

On the Anatomy of Magnoliaceæ.

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With Plates II-V.

Introductory Remarks.

The investigation of the present subject was begun in the autumn of 1890, at the suggestion of Prof. J. Matsumura, and was continued more than a year. During that time I received much useful advice from him, and also from Prof. R. Yatabe, to both of whom I am much indebted. The object of my researches was to find out what anatomical peculiarities characterize the Magnoliaceæ as a whole; what distinctive characters are presented by each of the different groups included in it; and to what extent all the species of it may be anatomically distinguished from one another.

These questions naturally present themselves, if we remember that systematic botanists in recent times have not agreed as to the limits of this family, and have treated its members in different ways. Some botanists extend its province by including certain tribes not usually admitted, while others restrict it by omitting tribes commonly included. Such indefiniteness as to its extent shows that this natural family is not very natural, and I hope that the study I have made of its anatomical characters may be of some service in remedying this defect.

I examined all the species of Magnoliaceæ that were accessible, including those placed in other families by some botanists. Such being the case I find it more convenient to use in my dissertation the term Magnoliaceæ in its wider sense. It also best answers my purpose to divide this family, as is done by Luerssen¹ and others, into four tribes; namely:—

Magnoliææ,

Schizandreeæ,

Illiciææ,

Trochodendreeæ.

The number of genera included in these tribes does not exceed fourteen, on the highest estimation, and that of the species known at present ranges between seventy and eighty. However, I could examine only twenty-four species and two varieties. Although the number of the species examined is small when compared with that of all the species known, yet those examined are distributed among ten genera, which are in their turn distributed among the four tribes. Therefore, I am perhaps right in believing that the anatomical characters of the species I examined represent fairly those of the whole family.

With the exception of two dried specimens in the herbarium of the Science College, which I was allowed to examine, the materials for my study were mostly obtained in the University Botanic Garden in Koishikawa. As I could get no specimens of the main root proceeding immediately from the seedling, but only of younger secondary roots, I examined these branchlets in order to get some knowledge of the anatomical characters of the young root, such as the arrangement of the xylem-plates, &c.

It will be well, I think, to define at once a few words which though often convenient to use in describing the structure of the plant-body, are yet somewhat vague in their meaning. “Sclerenchy-

1. Luerssen, *Grundzüge der Botanik*.

matous fibre" is used in the same sense as bast-fibre, and "scleroblast" in that of stone-cell; when either indefinitely is to be denoted, the expression "sclerenchymatous element" is often used. By "sclerenchymatous sheath" I mean the single mass of sclerenchymatous fibres, or the numerous isolated groups of them, which lie at the external limit of the fibro-vascular bundles and form a ring either continuous or interrupted at intervals. I consider this sheath to be a part of the bundles, and not an independent structure lying outside them. By "cortex" I mean all the tissues which lie outside the cambial zone. That part of it which corresponds to the phloëm (including the sclerenchymatous sheath, when this exists), I generally call the "inner cortex"; and all the parts outside this, the "outer" or "external cortex." In the case of very young roots I mean by "cortex" all the tissue lying outside the endodermis.

In the following pages the anatomical characters of each genus will be first described, and then compared. It might appear sufficient to have compared at once the characters of the different genera without giving a special description of each genus, but this would have led to confusion, as well as to the omission of many interesting isolated facts.

Anatomical Characters.

Under the headings, *Stem*, *Petiole*, *Blade*, and *Root*, the points of structure peculiar to each are described, while under the first are given also those points common to all four.

Tribe I. Trochodendreaë.

This tribe consists of three genera, species of each of which I examined.

Euptelæa.

E. polyandra, Sieb. et Zucc., is the only species of this genus which I examined. It is a small tree, found in many parts of Japan, in which the aromatic property so common in Magnoliaceæ is entirely absent.

Stem.—The epidermal cells present no peculiarity ; the cuticle is not well developed. There is found on the epidermis a number of lenticels, which appear to the naked eye as white specks. Cork is developed immediately beneath the epidermis, its cells being of comparatively large size, while those forming the other tissues are generally very small. The hypoderma is represented by a layer of somewhat thick-walled parenchymatous cells beneath the cork. Sclerenchymatous elements of any kind are totally absent in the outer cortex ; but there are found in it many sacs, each of which contains an aggregate of crystals of calcium oxalate (Pl. II, Fig. 2).

The sclerenchymatous ring which accompanies the fibro-vascular bundles is well developed, but is interrupted at the points where the large medullary rays run radially through the phloëm (Pl. II, Fig. 1). Sclerenchymatous elements are absent in the inner phloëm ; but a few scleroblasts find their way into those portions of the phloëm rays which run near the sclerenchymatous ring (Pl. II, Fig. 1, *s*). In specimens collected while the cambial zone is in activity, there is seldom seen any marked distinction between that zone and the xylem, gradual transition taking place from lignified cells to unlignified ones. (Pl. II, Fig. 1). In the phloëm portion sieve-tubes are distinctly to be seen, especially in longitudinal sections. The xylem contains vessels, tracheïds, fibres, and wood-parenchyma. The vessels generally have fibrous markings on their walls. In those portions of the xylem which border on the pith and constitute the medullary sheath there are found, in young specimens, groups of elongated cells with

thin unlignified walls. Each group surrounds the first-formed spiral vessels and is destined to be lignified in the course of time. Primary medullary rays usually consist of two or three radial rows of cells; besides these there are found numerous small rays consisting of a single row of cells.

The pith commonly consists of cells with thick, lignified, pitted walls, but sometimes there remains in the central portion of the pith a group of cells with unlignified walls.

Petiole.—On the epidermis a few hairs are sometimes present. They especially grow in the groove which runs longitudinally along the upper surface of the petiole. The hypoderma is present. The fibro-vascular bundles form a ring enclosing the pith. Sclerenchymatous fibres are well developed and constitute a continuous sheath around the bundles; they are unlignified in the basal portion of the petiole. The phloem portion is here and there crossed by the medullary rays, and the portion of the ray which bridges the phloem is made up of scleroblasts. Unlike that of the stem the pith is formed of thin-walled parenchyma.

Blade.—Its structure is generally compact. The stomata do not present any peculiarity. Hairs grow on the midrib and their base is often made up of several cells. The cuticle of the midrib forms a number of longitudinal ridges, which present in a cross section cuticular indentations (Pl. II, Fig. 3). Directly under the epidermis of the lower side of the blade there is found a layer of cells which forms the hypoderma. The arrangement of the fibro-vascular bundles of the midrib is not completely circular, but shows a discontinuous portion turned towards the upper surface of the blade. Aggregates of crystals are also met with in the cells of the cortical portion of the midrib.

Root.—In the older root the general structure does not differ

much from that of the stem, except that pith is absent. The sclerenchymatous ring contains both short and elongated elements. In the young root hairs are copiously found on the epidermis. The arrangement of xylem-plates seems to belong to the diarch type (Pl. II, Fig. 4, A). As the root becomes a little older the two xylem-plates which are opposite in their position become united, thus forming an elliptical mass of wood (Pl. II, Fig. 4, B). The endodermis remains cellulose as long as it exists.

Cercidiphyllum.

Of this genus I examined a single species, *C. japonicum*, Sieb. et Zucc. The plant is found in the mountainous parts of this country. It attains a great height and yields a valuable timber. It is not aromatic though the opposite statement is made by some authors.¹

Stem.—The tissue elements of this plant are very small in size; the compactness of texture of the wood is owing to this fact. The epidermis is early shed, so that except in very young shoots it is completely absent. The cork is very compact like the other tissues. The hypodermal layer is present under the cork. Cells containing prismatic crystals of calcium oxalate are abundantly found both in the outer cortex and in the phloëm, and are especially numerous in the phloëm rays (Pl. II, Fig. 5). The occurrence of these crystals is so common that I found them in various specimens collected in different seasons.

The groups of sclerenchymatous fibres are well developed and form bands alternating with the soft bast; but there does not exist a continuous sheath of sclerenchyma enclosing the fibro-vascular bundles. Sieve-plates are seen in the phloëm, though not very distinctly. The

1. Baillon, *Natural History of Plants*, (translated from the French).
Engler and Prantl, *Die natürlichen Pflanzenfamilien*.

xylem contains tracheæ, fibres, and wood-parenchyma. Bordered pits are found in the walls of the vessels; they appear in a surface view like a slit encircled by a halo, and not like an encircled spot as commonly seen in the wood of *Pinus*. Most of the medullary rays consist of single rows of cells.

The parenchymatous cells of the pith have thick lignified walls, even in the young specimen, and contain an ample quantity of starch.

Petiole.—The epidermis consists of a single layer of cells, and the cuticle is not well developed. The hypoderma is represented by a layer of thick-walled parenchymatous cells. There is present in the external cortex no sclerenchymatous element, but deeper in this region there lies a zone of tissue presenting an irregular appearance, due to the distortion of parenchymatous cells (Pl. II, Fig. 6, *a*). The fibro-vascular bundles are arranged in a circle, as in the stem, and enclose the pith in the centre (Pl. II, Fig. 6). The bundles are encircled by a well-developed sclerenchymatous sheath, which is interrupted by parenchymatous cells only at a few points (Pl. II, Fig. 6). The fibres are unlignified in the basal portion of the petiole. Prismatic crystals are found in the phloëm. The pith parenchyma unlike that of the stem has unlignified walls.

Blade.—Its general structure, as also the form of its stomata, has no peculiarity. There are several main-ribs instead of a single midrib, and their fibro-vascular bundles present a semi-circular arrangement, while those of the petiole are circularly arranged. A group of thick-walled cells is found within that portion of the epidermis, which lies on the upper side of the main-ribs. Aggregates of crystals are found in the cortical region of the main rib. The cuticular ridges are not so conspicuous as in the midrib of *Euptelea*.

Root.—The structure of the older root is similar to that of the stem. Crystals are copiously found here also in the phloëm.

Sclerenchymatous fibres are also well developed. In the young root the endodermis is distinctly seen, and the cells that constitute it remain cellulose. The xylem-plates present the tetrarch arrangement, but sometimes also the triarch.

Trochodendron.

To the present genus belongs the single species, *T. aralioides*, Sieb. et Zucc. It is a tree destitute of any aromatic property. It is grown in many parts of Japan. Articles of various shapes are made from its wood by means of the turning-lathe. Its bark yields bird-lime.

Stem.—The epidermis is of the usual structure. The cuticle is very well developed, and striæ, which are perpendicular to the cuticular surface, and coincident with the boundary lines between the epidermal cells, are distinctly seen. Cork is present immediately beneath the epidermis. The hypoderma is represented by a layer of somewhat thick-walled, closely arranged parenchymatous cells. The portion of the outer cortex which lies within the hypoderma consists of a loose tissue with many interstices, and trichoblasts are here found in great abundance. They are of peculiar shape and are characteristic of the present species (Pl. III, Fig. 9); many-armed trichoblasts are found in a few other genera of Magnoliaceæ, such as *Magnolia* and *Michelia*, but these are much simpler in form.

The sclerenchymatous sheath is well developed and almost uninterruptedly encircles the fibro-vascular bundles. Besides these fibres the sheath contains short sclerenchymatous cells or scleroblasts. A great number of oil drops is found both in the external cortex and in the phloëm. With the exception of a few spiral tracheæ found in the primary wood and of the parenchyma forming the medullary rays, the whole xylem is made up of tracheïds. The walls of the latter

present bordered pits of various forms, more numerous on their radial than on their tangential surface; and round pits are mostly present on the tangential surface, while elliptical forms predominate on the radial surface. The primary medullary rays are very broad, consisting of several rows of cells.

The parenchymatous cells of the pith have thick lignified walls, which are pitted, and there is no trichoblast, though the opposite is stated to be the case by certain writers.¹

Petiole.—The general structure is similar to that of the stem. A great many trichoblasts are found in the external cortex. The fibro-vascular bundles are so arranged as to present a somewhat semi-lunar form with its concave side turned to the upper side of the petiole (Pl. III, Fig. 7). The bundles are rather scattered in the basal portion of the petiole, but in the other portions they are more closely united. There exists at the external limit of the phloëm the sclerenchymatous sheath, but it consists of unlignified fibres.

Blade.—The contour of the epidermal cells is not wavy here as in the leaves of many other plants. The cuticle at the entrance of the stoma is elevated, and presents a cup-like appearance (Pl. III, Fig. 10). The palisade-parenchyma of the upper side of the blade consists of three or four layers of cells. Trichoblasts are met with in the region where the structure of the blade is loose, so that a number of intercellular spaces are left. The fibro-vascular bundles of the midrib are semi-circularly arranged, and a group of sclerenchymatous fibres is found in the cortical region lying on the bundles. The cuticular ridges of the midrib are wanting.

Root.—The general structure of the older root does not much differ from that of the stem. Trichoblasts are abundantly found in roots a little older, but their form is much simpler than that of those

¹ Engler und Prantl, *Die natürlichen Pflanzenfamilien*.

in the stem or leaf, and approaches that of the trichoblasts existing in the external cortex of some species of *Magnolia*. The hypoderma is absent. In the cortex of the young root there is found a number of cells with thick walls, slightly lignified (Pl. III, Fig. 8. *es*). Some of these cells are short and others are elongated. They are not the young stage of the sclerenchymatous elements found in the older root, and are destined to be soon shed off with the parenchymatous cells among which they are scattered. The true trichoblasts come into existence at a much later time, while the sclerenchymatous fibres do not appear at all in the root, or only in somewhat old roots. The arrangement of the xylem-plates is of the diarch type (Pl. III, Fig. 8). The endodermis and pericambium are not well marked in the present species (Pl. III, Fig. 8).

Tribe II. Illicieæ.

Two genera, *Illicium* and *Drimys*, were examined in this tribe.

Illicium.

In this genus I examined, two species; namely, *I. religiosum*, Sieb. et Zucc., and *I. Tashiroi*, Max. The former is a small tree with aromatic odour, and widely distributed in Japan. *I. Tashiroi* was discovered a few years ago in Riukiu or Loochoo by a Japanese botanist, Y. Tashiro, whose name the plant bears, and I examined only a dried specimen of it.

Stem.—The epidermis has no peculiarity and has no appendages. The cuticle is very well developed, and striæ, perpendicular to the cuticular surface, and corresponding to the limits of the epidermal cells, are distinctly seen, as in *Trochodendron*. In stems a little older cork is developed immediately beneath the epidermis. In the outer cortex there exists no layer of cells that can represent the hypoderma,

all the cells of this region being of similar form and, in most cases, having pitted thick walls. There is not found among them any kind of idioblasts, which abound in several other genera of the same family.

The phloëm portion of the fibro-vascular bundles is almost destitute of hard bast, and only at the external limit of the bundles are there found a few scattered sclerenchymatous fibres, which represent the sclerenchymatous sheath (Pl. III, Fig. 11, *sl*). The soft bast certainly contains sieve-tubes, but I was not able to detect them clearly. Oil-globules are often met with in the phloëm region, and are a probable cause of the characteristic odour which is given out when a branch of the plant is bruised. In the external cortex of *I. Tashiroi* certain cells are met with which seem to be a receptacle for an oily substance (Pl. III, Fig. 12, A); but in *I. religiosum* the existence of such cells can not be clearly detected, though some cells of the external cortex may be suspected to be of that nature. In the xylem there are found tracheæ, fibres, and wood-parenchyma. The medullary rays are very narrow, generally consisting of one or two rows of cells. In *I. religiosum* the demarcation of the annual rings is generally not very clear, owing to the fact that the xylem-elements formed at the end of autumn of the preceding year are similar in size to those which are formed at the beginning of the next spring.

The pith is surrounded by a medullary sheath, in which spiral tracheæ are found. The parenchymatous cells of the pith have thick walls which are often pitted. They are lignified in old specimens of *I. religiosum*; and in *I. Tashiroi* this is the case even in young specimens. According to Prantl¹ sclerenchymatous cells are found in the pith of *Illicieæ*, but I do not find them in my specimens.

Petiole.—The fibro-vascular bundles of the petiole do not form a

1. Engler und Prantl, *Die natürlichen Pflanzenfamilien*.

ring enclosing the pith, as they do in the stem ; but constitute a somewhat crescent-shaped group with its concave side turned to the upper surface of the petiole. The xylem portion is incompletely lignified as is proved by the action of reagents. In the phloëm no sclerenchymatous fibres are present. The bundles are partly enclosed by a row of parenchymatous cells containing starch-grains, which perhaps represent a bundle sheath. In all other respects the structure of the petiole is similar to that of the stem.

Blade.—The cuticle is well developed. The fibro-vascular bundles of the midrib are semi-circularly arranged, and a few sclerenchymatous fibres accompany the bundles. The cells forming the palisade-parenchyma lying at the midrib have their height diminished and become almost round. Resin sacs are not found at least in *I. religiosum*.

Root.—An old root almost resembles the stem in general structure. In the young root the arrangement of the xylem-plates is of a diarch type. The cells that constitute the endodermis remain cellulose. Oil-drops are scattered about in the cortex of the young root. No sclerenchymatous fibre is seen in the phloëm, even in old specimens.

Drimys.

I examined only a dried specimen of one species of this genus ; namely, *D. dipetala*, Fr. M., which had come from New South Wales, and I can only give a few points about its anatomical characters, since I have only a very imperfect knowledge of them.

In general structure this species resembles *I. religiosum*, but there exist some decided structural differences between them. Thus in *D. dipetala* a great number of resin-sacs are present in the outer cortex (Pl. III, Fig. 12, B) and even in the phloëm ; a well developed sclerenchymatous ring accompanies the fibro-vascular bundles, and

the xylem consists exclusively of tracheïds. The last character is only found in the present genus and in *Trochodendron* among Magnoliaceæ. The parenchymatous cells of the pith are lignified even in a young specimen, as in *I. Tashiroi*, but I have not here met with any sclerenchymatous cells scattered about, (as they are stated to be by Prantl). The leaf is almost sessile, and the fibro-vascular bundles of the very short petiole present a semi-circular arrangement, as in *Illicium*. The bundles are similarly arranged in the midrib. A number of resin-sacs are found in the mesophyll. In the epidermal cells of the leaf, crystals are often met with, which are probably calcium oxalate.

Tribe III. Schizandreæ.

This tribe consists of the following two genera :

Kadsura and Schizandra.

The two genera are so closely related in anatomical characters as to make it convenient to describe them together. Of *Kadsura* I examined *K. japonica*, L., and of *Schizandra* I examined *S. nigra* Max., and *S. chinensis*, Bail. The three are small climbing shrubs, found in several parts of Japan. When a cut portion of these plants is put in water it yields a large quantity of mucilage, which in the case of *K. japonica* is sometimes used for dressing the hair. The two species of *Schizandra* give out a sweet odour when any portion of them is bruised, but *K. japonica* gives out little or no odour, when similarly treated. The berries of *S. chinensis* are said to be edible.

Stem.—The epidermis consists of a single layer of cells, and the cuticle is not well developed. The hypoderma is not represented. The cork is well developed directly under the epidermis and is of the usual type. In the cortical parenchyma there are scattered about a few cells which contain oil globules (Pl. IV, Fig. 14, *ro*) ; these are pro-

bably the source of the characteristic odour which the plants give out when bruised. These cells are conspicuous in *Schizandra* by their size, being much larger than the cells of the surrounding parenchymatous cells, but in *K. japonica* the oil-cells are scarcely larger than the surrounding cells, and are, besides, seldom met with. The cells of the cortical parenchyma are sometimes pitted in *K. japonica* (Pl. IV, Fig. 14).

Sclerenchymatous fibres are generally found at the external limit of the phloem, constituting the sclerenchymatous sheath, but they are not much crowded, either forming only a thin layer or else small groups (Pl. IV, Fig. 13, *sl*). Some of these fibres are septate, as may be seen in *K. japonica* (Pl. IV, Fig. 21). Scattered about in the phloem (and also in the external cortex) there are found peculiar cells with thick lignified walls and a narrow lumen (Pl. IV, Fig. 20). Some of these cells are elongated like sclerenchymatous fibres, others are very short, simply round in form, or else provided with arms, which they push out freely among the surrounding cells. The outer layer of their thickened wall contains a great number of granules of calcium oxalate, which present an angular configuration, without the definite form of true crystals. These peculiar elements are structurally nothing else than sclerenchymatous fibres or scleroblasts, holding a number of granules imbedded close to one another in their walls, and for convenience' sake I will hereafter call them "crystal-bearing sclerenchymatous elements." I do not think that there exists any essential difference between them and the so-called spicular cells of *Welwitschia mirabilis*, which have been described by several authors, and are stated to be of the same nature as the crystal-bearing fibres found in *Araucaria*, &c. If I am right, the interesting fact is supplied of two groups of plants which are remote from each other in systematic position containing a very similar element in their

tissues. In the phloëm of *Kadsura* and *Schizandra* there are found many large intercellular spaces, which are apt to be mistaken for some kind of large ducts, but are really passages of lysigenetic origin. They are on all sides bounded—and the boundaries are often very irregular—by distorted and broken cells, and in sections cut from specimens preserved in alcohol, they are often found filled with a homogeneous, structureless substance. They seem to serve as reservoirs for the mucilage which abounds in these plants, and which is probably derived from the disorganization of the surrounding cells. They are most conspicuous in *Kadsura*. The xylem consists of tracheæ, fibres, and wood-parenchyma. The vessels are large, their diameter being several times greater than that of the surrounding tissue-elements, especially in *Kadsura*. The walls of the vessels are distinctly sculptured with bordered pits. The medullary rays mostly consist of a single-row of cells.

The pith consists of unligified parenchymatous cells, among which may be found a few sclerenchymatous cells in *Schizandra* (Pl. IV, Fig. 15), and a few crystal-bearing ones in *Kadsura*.

Petiole.—Unlike those of the stem the fibro-vascular bundles of the petiole are so arranged as to present a somewhat semi-lunar form with its concavity turned to the upper side of the petiole (Pl. IV, Fig. 18). In a section cut from the upper or middle portion of the petiole, these bundles lie in a few definite groups, as is shown in the figure just referred to, (where three distinct groups are seen); but in the basal portion they are more loosely arranged. There is not present either in the phloëm or in its neighbourhood, the common form of sclerenchymatous fibre or scleroblast; but scattered about in the parenchymatous tissue surrounding the bundles there are found the crystal-bearing sclerenchymatous elements (Pl. IV, Fig. 19, *cs*). In the case of *Kadsura* a single row of parenchymatous

cells which contain a quantity of starch-grains, partly encloses the bundles and faintly represents a bundle-sheath (Pl. IV, Fig. 18, *z*; Pl. IV, Fig. 19, *z*). In *Schizandra* some parenchymatous cells lying near the bundles contain crystals of calcium oxalate. These crystals are found either singly in a cell or as an aggregate. In the former case they attain a considerable size and are octahedral or prismatic in form, but in the latter case their exact form is indeterminate. Such crystals are not met with in the stem. In the existence of mucilage-reservoirs, as well as in other points not specified here, the structure of the petiole agrees with that of the stem.

Blade.—The stomata are of the usual form. Cuticular ridges are distinctly seen on the epidermis of the midrib. The arrangement of the fibro-vascular bundles in the midrib is similar to that in the petiole. Mucilage canals are found both in the midrib and in other parts of the blade. In the latter place they generally accompany the veins sent off from the midrib. Crystal-bearing sclerenchymatous elements are found both in the midrib and in the veins of *Kadsura japonica*, while they are rarely met with in the leaf of *Schizandra nigra*. On the contrary crystals both aggregated and solitary are copiously found in the midrib and veins of *Schizandra nigra*, while they are rare in the leaf-blades of *Kadsura*. Crystals forming aggregates are also found in the epidermal cells of *Schizandra* (Pl. IV, Fig. 16).

Root.—The crystal-bearing sclerenchymatous cells, the cells containing oil-globules, and some other peculiar structures, which are found both in the stem and leaf, are also met with in the root (Pl. IV, Fig. 14, D). However, the sclerenchymatous sheath, which is constantly found in the stem, is absent even in somewhat old roots. The intercellular passages which serve as mucilage-reservoirs are found

in the roots of *K. japonica* and *S. chinensis*, but in a somewhat old root of *S. nigra*, I found the passages not yet developed, and but little mucilage present. Thus it is seen that the formation of the passages has a close relation to the production of mucilage, a fact which seems to favour the view that the mucilage is derived from the disorganization of the pre-existing tissue. As to the number of xylem-plates in the young root, *K. japonica* and *S. nigra* agree, both presenting the diarch arrangement; but in *S. chinensis* the triarch, as well as the diarch one, may be seen (Pl. IV, Fig. 17). The pith is absent in old specimens.

Tribe IV. Magnolieae.

Under this tribe I examined the following three genera :

Magnolia, Michelia, and Liriodendron.

The anatomical elements of these genera may be described together, as they present nothing characteristic enough to distinguish the genera from each other. Only one species is known to belong to *Liriodendron*, and this I examined. Four species of *Michelia* were examined, and ten species and two varieties of *Magnolia*. All of these plants are trees and generally attain a great height. Aromatic properties are prevalent among them. The names of the species examined are as follows :

Magnolia stellata, Miq.

M. parviflora, Sieb. et Zucc.

These two are ornamental trees.

M. Kobus, D. C.

Also ornamental. Its wood is used in cabinet work.

M. hypoleuca, Sieb. et Zucc.

It is one of the most useful trees, its soft wood being ex-

tensively used for various purposes. Small articles of furniture, chopping blocks, &c., are made from it. It is also used for making pencils. The charcoal obtained from it is used for polishing lacquered ware. Also the tree is ornamental.

M. salicifolia, Miq.

M. obovata, Thunb.

M. obovata, Thunb. var. (commonly known as *Kanshiu-mokuren*).

M. conspicua, Salisb.

M. conspicua, Salisb. var. *purpurescens*, Max.

M. pumila, Andr.

M. Watsoni, Hook. fil.

M. grandiflora, L.

The last seven of the above plants are ornamental exotic trees.

Michelia compressa, L.

This is an ornamental tree. Small articles of furniture are sometimes made from its wood. It is grown in the hotter parts of this country.

M. Champaca, L.

M. longifolia, Blume.

M. fuscata, Blume.

These three are ornamental exotic trees; *M. Champaca* is said to be of some medicinal value.

Liriodendron tulipifera, L.

An exotic tree.

Stem.—The epidermis is of the usual structure with the cuticle well developed in many species. Epidermal hairs are found in all species of *Michelia* and in some of *Magnolia*, (e. g., *M. grandiflora*, *parvi-*

flora); but not in *Liriodendron*. Development of cork seems to take place in these genera immediately under the epidermis. The hypoderma is generally represented by a layer of thick-walled parenchymatous cells which are packed very closely (Pl. V., Fig. 22, *hp*). The cells constituting the hypoderma are in some cases transformed into scleroblasts, as is seen in *Magnolia grandiflora*, *hypoleuca* (Pl. V, Fig. 28, *hp*), *pumila*, *parviflora*, &c. Resin-sacs are scattered about in the external cortex. Each consists of a cell having a form similar to that of the surrounding parenchymatous cells, but distinguished from these by the nature of its contents, the thickness of its wall, and also in most cases by its size. These sacs are conspicuous in *Magnolia* and *Liriodendron*, but hardly so in *Michelia*. In many species they are found in the phloëm, and even in the pith. The contents of these sacs are probably the chief source of the aroma possessed by the species of these genera. Like that of the resin-sacs the occurrence, either singly or in groups, of scleroblasts in the external cortex is universal in these genera. These cells are, however, very rare in some species, *e. g.*, *Magnolia parviflora*. Some of them are many armed and may properly be called trichoblasts.

The sclerenchymatous fibres are greatly developed, and not only form a strong sheath to the fibro-vascular bundles, but are found mixed among the soft bast. A few scleroblasts are also found with the sclerenchymatous fibres that lie at the external limit of the phloëm, and with them constitute an almost continuous sheath. The phloëm portion consists of the usual elements. The xylem contains the tracheæ, fibrous elements, and wood-parenchyma. The vessels present bordered pits in their walls. The medullary rays vary in breadth, some consisting of three or four rows of cells, and others of a single row. Sclerenchymatous elements are generally absent in the phloëm rays.

The pith consists of unlignified cells, and is traversed in places by a kind of horizontal septa. This structure is known as "diaphragms" (Pl. V, Fig. 27, *dm*), and is universally found in the species included in the present tribe. In some species, *e.g.*, *Magnolia grandiflora*, it is very conspicuous and distinctly visible to the naked eye as streaks traversing the pith. A diaphragm consists of a horizontally stretched mass of scleroblasts, which, when highly developed, occupies an almost entire cross section of the pith, though it is inconsiderable in thickness; and this mass is continuous at several points with the wood-parenchyma that lies at the inner limit of the xylem. In *Liriodendron* the greater part of a diaphragm consists of cells with thick, pitted, but not lignified walls, while the remaining small portion is made up of scleroblasts. The diaphragms of *Magnolia hypoleuca* consist of scleroblasts having a very irregular shape. Those of *Magnolia parviflora* and *M. salicifolia* are not so well developed as those of other species.

Petiole.—The cuticle is strongly developed in *Michelia*, but not in *Liriodendron*. In *Magnolia* it is well developed in some species, but less so in others. Epidermal hairs are abundantly found in *Michelia*, but in *Liriodendron* they are almost absent. In *Magnolia* many species have the hairs well developed, while some are destitute of them. In *Magnolia parviflora* and a variety of *Magnolia obovata* (*Kanshiu-mokuren*) there are found, in addition to the kind of hairs common to other species, smaller hairs which are sometimes branched (Pl. V, Fig. 24, *ch*). The hairs are generally cuticularised, but in *Magnolia Kobus*, in which a few are found, they remain cellulose. Resin-sacs occur in the outer cortex of all the species, and even in the phloëm of some. The scleroblasts, which are often many-armed, are generally found in the external cortex; but in the single case of *Liriodendron* they are almost absent. The number of fibro-vascular bundles which enter

the petiole is variable, in some species exceeding twenty, in others being much fewer. These bundles are generally isolated from one another in the basal portion of the petiole, but in its upper portion they become gradually united so as to form a ring enclosing the pith. This arrangement is usually very regular, but sometimes several bundles stand isolated outside the main ring, and disturb the regularity of the arrangement. The sclerenchymatous fibres are very well developed and constitute the bundle sheath. They are generally unligified at the basal portion of the petiole, but in *Liriodendron* some of these fibres are lignified even in the basal portion. The diaphragms are present in the species examined. In several cases, however, they are only faintly represented by a few scleroblasts found in the pith; while in others (*e. g.*, *Michelia fuscata*), a broad mass of sclerenchymatous cells constitutes the diaphragm.

Blade.—With the exception of *Liriodendron* the cuticle is generally well-developed. In *Michelia* and *Magnolia* epidermal hairs are generally met with, especially on the lower surface of the leaf; while in *Liriodendron* many epidermal cells of the lower side of the leaf are provided each with a little protuberance, which is really an imperfect hair. In many cases the hair is not an elongation from a single epidermal cell, but several cells take part in forming its basal portion, as will be seen in referring to the figures, 25 and 26 (Pl. V). The stomata are generally elliptical in form, but in *Magnolia grandiflora* they are rather roundish, the curvature of the guard-cells being very great. In *Magnolia pumila* the cuticle is much raised at the entrance of the stomata, and presents a cup-like appearance, reminding us of the stomata of *Trochodendron* (Pl. V, Fig. 30). In *Magnolia grandiflora* there is found between the epidermis and the palisade-parenchyma a single layer of parenchymatous cells, which do not contain chlorophyll grains (Pl. V, Fig. 29). This layer extends to the very margin of

the leaf-blade, and some of the cells constituting it become sclerotic as this region is approached, and, together with the sclerenchymatous fibres that abound there, form a very strong margin to the blade. The blade of *Magnolia grandiflora* is also itself very thick, the palisade-parenchyma consisting of several layers of cells, but in *Magnolia salicifolia*, which has very thin leaves, there is only a single layer of cells constituting the palisade parenchyma. Although there are the few just noticed peculiarities to be detected in certain species, the general structure of the blade is similar in the three genera of *Magnoliaceæ*. The fibro-vascular bundles are circularly arranged in the midrib, as they also are in the petiole. Resin-sacs are found in the leaf-blades of all the species examined. The occurrence of stone-cells is also very general. *Magnolia pumila* contains somewhat elongated sclerenchymatous cells in the hypodermal region of the lower side of the midrib. Red patches are often met with in the mesophyll of some species of *Magnolia*, e. g., *M. obovata*, *M. conspicua*, and *M. conspicua* var. *purpurescens*. These were proved to be tannin.

Root.—The general structure of the older root does not much deviate from that of the stem. Resin-sacs are present without exception in the outer cortex. This region also contains a number of scleroblasts in some species, while it is destitute of them in others. The sclerenchymatous fibres are generally developed at the external limit of the phloëm. Pith is absent, and its place is occupied by a group of elongated woody fibres. In the young root the number of xylem-plates is very variable. Thus in *Liriodendron* their arrangement is diarch or triarch, but mostly the former. In *Michelia* it is triarch or tetrarch (Pl. V, Fig. 32, A). In *Magnolia* diarch, triarch, and tetrarch arrangements are each common; but in one species, namely, *Magnolia grandiflora*, the arrangement varies from the tetrarch to the heptarch. Generally, when the root becomes a little older the xylem-plates which

are separate at first, tend to unite and form one body of xylem ; but in *Magnolia grandiflora* they continue separate for a comparatively long time, so that there remains in the central portion a mass of unligified cells. In *Kanshiu-mokuren*, (a variety of *Magnolia obovata*), I saw only a continuous mass of ligified cells instead of separate xylem-plates, even in the youngest specimens obtainable. In general, the endodermis is distinctly marked off from the surrounding tissues (Pl. V, Fig. 32, *e*), and in most cases it is traceable even in somewhat old roots. In *Michelia compressa* and *Magnolia conspicua*, var. *purpurascens*, somewhat elongated cells with ligified walls appear very early in the cortex (Pl. V, Fig. 32, *es*), while the xylem-plates still remain separate. The walls of these cells in the latter species are not uniform in thickness, the part of the wall facing the circumference being not much ligified, while that facing the centre is thickened and ligified.

The cortex of the older root of *Magnolia Kobus* contains many elongated peculiar cells, found near the intercellular spaces of schizogenetic origin, which also abound in the root of this plant.

When the roots of some species of *Magnolicee*, such as *Michelia Champaca*, *Mich. compressa*, *Magnolia Kobus*, &c., are kept in alcohol they impart a red colour to it.

Anatomical Characters of Different Genera Compared.

In the foregoing pages the anatomical characters of each genus of the present family having been described, it is now possible to give a comparative view of them. The structural points to be compared will be treated under the same four principal heads as used in describing each genus : Stem, Petiole, Blade, and Root.

Stem.

The characters of the stem require fuller treatment than the rest, and will be compared under the several structures.

1. *Epidermis*.—The epidermis generally consists of a single layer

of cells. The cuticle is sometimes well developed, as in *Illicium*, *Drimys*, *Trochodendron*, and many species of *Magnolia*. Epidermal hairs are found only in the two genera, *Michelia* and *Magnolia* and in the latter genus are almost absent in some species.

2. *Cork*.—This structure presents no peculiarity. As with many other Dicotyledons, cork is here developed immediately beneath the epidermis. In *Euptelea* it is conspicuous from the size of its cells.

3. *Hypoderma*.—This is totally wanting in *Illicium*, *Drimys*, *Kadzura*, and *Schizandra* but present in all the other genera. When present, it consists of a layer of thick-walled and closely packed parenchymatous cells (Pl. V, Fig. 22, *hp*), and in some species of *Magnolia*, as *M. grandiflora*, *hypoleuca* (Pl. V, Fig. 28, *hp*), &c., these cells are transformed into scleroblasts.

4. *Secretory Reservoirs*.—Two kinds of these are found, resin- or oil-sacs and crystal-containing sacs, the latter chiefly found in *Euptelea* (Pl. II, Fig. 2) and *Cercidiphyllum* (Pl. II, Fig. 5). The crystals are of calcium oxalate in both genera; but in *Euptelea* they exist in the sac as an aggregate and are confined to the outer cortex, while in *Cercidiphyllum* they are not aggregated, and the sacs containing them exist in the phloëm, as well as in the outer cortex. In *Schizandra* crystal-containing sacs are confined to the leaf (petiole and blade). Resin-sacs universally occur in the external cortex of *Magnoliæ*, and in many cases are found in the phloëm, and sometimes even in the pith. Cells containing oily substances are also met with in the external cortex of *Schizandra* (Pl. IV, Fig. 14, C.D). Resin-sacs are also present in *Drimys* and *Illicium Tashiroi*, but absent in *Illicium religiosum*. *Trochodendron* is entirely destitute of any kind of reservoirs.

5. *Scleroblasts and Trichoblasts (in the external cortex)*.—The latter are simply a modified form of the former. Both forms of cells are

met with in Magnoliaceæ. Trichoblasts are very abundantly found in the external cortex of *Trochodendron*, and send their arms freely into the intercellular spaces which also abound in this region (Pl. III, Figs. 7 and 9). Their presence is a feature that distinguishes this genus from others. Scleroblasts are generally found in *Magnoliæ*, and in many cases are accompanied by trichoblasts. The external cortex of *Illicium*, (perhaps of *Drimys* also), *Euptelea*, and *Cercidiphyllum* is entirely destitute of them. *Kadzura* and *Schizandra* contain in their outer cortex and less often in their inner one a number of crystal-bearing sclerenchymatous cells (Pl. IV, Fig. 20), which are nothing more than scleroblasts with numerous crystals imbedded in their walls. Some of these cells are elongated and form crystal-bearing sclerenchymatous fibres.

6. *Fibro-vascular Bundles*.—The fibro-vascular bundles existing in the stem of Magnoliaceæ belong to the so-called collateral bundles, which are universally found in the stem of phanerogams, so that it is unnecessary to give an account of their general features. But there are certain structural points in the bundles peculiar to different genera which need to be noticed briefly under the following heads :

(1) *Sclerenchymatous Sheath*.—This is made up of sclerenchymatous fibres often accompanied by scleroblasts, and is more or less developed in all the genera. However, in *Illicium* it is very imperfectly represented by scattered fibres that are found at the external limit of the phloëm. It is poorly developed in *Kadzura* and *Shizandra* (Pl. IV, Fig. 13, *sl*) ; rather well developed in *Euptelea* and *Cercidiphyllum* ; in *Trochodendron* and all the three genera of *Magnoliæ* most strongly developed and, together with a number of scleroblasts existing there, constitutes an almost continuous ring of sclerenchyma. Such is also the case in *Drimys*.

(2) *Phloëm*.—The soft portion of the phloëm probably contains

those elements which are usually found in this region of other Dicotyledons, but clear detection of them was generally very difficult, and the presence of sieve-tubes was proved only in a few species. In *Cercidiphyllum* and all the three genera of *Magnoliceæ* the hard-bast or sclerenchymatous fibres are especially well developed, and are found among the soft bast. Also in *Kadzura* and *Schizandra* sclerenchymatous fibres are found among the soft bast, but these are heavily loaded with minute crystals, and transformed into the crystal-bearing sclerenchymatous fibres (Pl. IV. Fig. 20). Sacs containing crystals exist in the phloëm, as well as in the external cortex of *Cercidiphyllum* (Pl. II, Fig. 5). In *Kadzura* and *Schizandra* it is a remarkable feature that there exist in this region large intercellular passages, which serve as the reservoirs of mucilage.

(3) *Xylem*.—This portion generally consists of tracheæ, fibrous elements, and wood-parenchyma. But *Trochodendron* and *Drimys* are exceptional in this matter, their wood consisting almost exclusively of tracheïds. This peculiar structure of the xylem distinguishes these two genera from others of the *Magnoliceæ*, and at the same time allies them with *Coniferæ*. But, as stated by Prantl,* their wood may be distinguished from that of the latter family by the fact that in *Coniferæ* the cells of the medullary rays have their longer axis horizontal, while in *Drimys* and *Trochodendron* most of the cells of the medullary rays have their longer axis vertical. Bordered pits are found in the tracheïds of *Drimys* and *Trochodendron*; in the other genera where vessels are present, pits of this kind are generally found in their walls. It may be added that the exact determination of the various elements that constitute the xylem was not very easy.

(4) *Medullary Rays*.—Their breadth varies, consisting mostly of a single row of cells in *Illicium*, *Cercidiphyllum*, *Schizandra*, and *Kadzura*,

* Engler and Prantl, *Die natürlichen Pflanzenfamilien*.

but of several rows in *Trochodendron*. In *Magnoliæ* different breadths are found. In the phloëm rays of *Euptelea* a few scattered scleroblasts find their way among soft parenchymatous cells (Pl. II, Fig. 1, s).

7. *Pith*.—The parenchymatous cells of the pith are completely lignified in *Cercidiphyllum*, *Drimys*, and *Trochodendron*, even in young specimens. This is also the case in *Illicium Tashiroi*, but in *Illicium religiosum* they are unlignified in young specimens. The young stem of *Euptelea* often has a small portion of the pith remaining unlignified. The parenchymatous cells of the pith are unlignified in *Kadzura* and *Schizandra*, but a few sclerenchymatous cells are found in it (Pl. IV. Fig. 15). *Magnoliæ* are distinguished by the existence of diaphragms in their pith (Pl. V, Fig. 27, *dm*), the only part of the pith that here becomes lignified. As I have stated before, the asserted existence of stone-cells in the pith of *Illiciæ* is not verified by my specimens.

Petiole.

The structure of the stem having been comparatively described, there remains scarcely anything to be said of the petiole. I will here only notice a few anatomical points in which the structure of the petiole deviates from that of the stem.

The epidermal hairs are generally more strongly developed in the petiole than in the stem, as we see in many species of *Magnolia*; and even *Euptelea*, which bears no hair on its stem, has a few on the petiole. In those species which contain resin-sacs, scleroblasts, and trichoblasts in their stem, the presence of the same in the petiole is almost certain, as is also the case with crystal-bearing sclerenchymatous elements. A number of crystals is found in the outer cortex of the petiole of *Schizandra*, though none is present in the stem. The fibro-

vascular bundles are in many cases arranged as in the stem ; that is, in the cross section of the petiole, they present a circular arrangement enclosing the pith in the centre (Pl. II, Fig. 6). But in the petiole of *Illicium*, *Drimys*, *Trochodendron*, *Kadzura*, and *Schizandra*, the fibro-vascular bundles have a semi-circular arrangement with the concavity turned to the upper side of the petiole (Pl. III, Fig. 7). The sclerenchymatous sheath of the bundles is often wanting, as in the petiole of *Illicium*, *Drimys*, and *Schizandra*. *Trochodendron* has the sheath consisting of unligified fibres, while all the other genera have well developed sclerenchymatous sheaths (Pl. II, Fig. 6). The fibres forming these sheaths remain unligified at the basal portion of the petiole in all cases, except in the petiole of *Liriodendron*, where a few fibres are found ligified. Whether this local non-ligification of the fibres has some physiological meaning or not still remains undecided. In *Magnoliæ* diaphragms are found in the pith-portion of the petiole as in that of the stem.

Blade.

The general structure of the blade does not deviate from the dicotyledonous type. The upper portion of it is made up of palisade-parenchyma, which consists of vertically elongated cells varying in different species from one to several layers. Where these cells lie directly over the main ribs, their height is generally diminished and their form becomes almost round. The lower portion of the blade is generally made up of loose parenchyma ; but in those parts lying directly under the main ribs there is found a more compact parenchymatous tissue. In some genera, namely, *Illicium*, *Trochodendron*, *Magnolia*, and *Michelia*, the blade has a well developed cuticle. In *Schizandrea* the cuticle of the midrib—especially that of the lower surface—forms fine ridges running longitudinally (Pl. II, Fig. 3).

These ridges are also observable in *Euptelæa*, and less distinctly in *Cercidiphyllum*, but are wanting in *Trochodendron* which with these two genera forms *Trochodendraceæ*. Epidermal hairs are generally found in *Magnolia* and *Michelia*, and also in *Euptelæa*, but in other genera are almost wanting. In general the stomata do not present any peculiarity, being elliptical in form and accompanied by the two guard-cells, but in *Magnolia grandiflora* their form is nearly spherical and the guard-cells are pressed outward, so that they rest upon the neighbouring epidermal cells. Both in *Magnolia pumila* and *Trochodendron aralioides*, the cuticle is much raised around the entrance of the stomata, and presents a cup-like appearance (Pl. III, Fig. 10 ; Pl. V, Fig. 30). The arrangement of the fibro-vascular bundles of the midrib is circular in *Magnoliaceæ*, semi-circular in *Illiciaceæ* and *Schizandraceæ*. In all these cases the bundle arrangement of the petiole agrees with that of the midrib. In *Cercidiphyllum* and *Euptelæa* the bundles are circularly arranged in the petiole, but in the former they are semi-circularly arranged in the midrib, while in the latter their circle is incomplete in this part. But *Trochodendron aralioides* has the bundles semi-circularly arranged both in petiole and midrib. Thus in this respect the three genera of *Trochodendraceæ* do not agree with one another. Resin-sacs are present in the mesophyll, as well as in the midrib of the examined three genera of *Magnoliaceæ*. They are also present in these parts of *Drimys dipetala*, but have not been observed in those of *Illicium religiosum* or of *Schizandraceæ* and *Trochodendraceæ*, although in the former of these the occurrence of mucilage canals both in the mesophyll and the midrib is very common. The blade in a few genera contains crystals. Thus aggregates of crystals are found in the cortical region of the midrib of *Euptelæa* and *Cercidiphyllum*, and in that of *Schizandra*. In *Drimys dipetala* the epidermal cells contain a number of crystals. As to the existence of scleroblasts, trichoblasts,

and crystal-bearing sclerenchymatous elements, what I have stated in the case of the stem is applicable here to the blade.

Root.

The root, when it becomes a little older, presents the same structure as the stem, except that the central portion, which corresponds to the pith of the stem, is occupied by the xylem. Generally when scleroblasts, secretory reservoirs, &c. are found in the stem, they are also present in the root; but in the case of *Illicium religiosum*, sclerenchymatous elements are totally absent in the root, though a few fibres are present in the stem. In the young root radial bundles with the endodermis are present in the central portion, and are surrounded by the cortical parenchyma. The cells constituting the endodermis generally remain cellulose. The Caspary point is not clearly seen. Both endodermis and pericambium are generally well marked in the young root, except in that of *Trochodendron* (Pl. III, Fig. 8). In a few cases a number of cells with lignified thick walls are found in the cortical portion (Pl. III, Fig. 8, *es*; Pl. V, Fig. 32, *es*). The arrangement of the xylem-plates varies, there being usually found the diarch, triarch, and tetrarch types, while the number is not constant even in the same individual. In the single case of *Magnolia grandiflora* the tetrarch to heptarch arrangement is found. In this respect, therefore, any definite statement can not be given.

In all cases the number of xylem-plates was determined only in young branchlets of the secondary root, and not in the main root proceeding direct from the seedling, of which, as I have already mentioned, I could obtain no specimens.

Concluding Remarks.

Having given a comparative view of the anatomical characters of different genera of the present family, it remains now to summarise the results of my observations, which are mainly negative. Thus, I

have been unable to find any anatomical character that might serve to distinguish Magnoliaceæ as a whole from other dicotyledonous families. There is certainly not a single character common to all the members of this family, except such as are common to them and the members of other dicotyledonous families. Again, I have been unable to find in most of the species of this family any anatomical character that might serve to distinguish them one from another. However, I found that each of the distinct groups included in the family is marked out by certain anatomical characters, as the following synopsis shows.

A. With diaphragms in the pith :

<i>Magnolia,</i>	}	Tribe <i>Magnoliææ</i> .
<i>Michelia,</i>		
<i>Liriodendron.</i>		

B. Without diaphragms in the pith :

I. With crystal-bearing sclerenchymatous elements in the cortical portion of both stem and petiole :

<i>Kadsura,</i>	}	Tribe <i>Schizandreeæ</i> .
<i>Schizandra.</i>		

II. Without crystal-bearing sclerenchymatous elements in the cortical portion of stem and petiole :

1. A few scattered sclerenchymatous fibres present in the cortex of the stem ; though totally absent in that of the petiole, and that of the midrib of the blade. Resin-sacs either indistinct or wanting :

Illicium. Tribe *Illiciææ*.

2. Sclerenchymatous sheath well developed, and resin-sacs present both in stem and leaf :

Drimys. Tribe *Illiciææ*.

3. Sclerenchymatous fibres well developed in the

cortical portion of both stem and petiole, (in a single case only the fibres in the petiole remaining unligified). Resin-sacs wanting :

- a. With a great number of trichoblasts in the outer cortex, as well as in the mesophyll ; wood almost exclusively consisting of tracheïds :

Trochodendron. Tribe *Trochodendrea*.

- b. Cells containing single prismatic crystals abundantly found in the cortex of the stem :

Cercidiphyllum. Tribe *Trochodendrea*.

- c. Cells containing an aggregate of minute crystals often present in the outer cortex of the stem ; each aggregate presenting a stellate appearance :

Euptelaea. Tribe *Trochodendrea*.

As will be seen from the above synopsis, the four tribes of Magnoliaceæ may be distinguished from one another by certain anatomical characters more or less peculiar to each. Of these four tribes *Magnoliæ* and *Schizandreæ* are well defined in their characters and may be easily distinguished not only from each other, but from either of the other tribes. Although these two tribes are included in the same family by most botanists, yet there does not exist any anatomical character which seems to be sufficient to connect them. It is true that the secretory reservoirs found in the cortex of *Magnoliæ*, are faintly represented in *Schizandreæ* by reservoirs quite different in form; and that the diaphragms in the pith of *Magnoliæ* are said to be represented in *Schizandreæ* by a few sclerenchymatous cells.* But I hesitate to consider these points as sufficient connecting links,

* Baillon, *Natural History of Plants* (Translated from the French).

since there exist in other anatomical characters of these tribes such marked differences as those which I have pointed out. Thus, then from a purely anatomical point of view, *Magnoliæ* and *Schizandree* may be taken without any impropriety to be two distinct groups.

In *Illiciæ* the only two genera, *Illicium* and *Drimys*, which I examined, are markedly different in some points, though similar in general structure. On the one hand, the semicircular arrangement of the fibro-vascular bundles of the petiole allies this tribe to *Schizandree*, and on the other hand, the existence of resin-sacs in *Drimys*, and probably in some species of *Illicium*, allies it to *Magnoliæ*. Still the tribe *Illiciæ* is widely separated from these two tribes by the absence of certain anatomical characters possessed by one or the other of them: for instance, both the mucilage-canals and crystal-bearing sclerenchymatous elements of the *Schizandree*, and the diaphragms and scleroblasts which are found respectively in the pith and in the outer cortex of *Magnoliæ*, are wanting. Thus, here again is a tribe which may be anatomically considered as a distinct group.

The wood in *Drimys* is almost exclusively made up of tracheids, and the leaf-petiole has its fibro-vascular bundles arranged in a semicircle, points which ally this genus to *Trochodendron* in another tribe. Thus *Illiciæ* and *Trochodendree* might seem to be connected through these two genera, were it not that the very characters that ally *Trochodendron* to *Illiciæ*, widely separate this genus from *Euptelea* and *Cercidiphyllum*, the other two genera of *Trochodendree*. Further, these other two genera are not only but slightly related to each other, but are also destitute of any anatomical characters that may serve to connect them with the members of the other tribes. Such being the case, it is evident that the tribe *Trochodendree* is very indefinite in its anatomical characters, and that on these grounds we ought to place *Trochodendron* in the *Illiciæ*, and establish a new tribe, *Euptelea*,

which would include *Euptelea* and *Cercidiphyllum*, the remaining two genera of *Trochodendrea*.

Summing up, the *Magnoliaceae* may be split up into the following four groups :

First group, identical with *Magnoliaceae*.

Second group, identical with *Schizandreae*.

Third group, consisting of *Trochodendron* and the genera of *Illiciaceae*.

Fourth group, consisting of *Euptelea* and *Cercidiphyllum*.

Now, it is worth noticing that the four groups into which *Magnoliaceae* might be divided as the result of a purely anatomical study, correspond in the main to its four tribes, the distinction between which is based on the external characters ; and we should not perhaps be wrong in making the general statement that resemblance in the external characters of certain plants indicates that there also exists resemblance in their internal or anatomical structure.

As we have just seen *Illicium* and *Drimys* present some marked differences in their anatomical characters, as do also to some extent *Euptelea*, *Cercidiphyllum*, and *Trochodendron*, which are the three genera constituting *Trochodendreae* ; but *Magnolia*, *Michelia*, and *Liriodendron*, the three genera belonging to *Magnoliaceae* are so similar in their internal structure as not to be distinguishable from one another, and this is also the case with the two genera of *Schizandreae*, namely, *Schizandra* and *Kadsura*. From this we see that anatomical structure is not always to be relied upon in distinguishing different genera of the same tribe or family. However, we must remember that *Schizandra* and *Kadsura* have differences so slight in their generic characters* that Baillon combines them into one genus.† Again, *Magnolia*, *Michelia*, and *Liriodendron*

* Generic characters are generally founded on external peculiarities, and not on internal ones.


† Baillon, *The Natural History of Plants*, (Translated from the French).

are so related in their external characters that there are not wanting cases in which some species of one of the three genera is often placed in either of the other two.† If we except the case of such closely related genera, it is probably the rule that any two genera of the same tribe or family present anatomical characters of such difference as to distinguish them from each other.

If it is difficult in some cases to distinguish certain genera of the same tribe or family from one another by anatomical characters alone, much more would it be so to distinguish in this way species included in the same genus. Such is actually the case in the present family, and so it would perhaps be in other families.

I wish to express here my obligations to Professor Edward Divers for his kindness in looking through the present article and in suggesting many improvements in English.

† Thus, *Magnolia pumila*, Andr., *Liriodendron coco*, Lour, and *Liriodendron lilifera*, Linn, are synonymous; also *Michelia fuscata*, Blume, *Magnolia fuscata*, Andr., and *Liriodendron Figo*, D. C., are synonymous—*The Journal of the Linnean Society*, Vol. XXIII, No. 150.



Explanation of Plates.

List of Reference Letters.

(Those not found here are explained where they occur.)

- ac.* aggregate of crystals.
- c.* cambial zone.
- cp.* cortical parenchyma.
- cr.* crystals.
- cs.* crystal-bearing sclerenchymatous element.
- cu.* cuticle.
- dm.* diaphragm.
- e.* endodermis.
- eh.* epidermal hair.
- ep.* epidermis.
- es.* elongated sclerenchymatous cells.
- g.* guard cells.
- hp.* hypoderma.
- i.* intercellular space.
- il.* inner limit of xylem.
- k.* cork.
- m.* cells constituting medullary ray.
- md.* pith.
- mp.* passage containing mucilage.
- mp'.* passage containing mucilage in process of formation.
- p.* parenchymatous cells.
- pc.* pericambium.
- ph.* phloëm.
- pm.* cell constituting phloem ray.
- rc.* sac or reservoir containing crystals.
- ro.* sac or reservoir containing oily or resinous substance.
- s.* stone-cells or scleroblasts.

EXPLANATION OF PLATES.

- sq.* group of sclerenchymatous fibres.
 - sl.* sclerenchymatous fibres or bast fibres.
 - ss.* sclerenchymatous sheath.
 - t.* trichoblasts.
 - x.* xylem.
 - z.* one of the cells that form a row representing a bundle-sheath.
-

PLATE II.

Plate II.

- FIG. 1.—Cross section of phloëm and cambial zone of *Euptelea polyandra*. $\times 285$.
 w. a zone of newly formed wood, where lignification is incomplete.
- FIG. 2.—Longitudinal radial section of outer cortex of *Euptelea polyandra*, showing three crystal-containing sacs. $\times 355$.
- FIG. 3.—Cross section of epidermis of midrib of leaf of *Euptelea polyandra*, presenting cuticular ridges in cross section. $\times 355$.
- FIG. 4.—Cross section of young root of *Euptelea polyandra*: A, younger; B, a little older stage. $\times 200$.
- FIG. 5.—Longitudinal radial section of a portion of phloëm of *Cercidiphyllum japonicum*, showing crystal-containing sacs; *l* indicates the side nearer to the centre of the stem; *r*, the side farther from the centre. $\times 200$.
- FIG. 6.—Cross section of the middle portion of petiole of *Cercidiphyllum japonicum*; *a, a, a*, mark the zone where distorted cells are found. $\times 45$.
-

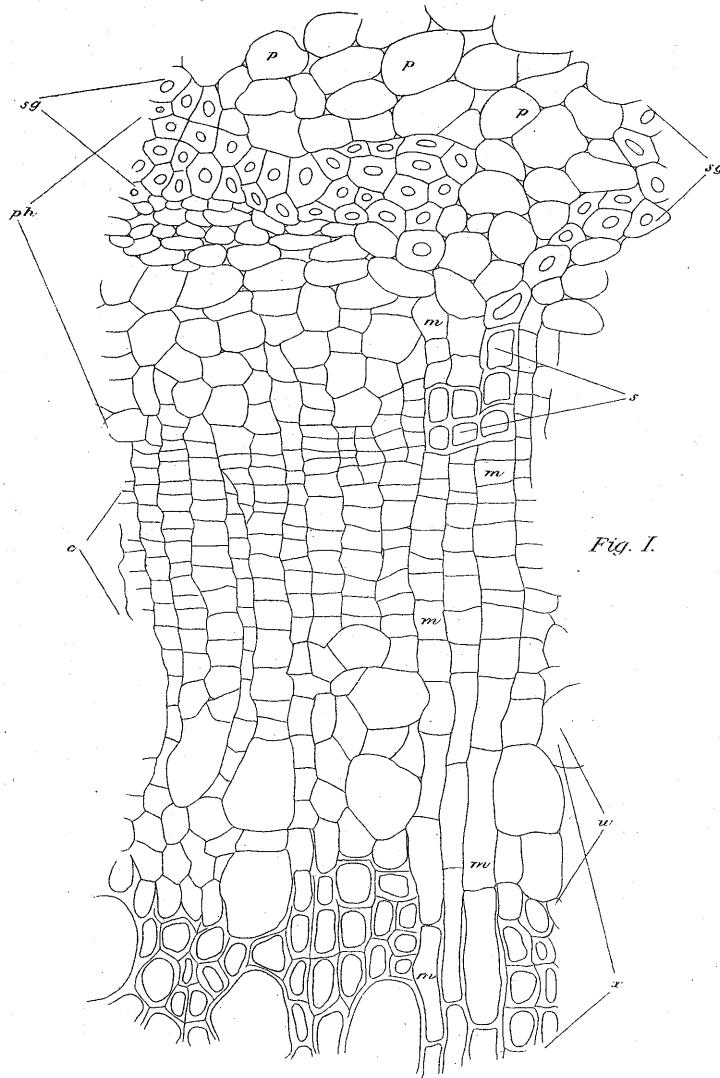


Fig. 1.

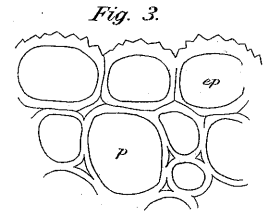


Fig. 3.

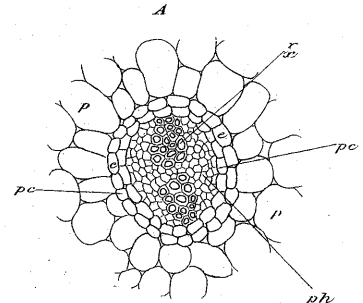


Fig. 4.

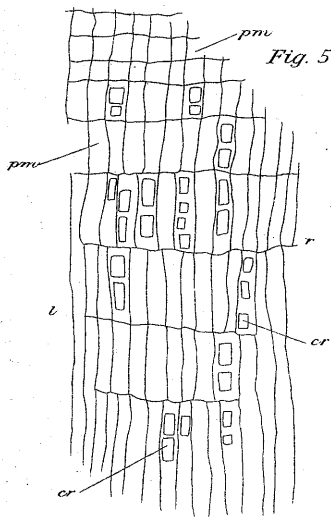
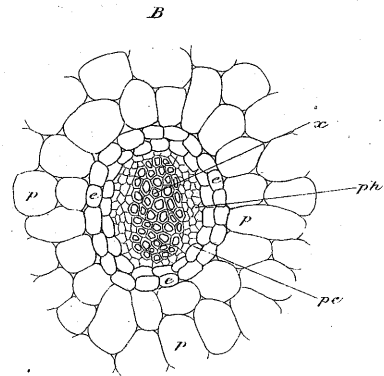


Fig. 5.

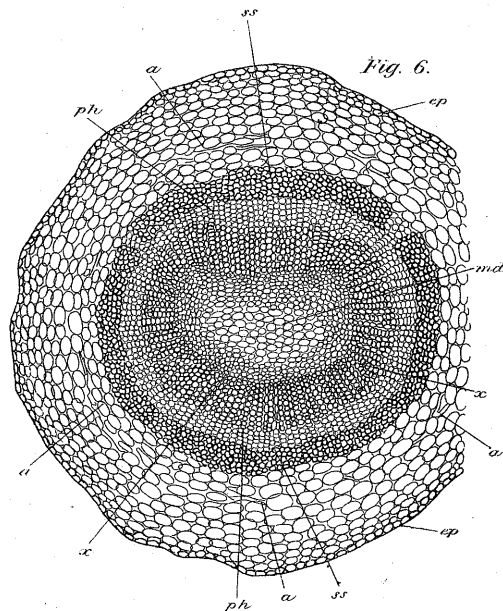


Fig. 6.

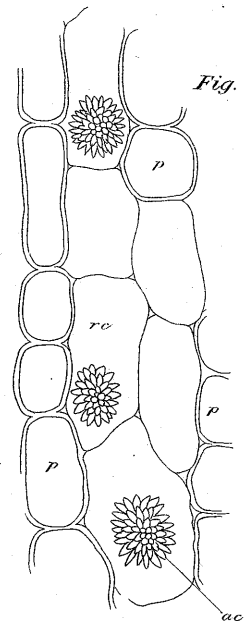


Fig. 2.

PLATE III.

Plate III.

- FIG. 7.—Cross section of the middle portion of petiole of *Trochodendron aralioides*.
×45.
- FIG. 8.—Cross section of young root of *Trochodendron aralioides*; endodermis and pericambium not well marked. ×200.
- FIG. 9.—A trichoblast (separated by maceration) from outer cortex of *Trochodendron aralioides*. ×130.
- FIG. 10.—Cross section of a stoma of *Trochodendron aralioides*; *cs*, cup-shaped cuticular elevation at the entrance of the stoma. ×445.
- FIG. 11.—Cross section of phloëm and a portion of xylem of *Illicium religiosum*.
×285.
- FIG. 12.—A, cross section of a small portion of outer cortex of *Illicium Tashiroi*, showing a resin sac; B, that of *Drimys dipetala*; (only dried specimens were examined). ×200.
-

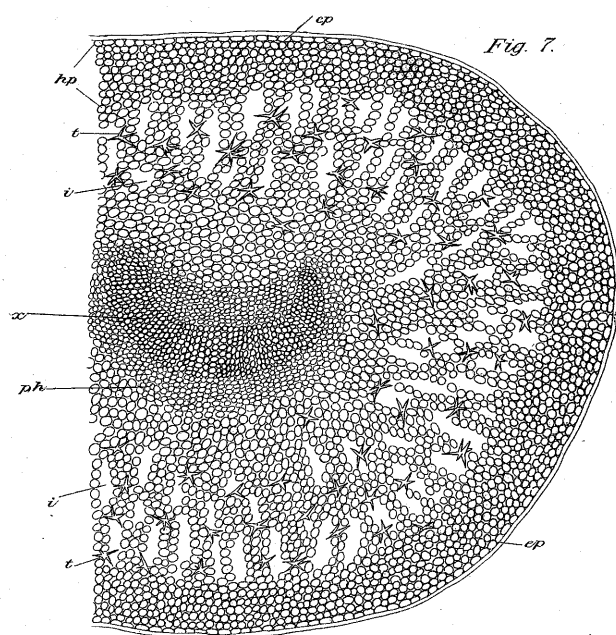


Fig. 7.

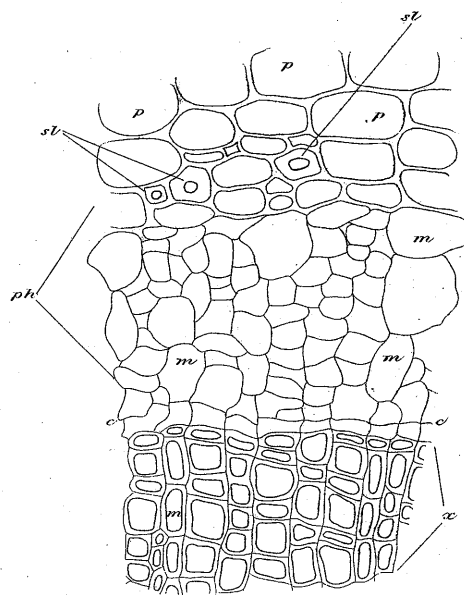


Fig. 11.

Fig. 9.



Fig. 8.

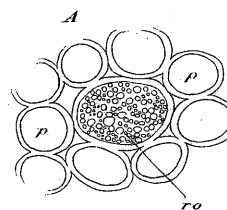
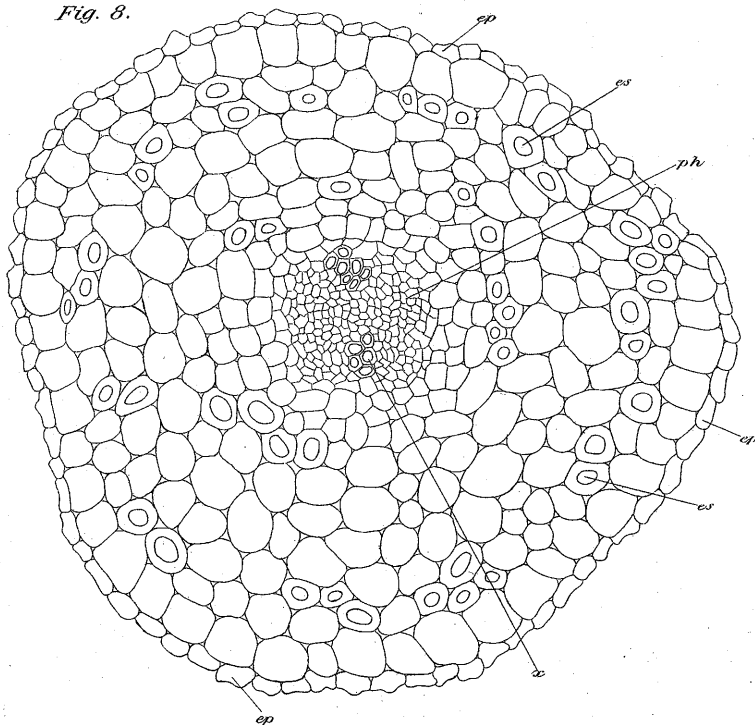


Fig. 12.

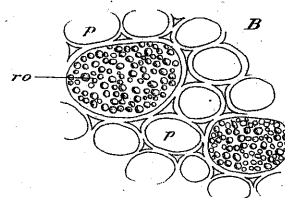


Fig. 10.

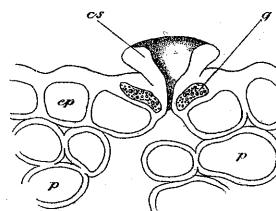


PLATE IV.

Plate IV.

- FIG. 13.—Cross section of outer cortex of *Kadzura japonica*. $\times 110$.
- FIG. 14.—A, secretory reservoir in longitudinal tangential section of outer cortex of *Schizandra nigra*; B, that of *S. chinensis*; C, that of *K. japonica*; D, that of root of *K. japonica*. All $\times 180$.
- FIG. 15.—Longitudinal section of pith of *Schizandra nigra*. $\times 45$.
- FIG. 16.—Superficial view of an epidermal cell of *Schizandra nigra* containing an aggregate of crystals. $\times 445$.
- FIG. 17.—A, cross section of young root of *S. chinensis*, presenting the triarch arrangement of xylem-plates; B, that of a little older one of the same. $\times 200$.
- FIG. 18.—Cross section of the middle portion of petiole of *Kadzura japonica*. $\times 45$.
- FIG. 19.—Cross section of a part of the fibro-vascular bundles of petiole of *Kadzura japonica*. $\times 200$.
- FIG. 20.—Various forms of crystal-bearing sclerenchymatous elements; A and B, from stem of *K. japonica*; C and D, from its petiole. $\times 200$.
- FIG. 21.—Septate bast-fibre from *K. japonica*. $\times 70$.
-

Fig. 13.

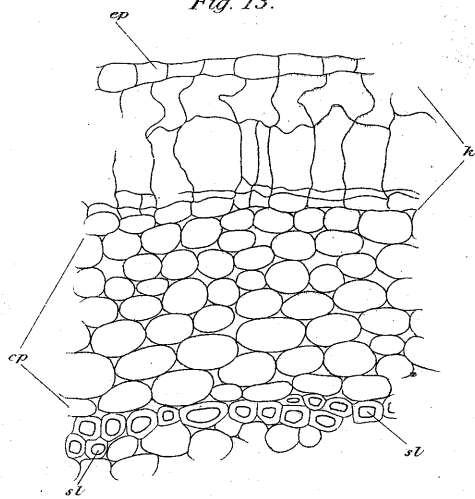


Fig. 15.

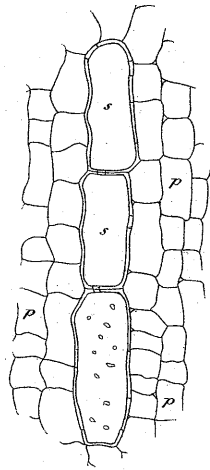


Fig. 17.

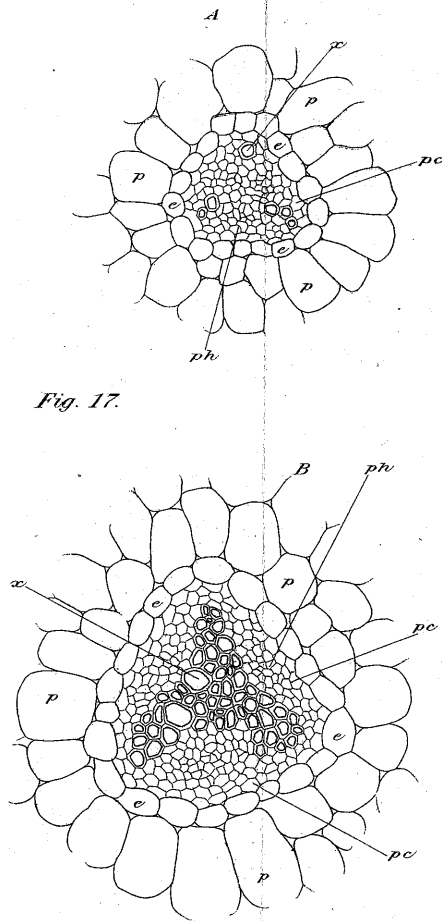


Fig. 19.

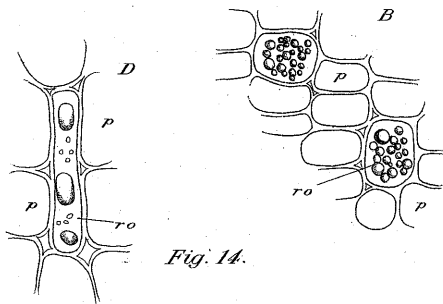
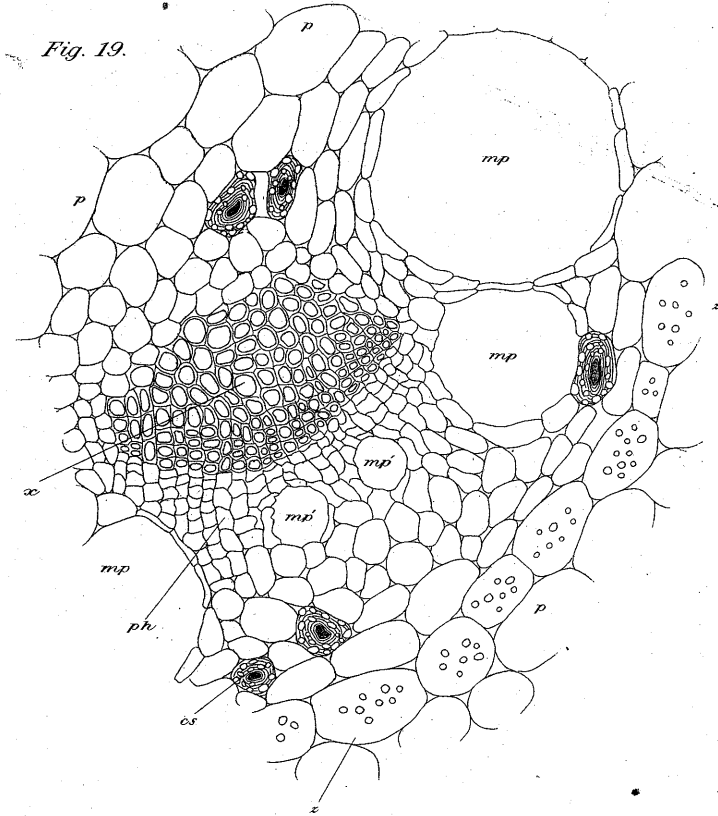


Fig. 21.



Fig. 16.

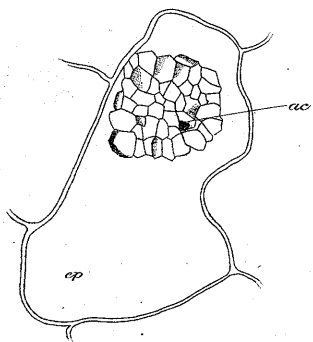


Fig. 20.

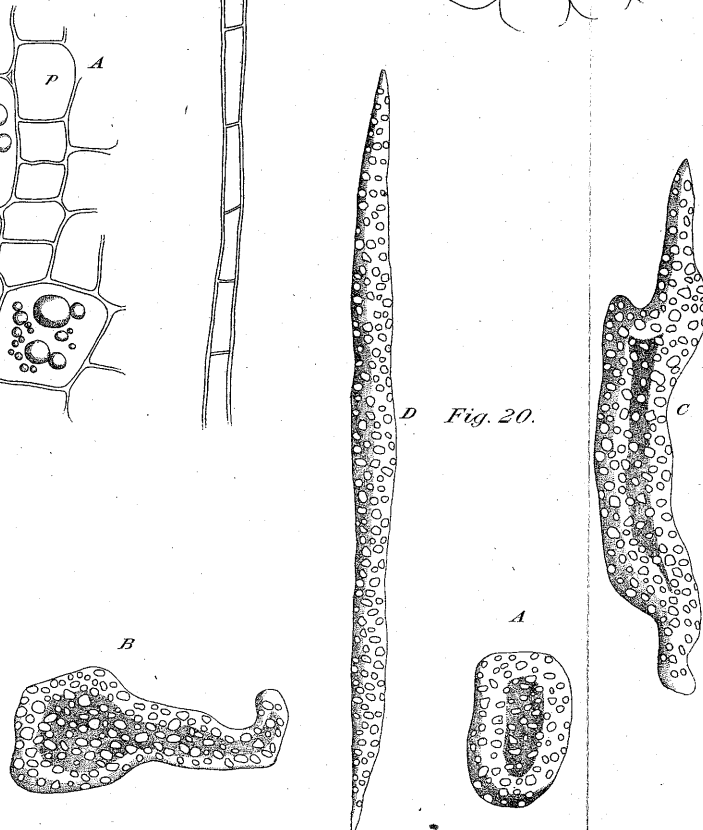


Fig. 18.

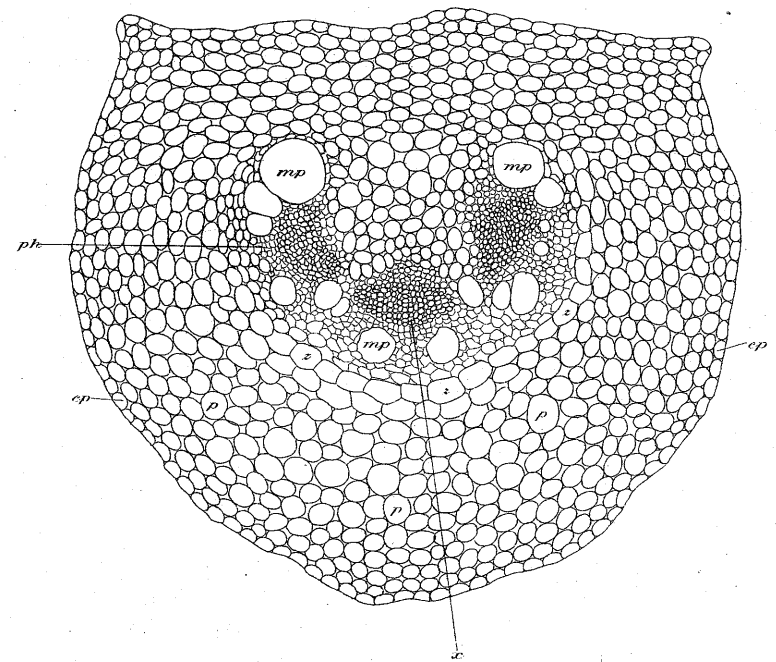


PLATE V.

Plate V.

- FIG. 22.—Cross section of outer cortex of *Magnolia obovata*. $\times 130$.
- FIG. 23.—Longitudinal tangential section of a small portion of outer cortex of *Michelia Champaca* showing resin sacs. $\times 130$.
- FIG. 24.—Epidermal hairs of the smaller kind found in *Magnolia obovata*, var. (*Kanshu-mokuren*). $\times 355$.
- FIG. 25.—The basal portion of an epidermal hair from the lower side of the leaf of *Magnolia conspicua*, var. *purpurescens*. $\times 355$.
- FIG. 26.—Superficial view of a portion of epidermis of *Magnolia Watsoni*; *bs*, basal portion of an epidermal hair cut crosswise. $\times 355$.
- FIG. 27.—A, pith of *Michelia compressa* in longitudinal section showing "diaphragms," ($\times 15$); B, the same in cross section, and more magnified ($\times 70$); C, in longitudinal section, and magnified as in B.
- FIG. 28.—Outer cortex of *Magnolia hypoleuca*, showing hypodermis; A, cross section of younger stage; B, cross section of a little older stage; C, longitudinal radial section of the same stage as B. $\times 130$.
- FIG. 29.—Cross section of the leaf of *Magnolia grandiflora*. *l*, a layer of cells lying directly below the epidermis of the upper side of the leaf. $\times 130$.
- FIG. 30.—Stoma of *Magnolia pumila* in cross section; *es*, a cup-shaped cuticular elevation at the entrance of the stoma. $\times 445$.
- FIG. 31.—Stoma of *Magnolia grandiflora* in cross section; guard cells lying directly upon epidermal cells. $\times 355$.
- FIG. 32.—A, cross section of young root of *Magnolia compressa*; B, longitudinal section of a small portion of the same, showing an elongated sclerenchymatous cell. $\times 200$.
-

Fig. 23.

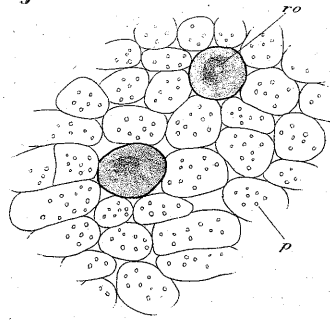


Fig. 26.

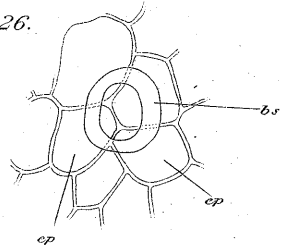


Fig. 25.

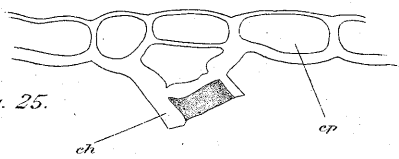


Fig. 24.

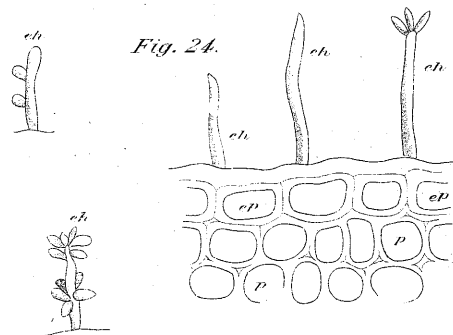


Fig. 28.

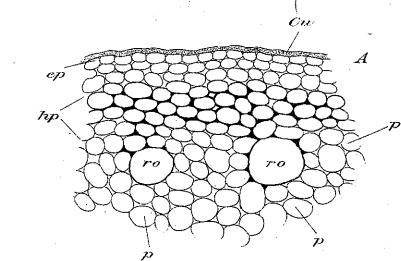


Fig. 31.

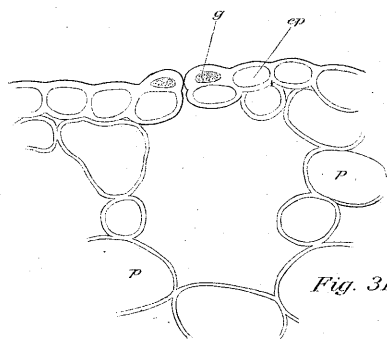


Fig. 27.

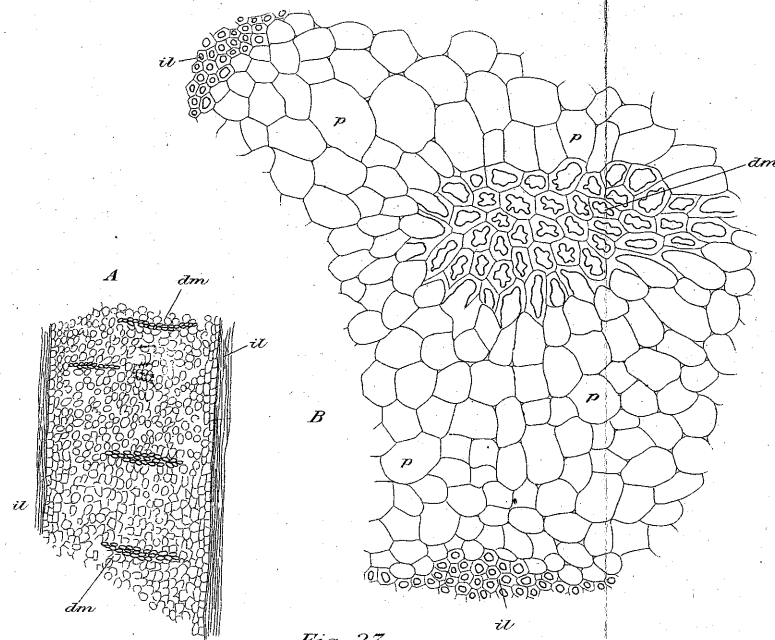


Fig. 29.

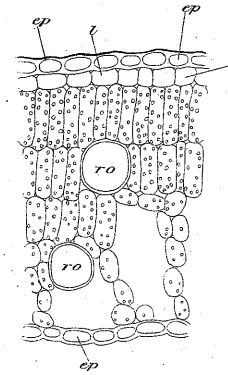


Fig. 22.

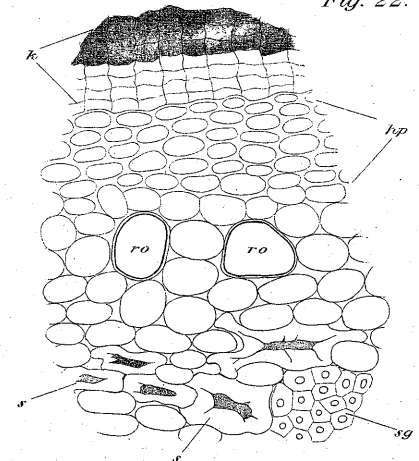


Fig. 30.

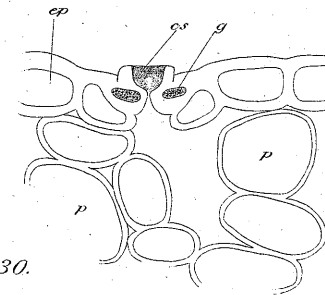


Fig. 32.

