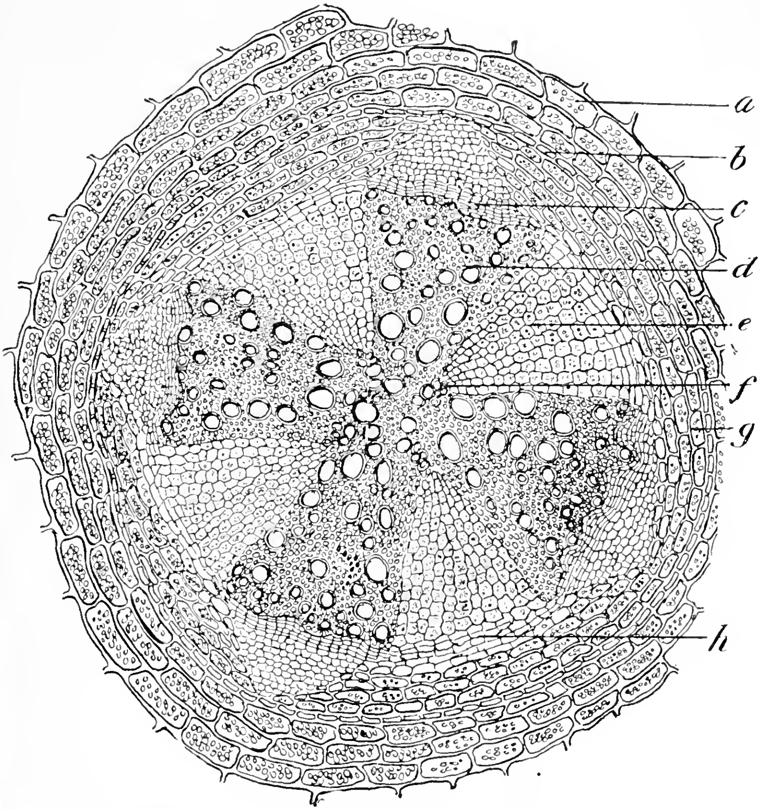


Fig. 217. Cimicifuga. Transverse section of the central part of a mature root in which the secondary changes are completed: a, parenchyma; b, endodermis; c, cambium zone; d, tracheæ in secondary xylem; e, broad, wedge-shaped medullary ray; f, outer portion of one of the primary xylem bundles; g, parenchyma beneath the endodermis; h, inter-fascicular cambium.—After Bastin.

(Fam. Ranunculaceæ), a perennial herb (Fig. 140), indigenous to Asia, Eastern Europe and North America (p. 268). The drug is collected in autumn, the United States furnishing the principal supply.

Description.—Rhizome horizontal, with numerous upright or curved branches and few roots, 2 to 15 cm. long, 1 to 2.5 cm. in diameter; externally dark brown, slightly annulate from circular scars of bud-scales, the upper surface with buds, stem-scars and stem-remnants, under and side portions with numerous root-scars and few roots; fracture horny; internally, bark dark green, about 1 mm. thick, wood dark brown, 4 to 5 mm. thick, distinctly radiate; pith 3 to 5 mm. in diameter; odor slight; taste bitter and acrid.

Roots brittle, nearly cylindrical or obtusely quadrangular; externally dark brown, longitudinally wrinkled, 3 to 12 cm. long, 1 to 2 mm. in diameter; fracture short; internally, bark dark brown, 0.2 to 0.4 mm. thick, wood light brown, usually four-rayed.

Inner Structure.—See Fig. 217.

Constituents.—Two crystalline principles soluble in chloroform; a colorless crystalline substance soluble in ether; a crystalline principle soluble in water; a trace of an alkaloid and several organic acids; considerable starch and a tannin-like principle giving a green color with ferric salts, thus distinguishing the drug from the rhizome of *Helleborus niger* (p. 495).

HYDRASTIS.—GOLDEN SEAL.—The dried rhizome and roots of *Hydrastis canadensis* (Fam. Ranunculaceæ), a perennial herb (Fig. 218) indigenous to the Eastern United States and Canada (p. 268). The rhizome and roots are collected in autumn.

Description.—Rhizome horizontal or oblique, sub-cylindrical, 2 to 5 cm. long, 3 to 6 mm. in diameter; externally yellowish or dark brown, slightly annulate from circular scars of bud-scales, upper surface with numerous short stem-remnants or stem-scars, under and side portions with numerous roots or root-scars; fracture short, waxy; internally deep yellow, bark about 0.5 mm. thick, wood radiate, about 1 mm. thick, pith light yellow; odor distinct; taste bitter.

Roots 4 to 7 cm. long, 0.2 to 0.4 mm. in diameter; internally bright yellow, wood somewhat quadrangular.

Inner Structure.—See Figs. 219, 292.

Constituents.—Two alkaloids—one, hydrastine, occurring to the extent of 2 to 3 per cent., and forming colorless, tasteless 4-sided prisms, although the salts are pale yellow and bitter; the other, berberine, occurring to the extent of 3 to 4 per cent. in the form of yellow needles, which are bitter and readily form compounds with acetone, alcohol and chloroform. In addition, the drug contains a small amount of an alkaloid, canadine (tetrahydro-berberine), and considerable starch. Calcium oxalate is wanting.

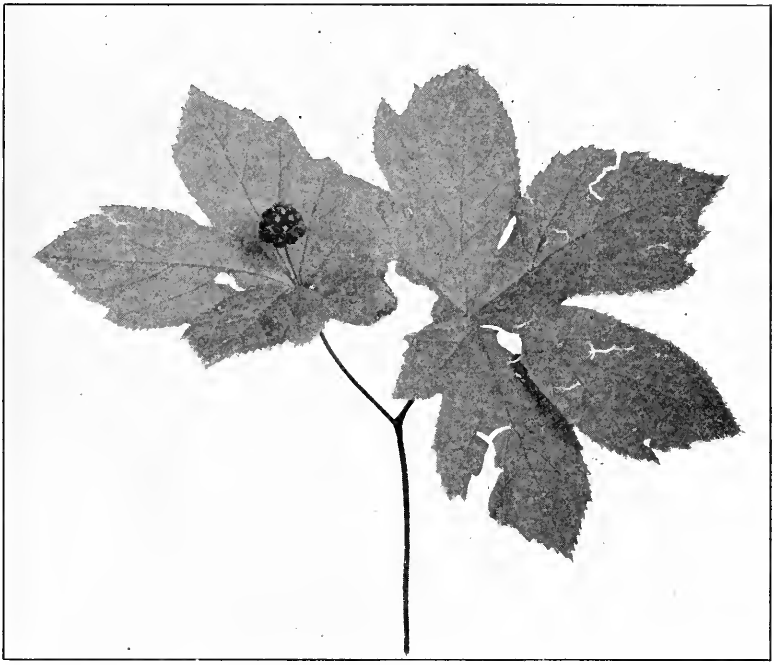


FIG. 218. Golden seal (*Hydrastis canadensis*): overground branch showing the two palmately lobed leaves and head of berries, which are crimson and resemble a raspberry fruit.

ALLIED PLANTS.—The alkaloid berberine, or a principle closely resembling it, is found in the following plants of the Ranunculaceæ: False rhubarb (*Thalictrum flavum*) of Europe; and the following plants growing in the United States: Gold-thread (*Coptis trifolia*), yellow root (*Xanthorrhiza apiifolia*), and marsh marigold (*Caltha palustris*). A principle resembling berberine is found in the following plants belonging to the Rutaceæ: Several species of Zieria found in Southern Australia and Tasmania, and *Toddalia aculeata* found in the mountains of Eastern Africa, tropical Asia and the Philippine Islands (see also p. 483).

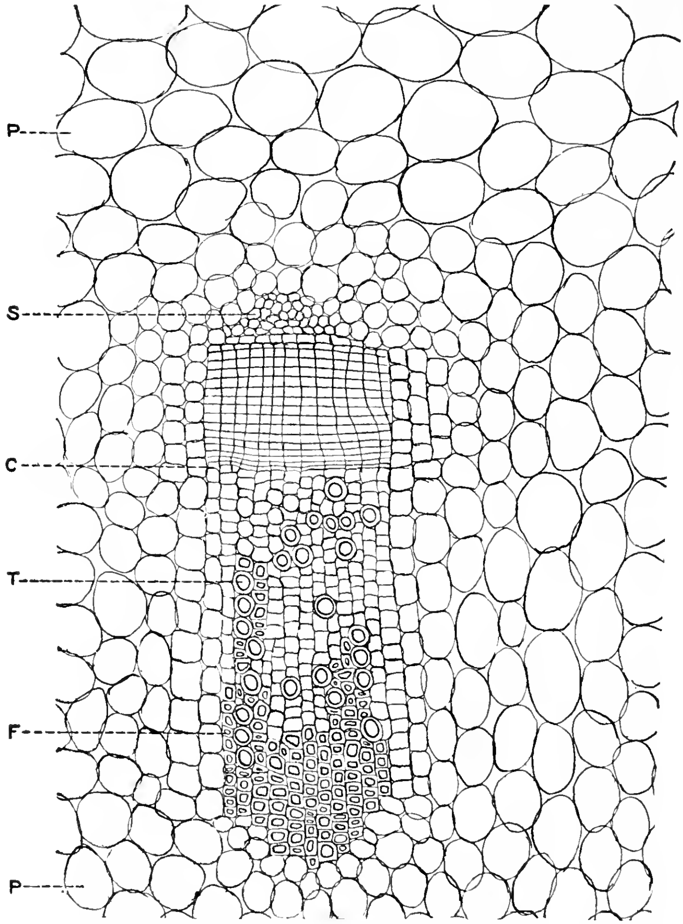


FIG. 219. Transverse section of a part of the rhizome of hydrastis near the cambium: P, parenchyma; S, sieve; C, cambium; T, tracheæ; F, wood fibers.

LEPTANDRA.—CULVER'S ROOT.—The dried rhizome and roots of *Leptandra virginica* (Fam. Scrophulariaceæ), a perennial herb growing in meadows and moist woods of the Eastern and Central United States and Canada (p. 376). The rhizome and roots are collected in autumn from plants of the second year's growth. When fresh the drug has an almond-like odor and a bitter, nauseous taste, which it loses in a measure on drying, and may be kept indefinitely (Fig. 207).

Description.—Rhizome horizontal, nearly cylindrical, somewhat branched, 4 to 10 cm. long, 3 to 8 mm. in diameter; externally light brown to brownish-red; annulate from circular scars of bud-scales, upper surface with conical buds, short stem-remnants or stem-scars, the under and side portions with numerous roots or root-scars; fracture tough; internally, bark dark brown, 0.3 to 1 mm. thick, wood about 0.5 to 1.5 mm. thick, pith light brown or brownish-black; odor slight; taste bitter, slightly acrid.

Roots from 1 to 4 cm. long, 0.5 to 1 mm. in diameter, externally smooth; longitudinally wrinkled, fracture short; internally, bark brownish-black, wood light brown.

Constituents.—Leptandrin, a glucoside, occurring in yellowish-green crystals; resin, about 6 per cent.; saponin; tannin; and starch. The drug yields a distillate containing formic acid.

SERPENTARIA.—The rhizome and roots of several species of Aristolochia (Fam. Aristolochiaceæ), perennial herbs indigenous to the Southern United States. There are two commercial varieties: (1) Virginia Snakeroot, yielded by *Aristolochia Serpentaria*, found growing east of the Mississippi, and (2) Texas or Red River Snakeroot, yielded by *Aristolochia reticulata*, growing west of the Mississippi. The rhizome and roots are collected in autumn and dried (p. 260).

Virginia Snakeroot.—Rhizome oblique, sub-cylindrical, with numerous slender roots and frequently with leaves or fruiting stems, 10 to 25 mm. long, and 1 to 2 mm. in diameter; externally dark brown, slightly annulate from scars of bud-scales, upper portion with stem-scars or stem-remnants, under and side portions with numerous roots and root-scars; fracture short; internally, bark dark brown, 0.3 to 0.5 mm. thick, wood yellow, radiate, porous, 1 to 1.5 mm. thick, pith 1 mm. in diameter; odor terebinthinate; taste bitter, aromatic.

Roots nearly straight, 4 to 7 cm. long, about 0.3 mm. in diameter, longitudinally wrinkled, bark light brown, wood yellowish, 5-rayed.

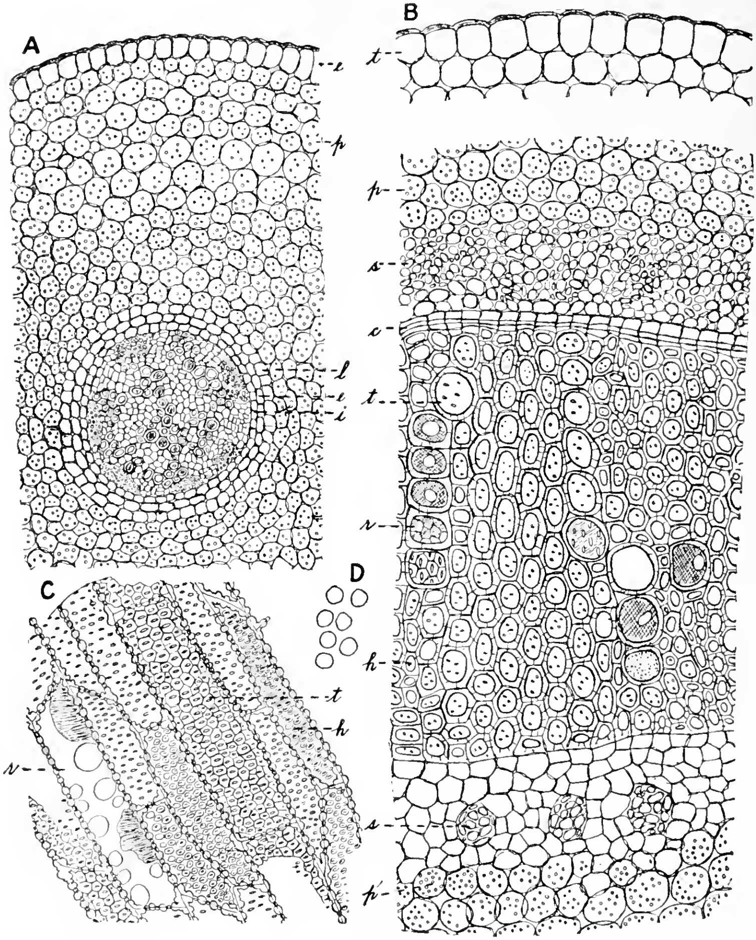


FIG. 220. Pinkroot (*Spigelia marilandica*): A, transverse section of root showing epidermis (e), parenchyma containing starch (p), peripheral layer of central cylinder (l), endodermis (e), internal layer of cortex (i). The central cylinder consists of six to eight radial fibrovascular bundles, and some of the tracheæ contain a brown gummy substance. B, transverse section of rhizome showing epidermis (t), the outer wall of which contains a yellowish-brown substance, parenchyma (p) of cortex containing starch, sieve of cortex (s), cambium (c), tracheæ (t), tracheæ (r) containing globular or somewhat irregular yellowish-brown masses, tracheids (h), internal sieve groups (s), parenchyma of pith (p′) containing starch. C, longitudinal section of the woody part of the rhizome; D, isolated starch grains, which are 2 to 5 μ in diameter.

TEXAS SNAKEROOT.—Rhizome 10 to 40 mm. long, 1 to 3 mm. in diameter; roots about 0.5 mm. in diameter, with numerous more or less interlacing rootlets.

CONSTITUENTS.—Volatile oil 0.5 to 1 per cent., the important constituent of which is borneol; a bitter poisonous principle, aristolochin (serpentarin); an alkaloidal principle, aristolochine; several organic acids; starch; ash about 10 per cent.

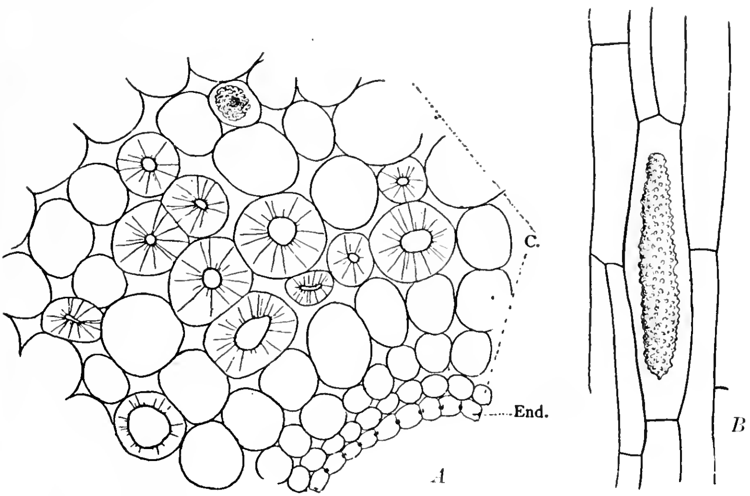


FIG. 221. *Ruellia ciliosa*, the rhizome and roots of which are a common adulterant of spigelia. A, transverse section of a secondary root: C, cortical parenchyma with one cystolith and a number of stone cells with very thick walls and radiating simple pores; End, endodermis. B, longitudinal section of the same root, showing a single cell with an elongated cystolith, the encrustation being of calcium carbonate.—After Holm.

SPIGELIA.—PINKROOT.—The rhizome and roots of *Spigelia marilandica* (Fam. Loganiaceæ), a pèrennial herb (Fig. 172) indigenous to the Southern United States (p. 362). Spigelia should be collected in autumn, carefully dried and preserved, and not kept longer than two years.

DESCRIPTION.—Rhizome horizontal or slightly oblique, more or less branched, 1.5 to 3 cm. long, 2 to 3 mm. in diameter; externally dark brown, slightly annulate from scars of bud-scales, the upper portion with stem-scars or stem-remnants, under and side portions with numerous roots and root-scars; fracture short; internally, bark dark brown, 0.2 to 0.5 mm. thick, wood yellow, slightly radiate, 1 to 1.5 mm. thick, pith 1 mm. in diameter; odor slightly aromatic; taste bitter, pungent.

Roots 5 to 10 cm. long, about 0.3 mm. in diameter, with numerous rootlets; externally dark brown, longitudinally wrinkled; internally light brown, wood nearly cylindrical, porous.

CONSTITUENTS.—A crystalline, volatile alkaloid, spigeline, which somewhat resembles coniine and nicotine and which forms precipitates with iodine or Mayer's reagent that are soluble in mineral acids; a bitter, acrid principle, volatile oil, resin, tannin and starch.

ADULTERANTS.—For some years past another rhizome has been substituted for Spigelia, viz.: that of *Ruellia ciliosa* (p. 377). The rhizome is oblique, with shorter internodes at the lower portion and the basal part of the aerial shoots usually remains attached. The roots are quite long, sparingly branched and generally coarser than those of Spigelia. The inner structure of Ruellia is quite distinct from Spigelia, showing numerous stone cells and cystoliths in the cortex (Fig. 221).

VALERIANA.—VALERIAN.—The rhizome and roots of *Valeriana officinalis* (Fam. Valerianaceæ), a perennial herb (p. 385) indigenous to Europe and Asia, and cultivated in Holland, Germany, England and the New England States, being more or less naturalized in this country as far south as New York and New Jersey. The rhizome is collected in autumn, cut into longitudinal slices and dried by artificial heat. There are several commercial varieties, and it is said that some of the drug is derived from *Valeriana sylvatica.*

DESCRIPTION.—Rhizome upright, slightly ellipsoidal, more or less truncate at both ends, from 2.5 to 4 cm. long and 1 to 2 cm. in diameter, usually cut longitudinally into two, four or more pieces; externally dark brown, upper portion with circular stem- and leaf-scars, the sides sometimes with short branches or stolons from 5 to 8 cm. long, with numerous roots and few root-scars; fracture short, horny; internally light brown; odor pronounced, becoming stronger on keeping the drug; taste somewhat aromatic.

Roots 3 to 10 cm. long, 0.5 to 1 mm. in diameter, longitudinally wrinkled; fracture brittle.

Constituents.—Volatile oil 0.5 to 3 per cent., of which 9.5 per cent. is bornyl valerate. It also contains bornyl formate, acetate and butyrate; borneol; pinene; camphene, and a sesquiterpene. The odor of valerian is due to the isovalerianic acid which is formed from the bornyl valerate by the action of an oxydase during the drying of the drug. The fresh drug contains 0.015 per cent. of an alkaloid and also a glucoside and a resin, all three of which are physiologically active, the two former being unstable. The drug also contains free formic and acetic acids and malates; tannin; saccharose; and starch.

Allied Plants.—Kesso root oil is obtained from Japanese Valerian (*Valeriana angustifolia*). The constituents are similar to those of the volatile oil in Valerian, but it contains in addition kessyl acetate and kessyl alcohol. Mexican Valerian, derived from *V. mexicana,* yields an oil containing about 89 per cent. of isovalerianic acid.

The small rhizomes of *Valeriana celtica*, a plant growing in the Styrian Alps, yield a volatile oil with an odor resembling that of Anthemis and patchouly.

Adulterants and Substitutes.—The most dangerous admixture that has been reported is Veratrum, which is readily distinguished (p. 492). *Cypripedium macranthum* (Fam. Orchidaceæ), of Germany, has been used as a substitute for valerian.

GERANIUM.—WILD OR SPOTTED CRANESBILL.—The dried rhizome of *Geranium maculatum* (Fam. Geraniaceæ), a perennial herb (Fig. 155), indigenous to Canada and the Eastern and Central United States (p. 301). The rhizome is collected in the late summer or early autumn.

Description.—Horizontal, cylindrical, tuberculate, curved or bent pieces, 2.5 to 5 cm. long, 3 to 10 mm. in diameter; externally dark brown, wrinkled, upper and side portions with numerous buds or circular stem-scars, under surface with numerous root-scars; fracture short; internally light brown, bark thin, wood indistinct, pith large; odor slight; taste astringent.

Constituents.—Tannin 15 to 25 per cent., which on hydrolysis yields gallic acid; starch; and calcium oxalate.

Allied Plants.—Other species of geranium contain similar principles.

PODOPHYLLUM.—MAY APPLE.—The rhizome of *Podophyllum peltatum* (Fam. Berberidaceæ), a perennial herb (Fig. 222) indigenous to Eastern North America (p. 273). The rhizome is collected late in summer and dried, after the removal of the rootlets. (Fig. 104.) Most of the commercial supplies come

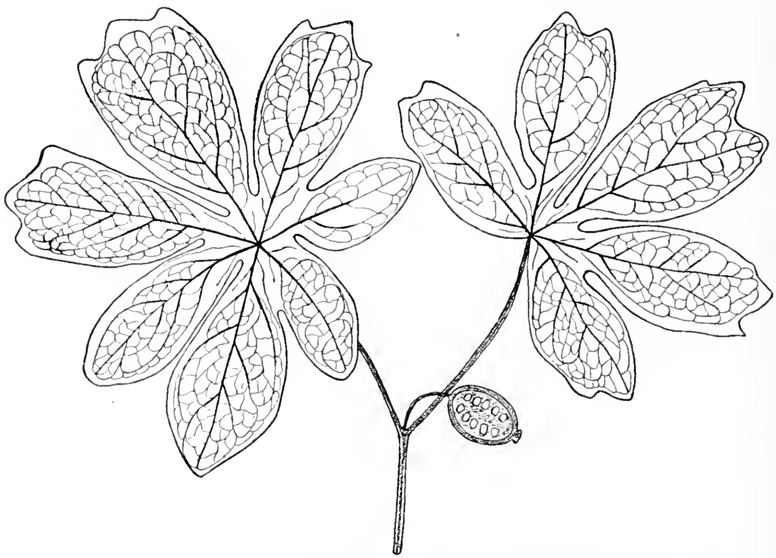


FIG. 222. Top of fertile shoot of May apple (*Podophyllum peltatum*) having two large peltate palmately lobed leaves, in the axil of which is the fleshy fruit containing numerous truncate ovoid seeds.

from the Central States. Both the leaves and the fruit apparently contain a purgative resin similar to that found in the rhizome. The berry, which is known as May, Indian, Hog or Devil's apple; wild or ground lemon, and Raccoon-berry, is generally considered to be edible, but several cases of poisoning from it have been recorded.

DESCRIPTION.—Horizontal, nearly cylindrical, flattened, sometimes branched, jointed, in pieces 3 to 8 cm. long, internodes 4 to 10 cm. long, 5 to 9 mm. in diameter, nodes 7 to 18 mm. in diameter and 5 to 12 mm. thick; externally dark brown, longitudinally wrinkled or nearly smooth, with irregular scars of bud-scales, nodes annulate from remains of bud-scales, upper part marked with large circular, depressed stem-scars and sometimes with buds; numerous root-scars at and near the lower portion of the nodes;

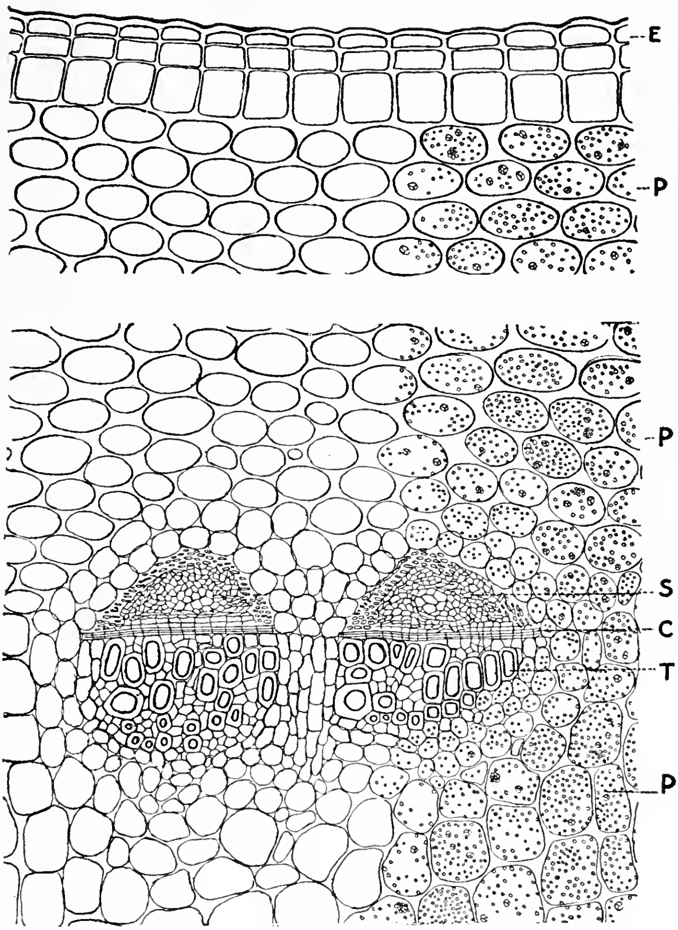


FIG. 223. Transverse section of podophyllum rhizome: E, epidermis; P, parenchyma containing starch; S, sieve; C, cambium; T, tracheæ.

fracture short; internally lemon-yellow, bark 1 mm. thick, wood yellowish, 0.5 mm. thick, pith large, white; odor slight; taste somewhat bitter and acrid.

Inner Structure.—See Fig. 223.

Constituents.—Resin (official as Resin of Podophyllum) 3.5 to 5 per cent., consisting of two poisonous principles: (a) podophyllotoxin, 20 per cent., occurring in white crystals that are sparingly soluble in water and yield on treatment with water podophyllic acid and picropodophyllin; and (b) picropodophyllin (an isomer of podophyllotoxin), which crystallizes in needles and is insoluble in water but soluble in 90 to 95 per cent. alcohol. The resin also contains a yellow crystalline coloring principle resembling quercetin, a green fixed oil and podophyllic acid. The rhizome also contains a purgative resin, podophylloresin; considerable starch, and some gallic acid.

Allied Plants.—The rhizome of *Podophyllum Emodi,* a plant growing on the lower slopes of the Himalayas, is larger and yields 11.4 to 12 per cent. of resin, which consists of but half as much podophyllotoxin as the resin obtained from *P. peltatum.*

SANGUINARIA.—BLOODROOT.—The rhizome of *Sanguinaria canadensis* (Fam. Papaveraceæ), a perennial herb (Fig. 148) indigenous to the Eastern and Central United States and Canada (p. 280). The rhizome should be collected in July or August and dried.

Description.—Horizontal, irregularly cylindrical, flattened, sometimes branched, 2.5 to 6 cm. long, 5 to 10 mm. in diameter; externally dark brown, slightly annulate, with few buds or stem-scars on upper surface and numerous root-scars on lower surface; fracture short and somewhat waxy; internally, bark dark brown, about 0.5 mm. thick, wood and pith with numerous reddish resin-cells; odor slight; taste bitter and acrid.

Shriveled rhizomes which are gray internally and free from starch should be rejected.

Constituents.—The drug contains a number of alkaloids, of which the most important is sanguinarine; it occurs to the extent of about 1 per cent., crystallizes in colorless needles and yields reddish salts with nitric or sulphuric acid. The other alkaloids include chelerythrine, which forms yellowish salts; protopine, also found in other plants (p. 282), and β- and γ-homochelidonine, which, like the last two alkaloids, are found in Chelidonium and some other plants (p. 281). In addition, the drug contains a reddish resin, several organic acids, as citric and malic, and considerable starch.

SCOPOLA.—BELLADONNA SCOPOLIA.—The dried rhizome of *Scopolia carniolica* (Fam. Solanaceæ), a perennial herb growing in the region of the Eastern Alps, Carpathian Mountains and neighboring regions.

DESCRIPTION.—Rhizome horizontal, nearly cylindrical, somewhat tortuous, usually cut longitudinally into pieces 5 to 12 cm. long, 7 to 15 mm. in diameter; externally grayish-brown, longitudinally furrowed, slightly annulate, with numerous circular stem-scars about 5 mm. in diameter, under portion with root-scars and root-remnants; fracture short, mealy; internally whitish or light grayish-brown, bark 1 mm. or less thick, wood slightly radiate, rather large, horny pith; odor slight; taste starchy, sweetish, afterward acrid. (Fig. 175a.)

The roots, which are attached to the rhizome or in separate pieces, are cylindrical, tapering, varying in diameter from 2 to 10 mm., longitudinally wrinkled, and marked by lenticular whitish areas resembling lenticels.

CONSTITUENTS.—About 0.6 per cent. of total alkaloids, including atropine, hyoscyamine and scopolamine (hyoscine). Scopolamine is official as a hydrobromide, and exists in the drug to the extent of 0.06 per cent. Scopolamine decomposes into scopoline and atropic acid when treated with boiling baryta water. Scopoline resembles tropine, a principle formed from atropine and hyoscyamine, when similarly treated (see Fig. 341).

ALLIED PLANTS.—Japanese belladonna is the rhizome of *Scopolia japonica*, growing in Japan, and closely related to *S. carniolica*. The drug resembles scopola and apparently contains the same principles. The rhizomes of six other species of Scopolia are also used.

SCOPOLIA LEAVES are used in medicine like belladonna leaves, and are said to be sometimes admixed with them. They are obovate, slightly acuminate, and taper gradually into the rather long petiole (p. 372; Fig. 273).

COLCHICI CORMUS.—COLCHICUM CORM.—The corm of *Colchicum autumnale* (Fam. Liliaceæ), a perennial bulbous plant, native of and growing in moist meadows and pastures of

England, Southern and Middle Europe and Northern Africa (p. 236). The corm is collected in early summer before the flowering period, deprived of the membranous, scaly coat, cut into transverse pieces, and dried at a temperature below 65° C. Tubers that are collected in the fall either during the flowering season or later are considered to be more active. The commercial supply is obtained from England and Germany.

DESCRIPTION.—Obconical, with a groove on one side, sometimes with fragments of the flower-stalk, usually in transverse, reniform sections from 15 to 20 mm. long, about 12 mm. wide and 3 to 5 mm. thick; externally dark brown, longitudinally wrinkled; fracture short, mealy; internally light brown, with numerous scattered fibrovascular bundles; odor slight; taste bitter and acrid.

INNER STRUCTURE.—See Fig. 310.

CONSTITUENTS.—A yellowish, amorphous alkaloid, COLCHICINE, about 0.4 per cent., which has a peculiar odor, particularly on heating slightly, is soluble in hot water and gives with concentrated sulphuric acid a yellowish solution which is colored deep red on heating. If the sulphuric acid contains a mere trace of nitric acid the solution of the alkaloid becomes yellowish-green, green, bluish-green, blue, violet, wine-red and finally yellow. The salts of colchicine are quite unstable. The drug also contains the alkaloid COLCHICEINE, which crystallizes in needles and is apparently formed during the extraction of the drug by reason of the decomposition of colchicine. The latter may be formed on the esterification of colchiceine with methyl alcohol. The corm also contains two resins; a large amount of starch; ash about 2.5 per cent.

SCILLA.—SQUILL.—The fleshy scales of the bulb of *Urginea maritima* (Fam. Liliaceæ), a perennial herb indigenous to the Mediterranean region. The bulbs are collected late in August, and after the removal of the membranous outer scales and the central portion, the fleshy scales are cut into transverse pieces and dried in sunlight or by artificial heat. The article used in France is collected from bulbs having reddish scales and is obtained from Algeria and Malta (p. 238).

DESCRIPTION.—In irregular, curved, flat, narrow, somewhat translucent pieces 3 to 5 cm. long, 5 to 8 mm. wide, 2 to 7 mm.

thick, whitish, lemon-yellow or light brown, epidermis forming a thin layer, mesophyll more or less shrunken, slightly crystalline and with numerous circular projections of fibrovascular bundles; fracture brittle when dry, tough when damp; odor slight; taste bitter and acrid.

Constituents.—Squill contains a number of active principles, of which the most important are the amorphous glucoside scillitoxin, which resembles digitoxin physiologically, and scillipicrin, an amorphous, bitter principle, which is employed as a diuretic. It also contains a yellow crystalline glucoside scillin; an amorphous bitter glucoside, scillain; a little volatile oil; sugar, about 22 per cent.; considerable calcium oxalate in the form of raphides (Fig. 281, *B*), which is associated in the parenchyma cells with a peculiar mucilage sinistrin, which yields levulose on hydrolysis.

Allied Plants.—The bulbs of several species of *Crinum* (Fam. Amaryllidaceæ) found growing in Brazil, China, Southern Asia and the East Indies are used as substitutes for squill.

III. PARTS OF ROOTS AND STEMS.

PITH, WOOD AND BARK.

The active principles are not uniformly distributed throughout all parts of the plant, but occur in greater amount in the bark than in the wood, as in Ipecac; in larger proportion in the root bark than in the stem bark, as in Granatum; and in larger amount in the inner bark and cortex than in the periderm layers, as in Quercus alba. This is in general true of herbaceous plants, as well as of trees and shrubs, but in most of the medicinal roots and rhizomes it has not been found economical to separate the bark from the wood, which usually contains some of the active principles. A large number of the barks alone of shrubs and trees are used medicinally. By the term bark is usually meant all that portion of the root or stem which is developed outside of the cambium, and this is commonly differentiated into two distinct parts—one next to the cambium, in which the life-processes take place, contains the greatest amount of active principles, and is known as the inner bark (Figs. 227, 231, 234); another, external to this, having a greater or less development of corky layers among more or less obliterated sieve and parenchymatous cells, is known as the OUTER BARK. The term bark is sometimes restricted to this outer layer, but this is more or less confusing and has not been generally adopted. The term BORK is frequently applied to the outer corky layers and the dead tissues enclosed by them (Figs. 237, 238). The term PERIDERM is applied to all the tissues produced by the phellogen, the older layers of periderm being included in the bork.

In a few cases the wood alone is employed in medicine and, like the bark, may be differentiated into two layers—the one next to the cambium, in which the ascent of the cell-sap takes place, known as the SAP-WOOD, and another at the center of the trunk or stem, which is usually darker in color and may contain resinous, coloring and other substances, and denominated the HEART-WOOD, the latter being the part usually employed in medicine and the arts.

The pith being in the nature of a reserve tissue may contain various of the carbohydrates. Sassafras pith furnishes an example of this, being used in medicine on account of the mucilage it contains.

The following artificial classification may be found of assistance in the study of the drugs of this class:

I. Barks.

1. With periderm.
    - *A. Yellowish-red to dark brown.*
        - *a.* Fracture short.
            - α Aromatic odor and taste.
                - Dark brown..........Cinnamomum Saigonicum
            - β Without aromatic odor and taste.
                - * Usually in quills.
                    - Few lenticels ....Cinchona
                    - Numerous lenticels ....Frangula
                - ** Usually in flattened or transversely curved pieces.
                    - Inner surface reddened with alkalies..........Rhamnus Purshiana
                    - Odor of Valerian....Viburnum Prunifolium
                    - Astringent ....Hamamelidis Cortex

I. Barks.—*Continued.*

b. Fracture fibrous.

Tough-fibrous ....Gossypii Cortex
Short-fibrous ....Rubus

B. Grayish to grayish-black.

a. Fracture fibrous.

Fracture silky-fibrous ....Euonymus
Fracture uneven, fibrous........Viburnum Opulus

b. Fracture short.

α With conical cork-wings...Southern Prickly Ash

β Cork-wings wanting.

Inner surface with acicular
crystals ....Northern Prickly Ash
Inner surface non-crystalline........Granatum

C. Greenish in color.

Fracture tough-fibrous ....Mezereum
Fracture short, granular.............Prunus Virginiana

2. Periderm removed.

A. Aromatic odor and taste.

Yellowish-brown ....Cinnamomum Zeylanicum
Reddish-brown ....Sassafras

B. Without aromatic properties.

a. Surface crystalline ....Quillaja
b. Surface non-crystalline.

Taste astringent...................Quercus Alba
Taste mucilaginous........................Ulmus

II. Woods.

1. Light or bright yellow..............................Quassia
2. Yellowish-red to yellowish-brown.

A. Imparts a violet or wine-color to water.....Hæmatoxylon

B. Coloring matter insoluble in water......Santalum Rubrum

III. Pith.

Whitish, light in weight......................Sassafras Medulla

CINNAMOMUM.—CINNAMON BARK.—The dried bark of the stem and branches of various species of Cinnamomum (Fam. Lauraceæ), trees indigenous to tropical Asia (p. 278), where they are now extensively cultivated, and from which three commercial kinds of bark are obtained: (1) Saigon Cinnamon, obtained from *Cinnamomum Loureirii* (?) and other species cultivated in Cochin China and other parts of China, and exported

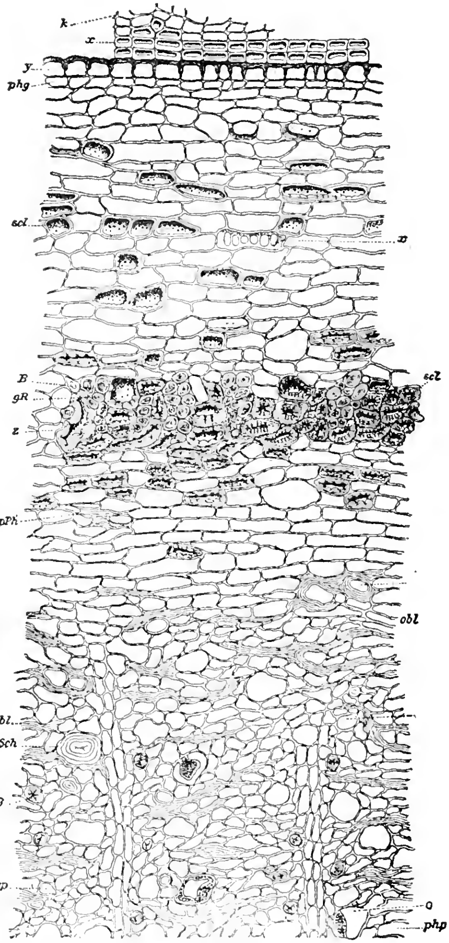


FIG. 224. Transverse section of Cassia cinnamon bark: k, cork; x, thick-walled cork cells; y, cork cells, the outer walls of which are thickened; phg, cork cambium; scl, stone cells; x, parenchyma cell with large pores; B, bast fibers; gR, short sclerenchyma; z, parenchyma separating the groups of sclerenchyma tissue; pPh, protophloem; obl, obliterated sieve; Sch, mucilage canals; php, bast parenchyma; o, oil cells.—After Tschirch and Oesterle.

from Saigon; (2) Cassia Cinnamon, yielded by *Cinnamomum Cassia*, cultivated in the southeastern provinces of the Chinese

Empire, and exported by way of Calcutta, and (3) Ceylon Cinnamon, collected from *Cinnamomum zeylanicum,* indigenous to and cultivated in Ceylon (Fig. 146).

Saigon Cinnamon.—In bundles about 30 to 40 cm. long, and 20 cm. wide, 10 cm. thick, weighing 1.5 to 2 K., and consisting of

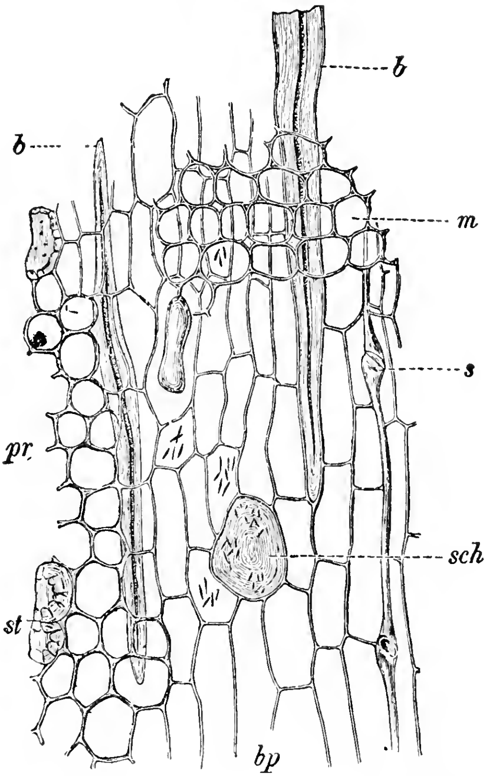


Fig. 225. Radial-longitudinal section of China Cassia (*Cinnamomum Cassia*) bark: pr, parenchyma of outer bark; bp, parenchyma of the inner bark, some of the cells of which contain raphides; b, bast fibers; st, stone cells; sch, mucilage cells; s, sieve; m, medullary rays.—After Moeller.

pieces varying in size and color from small, brownish-black single quills to large, thick, grayish-brown, transversely curved pieces. Pieces 6 to 30 cm. long, 1.5 to 3 cm. in diameter; bark 0.2 to 2 mm. thick; outer surface dark brown, longitudinally wrinkled, with grayish patches of foliaceous lichens, and numerous lenticels;

inner surface light brown, smooth; fracture short; thick inner bark separated from the very thin periderm by a layer of small stone cells; odor aromatic; taste mucilaginous, aromatic and pungent.

Cassia Cinnamon.—In quilled pieces, usually shorter than those of Saigon Cinnamon, the periderm more or less removed, and the bark aromatic and somewhat astringent.

Ceylon Cinnamon occurs in closely rolled double quills composed of numerous thin layers of the inner bark of the shoots; the odor is delicately aromatic, and very distinct from either Cassia or Saigon bark.

Inner Structure.—See Figs. 224, 225, 305.

Constituents.—The most important constituent is the volatile oil, which in Ceylon cinnamon is delicately aromatic and amounts to from 0.5 to 1 per cent., in Cassia from 0.93 to 1.64 per cent., and in the Saigon from 3 to 6 per cent., the latter bark being most pungent and aromatic. The oil of cinnamon consists in large part of cinnamic aldehyde (not present in the oil of the root bark) and other compounds, such as camphor, which is present in the oil from the root bark; safrol, which is found in the leaves; and eugenol, which is found in both leaves and stem bark and which gives the characteristic odor to Ceylon Cinnamon.

Cinnamon also contains the hexatomic alcohol mannitol (cinnamanin) giving the sweetish taste to the several barks; a tannin (3 to 5 per cent.) somewhat resembling that in *Quercus alba* and found in greatest amount in Cassia bark and least in the Saigon variety; a bitter principle especially characteristic of Cassia bark; and a mucilage which may be the source, at least in part, of the volatile oil.

Allied Plants.—Batavia Cassia or Fagot Cassia is the bark of *Cinnamomum Burmanni.* In double quills, the larger sometimes enclosing smaller quills, 5 to 8 cm. long, 5 to 15 mm. in diameter, bark 0.5 to 3 mm. thick; outer surface light or reddish-brown, nearly smooth; inner surface dark-brown with occasional longitudinal ridges and depressed areas; fracture short; odor pronounced, aromatic; taste aromatic and distinctly mucilaginous. It forms a shiny glutinous mass with water and yields with alcohol 11 to 17 per cent. of extract. A number of barks come into the market under the name of "CASSIA BARK." In fact Cassia Cinnamon is frequently known as China Cassia, or Canton Cassia or Cassia lignea, all being synonymous for the same variety of bark. Saigon Cinnamon is also known commercially as Saigon Cassia. The barks of other species of Cinnamomum also find their way into market and are used as substitutes or adulterants of Cassia Cinnamon. These are bitter or nearly tasteless and are free from any aromatic properties.

CLOVE BARK is obtained from *Dicypellium caryophyllatum* (Fam. Lauraceæ), a tree indigenous to Brazil. The bark comes in long quills consisting of 6 to 10 pieces of bark. Externally dark brown or purplish-brown; fracture short, with a circle of whitish stone cells near the periderm; odor clove-like; taste mucilaginous and aromatic, resembling cinnamon.

A number of other products are also derived from species of Cinnamomum, as the immature fruits of *C. Loureirii,* which constitute the CASSIA BUDS of the market. The latter are club- or top-shaped, 5 to 10 mm. in diameter, with a short stem or pedicel, externally dark brown, the 6-lobed perianth folded over the depressed and smooth ovary. The odor is aromatic; taste pungent, aromatic and astringent. Cassia buds yield a volatile oil containing cinnamic aldehyde, which resembles that of Cassia Cinnamon.

WILD CINNAMON, the bark of *Cinnamomum pedatinervum,* a tree indigenous to the Fiji Islands, yields a volatile oil containing from 40 to 50 per cent. of linalool and safrol, 15 to 20 per cent. of a terpene; 1 per cent. of eugenol, and about 3 per cent. of eugenol methyl ether.

CINCHONA.—CINCHONA BARK.—The dried bark of the stem and branches of various species of Cinchona (Fam. Rubiaceæ), trees indigenous to South America, but cultivated in nearly all tropical countries, from which latter the commercial supplies are obtained. There are two principal commercial varieties: (1) Red Cinchona, which is yielded by *Cinchona succirubra* (p. 379), and (2) Calisaya Bark, yielded by *Cinchona Ledgeriana Calisaya.* When the trees are from 6 to 9 years old they are considered to have the maximum amount of alkaloids and the bark of the trunk as well as the roots is removed and allowed to dry. The BARK OF THE STEM is used in the manufacture of galenicals, while the ROOT BARK is employed for the extraction of the alkaloids, especially quinine. Owing to the fact that light influences the production of quinine in the plant, it was customary to cover the bark of the trunk with moss or other materials, and this is known as "MOSSED BARK." For some time the cultivators removed the bark from the trunk in alternate strips, the de-

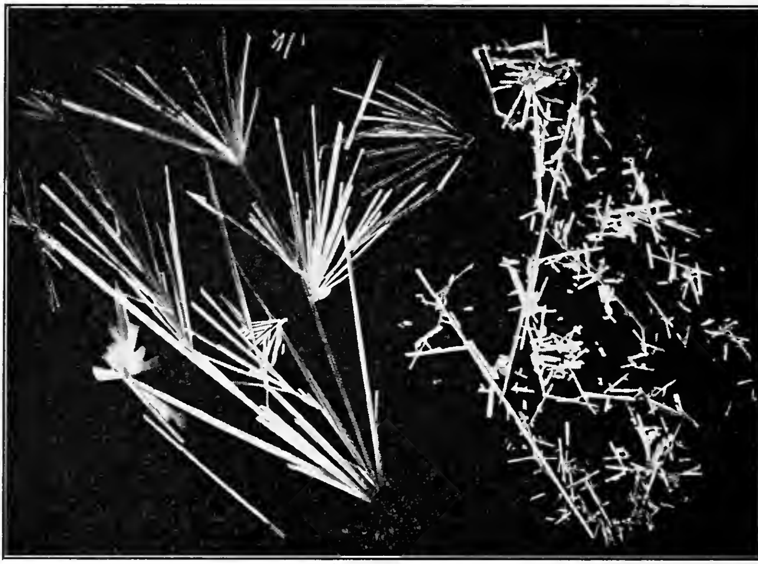


FIG. 226. Quinine sulphate: long orthorhombic needles from a dilute alcoholic solution.

nuded places being again covered, after which another layer of bark develops that is very rich in alkaloids and is known as "RENEWED BARK." The outer bark, consisting of the periderm layer and some of the cortex, is flattened out and allowed to dry under pressure, and constitutes the "FLAT" (or Tambla) bark (Fig. 226).

Most of the cinchona bark of commerce is now obtained from trees cultivated in Java. During the year 1902 some 600,000 kilos of cinchona bark were exported from this island alone. The older methods of cultivation have been entirely replaced by the selection of seeds from those plants that run high in alkaloids. The yield and quality of alkaloids in the bark are improved by hybridization of the best trees.

Red Cinchona.—Usually in double quills or rolled pieces which are cut into lengths from 25 to 40 cm. long, 15 to 20 mm. in diameter, bark 2 to 5 mm. thick; outer surface reddish or dark brown, with grayish patches of foliaceous lichens, longitudinally wrinkled, with few usually widely separated transverse fissures; inner surface reddish-brown, distinctly striate; fracture smooth in periderm, in inner bark with projecting bast fibers; odor distinct; taste bitter, astringent.

Calisaya Bark.—Gray or brownish-gray, with numerous patches of foliaceous lichens, having brownish-black and reddish-brown apothecia, and numerous transverse fissures, which give the bark a very characteristic appearance.

The trunk bark is comparatively thick, while renewed bark is comparatively smooth and uniform in color.

Inner Structure.—See Figs. *227*; 299, *B;* 307; 307a.

Constituents.—A large number of alkaloids have been isolated from this drug, of which the most important are quinine, quinidine, cinchonine and cinchonidine. The total alkaloids amount to about 6 or 7 per cent., of which from one-half to two-thirds is quinine in the yellow barks, whereas, in the red barks, cinchonidine exists in greater proportion. Quinine occurs in small crystals which are sparingly soluble in water, soluble in alcohol and readily form crystallizable salts with acids. On the successive addition of dilute sulphuric acid, bromine or chlorine water and ammonia water the solution becomes of an emerald-green color (thalleioquin). Quinidine, an isomer of quinine, crystallizes in rhombohedra or monoclinic prisms which are nearly insoluble in water and otherwise conforms to the characteristics given for quinine. The solutions of quinidine are, however, dextrogyre, while those of quinine are lævogyre. Cinchonine separates in lustrous prisms or needles which are nearly insoluble in water, and does not give the thalleioquin test, but forms a white precipitate upon the addition of dilute sulphuric acid, bromine water and ammonia. Cinchonidine crystallizes in prisms and resembles cinchonine in many of its properties. Its solutions, however, are lævogyre, while those of cinchonine are dextrogyre.

The other important alkaloids of Cinchona which have been separated are: Quinamine, hydroquinine, hydroquinidine, hydrocinchonidine and homocinchonidine. Of the other alkaloids which have been isolated the following may be mentioned: Conquinamine, paranine, paricine and quinamidine. Among the other

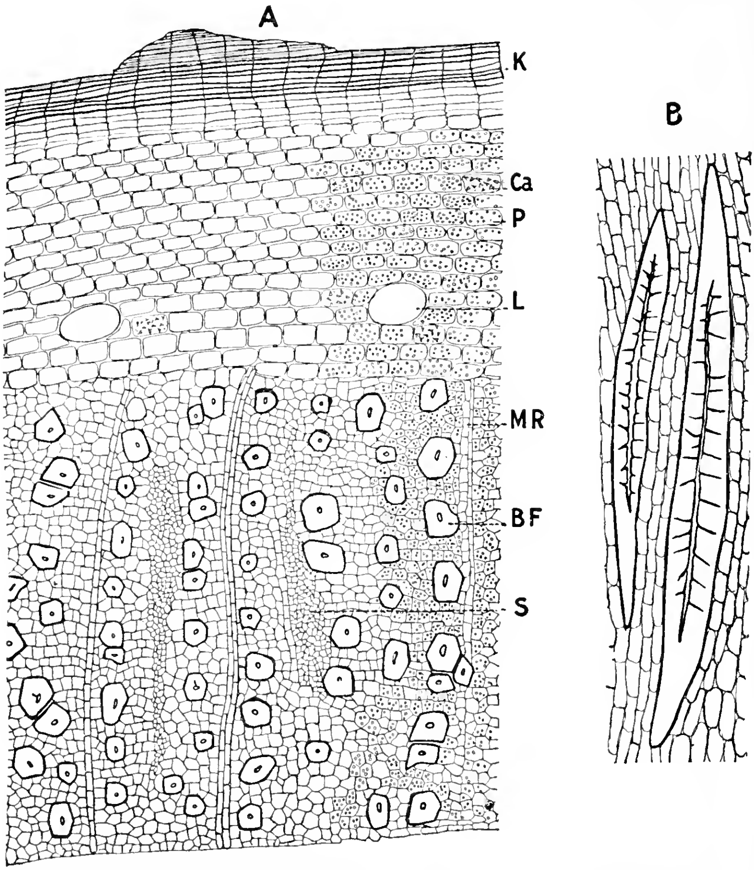


FIG. 227. A, transverse section of red cinchona: K, cork; Ca, cryptocrystalline crystals of calcium oxalate; P, parenchyma containing starch; L, latex cells containing gum, resin and tannin; MR, medullary rays; BF, bast fibers; S, sieve. B, longitudinal section of same showing two bast fibers surrounded by parenchyma cells.

constituents of Cinchona are: KINIC ACID from 5 to 9 per cent., which forms colorless rhombic prisms and yields a sublimate consisting of golden crystals of kinone (quinone) on treatment with manganese peroxide and sulphuric acid; KINOVIN (quinovin) an amorphous, bitter glucoside, to the amount of 0.11 to 1.74 per cent.; CINCHOTANNIC ACID from 2 to 4 per cent., which decomposes into the nearly insoluble CINCHONA RED, occurring in red barks to the extent of 10 per cent.; considerable starch; calcium oxalate in the form of cryptocrystalline crystals; and ash about 3 per cent. The red color in cinchona bark is due to an oxydase similar to that which causes the darkening of fruits when cut. If the fresh bark is heated in boiling water for 30 minutes and then dried it does not become red (see also Figs. 226, 233).

ALLIED PLANTS.—LOXA or Huanco (Cinchona pallida) bark is obtained from *Cinchona officinalis*, a shrub indigenous to Ecuador, which was the species first discovered. The plant is cultivated in nearly all the large cinchona plantations and yields a bark (Fig. 226) that contains 1 to 4 per cent. of total alkaloids, from one-half to two-thirds of which is quinine.

CUPREA BARK is obtained from *Remijia Purdieana* and *R. pedunculata*, of Central and Southern Colombia. It has a copper-red color, is hard, compact and heavy, contains numerous transversely elongated stone cells and 2 to 6 per cent. of alkaloids, of which one-third may be quinine. Cinchonidine has never been isolated from this bark. Cuprea bark also contains caffeate of quinine and caffeic acid, of which there is about 0.5 per cent., and which closely resembles the same acid obtained from caffeotannic acid in coffee.

FRANGULA.—ALDER BUCKTHORN BARK.—The dried bark of the stem and branches of *Rhamnus Frangula* (Fam. Rhamnaceæ), a shrub indigenous to Europe, Northern Africa and Central Asia; and naturalized in Northern New Jersey and Long Island. The bark is collected in spring and kept at least one year before being used, so as to render inert the irritating and nauseating principles which are destroyed by a ferment during the curing of the drug. The same results are said to be obtained by heating the bark at 37.7° C. for 48 hours (p. 326).

DESCRIPTION.—In single or double quills and transversely curved pieces, 2 to 20 cm. long, 1 to 3 cm. in diameter, bark 0.3 to 1 mm. thick; outer surface dark brown or purplish-black, longitudinally wrinkled, with numerous lenticels 1 to 3 mm. long, and with grayish patches of foliaceous lichens and groups of light brown or brownish-black apothecia; inner surface yellowish or dark brown, smooth, longitudinally striate, and reddened by alkalies; fracture short, with projecting bast fibers in inner bark; odor slight; taste slightly bitter.

INNER STRUCTURE.—See Fig. 228.

CONSTITUENTS.—A glucoside frangulin (rhamnoxanthin), which forms yellow crystals, is insoluble in water and nearly so in alcohol, gives a bright purple color on the addition of solutions

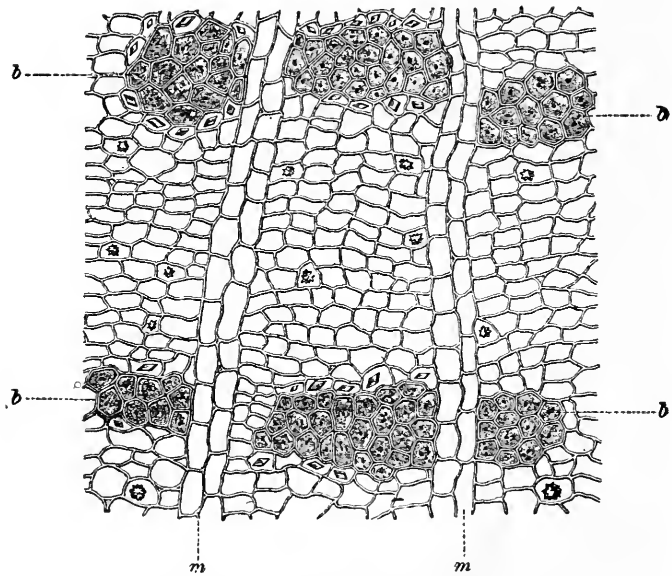


FIG. 228. Transverse section of inner bark of *Rhamnus Frangula:* b, bast fibers; surrounded by crystal fibers; m, medullary rays; parenchyma containing rosette aggregates of calcium oxalate.—After Vogl.

of the alkalies, and on hydrolysis yields rhamnose and emodin (see Rhubarb). It also contains the glucoside pseudofrangulin (frangulic acid), which yields pseudoemodin; rhamnoxanthin, a coloring principle; a volatile oil; tannin; starch; calcium oxalate; and ash 5 to 6 per cent.

ALLIED PLANTS.—The bark of *Rhamnus Carniolica* has been substituted for *R. Frangula.* The older pieces are distinguished by having a deeply fissured cork and groups of stone cells. In the younger bark the medullary rays are from 4 to 7 cells wide; otherwise the pieces resemble Frangula.

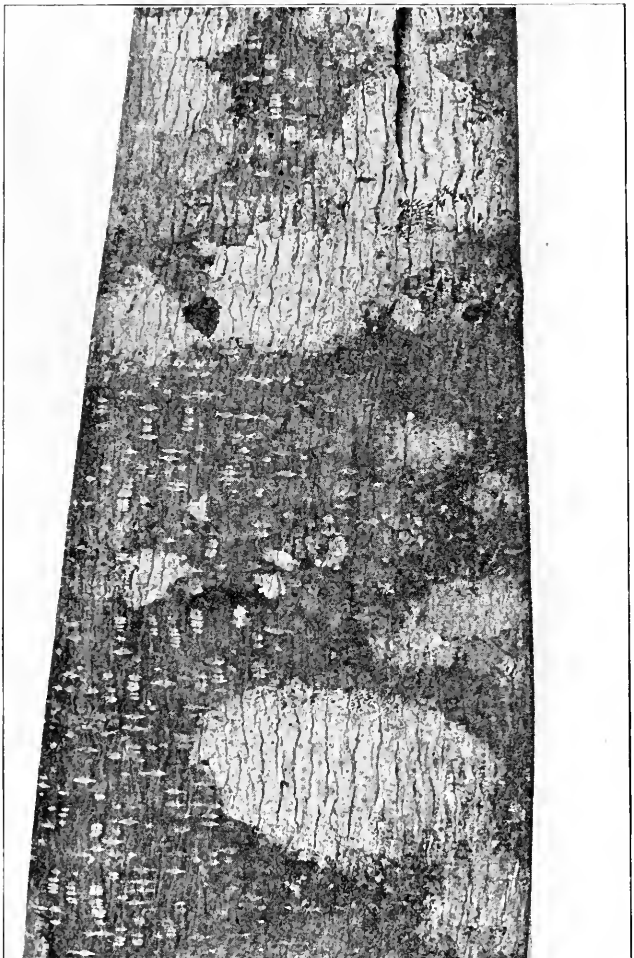


FIG. 229. Bark of *Rhamnus Purshiana* showing large whitish patches of lichens, and numerous lens-shaped lenticels.

RHAMNUS PURSHIANA.—CASCARA SAGRADA.—The bark of *Rhamnus Purshiana* (Fam. Rhamnaceæ), a shrub indigenous to Northern California, Washington, Oregon and the southwestern part of British America (p. 326). The bark is collected in spring and early summer, and kept at least one year before being used.

Description.—Usually in flattened or transversely curved pieces, occasionally in quills 2 to 10 cm. long, 1 to 3 cm. in diameter, bark 1 to 3 mm. thick; outer surface dark brown or brownish-red, frequently completely covered with grayish or whitish lichens (Fig. 229), several of which are peculiar to this bark, and with

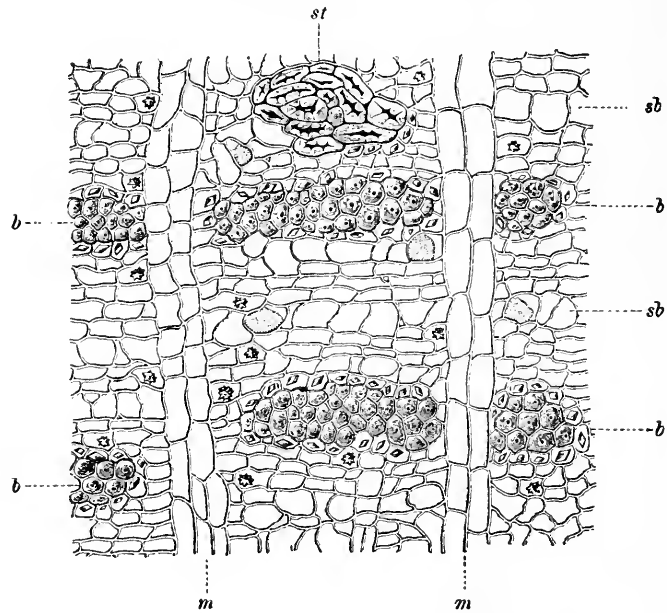


Fig. 229a. Transverse section of inner bark of *Rhamnus Purshiana:* st, group of stone cells; b, groups of bast fibers surrounded by crystal fibers; m, medullary rays; sb, sieve cells; parenchyma containing rosette aggregates of calcium oxalate.—After Vogl.

small groups of brownish apothecia, longitudinally wrinkled, sometimes with numerous lenticels 3 to 6 mm. long; inner surface light yellow or reddish-brown, smooth, longitudinally striate, turning red when moistened with solutions of the alkalies; fracture short, with projections of bast fibers in the inner bark, the medullary rays one to two cells wide, forming converging groups; in cross section the inner surface of the bark indistinctly crenate; odor distinct; taste bitter, slightly acrid.

Inner Structure.—See Figs. 229a, 304.

Constituents.—The nature of the active constituents of this drug is not known. It may contain the glucoside cascarin (purshianin), which on hydrolysis yields emodin and one or more active principles; and the neutral principle chrysarobin, which yields chrysophanic acid (see Rhubarb). The bark apparently contains emodin; isoemodin, a principle which is isomeric with emodin, insoluble in ammonia and resembles a similar principle in Frangula; a principle which yields on hydrolysis syringic acid; a fat consisting of rhamnol arachidate; a bitter principle; several resins; tannin; glucose; starch; calcium oxalate; and ash about 7 per cent.

Adulterants.—*Rhamnus californica*, a shrub indigenous to Southern California and the neighboring States, yields a bark which closely resembles that of Rhamnus Purshiana, but may be distinguished from it by the medullary rays, which are from 3 to 5 cells wide, and occur in more or less parallel wavy rows, and by the distinct crenation of the inner margin of the bark.

Allied Plants.—The fruits of *Rhamnus cathartica*, a shrub indigenous to Central and Southern Europe and Asia, are used under the name of Buckthorn berries. They are globular, about 5 mm. in diameter, greenish-brown or black, and consist of four 1-seeded nutlets; the seeds are dark brown and triangular-convex. The odor is slight but disagreeable. The taste is bitter and acrid, the saliva being colored yellow. The fruits contain a glucoside, rhamnonigrin, which yields emodin; a bitter principle; and three yellow coloring principles, viz.: rhamnocitrin, rhamnolutin and rhamnochrysin (see Fig. 92).

The fruits of *Rhamnus cathartica*, as well as of *R. infectoria* (known as French Berries) and of *R. saxatilis* (called Persian berries) have been used as yellow dyes. The fruits of several species growing in China yield a green indigo.

VIBURNUM PRUNIFOLIUM.—BLACK HAW BARK. The dried bark of the root of *Viburnum prunifolium* or of *V. Lentago* (Fam. Caprifoliaceæ), shrubs or small trees indigenous to the Eastern and Central United States (p. 382). The root bark is more highly esteemed than that of the stem and branches (Fig. 179).

Stem Bark.—In transversely curved pieces, or irregular oblong chips, 1.5 to 6 cm. long, 0.5 to 1.5 cm. in diameter, 0.5 to 1.5 mm. thick; outer surface brownish-red or grayish-brown, longitudinally wrinkled, periderm occasionally exfoliated, with occasional grayish patches of foliaceous lichens and numerous

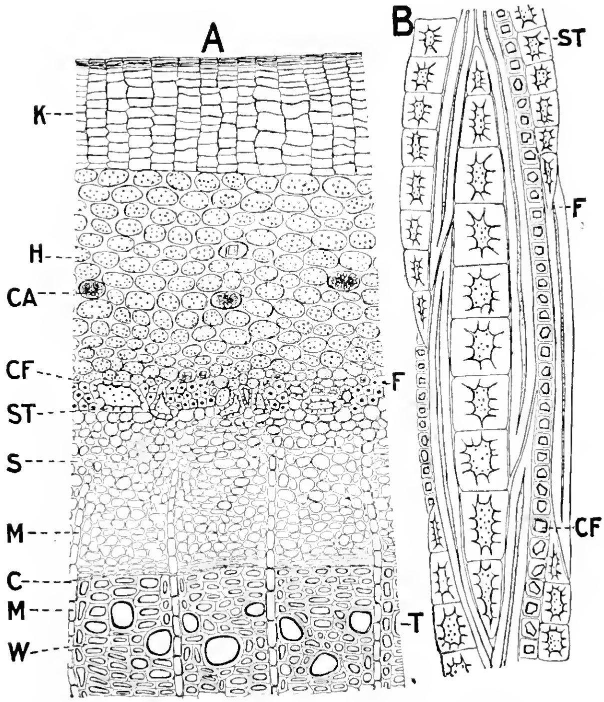


Fig. 230. *Hamamelis virginiana:* A, Transverse section of twig: K, cork; H, cells of hypodermis with simple pores, the cells containing chloroplasts and small starch grains; Ca, calcium oxalate crystals; Cf, crystal fibers; F, bast fibers with thick, strongly lignified walls; S, sieve cells; M, medullary rays; C, cambium; W, wood fibers; T, tracheæ. B, tangential section of a twig showing stone cells (St), crystal fibers (Cf), and thick-walled bast fibers.

lenticels; inner surface yellowish- or reddish-brown, longitudinally striate; fracture short, periderm brownish-red, inner bark with numerous light yellow groups of stone cells; odor slight; taste astringent and bitter.

Root Bark.—Somewhat resembling the stem bark, but smoother externally, without lichens and having fewer lenticels.

CONSTITUENTS.—A bitter, somewhat resinous principle, viburnin; valerianic (viburnic) acid and other organic acids; resin; tannin; calcium oxalate; ash about 10 per cent.

ADULTERANTS.—The barks of one or more allied species, especially *Viburnum dentatum* (page 383), are said sometimes to be substituted for the official bark.

HAMAMELIDIS CORTEX.—WITCHHAZEL BARK.—The bark and twigs of *Hamamelis virginiana* (Fam. Hamamelidaceæ), a shrub (Fig. 264) indigenous to Canada and the United States west to Minnesota and south to Texas (p. 286).

DESCRIPTION.—Bark in transversely curved pieces 5 to 20 cm. long, 5 to 15 mm. in diameter, bark 0.5 to 1 mm. thick; usually with the grayish-brown or reddish-brown periderm removed, outer surface light brownish-red, smooth; inner surface light reddish-brown, longitudinally striate; fracture short-fibrous; odor slight; taste astringent.

Twigs 2 to 5 mm. in diameter; the outer surface varying in color from yellowish-brown to blackish-brown, smooth or somewhat scurfy, longitudinally wrinkled, and with numerous small lenticels; small twigs somewhat zigzag from numerous leaf-scars; bark thin, easily separable from the whitish, hard, radiate wood; pith small (Fig. 230).

CONSTITUENTS.—Gallotannic acid, a glucosidal tannin, and gallic acid. The bark apparently also contains a volatile oil consisting chiefly of a terpene which is obtained by distillation in the preparation of hamamelis water or extract of witchhazel.

GOSSYPII CORTEX.—COTTON ROOT BARK.—The dried bark of the root of *Gossypium herbaceum*, and of other species of Gossypium (Fam. Malvaceæ), biennial or triennial herbs or shrubs indigenous to sub-tropical Asia and Africa, and now cultivated in all tropical and sub-tropical countries (p. 329).

DESCRIPTION.—In flexible, transversely curved or slightly quilled pieces, 6 to 30 cm. long, 5 to 15 mm. in diameter, bark 0.2 to 1 mm. thick; outer surface light brown, longitudinally wrinkled, with small lenticels, periderm frequently exfoliated; inner surface light brown, longitudinally striate; fracture tough, fibrous, surface light brown, tangentially striate, readily separable into fibrous layers; odor faint; taste slightly astringent and acrid.

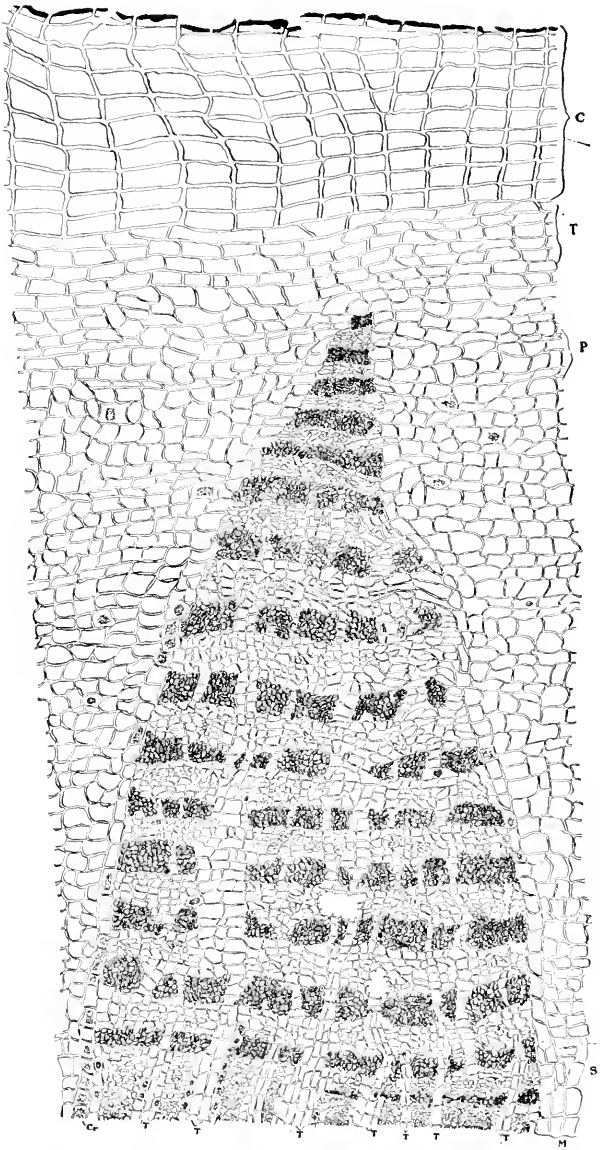


FIG. 231. Transverse section of cotton root bark: C, cork; Cr, rosette aggregates of calcium oxalate; B, bast; M, medullary rays; T, cells containing tannin; S, sieve.—After Morgan.

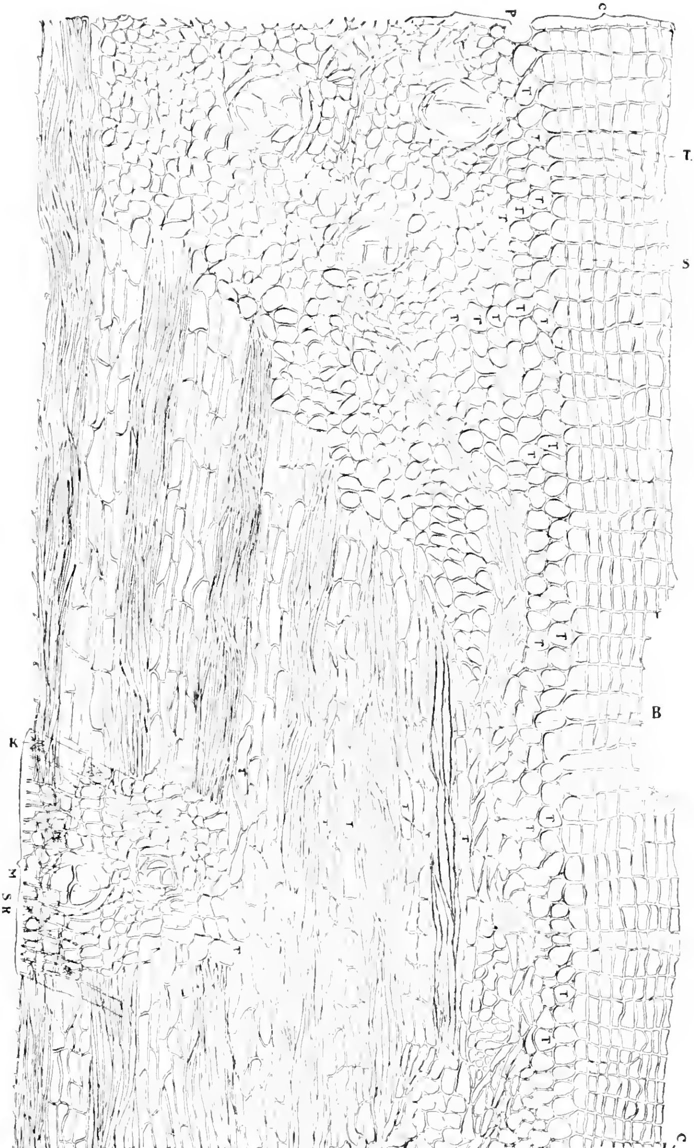


FIG. 231a. Longitudinal section of cotton root bark; C, cork cells; P, parenchyma; B, bast fibers; SR, secretion reservoirs; M, medullary rays; T, cells containing tannin; K, rosette aggregates of calcium oxalate.—After Morgan.

INNER STRUCTURE.—See Figs. 231; 231a; 300, *H*.

CONSTITUENTS.—About 8 per cent. of a peculiar, colorless acid resin, which is soluble in water and becomes reddish and insoluble on exposure to air. The drug also contains fixed oil; tannin; starch and calcium oxalate.

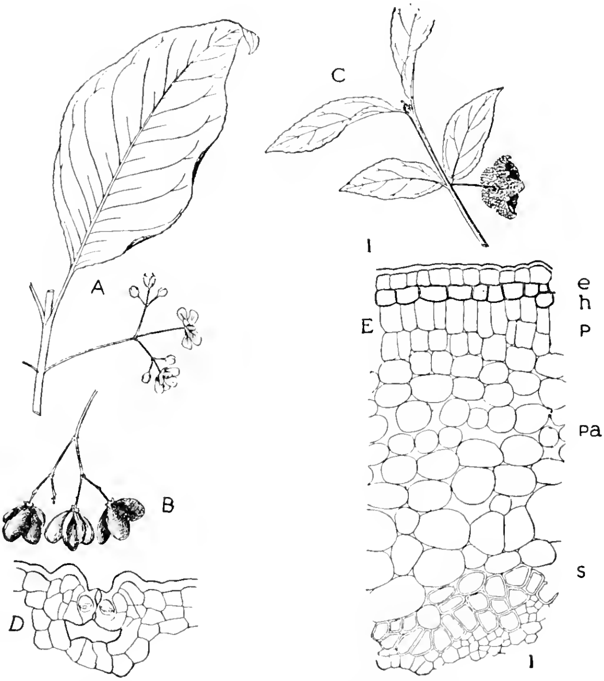


FIG. 232. *Euonymus atropropurcus:* A, flowering branch showing distinctly petiolate leaf; B, cluster of the smooth capsular fruits; *E. americanus:* C, fruiting branch showing the opposite almost sessile leaves and axillary verrucose capsule, D, cross-section of stem showing a stoma sunk beneath the epidermis; E, cross-section of stem showing epidermis (e), hypodermis (h), palisade cells of cortex (p), parenchyma cells (pa), pericycle (s) and portion of the leptome (l).—After Holm.

The FLOWERS of the cotton plant contain an interesting glucoside, gossypetin, which becomes green on oxidation and is colored orange-red with solutions of the alkalies. It somewhat resembles a similar principle found in arbor vitæ (*Thuja occidentalis*).

RUBUS.—BLACKBERRY BARK.—The bark of the rhizome of the perennial shrubs (p. 288) *Rubus villosus, R. nigro-*

baccus and *R. cuneifolius* (Fam. Rosaceæ). *R. villosus* occurs in dry fields from Canada to Virginia and as far west as Kansas. *R. nigrobaccus* (*R. allegheniensis*) or common blackberry occurs in woods in the Eastern and Central United States and extensively cultivated. *R. cuneifolius* is the sand blackberry and is found in sandy woods from New York to Florida and west to Missouri and Louisiana. The bark should be collected in spring or autumn and dried.

Description.—In flexible, transversely curved or slightly quilled pieces 4 to 20 cm. long, 3 to 5 mm. in diameter, bark 0.2 to 2 mm. thick; outer surface light brown, longitudinally wrinkled, with few root-scars, periderm frequently exfoliated; inner surface light brown, coarsely striate longitudinally; fracture short, fibrous, surface light brown, with oblique radiate wedges of bast; odor slight; taste astringent.

Constituents.—Tannin 10 to 20 per cent.; gallic acid about 0.4 per cent.; a bitter, crystalline glucoside villosin somewhat resembling saponin, about 0.8 per cent.; starch; calcium oxalate; ash about 3 per cent.

Allied Plants.—Blackberries (the fruits of *R. nigrobaccus*, *R. nigrobaccus sativus* and *R. villosus*), Red Raspberries (the fruit of *R. Idæus*, a plant native to the old world), Black Raspberries (the fruit of *R. occidentalis*, native of the Northern United States) and Strawberries (the fruits of cultivated varieties of *Fragaria chiloensis*, *F. vesca* and *F. virginiana*) all contain about 2 per cent. of malic and citric acids, 4 per cent. of levulose, about 4 per cent. of pectin substances and a small amount of volatile oil to which their distinctive flavors are due. Blackberries contain in addition considerable tannin and the wine made therefrom is valued in addition for its astringency.

EUONYMUS.—WAHOO BARK.—The dried bark of the root of *Euonymus atropurpureus* (Fam. Celastraceæ), a shrub (p. 323) indigenous to the Central and Eastern United States and Labrador.

Description.—Usually in transversely curved pieces, occasionally in single quills, 3 to 7 cm. long, 0.5 to 1.5 cm. in diameter, bark 0.5 to 1 mm. thick; very light; outer surface light brown, somewhat wrinkled, with scaly patches of soft cork, few lenticels, root-scars and adhering roots, which frequently perforate the bark; inner surface light brown, longitudinally striate, somewhat porous, occasionally with small pieces of yellow wood adhering; fracture short, with silky, projecting, modified bast fibers, cork light brown, inner and middle bark somewhat tangentially striate and with irregular, dark brown bast areas; odor faint; taste bitter; acrid (Fig. 232).

The stem bark occurs in very long, fibrous strips with a grayish-black cork and should be rejected.

Constituents.—Euonymin, a crystalline bitter glucoside 2.16 per cent., which resembles digitalin in its physiological action; volatile oil about 1.3 per cent.; a yellow and brown resin; dulcitol (isomeric with mannitol); euonic, malic, citric and tartaric acids; starch; and calcium oxalate.

Allied Plants.—*E. europæus* and other species of Euonymus are also used in medicine, and probably contain the same constituents.

VIBURNUM OPULUS.—CRAMP BARK.—The dried bark of the stem and branches of *Viburnum Opulus* (Fam. Caprifoliaceæ), a shrub with nearly erect branches indigenous to the Northern United States and Southern Canada, and also found growing in Europe and Asia (p. 382).

Description.—In transversely curved pieces, 6 to 20 cm. long, 1 to 2 cm. in diameter, 0.5 to 1.5 mm. thick; outer surface light brown or brownish-black, longitudinally wrinkled, periderm sometimes exfoliated, revealing a nearly smooth reddish-brown surface, with numerous grayish patches of foliaceous lichens, and small brownish-black apothecia and large brownish lenticels; inner surface light or reddish-brown, finely striate longitudinally, fracture uneven, fibrous, surface light or reddish-brown, with groups of stone cells and bast fibers; odor slight; taste astringent, bitter.

Constituents.—The constituents resemble those of *Viburnum prunifolium*.

XANTHOXYLUM.—PRICKLY ASH BARK.—The dried bark of *Xanthoxylum americanum* and *Fagara* (*Xanthoxylum*) *Clava-Herculis* (Fam. Rutaceæ). *X. americanum* is a shrub or small tree (p. 304) indigenous from Quebec to Virginia and west to South Dakota, Nebraska and Kansas, and yields Northern

Prickly Ash. *F. Clava-Herculis* is a shrub (p. 305) found south from Virginia to Texas, and furnishes the Southern Prickly Ash. The latter, however, appears to be less valuable medicinally.

Northern Prickly Ash.—In transversely curved pieces, occasionally in single quills, 2 to 17 cm. long, 1 to 2 cm. in diameter, 0.5 to 3 cm. thick; outer surface light brown to brownish-black, with grayish patches of foliaceous lichens, numerous small black apothecia and whitish lenticels; fracture short, uneven;

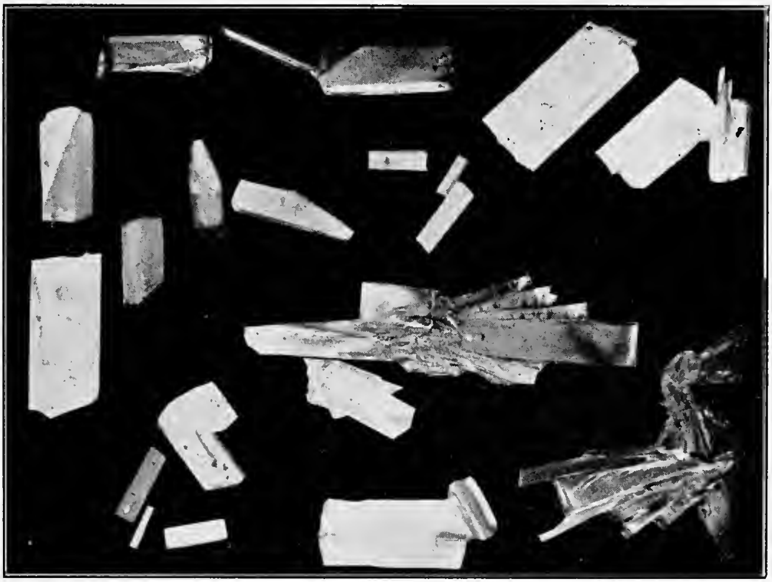


Fig. 233. Cinchonine sulphate: orthorhombic crystals from a saturated aqueous solution.

inner surface light brown, finely striate longitudinally, with numerous acicular crystals, phelloderm layer dark green, inner bark with groups of converging medullary rays; odor slight; taste bitter, acrid and pungent.

Southern Prickly Ash.—Transversely curved or irregularly oblong flattened pieces, occasionally in single quills 5 to 30 cm. long, 1 to 7 cm. in diameter, 1 to 4 mm. thick; outer surface with numerous conical cork-wings or their scars; inner surface free from acicular crystals (Fig. 238).

CONSTITUENTS.—Two resins, one acrid, the other crystalline and bitter; an acrid volatile oil; a bitter, alkaloidal principle, somewhat resembling berberine; a crystalline phenol compound xanthoxylin; ash about 12 per cent.

ALLIED PLANTS.—The fruits of both *X. americanum* and *Fagara Clava-Herculis* are found in commerce and known as Prickly Ash berries. They consist of 2 to 3 follicles, each of which is 5 to 6 mm. long, brownish-green, dehiscent along the ventral suture and contains one or two sub-globular, somewhat flattened, black, glossy seeds; odor is aromatic; taste pungent and bitter. Xanthoxylum fruits contain a volatile oil and resin.

GRANATUM.—POMEGRANATE BARK.—The dried bark of the root and stem of *Punica Granatum* (Fam. Punicaceæ), a shrub (p. 345) indigenous to Northwestern India, and cultivated in the sub-tropical regions of the Old World. The bark of the root is preferred to that of the stem and by some the drug obtained from wild plants is also preferred. The bark deteriorates with age and should not be used after it is a year or two old.

STEM BARK.—Usually in transversely curved pieces, occasionally in single quills, 2 to 8 cm. long, 5 to 20 mm. in diameter, bark 0.5 to 2 mm. thick; outer surface yellowish-brown, with grayish patches of foliaceous lichens, brownish-black apothecia and small lenticels, longitudinally wrinkled; inner surface light yellow or yellowish-brown, finely striate, smooth; fracture short, smooth, phelloderm layer dark green, inner bark light brown, somewhat checkered; odor slight; taste astringent.

ROOT BARK.—Dark brown, with slight longitudinal patches and scales of cork, green phelloderm layer wanting, medullary rays extending nearly to the outer surface.

INNER STRUCTURE.—See Fig. 234.

CONSTITUENTS.—Four alkaloids to the extent of 1 to 3 per cent. in the root bark, but only about half as much in the stem bark. The most important of these alkaloids is pelletierine, the tannate of which is official. PELLETIERINE (punicine) is a colorless, volatile liquid alkaloid, which readily absorbs oxygen and becomes dark on exposure to air. Its sulphate is lævorotatory. ISOPELLETIERINE (isomeric with pelletierine) is optically inactive and forms an amorphous sulphate. METHYLPELLETIERINE some-

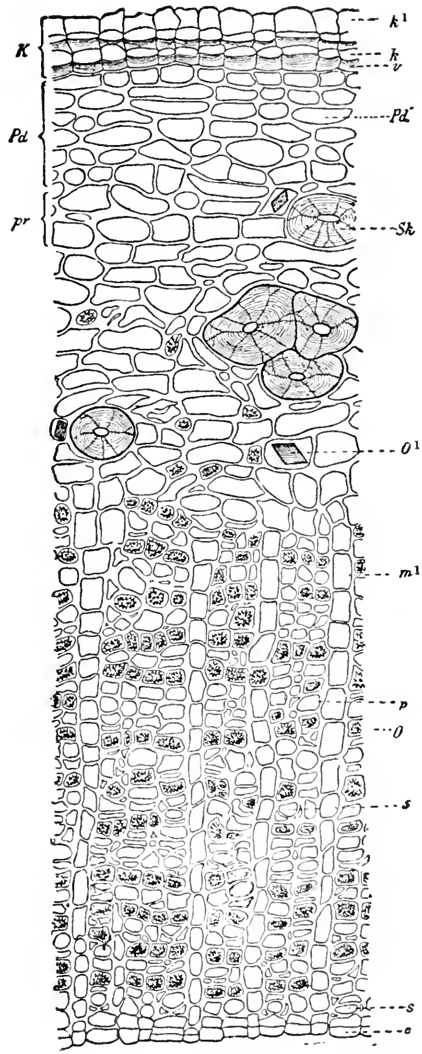


FIG. 234. Transverse section of granatum; K, corky layer composed of thin-walled cork cells (k^1) and thick-walled cork cells (k) only the inner walls (v) of which are thickened; Pd, phelloderm cells; pr, some parenchyma cells of the primary cortex; Sk, stone cells with thick, lamellated walls and fine branching pores; O, rosette aggregates of calcium oxalate; O^1, monoclinic prisms of calcium oxalate; m^1, medullary rays; s, sieve cells; p, parenchyma cells; c, cambium.—After Meyer.

what resembles pelletierine, but its hydrochloride is dextrorotatory. Pseudopelletierine (methylgranatonine) occurs in prisms, is optically inactive, and resembles in its reactions and decomposition products tropinone. The latter is formed from tropine, a compound which results on the decomposition of most of the solanaceous alkaloids. Granatum also contains 20 to 22 per cent. of a mixture of tannins, one of which yields gallic acid and the other ellagic acid. A yellow coloring principle, considerable starch and calcium oxalate are also present in the drug.

Allied Drugs.—The rind of the fruit of *Punica Granatum,* known as pomegranate rind, occurs in irregularly curved yellowish-brown fragments about 2 mm. thick. It contains 23.8 to 25 per cent. of a tannin which is colored bluish-black with ferric salts.

MEZEREUM.—MEZEREON BARK.—The dried bark of *Daphne Mezereum,* and of other species of Daphne (Fam. Thymelaceæ), shrubs indigenous to Europe and Asia, and naturalized in New England and Canada (p. 343). The bark is collected in early spring; it is dried and frequently made up into small bundles, the commercial supplies being obtained from Thuringia, Southern France and Algeria.

Description.—In flexible double quills or somewhat flattened strips 10 to 90 cm. long, 3 to 20 mm. in diameter, bark about 0.3 mm. thick; outer surface light or dark brown, smooth, obliquely striate or wrinkled, with numerous lenticels, occasional brownish-black apothecia, and sometimes with buds or bud-scars; inner surface yellowish-green, somewhat lustrous, finely striate; fracture tough, fibrous, the dark-brown periderm readily separable from the yellowish-green cortex, inner bark yellowish-green, lamellated; odor slight; taste very acrid.

Constituents.—An acrid resin known as mezerein; a crystalline, bitter glucoside daphnin (isomeric with æsculin) occurring in greatest amount in the stem bark during the flowering and fruiting season; volatile and fixed oils; malic acid; several sugars; and starch.

Allied Drugs.—The berry-like fruits of *Daphne Mezereum* and *D. Gnidium* are sub-globular, dark brown or brownish-black, about 5 mm. in diameter, with a black, glossy seed and acrid pungent taste. The fruits contain 0.38 per cent. of coccogonin, a principle which on sublimation gives off an odor of coumarin; 0.22 per cent. of an acrid resin; and 31 per cent. of a fixed oil which absorbs oxygen on exposure to air and is in the nature of a drying oil.

The barks of a number of other plants of this family are used like that of Mezereum, as *Daphnopsis Schwartzii* of the West Indies, *Lasiosiphon eriocephalus* of India and Ceylon, and various species of Stellera, Struthiola and Thymelæa.

PRUNUS VIRGINIANA.—WILD BLACK CHERRY BARK.—The bark of the stem and branches of *Prunus serotina* Ehrhart (Syn. *Prunus virginiana* Miller) (Fam. Rosaceæ), a tree (Fig. 150) indigenous to the Eastern and Central United States and Canada. The bark is collected in autumn, and should be carefully dried and preserved in air-tight containers (p. 287).

DESCRIPTION.—Usually in transversely curved pieces 2.5 to 8 cm. long, 1 to 5 cm. in diameter, 0.5 to 4 mm. thick; outer surface light brown or greenish-brown, somewhat glabrous, with numerous lenticels 3 to 4 mm. long; inner surface light brown, longitudinally striate and occasionally fissured; fracture short, granular; cork dark brown, thin, easily separable from the green phelloderm, inner bark porous and granular; odor of the drug distinct, and on the addition of water developing an odor of benzaldehyde and hydrocyanic acid; taste astringent, aromatic (Fig. 235).

The bark of the trunk is dark brown and rough externally.

CONSTITUENTS.—A cyanogenetic glucoside, identified by Power and Moore as l-mandelonitrile glucoside, a compound which has been prepared by Fischer by the partial hydrolysis of amygdalin and is isomeric with sambunigrin (d-mandelonitrile glucoside) from the leaves of *Sambucus nigra* and prulaurasin (dl-mandelonitrile glucoside) from the leaves of *Prunus laurocerasus*. It also contains a ferment resembling emulsin; β-methylæsculetin (methyl ether of di-hydroxy-coumarin) which probably occurs in combination as a crystalline glucoside, the solutions giving a blue fluorescence; a phytosterol; l-mandelic acid, oleic acid; p-coumaric acid; tri-methyl-gallic acid; ipuranol; dextrose; sugar; tannin 2.5 to 4.5 per cent.; starch and calcium oxalate. The yield of hydrocyanic acid varies from 0.23 to 0.32 per cent. (inner bark) to 0.03 per cent. (trunk bark) and varies even in the bark of the same thickness from the same tree. When the exposure is such that the chloroplastids are abundant in the cells of the bark, then the per cent. of the l-mandelonitrile glucoside is higher, whereas when the exposure is such that the cells do not take an active part in photosynthesis the per cent. of the glucoside is lower. In the latter case the

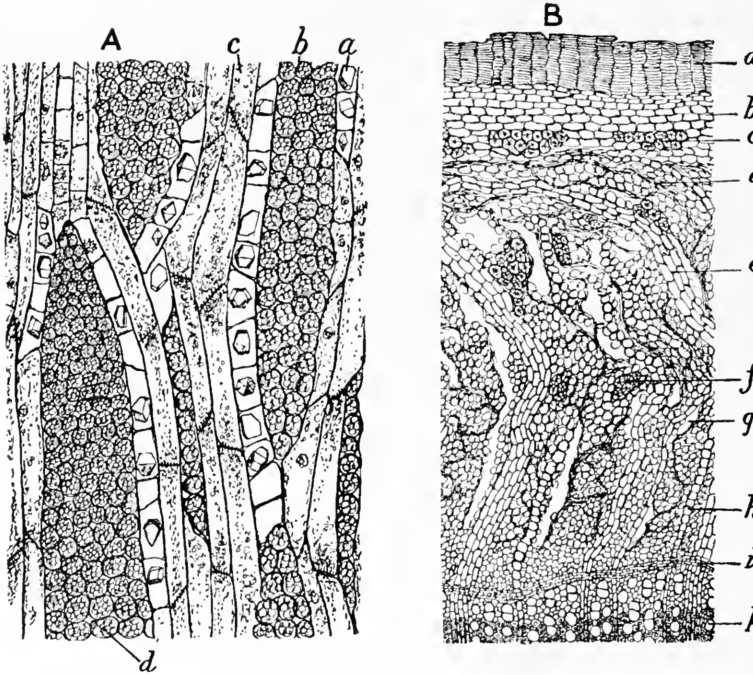


FIG. 235. *Prunus serotina* Ehrhart: A, longitudinal section of inner bark, showing crystals of calcium oxalate (a), medullary ray cells (b and d) containing starch, leptome or seive (c); B, transverse section of stem bark showing cork, probably secondary periderm (a), cells of cortex (b) containing chloroplasts, groups of sclerotic cells (c), compressed leptome in the outer portion of the bast layer (d), medullary ray cells (e), group of sclerotic cells (f), fissures (g) between medullary ray cells and adjacent phloem tissues, cambium zone (i), vessel or trachea in mature wood (k).—After Bastin.

bark is yellowish-brown. On keeping the bark for a year it deteriorates from 10 to 50 per cent.

The bark of *Prunus pseudo-cerasus* var. *Sieboldi* of Japan, contains a glucoside (sakuranin) which crystallizes in needles and is soluble in dilute alcohol, the solution being colored yellow with ferric chloride.

ADULTERANTS.—It is likely that the barks of other species of Prunus are now entering the market. They are more astringent and less aromatic.

ALLIED PLANTS.—The leaves of the CHERRY LAUREL (*Prunus Lauro-Cerasus*) are used in the fresh condition. They are oblong or oblong-lanceolate, about 15 cm. long, sharply serrate, coriaceous, with an almond-like odor on being bruised and an aromatic, bitter taste. They contain about 1.3 per cent. of a glucoside laurocerasin, which is associated with amygdalic acid; a ferment emulsin, which acts on the laurocerasin, causing it to be more slowly decomposed than amygdalin and yielding but half as much hydrocyanic acid (about 0.12 per cent.) and benzaldehyde (about 0.5 per cent). The leaves also contain a crystalline principle phyllic acid, which is insoluble in water, soluble in alcohol and occurs in the leaves of almond, peach and apple. A glucoside resembling laurocerasin is found in the leaves of *Sambucus nigra*.

The leaves of the PEACH (*Persica vulgaris*), which is extensively cultivated for its fruit, contain about 3 per cent. of amygdalin (see Almond).

The FRUIT of *Prunus serotina* consists of small, black drupes (Fig. 150), which when ripe are sweet, slightly acid and astringent. They are used in making a wine and might be employed in other preparations of wild cherry.

SASSAFRAS.—SASSAFRAS BARK.—The bark of the root of *Sassafras officinale* (Fam. Lauraceæ), a tree (Fig. 73) indigenous to Eastern North America (p. 277). The bark is collected in the early spring, or autumn, deprived of the periderm, and used either in the fresh or dried condition.

DESCRIPTION.—In transversely curved or recurved, irregular, oblong pieces, 3 to 8 cm. long, 10 to 30 mm. in diameter, 0.5 to 3 mm. thick; outer surface light reddish-brown, nearly smooth, somewhat porous; inner surface distinctly striate, somewhat scaly; fracture short, soft, surface slightly porous; odor aromatic; taste somewhat mucilaginous, astringent and aromatic.

INNER STRUCTURE.—See Fig. 236.

CONSTITUENTS.—Volatile oil 5 to 9 per cent.; tannin about 6 per cent.; a reddish-brown altered tannin compound (sassafrid) about 9 per cent.; resin and starch.

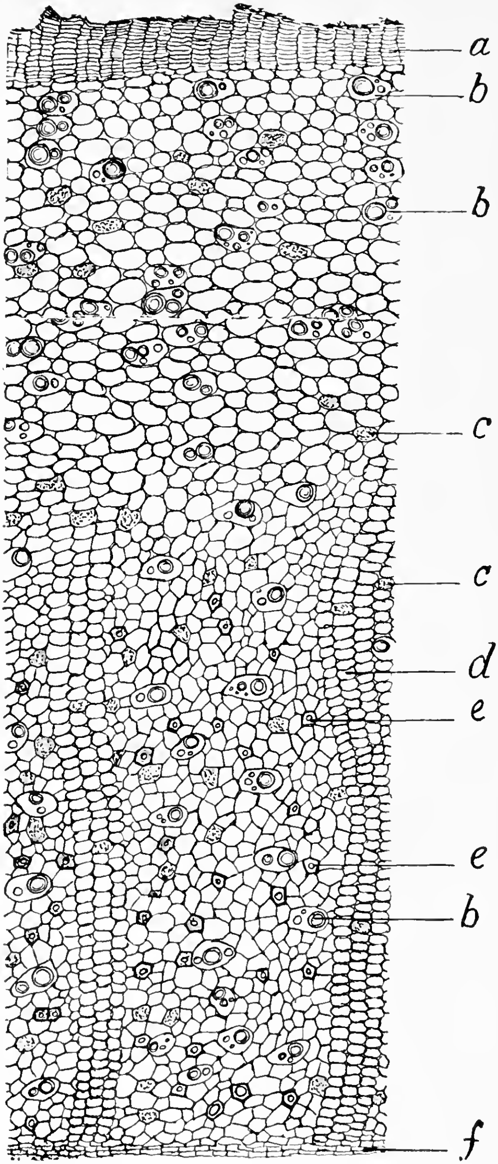


FIG. 236. Transverse section of root bark of sassafras: a, cork; b, oil cells; c, tannin cells; d, medullary rays; e, bast fibers; f, cambium.—After Bastin.

The principal constituent of the volatile oil is safrol. The oil from the leaves differs essentially in composition from that of the root bark, containing linalool and geraniol.

Allied Plants.—Other plants of this family also yield a volatile oil containing safrol, as *Beilschmiedia oppositifolia* of Queensland and New South Wales; *Mespilodaphne Sassafras* and *Nectandra Puchury-minor*, both of Brazil.

QUILLAJA.—SOAP BARK.—The bark of *Quillaja Saponaria* (Fam. Rosaceæ), a large tree indigenous to Chile and Peru. The bark is removed in large pieces, deprived of the periderm and dried (p. 290).

Description.—In flat pieces 25 to 90 cm. long, 10 to 15 cm. wide, 4 to 6 mm. thick; outer surface light brown, longitudinally striate, with numerous crystals of calcium oxalate and occasional patches of the dark-brown periderm; inner surface yellowish-brown, finely wrinkled, with numerous crystals of calcium oxalate, and occasional circular depressions, conical projections or transverse channels; fracture uneven, coarsely fibrous, surface porous and with groups of white sclerenchymatous fibers; odor slight; taste acrid.

Inner Structure.—See Fig. 315.

Constituents.—The drug contains two amorphous glucosides amounting to about 9 per cent., which are closely related to saponin—one soluble in alcohol and known as quillajic acid, and the other nearly insoluble in alcohol and known as quillajasapotoxin; it also contains starch and about 10 per cent. of calcium oxalate.

Substitutes.—A spurious Quillaja is being offered at the present time. The bark yields less saponin, is more brittle than the official bark and is covered with a thin, brownish layer.

QUERCUS.—WHITE OAK BARK.—The bark of *Quercus alba* (Fam. Cupuliferæ), a tree indigenous to the Eastern and Central United States and Canada. The bark is collected in spring from the branches and trunks of trees from ten to twenty-five years of age, and deprived of the periderm and dried (Fig. 135)

Description.—In flat, irregular, more or less oblong pieces 5 to 30 cm. long, 10 to 20 mm. in diameter, 2 to 4 mm. thick; outer surface light brown, longitudinally striate, with occasional patches of dark-brown periderm; inner surface yellowish-brown, coarsely striate and fissured longitudinally, and with detachable bast fibers; fracture uneven, coarsely fibrous, surface porous and dotted with

Fig. 237. White oak bark with the fissured corky layers (bork) still present.

groups of white sclerenchymatous cells and fibers; odor slight; taste astringent (Figs. 237; 300, *B*; 301, *A*).

Constituents.—Tannin about 10 per cent.; starch and calcium oxalate. The tannin yields upon sublimation a crystalline principle resembling pyrocatechin; upon fusion with potassium hydrate a phenol similar to protocatechuic acid is formed; dilute solutions are colored olive-brown with ferric chloride and possess a slight fluorescence; alkalies give a deep red color to the solutions.

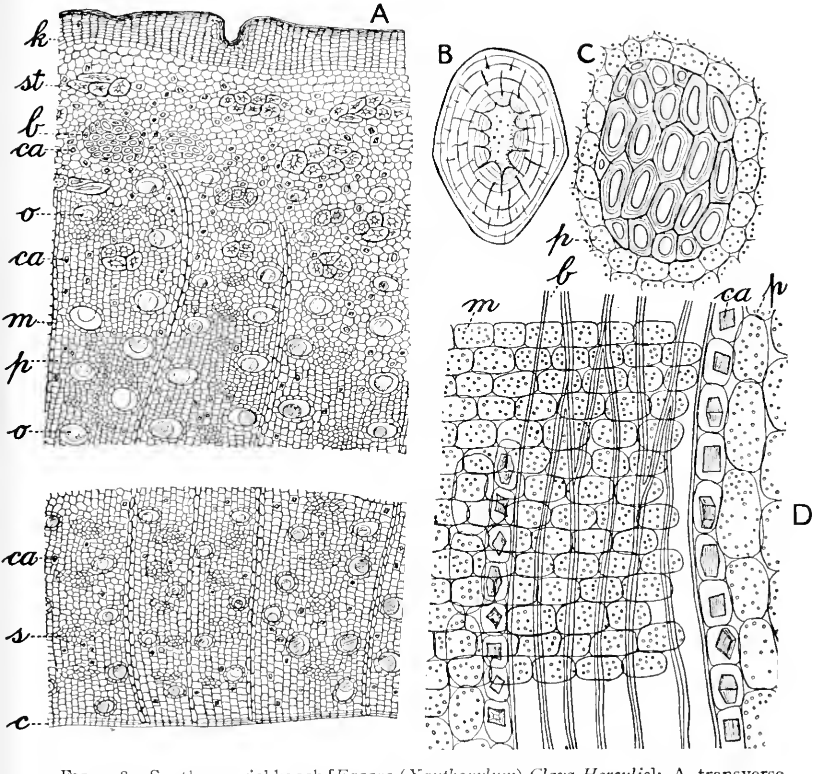


FIG. 238. Southern prickly ash [*Fagara* (*Xanthoxylum*) *Clava-Herculis*]: A, transverse section showing cork (k), stone cells (st), groups of primary bast fibers (b), calcium oxalate (ca), medullary rays (m), parenchyma (p) containing starch, oil-secretion reservoirs (o), sieve (s), cambium (c); B, isolated stone cell showing pores and lamellæ; C, group of bast fibers found in young, thin bark and surrounding parenchyma (p): D, longitudinal section near a group of bast fibers showing non-lignified bast fibers (b), calcium oxalate (ca) in crystal fibers, medullary rays (m), parenchyma (p) containing starch.

ALLIED PLANTS.—*Quercus rober*, indigenous to Europe, is the source of the bark used in England and Continental Europe; the bark closely resembles that of *Quercus alba*, but the periderm is not removed; it contains from 10 to 16 per cent. of tannin, besides gallic and ellagic acids. *Quercus velutina*, or black oak, yields the quercitron bark, which resembles that of *Quercus alba* but is reddish-brown, and tinges the saliva yellowish; it contains besides tannin a yellow glucosidal principle quercitrin, which yields quercetin, a yellow coloring principle.

ULMUS.—SLIPPERY-ELM BARK.—The bark of *Ulmus fulva* (Fam. Ulmaceæ), a tree indigenous to the Eastern and Central United States and Canada (p. 254). The bark is collected in spring (Fig. 99, *C*), deprived of the periderm and dried, the commercial article coming chiefly from Michigan.

DESCRIPTION.—In flat oblong pieces about 30 cm. long, 10 to 15 cm. in diameter, 3 to 4 mm. thick; outer surface light brown, longitudinally wrinkled and furrowed and with occasional dark-brown patches of periderm; inner surface yellowish or light brown, more or less uniformly wrinkled longitudinally; fracture fibrous, surface light brown, porous from large mucilage cells; odor slight, distinct; taste mucilaginous.

INNER STRUCTURE.—See Fig. 99, *C*.

CONSTITUENTS.—The principal constituent is mucilage; it also contains starch and calcium oxalate.

ALLIED PLANTS.—*Ulmus campestris*, or European elm, yields a bark which is dark brown, and contains, besides mucilage, a bitter principle and tannin.

QUASSIA.—QUASSIA WOOD.—The wood of *Picrasma excelsa* (Fam. Simarubaceæ), a tree indigenous to Jamaica and other islands of the West Indies (p. 309). The trees are felled and cut into billets. The latter are exported and afterward manufactured into "quassia cups," the shavings constituting the drug known as Jamaica Quassia. The market supply of this drug was at one time almost exclusively obtained from *Quassia amara* (Fam. Simarubaceæ), a small tree or shrub indigenous to Brazil and cultivated in Columbia, Panama, West Indies and other tropical countries (p. 309). The wood exported from Surinam is known as Surinam Quassia; this is the variety used in continental Europe and is now also official.

JAMAICA QUASSIA.—Usually in raspings, light or bright yellow, medullary rays two to five cells wide in transverse section (Fig. 239, *A*), the cells containing tetragonal prisms or cryptocrystalline crystals of calcium oxalate; fracture fibrous; odor slight; taste bitter.

SURINAM QUASSIA usually occurs in small billets; the medullary rays are 1 to 2 cells wide in transverse section, and calcium oxalate crystals are wanting (Fig. 239, *B*).

CONSTITUENTS.—Jamaica quassia contains from 0.05 to 0.75 per cent. of a bitter crystalline substance quassiin. This really consists of two crystalline bitter principles—α-picrasmin and

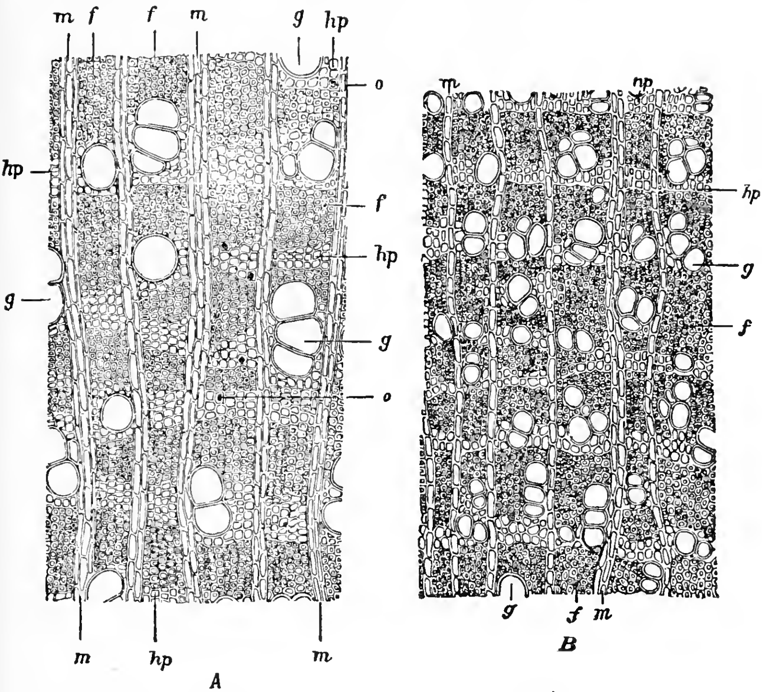


FIG. 239. A, transverse section of Jamaica quassia; B, transverse section of Surinam quassia: g, tracheæ; f, wood-fibers; hp, wood parenchyma; o, cells containing calcium oxalate; m, medullary rays.—After Meyer.

β-picrasmin. Jamaica Quassia also contains a crystalline alkaloidal principle which gives a blue fluorescence in acidified alcoholic solution.

Surinam quassia contains one or more bitter principles, which are related to the picrasmins of Jamaica quassia, and which are known as quassiins.

Allied Drugs.—The barks of *Picrasma excelsa* and *Quassia amara* are used in medicine and probably contain similar principles to the wood. The Surinam bark occurs in thinner, light-colored pieces and is sometimes admixed with the powdered drug. It is determined by the large stone cells. The wood of *Picræna quassioides* quite closely resembles Jamaica Quassia in general appearance, microscopical structure and chemical constituents. Bitter principles are also found in other species of Picrasma and Quassia. An allied bitter principle and an alkaloid are found in Cascara Amarga or Honduras Bark, which is derived from *Picræna Vellozii,* of Southern Brazil.

Simaruba is the bark of the root of *Simaruba amara* and *S. officinalis,* plants growing in Guiana. The bark comes in flat or somewhat curved pieces about 1 M. long, 7 cm. wide, 3 to 5 mm. thick; the outer corky surface is bluish-brown or dark brown, the periderm, however, being frequently removed, when it is grayish- or yellowish-brown; the fracture is tough-fibrous, and the surface shows the presence of light yellow stone cells. The taste is very bitter. Simaruba contains a crystalline bitter principle, giving a violet color with sulphuric acid; a crystalline non-bitter substance; a fluorescent principle; a resin; a volatile oil with an odor of benzoin; gallic acid, and calcium oxalate and malate.

HÆMATOXYLON.—LOGWOOD.—The heartwood of *Hæmatoxylon campechianum* (Fam. Leguminosæ), a tree indigenous to Central America, and naturalized in the West Indies. Much of the commercial logwood being used for dyeing is allowed to ferment, and as a result the chips become dark red and have a greenish, metallic lustre, but it is the unfermented wood that should be used for medicinal purposes (p. 295).

Description.—Usually in small chips, externally reddish-brown, freshly cut surface dark yellowish-red, in transverse section slightly radiate and with numerous, alternate, yellowish and reddish concentric rings, medullary rays four cells wide; fracture hard, fibrous; odor slight; taste sweet, astringent; the wood imparting to water a violet or wine color.

Constituents.—Hæmatoxylin, 10 to 12 per cent., occurs in colorless or pale yellow needles or prisms (Fig. 154), tastes like glycyrrhizin, becomes red on exposure to light and is soluble in water and alcohol. The solutions are colored with the alkalies, purplish-red, then purple and finally deep red. The compound formed with ammonia yields hæmatein, a dark violet, crystalline principle having a green, metallic lustre and which is supposed to form in the fermented wood used by dyers. Logwood also contains volatile oil, resin, tannin and calcium oxalate.

ALLIED PLANTS.—The woods of certain species of *Cæsalpinia* also contain red coloring principles and furnish the red woods of tropical America. BRAZIL WOOD is obtained from *C. echinata* and contains the principle known as brasilin, which is colorless when first extracted but assumes a red color on exposure; SAPPAM or false sandal wood is obtained from *C. Sappam* of Farther India. Red coloring principles are also found in other species of *Cæsalpinia* and in a number of other genera of the Leguminosæ as well.

SANTALUM RUBRUM.—RED SAUNDERS.—The heartwood of *Pterocarpus santalinus* (Fam. Leguminosæ), a tree (p. 295) indigenous to the southern part of Farther India, and cultivated in the Southern Philippines, Ceylon and Southern India, the chief supplies coming from Madras.

DESCRIPTION.—Usually in small chips or coarse powder, red or brownish-red, in transverse section slightly radiate, with numerous alternate lighter and darker concentric rings, medullary rays one cell wide; fracture hard, fibrous; inodorous; taste slight.

CONSTITUENTS.—A coloring principle santalin (santalic acid), which occurs in red needles that are insoluble in water, soluble in alcohol, forming a deep red solution which is colored violet with solutions of the alkalies. It also contains tannin and several colorless crystalline principles.

ALLIED PLANTS.—The African sandal wood or barwood is obtained from *P. santalinoides* of tropical West Africa. Camwood or African red-wood (obtained from *Baphia nitida*, in Sierra Leone) is also valued on account of its red coloring principle.

SASSAFRAS MEDULLA.—SASSAFRAS PITH.—The pith of young stems and branches of *Sassafras officinale* (Fam. Lauraceæ), a tree (Fig. 73) indigenous to Eastern North America (p. 277). The pith is collected late in autumn, after frost, and dried.

Description.—Cylindrical, cut longitudinally into pieces 2 to 10 cm. long, about 5 to 7 mm. in diameter, or in irregular, somewhat curved or angled pieces; very light; externally whitish or light brown, occasionally with small fragments of wood adhering; consisting of parenchyma cells with slightly lignified walls, having simple pores, and swelling perceptibly in water (Fig. 326); fracture short; slight odor of sassafras; taste mucilaginous.

Constituents.—The principle constituent is the mucilage, which is not precipitated by alcohol; it also contains a trace of volatile oil.

IV. FLOWERS.

In quite a number of plants, particularly the Labiatæ and Compositæ, principles having medicinal and other properties occur in relatively large amount in the flowers. These principles are, as a rule, more or less volatile and aromatic, many of them being used in perfumery and for flavoring, as well as for medicinal purposes.

KEY FOR THE STUDY OF FLOWERS.

I. Flower Buds.

With a stalk and globular upper portion............Caryophyllus
Small, ellipsoidal, composite heads......................Santonica

II. Expanded Flowers.

1. Flower heads.
   A. Tubular and ligulate florets.
   Ligulate florets, bright yellow.............Arnicæ Flores
   Ligulate florets, whitish.....................Matricaria
   B. Chiefly ligulate florets.
   Whitish globular heads......................Anthemis
2. Ligulate florets only.
   Corolla bright yellow............................Calendula

III. Entire Inflorescence.

Flowers pistillate, reddish-brown..........................Cusso

IV. Part of Flower.

Petals only..Rosa Gallica
Style and Stigma...Zea

CARYOPHYLLUS.—CLOVES.—The flower-buds of *Jambosa Caryophyllus* (Syn. *Eugenia Caryophyllata* and *E. aromatica*) (Fam. Myrtaceæ), an evergreen-tree indigenous to the Molucca Islands, where it is also cultivated, as well as in Zanzibar, Ceylon and Java (p. 346). The flower-buds are collected, dried in the sun or artificially, the color changing from a crimson to a brownish. The chief commercial supplies come from Amboyna, Penang and Zanzibar, the former two varieties being preferred.

DESCRIPTION.—About 15 mm. long, 3 to 6 mm. in diameter, more or less cylindrical, dark brown, calyx epigynous (Fig 83, *B*), with four incurved teeth about 3 mm. long, surmounted by a light brown globular portion consisting of four petals which are imbricated, punctate and alternate with the calyx teeth; stamens numerous, crowded and incurved, style one, ovary 2-locular, with numerous ovules; odor and taste strongly aromatic.

Cloves should not contain more than 5 per cent. of clove stems or yield more than 8 per cent. of ash; nor yield less than 10 per cent. of volatile ether extract or 12 per cent. of gallotannic acid.

INNER STRUCTURE.—See Fig. 312.

CONSTITUENTS.—The chief constituent is the volatile oil, which occurs to the extent of 15 to 20 per cent., and consists of caryophyllene and eugenol, the latter constituting 50 to 85 per cent. of the oil. The darkening of old oil of cloves is supposed to be due to furfurol, an aldehyde formed on decomposition of some of the carbohydrates and albuminoids. Cloves also contain an odorless, tasteless principle caryophyllin, which crystallizes in silky needles and yields upon the addition of fuming nitric acid crystals of caryophyllinic acid; vanillin; eugenin (isomeric with eugenol or eugenic acid), which resembles caryophyllin but becomes reddish with nitric acid; gallotannic acid 10 to 13 per cent.; calcium oxalate, and 5 to 7 per cent. of ash.

ADULTERANTS.—Clove stalks are less aromatic and yield from 4 to 7 per cent. of volatile oil. The so-called mother of cloves is the nearly ripe fruit of *Jambosa Caryophyllus* or clove tree, which furnishes cloves. The fruit is an ovoid, brownish berry about 25 mm. long; it is less aromatic than cloves and contains large, branching stone cells, or short bast fibers, and numerous pear-shaped or truncated starch grains from 10 to 40 μ in diameter.

It is stated that artificial cloves have been made by using starch, gum and oil of cloves; or from dough and clove powder. These are easily distinguished by adding the spurious article to water, when the compound disintegrates.

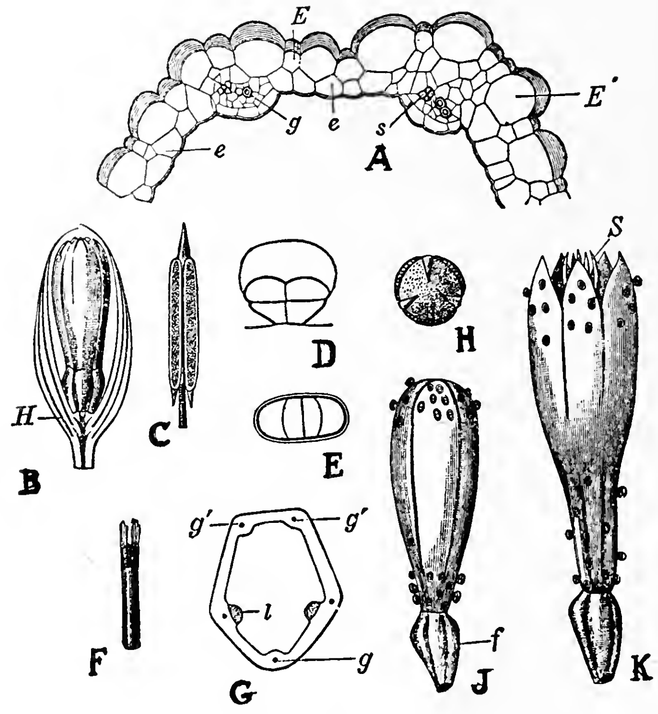


FIG. 240. Santonica. A, transverse section of the wall of the ovary: E, E[1], e, epidermal cells; g, tracheæ; s, sieve. B, longitudinal section through a flower bud showing involucre (H); C, stamen; D, glandular hair of a bud-scale; E, glandular hair as viewed from above; F, style; G, transverse section of the wall of the ovary showing tracheæ (g, g[1]) and conducting cells traversed by pollen tube (l); H, pollen grain; J, flower bud showing ovary (f); K, expanded flower showing stamens (S).—After Meyer.

SANTONICA.—LEVANT WORMSEED.—The flower-heads of *Artemisia Cina* (Fam. Compositæ), a small shrub (p. 397) indigenous to the deserts in Northern Turkestan. The flower-heads are collected in July and August before they expand, and carefully dried and preserved.

Description.—Oblong or ellipsoidal, 2 to 4 mm. long, 1 to 1.5 mm. in diameter; involucre ovoid, consisting of twelve to eighteen closely imbricated, ovate or ovate-lanceolate, glandular, somewhat shiny bracts, about 2 mm. long, with a yellowish-green or greenish-brown middle portion and whitish margin; torus flat, naked, with three to six unexpanded, perfect tubular flowers about 1.5 mm. long and completely inclosed by the upper bracts; ovary oblong; pappus wanting; odor distinct; taste aromatic.

Inner Structure.—See Fig. 240.

Constituents.—A crystalline neutral principle, santonin, which occurs to the extent of 2 to 3.5 per cent. just before the expansion of the flowers; volatile oil about 2 per cent., consisting chiefly of cineol, some terpineol, terpinene and inactive pinene; a crystalline principle artemisin, which is apparently oxysantonin; and a resin. Santonin crystallizes in rhombic prisms, becoming yellow on exposure to light; it is nearly insoluble in water, sparingly soluble in alcohol; and colored red by alcoholic solutions of the alkalies.

Allied Plants.—*Artemisia gallica,* a plant abundant in France, contains santonin and about 1 per cent. of a volatile oil.

ARNICA.—ARNICA FLOWERS.—The dried, expanded flower-heads of *Arnica montana* (Fam. Compositæ), a perennial herb (p. 394) indigenous to Central Europe, and growing in the mountains of Switzerland, Asia and Western North America. In Germany, on account of the involucre and torus being injured by the larvæ of the insect *Trypeta arnicivora,* these parts are removed and the florets alone used.

Description.—Sub-globular or truncate-conical, about 15 mm. in diameter; involucre campanulate, bracts twenty to twenty-four in two rows, linear-lanceolate, dark green, pubescent, glandular; torus solid, slightly convex, deeply pitted, bristly hairy; ray or ligulate florets (Fig. 241, *B*), fourteen to twenty, about 2 cm. long, bright yellow, pistillate, corolla 3-toothed, 7- to 12-veined, very pubescent and glandular below, ovary about 4 mm. long, erect, pubescent and glandular, pappus consisting of a single row of about thirty rough bristles; disk or tubular florets (Fig. 241, *C*), forty or fifty, about 17 mm. long, perfect, bright yellow, corolla 5-toothed, very glandular and pubescent below, ovary about 6 mm. long, glandular and pubescent; akene spindle-shaped, dark brown, finely striate, glandular-pubescent and surmounted by a pappus of white barbed bristles about 7 mm. long; odor distinct; taste bitter and acrid.

CONSTITUENTS.—A bitter crystalline principle, arnicin, about 4 per cent.; and volatile oil 0.04 to 0.07 per cent, consisting of a butyraceous substance.

ADULTERANTS.—Arnica flowers are not infrequently adulterated with the flowers of various other Compositæ, or even entirely substituted by them; of these may be mentioned the flowers of *Calendula officinalis* (see Calendula); species of Inula, the akenes

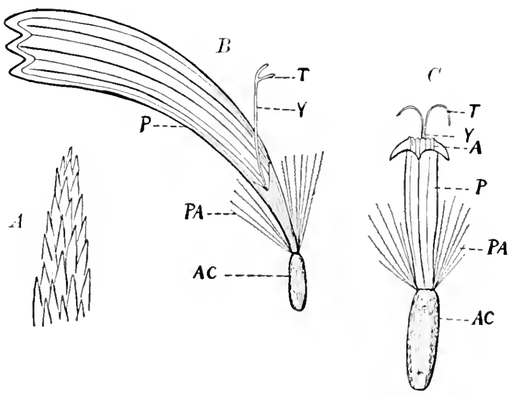


FIG. 241. Arnica florets: A, overlapping hairs of pappus considerably magnified; B, ray floret; C, disk floret. AC, inferior ovary becoming in fruit an akene; PA, pappus; P, corolla; A, anthers; Y, style; T, stigma.

of which are glabrous; and *Tragopogon pratensis*, the ligulate florets of which are 5-toothed at the apex (Fig. 181).

ALLIED DRUGS.—The rhizome and roots of *Arnica montana* are official in a number of pharmacopœias. The rhizome is oblique, about 5 cm. long and 3 mm. thick, the upper portion with buds or stem-remnants, externally dark brown, longitudinally wrinkled and irregularly annulate, with numerous light brown, fragile roots which may be 10 cm. long; fracture short, bark rather thick, with a single circle of large resin canals. The drug contains the bitter principle arnicin, which is also found in the flowers; and a volatile oil, 0.5 to 0.1 per cent., with a radish-like odor and consisting of hydrothymoquinone methyl ether, phloryl methyl ether, phloryl isobutyrate and formic and butyric acids. Arnica rhizome also contains about 10 per cent. of inulin.

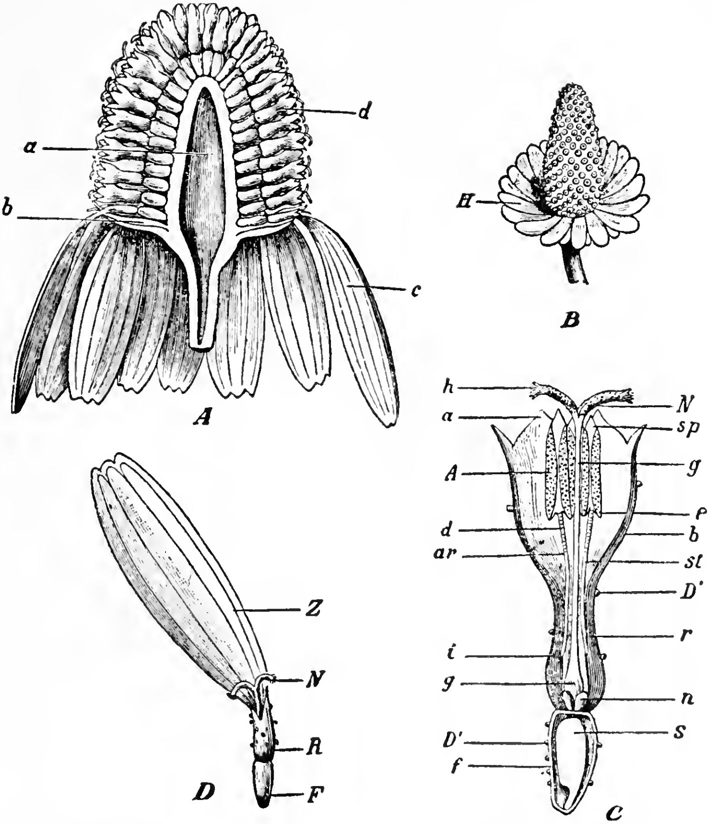


FIG. 242. Matricaria: A, longitudinal section of head showing torus (a), involucre (b), ray florets (c) and disk florets (d). B, head with the florets removed, showing the long conical torus and the involucre (H). C, tubular floret showing the ovary (f) with glandular hairs (D^1) and the embryo (S), which develops after fertilization; style (g) and bifid stigma (N), the surface of which is covered with hairs; n, nectaries; b, corolla tube with narrow lobes (a); stamens showing filaments (st), united anthers (A) and apex of connective (sp). D, ligulate floret showing ovary (F), and bifid stigma (N); tube of corolla (R) and the upper ligulate portion (Z).—After Meyer.

MATRICARIA.—WILD OR GERMAN CHAMOMILE.—The flower-heads of *Matricaria Chamomilla* (Fam. Compositæ), an annual herb (p. 394), indigenous to Europe and Western Asia, and naturalized in Australia and certain parts of the United States, including New York and Pennsylvania. The flower-heads are collected, when they are mature or expanded, from wild plants.

Description.—Rounded, conical, 3 to 10 mm. broad (Fig. 242); peduncle 0.5 to 3.5 cm. long, nearly glabrous; involucre hemispherical, scales twenty to thirty, imbricated, oblanceolate, the middle portion brownish, margin whitish, pubescent; torus ovoid, becoming conical and hollow, deeply pitted, naked, 3 to 5 mm. high, about 1.5 mm. in diameter; ray or ligulate florets (Fig. 242, *D*), twelve to eighteen, pistillate, about 12 mm. long, corolla white, 3-toothed, 4-veined; disk or tubular flowers (Fig. 242, *C*), numerous, yellowish, perfect, oblong, small, somewhat glandular, about 2.5 mm. long; akenes somewhat obovoid, about 0.5 mm. long; faintly 3- to 5-ribbed; pappus none, or forming a membranous crown; odor distinct; taste aromatic and bitter.

Constituents.—Volatile oil, about 0.25 per cent., of a viscid consistency and an intense blue color. The color is due to azulene, a principle similar to that found in the volatile oils derived from Absinthium, Achillea (yarrow), Sumbul and Valerian. The flowers are also said to contain a bitter principle anthemic acid, which forms colorless, silky needles soluble in water and alcohol, and anthemidin, which separates from the alcoholic solution in the form of a tasteless crystalline compound. Malic acid and tannin are also present in the drug. The oil when distilled from the involucre soon changes to yellow, finally becoming brown; while the oil from the flowers alone retains its deep-blue color even when exposed to light for some weeks.

Adulterants.—In *Anthemis arvensis* the receptacle is solid and conical and the involucral scales are lanceolate. In *Anthemis Cotula* the peduncles are slightly pubescent and the ligulate flowers neutral.

ANTHEMIS.—ROMAN OR ENGLISH CHAMOMILE.—The expanded flower-heads of *Anthemis nobilis* (Fam. Compositæ), a perennial herb indigenous to Southern and Western Europe and cultivated in Belgium, England, France, Germany, Hungary and the United States, and naturalized from Rhode Island to Michigan and south to Delaware (p. 393). The flowers are collected from cultivated plants, and dried by artificial means, the principal supplies coming from Belgium, France and Saxony.

Description.—Globular, compressed, 1.5 to 2 cm. in diameter; involucre hemispherical, with two or three rows of imbricated, nearly equal, somewhat elliptical, very pubescent scales, having a greenish middle portion and a yellowish margin; torus conical or convex, solid, 3 to 4 mm. high, occasionally hollow, and sometimes containing the larvæ of an insect; chaff-scales resembling the involucral scales, about 2 mm. long; ligulate florets numerous, 6 to 10 mm. long, corolla white, 3-toothed, 4-nerved, ovary about 1 mm. long, glandular, style slender, stigma bi-cleft; tubular florets few or none, lemon-yellow, perfect; akene oblong, pappus none; odor distinct; taste aromatic and bitter.

Constituents.—Volatile oil, which is bluish-green when fresh, 0.8 to 1 per cent.; a bitter crystalline glucoside anthemic acid (see Matricaria); 5.25 per cent. of resin; 1.50 per cent. of a bitter crystalline wax; and tannin. The volatile oil consists principally of the isobutyl, amyl and hexyl esters of butyric, angelic and tiglic acids, and anthemol, an isomer of camphor.

CALENDULA.—MARIGOLD.—The ligulate florets of *Calendula officinalis* (Fam. Compositæ), an annual herb indigenous to Southern Europe and the Levant, and widely cultivated as a garden plant. The flowers are collected when fully expanded, and dried (p. 394).

Description.—Florets usually without the ovary; corolla bright yellow, 15 to 25 mm. long, 1- to 3-toothed, 4- or 5-veined, margin nearly entire, tube sometimes inclosing the remains of a filiform style and bifid stigma, pubescent on the outer surface; ovary oblong, about 0.5 mm. long, pubescent; odor distinct; taste faintly saline, slightly bitter.

Constituents.—Volatile oil; an amorphous bitter principle; a gummy substance, calendulin, which forms with water a transparent mucilage that is not precipitated by tannin; and resin.

Allied Plants.—The florets of various Compositæ are sometimes admixed with or substituted for Calendula, of which the following may be mentioned together with their principal distinguishing characteristics: The ligulate corolla of *Taraxacum officinale* is 5-toothed; the ligulate corolla of *Arnica montana* is 7- to 12-veined; the ligulate corolla of *Tussilago Farfara* is linear, about 13 mm. long and about 0.3 mm. broad, apex acute, entire;

and the ray florets of *Tagetes patula* are somewhat spatulate, about 20 mm. long and 10 mm. wide, sometimes marked with darker stripes, and have undulate margins (Fig. 181).

CUSSO.—KOUSSO, BRAYERA.—The pistillate flowers of *Hagenia abyssinica* (Fam. Rosaceæ), a tree indigenous to

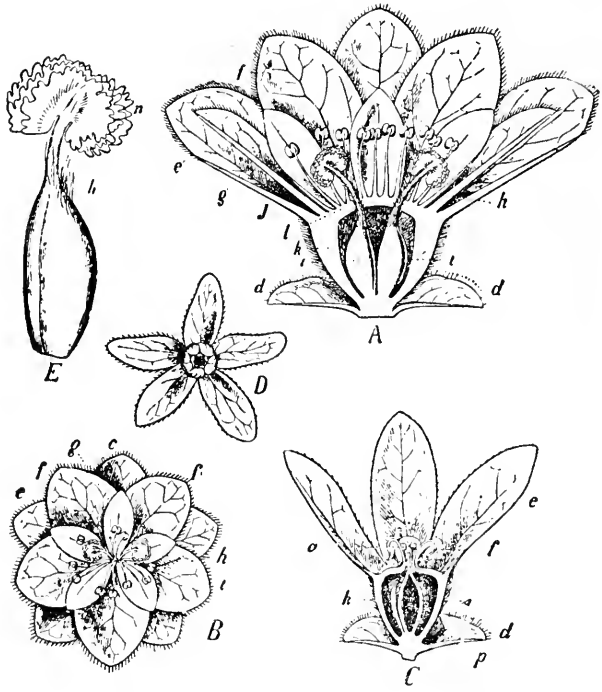


FIG. 243. Cusso: A, longitudinal section through an expanded pistillate flower showing bracts (d), outer series of sepals (e), inner series of sepals (f), petals (g), perianth tube (k), sterile stamens (h), pistil (i). B, mature flower viewed from above and showing the relation of sepals and petals. C, flower just before the maturing of the fruit showing pericarp (p), seed (s). D, mature pistillate flower as seen from above. E, pistil showing cylindrical ovary, slender style with hairs (h) and large, slightly lobed stigma.—After Meyer.

Northeastern Africa, and cultivated in Abyssinia. The entire panicles (Fig. 243) are collected soon after pollination and dried in the sun; the flowers are sometimes stripped from the panicles, or the panicles are made into rolls (p. 290).

DESCRIPTION.—In more or less cylindrical rolls about 30 cm. long and about 5 cm. in diameter; branches cylindrical, flattened, about 3 mm. in diameter, longitudinally furrowed or wrinkled, internodes about 15 mm. long, externally light brown, tomentose, glandular, internally, cork yellowish-brown, fibrovascular bundles in distinct wedges, bast and wood fibers yellow, distinct, pith large, yellowish-brown; flowers (Fig. 243) subtended by two ovate, reddish, pubescent and glandular bracts, pedicel short, calyx turbinate, pubescent below, consisting of two alternate whorls of four or five obovate or oblanceolate sepals, the outer ones 10 to 12 mm. long, obtuse, entire, purplish veined, persistent and becoming much elongated in the fruit, the inner about 3 to 4 mm. long, becoming shriveled and bent over the young fruit; carpels two, ovary about 1 mm. long, the upper portion very pubescent, styles exserted, about as long as the ovary, stigma large, compressed, with prominent papillæ; fruit an ovoid akene, about 2 mm. in diameter, inclosed by the remains of the calyx; odor slight; taste bitter and acrid.

CONSTITUENTS.—The active principle appears to be an amorphous substance cosotoxin; several other principles have been isolated, but their real nature and properties have not been fully determined; the drug also contains about 3 per cent. of an inactive crystalline principle cosin (koussein or brayerin), which is bitter and acrid, and sparingly soluble in water but soluble in alcohol; a crystalline principle which on hydrolysis yields isobutyric acid; about 6 per cent. of a resinous principle; volatile oil; tannin about 24 per cent., and about 5 per cent. of ash.

ADULTERANTS.—Sometimes the flowers are stripped from the panicles and sold as such, when the drug is known as "loose cusso." In this condition they are likely to be admixed with the staminate flowers, which, with their numerous stamens, are readily distinguishable and inferior in quality.

ROSA GALLICA.—RED ROSE.—The petals of *Rosa gallica* (Fam. Rosaceæ), a shrub (p. 289) indigenous to Southern Europe and probably Western Asia, and extensively cultivated in all parts of the world. The petals are obtained from cultivated plants before the expansion of the flower, the lower clawed portion usually being removed; they are used fresh or are carefully dried and preserved. The chief supply of the drug is from the south of France.

Description.—Imbricated, numerous, usually in small cones; petals broadly ovate, the upper part rose-colored and retuse, the lower part brownish-red, more or less rounded, acute or truncate, with numerous papillæ and fine longitudinal veins; texture velvety; odor agreeable; taste astringent and slightly bitter.

Constituents.—Volatile oil in small amount; a yellow, crystalline glucoside quercitrin, which yields, on decomposition, quercetin; tannin and gallic acid. The coloring principle is soluble in water and alcohol and gives a deep yellowish-red color with acids; a green color changing to brown with alkalies; purple or violet with potassium alum or iodine solutions; and a deep blue with ferrous or ferric salts.

Allied Plants.—The petals of *Rosa centifolia* are collected after the expansion of the flowers and dried; they are brownish and not so fragrant as those of *Rosa gallica*. The flowers of cultivated plants of *Rosa damascena* yield the commercial volatile oil of rose (p. 289).

ZEA.—CORN SILK.—The fresh styles and stigmas of *Zea Mays* (Fam. Gramineæ), an annual plant indigenous to tropical America and known only in cultivation, being cultivated widely in nearly all tropical, sub-tropical and temperate regions (p. 228).

Description.—In matted masses consisting of several hundred or more slender, very delicate, thread-like, purplish-red to greenish-white, more or less translucent styles; 10 to 20 cm. long; stigmas bifid, slender, 2 to 3 mm. long; slightly odorous; taste insipid.

When viewed under the microscope the upper part of the styles and the stigmas are seen to have numerous multicellular, non-glandular hairs from 0.2 to 0.5 mm. long, among which are numerous spinose pollen grains 10 to 15 μ in diameter.

Constituents.—Not much is known concerning the constituents of this drug, and the analyses have been chiefly of the dried commercial article. The fresh drug contains about 83 per cent. of water. The dried drug contains a volatile alkaloid; two resins about 5.5 per cent.; a crystalline principle, maizenic acid, about 1.25 per cent.; fixed oil, 5.25 per cent.; sugar; ash, about 12 per cent. The coloring principle of the fresh drug is soluble in water and alcohol and is changed to yellowish-red with acids, green with alkalies, purple with potassium alum, and olive-green changing to greenish-brown with ferric chloride.

V. FRUITS.

The fruits of a large number of plants are used in medicine; these vary greatly, not only in their medicinal properties, but also in their botanical origin. The active principles of fruits vary according to their stage of development, so that fruits which contain relatively large amounts of poisonous principles when green or immature, may be quite free therefrom and even edible when they are ripe. It is for this reason that by far the larger number of medicinal fruits are collected in the fully developed but unripe condition. (See Classification of Fruits, p. 151.)

KEY FOR THE STUDY OF FRUITS.

I. Entire Fruits.

1. Not more than 10 mm. long (exclusive of the stalk).

A. Cremocarps.

a. Hairy.

Slender pedicel, 4 to 10 mm. long..............Anisum

b. Nearly smooth.

α Mericarps more or less united.

Nearly globular.......................Coriandrum
Oblong, pedicel, 3 to 10 mm. long......Fœniculum

β Mericarps usually separate.

Dark brown, odor and taste aromatic.......Carum
Grayish-green, odor peculiar..............Conium

B. Dry drupes.

a. Hairy.

Pericarp reddish........................Rhus Glabra

b. Not hairy.

α Coarsely reticulate.

Slender pedicels, 5 to 7 mm. long.........Cubeba
Stalk wanting.............................Piper

β Not reticulate.

Inferior drupe.........................Pimenta

C. Caryopsis or Grain.................................Barley

I. Entire Fruits.—*Continued.*

2. Between 10 and 50 mm. long.

A. Drupes.

Epicarp thin and wrinkled; sarcocarp sweet........Prunum

Epicarp coriaceous, nearly smooth; sarcocarp acrid...Sabal

B. Not drupes.

Berry ....Capsicum
Capsule ....Cardamomum
Strobile ....Humulus

3. More than 50 mm. long.

Berry ....Colocynthis
Indehiscent legume..............................Cassia Fistula
Pod ....Vanilla
Syconium ....Ficus

II. Parts of Fruits.

1. Outer rind.

A. Fresh.

From sweet oranges...............Aurantii Dulcis Cortex
From lemons............................Limonis Cortex

B. Dried.

In quarters or in ribbon-like bands..Aurantii Amari Cortex

2. Pulp.

Blackish-brown masses or cakes...................Tamarindus

3. Glandular Hairs.

A glandular powder...............................Lupulinum

ANISUM.—ANISE.—The dried, ripe fruit of *Pimpinella Anisum* (Fam. Umbelliferæ), an annual herb (p. 352), indigenous to Asia Minor, Egypt and Greece, and cultivated in South America, Germany, Spain, Italy and Southern Russia. The drug is derived from cultivated plants, and that obtained from Spain, and known as "Alicante Anise," is preferred.

Description.—Mericarps usually coherent and attached to a slender pedicel 4 to 10 mm. long; cremocarp ovoid, laterally compressed, 4 to 5 mm. long, about 2 mm. in diameter, externally greenish-brown or grayish-green, with ten yellowish, filiform, primary ribs, finely pubescent, apex with a ring-like disk and two projecting divergent styles about 0.5 mm. long; internally yel-

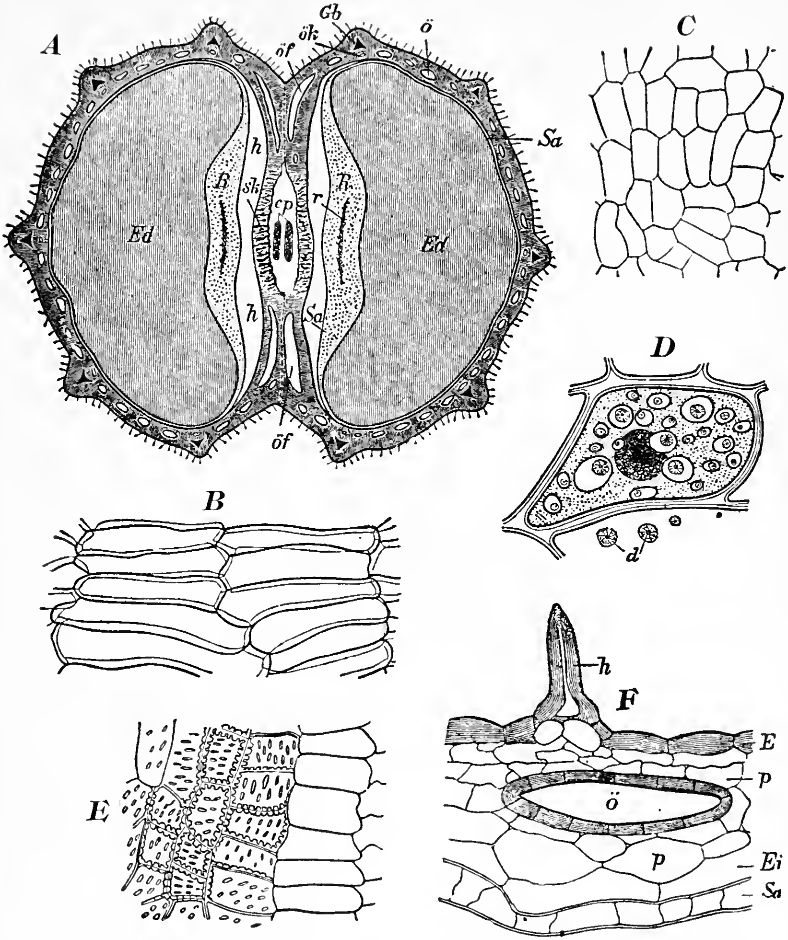


FIG. 244. Anise: A, transverse section of cremocarp showing carpophore (cp), wide vittæ (öf) on ventral (commissural) surface and smaller vittæ (ö, ök) between the ribs on the dorsal surface, fibrovascular bundles of ribs (Gb), sclerenchyma fibers (sk), an air cavity in the wall of the pericarp on the ventral side (h), raphe tissue (R) with fibrovascular bundle (r), seed-coat (Sa) and endosperm (Ed). B, inner epidermis of pericarp. C, epidermis of seed-coat. D, cell of endosperm showing a number of aleurone grains containing small rosette aggregates of calcium oxalate, a large nucleus in the center of the cell, and a few isolated aggregates of calcium oxalate (d). E, sclerenchyma cells of the inner epidermis of the pericarp in the neighborhood of the carpophore. F, transverse section of pericarp and seed-coat showing epidermal cells (E) and a non-glandular hair with thick, cutinized walls (h), parenchyma (p), a vitta (ö), inner epidermis (Ei) and seed-coat (Sa).—After Meyer.

lowish-brown, with a slender carpophore attached to each mericarp, the latter in section irregularly plano-convex, slightly concave on the commissural side and usually with two large vittæ on each face, dorsal surface with 30 to 40 vittæ; seed somewhat reniform in section, closely cohering to the pericarp, with a small embryo at the upper end of the reserve layer; odor and taste pleasantly aromatic.

INNER STRUCTURE.—See Fig. 244.

CONSTITUENTS.—Volatile oil (1 to 3 per cent.) consisting of about 80 to 90 per cent. of anethol (p-propenylanisol), and methyl-chavicol and terpenes; fixed oil 3 to 4 per cent.; calcium oxalate; ash about 7 per cent.

Russian aniseed is used chiefly for the manufacture of the volatile oil.

ALLIED DRUGS.—Illicium or star-anise (p. 274) yields an oil closely resembling that of anise. It contains 80 to 90 per cent. of anethol, d-pinene, d-phellandrene, ethyl ether of hydroquinone and possibly safrol (Fig. 144).

PIMPERNEL (or Pimpinella) the root of *Pimpinella Saxifraga* and *P. magna*, is used like anise. It occurs in fusiform pieces about 8 to 10 cm. long, 4 to 10 mm. in diameter, externally yellowish-brown, fracture short, internally whitish, with numerous yellowish resin canals; the taste is acrid, pungent and aromatic. The drug contains a volatile oil, an acrid resin, a tasteless crystalline principle pimpinellin, about 8 per cent. of sugar, starch and tannin.

ADULTERANTS.—Italian aniseed is sometimes contaminated with conium, and the friuts of some of the grasses and rushes as well.

CORIANDRUM.—CORIANDER.—The dried, ripe fruit of *Coriandrum sativum* (Fam. Umbelliferæ), an annual herb (p. 352), indigenous to the Mediterranean and Caucasian region, naturalized in the temperate parts of Europe, and cultivated there and in Africa and India. The fruit is collected when full grown from cultivated plants, from which it is separated by thrashing, and dried. The fruits from plants grown in Russia and Thuringia are preferred. The young plants, particularly the leaves, as well as immature fruits, emit a disagreeable odor, whence the name Coriandrum.

Description.—Mericarps usually coherent; cremocarp (Fig. 245) nearly globular, 4 to 5 mm. in diameter, externally light brown or rose-colored, with ten prominent, straight, longitudinal primary ribs, between which are faint, somewhat undulate secondary ribs, apex with 5 calyx teeth and a conical stylopodium about 0.5 mm. long, internally with a slender carpophore attached to each mericarp, the latter grayish-purple, concavo-convex, with two vittæ on the commissural surface; seed plano-convex, with a small embryo at the upper end of the reserve layer; odor and taste aromatic.

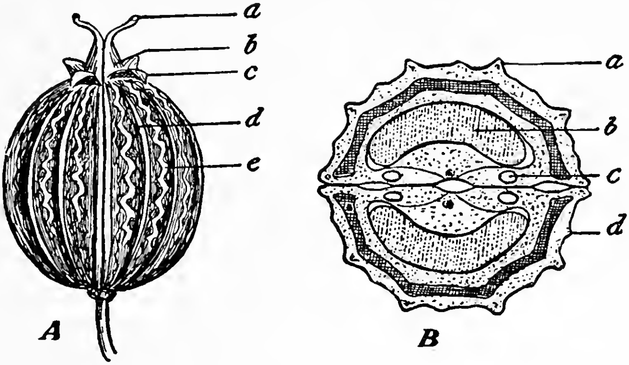


Fig. 245. Coriander: A, cremocarp showing remains of two stigmas (a), stylopodia (thickened persistent styles) (b), calyx teeth (c), straight primary ribs (d) and wavy, somewhat obscure, secondary ribs (e); B, transverse section of the cremocarp showing primary ribs (a), secondary ribs (d), vittæ (c) on commissural side, and seed (b).—After Bastin.

Constituents.—Volatile oil 0.5 to 1 per cent.; fixed oil about 13 per cent.; tannin; calcium oxalate; ash about 5 per cent. The volatile oil consists of about 90 per cent. of d-linalool (coriandrol), about 5 per cent. of d-pinene and some other constituents.

The unripe fruits are said to yield a volatile oil that has a fetid, bedbug-like odor, which it loses on keeping.

FŒNICULUM.—FENNEL.—The fruit of *Fœniculum vulgare,* and of the var. *dulce* (Fam. Umbelliferæ), perennial herbs indigenous to the Mediterranean region of Europe and Asia, and cultivated in France, Galicia, Germany, Roumania, Russia, India, and Japan. The fruit is collected when ripe and dried. That obtained from plants cultivated in Germany (Saxony and Thuringia), Galicia and Russia is preferred (p. 352).

Description.—Mericarps usually separated; cremocarp oblong or nearly cylindrical, straight, 4.5 to 8 mm. long, 2 to 3 mm. in diameter, externally yellowish-green, apex with a somewhat depressed disk, and a conical stylopodium about 0.5 mm. long, each mericarp with five prominent, yellowish, slightly winged primary ribs, internally somewhat greenish-brown, with a slender carpophore attached to each mericarp, the latter une-

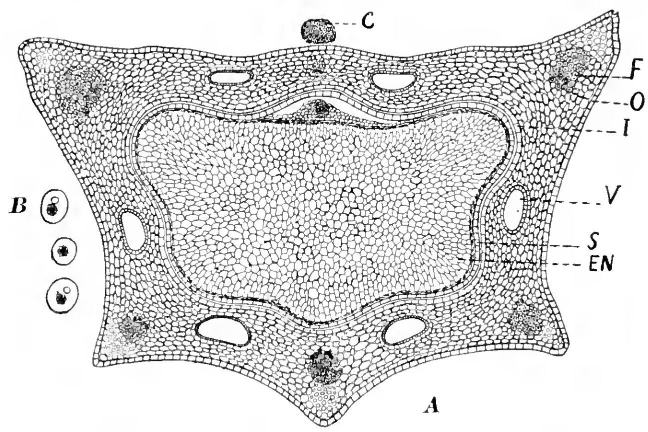


Fig. 246. A, transverse section through a mericarp of fennel: O, outer epidermis of pericarp; I, inner epidermis of pericarp; F, fibrovascular bundles; V, vittæ; S, seed-coat; EN, endosperm; C, section through the carpophore, which is composed chiefly of sclerenchymatous cells. B, isolated aleurone grains from cells of endosperm of fennel showing globoids and small rosette aggregates of calcium oxalate.

qually 5-angled in cross-section, the commissural surface slightly grooved and with two vittæ, dorsal surface with a single vitta between each of the primary ribs; seed irregularly plano-convex, with a small embryo at the upper end of the reserve layer; pedicel 3 to 10 mm. long; odor and taste aromatic.

Inner Structure.—See Fig. 246.

Constituents.—Volatile oil 2 to 6.5 per cent.; fixed oil about 12 per cent.; calcium oxalate, and about 7 per cent. of ash.

The volatile oil of fennel contains 50 to 60 per cent. of anethol; about 20 per cent. of fenchone, which gives the fruit its characteristic odor and taste; chavicol (isomer of anethol); anise ketone; anisic aldehyde; anisic acid, d-pinene and dipentene.

The sweet or ROMAN fennel, obtained from plants (*F. dulce*) cultivated in Southern France, has longer and somewhat curved mericarps, and yields about 2 per cent. of oil, containing considerable anethol but no fenchone. MACEDONIAN fennel oil contains considerable anethol, some limonene and phellandrene, but no fenchone. WILD BITTER fennel oil obtained from wild plants contains scarcely any anethol, but consists in part of phellandrene and fenchone.

ADULTERATIONS.—Fennel is frequently contaminated with wheat screenings, undeveloped fruits, various other umbelliferous fruits and dirt.

ALLIED DRUGS.—The more or less fusiform root of *Fœniculum vulgare* is also used like fennel. It is 8 to 15 cm. long, and has an aromatic odor and taste. Fennel root contains a volatile oil, resin, starch and sugar.

CARUM.—CARAWAY.—The fruit of *Carum Carvi* (Fam. Umbelliferæ), a biennial herb (p. 352) indigenous to Europe and Asia, and cultivated in England, Germany, Holland, Norway, Russia, Sweden and the United States, being naturalized in the Northern United States and parts of Canada. The plants are cut when the fruits are ripe, the latter being separated by thrashing. The fruits from plants grown in Holland are preferred.

DESCRIPTION.—Mericarps usually separated; cremocarp oblong, laterally compressed, 4 to 6 mm. long, 2 to 3 mm. in diameter, externally dark brown, surmounted by a small, somewhat globular stylopodium and 5 minute calyx teeth; primary ribs 10 in number, filiform, yellowish, between each of which are slight, secondary ribs; internally dark brown, mericarps curved, narrowed at both ends, and with a slender carpophore attached to each, the latter 5-angled in cross-section, the commissural surface with 2 vittæ, the dorsal surface with a vitta between each of the primary ribs; seeds irregularly oblong in section, with a small embryo at the upper end of the reserve layer; odor and taste aromatic.

INNER STRUCTURE.—See Fig. 247.

CONSTITUENTS.—Volatile oil from 5 to 7 per cent.; fixed oil; tannin; calcium oxalate, and 5 to 8 per cent. of ash.

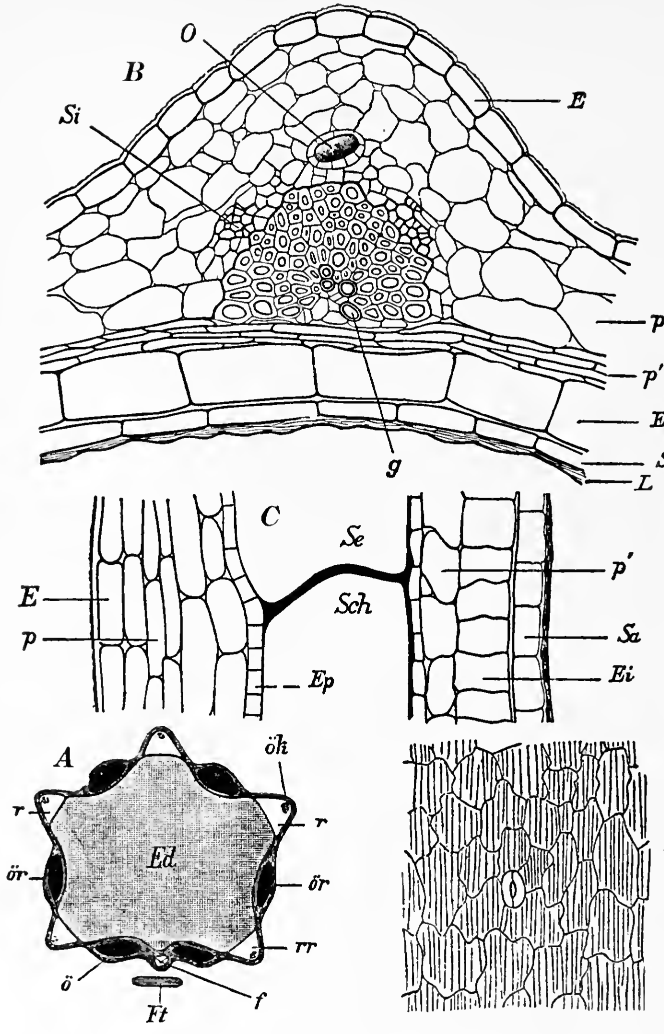


FIG. 247. Caraway: A, transverse section of a mericarp and carpophore (Ft) showing vittæ (ö, ör), primary ribs (r, rr,), with fibrovascular bundle (ök), tissue of raphe (f) and endosperm (Ed). B, transverse section through a primary rib showing part of pericarp and seed-coat, outer epidermal cells (E), a small vitta (O), sieve (Si), tracheæ (g), around which are thick-walled sclerenchymatic fibers; parenchyma (p, p^1), inner epidermis (Ei), outer epidermis of seed-coat (Sa) and collapsed cells (L) of remainder of seed-coat. C, longitudinal section through part of a mericarp showing outer epidermis (E), parenchyma (p, p^1), epithel (Ep) and separating wall (Sch) of vittæ (Se), inner epidermis of pericarp (Ei) and seed-coat (Sa). D, surface view of outer epidermis of fruit showing a single stoma. —After Meyer.

Volatile oil of caraway contains 50 to 60 per cent. of d-carvone (carvol), and 40 to 50 per cent. d-limonene (carven). Caraway oil, particularly carvone, is colored yellow on exposure to air, and the old oil gives a reddish-violet color with ferric chloride solution.

Allied Drugs.—The seeds of *Nigella sativa* and *N. damascena* (Fam. Ranunculaceæ), are used in medicine and for flavoring like caraway. They are commonly known as Black Caraway. The seeds are ovate, 3- to 4-angled, about 3 mm. long, externally black and reticulate; internally, a large, white, oily reserve layer in which is embedded the small, greenish embryo. Black caraway contains 1.5 per cent. of a volatile oil; 1.5 per cent. of a glucoside, melanthin, which resembles saponin and helleborin; a fluorescent alkaloid, damascenin, giving the volatile oil from *N. damascena* its fluorescence; another alkaloid, connigelline; and about 35 per cent. of a fixed oil.

CONIUM.—POISON HEMLOCK.—The fruit of *Conium maculatum* (Fam. Umbelliferæ), a large biennial herb indigenous to Europe, and naturalized in North and South America and in various parts of Asia (p. 352). The fruit is collected when full grown but still green from wild plants, carefully dried and preserved.

Description.—Mericarps usually separated; cremocarp broadly ovoid, slightly compressed laterally, 3 to 4 mm. long, about 2 mm. in diameter, with a pedicel 3 to 5 mm. long, externally grayish-green, with 10 straight more or less crenate yellowish ribs, stylopodium depressed, internally greenish-brown, with a slender carpophore attached to each mericarp, the latter 5-angled in cross-section and without any vittæ; seeds reniform, with a deep furrow on the commissural side, and with a small embryo at the upper end of the reserve layer; odor distinct; taste slight.

Inner Structure.—See Fig. 248.

Constituents.—The most important constituent is the liquid alkaloid coniine (hexa-hydropropyl pyridine), which exists to the extent of 0.5 to 3 per cent.; the drug also contains conydrine (oxyconiine), which crystallizes in plates, is dextrorotatory and very poisonous; pseudoconydrine (an isomer of conydrine), which crystallizes in needles; γ-CONICEINE, which is a colorless, oily alkaloid with a disagreeable odor, and 18 times more poisonous even than coniine; volatile oil, fixed oil, starch, calcium oxalate, and yields about 6 per cent. of ash.

Coniine is naturally combined in the drug with organic acids, from which it is liberated on treatment with alkalies, and may be readily extracted from the mixture by means of ether. When pure, coniine is a colorless, nearly odorless liquid and forms a

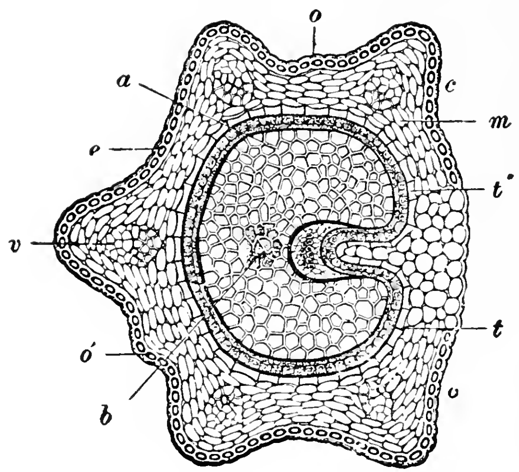


FIG. 248. Cross section of a mericarp of conium: c, c, commissural surface; e, portion without secondary ribs; o, portion showing slight development of secondary rib; o[1], secondary rib; v, fibrovascular bundle of pericarp (m); t, t[1], layers containing coniine; a, endosperm; b, tissues of the embryo.—After Flückiger.

number of crystalline salts. On the addition of concentrated sulphuric acid to coniine the latter is colored blood red and afterwards green. The disagreeable odor in commercial coniine, as well as in conium, is due to the alkaloid coniceine.

ALLIED DRUGS.—The entire fresh plant of *Conium maculatum* is used in the preparation of Succus Conii. It probably contains the same constituents as the fruit, but in smaller amounts. The root contains 0.018 to 0.047 per cent. of total alkaloids; the stems 0.064 per cent.; the leaves 0.187 per cent. and the flowers and flower stalks 0.236 per cent.

Water hemlock (*Cicuta maculata*) is a stout, perennial herb growing in wet meadows throughout the United States and Canada. The stems are streaked with purple, the leaves are pinnately compound, the leaflets being oblong-lanceolate and coarsely serrate; the flowers are white, occurring in large compound umbels. The fruit is ovoid, with prominent ribs and six conspicuous vittæ. The rhizome is large and fleshy and sometimes mistaken for parsnip. The fruits contain a volatile alkaloid, cicutine, which is said to resemble coniine, and about 1 per cent. of a volatile oil resembling oil of cumin. The rhizome, stems and leaves contain a resinous substance, cicutoxin, which is said to be quite poisonous.

RHUS GLABRA.—SUMAC BERRIES.—The fruit of *Rhus glabra* (Fam. Anacardiaceæ), a smooth, glaucous shrub, indigenous to Canada and the United States, extending as far west as Arizona (p. 321).

Description.—Drupe dry, superior, nearly globular, flattened, 3 to 4 mm. in diameter, 2.5 mm. thick, and with a slender peduncle about 2 mm. long; reddish externally, very pubescent, apex with a scar and with the remains of the style, base occasionally with the 5-cleft calyx; endocarp smooth, shiny, light red; 1-locular, 1-seeded; seed campylotropous, dark brown, smooth, hilum marked by a distinct scar, reserve layer wanting, embryo curved; inodorous; taste acidulous and astringent.

Constituents.—Tannic acid about 2 per cent.; gallic acid, and acid calcium and potassium malates.

Allied Drugs.—The leaves of *Rhus glabra* contain from 16 to 25 per cent. of tannin. The galls formed on the petioles and leaves resemble the Chinese or Japanese galls and contain about 60 per cent. of tannin and some gallic acid (p. 649).

CUBEBA.—CUBEB BERRIES.—The fruit of *Piper Cubeba* (Fam. Piperaceæ), a woody climber (p. 249), indigenous to Borneo, Java and Sumatra, where it is apparently also cultivated. The fruit is gathered when full grown but still green, and carefully dried in the sun, the commercial supplies being shipped from Batavia and Singapore.

Description.—Drupe dry, superior, globular, 4 to 6 mm. in diameter, with a straight, slender peduncle 5 to 7 mm. long;

externally dark brown, coarsely reticulate, apex with remains of 3 to 4 stigmas; pericarp about 0.3 mm. thick; internally light brown, smooth, oily, 1-locular, 1-seeded; seed atropous, broadly

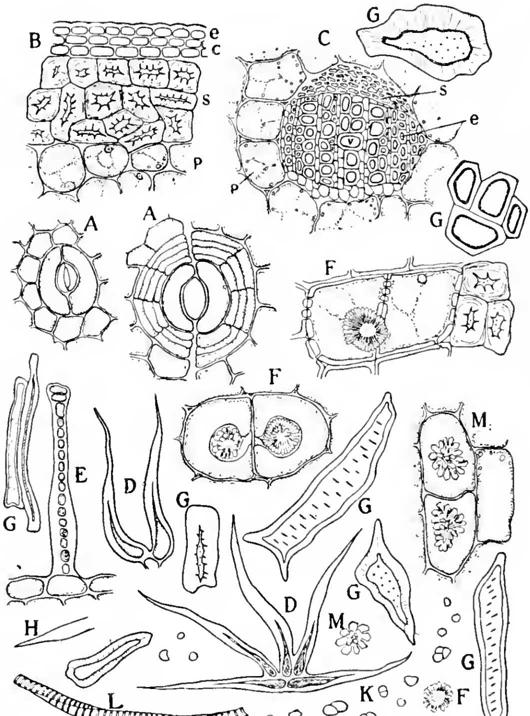


FIG. 249. Pericarp of fruit of *Juglans regia:* A, stomata of epicarp; B, cross-section of pericarp showing epidermis (e), cells with reddish-brown contents (c), sclerotic cells (s), parenchyma (p) containing protoplasm and starch grains; C, mestome strand of the sarcocarp showing vessels (v), libriform (l), leptome (s), parenchyma containing protoplasm and starch (p); D, non-glandular hairs from the apical and basal portions of fruit; E, glandular hairs from base of fruit similar to those found in large numbers on the surface of the butternut (*Juglans cinerea*); F, rosette aggregates resembling the membrane crystals of Rosanoff; G, sclerotic cells found in the powder; H, fragment of non-glandular hair; K, starch grains from 2 to 10 μ in diameter; L, tracheæ with annular markings; M, calcium oxalate crystals.

ovoid, 4 to 5 mm. in diameter, reddish-brown, straight, mostly smooth on one side where it lies against the pericarp, chalazal end with a broad scar, micropyle with a slight depression, a small embryo at the upper end of the reserve layer; odor distinct; taste aromatic and pungent.

INNER STRUCTURE.—See Fig. 250.

CONSTITUENTS.—Volatile oil 10 to 18 per cent., consisting chiefly of terpenes and sesquiterpenes and a sesquiterpene hydrate known as cubeb camphor; several resins, 2.5 to 3.5 per cent., one of which is acrid and one a so-called indifferent resin; cubebic acid, 1 to 3.5 per cent., this being colored reddish with sulphuric acid; a bitter crystalline principle, cubebin, 0.4 to 3 per cent.; fixed oil, 1 per cent.; gum, 8 per cent.; starch, and about 6 per cent. of ash.

ALLIED PLANTS.—A number of other species of Piper yield fruits resembling cubeb, as *Piper Clusii*, of West Africa; *P. borbonense*, of Bourbon, *P. sumatranum* and *P. pedicellosum*, of Farther India.

The fruit of *Toddalia lanceolata* (Fam. Rutaceæ) is used in Africa in place of cubeb (berries). The fruits of *Litsea citrata* have been sold as false cubeb, and those of *Litsea Cubeba* (Fam. Lauraceæ) are substituted for cubeb in Cochin China and China.

ADULTERANTS.—The fruits of other species of Piper sometimes find their way into market; these are grayish in color, somewhat bitter, and do not give a wine-colored reaction with sulphuric acid. Not infrequently a considerable amount of the rachis is present and this contains a relatively small amount of the active principles.

PIPER.—BLACK PEPPER.—The fruit of *Piper nigrum* (Fam. Piperaceæ), a woody, perennial climber (p. 247), indigenous to Cochin China and various parts of India and cultivated in the East Indies, West Indies and other tropical countries. The fruit is gathered when full grown, removed from the rachis and dried in the sun. The commercial supplies are obtained from plants cultivated in Java, Sumatra and other islands of the Malay Archipelago, the principal points of export being Batavia and Singapore. The latter furnishes the best grade of black pepper and as it is dried by artificial heat it has a somewhat smoky odor and taste. The most of the other black peppers or peppercorns are dried in the sun.

Description.—Drupe dry, superior, nearly globular, 4 to 6 mm. in diameter, epicarp very thin, easily separable from the sarcocarp; externally blackish-brown, coarsely reticulate, apex with remains of sessile stigma, base with scar of pedicel, sarcocarp and endocarp dark brown and with numerous longitudinal veins; seed atropous, broadly ovoid, 4 to 5 mm. in diameter,

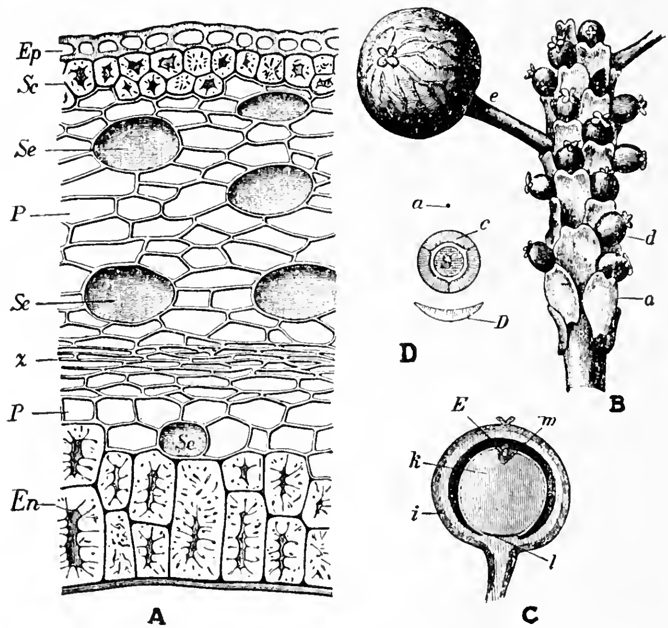


Fig. 250. Cubeb: A, transverse section of the pericarp showing epidermis (Ep), stone cells (Sc), oil cells (Se), parenchyma (P), collapsed parenchyma tissue (z), endocarp (En) composed of stone cells. B, spike showing bracts (o), young sessile fruits (d), and a mature fruit with long pedicel (e). C, longitudinal section of mature fruit showing pericarp (i), union (l) of seed and pericarp, large perisperm (k), small endosperm (m), which surrounds the embryo (E). D, flower diagram showing the position of the flower in reference to the rachis (a), bract (D) and pericarp (c) which surrounds the ovule (S).—After Meyer.

externally reddish-brown, micropylar end pointed, chalazal end marked by a small scar; internally yellowish-green; perisperm large and usually with a cavity near the middle 1 mm. or more wide, the endosperm small, situated at one end of the fruit and embryo small, frequently more or less shrivelled; odor aromatic, slightly empyreumatic; taste aromatic and pungent.

Black pepper should yield not less than 6 per cent. of a non-volatile ether extract nor less than 25 per cent. of starch. The ash should be not more than 7 per cent., of which only two per cent. is insoluble in hydrochloric acid. The crude fiber should be not more than 15 per cent.

Inner Structure.—The epicarp consists of a layer of polygonal cells with dark brown contents; beneath this, one or more interrupted rows of strongly lignified, more or less radially elongated stone cells occur; the sarcocarp contains a more or less interrupted layer of oil cells with suberized walls; the endocarp consists of characteristic stone cells, which are horse-shoe shaped, the inner and radial walls being thickened and commonly referred to as "beaker cells." The perisperm consists chiefly of radially elongated cells containing numerous starch grains which are 2 to 6 μ in diameter; some resin cells; cells containing needle-shaped crystals of piperine, and in the outer layers small aleurone grains (Figs. 121, *B*; 311).

Constituents.—Volatile oil 1 to 2 per cent., containing dipentene, phellandrene and a peculiar terpene; the alkaloid piperine, 4.5 to 8 per cent., which crystallizes in colorless, tasteless, 4-sided prisms which are colored bright green by means of concentrated sulphuric acid and formaldehyde, and with potassium hydrate or sulphuric acid give a red color; piperidine, a colorless liquid alkaloid, which is a derivative of piperine, about 0.5 per cent.; a pungent resin, chavicin; starch, 25 to 40 per cent.; tannin; proteins, about 10 per cent.; ash, about 5 per cent. (Fig. 340).

Allied Products.—The fruits of *Piper nigrum* are sometimes allowed to ripen and the epicarp is separated by hand or machinery after the fruits have been soaked in salt water or lime water. The fruits are then known as white peppercorns or white pepper, are nearly smooth, of a light gray or yellow color, and while less aromatic and pungent than the black pepper or black peppercorns, possess a fine flavor. White pepper yields 3.9 to 6.47 per cent. of piperine.

Piper longum, a shrub indigenous to the Malay Archipelago, yields the so-called "long pepper," which consists of the entire spikes of the immature fruit; the spikes are cylindrical, from 2.5 to 4 cm. long, about 5 mm. thick, of a grayish-black color, and the drupes are less aromatic and pungent than the official pepper. In structure long pepper is distinguished by the absence of oil cells in the sarcocarp, and "beaker cells" of the endocarp, and the larger starch grains (2 to 10 μ) in the perisperm. Long pepper yields about 1 per cent. of a volatile oil with the pungent taste of the oil of pepper but an odor resembling that of ginger; and about 4.24 per cent. of piperine.

Long pepper is also obtained from *Piper officinarum*, of Java, India and the Philippine Islands; *Piper sylvaticum*, of Eastern India; *Chavica officinarum*, of the West Indies; and *Peperomia acuminata*, of Peru.

ADULTERANTS.—The poorer black peppers, known as ACHEEN pepper, are light in weight, consist more or less of shells and are usually considerably broken. They are frequently contaminated with stems, earth and small stones. PENANG WHITE PEPPER has a grayish color and is coated with a substance containing considerable calcium carbonate. PEPPER HULLS or pepper shells, representing the broken pericarp of the fruit obtained in the preparation of white pepper, consist of small grayish-black fragments, containing numerous stone cells, and they yield a high percentage of fiber and ash.

SUBSTITUTES.—The fruit of *Embelia ribes* (Fam. Myrsinaceæ), a small tree of India, has been used as an adulterant of both pepper and cubeb. The blackish drupes resemble black pepper. They are very aromatic and yield a principle, embelic acid, which crystallizes in golden-yellow prisms, the alcoholic solution of which is colored red with ammonia.

The fruit of *Polyadenia pipericarpa* (Fam. Lauraceæ), of Sumatra, is also used in place of pepper. The fruits of a number of species of Xylopia (Fam. Anonaceæ) contain aromatic and bitter principles, some of these being used as a condiment like pepper, as *X. æthiopica*, which are also used as a medium of exchange by the natives of Uadai (Africa), and *X. grandiflora*, *X. sericea* and *X. frutescens* of Brazil. *X. aromatica* yields the Guinea pepper.

PIMENTA.—ALLSPICE.—The fruit of *Pimenta officinalis* (Fam. Myrtaceæ), a tree (p. 347) indigenous to the West Indies, Mexico, Central America and Venezuela, where it is also cultivated, especially in Jamaica. The panicles are collected when the fruit is full grown but still green, and dried in the sun, the fruit being subsequently separated.

DESCRIPTION.—Drupe dry, inferior, sub-globular, 5 to 7 mm. in diameter; externally dark brown, glandular-punctate; apex with four minute calyx teeth or forming a minute ring and surrounding the remnants of the somewhat depressed style; base with scar of pedicel or occasionally with a pedicel 4 to 6 mm. long; pericarp about 1 mm. thick; internally light brown, 2-locular, 2-seeded, dissepiments thin; seeds campylotropous, plano-convex, slightly reniform, about 4 mm. long and about 3 mm. thick, externally reddish-brown, smooth, somewhat wrinkled, shiny, internally dark brown, reserve layer wanting, embryo spirally curved, with a long, thick radicle and minute cotyledons; odor and taste aromatic, supposed to resemble those of a mixture of cloves and other spices, whence the name "Allspice."

CONSTITUENTS.—Volatile oil (3 to 4 per cent.) consisting of about 60 per cent. of eugenol; resin; an acrid fixed oil about 6 per cent.; tannin; starch; calcium oxalate; ash about 4 per cent.

ALLIED PLANTS.—A variety of *P. officinalis* yields a fruit with large drupes known as TOBASCO or Mexican Allspice. The structure of this fruit resembles that of pimenta, as also does the Crown Allspice obtained from *P. acris*, a tree of tropical America, the fruits of which are 8 to 10 mm. long.

MALTUM.—MALT.—The partially germinated and dried grains of *Hordeum sativum*, particularly of the variety *vulgare* (Fam. Gramineæ) (p. 228). In the preparation of malt the barley grains are soaked in water for 12 to 24 hours, placed in heaps, allowed to germinate, being occasionally stirred so that the heat generated on germination does not become excessive. After the protrusion of the caulicle and radicle the material is quickly dried and deprived of these parts.

BARLEY.—Narrow-ellipsoidal, somewhat 4-angled, 8 to 10 mm. long, 2 to 3 mm. in diameter, having an outer, readily separable coat consisting of the inner and outer pales, which are membranous, chaff-like, pale straw-color and somewhat translucent; within the pales and adhering to the base of the grain, two very small lodicules consisting chiefly of unicellular hairs from 0.5 to 1 mm. long. Grain nearly smooth, grooved on one side and with a slight projection at the apex consisting of numerous 1-celled hairs, usually with pollen grains adhering, embryo on side opposite the groove and forming a slight projection at the base of the grain; endosperm large and consisting chiefly of cells filled with spherical starch grains resembling those of wheat, the two to four outer layers of cubical cells containing aleurone grains. The embryo is connected with the endosperm by means of a sheathing membrane (by some regarded as a modified cotyledon), through which it obtains nutriment during germination. On germination the embryo produces about 5 multiple primary rootlets and a stem portion with sheathing green leaves (Fig. 321).

MALT.—Grains resembling those of barley, of a yellowish-brown to dark brown color, and with a short fracture; starch grains altered, exhibiting numerous radial and concentric fissures; odor agreeable and taste sweetish.

CONSTITUENTS.—Barley grains contain from 60 to 68 per cent. of starch; 12 to 18 per cent. of proteins; about 1.5 per cent. of sugar, and 1 to 3 per cent. of fixed oil. Two ferments are developed during the process of germination, namely, diastase, which acts on the starch, changing it to dextrin and maltose; and another ferment which acts on the proteins, converting them into peptones. The germinating seeds of barley contain a white crystallizable alkaloid, hordenine, which is slightly toxic.

Commercial malt contains nearly the same constituents as are found in barley, the starch grains being somewhat altered and converted partly into soluble starch through the action of the ferment diastase, a small amount of which is still present in malt after drying. In the preparation of the extract of malt the starch is mostly converted into dextrin and maltose, the proportion of the latter being larger.

PRUNUM.—PRUNE.—The fruit of *Prunus domestica*, and of the var. *Juliana* (Fam. Rosaceæ), a small tree (p. 287) indigenous to Southern Europe, and largely cultivated in Southern France, Germany, Asia Minor and California, but not found growing wild. The fruit is collected when ripe and partially dried by artificial means, or completely dried in the sun. The fruit exported from Bordeaux is of superior quality.

DESCRIPTION.—Drupe superior, fleshy, ellipsoidal, more or less compressed, 3.5 to 4 cm. long, about 3 cm. broad; externally brownish-black, glabrous, wrinkled, with two faint lines

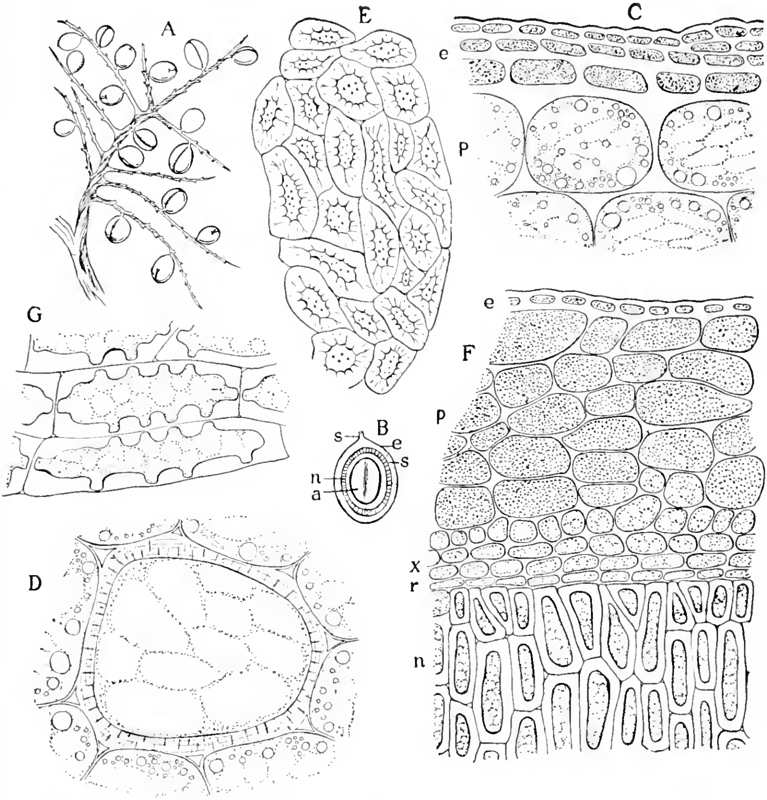


FIG. 251. Saw palmetto (*Serenoa serrulata*): A, fruiting branch; B, longitudinal section of fruit showing short stalk (s), epicarp (e), sarcocarp (s), endocarp (n), and anatropous seed with raphe (a); C, cross-section of outer portion of fruit showing epidermis (e) composed of several layers of cells having a dark reddish-brown content, cells of sarcocarp (p) with reddish-brown content and oil; D, a sclerotic cell from the sarcocarp showing the fine radiating pores and concentric lamellæ of the wall; E, sclerotic cells from endocarp; F, cross-section of portion of seed showing epidermal cells (e), large parenchyma cells (p), inner epidermis (x), perisperm (r), endosperm (n); G, some thick-walled endosperm cells from the inner portion of seed.

indicating the dorsal and ventral sutures, apex with a slight scar from the remains of the style, base with a depressed stalk-scar 3 to 5 mm. in diameter, sarcocarp yellowish-brown, fleshy, somewhat stringy, 1.5 cm. thick; taste sweet and acidulous; endocarp ellipsoidal, flattened, about 2 mm. thick, externally dark brown, reticulate, with a groove on one side, frequently extending nearly around the edge, internally light brown, smooth, 1-locular, 1-seeded, occasionally 2-seeded; seed about 2 cm. long, 8 mm. wide, 5 mm. thick, closely resembling Bitter Almond (see Amygdala Amara).

CONSTITUENTS.—Sugar 25 to 44 per cent.; organic acids, as malic and tartaric, partly free and partly combined, chiefly with potassium, about 2 per cent., and water about 30 per cent.

SABAL.—SAW PALMETTO.—The ripe drupe of *Sabal* (*Serenoa*) *serrulata* (Fam. Palmæ), a small palm found growing in sandy soil from South Carolina to Florida. The fruit is partially dried by artificial means (p. 231; Fig. 251).

DESCRIPTION.—Drupe superior, ellipsoidal, ovoid or somewhat globular, 1.5 to 3 cm. long, 1 to 1.5 cm. in diameter; externally brownish-black, smooth, somewhat oily, with few large, somewhat angular depressions due to the contraction of the inner layer on drying; apex marked by remains of style; base marked by stem-scar or with remains of stem; epicarp and sarcocarp together forming a thin coriaceous shell enclosing a hard but thin endocarp which is externally reddish-brown and somewhat fibrous, as is also the inner layer of the sarcocarp; inner layer of endocarp smooth, enclosing an ellipsoidal or ovoid, hard, somewhat flattened, anatropous, reddish-brown seed which is marked on the raphe side by an arillus-like appendage and on the opposite side near the end by the micropyle, which forms a slight projection; internally, with a large endosperm of thick-walled parenchyma and a very small embryo at the micropyle; odor pronounced, aromatic and fruity; taste sweetish, aromatic and slightly acrid.

CONSTITUENTS.—About 1.2 per cent. of a volatile oil (in the fresh fruit): 4 to 5 per cent. of a green or brownish oil, consisting of a number of fatty acids and their esters, as caproic, caprylic, capric, lauric, palmitic and oleic; a resin; considerable glucose and possibly an alkaloid.

CAPSICUM.—CAYENNE PEPPER (AFRICAN PEPPER).—The dried ripe fruit of one or more species of Capsicum, probably *Capsicum fastigiatum, Capsicum frutescens,* and *Cap-*

sicum minimum (Fam. Solanaceæ), shrubs indigenous to tropical America, and cultivated in tropical Africa, India and America, and Japan. The commercial supplies are obtained from plants cultivated in Natal, Sierra Leone and Zanzibar. The latter variety

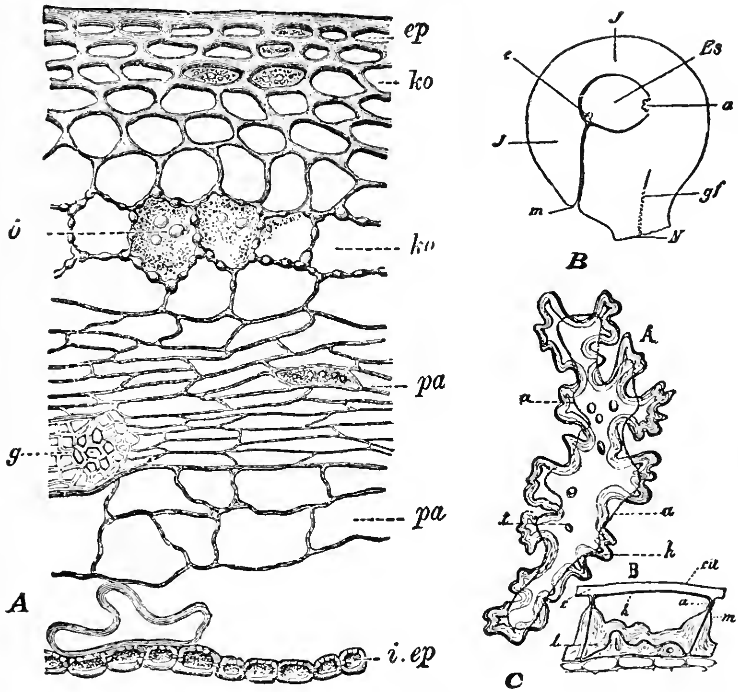


FIG. 252. Garden pepper (*Capsicum annuum*): A, transverse section of pericarp showing epidermis (ep); hypodermis (ko), some of the cells of which have thick suberized walls and contain oil (o) and resin; parenchyma (pa); fibrovascular bundle (g); inner epidermis (i, ep) composed of thick, lignified, porous cells. B, diagram of fertilized ovule showing hilum (N), micropyle (m), integument (J), fibrovascular bundle (gf), embryo-sac (Es), egg-cell (e), antipodal cells (a). C, longitudinal and transverse sections of a stone cell from the inner epidermis showing the thickening of the inner and side walls.—A, after Hanausek; B, C, after Meyer.

furnishes one of the best grades. Cayenne pepper is also known as red pepper or chillies (p. 375).

DESCRIPTION.—Oblong, conical, laterally compressed, 1.5 to 4 cm. long, 6 to 10 mm. in diameter, with an inconspicuous 5-toothed calyx and sometimes a slender, straight pedicel about

15 mm. long; externally yellowish- or brownish-red, glabrous, shiny, somewhat translucent, more or less shriveled; apex acute, base somewhat rounded; pericarp coriaceous, thin; inner surface with two or three distinct longitudinal ridges, longitudinally striate, 2- or 3-locular, dissepiments thin, united below; seeds 10 to 20, campylotropous, irregularly circular or obovate, flattened, pointed, about 3 to 4 mm. in diameter, 0.5 mm. thick, edge slightly thickened, embryo curved, embedded in the endosperm; odor distinct; taste of pericarp pungent, of dissepiments, very pungent.

Cayenne pepper should yield not less than 15 per cent. of non-volatile ether extract; nor more than 1.5 per cent. of starch; 6.5 per cent. of ash.

INNER STRUCTURE.—See Figs. 252; 301, *C*.

CONSTITUENTS.—Two crystalline pungent principles which are found principally in the dissepiments of the fruit: CAPSAICIN, which is slightly soluble in water and is volatile at 115° C., forming irritating vapors; and CAPSACUTIN, which is so powerful that 1 part in 11,000,000 of water has a distinct pungent taste. Capsicum also contains a volatile alkaloid resembling coniine; a volatile oil with an odor of parsley; resin; a small quantity of starch; a fixed oil, consisting of oleic, palmitic and stearic acids; and yields 4 to 6 per cent. of ash.

ALLIED DRUGS.—A capsicum of inferior quality known as BOMBAY PEPPER is obtained from plants growing in the vicinity of the River Niger in Africa. The fruits are dull yellow or brown in color, 2 to 3 cm. long and about 10 mm. in diameter.

JAPAN PEPPER resembles the official Cayenne pepper in size. The fruits are of a bright yellowish-red color, and more shiny but not so pungent. GARDEN OR POD-PEPPER, also known as paprika or Spanish pepper, is the product of *Capsicum annuum*, an herb extensively cultivated in Hungary, Italy and Spain, and this kind is recognized by the German Pharmacopœia. The fruits when fresh are 5 to 10 cm. long, 5 to 7 cm. in diameter, more or less inflated, externally of a bright green, yellow or red color; the pericarp is 2 to 3 mm. thick, enclosing a large cavity, which has 1 or 2 dissepiments at the base, and contains numerous flattened seeds about 3 to 5 mm. in diameter.

CARDAMOMUM.—CARDAMOM.—The fruit of *Elettaria Cardamomum* (Syn. *E. repens*) (Fam. Zingiberaceæ), a perennial herb (p. 242) indigenous to Farther India, and cultivated near the Malabar Coast and in Ceylon. The commercial article is obtained from wild plants growing in the southern part of the western coast of Farther India. The fruit is gathered in autumn—either the entire spike, when some of the fruits have matured, or the full-grown fruits are cut from the rachis in succession as they ripen; they are bleached by exposure to the sun,

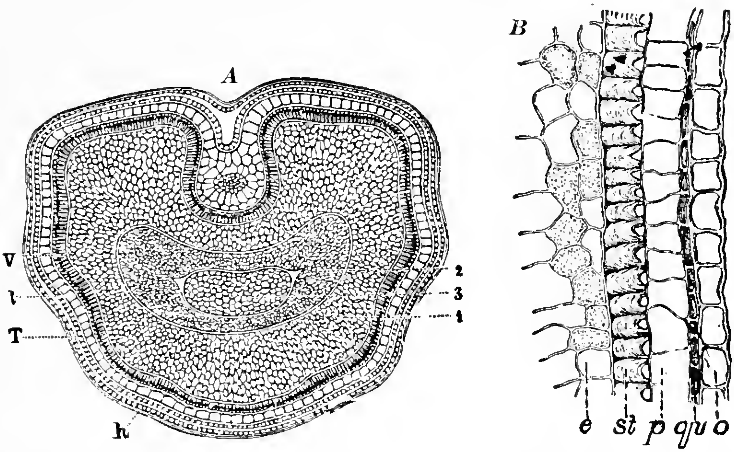


Fig. 253. Cardamom: A, transverse section showing the arillus (h), the several layers of the seed-coat (T, l, V), perisperm (1), endosperm (2) and embryo (3) at the center. B, transverse section of the seed-coat and perisperm of Malabar cardamom showing epidermal cells (o), cells having a brown content (qu), cells containing ethereal oil (p), brown stone cells (St) with very thick inner walls, and perisperm (e), the cells of which contain numerous small starch grains and usually a pair of small crystals which may be seen on treating sections with chloral.—A, after Meyer; B, after Moeller.

sometimes sulphurous acid or steam being also used, after which they are dried and freed from extraneous matter. Seeds which have been discharged from the capsules are inferior to those which have been retained. A greater portion goes to Bombay, from where it is estimated that 100,000 kilograms are exported yearly to London. The commercial varieties are known as Malabar and Mysore Cardamom.

Malabar Cardamom.—Capsule loculicidally dehiscent, broadly ellipsoidal, occasionally ovoid, more or less triangular in transverse section, 10 to 17 mm. long, 6 to 8 mm. in diameter, pericarp about 0.5 mm. thick; externally light brown or faintly pink, apex slightly beaked, and with remnants of style, base rounded, with scar of stalk, longitudinally striate, 3-grooved, 3-valved, 3-locular, dissepiments thin; seeds 15 to 18 in number, anatropous, irregularly angular, enclosed in a thin membranous aril, about 3 mm. long, externally dark reddish-brown, deeply wrinkled, embryo small, straight, endosperm and perisperm distinct; odor aromatic; taste aromatic, pungent (Fig. 90, *C*).

Mysore Cardamom.—Ovoid, somewhat oblong, white or very light brown, 12 to 20 mm. long, 7 to 9 mm. in diameter, nearly smooth or faintly striate longitudinally; seeds 9 to 12, and less pungent than those of Malabar Cardamom.

Inner Structure.—See Fig. 253.

Constituents.—Volatile oil 4 to 5 per cent., with a penetrating but agreeable odor and a camphoraceous, burning taste; fixed oil 10 per cent.; starch about 3 per cent.; calcium oxalate; ash 4 to 6 per cent. The pericarp contains about 0.2 per cent. of a volatile oil.

Allied Plants.—Ceylon Cardamom is obtained from wild plants of *Elettaria major*. The capsules are 2 to 4 cm. long and about 10 mm. in diameter, distinctly triangular in transverse section, deeply striate longitudinally and slightly pubescent. In each loculus there are about 20 seeds, which are about 4 mm. long, bitter and less aromatic than the official cardamom.

The so-called bastard cardamoms are yielded by one or more species of Amomum, but these rarely find their way to market.

HUMULUS.—HOPS.—The fruit of *Humulus Lupulus* (Fam. Moraceæ), a perennial herbaceous climber (Fig. 136), indigenous to Europe, Asia and North America, and extensively cultivated in England, Germany and various parts of the United States, South America and Australia, where it is also naturalized (p. 255). Hops are collected in September, when they are ripe, carefully dried by means of artificial heat, and packed into bales or sent loose into commerce. They are sometimes treated with sulphur dioxide to improve the color and to prevent change of the active principles. The development of the odor of valerianic acid is said to be prevented by sprinkling the hops with a small quantity of alcohol before packing them. Hops lose their active properties on keeping.

DESCRIPTION.—Cone-like, flattened, oblong or ovoid, 2 to 3 cm. long, 1.5 to 2 cm. wide, about 7 mm. thick, consisting of a sharp-undulate rachis and about 50 membranous bracts, the latter distinctly veined, light green or brownish-green, glandular-hairy, entire, 10 to 14 mm. long, 7 to 11 mm. broad, with acute apex and rounded base, frequently infolded on one side and enclosing a sub-globular, light-brown, very glandular akene; the seed with two flat, spirally coiled cotyledons and without a reserve layer; odor aromatic; taste bitter.

CONSTITUENTS.—Volatile oil about 0.7 per cent., of which 60 to 70 per cent. is humulene; a crystalline, bitter principle, lupamaric acid; tannin 4 to 5 per cent.; resin 10 to 18 per cent.; asparagin, about 1 per cent.; trimethylamine; choline or lupuline; malic and citric acids, chiefly in the form of salts; calcium oxalate, and ash about 10 per cent.

COLOCYNTHIS.—BITTER APPLE.—The fruit of *Citrullus Colocynthis* (Fam. Cucurbitaceæ), a perennial herbaceous vine (p. 386), indigenous to warm, dry regions of Africa and Asia, and cultivated in the northwestern provinces of India and the countries bordering the Mediterranean. The fruit is collected in autumn when ripe, and after removal of the epicarp by paring, is quickly dried in the sun or by artificial means. The commercial supplies are obtained from Turkey and Spain, the finer grade coming from Turkey. The seeds should be removed from the pulp before it is used.

DESCRIPTION.—Berry nearly globular, 6 to 7 cm. in diameter (Fig. 254); light; externally yellowish-white; internally, with three longitudinal, somewhat elliptical fissures 8 to 14 mm. wide; seeds numerous, ovoid, compressed, yellowish-green, and borne on the divided parietal placentas between the fissures; odor slight; taste very bitter (Fig. 93).

CONSTITUENTS.—A bitter glucoside, colocynthin, 0.2 to 0.5 per cent., which may be crystallized but usually is obtained as an amorphous powder that is inflammable, soluble in water and alcohol, and yields upon hydrolysis colocynthein; a tasteless resin,

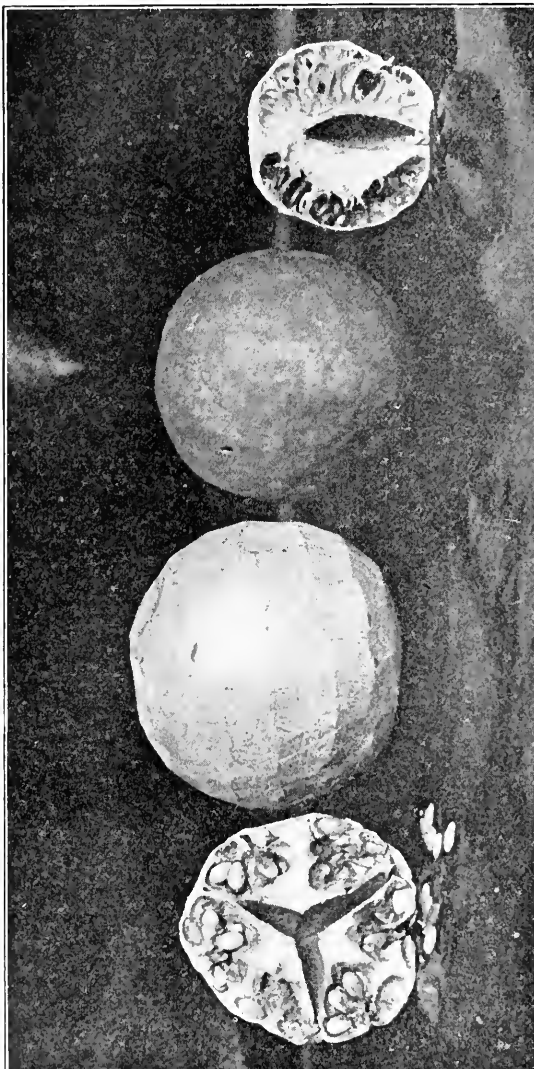


FIG. 254. Colocynth fruits. Beginning at the left, is seen a transverse section, fruit with periderm removed, fruit with periderm present, and longitudinal section.

colocynthitin, which occurs in small, white prisms; fixed oil in pulp about 3 per cent., and in seeds about 15 per cent.; ash about 10 per cent. in pulp and about 3 per cent. in the seeds.

Attempts have been made to grow Colocynth in England and in New Mexico. The fruits are much larger than the official, and while very bitter appear to be less active than the fruits obtained from wild plants.

CASSIA FISTULA.—PURGING CASSIA.—The ripe fruit of *Cassia Fistula* (Fam. Leguminosæ), a tree (p. 293) indigenous to India, and naturalized in tropical Africa, South America and the West Indies. The principal supply of the drug used in this country comes from tropical America.

Description.—Legume straight, many-locular, indehiscent, cylindrical, 25 to 50 cm. long, 15 to 20 mm. in diameter; externally reddish-brown, apex acute or acuminate, base rounded, sometimes with a woody pedicel about 15 mm. long and 4 mm. in diameter, smooth, shiny, transversely striate, on one side a longitudinal groove (the ventral suture), and on the other a smooth line or slight ridge (the dorsal suture); pericarp hard and woody; internally divided by transverse partitions into numerous compartments about 5 mm. long, each containing a brownish-black pulp and a single seed; seed anatropous, ovoid, compressed, about 8 mm. long, 6 mm. wide, 4 mm. thick, light brown, the raphe as a distinct line on one of the compressed sides, internally light yellow, embryo curved and embedded in the endosperm; odor of pulp distinct, prune-like; taste sweet.

Constituents.—The fruit yields about 30 per cent. of pulp, which contains 40 to 60 per cent. of sugar. The drug apparently does not owe its laxative properties to any of the anthraquinone derivatives found in senna and related plants.

Allied Plants.—The legumes of related species of Cassia found in tropical America are similar to those of *Cassia Fistula*, and are also used in medicine.

VANILLA.—The fruit of *Vanilla planifolia* (Fam. Orchidaceæ), a perennial climbing plant indigenous to Eastern Mexico, and now cultivated (p. 245) in various tropical islands, including the Seychelles, Mauritius, Java, as well as in the provinces of Vera Cruz and Oaxaca, in Mexico, from whence the best

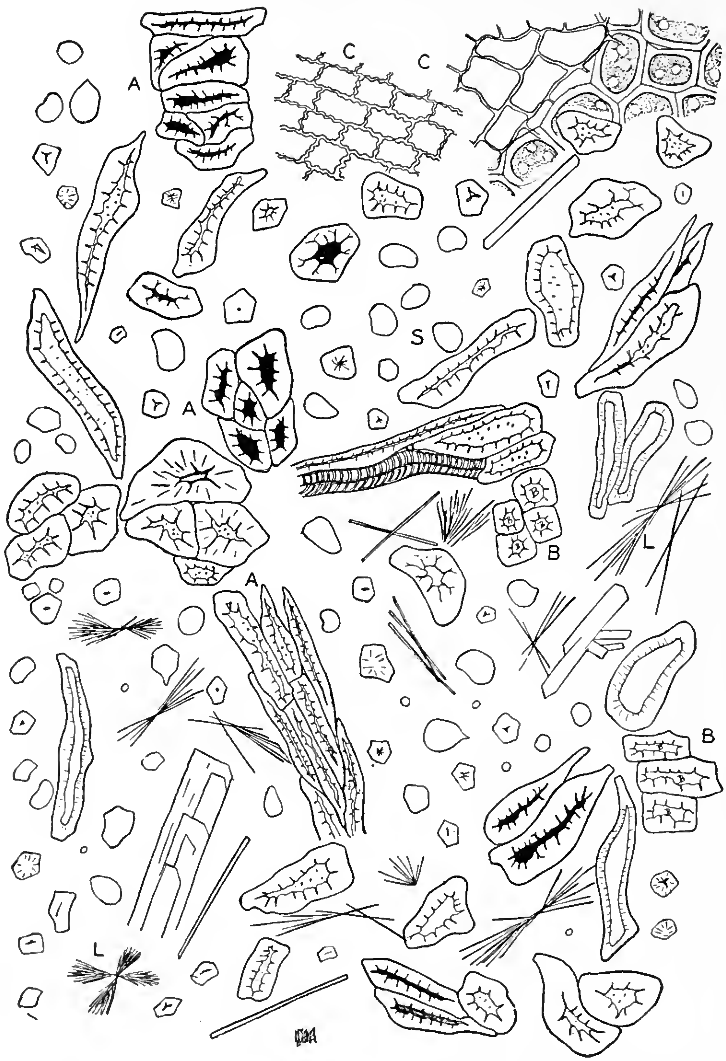


Fig. 255. A mixture sold as ground black pepper: A, stone cells of olive endocarp; S, corn and wheat starch grains; B, stone cells of pepper hulls; C, fragments of seed coat and pericarp of cayenne pepper; L, crystals of calcium sulphate which separate on mounting the specimen in 25 per cent. sulphuric acid.

fruit is derived. Most of the vanilla used in the United States comes from Mexico. Some of the Reunion (or Bourbon) fruit is now also entering the market. For method of curing the fruit see p. 245.

Mexican Vanilla.—Pods narrow, linear, about 20 cm. long, 7 mm. in diameter, 4 mm. thick; apex oblique, with a circular scar; base curved or bent, with a slightly enlarged circular scar; externally blackish-brown, longitudinally wrinkled, moist, glossy, sometimes with acicular crystals or monoclinic prisms; pericarp about 1 mm. thick; internally dark brown, 1-locular, with numerous seeds embedded in a dark-colored pulp; seeds anatropous, ovoid, flattened, 0.2 to 0.3 mm. in diameter, black, finely reticulate, reserve layers wanting, embryo shrunken; odor and taste distinct.

Bourbon Vanilla resembles the Mexican Vanilla, but is about two-thirds as long and the outer surface is usually covered with crystals.

Inner Structure.—See Figs. 256, 313.

Constituents.—An odorous crystalline principle, vanillin, from 1.5 to 3 per cent.; an odorous, balsamic or resinous principle, which is developed during the process of curing and to which the peculiar odor of vanilla is due; sugar about 10 per cent.; fixed oil about 10 per cent.; calcium oxalate in raphides; ash about 5 per cent.

Vanillin or methyl protocatechuic aldehyde is manufactured on a large scale from eugenol or coniferin. It occurs in white, acicular crystals, which are sparingly soluble in water, soluble in aclohol and glycerin, the solutions being colored blue with ferric chloride. Vanillin may be formed as a result of certain oxidation changes rather than through the action of a ferment like emulsin which, as has been recently shown, does not exist in the fresh pods (Fig. 128).

The fruits of a number of species of Vanilla yield vanillin, which is also found in the Orchid *Selenipedium Chica,* of Panama; the fruit of *Rosa canina*, of Northern and Middle Europe; the flowers of *Spiræa Ulmaria;* the balsams and resins of the genus *Toluifera;* in the seeds of *Lupinus albus,* of Europe, which is cultivated; and in the bulbs of Dahlia.

Commercial Varieties.—In addition to the Mexican and Bourbon beans other varieties are found in the market. Mauritius Vanilla occurs in cylindrical pods that are nearly as long as the Mexican variety, but paler in color and less odorous.

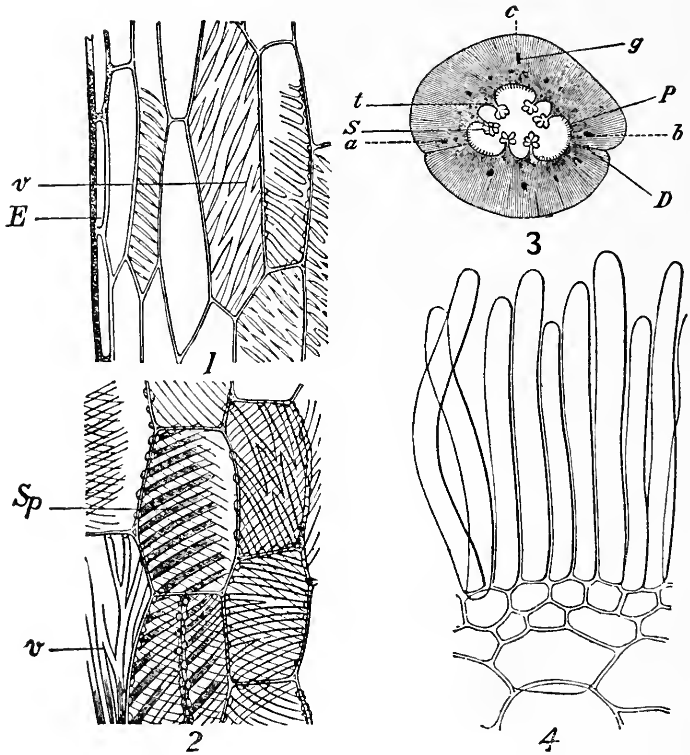


Fig. 256. Vanilla: 3, transverse section of an unripe fruit showing lines of union of the three carpels (a, b, c), line of dehiscence (D), placenta (t), seeds (S), fibrovascular bundle (g), papillæ (P). 1, radial-longitudinal section of the outer part of the pericarp showing epidermis (E), and parenchyma cells with oblique pores (v). 2, tangential-longitudinal section of the outer part of the pericarp showing cells with oblique pores (v) and spirally thickened bands (Sp). 4, inner layer of the pericarp showing the very long simple hairs or papillæ seen at P in No. 3.—After Meyer.

Tahiti Vanilla, which is produced on the Island of Tahiti and the Hawaiian Islands, occurs in somewhat broader, flattened pods. The pods are nearly as long as the Mexican variety and sharply attenuated and twisted at the lower portion. The color is reddish-brown and the odor is disagreeable, unfitting it for use for flavoring. Vanillons are the fruits of wild plants and are used in the manufacture of tobacco and sachet powders. They are 10 to 12 cm. long, 1.5 to 2.5 cm. in diameter, gradually tapering towards each end, somewhat triangular in outline, externally dark-brown to reddish-brown, frequently with transverse markings, due to their being wrapped with twine during the process of curing, when they are spoken of as "braided," and generally longitudinally split; the odor is peculiar, somewhat resembling "heliotrope," and is due to the phenol aldehyde heliotropin (piperonal) which is closely related to vanillin.

Pompona Vanilla is the fruit of wild and cultivated plants of *Vanilla pompona*, which is considered to be the original plant from which *V. planifolia* has been derived by cultivation. The fruits resemble the vanillons in appearance, but the odor is disagreeable, like that of Tahiti Vanilla.

Vanilla splits and cuts represent the more mature fruits in which dehiscence has taken place and which are cut up into short lengths.

Tonka seeds contain the odorous principle coumarin, which somewhat resembles vanillin. The ripe seeds of *Coumarouna odorata* (Fam. Leguminosæ), growing in the northern part of the Amazon region, furnish Dutch tonka, and *C. oppositifolia*, of Northern Brazil and Guiana, yields the English tonka. The seeds are oblong-ovoid, somewhat flattened, 3 to 4 cm. long and about 1 cm. wide, externally nearly black, frequently with numerous white crystals, the coriaceous testa being deeply wrinkled; internally yellowish-brown, consisting of two plano-convex cotyledons, enclosing a plumule with two pinnately-compound leaves and a fleshy radicle which is directed towards the micropyle situated at the rounded end of the seed; the odor is fragrant, and the taste aromatic and somewhat pungent. Tonka seeds contain 1.5 to 3 per cent. of coumarin or ortho-oxycinnamic anhydride, which forms colorless prisms having a fragrant odor and a bitter, aromatic taste. Coumarin is sparingly soluble in water, but quite so in alcohol. Tonka also contains a large quantity of a fixed oil, irregularly elongated aleurone grains 10 to 35 μ long, and spherical starch grains from 4 to 9 μ in diameter (Fig. 131).

Coumarin is rather widely distributed in nature. Of the plants in which it has been found the following may be mentioned: Vanilla grass or sweet vernal grass (*Anthoxanthum odoratum*); Carolina vanilla or dog's tongue (*Trilisa odoratissima*), one of the Compositæ; the yellow melilot (*Melilotus officinalis*), a leguminous herb found in waste places in the Eastern United States and in which it occurs free as well as combined with melilotic acid; other species of *Melilotus,* as well as in other genera of the Leguminosæ; sweet-scented bed straw (*Galium triflorum*), an herb of the Rubiaceæ growing in the United States; the rhizome of *Vitis sessilifolia* (Vitaceæ) of Brazil, and in *Prunus Mahaleb* (Fam. Rosaceæ), of Europe.

A number of the orchids contain coumarin, and these belong chiefly to the genus Orchis, as *Orchis odoratissima,* of Europe; *O. coriophora,* of Europe and the Orient; *O. Simia,* of Europe and the Orient; *O. militaris,* of Europe and Asia; *Habenaria conopsea,* of Europe and Asia; *Aceras anthropophora,* of Europe and Arabia.

FICUS.—FIG.—The fruit of *Ficus Carica* (Fam. Moraceæ), a tree indigenous to Persia and cultivated in most sub-tropical and tropical countries. The fruit is collected when ripe, partially dried in the sun, and tightly packed in boxes (p. 255).

DESCRIPTION.—Syconium pyriform or obovoid, usually compressed, about 6 cm. long and 1.5 cm. in diameter; externally light brown, longitudinally veined, wrinkled, frequently with an efflorescence of grape sugar, apex with a small scaly orifice, base with a scar or stalk about 7 mm. long and 4 mm. thick, and also with a leaf-remnant; torus hollow, the walls 2 to 3 mm. thick, coriaceous, tough, the inner portion with numerous lanceolate divisions, upon which are borne numerous ovoid, brownish-yellow, glossy akenes about 1 mm. in diameter, the latter with a reserve layer and a curved embryo; odor distinct, fruit-like; taste sweet.

CONSTITUENTS.—Grape sugar 50 to 60 per cent.; about 1.5 per cent. of fat in the form of oily globules found in the milk-vessels; starch in the form of spherical grains; water about 30 per cent. in the partially dried fruit.

ALLIED PLANTS.—Other species of Ficus also yield edible figs, as the mulberry fig tree (*F. Sycomorus*), of Africa; *F.*

regligiosa, of India; *F. glomerata,* of Burmah; the false banyan tree, *F. bengalensis,* of tropical Africa and India; and *F. Rumphii,* of Asia.

A peptonizing ferment is obtained from the milk-juice of *Ficus Carica, F. Sycomorus,* of Africa, and *F. exima,* of Brazil.

When figs are dried, roasted and ground they form a coffee substitute kown as Fig Coffee, which is also used sometimes as an adulterant of coffee. It is detected by the large, thin-walled and broad non-glandular hairs of the outer epidermis; the broad latex-tubes, 30 to 50 μ wide, and the small akenes. The latter somewhat resemble the akenes of strawberry fruits, but are distinguished by the reticulated thickening of the outer cell-wall.

AURANTII DULCIS CORTEX.—SWEET ORANGE PEEL.—The outer layer of the rind of the fresh fruit of *Citrus Aurantium sinensis* (Fam. Rutaceæ), a tree quite extensively cultivated in sub-tropical countries and warm-temperate regions (p. 306). The outer yellowish layer is the part employed, and is usually removed from the fruit by grating. The dried rind is an article of commerce.

Description.—Cut into small pieces or shreds, externally orange-yellow, with numerous circular depressions and numerous large oil-secretion reservoirs; texture coriaceous, tough; soft when fresh; odor aromatic; taste slightly bitter.

Constituents.—Resembling those of bitter orange peel, except that there is but a very small quantity of the bitter principle. The volatile oil which exists in large reservoirs beneath the epidermis is obtained by expression from the fresh peel and is official. It consists of about 90 per cent. of d-limonene and 5 per cent. of citral, citronellal and the methyl ester of anthranylic acid.

LIMONIS CORTEX.—LEMON PEEL:—The rind of the fresh fruit of *Citrus medica Limonum* (Fam. Rutaceæ), a tree (p. 308) indigenous to Northern India and cultivated in the European countries bordering the Mediterranean, the West Indies and other tropical and sub-tropical countries. The outer yellowish layer is the part used and it is removed by grating.

Description.—In freshly grated, lemon-yellow fragments, with numerous large oil-secretion reservoirs and oil-globules; odor aromatic; taste aromatic and slightly bitter.

Constituents.—Volatile oil; a very small quantity of hesperidin and other bitter principles (see bitter orange peel); a principle resembling tannin; calcium oxalate; ash about 4 per cent. The volatile oil obtained by expression from fresh lemon peel consists of 90 per cent. d-limonene; 7 to 10 per cent. of citral, which is the most important constituent; and a small quantity of citronellal, geranyl acetate, terpineol, methyl heptenone, a sesquiterpene and octyl and nonyl aldehydes.

AURANTII AMARI CORTEX.—BITTER ORANGE PEEL.—The rind of the unripe fruit of *Citrus Aurantium amara* (Fam. Rutaceæ), a tree (Fig. 158) indigenous to Northern India and cultivated in the Mediterranean region, the West Indies and the States bordering on the Gulf of Mexico (p. 306). The fruit is collected before it is ripe, the rind removed and used either in the fresh or dried condition. The commercial article is obtained from Malta, Sicily and Spain.

Description.—Usually cut longitudinally into quarters; elliptical, acute at both ends, 4 to 6 cm. long, 2 to 3 cm. wide, 2 to 6 mm. thick; externally yellowish or brownish-green, with numerous circular depressions, a scar at one end and occasionally the remains of the calyx; internally light yellowish-brown, wrinkled, with numerous conical projections and numerous large oil-secretion reservoirs; fracture short, tough, surface porous; odor aromatic; taste aromatic and bitter.

Occasionally in ribbon-like bands 2 to 12 cm. long, 5 to 10 mm. wide, about 2 mm. thick; externally yellowish-brown.

Constituents.—Volatile oil, resembling that of sweet orange peel but with a superior flavor and a bitter taste; several bitter principles: (a) aurantiamarin (1.5 to 2.5 per cent.), an amorphous, bitter glucoside, to which the bitter taste is chiefly due; (b) aurantiamaric acid (0.1 per cent.), a very bitter, green, amorphous, resinous principle; (c) naringin (aurantiin), a yellowish, crystalline, bitter glucoside; (d) isohesperidin (0.4 to 3 per cent.), a slightly bitter glucoside. The drug also contains 5 to 8 per cent. of a white, crystalline, tasteless glucoside hesperidin, which separates in sphere-crystals on placing the fresh fruit in alcohol. Hesperidin is colored reddish-brown with ferric chloride and on hydrolysis yields a sweet principle hesperetin, which crystallizes in prisms. A fixed oil, resin, and a principle resembling tannin; calcium oxalate, in the form of rhombohedral crystals; and ash about 5 per cent. are also present.

ALLIED DRUGS.—The immature fruits of *Citrus Aurantium* are sometimes collected and are known as ORANGE BERRIES. They are nearly globular; 5 to 20 mm. in diameter, greenish or brownish-black, granular rugose; the internal structure resembles that of orange fruits, but the seeds are rudimentary; and the taste is aromatic and bitter.

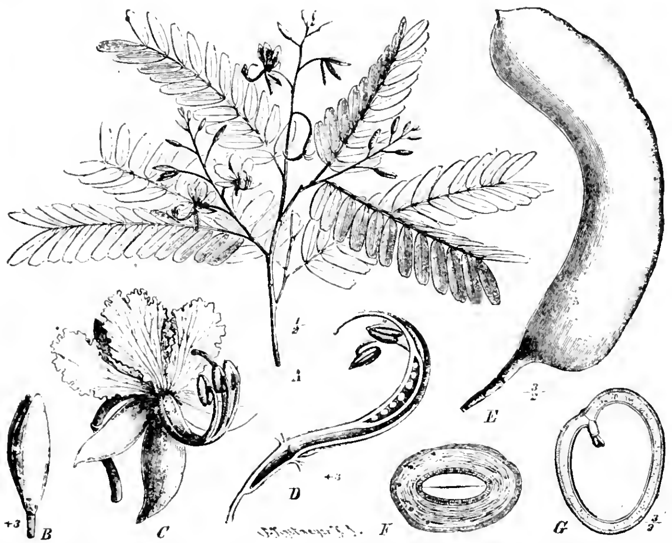


FIG 256a. *Tamarindus indica:* A, flowering branch with paripinnate leaves; B, flower bud; C, dorsiventral (irregular) flower; D, longitudinal section of flower showing unilocular ovary; E, somewhat curved, indehiscent legume; F, G, transverse and longitudinal sections of the seed.—After Taubert.

TAMARINDUS.—TAMARIND.—The preserved pulp of the ripe fruit of *Tamarindus indica* (Fam. Leguminosæ), a tree (Fig. 256a) indigenous to tropical Africa and cultivated in the West and East Indies (p. 294) from whence the two chief commercial varieties are obtained.

WEST INDIAN TAMARIND.—Usually a blackish-brown mass, with a distinct odor and strongly acidulous, sweet taste, and in which are embedded numerous seeds enclosed in a loose, tough membrane; seeds anatropous, oblong or flattened-quadrangular, 12 to 14 mm. long, 8 to 11 mm. broad, 5 to 7 mm. thick, dark reddish-brown, smooth, one edge furrowed, transversely striate, very hard; cotyledons plano-convex.

East Indian Tamarind.—In blackish cakes, containing less sugar and more acid.

Constituents.—Tartaric acid 5 to 9 per cent.; citric acid 3 to 6 per cent.; potassium bitartrate 6 to 7.3 per cent., and other salts of organic acids; invert sugar 32 to 42 per cent.; tannin (in the seed-coats).

Allied Plants.—The pulp of the fruits of several species of *Nephelium* (Fam. Sapindaceæ), of Southern China, resembles tamarind.

LUPULINUM.—LUPULIN.—A powder separated from Hops (see Humulus), and consisting chiefly of the glandular hairs. Lupulin may be systematically separated from the hops, or it may be obtained as a by-product during the handling of the hops. Commercial lupulin consists for the most part of sweepings collected where hops are prepared for the market, the extraneous matter being removed by sifting and washing. The powder is then carefully dried and preserved.

Description.—Granular, yellowish- or reddish-brown, consisting of glandular hairs with a somewhat globular or ellipsoidal, bright-yellow, multicellular head 0.1 to 0.3 mm. in diameter (Figs. 136, *J; 298*); odor aromatic; taste aromatic and bitter.

Not less than 60 per cent. of lupulin should be soluble in ether, and the ash should not be more than 10 per cent.

Constituents.—A volatile oil, identical with that of hops, about 3 per cent.; a crystalline bitter principle lupamaric acid (hop bitter), which becomes yellow on exposure to air and on hydrolysis yields lupuliretin and a crystalline substance lupulic acid; a tasteless resin; myricin; valerianic acid, which together with the oil is obtained on the distillation of lupulin with water; and ash from 3 to 5 per cent.

The volatile oil of hops or lupulin is sparingly soluble in alcohol and is not converted into valerianic acid by means of oxidizing agents. This acid is, however, produced upon treating the extract of hops with potassium permanganate.

VI. LEAVES AND HERBS.

Some of the most valuable and potent vegetable drugs are those furnished by leaves and herbs. In quite a number of instances the leaves alone are collected; not infrequently, as with herbaceous plants, the leaves, together with the flowering and fruiting tops, are collected; rarely, however, are the tops alone employed; occasionally the drug may consist of the entire plant. It may be noted in this connection that some of the so-called leaf-drugs, as belladonna, hyoscyamus and stramonium, may contain the tops of the plants as well, and some of the commercial herbs, as lobelia, may consist entirely of leaves.

KEY FOR THE STUDY OF LEAVES AND HERBS.

I. Leaves.

1. Whole Leaves.
   A. Texture coriaceous.
      a. Margin entire.
         α Glandular-punctate.
            Apex emarginate......................Pilocarpus
            Scythe-shaped ....Eucalyptus
         β Not glandular-punctate.
            Apex obtuse..........................Uva Ursi
      b. Margin dentate or serrate.
         Glandular-punctate ....Buchu
         Not glandular-punctate ....Chimaphila
   B. Texture not coriaceous.
      a. Margin entire.
         Not less than 15 mm. broad....................Coca
         Not more than 15 mm. broad...,...............Senna
      b. Margin not entire.
         Margin sinuate.........................Hamamelis
         Margin crenulate............................Salvia
2. Leaves crumpled or in broken fragments.
   A. Texture coriaceous.
      Upper surface resinous.......................Eriodictyon
   B. Texture not coriaceous.
      a. Hairy.
         Surface reticulate, veins whitish.............Digitalis
         Surface reticulate, veins brownish.............Matico
         Surface not reticulate...................Hyoscyamus

I. Leaves.—*Continued.*

b. Not very hairy.
Margin entire........................Belladonnæ Folia
Margin sinuate........................Stramonii Folia

II. Leaves and Flowering Tops.

1. With composite flowers.
Leaves reticulate..................................Eupatorium
Leaves resinous......................................Grindelia
2. With labiate flowers.
A. Very hairy.
Taste bitter..................................Marrubium
B. Not very hairy.
a. Margin slightly serrate.
Leaves dark green, pubescent...............Hedeoma
b. Margin serrate, midrib and veins somewhat rose- or purple-colored.
Taste aromatic, followed by a cooling sensation...................Mentha Piperita
Taste aromatic......................Mentha Viridis
3. Odor heavy, like that of tobacco.
A. Margin entire.
Purplish flowers, brownish berries.......Belladonnæ Folia
B. Margin not entire.
Margin sinuate, surface hairy.................Hyoscyamus
Petiolate, margin four-lobed, surface not hairy......................Stramonii Folia
4. With inflated capsules.
Leaf divisions with gland-like apex....................Lobelia

III. Flowering Tops, leaves few.

Compressed resinous masses......................Cannabis Indica

IV. Stem Tops, leaves few.

Branches with yellowish-green wings...................Scoparius

V. Entire Plant.

Stems cylindrical, leaves entire, capsule bicarpellary........Chirata
Stems square, leaves serrate, flowers bilabiate...........Scutellaria

PILOCARPUS.—JABORANDI.—The leaflets of various species of Pilocarpus (Fam. Rutaceæ), shrubs (Fig. 257) indigenous to Brazil. There are three principal commercial varieties: (1) Pernambuco Jaborandi, obtained from *P. Jaborandi;* (2)

Paraguay Jaborandi, yielded by *P. pinnatifolius,* and (3) Maranham Jaborandi, obtained from *P. microphyllus.* The name, jaborandi, is applied to a number of other plants growing in Brazil besides those of the genus Pilocarpus (p. 305).

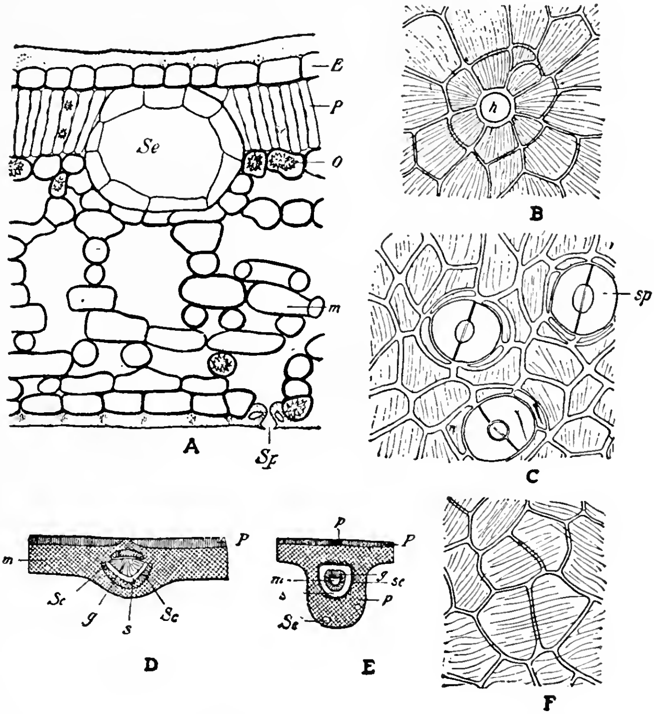


FIG. 257. *Pilocarpus pinnatifolius:* A, transverse section of lamina showing upper epidermis (E), oil gland (Se), palisade cells (P), some of which contain rosette aggregates of calcium oxalate, loose parenchyma (m), some of the cells of which contain calcium oxalate (o), and lower epidermis with a stoma (Sp). B, surface view of epidermis showing basal portion of a non-glandular hair (h). The remains of hairs are often found, the hairs themselves having been rubbed off. C, view of the under surface of the lamina showing stomata (sp). D, diagram showing the arrangements of the tissues in one of the secondary veins: P, palisade cells; m, loose parenchyma; Sc, sclerenchyma; s, sieve; g, tracheæ. E, transverse section of the primary or middle vein showing palisade cells (P), elongated parenchyma (p), oil glands (Se), sieve (s), tracheæ (g), which surrounds parenchyma (m), thus distinguishing it from the secondary vein. F, surface view of upper epidermis of lamina.—After Meyer.

PERNAMBUCO JABORANDI.—Elliptical, lanceolate or oblong-lanceolate, 6 to 12 cm. long, 1.5 to 4 cm. broad; apex obtuse, more or less emarginate; base rounded or acute, unequal; margin entire, slightly revolute; upper surface dark green or brownish-green, glabrous, midrib more or less depressed near the apex, veins of the first order prominent, diverging at an angle of 35° to 50° and uniting with each other near the margin; under surface yellowish- or greenish-brown, pubescent, with numerous light-brown projections, midrib prominent, yellowish-brown; petiolule 3 to 5 mm. long; glandular-punctate; texture coriaceous, brittle; odor slight; taste bitter, somewhat aromatic, becoming pungent.

Paraguay Jaborandi.—Oblong-lanceolate, ovate or obovate, 8 to 12 cm. long, 2.5 to 5 cm. broad; apex slightly emarginate; base equal; margin very slightly revolute; upper surface dark green, midrib and veins of the first order not very prominent, the latter diverging at an angle of 25° to 45°; under surface grayish-green or light green, glabrous, with numerous papillæ; midrib yellowish, with few short hairs; frequently with numerous black disks of a species of Puccinia on both surfaces; texture as in Pernambuco jaborandi, but only about one-half as thick.

Maranham Jaborandi.—Oblong-ovate, or oblanceolate, 1.5 to 4 cm. long, 1.5 to 2.5 cm. broad; apex deeply emarginate; base tapering into the petiolule; margin distinctly revolute; upper surface bright green, glabrous, sometimes shiny, midrib prominent, veins of the first order not very prominent, diverging at an angle of 35° to 45°; under surface grayish-green; frequently with numerous black disks of a species of Puccinia on both surfaces; petiolule about 8 mm. long; texture as in Paraguay jaborandi but thinner.

Inner Structure.—See Fig. 257.

Constituents.—About 0.5 to 1 per cent. of the alkaloid pilocarpine, which occurs as a colorless, syrupy liquid, but forms well-defined crystalline salts, the hydrochloride and nitrate being official. It is very soluble in water, the solutions being dextrorotatory. Pilocarpine is decomposed by heat or alkalies and yields an isomeric substance, isopilocarpine, which is an oily compound and is usually present in the commercial nitrate of pilocarpine. The alkaloid pilocarpidine has been obtained from the mother liquors, after the crystallization of pilocarpine, as a syrupy substance forming a crystalline nitrate and resembling somewhat pilocarpine in its physiological action. An alkaloid related to pilocarpidine has been isolated from the leaves of *P. pinnatifolius* in the form of an amorphous substance called JABORINE, and resembling atropin in its physiological properties. Recent investigations do not seem to show that these alkaloids occur in either the leaves of Paraguay or Maranham Jaborandi. Fresh pilocarpus leaves also yield 0.2 to 1.1 per cent. of a volatile oil which contains a hydrocarbon pilocarpene and a stearoptene belonging to the olefine series.

ALLIED DRUGS.—Nearly all of the species of Pilocarpus contain some pilocarpine, as well as other principles which are found in the official leaves. Many of these find their way into commerce and in some instances their assays compare favorably with the official leaves. ARACATI JABORANDI is obtained from *P. spicatus*, the leaflets being broad and coriaceous and said to contain 0.16 per cent. of alkaloids. The leaflets of *P. racemosus* of the West Indies are large and membranous and contain about .66 per cent. of pilocarpine.

EUCALYPTUS.—The leaves of *Eucalyptus Globulus* (Fam. Myrtaceæ), a tree (Fig. 258) indigenous to Eastern Australia and Tasmania, and cultivated in Southern Europe, California and the Southern United States (p. 346). The leaves are collected from older parts of the tree and dried, the principal part of the commercial supply coming from the south of France.

DESCRIPTION.—Bilateral, lanceolate, scythe-shaped, 15 to 30 cm. long, 2.5 to 5 cm. broad; apex acuminate; base somewhat unequal, acute; margin entire, revolute; surface light green, glabrous, with numerous small, circular, reddish-brown depressions or projections in the neighborhood of the stomata and veins, consisting of cork cells [1]; midrib usually with a small groove on one side; veins of the first order diverging at an angle of about 55°, running to within 1 mm. of the edge, where they anastomose, forming a vein parallel with the margin; petiole 2 to 3 cm. long, flattened and somewhat twisted; glandular-punctate; texture coriaceous; odor slightly aromatic; taste aromatic, somewhat bitter and cooling.

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[1] These corky patches appear to be due to an irritation caused by some of the constituents.

CONSTITUENTS.—Volatile oil 3 to 6 per cent., of which over 60 per cent. is eucalyptol (cineol), the remainder consisting of d-pinene (eucalypten) and other terpenes; several resins, one of which is crystalline and colored brownish-red with ferric chloride; a neutral bitter principle; eucalyptic acid; tannin and calcium oxalate.

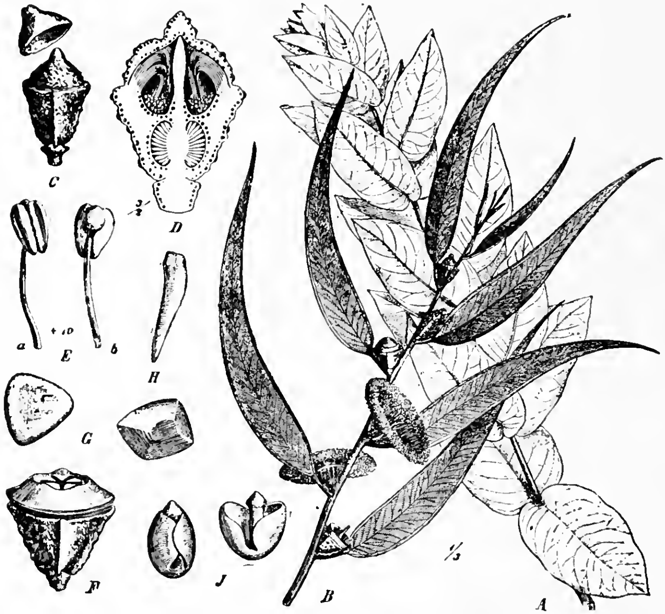

FIG. 258. *Eucalyptus Globulus:* A, young branch with opposite, oblong, dorsiventral, sessile leaves. B, flowering branch with scythe-shaped, petiolate, scattered, bilateral leaves. C, flower-bud showing the detached upper portion of the perianth (operculum or lid) which covers the stamens until they are fully mature. D, longitudinal section of a flower bud showing incurved filaments which curve outwards when the flower matures. E, stamens in two views, F, truncated capsule or pyxis. G, two fertile seeds. H, sterile seed, seeds of this kind usually being most numerous. J, two germinating plants.—A–F, after Niedenzu; G–J, after Müller.

ALLIED PLANTS.—The following Eucalypts yield an oil consisting principally of eucalyptol and pinene, and in which the eucalyptol exceeds 40 per cent., phellandrene being absent: *Eucalyptus resinifera, E. polyanthema, E. Behriana, E. Rossii, E. pendula, E. dealbata, E. tereticornis linearis, E. rostrata borealis, E. maculosa, E. camphora, E. punctata, E. squamosa, E. Bridgesiana, E. goniocalyx, E. bicolor, E. viminalis, E. populifolia,* *E. longifolia, E. Maideni, E. Globulus, E. pulverulenta, E. cinerea, E. Stuartiana, E. Stuartiana* var. *cordata, E. Morrisii, E. Smithii* and *E. sideroxylon.*

UVA URSI.—RED BEARBERRY.—The leaves of *Arctostaphylos Uva-ursi* (Fam. Ericaceæ), a procumbent shrub indigenous to Europe, Asia and the Northern United States and Canada (p. 357).

DESCRIPTION.—Obovate, spatulate, 18 to 30 mm. long, 6 to 10 mm. broad; apex obtuse; base acute, tapering; margin entire, slightly revolute; upper surface dark green, glabrous, finely reticulate; under surface yellowish-green; petiole about 3 mm. long, slightly pubescent; texture coriaceous, brittle; odor slight; taste slightly bitter, astringent.

When a solution of vanillin and hydrochloric acid, to which a few drops of fresh ferrous sulphate solution are added, is applied to a section of Uva Ursi a crimson color is produced which distinguishes the drug from its adulterants, with the exception of *Vaccinium Vitis-Idæa.* It is distinguished from leaves of the latter plant as well as other adulterants by becoming bluish-black with ferrous sulphate.

CONSTITUENTS.—Two glucosides—arbutin and ericolin; a crystalline, resinous principle ursone; tannin about 5 per cent.; gallic acid; ellagic acid; a yellow, crystalline coloring principle; calcium oxalate; ash about 3 per cent.

ARBUTIN forms colorless, bitter needles, which are soluble in water and alcohol, the solutions being colored azure blue upon the addition of an alkali followed by phosphomolybdic acid. It yields on hydrolysis hydroquinone (arctuvin) and methyl hydroquinone.

ERICOLIN is a yellow, hygroscopic, bitter substance, which yields on hydrolysis the volatile oil ericinol. URSONE occurs in tasteless needles insoluble in water and capable of being sublimed.

ALLIED PLANTS.—Various other species of Arctostaphylos contain principles similar to Uva Ursi. The leaves of trailing arbutus (*Epigæa repens*) contain ericolin and possibly arbutin. Ericolin occurs in a number of species of Ledum and Rhododendron, and European huckleberry (*Vaccinium myrtillus*), small cranberry (*Oxycoccus palustris*) and heather (*Calluna vulgaris*), all of

Europe. The two latter plants are naturalized in New Jersey, the New England States and Eastern Canada. A number of species of Rhododendron contain, in addition to andromedotoxin (see page 357), the same principles found in Uva Ursi. Marsh tea or narrow-leaved Labrador tea (*Ledum palustre*), growing in the Northeastern United States and Canada, as well as Northern Europe and Asia, contains ericolin, arbutin, an ethereal oil (the principal component of which is Ledum camphor), valerianic, acetic and butyric acids. (Compare also Chimaphila.)

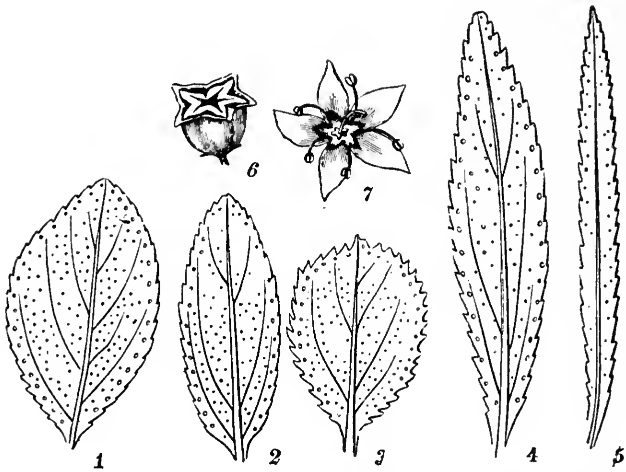

FIG. 259. Buchu leaves showing oil glands which give the leaves the glandular-punctate appearance: 1, *Barosma crenata ovalis;* 2, *B. crenulata latifolia;* 3, *B. betulina;* 4, *B. serratifolia;* 5, *Empleurum ensatum;* 6, dehiscent fruit of *B. crenulata;* 7, flower of the same.—After Tschirch.

BUCHU.—The leaves of several species of Barosma (Fam. Rutaceæ), a shrub indigenous to Cape Colony. There are two chief commercial varieties: (1) Short Buchu obtained from *B. betulina* and (2) Long Buchu, obtained from *B. serratifolia*, the short buchu being official (p. 306; Fig. 259).

SHORT BUCHU.—Obovate, rhomboid-obovate, ovate or elliptical or somewhat cuneate; 9 to 18 mm. long, 6 to 12 mm. broad; apex obtuse, somewhat recurved; base acute or cuneate; margin sharply dentate or denticulate and with an oil-secretion reservoir at the base of each tooth; upper surface yellowish-green, glabrous; under surface yellowish-green, longitudinally striate; both surfaces papillose; petiole about 1 mm. long; texture coriaceous; odor and taste distinct, aromatic (Fig. 158).

Long Buchu.—Linear-lanceolate, 25 to 40 mm. long, 4 to 6 mm. broad; margin sharply serrate and glandular; apex somewhat rounded or truncate.

Constituents.—Short buchu contains about 1.2 to 1.45 per cent. of volatile oil, of which about 30 per cent. is the crystalline body diosphenol; long buchu contains only about one-third as much volatile oil and it contains little or no diosphenol; buchu also contains two crystalline glucosides, diosmin and hesperidin (see Aurantii Amari Cortex); mucilage and calcium oxalate.

Allied Plants.—The leaves of *Barosma crenulata* are occasionally found in the market; they are ovate, obovate or oblong-lanceolate, about twice as broad as long buchu, with slightly toothed and glandular margin, more or less rounded apex, and yield 1.6 per cent. of volatile oil resembling that of short buchu.

Adulterants.—The leaves of *Empleurum ensatum* (Fam. Rutaceæ) have been offered for long buchu. (See Fig. 259.) They have a bitter taste and yield about 1 per cent. of a volatile oil which does not contain a crystalline principle.

The trifoliate leaves of *Psoralea obliqua* are obtained from a South African shrub. The leaflets are oblique or unequal-sided, dentate, bitter, glandular and have numerous simple hairs.

Karoo Buchu is derived from *Diosma succulenta*, of South Africa. The leaves are ovate, 3 to 6 mm. long, coriaceous, obtuse and slightly recurved at the apex. They yield an oil with a peppermint-like odor containing diosphenol, and 26 per cent. of extractive. The leaves of aniseed buchu (*B. pulchella*) are smaller than those of *B. betulina* and have an odor of citronella.

CHIMAPHILA.—PIPSISSEWA.—The dried leaves of *Chimaphila umbellata* (Fam. Ericaceæ), a perennial herb (p. 355) indigenous to the United States and Southern Canada and Northern Europe and Siberia.

Description.—Lanceolate or oblanceolate, 2.5 to 5 cm. long, 8 to 18 mm. broad; apex obtuse or acute; base acute or cuneate; margin sharply serrate; upper surface dark green, not mottled, glabrous, shiny; midrib and veins depressed, the latter diverging at an angle of about 60° and uniting with each other near the margin; under surface yellowish-green; petiole about 1 mm. long; texture coriaceous, brittle; odor slight; taste astringent, bitter.

CONSTITUENTS.—A neutral, tasteless principle chimaphilin, occurring in golden-yellow needles; two glucosides—arbutin and ericolin (see Uva Ursi); several other crystalline principles; a volatile oil; tannin 4 to 5 per cent.; calcium oxalate; ash about 5 per cent.

COCA.—COCA LEAVES.—The leaves of *Erythroxylon Coca,* and its varieties (Fam. Erythroxylaceæ), shrubs (Fig. 260) probably indigenous to Bolivia and Peru, where they are extensively cultivated, as well as in Java and Ceylon (p. 303). The leaves when fully grown are picked and quickly dried in the sun. Two or three harvests are obtained a year. There are two principal commercial varieties—Bolivian (Huanco) and Peruvian (Truxillo), the former being preferred. On keeping the leaves the alkaloid cocaine is dissipated and they lose their stimulating properties, particularly if they are not thoroughly dried.

BOLIVIAN COCA.—Oval, obovate or elliptical, 3 to 7 cm. long, 2 to 3 cm. broad (Fig. 260); apex acute, slightly mucronate; base acute; margin entire, somewhat revolute; upper surface dark green, glabrous, midrib with a distinct ridge; under surface yellowish-green, distinctly undulate, with numerous minute papillæ, frequently with a parallel line about 4 mm. from the midrib on either side and extending from the base to the apex; petiole dark brown, 1 to 6 mm. long; texture somewhat coriaceous; odor distinct; with a bitter taste, and producing a sensation of numbness.

PERUVIAN COCA.—Leaves usually more broken, 3 to 5.5 cm. long, 1.5 to 2 cm. broad; upper surface light green, ridge on the midrib faint or wanting; under surface light yellowish-green, the curved line on either side of the midrib usually wanting; more or less fragile; sensation of numbness on tasting the drug not so pronounced.

The flowers of a species of Inga (Fam. Leguminosæ) are frequently present. The pedicel is about 2 mm. long; the calyx yellowish-brown, about 1 cm. long, five-toothed, pubescent; corolla cylindrical, or somewhat funnel-shaped, 5-toothed, about

1 cm. long, yellowish-brown, very pubescent; stamens numerous, more or less united into a tube, exserted; filaments reddish-brown.

INNER STRUCTURE.—See Figs. 261, 286.

CONSTITUENTS.—Several alkaloids, including cocaine, cinnamyl-cocaine, truxilline and ecgonine. Of these cocaine is the

FIG. 260. Flowering branch of *Erythroxylon Coca* showing the parallel lines on either side of the midrib, which are not true veins, but due to an extra development of hypodermal cells in this region.—After Reiche.

most important, the Bolivian leaves containing the greatest amount, or 0.5 to 1 per cent.; the other alkaloids preponderate in the Peruvian leaves, which usually do not contain more than one-half or two-thirds as much cocaine as the Bolivian leaves; the Java leaves also contain benzoyl-pseudotropine; in addition, coca leaves contain a volatile aromatic principle; a tannin giving a green color with ferric salts; and calcium oxalate.

Cocaine (benzoyl-methyl-ecgonine) occurs in monoclinic prisms which are sparingly soluble in water, soluble in alcohol,

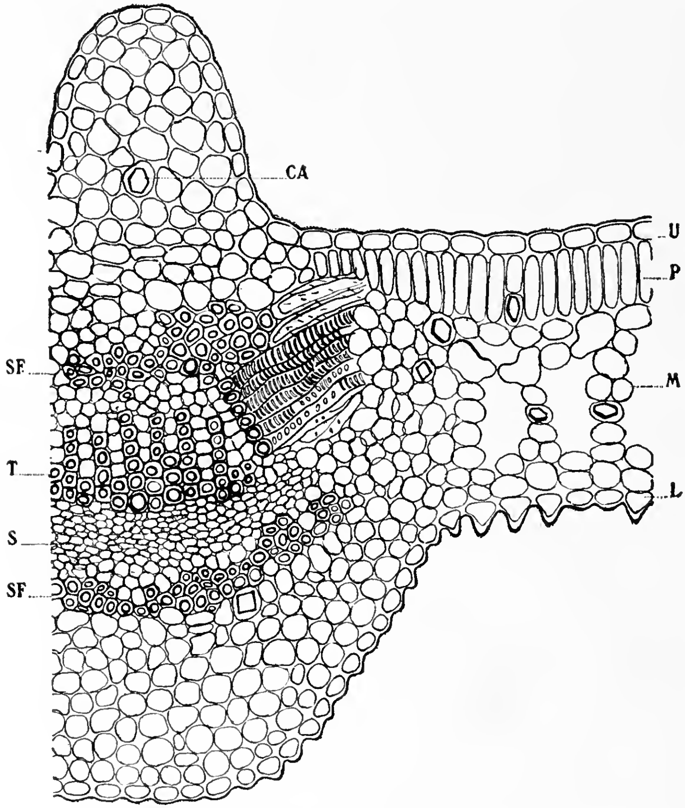

Fig. 261. Transverse section of coca leaf near the midrib: U, upper epidermis; P, palisade cells, some of which contain monoclinic prisms of calcium oxalate; M, loose parenchyma, some of the cells of which also contain monoclinic prisms of calcium oxalate; L, lower epidermis with distinct papillæ; CA, monoclinic prism of calcium oxalate, SF, sclerenchymatic fibers; T, tracheæ; S, sieve.

the solution having a bitter taste and producing a characteristic numbness. It forms crystalline salts and yields, on hydrolysis, which is rather easily accomplished, benzoic acid, methyl alcohol and ecgonine. (See Fig. 157, also Part IV.)

ECGONINE crystallizes in monoclinic prisms, which are slightly bitter, readily soluble in water and sparingly soluble in alcohol. CINNAMYL COCAINE is found in commercial cocaine and occurs in rosettes of needle-shaped crystals which are nearly insoluble in water, soluble in alcohol and on hydrolysis yield cinnamic acid, methyl alcohol and ecgonine. α-TRUXILLINE (cocamine) is a bitter alkaloid which occurs either in an amorphous form or in large crystals and yields on hydrolysis truxillic acid, methyl alcohol and ecgonine. Truxilline occurs sometimes to the extent of 0.5 per cent. in Peruvian (Truxillo) leaves. Cocaine is found in the seeds and roots as well as in the leaves. The leaves contain a small amount of methyl salicylate.

It has been shown that young coca leaves contain 2.02 per cent. of total alkaloids, or more than twice as much as the older leaves, while the amount of ash yielded by them is slightly less, being 6.4 per cent. The constituents of Ceylon Coca resemble those of the Java variety.

SENNA.—SENNA LEAVES.—The leaflets of various species of Cassia (Fam. Leguminosæ), small shrubs indigenous to Upper Egypt and Southern Arabia. There are two important commercial varieties: (1) Alexandrian Senna, derived from wild plants (Fig. 262) of *Cassia acutifolia*, a small shrub growing in the region of the Nile River from Assouan to Kordofan (p. 292), and exported by way of Alexandria and Red Sea ports; (2) Indian or Tinnivelly Senna, derived from cultivated plants of *Cassia angustifolia*, growing on the East African coast, in Arabia and Northwestern India, and cultivated in Southern India (p. 292). The leaves are carefully collected and dried, the Tinnivelly variety being more largely used, although the Alexandrian is more highly esteemed.

ALEXANDRIAN SENNA.—Lanceolate or ovate-lanceolate; 1.5 to 3 cm. long, 5 to 8 mm. broad (Fig. 262, *F*); apex acute, mucronate; base unequal, acute; margin entire; upper surface pale green, nearly glabrous, midrib sometimes depressed, veins of first order more or less prominent, under surface light grayish-green, midrib prominent, minutely pubescent, especially near the veins; petiolule about 1 mm. long; texture coriaceous, fibrous; odor slight; taste somewhat bitter.

TINNIVELLY SENNA.—From 2.5 to 5 cm. long (Fig. 262, *H*), upper surface light green, lower surface slightly pubescent.

INNER STRUCTURE.—See Fig. 263.

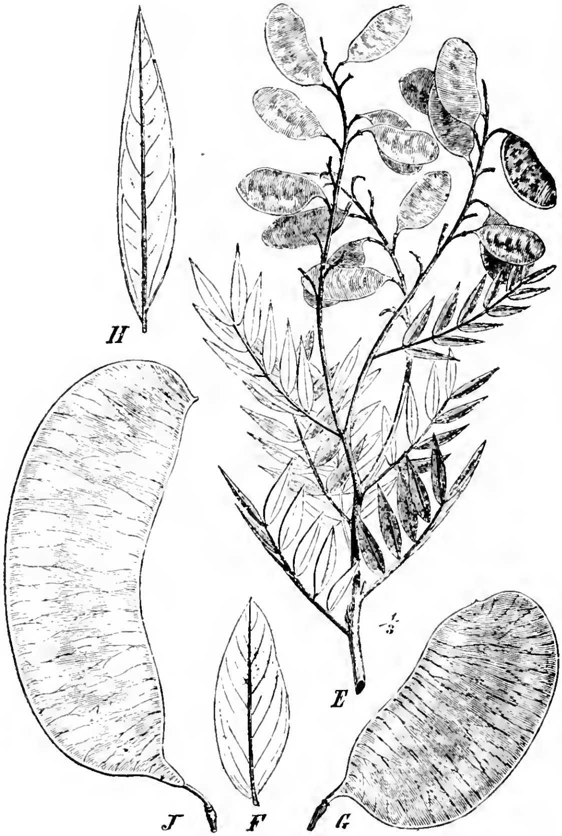

FIG. 262. *Cassia acutifolia:* E, fruiting branch; F, a single leaflet; G, a pod. *Cassia angustifolia:* H, a single leaf; J, a pod.—After Taubert.

CONSTITUENTS.—Senna leaves contain several glucosides which yield oxymethylanthraquinone compounds resembling those found in aloes and rhubarb; a glucosidal substance, ANTHRAGLUCOSENNIN, which occurs as a brown-black powder and yields on hydrolysis senna-emodin (tri-oxymethylanthraquinone) and senna-chryosphanic acid (di-oxymethylanthraquinone). (See Rhubarb.) Anthraglucosennin when acted upon by alkalies produces an amorphous black powder, SENNA-NIGRIN, which also

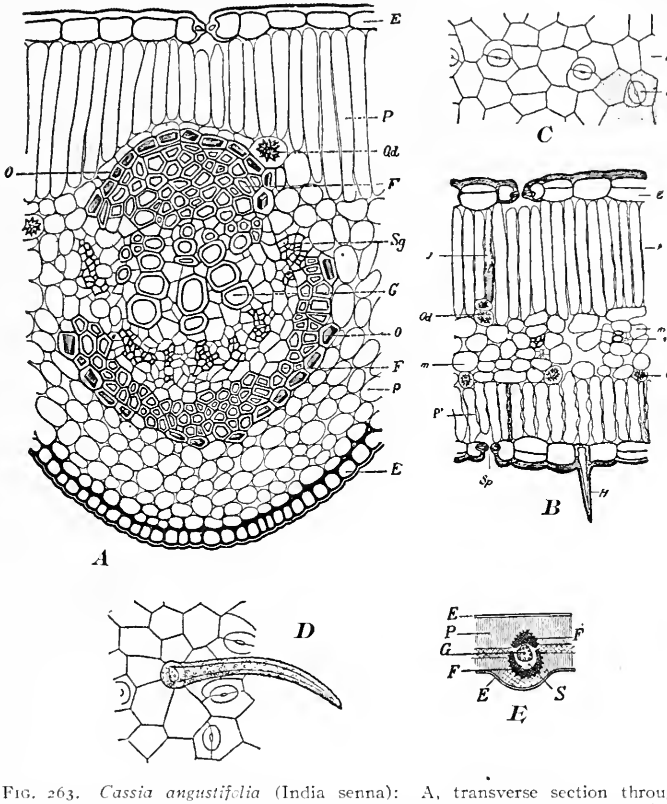

FIG. 263. *Cassia angustifolia* (India senna): A, transverse section through the middle vein showing upper epidermis (E), palisade cells (P), rosette aggregate of calcium oxalate (Od), monoclinic prisms of calcium oxalate (o), tracheæ (G), sieve (Sg), sclerenchyma fibers (F), lower epidermis with rather thick-walled cells (E). B, transverse section through portion of leaf between the veins showing the absence of monoclinic prisms of calcium oxalate, the presence of palisade cells and stomata in both the lower and upper portion, and a hair (H) on the lower surface. C, lower epidermis on surface view; D, upper epidermis showing stomata and a single hair. E, diagram of section through the middle vein, the letters corresponding to those in A.—After Meyer.

yields on hydrolysis emodin and chrysophanic acid. Senna also contains a yellowish, amorphous glucoside, GLUCOSENNIN; a reddish-brown, amorphous substance, SENNA-RHAMNETIN, which differs from rhamnetin found in the fruit of *Rhamnus cathartica* in that the latter is crystalline and forms a fluorescent solution with sulphuric acid; senna-isoemodin (isomeric with senna-emodin), which is soluble in petroleum ether; CATHARTIC ACID; calcium oxalate; and ash 10 to 12 per cent. The active principles of senna are emodin, chrysophanic acid and cathartic acid. The percentage of emodin is from 0.8 per cent. in Tinnivelly leaves to 1 per cent. in the Alexandria variety.

ALLIED PLANTS.—Senna pods (Fig. 262), derived from both *C. acutifolia* and *C. angustifolia*, are also found in the market, either admixed with the leaves or sold separately; they are from 3.5 to 7 cm. long and about 2 cm. broad, greenish to dark brown externally, and contain from five to seven obovate, dark brown, nearly smooth seeds. They contain apparently the same active principles as the leaves.

Similar principles are found in other species of Cassia, especially in the AMERICAN SENNA (*C. marilandica*), which is an herbaceous perennial (Fig. 152), indigenous to the Eastern and Central United States and Canada, with 12- to 20-foliate leaves, yellow flowers and a linear, slightly curved legume. The leaves of senna are sometimes admixed with those of *Cassia obovata*, which are broad and obovate, while the pods of the latter species are distinctly curved. Mecca or ARABIAN SENNA is obtained from a variety of *C. angustifolia*, growing in Arabia. The leaves of *C. holosericea*, of Abyssinia, are quite hairy and found occasionally in the market under the name of ADEN SENNA. The leaves of other members of the Leguminosæ are used like senna, as *Cytisus purgans* of Southern France, *Tephrosia Apollinea* of Egypt, and *Colutea cruenta* of the Caucasus region.

The root of *Viviania esculenta* (Fam. Geraniaceæ), of the East Indies contains a principle resembling cathartic acid, a glucoside also found in senna and rhubarb.

HAMAMELIDIS FOLIA.—WITCHHAZEL LEAVES.—The leaves of *Hamamelis virginiana* (Fam. Hamamelidaceæ), a shrub (Fig. 264) indigenous to the Eastern and Middle United States and Canada (p. 286). The leaves are collected in autumn, and are used in the fresh condition, or dried; when dried they should be carefully preserved and not kept longer than one year.

Description.—Broadly elliptical, or rhomboid-obovate, more or less unequal; 3.5 to 12 cm. long, 2.5 to 7 cm. broad; apex rounded, acute or acuminate; base obliquely cordate; margin sin-

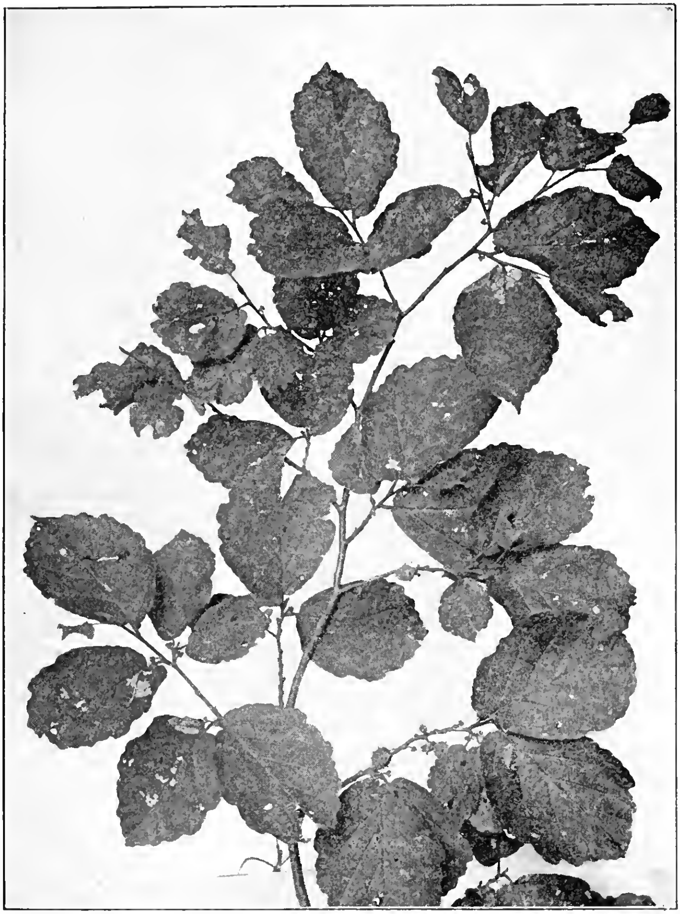

Fig. 264. Branch of Witchhazel (*Hamamelis virginiana*) showing alternate, short-petiolate and pinnate-reticulately veined leaves, having a broadly oval or obovate outline, round, acute, or slightly acuminate apex; slightly cordate, inequilateral base; and undulate or sinuous margin.

uate or sinuate-dentate; upper surface dark green, veins of the first order diverging at an angle of about 60° and running nearly parallel to the margin, with grayish patches of a mold and slightly pubescent; under surface light green, pubescent, midrib and veins prominent; petiole 5 to 12 mm. long; texture coarse, brittle; odor slight; taste astringent.

CONSTITUENTS.—Volatile oil; a bitter principle; tannin, about 3 per cent.; gallic acid, and calcium oxalate.

The distillate, obtained on distilling either the fresh or dried leaves of Hamamelis with water, contains an aromatic substance that apparently does not exist as such in the leaves. The substance sold as hamamelin is a mixture consisting of an evaporated alcoholic extract of either the leaves or bark, that of the former being greenish-black and more permanent and the latter brownish-black and more or less hygroscopic.

SALVIA.—SAGE.—The leaves of *Salvia officinalis* (Fam. Labiatæ), a perennial herb (p. 368) indigenous to Southern Europe, and cultivated in England, France, Germany and the United States, both for use as a drug and as a pot herb. The leaves are collected when the plants are in flower, and carefully dried in the shade.

DESCRIPTION.—Oblong-lanceolate or ovate, 2 to 10 cm. long, 1 to 2.5 cm. broad; apex acute; base rounded or somewhat heart-shaped, frequently lobed; margin crenulate; upper surface grayish-green, densely pubescent (Fig. 284, *F*) when the leaves are young, the older leaves being nearly smooth, midrib and veins depressed; under surface light grayish-green, midrib prominent, veins of first order diverging at an angle of 55° and running nearly parallel to the margin, minutely reticulate and densely pubescent; petiole 1 to 4 cm. long, upper side grooved, grayish purple; texture velvety, more or less pliable; odor aromatic; taste aromatic and bitter.

CONSTITUENTS.—Volatile oil 0.5 to 2.5 per cent., containing pinene, cineol, thujon and borneol; a bitter principle somewhat resembling marrubiin; resin; and tannin, or a principle closely resembling it in its astringency and behavior with ferric salts.

ALLIED PLANTS.—The oil from Muscatel Sage (*Salvia Sclarea*) has an odor of lavender and apparently contains linalyl acetate.

ERIODICTYON.—YERBA SANTA.—The dried leaves of *Eriodictyon californicum* (Syn. *E. glutinosum*) (Fam. Hydrophyllaceæ), an evergreen shrub (p. 367) indigenous to the mountains of California and Northern Mexico.

Description.—Usually broken into fragments; lamina lanceolate, 7 to 15 cm. long, 1 to 3 cm. broad; apex acute; base acute, slightly tapering into the petiole; margin nearly entire or unevenly serrate; upper surface yellowish-green, glabrous, resinous; under surface grayish-green, reticulate, minutely tomentose between the reticulations, midrib light yellow, prominent; petiole 5 to 10 mm. long; texture coriaceous, brittle; odor and taste balsamic.

Constituents.—A greenish-yellow acrid resin about 9 per cent.; a yellow crystalline principle eriodictyonic acid (about 2 per cent.), with a somewhat sweetish but acid taste and becoming reddish-black with ferric chloride; volatile oil; ericolin (see Uva Ursi); an inert resin; tannin, and calcium oxalate.

DIGITALIS.—FOX GLOVE.—The leaves of *Digitalis purpurea* (Fam. Scrophulariaceæ), a biennial herb (Fig. 265) probably indigenous to Central and Southern Europe, and cultivated and naturalized in various parts of Europe and the United States and Canada (p. 376). The leaves are collected in June from plants of the second year's growth, just before the commencement of flowering, immediately dried (preferably with the leaves on the stem as in the drying of tobacco), and carefully preserved. Germany furnishes the chief supply, the leaves from both cultivated and wild plants being used. Digitalis leaves should be carefully dried, stored in bottles or tight tin cans in which a bottle containing freshly burnt lime is placed, the latter container being covered with perforated parchment. The leaves should not be kept longer than one year.

Description.—Usually more or less crumpled and broken into fragments; lamina ovate-oblong or ovate-lanceolate, 10 to 25 cm. long, 5 to 15 cm. broad; apex obtuse or rounded; base somewhat cuneate, tapering into the petiole; margin dentate or crenate, the divisions with a yellowish-brown gland-like apex; upper surface dark green, minutely hairy, somewhat wrinkled, with a single water-pore near the apex of each tooth; under surface grayish-green, midrib grayish-brown, prominent, from which veins of the first order diverge at angles of 45° to 65° and unite with one another near the margin, and from which arise other anastomosing veins, giving a distinctly reticulate appearance; distinctly pubescent on the veins and frequently on the reticulations; petiole

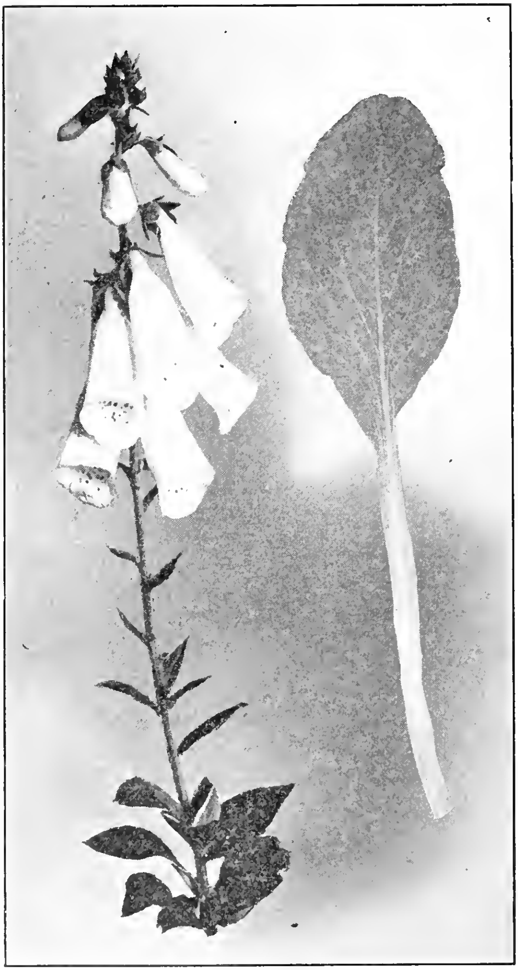

FIG. 265. Foxglove (*Digitalis purpurea*): The terminal 1-sided raceme with slightly irregular, declined, tubular flowers, and a leaf of the first year's plant with long, winged or laminate petiole.

about one-third the length of the lamina or in the upper leaves nearly wanting, grayish-brown, laminated; texture fragile; odor distinct; taste bitter.

Leaves that are more than 30 cm. long should be rejected, as also the tuft of radical leaves of the first-year plant.

INNER STRUCTURE.—See Fig. 266.

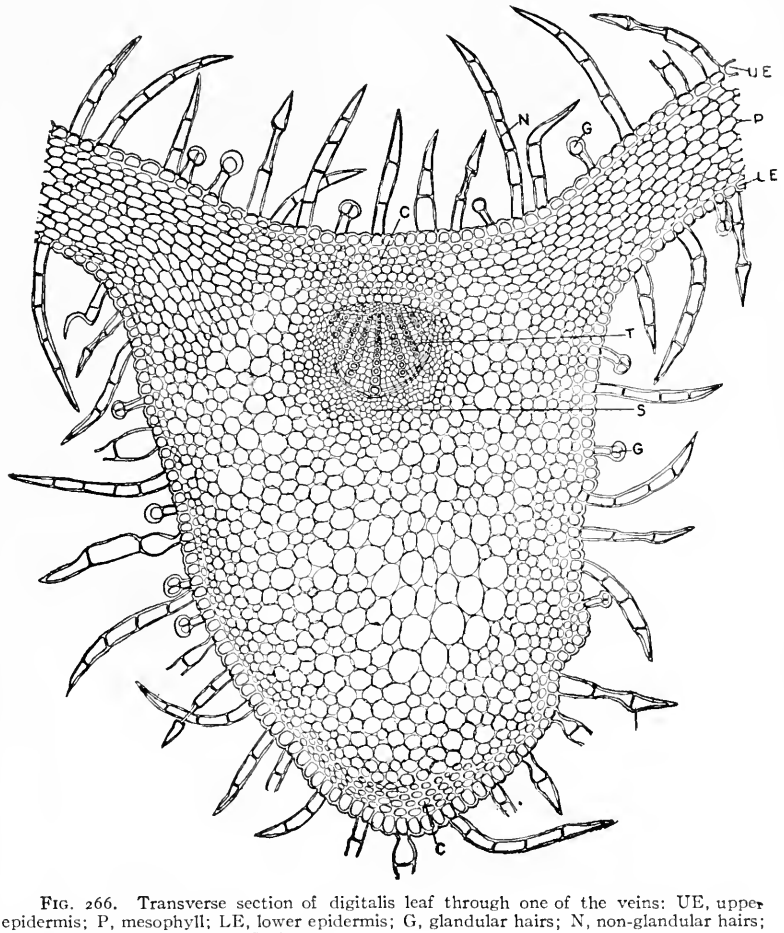

FIG. 266. Transverse section of digitalis leaf through one of the veins: UE, upper epidermis; P, mesophyll; LE, lower epidermis; G, glandular hairs; N, non-glandular hairs; C, collenchyma; T, tracheæ; S, sieve.

CONSTITUENTS.—Several crystalline glucosides, including digitoxin (0.2 to 0.3 per cent.), digitalin and digitonin, the former two being the more important. The drug also contains a volatile oil containing a stearoptene digitalosmin, which has the odor of digitalis and a nauseous, acrid taste; a volatile principle, antirrhinic acid, somewhat resembling valerianic acid; digitalic acid, separating in white needles; two coloring principles, one red and the other yellow, resembling chrysophan, a glucoside found in rhubarb; an oxydase ferment which occurs in the recently dried leaves; and ash 10 to 16 per cent. (see Fig. 335).

DIGITOXIN occurs in white, needle-shaped crystals which are insoluble in water but more or less soluble in alcohol, of a bitter taste and colored deep green with hydrochloric acid. DIGITALIN (digitalinum verum) occurs in white, rather characteristic granules which are sparingly soluble in water and more or less soluble in alcohol, forming yellowish-colored solutions with concentrated hydrochloric or sulphuric acid. If the latter acid contains a trace of ferric sulphate solution a permanent bluish-red color is produced. DIGITONIN is a saponin-like crystalline substance which is nearly insoluble in water, somewhat soluble in alcohol, and remains colorless on treatment with hydrochloric acid, but a dilute sulphuric acid solution becomes garnet-red in color on boiling for some time. DIGITALEIN occurs as a yellowish-white powder and is supposed to be a mixture of digitoxin, digitalin and digitonin. FRENCH DIGITALIN consists chiefly of digitoxin, while in GERMAN DIGITALIN the principal substance is digitonin. The latter is distinguished by being more soluble in both water and alcohol. DIGITIN is a physiologically inactive substance. Nativelle's DIGITALINE CRISTALLISÉE consists chiefly of digitoxin.

ALLIED DRUGS.—The seeds of *Digitalis purpurea* are about 1 mm. or less in diameter, yellowish- or dark-brown, oblong or spatulate in section, more or less plano-convex and somewhat tuberculate. They contain apparently the same principles as the leaves. The digitoxin is said to be different from that obtained from the leaves and is known as α-digitoxin. It is claimed that the leaves of the first year's non-flowering plant when properly dried are equally as active as the official leaves.

The leaves of *Digitalis grandiflora* growing abundantly in Switzerland appear to be as efficient as those of *Digitalis purpurea*.

ADULTERANTS.—The leaves of other cultivated varieties of Digitalis have been substituted for those of *D. purpurea*, as those of the Mammoth Foxglove (*D. monstrosa*), which is distinguished by producing long, spike-like racemes which are terminated by one large flower.

MATICO.—The dried leaves of *Piper angustifolium* (Fam. Piperaceæ), a shrub indigenous to Peru and Bolivia (p. 249).

Description.—Usually in large, compressed, matted masses; lamina narrow, oblong-lanceolate, 10 to 20 cm. long, 2 to 5 cm. broad; apex acute and long-tapering; base unequal, slightly cordate; margin finely crenulate, with broad, truncate teeth; upper surface dark green, tessellated, harsh to the touch from the presence of numerous very small papillæ and minute, bristly hairs; lower surface grayish-green, reticulate, matted hairy, velvety to the touch, the veins being very prominent and yellowish-brown, those of the first order diverging at an angle of 65° to 80°, then curving and converging at the apex; petiole 2 to 3 mm. long, texture fragile when dry; odor pronounced, aromatic; taste aromatic, pungent, pepper-like.

The drug is generally admixed with the flower spikes, which are 2.5 to 15 cm. long and about 2 mm. in diameter, yellowish-brown, and consisting of very small perfect flowers, which are subtended by bracts fringed on the margin with long, multicellular, non-glandular hairs; or the spikes may bear the mature fruits, consisting of somewhat cubical or tetragonal, reddish-brown drupes, which are 0.5 to 1 mm. in diameter and finely reticulate, somewhat like the seeds of lobelia (see p. 629).

A few of the jointed stems with swollen nodes are also present.

Constituents.—Volatile oil, resin, a bitter principle, and artanthic acid (see p. 249). For analyses of recent admixtures and substitutes see Thoms in *Arbeiten a. d. Ph. Ins.*, Berlin, 1910.

Allied Plants.—The drug is frequently admixed with, or entirely substituted by, other species of Piper. Of these may be mentioned *P. camphoriferum* (the oil of which contains borneol and camphor), *P. lineatum, P. angustifolium Ossanum, P. acutifolium subverbascifolium, P. mollicomum* and *P. asperifolium.*

HYOSCYAMUS.—HENBANE.—The leaves and flowering tops of *Hyoscyamus niger* (Fam. Solanaceæ), an annual or biennial herb (Fig. 267) probably indigenous to Europe, Western Asia and Northern Africa and cultivated in Germany, Russia, England and the Northern United States and Canada, and also naturalized in waste places (p. 372). The leaves are collected shortly after flowering from biennial plants of the second year's growth, and carefully dried and preserved. The commercial article comes chiefly from Germany.

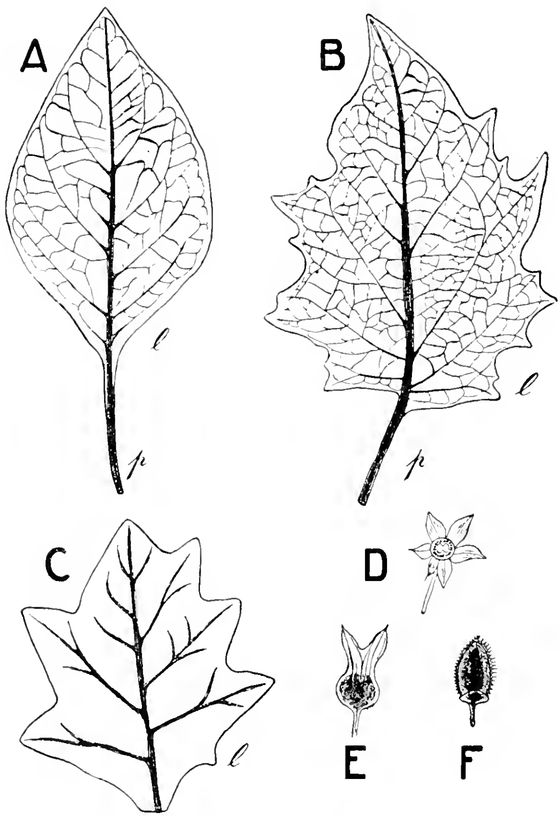

FIG. 267. Leaves and fruits of solanaceous drugs: A, D, Belladonna; B, F, Stramonium; C, E, Hyoscyamus.

DESCRIPTION.—Usually in irregular, matted fragments. Stem hollow, cylindrical, flattened, longitudinally furrowed and wrinkled, 3 to 4 mm. in diameter; internodes 1 to 3.5 cm. long. Leaves ovate or ovate-lanceolate, 5 to 10 cm. long, 2 to 7 cm. broad, apex acuminate; base amplexicaul; margin acutely four-lobed; upper surface dark green and pubescent; under surface grayish-green and glandular-pubescent (Fig. 287, *B*); midrib yellowish-green, from which veins of the first order diverge at an angle of from 10° to 35° and pass into the lobes; texture fragile. Flowers solitary and with a pedicel about 4 mm. long; calyx tubular, 5-toothed, about 10 mm. long, outer surface very pubescent; corolla 5-parted, the lobes more or less unequal, somewhat spreading, the tube purplish, the limb yellowish, reticulate from purplish veins; stamens five, declined, mostly exserted; stigma capitate. Fruit, a two-locular pyxis. Seeds numerous, campylotropous, somewhat reniform, flattened, 1 mm. long, light brown, finely pitted, with a curved embryo embedded in the endosperm. Odor distinct. Taste bitter and somewhat acrid.

Inner Structure.—See Figs. 282, *A*; 287, *B*; 302, *A*.

Constituents.—The alkaloids hyoscyamine and hyoscine (scopolamine) 0.08 to 0.15 per cent., of which three-fourths is hyoscyamine; an odorous principle in the nature of a butyric ether or butyrin; a glucosidal bitter principle, hyospicrin; potassium nitrate, about 2 per cent., and calcium oxalate.

Hyoscyamine (an isomer of atropine) occurs in colorless, silky needles with an acrid, disagreeable taste, partly soluble in water, soluble in alcohol, and is readily decomposed into atropine. It forms crystalline salts, of which the hydrobromide is official. Hyoscine forms prismatic crystals, which are soluble in water and alcohol, and yields scopoline (oscine) and tropic acid.

Allied Plants.—Hyoscyamine is also found in *Datura Stramonium, Atropa Belladonna, Anisodus luridus, Duboisia myoporoides, Lactuca sativa* and *L. virosa* (p. 392), the two latter plants belonging to the Compositæ. Hyoscine (scopolamine) is also present in belladonna root, the seeds of *Hyoscyamus niger* (p. 372), the leaves of *Datura Stramonium, Datura fastuosa* of the East Indies, the leaves of *Duboisia myoporoides* and the roots of *Scopolia japonica* and *S. atropoides*.

The leaves of *Hyoscyamus muticus* (Fig. 269), a plant growing in Egypt, yield 1.34 per cent. of alkaloids consisting of practically pure hyoscyamine.

Duboisia leaves are obtained from *Duboisia myoporoides*, a large shrub indigenous to Australia. They are short-petiolate, 7 to 10 cm. long, 1.5 to 2.5 cm. broad, with acute or narrow apex and base, and entire or somewhat revolute margin. In the drug they usually occur in broken fragments, which are thin, greenish-brown, and have a slight narcotic odor and bitter taste. They contain in addition to hyoscyamine (duboisine) and hyoscine, the alkaloid PSEUDOHYOSCYAMINE, which occurs in small, needle-shaped crystals that are difficultly soluble in water but readily soluble in alcohol. *Duboisia Leichardtii* also contains a large amount of alkaloids resembling those of Duboisia. PITURI or Australian tobacco is the leaf of *Duboisia Hopwoodii,* and is used in Australia like tobacco. It contains 2.5 per cent. of a liquid alkaloid piturine, which has a pungent odor and taste, and closely resembles nicotine.

BELLADONNÆ FOLIA.—BELLADONNA LEAVES.—The leaves and flowering tops of *Atropa Belladonna* (Fam. Solanaceæ), a perennial herb (Fig. 268) native of Central and Southern Europe, Asia Minor and Persia, and cultivated in England and Germany, from which countries most of the commercial supply is obtained (p. 372). The leaves and tops are gathered when the plants are in flower, and used fresh or after being dried.

DESCRIPTION.—Usually in irregular, matted fragments. Stem hollow, cylindrical, flattened, longitudinally furrowed and wrinkled, 1.5 to 2 mm. in diameter, internodes from 2.5 to 6.5 cm. long. Leaves single or in unequal pairs, broadly ovate or somewhat elliptical, 6 to 15 cm. long, 2.5 to 7 cm. broad; apex acuminate; base acute, somewhat unequal and tapering into the petiole; margin entire; upper surface dark green, glabrous, epidermis with distinct papillæ; under surface grayish-green, slightly pubescent (Fig. 287, *C*) on the veins, epidermis distinctly sinuate, midrib dark brown, the veins of the first order diverging from it at angles of about 45° and running nearly parallel to near the margin; petiole dark brown, 5 to 15 mm. long and semi-circular in cross section; texture fragile. Flowers solitary, pedicel 1.5 to 2 cm. long; calyx deeply 5-cleft, about 1 cm. long, outer surface slightly pubescent; corolla 5-parted, about 2 cm. long, campanulate, yellowish-purple; stamens five, included; style somewhat exserted. Fruit, a superior berry, globular, dark green, 7 to 10 mm. in diameter, 2-locular, many-seeded. Seeds campylotropous, somewhat reniform, flattened, light brown; testa finely pitted, with a curved embryo embedded in the endosperm. Odor distinct, heavy. Taste somewhat disagreeable.

FIG. 268. *Atropa Belladonna* showing the alternate, petiolate, ovate, entire leaves, in the axils of which are the solitary fruits or flowers with large, leafly bracts.

INNER STRUCTURE.—See Figs. 285, *K*; 287, *C*.

CONSTITUENTS.—Several alkaloids amounting to from 0.3 to 0.7 per cent., of which hyoscyamine (see Hyoscyamus) exists in largest proportion. The drug also contains hyoscine (scopolamine), atropine, formed from hyoscyamine, and belladonnine, formed from atropine; a fluorescent principle β-methyl-æsculetin (atrosin or chrysatropic acid), which resembles a similar principle found in gelsemium; malic acid and calcium oxalate in the form of sphenoidal micro-crystals (Fig. 287, *C*).

Atropine is a powerful mydriatic alkaloid which occurs in colorless or white acicular crystals that are soluble in alcohol but sparingly soluble in water. It is optically inactive and may be sublimed without decomposition. The aqueous solutions are, however, easily decomposed, acquiring a yellow color and a disagreeable odor. On treating atropine with nitric acid and potassium hydrate a violet color is produced. On hydrolysis atropine yields tropin and tropic acid. Upon heating atropine with nitric acid so as to cause the loss of a molecule of water the alkaloid apoatropine (atropamine or anhydro-atropine) is formed, which has been isolated from belladonna root and which does not possess any mydriatic properties. On heating apoatropine with hydrochloric acid or upon simply heating it for some time alone the base belladonnine (oxyatropine) is formed (see Figs. 142, 341).

The amount of alkaloids varies in different parts of the plant and has been given as follows: Roots, 0.06 per cent.; stems, 0.04 per cent.; leaves, 0.2 per cent.; unripe berries, 0.19 per cent.; ripe berries, 0.21 per cent.; and seeds, 0.33 per cent.

Adulterants.—The leaves of *Scopolia carniolica* (p. 509; Fig. 273) and *Phytolacca decandra* (Fig. 139) have been recently reported as substitutes.

STRAMONIUM.—STRAMONIUM LEAVES.—The leaves and flowering tops of *Datura Stramonium* (Fam. Solanaceæ), an annual herb (Fig. 267) probably indigenous to the region of the Caspian Sea, naturalized in waste places in Europe and North America, and cultivated in France, Germany and Hungary (p. 372). The leaves and tops are collected when the plant is in flower, and are carefully dried and preserved, the chief of the commercial supply being obtained from cultivated plants.

Description.—Usually in irregular, matted fragments. Stem cylindrical, flattened, longitudinally furrowed and wrinkled, 2 to 5 mm. in diameter; internodes 1.5 to 2 cm. long. Leaves ovate, 6 to 20 cm. long, 2 to 12 cm. broad; apex acuminate; base unequal, one side extending 3 to 12 mm. below the other; margin irregularly sinuate-lobed, the lobes acute; upper surface dark green, nearly glabrous, under surface yellowish-green, glabrous, slightly pubescent (Fig. 287, *D*) on the veins, midrib dark brown,

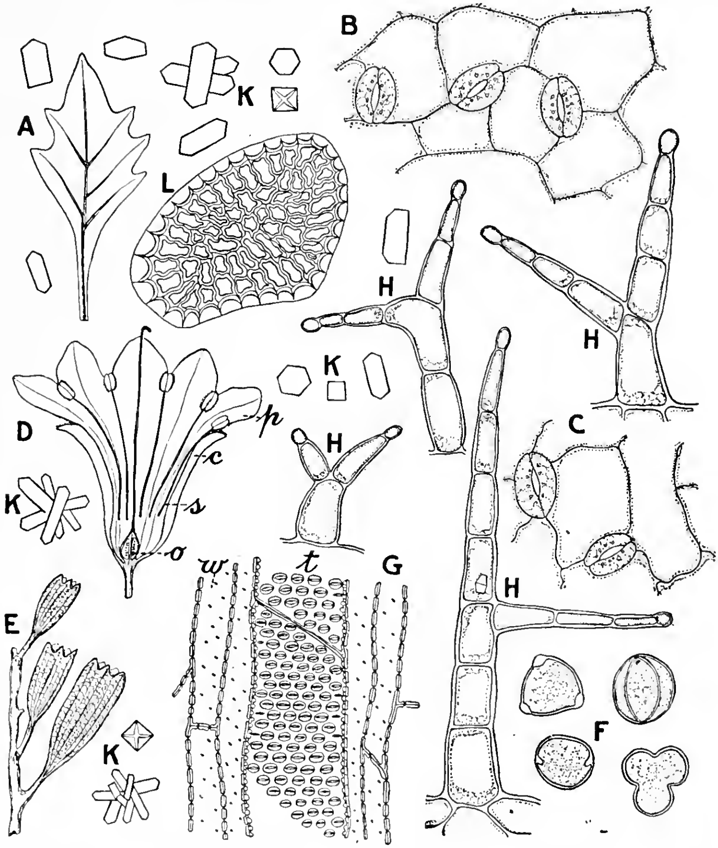

Fig. 269. *Hyoscyamus muticus:* A, leaf; B, portion of upper surface of leaf; C, portion of lower surface; D, section of flower showing calyx (c), lobed corolla (p), stamens inserted on corolla tube (s), ovary (o); E, portion of stalk with fruits showing cylindrical calyx; F, pollen grains in different views; G, portion of xylem of stem showing tracheæ (t) with bordered pores, wood fibers (w) with oblique simple pores; H, characteristic branching hairs found on the stem, leaves and calyx; K, crystals of calcium oxalate; L, seed with epidermal cells having wavy walls, those at the edge being seen in section and showing that the outer wall is not thickened.

veins of the first order diverging from it at an angle of 45° to 65°, dividing near the margin and the main branches passing into the lobes; petiole dark brown, 0.5 to 4.5 cm. long, circular in cross-section; texture fragile. Flowers solitary, pedicel 2 to 10 mm.

long, calyx 5-toothed, about 4 cm. long, separating transversely near the base at maturity, the upper part falling away; corolla funnel-shaped, yellowish- or purplish-white, about 8 cm. long, limb plaited, 5-lobed; stamens five, included, inserted near the middle of the corolla tube; stigma slightly 2-lobed. The immature fruit somewhat conical, 4-valved. Seeds numerous. Odor disagreeable. Taste unpleasant, nauseous.

Inner Structure.—See Figs. 117; 287, *D;* 285, *C.*

Constituents.—The important constituents of Stramonium leaves are similar to those of belladonna leaves, the amount of total alkaloids, however, being about one-half less (0.2 to 0.4 per cent). The substance known as daturine is a mixture of hyoscyamine and atropine, the former being in excess (see Belladonnæ Folia and Hyoscyamus). Stramonium leaves also contain a volatile oil, resin, and yield about 17 per cent. of ash, containing considerable potassium nitrate.

The amount of total alkaloids varies in different parts of the same plant and has been reported as follows: Roots, 0.02 per cent.; stems, 0.02 per cent.; leaves, 0.07 per cent., and seeds, 0.25 per cent.

Stramonii Semen (Stramonium Seed).—Campylotropous, reniform, flattened, about 3 to 4 mm. long, 2 to 3 mm. broad; externally bluish-black, minutely reticulate; hard but easily cut lengthwise along the edge; internally (Fig. 122, *B*) whitish, the reserve layer occupying about one-half the seed, the embryo crook-shaped; odor slight, disagreeable when the drug is bruised; taste bitter. They contain about 25 per cent. of fixed oil; proteins; about 0.4 per cent. of alkaloids, consisting principally of hyoscyamine, together with a small proportion of atropine and scopolamine (hyoscine); ash 2 to 3 per cent.

Allied Drugs.—See Hyoscyamus and Belladonnæ Folia.

The Purple Stramonium (*Datura Tatula*) which is naturalized in the United States from tropical America resembles *D. Stramonium*, but the stems and flowers are purplish. The constituents in the two plants are similar. Several other species are also used in medicine, as *Datura arborea* indigenous to Chile and Peru, and cultivated for its handsome flowers. The leaves contain 0.44 per cent. of total alkaloids.

EUPATORIUM.—BONESET.—The leaves and flowering tops of *Eupatorium perfoliatum* (Fam. Compositæ), a perennial herb (Fig. 270) indigenous to Eastern and Central North America (p. 392). Boneset is collected in July and August and dried.

FIG. 270. 1. *Eupatorium perfoliatum* with opposite, connate-perfoliate leaves and cymose-paniculate inflorescence. 2. *Eupatorium purpureum* with verticillate, petiolate leaves, and a large terminal panicle of flowers.

DESCRIPTION.—Usually in more or less broken fragments. Stem cylindrical, somewhat quadrangular, flattened, about 3 mm. in diameter, longitudinally wrinkled, tomentose; internodes 5 to 8 cm. long. Leaves lanceolate, opposite, 10 to 20 cm. long, 2 to 4 cm. broad; apex acuminate; base connate-perfoliate; margin crenate-serrate; upper surface dark green, midrib and veins depressed, reticulate, glabrous, except near the margin; under surface yellowish- or brownish-green, midrib prominent, reticulate, very tomentose, with glistening yellow resin masses. Flowers in large cymose panicles; heads 10- to 15-flowered, about 5 mm. long, torus flat; involucre light green, oblong, the scales imbricate, linear-lanceolate, hairy; corolla 5-toothed, whitish; anthers purplish, included; style deeply cleft, much exserted. Akenes 5-angled, pappus consisting of a single row of about twenty rough bristles. Odor aromatic. Taste bitter.

Constituents.—Volatile oil; a bitter, crystalline glucoside eupatorin; resin; a crystalline wax; a glucosidal coloring principle related to tannin but crystallizing in small yellow needles, and giving an orange-red precipitate with lead acetate solution; a glucosidal tannin, which is colored deep green with ferric chloride and gives a yellow precipitate with lead acetate solution; gallic acid; ash 7.5 to 9.9 per cent.

Allied Plants.—Purple boneset or Joe-pye weed (*Eupatorium purpureum*), a common herb (Fig. 270) in low grounds in Eastern and Central North America, is a tall stout herb, with oblong-lanceolate leaves, 3 to 6 in a whorl and light purplish-red flowers in dense corymbs. Purple boneset contains a volatile oil, 0.07 per cent.; a yellow crystalline principle euparin, which somewhat resembles quercitrin; resin, 0.25 per cent.; calcium oxalate, 1.82 per cent.; and ash, 14 per cent. Dog-fennel (*E. fœniculaceum*), a perennial herb, with alternate, 1- to 2-pinnately parted leaves and white flowers, which is common in the Southern States, yields a volatile oil which contains considerable phellandrene.

The root of *Eupatorium perfoliatum* contains about 5 per cent. of inulin.

GRINDELIA.—The leaves and flowering tops of *Grindelia robusta* and *Grindelia squarrosa* (Fam. Compositæ), perennial herbs (p. 393) indigenous to Western North America, *G. robusta*, growing west of the Rocky Mountains, and *G. squarrosa*, eastward therefrom as far as the Mississippi. Grindelia is collected in early summer when the leaves and tops are covered with a resinous exudation, and dried.

Grindelia Robusta.—Stem cylindrical, lemon-yellow or rose-colored, 2 to 3 mm. in diameter, longitudinally wrinkled, glandular-hairy, nearly glabrous, resinous; internodes 8 to 35 mm. long.

Leaf lanceolate or elliptical; apex acute; base sessile or amplexicaul; margin entire or spinosely toothed; upper surface light green or yellowish-green, covered with resin and with occasional black disks of a species of *Puccinia;* under surface grayish-green, somewhat resinous; texture somewhat coriaceous, brittle when dry. Heads many-flowered, globular or truncate-conical, about 1 to 2 cm. in diameter, with numerous lanceolate-acuminate, imbricate and resinous involucral bracts; torus flat, deeply pitted; ray-flowers brownish-yellow and pistillate; tubular flowers yellowish-brown, perfect. Akenes slightly curved, somewhat compressed, about 3 mm. long, and 1- to 2-dentate or auriculate-bordered at the summit. Odor aromatic; taste aromatic and bitter.

Grindelia Squarrosa.—The leaves are linear, the akenes are 4-angled and more or less truncate at the apex.

Constituents.—Resinous substances amounting to about 21 per cent., including a soft greenish resin soluble in petroleum ether, a dark colored resin soluble in ether and a dark colored, amorphous resin soluble in alcohol; a lævo-rotatory sugar l-glucose; tannin 1.5 per cent.; a volatile oil having the characteristic odor of the drug; and about 8 per cent. of ash. The drug has also been reported to contain two glucosides, 0.8 per cent. (*G. squarrosa*) to 2 per cent. (*G. robusta*), somewhat resembling the saponins in quillaja and senega; and a bitter crystalline alkaloid, grindeline.

Substitutes.—Most of the drug on the market at the present time appears to be derived from *Grindelia camporum*, the common Gum plant of California. The upper leaves are more or less oblong or spatulate and the akenes are usually bi-auriculate at the summit.

The commercial drug is also derived from *Grindelia cuneifolia* and its variety *paludosa*, growing in the marshes of upper California. The leaves are cuneate and less coriaceous than those of *G. camporum*, but the akenes are similar.

Allied Plants.—Other species of Grindelia growing in the Western United States and Mexico are similarly employed, as *G. hirsutula*, the stems of which are purplish-red and pubescent; and *G. glutinosa*, in which the leaves are glabrous, rounded at the apex and the pappus 5- to 8-toothed.

MARRUBIUM.—WHITE HOREHOUND.—The leaves and flowering tops of *Marrubium vulgare* (Fam. Labiatæ), a perennial herb (p. 368) indigenous to Europe and Asia, and cultivated in various parts of Europe and the United States, being naturalized in waste places from Texas and Mexico to Maine and Ontario.

DESCRIPTION.—Stem quadrangular, yellowish- or grayish-green, 3 to 5 mm. in diameter, very pubescent; internodes 2 to 5 cm. long. Leaves broadly ovate, opposite, 1.5 to 6 cm. long, 8 to 25 mm. broad; apex obtuse; base acute or rounded; margin coarsely crenate; upper surface dark green, pubescent, veins depressed, those of the first order diverging at an angle of about 65° and branching near the margin; under surface grayish-green, very pubescent, veins prominent; petiole 0.5 to 3 cm. long, very pubescent. Flowers sessile, in axillary clusters; calyx tubular, about 5 mm. long, 5- to 10-nerved, very pubescent and with 10 recurved, bristle-like lobes; corolla whitish or light brown, about 7 mm. long, upper lip erect, entire or bifid, lower lip 3-lobed, the middle lobe the largest and emarginate; stamens four, included. Nutlets brownish-black, ellipsoidal, slightly compressed, about 1.5 mm. long, nearly smooth. Odor slight, aromatic. Taste aromatic and bitter.

CONSTITUENTS.—A bitter, somewhat acrid principle marrubiin, 0.02 to 4 per cent., which forms prismatic crystals and is sparingly soluble in water; several other bitter principles; a volatile oil; a resin; and tannin.

ALLIED PLANTS.—Black horehound or *Marrubium peregrinum*, an herb of the old world, has ovate or lanceolate, dentate-serrate, grayish, hairy leaves and flowers with straight calyx-lobes. *Ballota nigra* (Fam. Labiatæ) has cordate, rough-hairy, dark green leaves, pale purple flowers and a disagreeable odor. Water horehound or *Lycopus europæus* has ovate-lanceolate, lobed or divided leaves, the calyx lobes being triangular.

HEDEOMA.—AMERICAN PENNYROYAL.—The leaves and flowering tops of *Hedeoma pulegioides* (Fam. Labiatæ), an annual herb (Fig. 271) indigenous to the Eastern and Central United States and Canada (p. 369). Pennyroyal should be collected in July or August and dried.

DESCRIPTION.—Stem quadrangular, 1 to 2 mm. in diameter, light or reddish-brown, with numerous spreading hairs. Leaves

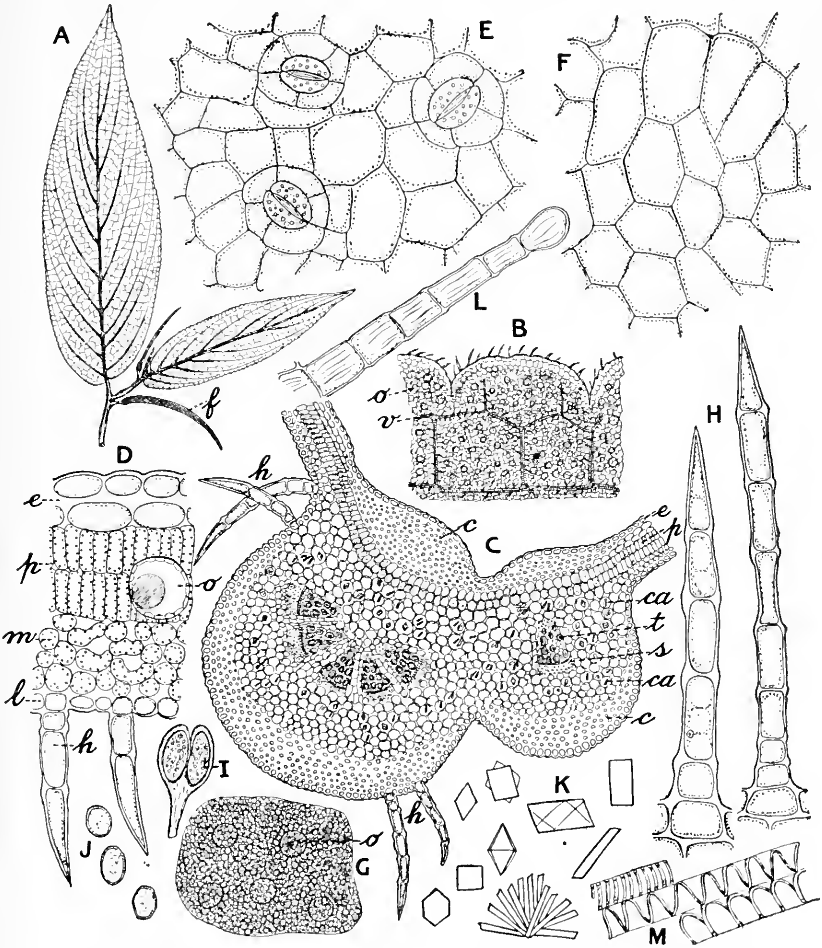

FIG. 271. Matico: A, branch with leaves and flower spikes (f); B, section of leaf showing one of the truncate teeth, fibrovascular bundle (v), oil-secretion reservoirs (o); C, transverse section of leaf near two veins, showing upper epidermis of several layers (e), palisade cells (p), tracheæ (t), sieve (s), collenchyma (c), loose parenchyma containing crystals of calcium oxalate (ca), hairs (h); D, transverse section of leaf showing in addition an oil-secretion reservoir (o); E, portion of lower epidermis showing three stomata; F, portion of upper epidermis; G, portion of leaf showing the glandular-punctate character due to the oil-secretion reservoirs (o); H, non-glandular hairs; I, stamen; J, pollen grains, which are about 10 μ in diameter; K, prisms of calcium oxalate; L, a hair from the perianth; M, tracheæ from the stem with spiral and annular markings.

elliptical or ovate, opposite, 15 to 35 mm. long, 5 to 14 mm. broad; apex obtuse; base tapering into the petiole; margin remotely serrate; upper surface dark green, pubescent on the nerves, slightly glandular-hairy; under surface light green, pubescent, glandular-hairy, veins of the first order diverging at an angle of 45° to 65°, curving upwards and uniting near the margin; petiole 3 to 6 mm. long, with numerous spreading hairs and slightly laminate in the upper portion. Inflorescence in six-flowered axillary whorls; calyx tubular, about 5 mm. long, ovoid or slightly curved on the lower side near the base, bilabiate, upper lip 3-toothed, lower lip with two linear-lanceolate divisions, 13-nerved, longitudinally striate, pubescent; corolla about the size of the calyx, purplish, pubescent, upper lip erect, flat, emarginate, the lower spreading and 3-lobed; fertile stamens two, exserted, ascending, the sterile upper pair rarely with anthers. Nutlets nearly spherical or ovoid, about 0.5 mm. in diameter. Odor strongly aromatic. Taste aromatic.

Constituents.—Volatile oil, a bitter principle and tannin. The dried leaves yield about 3 per cent. of volatile oil, while the dried stems and leaves yield only 1.3 per cent. The volatile oil is official and consists chiefly of a ketone pulegone, which gives the oil its peculiar properties. The oil also probably contains two other ketones: (a) hedeomol and (b) another resembling menthone. Several acids have also been found in this oil: formic, acetic and isoheptylic.

Allied Plants.—*Mentha Pulegium*, or European pennyroyal, apparently contains principles similar to the American pennyroyal, and is distinguished from the latter by the more or less oval, serrate leaves, and the cymose inflorescence and four-lobed corolla. The oil of European pennyroyal closely resembles that of Hedeoma and is frequently substituted for it.

Wild Mint (*Mentha canadensis*), a perennial herb common in wet places in the United States, has ovate-oblong or lanceolate leaves, in the axils of which whorls or globular clusters of flowers arise. The plant has an odor of pennyroyal and yields 1.25 per cent. of a volatile oil from which pulegone and thymol or carvacrol have been isolated.

Water Mint (*Mentha aquatica*), a plant found in wet places from New England to Delaware, yields about 0.34 per cent. of a volatile oil having the odor of pennyroyal.

Oil of Russian pennyroyal contains pulegone, but the botanical origin is not known.

MENTHA PIPERITA.—PEPPERMINT.—The leaves and flowering tops of *Mentha piperita* (Fam. Labiatæ), a perennial herb (Fig. 175) indigenous to Europe, naturalized in the Eastern and Central United States and Canada, and cultivated in Michigan and New York (p. 370). Peppermint should be collected during dry weather, in August and September, when the plant is in flower, and carefully dried and preserved. Peppermint is cultivated in Michigan chiefly for its volatile oil. This State produces annually over 6,800 K. of peppermint oil. Wayne County, in New York State, produces 1,480 K.; Indiana State, 1,280 K., and other localities about 400 K. annually. Japan produces about 70,000 K. annually; England, 9,000 K.; France, 3,000 K.; Russia, 1200 K.; Germany, 800 K., and Italy, 600 K.

DESCRIPTION.—Stem quadrangular, 1 to 3 mm. in diameter, purplish-green, with scattered deflexed hairs, internodes 1.5 to 5 cm. long. Leaves ovate-lanceolate, opposite, 1.5 to 8 cm. long, 0.5 to 2.5 cm. broad; apex acute; base acute or rounded; margin sharply serrate; upper surface dark green, midrib and veins rose-colored, the latter diverging at an angle of about 60°, curving upward and uniting near the margin; under surface light green, slightly pubescent on the veins, glandular-pubescent; petiole 4 to 10 mm. long, slightly pubescent. Inflorescence in axillary whorls or in compact spikes; peduncle wanting or about 3 mm. long, pedicel about 1 mm. long; calyx tubular, equally 5-toothed, about 2 mm. long, purplish, glandular-punctate; corolla tubular, nearly regular, 4-cleft, about 3 mm. long, purplish; stamens four, erect, distant. Nutlets ellipsoidal, about 0.5 mm. in diameter, blackish-brown. Odor aromatic. Taste aromatic, followed by a cooling sensation.

CONSTITUENTS.—Volatile oil, containing 50 to 60 per cent. of menthol, about 1 per cent.; resin and tannin. AMERICAN peppermint oil consists of about 17 different chemical constituents, a larger number than is found in any other oil. The most important constituent is the stearoptene MENTHOL, of which 40 to 45 per cent. is free and 8 to 14 per cent. is combined in various esters. Menthol occurs in colorless, acicular crystals, which are insoluble in water but soluble in alcohol, and on boiling with a sulphuric acid solution (50 per cent.) it becomes of a deep blue color, the acid solution becoming brown. American peppermint oil also contains: Acetaldehyde, isovaleraldehyde, acetic acid, valerianic acid, pinene, phellandrene, cineol, l-limonene, menthone, menthyl acetate, menthyl iso-valerianate, menthyl ester, a lactone cadinene, amyl alcohol, and dimethyl sulphide.

English peppermint oil is very highly prized on account of its fine aroma and pleasant taste. It consists of 50 to 60 per cent. of free menthol, 3 to 14 per cent. of menthol combined as esters, and 9 to 12 per cent. of menthone, a substance capable of being transformed into menthol. This oil also contains: Phellandrene, limonene, cadinene, acetic acid and iso-valerianic acid.

Japanese peppermint oil is obtained from *Mentha arvensis piperascens*. The oil has a bitter taste and consists of free menthol 65 to 85 per cent.; menthol combined as esters, 3 to 6 per cent.; and a body isomeric with borneol.

MENTHA VIRIDIS.—SPEARMINT.—The leaves and flowering tops of *Mentha spicata* (Syn. *Mentha viridis*) (Fam. Labiatæ), a perennial herb indigenous to Europe and cultivated and naturalized in various parts of North America. It should be collected in the same manner as peppermint (p. 370).

Spearmint is extensively cultivated in Michigan and New York, these states producing annually about 500 K. of volatile oil.

Description.—Closely resembling peppermint (see Mentha Piperita), but the stems are usually more purple, the leaves sessile or nearly so, inflorescence either in slender, interrupted cylindrical spikes or crowded lanceolate spikes; odor and taste aromatic, characteristic, the taste not being followed by a cooling sensation.

Constituents.—Volatile oil about 0.3 per cent. in the fresh leaves; resin, and tannin. American oil of spearmint consists of about 56 per cent. of carvone, a considerable amount of l-limonene and possibly also l-pinene. The constituent giving the oil its characteristic odor is not known.

Allied Plants.—Russian spearmint oil is obtained from an undetermined plant and consists of l-linalool, 50 to 60 per cent.; 20 per cent. of cineol, 5 to 10 per cent. of l-carvone and possibly also l-limonene.

GERMAN spearmint oil is obtained from *Mentha crispa,* which is regarded as a cultural variety of *M. arvensis.* The plant is sparingly naturalized in the United States from Europe. It somewhat resembles *M. piperita,* but is distinguished by its cuspid, irregularly dentate leaves. It yields an oil containing carvone.

LOBELIA.—The leaves and flowering tops of *Lobelia inflata* (Fam. Campanulaceæ), an annual herb (Fig. 272) indigenous to the Eastern and Central United States and Canada, and cultivated in New York and Massachusetts (p. 388). Lobelia should be collected after a portion of the capsules have become inflated, carefully dried and preserved.

DESCRIPTION.—Stem cylindrical, somewhat angular, slightly winged, light brown, with numerous spreading hairs, internodes 2 to 3 cm. long. Leaves elliptical or ovate-lanceolate, alternate, 4 to 9 cm. long, 8 to 30 mm. broad; apex acute or acuminate; base obtuse or acute; margin irregularly denticulate, the divisions with a yellowish-brown, gland-like apex; upper surface yellowish-green or light brown and with scattered bristly hairs; under surface light brown, with numerous bristly hairs, the veins of the first order diverging at an angle of about 65° and curving upward near the margin; petiole either wanting or about 1 mm. long. Inflorescence in leafy spikes; pedicel about 3 mm. long; calyx 5-parted, about 5 mm. long, the subulate lobes about as long as the tube; corolla 5-parted, tubular, about as long as the calyx, pale blue, upper portion cleft nearly to the base, the lobes on either side of the cleft erect or recurved, the other three united; stamens with anthers united above into a curved tube; stigma 2-lobed, ovary 2-locular. Fruit an ovoid, inflated capsule 5 to 8 mm. long, opening at the summit, apex with the remains of the calyx. Seeds numerous, brownish, somewhat ellipsoidal or ovoid, about 0.7 mm. long, coarsely reticulate. Odor slight; taste mild, becoming acrid.

CONSTITUENTS.—An amorphous, acrid, emetic alkaloid LOBELINE, which decomposes readily on heating, and is contained in greatest amount in the seeds; a non-acrid but pungent volatile oil LOBELIANIN; a colorless, tasteless, crystalline, neutral principle INFLATIN, which is intimately associated with the alkaloid; and lobelic acid, which is combined with the alkaloid lobeline. LOBELACRIN is regarded as the lobelate of lobeline. The seeds contain in addition a fixed oil which when pure is bland, non-acrid and somewhat resembles that of linseed. As it is usually seen on the

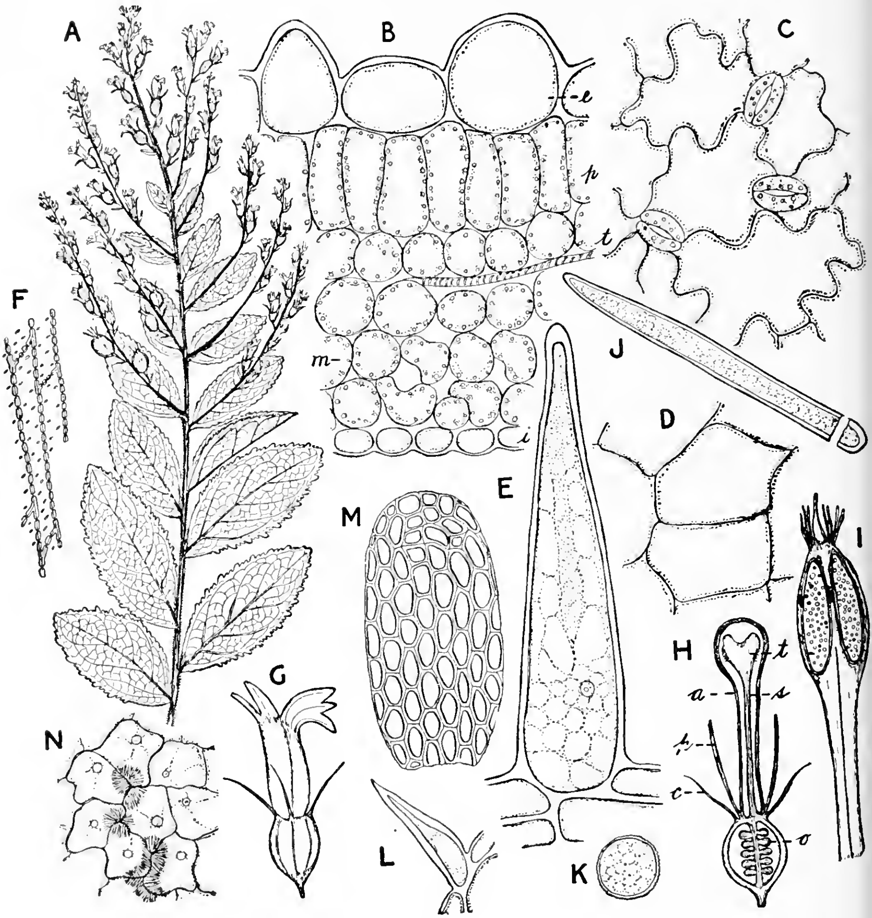

Fig. 272. Indian tobacco (*Lobelia inflata*): A, upper portion of shoot showing the dentate-denticulate leaves and the inflated capsules which develop soon after fertilization; B, transverse section of leaf showing the large epidermal cells (e), palisade cells (p), tracheæ (t), loose parenchyma (m) and lower epidermis (i); C, surface section of lower epidermis showing 3 elliptical stomata; D, surface section of upper epidermis; E, one of the hairs which are found on the stems and leaves; F, wood fibers of the stem; G, a flower; H, longitudinal section of flower showing the ovary with ovules (o), style (s), hairy bifid stigma (t), united stamens (a), corolla (p) and calyx (c); I, longitudinal section of stamen showing the hairy apex; J, hair from stamen; K, pollen grain; L, hair from calyx; M, seed with reticulate seed-coat; N, upper epidermis of corolla showing spherite crystals of a carbohydrate.

market it is of a greenish color and quite acrid and is said to contain all the active principles of the drug.

Allied Plants.—Red lobelia or Cardinal flower, *Lobelia cardinalis,* and blue lobelia, *L. syphilitica,* as well as a large number of other species of Lobelia, are used to some extent in medicine. *Lobelia nicotianæfolia* of India and *Delissea acuminata* of the Hawaiian Islands have properties similar to *Lobelia inflata.*

Adulterants.—The seeds of mullein (*Verbascum Thapsus*) are commonly used as an adulterant of Lobelia seeds, but are distinguished from them by not being reticulate.

CANNABIS INDICA.—EAST INDIAN HEMP.—The flowering tops of the pistillate plants of *Cannabis sativa* (Fam. Moraceæ), an annual herb (Fig. 273) indigenous to Central and Western Asia, and cultivated in India and other tropical countries and also in temperate regions for the fiber and seed (p. 255). The drug, however, is obtained from plants cultivated in tropical India. The flowering tops are made into more or less compressed masses, forming what is known as "ganja" or "guaza." The best grade of ganja is obtained from unfertilized plants grown in Bengal. The leaves may be collected and dried separately and constitute what is known as "bhang." The resin which separates from ganja and bhang, or that which is collected from the growing plant, constitutes the product known as "charas" (p. 255). *Cannabis sativa* has become naturalized in the Central United States, and, while the American drug was at one time official, is now but little used in medicine. Fruiting spikes with mature seeds should be removed.

Description.—Usually in compressed masses 5 to 14 cm. long. Stem cylindrical, about 3 mm. in diameter, longitudinally furrowed and wrinkled, light green, pubescent, internodes 2 to 20 mm. long. Leaf digitately compound, with three to seven linear-lanceolate, nearly sessile leaflets, apex of leaflets acuminate, base acute or cuneate, margin deeply serrate; upper and under surfaces dark green, pubescent, glandular, veins of the first order diverging at an angle of 65° and terminating in the teeth; petiole 1 to 5 cm. long. Inflorescence in sessile spikes, each flower subtended by an ovate, pubescent bract; calyx entire, ovate or oblong-acuminate, about 4 mm. long, dark green, pubescent, split longitudinally on one side, somewhat enlarged at the base and folded around the ovary; styles two, about 8 mm. long, filiform, pubescent, ovary oblong, about 1 mm. long, with a single campylotropous ovule. Odor distinct. Taste slightly acrid.

CONSTITUENTS.—From 15 to 20 per cent. of a resin (called CANNABIN), consisting of a number of substances, one of which,

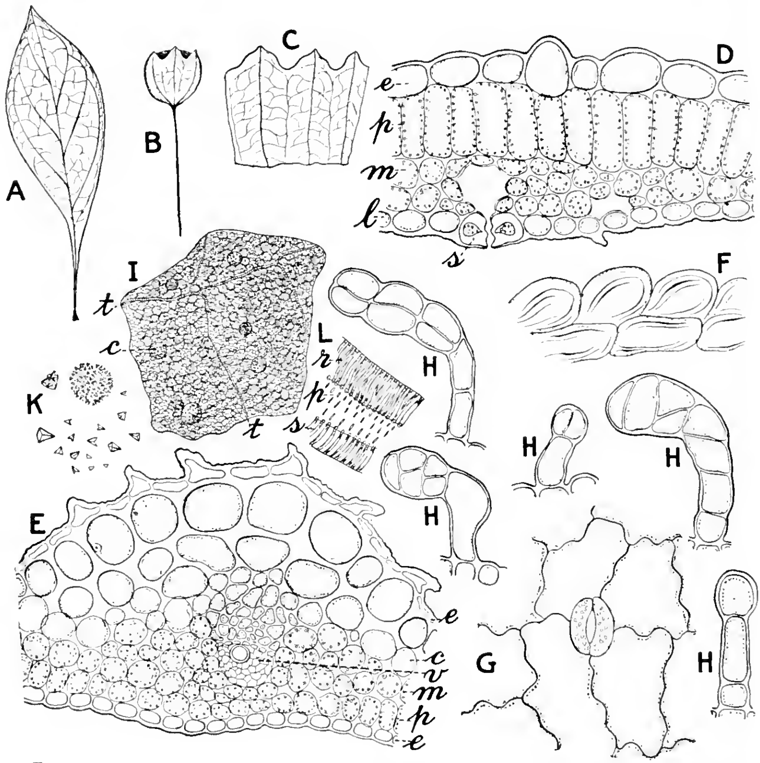

FIG. 273. *Scopolia carniolica:* A, leaf; B, a fruit showing long stalk and slightly lobed calyx; C, portion of calyx showing broadly acute lobes; D, E, transverse sections of leaf showing upper epidermis (e), palisade cells (p), loose parenchyma (m), collenchyma (c), lower epidermis (l), fibrovascular bundle with a single trachea (v), stoma (s); F, epidermal cells of lower surface showing foldings due to irregularity of the outer walls; G, epidermal cells and stoma from lower surface; H, glandular hairs (which are only occasionally found); I, fragment of leaf showing spiral tracheæ (t), cells containing crypto-crystalline crystals of calcium oxalate (c); K, isolated crystals of calcium oxalate, which sometimes occur in aggregates from 25 to 40 μ in diameter; L, fragment of stem showing tracheæ with reticulate thickening (r), simple pores (p) and spiral thickening (s).

CANNABINOL (cannabindon) occurs as a red, oily substance and is said to possess the intoxicating properties of the drug. The drug also contains 0.3 per cent. of a yellowish VOLATILE OIL, which consists chiefly of a sesquiterpene, cannibene and a stearoptene. A similar sesquiterpene is present in the staminate plant of *Canna-*

bis gigantea. The non-flowering herb yields about 1 per cent. of a narcotic volatile oil which has an odor that is not unpleasant. The volatile alkaloid cannabinene is supposed to be trimethylamine.

ALLIED DRUGS.—The alkaloids harmine and harmaline are found in the seeds of *Peganum Harmala* (Fam. Zygophyllaceæ) of India, and have narcotic properties similar to Cannabis indica.

SCOPARIUS.—BROOM.—The tops of *Cytisus Scoparius* (Fam. Leguminosæ), a shrub (p. 294) indigenous to the temperate parts of Europe, and naturalized in waste places from Virginia to Nova Scotia. The tops are gathered before flowering and are used in the fresh condition, or they are dried.

DESCRIPTION.—Usually cut into pieces; branches alternate, pentangular, 2 to 3 mm. thick; externally dark green, with 5 yellowish-green wings and numerous reddish-brown cork patches, the younger branches somewhat pubescent; fracture short, fibrous, or of the larger pieces, tough, splintery; internally yellowish, bark thin, wood slightly porous, pith large, about 1 mm. in diameter. Leaves elliptical, obovate, simple above, 5 to 10 mm. long, 3 to 4 mm. broad, digitately trifoliate below; apex of both leaves and leaflets acute; base acute; margin entire; upper surface dark green, nearly glabrous; under surface slightly pubescent; petiole wanting in the simple leaves and about 5 mm. long in the compound leaves, pubescent. Odor peculiar. Taste bitter.

CONSTITUENTS.—A volatile liquid alkaloid sparteine (0.03 per cent.), forming crystalline salts, the sulphate of which has physiological properties similar to digitalin; a yellow crystalline principle scoparin, which yields picric acid on treatment with nitric acid; volatile oil; tannin; ash about 5 per cent.

ALLIED PLANTS.—Several plants of the Leguminosæ are used like Scoparius. Spanish broom is obtained from *Spartium junceum*, a shrub indigenous to the Mediterranean region. *Coronilla scorpioides* yields a yellow glucoside coronillin.

CHIRATA.—The entire plant of *Swertia Chirata* (Fam. Gentianaceæ), an annual herb (p. 362) indigenous to the mountains of Northern India. The plants are collected after the capsules are fully formed, dried and made into bundles.

DESCRIPTION.—Usually in flat bundles tied with a strip of bamboo and about 1 M. long, 15 cm. wide and 7 cm. thick. Root simple, tapering, about 7 mm. thick near the crown; externally yellowish-brown, wrinkled, with few rootlets; internally, bark whitish, about 2 mm. thick, wood yellow, porous, radiate. Stem cylindrical, flattened, quadrangular above, each angle with a decurrent wing, about 1 M. long, 4 to 6 mm. thick, yellowish- or purplish-brown, longitudinally wrinkled, internodes 3 to 8 cm. long; internally, bark yellowish-brown, very thin, easily separable, wood yellowish, slightly porous, radiate, 0.5 to 1 mm. thick, pith lemon-yellow, 2 to 3 mm. in diameter, easily separable from the wood, sometimes wanting. Leaves opposite, ovate-lanceolate, about 6 cm. long, 2.5 cm. in diameter; apex acuminate; base somewhat amplexicaul; margin entire; upper and under surfaces brownish-green, midrib prominent and with 3 to 7 parallel lateral veins. Inflorescence a large panicle; flowers numerous, regular; calyx about 4 mm. long and with 4 lanceolate divisions; corolla yellow, rotate, about 10 mm. long, with 4 lanceolate lobes, each with a pair of nectaries near the base; stamens 4, inserted at the base of the corolla tube; style slender, with two recurved stigmas; ovary 1-locular, with 2 parietal placentas. Fruit a superior, ovoid, pointed, yellowish-brown, bicarpellary, unilocular capsule. Seeds numerous, anatropous, somewhat oblong, flattened, about 0.5 mm. long, testa reticulate; embryo small, straight, embedded in the endosperm. Odor slight. Taste extremely bitter.

Constituents.—A bitter glucoside chiratin, which is precipitated by tannin and yields on hydrolysis two bitter principles: ophelic acid and chiratogenin, the latter being insoluble in water. Ophelic acid is a brown hygroscopic substance which is readily soluble in water and alcohol and heating with Trommer's reagent causes the deposition of yellowish cuprous oxide. The drug also contains resin, tannin and 4 to 8 per cent. of ash.

Allied Plants.—Other species of *Swertia*, as well as other bitter plants known in India as "chiretta," find their way into the market, but are, however, easily distinguished from the true drug.

SCUTELLARIA.—SKULLCAP.—The dried herb of *Scutellaria lateriflora* (Fam. Labiatæ), a perennial herbaceous plant growing in wet places in the United States and Canada. The plant blooms from July to September, when the herb should be collected (p. 368, Fig. 180).

Description.—Stem quadrangular, 1 to 4 mm. in diameter, varying in color from yellowish-green to purplish-red, mostly glabrous below and hairy above. Leaves ovate, ovate-oblong, or ovate-lanceolate, opposite, 1.5 to 8 cm. long, 0.5 to 2.5 cm. broad; apex acute or acuminate; base acute, rounded or sub-cordate; margin coarsely serrate; upper surface dark green, glabrous; under surface light green, nearly smooth, veins of the first order diverging at an angle of 65°, curving upward and anastomosing near the margin; petiole 2 to 10 mm. long. Flowers axillary and solitary above or in 1-sided racemes; calyx campanulate, toothed, about 2 mm. long; corolla white or blue, about 6 mm. long, the limb 2-lipped; stamens 4, didynamous, hairy, the anthers of the upper pair with 2 pollen sacs, the lower with one; style unequally 2-cleft and ovary deeply 4-parted. Fruit consisting of 4 ellipsoidal, distinctly tuberculate, light brown nutlets about 1 mm. long, borne on an enlarged torus known as the gynobase, and enclosed by the persistent bilabiate calyx, the upper part of which becomes helmet-shaped after fertilization, whence the name "Skullcap." Odor slight. Taste bitter.

Constituents.—A bitter crystalline glucoside scutellarin; a small quantity of volatile oil, of which little is known.

Allied Plants.—Several species of Scutellaria growing in the United States are sometimes substituted for the official drug, nearly all of which have the flowers in terminal panicled racemes. Heart-leaved skullcap (*Scutellaria cordifolia*) is densely glandular pubescent, even the corolla being hairy; Hairy skullcap (*S. pilosa*) is pubescent below, with numerous glandular hairs above, and the corolla is nearly glabrous; Hyssop skullcap (*S. integrifolia*) has linear entire upper leaves; in Marsh skullcap (*S. galericulata*) the flowers occur in the axils of the nearly sessile, narrow leaves. The European skullcap (*S. altissima*) has broad, ovate, glabrous leaves and terminal panicles of blue flowers.

Substitutes.—*Scutellaria canescens*, a plant growing west of the Mississippi, furnishes much of the drug on the market. The plant is more robust than *S. lateriflora;* the leaves are oblong, petiolate, 10 to 12 cm. long, 3 to 5 cm. broad, very hairy on the under surface, with prominent veins, and crenate-dentate margin; and the flowers are large, blue and in terminal racemes.

VII. EXUDATIONS, JUICES AND OTHER PLANT PRODUCTS.

A large number of substances are used in medicine which represent to a greater or less extent the constituents of the cells or alteration or decomposition products of them. These include exudations, inspissated juices, extracts, products of distillation, etc. The exudation products of milk-vessels or secretion reservoirs are eliminated either through natural or artificial wounds of the stem, and they are collected in special receptacles, as in the case of gamboge, scammony and turpentine; or they are allowed to dry and more or less harden on the stem, afterward being collected, as acacia and tragacanth; or the more or less plastic or partially dried exudation may be made into masses, as those of lactucarium and opium. These products may be grouped according to their origin, some of them being derived from the Coniferæ:

1. Natural Exudations.

Carbohydrates	Gummy exudations	Acacia
		Tragacantha
	Saccharine exudation	Manna
Resinous products	Balsam	Styrax
	Balsamic resin	Benzoin
	Oleo-resins	Terebinthina
		Terebinthina canadensis
	Gum-resins	Asafetida
		Cambogia
		Myrrha
		Scammonium
	Resins	Guaiacum
		Mastiche
		Pix burgundica
Milk-juices		Elastica
		Lactucarium
		Opium

2. An Excrescence.

Formed as a result of the puncture of an insect............................Galla

3. Artificially Prepared Products.

Carbohydrates—Starch grains		Amylum
Non-carbohydrates	Extract	Gambir or Catechu
	Inspissated juices	Aloe
		Kino
Product of destructive distillation		Pix Liquida
Residue from the distillation of turpentine		Colophony

For convenience in study, as well as identification, the drugs of this class may also be grouped as follows:

I. Solid.

1. In powder form.

    White, inodorous, nearly tasteless.................... Amylum

2. In tears and masses.

    A. More or less spherical in form.

    a. In tears.

    Whitish or yellowish-white, mucilaginous..... Acacia
    Pale yellowish or greenish-yellow, resinous... Mastiche

    b. Excrescence.

    Somewhat spherical .... Galla

    B. In cylindrical pieces.

    Grayish orange-brown .... Cambogia
    Blackish-brown (see seeds)..................... Guarana

    C. In cubes.

    Dull reddish-brown .... Gambir

    D. In quadrangular pieces, one side convex.

    Dull reddish- or grayish-brown, odor opium-like .... Lactucarium

    E. In three-sided elongated pieces.

    Yellowish-white, odor of maple sugar............. Manna

    F. In bands.

    Whitish or pale-yellowish, mucilaginous...... Tragacantha

    G. In angular fragments.

    Whitish, inodorous and nearly tasteless........... Amylum
    Amber-colored, odor terebinthinate.... Colophony (Resina)
    Small, dark, reddish-brown, brittle, astringent pieces.. Kino
    Greenish-gray or brownish-black, odor peculiar .... Scammonium

    H. In rounded masses.

    Grayish-brown, odor distinct, heavy................ Opium

    I. In irregular masses.

    Orange-brown to blackish-brown, odor distinct, taste bitter .... Aloe
    Dark reddish-brown, astringent.................. Catechu
    Brownish-black, elastic .... Elastica
    Greenish-brown, odor balsamic.................. Guaiacum
    Reddish-brown or yellowish-brown, odor terebinthinate .... Pix Burgundica

I. Solid.—*Continued.*

J. In irregular masses composed of matrix and tears.

Whitish tears, matrix yellowish-brown or brownish-gray, odor alliaceous................Asafetida
Yellowish-brown tears, matrix reddish-brown, odor balsamic ....Benzoinum

K. In masses composed of tears.

Brownish-red or yellowish-brown, balsamic........Myrrha
Yellowish, terebinthinate ....Terebinthina

II. Liquid or Semi-Liquid.

Blackish-brown, empyreumatic and terebinthinate.......Pix Liquida
Grayish, balsamic.......................................Styrax
Pale yellowish, transparent, terebinthinate..Terebinthina Canadensis

AMYLUM.—STARCH.—The starch grains obtained from the grains of wheat (*Triticum sativum* and its varieties), corn (*Zea Mays*, p. 228) and rice (*Oryza sativa*) (Fam. Gramineæ). The grains are separated from the cells, purified in various ways, and subsequently washed with large quantities of water. In the U. S. Pharmacopœia corn starch alone is recognized.

In the preparation of corn starch the corn grains are softened by being placed in running water and kept at a temperature of about 60° C. for several days, care being taken to prevent any fermentation. The grains are then crushed between burr-stones and the paste carried by means of water to large sieves, the strained magma then being reground and carried to sieves made of bolting cloth. The milky-fluid containing the starch is then run into settling vats, the starch separating out. The starch is then freed from oil, albuminoids and other substances by treating it with a 15 per cent. solution of caustic soda. The supernatant liquid is removed and the starch washed with water to remove all traces of alkali. The starchy mixture is allowed to stand, when the starch separates out and is dried. Commercial starch is likely to contain some free alkali, which is readily detected by the addition of an aqueous solution of fuchsin, which becomes decolorized immediately in the presence of a starch containing free alkali.

Corn Starch.—In fine powder or irregular, angular, white, inodorous, tasteless masses; grains somewhat spherical, but usually polygonal, with a lenticular, circular or triangular point of origin of growth, about 10 to 25 μ in diameter (Fig. 316, *D*). Corn starch grains differ in structure in the different varieties (p. 229).

Wheat Starch.—Usually in a fine powder consisting of nearly spherical or ellipsoidal grains with point of origin of growth and lamellæ more or less indistinct, about 15 to 40 μ in diameter (Fig. 316, *C*).

Rice Starch.—Usually in a grayish-white powder consisting of minute angular grains about 5 to 8 μ in diameter and with point of origin of growth and lamellæ indistinct.

Starch is insoluble in cold water or alcohol, but forms a white jelly when boiled with water, which, when cool, gives a deep-blue color with iodine and should give a neutral reaction to litmus paper (commercial cornstarch is usually alkaline); ash not more than 1 per cent.

Structure of Starch Grains.—See Figs. 96, 97, 316, 317.

Composition of Starch Grains.—See p. 162.

ACACIA.—GUM ARABIC.—A dried, gummy exudation from the stem and branches of *Acacia Senegal* and probably other species of *Acacia* (Fam. Leguminosæ), trees (Fig. 153) growing in sandy soil and forming forests in tropical Africa (p. 294). The gum exudes spontaneously from the bark of the tree and is apparently formed by the action of a ferment on the cell-contents as it does not contain any remains of cell walls. The trees are also incised, which increases the production of gum. The more or less hardened pieces are collected and then sorted into different grades, the market supplies being obtained from Egypt by way of Alexandria (Kordofan gum), from the Soudan by way of Suakin ("Turkey sorts" and "Trieste picked"), and from Senegambia by way of the port of St. Louis. The Kordofan gum is considered to be the best.

Description.—In roundish tears of variable size, or broken into angular fragments; externally whitish or yellowish-white, with numerous minute fissures; translucent; very brittle, with a glass-like, sometimes iridescent fracture; nearly inodorous; taste mucilaginous.

Acacia is not soluble in alcohol, but is completely soluble in cold water; the solution is adhesive, gives an acid reaction with litmus paper, 10 c.c. of a 10 per cent. solution does not yield a gelatinous precipitate with 0.2 c.c. of normal lead acetate test solution, but is precipitated with 0.1 c.c. of a test solution of ferric chloride (Mesquite gum is not precipitated); a cold solution does not give a bluish or reddish color with iodine (absence of artificial gums containing starch or dextrin), or a brownish-black precipitate with ferric chloride (absence of gum of Australian species). A 10 per cent. aqueous solution of acacia when examined by the polariscope should show but a slight lævoration.

The powder contains few or no altered or unaltered starch grains or vegetable tissues.

Constituents.—A crystalline glucoside, which is apparently arabic acid (arabin or gummic acid) in combination with calcium, magnesium and potassium, and which constitutes the greater part of the gum; water, 12 to 17 per cent.; ash 2.7 to 4 per cent.

Allied Plants.—The best grade of gum Arabic (gum Senegal) is obtained from *Acacia Senegal* and *A. glaucophylla,* both of tropical Africa. Gums with a brown or red color are obtained from *A. arabica, A. Seyal, A. stenocarpa* and *A. Ehrenbergiana.* There are a number of gums which have many of the properties of gum Arabic, as Cape gum, from *A. horrida* and *A. Giraffæ;* Australian or wattle gum, from the golden wattle (*A. pycnantha*), tan wattle (*A. decurrens*) and *A. homalophylla.* Gums are also obtained from other genera of the Leguminosæ, as Mesquite gum, from *Prosopis juliflora,* of the Southern United States and Mexico.

Ghatti gum or Indian gum is an exudation from the wood of *Anogeissus latifolia* (Fam. Combretaceæ) a tree indigenous to India and Ceylon. It occurs in yellowish-white tears with a dull rough surface and a vitreous fracture. It is entirely soluble in cold water, forming a very viscous mucilage.

An artificial gum has been prepared by heating starch with sulphuric acid in an autoclave, the resulting product being neutralized, washed and then dried. It is said to resemble acacia in appearance and adhesiveness.

The powder, while sometimes adulterated with dextrin and rice starch, is more frequently mixed with inferior gums, especially the Mesquite gum. The tears of Mesquite gum are nearly smooth, light yellowish-brown to dark-brown, more or less opaque, but translucent and glassy when fractured. The powder is of a whitish or grayish-white color. The gum is further distinguished by not giving precipitates with lead sub-acetate, ferric chloride and sodium borate. Mesquite forms an adhesive mucilage and can be used as an emulsifying agent.

MASTICHE.—MASTIC.—The dried, resinous exudation from *Pistacia Lentiscus* (Fam. Anacardiaceæ), a large shrub (p. 321) indigenous to the Mediterranean region. The resin exudes through incisions made in the bark, and when dry is collected. The chief source of supply is the island of Scio.

Description.—Somewhat globular or ovoid tears 3 to 7 mm. long, pale yellow or greenish-yellow, translucent, having a glass-like luster, comparatively free from a whitish dust; brittle; fracture conchoidal, becoming plastic when chewed; odor slight, balsamic; taste mild, terebinthinate.

Mastic is completely soluble in ether, acetone and volatile oils. It is almost completely soluble in alcohol, the solution giving an acid reaction with litmus paper.

Constituents.—About 90 per cent. of a resin, consisting of α-resin (mastichic acid), which is soluble in alcohol, and β-resin (masticin), which is insoluble in alcohol; a volatile oil, 1 to 2.5 per cent., with the balsamic odor of the drug and consisting chiefly of d-pinene. A small quantity of a bitter principle is also present, which is soluble in hot water and is precipitated by tannin.

Sandarac (p. 81) is a resin which somewhat resembles mastic. It occurs in pale yellow, cylindrical tears which are brittle and not plastic on being chewed. It is soluble in alcohol and ether, and only partially soluble in chloroform, oil of turpentine and carbon disulphide. Sandarac consists chiefly of resin which is composed of sandaracinic acid, sandaracinolic acid, sandaracopimaric acid, small quantities of two other resin acids, and sandaracoresene. It also contains about 1 per cent. of volatile oil which is composed principally of pinene.

Allied Plants.—Various other species of Pistacia found in India and Northern Africa yield resins resembling mastic. American mastic is obtained from the Peruvian Peppertree (*Schinus*

Molle). Similar resins are found in other genera of the Anacardiaceæ, as *Astronium* and *Semecarpus*.

Chios Turpentine is a product resembling mastic which is obtained from *Pistachia terebinthinus* (Fam. Anacardiaceæ) and consists of 10 to 12 per cent. of a volatile oil (consisting chiefly of pinene) and 80 to 90 per cent. of resin.

GALLA.—NUTGALL.—An abnormal development on the young twigs of *Quercus infectoria* (Fam. Cupuliferæ), due to the puncture and presence of the deposited ova of a Hymenopterous insect, *Cynips tinctoria*. The galls are collected before the maturing of the insect, and are obtained principally from Aleppo, in Asiatic Turkey (p. 252).

Aleppo Galls.—Somewhat spherical, 1 to 2 cm. in diameter; externally grayish-brown or dark grayish-green, more or less tuberculate above, the basal portion nearly smooth, and contracted into a short stalk, sometimes with a perforation on one side; heavy; fracture horny; internally yellowish or dark brown, consisting of a central portion which contains starch, and occasionally the partly developed insect, and an outer zone which is porous, lustrous and occasionally traversed by a radial canal, these two zones being separated by a layer of nearly isodiametric stone cells or parenchyma cells with thick cellulose walls; odor slight; taste strongly astringent.

Constituents.—The principal constituent is tannic acid, which is found to the extent of 50 to 70 per cent.; the drug also contains gallic acid 2 to 4 per cent., starch and resin.

Tannic acid (gallotannic acid or digallic acid) is a yellowish-white amorphous substance, with a characteristic odor and astringent taste. It is soluble in cold water and alcohol; forms amorphous salts; gives a blue color and precipitate with ferric chloride; forms a soluble compound with iodine and prevents the latter from giving the characteristic reaction with starch.

Two classes of tannic acid are recognized, depending on their behavior with iron salts and other reagents: (1) Tannic acid, giving a bluish color with ferric chloride, as that of Aleppo galls, and also found in chestnut (*Castanea*), pomegranate (*Punica*) and sumac (*Rhus*); (2) tannic acid, giving a greenish color with ferric chloride, as that contained in oak barks (*Quercus*), catechu (*Acacia*), kino (*Pterocarpus*), rhatany (*Krameria*), canaigre (*Rumex*), tormentilla (*Potentilla*) and mangrove (*Rhizophora*).

Gallic acid crystallizes in silky needles or prisms which are inodorous and possess a faintly astringent taste. It is sparingly soluble in cold water, but soluble in alcohol; forms crystalline compounds with the alkalies, alkaline earths, lead and copper salts; and gives a bluish-black ppt. with ferric chloride, which is soluble in acetic acid and loses its color on boiling (Fig. 164).

There are three stages in the development of galls corresponding to the development of the insect and during which the composition varies: (1) When the galls are first formed and the larva is beginning to develop, the cells of the outer zone, as well as those of the central zone, contain numerous small starch grains. (2) When the insect reaches the chrysalis stage the starch in the cells near the middle of the galls is replaced in part by gallic acid, while the cells at the center and near the periphery contain masses of tannic acid. (3) When the winged insect is developed nearly all of the cells contain amorphous masses of tannic acid with some adhering crystals of gallic acid. After the insect has emerged from the gall the constituents again undergo change, depending largely on the presence of moisture, when the tannic acid is changd into an insoluble oxidation product and the gall becomes more porous, constituting the so-called white gall of commerce.

Allied Plants.—On a number of species of Rhus, galls due to the stings of certain plant lice (*Aphis*) are formed, as Chinese galls, formed on *Rhus semialata;* Japanese galls, formed on *R. japonica*, and American Rhus galls, formed on *Rhus glabra* (Fig. 164) and *R. hirta*. Chinese and Japanese galls are very rich in tannin, and as they contain less coloring matter than the oak galls are used in the manufacture of gallic acid. They are more or less irregular in shape, but somewhat ovoid, more or less tuberculate, grayish-brown, very hairy, light in weight, brittle. The wall is about 1 mm. thick, and the cavity contains the remains of numerous insects.

American nutgalls are formed on *Quercus coccinea* and *Q. imbricaria* by *Cynips aciculata*. When fresh they are globular, 1.5 to 3 cm. in diameter, and of a yellowish, somewhat mottled color. On drying they become yellowish or dark brown and much shrivelled externally. TEXAS NUTGALLS are formed on the live oak (*Quercus virens*) and yield 40 per cent. of tannic acid. CALIFORNIA OAK BALLS are excrescences on *Quercus lobata* and are about 5 cm. in diameter, and said to contain considerable tannic acid.

Other tannin-yielding plants are found in the following families: Combretaceæ (p. 348), Leguminosæ (p. 292), Myrtaceæ (p. 346).

CAMBOGIA.—GAMBOGE.—A gum-resin obtained from *Garcinia Hanburyi* (Fam. Guttiferæ), a tree (Fig. 168) found growing on the Malabar coast and in Travancore (p. 335). Spiral incisions are made in the bark of the trees, and the gum-resin which exudes is collected in hollow bamboo stems; it is then allowed to dry slowly, after which the bamboo is removed. It is chiefly exported by way of Singapore and is known commercially as pipe gamboge.

DESCRIPTION.—In cylindrical pieces, frequently hollow in the center, of variable length, 2 to 5 cm. in diameter; externally grayish orange-brown, longitudinally striate, due to the ridges on the inner surface of the bamboo canes in which they have been dried; hard; fracture short, the fractured surface being orange-red, waxy and somewhat porous; inodorous; taste very acrid.

The powder is bright yellow, sternutatory, and contains few or no starch grains; not more than 25 per cent. should be insoluble in alcohol. The resin is soluble in solutions of the alkalies, with the production of an orange-red color.

CONSTITUENTS.—Gum allied to arabin, 15 to 20 per cent.; a resin known as cambogic acid, about 75 per cent.; a volatile oil; ash, 1 to 3 per cent.

CAKE GAMBOGE is collected in Saigon and Cochin from the same plant that yields pipe gamboge. The product is, however, collected in leaves and then allowed to dry. It occurs in irregular orange-red masses, weighing 1 to 2 K., and is not so brittle as pipe gamboge, but is less uniform in composition and may contain impurities.

ALLIED PLANTS.—A drastic gum-resin is also obtained from *Garcinia Morella* and other members of the Guttiferæ, of India and Malaya, as *G. collina*, of New Caledonia; *Vismia laccifera*, of Brazil; *Clusia rosea*, of the West Indies and South America, and *Clusia macrocarpa*, of Guiana. Gamboge of a poor quality is obtained from *Arasina Gurgi*, of India.

ADULTERANTS.—Gamboge is sometimes adulterated with vegetable fragments, inorganic substances, as sand, etc., and wheat or rice flour, which it may contain to the extent of nearly 50 per cent.

LACTUCARIUM.—The dried milk-juice of *Lactuca virosa* and other species of *Lactuca* (Fam. Compositæ), biennial herbs (p. 392) indigenous to Central and Southern Europe and cultivated in France, England and Germany, certain species being more or less naturalized in the United States. Lactucarium is obtained by cutting off the tops of the stems; and when the latex which exudes is partially hardened, it is collected and dried in hemispherical earthen cups until it can be cut into pieces, which are usually four in number, these being further dried.

DESCRIPTION.—In irregular, angular pieces or quadrangular sections, one surface of which is convex; externally dull reddish- or grayish-brown; fracture tough, waxy; internally light brown or yellowish, somewhat porous; odor distinct, opium-like; taste bitter.

Lactucarium is partly soluble in alcohol and in ether, and about 50 per cent. is soluble in water, but the solution should not give a reaction for starch.

CONSTITUENTS.—Three bitter principles: lactucin, which occurs in white rhombic prisms that are sparingly soluble in water; lactucopicrin, a brown, amorphous, very bitter principle which is readily soluble in water and alcohol; and lactucic acid, a yellow, very bitter substance crystallizing with difficulty and colored red by alkalies. The drug also contains about 50 per cent. of a colorless, odorless and tasteless crystalline principle, lactucerin (lactucon); α- and β-lactucerol in the form of acetates; volatile oil; mannitol; organic acids, as citric, malic and oxalic, and 7 to 10 per cent. of ash.

A mydriatic alkaloid has been found in *Lactuca virosa* and in *L. muralis*.

MANNA.—The dried, saccharine exudation from the stems of *Fraxinus Ornus* (Fam. Oleaceæ), a small tree (p. 360) indigenous to Southern Europe, where it is also cultivated, particularly in Sicily. Manna is obtained by making transverse or oblique incisions in the bark, the exudation flowing down the side of the tree where it hardens, or it is collected in special receptacles. Several commercial varieties are recognized: LARGE FLAKE manna, consisting of light-colored pieces 10 to 20 cm. long; and SMALL FLAKE manna, which occurs in smaller light yellowish-brown pieces. The former is preferred.

DESCRIPTION.—In irregular, 3-sided, more or less elongated pieces, one side being smooth and concave; externally yellowish-white; friable, somewhat waxy; internally whitish, porous and crystalline; odor suggestive of maple sugar; taste sweet, slightly bitter and acrid.

CONSTITUENTS.—The principal constituent is MANNITOL (80 to 90 per cent.), which crystallizes in colorless needles that are soluble in water and sparingly soluble in alcohol; on sublimation it yields a sweet, syrupy liquid, MANNITAN; the solutions of mannitol do not ferment nor is it decomposed with dilute acids. Manna also contains a green, fluorescent glucosidal principle FRAXIN (resembling æsculin), which occurs in bitter, colorless prisms that are soluble in water and alcohol; dextrose, as high as 16 per cent.; mucilage; resin, and 1.3 to 4 per cent. ash (Fig. 149).

ALLIED PRODUCTS.—A number of other species of Fraxinus indigenous to Europe also yield manna. The term "manna" is applied to a number of exudations obtained from different sources and of varying composition. (See Ebert in *Zeits. allgem. oesterr. Apoth. Ver.*, 46, p. 427, 1908, and *Apoth. Zeit.*, 24, p. 44, 1909). For crystals of mannitol, see Fig. 149, p. 290.

Manna of inferior quality, known as "sorts," is obtained from incisions lower down on the stem, and consists of brownish-yellow, more or less agglutinated tears, which are sticky and but slightly crystalline.

The leaves of a number of species of Eucalyptus (Fam. Myrtaceæ) secrete a manna-like carbohydrate, as *E. Gunnii* and *E. resinifera*. (See in this connection Coniferæ, p. 81; Leguminosæ, p. 292; Myrtaceæ, p. 346.)

TRAGACANTHA.—TRAGACANTH.—A gummy exudation from the stem of *Astragalus gummifer* and other species of *Astragalus* (Fam. Leguminosæ), small shrubs indigenous to Southeastern Europe and Western Asia (p. 294). Some of the walls of the pith and medullary rays are transformed into mucilage (Fig. 274), which exudes spontaneously, but is obtained in commercial quantities by making incisions in the bark, the gum

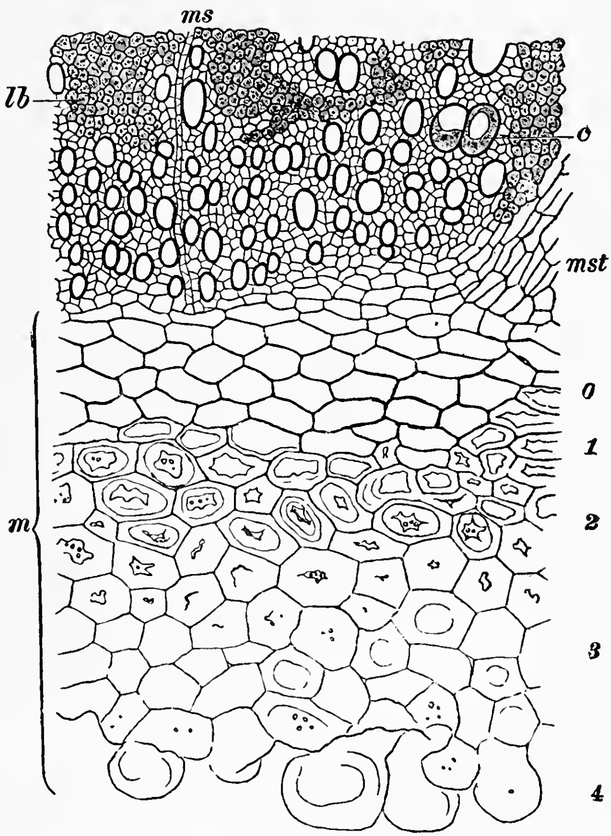

FIG. 274. Cross section through pith (m) and the inner portion of the wood (lb) of *Astragalus gummifer* showing stages in the modification of the cell-walls in the formation of gum tragacanth (0, 1, 2, 3, 4). Some of the tracheæ (c) contain globular masses of gum.—After Tschirch.

being collected after it dries. The principal points of export are Smyrna and various ports along the Persian Gulf; that obtained from the latter is known as Persian or Syrian Tragacanth and is preferred.

PERSIAN OR SYRIAN TRAGACANTH.—In flattened, lamellated, ribbon-like pieces, 0.5 to 2.5 cm. long, about 1 cm. wide and from 1 to 3 mm. thick, irregularly oblong, more or less curved; externally nearly colorless or pale yellowish, with numerous concentric ridges or lamellæ; translucent; fracture short, tough, horny, rendered more easily pulverizable by a heat of 50° C.; inodorous; taste insipid.

CONSTITUENTS.—BASSORIN (traganthin), 60 to 70 per cent., which gives the mucilage made from this gum its peculiar density, and which serves to distinguish it from acacia, which contains little or no bassorin; a carbohydrate apparently in the nature of an insoluble compound of arabic (gummic) acid, which swells in water but is insoluble in it; ARABIN, about 10 per cent., soluble in water and probably formed from traganthin; starch; ash about 3 per cent., of which one-half is calcium carbonate.

A solution of 2 Gm. of gum tragacanth and 100 c.c. of water is neutral in reaction to litmus; gives a blue color with iodine; froths on shaking with an equal volume of a 5 per cent. solution of potassium hydroxide, becoming yellow on heating; darkens slowly when 2 per cent. of powdered borax is dissolved in it in the cold, but does not change in consistency even on standing 2 or 3 days (while Indian gum becomes slimy and stringy).

INDIAN GUM is obtained from *Cochlospermum gossypium* (Fam. Bixaceæ) and is used in India as a substitute for tragacanth. This name is also applied to a gum obtained from *Sterculia urens*, a tree growing in Africa and Australia. The gum occurs in vermiform or rounded tears, with a dull, rough surface and uniform vitreous fracture. For detection in tragacanth, see above.

Ghatti gum is also called Indian gum (p. 644).

SARCOCOLLA is a gummy exudation of *Penæa Sarcocolla* and *P. mucronata* (Fam. Penæaceæ, one of the Myrtifloræ), small shrubs indigenous to Southern and Central Africa. The gum occurs in small, globular, yellowish-red or brownish-red friable grains, which are often agglutinated into masses and admixed with a few hairs. Sarcocolla has a licorice-like taste. It is soluble in water and alcohol, and contains an uncrystallizable principle sarcocollin, having a taste of glycyrrhizin; a resin; and a gum.

COLOPHONY.—ROSIN OR RESIN.—The residue after the distillation of the crude oleo-resin (or turpentine) of *Pinus palustris* and other species of *Pinus* (Fam. Coniferæ), evergreen trees (Fig. 47, *B*) indigenous to the Southern United States (p. 81). There are two commercial varieties of Colophony: (1) one which is amber colored and derived from the oleo-resin of trees tapped for the first time; and (2) a yellowish-red or reddish-brown variety derived from the oleo-resin of trees that have been tapped for a number of years. The former kind is preferred.

DESCRIPTION.—Usually in sharp, angular fragments; translucent, amber-colored, usually covered with a yellowish dust, hard, brittle, pulverizable, fracture shiny and shallow-conchoidal; odor and taste faintly terebinthinate.

Resin has a specific gravity of 1.070 to 1.080, and it is soluble in alcohol, ether, benzol, carbon disulphide, acetic acid, fixed and volatile oils and in solutions of potassium or sodium hydrate.

On heating a small quantity of colophony and neutral methyl sulphate or neutral ethyl sulphate in a test-tube the mixture assumes a rose, then violet and finally a deep violet color.

CONSTITUENTS.—From 80 to 90 per cent. of an anhydride of abietic acid, which on treatment with alcohol is changed into abietic acid, which latter is crystalline; sylvic acid, which is probably a decomposition product of abietic acid; ash, about 1 per cent.

WHITE ROSIN, prepared by agitating melted rosin in water, occurs in whitish, opaque masses, due to inclusion of air.

Rosin is not infrequently used as an adulterant of other resinous products, as of Burgundy pitch and Venice turpentine. A mixture of rosin and oil of turpentine is sometimes substituted for the latter.

RESINS are a class of substances which may be looked upon as final products in destructive metabolism. They result from the oxidation of oils and allied products and usually accompany them, as oleo-resins, gum-resins, etc. They are insoluble in water, soluble in alcohol, acetone, ether and similar solvents, and burn with a yellow flame, forming considerable soot. Several kinds of resins are recognized, depending upon the nature and constitution of their important constituents:

(1) Resinolic Acid Resins include those that contain a large proportion of oxy-acids, which have been obtained in a crystalline condition, as abietic acid in colophony; copaivic and oxycopaivic acids, in copaiba; guaiaconic acid, in guaiac; pimaric acid, in Burgundy pitch and frankincense; and sandaracolic acid, in Sandarac.

(2) Resinol Resins are alcoholic or phenolic resins, a number of which have been crystallized, as benzoresinol, from benzoin; storesinol, from styrax; gurjuresinol, from gurjun balsam; and guaiacresinol, from guaiac resin.

(3) Resinotannol Resins are aromatic derivatives that behave towards iron salts and some other reagents like tannin and yield picric acid on oxidation with nitric acid. The following have been isolated: Aloeresinotannol, from aloes; ammoresinotannol and galbaresinotannol, from ammoniac; peruresinotannol, from balsam of Peru; siaresinotannol and sinnaresinotannol, from benzoin; and toluresinotannol, from balsam of tolu.

(4) Resene Resins form a group of resins which appear to be associated with bitter principles. They are insoluble in alkalies and with difficulty acted upon by reagents. They include alban and fluavil, from gutta percha; copalresene, from copal; dammaresene, from dammar; dracoresene, from dragon's blood; olibanoresene, from olibanum.

(5) Glucoresins or glucosidal resins, as the resins of jalap (p. 452) and scammony (p. 657).

Resins occur in 33 families of the Spermophytes.

KINO.—MALABAR OR EAST INDIAN KINO.—The inspissated juice of *Pterocarpus Marsupium*, and probably other species of Pterocarpus (Fam. Leguminosæ), trees (p. 294) indigenous to Southern India and Ceylon. The juice exudes through incisions made in the bark, and is allowed to dry in the sun. The drug is exported from Madras and is known as Malabar or East Indian Kino.

Description.—Small, angular, opaque, black or reddish-black, translucent, glistening, brittle pieces, nearly free from dust; the thin laminæ appearing transparent and ruby-red at the edges; inodorous; sweetish, very astringent and adhering to the teeth when chewed, the saliva being colored red.

Kino is entirely soluble in alcohol, only partly soluble in cold water, and not less than 80 per cent. should be soluble in boiling water, the solution having an acid reaction.

Constituents.—Tannin, 40 to 80 per cent., which resembles catechutannin and gives a blackish-green color and precipitate with ferric chloride, a violet color with ferrous salts, and the aqueous solutions of which deposit on exposure to air an insoluble, amorphous, reddish substance, kino red; 1.5 per cent. of kinoin, a colorless, crystalline substance, which is sparingly soluble in water and yields on hydrolysis, kino red. Kino also contains a small quantity of catechol (pyrocatechin), kino red, gallic acid, resin, gum, pectin, 13 to 15 per cent. of moisture; and yields 2 to 6 per cent. of ash.

Allied Products.—The term kino is applied to various astringent plant juices which, while they contain large amounts of tannin, do not appear to be as valuable as either the Malabar or Australian kino.

Allied Plants.—Australian kino (Red gum or Eucalyptus gum) is obtained from *Eucalyptus rostrata* and other species of Eucalyptus. It occurs in masses or small fragments, which are of a ruby or garnet-red color (not reddish-black), somewhat dusty, but not so brittle as Malabar kino. It contains 45 to 50 per cent. of tannic acid; kino red, and catechin. About 80 to 90 per cent. is soluble in cold water, the solution having a neutral reaction. Australian kino seems to be more unstable than Malabar kino and is converted into insoluble kino red, particularly if not thoroughly dried.

Eucalyptus kino is also obtained from the following species: Iron-bark tree (*E. Leucoxylon*), *E. Gunnii, E. obliqua, E. piperata, E. ficifolia, E. stellutata, E. macrorhyncha, E. amygdalina radiata.* Several species of *Angophora* yield a kino which is wholly soluble in alcohol and is entirely free from gum. So-called Botany Bay (Australian) kino was at one time supposed to be obtained from *Eucalyptus resinifera.*

Jamaica kino is obtained from *Coccoloba uvifera* (Fam. Polygonaceæ. A number of other India species of *Pterocarpus* also furnish kino. An African or Gambia kino is obtained from *P. erinaceus,* of Senegambia.

BUTEA or BENGAL kino is obtained from *Butea monosperma*, a tree growing in Western India and Farther India.

American DRAGON'S BLOOD, resembling black kino, is obtained from *P. Draco*, of the West Indies and Guiana. A false dragon's blood is obtained from *Copaiba Mopane*, of Southwestern Africa.

A tannin resembling kino is obtained from the Jambul tree (*Syzygium Jambolana*), of India. Tannin is also found in the root bark of *Jambosa vulgaris*, of the East Indies; the bark of *Myrtus brabantica*, of Mexico and Peru. A tannin and a coloring principle are found in the bark of *Myrtus Arayan*, of Mexico and Peru. A tannin and resin are found in the bark of *Psidium Guajava*, of South America and the West Indies; *Spermolepis gummifera*, of New Caledonia, and the Myrtle tree (*Myrtus communis*), of Southern Asia and the Mediterranean region, the tannin in the latter plant occurring in larger proportion in the galls which are produced upon it.

SCAMMONIUM.—SCAMMONY.—A gum-resin obtained by incising the root of *Convolvulus Scammonia* (Fam. Convolvulaceæ), a perennial, twining herb (p. 366) indigenous to Syria, Asia Minor and Greece. The incisions are made in the upper part of the root in June, and the exuding gum-resin is collected in mussel shells, the product from a number of roots being mixed together, after which it is allowed to dry. The principal points of export are Smyrna and Aleppo. The natural exudation free from extraneous matter is known as native or VIRGIN scammony.

SMYRNA SCAMMONY.—In circular, flattened cakes, 10 to 12 cm. in diameter and about 1 cm. in thickness, or irregular, angular pieces of variable size; greenish-gray or brownish-black, often covered with a grayish-white powder, formed by the rubbing of the pieces against one another in transportation; very brittle; fracture sharp; internally porous, lustrous and of a uniform brownish-black color, being more or less translucent in thin fragments; odor peculiar, somewhat cheese-like; taste slightly acrid.

Scammony is easily powdered and forms a milky emulsion with water. It does not effervesce on the addition of diluted hydrochloric acid (absence of calcium carbonate); an alcoholic solution is not colored blue on the addition of tincture of ferric chloride (absence of guaiac resin); ether dissolves not less than

70 per cent. (distinction from jalap resin), and when the residue on evaporation of the ethereal solution is dissolved in a hot solution of potassium hydrate it is not reprecipitated on the addition of diluted sulphuric acid. The saponification value of genuine scammony resin is from 238 to 240.5.

CONSTITUENTS.—From 75 to 95 per cent. of a glucosidal resin (scammonin), which is completely soluble in ether; gum, 5 to 8 per cent.; ash, not more than 3 per cent. SCAMMONIN is apparently identical with the resin in *Ipomœa orizabensis* and the ether-soluble resin in jalap. It occurs as a white powder, which on treatment with alkalies yields the glucoside SCAMMONIC ACID. The latter on hydrolysis decomposes into scammonolic acid and glucose. An anhydride of scammonolic acid, SCAMMONOL, some valerianic acid and sugar are formed on treating scammonin with mineral acids. The peculiar cheese-like odor of the resin is due to the formation of a volatile, fatty acid during the drying process.

ADULTERANTS.—Scammony is adulterated with inorganic substances, various starchy products, foreign resins, such as guaiac, and an extract of the juice of the root of *Convolvulus althæoides,* a plant indigenous to the countries of the Mediterranean.

Mexican scammony resin is obtained from *Ipomœa orizabensis* (yield 16 per cent.). The saponification value is about 186.

MONTPELLIER SCAMMONY is the natural exudation of *Marsdenia erecta* (Fam. Asclepiadaceæ), a plant indigenous to Southern Europe. It contains 50 to 60 per cent. of starch, 10 to 21 per cent. of resin, and yields 11 to 18 per cent. of ash.

SCAMMONY ROOT is official in the British Pharmacopœia. It is the dried root of *C. Scammonia,* and occurs in large, nearly cylindrical, spirally twisted pieces from 2.5 to 7.5 cm. in diameter; externally it is yellowish-gray or brownish-gray and is longitudinally furrowed; the fracture is coarsely fibrous from the presence of projecting wood fibers; internally it is whitish-gray, with the collateral fibrovascular bundles in radial rows forming concentric circles, the phloem of each containing numerous dark resin cells; the odor is like that of jalap, and the taste is first sweetish and then acrid. Scammony root contains about 5 per cent. of the glucoresin, scammonin; starch, and a sugar. It is used in the preparation of an alcoholic, resinous extract, known as

Scammoniæ Resina, which occurs in brownish, translucent pieces that are brittle, shiny on the broken surfaces, fragrant and acrid. It does not form an emulsion with water (distinction from the natural resin), and is readily soluble in ether, consisting almost entirely of scammonin.

OPIUM.—The dried milk-juice of the capsules of *Papaver somniferum* (Fam. Papaveraceæ), an annual herb (Fig. 147), probably indigenous to Asia (p. 280), and now cultivated in Asia Minor, China, India, Persia and European Turkey. Experiments have been made both in this country and Europe to cultivate the opium poppy, but so far these experiments have been unprofitable. Opium is obtained by making transverse, oblique or longitudinal incisions in the unripe capsule (Fig. 91); the latex which exudes is collected when partly dry and made into a mass. The latter is enclosed in a covering of rumex or poppy leaves and further dried, subsequently being packed in bags with rumex berries to prevent the masses from sticking together. While there are a number of varieties of opium, that used in this country is principally from Turkey and is exported chiefly from Smyrna and Constantinople. There are two principal kinds of Smyrna opium, namely, Karahissar, which occurs in spherical, somewhat flattened masses, and Balukissar, which is in the form of flattened, plano-convex masses, both kinds being wrapped in poppy leaves, packed with Rumex seeds, and yielding about 13 per cent. of morphine.

Turkey Opium.—In irregular, flattened, more or less rounded masses of variable size and weighing from 250 to 1,000 grammes; externally grayish-brown, covered with remnants of poppy leaves and with occasional fruits of a species of Rumex; internally dark brown, granular, somewhat lustrous, more or less plastic when fresh, but becoming hard and darker on keeping; odor distinct, heavy; taste peculiar, bitter (Fig. 314).

Constituents.—A large number of alkaloids have been obtained from opium and its extracts, some of which are, no doubt, alteration products of the alkaloids naturally occurring in the drug; the most important of these is morphine, which exists to the extent of 5 to 22 per cent., the largest amount being obtained from Turkey opium, the Persian ranking next, and the smallest amount being obtained from Indian opium.

Morphine occurs in rhombic prisms or fine needles, which are nearly insoluble in water or oil of anise, and sparingly soluble in alcohol, and it forms crystallizable salts which are readily soluble in water, the solutions being lævorotatory. On the addition of morphine to concentrated sulphuric acid containing a little potassium dichromate, little or no change is produced at first, but the solution later becomes of a green color. On the addition first of some cane sugar to morphine and then of concentrated sulphuric acid and a little bromine water, the solution becomes purplish-red, changing to violet-blue, blue-green and finally a dingy yellow. Morphine gives a blue color with dilute solutions of ferric chloride, which is destroyed on heating, and it gives an orange or reddish color with nitric acid. On heating morphine in a sealed tube with hydrochloric acid a new salt is formed, known as apomorphine hydrochloride. The latter occurs in minute, nearly colorless, monoclinic prisms, which become greenish on exposure to air and moisture; and the solutions are colored reddish on the addition of dilute solutions of ferric chloride. Pseudomorphine is a crystalline compound that is formed on heating alkaline solutions of morphine with oxidizing agents. It is insoluble in water, alcohol or even dilute sulphuric acid, but is readily soluble in a solution of potassium hydrate (Fig. 338).

Codeine (or methyl morphine) occurs in opium to the extent of 0.5 to 2 per cent. It forms translucent, octahedral crystals or rhombic prisms, which are soluble in alcohol and oil of anise; somewhat soluble in water, and readily forms crystallizable salts. On heating codeine with concentrated sulphuric acid the solution is colored blue. On the addition of concentrated sulphuric acid containing traces of iron or nitric acid to codeine the solution becomes green, changing to blue, a blue precipitate finally separating. Dilute solutions of ferric chloride give a blue color with codeine, which is permanent if the solution be gently warmed. Codeine crystals are colored red with nitric acid, the solution remaining colorless or only becoming yellow on heating. On heating a solution of codeine hydrochloride in an autoclave with zinc chloride, an amorphous, yellowish-gray powder is formed, known as apocodeine hydrochloride, and having the same physiological action as apomorphine hydrochloride (Figs. 332, 333).

Some opium obtained from plants cultivated in France yielded 2.81 per cent. of codeine, while the morphine was but 2.41 per cent. and the narcotine 0.10 per cent.

NARCOTINE (opianine) occurs to the extent of 0.75 to 9 per cent. in opium, chiefly as a free base. It is found in greater amount in Persian and Indian opium than in Turkey opium. It forms colorless, shining, rhombic prisms or needles, that are tasteless, insoluble in water but soluble in alcohol. With concentrated sulphuric acid narcotine is colored greenish-yellow, the solution on heating changing to red and finally violet. It may be converted into a number of compounds, of which hydrocotarnine and vanillin are probably the most interesting (Fig. 339).

PAPAVERINE occurs to the extent of about 1 per cent. and forms colorless needles or prisms, which are partly soluble in water and alcohol, and colored deep purple or violet-blue on warming with sulphuric acid.

THEBAINE (paramorphine) occurs to the extent of 0.15 per cent. in opium. It crystallizes in prisms which are insoluble in water or alkaline solutions, soluble in alcohol, and gives with sulphuric acid a deep red color.

NARCEINE (0.1 to 0.2 per cent.) occurs in silky needles or quadrangular prisms, which are nearly insoluble in cold water and alcohol, and are colored blue with iodine solutions and blood-red with chlorine water and ammonia.

PROTOPINE occurs in monoclinic prisms, which are insoluble in water and sparingly soluble in alcohol, the solution having a bitter taste. Sulphuric acid dissolves protopine with a beautiful blue-violet color, which later becomes dull violet and finally greenish. Protopine is also found in a number of other plants of the Papaveraceæ, as the roots of *Macleya cordata* and *Chelidonium majus;* the rhizome of Sanguinaria, and other plants as well (p. 282).

Of the other alkaloids in opium the following may be mentioned: Codamine, cryptopine, gnoscopine, lanthopine, laudanine, laudanosine, meconine, meconidine and xanthaline.

Opium also contains from 3 to 5 per cent. of meconic acid, which exists in combination with morphine, codeine and other alkaloids. It forms rhombic prisms that are soluble in water and alcohol and give a deep red color to solutions of ferric chloride, which is not altered on the addition of dilute hydrochloric acid.

The yield of ash in Opium is from 4 to 8 per cent.

PERSIAN OPIUM.—Usually in masses weighing about 350 grammes, and internally more or less homogeneous. There are three commercial kinds of Persian opium: (1) Persian green, which is in plano-convex masses that are of a greenish color and with a closely adhering covering of leaf-tissue; (2) Persian white, which is in oblong, cubical masses, that are coated with a layer of closely adhering white paper; (3) Persian red, which is in either oblong, cubical, or truncate, cone-like masses, that are covered with a grayish-white layer and usually wrapped in red paper.

TURKEY OPIUM is produced in various parts of European and Asiatic Turkey, and there are three principal kinds on the market, namely: (1) Malatia opium, which is in the form of ellipsoidal or oblong, flattened cakes, with a closely adhering coating of leaf-tissue, and yields about 10 per cent. of morphine; (2) Salonica opium, which is in the form of long, broad, flattened cakes, coated with leaf-tissue, and yields about 15 per cent. of morphine; (3) Gheve opium, which is obtained from plants with red flowers, occurs in flat, oval masses, wrapped in poppy leaves, and yields 12.5 per cent. of morphine.

EGYPTIAN OPIUM is in flat, nearly square masses, that are covered with poppy leaves, and yields from 3.5 to 7 per cent. of morphine.

INDIAN OPIUM is in flat cakes weighing about 200 grammes, or rounded masses weighing about 2 kilogrammes, wrapped in oiled paper. This variety is sent chiefly to China.

ADULTERANTS.—Opium sometimes contains fragments of the capsules, the pulp of figs and other fruits, tragacanth, starch, and various inorganic substances, as clay, sand, stone, lead piping, lead bullets, etc. While starch is not usually admixed with Turkey opium it is nearly always present in the Persian variety.

ALOE.—ALOES.—The inspissated juice of the leaves of various species of Aloe (Fam. Liliaceæ), perennial succulents (Fig. 130) indigenous to Africa and India and naturalized in the West Indies (p. 237). There are three principal commercial varieties of aloes: (1) Socotrine (and Zanzibar) Aloes, derived from *Aloe Perryi,* and probably other species of Aloe, growing on the island of Socotra and in Eastern Africa, and exported by way of Bombay; (2) Curaçao (and Barbadoes) Aloes, obtained from *Aloe chinensis* and *Aloe vera,* growing in Curaçao and other

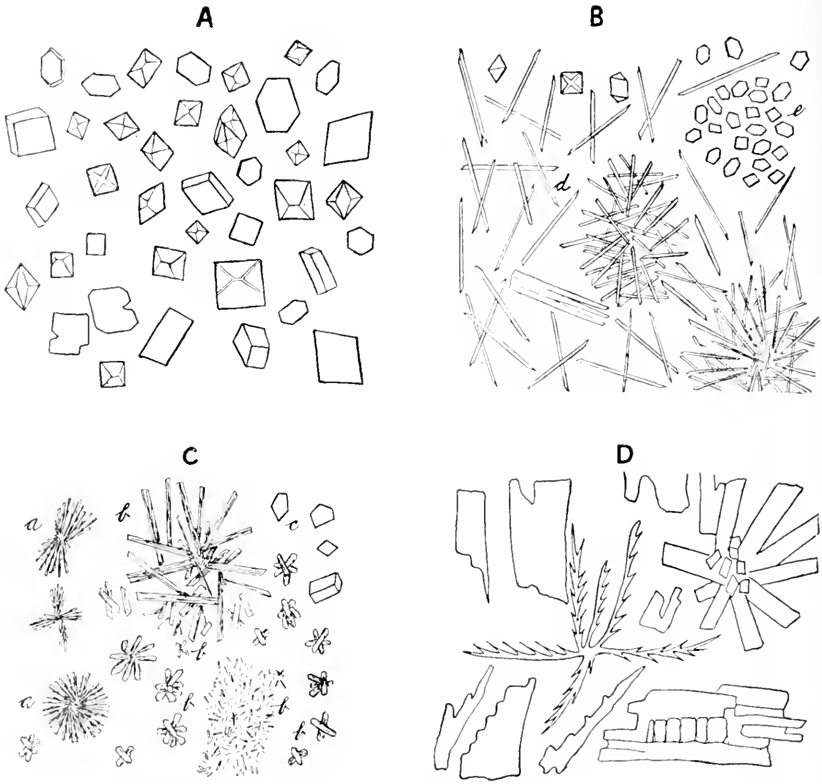

FIG. 275. Crystals from exudations and extracts: A, crystals found in the residue after treatment of catechu with water; B, long prisms of catechin (d) found on treatment of gambir with chloral solution, the crystals soon dissolving, and prismatic plates (e) usually seen in glycerin mounts of gambir; C, crystals from aloes, including aloin (a), broad prisms (b) from Barbadoes aloes, and plates (c) from Cape aloes; D, crystals of benzoic acid obtained by subliming benzoin on a slide or in a watch crystal.

islands of the Dutch West Indies; and (3) Cape and Uganda Aloes, obtained probably from *Aloe ferox,* growing in Southern Africa, and exported from Cape Town and Mossel Bay. The leaves of the Aloe plant are cut transversely and the juice which exudes is allowed to evaporate spontaneously, it being usually, however, concentrated by boiling and then poured into boxes or gourds, and occasionally it is found in commerce enclosed in monkey-skins (Fig. 275). Socotrine aloes commands the highest price. The latter variety when fresh has an unpleasant odor, but on keeping develops an odor resembling myrrh and saffron.

1. SOCOTRINE ALOES.—In yellowish-brown to dark-brown opaque masses, or smooth and glassy, fracture somewhat conchoidal; odor saffron-like; powder yellowish-brown or brownish-yellow, giving a yellowish or reddish-brown color with nitric acid. About 50 per cent. of socotrine aloes is soluble in cold water. It is almost completely soluble in 60 per cent. alcohol or in water at 100° C. On cooling the latter solution there separates from 40 to 60 per cent. of the so-called " resin of aloes," which is soluble in alkalies with a red color and is reprecipitated on the addition of acids. About 36.6 per cent. of aloes is soluble in chloroform, and from 4 to 5.5 per cent. in ether, the solution being of a yellow color. It should contain not more than 8 per cent. of moisture and yield not more than 4 per cent. of ash.

ZANZIBAR ALOES is a hepatic (or liver-colored) variety of Socotrine Aloes, produced by slowly evaporating the juice of the plant. It comes into market frequently in monkey-skins, has a dark brown color, a dull, waxy fracture, and a nearly smooth, even surface. It is crystalline under the microscope and forms a reddish-yellow powder that is colored dark yellow with nitric acid.

2. CURAÇAO ALOES.—Orange to blackish-brown opaque masses, translucent in thin pieces; fracture uneven, waxy, somewhat resinous, occasionally exhibiting microscopical crystals of aloin; odor distinct, unpleasant; taste nauseous, bitter. The powder is dark brown and gives an immediate deep REDDISH COLOR WITH COLD NITRIC ACID or with solutions of the alkalies.

About 70 per cent. of Curaçao Aloes is soluble in cold water. It is almost completely soluble in 60 per cent. alcohol or boiling water; on cooling the solution made with boiling water there separates from 40 to 60 per cent. of " resin of aloes," which is similar to that of Socotrine aloes. About 66.6 per cent. is soluble in chloroform and not less than 10 per cent. in ether. It contains less than 8 per cent. of moisture and yields from 1.5 to 4 per cent. of ash.

Barbadoes Aloes is a hepatic variety of Curaçao Aloes, which is not obtained at the present time from Barbadoes, but from the Dutch West Indies. It occurs in dark brown, dull, opaque masses, giving a yellow powder that is colored red with nitric acid. About 72.4 per cent. of fresh and 62.8 per cent. of old Barbadoes aloes is soluble in chloroform. It contains about 9 per cent. of moisture.

3. Cape Aloes.—Of a reddish-brown or of an olive-black color, transparent in thin pieces; fracture smooth and glassy; powder greenish-yellow, becoming light brown and giving a greenish color with nitric acid.

About 65 per cent. of Cape aloes is soluble in cold water. It is almost completely soluble in alcohol or boiling water; and the latter solution gives a precipitate of 60 per cent. of "resin of aloes." From 81 to 86.8 per cent. is soluble in chloroform, and from 1.5 to 6.5 per cent. in ether. It contains about 9 per cent. of moisture, and yields but a small percentage of ash.

Uganda (or crown) Aloes is a hepatic variety of Cape Aloes prepared by allowing the juice to stand and undergo a partial fermentation, after which the clear liquor is decanted and evaporated by exposure to the sun. It occurs in reddish-brown masses, producing a powder, which is colored yellow to brown with nitric acid.

Constituents.—A crystalline, bitter principle, aloin, the percentage (4.5 to 30 per cent.) and composition of which vary in the different varieties, and which is supposed to occur in largest amount in old aloes; emodin (see Rhubarb); a pale yellow, volatile oil, which is apparently not identical in the different varieties, giving them their characteristic odors; 13 to 63 per cent. of resinous material, which consists chiefly of a resinotannol ester of cinnamic acid (Curaçao and Barbadoes Aloes) or of a resinotannol ester of paracumaric acid (Cape Aloes); and 1 to 4 per cent. of ash.

Aloin is a neutral, bitter principle, which on distillation with zinc dust yields anthracene. It forms minute, lemon-yellow to yellowish-brown acicular crystals, which are sparingly soluble in water but more so in alcohol, the solutions becoming brown on standing. Alkaline solutions of aloin have a deep red color and exhibit a greenish-red fluorescence. Upon the addition of aloin to sulphuric acid a yellowish-red solution is formed, which upon the addition of a small quantity of potassium dichromate is changed to olive-green and finally to a blue color. Ferric chloride gives a brownish-green color to an alcoholic solution of aloin. The amount of aloin varies from 4 to 10 per cent. in Socotrine (Zanzibar) aloes, is about 6 per cent. in Cape (Uganda) aloes and is stated to range from 10 to 30 per cent. in Curaçao (Barbadoes) aloes. The aloin obtained from Curaçao or Barbadoes aloes gives with nitric acid a cherry-red color or with Klunge's reagent a deep red color. These color reactions are due to the presence of about 0.5 per cent. of an isomeric body (isobarbaloin), which is not found in the aloins of Socotrine and Cape Aloes. Alcoholic solutions of barbaloin and isobarbaloin lose their bitterness on standing, the aloin being replaced in part at least by a sugar *aloinose*, which forms yellow crystals that are colored red and then green with concentrated hydrochloric acid and orcin. Aloin is considered by some to be an emodin-glucoside which on oxidation splits off emodin, the latter on further oxidation forming rhein. (See also Fig. 275, C.)

Adulterants.—Aloes formerly contained various mechanical impurities, and this was the reason for the introduction of a purified aloes into the U. S. Pharmacopœia. As heat impairs the quality of aloes and as the requirements forbid adulteration the untreated aloes should be employed. The aloin is sometimes removed, as in the Curaçao aloes, when it has the appearance of Cape aloes and is sometimes sold for it. Recently aloes has been coming into market packed in thin layers separated by paper.

Allied Plants.—Natal Aloes is a hepatic variety of Aloes which was at one time exported from Natal, the botanical origin being unknown. It occurs in grayish-brown or greenish-black, dull, opaque masses, often covered with a brownish powder. The odor somewhat resembles that of Cape Aloes. The powder is grayish-green or pale yellowish-brown and microcrystalline, giving a permanent crimson color with nitric acid and a deep blue with sulphuric acid and vapor of nitric acid. The latter test serves to distinguish this aloes from all the other varieties. The drug contains aloin (nataloin), but not emodin. Both Natal Aloes and nataloin are physiologically inactive.

Jaffarabad Aloes is a vitreous variety obtained from the East Indies and is exported from Bombay. It occurs in circular, flattened cakes, of a deep black color externally, and with a black, glossy, slightly porous or somewhat laminated fracture. It yields 13 to 20 per cent. of aloin, which is apparently chiefly barbaloin, and gives a deep crimson color with nitric acid.

CATECHU.—An extract prepared from the heartwood of *Acacia Catechu* (Fam. Leguminosæ), a tree (p. 294) indigenous to India and Burmah, and from the leaves and twigs of *Uncaria (Ourouparia) Gambir* (Fam. Rubicaceæ), a climbing shrub or liane indigenous to Malacca, Java and Sumatra and mostly cultivated near Singapore, the former being known as "black catechu" or "cutch," and the latter as "pale catechu," "gambir," or "terra japonica." These extracts are prepared by boiling the parts of the trees and shrubs yielding them with water, evaporating the strained liquid to a syrupy consistence and allowing it to harden.

Black Catechu.—In irregular masses, with fragments of leaves or mats upon the outside, dark brown, somewhat shiny; brittle, more or less porous internally; odor slight; taste astringent and sweetish.

Catechu is somewhat soluble in cold water, the undissolved portion containing acicular crystals of catechin and crystals of another substance resembling octahedra (Fig. 275, A), but anisotropic; almost entirely soluble in boiling water, the solution giving an acid reaction, a dense precipitate with copper sulphate and a greenish-black precipitate with dilute ferric chloride solution; not less than 70 per cent. should be soluble in 90 per cent. alcohol. Few or no starch grains or vegetable tissues should be present, and the ash should not be more than 5 per cent.

Gambir or Pale Catechu.—Usually in more or less porous irregular cubes, about 25 mm. in diameter; externally dull reddish-brown; friable; internally paler, consisting chiefly of microscopic crystals when examined in a drop of oil; odor slight; taste bitter and very astringent. The aqueous solution gives an intense green color with dilute ferric chloride and does not yield a precipitate with copper sulphate solution. (See also Fig. 275, B.)

Constituents.—Catechutannic acid, 25 (black catechu) or 22 to 50 per cent. (pale catechu), giving a green color and precipitate with ferric chloride and in other respects resembling the tannin in oak bark, kino and krameria; a substance somewhat resembling gallic acid, catechin, which crystallizes in silky needles; catechu-red; quercetin (p. 544), and ash about 3 per cent. Pale catechu contains in addition a fluorescent principle.

ALLIED PLANTS.—Black catechu is also extracted from the wood of *Acacia Suma,* of India. The barks of a number of species of Acacia growing in Australia, and known as WATTLE BARKS, are used in the preparation of an extract resembling black catechu. The tannin of *Acacia arabica* and of several species of *Cæsalpinia* yield on hydrolysis gallic and ellagic acids.

A tannin resembling catechu is obtained from the bark of *Eugenia Smithii* (Fam. Myrtaceæ), of Australia. A catechu-like extract is obtained from the bark of the Mahogany Tree (*Swietenia Mahogoni*), one of the Meliaceæ, of the West Indies and Peru.

An extract (known as THAN), prepared from *Terminalia Oliveri* (Fam. Combretaceæ), a large tree growing in the dry regions of the Irrawaddy Valley, is used to adulterate Catechu. It contains a dark red coloring principle, but apparently no tannin, although the latter has been reported as occurring to the extent of between 14 and 68 per cent.

Mangrove extract is sometimes sold for catechu (p. 346).

ELASTICA.—CAOUTCHOUC, INDIA-RUBBER.—The latex or milk-juice of *Hevea braziliensis,* and probably other species of Hevea (Fam. Euphorbiaceæ), trees indigenous to Brazil (p. 316). The milk-juice is obtained by making incisions in the bark of the tree and is collected in small cups fastened to the trees. This is then poured into a larger vessel in which is placed a wooden paddle. The latter, with adhering latex, is dexterously revolved in an open fire until coagulated, new material being added from time to time until flask-shaped masses are formed, which are then removed, and constitute the commercial article known as "bolacho." The best grade, known as Para Rubber, is official.

DESCRIPTION.—In elastic flask-shaped masses or pieces of varying form and size; light, floating in water; externally brownish to brownish-black; internally brownish, consisting of a number of thin, alternate light and dark layers, due to the superimposed coats of latex formed during the drying process; odor slight, empyreumatic; nearly tasteless.

Caoutchouc is insoluble in water, dilute acids, or dilute solutions of the alkalies; more or less soluble in chloroform, carbon disulphide, oil of turpentine, benzin and benzol. It melts at about 125° C., remaining soft and adhesive after cooling.

CONSTITUENTS.—Caoutchouc consists chiefly of two hydrocarbons, one of which is ductile and readily soluble in chloroform, and the other elastic and less soluble in chloroform; it also contains 1 to 2 per cent. of resin, volatile oil, etc.

ALLIED PLANTS.—AFRICAN rubber is obtained from several species of *Landolphia* and *Kickxia africana* (Fam. Apocynaceæ). BAHIA rubber is derived from *Hancornia speciosa* (Fam. Apocynaceæ). CENTRAL AMERICAN or PANAMA rubber is obtained from *Castilloa elastica* (Fam. Moraceæ). CEARÁ rubber is the product of *Manihot Glaziovii* (Fam. Euphorbiaceæ). EAST INDIA rubber is the product of the commonly cultivated rubber plant, *Ficus elastica* (Fam. Moraceæ). PENANG or BORNEO rubber is the product of several species of Urceola (Fam. Apocynaceæ).

VULCANIZATION OF RUBBER.—Caoutchouc retains its elastic and other properties and is not affected by heat if it is first purified and then mixed with sulphur or sulphides. Ordinary rubber articles are prepared in this manner. Hard rubber articles are manufactured from Borneo rubber, to which colophony, gum balata and caoutchouc are added; a number of mineral substances being added to cheapen as well as to color the final product.

GUAIACUM.—GUAIAC RESIN.—A resin obtained from the stem and branches of *Guaiacum officinale*, a small tree growing in Florida, the Antilles and Northern South America, and *Guaiacum sanctum* (Fam. Zygophyllaceæ), indigenous to the West Indies and the northern part of South America. The resin exudes spontaneously or is obtained from incisions in the bark or by heating the fallen trunks. The commercial article comes chiefly from Cuba and Hayti. The resin obtained from trees growing in the Bahama Islands is most highly esteemed (p. 303; Fig. 156).

DESCRIPTION.—Usually in irregular masses; externally greenish-brown, frequently covered with a greenish powder; brittle, the fracture having a glassy luster and being yellowish-green or reddish-brown and more or less transparent in thin pieces; fusible; odor balsamic; taste somewhat acrid.

The powder of guaiac is of a grayish color, but becomes green on exposure to the air, and on heating gives off an odor of benzoin. It is readily soluble in ether, alcohol, chloroform, solutions of the alkalies or chloral hydrate. It is sparingly soluble in benzol, fixed or volatile oils. The alcoholic solution has a brown color, which is changed to blue by the addition of ferric chloride, or oxidizing agents (as chromic acid or ozone) or through the action of chlorine, bromine or iodine. An alcoholic solution of guaiac is colored blue by enzymes. The blue color is destroyed on the addition of reducing substances.

CONSTITUENTS.—Several acids are present, including guaiaconic, guaiaretic, guaiacresin, guaiacinic, and guaiacic. GUAIACONIC acid (alpha resin) occurs to the extent of 50 to 70 per cent., and forms a brown powder which is insoluble in water, soluble in alcohol and gives a blue color with nitric acid and other oxidizing agents; and on dry distillation yields guaiac oil and pyroguaiacin. Recent investigations show that guaiaconic acid consists of two crystalline substances: α-guaiaconic acid and β-guaiaconic acid. The latter crystallizes in rhombohedra and does not give a blue color with oxidizing agents. When a solution of α-guaiaconic acid in chloroform is treated with lead peroxide GUAIAC BLUE is formed, which may be obtained as a blue mass with metallic luster on evaporating the chloroformic solution. On reduction with sulphurous acid it is changed to α-guaiaconic acid. GUAIARETIC acid (about 10 per cent.) occurs in colorless needles and forms crystalline salts with the alkalies. GUAIACRESIN acid occurs in white, shining plates that are soluble in alcohol and give on dry distillation the same products as guaiaconic acid. GUAIACINIC acid (beta resin) occurs as a yellowish-brown powder and yields on dry distillation tiglic aldehyde (dimethyl acrolein). GUAIACIC acid forms colorless needles which are soluble in water, but probably does not occur in the natural product, being in the nature of a decomposition product. Guaiac resin also contains a yellow coloring principle, GUAIAC YELLOW (about 0.7 per cent.), which occurs in light yellow, hard octahedra that are sparingly soluble in hot water and give a blue color with concentrated sulphuric acid; and a light yellow, rather thick ethereal oil (guaiac oil), which cannot be obtained by distillation and possesses a characteristic aromatic odor. Among the other constituents are vanillin and a yellow gum. The yield of ash should not be more than 4 per cent. Guaiac wood yields from 20 to 25 per cent. of resin.

Of particular interest are the decomposition products obtained on heating guaiac resin. On dry distillation the following substances are obtained: Tiglic aldehyde; a colorless, aromatic liquid with the odor of benzaldehyde; guaiac oil; and a crystalline substance, pyroguaiacin, which on distillation with zinc yields guaiacene (an aldehyde of tiglic acid).

PIX BURGUNDICA.—BURGUNDY PITCH.—The resinous exudation of the stems of the Norway Spruce Fir, *Picea excelsa* (Fam. Coniferæ), an evergreen tree indigenous to Europe and Northern Asia (p. 81). The resin is obtained by making incisions through the bark into the wood, the resin exuding and solidifying; it is then collected and purified by melting it in hot water and straining the mixture. The chief supplies of the drug come from Finland, the Black Forest (Germany) and the Jura Mountains. It is doubtful if the commercial supplies have ever been derived from the French province, Burgundy, from which it takes its name.

DESCRIPTION.—Irregular, hard, opaque or translucent pieces, more or less plastic and strongly adhesive, yellowish-brown or reddish-brown, brittle, the fracture shiny, conchoidal; odor agreeably terebinthinate; taste aromatic and sweetish.

Burgundy Pitch is partly soluble in cold alcohol (1 to 20), and almost entirely soluble in boiling alcohol or in glacial acetic acid.

CONSTITUENTS.—Chiefly resin, consisting of two crystallizable resin acids: dextropimaric and lævopimaric acids; a volatile oil (isomeric with oil of turpentine), about 5 per cent., to which its peculiar fragrance is due; and about 10 per cent. or less of water, which is included during the preparation.

ADULTERANTS.—Burgundy pitch is sometimes substituted by various mixtures, as of other coniferous products and palm oil; these are distinguished by being more or less opaque and somewhat porous, and not having the characteristic odor of the genuine article, and also by the formation of a turbid mixture on the addition of two parts by weight of glacial acetic acid.

Allied Plants.—Canada (or Hemlock) Pitch is the oleo-resin of the common Hemlock [*Tsuga* (*Abies*) *canadensis*] which is obtained by making incisions in the trunk and collecting the exudate, or by boiling pieces of the wood and bark and skimming off the melted oleo-resin. It occurs in dark, reddish-brown, opaque or translucent pieces resembling Burgundy Pitch, and probably contains similar constituents.

ASAFETIDA.—A gum-resin obtained from the root of *Ferula fœtida* and other species of Ferula (Fam. Umbelliferæ), perennial herbs (p. 352) indigenous to Eastern Persia and Western Afghanistan. Asafetida is obtained by incising the crown of the root, when the gum-resin exudes, hardens and is then scraped from the root. It is exported by way of Bombay.

Description.—In irregular masses composed of tears, from 1 to 2.5 cm. in diameter, which when fresh are tough, yellowish-white and translucent or milky white and opaque, changing gradually to pinkish and finally reddish-brown, and becoming, on drying, hard and brittle; internally yellowish and translucent or milky white and opaque; odor persistent, alliaceous; taste bitter, alliaceous and acrid.

Asafetida yields a milk-white emulsion when triturated with water, which becomes yellowish on the addition of solutions of the alkalies. Treated with strong hydrochloric acid, the filtrate gives a blue fluorescence on making it alkaline with ammonia water (distinguishing it from ammoniac). The freshly fractured surface gives a greenish color on the application of a few drops of 40 per cent. nitric acid solution (distinguishing it from galbanum). Not less than 40 to 50 per cent. should dissolve in alcohol.

Constituents.—About 60 per cent. of a reddish-brown amorphous resin (consisting of the ferulaic ester of asa-resinotannol), yielding on dry distillation umbelliferone; on treatment with sulphuric acid, resorcin, and on fusion with potassium hydrate, protocatechuic acid; from 3 to 6.7 per cent. of a volatile oil, consisting in part of hexenyl sulphide, hexenyl disulphide, pinene and cadinene, and to which the odor of the drug is due; about 1.28

per cent. of FERULAIC ACID (chemically related to vanillin, eugenol and cinnamic acid), which occurs in iridescent, tasteless, odorless needles and yields on fusion with potassium hydroxide, acetic, oxalic and protocatechuic acids. The drug also contains 0.06 per cent. of vanillin; 0.60 per cent. of free asa-resinotannol, and formic, acetic, valerianic and malic acids; and ash 5 to 10 per cent.

ADULTERANTS.—Asafetida frequently contains fragments of vegetable tissues, red clay, sand and stones; it is sometimes adulterated with dirty white, gritty masses of gypsum, at other times with barley or wheat flour or translucent gums. Recently it has been adulterated with pieces of rose-colored marble.

BENZOINUM.—BENZOIN.—A balsamic resin obtained from *Styrax Benzoin,* and probably other species of Styrax (Fam. Styraceæ), trees (p. 360) indigenous to Java, Sumatra and Siam. The resin flows from incisions made in the bark, hardens, and is then collected, the commercial varieties being known as Siam and Sumatra Benzoin, the former being preferred. The composition of the resin varies according to the age of the tree, the youngest trees yielding the best product. The constituents of the commercial resin are not found in the tissues of the tree, but appear to develop as a pathological product due to an injury of the trees resulting from the manner of incising the bark, although probably the exposure of the resin to the air has an influence on the constituents.

SUMATRA BENZOIN.—In irregular masses composed of yellowish or reddish-brown tears of variable size and a reddish-brown and translucent or grayish-brown and opaque matrix; brittle, the tears internally being milky white; becoming soft on warming, and yielding benzoic acid on sublimation; odor agreeable, balsamic, resembling that of styrax; taste slightly aromatic. About 80 per cent. is soluble in a solution of potassium hydroxide or in 95 per cent. alcohol.

SIAM BENZOIN occurs in concavo-convex tears; it has a vanilla-like odor and is almost completely soluble in solutions of the alkalies or in alcohol; it is further distinguished from the Sumatra variety in not containing cinnamic acid, and therefore does not yield benzaldehyde on boiling an acidulated solution with potassium permanganate.

CONSTITUENTS OF SUMATRA BENZOIN.—About 75 per cent. of a resinous substance, BENZORESIN, which consists of two esters: (a) an ester of cinnamic acid and resinotannol (92.6 per cent), and (b) an ester of cinnamic acid and benzoresinol. Benzoresin on decomposition yields 30.3 per cent. of CINNAMIC ACID, 64.5 per cent. of RESINOTANNOL, which is soluble in a concentrated sodium salicylate solution, and 5.2 per cent. of BENZORESINOL.

Sumatra benzoin also contains traces of BENZALDEHYDE and BENZOL; 0.1 to 1 per cent. of vanillin; 1 per cent. of the phenylpropyl ester of cinnamic acid; 2 to 3 per cent. of styracin (cinnamic cinnamate); and 14 to 17 per cent. of insoluble matter consisting chiefly of woody tissues.

CONSTITUENTS OF SIAM BENZOIN.—It consists largely of a resinous substance, SIABENZORESIN, which is composed of about 90 per cent. of an ester of benzoic acid and siaresinotannol, and about 10 per cent. of an ester of benzoic acid and benzoresinol. SIABENZORESIN on saponification yields 38.2 per cent. of BENZOIC ACID, 56.7 per cent. of SIARESINOTANNOL, and 5.1 per cent. of BENZORESINOL.

Siam benzoin also contains 0.3 per cent. of a neutral AROMATIC LIQUID, which is probably an ester of benzoic acid, the nature of the alcohol not having been determined as yet; 0.15 to 1.5 per cent. of VANILLIN; a small quantity of free BENZOIC ACID, and 1.3 to 3.3 per cent. of impurities in the form of woody tissues. PENANG BENZOIN has an odor of styrax, and in composition resembles Siam benzoin. It contains considerable benzoic acid, and it and PALEMBANG benzoin, also from Sumatra, are a source of benzoic acid.

MYRRHA.—MYRRH.—The dried gum-resin from the stem of *Commiphora abyssinica* and *C. Schimperi* (Fam. Burseraceæ), rather large shrubs indigenous to Northeastern Africa (chiefly Somali Land) and Southern Arabia (p. 310). The gum-resin exudes spontaneously or from incisions made in the bark; it is first of a yellowish color but soon hardens, becoming darker, and is then collected. There are two principal commercial varieties of Myrrh, the one known as African or Somali Myrrh, and the other as Arabian or Yemen Myrrh, the former being considered the better.

DESCRIPTION.—In irregular agglutinated tears or masses of variable size; externally rough and uneven, yellowish- or reddish-brown, covered with a yellowish powder; brittle, the fractured surface waxy, granular, oily, slightly mottled, somewhat translucent in thin pieces; odor balsamic; taste aromatic, bitter and acrid.

Myrrh forms a brownish-yellow emulsion when triturated with water (distinction from other gum-resins); an ethereal solution treated with bromine vapor becomes reddish (distinction from East Indian myrrh); when moistened with nitric acid it becomes purplish (distinction from false myrrh or bdellium); not more than 70 per cent. is insoluble in alcohol.

CONSTITUENTS.—A yellowish or yellowish-green, rather thick volatile oil, 2.5 to 8 per cent., having the characteristic odor of myrrh; resin, 25 to 40 per cent., composed of several constituents, one of which yields protocatechuic acid and pyrocatechin; gum, about 60 per cent., consisting of a soluble and insoluble portion and forming a mucilage that does not readily ferment; a bitter principle, sparingly soluble in water but soluble in alcohol; ash, 5 to 10 per cent.

The volatile oil of myrrh consists of cuminal (about 1 per cent.), eugenol, meta-cresol, pinene, limonene, dipentene and two sesquiterpenes. The acidity of old oil is due to free acetic and palmitic acids.

ADULTERANTS.—Myrrh is frequently admixed with gums and other gum-resins, including several kinds of Bdellium which are obtained from various species of Commiphora, and which are characterized by not giving a purplish color with nitric acid. Of these the following may be mentioned: AFRICAN BDELLIUM, which occurs in yellowish-brown masses, that are reddish in transmitted light and have a pepper-like odor and bitter taste; INDIAN BDELLIUM, occurring in irregular, reddish-brown masses, covered with minute spicules of resin, and having a terebinthinate odor and an acrid taste; and OPAQUE BDELLIUM, which occurs in yellowish, hard, opaque masses, with a faint odor and bitter taste, and the alcoholic solution of which is colored black with ferric chloride. Thin pieces of a bark are frequently present in opaque bdellium.

Bisabol, or East Indian myrrh, is exported from Eastern Africa and Asia; it closely resembles true myrrh, but is distinguished from it by the ethereal solution not becoming reddish with bromine vapor. Furthermore, on mixing 6 drops of a petroleum ether solution (one part of myrrh to 15 of ether) with 3 c.c. of glacial acetic acid and then adding this liquid carefully to 3 c.c. of concentrated sulphuric acid, a rose-colored zone is at first developed, and finally the entire acetic acid solution assumes the same color. With genuine myrrh the solution is colored a very pale rose color.

Allied Plants.—Opopanax is a balsam-like product obtained from *Commiphora Kataf*, a plant indigenous to Arabia, and is supposed to be the Myrrh mentioned in the Bible. It yields from 6 to 10 per cent. of a greenish-yellow volatile oil with a pleasant balsamic odor; and also contains opo-resinotannol (a compound not yielding umbelliferone on distillation) both free and combined with ferulaic acid; free ferulaic acid; vanillin, and a gum containing bassorin.

Mulu Kilavary is a gummy exudation obtained from *Commiphora Berryi*, a plant growing in India. It occurs in yellowish-brown or dark brown translucent fragments, having a conchoidal, oily fracture, and consists chiefly of gum, with a small quantity of a tasteless resin and a volatile oil.

TEREBINTHINA.—TURPENTINE.—An oleo-resin obtained from *Pinus palustris* and other species of Pinus (Fam. Coniferæ), evergreen trees (Figs. 47, 48) indigenous to the Southern United States (p. 81). The oleo-resin is secreted in the sapwood and is obtained by making triangular incisions in the bark and wood in the spring; it flows into cavities (or boxes) made lower down on the trunk, from which it is dipped into barrels or other receptacles. The product of the first year's cutting is of superior quality and is known as "virgin" turpentine. It yields about 15 per cent. of oil of turpentine, while the product of the second or third year yields 10 per cent.

Description.—In yellowish, opaque masses, brittle in the cold; lighter internally, sticky and more or less shiny; odor and taste terebinthinate. One part dissolved in 5 parts of alcohol gives a clear solution having an acid reaction.

Constituents.—Turpentine consists of 70 to 80 per cent. of resin and 15 to 30 per cent. of volatile oil; it also contians a bitter principle and various organic acids, as pinic, sylvic, etc.

Oil of Turpentine is obtained chiefly from the following pines growing in the Southern States: *Pinus palustris, P. glabra, P. cubensis, P. echinata* and *P. Tæda*. The important constituent is the hydrocarbon pinene ($C_{10}H_{16}$), which in the oil from some plants is dextro-rotatory, while in that from other plants it is

Fig. 276. Typical view in the Adirondacks showing the spire-like balsams (*Abies balsamea*) and a single white pine (*Pinus Strobus*).

lævo-rotatory. On allowing a moisture-containing oil to stand exposed to the light, crystals of pinol hydrate separate out in the course of time.

Allied Plants.—Various other species of Pinus yield an oleo-resin resembling turpentine, as *Pinus Tæda*, a tall tree growing in the regions where *Pinus palustris* is found; the yield of oleo-resin from this and other trees is considerably less. *Pinus sylvestris*, or Scotch fir, which is indigenous to the mountains of Europe and Asia and extensively cultivated in this country, is the source of much of the turpentine used in Europe.

Bordeaux turpentine is a product resembling American turpentine, and is obtained from *Pinus maritima* and other species of Pinus growing in Southern France, the resin consisting chiefly, however, of the anhydride of pimaric acid.

Austrian turpentine oil is obtained from *Pinus Laricio,* and apparently consists of dextro-rotatory pinene.

The oil known as French turpentine oil is derived from *Pinus pinaster,* and, while it resembles the American variety, consists entirely of lævo-rotatory pinene.

Pine needle oil is obtained by steam distillation from the leaves of *Pinus pumilio*, a tree of the Tyrolese Alps. It is a colorless oil with an aromatic odor and taste, and contains from 5 to 7 per cent. of bornyl acetate, cadinene, phellandrene, pinene and sylvestrine.

Pine needle oil is also obtained to a limited extent from the Scotch fir (*Pinus sylvestris*). The German product closely resembles the oil obtained from *Pinus pumilio*, as probably also does the Swedish oil, but the English oil is lævo-rotatory.

PIX LIQUIDA.—TAR.—A product obtained by the destructive distillation of the wood of *Pinus palustris* and other species of Pinus (Fam. Coniferæ), evergreen trees (Figs. 47, 276) indigenous to the Southern United States, particularly near the Atlantic Coast and the Gulf of Mexico (p. 81). Tar is obtained by distillation of the wood without access of air, the tarry liquid being separated from the aqueous mixture consisting of wood naphtha and pyroligneous (crude acetic) acid. The amount of tar obtained in the operation varies, depending on how rapidly the wood has been heated. If the wood is heated slowly the yield is about 5 per cent., if rapidly heated it is increased to nearly 10 per cent.

Description.—Semi-fluid, viscid, blackish-brown, non-crystalline, transparent in thin layers, becoming granular or crystalline (due to the separation of pyrocatechin) and opaque with age; odor peculiar, aromatic, taste pungent. Tar is soluble in alcohol, fixed or volatile oils, and solutions of potassium or sodium hydrate; it is heavier than water and slightly soluble in it; the solution is of a pale yellowish-brown color, has an acid reaction, yields with a dilute solution of ferric chloride, a reddish color, with the test-solution, an olive-green color, due to the presence of pyrocatechin (this distinguishing it from Juniper Tar), and is colored brownish-red by an equal volume of calcium hydrate test-solution. The petroleum ether extract is colored greenish by a 0.1 per cent. solution of copper acetate.

CONSTITUENTS.—Tar consists of a resinous substance, with which are admixed a small quantity of turpentine, acetic acid, methyl alcohol and various volatile empyreumatic substances. On distillation 4 distinct classes of products are obtained: (1) An AQUEOUS DISTILLATE, from 10 to 20 per cent., consisting chiefly of acetic acid, methyl alcohol and acetone. (2) A LIGHT OILY DISTILLATE, from 10 to 15 per cent., coming over under 150° C., and consisting of mesit, toluene, xylene, cumene, methene and eupion, which products are used as solvents for varnishes and similar substances. (3) A HEAVY OILY DISTILLATE, about 15 per cent., distilling over between 150° and 250° C., and consisting of the CREOSOTE OILS, viz.: phenol, cresol, creosote, paraffin, naphthalene, pyrene, chrysene, retene and some other substances. (4) A black resinous mass, called PITCH (50 to 65 per cent.) which has the odor of tar and is still official in some pharmacopœias.

In the distillation of pine wood tar the distillate which is lighter than water contains a volatile oil known as OIL OF TAR (Oleum Picis Liquidæ). When recently prepared it is colorless, but it gradually darkens, becoming finally dark reddish-brown, there separating at the same time a blackish, resinous substance. Oil of tar consists chiefly of oil of turpentine, with some of the lighter hydrocarbons and phenol compounds, acetic and other acids, and a number of empyreumatic products.

ALLIED PRODUCTS.—BEECH WOOD TAR is the product of the destructive distillation of the wood of *Fagus sylvatica* and *F. ferruginea* (Fam. Fagaceæ). It is distinguished from pine tar by the petroleum ether extract not giving a green color with copper acetate solution, and in the creosote oils containing a considerable amount of GUAIACOL. The official creosote is a mixture of guaiacol and creosol with some other phenol derivatives, as xylenol, methyl creosol and methyl guaiacol, obtained from the heavy oily distillate of beech wood tar. Guaiacol is of interest because on treatment with chemicals it may be converted into vanillin.

Birch tar is the product of the destructive distillation of the wood and bark of the white birch (*Betula alba*). It is chiefly made in Russia, has a strong, penetrating odor and does not solidify. It is distinguished from beech wood tar and pine tar in not being completely soluble in 95 per cent. acetic acid, and is distinguished from juniper tar by not being entirely dissolved in anilin and in being colored greenish with ferric chloride.

An oily product is obtained in the destructive distillation of the wood of the Prickly cedar (*Juniperus Oxycedrus*), a tree indigenous to the countries bordering the Mediterranean, and is official as oil of cade. It is a brown, viscid liquid with a tarry odor and a pungent, bitter taste. The oil varies in composition and the only constituent that has been isolated is the sesquiterpene cadinene. Of the phenols which it contains nothing is known.

An oil known as Kien oil is obtained by the destructive distillation of the wood of the root of *Pinus sylvestris*. The oil is prepared in Germany, Russia, Finland and Sweden, and consists of d-pinene, d-sylvestrine and in addition, in all except the Swedish oil, dipentene has been determined.

STYRAX.—STORAX.—A balsam obtained from the trunk of *Liquidambar orientalis* (Fam. Hamamelidaceæ), a tree (p. 286) indigenous to Asia Minor and the Levant. The balsam is a pathological product and is produced by bruising the bark of the tree, removing it and then boiling the inner bark in sea-water, the balsam which rises to the surface being skimmed off.

Description.—A viscid, grayish, more or less opaque semi-liquid mass, depositing on standing a heavier, dark brown, oleo-resinous stratum; translucent in thin layers; odor agreeable; taste balsamic.

Storax is insoluble in water; between 60 and 70 per cent. is soluble in warm alcohol, and the residue on evaporation of the alcoholic solution is almost completely soluble in ether, carbon disulphide, or benzol, but insoluble in benzin; the portion undissolved after thorough extraction with boiling alcohol should not be more than 4 per cent. When boiled with a solution of potassium dichromate and sulphuric acid it evolves an odor resembling that of bitter almonds (due to the presence of cinnamic acid);

it forms little or no foam when mixed with an equal volume of alcohol and shaken with ammonia water, indicating the absence of turpentine and fixed oils.

CONSTITUENTS.—Storax consists of about 50 per cent. of two resin alcohols, α-storesin and β-storesin, which are partly free, partly in combination with cinnamic acid and partly with sodium. α-STORESIN (α-storesinol) is an amorphous substance that is very sparingly soluble in water and forms a crystalline compound with potassium. β-STORESIN (β-storesinol) occurs in white flakes which are somewhat soluble in water but do not form a crystalline compound with potassium. Storax also contains from 10 to 20 per cent. of an ester consisting of cinnamic acid and storesin; from 5 to 10 per cent. of cinnamyl or styryl cinnamate (STYRACIN) which occurs in colorless, odorless and tasteless needles and which on hydrolysis yields cinnamic alcohol (styrone) and a salt of cinnamic acid; about 10 per cent. of an odorless, viscid substance, PHENYL PROPYL CINNAMATE; from 2 to 3 per cent. of PHENYL ETHYLENE (styrol or styrene), which occurs as a colorless liquid possessing the odor and pungent taste of storax; from 0.5 to 1 per cent. of a VOLATILE OIL which is lævo-rotatory and consists of a hydrocarbon, styrene, about 0.4 per cent. of an oxygenated compound (styrocamphene), and cinnamates of ethyl, benzyl, phenyl-propyl and cinnamic alcohols; from 2 to 5 per cent. of free cinnamic acid; a small quantity of iso-cinnamic acid which occurs in colorless crystals; a crystallizable susbtance, styrogenin; about 0.15 per cent. of VANILLIN; a trace of benzoic acid; ethyl vanillin; resin, and caoutchouc. Storax sometimes yields more than 20 per cent. of free cinnamic acid and is the best available source of this substance.

ALLIED PLANTS.—*Liquidambar Styraciflua*, a tree indigenous to the Eastern and Southern United States and Mexico, yields the American storax, which occurs as a yellowish-brown, semi-liquid mass somewhat resembling Levant storax. It probably contains related storesins (storesinols), which appear to form similar combinations with cinnamic acid. On distillation of the fresh balsam about 7 per cent. of a volatile oil is obtained, which is dextrorotatory and contains styrol and a body with the odor of oil of turpentine, the cinnamyl-ethyl-ester and cinnamyl-benzyl-ester being wanting. It also contains phenyl propyl cinnamate, styracin, styrol, free cinnamic acid and vanillin.

Styrax is also obtained from *Altingia excelsa,* of the Indian Archipelago. It yields a soft, white, crystalline balsam developing the fragrant odor of styrol and contains about 50 per cent. of an ester of cinnamic acid. A brown solid balsam is also obtained from this tree. It has an odor of cinnamon and contains a trace of free cinnamic acid and 9.7 per cent. of cinnamic acid in the form of an ester. The oil from this plant is known as "Rasamala wood oil," and contains a ketone.

TEREBINTHINA CANADENSIS.—CANADA TURPENTINE, CANADA BALSAM OR BALSAM OF FIR.—A liquid oleo-resin obtained from *Abies balsamea* (Fam. Coniferæ), a tall evergreen tree (Fig. 276) indigenous to the Northern United States and Canada (p. 79). The oleo-resin occurs normally in reservoirs in the bark and forms in vesicles or blisters on the surface, from which it is obtained by puncturing them with the spout of a can used by the balsam collectors. Canada Turpentine is collected chiefly in Quebec.

DESCRIPTION.—Viscid, pale yellow or greenish-yellow, occasionally with a greenish fluorescence; transparent; odor agreeable, terebinthinate; taste bitter, slightly acrid.

When exposed to the air Canada turpentine gradually dries, forming a transparent varnish; it solidifies on mixing 5 or 6 parts with 1 part of magnesia previously moistened with water (distinguishing it from other coniferous resins); it is completely soluble in ether, chloroform, benzol or oil of turpentine, and about 80 per cent. is soluble in alcohol (distinguishing it from other coniferous resins).

CONSTITUENTS.—About 75 per cent. of a resinous substance, consisting chiefly of 4 acid resins: canadinic, canadolic, and α- and β-canadinolic resins, and 11 to 12 per cent. of an indifferent resin canadoresene; 16 to 25 per cent. of a volatile oil, consisting chiefly of l-pinene; and pimaric acid.

ALLIED PLANTS.—STRASBURG TURPENTINE is the product of the European silver fir (*Abies alba*). It closely resembles the Canada turpentine, but has a lemon-like odor. It contains 24 to 30 per cent. of a greenish, fluorescent volatile oil, consisting chiefly of l-pinene; 46 to 50 per cent. of α- and β-abietinolic acid; about 2 per cent. of a crystalline resin, abietolic acid; 10 per cent. of an amorphous resin, abiennic acid; and small quantities of a bitter principle, succinic acid and a coloring principle.

VENICE TURPENTINE is the product of the European larch (*Larix decidua*) and occurs as a yellowish or greenish-yellow, nearly transparent, slightly turbid, viscid liquid, with a terebinthinate odor and a bitter, aromatic taste. It consists of about 20 per cent. of a volatile oil, consisting chiefly of pinene; 60 to 64 per cent. of three acid resins, one of which is crystalline; and about 15 per cent. of an indifferent resin.

DRUGS DERIVED FROM THE CONIFERÆ.

In addition to the volatile oils, resins and allied products obtained from the Coniferæ (described under Exudations, pages 653–682), the tops and fruits of several of the plants are official in the various pharmacopœias. In the Coniferæ the tracheæ and wood fibers are replaced by tracheids (p. 191). This structure is for the most part characteristic of the Gymnosperms, and there are very few Angiosperms in which tracheids alone are found, ipecac root being one of the exceptions (Figs. 203, 291). The flowers of the Coniferæ have open carpels, and the fruits consist of dry cones or of berry-like cones, in which there is partial coalescence of the fleshy scales or carpels (p. 78).

SABINA.—SAVIN.—The young and tender, green branches of *Juniperus Sabina* (Fam. Coniferæ), an evergreen shrub indigenous to the mountainous regions of Southern and Central Europe and extending as far as Siberia. The young branches are collected in the spring, stripped from the older woody branches and dried. In the preparation of the volatile oil, which is official, they are used in the green state.

DESCRIPTION.—Branchlets 1 to 5 cm. long, 1 to 2 mm. in diameter; covered with closely appressed (except those at the base of the branches or branch-scars), grayish- or brownish-green, rhomboidal, scale-like leaves which are about 1 mm. long, 4-ranked, closely imbricated, thus completely covering the branchlets, and show in cross-section a single large oil-gland directly beneath the epidermis of the dorsal surface. Some of the berry-like fruits are usually present. They are globular or ellipsoidal, brownish-yellow or purplish-black, 5 to 7 mm. in diameter, with a whitish bloom, more or less tuberculate, due to the tips of the fleshy scales, and wrinkled; the pulp is brownish and contains from 2 to 6 ovoid, yellowish-brown seeds, 3 to 4 mm. long, longitudinally grooved, particularly on the dorsal side, and enclosed by a resinous membrane. The odor is slightly terebinthinate, and the taste, bitterish and resinous. (See also Fig. 51.)

CONSTITUENTS.—From 4 to 6 per cent. of a volatile oil consisting of about 10 per cent. of an alcohol sabinol, 40 to 44 per cent. of an ester of sabinol and acetic acid, a sesquiterpene, and a principle with an odor of cumin aldehyde; resin, and a small amount of tannin.

ALLIED PLANTS.—Red Cedar (*Juniperus virginiana*) is a tree or shrub of wide distribution in North America. The fruits are purple, smaller, and contain fewer seeds than those of *J. Sabina.* The constituents are also similar. The volatile oil of the wood is known as red cedar wood oil and occurs to the extent of 2.5 to 4.5 per cent. The oil consists of so-called cedar camphor, or cedrol, and cedrene.

JUNIPER BERRIES are obtained from *Juniperus communis*, a small evergreen tree with subulate, prickly-pointed, verticillate leaves, which is indigenous to North America, Europe and Asia. The berry-like fruits are nearly globular, from 5 to 10 mm. in diameter, somewhat wrinkled, purplish-black or dark brown, frequently with a whitish bloom, with 3 to 6 minute bracts at the base, and a triangular scar at the apex marking the line of separation of the carpels. The pulp is brownish and usually contains three ovoid seeds, attached to which are 3 to 4 ellipsoidal oleoresinous masses. The odor is slight and the taste is sweet and resinous. Juniper berries contain 0.5 to 1.5 per cent. of a volatile oil containing pinene, cadinene, and a juniper camphor; 10 per cent. of resin; 15 to 30 per cent. of dextrose; a yellow coloring principle; and yield 2 to 4 per cent. of ash. The oil and the fruits are chiefly used in the manufacture of gin.

The young twigs of ARBOR VITÆ (*Thuja occidentalis*), a conical tree indigenous from Canada to Virginia and extensively cultivated, are also used in medicine. The leaves are 4-ranked, of two kinds, those of the lateral pairs being more or less elongated, clasping, and triangular in section, those of the other pair being flattened, appressed and with a prominent oleo-resinous gland near the middle on the dorsal or outer surface, the arrangement of the leaves being such as to give the branches a flattish appearance. The fruits are small cones with six to ten carpels, each bearing a narrow-winged seed. Thuja contains 1 per cent. of a volatile oil with an odor resembling tansy and containing d-pinene, l-fenchone, d-thujone, and an inactive oxime; two resins; a glucoside thujin, which resembles quercitrin; a bitter glucoside pinicrin, and pinitannic acid (which two latter principles are also found in *Pinus sylvestris*).

DRUGS DERIVED FROM THALLOPHYTES AND ARCHEGONIATES.

Not very many of the lower plants furnish important drugs, there being probably not more than five or six drugs from this source that are official in the different pharmacopœias. For purposes of identification they may be grouped as follows:

Rhizome	Aspidium
Entire, yellowish-white, cartilaginous thallus	Chondrus
Entire, grayish-brown, papery thallus	Cetraria
Purplish-black cylindrical grains	Ergota
Light yellow powder	Lycopodium

ASPIDIUM.—MALE FERN.—The rhizome and stipes of *Aspidium* (*Dryopteris* or *Nephrodium*) *Filix mas* and *Aspidium marginale* (Fam. Polypodiaceæ), perennials, of which *Aspidium Filix mas* (Fig. 277) is more widely distributed, being indigenous to Europe, Asia, North America, west of the Rocky Mountains, and in the Andes of South America; while *A. marginale* is found in the Eastern and Central United States and extends north to Prince Edward's Island (p. 61). The rhizome is collected in early autumn, the leaves cut off, leaving the lower portions or stipes attached to the rhizomes; the dead portions of

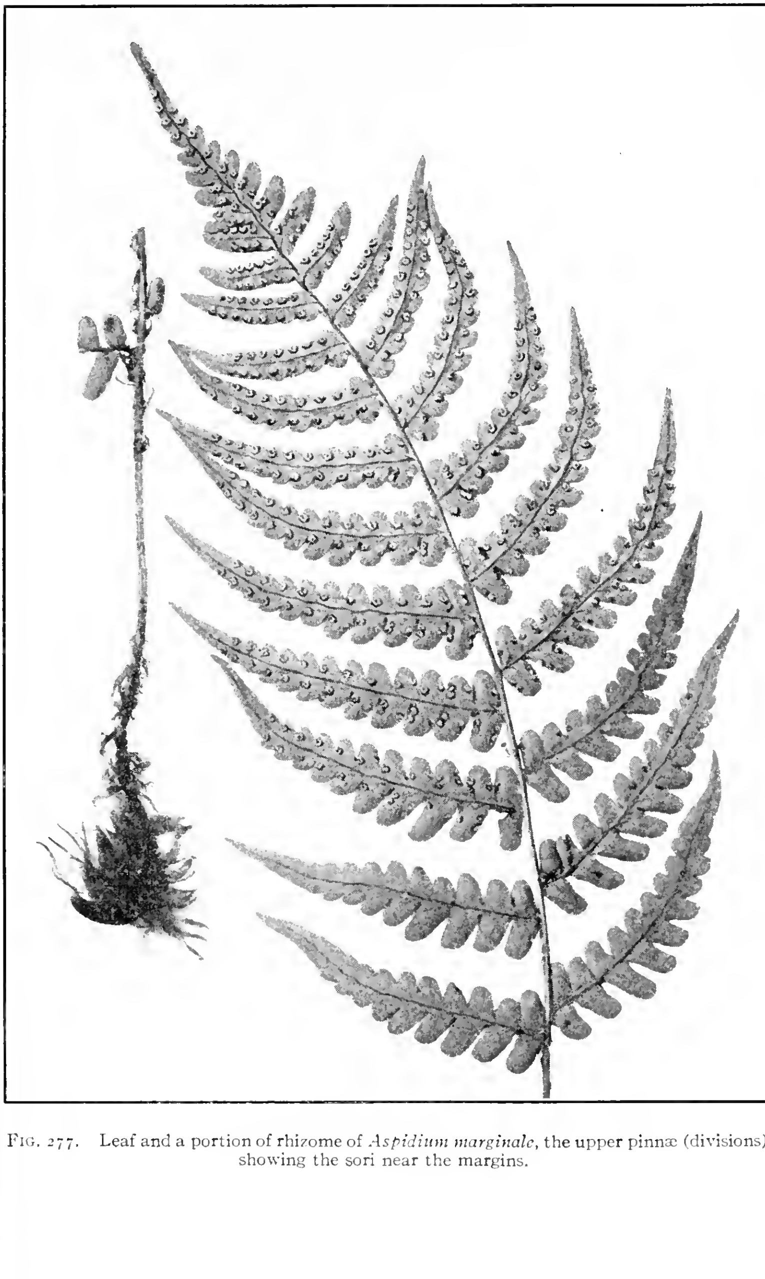

FIG. 277. Leaf and a portion of rhizome of *Aspidium marginale*, the upper pinnæ (divisions) showing the sori near the margins.

the rhizomes and the chaff are removed. Usually the drug consists of the stipes only, which are separated from the rhizome, the periderm being removed (Fig. 277a, *A*). The drug is carefully dried and preserved and should not be used after it loses its green color.

Description.—Of horizontal or oblique growth, 5 to 15 cm. long and 1 to 2.5 cm. thick, mostly covered with nearly cylindrical,

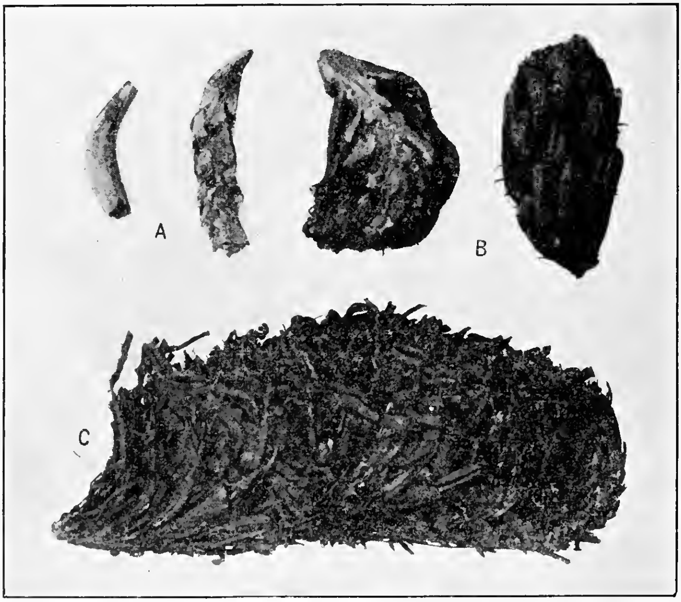

Fig. 277a. A, B, *Aspidium Filix mas* showing a decorticated stipe and piece of rhizome (A), and rhizomes with stipes attached (B); C, probably the rhizome of *Osmunda Claytoniana*, which is sometimes substituted for Aspidium.

slightly curved stipe-remnants (Fig. 277a), which are about 25 mm. long and 5 to 10 mm. thick, between which is a dense mass of dark-brown, glossy, transparent and soft-chaffy scales; internally spongy, pale green, becoming brownish with age; in transverse section showing an interrupted circle of about six (*A. marginale*) or seven to nine (*A. Filix mas*) groups of fibro-vascular tissue, each of which is surrounded by an endodermis-like layer; odor slight, taste acrid, somewhat bitter and nauseous.

Inner Structure.—See Figs. 45, 278, 297.

Constituents.—An active, amorphous substance, filicic acid, 2 to 8 per cent., being contained apparently in greatest abundance in rhizomes collected in autumn, and readily decomposing with the formation of an inactive but crystalline anhydride; and filicic anhydride (filicin, or so-called crystalline filicic acid). The latter occurs from 19 to 31 per cent. in the drug, and may be converted into filicic acid by dissolving in alkalies and precipitating with acids. The drug also contains from 0.025 to 0.045 per cent. of a light yellow volatile oil with an intense odor of the drug and an aromatic, burning taste. It consists of free butyric and allied acids and hexyl and octyl esters of the fatty acid series, ranging from butyric acid to pelargonic. From 6 to 7 per cent. of a green fixed oil is present, which consists of the glycerides of filixolic and filosmylic acids, the latter being volatile. Among the other constituents are a small amount of a bitter principle; about 10 per cent. of filixtannic acid; a soft black resin and a hard red resin; about 11 per cent. of an uncrystallizable sugar; starch, and 2 to 3 per cent. of ash.

Allied Plants.—The rhizome of *Aspidium spinulosum* appears to possess properties similar to the official drug; it somewhat resembles that of *A. Filix mas,* but the chaffy scales possess marginal glandular hairs and the number of fibrovascular bundles in the rhizome is usually but 6 or 7.

Adulterants.—The rhizomes of other ferns are sometimes substituted for those of the true drug. The botanical origin of these substitutes is not clear. A very common substitute is shown in Fig. 277a, *C*, which is derived from *Osmunda Claytoniana* (Fig. 45) or a related species. It occurs in large pieces with coarse, wiry roots, flattened stipes and is free from chaffy scales.

CHONDRUS.—IRISH MOSS OR CARRAGHEEN.—The entire plant of *Chondrus crispus* (Fam. Gigartinaceæ), a common red alga (Fig. 9) found along the northwestern coast of Ireland and the coast of Massachusetts (p. 16). The plants are collected chiefly during June and July, spread out on the beach and bleached by the action of the sun and dew, then treated with salt water, finally dried and stored. The chief points of collection in this country are 15 to 25 miles south of Boston.

Description.—Consisting of a number of dichotomously branching, somewhat enlarged segments, becoming emarginate or two-lobed, which arise from a slender, somewhat flattened base about one-half the length of the entire thallus; yellowish-white, translucent, sometimes with fruit-bodies or sporangia embedded

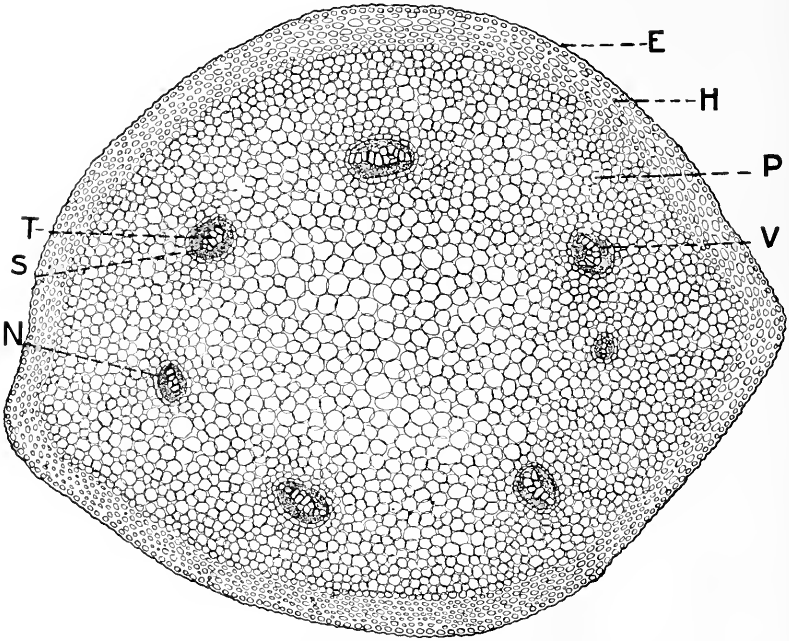

Fig. 278. Transverse section of stipe of *Aspidium marginale* showing epidermis (E), hypodermis (H), endodermis (N) of fibrovascular bundle (V), sieve (S), tracheæ (T).

near the apex of the segments; somewhat cartilaginous; having a slight saline odor and a mucilaginous, somewhat saline taste.

One part of Chondrus boiled for ten minutes with 30 parts of water yields a solution which gelatinizes on cooling, and is not colored blue by iodine test-solution (absence of starch); nor precipitated by alcohol (distinction from true plant gums); nor precipitated by tannin (distinction from gelatin); nor precipitated by lead acetate (distinguishing it from pectin).

Constituents.—From 55 to 90 per cent. of carrageenin, a mucilaginous principle which is but slightly adhesive; about 10 per cent. of proteins, and 10 to 15 per cent. of ash, consisting of calcium oxalate and compounds of sodium, potassium, magnesium and calcium with chlorine, iodine, bromine and sulphur.

Allied Plants.—*Gigartina mamillosa* (Fig. 278a) somewhat resembles Chondrus, but it is most abundant north of the region where Chondrus is gathered and so rarely enters com-

Fig. 278a. *Gigartina mamillosa*, a red seaweed closely related to *Chondrus crispus*, showing dichotomously branching thallus bearing at the upper part numerous cylindrical outgrowths in which the fruit bodies (sporangia) are found.—After Kutzing.

merce. It is distinguished by having the sporangia borne on short, tuberculated projections or stalks scattered over the upper portion of the segments.

For other Marine Algæ used in medicine, see p. 16.

An artificial gum is prepared by adding starch to the mucilage of chondrus, and is said to be a good substitute for acacia and may be employed as a base for fixing colors in fabrics.

CETRARIA.—ICELAND MOSS.—The entire dried plant of *Cetraria islandica*, one of the Ascolichens (Fig. 26), which is widely distributed over the northern part of both continents (p. 40). The chief commercial supplies are obtained from Scandinavia, Germany, Switzerland and parts of Austria.

Description.—Consisting of a number of somewhat dichotomously branching, more or less curled, papery, fringed segments, 5 to 10 cm. long and about 5 mm. wide; upper surface greenish-brown, with occasional dark reddish-brown cupular apothecia; under surface grayish, with numerous small, whitish, depressed spots; tough when damp, but brittle when dry; odor slight; taste mucilaginous and bitter.

Constituents.—The principal constituents are lichenin and isolichenin (about 70 per cent.), the former of which appears to be intermediate between starch and cellulose, and is soluble in hot water, the solution becoming gelatinous on cooling, but not colored blue with iodine; isolichenin (dextrolichenin) somewhat resembles soluble starch, being soluble in cold water and giving a blue reaction with iodine. The drug also contains 2 to 3 per cent. of a bitter crystalline principle, cetrarin, which is colored blue with concentrated hydrochloric acid and yields on hydrolysis cetraric acid, which is also intensely bitter; 1 per cent. of a tasteless, crystalline principle, lichenostearic acid; several organic acids, as oxalic, tartaric and fumaric (lichenic); about 15 per cent. of cellulose; about 3.6 per cent. of an uncrystallizable sugar; 3.7 per cent. of gum; a principle resembling chlorophyll thallochlor, which is unaffected by hydrochloric acid, and yields less than 2 per cent. of ash.

The bitter principle in Cetraria may be removed by treating the drug with a 1 per cent. solution of potassium carbonate at about 60° C. for several hours.

Iceland moss jelly (*Gelatina lichenis islandica*) is official in the German Pharmacopœia, and is prepared by making a decoction of 3 parts of washed cetraria and 100 parts of water, adding three parts of sugar and evaporating the whole to 10 parts. Dried, saccharated iceland moss, which is official in the French Codex, is prepared somewhat similarly to the Iceland moss jelly, but the product is evaporated to dryness and then powdered.

Allied Plants.—*Usnea barbata* and *Cornicularia aculeata* contain a principle resembling lichenin, which on hydrolysis yields glucose. *Evernia prunastri* contains a carbohydrate evernin, which resembles lichenin but is dextrogyrate. The following lichens do not contain lichenin, but yield carbohydrates which on hydrolysis give little or no glucose: *Cladonia rangiferina* contains 30 per cent. of mannose; *Stereocaulon pascale* and *Peltigeria aphthosa* yield on hydrolysis dextromannose and dextrogalactose.

ERGOTA.—ERGOT OF RYE.—The sclerotium of *Claviceps purpurea* (Fam. Hypocreaceæ), a fungus having two distinct periods in its life history—an active and a resting stage (Fig. 19). During the latter it forms a compact mycelium, or sclerotium, which replaces the flowers and grains of rye. Ergot is picked by hand from the ears of rye, or it is separated after the thrashing of the rye; it is carefully dried, and preserved against the attacks of insects by the use of small quantities of chloroform. It deteriorates with age, particularly when powdered, and is not considered so valuable after one year. Various methods have been proposed for preparing the drug so as to preserve its medicinal properties for a longer period of time (p. 422). Russia, Spain and Germany furnish the chief part of the commercial supply, the Russian drug being considered the most active (p. 27).

Spanish ergot usually consists of large grains, having a fine appearance, but is not so active as that from the other countries mentioned, and contains considerable starch.

Description.—Sub-cylindrical, tapering toward but obtuse at both ends, somewhat curved, 2 to 4 cm. long and about 3 mm. thick; externally purplish-black, longitudinally furrowed, occasionally transversely fissured, one end with the whitish remains of mycelial threads, fracture short; internally whitish or pinkish-white, sections somewhat triangular or two-lobed; odor peculiar, heavy, increased by trituration with potassium or sodium hydrate solution; taste oily and disagreeable.

Constituents.—The constituents of ergot have been the subject of considerable investigation, and the results have been more or less contradictory. Of the large number of substances which it contains the following may be mentioned:

The most important physiologically active substances are cornutine and sphacelinic acid. The crystallizable alkaloid cornutine of Keller is insoluble in water and the dilute alcoholic solutions have a blue fluorescence. With concentrated sulphuric acid it produces a violet-blue color. SPHACELINIC ACID (sphacelotoxin) is a non-nitrogenous, resinous substance, which is insoluble in water but soluble in alcohol and is readily decomposed by chemicals.

An amorphous alkaloid ERGOTOXINE has recently been isolated. It forms crystallizable salts with oxalic, tartaric and phosphoric acids and possesses the physiological properties of the drug. The dose of the alkaloid is a few milligrams and for injection it is dissolved in a dilute solution of sodium hydrate. Ergotoxine is supposed to be an anhydride of ergotinine which crystallizes in long needles but does not form crystalline salts.

The alkaloid ECBOLINE (Wenzell), which exists to the extent of 0.16 per cent., somewhat resembles cornutine in its physiological action in contracting the muscles. The alkaloid ERGOTINE (about 0.04 per cent.) described by Wenzell may be (like the alkaloid PICROSCLEROTINE of Dragendorff) similar to the ERGOTININE of Tanret, which, according to Keller, owes its activity to the presence of cornutine.

The substance known as SECALINTOXIN is a compound of sphacelinic acid (sphacelotoxin) and a physiologically inactive crystalline substance, SECALINE. The drug also contains a crystallizable phenolic body, CHRYSOTOXIN; an amorphous, nitrogenous, glucosidal acid, ERGOTINIC ACID (SCLEROTIC ACID), which is soluble in water and easily decomposed by the digestive secretions; choline; leucine (amido-caproic acid); a crystalline monatomic alcohol, phytosterin (cholesterin), also found in some animal fats; a crystalline substance, ergosterin; an amorphous red coloring principle, sclererythrin; about 2 per cent. of a crystalline sugar, mycose, occurring in rhombic octahedra; 13 to 35 per cent. of a yellowish, non-drying oil which is bland when pure, consisting of 68 per cent. of oleic acid, 22 per cent. of oxyoleic and 5 per cent. of palmitic acid; a fat hydrolyzing enzyme; and starch. The pressor activity of aqueous extracts is due to *p*. hydroxyphenylethylamine and a trace of isoamylamine.

ALLIED PLANTS.—Ergot is also found on other cereals, as wheat, barley and rice.

Ustilago Maydis (Fam. Ustilaginaceæ), the fungus found upon the stem and flowers of *Zea Mays*, was formerly official as

Ustilago (corn smut); it occurs in irregular, somewhat cylindrical or globose masses from 10 to 15 cm. in diameter (Fig. 22), consisting of a whitish membrane, becoming dark with age, and a brownish-black mass of spores, which are nearly spherical and about 7 μ in diameter (Fig. 23). The drug has a heavy odor and a disagreeable taste. Ustilago should be carefully dried and not kept longer than one year. Corn Smut contains a crystallizable alkaloid, ustilagine, which is soluble in water and alcohol and forms crystalline salts; from 0.5 to 5.5 per cent. of a crystallizable acid substance, maizenic acid, which resembles sclerotic

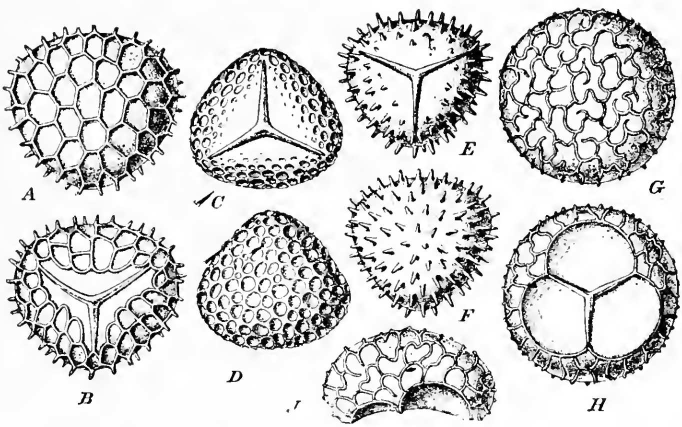

Fig. 278b. Spores of various species of Lycopodium. A, B, reticulated spores of *Lycopodium clavatum;* C, D, spores of *L. phyllanthum* marked by pores; E, F, spinous spores of *L. densum;* G, H, J, spores of *L. inundatum* with wavy reticulations.—After Pritzel.

acid; about 1.5 per cent. of a volatile base resembling trimethylamine; 2.5 to 6.5 per cent. of a dark brown fixed oil, insoluble in alcohol and having the odor of the drug; about 8 per cent. of two resins, one being soluble in alcohol and the other in ether; 3.75 per cent. of a non-reducing sugar which crystallizes in needles; and yields 4.5 per cent. of ash.

LYCOPODIUM.—The spores of *Lycopodium clavatum*, and of other species of Lycopodium (Fam. Lycopodiaceæ), perennial herbs (Fig. 46) indigenous to Europe, Asia, North America and Central America. The spores are obtained from the ripened cones by shaking the fruiting tops (sporogonia) and the extraneous matter is removed by sieving. The principal sources of supply of Lycopodium are Germany, Russia and Switzerland (p. 66).

Description.—A light-yellow, very mobile powder, nearly inodorous and tasteless, floating upon water and not wetted by it, but sinking on being boiled with it, and burning quickly when thrown into a flame.

Spores tetrahedral (Fig. 278b), from 25 to 40 μ in diameter, with one convex side, and delicately reticulate on the surface.

Constituents.—About 50 per cent. of a deep green, odorless, non-drying oil with an acid reaction, which consists chiefly of oleic acid, with some lycopodic (di-oxy-stearic), palmitic, and myristic acids (Rathje, *Archiv. Pharm.*, 246, p. 699, 1908); a small amount of phytosterin, and 3 to 8.2 per cent. of glycerin. The spores also contain 5.3 per cent. of a nitrogenous substance; about 3 per cent. of a sugar, and yield about 1 per cent. of ash. On heating with a solution of potassium hydrate monomethylamine is liberated, and on macerating the spores in alcohol a part of the alcohol is converted into an aldehyde.

Allied Plants.—The spores of other species of Lycopodium are sometimes collected with those of *L. clavatum,* as Fir club moss (*L. Selago*); stiff club moss (*L. annotinum*); bog club moss (*L. inundatum*), and the ground pine (*L. complanatum*) (Fig. 46, illus. 2). From the latter an alkaloid, lycopodine, has been isolated. A toxic alkaloid, piliganine, has been obtained from piligan (*L. Saururus*), growing in Brazil. *L. polytrichoides,* of the Hawaiian Islands; *L. rubrum*, of Venezuela; *L. cernuum,* of the Tropics, and *L. Selago* of Europe, are also employed in medicine.

Adulterants.—Lycopodium is sometimes admixed with pine pollen, starchy materials, and various inorganic substances, as sulphur, talc and gypsum. A recent adulterant of Lycopodium has been found to consist of corn starch which had been treated in a special manner and then colored with methyl orange. An artificial lycopodium is prepared by treating Bordeaux turpentine (galipot resin) at near the melting point with dry ammonia, the resulting product being then dried and powdered. The fragments are irregular, transparent and are readily detected by means of the microscope.

CHAPTER II.

POWDERED VEGETABLE DRUGS AND FOODS.

INASMUCH as a large proportion of vegetable drugs frequently occur in the market in a powdered or ground condition, it becomes of first importance to be able to identify them, as well as to determine their quality in this form. Without a microscopical examination or chemical analysis this would then depend on such factors as color, odor and taste. With some drugs an estimation of quality based on these properties would be of more or less value, particularly those containing aromatic and bitter principles; yet it would soon be found that a more detailed examination would be required to determine their degree of purity or even to identify them with certainty in all cases.

CLASSIFICATION.—It was not considered desirable to give a detailed description of the powder under each drug in the chapter on crude drugs, for the reason that the identity of the drug as a root, rhizome, bark, etc., is lost, and in the examination of a given powder it is usually found advantageous to compare it with those powders having a similar color. By a careful comparison of the powders of the vegetable drugs, it has been found that according to their colors they form five main groups, as follows: (1) Greenish powders, (2) yellowish powders, (3) brownish powders, (4) reddish powders, (5) whitish powders. These groups are then subdivided according to the kinds of cells and the nature of the cell-walls and cell-contents.

ADULTERANTS.—Powdered drugs are frequently adulterated either by the use of wheat middlings or by the use of exhausted powders, *i.e.*, those from which the active or important constituents have been extracted. The following examples serve to illustrate the methods in use: Powdered cloves are occasionally admixed with the exhausted powder, or the exhausted powder alone, to which a small quantity of oil of cloves and some coloring matter are added, is sold as powdered cloves. Exhausted gentian, to which has been added a small quantity of a bitter drug like aloes is sold in place of the genuine drug. In some cases, as in that of ground flaxseed, an attempt is made to supply the deficiency in oil of the exhausted product by adding a petroleum oil. In the case of a number of drugs, such as rhubarb, licorice and belladonna root, much of the commercial powder consists, in part at least, of the exhausted powder. In order to guard against the use of exhausted drugs there is a disposition to lay considerable stress upon the AMOUNT OF EXTRACTIVE (aqueous, alcoholic or ethereal) yielded by different drugs. In many instances drugs that are worm-eaten, or admixed with other drugs or plant parts, are used in the preparation of powdered drugs.

REAGENTS.—For the rapid differentiation and study of the characteristic tissues and cell-contents of the powder it is necessary to employ reagents which render the particles more or less transparent and at the same time do not destroy their characters. The most satisfactory reagent of this kind for general purposes is an aqueous solution of chloral or a solution of chloral and glycerin; about a milligram of the powder is mounted in a few drops of the solution, the preparation is gently heated, then allowed to cool, and examined; if it is not sufficiently transparent, it is heated again. The reagent causes a swelling of the cell-wall and is not applicable in the study of starch grains, but it is very useful in the study of mechanical tissues, hairs and calcium oxalate.

After having determined the presence of starch, a separate mount of the powder in water is made and the size and markings of the grains noted.

For the examination of more or less lignified cells, mounts are made, either in phloroglucin or aniline sulphate solution; in some cases it is advantageous to apply these solutions after the specimen has been previously treated with chloral. Sometimes it is desirable to study the mechanical cells more closely, and Schulze's macerating fluid (p. 188) may be used for isolating them.

EXAMINATION.—Before making a microscopical examination of coarsely comminuted or powdered drugs or foods it is desirable to mix a small quantity of the material with a little water contained in a watch crystal or small beaker and note such features as the following: (1) If the particles sink or float. In all genuine coffee, for instance, the particles rise to the surface, whereas in the substitutes and adulterants they sink. (2) If the particles disintegrate. All artificial products, as coffee and nutmeg, when made from exhausted powders or spurious substances, slowly disintegrate, leaving a fine sediment. (3) The color of the solution. A chelidonium powder, for instance, gives a golden-yellow solution, as also do many drugs containing berberine and allied principles. (4) Behavior of the solution and particles toward alkalies or dilute hydrochloric acid. Drugs containing oxymethyl-anthraquinone derivatives, as senna, rhubarb, aloes, frangula and cascara sagrada, are colored a deep red with alkalies. The particles of ruellia give a distinct effervescence with hydrochloric acid particularly if the mixture is slightly heated. The presence or absence of starch may be determined by heating the mixture, to which has been added a few drops of dilute hydrochloric acid, filtering, and adding iodine to the filtrate when cool. (5) The odor of the mixture, particularly on warming, is of considerable value, as in the detection of belladonna in inula or of conium in anise. The odor is also of value in recognizing the specimen, as very many drugs have a characteristic odor. The odor of a specimen is sometimes, however, misleading, as a number of substances not at all related may have a similar odor. The odor of elm bark, for instance, is possessed by other substances, as fenugreek and wheat middlings, particularly if these substances are kept in a closed vessel.

The fixed oil which occurs in considerable quantity in many seeds interferes with their microscopical examination, and it is necessary to remove this before making mounts of the material. This can be accomplished by treating the powder with chloroform, xylol, acetone, ether, or other similar solvents. Alcohol as a rule is not a good solvent for these oils. The solvent may be added directly to the mount and the solution absorbed by means of filter paper. The following drugs and foods contain fixed oil and should be treated in this way: Almond, anisum, cacao, cardamom, carum, conium, coriandrum, cubeba, ergota, linum, macis, myristica, pimenta, pepo, piper, sinapis alba, sinapis nigra, staphisagria, strophanthus, and the various cereal products.

All powders contain a certain amount of fragments of cell walls and other materials which are more or less alike in the different powders, and it is important that this fact be borne in mind in order that attention may be especially directed to those elements of the powder which have a diagnostic value. The latter while relatively few in number, are easily identified and the distinguishing features readily determined in nearly all cases.

Inasmuch as the size and shape of starch grains and calcium oxalate crystals are characteristic for very many drugs, classifications of these based on the foregoing characters are given before taking up the study of the individual powders.

A. DRUGS AND FOODS CONTAINING STARCH.

The more important vegetable drugs, including some of the commercial starches, are here grouped according to the size and shape, or other characters, of the starch grains:

SIMPLE SPHERICAL GRAINS.

Not more than 5 μ in diameter: Cimicifuga, cypripedium, frangula (Fig. 228), hydrastis (Fig. 292), leptandra, piper (Fig. 311), prunus virginiana, quassia (Fig. 239), quercus alba, rhamnus purshiana (Figs. 229a, 304), spigelia, viburnum opulus and viburnum prunifolium.

Not more than 10 μ in diameter: Calamus (Fig. 101, *B*), euonymus, gelsemium (Fig. 208), granatum (Fig. 234), quillaja (Figs. 281, *C;* 315), sanguinaria, serpentaria, tonka, ulmus, xanthoxylum.

Not more than 15 μ in diameter: Apocynum (Fig. 202), cinchona (Figs. 227, 307, 307a), colchici semen (in caruncle only), convallaria, sumbul, valeriana.

Not more than 20 μ in diameter: Glycyrrhiza (Figs. 104; 282,*B;* 204), phytolacca.

Not more than 30 μ in diameter: Rumex, stillingia.

COMPOUND SPHERICAL OR POLYGONAL GRAINS.

Two- to three-compound: Belladonnæ radix, 5 to 15 μ (Figs. 200; 281, *D;* 303); sassafras, 7 to 20 μ (Fig. 236); and veratrum viride, 7 to 20 μ (Figs. 215, 216).

Two- to four-compound: Aconitum, 4 to 12 μ (Figs. 206, 309); cinnamomum, 7 to 15 μ (Figs. 224, 225, 305); colchici cormus, 7 to 20 μ;

ipecacuanha, 4 to 14 μ (those of Carthagena ipecac being uniformly larger) (Figs. 203, 291); krameria, 20 to 30 μ (Fig. 196); rheum, 5 to 20 μ (Figs. 281, *A;* 289), and sarsaparilla, 7 to 20 μ (Figs. 193, 194).

Two- to six-compound: Podophyllum, 5 to 12 μ (Fig. 223).

More than six-compound: Capsicum, 3 to 7 μ (Figs. 252; 301, *C*); cardamomum, 1 to 4 μ (Fig. 253); cubeba, 1 to 4 μ (Fig. 250); gossypii cortex, 5 to 20 μ (Figs. 231, 231a); mezereum, 10 to 15 μ; myristica, 5 to 7 μ; pimenta, 7 to 10 μ, and rubus, 3 to 7 μ.

ELLIPSOIDAL OR OVOID GRAINS.

Althæa, 10 to 20 μ; geranium, 10 to 15 μ; glycyrrhiza, 5 to 10 μ (Figs. 104; 282, *B*); pareira, 7 to 15 μ; physostigma, 25 to 40 μ; rumex, 10 to 20 μ; stillingia, 15 to 30 μ; strophanthus, 2 to 4 μ (Figs. 186, 306), and zingiber, 15 to 30 μ (Figs. 212; 317, *C*).

GRAINS OF CHARACTERISTIC SHAPE.

Calumba, 25 to 35 μ (Fig. 198); iris florentina, 15 to 30 μ (Figs. 317, 320), and potato and other starches (pp. 785–789).

ALTERED GRAINS.

Guarana, 10 μ; jalapa, 15 to 35 μ (also two- to three-compound) (Fig. 288); tragacantha, 2 to 10 μ; turmeric in masses, 70 to 140 μ (Fig. 290).

AMYLODEXTRIN GRAINS.

Mace (Fig. 190) contains starch grains, which give a reddish color with iodine.

B. DRUGS AND FOODS WITHOUT STARCH.

The following are some of the drugs which do not contain starch:

Amygdala amara and A. dulcis (Figs. 187; 188; 302, *D;* 319), anisum (Fig. 244), aurantii amari cortex, aurantii dulcis cortex, coffee, carum, caryophyllus (Fig. 312), cocculus, colocynthis, conium (Fig. 248), coriandrum (Fig. 245), cydonium, fœniculum, gentiana (Fig. 300, *A*), hæmatoxylon, illicium (Fig. 302, *I*), lappa, limonis cortex, linum (Figs. 184, 293), nux vomica (except in pulp adhering to seed) (Fig. 318), pyrethrum, quassia (Figs. 239; 299, *C*), rhus glabra (Fig. 285, *I*), santalum rubrum, scilla (Fig. 281, *B*), senega, sinapis alba (Fig. 302, *E, F*), sinapis nigra, staphisagria, stramonii semen, taraxacum (Fig. 101, *D*); triticum and vanilla (Figs. 256; 285, *G;* 313).

Leaves, herbs and flowers do not, as a rule, contain reserve starch.

A. DRUGS AND FOODS WITH CALCIUM OXALATE CRYSTALS.

1. CRYSTALS IN ROSETTE AGGREGATES.

Not more than 7 μ in diameter: Anisum (Fig. 244), calendula (Fig. 296), carum (Fig. 247), conium (Fig. 248), coriandrum (Fig. 245), fœniculum (Fig. 246).

Not more than 15 μ in diameter: Caryophyllus (Fig. 312) and humulus (Fig. 298).

Not more than 25 μ in diameter: Althæa (Fig. 99, *B*), buchu, cannabis indica (Fig. 279), castanea, cusso, eriodictyon (Figs. 283, *A;* 285, *F*), euonymus (Fig. 300, *E*), frangula (prisms and pyramids also occur) (Fig. 228), galla, gossypii cortex (Fig. 231), granatum (Fig. 234), pimenta (Fig. 302, *B*), senna (Fig. 263), stramonii folia (Fig. 117).

Not more than 35 μ in diameter: Jalapa (Fig. 288), pilocarpus (Fig. 257), rumex, stillingia, viburnum prunifolium and viburnum opulus (occasionally).

Not more than 100 μ in diameter: Chimaphila, 40 to 60 μ; geranium, 45 to 70 μ, and rheum, 50 to 100 μ (Figs. 281, *A;* 289).

2. CRYSTALS IN MONOCLINIC PRISMS OR PYRAMIDS.

Not more than 10 μ in diameter: Coca (Fig. 286), hyoscyamus (Fig. 282, *A*), and uva ursi (Fig. 300, *D*).

Not more than 20 μ in diameter: Calumba (in stone cells, Fig. 302, *H*), frangula (Fig. 228), granatum (rosette aggregates also occur, Fig. 234), hamamelis, quercus alba (rosette aggregates also occur) (Figs. 300, *B, F*), rhamnus purshiana (Fig. 229a), and senna (Figs. 263).

Not more than 30 μ in diameter: Cardamomum (Fig. 253), eucalyptus, gelsemium (Fig. 208), pimenta (occasional) (Fig. 302, *B*), prunus virginiana, quassia (cryptocrystalline crystals also occur) (Fig. 239), vanilla (Figs. 256, 313), viburnum opulus, viburnum prunifolium (occasional), and xanthoxylum.

Not more than 100 or 200 μ in diameter: Krameria, about 100 μ (Figs. 196; 300, *C*), and quillaja, 35 to 200 μ (Figs. 315; 281, *C;* 300, *G*).

3. CRYSTAL FIBERS PRESENT.

Crystal fibers occur in the following drugs, which are grouped according to the size of the individual crystals:

Not more than 10 μ in diameter: Uva ursi (Fig. 300, *D*).

Not more than 20 μ in diameter: Frangula (Fig. 228), glycyrrhiza (Figs. 104, 282, *B*), hamamelis, hæmatoxylon, quercus alba (Fig. 300, *B, F*) and rhamnus purshiana (Figs. 229a, 304).

Not more than 30 μ in diameter: Prunus virginiana.

About 35 μ in diameter: Quillaja (Figs. 315; 281, *C;* 300, *G*).

4. CRYSTALS IN RAPHIDES.

Raphides are found in the following drugs, and of the length given with each:

Belladonnæ folia (occasionally) (Figs. 285, *K;* 287, *C*) ; cinnamomum, about 5 μ (Figs. 224, 225, 305) ; convallaria, about 45 μ; cypripedium, about 40 μ; ipecacuanha, 20 to 40 μ (Figs. 203, 291) ; phytolacca, about 30 μ; sarsaparilla, 6 to 8 μ (Figs. 193, 194) ; scilla, 0.1 to 1.0 mm. (Fig. 281, *B*) ; vanilla, about 400 μ (Figs. 256; 285, *G;* 313) ; veratrum viride, about 45 μ (Figs. 215, 216).

5. SPHENOIDAL MICRO-CRYSTALS.

Sphenoidal micro-crystals are found in the following drugs:

Belladonnæ folia (Fig. 287, *C*), belladonnæ radix (Fig. 281, *D*), cinchona (Figs. 227, 307), dulcamara, phytolacca, quassia, solanum carolinense and tabacum.

6. MEMBRANE CRYSTALS.

Membrane crystals are found in the following drugs:

Aurantii amari cortex, 15 to 20 μ, and aurantii dulcis cortex, 20 to 30 μ.

B. DRUGS WITHOUT CALCIUM OXALATE.

In the following drugs, calcium oxalate crystals are either wanting entirely or so few as to be without any diagnostic value:

Aconitum, apocynum (Fig. 202), arnica (Fig. 241), capsicum (Figs. 252; 301, *C*), chirata, cimicifuga, colchici cormus, colchici semen, colocynthis, cubeba (Fig. 250), digitalis (Figs. 266; 284, *E;* 285, *D;* 287, *A*), eupatorium, gentiana (Fig. 300, *A*), grindelia, hydrastis (Figs. 219, 292), lappa, leptandra, linum (Figs. 184, 293), lobelia, marrubium, mentha piperita, mentha viridis, mezereum, myristica, nux vomica (Figs. 283, *B;* 318), pareira, physostigma, piper (Fig. 311), podophyllum (Fig. 223), rhus glabra (Fig. 285, *I*), rosa gallica, sabina, sanguinaria, santonica (Fig. 240), sassafras (Fig. 236), senega, serpentaria, sinapis alba (Figs. 294; 302, *E, F*), sinapis nigra (Fig. 295), spigelia, staphisagria, strophanthus (Figs. 186; 284, *A;* 306), sumbul, valeriana and zingiber (Fig. 212).

C. SUBSTANCES MISTAKEN FOR CALCIUM OXALATE.

Calcium oxalate crystals have been mistaken for crystalline sugar, and it should also be pointed out that some of the soluble carbohydrates, as hesperidin and inulin, may be mistaken for sphero-crystals of calcium oxalate, which latter are of rare occurrence. Some of the soluble carbohydrates, including inulin (Fig. 105) occur in sphero-crystals or irregular spherical aggregates, which are more or less easily soluble in water. They are found in buchu, hedeoma, inula, lappa, pyrethrum, taraxacum and triticum.

D. DRUGS CONTAINING CALCIUM CARBONATE.

Cannabis indica (Fig. 284, *C*) and ruellia (Fig. 221).

KEY FOR THE STUDY OF POWDERS.

POWDERS OF A GREENISH COLOR.

I. Crystals of Calcium Oxalate present.

A. Crystals in rosette aggregates.

a. Glandular and non-glandular hairs present.

Cystoliths of calcium carbonate.........1. Cannabis Indica
Twisted non-glandular hairs................2. Eriodictyon
Starch grains 15 to 40 μ in diameter..........3. Galla
Large multicellular glandular hairs............4. Humulus
Numerous pollen grains..................5. Insect Powder
Glandular hairs few....................6. Stramonii Folia

b. Glandular hairs wanting.

Hairs with slight projections.................7. Pilocarpus
Characteristic stone cells..........................8. Tea

c. Glandular and non-glandular hairs wanting.

Sphere-crystals of a carbohydrate................9. Buchu
Crystals 1 to 2 μ in protein grains..............10. Conium
Crystals 15 μ...............................11. Castanea
Crystals 40 to 60 μ........................12. Chimaphila
Outer wall of epidermal cells very thick.....13. Eucalyptus
Crystal fibers...........................14. Granatum

B. In monoclinic prisms.

a. Glandular and non-glandular hairs present.

Crystals about 10 μ.......................15. Hyoscyamus

B. In monoclinic prisms.—*Continued.*

b. Only non-glandular hairs present.

Characteristic stone cells.......16. Cardamomum (Ceylon)
Crystal fibers.....................17. Hamamelidis Folia
Fragments reddish with alkalies................18. Senna
Non-glandular hairs few....................19. Uva Ursi

c. Glandular and non-glandular hairs wanting.

Epidermal cells with papillæ......................20. Coca
Few fragments of tissues....................21. Guaiacum
Few crystal fibers and non-glandular hairs....22. Uva Ursi

C. In crystal fibers.

Rosette-shaped crystals numerous............23. Granatum
Crystal fibers few..........................24. Uva Ursi

D. In sphenoidal micro-crystals.

a. With hairs.

Hairs few..........................25. Belladonnæ Folia
Non-glandular hairs numerous...............26. Tabacum
Starch grains 10 to 35 μ...........27. Solanum Carolinense

b. Hairs few or wanting.

Starch grains 5 to 7 μ.....................28. Dulcamara

II. Calcium Oxalate Crystals wanting.

A. Cystoliths of calcium carbonate present.

Glandular and non-glandular hairs.....29. Cannabis Indica
Stone cells characteristic.......................30. Ruellia

B. Calcium carbonate wanting.

a. Glandular and non-glandular hairs present.

α Fragments of pappus present.

Pollen grains 10 to 20 μ..............31. Eupatorium
Pollen grains about 25 μ................32. Grindelia

β Fragments of pappus wanting.

1. Glandular hairs with 1- and 2-celled heads.

Non-glandular hairs characteristic....33. Digitalis

2. Glandular hairs with 1- to 8-celled head.

Odor characteristic................34. Hedeoma
Non-glandular hairs twisted......35. Marrubium
Non-glandular hairs 1- to 8-celled.
36. Mentha Piperita
Non-glandular hairs 1- to 3-celled..37. Scutellaria
Non-glandular hairs parallel with surface of leaf.
38. Salvia

B. Calcium carbonate wanting.—*Continued.*

b. Glandular hairs wanting.

α With non-glandular hairs.

1. Pollen grains present.

* Hairs numerous.

Non-glandular hairs 1-celled......39. Lobelia
Non-glandular hairs 1- to 6-celled..40. Matico

** Hairs very few.

Cells of non-glandular hairs very short, oblong......................41. Tanacetum

2. Pollen grains wanting.

Hairs 1-celled, with thick walls.....42. Scoparius

β Non-glandular hairs wanting.

Starch grains present................43. Cardamomum
With tracheids..........................43a. Sabina
Without starch grains................44. Staphisagria
Aqueous solution of a golden-yellow color.
45. Chelidonium

POWDERS OF A YELLOWISH COLOR.

I. Fragments of Vegetable Tissue present.

A. Containing starch.

a. With calcium oxalate crystals.

α In rosette aggregates.

Crystal fibers............................46. Frangula
Isodiametric stone cells............47. Galla (Aleppo)
Starch grains swollen......................48. Jalapa
Calcium oxalate crystals 50 to 100 μ........49. Rheum

β In monoclinic prisms.

Characteristic starch grains...............50. Calumba
Starch grains swollen....................51. Curcuma
Crystal fibers..........................52. Frangula
Long sclerenchymatous fibers...........53. Gelsemium
Tracheæ with bordered pores.............54. Quassia

γ In crystal fibers.

With cork fragments........55. Glycyrrhiza (Spanish)
Without cork fragments....56. Glycyrrhiza (Russian)

δ In raphides.

Tracheids with bordered pores.........57. Ipecacuanha
Long sclerenchymatous fibers..........58. Phytolacca
Endodermal cells with thick walls.59. VeratrumViride

A. Containing starch.—*Continued.*

b. Calcium oxalate wanting.

α Stone cells present.

Characteristic starch grains...............60. Calumba

β Stone cells wanting.

1. Starch grains 15 to 30 μ in diameter.

With yellow oil-secretion cells.......61. Zingiber

2. Starch grains 5 to 15 μ in diameter.

Long non-lignified bast fibers......62. Mezereum
Ducts large.........................63. Pareira
Lignified sclerenchymatous fibers..64. Serpentaria
Powder lemon-yellow..............65. Berberis

3. Starch grains less than 5 μ in diameter.

Crystals of alkaloids with sulphuric acid.
66. Hydrastis

4. Starch grains altered.

Large cells with swollen grains......67. Curcuma

B. Starch grains few or none.

a. Calcium oxalate crystals present.

α In rosette aggregates.

Non-glandular hairs......................68. Anisum
Oil-like globules in epidermis...........69. Calendula
Non-glandular hairs wanting..........70. Fœniculum

β In monoclinic prisms.

Crystals 15 to 20 μ.........71. Aurantii Amari Cortex
Crystals 20 to 30 μ.........72. Aurantii Dulcis Cortex

γ In raphides.

Crystals 0.1 to 1 mm. long..................73. Scilla

b. Calcium oxalate crystals wanting.

α Sclerenchymatous cells or fibers present.

1. Dark pigment cells wanting.

Stone cells with thickened inner walls.
74. Sinapis alba
Stone cells ellipsoidal, uniformly thickened.
75. Pepo
Parenchyma cells large, thin-walled.
76. Colocynthis

2. Pigment cells present.

Stone cells with thickened inner walls.
77. Sinapis Nigra
Characteristic sclerenchymatous cells and fibers.
78. Fenugreek

2. Pigment cells present.—*Continued.*

Short sclerenchymatous fibers..........79. Linum
A colorless layer of cells with minute starch grains..........................80. Cydonium

β Sclerenchymatous tissue wanting.

1. Pollen grains numerous.

Fragments of pappus..........81. Arnicæ Flores
Pollen grains smooth...............82. Sambucus
Pollen grains spinose..............83. Matricaria

2. Pollen grains few.

Pollen grains prickly..............84. Calendula
Pollen grains nearly smooth..........85. Crocus
Corolla white......................86. Anthemis
Bitter, ducts scalariform......... ....87. Chirata

3. Pollen grains wanting.

* Fibrovascular tissue present.

Containing inulin masses..........88. Lappa
Sclerenchymatous fibers numerous.89. Senega
Starch and scalariform tracheæ. .90. Aspidium

** Fibrovascular tissue wanting.

Few fragments of tissues..... 91. Cambogia
Large glandular hairs....... 92. Lupulinum
Tetrahedral spores...........93. Lycopodium

II. Few or No Fragments of Vegetable Tissue.

A. Giving off odor of sulphur dioxide on heating.

Rounded masses in chains..................94. Sulphur Lotum
Rounded masses in irregular groups..95. Sulphur Præcipitatum

B. No odor of SO_2 on heating.

a. Nearly colorless in glycerin mount.

Transparent, irregular masses................96. Mastiche

b. Yellowish in glycerin mount.

α Containing oil globules.

Irregular masses....................97. Scammonium

β Transparent or translucent.

Soluble in cold alcohol.................98. Colophony
Insoluble in cold alcohol.................99. Sandarac
Reddish with alkalies..............100. Aloe (Cape)

γ More opaque.

Light or grayish particles............101. Ammoniac
Yellowish particles....................102. Cambogia

POWDERS OF A BROWNISH COLOR.

I. Fibrovascular Tissue present.

A. CONTAINING STARCH.

a. Calcium oxalate crystals present.

α *In rosette aggregates.*

1. With sclerenchymatous fibers.

* Containing oil, resin or tannin masses.

Sclerenchymatous fibers few. 103. Belladonnæ Radix
Starch grains 4 to 20 μ... 104. Gossypii Cortex
Starch grains 3 to 7 μ, compound.. 105. Rubus
Crystals 10 to 35 μ.............. 106. Juglans
Crystals 35 to 70 μ.... 107. Aralia Nudicaulis
Starch grains 15 to 30 μ........ 108. Stillingia
Modified bast fibers........... 109. Euonymus
Red with alkalies................ 110. Rumex
Fibers few..................... 110a. Canella

** No resin or tannin masses.

Crystals about 25 μ............... 111. Althæa

2. Sclerenchymatous fibers wanting.

* Containing tannin.

† With oil-secretion reservoirs.

Starch grains ellipsoidal. 112. Fruit of Clove
Reddish brown tannin masses. 113. Pimenta

†† Oil-secretion reservoirs wanting.

Light-brown tannin masses..... 114. Galla
Calcium oxalate 45 to 70 μ. 115. Geranium
Calcium oxalate 50 to 100 μ... 116. Rheum

** Without tannin.

Sphenoidal micro-crystals. 117. Belladonnæ Radix

β *Crystals in monoclinic prisms and pyramids.*

Crystal fibers.......................... 118. Frangula
Sclerenchymatous fibers characteristic... 119. Krameria
Crystal fibers and stone cells.. 120. Rhamnus Purshiana
Crystals in stone cells.................. 121. Juniperus

γ *Crystal fibers present.*

1. Sclerenchymatous fibers strongly lignified.

* Colored reddish with alkalies.

Without stone cells........... 122. Frangula
With stone cells...., 123. Rhamnus Purshiana

1. Sclerenchymatous fibers strongly lignified.—*Continued*

** Not colored reddish with alkalies.

Stone cells characteristic...124. Quercus Alba

Stone cells characteristic. 125. Prunus Virginiana

Taste bitter, acrid.......126. Myrica Cerifera

Taste sweetish, slightly bitter. 127. Pulvis Glycyrrhizæ Compositus

2. Sclerenchymatous fibers not strongly lignified.

Fragments of ducts.................128. Calamus

No fragments of ducts................129. Ulmus

δ *Calcium oxalate in raphides.*

1. Raphides not more than 10 μ long.

No fragments of ducts........130. Cinnamomum

Fragments of ducts present......131. Sarsaparilla

2. Raphides 40 to 45 μ long.

Spherical starch grains 3 to 12 μ. 132. Convallaria

Thick-walled parenchyma with simple pores. 133. Cypripedium

Ellipsoidal starch grains 7 to 20 μ. 134. Veratrum Viride

3. Raphides 200 μ long.

Starch grains 4 to 15 μ...........135. Hydrangea

ε *Calcium oxalate in sphenoidal micro-crystals.*

Sclerenchymatous fibers few....136. Belladonnæ Radix

Bast fibers characteristic................137. Cinchona

b. Calcium oxalate crystals wanting.

α With non-glandular hairs.

Greenish fragments with sulphuric acid. 138. Strophanthus

β Non-glandular hairs wanting.

1. Sclerenchymatous fibers present.

* Tracheæ numerous.

† Starch grains 2 to 5 μ in diameter.

Ducts large and with bordered pores. 139. Cimicifuga

Thick-walled parenchyma with simple pores.................140. Cypripedium

Scalariform ducts.........141. Leptandra

Tracheæ with reddish contents.142. Spigelia

* Tracheæ numerous.—*Continued.*

†† Starch grains 5 to 15 or 20 μ in diameter.

Characteristic starch grains. 143. Zingiber
Odor of coumarin............144. Tonka
Chocolate taste.........145. Cocoa Shells
Fragments of milk vessels. 146. Apocynum
Raphides 45 μ long......147. Convallaria
Raphides 6 to 8 μ long...148. Sarsaparilla
Ducts with bordered pores...149. Sumbul
Stone cells characteristic...150. Valeriana
Stone cells.............151. Methysticum

** Tracheæ few or none.

Characteristic bast fibers.......152. Cinchona
Raphides about 5 μ long...153. Cinnamomum
Short sclerenchymatous fibers.....154. Coffee
Starch grains 7 to 20 μ, compound.
155. Sassafras

2. Sclerenchymatous fibers wanting.

* Stone cells present.

† Giving tannin reaction with ferric salts.

Stone cells characteristic......156. Cacao
Altered starch grains.......157. Guarana
Stone cells characteristic.......158. Piper
Thick-walled endosperm cells.
159. Colchici Semen

†† Not becoming blue or green with ferric salts.

Starch grains 4 to 12 μ.....160. Aconitum
Starch grains 25 to 40 μ. 161. Physostigma

** Stone cells wanting.

Starch grains 7 to 20 μ...162. Colchici Cormus
Altered starch grains...........163. Guarana
Numerous oil globules.........164. Myristica
Amylo-dextrin starch grains.......165. Macis
Few fragments of vegetable tissue. 166. Opium
Starch grains 5 to 12 μ.....167. Podophyllum
Odor characteristic........168. Chenopodium

B. Starch grains few or none.

a. Containing calcium oxalate.

α *In rosette aggregates.*

1. Small crystals in aleurone grains.

With non-glandular hairs............169. Anisum
Calcium oxalate 0.5 to 1 μ.............170. Carum
Calcium oxalate 3 to 7 μ.........171. Coriandrum
Calcium oxalate 1 to 2 μ..........172. Fœniculum

α In rosette-shaped crystals.—Continued.

2. Crystals not less than 10 μ in diameter.

* Pollen grains numerous.

Crystals numerous..........173. Caryophyllus

Crystals few..............174. Insect Powder

** Pollen grains few.

† Ducts present.

Glandular and non-glandular hairs.

175. Cusso

†† Ducts wanting.

Stone cells few....176. Viburnum Opulus

Stone cells numerous.

177. Viburnum Prunifolium

β Calcium oxalate in monoclinic prisms.

1. Numerous seeds.

Characteristic odor....................178. Vanilla

2. Seeds wanting.

Stone cells few.............179. Viburnum Opulus

Stone cells numerous, characteristic.

180. Viburnum Prunifolium

Numerous oil globules..........181. Xanthoxylum

γ Calcium oxalate in crystal fibers.

Stone cells characteristic............182. Quercus Alba

b. Calcium oxalate wanting.

α Containing pollen grains.

Non-glandular hairs numerous.....183. Arnicæ Flores

Spherical pollen grains....................184. Crocus

Non-glandular hairs few................185. Santonica

β Pollen grains wanting.

1. Stone cells numerous.

Fragments wine-colored with sulphuric acid.

186. Cubeba

Characteristic stone cells.........187. Delphinium

Green fluorescence in chloral mount.

188. Stramonii Semen

Ducts reticulate..................189. Pyrethrum

2. Stone cells wanting.

Non-lignified intermediate fibers....190. Gentiana

Few fragments of tissues............191. Opium

Tracheæ with elongated, narrow pores.

192. Taraxacum

Tracheæ with large, simple pores.....193. Chicory

Ducts spiral, annular or with simple pores.

194. Triticum

II. Without Fibrovascular Tissue.

A. With cellular tissues.

Spores about 7 μ....................................195. Ustilago
Numerous oil globules...............................196. Ergota
Thick-walled cells of capsules........................197. Opium
Fragments of woody tissues....................198. Goa Powder

B. Without cellular tissues.

a. Possessing oil.

Grayish fragments...........................199. Asafetida
Yellowish or yellowish-brown fragments.......200. Myrrha

b. Without oil.

α *Remaining opaque in glycerin.*

Characteristic odor..............201. Aloes (Socotrine)
Characteristic odor.......................202. Benzoinum
Grayish opaque fragments.............203. Elaterinum
Brownish angular masses.............204. Lactucarium

β *More or less translucent in glycerin.*

Dark brown......................205. Aloes (Curaçao)
Yellowish-brown...............206. Aloes (Socotrine)
With acicular crystals.......................207. Gambir
With rhombohedral crystals..............208. Catechu
Fragments translucent, deep red............209. Kino

POWDERS OF A REDDISH COLOR.

I. Containing Starch.

Very light pink, crystals present........................210. Quillaja
Reddish, crystals wanting..........................211. Sanguinaria

II. Without Starch.

A. Stone cells present.

Characteristic stone cells.........................212. Capsicum
Characteristic stone cells...........................213. Illicium
Mucilage cells and sclerenchymatous fibers.......214. Cydonium
Characteristic glandular hairs..................215. Rhus Glabra
Non-glandular hairs 0.5 to 2 mm. long..216. Rosæ Caninæ Fructus
Woody tissues only.....................217. Willow Charcoal

B. Stone cells wanting.

a. With wood fibers.

Coloring principle soluble in water......218. Hæmatoxylon
Coloring principle insoluble in water.219. Santalum Rubrum

b. Wood fibers wanting.

Blue with sulphuric acid.......................220. Crocus
Containing tannin...............................221. Kino
Large glandular hairs.....................222. Lupulinum

b. Wood fibers wanting.—*Continued.*

Characteristic odor............................223. Opium
Epidermal cells with papillæ.............224. Rosa Gallica
Fragments of anthers.................225. Rosa Centifolia
Long, slender styles.............................226. Zea

POWDERS OF A WHITISH APPEARANCE.

I. Plant Tissues or Cell-Contents recognizable.

A. Containing starch.

a. Only unaltered starch grains present.

Excentral and fissured point of origin of growth.
227. Maranta Starch
Excentral and circular point of origin of growth.
228. Potato Starch
Polygonal grains.........................229. Corn Starch
Small, polygonal, compound grains........230. Rice Starch
Ellipsoidal, point of origin of growth indistinct.
231. Wheat Starch
Characteristic grains..................232. Other Starches

b. Altered and unaltered starch grains present.

Becomes pasty on addition of cold water......233. Dextrin
Becomes pasty with hot water...................234. Sago
Disintegrates with water............235. Sago (Imitation)

c. Plant tissues in addition to starch.

α Do not readily dissolve or swell in cold water.

Polygonal starch grains................236. Corn Meal
Free from hairs.......................237. Corn Bran
Starch grains 5 to 40 μ in diameter....238. Wheat Flour
Hairs with thick walls and narrow lumen.
239. Wheat Middlings
Starch grains 20 to 60 μ in diameter....240. Rye Flour
Thin-walled hairs with large lumen. 241. Rye Middlings
Starch grains 5 to 25 μ in diameter...242. Barley Flour
Sclerenchyma fibers with brown contents.
243. Buckwheat Flour
Starch grains 2 to 10 μ in diameter.....244. Rice Flour
Hairs broader near the middle...........245. Oat Meal
Lignified hairs, starch grains few.....246. Nux Vomica
Characteristic starch grains............247. Orris Root
Very long prisms of calcium oxalate......248. Quillaja
Raphides of calcium oxalate..............249. Bryonia
Aromatic odor........................249a. Calamus
Thin-walled bast fibers..................249b. Ulmus

c. Plant tissues in addition to starch.—*Continued.*

β Soluble or swelling in cold water to form a sticky mass.
Starch and fragments of ducts.......250. Tragacantha

B. Without starch.

a. Calcium oxalate present.
Raphides 0.1 to 1 mm..........................251. Scilla

b. Calcium oxalate wanting.
Characteristic lignified hairs..............252. Nux Vomica
Characteristic stone cells.....................253. Almond

II. Absence of Plant Tissues.

A. Soluble in water.
Forming a mucilage with water.....................254. Acacia
Monoclinic prisms..............................255. Saccharum

B. Insoluble in water.

a. Soluble in alcohol.
Irregular fragments........................256. Camphora

b. Insoluble in alcohol.

α Reddish color with sulphuric acid.
Gritty; monoclinic prisms of various sizes.
257. Saccharum Lactis

β No color reaction with sulphuric acid.

1. Soapy feel.
Broken crystals........................258. Talc

2. Soluble in acetic acid.

* With effervescence.
In prisms or irregular angular fragments.
259. Precipitated Calcium Carbonate
An amorphous powder...260. Prepared Chalk
Rhombic crystals or irregular fragments.
. 261. Barium Carbonate

** Without effervescence.
Rounded masses........262. Heavy Magnesia
Very light..............263. Light Magnesia

3. Insoluble in acetic acid.

* Soluble in nitric acid.
Tetragonal or cubical crystals.
264. Precipitated Calcium Phosphate
Acicular crystals.......265. Calcium Sulphate
Rhombic prisms or crystals of various sizes.
266. Barium Sulphate
Irregular fragments..........267. Terra Alba

POWDERS OF A GREENISH COLOR.

In this group are included all those drugs which in a powdered condition are of a light-green, yellowish-green or dark-green (sap-green) color. Most of the powders of the leaves and herbs belong to this class.

I. CRYSTALS OF CALCIUM OXALATE PRESENT.

A. CRYSTALS IN ROSETTE AGGREGATES.

a. GLANDULAR AND NON-GLANDULAR HAIRS PRESENT.

1. CANNABIS INDICA.—Dark green (Figs. 284, *C; 279*); non-glandular hairs, 1-celled, more or less curved, with numerous slight projections, and sometimes with cystoliths of calcium carbonate; glandular hairs two kinds—either with short unicellular or multicellular stalks—and 8- to 16-celled glandular heads; calcium oxalate, in rosette aggregates about 20 μ in diameter; numerous oil globules and resin fragments; few nearly spherical pollen grains 25 to 35 μ in diameter, with numerous centrifugal projections, among club-shaped unicellular hairs of style; ducts spiral or with simple or bordered pores; sclerenchymatous fibers long, thin-walled, non-lignified, and with few simple pores; laticiferous vessels with reddish-brown contents. When mature seeds are present, palisade-like stone cells occur, which are very thick-walled, and have a small lumen.

2. ERIODICTYON.—Dark green; calcium oxalate in rosette aggregates, 20 to 25 μ in diameter; non-glandular hairs 1-celled and thick-walled (Fig. 283, *A*); glandular hairs with 1-celled stalk and 6- to 8-celled glandular head (Fig. 285, *F*). In powder of the stems occur: ducts, spiral or with simple or bordered pores; sclerenchymatous fibers either non-lignified and thin-walled, or lignified and thick-walled, and with numerous simple pores; pith cells somewhat tabular, thick-walled, slightly lignified, and with numerous simple pores.

3. GALLA (Chinese or Japanese).—Grayish-green; calcium oxalate crystals about 20 μ in diameter; starch grains 15 to 40 μ

in diameter; non-glandular hairs; milk vessels accompanying ducts. Mounts in glycerin may show acicular crystals.

4. HUMULUS.—Light green; calcium oxalate in rosette aggregates, 10 to 15 μ in diameter; non-glandular hairs unicellular, more or less bent, thin-walled, 0.2 to 0.3 mm. long; glandular hairs of two kinds (Fig. 298), either with a 3-celled stalk

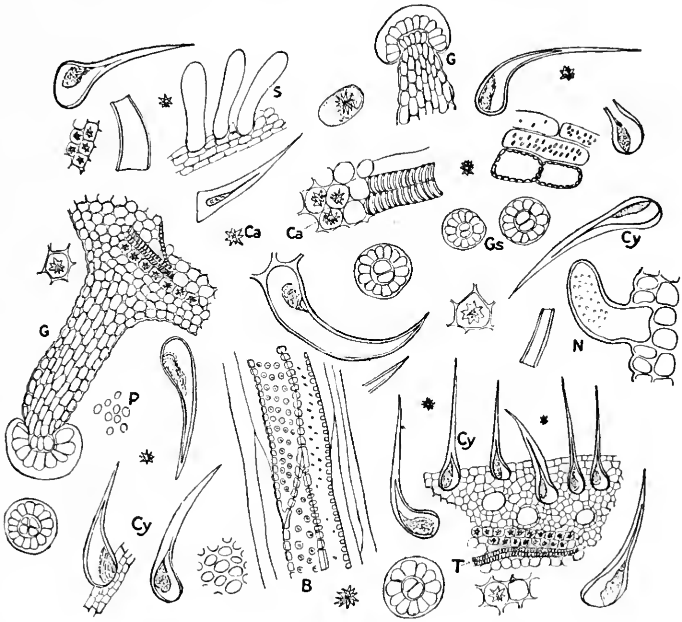

FIG. 279. Cannabis indica: Cy, non-glandular hairs containing calcium carbonate in the form of cystoliths; G, multicellular glandular hairs of the bracts; Gs, multicellular heads of glandular hairs; S, papillæ of stigma; B, tracheæ with bordered pores, present in stem fragments; T, tracheæ with annular markings; P, pollen grains; Ca, rosette aggregates of calcium oxalate; N, thick-walled non-glandular hair with numerous papillæ on the surface.

and a nearly colorless, multicellular, glandular head about 50 μ in diameter, or with a short 4-celled stalk and a multicellular, bright yellow, glandular head 0.1 to 0.3 mm. in diameter (Fig. 136).

5. INSECT POWDER (Persian) (p. 395).—Grayish-green (Fig. 280); with numerous rounded and prickly pollen grains, 25 μ in diameter; a few crystals 2 to 8 μ in diameter, in stone cells or in parenchyma adjoining; sclerenchyma fibers about 20 μ

in diameter and 100 to 160 μ long; fragments of T-shaped non-glandular hairs less numerous than in Dalmatian powder; characteristic, isolated, somewhat rounded or elliptical parenchyma cells, also occurring in papillæ-like fragments; fragments of

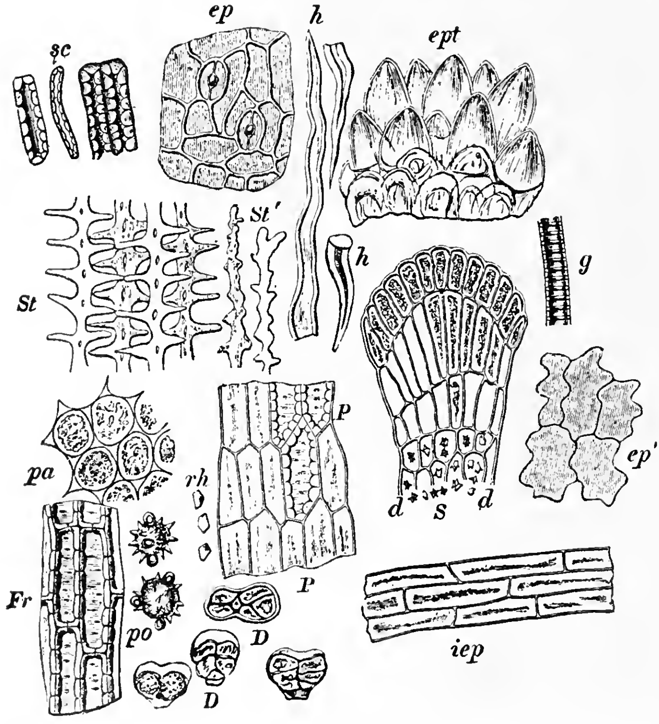

FIG. 280. Flores Pyrethri (Insect flowers): sc, stone cells; ep, upper epidermis of a bract; h, h, non-glandular hairs of bracts; ept, papillæ on the upper surface of the ligulate corolla; St, St', loose parenchyma of the ligulate corolla; g, a trachea of a bract with annular thickening; S, tooth of a tubular floret, some of the cells of which contain rosette aggregates of calcium oxalate; ep', epidermis of the under surface of a ligulate corolla; P, section of pappus showing some of the lignified cells, some of which contain monoclinic prisms as shown at rh; pa, parenchyma of a bract; Fr, somewhat thickened, porous cells of the pericarp; D, glandular hairs found on the wall of the ovary; po, pollen grains; iep, cells of the involucre between the bracts.—After Hanausek.

acute papillæ (epidermis of corolla), which are more numerous than in Dalmation powder; glandular hairs about 50 μ in diameter, being smaller than in Dalmatian powder; rose-colored fragments in chloral mounts possibly more numerous in the Persian powder.

6. STRAMONII FOLIA.—Dark green (Fig. 117); calcium oxalate in rosette aggregates 10 to 20 μ in diameter; non-glandular hairs few, 2- to 3-celled, with numerous slight centrifugal projections; glandular hairs few, stalk 1- to 2-celled, glandular head 2- to 4-celled (Figs. 106, *A*; 285, *C*; 287, *D*).

b. GLANDULAR HAIRS WANTING.

7. PILOCARPUS.—Dark green (Fig. 257); epidermal cells on surface view 5- to 6-sided, walls straight; calcium oxalate crystals in rosette aggregates, 20 to 30 μ in diameter, frequently in palisade cells and also in cells in the air spaces of the stomata; mesophyll cells frequently with reddish-brown tannin masses, turning green with ammonio-ferric sulphate solution; non-glandular hairs 1-celled, thick-walled, with numerous slight centrifugal projections, 0.4 to 0.6 mm. long in *P. Jaborandi* and 40 to 60 μ in *P. pinnatifolius* and *P. microphyllus*. In *P. microphyllus* the stomata are smaller than in the other two species.

8. TEA.—Large, elongated, irregular and colorless stone cells (idioblasts); numerous unicellular, long, thick-walled, non-glandular hairs 10 μ wide; rosette aggregates of calcium oxalate 10 μ in diameter; characteristic stomata 30 to 60 μ in diameter, with 3 or 4 accompanying cells. Adulterants are distinguished by possessing chiefly other forms of calcium oxalate crystals and hairs.

Allied Plants.—Maté or Paraguay tea (p. 322) is distinguished by the stomata, which are much larger than the epidermal cells of the lower surface; the epidermal cells occurring near the veins are in nearly parallel rows and with a striated surface; sclerenchymatous fibers are associated with the tracheæ, and calcium oxalate occurs in rosette aggregates.

Adulterants.—Ash leaves (species of *Fraxinus*) have rather characteristic "horned" stomata, due to the extra development of the cutinous layers at the poles of the stomata; the epidermal cells are very wavy in outline. Camellia leaves contain idioblasts (similar to those in tea leaves) and calcium oxalate crystals, but the lower epidermis is thick-walled and with centripetal thickening. Cherry leaves (*Prunus avium*) have numerous small rosette aggregates of calcium oxalate in the lower epidermal cells. GROMWELL leaves (*Lithospermum officinale*) have stiff, scythe-shaped hairs with centrifugal thickening of cuticle. MAPLE leaves (*Acer*

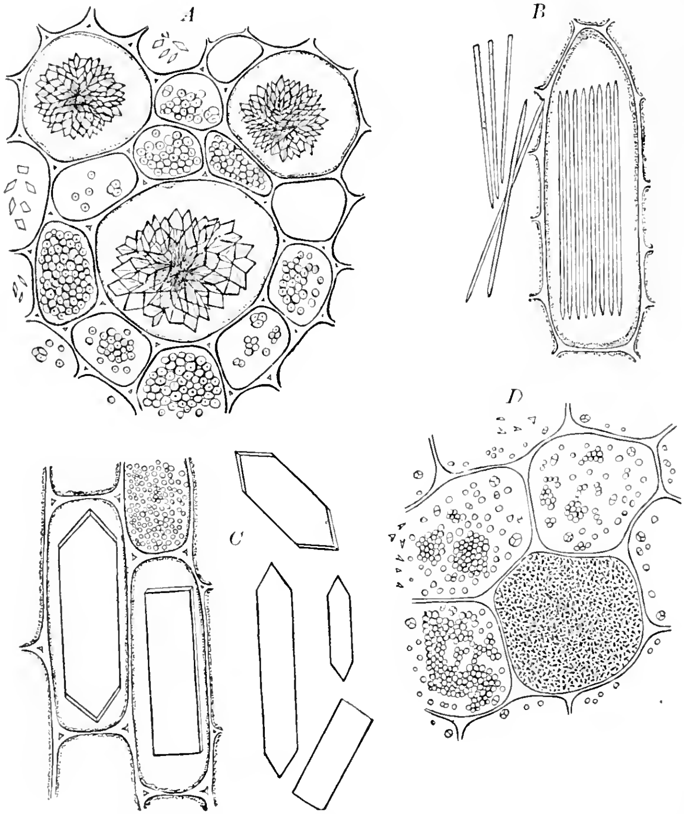

FIG. 281. Forms of calcium oxalate crystals: A, transverse section of rheum showing rosette aggregates of calcium oxalate in three of the cells and starch grains in some of the others; B, longitudinal section of scilla showing raphides; C, longitudinal section of quillaja showing large monoclinic prisms of calcium oxalate and also some starch grains; D, transverse section of belladonna root showing one cell filled with sphenoidal micro-crystals, the remaining cells containing starch.

Negundo) have non-glandular and glandular hairs, the latter with 2- to 3-celled stalk and large, unicellular head. MEADOW-SWEET (*Spiræa Ulmaria*) has unicellular, thin-walled, non-glandular hairs, the basal walls of which are truncate; the glandular hairs have either a 3-celled or multicellular stalk and a large, multicellular head. MOUNTAIN ASH or European Rowan (*Sorbus Aucuparia*) possesses long, thin-walled, non-glandular hairs with rounded base. MULBERRY leaves (*Morus alba* and *M. nigra*) have cystoliths in epidermal cells, non-glandular and glandular hairs, the latter with unicellular stalk and 5- to 9-celled head. OAK leaves (*Quercus pedunculata* and *Q. sessiliflora*) have 2- to 3-celled, non-glandular hairs and stomata only on epidermis of lower surface. SLOE leaves (*Prunus spinosa*) have rather characteristic crystal fibers. STRAWBERRY (*Fragaria vesca*) has long, unicellular, non-glandular hairs, the basal portion of which has a thick wall with simple pores, and glandular hairs consisting of a 3-celled stalk and large head, the cells swelling considerably in chloral solutions. The leaves of the WILLOW-HERB (*Epilobium angustifolium*) contain numerous raphides and the non-glandular hairs are slightly wavy, rather broad and with rounded ends. WILLOW leaves (species of *Salix*) have small stomata (about 25 μ in diameter) with two accompanying cells; the hairs are crooked and with thin walls; the calcium oxalate occurs in rosette aggregates and monoclinic prisms. WISTARIA (*Kraunhia floribunda*) has non-glandular hairs with 2 short basal cells and a long, thin-walled pointed cell; stomata only occur in the lower epidermis.

c. GLANDULAR AND NON-GLANDULAR HAIRS WANTING.

9. BUCHU.—Light green; calcium oxalate in rosette aggregates, 15 to 25 μ in diameter; epidermal cells with irregular masses or sphero-crystals of a carbohydrate, 30 to 50 μ in diameter, and with walls modified to mucilage; oil globules numerous (Fig. 158).

10. CONIUM.—Grayish-green or yellowish-brown (Fig. 248); calcium oxalate crystals in rosette aggregates, 1 to 2 μ in diameter, those in aleurone grains about 5 μ in diameter; parenchyma with chloroplastids and starch grains 2 to 4 μ in diameter; sclerenchymatous fibers long, thin-walled, with numerous simple oblique pores; intermediate fibers with reticulated walls; cells of pericarp nearly isodiametric, yellowish, irregularly thickened, somewhat collenchymatous; oil globules numerous.

11. CASTANEA.—The cells contain tannin masses, giving a blue color with ferric chloride. (See No. 18, under Senna.)

12. CHIMAPHILA.—Dark green; calcium oxalate in rosette aggregates 40 to 60 μ in diameter; mesophyll with irregular, reddish-brown tannin masses.

13. EUCALYPTUS.—Light green; calcium oxalate in rosette aggregates or monoclinic prisms 15 to 25 μ in diameter; outer wall of epidermal cells about 20 μ thick. In leaves from younger parts of the tree the outer wall of the epidermal cells is 5 to 8 μ thick.

14. GRANATUM.—(See No. 23.)

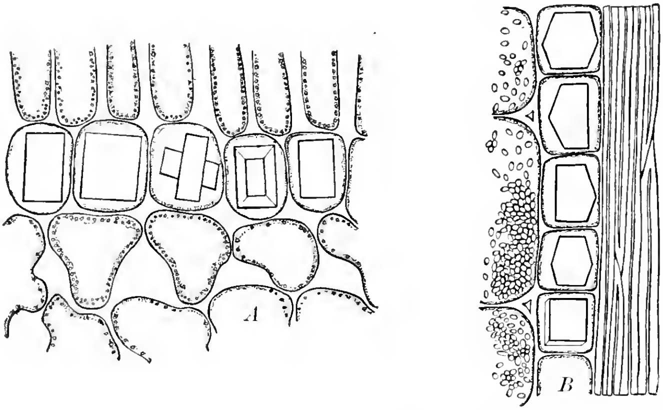

FIG. 282. A, transverse section of hyoscyamus leaf showing monoclinic prisms of calcium oxalate, also a twin-crystal; B, longitudinal section of glycyrrhiza showing a crystal fiber, *i.e.*, a row of superimposed cells, each containing a polygonal monoclinic prism of calcium oxalate, the crystal filling the cell. Adjoining the crystal fiber is a group of bast fibers on one side and some cells containing starch on the other.

B. CALCIUM OXALATE IN MONOCLINIC PRISMS.

a. GLANDULAR AND NON-GLANDULAR HAIRS PRESENT.

15. HYOSCYAMUS.—Dark green (Fig. 282, *A*), calcium oxalate in single or twin monoclinic prisms about 10 μ in diameter, occasionally in rosette-shaped crystals; non-glandular hairs numerous, 1- to 5-celled; glandular hairs numerous, of three different kinds, stalks 1- to 4-celled, glandular heads one- to many-celled (see also Figs. 287, *B*; 302, *A*).

b. ONLY NON-GLANDULAR HAIRS PRESENT.

16. CARDAMOMUM.—(See No. 43.)

17. HAMAMELIDIS FOLIA.—Dark green; calcium oxalate in monoclinic prisms 7 to 20 μ in diameter, frequently in crystal fibers; non-glandular hairs 1-celled, about 0.5 mm. long, more or less curved, thick-walled, with yellowish-brown contents, arranged in groups of about fifteen, and spreading from the base; mesophyll with irregular tannin masses; sclerenchymatous fibers thick-walled, lignified and with simple pores.

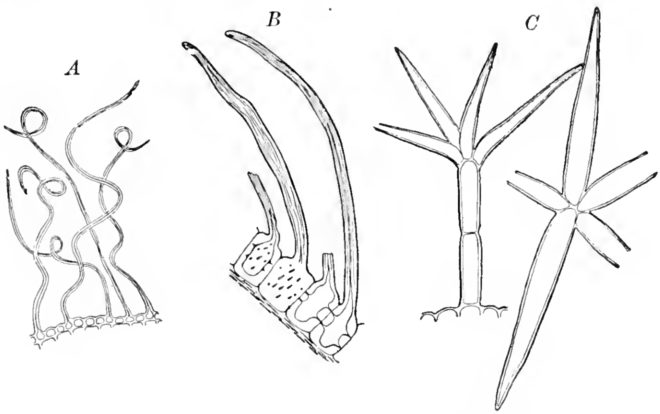

FIG. 283. Forms of non-glandular hairs: A, twisted hairs from under surface of leaf of eriodictyon; B, lignified hairs from the epidermis of nux vomica; C, branching hairs from the leaf of mullein (*Verbascum thapsus*).

18. SENNA.—Light green (Figs. 263; 284, *D*); non-glandular hairs 0.1 to 0.2 mm. long, 1-celled, thick-walled, the wall of the upper part strongly cutinized, with numerous slight centrifugal projections; calcium oxalate in rosette aggregates, or occasionally in monoclinic prisms, 10 to 20 μ in diameter; fragments colored reddish with potassium hydrate solution.

The powder of Indian senna (*Cassia angustifolia*) is dark green and has relatively few non-glandular hairs. In the powder of Argel Leaves (*Solenostemma Argel*, Fam. Asclepiadaceæ) the non-glandular hairs are 3- to 4-celled. In the leaves of *Castanea dentata* (Fam. Fagaceæ) the non-glandular hairs are relatively few, 0.2 to 0.5 mm. long, nearly smooth, thick-walled, occasionally in groups of three to eight and spreading from the base. The calcium oxalate crystals are numerous, in rosette aggregates or in monoclinic prisms, 10 to 35 μ in diameter, occasionally in crys-

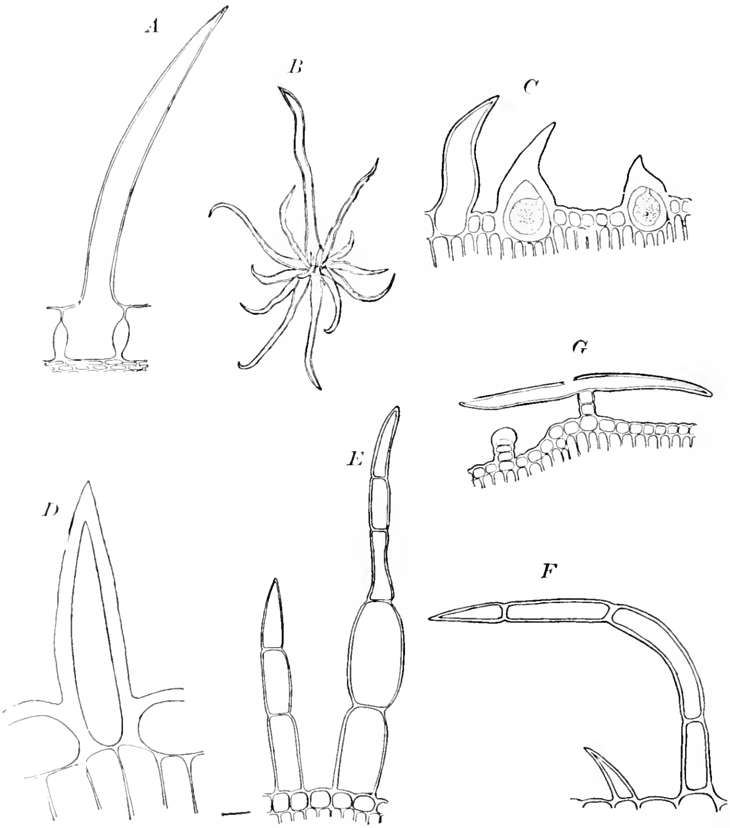

FIG. 284. Forms of non-glandular hairs: A, hair from the epidermis of strophanthus; B, a hair from the capsule of *Mallotus philippinensis* (found in the drug known as kamala); C, hairs from the leaves and bracts of cannabis indica, two of them containing cystoliths of calcium carbonate; D, a hair from the under surface of the leaf of senna; E, hairs from leaf of digitalis; F, two forms of hairs from sage leaf; G, two forms of hairs from the leaves of wormwood (*Artemisia Absinthium*): a T-shaped non-glandular hair and a short glandular hair.

tal fibers; the parenchymatous cells contain irregular yellowish-brown tannin masses which are colored blue with ammonio-ferric alum solution.

19. UVA URSI.—(See No. 22.)

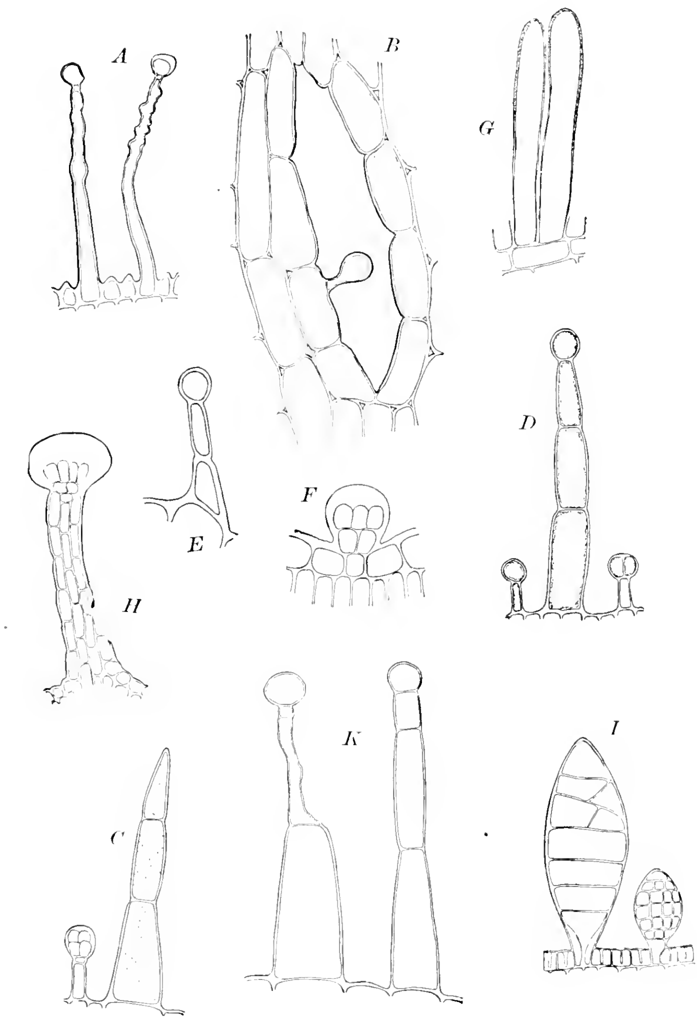

Fig. 285. Forms of glandular hairs: A, corkscrew-like hairs from the inner surface of the spurred corolla of lavender; B, longitudinal section of rhizome of *Aspidium marginale* showing large intercellular space and an internal oil-secretion hair; C, hairs from stramonium leaf; D, hairs from digitalis; E, hair from sage; F, hair from eriodictyon; G, hairs from inner walls of pericarp of vanilla; H, hair from cannabis indica; I, hairs from surface of fruit of *Rhus glabra;* K, hairs from belladonna leaf.

c. GLANDULAR AND NON-GLANDULAR HAIRS WANTING.

20. COCA.—Dark green (Fig. 286), calcium oxalate in monoclinic prisms 3 to 10 μ in diameter; walls of under epidermal cells extended as minute papillæ (Fig. 261).

21. GUAIACUM.—Dark green (p. 669); numerous lemon-yellow or dark brown resin masses, which when mounted in

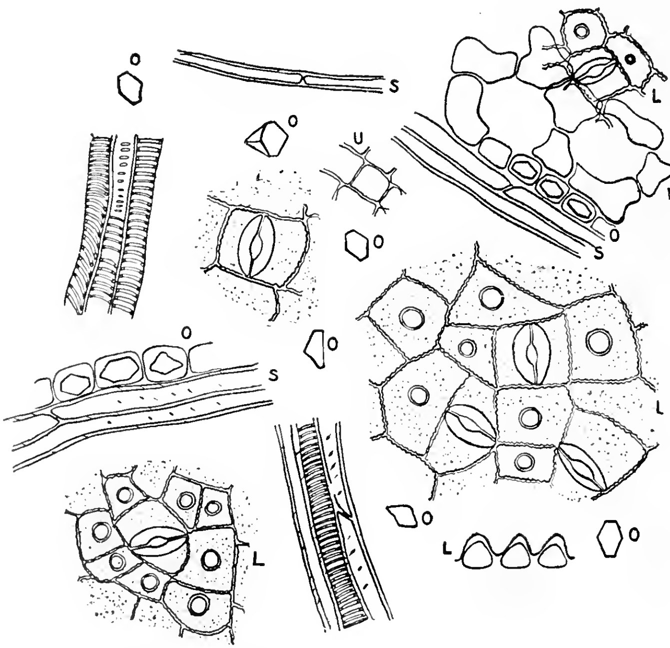

FIG. 286. Coca leaf: O, hexagonal prisms of calcium oxalate; U, surface view of a cell of the upper epidermis; L, view of fragments of lower epidermis in surface and cross sections, showing elliptical stomata, and cells with circles which represent papillæ in surface view; S, sclerenchymatic fibers; M, loose parenchyma. Two fragments with annular tracheæ are also shown.

chloral are wine-colored at the margin; few fragments of tissues with characteristic sclerenchymatous cells and fibers; few crystals of calcium oxalate in monoclinic prisms.

22. UVA URSI.—Yellowish-green; calcium oxalate in monoclinic prisms 7 to 10 μ in diameter, frequently in crystal fibers; non-glandular hairs few, somewhat curved, 1-celled, thick-walled,

longitudinally striate; mesophyll with irregular, yellowish-brown tannin masses; characteristic sclerenchymatous fibers (Fig. 300, *D*).

C. CALCIUM OXALATE IN CRYSTAL FIBERS.

23. GRANATUM.—Dark green (Fig. 234), crystal fibers containing calcium oxalate in rosette aggregates and monoclinic prisms, about 15 μ in diameter; sclerenchymatous cells non-lignified, thick-walled, with distinct lamellæ, simple, more or less branching pores; starch grains spherical, 5 to 7 μ in diameter; some parenchymatous cells with marked centripetal thickenings, others with irregular tannin masses. The powder of the root bark is free from chloroplastids; the cork cells are more numerous and the sclerenchymatous cells more irregular in shape.

24. UVA URSI.—(See No. 22.)

D. CALCIUM OXALATE IN SPHENOIDAL MICRO-CRYSTALS.

a. WITH HAIRS.

25. BELLADONNÆ FOLIA.—Dark green (Fig. 287, *C*); calcium oxalate in sphenoidal micro-crystals; non-glandular hairs few, simple, 2- to 5-celled; glandular hairs few, of two kinds, stalks one- to three-celled, glandular heads one- to many-celled (Fig. 285, *K*).

26. TABACUM.—Greenish-brown; non-glandular hairs, 3- to 6-celled, with a broad basal cell and not infrequently branching apical cells; glandular hairs of two kinds, either with a 1-celled stalk or 3- to 5-celled stalk, the head in each case being rather small and with 8 to 9 cells; stomata large and with 2 or 3 neighboring cells; epidermal cells striated and somewhat granular on surface view; the cells of the mesophyll with a greenish-brown content, and some of them with sphenoidal micro-crystals. The following leaves have been used as adulterants: Chestnut (see No. 11), cherry (see No. 8), rose, melilot, cabbage, chicory, beet, and lappa. In the manufacture of plug tobacco various other substances are added; as, licorice (Figs. 104; 204; 282, *B*),

cloves (Fig. 312), anise (Fig. 244), orris root (Figs. 317, 320), vanilla (Figs. 256, 313), tamarinds, prunes, besides other substances.

27. SOLANUM CAROLINENSE (Horse nettle).—Starch grains spherical, ellipsoidal, ovoid and 2- to 4-compound, varying in size from 10 to 35 μ and with distinct lamellæ; non-glandular hairs, stellate, 1- to 2-celled; abundance of parenchyma with sphenoidal micro-crystals; ducts very broad, with oblique circular pores closely resembling those in glycyrrhiza; wood fibers long, the walls being 1 to 2 μ thick (Fig. 176a).

b. HAIRS FEW OR WANTING.

28. DULCAMARA.—Calcium oxalate in sphenoidal micro-crystals; starch grains 5 to 7 μ in diameter; acicular crystals in parenchyma of bark; tracheæ with bordered pores, 35 to 45 μ wide, and accompanied by sclerenchymatic fibers; an occasional single bast fiber; cork cells present. The following drugs have been substituted for Dulcamara: The stems of false bittersweet (*Celastrus scandens*) which are more woody and not hollow; hop stems which are rough hairy; and the rhizome of Saponaria which is terete and wrinkled.

II. CALCIUM OXALATE CRYSTALS FEW OR WANTING.

A. CYSTOLITHS OF CALCIUM CARBONATE PRESENT.

29. CANNABIS INDICA.—(See No. 1.)

30. RUELLIA.—This is a rather common adulterant of spigelia, and somewhat resembles it, but is readily distinguished from it by an effervescence on the addition of dilute hydrochloric acid. This effervescence is due to the presence of cystoliths in some of the cells of the cortex (Fig. 221). The cystolith-containing cells are spherical in transverse section and about 20 μ wide, but in longitudinal view are about 80 μ long. Numerous stone cells also occur; these are thick-walled and with numerous radiate simple pores.

B. CALCIUM CARBONATE WANTING.

a. GLANDULAR AND NON-GLANDULAR HAIRS PRESENT.

α *Fragments of Pappus Present.*

31. EUPATORIUM.—Dark green; non-glandular hairs of two kinds, 2- to 8-celled, thin-walled, finely striate, one kind with acute end-cell and the other with rounded end-cell; glandular hairs either 6- to 8-celled in a double row, and with 2-celled glandular head, or short-stalked and with 4- to 12-celled glandular head; pollen grains ellipsoidal, 10 to 20 μ in diameter and with numerous centrifugal projections; pappus occurring as a multicellular axis about 30 μ in diameter and with short unicellular alternate branches; ducts spiral, annular, or with bordered pores; sclerenchymatous fibers thin-walled, non-lignified, with few, simple, oblique pores.

32. GRINDELIA.—Light green; tracheæ spiral, annular, or with bordered pores, strongly lignified; sclerenchyma fibers thin-walled, non-lignified, with numerous simple more or less oblique pores; pollen grains spherical, about 25 μ in diameter, with numerous centrifugal projections; glandular hairs depressed, globular, multicellular; numerous oil globules and resin masses; pappus consisting of a multicellular axis with minute teeth.

β *Fragments of Pappus Wanting.*

33. DIGITALIS.—Dark green (Figs. 284, *E*; 287, *A*); non-glandular hairs simple, consisting of 2 to 5 superimposed cells, straight or slightly curved; glandular hairs with 1-celled stalk and 1- to 2-celled glandular head; stone cells, star-shaped hairs and calcium oxalate crystals wanting (Figs. 266; 285, *D*).

ADULTERANTS.—The leaves of Matico (see No. 40) have numerous stomata and the non-glandular hairs are from 2- to 6-celled. The leaves of *Salvia Sclarea* (Fam. Labiatæ) have non-glandular hairs somewhat resembling Digitalis, but the glandular hairs are of the labiate type with large, 8-celled, glandular heads. The leaves of *Verbascum Phlomoides* (Fam. Scrophulariaceæ) have multicellular, branching, non-glandular hairs resembling those of *V. thapsus* (Fig. 283, *C*), and small glandular

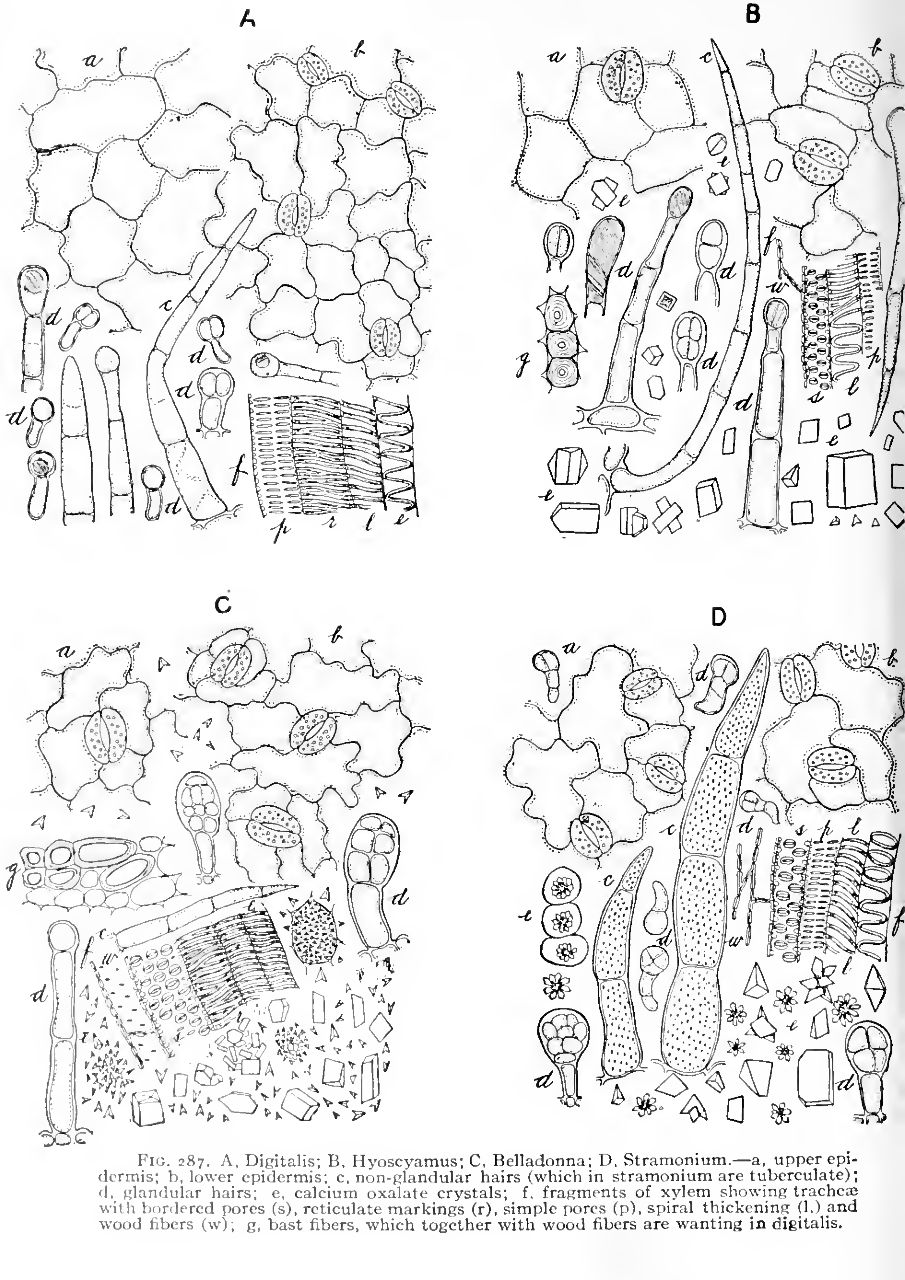

FIG. 287. A, Digitalis; B, Hyoscyamus; C, Belladonna; D, Stramonium.—a, upper epidermis; b, lower epidermis; c, non-glandular hairs (which in stramonium are tuberculate); d, glandular hairs; e, calcium oxalate crystals; f, fragments of xylem showing tracheæ with bordered pores (s), reticulate markings (r), simple pores (p), spiral thickening (l,) and wood fibers (w); g, bast fibers, which together with wood fibers are wanting in digitalis.

hairs resembling those of digitalis. The non-glandular hairs of *Inula Conyza* (Fam. Compositæ) are 3- to 4-celled, with thick walls, the basal cell being broad and truncate.

34. HEDEOMA.—Dark green; non-glandular hairs slightly curved, 2- to 3-celled, thick-walled, with numerous slight centrifugal projections; glandular hairs with 1-celled stalk and 8-celled glandular head; pollen grains somewhat spherical, about 35 μ in diameter, nearly smooth; tracheæ spiral or with simple and bordered pores; sclerenchymatous fibers long, thin-walled, lignified, with numerous simple pores; epidermal cells with sphere-crystals or irregular masses of a carbohydrate.

35. MARRUBIUM.—Dark green; non-glandular hairs much twisted, 1- to 7-celled, thin-walled, smooth, frequently arranged in groups of about six or eight, and spreading from the base; glandular hairs with 1-celled stalk and 8-celled glandular head; pollen grains spherical, about 25 μ in diameter, and with numerous centrifugal projections; tracheæ spiral, annular, or reticulate, slightly lignified; sclerenchymatous fibers thin-walled, non-lignified, with few simple pores.

36. MENTHA PIPERITA.—Dark green; non-glandular hairs 1- to 8-celled, thin-walled, with numerous slight projections; glandular hairs two kinds, 1- or 3-celled stalk and 1- or 8-celled glandular head; pollen grains somewhat spherical, smooth, about 35 μ in diameter; tracheæ spiral, or with simple and bordered pores, and slightly lignified; sclerenchymatous fibers thin-walled, non-lignified, with numerous oblique pores. Contamination with *M. spicata* is said to be common (Fig. 175).

37. SCUTELLARIA.—Dark green; non-glandular hairs, 1- to 3-celled, 100 to 200 μ long, the walls with numerous slight centrifugal projections, the basal cell being large, broadly cylindrical, and the apical cell narrow and with a sharp, frequently recurved apex; glandular hairs with a 1- to 2-celled stalk and large, glandular head, composed of 6 or 8 cells placed side by side, indistinct; pollen grains nearly spherical or ellipsoidal, smooth and 15 to 25 μ in diameter; fragments of corolla colored light pink with chloral solution; narrow tracheæ with scalariform and reticulate thickenings, or bordered pores; sclerenchymatous fibers narrow, with walls 4 or 5 μ thick and with simple pores;

epidermal cells of stem and corolla with distinct striæ; the stomata broadly elliptical and with very small openings. In *Scutellaria canescens* the non-glandular hairs are 3- to 5-celled and vary in length from 0.3 to 1 mm.; the glandular hairs have a 4-celled stalk and 8-celled head, are larger and more prominent than in *S. lateriflora;* and the opening between the guard cells is on surface view long and narrow (Fig. 180).

38. SALVIA.—Dark green; non-glandular hairs 1- to 6-celled, filled with air (Fig. 284, *F*) glandular hairs numerous, of two kinds, stalks 1- to 3-celled, glandular heads unicellular or 8-celled (Fig. 285, *E*).

b. GLANDULAR HAIRS WANTING.

a With Non-glandular Hairs.

39. LOBELIA.—Dark green; non-glandular hairs, 1-celled, 0.3 to 0.6 mm. long, walls moderately thick, with numerous slight centrifugal projections; pollen grains ellipsoidal, smooth, 15 to 30 μ in diameter; laticiferous vessels branched; tracheæ spiral, or with scalariform and bordered pores; sclerenchymatous fibers comparatively thin-walled, non-lignified, and with simple oblique pores. Seeds about 100 μ long, reticulate (Fig 272).

40. MATICO.—Grayish-green; non-glandular hairs numerous 1- to 6-celled, varying from 0.2 to 1 mm. in length, with walls 2 to 4 μ thick and striate, the apical cell being sharply pointed; numerous globular, yellowish or reddish resin masses in oil glands of leaf; fragments of perianth with fan-shaped upper portion, composed of numerous long, non-glandular hairs, which are much collapsed and deeply striate; seeds reddish-brown and distinctly reticulate (Fig. 271).

41. TANACETUM.—Yellowish-green; non-glandular hairs few, 4- to 5-celled, about 150 μ long, the individual cells being somewhat oblong and with yellowish-brown contents; glandular hairs on akenes with short stalk and large, ellipsoidal head; involucral bracts with a row of transparent marginal cells and central portion with narrow, thick-walled, libriform cells with numerous simple pores; pollen grains spherical or somewhat triangular, thick-walled and with numerous spinose, centrifugal projections;

narrow tracheæ with scalariform and reticulate thickenings or bordered pores; sclerenchymatic fibers thin-walled and free from pores.

42. SCOPARIUS.—Dark green; non-glandular hairs 1-celled, 0.5 to 0.7 mm. long, thick-walled; tracheæ spiral or double spiral, slightly lignified; sclerenchymatous fibers narrow, thin-walled and with simple pores.

β Non-glandular Hairs Wanting.

43. CARDAMOMUM.—Greenish-brown; stone cells dark brown, slightly elongated, 15 to 25 μ in diameter, the inner wall thickened; outer epidermal cells 20 to 30 μ in diameter, elongated on surface view, inner and outer walls thickened; oil-secretion cells with suberized walls; starch grains spherical or angular, single or compound, 1 to 4 μ in diameter; monoclinic prisms of calcium oxalate few, 10 to 25 μ in diameter. The powder of the pericarp and seeds is pinkish and contains in addition, sclerenchyma fibers which are non-lignified, relatively thin-walled and with simple, slightly oblique pores; not more than 10 per cent. of ash. The powder of Ceylon cardamom contains the unicellular hairs of the capsule; and the cells, as also the starch grains and calcium oxalate crystals, are larger (Fig. 253).

43a. SABINA.—Starch, 4 μ; characteristic hypodermis, consisting of long fibers 15 μ wide, associated with epidermis; narrow tracheids; numerous oleo-resin masses (Fig. 51).

44. STAPHISAGRIA.—Dark green; sclerenchymatous cells somewhat ovate in cross-section, more or less thick-walled and non-lignified; parenchyma containing oil and aleurone.

45. CHELIDONIUM.—Light green; aqueous solution golden yellow; numerous small, somewhat plano-convex or reniform, slightly reticulate seeds, which are about 1 mm. long; fragments of leaves with spiral tracheæ, and latex tubes with light yellowish contents; elliptical or spherical stomata on lower surface only, walls rather indistinct; pollen grains spherical, nearly smooth, with 3 pores and 20 to 25 μ in diameter; fragments of petals with distinctly yellowish fibrovascular bundles. Hairs, starch grains and calcium oxalate crystals are wanting.

POWDERS OF A YELLOWISH COLOR.

In this group are included all those powdered drugs which are of a light yellow (light yellow ochre), dark yellow (dark yellow ochre), lemon-yellow, bright yellow (luminous yellow) or yellowish-brown color. Representatives of all the different kinds of drugs are found in this group.

I. FRAGMENTS OF VEGETABLE TISSUE PRESENT.

A. CONTAINING STARCH.

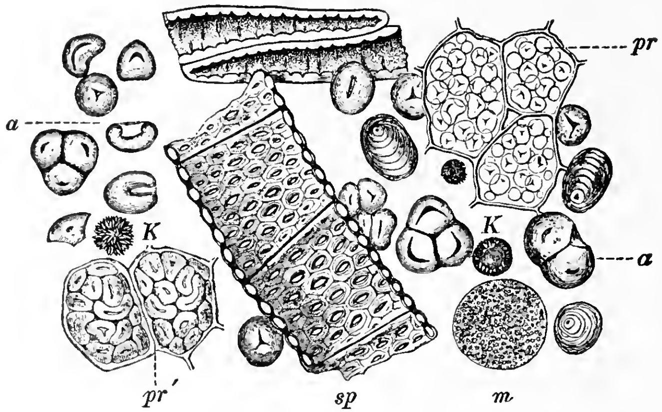

FIG. 288. Jalap: pr, parenchyma containing unaltered starch grains; pr', parenchyma containing swollen starch grains; a, starch grains; K, rosette aggregates of calcium oxalate; m, globular mass of resin; sp, fragment of trachea with bordered pores.—After Vogl.

a. CALCIUM OXALATE PRESENT.

α *In Rosette Aggregates.*

46. FRANGULA.—(See No. 52.)

47. GALLA (ALEPPO).—Dark yellow crystals 10 μ; starch grains 10 μ in diameter, single or sometimes in groups; stone cells; tannin; crystals of gallic acid. *Chinese or Japanese Galls.*—Grayish-green; crystals few, about 20 μ in diameter; starch grains about 40 μ in diameter; non-glandular hairs; milk vessels accompanying ducts. The mounts in glycerin show acicular crystals of gallic acid.

48. JALAPA.—Dark yellow; crystals of calcium oxalate in rosette aggregates, 30 to 35 μ in diameter; starch grains ellipsoidal and ovoid, with somewhat excentral lamellæ, 15 to 35 μ in diameter, 1- to 3-compound and in some cases more or less swollen; resin cells yellowish-brown; sclerenchymatous fibers few, with simple pores (Fig. 195). Tubers deficient in resin are lighter in color, contain more starch and less calcium oxalate (Fig. 288).

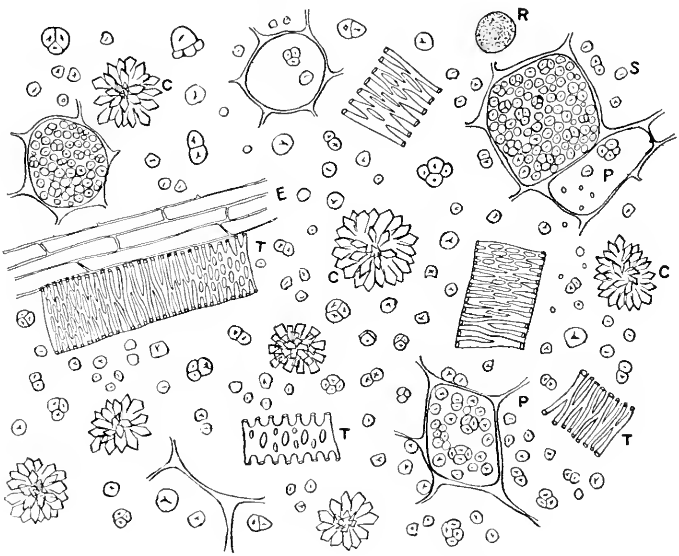

FIG. 289. Rhubarb: C, rosette aggregates of calcium oxalate; P, parenchyma containing starch grains (S); T, tracheæ; E, sieve; R, reddish-brown masses.

49. RHEUM.—Yellowish-brown (Figs. 281, *A*; 289); crystals of calcium oxalate in rosette aggregates, 50 to 100 μ in diameter; starch grains somewhat spherical, 5 to 20 μ in diameter, either single or 2- to 4-compound; tracheæ few, scalariform. The powder is colored reddish with alkalies. A common adulterant is "wheat middlings." (See No. 239.) The exhausted drug is frequently added to the powder and may be detected by the somewhat altered starch grains and the decrease in the amount of the aqueous or dilute alcoholic extract, which in genuine rhubarb is about 35 per cent.

Rhapontic rhubarb contains a crystalline glucoside rhaponticin, which is colored purplish-red with sulphuric acid, changing to orange. It is insoluble in ether and readily separates from a dilute alcoholic fluid extract on the addition of ether.

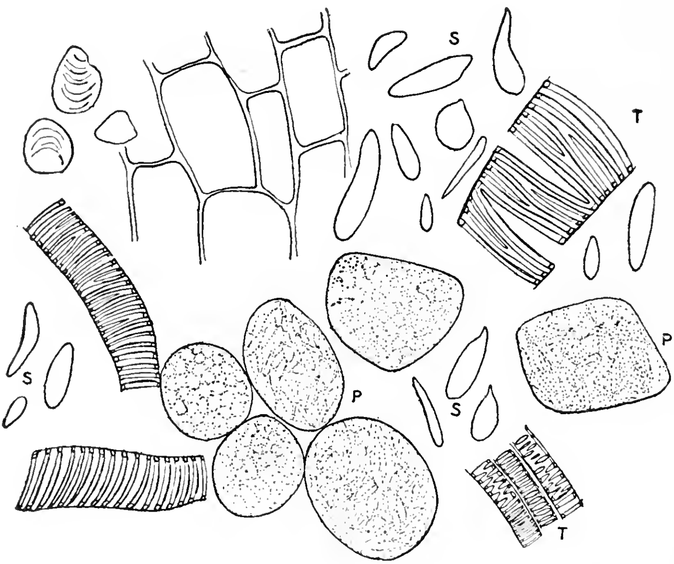

Fig. 290. Curcuma (Turmeric): P, fragments of parenchyma containing swollen and altered starch grains which form an indistinguishable mass within the cells and constitute the greater proportion of the powder; T, tracheæ; S, unaltered starch grains.

β In Monoclinic Prisms.

50. CALUMBA.—(See No. 60.)

51. CURCUMA.—Bright yellow (Fig. 290); crystals few, 2 to 4 μ in diameter; altered starch grains (test with iodine) in irregular masses from 100 to 140 μ in diameter, having the shape of the cell in which they occur; bright yellow oil-secretion cells; the pigment is soluble in solutions of chloral or chloral-glycerin, essential oils and alcohol. The latter solution becomes cherry-red with boric acid, changing to bluish-black with ammonia. Curry powder consists of allspice, caraway, cardamom, clove, coriander, fenugreek, ginger, pepper and turmeric.

52. FRANGULA.—Yellowish-brown (Fig. 228); bast fibers lignified, much thickened, with numerous pores; crystal fibers containing small monoclinic prisms of calcium oxalate; calcium oxalate also in rosette aggregates or monoclinic prisms, 5 to 20 μ in diameter; starch grains nearly spherical, about 4 μ in diameter, not numerous; parenchymatous cells with yellowish contents colored red by alkalies.

53. GELSEMIUM.—Dark yellow (Fig. 208); tracheæ with simple pores; sclerenchymatous fibers long, narrow, lignified; starch grains spherical, from 4 to 8 μ in diameter; calcium oxalate in monoclinic prisms 15 to 30 μ in diameter. In the powder of the overground stem collenchymatous cells containing chloroplastids occur (Fig. 208, *A*).

54. QUASSIA.—Light yellow (Fig. 239); tracheæ large, with bordered pores; sclerenchymatous fibers long, thin-walled and with oblique pores; medullary rays with calcium oxalate in monoclinic prisms or in cryptocrystalline crystals, or with few spherical starch grains. When bark of the wood is present a few stone cells and cork cells are also present. In the bark of Surinam quassia stone cells are numerous. (See also Fig. 299, *C*.)

γ *In Crystal Fibers.*

55. GLYCYRRHIZA (SPANISH).—Bright yellow (Figs. 104; 204; 282, *B*); sclerenchymatous fibers numerous; crystal fibers containing monoclinic prisms of calcium oxalate; starch grains somewhat spherical, 2 to 20 μ in diameter; fragments of cork. The aqueous extract amounts to about 30 per cent.

56. GLYCYRRHIZA (RUSSIAN).—Bright yellow; containing few or no fragments of cork; taste not so bitter as that of Spanish licorice.

δ *In Raphides.*

57. IPECACUANHA.—Dark yellow (Figs. 203; 291; 299, *A*); tracheids with simple oblique or bordered pores, sometimes containing starch grains; calcium oxalate in raphides 20 to 40 μ long; starch grains ellipsoidal, 4 to 14 μ in diameter, single or 2- to 4-compound. In Carthagena ipecac the starch grains are uniformly larger, 4 to 15 μ in diameter.

Substitutes of Ipecac.—The root of *Richardsonia scabra* has simple and compound starch grains from 20 to 40 μ in diameter; the root of *Triosteum perfoliatum* and the bark of *Naregamia alata* contain starch grains and rosette aggregates of calcium oxalate, the latter containing in addition orange-red secretion cells; the root of *Heteropteris pauciflora* (Fam. Malpighiaceæ) is free from starch but contains rosette aggregates of calcium oxalate, brown pigment cells and stone cells.

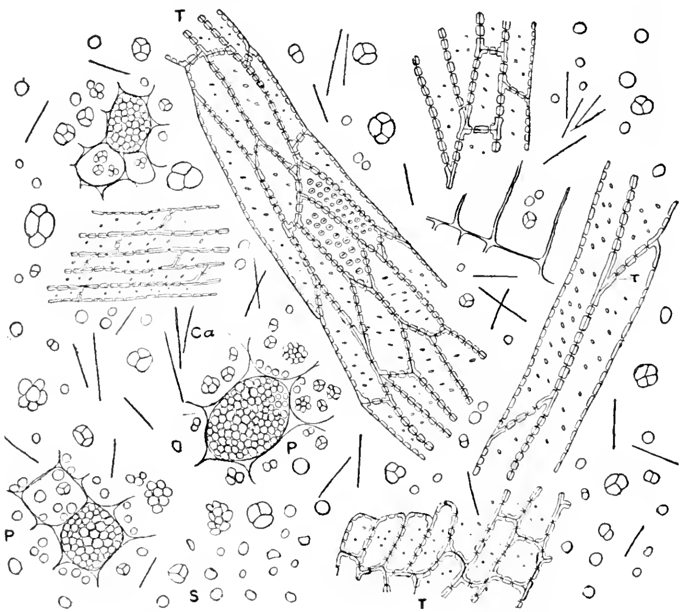

Fig. 291. Rio ipecac: T, tracheids; P, parenchyma containing starch; S, starch grains; Ca, raphides of calcium oxalate.

58. PHYTOLACCA.—Dark yellow; sternutatory; fragments with long sclerenchymatous fibers and large scalariform tracheæ; starch grains 7 to 18 μ in diameter; calcium oxalate in raphides 30 μ long, or in cryptocrystalline crystals (Figs. 191, 200).

59. VERATRUM.—Yellowish-brown (Figs. 215, 216); sternutatory; tracheæ slightly lignified, scalariform or reticulate; sclerenchymatous fibers thin-walled, narrow, slightly lignified; calcium oxalate in raphides 45 μ long; starch grains nearly ellip-

soidal, 7 to 20 μ in diameter, single or 2- to 3-compound, point of origin of growth circular or slightly cleft; endodermal cells thickened on the inner tangential wall. The powders of *Veratrum album* and *Veratrum viride* cannot be distinguished one from the other by their microscopic characters, but appear to differ chemically, a mount of *V. viride* in concentrated sulphuric acid having a yellowish-red color and that of *V. album* a dull red color. The so-called powdered hellebore, used as an insecticide by gardeners consists of either *V. album* or *V. viride*, the former being mostly employed.

b. CALCIUM OXALATE WANTING.

α *Stone Cells Present.*

60. CALUMBA.—Bright yellow (Figs. 198; 302, *H*); stone cells containing one or more monoclinic prismatic crystals of calcium oxalate; starch grains single, irregular, 25 to 35 μ long, with excentral and distinct lamellæ.

β *Stone Cells Wanting.*

1. Starch Grains 15 to 30 μ in Diameter.

61. ZINGIBER.—Light yellow (Figs. 212, 214, 317); starch grains ellipsoidal or somewhat ovoid, slightly beaked, 15 to 60 μ in diameter; secretion cells with suberized walls and yellowish, oily contents; tracheæ large, thin-walled, annular or reticulate; sclerenchymatous fibers long, thin-walled, with oblique pores. The powder of African Ginger is dark yellow or dark brown, more aromatic and pungent, and has numerous fragments of cork.

In Japan Ginger (p. 488) there are numerous compound grains varying from 4 to 25 μ in diameter, while in Calcutta ginger there are numerous spherical grains (15 to 25 μ) resembling those of wheat. Exhausted ginger is sometimes used to adulterate powdered ginger. If the exhaustion has been by means of water the starch grains are somewhat altered. If the extraction has been made with alcohol the yellowish-brown resinous cells are not so pronounced. Ginger, particularly the decorticated varieties, loses on keeping part of the pale yellowish oil, which is replaced in part by a reddish resin. Ginger is also sometimes adulterated with wheat middlings (No. 239), and flaxseed meal (Figs. 184, 293). Curcuma (Fig. 290) is sometimes added to an exhausted or adulterated ginger to bring up the color to that of the normal drug.

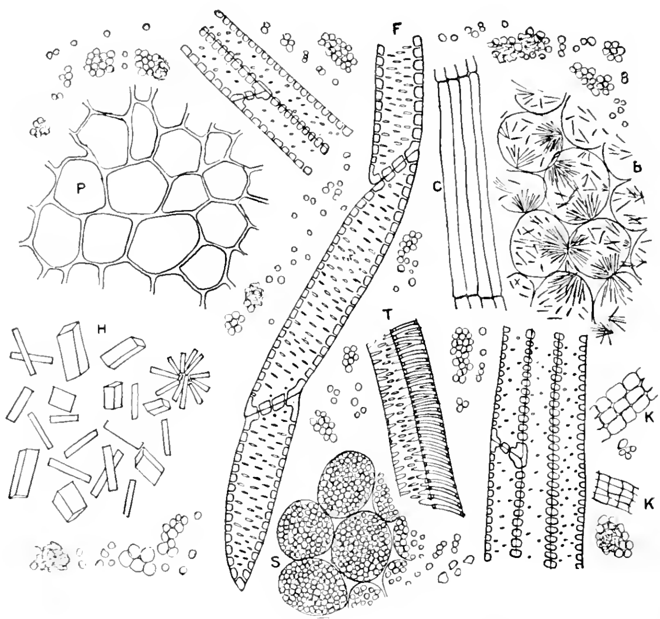

FIG. 292. Hydrastis: P, parenchyma; S, parenchyma containing starch; T, tracheæ with annular and reticulate thickenings of the walls; F, tracheids with simple pores; C, cambium; K, cork; B, parenchyma cells showing the separation of acicular crystals of one of the alkaloids on the addition of concentrated sulphuric acid; H, prisms of one of the alkaloids which separate on the addition of concentrated sulphuric acid to a powder previously moistened with water.

2. Starch Grains 5 to 15 μ in Diameter.

62. MEZEREUM.—Dark yellow; sternutatory; bast fibers numerous, long, thin-walled, non-lignified; starch grains somewhat spherical, 10 to 15 μ in diameter, single or compound.

63. PAREIRA.—Dark yellow; sclerenchymatous cells numerous, more or less thick-walled and slightly lignified; sclerenchy-

matous fibers slightly lignified and with oblique, simple or bordered pores; tracheæ nearly 0.2 mm. in diameter, short, non-lignified and with simple pores; starch grains nearly ellipsoidal, 7 to 15 μ in diameter.

64. SERPENTARIA.—Dark yellow; tracheæ lignified, spiral or with simple pores; sclerenchymatous fibers lignified; parenchyma with yellowish or dark brown contents; starch grains nearly spherical, 10 μ in diameter. The rhizome of yellow root (*Jeffersonia diphylla*) is sometimes substituted for serpentaria, from which it is distinguished by its lack of odor and by having a bitter, acrid taste.

65. BERBERIS.—Tracheæ 50 μ wide, with bordered pores and scalariform and reticulate thickening of the wall; wood fibers 20 μ wide and with walls 8 μ thick; medullary rays yellow, about 9 rows wide, the cells containing starch grains which are about 10 μ in diameter; bast fibers about 15 μ wide and with walls 4 μ thick; cork cells distinct; parenchyma of cortex with brownish-colored substance.

3. Starch Grains Less Than 5 μ in Diameter.

66. HYDRASTIS.—Bright yellow; tracheæ with simple pores; sclerenchymatous fibers short, thin-walled, with simple pores; starch grains spherical, about 4 μ in diameter (Figs. 219, 292).

4. Starch Grains Altered.

67. CURCUMA.—(See No. 51.)

B. STARCH GRAINS FEW OR NONE.

a. CALCIUM OXALATE CRYSTALS PRESENT.

a In Rosette Aggregates.

68. ANISUM.—Yellowish-brown; non-glandular hairs 25 to 200 μ long and 10 to 15 μ wide, 1-celled, straight or curved, with numerous slight centrifugal projections; calcium oxalate crystals rosette-shaped, 2 to 3 μ in diameter, in aleurone grains about 6 μ

in diameter; vittæ (in fragments) from 10 to 150 μ wide and showing a marked tendency to branch; long, narrow, brownish epidermal cells; sclerenchymatous cells of carpophore short, with simple pores and occasional scalariform thickenings (Fig. 244).

Italian Anise is occasionally ADMIXED WITH CONIUM, which is distinguished by the absence of hairs and vittæ and the presence of coniine, which is determined by the development of the characteristic odor on rubbing up the powder with alkalies or placing the powder in a solution of potassium or sodium hydrate. The following micro-chemical tests may be useful in determining the presence of coniine, which occurs in the parenchyma and epidermal cells of the fruit: Ammonium vanadinate and sulphuric acid produce a blue color; iodine solution gives a reddish-brown color; and picric acid gives a granular precipitate.

69. CALENDULA.—Bright yellow; epidermal cells long, narrow, with numerous oil-like globules, irregular chromoplastids and somewhat sinuate walls; pollen grains spherical, with numerous centrifugal projections, 3-pored, about 40 μ in diameter; non-glandular hairs consisting of a double row of cells and with a 1- or 2-celled apex; calcium oxalate in rosette-shaped crystals about 4 μ in diameter. On adding the powder to water the latter becomes a pale straw-color (Fig. 296, *B*).

70. FŒNICULUM.—Yellowish-brown; calcium oxalate in rosette aggregates 1 to 2 μ in diameter, in aleurone grains 3 to 6 μ in diameter; fragments containing vittæ, which are 100 to 200 μ wide; short, narrow, yellowish-brown epidermal cells of pericarp; sclerenchymatous fibers few, thick-walled, with oblique pores; parenchymatous cells slightly elongated or thick-walled, with numerous simple pores, and occasionally reticulately thickened; oil globules numerous (Figs. 97, 246).

β *In Monoclinic Prisms.*

71. AURANTII AMARI CORTEX.—Dark yellow; parenchymatous cells either somewhat collenchymatous or with simple pores, walls 10 to 15 μ thick; calcium oxalate in monoclinic prisms 15 to 20 μ in diameter; tracheæ few, spiral, annular or with simple pores.

72. AURANTII DULCIS CORTEX.—Light brown; calcium oxalate in monoclinic prisms 20 to 30 μ in diameter; walls of parenchymatous cells about 4 μ thick.

γ *In Raphides.*

73. SCILLA.—Light yellow; calcium oxalate mostly in raphides from 0.1 to 1 mm. in length; few tracheæ and fragments of epidermis (Fig. 281, *B*).

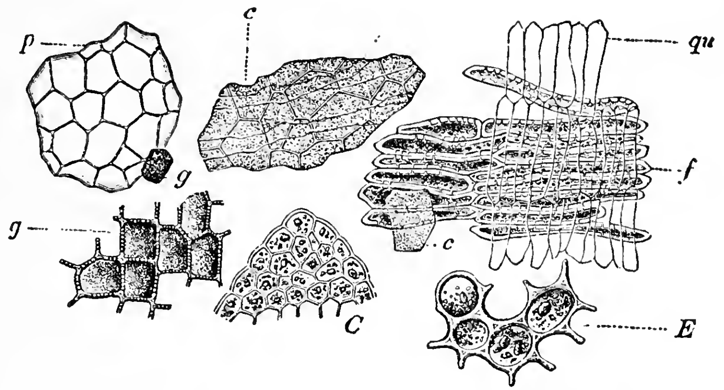

FIG. 293. Ground flaxseed: p, epidermis; c, epidermal cells with broken cutinized layer; E, parenchyma cells beneath the epidermis; f, short sclerenchymatic fibers; qu, colorless cells beneath the sclerenchymatic fibers; g, pigment cells with thick porous walls and yellowish-brown contents; C, cells of cotyledons containing aleurone grains.—After Moeller.

b. CALCIUM OXALATE CRYSTALS WANTING.

a Sclerenchymatous Cells or Fibers Present.

1. Dark Pigment Cells Wanting.

74. SINAPIS ALBA.—Light yellow (Figs. 294; 302, *E, F*); fragments of seed-coat with mucilaginous epidermal cells; a subepidermal collenchymatous layer of 1 or 2 rows of cells; a layer of radially elongated palisade or STONE CELLS (forming the so-called "beaker cells"), the walls of the lower part being slightly thickened and polygonal in surface view; two or more inner layers of thin-walled colorless cells; a single layer of cells containing aleurone grains and fixed oil, and some obliterated cells,

which together constitute the endosperm. The embryo makes up the greater portion of the seed, and the cells contain aleurone grains with fixed oil.

Ground White Mustard or white mustard flour is prepared from the seed of *Sinapis alba* with or without the removal of a part of the seed-coat (hulls) and the fixed oil. In fact, not infrequently mustard seed-cake is employed.

Prepared Mustard (German Mustard, French Mustard or Mustard Paste) is a paste composed of a mixture of ground mustard (either *Sinapis alba* or *Brassica nigra,* or both), salt, spices and vinegar. It should contain not more than 24 per cent.

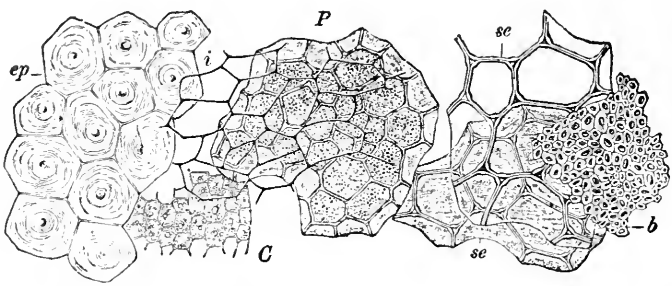

Fig. 294. White mustard. Surface view of the different tissues as seen in the powder: ep, polygonal cells of the outer epidermis showing mucilage lamellæ and the reduced lumen due to swelling of the lamellæ; se, collenchymatic cells beneath the epidermis; b, elongated stone cells (so-called beaker cells); i, parenchyma cells beneath the stone cells, which are distinguished from the corresponding layer in a number of other seeds by not containing any pigment; P, cells of endosperm containing aleurone; C, tissue of cotyledon containing aleurone grains and oil.—After Moeller.

of oil; not less than 35 per cent. of protein substances, and not more than 12 per cent. of crude fiber. Prepared mustard is sometimes adulterated with white mustard hulls separated from the seed before expression of the fixed oil.

Allied Plant.—In Indian Colza (*Brassica campestris Sarson*) the epidermis forms a homogeneous layer, a sub-epidermal layer not being present.

75. PEPO.—Few ellipsoidal starch grains 2 to 4 μ in diameter in cells of outer epidermis and endosperm; characteristic, ellipsoidal, lignified, thick-walled cells, from 45 to 100 μ in diameter and with simple pores; yellow pigment cells of seed-coat; oil and protein grains in embryo.

76. COLOCYNTHIS.—Light yellow; stone cells isodiametric, slightly thickened, non-lignified, with large simple pores; parenchymatous cells large, thin-walled, with large, simple pores. The powder in which seeds are present contains numerous oil globules, and the outer epidermal cells have reticulated thickenings; the stone cells are nearly isodiametric or irregular, with straight or undulate walls, which are more or less thickened, strongly lignified and with simple pores (Fig. 93).

2. Pigment Cells Present.

77. SINAPIS NIGRA.—Yellowish-brown (Fig. 295); fragments of seed-coat with mucilaginous epidermal cells; a single layer of thin-walled, unequal sub-epidermal cells; a layer of palisade or stone cells (so-called "beaker cells"), thickened much the same as in *Sinapis alba,* but of unequal height, giving a section a somewhat reticulate appearance (Fig. 295, *B*); a pigment layer of one or two cells which may be tabular or considerably elongated tangentially and with a brown content which is colored blue with ferric chloride, as in flaxseed. The endosperm and embryo contain fixed oil and aleurone grains, these layers practically making up most of the drug. Starch grains are not present in mustard and the powder should not contain more than ten granules to a milligram.

Ground Black Mustard or Black Mustard Flour is usually prepared from the cake which has been deprived of the hulls and part of the oil. It is customary to mix some of the white mustard with the black mustard, it being supposed that the excess of the ferment in *S. alba* will change the unconverted glucoside into volatile oil of mustard. It is likely, however, that the enhanced quality of the product is due to the pungent and non-volatile character of the oil in white mustard.

Mustard Paste (see Sinapis alba, No. 74) is sometimes adulterated with starches. At one time this was considered to be necessary on account of the pungency of the drug.

Allied Plants.—In Russian or Sarepta Mustard (*Brassica Besseriana*) the sub-epidermal cells are scarcely apparent and the stone cells are somewhat triangular on surface view. In Charlock seeds (*Brassica Sinapistrum*) the stone cells contain a brown pigment which is colored deep red on treatment with chloral hydrate, particularly if the preparation is heated.

78. FŒNUM GRÆCUM (FENUGREEK).—The dried, ripe seeds of *Trigonella Fœnum-græcum* (Fam. Leguminosæ), an herb which is cultivated in Southern Europe and in tropical and sub-tropical Asia and Africa. The seeds are oblong, flattened, about 3 mm. long and broad and 2 mm. thick; brownish-yellow, with a diagonal groove, otherwise nearly smooth; they are hard, and have a peculiar odor and bitter, mucilaginous taste. Fenugreek contains 22 per cent. of proteins; 28 per cent. of mucilage

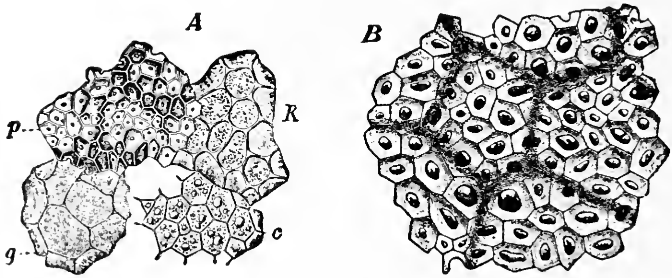

Fig. 295. Black mustard. A, surface view of some of the characteristic cells seen in the powder: p, elongated stone cells (beaker cells), beneath which is the pigment layer (g); K, endosperm cells containing aleurone; c, cells of cotyledon containing aleurone and oil. B, enlarged surface view of the stone cells, showing a shadow-like reticulum composed of broad lines which appearance is due to the fact that some of the cells are higher than others.—After Moeller.

(in the cells of the endosperm); 0.13 per cent. of trigonelline (isomeric with pyridine-betaine); 0.05 per cent. of choline; and an odorous hydrocarbon.

Powder.—Yellowish-brown; an outer epidermal layer of mucilage cells beneath which occur 1 to 3 layers of radially elongated stone cells with a triangular lumen and thick, porous walls. As seen in transverse section the stone cells are polygonal in outline and have simple, narrow, and distinct pores; beneath the latter is a layer of broad, thick-walled cells with large, radiate, simple pores; the endosperm consists chiefly of mucilage cells with wavy mucilaginous inner walls and a single layer of small aleurone cells; the embryo consists of yellowish cells containing aleurone grains.

79. LINUM (Linseed or Flaxseed Meal).—Lemon-yellow (Figs. 99, *A*; 184; 293); fragments of seed-coat with mucilaginous epidermal cells; a sub-epidermal tissue composed of two rows of yellowish cells with rather large intercellular spaces; a layer of SCLERENCHYMATOUS FIBERS, which are 100 to 250 μ long and about 10 μ in diameter and with numerous simple pores; several layers of obliterated cells; and a layer of pigment cells which are more or less tabular or polygonal, tangentially elongated and with a reddish- or yellowish-brown pigment, which is colored dark blue with ferric chloride. The endosperm is made up of 2 to 6 layers of cells containing oil and difficultly distinguishable protein grains. The embryo contains considerable oil and large aleurone grains 10 to 20 μ in diameter, the crystalloids of which can be more readily discerned on treating the material first with chloroform and then mounting it in iodine solution. Flaxseed does not contain starch and the commercial product should not show more than 10 starch grains to a milligram of powder; it should yield not less than 30 per cent. of a saponifiable oil, and not more than 3.5 per cent. of ash.

Ground flaxseed is sometimes infested by maggots. In order to obviate this it should be recently prepared and carefully preserved in tin cans with the addition of a few drops of chloroform.

Allied Plant.—In False Flax (*Camelina sativa*) of Europe, the sclerenchymatous fibers are replaced by broad, short stone cells, and the epidermal cells on the addition of water eject a central column of mucilage.

80. CYDONIUM.—Yellowish-red or reddish-brown; fragments of seed-coat with polygonal, mucilaginous epidermal cells, the walls of which are readily stained with methylene blue; a number of rows of sclerenchymatous fibers with strongly thickened walls and brown contents; several layers of elongated, thin-walled cells resembling the "tube cells" in cereals; a colorless layer with minute starch grains; and an inner epidermis, the cells of which contain a brown pigment. The perisperm consists of several layers of more or less obliterated cells. The outer layers of the endosperm, as well as the cells of the embryo, contain aleurone grains and a fixed oil. The structure of quince seed resembles quite closely that of pear and apple seeds.

β Sclerenchymatous Tissue Wanting.

1. Pollen Grains Numerous.

81. ARNICÆ FLORES.—Yellowish-brown; pollen grains spherical, with numerous centrifugal projections, 3-pored, 25 to 35 μ in diameter; non-glandular hairs of three kinds—either unicellular, 5- or 6-celled or consisting of a pair of united unicellular hairs with numerous pores on the dividing wall; glandular hairs of three kinds—either with a large unicellular stalk and unicellular glandular head, or with a stalk of a single row of 4 cells and a 1-celled glandular head, or a stalk of a double row of 5 cells and a 2-celled glandular head; pappus consisting of a multicellular axis with unicellular branches (Figs. 119, *B*; 241).

82. SAMBUCUS.—Starch grains not present; pollen grains numerous, spherical or elliptical and nearly smooth, about 18 μ in diameter; numerous fragments composed of broken or whole anthers; corolla with dentate papillæ; oil globules from secretion cells; in calyx some rosette aggregates of calcium oxalate; in flower stalk, large spiral duct 30 μ wide, and parenchyma with brown contents.

83. MATRICARIA.—Pollen grains numerous, nearly spherical or triangular, very spinose, from 18 to 25 μ in diameter; fragments of corolla with glandular hairs; characteristic cells of anther; stigma with papillæ; peculiar ladder-like cells of wall of akene; sclerenchyma fibers of involucral scales.

2. Pollen Grains Few.

84. CALENDULA.—Bright yellow (Fig. 296, *B*); characteristic tissue of petals containing oily drops; few pollen grains; colored brownish with sulphuric acid.

85. CROCUS.—Orange-red (Fig. 296, *A*); glycerin mount of deep orange color; few, nearly smooth, nearly spherical pollen grains, 85 to 100 μ in diameter; papillæ of stigma; coloring principle soluble in water but not in fatty oils, being the reverse in capsicum; with sulphuric acid fragments become blue immediately.

86. ANTHEMIS.—Non-glandular and glandular hairs; spherical, prickly pollen grains about 30 μ in diameter, which are

not usually very numerous; papillæ of corolla and stigma; sclerenchyma fibers 10 μ wide, the walls of which are very much thickened; small rosette aggregates of calcium oxalate sometimes present; characteristic cells of anther.

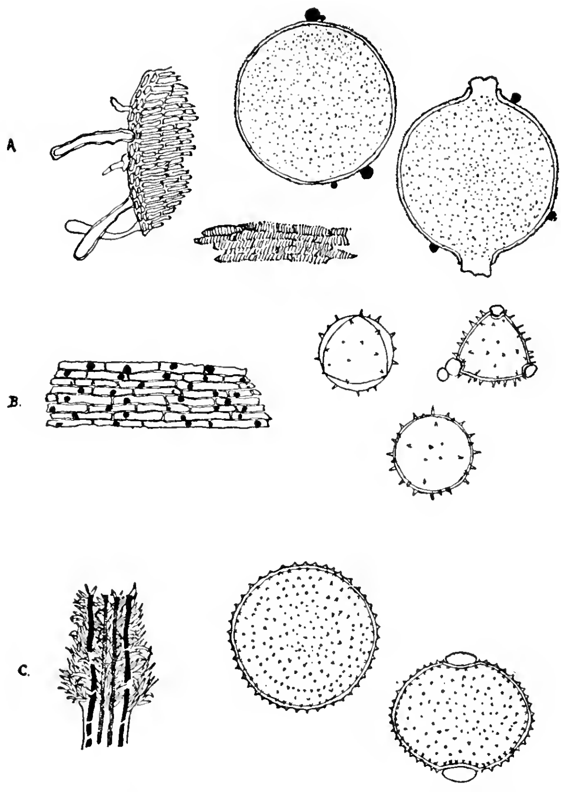

FIG. 296. A, Crocus (Spanish saffron) showing two spherical pollen grains, a fragment of stigma with papillæ, and fragment of an anther; B, Calendula showing 3 spinose pollen grains and fragment of corolla, the cells of which contain oil-like globules; C, Carthamus (so-called American saffron) showing 2 slightly spinose pollen grains and a fragment of the corolla with brown laticiferous vessels and numerous unicellular hairs.—After Weakley.

87. CHIRATA.—Dark yellow; tracheæ spiral, scalariform or with simple pores; sclerenchymatous fibers long, narrow, thick-walled, more or less lignified, and with oblique pores; parenchymatous cells of pith large, slightly lignified, and with numerous

simple pores; pollen grains oblong or ellipsoidal, very prickly, about 35 μ in diameter; collenchymatous cells with yellowish-brown resin and tannin masses.

3. Pollen Grains Wanting.

* *Fibrovascular Tissue Present.*

88. LAPPA.—Light yellow; parenchymatous cells with irregular crystalloidal masses of inulin; tracheæ few, reticulate, sometimes associated with few narrow sclerenchymatous fibers.

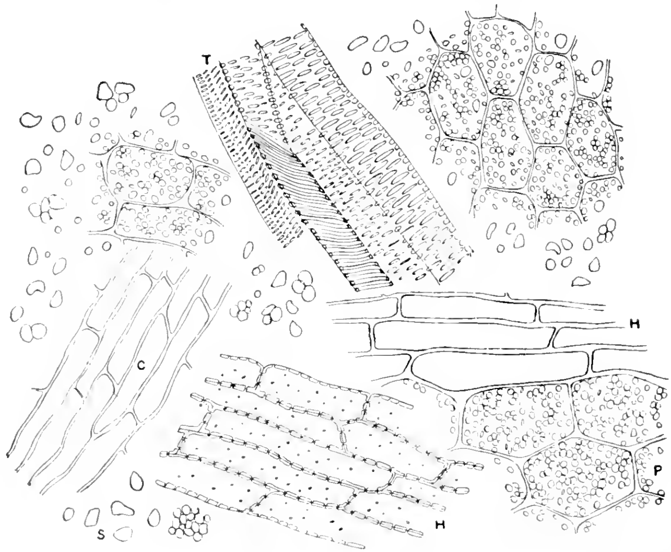

FIG. 297. Aspidium: P, parenchyma containing starch grains; S, starch grains; T, tracheæ; H, hypodermal cells with thickened walls and simple pores, C, yellow, thick-walled cells of chaff.

89. SENEGA.—Dark yellow; odor penetrating; slightly sternutatory; sclerenchymatous fibers thick-walled, non-lignified, with oblique simple pores; tracheæ short, lignified, with simple and bordered pores; medullary-ray cells somewhat lignified, with large simple pores. Quillaja (Figs. 281, *C;* 300, *G;* 315) is distinguished from senega by having large monoclinic pyramids of calcium oxalate, starch and numerous lignified bast fibers and stone cells.

90. ASPIDIUM.—Light brown or light greenish-brown (Figs. 278; 285, *B*; 297); starch grains numerous, ellipsoidal, ovoid, oblong and irregularly shaped, varying in length from 2 to 18 μ; numerous small oil globules seen in chloral mounts; tracheæ long and with scalariform and reticulate thickenings, the cells being 25 to 75 μ in width. The tracheæ are colored reddish-violet on the addition of concentrated sulphuric acid, the reaction resembling that of lignified cells with phloroglucin; few reddish-brown epidermal cells are present, and the strongly lignified cells

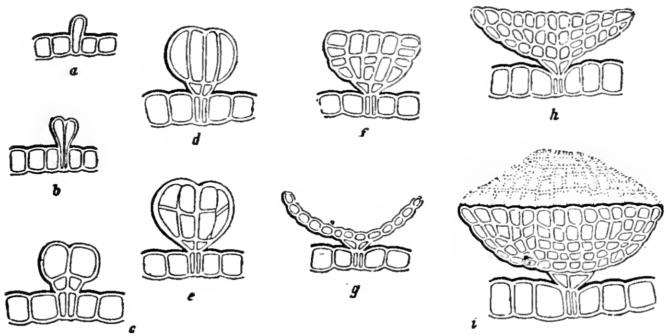

FIG. 298. Lupulin: a–h, successive stages in the development of the glandular hairs on the bracts and floral envelopes of Humulus; g, longitudinal section through a mature hair as seen at h; i, glandular hair with the cuticle raised due to the accumulation and pressure of the oily secretion beneath it.—After Holzner.

of the hypodermis resemble the libriform cells in higher plants. Many of the cells of the parenchyma contain nuclei which may be differentiated by the use of iodine green or methyl green.

** *Fibrovascular Tissue Wanting.*

91. CAMBOGIA.—Bright yellow; sternutatory; containing few or no starch grains. Not more than 25 per cent. should be insoluble in alcohol, and the ash should not be more than 3 per cent. (p. 648).

92. LUPULINUM.—(See No. 222.)

93. LYCOPODIUM.—Light yellow; spores tetrahedral, delicately reticulate, 25 to 40 μ in diameter (Fig. 278b).

II. FEW OR NO FRAGMENTS OF VEGETABLE TISSUE.

A. GIVING OFF ODOR OF SULPHUR DIOXIDE ON HEATING.

94. SULPHUR LOTUM.—In small chain-like masses in glycerin mounts.

95. SULPHUR PRÆCIPITATUM.—Small rounded masses in irregular groups in glycerin mounts.

B. NO ODOR OF SULPHUR DIOXIDE WHEN HEATED.

a. NEARLY COLORLESS IN GLYCERIN MOUNT.

96. MASTICHE.—Transparent, irregular masses. (See p. 645.)

b. YELLOWISH IN GLYCERIN MOUNT.

α *Containing Oil Globules.*

97. SCAMMONIUM.—Irregular masses. (See p. 656.)

β *Transparent or Translucent.*

98. COLOPHONY.—Irregular masses, soluble in cold alcohol (95 per cent.) forming a straw-colored liquid, which becomes milky-white on addition of water; on heating fragments of resin in water they melt, run together and form a sticky mass.

99. SANDARAC.—Almost insoluble in alcohol (95 per cent.), the solution remaining almost colorless; the fragments do not melt when heated with water. (See p. 81.)

100. ALOE (CAPE).—In glycerin mount some fragments are conchoidal; the particles become clear and dissolve, leaving a few colorless lens-shaped or fine acicular crystals. The latter are more abundant in Barbadoes aloes. (See p. 664.)

γ *More Opaque.*

101. AMMONIAC.—Irregular, faint yellow, opaque masses, made up of small, whitish or grayish particles.

102. CAMBOGIA.—Irregular, bright yellow masses, made up of small yellow particles (p. 648).

POWDERS OF A BROWNISH COLOR.

This group includes all those powdered drugs which have a light brown (raw sienna or raw umber), dark brown (Vandyke brown), blackish-brown (sepia), or grayish-brown color. This is the largest group and includes most of the powdered roots, rhizomes and barks, together with a few flowers, fruits and seeds.

I. FIBROVASCULAR TISSUE PRESENT.

A. CONTAINING STARCH.

a. CALCIUM OXALATE CRYSTALS PRESENT.

α In Rosette Aggregates.

1. With Sclerenchymatous Fibers.

* *Containing Oil, Resin or Tannin Masses.*

103. BELLADONNÆ RADIX.—(See No. 117.)

104. GOSSYPII CORTEX.—Light brown (Figs. 231; 231a; 300, *H*); bast fibers long, narrow, thick-walled, lignified; starch grains somewhat spherical, 4 to 20 μ in diameter, single or compound; parenchymatous cells with irregular yellowish and reddish tannin masses; calcium oxalate crystals rosette-shaped, about 20 μ in diameter.

105. RUBUS.—Light brown; bast fibers numerous, long, thick-walled, lignified; calcium oxalate in rosette aggregates 25 to 30 μ in diameter; starch grains nearly spherical, 3 to 7 μ in diameter, single or compound.

106. JUGLANS.—Crystals usually in rosette aggregates 15 to 35 μ or sometimes in monoclinic prisms 10 to 15 μ, occurring in parenchyma or occasionally in crystal fibers; bast fibers, 30 μ wide and very long; stone cells, 35 to 50 μ; oily drops and purplish-brown tannin masses in parenchyma. *J. cinerea* is distinguished from *J. alba* and *J. nigra* in that both of the latter possess numerous crystal fibers containing prismatic or rhombohedral

crystals. *J. nigra* has also in the medullary rays rosette aggregates of calcium oxalate. *J. regia* appears more nearly to resemble *J. cinerea.*

107. ARALIA NUDICAULIS (American Sarsaparilla).—(Fig. 192.) Light brown; rosette aggregates of calcium oxalate from 35 to 70 μ; spherical starch grains, from 10 to 15 μ; tracheæ with scalariform and reticulate thickenings, also simple and bordered pores; wood fibers long, with slightly thickened walls and simple pores; large oil glands, and brown cork cells.

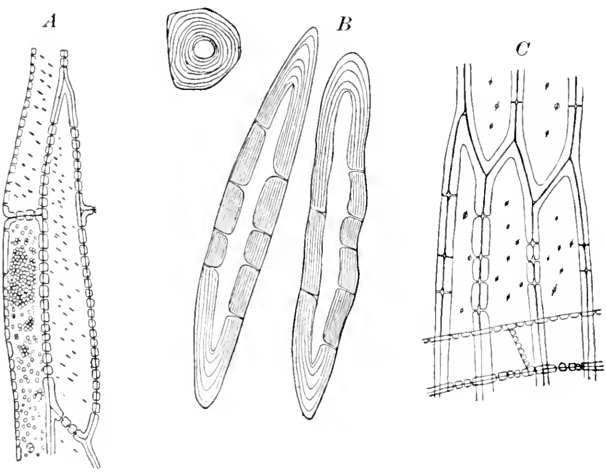

FIG. 299. Several forms of sclerenchymatic fibers: A, intermediate fibers from wood of ipecac showing lignified walls with oblique simple pores and one cell containing starch; B, bast fibers from cinchona showing in transverse section a stratification of the wall, and in longitudinal section a striation of the walls; C, longitudinal section of quassia showing tracheids with bordered pores and medullary-ray cells.

108. STILLINGIA.—Light brown; sclerenchymatous fibers very long, thick-walled and swelling perceptibly in potassium hydrate solution; starch grains spherical or ellipsoidal, 15 to 30 μ in diameter; secretion cells containing oil, resin and a brown pigment; calcium oxalate crystals rosette-shaped, 35 μ in diameter.

109. EUONYMUS.—Light brown (Fig. 300, *E*); bast fibers long, thin-walled, non-lignified, the walls frequently modified to mucilage and possessing numerous small, more or less oblique pores, and irregular ends; starch grains spherical, 4 to 10 μ in

diameter; cork, thin-walled, white; secretion cells with yellowish or brownish masses; rosette aggregates of calcium oxalate, 15 to 20 μ in diameter. The stem-bark as well as the whole twigs of *E. atropurpureus* are frequently admixed with or substituted for Euonymus (Fig. 232).

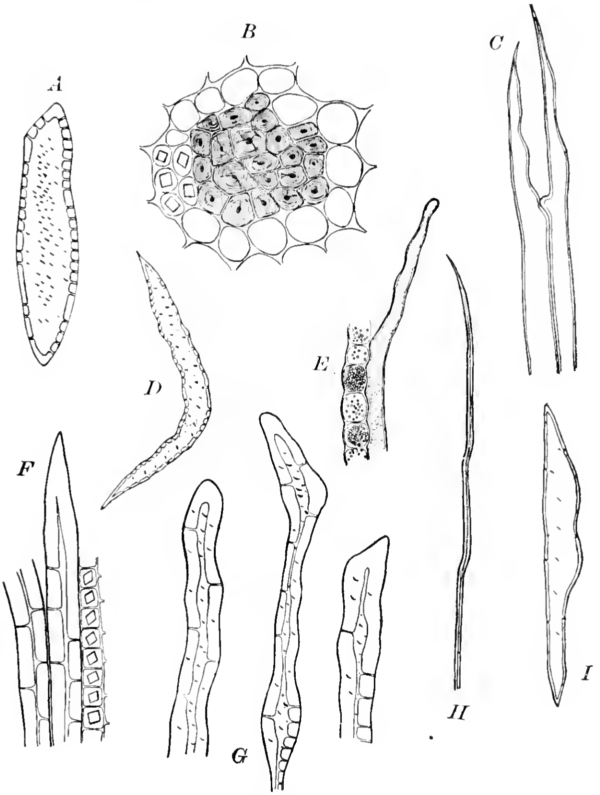

FIG. 300. Various forms of sclerenchymatic fibers: A, intermediate fiber of gentian the walls consisting of cellulose and having simple oblique pores; B, transverse section of a group of bast fibers in white oak bark, and a few crystal fibers; C, portions of two bast fibers from krameria; D, sclerenchymatous fiber from leaf of uva ursi; E, portion of modified bast fiber of euonymus; F, portions of bast fibers and a crystal fiber of white oak bark G, portions of sclerenchymatous fibers of quillaja showing unequal thickening; H, portion of bast fiber of cotton root bark; I, isolated sclerenchymatous fiber of ginger.

110. RUMEX.—Dark brown; calcium oxalate in rosette aggregates from 20 to 35 μ in diameter; starch grains numerous, ellipsoidal or narrowly elongated, from 10 to 18 μ in length; stone

cells occurring beneath the cork cells, 40 to 125 μ in diameter, with walls that are somewhat lamellated, 15 to 20 μ thick and with few simple pores; cork cells light brown; sclerenchymatic fibers wanting; tracheæ about 100 μ wide, with scalariform and reticulate thickenings of the wall. On mixing the powder with water and adding a solution of one of the alkalies a red color is produced. In *Rumex hymenosepalus* the parenchyma cells are about 200 μ in diameter, with reddish colored walls and contain numerous spherical or ellipsoidal starch grains from 8 to 15 μ in diameter; calcium oxalate crystals are few or wanting.

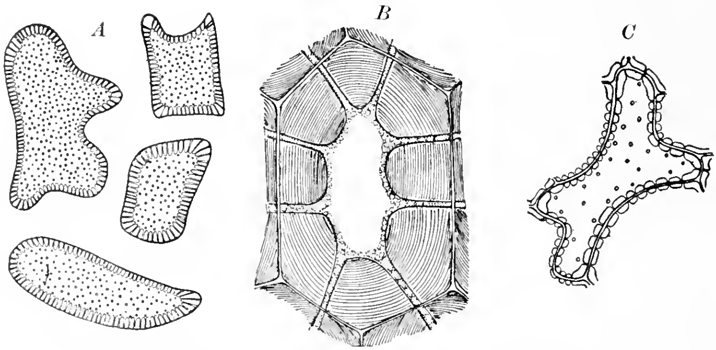

FIG. 301. Several forms of stone cells: A, white oak bark; B, white cinnamon or canella bark (*Canella alba*); C, seed-coat of capsicum.

110a. CANELLA (White Cinnamon).—Light brown or light reddish-brown; calcium oxalate in rosette aggregates, from 20 to 50 μ in diameter; starch grains simple or 2- to 3-compound, 5 to 10 μ in diameter; numerous stone cells, about 75 μ in diameter, the inner walls of which are considerably thickened, and with branching pores; sclerenchymatic fibers occasionally present; numerous large oil cells with suberized walls (Fig. 301, *B*).

** *No Resin or Tannin Masses.*

111. ALTHÆA.—Light brown (Fig. 99, *B*); sclerenchyma fibers long and not strongly lignified; rosette aggregates of calcium oxalate, about 25 μ in diameter; starch grains somewhat ellipsoidal, 10 to 20 μ in diameter.

2. Sclerenchymatous Fibers Wanting.

* *Containing Tannin.*

† With Oil-Secretion Reservoirs.

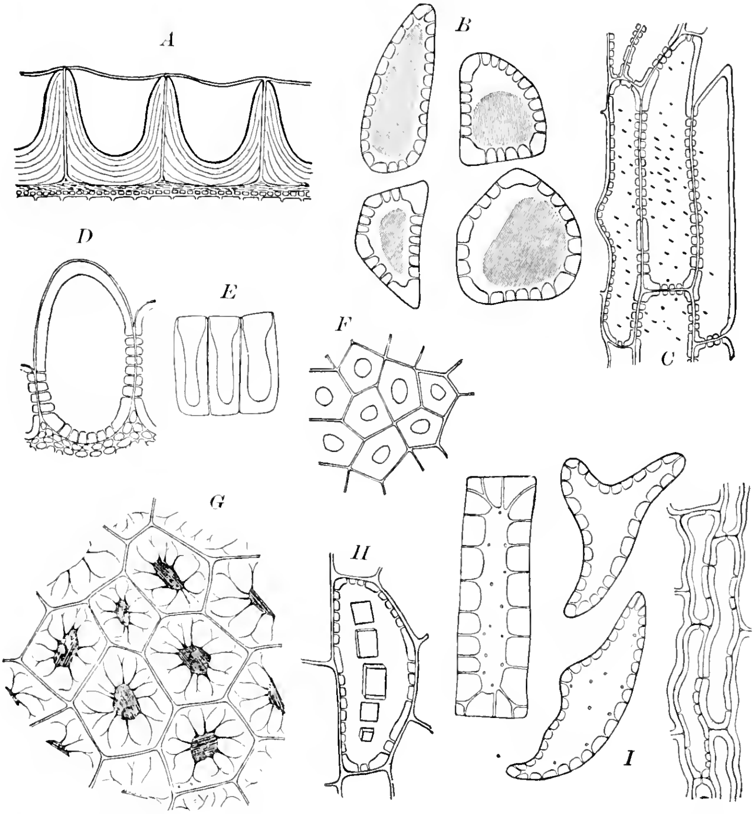

FIG. 302. Various forms of stone cells: A, epidermis of hyoscyamus seeds; B, pericarp of pimenta, containing brownish tannin masses; C, seed-coat of coffee; D, seed-coat of almond; E, transverse section of seed-coat of white mustard showing beaker cells; F, surface view of beaker cells of seed-coat of white mustard; G, transverse section through stone cells of endocarp of olive, the lumen containing air; H, a stone cell from the periderm of calumba, containing numerous monoclinic prisms of calcium oxalate; I, various forms of stone cells isolated from pericarp of star anise.

112. CLOVE FRUIT.—(See No. 173.)

113. PIMENTA.—Dark brown (Fig. 302, *B*); rosette aggregates of calcium oxalate, occasionally in monoclinic prisms,

about 10 μ in diameter; starch grains somewhat spherical, about 10 μ in diameter, single or 2- to 3-compound, each with a distinct cleft at the middle; stone cells nearly isodiametric, thin-walled, with numerous simple pores and branched canals and nearly colorless contents; oil-secretion reservoirs with wine-colored contents; oil globules numerous; parenchymatous cells occasionally lignified, and with irregular reddish-brown tannin masses, which are colored greenish with ammonio-ferric sulphate solution; non-glandular hairs from 100 to 200 μ long, with very thick walls and narrow lumen, particularly towards the apex.

Allspice stems, which are always present to a greater or less extent in ground Pimenta have rather characteristic unicellular hairs that are somewhat swollen on one side.

Ground allspice has been adulterated with clove stems (Fig. 312), cocoa shells (No. 145), and the endocarp of the olive (Fig. 302, *G*). The presence of COCOANUT SHELLS is determined by the yellow stone cells, which have thick yellow walls with branching pores and dark brown contents. The stone cells vary from polygonal and isodiametric cells to cylindrical and wedge-shaped forms that are quite characteristic; fragments of long, thick-walled, porous fibers with accompanying stegmatic cells, each containing a spherical, tuberculated silicious granule, are also present. The dark brown fragments in the powder are not affected by bleaching agents, such as Schulze's macerating solution.

The various spices have been adulterated with the following substances: The hulls of *Sinapis alba* (see No. 74); walnut shells (*Juglans regia*) which are distinguished by their colorless stone cells and brown parenchyma; and shells of the Brazil nut (*Bertholletia excelsa*, Fam. Myrtaceæ) which are identified by the isodiametric stone cells with colorless walls and dark brown contents, and the brown parenchyma.

†† Oil-Secretion Reservoirs Wanting.

114. GALLA (ALEPPO).—Dark yellow; crystals of calcium oxalate 10 μ in diameter; starch grains 10 to 40 μ in diameter, single or sometimes in groups; stone cells; tannin; crystals of gallic acid.

115. GERANIUM.—Dark brown; starch grains somewhat ellipsoidal or ovoid, 10 to 15 μ in diameter; rosette aggregates of calcium oxalate, 45 to 70 μ in diameter; tracheæ annular or scalariform; parenchyma with irregular tannin masses.

116. RHEUM.—(See No. 49.)

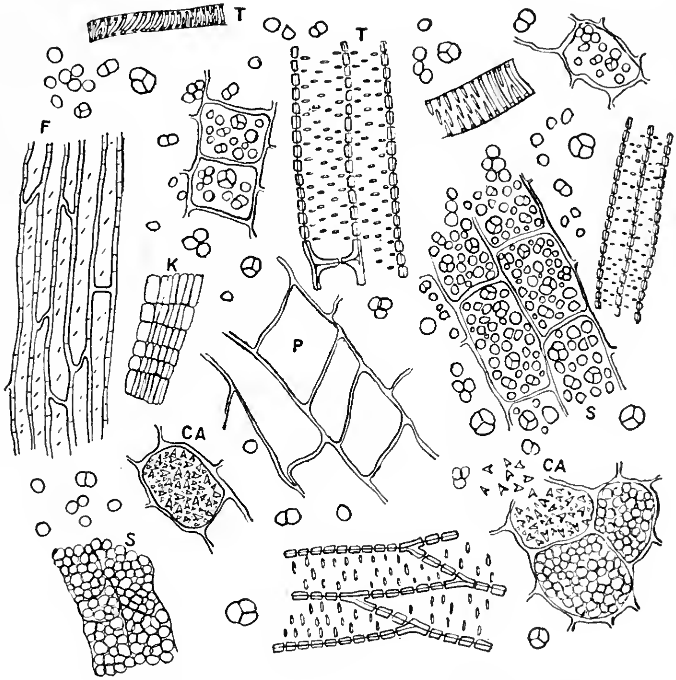

FIG. 303. Belladonna root: S, parenchyma cells containing starch; CA, cells containing cryptocrystalline crystals of calcium oxalate; K, cork; T, fragments of tracheæ with annular markings or simple pores; P, parenchyma; F, wood fibers with narrow oblique pores.

** *Without Tannin.*

117. BELLADONNÆ RADIX.—Light brown (Figs. 191, 199, 303); calcium oxalate in sphenoidal micro-crystals; tracheæ few, scalariform or with *bordered* pores; sclerenchymatous fibers relatively few; starch grains numerous, spherical, 5 to 15 μ in diameter (Fig. 200).

β Crystals in Monoclinic Prisms and Pyramids.

118. FRANGULA.—(See No. 52.)

119. KRAMERIA.—Light brown (Figs. 196; 300, *C*); sclerenchymatous fibers peculiarly bent, 0.3 to 0.5 mm. long and 15 μ thick; calcium oxalate in monoclinic prisms and pyramids about 0.1 mm. long; starch grains somewhat spherical, 20 to 30 μ in

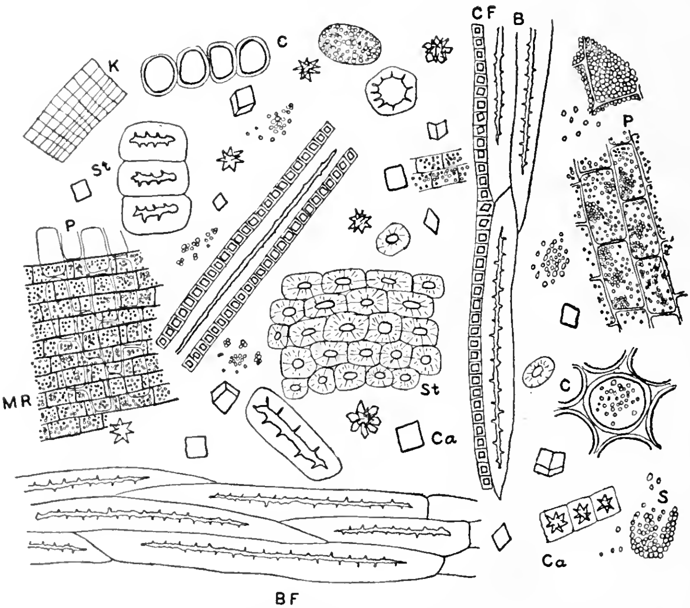

FIG. 304. Rhamnus Purshiana: B, BF, bast fibers; CF, crystal fibers; Ca, Calcium oxalate crystals; S, starch grains; P, parenchyma; MR, medullary rays; St, stone cells; C, thick-walled parenchyma of outer cortex; K, cork.

diameter, single or 2- to 4-compound. In Savanilla rhatany the sclerenchymatous fibers are 0.5 to 0.8 mm. long and 10 to 40 μ wide.

An alcoholic extract of Peruvian rhatany gives with alcoholic lead acetate a reddish-brown precipitate and a light-brown filtrate. The tincture of Savanilla rhatany gives a purplish precipitate and a colorless filtrate with this reagent.

120. RHAMNUS PURSHIANA.—(See No. 123.)

121. JUNIPERUS.—Calcium oxalate in monoclinic prisms about 30 μ in diameter, occurring in stone cells, which are about 60 μ in diameter and with walls that are about 15 μ in thickness; a small number of nearly spherical starch grains from 5 to 7 μ in diameter; fragments with oil glands and brown pigment cells.

γ *Crystal Fibers Present*

1. Sclerenchymatous Fibers Strongly Lignified.

* *Colored Reddish With Alkalies.*

122. FRANGULA.—(See No. 52.)

123. RHAMNUS PURSHIANA.—Light brown (Figs. 229, *A*; 304); bast fibers long, much thickened, lignified; stone cells very thick-walled, about 50 μ in diameter; crystal fibers containing monoclinic crystals of calcium oxalate; calcium oxalate also in rosette aggregates or monoclinic prisms 5 to 20 μ in diameter; starch grains spherical, about 4 μ in diameter; parenchymatous cells with yellowish contents colored red with alkalies.

** *Not Colored Reddish With Alkalies.*

124. QUERCUS ALBA.—(See No. 182.)

125. PRUNUS VIRGINIANA.—Light brown; bast fibers and stone cells with much thickened and strongly lignified walls; crystal fibers containing monoclinic prisms and rosette aggregates of calcium oxalate 20 to 30 μ in diameter; starch grains nearly spherical, 3 to 4 μ in diameter.

126. MYRICA CERIFERA.—Greenish-brown (p. 250); crystals in rosette aggregates about 45 μ in diameter, or in monoclinic prisms from 15 to 20 μ in diameter; crystal fibers, accompanying long bast fibers, the latter being 100 μ in diameter and with walls about 25 μ in thickness; starch grains about 7 μ in diameter, also occurring in 2- to 4-compound grains.

127. PULVIS GLYCYRRHIZÆ COMPOSITUS.—Tissues of glycyrrhiza (Figs. 104; 204; 282, *B*) and senna (Figs. 263; 284, *D*); granules of sulphur (see No. 94); crystals of sugar, and masses of manna.

2. Sclerenchymatous Fibers Not Strongly Lignified.

128. CALAMUS.—Light brown (Fig. 101, *B*); tracheæ spiral, scalariform or reticulate; sclerenchymatous fibers slightly lignified, with oblique simple pores; starch grains nearly spherical, 4 to 8 μ in diameter; crystal fibers containing monoclinic crystals of calcium oxalate; oil-secretion cells with suberized walls; contents of parenchymatous cells colored ruby-red by a strong alcoholic solution of vanillin and hydrochloric acid. The powder of the peeled rhizome is less aromatic, and cells of the epidermis and cork, and crystal fibers are wanting. The yield of aqueous extract should be between 18 and 20 per cent. Powdered calamus has been reported as being admixed with as much as 30 per cent. of diatomaceous earth.

129. ULMUS.—Light brown (Fig. 99, *C*); bast fibers thin-walled, non-lignified; crystal fibers containing monoclinic prisms of calcium oxalate 10 to 25 μ in diameter; starch grains spherical, 5 to 10 μ in diameter.

Ground elm bark has been reported to be adulterated with wheat starch or wheat middlings, but this does not seem to be the case. The small quantity of wheat starch which is sometimes detected is considered to be in the nature of an accidental contamination. The usual adulterant is a bark from which the mucilage has been extracted or at least barks poor in mucilage are sometimes found on the market. Good elm bark gives a rather thick mucilage on digesting one part of the ground bark in 40 to 45 parts of cold water.

δ Calcium Oxalate in Raphides.

130. CINNAMOMUM (Saigon).—Dark brown; bast fibers much thickened; stone cells nearly isodiametric, more or less thickened, with numerous pores; calcium oxalate in raphides about 5 μ long; starch grains somewhat spherical, 7 to 15 μ in diameter, single or 2- to 4-compound; parenchyma with irregular tannin masses; oil-secretion cells. Cassia Cinnamon has fewer cork cells and more sclerenchymatous cells and fibers. Ceylon Cinnamon has no cork cells and the stone cells are more elongated, irregular in outline and unevenly thickened (Figs. 224, 225, 305).

The powder of Cassia buds (flowers of *Cinnamomum Cassia*) is characterized by numerous thick-walled, irregularly curved simple hairs; fragments of reticulate and scalariform tracheæ; and broad, blunt bast fibers.

131. SARSAPARILLA.—Dark brown (Figs. 193, 194); sclerenchymatous fibers very thick-walled, somewhat lignified; tracheæ large, strongly lignified, scalariform, reticulate, and with simple pores; the walls of endodermis and hypodermis variously thickened; starch grains somewhat spherical, 7 to 20 μ in diameter,

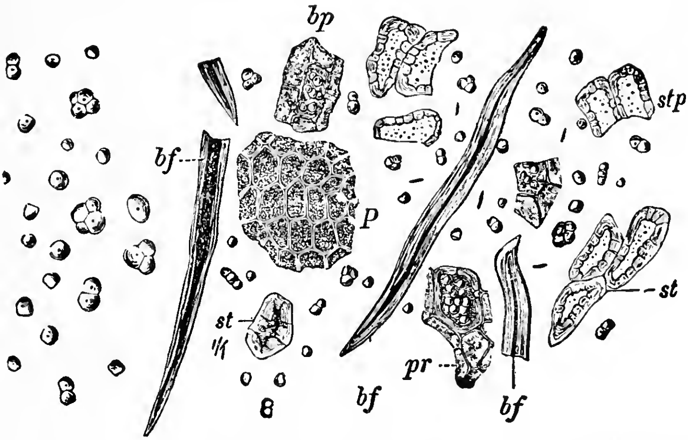

FIG. 305. Cassia cinnamon: st, stp, stone cells; pr, bp, parenchyma containing starch grains; bf, bast fibers; P, cork cells with lignified walls. Numerous simple and compound starch grains are shown at the left and among the fragments of tissues.—After Moeller.

single or 2- to 4-compound; calcium oxalate in raphides 6 to 8 μ long. It is distinguished from American Sarsaparilla, yielded by *Aralia nudicaulis,* in that the latter has rosette aggregates of calcium oxalate 35 to 80 μ in diameter (Fig. 192).

132. CONVALLARIA.—Dark brown (Fig. 114); calcium oxalate in raphides about 45 μ long; starch grains somewhat spherical, 3 to 12 μ in diameter, single or 2- to 4-compound; tracheæ spiral or scalariform; sclerenchymatous fibers long, thin-walled, with simple pores; endodermis with inner walls much thickened.

133. CYPRIPEDIUM.—Yellowish or brownish-black; calcium oxalate in raphides about 40 μ long; starch grains somewhat spherical, 2 to 4 μ in diameter, single or compound; tracheæ spiral, scalariform or with simple pores; sclerenchymatous fibers long, thin-walled; parenchyma thick-walled, with numerous simple pores (Fig. 213).

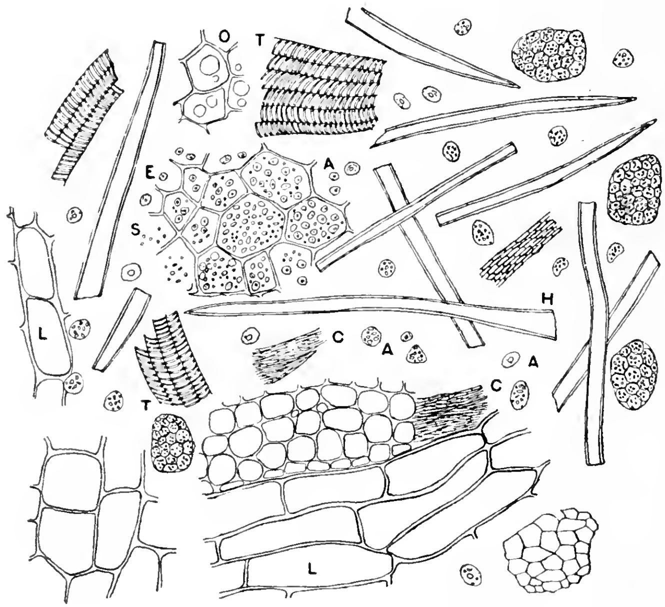

FIG. 306. Strophanthus: H, fragments of upper portion of non-glandular hairs; L, basal portion of non-glandular hairs; E, cells of endosperm with aleurone grains (A) and starch grains (S); P, parenchyma of cotyledons with aleurone grains; T, tracheæ; C, collapsed cells of seed-coat; A, aleurone grains; O, parenchyma containing oil globules.

134. VERATRUM VIRIDE.—(See No. 59.)

135. HYDRANGEA ARBORESCENS.—Raphides 200 μ long; starch grains 4 to 15 μ in diameter; numerous sclerenchyma fibers with very thick walls, narrow lumen and simple pores.

ε Calcium Oxalate in Sphenoidal Micro-crystals.

136. BELLADONNÆ RADIX.—(See No. 117.)

137. CINCHONA.—(See No. 152.)

b. CALCIUM OXALATE CRYSTALS WANTING.

α *With Non-glandular Hairs.*

138. STROPHANTHUS.—Dark brown (Figs. 186; 284, *A;* 306); epidermal cells modified to long, 1-celled, non-lignified hairs, containing, in *S. Kombe,* colorless or yellowish-green granules and in *S. hispidus,* dark brown granules; parenchyma with fixed oil and aleurone grains; starch grains ellipsoidal, 4 μ in diameter.

β *Non-glandular Hairs Wanting.*

1. Sclerenchymatous Fibers Present.

* *Tracheæ Numerous.*

† Starch Grains 2 to 5 μ in Diameter.

139. CIMICIFUGA.—Brownish-black (Fig. 217); tracheæ large, scalariform or with bordered pores; sclerenchymatous fibers numerous; starch grains nearly spherical, 3 to 5 μ in diameter; cells of periderm thick-walled and with reddish-brown contents.

140. CYPRIPEDIUM.—(See No. 133.)

141. LEPTANDRA.—Dark brown; tracheæ scalariform or with simple pores; sclerenchymatous fibers narrow, thick-walled, with numerous simple pores; starch grains nearly spherical, 2 to 4 μ in diameter; parenchymatous cells nearly isodiametric or elongated, containing starch grains and a brownish-black pigment.

142. SPIGELIA.—Brownish-black; tracheæ few, lignified, spiral or with simple pores; sclerenchymatous fibers long, narrow, lignified, with simple, oblique pores; starch grains spherical, about 4 μ in diameter (Fig. 220). A not unusual substitute for spigelia is the rhizome and roots of *Ruellia ciliosa* (Fig. 221) (No. 30).

†† Starch Grains 5 to 15 or 20 μ in Diameter.

143. ZINGIBER.—African and Calcutta ginger (p. 488) are light brown in color, and the tissues resemble those in Jamaica ginger (Fig. 214) (No. 61).

144. TONKA.—The parenchyma cells of the cotyledons contain numerous spherical starch grains from 4 to 9 μ in diameter;

large, irregular aleurone grains 20 to 35 μ long, and considerable fixed oil. The easily separable seed-coat contains rather characteristic stone cells, which on surface view are polygonal and possess rather porous, somewhat thickened walls and brownish-red or brownish-black contents. Beneath the stone cells is a layer of broad, irregularly-shaped cells with rather thick walls and numerous intercellular spaces.

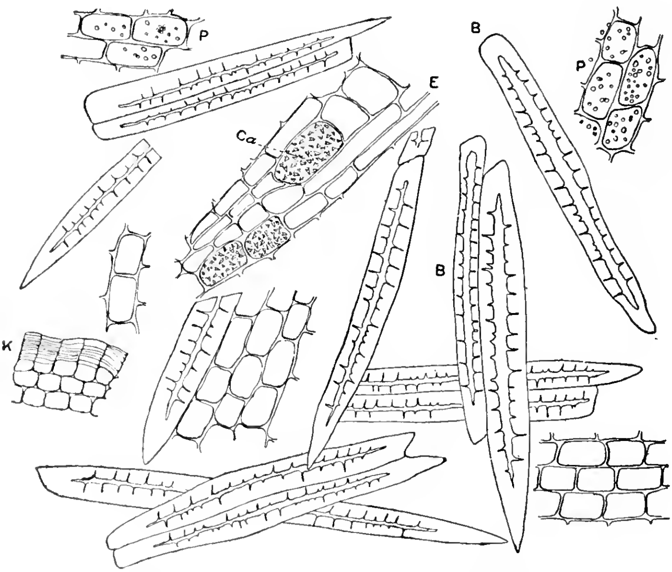

FIG. 307. Cinchona: B, bast fibers; Ca, cryptocrystalline crystals of calcium oxalate; P, parenchyma containing few small spherical starch grains; E, sieve; K, cork.

145. COCOA SHELLS.—Little or no starch; oil globules; characteristic, brownish, adhesive fragments, possessing more or less hexagonal epidermal cells; peculiar, small, tabular mucilage cells and a layer of nearly isodiametric stone cells 10 by 10 μ, the walls of which are 4 μ thick (Fig. 308).

146. APOCYNUM.—Dark brown (Fig. 202); sclerenchymatous fibers numerous; fragments of laticiferous vessels yellowish; starch grains somewhat spherical, 7 to 15 μ in diameter. In *Apocynum androsæmifolium* small groups of stone cells occur.

147. CONVALLARIA.—(See No. 132.)

148. SARSAPARILLA.—(See No. 131.)

149. SUMBUL.—Dark brown; sclerenchymatous fibers numerous, narrow and lignified; tracheæ short, lignified, scalariform, or with simple or bordered pores; oil and resin-secretion reservoirs; starch grains nearly spherical, 4 to 15 μ in diameter.

150. VALERIANA.—Brownish-black; tracheæ strongly lignified, scalariform or with simple pores; sclerenchymatous fibers thin-walled, more or less lignified, with numerous simple pores; starch grains nearly spherical, 7 to 15 μ in diameter; stone cells nearly isodiametric, with very thick walls and numerous simple pores.

151. METHYSTICUM (KAVA-KAVA).—Starch grains numerous, spherical, about 35 μ in diameter, often with radial clefts or triangular fissures at the center; yellowish resin and oil cells; sclerenchyma fibers narrow, with thin, strongly lignified walls.

*** Tracheæ Few or None.*

152. CINCHONA.—Light brown (Figs. 227; 299, *B;* 307; 307a); bast fibers spindle-shaped, thick-walled, strongly lignified, with numerous simple pores; starch grains nearly spherical, 4 to 12 μ in diameter; parenchymatous cells with reddish-brown tannin masses.

153. CINNAMOMUM.—(See No. 130.)

154. COFFEE.—Brownish; characteristic fragments of seed-coat made up of parenchyma and spindle-shaped stone cells 0.2 to 1 mm. long and 15 to 50 μ wide, the latter occurring singly or in pairs with more or less thickened, porous walls. The cells of the endosperm have brownish-colored, porous walls, 10 μ thick, and contain oil, aleurone and starch. Ground coffee varies in the fineness of the particles, which are lighter than water and float on the surface. This is an important distinction between genuine coffee and the "substitutes" or "imitation" products which sink on being mixed with water (Fig. 302, *C*).

Coffee Hulls, also known as Sultan or Sacca coffee, are sometimes substituted for coffee. These consist of the outer layer of the pericarp and are characterized by a layer of somewhat curved, elongated cells which lie close to one another (palisade cells), and the walls of which are mucilaginous and stained by safranin and methylene blue, the yellowish protoplasmic contents not being affected.

Carob Bean (*Ceratonia Siliqua*, Fam. Leguminosæ) in a ground condition is not only used as cattle food, but has been

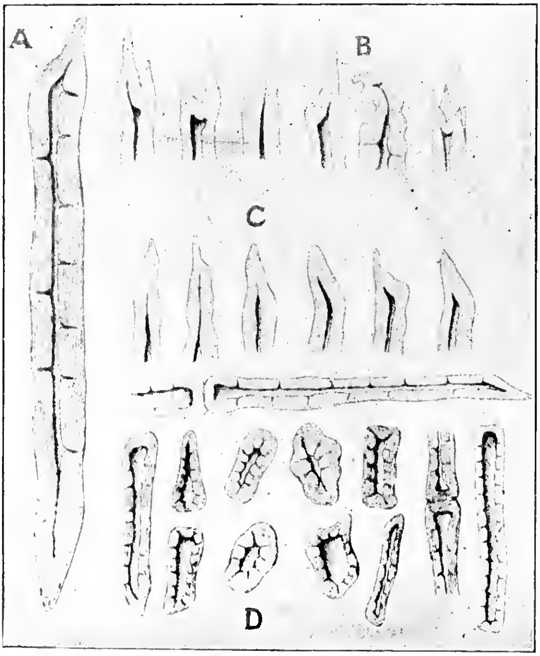

Fig. 307a. A, C, bast fibers of the bark of *Cinchona succirubra;* B, bast fibers of the bark of *Cinchona Ledgeriana;* D, stone cells of Cuprea bark (*Remijia pedunculata*).—After Oesterle and Tschirch.

substituted for coffee. It is distinguished by the sclerenchymatic and crystal fibers, and the cells of the mesocarp, which contain reddish-brown, spiral masses that are colored a deep violet or blue on heating with solutions of the alkalies.

Coffee Substitutes.—The following are commonly employed: Chicory (see No. 193); a number of the cereals and cereal products (see Nos. 236 to 245); and soja beans; lupines, peas, beans and hedionda, the seeds of *Cassia fœtida*. Of the latter may be mentioned the Mogdad Coffee, the seeds of *Cassia occidentalis* which are used in various tropical countries. The seeds are free from starch and the cells of the endosperm are thick-walled and contain a brown protein substance.

Of COFFEE ADULTERANTS the following may be mentioned: Ground ivory nut (*Phytelephas macrocarpa* (Fig. 173), which is distinguished by the thick-walled cells of the endosperm; and the ground kernels of the acorns of several species of Quercus, which are readily identified by the elongated, more or less swollen, distorted starch grains that have a prominent elongated cleft in the middle (Fig. 135).

155. SASSAFRAS.—Light brown (Fig. 236); bast fibers thick-walled, lignified, usually single or not more than two or three together; starch grains 7 to 20 μ in diameter, single or 2- to 3-compound; parenchymatous cells with irregular masses of tannin; oil globules numerous. The stem bark contains groups of bast fibers and stone cells, and the parenchymatous cells contain chloroplastids.

2. Sclerenchymatous Fibers Wanting.

* *Stone Cells Present.*

† Giving Tannin Reaction with Ferric Salts.

156. CACAO.—Reddish-brown (Fig. 308); consisting chiefly of protein grains, oil and starch (grains 4 to 8 μ in diameter); fragments with brownish or purplish-brown contents (cacao red); fat crystals in little prisms or needles; few fragments of seed-coat consisting of hexagonal epidermal cells, a peculiar mucilage layer of small tabular cells and a layer of nearly isodiametric stone cells 10 by 10 μ, the walls of which are 4 μ thick.

Cacao starch grains show a tendency to cohere and on gently heating a section in water, after removal of part of the oil with ether or chloroform, the compound grains swell into angular, spherical or irregular masses which vary from 15 to several hundred microns in diameter (Fig. 308). The smaller masses thus produced bear a close resemblance to the starch grains of corn and wheat. The central triangular marking of the mass which resembles that of a corn starch grain is formed from the adjoining walls of three individual grains. Most of the aggregates, however, swell into rounded masses (35 μ in diameter) resembling wheat starch grains, and have a clearly defined wall and nearly homogenous, hyaline contents. They may be distinguished from wheat starch by the use of dilute alkali or acid solutions, which cause an immediate breaking down of the masses without the successive changes in structure noticed on similar treatment of wheat starch grains (Fig. 96).

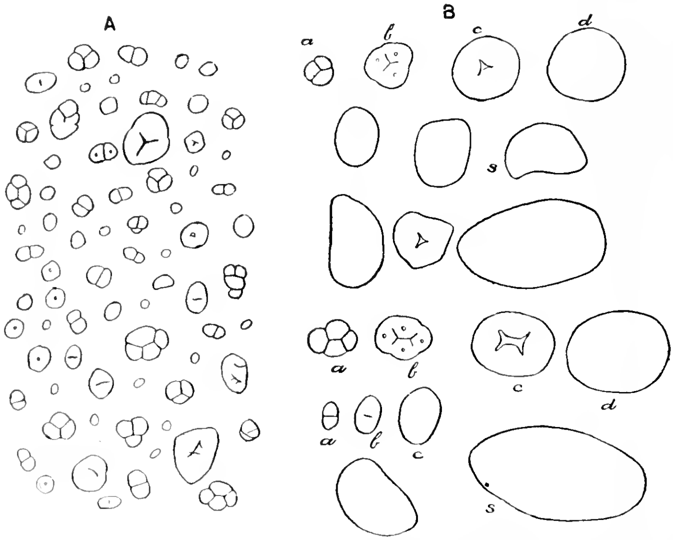

FIG. 308. Cacao starch: A, starch grains of commercial cacao powder, or chocolate, after removal of the oil by means of ether; B, altered starch grains of cacao produced by making sections or scrapings of the raw cacao bean, removing the oil with ether, mounting on a slide in water and heating at a temperature of 70° C, for a few seconds; a, b, c, d, successive stages in the alteration of 2-, 3-, and 4-compound grains, the various masses showing resemblance in size and form to the single grains of corn, wheat and even potato starch as seen in some of the swollen masses (S).

PLAIN CHOCOLATE or cocoa mass is obtained by grinding the broken cotyledons (cocoa nibs) in a mill and separating the pasty mass, which is molded into forms that usually weigh a pound. COCOA is the plain chocolate from which a part of the fat (cocoa butter) has been removed, the resulting product being then powdered. SWEET CHOCOLATE is plain chocolate to which sugar and various flavoring substances are added. MILK CHOCOLATE is a sweet chocolate to which "milk powder" is added.

ADULTERANTS.—All chocolate products may be adulterated with any of the cereal starches, those of corn, wheat and rice being usually employed.

157. GUARANA.—Dark brown; parenchyma thin-walled, containing nearly spherical, more or less altered starch grains 10 μ in diameter; sclerenchymatous cells nearly isodiametric, non-ligni-

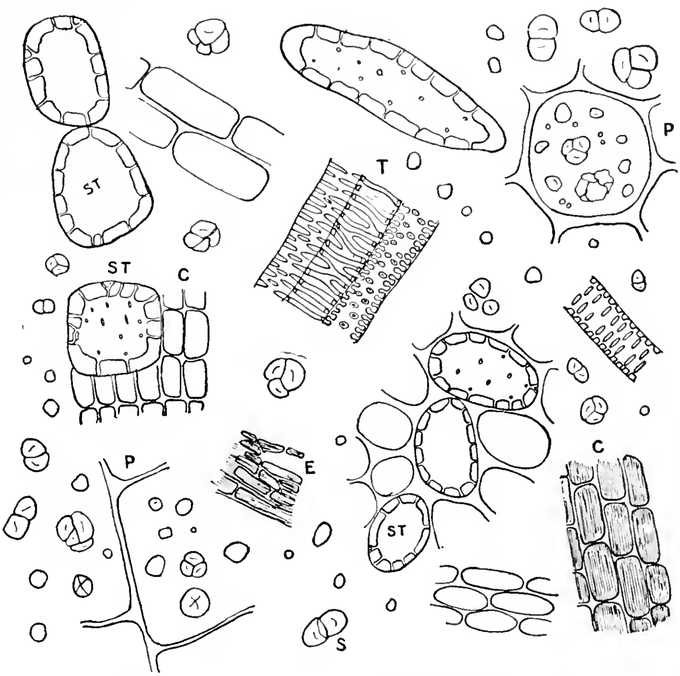

FIG. 309. Aconite: T, tracheæ with scalariform thickenings or bordered pores, ST, stone cells; P, parenchyma with starch grains; S, starch grains; C, E, cork.

fied; sclerenchymatous fibers few, narrow; tracheæ few, narrow, annular or scalariform. (See also Fig. 159.)

158. PIPER.—Dark brown (Fig. 311); stone cells nearly isodiametric, uniformly thickened or with only three walls thickened, the contents consisting of yellowish-brown tannin masses, which give a blue reaction with ferric ammonium sulphate solution; starch grains spherical, 1 to 2 μ in diameter; parenchyma with remains of chromoplastids and reddish-brown tannin masses;

oil-secretion cells with suberized walls; oil globules numerous. (For chemical standard of purity see page 573.)

ADULTERANTS.—Ground black pepper is sometimes adulterated with PEPPER HULLS or pepper shells, which are the outer layers of the ripe fruit and are obtained in the preparation of white pepper (Fig. 255). Pepper hulls consist chiefly of the stone

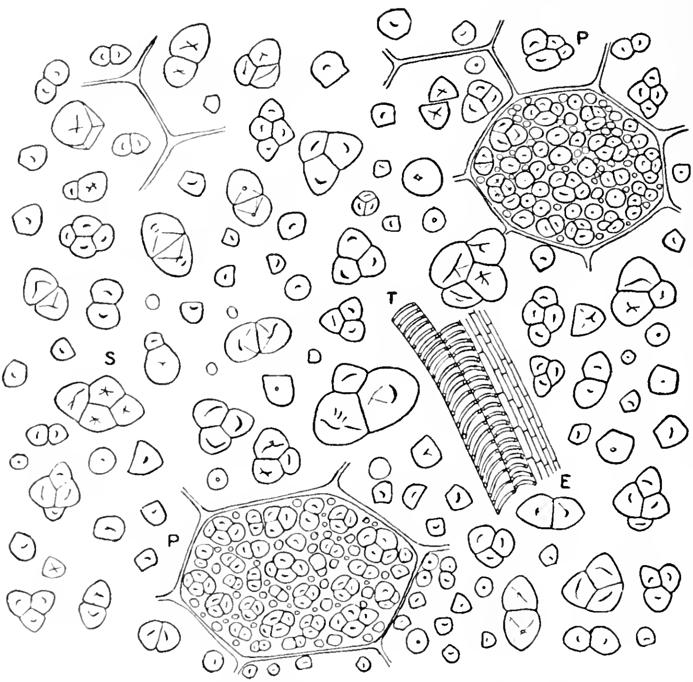

FIG. 310. Colchicum corm: S, 2- to 4-compound starch grains which make up the greater proportion of the powder; P, parenchyma with numerous starch grains; T, tracheæ; E, sieve.

cells described above. They increase the percentage of crude fiber and ash in the powder, the latter being due to adhering dirt. Ground black pepper sometimes consists of a mixture of pepper hulls, capsicum (Figs. 252; 301, *C*) and the endocarp of the olive (Fig. 302, *G*). In the latter the lumen of the stone cells is filled with air. Black pepper has also been adulterated with flaxseed meal and buckwheat hulls (Fig. 138). The latter are distinguished by the epidermal cells with peculiar diagonal thickening of the walls and the hypodermal fibers which have thick, porous walls and brown contents. (See also under Pimenta, No. 113.)

159. COLCHICI SEMEN.—Light or dark brown; sclerenchymatous cells with pigment soluble in potassium hydrate solution, and reacting with iron salts somewhat like tannin; cells of endosperm thick-walled, with simple pores and few oil globules; parenchymatous cells of strophiole thin-walled, and with numerous nearly spherical starch grains 7 to 15 μ in diameter.

†† Not Becoming Blue or Green with Ferric Salts.

160. ACONITUM.—Dark brown (Figs. 206, 309); tracheæ few, spiral, scalariform, reticulate, or with simple pores; stone cells nearly isodiametric, variously thickened, associated with thick-walled parenchyma, the latter swelling in water; starch grains somewhat spherical, 4 to 12 μ in diameter, single or 2- to 4-compound.

161. PHYSOSTIGMA.—Brownish-black; taste starchy; stone cells nearly isodiametric or elongated, the contents reddened by alkalies; starch grains ellipsoidal, about 25 to 40 μ in diameter; oil globules numerous. (See also Fig. 189.)

** *Stone Cells Wanting.*

162. COLCHICI CORMUS.—Light or dark brown; starch grains irregularly spherical or ovoid, 7 to 20 μ in diameter, single or 2- to 4-compound; tracheæ few, spiral or scalariform (Fig. 310).

163. GUARANA.—(See No. 157.)

164. MYRISTICA.—Light brown; perisperm cells with reddish contents; starch grains somewhat spherical, 5 to 7 μ in diameter, generally in groups; globules of fixed oil numerous.

165. MACIS.—Amylodextrin starch grains (Fig. 190) which are colored red with iodine. For other characteristics of genuine mace and the study of allied products and substitutes see p. 443.

166. OPIUM.—(See No. 197.)

167. PODOPHYLLUM.—Light brown (Fig. 223); starch grains somewhat spherical, 5 to 12 μ in diameter, single or 2- to 6-compound; tracheæ few, scalariform, spiral, reticulate, or with simple pores.

168. CHENOPODIUM.—Yellowish-brown; seeds blackish, shiny, reniform, about 150 μ in diameter; seed-coat with polygonal, thin-walled pigment cells; numerous starch grains and small aleurone grains.

B. STARCH GRAINS FEW OR NONE.

a. CONTAINING CALCIUM OXALATE.

α In Rosette Aggregates.

1. Small Crystals in Aleurone Grains.

169. ANISUM.—(See No. 68.)

170. CARUM.—Dark brown (Fig. 247); calcium oxalate crystals in rosette aggregates, 0.5 to 1 μ in diameter in aleurone grains; fragments of light yellow vittæ, together with nearly isodiametric or polygonal, yellowish-brown, inner epidermal cells of pericarp; sclerenchymatous fibers few, thick-walled, slightly lignified, with numerous simple pores; oil globules numerous.

171. CORIANDRUM.—Light brown (Fig. 245); calcium oxalate crystals in rosette aggregates and 3 to 7 μ in diameter in aleurone grains; fragments of light yellow vittæ and long, narrow, yellowish, inner epidermal cells; sclerenchymatous cells irregularly curved, yellowish, thick-walled, lignified and with numerous simple pores; oil globules numerous.

172. FŒNICULUM.—(See No. 70.)

2. Crystals Not Less Than 10 μ in Diameter.

** Pollen Grains Numerous.*

173. CARYOPHYLLUS.—Light brown (Fig. 312); pollen grains tetrahedral, somewhat spherical, with three pores, about 15 μ in diameter; calcium oxalate crystals in rosette aggregates 10 to 15 μ in diameter, occasionally in crystal fibers; sclerenchymatous fibers spindle-shaped, thick-walled, strongly lignified and with simple oblique pores; tracheæ spiral, thick-walled; oil glob-

ules numerous. The powder of CLOVE STEMS is less aromatic and contains numerous yellow, nearly isodiametric and irregular thick-walled stone cells with numerous canals and also scalariform and reticulate tracheæ. The powder of the fruit of cloves, or so-called MOTHER OF CLOVES, contains numerous single, oblong and irreg-

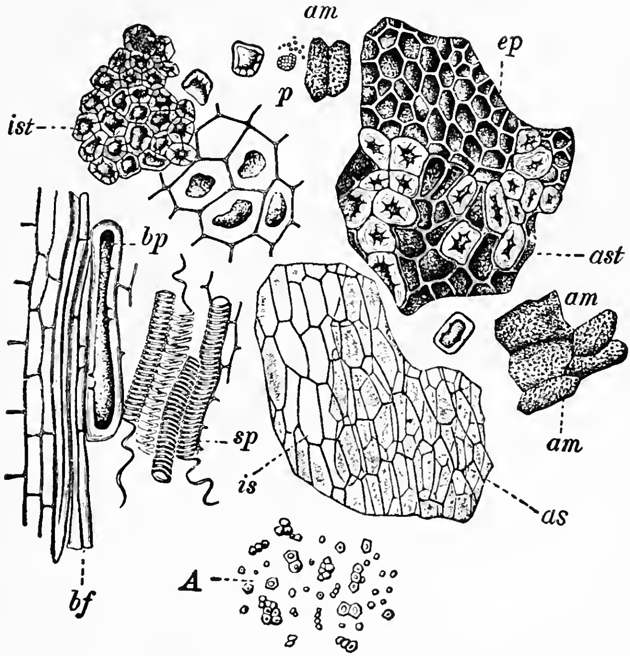

FIG. 311. Black pepper: ep, polygonal cells of the epicarp, beneath which are the hypodermal stone cells (ast); bf, elongated bast fibers; bp, short bast fibers; sp, tracheæ with spiral markings; ist, stone cells of the endocarp; is, as, fragments of tissues beneath the endocarp; am, parenchyma cells of perisperm containing starch grains; A, starch grains; p, oil cells.—After Moeller.

ular starch grains with excentral point of origin of growth, and varying in size from 10 to 35 μ. The pericarp of the fruit also contains numerous irregular stone cells and sclerenchyma fibers, the latter varying from short to 5 mm. or more in length and being very irregular or knotty in outline. (For adulterants see Pimenta No. 113 and p. 549.)

174. INSECT POWDER.—(See No. 5.)

** *Pollen Grains Few.*

† *Tracheæ Present.*

175. CUSSO.—Light brown (Figs. 150, 243); calcium oxalate in rosette aggregates, about 20 μ in diameter; non-glandular hairs 1-celled, curved, thick-walled, 0.2 to 0.5 mm. long; glandular hairs with 2- or 3-celled stalk, glandular head unicellular or consisting of one or two pairs of cells; tracheæ spiral, scalariform, or with bordered pores; sclerenchymatous fibers long, thick-walled, strongly lignified, with numerous simple oblique pores; parenchyma of pith more or less lignified and with simple pores; pollen grains few, somewhat ellipsoidal, 25 to 40 μ in diameter, with three pores.

†† *Tracheæ Wanting.*

176. VIBURNUM OPULUS.—(See No. 179.)

177. VIBURNUM PRUNIFOLIUM.—Dark brown; calcium oxalate in rosette aggregates and few monoclinic prisms 15 to 35 μ in diameter; crystal fibers with rosette aggregates and occasional monoclinic prisms of calcium oxalate; stone cells large, numerous, irregular, thick-walled and with a few canals; bast fibers comparatively few, lignified. The barks of other species of Viburnum are frequently substituted for *V. prunifolium.*

β *Calcium Oxalate in Monoclinic Prisms.*

1. Numerous Seeds.

178. VANILLA.—Blackish-brown (Figs. 256; 285, *G;* 313); calcium oxalate in monoclinic prisms 7 to 35 μ in diameter or in raphides about 0.4 mm. long; occasional unicellular glandular papillæ with rounded apex and containing oil-like globules of a balsam; sclerenchymatous fibers more or less thick-walled, strongly lignified and with numerous oval pores; tracheæ with spiral or reticulate thickenings; minute, black, ovoid seeds about 0.5 mm. in diameter, the structure being apparent only after boiling with chloral solution or solutions of the alkalies. The powder on treatment with a phloroglucin solution and sulphuric acid assumes a deep red color, due to the presence of vanillin.

The powder is frequently admixed with tonka, which is easily determined by the presence of starch grains (see No. 144). Some of the so-called vanilla powders are mixtures containing vanillin or coumarin but none of the tissues of either vanilla or tonka.

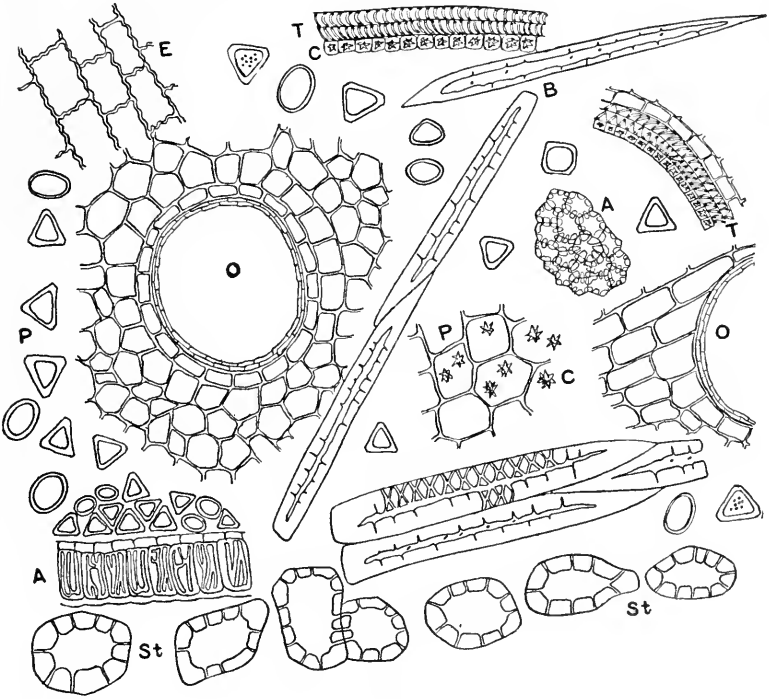

FIG. 312. Cloves: B, bast fibers; A, fragments of anther showing cells with characteristic marking or thickening of the walls; P, pollen grains which appear triangular in outline when mounted in water; O, oil glands, the large one to the left being from a petal; E, surface view of epidermal cells of petal; P, parenchyma; C, calcium oxalate; T, tracheæ; St, seven stone cells from the young branches or twigs, the so-called "clove stems."

2. Seeds Wanting.

179. VIBURNUM OPULUS.—Light brown; calcium oxalate in monoclinic prisms, or few rosette aggregates 15 to 30 μ in diameter; crystal fibers with monoclinic prisms of calcium oxalate; stone cells few, relatively thick-walled; bast fibers numerous, lignified.

180. VIBURNUM PRUNIFOLIUM.—(See No. 177.)

181. XANTHOXYLUM.—Dark brown; calcium oxalate in monoclinic prisms 10 to 25 μ in diameter; starch grains nearly spherical, 4 to 10 μ in diameter; oil-secretion cells colorless; cork cells strongly lignified; bast fibers few, thick-walled, slightly lignified, swelling perceptibly in chloral (Fig. 238).

In Southern Prickly Ash (Fig. 233) occur groups of large, more or less lignified sclerenchymatous cells, and the lignified cork cells are more numerous.

γ *Calcium Oxalate in Crystal Fibers.*

182. QUERCUS ALBA.—Light brown (Figs. 135, 300); bast fibers long, thick-walled, lignified; crystal fibers containing rosette aggregates or monoclinic prisms of calcium oxalate about 10 to 20 μ in diameter; stone cells thick-walled, with numerous lamellæ and simple pores (Fig. 301, *A*); parenchyma with irregular yellowish-brown tannin masses.

b. CALCIUM OXALATE WANTING.

α *Containing Pollen Grains.*

183. ARNICÆ FLORES.—(See No. 81.)

184. CROCUS.—(See No. 85.)

185. SANTONICA.—Light brown (Fig. 240); pollen grains nearly spherical, nearly smooth, 3-pored, 15 to 20 μ in diameter; glandular hairs of two kinds, either with 1 or 2 short cells or with 2 to 3 pairs of cells. If a few c.c. of an alcoholic (95 per cent.) extract be heated with a few drops of potassium hydrate solution, a reddish color is produced.

β *Pollen Grains Wanting.*

1. Stone Cells Numerous.

186. CUBEBA.—Light brown (Fig. 250); stone cells single or in isolated groups, nearly isodiametric, thick-walled, with numerous simple pores, and colorless or light-yellow contents; sclerenchymatous fibers few, short, thick-walled, strongly lignified; parenchymatous cells with reddish-brown tannin masses; oil-secre-

tion cells with suberized walls; oil globules numerous; fragments of powder becoming wine-colored with sulphuric acid (Fig. 334).

187. DELPHINIUM.—Grayish-brown or light brown; stone cells of outer epidermis radially elongated, with thick walls and simple pores resembling those of staphisagria; a layer of pigment cells; fixed oil, and aleurone grains.

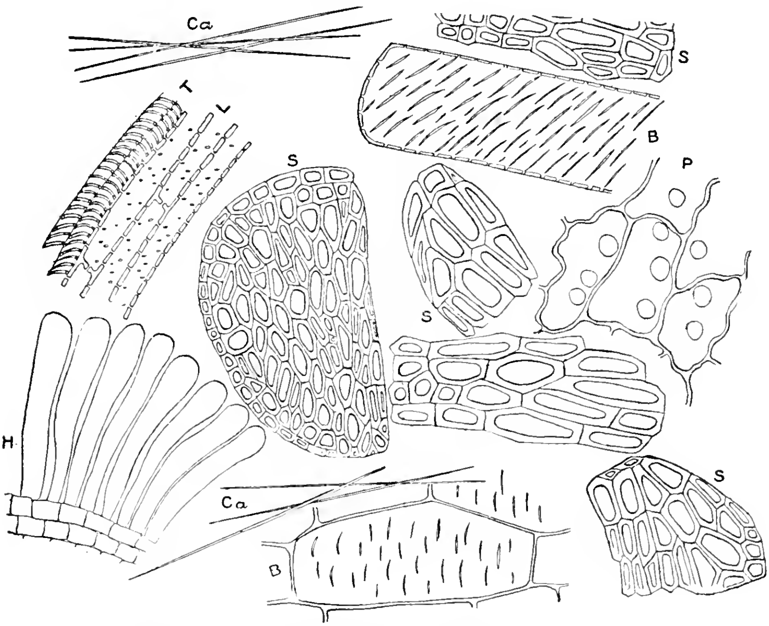

FIG. 313. Vanilla: S, fragments of seeds showing characteristic stone cells; B, parenchyma cells with narrow-elongated simple pores; P, parenchyma containing oil globules; T, tracheæ; L, lignified cells with simple pores; Ca, raphides of calcium oxalate; H, papillæ-like hairs from the inner surface of the pericarp which are occasionally seen massed together.

188. STRAMONII SEMEN.—Brownish-black or grayish-black (Fig. 122, *B*); epidermal cells with thick mucilaginous outer walls, a small lumen and dark brown contents. Beneath the epidermis is a layer of thick-walled, nearly colorless cells with distinct, crescent-shaped lamellæ in the radial walls and reticulate pores. The cells of the endosperm contain considerable oil and more or less numerous aleurone grains, the latter having 1 or 2 crystalloids and a number of globoids.

189. PYRETHRUM.—Dark brown; parenchymatous cells with irregular crystalloidal masses of inulin; periderm with nearly isodiametric stone cells, the contents of which are yellowish-brown; tracheæ reticulate, narrow; sclerenchymatous fibers few; secretion reservoirs with oil and resin (Fig. 101, *E*).

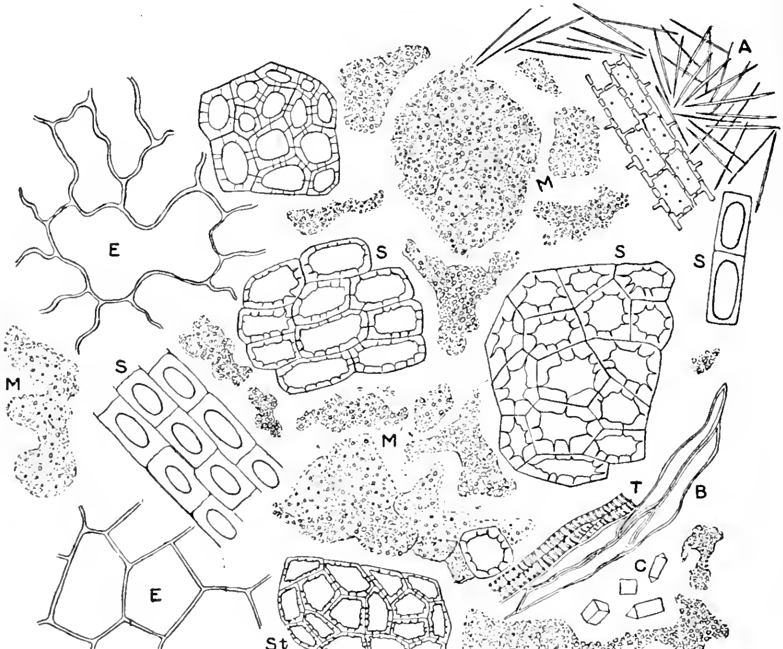

FIG. 314. Powdered opium: M, protoplasm-like latex, which constitutes the greater proportion of the powder; S, St, thick-walled cells of capsule; A, needle-shaped crystals which sometimes separate in a chloral-iodine mount. The following Rumex tissues are also generally present: E, epidermal cells of leaf; B, bast fibers and T, tracheæ from Rumex fruit; C, crystals (probably of calcium oxalate).

The root of *Anacyclus officinarum* contains tannin and an aqueous extract gives a precipitate with ammonio-ferric-alum solution.

2. Stone Cells Wanting.

190. GENTIANA.—Light brown (Figs. 210, 300); ducts scalariform or reticulate; intermediate fibers non-lignified and with

irregular, simple, oblique pores; few globules of fixed oil; aqueous extract not less than 33 per cent. A substitute has been offered consisting of the exhausted drug to which aloes had been added. Ground olive endocarp has also been found in the powder.

191. OPIUM.—(See No. 197.)

192. TARAXACUM.—Light brown; parenchyma containing irregular crystalloidal masses of inulin; laticiferous vessels yellowish-brown (Figs. 101, 197a); tracheæ reticulate; intermediate fibers non-lignified, with irregular simple and oblique pores.

193. CICHORIUM (or Chicory).—Irregular masses of inulin in the parenchyma cells; branching latex vessels from 5 to 10 μ wide; tracheæ short, more or less cylindrical, with pointed ends, from 100 to 200 μ long and 20 to 40 μ wide, with large, elliptical, simple pores. Associated with the tracheæ are slightly thickened, elongated parenchyma cells with narrow, oblique pores.

194. TRITICUM.—Light brown; tracheæ lignified, with spiral or annular thickenings or simple pores; sclerenchymatous fibers long, thick-walled, strongly lignified; endodermal cells with inner walls thickened and slightly lignified; parenchyma with irregular masses of a soluble carbohydrate.

II. WITHOUT FIBROVASCULAR TISSUE.

A. WITH CELLULAR TISSUES.

195. USTILAGO.—Grayish-brown (Figs. 22, 23); nearly spherical spores 7 by 7 μ; little or no foreign substances. Spores of *Coprinus comatus*, blackish and ellipsoidal, 5 by 10 μ. Spores of *Agaricus campestris* more brownish than those of corn smut, ovoid and about 5 by 7 μ.

196. ERGOTA.—Oil globules; red or violet coloration in chloral or sulphuric acid; false parenchyma of compacted hyphæ.

197. OPIUM.—Brownish (Fig. 314); in glycerin mounts showing grayish-brown, irregular granular masses 35 to 40 μ in diameter; little or no starch; thick-walled polygonal cells of epidermis of capsule; epidermal cells of Rumex leaves (used in wrapping opium) somewhat polygonal on surface view, with elliptical stomata about 70 μ long, having a narrow opening; fragments of wings of Rumex fruits (used to prevent cohesion of

opium masses), with prominent, brown-colored fibrovascular tissue composed of spiral tracheæ and narrow sclerenchymatic fibers; parenchyma of seeds colorless, containing air; epidermal cells with large, elliptical, oblique pores; taste bitter; sparingly soluble in water or potassium hydrate solution. The Smyrna opium has the largest number of epidermal cells of capsule, the Indian few or none and the Persian very few. The Persian always has an appreciable amount of starch.

198. GOA POWDER is formed as a result of pathological changes in the woody tissues of *Vouacapoua Araroba* (Fam. Leguminosæ), a forest tree of Brazil. It is obtained by cutting down the trees, splitting the trunk and removing the powder from the clefts or cavities. When fresh the powder is of a light yellow color, but on exposure to air it becomes dark brown or brownish-purple. It is composed of small, wine-colored, somewhat translucent, irregular, angular fragments, with a few fragments of tracheæ and libriform cells with bordered pores. It is nearly insoluble in water, soluble in alcohol, chloroform and solutions of the alkalies, the latter being colored deep red and showing a green fluorescence. It should contain between 50 and 75 per cent. of a neutral principle, chrysarobin, which is official. The latter is a crystalline yellow substance. Chrysarobin forms a red colored solution with solutions of the alkalies (due to the formation of chrysophanic acid) or sulphuric acid; on pouring the sulphuric acid solution into an excess of water the chrysarobin is re-deposited. Goa powder also contains about 2 per cent. of resin; 7 per cent. of bitter extractive; a small amount of chrysophanic acid, and yields about 3 per cent. of ash. Mounts of the powder sometimes show colorless prismatic crystals.

B. WITHOUT CELLULAR TISSUES.

a. POSSESSING OIL.

199. ASAFETIDA.—In a glycerin mount the powder shows irregular grayish (or gray streaked with brown) masses; these are opaque and become milky white on the edge from the presence of oil. The stony asafetida is pulverulent and contains less oil (p. 671).

200. MYRRHA.—In glycerin mount the powder appears in yellowish or yellowish-brown irregular fragments made up of a grayish matrix containing yellowish or yellowish-brown oil globules (p. 674).

b. WITHOUT OIL.

α Remaining Opaque (Not Affected) in Glycerin.

201. ALOES (SOCOTRINE).—Slightly affected. (See No. 206.)

202. BENZOINUM.—Irregular, colorless and wine-colored fragments; some rosette-shaped groups and collections of small tetragonal crystals. Upon covering a fragment on a slide with a watch crystal and cautiously heating, crystals of benzoic acid are sublimed on the watch crystal (p. 672).

203. ELATERINUM.—Grayish and grayish-brown, more or less opaque, irregular fragments; upon heating a fragment with phenol, and when cool, adding sulphuric acid, a deep-red coloration is produced. Potassium hydrate has no action on elaterin (p. 387).

204. LACTUCARIUM.—Grayish-brown and dark brown, irregular and rather angular masses; with alkalies they become reddish-brown and then a dirty brown; with sulphuric acid they are but slightly affected (p. 649).

β Becoming More or Less Translucent in Glycerin.

205. ALOES (CURAÇAO).—In a glycerin mount the particles become clear and behave like Cape aloes, but generally numerous acicular, or large prismatic crystals remain, or separate in the clear yellow space where the fragment of aloes was originally. The fragments are colored red with solutions of the alkalies (p. 663). (See also Fig. 275, C.)

206. ALOES (SOCOTRINE).—In a glycerin mount the fragments are not very perceptibly affected. At the most there is but a faint yellowish color around the grayish or grayish-brown masses. In old Socotrine aloes the gray masses look like rosette crystals. The fragments are colored red with alkalies (p. 663).

207. GAMBIR.—Dark brown (p. 666); with numerous acicular crystals 10 to 60 μ long; occasionally large cubical prisms; also fragments of vegetable tissue. In inferior grades of gambir spores of fungi are sometimes abundant (Fig. 275).

208. CATECHU.—Large, opaque, dark brownish-red masses which gradually become transparent on the edge and dissolve with a sherry-wine color; fragments of sclerenchyma (Fig. 275).

209. KINO.—The blackish-brown fragments become clearer and of a deeper red color as compared to catechu (p. 654).

POWDERS OF A REDDISH COLOR.

This group includes those powdered drugs which are of a pinkish, reddish, brownish-red (brown madder), or rose color.

I. CONTAINING STARCH.

210. QUILLAJA.—Pinkish (Figs. 281, *C;* 300, *G;* 315); very sternutatory; calcium oxalate in monoclinic pyramids from 35 to 200 μ long; bast fibers numerous, thick-walled, strongly lignified; crystal fibers containing monoclinic prisms of calcium oxalate; stone cells more or less thick-walled and with simple oblique pores; starch grains nearly spherical, 3 to 10 μ in diameter.

211. SANGUINARIA.—Reddish; starch grains spherical, 4 to 8 μ in diameter; reddish secretion cells; tracheæ few, reticulate.

II. WITHOUT STARCH.

A. STONE CELLS PRESENT.

212. CAPSICUM.—Brownish-red (Figs. 252; 301, *C*); stone cells of two kinds, either nearly isodiametric, uniformly thickened and with middle lamella slightly lignified, or somewhat elongated on surface view, convolutely thickened on the inner and side walls and strongly lignified; starch grains somewhat spherical, about 3 to 7 μ in diameter, single or compound; glandular hairs with 1- to 3-celled stalk and multicellular glandular head; collenchymatous cells with suberized walls; parenchymatous cells with yellowish-red oil globules and irregular masses of chromoplastids. (See Figs. 214, 255.)

Powdered capsicum is sometimes admixed with about 1 per cent. of a fixed oil to improve its appearance, and such powders are likely to contain in addition some of the commercial starches or by-products obtained in the manufacture of cereal products.

213. ILLICIUM (or Star Anise).—Dark reddish-brown (Fig. 144); stone (or palisade) cells 0.3 to 0.6 mm. long and 20 to 50 μ wide, with slightly thickened walls and

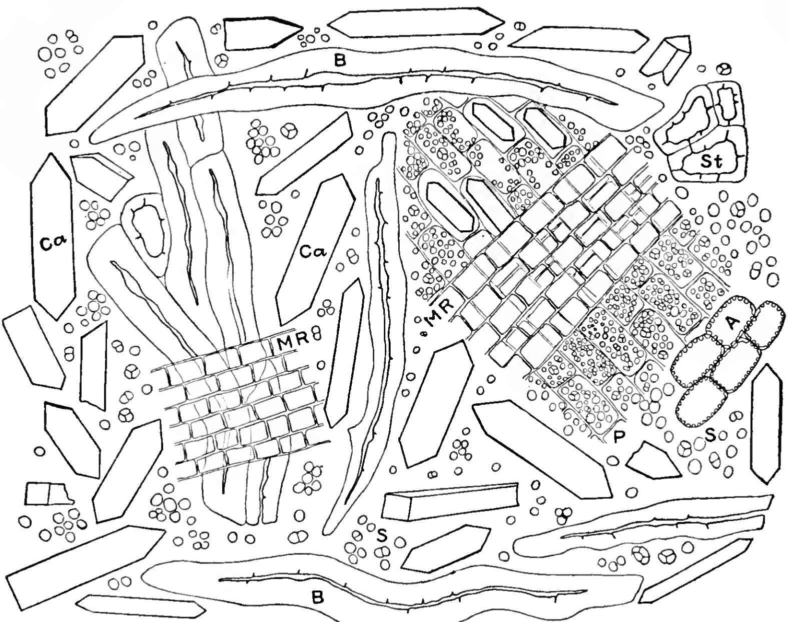

FIG. 315. Soap bark: Ca, pyramids of calcium oxalate; B, bast fibers; St, stone cells; S, starch grains; P, parenchyma containing starch and calcium oxalate; MR, medullary rays; A, parenchyma with simple pores.

simple pores; isodiametric stone cells with thickened walls and branching pores (astrosclereids); long sclerenchymatic fibers with more or less irregularly thickened walls and simple pores; outer epidermal cells with striated cuticle; aleurone grains from 10 to 20 μ in diameter, usually containing globoids. The poisonous shikimi fruit is distinguished by somewhat shorter palisade cells; somewhat rounded stone cells; the aleurone grains contain crystalloids; alcoholic solutions yield an oil with a disagreeable odor.

214. CYDONIUM.—(See No. 80.)

215. RHUS GLABRA.—Brownish-red (Fig. 285, *I*); non-glandular hairs unicellular, narrow, thick-walled, filled with air, or multicellular, cylindrical, ellipsoidal or spatulate and with a wine-colored pigment; glandular hairs with 1-celled stalk and multicellular globular or ellipsoidal head, with yellowish-brown contents; stone cells about 20 μ in diameter, thick-walled, strongly lignified, with numerous pores; oil globules numerous.

216. ROSA CANINA (or Rose Hips).—Dark brownish-red; non-glandular hairs of torus unicellular, from 0.5 to 2 mm. long, about 35 μ wide, gradually tapering toward the base as well as apex, with very thick walls and narrow lumen; parenchyma cells with brownish-red masses of plastids; calcium oxalate crystals in rosette aggregates from 35 to 50 μ in diameter; sclerenchymatous cells and fibers of seed-coat with colorless, rather thick walls and numerous simple and branching pores; an inner epidermis of elongated cells containing a brown pigment; the cells of the embryo with small, nearly spherical aleurone grains and considerable oil.

217. WILLOW CHARCOAL.—Wine-colored or dark reddish, or blackish, irregular-shaped fragments, composed of woody tissues. Willow charcoal is frequently used to color cattle-foods, particularly those the basis of which is wheat-middlings.

B. STONE CELLS WANTING.

a. WITH WOOD FIBERS.

218. HÆMATOXYLON.—Reddish; tracheæ with simple pores; sclerenchymatous fibers long, thin-walled; crystal fibers with monoclinic crystals of calcium oxalate.

219. SANTALUM RUBRUM.—Reddish; tracheæ with bordered pores; sclerenchymatous fibers long, thin-walled; crystal fibers with monoclinic crystals of calcium oxalate. The coloring principle is insoluble in water but soluble in alcohol and solutions of the alkalies.

b. WOOD FIBERS WANTING.

220. CROCUS.—(See No. 85.)

221. KINO.—(See No. 209.)

222. LUPULINUM.—Reddish-brown (Fig. 298); large, characteristic glandular hairs about 20 μ in diameter. In fresh Lupulin there are more light yellow glandular hairs than in old. In the latter there are browner or grayish-brown resinous masses replacing the light yellow oil. The amount of Humulus fragments should not be too large in Lupulin of good quality (Fig. 136).

223. OPIUM.—(See No. 197.)

224. ROSA GALLICA.—Rose-colored; epidermis with acute papillæ; pollen grains few, broadly spherical, 30 μ in diameter (p. 557).

225. ROSA CENTIFOLIA.—Pollen grains nearly smooth and elliptical, from 15 to 30 μ long; fragments of corolla pinkish with chloral; papillæ of corolla somewhat rounded; cells of anther; long, 1-celled, non-glandular hairs around ovary. A hydro-alcoholic solution becomes yellowish-red with acids.

226. ZEA.—Style with spiral and annular tracheæ; numerous non-glandular hairs consisting of 2 parallel rows of cells, and from 0.5 to 1 mm. long (p. 558).

POWDERS OF A WHITISH APPEARANCE.

This group includes all those powders which are light in color, and comprises chiefly the commercial starches, cereals, gums and some of the inorganic substances which are occasionally used as adulterants.

I. PLANT TISSUES OR CELL-CONTENTS RECOGNIZABLE.

A. CONTAINING STARCH.

a. ONLY UNALTERED STARCH GRAINS PRESENT.

Grains characteristic for each; completely soluble in glycerin on heating, and precipitated on the addition of alcohol, the precipitate being soluble in water.

227. ARROWROOT STARCH.—There are a number of commercial kinds of this starch, depending upon the countries in which it is produced (p. 244). BERMUDA arrowroot is in the form of somewhat hard, irregular granules or masses, varying from

1 to 6 mm. in diameter. When rubbed between the fingers it is reduced to a smooth powder, which is velvety to the touch. The starch grains (Fig. 316, *B*) vary in shape from ellipsoidal to ovoid

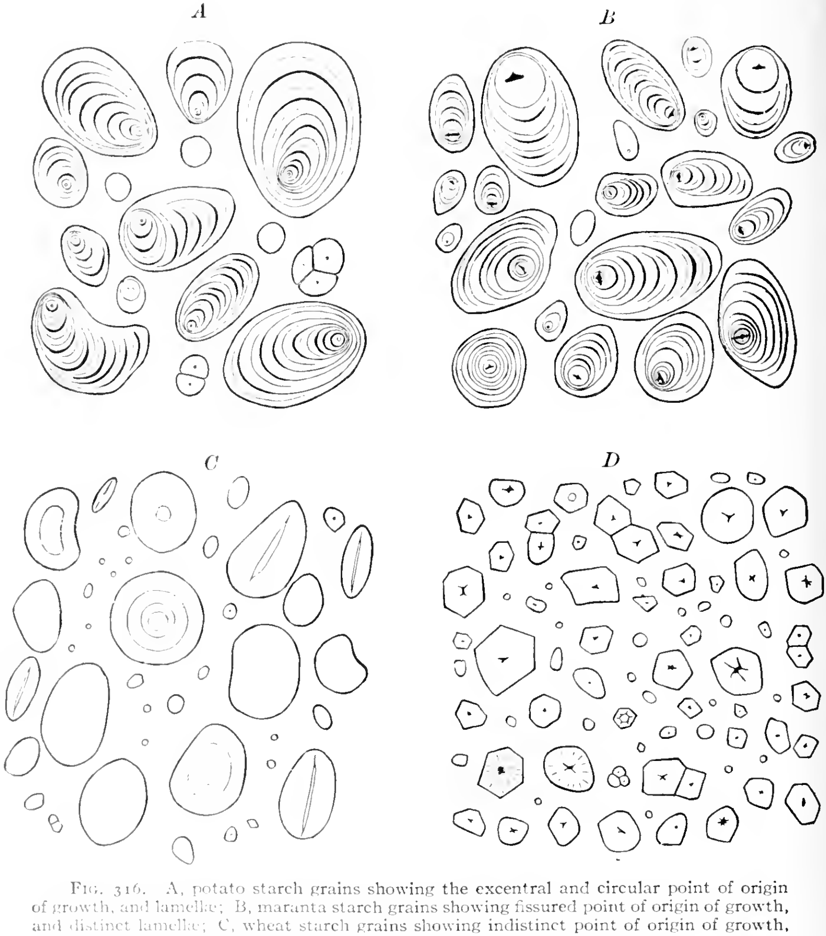

FIG. 316. A, potato starch grains showing the excentral and circular point of origin of growth, and lamellæ; B, maranta starch grains showing fissured point of origin of growth, and distinct lamellæ; C, wheat starch grains showing indistinct point of origin of growth, and lamellæ; D, corn starch grains, which are more or less polygonal in outline and have a 3- to 5-angled point of origin of growth.

or oblong, and from 10 to 65 μ in diameter. The lamellæ are mostly indistinct and there is usually a transverse or crescent-shaped cleft at the middle or near the broad end of the grain.

MONTSERRAT arrowroot closely resembles the Bermuda starch, but the grains are a little larger and more of them show the cleft. ST. VINCENT arrowroot is slightly darker in color and is in the form of masses or granules, which are sometimes 20 mm. in diameter. The starch grains resemble those of the Bermuda arrowroot, but the grains having clefts are more numerous.

The arrowroot starches all show a distinct cross with the micropolariscope and a marked play of colors when a selenite plate is used. These starches usually contain about 15 per cent. of water, the remainder being composed of the starch grains.

228. POTATO STARCH occurs as a more or less finely granular powder, and appears to have less tendency to form coherent masses than arrowroot starch. The grains (Figs. 95; 96; 316, *A*) are somewhat shell-shaped, having distinct lamellæ and a circular point of origin of growth, which is at the smaller end of the grain. They vary in size from 50 to 100 μ, there being a large number of smaller, somewhat ellipsoidal or spherical grains, and a few 2- or 3-compound grains. Under the micropolariscope the grains show a distinct cross (Fig. 95), and a striking play of colors when a selenite plate is used. On heating the starch to a temperature of 65° C. or treating it with very dilute alkali or acid solutions, the grains swell to four times their original size and finally burst, passing through the successive changes in structure illustrated in Fig. 96.

229. CORN STARCH.—This occurs as a fine, somewhat cream-colored, mobile powder, which is practically free from cohering particles. The starch grains (Fig. 316, *D*) are more or less polygonal or somewhat rounded, usually with a distinct circular, or 2- to 5-rayed cleft in the center, and vary from 10 to 35 μ in diameter. When examined by means of the micropolariscope the grains show a distinct cross, but the display of colors when the selenite plate is used is less pronounced than in potato starch. This starch frequently contains traces of alkalies, which may be detected by adding 0.5 Gm. of the starch to 2 c.c. of an aqueous solution of fuchsin, when the latter is decolorized. Corn starch is official (p. 642). It should also be stated that the different kinds of corn produce starches that are somewhat different in character (p. 229).

230. RICE STARCH.—This is prepared by the use of chemicals much the same as in the preparation of corn starch (p. 643). and is either in the form of a white or cream-colored powder or small, irregular masses. The individual grains like those of oat (Fig. 317, *E*), are polygonal, from 2 to 10 μ in diameter, with a central cleft, and usually united into small aggregates of two or more. The product sold for rice starch is frequently rice flour, and is characterized by the large, oval aggregates of numerous grains, as well as cellular tissue. (See No. 244.)

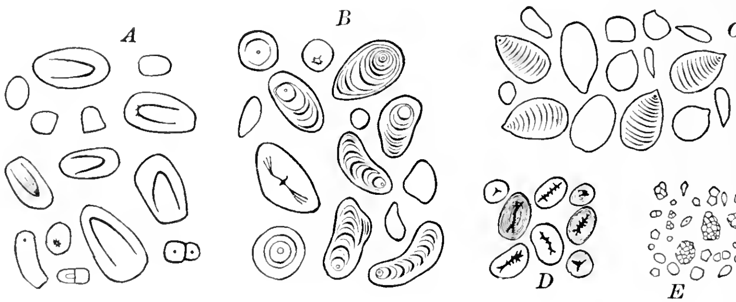

FIG. 317. A, starch grains of *Iris florentina* showing peculiar horseshoe-like fissure extending from point of origin of growth; B, irregular starch grains of calumba root; C, peculiar beaked starch grains of ginger rhizome; D, starch grains of bean showing irregular longitudinal fissures; E, compound starch grains of oat.

231. WHEAT STARCH usually occurs in very hard, somewhat elongated and columnar or irregular masses, varying from 1 to 3 cm. in length. The starch grains are more or less rounded or flattened-circular, and depending upon the surface presented to view under the microscope, appear circular or elliptical in outline; they vary from 15 to 35 μ in diameter and are without distinct markings except when heated or treated with dilute acid or alkaline solutions (Fig. 96). When viewed under the micropolariscope the grains do not show a distinct cross and the play of colors when the selenite plate is used is scarcely discernible. Wheat starch does not agglutinate on mixing with water as wheat flour does (Fig. 95).

232. OTHER STARCHES.—Among the other commercial starches the following may be mentioned:

a. Consisting of SINGLE GRAINS: YAM starch (from several species of Dioscorea) occurs in narrow, ellipsoidal grains, 30 to 50 μ long, with distinct lamellæ and point of origin of growth at narrow end. CANNA starch (*tous les mois* arrowroot), derived from several species of Canna, occurs in broadly elliptical or ovate grains varying from 50 to 125 μ in diameter and with distinct lamellæ and circular point of origin of growth. BEAN starch consists of ellipsoidal or reniform grains, which vary from 25 to 50 μ in length and have a distinct, branching, elongated cleft in the middle. PEA-starch grains resemble those of bean starch, but the grains are smaller and more or less irregular on the surface (Figs. 95; 317, *D*). QUEENSLAND ARROWROOT is obtained from *Canna edulis*.

b. Consisting of 2- TO 3-COMPOUND GRAINS: CASSAVA or tapioca starch is obtained from the Sweet and Bitter Cassava (p. 318), and occurs in somewhat plano-convex or bell-shaped, 2- to 3-, or even 4- to 8-compound grains, which vary from 6 to 30 μ in diameter and have a distinct central, circular, or radiating cleft. SWEET POTATO starch resembles Cassava starch, but some of the grains are larger.

b. ALTERED AND UNALTERED STARCH GRAINS PRESENT.

233. DEXTRIN.—Sticky mass with water, consisting chiefly of altered starch grains, but usually sufficient unaltered grains are present to determine the source of the dextrin.

234. SAGO starch is obtained from *Cycas revoluta* and other cycads as well as a number of palms (p. 233). It occurs in commerce in small, horny granules, which are slowly affected by cold water, when there separates the characteristic elliptical or truncate-elliptical starch grains. The latter vary from 15 to 50 μ long and have a large central area surrounded by rather narrow, distinct, altered lamellæ.

235. SAGO (IMITATION).—Breaks down quickly in water and shows characteristic corn starch grains.

c. PLANT TISSUES IN ADDITION TO STARCH GRAINS.

The former remain upon treatment with hot glycerin.

a Do Not Readily Dissolve or Swell in Cold Water.

236. CORN MEAL is whitish or yellowish, and in addition to the parenchyma which contains oil and characteristic starch grains there are also present fragments of the pericarp. The latter are free from hairs; the cells of the epicarp have thick walls with simple pores; beneath the latter occurs a layer of parenchyma cells which are thin-walled, more or less branching, between which are large intercellular spaces; running at right angles across the branching parenchyma cells are narrow, thin-walled tube cells, which are also found in the other cereals. Corn Meal contains more starch and oil and little hull, as compared to corn bran. In Broom Corn and Sugar Sorghum the tangential walls of the cells of the epicarp are undulate and distinctly porous; and the more or less polygonal cells of the perisperm are quite prominent. These two kinds of cells serve to distinguish these fruits from either corn or any of the other cereals.

237. CORN BRAN.—Less starch and oil and more hull, as compared to cornmeal. (See No. 236.)

238. WHEAT FLOUR.—Agglutinates with water (distinction from wheat starch); little tissue of wheat grain. (See No. 239.)

239. WHEAT MIDDLINGS are grayish-white and in addition to the characteristic starch grains (Figs. 95; 96; 316, *C*) there are numerous fragments of tissues, as the thick-walled polygonal cells of the endosperm, which contain small aleurone grains and have a more or less distinct nucleus; the cells of the embryo containing aleurone grains and fixed oil; and the tissues of the pericarp. The latter include unicellular *hairs*, which are 0.5 to 1 mm. in length and 15 to 25 μ in diameter, have a sharply pointed apex and rounded base, and a narrow lumen, which is but 1 or 2 μ wide; a layer of *tangentially elongated cells* from 100 to 200 μ long and 15 to 25 μ in diameter, which are slightly thickened and with simple pores; and running across the latter are a number of more or less isolated vermiform cells with rounded ends (Fig. 321).

Wheat bran is said to be sometimes adulterated with "inner coffee hulls," which consist of the inner tissues of the pericarp of the coffee fruit (see No. 154), and are readily detected by the fragments of palisade cells and the somewhat elongated, narrow, sclerenchymatic fibers which cross one another.

240. RYE FLOUR is faintly grayish-white, the starch grains closely resembling those of wheat, but sometimes larger (20 to 60 μ); the lamellæ are distinct and the point of origin of growth is sometimes marked by a star-shaped cleft or fissure. Rye flour when mixed with water does not agglutinate like wheat flour. A few fragments of the pericarp are also present (Fig. 321).

241. RYE MIDDLINGS.—In addition to the starch grains in rye flour a considerable amount of the tissues of the pericarp are present. The latter closely resemble those of wheat, but *hairs* from the apex of the fruit have thinner walls, the lumen being 2 or 3 times the thickness of the walls; and the *tangentially elongated cells* have simple pores only on the tangential walls, and do not lie close together, so that there are intercellular spaces between them (Fig. 321).

242. BARLEY FLOUR.—The starch grains closely resemble those of wheat, but are smaller, usually not more than 25 μ in diameter, and in the case of malt the grains show distinct radial and circular clefts, due to the action of the diastase; the *hairs* from the apex of the grain resemble those of both wheat and rye but are shorter than either, being from 40 to 150 μ long; the *tangentially elongated cells* are non-porous, the walls being 1 to 2 μ thick (Fig. 321).

243. BUCKWHEAT FLOUR.—Light grayish-brown; pericarp of elongated epidermal cells with latticed walls, due to the pores of the outer and inner walls running obliquely and at right angles to each other; short sclerenchymatic fibers with somewhat curved or oblique end walls, large simple pores and brown contents; parenchyma with brown contents. Seed-coat showing in surface section epidermal cells with undulate walls; branching parenchyma with greenish or brownish-yellow contents; and an inner epidermis of elongated cells. Endosperm having a layer of cells containing aleurone grains, resembling those found in the true cereals, and parenchyma with numerous angular or somewhat rounded or ellipsoidal starch grains (resembling those of rice or oat), with distinct central cleft and varying from 5 to 12 μ in diameter (Fig. 138).

244. RICE FLOUR consists chiefly of the small, angular starch grains and aggregates like those of oat (Fig. 317, *E*). There are also present some of the polygonal cells containing aleurone grains and a few fragments of the pericarp. The latter is especially characterized by the radially elongated cells of the epicarp, which are 100 to 500 μ long and 25 to 100 μ wide, and the end walls of which are deeply undulate, resembling the epidermal cells of some leaves.

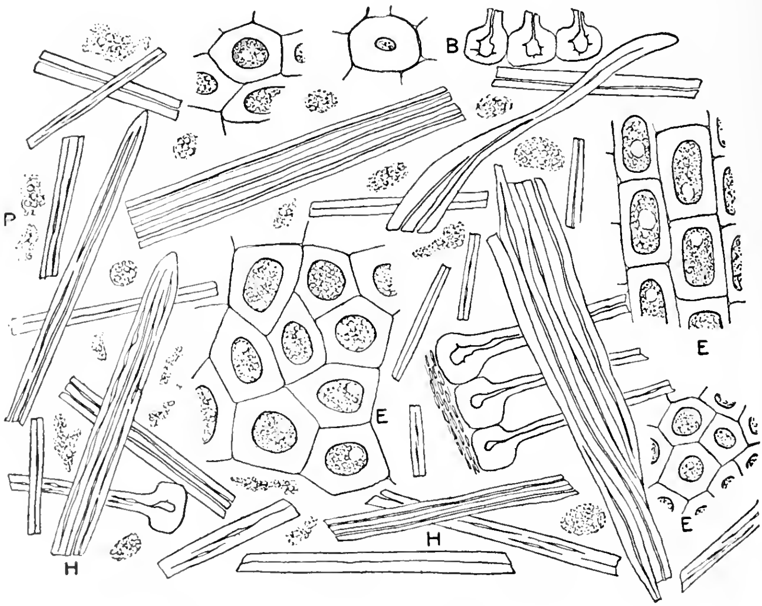

FIG. 318. Nux Vomica: H, fragments of lignified hairs of seed-coat; B, basal portion of hairs; E, thick-walled parenchyma cells of endosperm containing one or more oil globules and protoplasm; P, isolated protoplasmic substance from endosperm cells.

245. OATMEAL OR ROLLED OATS.—The starch grains are small and, like those in rice, in aggregate masses, which are more or less rounded, polygonal or pear-shaped. The endosperm consists of a single layer of cells containing aleurone grains, but the walls are 3 to 5 μ thick. The cells of the epicarp are longitudinally elongated and possess very thin, porous walls, those situated at the upper end of the grain having long, unicellular hairs, which are about 20 μ wide near the middle portion, and

taper gradually towards the base as well as towards the apex. The other tissues of the pericarp are not so conspicuous as in the other cereals (Fig. 120).

246. NUX VOMICA.—(See No. 252.)

247. ORRIS ROOT.—Characteristic starch grains 15 to 30 μ in diameter; scalariform tracheæ 25 μ in diameter; no cork; calcium oxalate in raphides or in long pyramids (Figs. 317, *A*; 320). Coarse angular fragments of orris root, which have been colored with yellow, green and red aniline dyes, are sometimes present in a so-named Japanese pot pourri which is used for filling rose jars.

248. QUILLAJA.—(See No. 210.)

249. BRYONIA.—Starch grains single or two or more compound, from 10 to 20 μ in diameter; occasional acicular crystals 200 μ in length; tracheæ 35 to 60 μ wide, associated with yellowish colored cells; cork cells yellow; powder colored purplish and reddish-brown with sulphuric acid.

249a. CALAMUS.—(See No. 128.)

249b. ULMUS.—(See No. 129.)

β Soluble in or Swelling in Cold Water to Form a Sticky Mass.

250. TRAGACANTHA.—Slowly affected by water; fragments of tracheæ and parenchyma; starch grains more or less spherical and from 2 to 10 μ in diameter (p. 652).

B. WITHOUT STARCH.

a. CALCIUM OXALATE PRESENT.

251. SCILLA.—Raphides very long, being sometimes 1 or 2 mm. in length, and occurring either in mucilage cells or free in the powder or agglutinated mass; also isolated fragments of fibrovascular tissue (Fig. 281, *B*).

b. CALCIUM OXALATE WANTING.

252. NUX VOMICA.—Grayish-white (Figs. 173, 318); odor slight; taste intensely and persistently bitter; epidermal cells modified to strongly lignified hairs; endosperm cells containing

a fixed oil and aleurone grains (Fig. 318, *E*). Small, nearly spherical starch grains occur in the tissues of adhering fruit pulp. It is occasionally adulterated with olive endocarp and seeds of *Metroxylon vitiense*.

253. ALMOND.—Both bitter almonds and sweet almonds have characteristic, rectangular, somewhat rounded stone cells in the outer epidermal layer of the seed-coat. These stone cells are from 70 to 175 μ long and from 65 to 100 μ wide; the walls are from 10 to 15 μ thick and have numerous simple pores. The seed-

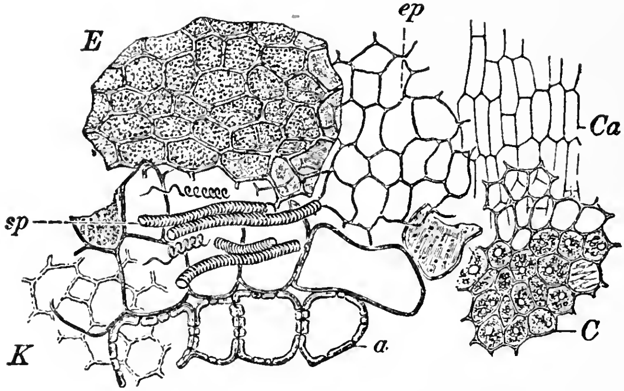

FIG. 319. Almond meal: a, stone cells of the outer epidermis; K, brown hypodermal cells; sp, spiral tracheæ of the seed-coat; ep, cells of inner epidermis with brown contents; E, cells of the endosperm containing numerous small aleurone grains; Ca, epidermal cells of cotyledons; C, parenchyma of the cotyledons containing aleurone grains and oil.—After Moeller.

coat also contains tracheæ with spiral thickenings, associated with which are cells containing rosette-shaped or prismatic crystals of calcium oxalate that are about 7 μ in diameter. The endosperm consists of a single layer of nearly cubical cells about 15 μ in diameter. The cells of the embryo contain numerous aleurone grains, which are from 5 to 15 μ in diameter and consist of crystalloids, globoids and calcium oxalate (Figs. 187; 188; 302, *D*; 319).

SUBSTITUTES.—The seeds of other plants of the Rosaceæ are sometimes substituted for Almond seeds. These usually have a bitter and more or less disagreeable taste; the outer epidermal cells in apricot and plum being elongated tangentially, while those of peach are somewhat narrower and more or less conical.

ALMOND MEAL consists chiefly of the tissues of the embryo. The so-called almond meal which is used as a cleansing agent consists of ALMOND CAKE, a by-product in the manufacture of almond oil, to which are added other substances to give it a pleasant odor, as orris root (see No. 247). A spurious almond meal consists of wheat middlings to which powdered soap and some volatile oil or triple extract are added.

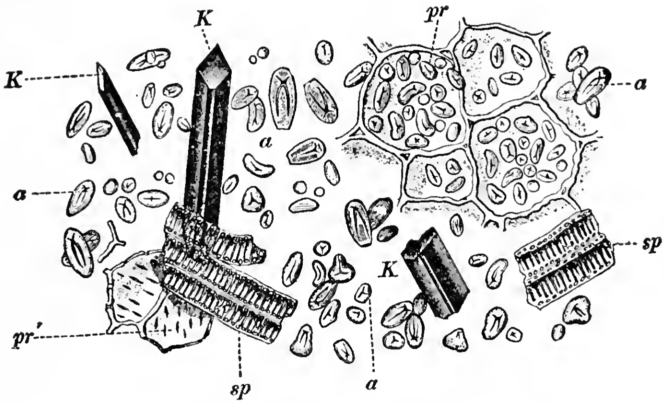

FIG. 320. Orris root: pr, parenchyma containing starch grains; a, starch grains with characteristic cleft; pr', parenchyma with narrow oblique pores; sp, fragments of tracheæ; K, prisms of calcium oxalate.—After Vogl.

II. ABSENCE OF PLANT TISSUES.

A. SOLUBLE IN WATER.

254. ACACIA (WHITE).—Soluble in cold water forming a sticky mass; few plant tissues present (p. 643).

255. SACCHARUM.—Crystals in rhombic prisms which are insoluble in fixed oils, chloroform or ether, but soluble in water, alcohol or glycerin.

B. INSOLUBLE IN WATER.

a. SOLUBLE IN ALCOHOL.

256. CAMPHORA.—Liquefies in mounts of glycerin and chloral; glycerin mounts show irregular masses, nearly insoluble in water but soluble in alcohol, and fixed and volatile oils.

b. INSOLUBLE IN ALCOHOL.

a Reddish Color With Sulphuric Acid After Some Time.

257. SACCHARUM LACTIS.—Small and large irregular-shaped crystals insoluble in mounts of glycerin, or alcohol.

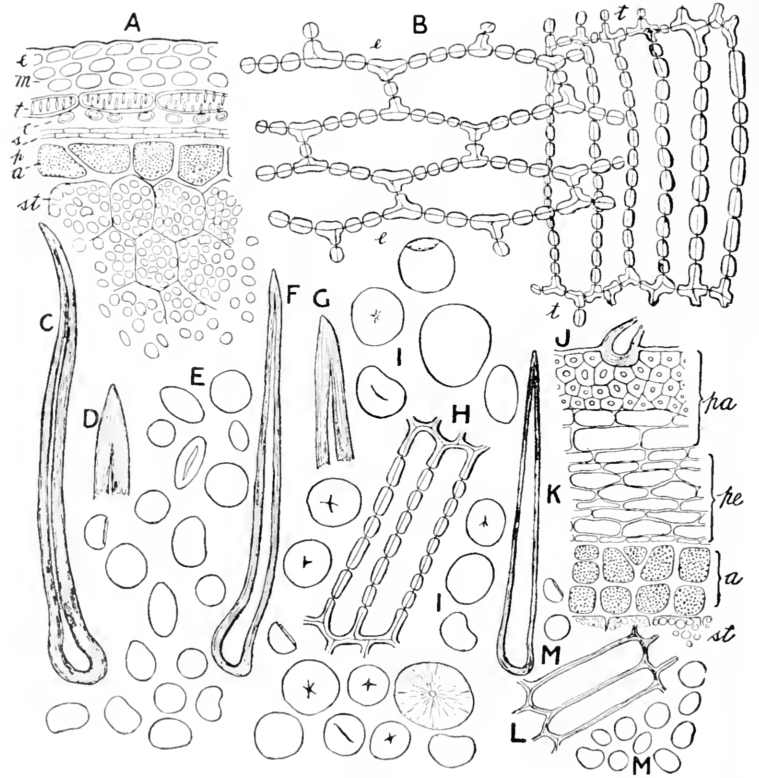

FIG. 321. Wheat grain (*Triticum sativum*): A, transverse section showing epicarp (e), cells of mesocarp (m), tangentially elongated cells (querzellen) (t), tube cells (c), spermoderm (s), perisperm (p), aleurone cells (a), parenchyma containing starch (st); B, surface section of pericarp showing relation of epidermal cells (e) to tangentially elongated cells (t); C, hair from the apex of the grain with thick wall and very narrow lumen; D, apical portion of a hair; E, starch grains.

Rye grain (*Secale cereale*): F, hair with wall comparatively thinner than in the hair of the wheat grain; G, apical portion of a hair; H, tangentially elongated cells in which the pores occur only on the tangential walls; I, starch grains which vary from 20 to 70 μ in diameter, and occasionally have delicate clefts.

Barley grain (*Hordeum sativum*): J, transverse section of palet (pa) and pericarp (pe), aleurone layer (a) composed of two or three rows of cells, parenchyma of endosperm containing starch (st); K, hair from epicarp with very thin wall and large lumen; L, tangentially elongated cells which differ from those of wheat and rye in being without pores; M, starch grains which resemble those of wheat but are uniformly smaller.

β No Color Reaction With Sulphuric Acid.

1. Soapy Feel.

258. TALCUM (MAGNESIUM SILICATE).—Rather long, irregular, lustrous and broken crystals.

2. Soluble in Acetic Acid.

* With Effervescence.

259. CALCII CARBONAS PRÆCIPITATUS.—By adding hot solution of ammonium oxalate to an acetic acid solution of this salt on a slide, crystals of calcium oxalate are obtained. Mounts in glycerin show rosette aggregates or cubical crystals of a rather uniform size.

260. CRETA PRÆPARATA.—Same treatment as above. The resulting calcium oxalate crystals are triangular and cubical and not of uniform size.

261. BARIUM CARBONATE.—Add sulphuric acid, and in glycerin mount the barium sulphate precipitate occurs in very small particles.

** Soluble in Acetic Acid Without Effervescence.

262. MAGNESIA PONDEROSA.—In glycerin mount alone small, rounded masses are observed, frequently grouped together; if a few milligrams be dissolved in citric acid on a slide or watch crystal, then a few drops (excess) of ammonium hydrate and sodium phosphate solution be added, and stirred vigorously with a glass rod, triangular or tetragonal crystals are formed.

263. MAGNESIA.—In a glycerin mount the masses have the appearance of heavy magnesia, but are larger and more transparent. On treatment with citric acid, ammonium hydrate and sodium phosphate, the crystals of ammonium-magnesium phosphate in glycerin mount are large, star-shaped, and look like snow crystals.

3. Insoluble in Acetic Acid.

* Soluble in Nitric Acid.

If necessary, in deciding on any of the next four powders, they are to be fused with potassium carbonate or sodium carbonate, and a regular qualitative chemical separation effected.

264. CALCII PHOSPHAS PRÆCIPITATUS.—In glycerin mount alone small tetragonal and cubical crystals are observed.

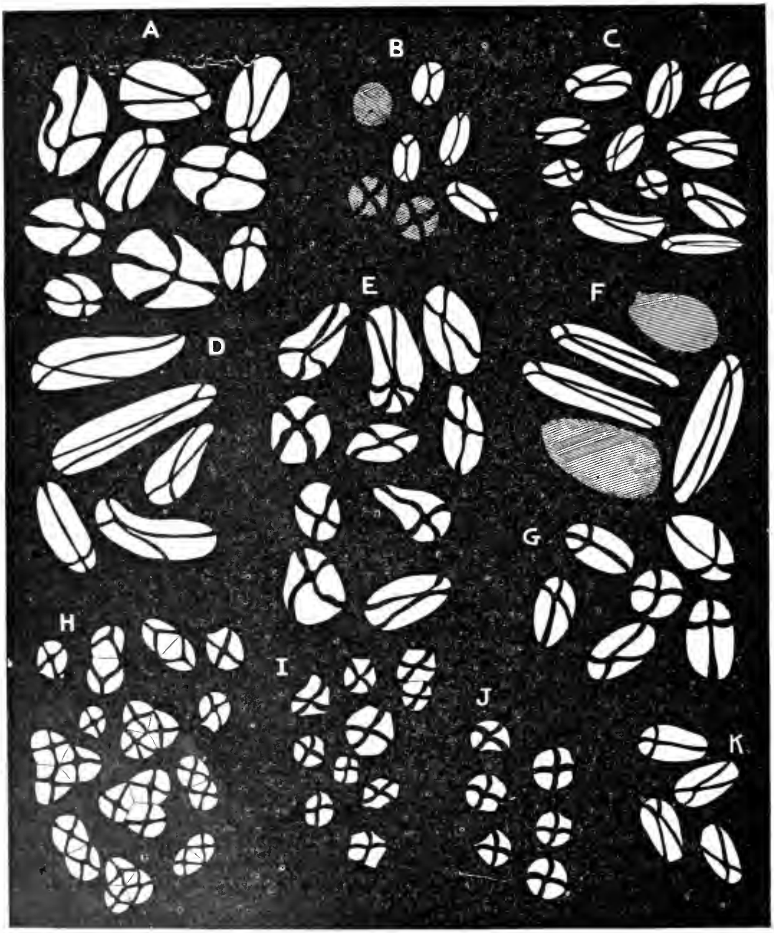

FIG. 322. Larger grains of various starches as viewed through the micropolariscope when mounted in oil: A, potato (70–80 μ); B, wheat (30–40 μ); C, ginger (30–50 μ); D, galangal (45–55 μ); E, calumba (40–60 μ); F, zedoary (50–75 μ); G, maranta (35–50 μ); H, colchicum (10–20 μ); I, corn (20–25 μ); J, cassava (20–35μ); K, orris root (30–35 μ)

If to a few milligrams of the powder on a slide a few drops of nitric acid are added, and then a small quantity of ammonium molybdate solution, stirring well with a glass rod, small, yellow, diamond-shaped crystals are observed, which are permanent in glycerin mounts.

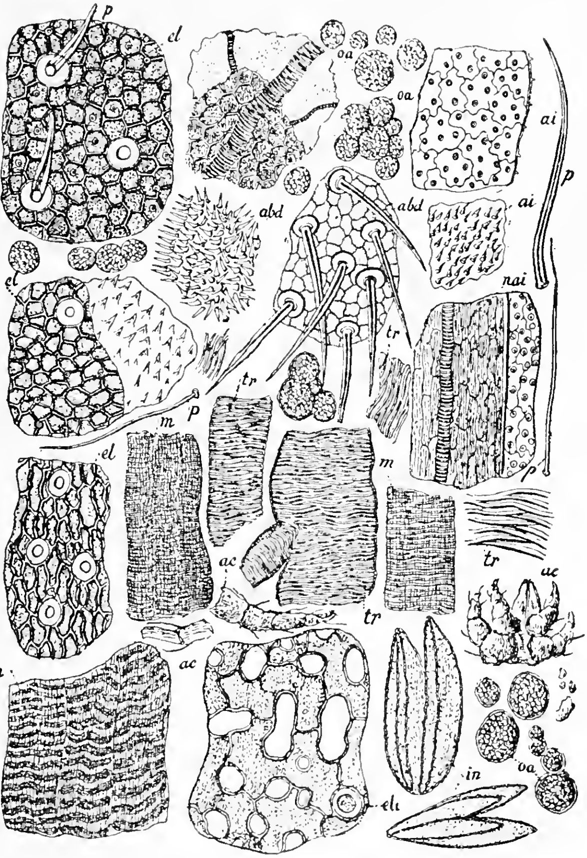

Fig. 322, A. Cantharides (*Cantharis vesicatoria*): abd, fragments of abdomen; ai, fragments of wings; ac, fragments of mites; el, fragments of elytra showing the external surface; eli, fragments of elytra showing internal surface, when cleared with Javel water; m, fragments of muscles; in, undetermined fragments; oa, eggs of mites; p, hairs from abdomen, thorax and wings.—After Collin.

265. CALCII SULPHAS.—In glycerin mount alone needle-shaped crystals, or long crystals in masses which look like a group of sclerenchyma fibers, are observed.

PART III.—REAGENTS AND MICROSCOPIC TECHNIQUE.

THE reagents that have been recommended for microscopical work are quite numerous, and while nearly all of them may have more or less special merit, the number of reagents actually required in practice is fortunately quite small.

It is important that the student recognize the necessity for a thorough understanding of the structure of the material under examination rather than place too much dependence upon the effects produced by reagents; in other words, the study of structure should precede the use of reagents, particularly stains, when it will often be found that the latter can be dispensed with entirely.

The chemicals that are employed in microscopical work, either as reagents or for other purposes, may be classified as follows: (1) Preservatives, (2) Fixing and Killing Agents, (3) Hardening and Dehydrating Agents, (4) Clearing Agents, (5) Stains and (6) Special Reagents.

PRESERVATIVES are substances used to preserve material which is to be examined. The most important of these are alcohol (from 40 to 95 per cent.) and formalin [2 to 6 per cent. aqueous or alcoholic (60 per cent. alcohol) solution], the latter of which is considered advantageous in the preservation of specimens containing coloring substances, as leaves, flowers, etc. Almost any antiseptic of the proper strength may be used as a preservative.

FIXING OR KILLING AGENTS are more especially employed in the study of the protoplasmic cell-contents, where by their use the life-processes of the cell are brought to a sudden termination, the object being to fix the contents in a condition approaching as nearly as possible the normal living state. In order to carry out this operation successfully, the living specimen must be placed in the fixing or killing agent as soon as collected, and if the specimen is large it should be cut into small pieces. The following are some of the common fixing agents: Chromic acid in 0.5 to 1 per cent. aqueous solution; osmic acid in 1 to 2 per cent. aqueous solution;

Flemming's mixture, which is an aqueous solution of chromic acid (0.25 per cent.) containing 0.1 per cent. of osmic acid and 0.1 per cent. of acetic acid; picric acid in concentrated aqueous or alcoholic solution; picric-sulphuric acid, a concentrated aqueous solution of picric acid containing 2 per cent. by volume of sulphuric acid; and mercuric chloride (corrosive sublimate) used in 0.1 to 1 per cent. aqueous or alcoholic solution.

Hardening or Dehydrating Agents are those substances which are employed for the purpose of hardening the specimen so as to facilitate sectioning and for removing the water, which would interfere with its examination. Alcohol is to be regarded as the principal hardening or dehydrating agent, and considerable care is necessary in its use; the specimen is treated successively with alcoholic solutions of gradually increasing strength, beginning with a 35 per cent. solution, in which the specimen is kept for twenty-four hours; then it is placed in 50 per cent. alcohol for from six to twenty-four hours, and then in 70 per cent. alcohol, in which it may be kept until ready for use. In order to avoid shrinking of the material at this stage, it may be kept in a solution of alcohol and glycerin, or oil of bergamot, or a mixture of xylol and paraffin. When the material is to be examined it should be removed to 85 per cent. alcohol for from six to twenty-four hours, then to 95 per cent. alcohol and absolute alcohol successively for the same length of time. Of the other dehydrating agents the most important are anhydrous glycerin, pure carbolic acid, and anhydrous sulphuric acid, the latter being used in a desiccator and not applied directly to the specimen.

Making of Sections.—Sections of roots, stems, barks and many fruits and seeds can be made directly without embedding the material, and while sections can be made holding the material in the hand, between the thumb and three fingers, the hand microtome for holding the material may be used by those who are less experienced. In the sectioning of leaves and other material that is not firm, and fruits and seeds which are too small to hold in the hand, the material should be embedded in some substance which will hold it and give it stability. When the tissues are not too hard the material may be placed between pieces of elder or sunflower pith. In some cases the making of sections is facilitated by moistening both the pith and the razor. In the case of seeds and fruits which are very small and at the same time very hard, as colchicum and mustard, it is best to use a velvet or fine grade of cork for holding the material. The cork is indented by means of forceps and the seed or fruit forced into the cavity.

In the case of very delicate tissues, where the protoplasmic contents of the cells are to be studied, as in the ovaries of flowers, prothalli of ferns and other parts of the plant, where cell division is going on, the material should be embedded in paraffin or celloidin, subsequently hardened, and sectioned by means of a finely adjusted microtome.

Clearing Agents.—Most dehydrating agents are also clearing agents, because of the fact that the air and water in the specimen are replaced by a medium having greater refractive properties. Some clearing agents act chemically on the tissues and cell-contents. Among the clearing agents most frequently employed are: Chloral in saturated aqueous solution, and chloral-glycerin solution (a solution of equal parts of glycerin and water saturated with chloral). Essential oils, as clove, turpentine, cedar, marjoram, etc., are also useful for this purpose, particularly when the specimen is to be mounted in Canada balsam.

Staining Agents are those that produce more or less definitely colored compounds with the cell-contents or walls. They include: (1) the Aniline Dyes and (2) Non-aniline Stains.

The aniline stains may be used in aqueous solutions, weak alcoholic solutions or strong alcoholic solutions, containing from 1 to 3 per cent. of the dye. The following are the aniline stains most frequently employed: Aniline blue, Bismarck brown, fuchsin, gentian violet, methylene blue, methyl violet and safranin. In addition to these, aniline hydrochloride or sulphate is used in what is known as Wiesner's Reagent, which is a 25 per cent. solution of alcohol containing 5 per cent. of either of these salts, a drop of either hydrochloric or sulphuric acid being used with a drop of the solution, according as the hydrochloride or sulphate has been used.

Loeffler's Methylene Blue.—This reagent is prepared by adding 30 c.c. of a concentrated alcoholic solution of methylene blue to 100 c.c. of water containing 10 milligrams of potassium hydrate.

Ziel's Carbol-fuchsin.—This solution is prepared by adding 15 c.c. of a concentrated alcoholic solution of fuchsin to 100 c.c. of water containing 5 grams of carbolic acid.

Aniline Dyes are usually employed in concentrated aqueous solution, but owing to the difference in solubility of the dyes the solutions vary in strength. Saturated solutions of eosin or gentian violet may be prepared by dissolving 1 gram of the dye in 100 c.c.

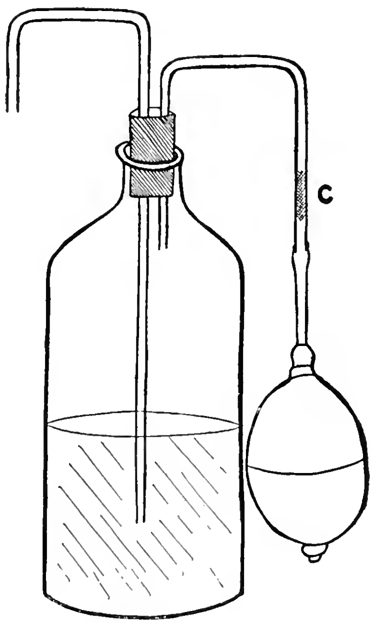

Fig. 323. Reagent bottle for sterile solutions.

of water, while to make a saturated solution of methylene blue requires 0.400 Gm. of the dye to 100 c.c. of water. Some investigators prefer to replace the distilled water with aniline water, which is prepared by adding about 3 grams of anilin oil to 100 c.c. of distilled water.

Reagent Bottle for Sterile Solutions.—The solutions of the aniline dyes as ordinarily prepared deteriorate more or less rapidly and are usually made up fresh each time they are required for use. These solutions, as well as other reagents that are prone to decomposition, may, however, be kept for months or even years by preparing them with care and keeping them in a special kind of bottle (Fig. 323). An ordinary bottle may be used, and is fitted with a rubber stopper perforated so as to allow the introduction of two glass tubes. These tubes are bent twice at right

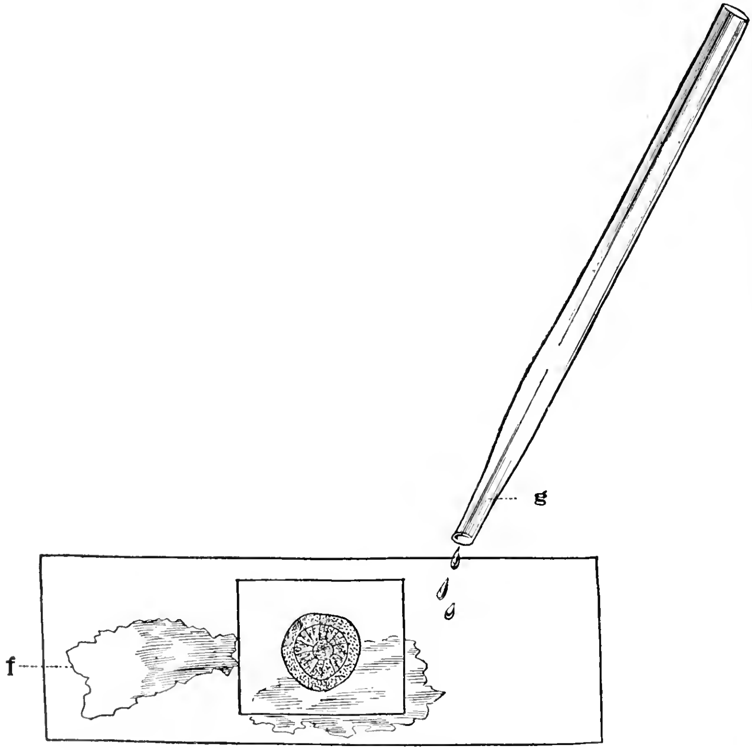

FIG. 324. Method of applying reagent to material already mounted. g, pipette; f, filter paper.

angles and the free ends directed downwards. One of the tubes is connected with an atomizer bulb and serves for forcing out the liquid. A small plug of absorbent cotton is placed in the tube at the point *C*, so as to filter the air. This may be improved by blowing a bulb in the tube for holding the cotton. The bottle should be sterilized before placing the solution in it, and the solution should be made by adding the dye to sterile water contained

EFFECTS OF IMPORTANT MICRO-CHEMICAL REAGENTS.

Reagent	Starch Grains	Calcium Oxalate Crystals	Stone Cells	Tracheæ	Wood and Bast Fibers	Parenchyma	Cork and Cutin	Protein Crystalloids	Protoplasmic Contents
Distilled water	Brings out the structure	....	....	....	....	....	....	Dissolves the ground-mass, bringing out the definition of the crystalloids	....
Chloral solution or potassium hydrate solution	Swell and finally dissolve	Clears the sections, bringing out the definition of the crystals	Clears the tissues, bringing out the lamellæ and pores	Clears the tissues, bringing out the markings of the walls	Clears the tissues, bringing out the pores	Has a clearing effect, and swells the walls	Become yellow	Dissolve	Swell and finally dissolve
Phloroglucin and hydrochloric acid	The acid brings out the structure of the grains, finally dissolving them	The acid dissolves the crystals	The walls become purplish-red	The walls become purplish-red	The walls may or may not be colored purplish-red	....	....	The acid has a solvent effect	....
Anilin sulphate and sulphuric acid	The acid brings out the structure of the grains, finally dissolving them	Cause the separation of fine needles of calcium sulphate	The walls become bright-yellow	The walls become bright yellow	The walls may or may not be colored bright yellow	....	....	The acid has a solvent effect	....
Iodine solution	Pale blue to bluish-black, depending upon the strength of reagent	....	The walls turn yellow	The walls turn yellowish-brown	The walls turn yellowish-brown	The walls are colored yellow	The walls are colored yellow	The crystalloids are colored yellowish or yellowish-brown	Become yellowish
Chlor-zinc-iodide	Swell and are colored blue	....	The walls turn yellowish- to reddish-brown	The walls turn yellowish-brown	The walls turn yellowish- to reddish-brown	The walls become lavender or violet	The walls become yellowish-brown	Become yellowish-brown. Dissolve	Become yellow
Sulphuric acid	Dissolve	Causes separation of calcium sulphate needles	Swell and finally dissolve	Swell and dissolve slowly	Swell and finally dissolve	Dissolves	Dissolve very slowly	Dissolve slowly	Dissolve slowly

in the bottle. The solution may be afterwards further sterilized by means of steam if this should be found necessary, as in this way only a perfectly sterile solution could be produced.

The non-aniline stains give, as a rule, more reliable and constant results in the study of cell walls, as in the roots, stems and other parts of the plant, than the aniline stains. They include the following:

BEALE'S CARMINE SOLUTION, which is made as follows: Mix 0.6 Gm. carmine with 3.75 Gm. ammonia water (10 per cent.); heat on a water-bath for several minutes; then add 60 Gm. of glycerin, 60 Gm. of water and 15 Gm. of alcohol, and filter.

GRENACHER'S BORAX-CARMINE SOLUTION.—Dissolve 2 to 3 Gm. of carmine and 4 Gm. of borax in 93 c.c. of water and then add 100 c.c. of alcohol (70 per cent.); shake and filter. When this stain is employed the sections are freed from an excess by the use of alcoholic solutions of borax or oxalic acid.

HOYER'S PICRO-CARMINE SOLUTION is made by dissolving carmine in a concentrated solution of neutral ammonium picrate. A solution of carmine and picric acid is known as Picro-Carmine Solution. Carmine solutions give, with cellulose, the nucleus and proteins a red color.

CHLOR-ZINC-IODIDE SOLUTION, or Schulze's Cellulose Reagent, consists of anhydrous zinc chloride, 25 Gm.; potassium iodide, 8 Gm., and water, 8.5 Gm., to which as much iodine is added as the solution will dissolve. This reagent gives a violet color with cell walls containing cellulose. Of the cell contents starch is the only one which is affected by it, being colored blue.

BOHMER'S HÆMATOXYLIN SOLUTION is prepared by mixing the two following solutions and filtering after allowing the mixture to stand for several days: (*a*) one part of a 3.5 per cent. alcoholic (95 per cent.) solution of hæmatoxylin and (*b*) three parts of a 0.4 per cent. aqueous solution of potassium alum.

DELAFIELD'S HÆMATOXYLIN SOLUTION, which is also incorrectly called "Grenacher's Hæmatoxylin Solution," is made by mixing the following solutions: (*a*) Hæmatoxylin 4 Gm., alcohol 25 c.c. and (*b*) 400 c.c. of a saturated aqueous solution of ammonia alum; this solution is exposed to the light for three or four days, filtered, and then 100 c.c. each of glycerin and methyl alcohol are added, the solution allowed to stand for several days and finally filtered. An excess of the stain is removed from the sections by subsequent washing either with a 2 per cent. alum solution or an acidified alcoholic solution. This solution gives to cellulose, lignin and the protoplasmic cell contents a violet color.

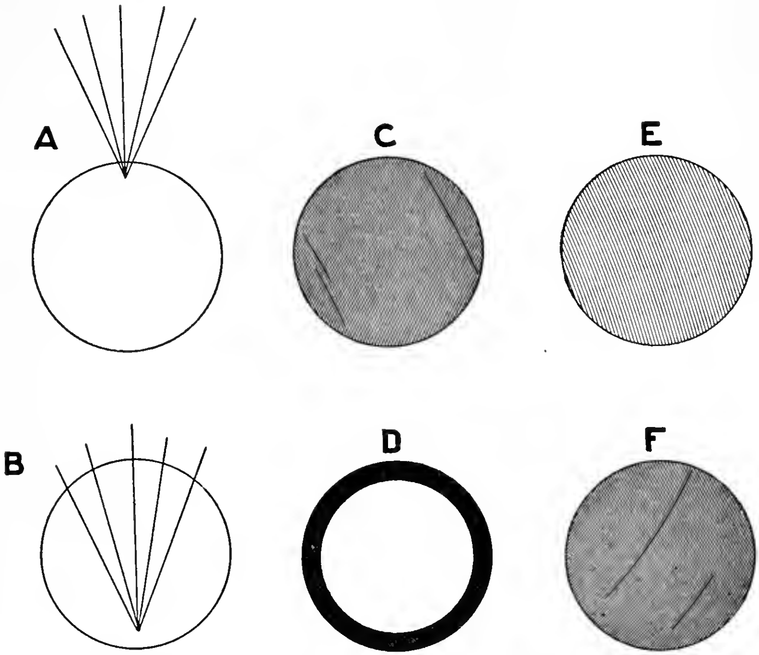

Fig. 325. Diagrams showing the difference between an air-bubble and an oil-globule in different foci: When the focus is above, as at A, the air-bubble (C) is dark gray and the oil-globule (E) light gray. When the focus is at the lower portion, as at B, the air-bubble (D) is light in the center and the oil-globule (F) dark gray. The same optical effects as are obtained with oil-globules are observed with cell walls, starch grains and crystals.

Iodine and Potassium-Iodide Solution consists of iodine, 13 Gm.; potassium iodide, 20 Gm.; water, 100 c.c.

Iodine Water is prepared by adding as much iodine to distilled and sterilized water as it will dissolve (about 1 : 5,000).

Chloral-Iodine Solution consists of a saturated aqueous solution of chloral, to which iodine is added. This reagent is useful for staining the starch grains in the chloroplasts.

PHLOROGLUCIN SOLUTION, used as a test for lignin (p. 182), is a 0.5 to 2 per cent. alcoholic solution of phloroglucin, which is used in conjunction with hydrochloric acid.

IRON SOLUTIONS are aqueous or alcoholic solutions containing 5 to 20 per cent. of ferric acetate or ferric chloride. These are mostly used as tests for tannin, giving either a bluish-black or greenish-black coloration or precipitate.

COPPER-ACETATE SOLUTION is a 7 per cent. aqueous solution of cupric acetate (p. 181). It is the most distinctive test for tannin, particularly with fresh material, producing a reddish-brown precipitate in the cells containing tannin. The fresh material should be cut into small pieces and immediately placed in the solution of copper acetate and allowed to remain for from 24 to 48 hours. The excess of the reagent is then washed out and the material placed in alcohol.

SCHULZE'S MACERATING SOLUTION is prepared by adding crystals of potassium chlorate from time to time to warm concentrated nitric acid. It is employed in the isolation of lignified cells. The material is allowed to remain in the solution for a short time or until there appears to be a disintegration of the tissues. A large excess of water is then added. The material is carefully washed, the cells teased apart and mounted in a solution of methylene blue.

SPECIAL REAGENTS comprise all those substances which are employed in the morphological study of the cells, and include solutions of the alkalies (0.1 to 6 per cent.), solutions of the mineral acids, which may be weak or concentrated, and solutions of organic acids, as acetic and citric.

DOUBLE STAINING, or the use of two stains in the examination of a specimen, furnishes not only a means of beautifying the specimen, but also has a certain diagnostic value. The following are some of the combinations used: (*a*) aqueous solutions of carmine in connection with alcoholic solutions of iodine green; (*b*) alcoholic solutions of hæmatoxylin and safranin; (*c*) solutions of eosin and methylene blue; (*d*) solutions of fuchsin and methylene blue; (*e*) solutions of gentian violet and Bismarck brown.

MOUNTING OF SPECIMENS.—Microscopic preparations or mounts are of two kinds: they may serve a temporary purpose only or they may be prepared so as to serve for future study, the latter being known as PERMANENT MOUNTS.

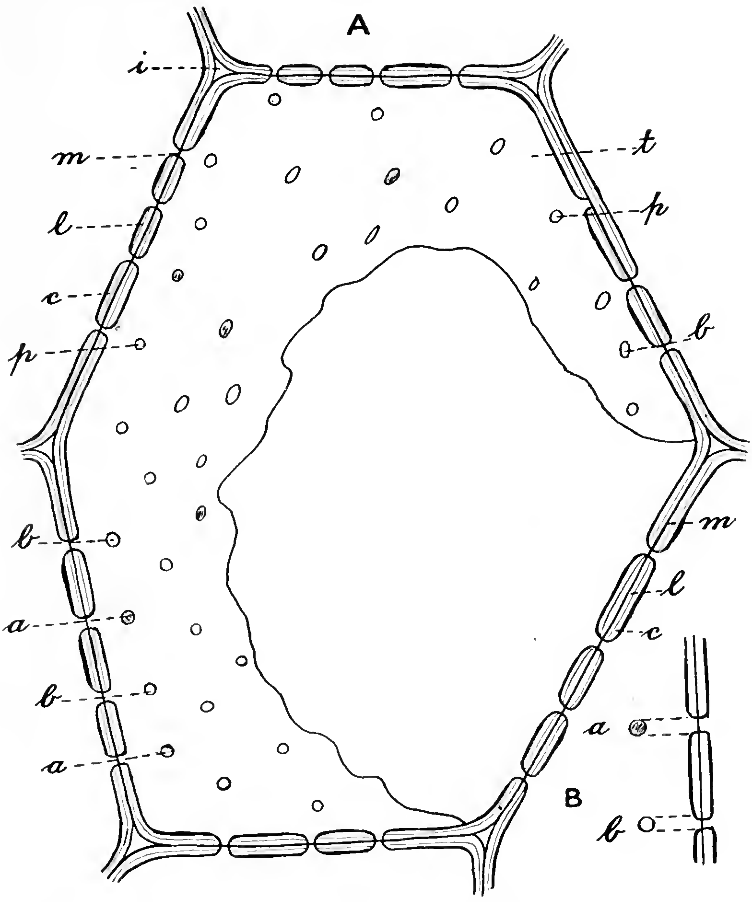

FIG. 326. A cell from sassafras pith showing intercellular space (i); middle lamella (m); layer of lignin (l); and layer of cellulose (c), which is subsequently modified to mucilage; simple pores (p) which are seen in the lower wall, the section being slightly oblique. B, portion of wall showing the appearance of the pores when the view is transverse to the wall and the focus is at the upper part of the pore (a) or at the lower part (b).

In taking up the study of a specimen it should first be mounted in water and examined; then the water may be replaced by a weak aqueous solution of glycerin (5 to 10 per cent.) and the specimen examined again. After this preliminary examination other agents and reagents may be employed. Specimens mounted in glycerin will keep for several days and even months. Generally speaking, the only effect which the glycerin has on the tissues or contents

FIG. 327. Crystals of some of the common reagents which not infrequently separate on the slide and may be mistaken for cell contents: A, isotropic crystals of chloral which occur in cubes about 10 μ in diameter or long needles about 50 μ long; B, phloroglucin which occurs in broad rectangular plates or ellipsoidal discs from 10 to 35 μ in diameter which are doubly refracting with a play of colors; C, cubes of potassium iodide which are isotropic; D, crystals from potassium hydrate solution which separate in broad prisms and branching chains that are doubly refracting and give marked color effects.

is that of swelling them, which is obviated, to a greater or less extent, however, if the glycerin is washed out after an examination is made.

In addition to the methods involving the use of glycerin, there are two ways of making permanent mounts, depending upon the employment either of Canada balsam or glycerin jelly as the mounting medium. The method involving the use of the latter is the simpler, and leaves the specimen in such a condition that a re-examination with reagents can be made if desirable. GLYCERIN-JELLY mounts are made as follows: Specimens which have been previously treated are transferred to glycerin and allowed to remain for several hours, the excess of glycerin removed, and the specimen transferred to a warm slide on which a drop of glycerin jelly[1] has been placed. The preparation is warmed slightly to remove air-bubbles, and a warm cover-glass applied, care being taken to prevent the formation of air-bubbles. Evaporation of the glycerin jelly is prevented by the use of shellac cements, asphalt varnish or candlewax.

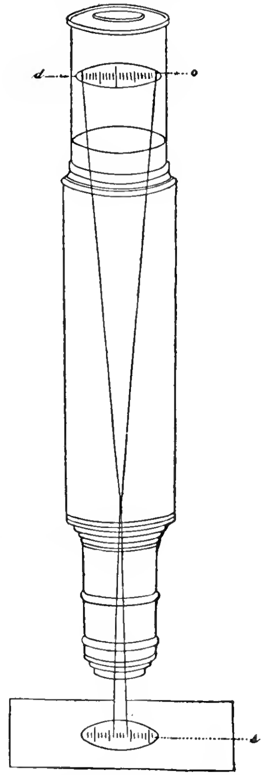

FIG. 328. Section of microscope showing the relation of the ocular micrometer (o) and the stage micrometer (s). As here represented 20 divisions of the ocular scale are equivalent to 4 divisions of the stage micrometer, and thus each division of the ocular is equivalent to 2 microns (see p. 813). d, diaphragm in eye-piece, on which the ocular micrometer rests.

The following method may be used for the preparation of CANADA BALSAM MOUNTS: The specimen is cleared, dehydrated by the use of alcohol and then placed in chloroform or benzol. The clearing of the specimen is materially assisted by placing it in oil of cloves or turpentine prior to mounting it. A drop of Canada balsam solution (1 part of balsam to 3 parts of chloroform or benzol) is placed on a slide and the specimen mounted. When nearly dry, scrape off the excess of balsam, clean the slide and coverglass with chloroform or benzol, and ring with cement.

[1] KAISER'S GLYCERIN JELLY.—Soak 7 Gm. of gelatin in 42 Gm. of water for two hours; dissolve 1 Gm. of carbolic acid in 49 Gm. of glycerin; mix the two solutions; heat on a water-bath, with occasional stirring, for fifteen minutes, and finally filter through glass wool. The jelly is warmed slightly to liquefy it before using.

Dried Material.—Most of the vegetable drugs and some of the vegetable foods occur in commerce in a more or less dried condition, and in order to study them microscopically it is usually necessary to give them some preliminary treatment. With the majority of drugs, soaking in hot or cold water for from a few minutes to a few hours will render them sufficiently pliable or soft for sectioning. After this the material is hardened by placing it in alcohol (60 to 70 per cent.) for a few hours or over night. It may then be sectioned and treated with special reagents or stains as desired. Very hard material, as the shells of nuts and seeds, may be softened by soaking in solutions of potassium hydrate.

Some Practical Suggestions.—The following are some of the rules which should be borne in mind by the student when using the microscope in the examination of vegetable drug material:

1. Always mount the sections (including powdered material) in water or other suitable reagent prior to examination, never attempting to examine dry material except in special cases.

2. Use sufficient of the mounting medium or reagent to cover the specimen, but avoid an excess or more than will be held under the cover-glass.

3. Always endeavor to have the object properly illuminated by making use of the concave mirror.

4. Always be particular about having the eye-piece and objectives clean.

5. In examining a preparation, always use the low-power objective first.

6. The edge of a section is always the thinnest, and this part being the best for study, should be brought to the center of the field.

7. When the object is properly centered, raise the objective, swing it to one side, bring the high-power objective into its place, and cautiously lower it until it is brought to about the distance of a millimeter from the cover-glass. Then holding the slide with the left hand, the proper focus of the object is obtained by making use first of the coarse adjustment and then of the fine adjustment, the right hand being used for this purpose. In

examining the object always hold the slide with the left hand, and use the right hand for maintaining the proper focus by means of either the coarse or fine adjustment.

8. In all cases where practicable make drawings of the sections examined.

9. In some cases it is desirable to apply a reagent after the material has been mounted, as in the addition of an iodine solution to a section to determine the presence of starch, and this is accomplished by placing a drop or two of the reagent, by means of a pipette or dropper, near the edge of the cover on one side and taking up the excess of liquid by temporarily placing a piece of filter paper on the opposite side (Fig. 324).

Air-Bubbles.—The beginner in the use of the microscope is often confused by the presence of air-bubbles, mistaking them for portions of the material under examination, as starch grains, oil-globules or even the cells themselves. While it is not practicable to avoid their presence entirely, their identity may be determined by the manner of focussing upon them. When focussing above on an air-bubble it always appears dark (Fig. 325, *C*), but when the focus is lowered, it becomes lighter (Fig. 325, *D*) ; while in the case of an oil-globule or starch grain the reverse is true, *i.e.*, it is lightest when the focus is above (Fig. 325, *E*) and darker when the focus is lowered (Fig. 325, *F*). To obviate as much as possible the formation of air-bubbles, the edge of the cover-glass should first be applied to the liquid on one side and then allowed to drop upon it. When particular care is required, a pair of forceps may be used for holding the cover and lowering it gradually.

Frequently also simple pores in the cell-walls are mistaken for cell-contents, and sometimes even the lumen of the cell has been mistaken for a prism of calcium oxalate. The beginner will therefore find it an advantage to study the simple pores in the pith cells of elder or sassafras (Fig. 326). In sections showing either the upper or lower wall of the cells, the pores appear as circular or elliptical markings, which may be mistaken for cell-contents, but which in focussing upon them are seen to be optical or microscopical sections of the pores.

Micrometry or Microscopic Measurement.—In the microscopic study of vegetable drugs a knowledge of the comparative size of the elements is often of much help in determining the identity of material under examination, and for this reason the student should early learn to measure the characteristic elements, or those showing a variation in size in different plants, as starch grains, calcium oxalate crystals, diameter of cells, thickness of cell-walls, etc. The method best adapted for this work is that involving the use of a micrometric scale which is placed in the eye-piece and known as the ocular micrometer. But to determine the value of the ocular micrometer it is necessary to use another scale known as the stage micrometer. The stage micrometer, as its name indicates, is used on the stage, and when placed in juxtaposition to an object indicates its size. However, it is obviously impracticable always to place an object along side of the scale, and hence in practice the ocular micrometer is used, the value of the divisions of which are determined by comparison with those of the stage micrometer (Fig. 328). The value of the divisions of the ocular scale varies for different objectives, eye-pieces and tube lengths, hence it is necessary to ascertain the value of the divisions for the different optical combinations and tube lengths employed. The stage micrometer is usually divided into tenths and hundredths of a millimeter, and the millimeter being equivalent to 1000 microns (μ), the smaller divisions are equivalent to 10 microns (10 μ). For example, we may suppose, using a low-power objective, that 10 divisions of the ocular scale equal 20 of the smaller divisions of the stage micrometer. Thus, 20 divisions of the stage micrometer are equivalent to 20 times 10 μ, or 200 μ; then, since 10 divisions of the ocular scale equal 20 divisions of the stage micrometer, one division of the ocular scale is equivalent to 1/10 of 200 μ, or 20 μ. Or, using the high-power objective, we may suppose that 80 divisions of the ocular scale equal 24 divisions of the stage micrometer. Thus, 1 division of the ocular micrometer is equivalent to 1/80 of 240 μ, or 3 μ. Then, if an object has a diameter covering 3 divisions of the ocular micrometer, its diameter is equivalent to 3 times 3 μ (the value of one division), or 9 μ.

The MICRO-POLARISCOPE is a useful accessory in conjunction with the microscope. It is useful in the study of technical products, and is chiefly applicable in the examination of crystals, starch grains and cell-walls. A number of substances, owing to certain peculiarities of structure, are double-refracting or ANISOTROPIC, *i.e.*, they polarize light. If the double refraction is strong enough these substances show a play of colors. Of these may be mentioned the raphides and the rosette aggregates of calcium oxalate, cane sugar, citric acid, benzoic acid, caffeine, salicin, aloin, phloroglucin, and the salts of berberine, strychnine, and atropine. The acicular crystals which separate in chloral preparations of gambir also show a play of colors. Among the substances which are anisotropic but give no chromatic effects are starch grains, inulin, mannit, the rhombohedra in catechu and the various types of cell-walls. All substances which form crystals belonging to the isometric system are ISOTROPIC or single-refracting, *i.e.*, do not polarize light, as sodium chloride, the octahedra in gambir, potassium iodide and chloral.

When glass, which is an isotropic compound, is heated and suddenly cooled it is changed into an anisotropic body. Microscopic glass beads formed by quickly cooling very thin pieces of glass show polarization effects similar to those of wheat starch grains. This has led to the supposition that the polarization effects produced by starch grains are due to tension rather than to a crystalline structure. But this point cannot be definitely settled until it has been determined whether any of the substances composing the layers of the starch grain are capable of crystallization.

The MICRO-SPECTROSCOPE is useful in the study of chlorophyll either in the plant cells or in solution. It may also be used in the study of the absorption spectra of other plant color substances.

PART IV.—MICRO-ANALYSIS.

The value of the microscope is well established in the examination of drugs, foods and technical products. In the preceding pages the greatest prominence is given to the ANATOMICAL OR HISTOLOGICAL METHOD of analysis, based largely upon the study of the form of cells, and the structure and composition of cell walls. In a number of instances, the study of cell-contents, as of starch grains and crystals of calcium oxalate, affords as was seen an important clue to the identity of a product. There are, however, many plant substances which are found in a crystalline condition in the living plant and commercial product and in the preparations made from them. A number of books have been published dealing with the micro-chemistry or histochemistry of some of these substances. For the most part the study of these microscopic crystals has been of a very general nature, in that statements are given regarding the general shape of the crystals or their aggregates and their behavior with certain test solutions. The time has come when the study of the crystalline substances found in drugs and their preparations requires, if any real progress is to be made in this direction, that the CRYSTALLOGRAPHIC METHOD of analysis be introduced into pharmacognosy. This method originated in the examination of thin sections of rocks and it has been possible by this study to identify the numerous rock-forming mineral species. In those species which are mixed crystals, *i.e.*, made up of isomorphous mixtures of two or more components, it has been possible to determine with some accuracy their composition simply by their optical properties, as for example the feldspars. Furthermore, it has been possible to draw conclusions as to the ultimate composition of rocks and the conditions under which they were formed.

The value and possibilities of the employment of the crystallographic method in biological studies is well exemplified in the recent work of Reichert and Brown, "The Crystallography

Salicin. Orthorhombic crystals from alcoholic solution.

Cocaine hydrochloride. Aggregates from aqueous solution.

CRYSTALS IN POLARIZED LIGHT (Crossed nicols).

of the Hemoglobins." * By special means individual crystals of the hemoglobins were obtained and by purely crystallographic methods, including a study of the forms and optical properties of such crystals, the hemoglobins of the 200 species of animals studied were differentiated in a manner that could not have been accomplished by chemical analysis or other methods of procedure.

A careful study of much that has been written, and especially of the illustrations that have been made, of micro-crystals in plants and drugs, shows that erroneous conclusions may be easily drawn from the general appearance of crystalline precipitates or aggregates of crystals that are formed. For instance, Vogl has shown that the sphero-crystals, found in the glandular hairs of *Mentha piperita* and considered by some to be menthol, are found in leaves of many of the Labiatæ. (See also Figs. 158, 175, 272.) Again very many substances produce aggregate groups which closely resemble each other, as of citric acid, cocaine hydrochloride, etc.

In regard to the value of the crystallographic method we quote the following paragraph from Brown (*loc. cit.*): "When a chemical compound solidifies from fusion, solution or vapor under conditions which are favorable to the development of individuals, its particles tend to arrange themselves in regular order, so that a definite structure is produced. The external form of the individuals is also regular, being bounded by planes in definite relation to each other so that polyhedral solids are produced which are called CRYSTALS. The regular arrangement of the atoms among themselves, and of the molecules which they build up, is so characteristic of substances of definite composition that the crystalline condition of dead matter is the normal condition. Differences in chemical constitution are accompanied by differences of physical structure, and the crystallographic test of differences of chemical constitution is recognized as the most delicate test of such differences."

It is apparent that apart from their solubility, color reactions, behavior towards reagents, etc., the substances with which we are dealing should be prepared in such a manner that isolated

* Published by the Carnegie Institution of Washington, 1909.

crystals are formed and not aggregates or groups. These isolated crystals can then be studied independently. The reason why aggregates are formed is because the crystals are permitted to grow too rapidly on the slide. This is usually the case in the usual method of procedure in securing crystals, *i.e.*, by adding a drop of a solution to the slide, and then allowing it to evaporate spontaneously, under ordinary conditions. If on the other hand the rate of evaporation is lessened so that there is a slowing down of the growth of the crystals, individuals may be obtained of almost any size desired. And it will be found that these isolated crystals may be quite as easily prepared as the aggregates which seem so characteristic to the average student. Special methods, however, may be necessary to obtain such isolated crystals. For instance, single crystals of menthol (Fig. 337, A) are obtained by means of sublimation rather than from solutions. Cumarin crystals (Fig. 131) are easily obtained by controlling the temperature of the melted mass, etc.

The interest in these crystalline substances is becoming greater as foods and drugs and technical products are subject to standards of purity. Most of the crystalline constituents common to plant products are usually said to be calcium oxalate. This substance is insoluble in water, alcohol, and acetic acid, soluble in the mineral acids and occurs usually in definite crystals. These crystals are rather easily studied in Iris (Fig. 320), Quillaja (Fig. 281, *C*) etc. (see page 170). They are found to crystallize either in the tetragonal or monoclinic systems, sphenoids of the latter being present in Belladonna (Fig. 281, *D*), Scopola (Fig. 175, *a*), etc.

Some substances occur in a crystalline form even upon the commercial product as vanillin upon vanilla pods and cumarin upon tonka seeds; or crystals may be found in special cells as in Piper album and Piper nigrum. In alcoholic material particularly of fresh drugs characteristic sphero-crystals are found as in Inula (Fig. 182). Sometimes similar sphero-crystals are observed upon soaking the drug of commerce in water and then adding alcohol as in Scilla. Again crystalline substances separate upon the addition of mineral acids, as when nitric acid or sulphuric acid is added to sections of Hydrastis

(Fig. 292). Again upon dissolving the product either in water, as with catechu (Fig. 275, *A*) or in solutions of chloral, as with gambir (Fig. 275, *B*) a crystalline residue remains. Finally upon extracting the dried drug with suitable solvents as Prollius' solution and evaporating the solvent, characteristic crystals separate as with coca, hydrastis, nux-vomica, cinchona, cola, guarana, etc.; or distinct crystalline precipitates may be obtained upon addition of special reagents as palladous chloride to solutions containing cocaine hydrochloride (Fig. 157), or gold chloride to solutions containing caffeine (Fig. 149).

Cognizance of these crystals is being taken to some extent in all of the progressive pharmacopœias and in numerous papers published during the past ten years. The subject is in a more or less chaotic condition at present and pharmacognosists must recognize the importance of the careful study of these microscopic crystals. Superficial descriptions and color reactions will not alone serve to identify these substances. Like the mineralogist in the study of rock sections the pharmacognosist must employ the petrographical microscope, and it is at once apparent that sooner or later the principles of physical and chemical crystallography must be employed by students in pharmacy as well as by the analyst. The work is by no means so simple as in ordinary microscopic work, but when the principles governing the optical study of crystals are mastered, the study will be found quite as satisfactory, and will appeal to the pharmacist not only as a fertile field for research, but as one of the most promising methods for the identification of drugs and affording an important clue to their quality and real valuation.

The study of microscopic crystals is accomplished by means of the petrographical microscope. Brown (*loc. cit.*) has stated succinctly the nature and use of this instrument:

"The necessity of studying small crystals, . . . has resulted in the evolution of a form of microscope which is at once a goniometer, a polariscope, and an instrument for measuring optic axial angles—in short, for determining the physical crystallographic constants of small crystals. . . . The polariscope portion of the petrographical microscope enables the observer to determine the position and relative value of the elasticity axes of crystals, to observe the position of the optic axes, and to determine their inclination to each other and to the elasticity axes. From these data the optical character of the crystal is determined. These OPTICAL REACTIONS may be studied by this instrument with as much ease, and in general with as much accuracy, as with the larger and better graduated polariscope; and the data thus obtained are quite as accurate in most cases as those obtained by the use of the larger instruments. The use of the special eye-pieces arranged with artificial twins of calcite or quartz enables the observer to determine the extinction angles of the crystals with as much accuracy as can be done with any form of polariscope.

"From such observations made with the aid of this form of microscope, the following constants may be determined:

"(1) The plane angles of the crystals, in most cases the interfacial angles, giving the data from which the axial ratios are computed—in other words the morphological constants of single crystals.

"(2) The relation of the composite crystals or twins to each other, their angles, and the position of the twin plane, twin axis, composition plane, and other constants of the twin crystals.

"(3) The pleochroism of the crystals, the character of the colors of the light vibrating parallel to the elasticity axes in the crystal. This is effected by the use of the single polarizing prism below the stage. By analyzing this light with the micro-spectroscope the differences of tint and color may be given quantitative values in wave lengths.

"(4) The position and relative values of the light elasticity axes in the crystals, upon which depend the angles of extinction of the crystals, measured from certain crystallographic axes or planes or edges. In uniaxial crystals (tetragonal and hexagonal systems) there are two such elasticity axes—the ordinary ray designated as ω, and the extraordinary ray, designated as ε. Either one of these may be the axis of greater or less elasticity; and according as the extraordinary ray is the axis of less elasticity or of greater elasticity the crystal is called optically POSITIVE or optically NEGATIVE. In biaxial crystals (orthorhombic, monoclinic and triclinic systems) there are three elasticity axes at right angles to each other, and these are designated as $\mathfrak{a}$, the axis of greatest elasticity; $\mathfrak{b}$, the axis of mean elasticity; and $\mathfrak{c}$, the axis of least elasticity.*

"(5) The position and angle of inclination of the optic axes or lines of single refraction through the crystals. These always lie in the plane of the elasticity axes $\mathfrak{a}$ and $\mathfrak{c}$ and the angles between the optic axes are bisected by the axes $\mathfrak{a}$ and $\mathfrak{c}$. According as to whether $\mathfrak{c}$ or $\mathfrak{a}$ is the axis bisecting the acute angle, the ACUTE BISECTRIX, Bx_a, the crystal is called optically POSITIVE or optically NEGATIVE. Thus if $Bx_a = \mathfrak{c}$, the optical character is POSITIVE. The apparent angle between the optic axes is determined by means of an eye-piece micrometer in an observation of the interference figure, looking along the acute bisectrix of the optic axes and this angle is designated as $2E$. The character of the double refraction may be determined by this angle."

It is not possible in this work even to attempt to treat of the principles underlying the study of physical crystallography. The study is one requiring special laboratory instruction. Of the excellent works which the student will find useful the following may be mentioned:

P. GROTH: Physikalische Krystallographie, 4th Ed., 1905.

THEODOR LIEBISCH: Grundriss der Physikalischen Krystallographie, 1896.

HENRY A. MIERS: Mineralogy, 1902. In this work will be found several excellent chapters dealing with the principles of the measurement of crystals and the study of their optical properties.

ROSENBUSCH AND WÜLFING: Mikroskopische Physiographie der Mineralien und Gesteine.

P. GROTH: An introduction to chemical crystallography. Translated by Hugh Marshall, 1906.

In the *Zeitschrift für Krystallographie* will be found references to the crystallographic studies which have been made upon some of the important plant constituents, but as these studies were mostly made upon relatively large crystals, which could be measured and examined by means of the goniometer, these ob-

* Elasticity in the optical sense is the reciprocal of refractive index; hence $\mathfrak{a}$, $\mathfrak{b}$, $\mathfrak{c}$, are the axes of least, mean and greatest refractive index.

servations had to be interpreted and applied to crystals which were formed upon microscopic slides. The author was fortunate in having the co-operation of Charles Travis, Ph.D., of the University of Pennsylvania, to whom is due the credit for the careful studies of the crystals described in this part of this text-book.

A rather large number of substances were examined and only a few of the more important are included at this time. While drawings might have been made to illustrate the form of crystals and optical orientations it was deemed advisable to use some of the photo-micrographs made by the author. The four-color plate is introduced to show the chromatic effects observed by using crossed nicols. The plate illustrates salicin and cocaine hydrochloride and is a nearly exact reproduction of the effects obtained with the micro-polariscope, the electros having been made from Lumiére autochrome plates, using direct sunlight.

The method of obtaining the crystals was rather simple. The solvents used were distilled water, alcohol, ether, chloroform and a mixture of chloroform and alcohol. To a weighed amount of the substance was added a sufficient quantity of solvent to give a saturated solution. A drop of this was added to a slide which was covered either with a bell-jar or the cover of a Petri dish. If the crystals formed too rapidly, giving rise to crystal aggregates, more dilute solutions were made from the original solution until single crystals were obtained therefrom. In some instances as with physostigmine salicylate, where the edges of the crystal are likely to be re-dissolved, the slides were finally dried in a desiccator over sulphuric acid. With caffeine gold chloride, the best crystals were obtained when the solutions were relatively weak. Again, it was found that after crystals were mounted in balsam, as cocaine hydrochloride, caffeine gold chloride, etc., that the isolated crystals grew considerably in size at the expense of amorphous material. A rather unique instance of growth of large crystals was with menthol when the slide containing the silky aggregates was covered with another slide. Finally it should be stated that some patience and experience are necessary to obtain satisfactory crystals.

The scope of this volume is necessarily limited but the examples which follow will be at least sufficient to show the possibilities of the crystallographic method of study.

ACONITINE ($C_{34}H_{47}NO_{11}$).

Occurrence: See pp. 477–480.

Aconitine (acetyl-benzoyl-aconine) occurs in colorless, nearly transparent, glistening crystals. From alcoholic solution orthorhombic prisms (Fig. 142) usually predominate while from

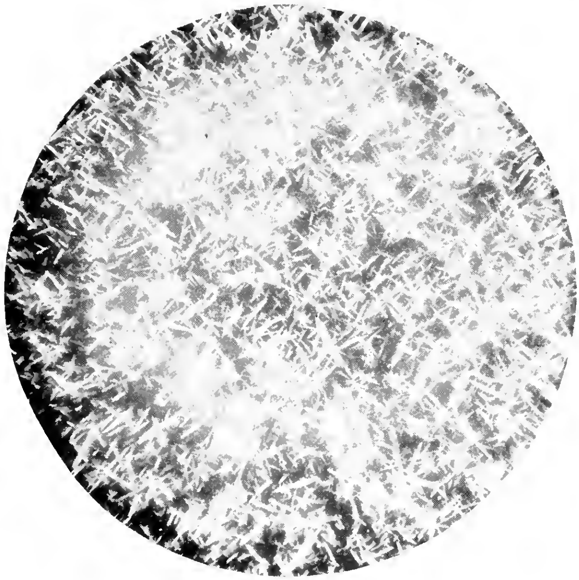

FIG. 329. Berberine hydrochloride: small orthorhombic needles, from aqueous solution.

solutions in which chloroform is the solvent, the tendency is for small isolated rosette-aggregates to separate. The crystals vary in length from 0.1 mm. to 1 mm., although crystals as large as 1 cm. in length and 0.5 cm. in thickness have been obtained. Upon rapidly heating the M. P. is 197°–198° C. At 25° C. one part of aconitine is soluble in 3226 parts of water; 22 parts of alcohol; 44 parts of ether; and 5.6 parts of benzene.*

* Atherton Seidell, Solubilities of Inorganic and Organic Substances.

The gold salt of aconitine is amorphous when first precipitated but may be obtained in three crystalline modifications by the use of various solvents.*

ACONITINE.—Crystals from alcoholic solutions (Fig. 142).

Orthorhombic: $a:b:c = 0.5456:1:0.3885$.†

Forms observed: Brachypinacoid (010); macropinacoid (100); and pyramid (121).

Angles: The angle between the edges of the pyramid (121) on the brachypinacoid ($010-121 \wedge 010-\bar{1}21$) $= 70° 54'$ (normals); angle between the edges of the same pyramid on the macropinacoid ($100-121 \wedge 100-1\bar{2}1$) $= 75° 40'$.

Cleavage parallel to the macropinacoid.

Habit: Commonly tabular on the brachypinacoid; the crystal more or less elongated on the *c* axis and bounded by the macropinacoid and the pyramid (121); sometimes tabular on the macropinacoid. In the former case the angle of the termination is 109° 06′ and in the latter 104° 20′.

Optical properties: $\mathfrak{a} = c$; $\mathfrak{b} = b$; $\mathfrak{c} = a$. The axial plane is the brachypinacoid. $Bx_a = a$; optical sign +. $2E_{Na} = 56° 10'$. Dispersion of the axis strong, $\rho < \nu$. When the crystal is of the second habit mentioned, *i.e.*, tabular on the macropinacoid. an interference figure is observed. Owing to the strong dispersion of the axes the hyperbolæ are colored.

ASPARAGIN ($C_4H_8N_2O_3 + H_2O$).

Asparagin (β-asparagin, the monamide of aspartic acid) is an amido compound which is most widely distributed throughout the vegetable kingdom. It is not only found in reserve organs as the tubers of the potato and dahlia, the roots of althæa, belladonna, etc., and the seeds of the chestnut tree, but it also occurs in young shoots as of asparagus and in peas, beans, and other members of the Leguminosæ. Asparagin has also been detected in some of the fungi as the Agaricineæ and certain of the Myxomycetes. Unlike certain derivatives of urea it is a

* J. W. Brühl, Die Pflanzen-Alkaloide.

† A. E. Tutton, *Zeitschr. f. Krystallog.*, 1891, **19**, p. 178.

plastic product playing a very important rôle in plant metabolism. On account of its crystalline character and solubility in water, it is classed among the translocatory substances, appearing not only when proteids are being utilized by the plant, but when they are being formed. The crystals of asparagin are formed rather easily from the expressed juices of young shoots, and may be obtained even in sections upon mounting them in glycerin. The crystals vary in length from 0.3 mm. to 1.5 mm.

Fig. 330. Berberine sulphate: orthorhombic crystals from aqueous solution.

Asparagin occurs in two forms, one of which is lævo-rotatory and the other dextro-rotatory; the former is the one usually present in plants. At 17.5° C. 1 part of asparagin is soluble in 47 parts of distilled water; at 98° C., 1 part is soluble in 1.9 parts of distilled water.

Asparagin.—Crystals from aqueous solutions (Fig. 95). Orthorhombic (sphenoidal?): $a:b:c = 0.4735:1:0.8273$.*

* Grattarola, *Zeitschr. f. Krystallog.*, 1892, **20**, p. 618.

Forms observed: Base (001); unit prism (110); brachydome (011).

Angles: Angle $110 \wedge 1\bar{1}0 = 50^\circ\ 40\frac{1}{2}'$ (normals).

Habit: Crystals tabular on the base. The smaller crystals are combinations of base (001) and prism (110) (Fig. 95, a); often with one or both of the acute angles of the prism truncated by the faces of the brachydome (011) (Fig. 95, b). In the larger crystals the brachydome is more developed, and the

Fig. 331. Brucine sulphate: orthorhombic crystals from aqueous solution.

crystal is either equidimensional (Fig. 95, c) or elongated on the *a* axis (Fig. 95, d).

Optical properties: $\mathfrak{a} = a$; $\mathfrak{b} = b$; $\mathfrak{c} = c$. Axial plane the brachypinacoid. $Bx_a = c$. Optical sign +. Axial angle large, $2V = ca.\ 87^\circ$.

BRUCINE SULPHATE $[C_{23}H_{26}N_2O_4)_2H_2SO_4 + 3\frac{1}{2}H_2O]$.

Occurrence: See p. 437.

Brucine is always associated in the plant kingdom with strychnine. It contains two methoxyl-groups and is looked upon as being di-methoxy-strychnine. If crystallized from hot water it contains 4 molecules of water of crystallization, but when crystallized from alcoholic solutions it contains but two molecules.* A number of salts are used in medicine and the sulphate alone was examined. The crystals of brucine sulphate vary in length from 1 to 2.5 mm. (Fig. 331).

Brucine Sulphate.—Crystals from saturated aqueous solution.

Orthorhombic: $a:b:c = 0.8329:1:c$.

Forms observed: Base (001); brachypinacoid (010); and unit prism (110).

Angles: Angle $110 \wedge 1\bar{1}0 = 79° 35'$. Cleavages parallel to the unit prism and base.

Habit: Tabular on the base; the crystal elongated along the *a* axis, bounded by the brachypinacoid and unit prism (Fig. 331). In some cases the pyramid (11*c*) replaces the prism, or at least truncates the prism base edge. The base is often replaced by a series of flat brachydomes so that a cross-section of the crystal parallel to the macropinacoid is lens-shaped.

Optical properties: $\mathfrak{a} = a$; $\mathfrak{b} = c$; $\mathfrak{c} = b$. Axial plane the base (001). $Bx_a = b$; optical sign +. $2E$ = large. An interference figure is visible on the brachypinacoid.

Caffeine ($C_8H_{10}N_4O_2 + H_2O$).

Occurrence: See pp. 435, 436.

Caffeine (theine, or trimethyl-xanthine), while it can be produced synthetically, is usually prepared from tea and tea dust or sweepings. If crystallized from aqueous solutions it contains one molecule of water of crystallization which is wanting if it is crystallized from alcohol, chloroform or ether. The crystals from aqueous solutions may attain a length of 20 mm.

At 25° C. one part of caffeine is soluble in 45.6 parts of water; 53.2 parts of alcohol; 375 parts of ether; and 8 parts of chloroform.

Caffeine.—Crystals from aqueous solutions.

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* O. A. Oesterle, Grundriss der Pharmakochemie.

Monoclinic (?): No axial ratios obtainable.

Forms observed: The crystals are very fine needles and the forms appearing cannot be identified.

Optical properties: Certain of the crystals extinguish straight, and others at a maximum angle of 31½°, which would indicate that the crystals are monoclinic and are observed in different aspects. Calling *c* the direction of elongation of the needles the orientation is:* $\mathfrak{a} \wedge c = 31\frac{1}{2}°$; $\mathfrak{c} \wedge c = 58\frac{1}{2}°$. Some of the crystals show no complete extinction, as was also seen to be the case with cocaine palladous chloride, and probably for the same reason (see page 833).

Caffeine Gold Chloride ($C_8H_{10}N_4O_2.HCl.AuCl_3 + 2H_2O$).

Solutions of caffeine give with gold chloride and some other reagents crystalline precipitates.† To prepare caffeine gold chloride the caffeine may be dissolved in distilled water, dilute alcohol, absolute alcohol or a mixture of equal parts of absolute alcohol and chloroform. One or two drops of the caffeine solution are placed upon a slide, to which is then added one or two drops of an aqueous solution of gold chloride. The two solutions are mixed by the use of a glass rod and then allowed to crystallize. Crystals of caffeine gold chloride (Fig. 159) are usually formed rather quickly, larger crystals being obtained from the more dilute solutions of caffeine. The crystals are also formed in solutions of caffeine acidulated with hydrochloric acid. The microscopic crystals of caffeine gold chloride vary in length from 0.4 mm. to 4 mm. They are said to be decomposed, at least in part, on washing with either alcohol or water. The Pharmacopœia Helvetica gives the following micro-chemical test for determining the presence of caffeine in cola: Transverse sections of the cotyledons are placed in strong hydrochloric acid and slightly heated; then one or two drops of a solution of gold

* Here $\mathfrak{a}$ and $\mathfrak{c}$ are simply the axes of greatest and least refractive index for the observed aspect of the crystal, and not necessarily the greatest and least for the whole crystal.

† Nicholson, *Ann. Chem. Pharm.*, 1847, **62**, p. 71; and E. Schmidt, *Ibid.*, 1883, **217**, p. 283.

chloride are added and the sections pushed to one side. The liquid is allowed to evaporate and near the edge of the residue branching groups of needles of caffeine gold chloride separate.

Caffeine Gold Chloride.

Orthorhombic: No axial ratio determinable.

Forms observed: The three pinacoids (100), (010) and (001).

Habit: Tabular on the brachypinacoid, elongated on the *c* axis with a ratio of length to width of 10:1 or over. The terminations of the rod are often more or less imperfectly formed, perhaps from re-solution, the ends sometimes being concave as in Fig. 159, but more often convex.

Optical properties: The extinction is straight. The axis of least refractive index is the long dimension of the crystal ($\mathfrak{a} = c$).

Pleochroism: $\mathfrak{a}$ pale lemon yellow.

$\mathfrak{c}$ somewhat darker yellow.

Among the larger lath-shaped crystals of the caffeine gold chloride there may be observed smaller, needle-like crystals, resembling the former in color and pleochroism but sometimes showing oblique extinction. Calling *c* the direction of elongation, the angle $\mathfrak{a} \wedge c = 30°$ approximately.

The pleochroism is the same as in the larger lath-shaped crystals, *i.e.*:

$\mathfrak{a}$ pale lemon yellow.

$\mathfrak{c}$ somewhat darker yellow.

The relationship between these two kinds of crystals is not clear. It is possible that the larger crystals are a pseudosymmetric modification of the second type; or again, the second kind of crystal agrees so closely in habit and optical orientation with caffeine, that it may be simply caffeine colored by absorption of gold chloride, or of the double salt.

Cocaine ($C_{17}H_{21}NO_4$).

Occurrence: See pp. 604–607.

Cocaine (the methyl ester of benzoyl-ecgonin). At 25° C. one part of cocaine is soluble in 600 parts of water; 5 parts of alcohol; 3.8 parts of ether; and one part of chloroform or benzene. It is insoluble in glycerin. The individual crystals as usually obtained on a microscopic slide vary in length from 0.4 mm. to 2 mm. (Fig. 157, *A*).

COCAINE.—Crystals from dilute alcohol, or a mixture of alcohol, ether and chloroform.

Monoclinic: $a:b:c = 0.8432:1:1.032$; $\beta = 73° \ 50'$.*

Forms observed: Base (001); orthopinacoid (100); prism (110); and clinodome (0$\bar{1}$1) (?).

Angles: Angle on the base between the prism-base edges $(001\text{-}110 \wedge 001\text{-}\bar{1}10) = 99° \ 44'$ (normals).

Habit: Tabular on the base, elongated along the *b* axis. The crystals are apparently hemimorphic, the termination on one end of the *b* axis being the prism faces, and on the other end the clinodome. This hemimorphism is, however, not certain. It was not observed by Fock (*loc. cit.*).

Optical properties: As viewed on the base, the elongation of the crystal (*b* axis) is the direction of least refractive index. The optical orientation further than this was not determined.

COCAINE HYDROCHLORIDE ($C_{17}H_{21}NO_4.HCl$).

Cocaine hydrochloride occurs in two forms, the hydrous salt crystallizing from aqueous solutions; and the anhydrous, from non-aqueous solvents, such as alcohol. The latter is supposedly the official salt and is erroneously stated in the U. S. P. to crystallize in monoclinic prisms. At 25° C. one part of cocaine hydrochloride is soluble in 0.4 part of water; 2.6 parts of alcohol; 18.5 parts of chloroform; and 4 parts of glycerin. The microscopic crystals of the anhydrous salt may attain a length of 3 mm. (Fig. 157, *B*). The hydrous salt affords long needles or elongated plates, which, when crystallized on a microscopic slide, may be as much as 20 mm. long.

COCAINE HYDROCHLORIDE (anhydrous).—Crystals from solution in a mixture of equal parts of alcohol and chloroform.

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* Tschermak in Lossen's paper, *Ann. Chem. Pharm.*, 1865, **133**, p. 355. See also A. Fock, *Zeitschr. f. Krystallog.*, 1890, **17**, p. 370.

Orthorhombic sphenoidal: $a:b:c = 0.3294:1:0.9758$.*

Forms observed: Base (001); macropinacoid (100); brachypinacoid (010); macrodome (101); and prism (140).

Angles: Angle $140 \wedge 1\bar{4}0 = 105° 36'$.

Habit: Tabular on the base, bounded by the brachypinacoid and macropinacoid or macrodome, the elongation being in the direction of the *b* axis, with a ratio of length to width of about 2 or 3:1. It is possible that the macropinacoid does not appear, since it is difficult to distinguish between the macropinacoid and the two faces on the macrodome in thin crystals. One or more faces of the prism (140) are usually present, unsymmetrically arranged. Interpenetrating twins on the prisms (470) and (130) are observed, the angles between the longer axes being approximately 60° and 90° in the two cases respectively.

Optical properties: $\mathfrak{a}=c$; $\mathfrak{b}=b$; $\mathfrak{c}=a$. The axial plane is the brachypinacoid. $Bx_a=c$. Optical sign —. An interference figure is visible on the base.

COCAINE HYDROCHLORIDE ($C_{17}H_{21}NO_4.HCl+2H_2O$).—Crystals from aqueous solution.

Orthorhombic: $a:b:c = 0.894:1:c$.

Forms observed: Base (001); brachypinacoid (010); macropinacoid (100); and unit prism (110).

Habit: Tabular on the base, elongated along the *a* axis, the crystals being extremely thin but having considerable width. In some cases, however, they become quite narrow and needle-like; this is often the case when radiating aggregates are formed. (See four-color plate.)

Optical properties: $\mathfrak{a}=a$; $\mathfrak{b}=b$; $\mathfrak{c}=c$. Axial plane the macropinacoid. $Bx_a=c$. Optical sign +. A very good interference figure is seen on the base and shows that $2E$ is not very large, although the emergence of the optic axes was not observed.

COCAINE HYDROCHLORIDE AND PALLADOUS CHLORIDE.

Cocaine and cocaine hydrochloride give with a number of reagents, including palladous chloride, characteristic crystalline

* Valentin, *Zeitschr. f. Krystallog.*, 1889, 15, p. 36.

double salts.* The crystals of cocaine hydrochloride and palladous chloride are prepared in the same manner as the caffeine gold chloride, with the exception that to the solution containing the cocaine hydrochloride a small quantity of hydrochloric acid is added. To a few drops of this solution upon a slide are added a few drops of the solution of palladous chloride, the two are mixed by means of a glass rod and the slide is set aside to allow the crystals to form. This frequently occurs almost immediately. The individual crystals (Fig. 157, *C*) vary in length from 0.3 mm. to 1.6 mm. Skeleton crystals are also formed from .5 mm. to 6 mm. long (Fig. 157, *D*).

COCAINE HYDROCHLORIDE AND PALLADOUS CHLORIDE.

Monoclinic (?): $a:b:c = ?$ $\beta = 109°$.

Forms observed: Clinopinacoid (010); orthopinacoid (100); and base (001).

Angles: Angle $100 \wedge 001 = 71°$ (normals).

Habit: Tabular on the clinopinacoid and elongated along the *c* axis, the usual ratio of length to width being 10 : 1 or over.

Twins.—(a) Twinning plane the orthopinacoid and composition face the same plane (gypsum type). (b) Twinning plane the orthopinacoid and composition face the clinopinacoid (Carlsbad type). The occurrence of the latter type of twinning is assumed largely for optical reasons as is noted below.

The crystals have a strong tendency to form radiating aggregates (Fig. 157, *C*), and skeleton crystals (Fig. 157, *D*), due no doubt to the fact that the substance is only slightly soluble and the crystals therefore form rapidly.

Optical properties: The extinction direction is 20° from the long dimension of the crystal and lies in the *acute* angle; this direction is that of least refractive index. The orientation is therefore: $\mathfrak{a} \wedge c = 20°$ in the acute angle; $\mathfrak{c} \wedge a = 39°$ in the obtuse angle.†

* W. Lossen, *Ann. Chem. Pharm.*, 1865, **133**, p. 355; and Howard and Stephenson, Proc. A. O. A. C., Nov., 1908, printed in Bulletin No. 122, pp. 97–100, of Bureau of Chemistry, U. S. Department of Agriculture.

† See footnote (*) on p. 828.

Certain crystals have no definite extinction, but show a direction of minimum illumination at 15° or less from the long direction of the crystal. This might be explained by the Carlsbad twinning, referred to above, which explanation is rendered more probable by the fact that the position of minimum illumination in such crystals varies in different parts. The fact that such crystals show a strong double refraction would preclude the possibility of their being in such a position that an optic axis is nearly vertical.

Pleochroism: 𝔞 = pale yellow.
𝔠 = reddish-yellow.

An interference figure was not obtained.

CODEINE SULPHATE [$(C_{18}H_{21}NO_3)_2.H_2SO_4 + 5H_2O$].

Occurrence: See p. 659.

Codeine (the methyl ether of morphine) forms anhydrous crystals from solutions in ether or benzol but the crystals from aqueous solutions contain one molecule of water of crystallization.* Microscopic x-shaped skeleton crystals separate from alcoholic solutions which vary in length from about 50 μ to 100 μ (Fig. 332). It forms crystallizable salts, of which the sulphate only will be described. At 25° C. one part of codeine sulphate is soluble in 30 parts of water, and 1035 parts of alcohol. It is insoluble in chloroform or ether. The microscopic crystals from hot alcoholic solutions vary in length from 0.3 mm. to 2.5 mm. (Fig. 333).

CODEINE SULPHATE.—Crystals from alcoholic solution.

Orthorhombic: $a:b:c = 0.288:1:0.419$.

Forms observed: Macropinacoid (100); base (001); unit prism (110); brachydome (011); and brachypinacoid (010) (?).

Angles: Angle $110 \wedge 1\bar{1}0 = 32°$ approximately; $011 \wedge 0\bar{1}1 = 45° 30'$.

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* Oesterle, Pharmakochemie, p. 101; and Brühl, Die Pflanzen-Alkaloide, p. 341.

Habit: Tabular on the macropinacoid, the crystal being elongated on the *c* axis and terminated by the faces of the brachydome (011). The ratio of length to width is 2:1 or over, the crystals often appearing rod-like and needle-like. The base sometimes appears to the exclusion of the brachydome, giving a square-ended crystal. The prism bevels the long edges of the crystal at a very acute angle, which was only approximately determined, hence the $a:b$ ratio given above is largely in error.

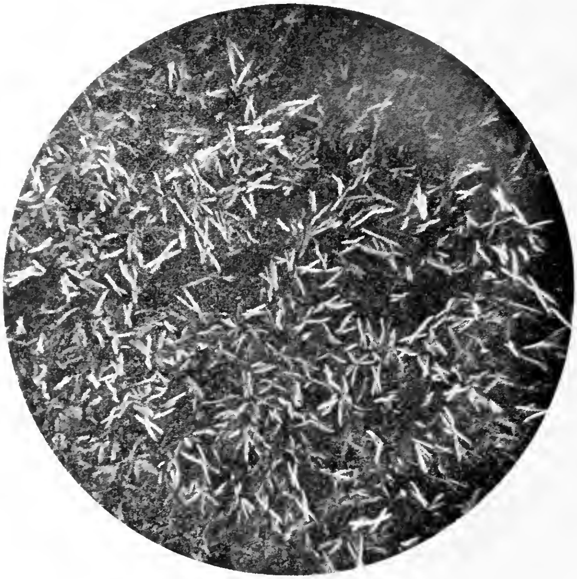

FIG. 332. Codeine: x-shaped skeleton crystals from 10 per cent. alcoholic solution.

X-shaped interpenetrating twins are observed, the angle between the long dimensions of the two individuals being about 30°. The twinning law was not determined.

Optical properties: The direction of greatest elongation of the crystal (*c*) is the direction of less refractive index for the aspect on the macropinacoid. No good interference figure was obtained, although it is probable that the axial plane is the brachypinacoid (010). If this is the case the orientation is $\mathfrak{a} = c$; $\mathfrak{b} = b$; $\mathfrak{c} = a$.

CUBEBIN ($C_{10}H_{10}O_3$).

Occurrence: See p. 571.

Cubebin is prepared by first removing the oil from the Cubeb fruits by distillation and then extracting the cubebin with boiling alcohol. The solvent is then removed by distillation and the residue washed with water and treated with a mixture of 5 parts of alcohol (90 p. c.) and 2 parts of water, which dissolves

FIG. 333. Codeine sulphate: orthorhombic crystals from hot alcoholic solution.

the cubebin leaving the fatty substances behind. The alcoholic solution is evaporated and the reddish-brown residue treated with a potassium hydrate solution (1:4) until all the resin is removed. The residue contains the cubebin as a pale yellow substance which upon re-crystallization from hot alcohol is obtained in the pure condition. It occurs in white rod-like crystals which are nearly insoluble in water and at 15° C. one part dissolves in 75 parts of alcohol and 30 parts of ether. It is also soluble in chloroform and acetic acid.* The microscopic crystals obtained from Prollius' solution vary in length from 100 μ to 300 μ (Fig. 334). In among the crystals liquid drops of amorphous material were observed, which later changed to more or less distinct crystalline aggregates.

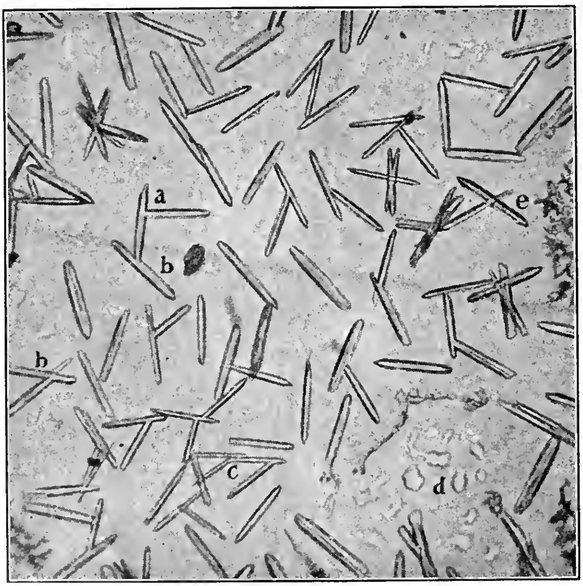

FIG. 334. Cubebin: orthorhombic crystals from Prollius' solution, showing various types of twinning (a, b, e); d, amorphous material in the form of oily drops (under-cooled liquid); e, this amorphous material crystallizing in aggregates.

CUBEBIN.—Crystals obtained from Prollius' solution.

Orthorhombic: $b:c = 1:0.273$ (?).

Habit: The crystals of cubebin observed were rods elongated on the c axis, with a ratio of length to width of about 10 : 1; they were not well terminated. Three kinds of twinning were observed, giving x-shaped or branched crystals; the angles between the c axes in these twins measured about 40°, 69° and 85°

* E. Schmidt, Lehrbuch der Pharmaceutischen Chemie.

respectively. In addition, in a very few cases a terminal edge was observed, making an angle of 75° with the c axis. If we assume that these twins are seen in the same aspect and that this is the macropinacoid, *i.e.*, that all the twinning planes and the termination are brachydomes, we have an axial ratio $b:c=1:0.2734$, and the three kinds of twins may be explained as follows:

	Calculated.	Observed.
1. Twinning plane 043, angle	$c \wedge c' = 40° \ 14'$	40°
2. Twinning plane 052, angle	$c \wedge c' = 68° \ 40'$	69°
3. Twinning plane 041, angle	$c \wedge c' = 84° \ 52'$	85°
Termination (011), angle	$011 \wedge 0\bar{1}1 = 149° \ 24'$	150°

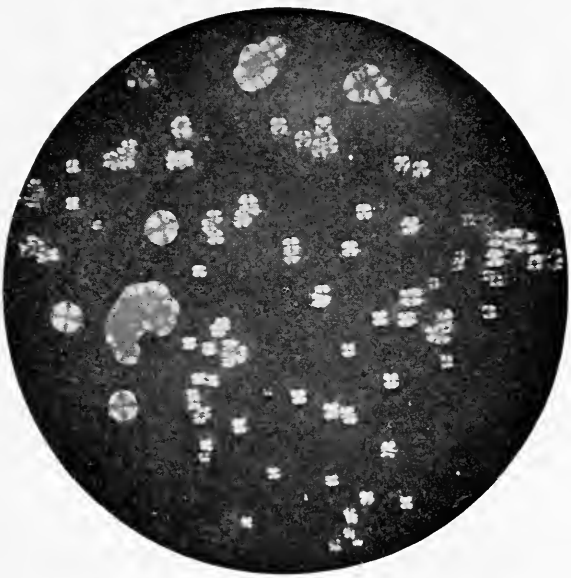

Fig. 335. Digitoxin: sphero-crystals from an alcoholic solution.

The twinning planes and the termination may, however, be pyramids with the same $a:b$ ratio.

Optical properties: The extinction is straight. In the majority of cases, the length is the direction of least refractive index, but in others the reverse is true. This would indicate that $\mathfrak{b}=c$. This is confirmed by the interference figure which is given by the larger crystals, which shows that the axial plane is perpendicular to the long dimension of the crystal. No interference figure was obtained on the twinned crystals (which were smaller), so that their orientation is doubtful as noted above.

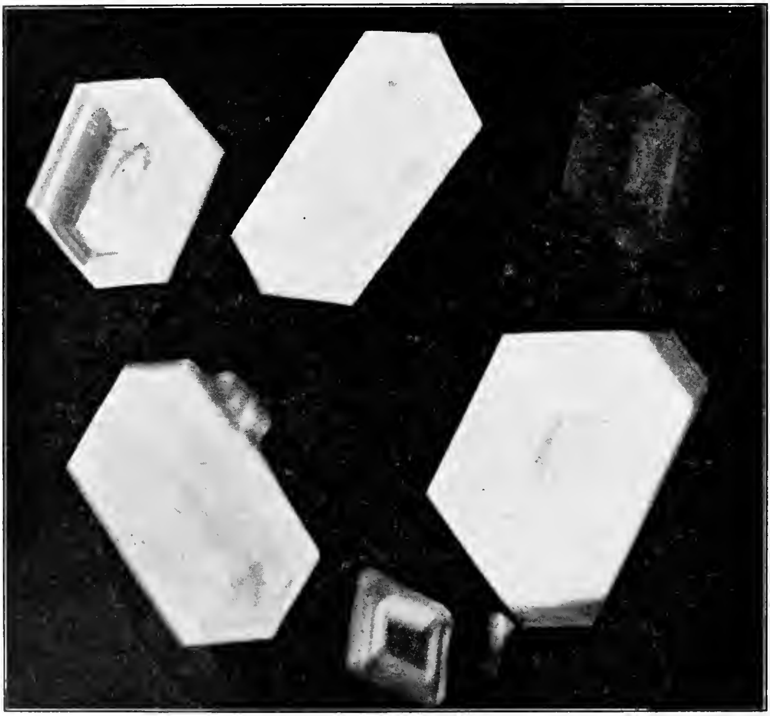

FIG. 336. Hydrastine: large nearly equidimensional crystals from alcoholic solution.

HYDRASTINE ($C_{21}H_{21}NO_6$).

Occurrence: See p. 498.

Hydrastine occurs in the drug in part in the free condition as well as combined. At 18°–22° C. one part of hydrastine is soluble in 30,303 parts of water; about 130 parts of alcohol; 196 parts of ether; 1 part of chloroform; and 11 parts of benzene. At 80° C. one part of hydrastine is soluble in 4000 parts of water; and at 60° C. one part is soluble in 17 parts of alcohol.* When crystallized upon a microscopic slide from alcoholic solutions the crystals of hydrastine vary in length from 0.1 mm. to 1.2 mm. (Fig. 336).

HYDRASTINE.—Crystals from alcoholic solution.

Orthorhombic: $a:b:c = 0.8461:1:0.3761$.†

Forms observed: Prisms (110) and (870); macrodome (201).

Angles: angle $110 \wedge 1\bar{1}0 = 80° 28'$
$870 \wedge 8\bar{7}0 = 73° 02'$
$201 \wedge \bar{2}01 = 83° 16'$

Plane angle on (870) between the edges of (201) and (870) $(870-201 \wedge 870-8\bar{7}0) = 62° 7'$.

Habit: Crystals usually show a combination of prism (870) and macrodome (201), flattened on one pair of the prism faces (Fig. 336). The larger crystals are nearly equi dimensional; the smaller ones often being elongated on the *c* axis, with the ratio of length to width of 3:1 or over.

In the usual aspect, lying on one of the (870) prism faces, the crystal appears as a flat plate bounded by six edges, making angles with each other of approximately 120°. If the length and width are the same, this gives the appearance of a more or less distorted hexagon. As may be seen from the above, however, this hexagon is not regular but has two angles of 124° and four angles of 118° (118° = 180° — 62°). The unit prism (110) is of rare occurrence and is observed on the larger crystals.

Optical properties: Owing to the habit it is difficult to obtain a crystal in such a position that it would afford a view along one of the bisectrices. However, it would seem from what could be obtained, that the axial plane is the brachypinacoid (010), and $Bx_a = a$. In the usual aspect of the crystals on the prism face, the *c* axis is the direction of greatest refractive index.

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* A. Seidell, Solubilities of Inorganic and Organic Substances.

† E. A. Wülfing, *Zeitschr. f. Krystallog.*, 1888, 14, p. 99.

MENTHOL ($C_{10}H_{20}O$).

Occurrence: See pp. 631, 632.

Menthol, $C_6H_9.CH_3.OH.C_3H_7$ (1, 3, 4), occurs in peppermint oil only in the lævorotatory modification.* It melts at about 42° C. and on cooling crystallizes in aggregates composed of fine needles (Fig. 337, B). Upon sublimation short rods are obtained (Fig. 337, A); and if a slide of the aggregates is covered with another slide large needles may be formed. Menthol is very soluble in alcohol, ether and chloroform and sparingly soluble in water. It separates from peppermint oil upon cooling.

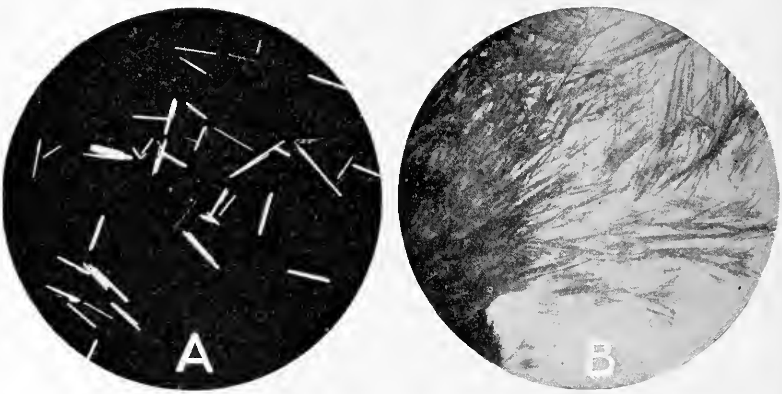

FIG. 337. Menthol: A, individual crystals obtained by sublimation; B, the commonly occurring aggregates of very fine needles.

MENTHOL.

Orthorhombic.

Habit: Crystals appear as long needles without terminations.

Optical properties: The long dimension of the crystal is uniformly the direction of least refractive index. This is confirmed by the interference figure which may be seen in certain aspects and shows that the axial plane is parallel to the long dimension. If this long dimension is called the vertical axis we therefore have $\mathfrak{a} = c$.

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* Gildemeister and Hoffmann, Die Aetherischen Oele.

MORPHINE SULPHATE $[(C_{17}H_{19}NO_3)_2.H_2SO_4 + 5H_2O]$.

Morphine is a derivative of 3–6 dioxy-phenanthryleneoxide * which crystallizes from alcoholic solutions in orthorhombic prisms or needle-like crystals, containing one molecule of water of crystallization $(C_{17}H_{19}NO_3.H_2O)$* which it gradually loses at 75° C. It forms a number of crystalline salts of which the

FIG. 338. Morphine sulphate: orthorhombic crystals from aqueous solution.

sulphate is here only described. There are at least two different morphine sulphates,† the neutral salt containing 5 molecules of water of crystallization being the article usually found in commerce. It readily loses some of its water of crystallization even at a temperature of 30°–40° C. At 25° C. one part of

* Oesterle, Pharmakochemie.

† Brühl, Pflanzen-Alkaloide.

morphine sulphate is soluble in 15.3 parts of water; 465 parts of alcohol; it is nearly insoluble in ether or chloroform. The crystals formed on a slide from alcoholic solutions vary in length from 0.1 mm. to 0.8 mm. (Fig. 338). When prepared from aqueous solutions they may attain a length of 20 mm.

Morphine Sulphate.—Crystals from aqueous solution.

Orthorhombic: $a:b = 0.437:1$.

Forms observed: Base (001); brachypinacoid (010); macropinacoid (100); and unit prism (110).

Angles: Angle $110 \wedge 1\bar{1}0 = 47°-10$.

Habit: Tabular on the base, elongated along the *a* axis, the crystals appearing as needles which are often grouped in radiating aggregates, or as long thin plates. The termination is the unit prism, rarely the macropinacoid.

Optical properties: $\mathfrak{a} = a$; $\mathfrak{b} = b$; $\mathfrak{c} = c$. An interference figure is obtained on the base, which shows that the axial plane is the brachypinacoid, but the apparent axial angle is so large that it is impossible to state whether *c* is the acute or obtuse bisectrix.

The crystals from alcohol seem to be optically identical with the above. The unit prism, however, rarely appears, the crystals being for the most part square ended rods.

Narcotine ($C_{22}H_{23}NO_7$).

Occurrence: See p. 660.

Narcotine [$C_{19}H_{14}NO_4.(OCH_3)_3$] exists in opium to a very large extent as a free base. At about 15° C. one part of narcotine is soluble in 100 parts of alcohol (85 per cent.); 166 parts of ether; 2.7 parts of chloroform; and 22 parts of benzene. One part of narcotine is soluble in about 7000 parts of boiling water. Narcotine is a feeble base and forms salts which for the most part crystallize with difficulty or not at all. A crystalline double salt, however, is readily formed with methyl-iodide.* The crystals of narcotine prepared on microscopic slides from alcoholic solution vary in length from 0.4 mm. to 2 mm. (Fig. 339).

* Brühl, Die Pflanzen-Alkaloide.

NARCOTINE.—Crystals from alcoholic solutions.

Orthorhombic sphenoidal: $a:b:c = 0.532:1:c$.

Forms observed: Base (001); brachypinacoid (010); and sphenoid (111).

Angles: Angle on base between the base-sphenoid edge and brachypinacoid (001–111 ∧ 001–010) = 62° (normals).

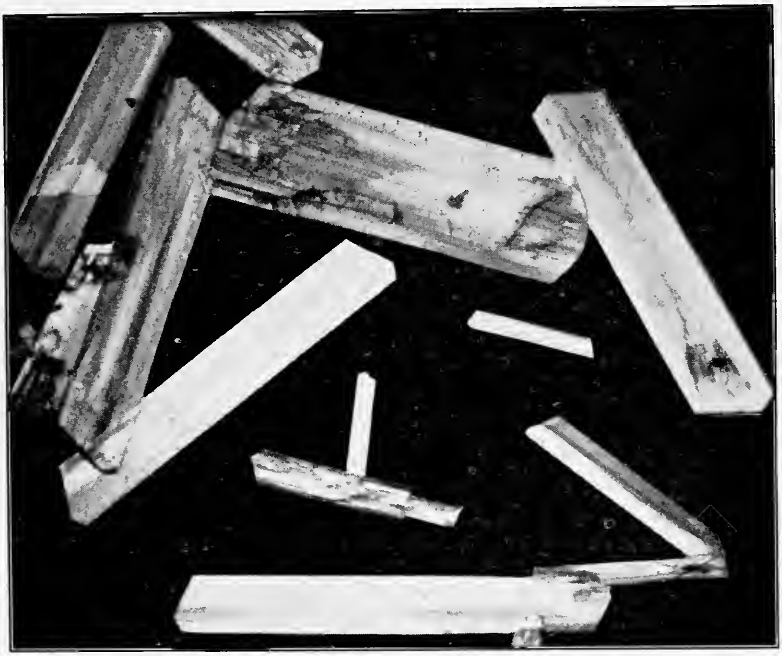

FIG. 339. Narcotine: orthorhombic crystals from alcoholic solution.

Habit: Tabular on the base, elongated along the a axis, the end terminations being the faces of the sphenoid (111), which are inclined to the base. By focussing down upon the crystal it is seen that the edge between the two sphenoid faces slopes in opposite directions at the two ends of the crystal.

Optical properties: $\mathfrak{a} = a$; $\mathfrak{b} = b$; $\mathfrak{c} = c$. The axial plane is the brachypinacoid. An interference figure is observed on the base and shows that $2E$ is large; apparently $Bx_a = c$; and the optical sign is +.

PHYSOSTIGMINE SALICYLATE ($C_{15}H_{21}N_3O_2.C_7H_6O_3$).

Occurrence: See p. 439.

Physostigmine (or eserine) forms from solutions in benzene rather large crystals having a M. P. of 105–106° C. The salts of physostigmine are quite easily decomposed and not easily crystallizable. The benzoate, salicylate and the double salt formed with potassium-mercuric-iodide yield, however, good crystals. The salicylate of physostigmine usually occurs in needle-like crystals or large prisms, one part at 25° C. being soluble in 72.5 parts of water; 12.7 parts of alcohol; 8.6 parts of chloroform; and 175 parts of ether. From solutions in chloroform single crystals may be obtained which vary in length from 0.4 to 1.5 mm. (Fig. 189); large characteristic aggregates are also formed. The crystals are easily decomposed and best kept in a desiccator.

PHYSOSTIGMINE SALICYLATE.—Crystals from solutions in chloroform.

Orthorhombic: $a:b:c = 0.869:1:c$.

Forms observed: Base (001); macropinacoid (100); brachypinacoid (010); unit prism (110).

Angles: Angle $110 \wedge 1\bar{1}0 = 82°$.

Habit: Tabular on the base, elongated along the *a* axis. The crystal is terminated by the macropinacoid or the unit prism. The latter form may possibly be actually a pyramid, but this cannot be definitely decided upon owing to the thinness of the crystals on which it occurred. In the majority of cases the crystal is terminated simply by the pinacoid with the corners and faces more or less rounded as if by re-solution. The individuals are usually grouped in radiating aggregates.

Optical properties: $\mathfrak{a} = b$; $\mathfrak{b} = a$; $\mathfrak{c} = c$. The axial plane is the macropinacoid. $Bx_a = c$. Optical sign +. The apparent angle $2E$, between the optic axes, is not large, so that both axes may be observed in the interference figure seen on the base. Certain individuals are in such a position on the slide that the interference figure shows the emergence of one optic axis, and from the figure it seems that the obliquity of such individuals is nearly constant. These individuals may all be lying upon a definite brachydome instead of upon the base.

Piperine ($C_{17}H_{19}NO_3$).

Occurrence: See pp. 573, 574.

Piperine is rather easily prepared from white pepper as follows: The ground pepper is mixed with an equal weight of lime and a small quantity of water is added. The mixture is heated to boiling for about 15 minutes, and is then evaporated and carefully dried upon a water-bath. The residue is powdered and extracted with ether. The ethereal solution contains the piperine, which separates in the form of crystals. It is purified by re-crystallization from hot alcoholic solutions.*

Piperine is a weak base, dissolving in dilute acids without forming salts and on this account may be separated from acid solutions with petroleum ether. It forms crystalline double salts with platinic chloride, mercuric chloride and iodine-potassium-iodide. At 25° C. one part of piperine is soluble in 15 parts of alcohol; 36 parts of ether; and 1.7 parts of chloroform. It is nearly insoluble in water. The individual crystals formed on a microscopic slide from hot alcoholic solutions of piperine vary in length from 0.1 mm. to 1.5 mm. (Fig. 340). Isolated aggregates are also formed. As in cubebin we find numerous oily-looking drops of the amorphous substance, but with piperine they often have the outline of crystals, as if the latter were first formed, and later transformed by fusion or otherwise into the amorphous material. On the other hand the crystals grow, on long standing, at the expense of the drops. In sections of the crude drug it is not at all uncommon to find in the oil secretion cells the characteristic crystals of piperine. Molisch † has given a number of methods for the micro-detection of piperine in sections.

* Brühl, Die Pflanzen-Alkaloide.

† Hans Molisch, Grundriss einer Histochemie der Pflanzlichen Genussmittel. (1891), pp. 27-29.

PIPERINE.—Crystals from hot alcoholic solutions (Fig. 340).

Monoclinic: $a:b = 0.9837:1$; $\beta = 109° \ 37\tfrac{3}{4}'$.*

Forms observed: Clinopinacoid (010); orthopinacoid (100); and base (001).

FIG. 340. Piperine: monoclinic crystals, mostly on the clinopinacoid, showing the oblique terminations, obtained from hot alcoholic solution.

Angles: Angle $100 \wedge 001 = 70\tfrac{1}{2}°$ ($70° \ 22\tfrac{1}{4}'$).

Habit: Tabular on the clinopinacoid, elongated along the *c* axis. The smaller crystals are rod-like or needle-like. In the larger crystals the ratio of length to width may become as small as 2:1 or less. These larger crystals are often thicker in the

* F. M. Jaeger, *Zeitschr. f. Krystallog.*, 1907–08, 44, p. 574.

center than at the edges and are bounded by oscillatory combinations of the clinopinacoid with a prism and a clinodome respectively.

Optical properties: The extinction angle measured from the c axis is 36° in the obtuse angle, and this direction is that of least refractive index for the aspect given. No definite interference figure is observed on the clinopinacoid, and the axial plane is therefore apparently parallel to this form. If this is the case the optical orientation is $\mathfrak{a} \wedge c = 36°$ in the obtuse angle; $\mathfrak{b} = b$; $\mathfrak{c} \wedge a = 16\frac{1}{2}°$ in the acute angle.

FIG. 341. Scopolamine hydrobromide: crystal aggregates from an alcoholic solution.

QUININE SULPHATE [$(C_{20}H_{24}N_2O_2)_2.H_2SO_4 + 7H_2O$].

Occurrence: See p. 519.

The alkaloid quinine ($C_{20}H_{24}N_2O_2$) is the methoxy-derivative of cinchonine and separates in anhydrous crystals from hot aqueous solutions. If the hot solution, in dilute alcohol, is kept for some time at 30° C., then on cooling long silky needles form. There is another modification, occurring as a flaky powder and containing three molecules of water of crystallization ($C_{20}H_{24}N_2$-$O_2 + 3H_2O$), which is official. Some authors consider, however, that there is only one molecule of water of crystallization in this hydrous salt.* The hydrous salt has a M. P. of 57° while the anhydrous crystals melt at 175°. Quinine is a strong base, forming with acids basic and neutral salts. The neutral sulphate is largely used and is here considered.

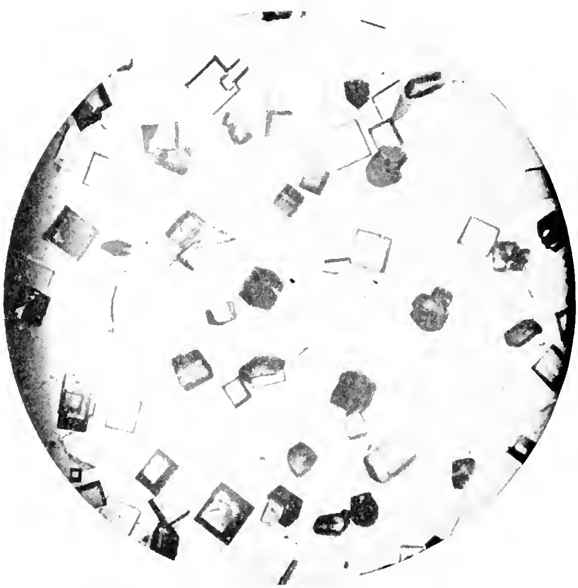

FIG. 342. Strychnine sulphate: tetragonal crystals from aqueous solution, in ordinary light, showing basal and side aspects.

There are several modifications of quinine sulphate: (1) The neutral sulphate containing eight molecules of water of crystallization [$(C_{20}H_{24}N_2O_2)_2.H_2SO_4 + 8H_2O$], is obtained upon neutralizing the base with sulphuric acid and crystallizing from hot water. (2) Upon exposing the former over sulphuric acid it loses six molecules of water of crystallization giving [$(C_{20}H_{24}N_2O_2)_2.H_2SO_4 + 2H_2O$]. This same salt is formed upon re-crystallizing (1) from hot alcoholic solutions. (3) The

* O. A. Oesterle, Grundriss der Pharmakochemie.

acid sulphate or bisulphate contains seven molecules of water of crystallization ($C_{20}H_{24}N_2O_2.H_2SO_4 + 7H_2O$), is also official, and has been described.* (4) There is also a tetrasulphate of quinine having the formula ($C_{20}H_{20}N_2O_2.2H_2SO_4 + 7H_2O$).†

At 25° C. one part of quinine sulphate (containing $8H_2O$) is soluble in 720 parts of water; 86 parts of alcohol; 400 parts of chloroform. It is readily soluble in a mixture of chloroform (2 parts) and absolute alcohol (1 part); and one part is soluble in 36 parts of glycerin at 25° C. It is only sparingly soluble in ether. When crystallized from a dilute alcoholic solution, upon a microscopical slide, the individual needles may attain a length of 4 mm. (Fig. 226).

$(C_{20}H_{20}N_2O_2)_2.H_2SO_4 + 8H_2O$. Crystals from aqueous solution.

Orthorhombic.

Forms observed: The three pinacoids: (100), (010) and (001).

Cleavage parallel to (100) and (010).

Habit: Tabular on the base, elongated on the *a* axis, giving crystals which are commonly needle-like with square terminations.

Optical properties: $\mathfrak{a} = c$; $\mathfrak{b} = b$; $\mathfrak{c} = a$. An interference figure is observed on the base, showing that the axial plane is the brachypinacoid and that $2E$ is large.

Salicin ($C_{13}H_{18}O_7$).

Occurrence: See p. 250.

Salicin, through the action of ferments, yields saligenin and glucose.‡ The crystals of commerce occur in the form of prisms or needles. At 25° C. one part of salicin is soluble in 21 parts of water and 71 parts of alcohol. It is insoluble in ether and chloroform. The individual crystals, which separate upon a microscopic slide from alcoholic or aqueous solutions, vary in length from 0.3 mm. to 5. mm. (see four-color plate). The

* Th. Hjortdahl, *Zeitschr. f. Krystallog.*, 1879, **3**, pp. 303, 304; see also Hahn, *Arch. d. Pharm.*, 1859, **99**, p. 148.

† Brühl, Die Pflanzen-Alkaloide, pp. 182, 183.

‡ O. A. Oesterle, Grundriss der Pharmakochemie.

crystals have a tendency to arrange themselves in feather-like aggregates.

Salicin.—Crystals from alcoholic solutions. No axial ratio obtainable.

Orthorhombic.

Fig. 343. Strychnine sulphate: tetragonal crystals in polarized light, showing side aspect.

Forms observed: The three pinacoids: (100), (010) and (001).

Habit: Tabular on the base, elongated along the *a* axis. The crystals are commonly long thin plates, with square terminations, and are often grouped in aggregates in which the individuals are nearly parallel (see four-color plate).

Optical properties: $\mathfrak{a} = a$; $\mathfrak{b} = b$; $\mathfrak{c} = c$. Axial plane the brachypinacoid. A good interference figure is observed on the base, and although the emergence of the axes was not observed, c is probably the acute bisectrix with the value of $2E$, large.

STRYCHNINE SULPHATE $[(C_{21}H_{22}N_2O_2)_2.H_2SO_4 + 6H_2O]$.

Occurrence: See p. 437.

Strychnine crystallizes in anhydrous orthorhombic crystals from alcoholic solutions. It forms crystallizable salts with the various acids, as well as double salts with platinic chloride and gold chloride. Of the salts, the sulphates are commercially the most important. According to Rammelsberg * there are three strychnine sulphates: (1) An acid salt, with two molecules of water of crystallization $(C_{21}H_{22}N_2O_2.H_2SO_4 + 2H_2O)$ and crystallizing in needles, crystal form not given. (2) A neutral salt with 5 molecules of water of crystallization $[(C_{21}H_{22}N_2O_2)_2$.-$H_2SO_4 + 5H_2O]$, orthorhombic (?), from hot aqueous solutions. (3) A neutral salt with six molecules of water of crystallization $[(C_{21}H_{22}N_2O_2)_2.H_2SO_4 + 6H_2O]$, tetragonal, obtained from aqueous solutions at the ordinary temperature. This latter is the most characteristic form and is the one here described. At 25° C. one part of strychnine sulphate is soluble in 31 parts of water: 65 parts of alcohol; and 325 parts of chloroform. It is nearly insoluble in ether. Crystals obtained on a microscopic slide from solutions in water, alcohol, dilute alcohol or a mixture of alcohol and chloroform vary in size from 0.40 mm. to 2.0 mm. (Figs. 342–344).

STRYCHNINE SULPHATE.—Crystals from aqueous solution.

Tetragonal trapezohedral: $a : c = 1 : 3.312$.†

Forms observed: Base (001); and pyramid of the first order (221).

Angles: Angle $221 \wedge 22\bar{1} = 24° 6'$.

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* C. Rammelsberg, *Ber. d. deutsch. chem. Ges.*, 1881, **14**, p. 1231; abstract in *Zeitschr. f. Krystallog.*, 1884, **9**, p. 108.

† Des Cloizeaux. See Groth's Physikalische Krystallographie (1905), 4th Ed., p. 431.

Habit: Crystals commonly tabular on the base and appearing as square plates. Occasional crystals are seen in the side aspect showing the pyramid (221). This face does not appear as a smooth plane, but as a rough striated surface more or less curved, the striations being parallel to the base (Fig. 343).

Optical properties: Uniaxial, optical sign —. Small crystals in the usual aspect (on the base) show no polarization effect. Larger crystals show a faint illumination between crossed nicols,

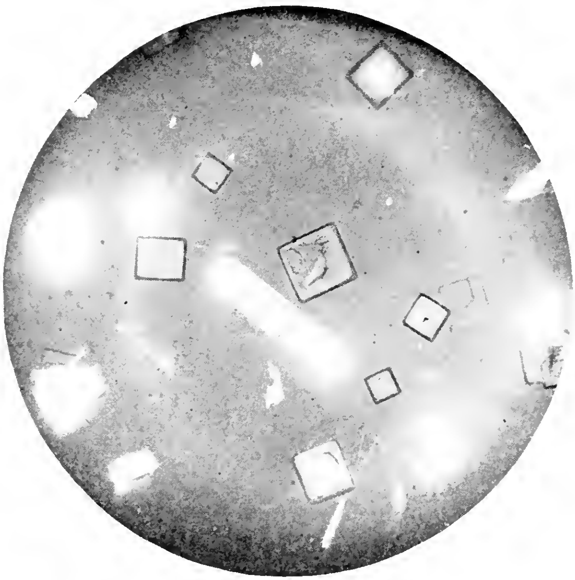

Fig. 344. Strychnine sulphate: tetragonal crystals from aqueous solution, showing basal aspect in polarized light. Also one large crystal of a second form (orthorhombic?) of strychnine sulphate.

owing to optical anomalies and to the rotation of the plane of polarized light, which amounts to about 10° per mm. thickness. Crystals seen on the side view show a strong double refraction.

Vanillin ($C_8H_8O_3$).

Occurrence: See pp. 587, 672, 673 and 680. See also Czapek.*

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* Czapek, Biochemie der Pflanzen, ii, p. 551.

Vanillin, or the methyl ether of protocatechuic aldehyde, $C_6H_3.CHO.OCH_3.OH$(1, 3, 4), is not found in the plant kingdom as such but appears to be formed as a result of the decomposition of other substances. It is prepared from vanilla pods, potato parings and Siam benzoin. The commercial article is prepared synthetically from eugenol, guaiacol and coniferin.*

The M. P. is 80°-81° C., which serves to distinguish it from cumarin which has a M. P. 67° C.; acetanilide (M. P. 113°); and benzoic acid (M. P. 120° C.). At 80° C. one part of vanillin is soluble in 15 parts of water and very soluble in alcohol, ether, chloroform and glycerin. The individual crystals from hot aqueous solutions vary in length from 0.3 mm. to 4 mm. (Fig. 128).

VANILLIN.—Crystals from hot aqueous solutions.

Orthorhombic: $a:b = 0.560:1$.

Forms observed: Base (001); brachypinacoid (010); unit prism (110); brachydome (01*c*); and pyramid (11*c*). These two latter forms are doubtful.

Angles: Angles $110 \wedge 1\bar{1}0 = 58° 30'$.

Habit: Tabular on the base, elongated along the *a* axis, the ratio of length to width being 10:1 or over. The end of the crystal is terminated by the unit prism, the two faces of which are often unequally developed, one face being sometimes entirely absent so that the termination is oblique.

Optical properties: The *a* axis is that of least refractive index for the basal aspect. An interference figure is observed on the base showing that the *c* axis is a bisectrix, and the axial plane is probably the brachypinacoid. If this is the case the optical orientation is $\mathfrak{a} = a$; $\mathfrak{b} = b$; $\mathfrak{c} = c$.

* Oesterle, Grundriss der Pharmakochemie, pp. 261-268.

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