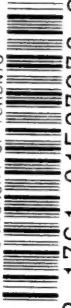


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**A GUIDE TO THE IDENTIFICATION
OF OUR MORE USEFUL TIMBERS**

CAMBRIDGE UNIVERSITY PRESS

C. F. CLAY, MANAGER

LONDON : FETTER LANE, E.C. 4



NEW YORK : THE MACMILLAN CO.

BOMBAY

CALCUTTA

MADRAS

} MACMILLAN AND CO., LTD.

TORONTO : THE MACMILLAN CO. OF
CANADA, LTD.

TOKYO : MARUZEN-KABUSHIKA-KAISHA

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100
A GUIDE TO THE IDENTIFICATION
OF OUR MORE USEFUL TIMBERS

BEING A MANUAL FOR THE USE OF
STUDENTS OF FORESTRY

BY

HERBERT STONE

LECTURER IN FORESTRY (WOOD)

CAMBRIDGE
AT THE UNIVERSITY PRESS

1920

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PREFACE

THIS GUIDE aims at giving information on certain points which are not easily accessible elsewhere or have hitherto been treated in a manner unsuitable to our purpose. It is therefore assumed that the reader has sufficient knowledge of the elementary structure of wood, to follow the descriptions. Two objects are kept in view: firstly the observation of the characters of the different species, and secondly the utilization of those characters to discriminate between one species and another.

No so-called "specific gravities" are given, since those so far recorded are taken either from long series of well-worked species which have so wide a range as to be quite useless for comparison (for instance between 0.45 and 0.90 for the Scots Fir), or from short series of less familiar woods (say 0.70 and 0.75); the latter, in spite of appearing to vary but little, may average the same as the former. Hence the rather vague terms "heavy," "moderately heavy," and so on are used, since at least they do not mislead.

The illustrations are restricted to figures (taken from photographs of sections in the Cambridge Research laboratory) which are deemed necessary where the critical detail can be seen only by means of the microscope or where such detail is a difference of degree and not of kind.

The Generic numbers attached to the species are those of Bentham and Hooker's *Genera Plantarum*, according to which system, the specimens of wood in the collection of the School of Forestry are arranged. Any specimen needed for comparison can be found immediately by means of these numbers.

Every effort has been made to find points of difference in kind, those of degree, such as the varying size or numbers of the rays and vessels, etc., or the colour, hardness, weight, etc. not being reliable. This has been done satisfactorily in all cases except those of the Poplars, Willows and Horse Chestnut, a most difficult group, the Common and Wych Elms, and the Mahoganies: all these cases demand a training of the senses only to be acquired by the handling of many specimens.

HERBERT STONE.

WOOD RESEARCH LABORATORY,
CAMBRIDGE.
April, 1920.



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INTRODUCTORY NOTE

THE first part of each description contains the information necessary for the identification of each species, except a few which can be known by experience only (i.e. by acquaintance with their external appearance).

Students are not expected to learn by heart all the details of the first portion but will be expected to observe them, as this course is intended to be a training in observation, for which there is nothing better than a study of the structure of wood. The second portion of each description is intended for use when there is doubt between species.

The key is for general use and is not necessary as a part of the course, but students are recommended to accustom themselves to the use of such keys. It is frankly empirical, as it is not desirable to introduce a scientific and more difficult key at this stage; moreover all keys are useless as soon as additional species are introduced.

Be sure of your section by first examining the transverse and comparing it with the others as, in curly wood sometimes, the former may crop out anywhere. (See specimen 460/6703 of Alder which shows the transverse section on two adjacent edges of the same corner.)

Always search for the widest and best developed ring.

Be sure that you are certain which is the inner (pith) side and which the outer (bark) side of the ring.

In difficult cases, make notes of your observations.

Wet a portion only of the surface of the wood.

Be sure that the colour of the wood is not due to external influences (light, weathering, fading, etc.).

Hold the wood towards the light to observe rays in transverse section and away from the light to see resin-canals on the plank-face. Note colour, hardness, weight, texture, surface, lustre, and smell.

When comparing two woods, hold them side by side so that a portion of the surface of each is visible under the lens at the same time.

Never come to a decision before using the lens.

Acquire the habit of running down the species, step by step, by asking yourself the following questions:

Is the wood a Conifer or a Broad-leaf?

(a) **If a Conifer** (see p. 35):

Has it vertical and horizontal resin-canals?

Does the horizontal resin-canal occupy much or little of the transverse diameter of the ray in tangential section (see figs. 7-9)?

INTRODUCTORY NOTE

How many pits are to be seen in the cross-field and do they occupy much or little of the space (see figs. 4-6 and p. 37)?

Are there any resin-cells present and can they be seen as darkish bands in the solid wood in transverse section? Have the vertical tracheids spiral thickenings?

Are there any tracheids in the rays (radial section)?

Is the epithelium of the resin-canals of thin or thick-walled cells?

Is the wood odourless or fragrant?

(b) If a Broad-leaf (see p. 3):

Is there a pore-ring?

Is the pore-ring of two or more rows of vessels or is it of a single row? Is the single row crowded or scantily provided with pores? Are the pores made more evident by light coloured tissue packed between them?

How are the pores of the autumn wood arranged?

Are large and small rays both present?

Are the large rays many-rowed (multiseriate), or aggregate (i.e. composed of many smaller rays as in a bunch)?

If small, are the rays still visible with the unaided eye?

Are there uniseriate as well as multiseriate rays present?

Are the large rays evenly distributed in transverse section or are they in patches, or casual in their occurrence?

Are the rays bright or dull in any section?

If the wood is diffuse-porous, are the pores widely isolated or apparently crowded as seen with the lens?

Do the pores diminish in size or numbers from the inner to the outer side of the ring?

Is this a sudden or gradual diminution in size of the pores from within outwards?

If the pores be crowded, is there any arrangement to be discerned at any point where they thin out?

Is the parenchyma visible (with eye or lens)? Is it in close connection with the pores (vasicentric "a"), or is it independent of the pores and concentric in direction ("b")? Are both "a" and "b" present?

What is the colour of the silver-grain and how much of the surface of the wood does it cover?

I. BROAD-LEAVED TREES

TULIP TREE (CANARY WHITEWOOD)

Liriodendron tulipifera Linn. Magnoliaceæ.

A diffuse-pored wood of a white colour sometimes with a greenish tinge, deepening to brown or even black by exposure to the light. Distinctly green when polished. Soft and light in weight. A sapwood tree.

Transverse section. Boundary a very clear, fine line, lighter in colour than the fibres.

Parenchyma not visible with lens: dispersed amongst the fibres.

Vessels, small (lens), crowded and evenly distributed throughout the section, diminishing a little, regularly outwards to the boundary.

Rays very clear though small, visible at arm's length especially when wetted; direct, not avoiding or running round the pores; slightly nodose where crossing the boundaries; much lighter in colour than the ground-fibres; multiseriate (microscope): uniseriate rays rare.

Radial section. Boundary clear, vessels fine, but still visible; rays obscure (but though small yet very distinct when wet or polished).

Tangential section, as the radial, but the boundaries are somewhat more prominent; in darkened wood they appear frequently as hoary loops. Rays very obscure even with lens.

May be confused with:

Willow (colour pinkish-brown: uniseriate rays).

Poplar (white or brownish-white: rays uniseriate).

Horse Chestnut (white: very light in weight: rays uniseriate).

Birch (white or ecru: rays chiefly multiseriate just visible to the naked eye: many uniseriate).

Lime (white or ecru: rays chiefly multiseriate, many uniseriate: just visible).

Sycamore (white: rays in tangential section produce a half-tone effect: in transverse section the larger are thick and thin, irregularly spaced, and of seldom less than 5 rows of cells wide, still uniseriate rays are abundant).

May be distinguished by:

Colour white to brown or greenish-brown: multiseriate rays which in transverse section are visible at arm's length.

As above, rays multiseriate.

As above, rays multiseriate.

As above, uniseriate rays very rare.

As above, uniseriate rays very rare.

Rays in tangential section, obscure, no half-tone effect: in transverse section regular in size and spacing: uniseriate rays rare. Septa of the vessels with grids (scalariform).

LIME TREE

Tilia vulgaris Heyne: synonyms, *T. europæa* Linn.; *T. cordata* Mill.
Tiliaceæ.

A diffuse-pored wood of medium hardness and weight. Colour white or ecru, uniform. A sapwood tree.

Transverse section. Compare Fig. 3. Boundary a single continuous row of vessels little if any larger than those of the Autumn wood. Parenchyma not visible with lens, dispersed throughout the fibres. Vessels very small (lens or to good sight), evenly distributed: diminishing a little in the outside of the pore-ring.

Rays visible, very fine, rather irregular in size and spacing: direct (not avoiding the vessels): brown, lighter in colour than the ground: multi-seriate.

Radial section. Boundaries fairly clear: vessels visible but very fine, septa absorbed, no grids: rays obscure yet visible (especially when wetted), pale brown.

Tangential section. As the radial, but the boundaries are much clearer though rarely prominent: vessels very fine, but visible: rays (lens); no half-tone effect.

May be confused with:

Willow (light weight: uniseriate rays).

Poplar (uniseriate rays which are sinuous in transverse section, i.e. as though wriggling between the vessels).

Birch (medium coarse grain: vessels in oblique lines in transverse section and rather widely isolated from one another (Fig. 2): little difference in size between Spring and Autumn vessels: grids in the vessels).

Tulip-tree (rays very clear in transverse section being visible even at arm's length: boundary a fine whitish line: uniseriate rays very rare).

Sycamore (rays in transverse section, visible at arm's length: in tangential section they produce a half-tone effect).

May be distinguished by:

Medium weight: chiefly multi-seriate rays; many uniseriate.

Multiseriate rays which are visible in transverse section and are direct not wriggling.

Fine grain: vessels in short curves at times but never in oblique lines passing across the whole width of the ring: a difference in size between Spring and Autumn vessels: no grids in the vessels.

Rays in transverse section, visible but by no means prominent: boundary a line of contrast or at most a row of small pores: uniseriate rays abundant.

Rays as last (above): no half-tone effect in tangential section.

MAHOGANY (CUBAN)

Swietenia Mahagoni Jacq. Meliaceæ.

A hard, heavy, rich red wood, striped as a rule with lighter and darker bands. Grain coarse, open and generally cross. Surface bright.

Transverse section. Boundary a fine line of lighter colour, just visible.

Parenchyma vasicentric (sheathing the vessels) very scanty if any: perhaps the boundary line may, also, be of this tissue.

Vessels rather large, readily visible when filled with white substance and just visible when filled with black. Few and widely isolated: fairly uniformly distributed with a tendency to oblique lines. Contents mostly black and red, some white and sometimes even green. Mostly single, some pairs and a few radial groups of three pores.

Rays just visible, fine sub-regular in size and spacing, at intervals of the width of a vessel apart, multiseriate.

Radial section. Boundary hardly traceable: vessels as medium-coarse grooves with a few resin drops. Silver-grain prominent as narrow, closely-arranged flakes of a lighter colour but duller, than the fibres.

Tangential section. Boundaries sometimes hardly perceptible, yet clear, fine lines (lens). Rays visible with lens as minute brown lines. Under microscope they are seen to be distorted as though a strand of fibres had been pulled across, thus sub-dividing them. Wood-fibres septate.

May be confused with many similarly-coloured woods, especially Honduras, Tabasco, African and other Mahoganies.

Honduras and Tabasco (rays symmetrical in tangential section). Cuban: rays distorted in tangential section.

See note at end of Tabasco Mahogany.

MAHOGANY (HONDURAS)

Reputed to be *Swietenia macrophylla* King. Meliaceæ.

A rather light diffuse-porous wood of medium hardness. Uniform reddish-brown colour, usually very straight-grained. A few minute glistening beads of resin or gum may be seen here and there.

Transverse section. Boundary, a fine, but readily visible, white line.

Parenchyma vasicentric (sheathing the vessels) very scanty or none. Perhaps the boundary line is of this tissue also.

Vessels rather large, just visible, widely isolated and evenly distributed. Much more numerous than in Cuban Mahogany. Single or in pairs or radial groups of three: contents not so often visible in this section, little,

if any, white substance. Rays visible at arm's length yet very fine, sometimes sinuous as though wriggling their way amongst the vessels; sub-regular in size and spacing, the width of a vessel apart. Multiseriate.

Radial section. Boundary visible with great difficulty, if at all, without lens. Rays visible, more so when wet. A little white deposit in the ray cells.

Tangential section. As the radial, but the boundaries sometimes very obscure indeed. Vessels as rather fine grooves evenly disposed over the surface. Rays (microscope), symmetrical, i.e. not lop-sided or subdivided by strands of fibres drawn across them (compare Fig. 10).

(See note to following variety.)

MAHOGANY (TABASCO)

Reputed to be *Swietenia macrophylla* King. (Meliaceæ.)

A rich brownish-red wood of uniform colour: grain medium coarse, open and straight: surface lustrous in radial section at least.

A rather pretty silver-grain of small flakes.

Transverse section. Boundary a fine light-coloured line. Parenchyma vasicentric (sheathing the vessels), very scanty or none. Perhaps the boundary line is of this tissue. Structure as the Honduras Mahogany, which is to be compared.

May be confused with many other similar woods, particularly Honduras Mahogany. If any difference is to be discerned it is in the rather larger vessels in the present variety and the boundaries of the rings which in tangential section are usually evident though sometimes but faintly, contrasting with the ground. Tabasco is no doubt of the same species as the Honduras, but differs in quality and colour.

From the Cuban Mahogany which is reputed to be the true *Swietenia Mahagoni* and which I believe it to be, both Tabasco and Honduras may be distinguished by the white substance being more abundant in the rays whereas in the Cuban it is more abundant in the vessels. Further the present species is much straighter in the grain, softer and lighter in weight. The rays in tangential section are different, those of the Cuban being distorted and of the Honduras and Tabasco, symmetrical.

HORSE CHESTNUT

Æsculus Hippocastanum Linn. Hippocastanaceæ.

A diffuse-porous wood of a white colour sometimes with a slight yellow tinge, very fine grain and light in weight.

Transverse section. Colour, creamy white when cleanly cut. Boundaries, some fine lines and sometimes a single ring of vessels, which are a little larger than those of the later wood. Parenchyma invisible with lens, dispersed throughout the fibres. Vessels the smallest on record, just visible with a good lens, evenly distributed. Rays exceedingly fine (lens).

Radial section. Boundaries traceable, but faint: vessels scarcely perceptible; rays just visible in certain lights and slightly darker than the ground. Five to eight round pits in the cross-fields of the edge cells which are prostrate: vessels sometimes spirally thickened but very difficult to find¹.

Tangential section. As the radial, but the boundaries are clearer in the form of loops sometimes minutely fringed: rays scarcely if at all visible even with lens.

May be confused with:

Willow¹, when light-coloured (vessels in longitudinal section visible though small).

Poplar¹ [medium coarse grain: medium weight (but in *P. nigra* no certain character available). Colour of transverse section when clear cut, silvery grey].

Lime and Birch (both multiseriate rays: medium weight).

Tulip-tree (rays multiseriate, very clear).

Sycamore (rays multiseriate, bright and prominent).

May be distinguished by:

Vessels in longitudinal section scarcely perceptible: a one-rowed pore-ring frequently present.

Vessels in longitudinal section scarcely perceptible: fine grain light weight: a fine pore-ring frequently present. Transverse section when clean cut, creamy white.

Uniseriate rays: light in weight.

Rays obscure in transverse section, uniseriate.

Obscure rays (lens).

¹ See note to Willow on microscopic details.

SYCAMORE

Acer Pseudo-Platanus Linn. Aceraceæ.

A moderately hard and heavy, diffuse-porous wood of uniform structure. Colour, white with characteristic lines (the ring boundaries), and a fine hatching or half-tone effect produced by the rays in tangential section. A sapwood tree.

Transverse section. Boundary an extremely fine line, clear, but not prominent. Parenchyma not visible with lens; dispersed among the fibres. Vessels small (lens), fairly evenly distributed: no great variation in size. Rays small, but very clear and bright, visible at arm's length especially when wetted: very irregular in size and spacing.

Radial section. Boundaries clear: vessels very fine, but yet visible. Rays (prominent when wetted or polished), white to brownish.

Tangential section. As the radial, but the boundaries appear as prominent, but fine loops. Rays minute, but from their abundance producing the half-tone effect referred to above: the rays are individually clearly visible though so small.

May be confused with:

Poplar (the white kinds, which have medium coarse grain and obscure uniseriate rays).

Birch (medium coarse grain: rays in transverse section just visible).

Acer campestre (rays very difficult to see in transverse section by reason of the lack of contrast in colour with the ground. If the half-tone effect be produced, the rays are not individually visible).

Tulip-tree (silver-grain of a lighter colour than the ground: weight of wood, light. Watery and alcoholic extracts, pale green. Rays seldom, if ever, more than three rows of cells wide: one-rowed rays rare). Septa of vessels with grids.

Lime [rays obscure in transverse section though just visible. Reaction (watery extract) with perchloride of iron, olive].

May be distinguished by:

Rays very clear and visible at arm's length in transverse section: grain fine.

As above.

Rays in transverse section very clear as above: half-tone effect in tangential section pronounced, each ray though small, being visible to the unaided eye.

Medium weight: silver-grain darker than the ground. Watery extract pale brown; alcoholic, colourless. The larger rays seldom, if ever, less than five rows of cells wide but many small rays of one row only, occur. No grids.

Rays prominent and bright in transverse section. Perchloride of iron darkens and clouds the watery extract.

FALSE ACACIA

Robinia Pseudo-Acacia Linn. Leguminosæ (Papilionatæ).

A hard, heavy wood of a whitish-greenish brown colour to dark brown streaked with pale lines: ring-porous with frequently a prominent zigzag tracery in tangential section. Structure particularly clear in transverse section where the fibres are very dense and take a sort of natural polish from the tool. Lustre in longitudinal section often metallic. A very variable wood. A heartwood tree. Sapwood narrow, from 1-5 rings only.

Transverse section. Boundary, the scanty pore-ring compacted and rendered evident and often conspicuous, by much light-coloured parenchyma. Contour sub-regular.

Parenchyma as above, but in the dense, well-grown wood, confined to small amounts around or attached to the vessels (i.e. vasicentric): in the outer zone of the late wood, sometimes joining up a few groups of pores to short lines and angles or even running to concentric lines. Colour of the parenchyma, white or greenish-white: it remains so after the wood has been darkened by exposure.

Vessels small yet individually visible, diminishing a little and regularly outwards to the boundary. Excepting those of the pore-ring, they are widely isolated radially (i.e. the groups, which may be of from one to three, or even more vessels). The vessels of the pore-ring are scarcely larger than those produced immediately after. All are choked with thyloses which are visible with the lens.

(Obs. In some cases all the pores are connected into concentric lines; see the 4-ft plank No. 279/1691.)

Rays visible at arm's length, irregular in size and spacing, at intervals of the width of a pore or less. They appear at times to run through the edges of the vessels, but in reality they pass through their sheaths of parenchyma (a). Colour of rays, white, yellow or brown.

Radial section. Boundary conspicuous as a band of coarse vessels along which the parenchyma (a) appears as a prominent, hoary stripe. Rays dull and inconspicuous though fairly large hoary or white flakes.

Tangential section. As the radial, but the boundaries are very conspicuous coarsely-fringed loops with broad patches of dull, hoary parenchyma. Under the microscope the rays are seen to be low (the highest equal to about the length of ten of the parenchyma cells of same wood), in comparison with those of the *Laburnum* and are in palisade as in that species (see Fig. 12).

Reaction of perchloride of iron upon the watery extract, inky.

May be confused with:

Laburnum [thyloses few: rays high in tangential section (microscope)].

Elms (rays dark-coloured: parenchyma cells alternate).

Mulberry [wood greenish-white turning deep chocolate-brown. Parenchyma-cells (microscope) alternate. To the naked eye the parenchyma (a) is often dark-coloured: thyloses few or wanting].

May be distinguished by:

Vessels choked with thyloses, rays low in tangential section.

Rays light-coloured: parenchyma cells in palisade.

All vessels choked with thyloses, which are visible with the lens. Wood greenish-white, darkening considerably to a brown (hazel) colour but by no means so deeply and always remaining relieved by alternate stripes of a lighter colour.

LABURNUM

Laburnum anagyroides Medic.: synonyms, *Laburnum vulgare* J. Presl.;
Cytisus Laburnum Linn. Leguminosæ (Papilionatæ).

A hard, heavy wood of a greenish to deep brown colour, sometimes almost black. Generally in small pieces. Lustre satiny. Structure clear. A heartwood tree. Sapwood narrow, of 2-5 rings only.

Transverse section. Boundary, the pore-ring of about three rows of small pores compacted by parenchyma. Parenchyma vasicentric (sheathing the vessels) and joining them up to oblique lines that sometimes form crosses, angles and even lines. The latter flatten out much in the Autumn wood. Vessels small, not individually visible: those of the pore-ring not much larger than those in the later wood external to it: diminishing regularly outwards towards the boundary and nearly always linked up to others by parenchyma. Thyloses few and not very evident. Rays just visible at arm's length, though fine: irregular in size and spacing, at intervals of 3-4 times the width of a pore: colour, white, yellow or brown.

Radial section. Boundaries, conspicuous as lines of vessels accompanied by parenchyma of a lighter colour. Rays inconspicuous but quite evident, narrow flakes.

Tangential section. As the radial, but the boundaries are loops with conspicuous fringes and bands and patches of parenchyma. A zigzag tracery within the loops in the Autumn wood. Under the microscope the parenchyma is seen to be in palisade and the rays are high in proportion of those of Robinia: the highest are equal to that of about 30 parenchyma-cells of the same wood.

May be confused with:

Robinia (thyloses very abundant, the vessels being packed with them: rays low in tangential section (microscope): silver-grain and parenchyma remain white while the fibres deepen in colour).

Mulberry (parenchyma-cells alternate).

Elms (pores of the pore-ring much larger than those of the later wood: parenchyma-cells alternate).

May be distinguished by:

Rays high in tangential section, thyloses rare; silver-grain though whitish, darkens to brown on exposure.

Parenchyma-cells in palisade.

Pores of the pore-ring scarcely larger than those following on: parenchyma-cells in palisade in vertical section (microscope).

PEAR TREE

Pyrus communis Linn. Rosaceæ (Pomoideæ.)

A diffuse-porous wood of uniform structure: colour, brown to reddish-brown: rather hard and heavy. Sapwood not clearly differentiated from the heart.

Transverse section. Boundary a line of contrast in the density of successive rings.

Parenchyma not visible with lens: dispersed amongst the fibres.

Vessels small (lens), apparently crowded throughout the ring: diminishing considerably and regularly in size from the Spring to the Autumn wood. They occupy practically the major part of the section.

Rays fine but yet visible, numerous, at nearly regular intervals of the width of a large vessel apart: brown and lighter in colour and brighter than the fibres: multiseriate.

Radial section. Boundaries scarcely visible as are the vessels also. Rays, rather prominent, narrow, brown flakes occupying about half the surface. No spiral thickenings nor grids.

Tangential section. As the radial, but the boundaries are rather clearer yet inconspicuous. They are feebly fringed indicating slightly larger vessels at this point. Rays indistinguishable even with lens when wetted.

Watery extract, rich red, more intense than the colour of the wood.

May be confused with:

White Poplars (*P. alba*) (grain medium coarse, lustre silky, rays uniseriate).

Willows when dark-coloured and dense (much lighter in weight, rays uniseriate: reaction of watery extract with perchloride of iron, brown).

Alder when wide rays are absent (weight rather light: vessels tending to a radial arrangement and distinctly less numerous in the Autumn wood. Watery extract pale brown or nearly colourless).

Mountain Ash and Apple [watery extract pale yellow (citron)].

Other species of *Pyrus*.

May be distinguished by:

Grain very fine: rays multiseriate.

Medium heavy weight: great solidity: multiseriate rays: vessels occupy practically the whole of the ring uniformly. Reaction with perchloride of iron, olive.

As above. Watery extract, rich red.

Watery extract rich red.

No certain characters beyond general appearance.

RED GUM

Also known as Satin Walnut and the sapwood as Hazel Pine.

Liquidambar styraciflua Linn. Hamamelidaceæ.

A rather light, soft, diffuse-porous wood of a fawn, reddish or brownish colour, frequently striped with dusky bands. The sapwood is brownish-white. A wood which is very easy to work but badly given to warping and sinking. Lustre micaceous from the numerous drops of gum.

Transverse section. Boundary clear though not prominent, the limit being a fine line or zone of Autumn wood of varying sharpness. The smoky zones are independent of the structure.

Vessels very small (lens), little variation in size, evenly crowded throughout the ring though straggling lines may occasionally be discerned. Sometimes a few contain gum.

Rays, just visible in certain lights, very small, numerous and about the width of a large pore apart: brown.

Parenchyma, not visible but abundantly dispersed amongst the fibres as isolated cells. Wood-fibres mostly square in section.

Radial section. Boundaries rarely traceable but the dusky stripes often prominent. Vessels as innumerable fine scratches, many containing gum. Rays, fine inconspicuous flakes of about the same colour as the ground.

Tangential section. As the radial, but the rays are imperceptible even with the lens. The smoky bands widen out in this section.

Red Gum may be confused with:

True Walnut (vessels very large, rare and isolated: usually with black linings in vertical section: concentric parenchyma (b), present: surface bright).

Pear-tree (very compact and solid: watery extract deep rich red).

Alder (large rays when present: vessels thin out towards the outer side of the rings).

May be distinguished by:

Vessels very small, abundant, crowded, crystalline in vertical section: no (b) parenchyma: surface very dull but often covered with glistening points.

Light and soft: watery extract faint brown or dirty white.

Rays all very fine: vessels uniformly crowded throughout the rings: many glistening points on the surface.

ASH

Fraxinus excelsior Linn. Oleaceæ.

A rather hard, heavy ring-porous wood of a whitish or light brownish colour (rarely brown as in the Hungarian Ash): heartwood only in old trees and then a sign of decline.

Transverse section. Parenchyma vasicentric, white, surrounding the small pores of the Autumn wood, chiefly in the outermost zone of the ring where it sometimes unites a few groups of pores to arcs, angles and short lines. These lines are rarely of any length being usually mere scraps. The limit of the ring is of parenchyma also.

Vessels of the pore-ring very large and conspicuous, of 2-4 rows of pores, gradually diminishing in size for a short time, and then very abruptly, those of the outer zone being very minute. Often sub-divided (mother and daughter) groups. A strong tendency to oblique lines amongst the pores which then leave rounded spaces of unoccupied wood.

Rays scarcely, if at all, visible to the unaided eye, very fine, whitish, irregular in size and spacing, at intervals of about the width of a large pore apart; multiseriate.

Radial section. Parallel bands of coarse grooves (the boundaries) very prominent by reason of the pore-rings. The grooves are generally brownish or yellowish within. Pith large, about $\frac{1}{4}$ inch diameter, soft, grey.

Tangential section. As the radial, but the boundaries are still more prominent being coarsely fringed loops. Zigzag tracery rarely indicated and then very discontinuous. Rays minute, visible with the lens with care.

May be confused with:

Elm when light coloured, especially the Wych Elm (pores in the Autumn wood in pronounced, practically continuous, concentric lines. Rays and parenchyma, deep brown).

Chestnut (pores in the Autumn wood in radial streams).

Ailanthus glandulosus and *Gymnocladus canadensis* (rays in transverse section visible at arm's length).

Hickory (parenchyma (b) in concentric lines easily visible with the lens, and sometimes with the naked eye).

May be distinguished by:

Pores in the Autumn wood, joined here and there with white parenchyma producing short lines, arcs and angles. Rays very obscure, nearly colourless.

Pores in the Autumn wood never in radial streams (see above).

Rays obscure, need lens.

Parenchyma (a) vasicentric, joining a few groups in the Autumn wood only. No parenchyma (b).

TEAK

Tectona grandis Linn. Verbenaceæ.

A rather hard, heavy wood of a uniform rich brown colour to neutral brown: grain coarse, open and straight. Structure clearly visible. Smell when worked, like leather. Greasy to the touch.

Transverse section. Boundary a very clear fine line of light-coloured parenchyma accompanied by a scanty ring of pores, together giving the wood the appearance of being ring-porous.

Parenchyma otherwise scanty, surrounding the vessels (vasicentric), hardly visible with lens. Sometimes the parenchyma joins up a few vessels in the late Autumn wood.

Vessels visible individually, those of the pore-ring larger than the rest. Those of the later wood diminishing abruptly immediately outside the pore-ring and afterwards more gradually, outwards. Very few and widely isolated in the outer zone with a tendency to leave rounded empty spaces. Mostly single, a few twinned. Contents often white (said to be phosphate of lime or apatite).

Rays scarcely visible, very fine, sub-regular in size and spacing, at intervals of about the width of a vessel apart.

Radial section. Boundary, the coarser lines of vessels. Rays, fairly conspicuous, narrow flakes visible chiefly by reflection.

Tangential section. Boundary indicated by the fringes only, as a rule. The parenchyma may be prominent at times, and obscure at others. Rays, minute, needing lens.

May be confused with:

Elm (concentric lines of vessels in the Autumn wood).

Mulberry when darkened by exposure (wood greenish-white when freshly cut. Smell, none: surface clean).

Oaks and Chestnut (radial streams of vessels in transverse section).

May be distinguished by:

Vessels isolated in the Autumn wood.

Wood brown throughout: smell offensive: surface greasy.

Vessels isolated in the Autumn wood.

BOXWOOD

Buxus sempervirens Linn. Buxaceæ.

A very hard, heavy wood of a yellowish colour striped with lighter and somewhat darker bands. Diffuse-porous. Cold to the touch: generally sinks in water. Very resistant to splitting.

Transverse section. Boundary a line of contrast in the density of adjoining rings; frequently a narrow zone in the outer Autumn wood without pores, which zone therefore appears darker.

Parenchyma invisible with the lens: dispersed throughout the fibres.

Vessels just visible with good lens, exceedingly small, numerous and regularly distributed except in the darker zone already referred to.

Rays exceedingly fine and numerous, clearly visible with lens.

Radial section. Boundaries clean-cut: vessels invisible to the naked eye: rays obscure yet visible as minute flakes.

Tangential section. As the radial, but the boundaries are clearly indicated by sharp, unfringed loops of varying depth of colour. Rays exceedingly minute yet multiseriate.

Not easily confused with any other woods but the species of the same genus and with the West Indian Box (so-called). This latter and the Cape Boxwood (*Buxus Macowani*) are generally readily fissile and show little or no contrast of colour between the zones of the ring. The European Boxwood will break rather than split and the zones of the ring are alternately light and dark yellow. From the West Indian Box it may be further distinguished by the form of the pith. In that wood the pith is round and generally defective from shakes whereas that of the true Boxwoods, is four-lobed or in *B. sempervirens*, winged. Again our species has but little capacity for water but the West Indian Box is very absorbent.

COMMON ELM

Ulmus campestris Linn. Ulmaceæ.

A rather hard, heavy, ring-porous wood of a brown colour striped with darker brown (the pore-rings) and a prominent silver-grain of narrow, brown flakes. A heartwood-tree. Sapwood narrow. Wood resistant to splitting.

Transverse section. Boundary, the pore-ring compacted by much parenchyma. Contour sub-regular.

Parenchyma (a) abundant around the vessels (vasicentric), extending laterally or obliquely and joining up the vessels to concentric or oblique lines (in very wide rings of quickly-grown wood, the parenchyma (a) in the Spring zones may however be scarcely more than sheaths around the vessels).

Vessels of the pore-ring readily visible, of two to three rows. Those of the Autumn wood in concentric wavy, nearly continuous lines that become flatter as they approach the outer boundary. The lines in wide rings are at first very oblique. The vessels are single or in radial, sub-divided pairs and threes or more.

Rays sometimes visible when dry, always when wet: irregular in size, but sub-regular in spacing, at intervals from about the width of a vessel apart, to twice that distance.

Radial section. Boundaries (the pore-rings), very prominent, between which are seen fine brown lines which are practically continuous (i.e. lines of Autumn vessels). These may be full of thyloses which are spherical not flattened. Spirally thickened fibres abundant and clear (microscope).

Tangential section. As the radial but the rays are extremely minute. By reason of their numbers and dark colour, they produce a half-tone effect that imparts a very soft appearance to the surface of the wood. In the Autumn wood, a pretty zigzag tracery is seen within the coarsely-fringed loops. When viewed by the microscope in tangential section, the rays have the contour of a broad-beamed boat (Fig. 10).

The light-brown watery extract gives a brown precipitate with perchloride of iron; it does not turn inky.

May be confused with:

Other Elms such as Wych Elm [hard to work; rays in tangential section narrow of the form of a racing "eight" (Fig. 11). Reaction with perchloride of iron, golden, no precipitate (constant?)]. Spirally thickened fibres rare and obscure.

May be distinguished by:

Its capacity for the holding of nails and easy working. Rays in tangential section dark, but producing a pronounced half-tone effect and under the microscope they appear as stout bodies having the outline of a steamer (Fig. 10). Reaction slight, brown precipitate. Spiral fibres abundant and clear.

American Elm (heavy and hard: vessels of the pore-ring of one row only: annual rings much reduced in width, rays scarcely visible even when wetted).

Mulberry (wood greenish-white when freshly planed, the brown colour being superficial: concentric lines of Autumn pores developed only in the Autumn wood, if at all, the vessels being for the most part isolated. Silver-grain lighter than the fibres).

False Acacia [silver-grain and rays in all sections, light-coloured. Parenchyma in vertical section, in palisade (see Fig. 12)].

Laburnum. As False Acacia, but surface darkens all over and the silver-grain tends to become obscure.

Pore-ring of two or more rows of vessels: rays generally visible when dry, always so when wetted (transverse section).

Colour brown throughout though darker, on the surface: concentric lines present everywhere except in the inner Spring zone of very wide rings. Silver-grain darker than the fibres.

Rays dark brown. Parenchyma alternate (see Fig. 10).

As above: surface darkens but little and the silver-grain remains prominent.

WYCH ELM

Ulmus montana With: synonym, *U. effusa* Sibth., not Willd. Ulmaceae

A wood so much resembling that of the Common Elm that no distinction that is constant can be found. It is only by long practice that the two woods can be distinguished. The working qualities are the best guide: the present species is troublesome to work, but easily riven. The developed rings sometimes have but one row of pores.

(Note. *Ulmus effusa* is a bad species according to the *Index Kewensis*. *U. montana* was included by Linnaeus under the same title of *U. campestris*.)

The golden watery extract changes but little with perchloride of iron: it does not turn inky. Spirally thickened fibres difficult to find.

If our specimens be characteristic, then the points to be looked for are the less-pronounced half-tone effect produced by the rays in tangential section and (under the microscope) a corresponding difference in the shape of the rays (see Figs. 10, 11). In *U. montana*, they are narrow spindle-shaped bodies of a form which may be compared to the outline of a racing skiff, while those of *U. campestris* are more like that of a steamer. The consequence of this difference of form is, that the rays of the latter species are more evident to the naked eye.

The Wych Elm is hard to work, tough and elastic. *U. campestris* is much easier to work and though tenacious of nails is comparatively inelastic. The appearance of some specimens of Wych Elm, suggests *A. fraxinifolia* rather than Elm (the zigzag fringes of the latter of course, apart).

ELM (AMERICAN)

Ulmus americana Linn. Ulmaceæ.

A moderately hard and heavy, ring-porous wood of a pale brownish-white, cane-like colour: not much resembling English Elm. Structure badly developed in most rings, as little Autumn wood is produced.

Transverse section. Boundary, the pore-ring compacted by much parenchyma (a) of a light colour, which almost smothers the pores and greatly affects the colour of the section. The parenchyma occupies half or more of the transverse surface.

Vessels of the pore-ring usually of one row only. Those of the Autumn wood much smaller and joined up into very delicate, light-coloured, concentric wavy lines.

Radial section. Silver-grain pale and inconspicuous.

Tangential section. Rays difficult to see even with the lens: no half-tone effect produced. Grain rather fine. Other characters much as in the Common Elm which should be compared.

Ulmus racemosa Thomas, the Rock Elm, is similar to the above but generally of slower growth.

May be confused with:

May be distinguished by:

Common Elm (pore-ring of several rows of pores: coarse texture: surface very soft-looking from the half-tone effect produced by the brown rays in tangential section).

A one-rowed pore-ring, fine cane-like texture: no half-tone.

Wych Elm (fast-grown, pore-ring of two or more rows except in badly developed rings. Silver-grain clear. Parenchyma an extremely small proportion of the area).

Slow-grown: pore-ring rarely if ever of more than one row even in well-developed rings.

PLANE TREE

Platanus orientalis Linn.: synonym, *P. acerifolia*. Willd. Platanaceæ.

A whitish, ecru or brown wood with a remarkably conspicuous though dull silver-grain. Medium weight and hardness. Sapwood merges gradually into the darker central wood.

Transverse section. (Note. Under microscope in transverse section, this wood is indistinguishable from Beech.) Boundaries sometimes very clear, but sometimes not traceable over large areas. Contour crenate (i.e. arched outwards) between the rays (lens).

Parenchyma not visible with lens.

Vessels just visible? very small, diminishing in size though but little, outwards to the boundary: crowded (lens) throughout the ring.

Rays large, very numerous and close but inconspicuous (unless wetted) on account of their lack of lustre: nodose where they cross the boundaries.

Radial section. Silver-grain very conspicuous though dull, occupying a large proportion of the surface. Boundaries hardly traceable.

Tangential section. A great contrast to the radial: the rays produce a somewhat matt surface, the individual rays being obscure though still quite visible. Small (uniseriate) rays very rare.

May be confused with:

Beech (rays in tangential section widely separated, bright and distinct, many small ones: ring-boundaries, sharp in all sections).

Alder (large rays rare and widely separated. Silver-grain, scanty, pale and straggling).

Western Plane-tree (boundaries of the rings very sharp everywhere).

May be distinguished by:

Rays in tangential section, though more abundant and closer together, are dull and produce a matt surface: small rays rare. Ring boundaries obscure in all sections.

Rays abundant and close together in all sections.

Boundaries variable, sometimes fairly definite but usually indistinguishable over long radial distances.

HICKORY

Carya alba Nutt. or *Carya amara* Nutt. Juglandaceæ.

A coarsely ring-porous wood, usually white, much resembling Ash (i.e. the sapwood which is the most used), but sometimes of a warm brown colour (the heartwood). Hard and heavy.

Transverse section. Boundary, a line of contrast in the density of succeeding rings accompanied by a scanty row of very large vessels.

Parenchyma doubtfully of two kinds (in any case the vasicentric is not present in our specimens though I cannot believe that it is entirely absent). Parenchyma (b) very prominent when viewed with the lens, and frequently visible to the naked eye. It is of a white colour and in concentric bars, which make sub-continuous lines in tangential direction. It is present in the Spring wood as much as in the later wood.

Vessels, of the pore-ring very large indeed, and visible individually as perforations. They diminish in size abruptly, immediately outside the pore-ring. Very few vessels in the later wood where they are widely isolated. They are single or twinned with some radial groups of three or four (mother and daughter groups).

Rays very fine, but clear (lens), somewhat irregular in size and spacing, about the width of a large vessel or less apart: rather lighter in colour, than the ground (white in the sapwood, brown in the heartwood).

Radial section. Boundaries not easily traceable as the pore-bands (rings) are discontinuous though coarse. Rays obscure and small, just visible? multiseriate.

Tangential section. As the radial, but the boundaries are very coarsely-fringed loops, somewhat interrupted. Much smooth wood within the loops. Rays (lens), inconspicuous.

The heartwood of Hickory may be confused with: *May be distinguished by:*

Walnut (parenchyma (b) in transverse section, very obscure).

Parenchyma (b) very evident with lens or even visible to the unaided eye.

Chestnut (radial streams of vessels).

Vessels scattered in the Autumn wood.

Oak (large and small rays).

Small rays only.

Elm (undulating concentric lines of Autumn vessels).

Vessels scattered in the Autumn wood.

The sapwood may be confused with:

Ash (vessels in minute angles and arcs in the Autumn wood. Parenchyma (a) vasicentric only, around the vessels joining a few groups in the Autumn wood).

Vessels scattered: concentric parenchyma (b) present, often visible to the naked eye.

WALNUT

Juglans regia Linn. Juglandaceæ.

A feeble or bastard-ring-porous wood of a characteristic neutral-brown colour to which it gives its name: often striped with blackish lines. The grain (exposed vessels) has black linings also. Rather hard and heavy. A heartwood tree. Sapwood whitish or ecru.

Transverse section. Boundary a line of contrast in the density of succeeding rings or often a thin band of denser tissue along which are found a loose row of large vessels.

Parenchyma of two sorts (**a**) very scanty, vasicentric, not visible with lens; (**b**) in minute bars, very fine, generally visible in the Autumn zone (needs lens and careful search, being difficult to see even with microscope in this section and needs oblique light. To make sure that the nature of this tissue is properly grasped, the student should compare the Hickory in which this parenchyma (**b**) is visible with the naked eye). There is also some parenchyma dispersed amongst the fibres.

Vessels just visible, rather large, very few and widely isolated, often twinned or in radial threes and fours. The vessels diminish gradually in size outwards to the boundary.

Rays very fine, multiseriate, regular in size, but rather irregular in spacing, at intervals from the width of a vessel apart, to double that distance: brown, lighter in colour than the ground.

Radial section. Boundaries somewhat indefinite. Vessels rather coarse, black or blackish within. Rays just visible as a half-tone effect.

Tangential section. As the radial, but the boundaries appear as coarse, but thinly-fringed loops frequently accompanied by a paler zone corresponding to the Spring wood. Rays need lens, but by their numbers and colour, impart a soft tone to the surface.

May be confused with:

The heartwood of Hickory [parenchyma (**b**) very clear and light-coloured. Pore-ring loose but very prominent].

Red Gum or Satin Walnut [pores very small and crowded (lens), and indistinguishable with unaided eye on plank face. Wood soft and light].

American Black Walnut (*J. nigra* Linn.), colour tending to purplish-brown, grain usually straight.

May be distinguished by:

Parenchyma (**b**) very difficult to see (lens). Pore-ring loose and made evident by the light-coloured tissue around the pores rather than by the pores themselves.

Pores very large and widely isolated, becoming rapidly smaller towards the outer boundary of the ring. On plank face they appear as shiny, black-lined grooves. Wood hard and heavy.

Colour tending to drab-brown, grain usually curly: no certain distinction.

BIRCH

Betula alba Linn.: synonyms, *B. verrucosa* Ehrh.; *B. nigra* Duham.
Betulaceæ.

A diffuse-porous wood of medium weight and hardness. Colour white, ecru or more rarely brownish. A sapwood tree.

Transverse section (compare Fig. 2). Boundary just perceptible, a line of contrast in the density of successive rings (sometimes a thin line of flattened cells, under microscope).

Parenchyma not visible with the lens (except as to the line just mentioned); it is dispersed amongst the fibres.

Vessels just visible, a tendency to arrange themselves in oblique lines, which here and there are quite distinct and run across the whole width of the ring in well-developed rings (they are best seen on a surface which has been wetted, and allowed to dry). The oblique lines frequently make angles one with another. The vessels diminish in size, but very slightly, from the inner side of the ring outwards. They are isolated widely and in either single or in sub-divided (mother and daughter) groups of two or three vessels.

Rays just visible, yellow to brown, and of a colour different to that of the fibres: they are almost direct (i.e. not wriggling between the vessels), irregular in spacing, at intervals sometimes equal to the width of a vessel but generally much more.

Radial section. Boundaries visible, but not prominent. Silver-grain brown, rather inconspicuous except when wet or polished: grain medium coarse. Septa of vessels with grids (scalariform: microscope needed).

Tangential section. As the radial, but the boundaries are loops with feeble fringes: the surface of the wood, especially where cross-grained, shows vague zigzag in patches. Rays multiseriate.

Pith flecks abundant in the early rings. Grids of septa of vessels appear in this section as rows of dots or, when torn, like rake-teeth.

May be confused with:

¹Lime (finer grain and paler silver-grain: vessels in transverse section not in oblique lines passing across the whole width of the ring; rather crowded. No grids in the septa. Wood warm to the touch).

Willows (light in weight: colour pinkish-brown, grain fine, rays uniseriate (they seem to meander amongst the pores)).

May be distinguished by:

Coarser grain: vessels in transverse section in well-developed rings in oblique lines making angles: widely isolated. Grids in the septa. Wood cold to the touch.

Medium weight: colour ecru to brownish: grain rather coarse: rays multiseriate, firm and straight.

¹ Although the distinguishing characters seem vague on paper yet in a thin transverse section under microscope ($\times 20$) of Lime and Birch they are very readily recognised (see Figs. 2 and 3).

Tulip-tree (rays clearly visible at arm's length).

Sycamore (rays very bright, visible at arm's length).

Field Maple (great solidity: vessels not in oblique lines but scattered).

Poplars (vessels if tending to oblique lines, yet the latter are rarely developed in the Spring wood: rays uniseriate).

Horse Chestnut (uniseriate rays, fine pores, light weight, soft and warm to the touch).

Rays just visible to the naked eye.

Very inconspicuous rays.

Very inconspicuous rays: vessels in oblique lines.

Vessels in oblique lines which pass right across the rings when latter are well developed: rays multiseriate, firm and straight.

Multiseriate rays, rather coarse pores, medium weight and hardness: cold to the touch.

ALDER

Alnus glutinosa Medic. Betulaceæ.

A diffuse-porous brownish or ecru-coloured wood of medium hardness. Rather plain unless the rare, pale straggling rays appear in radial section. A sapwood tree.

Transverse section. Boundary, a line of contrast in density between the rings, sometimes very clear or may be very obscure. Contour crenate (arched outwards), between the large rays, where a notch occurs: this is large in proportion to the size of the ray.

Parenchyma. Invisible with lens.

Vessels small, just visible, diminishing in size regularly outwards to the Autumn wood; to the lens, apparently crowded and occupying much of the section, but thinning out in the outer side of the ring: a tendency to a radial disposition.

Rays of two kinds, simple and compound: the larger rare and casual, and sometimes absent over wide areas, at others in groups: dull and obscure unless wetted: nodose at the point where they cross the boundaries.

Radial section. Boundaries obscure or sharp in places: vessels just visible, rays rare and dull, but very long and straggling when properly exposed.

Tangential section. As the radial, but the boundaries rather more definite: the rays appear as brownish spindle-shaped bodies, which are readily visible, but need looking for: height from one to many inches. The smaller rays appear as a fine, but quite visible, brown secondary silver-grain.

May be confused with:

Plane tree (large rays crowded occupy half the section: silver-grain very conspicuous and covering much of the surface).

Beech (silver-grain conspicuous though small: rays bright and readily visible in all sections: in tangential section they are not more than $\frac{1}{2}$ inch high).

Pear (watery extract rich red).

May be distinguished by:

Large rays rare: silver-grain (when well exposed) of widely separated flakes which are pale and straggling.

Silver-grain as above, dull rays in tangential section, 1 inch or more high.

Watery extract very pale brown, nearly colourless.

HORNBEAM

Carpinus Betulus Linn. Betulaceæ.

A diffuse-porous wood of a white colour, very hard and heavy, showing in transverse section the very marked undulating contour of the rings. A sapwood tree.

Transverse section. Boundary, a line of contrast in the density of succeeding rings, along which may be found a scanty line of small pores. Contour as above, in bold waves which become more accentuated as the tree ages. This particular contour has nothing to do with the shape of the pith, as is sometimes stated.

Parenchyma (a) vasicentric, very scanty and invisible with lens, and (b) in fine bars between the rays, very scanty also (needs microscope).

Vessels very small (lens), those of the boundary a little the larger: those of the greater part of the ring minute and disposed more or less radially between the small rays. They thin out in the Autumn wood.

Rays of two kinds (small and aggregate, i.e. bunches of small rays). The aggregate rays are readily visible, white, casual in their occurrence, being sometimes in groups, and at others absent over wide areas of the section. The smaller rays need lens.

Radial section. Very smooth and plain. Boundary sometimes apparent. Vessels very fine. Rays broad, white flakes which contrast but little with the ground.

Tangential section. As the radial, but the rays are merely high spindle-shaped bodies that are often obscure.

Not easily confused with:

Any other wood except perhaps Holly which has rings of regular contour; rays numerous and regular in occurrence rarely exceeding $\frac{1}{4}$ inch high in tangential section, and though small are multiseriate. Its silver-grain appears as very narrow flakes.

May be distinguished by:

Undulating contour of rings, large rays which are few and casual, and high in tangential section (1 to several inches). The small ones are uni- and multi-seriate mixed.

THE DECIDUOUS OAKS

For example, *Quercus robur* var. *sessiliflora* Salisb. *Q. pedunculata* Ehrh., and others. Fagaceæ.

Ring-porous brown or reddish-brown woods with a conspicuous silver-grain. Hard and heavy. Heartwood trees. Sapwood wide.

Transverse section. Boundary, the pore-ring.

Parenchyma of two kinds, (a) imbedding the vessels (vasicentric), abundant and clearly visible. It unites the vessels to radial streams. Parenchyma (b) in concentric lines or narrow zones chiefly in the Autumn wood, usually very obscure and needing a cleanly-cut section, and the lens. [Compare the American Red Oak, where this parenchyma (b) is very clearly shown.]

Vessels coarse, in radial streams as above. They diminish greatly and regularly in size outwards to the Autumn boundary. Thyloses present in most species.

Rays prominent, of two kinds, large (multiseriate), and small (uniseriate). The larger are very irregular in size and spacing, the smaller regular and about the width of a large vessel apart. Colour of the large rays brown, lighter than that of the fibres.

Radial section. Boundaries very prominent and of coarse vessels. Rays conspicuous as a silver-grain (or flower), which is lustrous or dull according to the incidence of the light. Thyloses generally visible with lens as débris in the grooves.

Tangential section. Boundaries appear as coarsely-fringed loops: rays long, brown, spindle-shaped bodies best seen in the Autumn wood within the loops: height 1-2½ inches or even more.

May be confused with:

Chestnut (rays need lens in all sections except the radial where they are very minute flakes).

Evergreen Oaks (no pore-ring).

Elms (vessels in the Autumn wood in concentric lines).

May be distinguished by:

Rays visible in all sections especially the radial.

Prominent pore-ring.

Radial streams of vessels.

OAK (AMERICAN WHITE)

Quercus alba Linn. Fagaceæ.

A hard, heavy ring-porous wood much resembling English Oak, but of a neutral-brown colour which is far less agreeable to the eye, especially when polished.

May be confused with:

American Red Oak (reddish-brown colour, watery extract clear or greenish. Thyloses rare, if any).

English Oaks (thyloses present but in small quantity: in any case the vessels are not packed with them. Colour warm, brown).

May be distinguished by:

Neutral brown colour: watery extract very deep nut-brown: vessels almost always packed with thyloses.

All vessels packed with thyloses. Colour of wood, a disagreeable neutral brown.

OAK (AMERICAN RED)

Quercus rubra Linn. Fagaceæ.

A rather hard and heavy ring-porous wood resembling English Oak, but with a distinctly pinkish tinge.

Structure, that of the deciduous Oaks. The slight differences given below may or may not be constant.

Transverse section. Parenchyma (b). The concentric lines are very clear and regular, and visible to the unaided eye.

Vessels contain few or no thyloses.

Tangential section. Rays very much more evident than in the English Oaks, and much less in height (up to about $\frac{3}{4}$ inch as against one to three inches). Their clearness and prominence suggest a resemblance to those of the Beech.

Reaction, watery extract nearly colourless or greenish.

May be confused with other deciduous Oaks especially the English Oaks and the American White Oak (*Q. alba*). From these it is easily distinguished by the watery extract which in the case of the present species is nearly colourless but in the others is deep nut brown. The extract of the American Red is, or becomes, slightly green after 24 hours, while that of the others remains as before.

It is commonly stated that the Red Oak has no thyloses and may be identified by this means. It is true that thyloses are very much less abundant and indeed rare, in this species, but they can generally be found (at least in our specimens).

EVERGREEN, HOLM OR HOLLY OAK

Quercus Ilex Linn. Fagaceæ.

This wood, as in all evergreen Oaks, is hard and heavy, with a very showy silver-grain that is much deeper in colour than the ground fibres.

Structure, as in the deciduous Oaks (apart from the absence of the prominent pore-ring) although in appearance very different. The sap-wood merges gradually into the heart.

Transverse section. Boundary, a narrow band of denser wood.

Parenchyma of two kinds as usual in the Oaks and their allies: (a) imbedding the vessels, and uniting them to the radial streams, which in this case may extend over many inches of radius without interruption, and (b) concentric and independent of the vessels. These latter zones are numerous and far more apparent than they are as a rule, in the English Oaks.

Vessels few, but very large. Groups of rather larger ones, which are widely isolated occur here and there in the Spring wood, and sometimes suggest a pore-ring.

Rays, of two kinds, large and small, the former extremely conspicuous and broad (almost the broadest on record).

Radial section. Boundaries inconspicuous, but sharp. Silver-grain very prominent and beautiful.

Tangential section. As the radial, but the rays appear as unsymmetrically spindle-shaped bodies of irregular size. They seem as though cut up by strands of fibres passing obliquely across them.

May be confused with:

Deciduous Oaks (prominent pore-ring).

May be distinguished by:

Pore-ring absent or at most but feebly indicated.

SWEET, SPANISH OR EDIBLE CHESTNUT

Castanea sativa Mill.: synonyms, *C. vesca* Gaertn.; *C. vulgaris* Lam.
Fagaceæ.

A ring-porous, brown wood of uniform colour, coarse grain and medium hardness and weight. A heartwood tree: sapwood narrow.

Transverse section. Boundary, the pore-ring.

Parenchyma of two kinds, (a) (vasicentric) imbedding the vessels at times into radial streams and at others nearly absent. It is usually visible at arm's length, but it is exceedingly capricious in its appearance [for (b) see below].

Vessels very large and prominent especially in the pore-ring. In the Autumn wood they are in radial streams, sometimes branching and slightly oblique to the radius: they leave wide, empty spaces between the streams as in the Oak. The vessels diminish very much in size in a regular manner, outwards to the boundary of the ring. Thyloses rare, if any.

Rays very fine (lens), numerous and regular in size and spacing, at intervals of about the width of a large vessel apart.

Radial section. Boundaries (pore-rings), very conspicuous as coarse (often sinuous) bands of vessels. Rays very obscure, generally invisible except with lens. Parenchyma (b) concentric in zones of one cell wide visible only in transparent section (microscope).

Tangential section. Boundaries, the coarsely-fringed loops; rays just perceptible (lens) when wetted.

May be confused with:

Oak (large rays which show up as a prominent silver-grain in radial section, and in tangential section as brown, spindle-shaped lines of 1 inch or more in height).

Ash (vessels in small arcs or angles in the Autumn wood).

Elms, Robinia, Mulberry, Ailanthus, Gleditschia (vessels in concentric lines, arcs, angles, etc., at least in the Autumn wood).

Teak (vessels isolated in the Autumn wood).

May be distinguished by:

Rays visible only with lens in transverse and tangential sections and doubtfully with the unaided eye in radial section.

Vessels in radial streams nearly always shown up by light-coloured parenchyma.

As above.

As above.

BEECH

Fagus sylvatica Linn. Fagaceæ.

A diffuse-porous wood of a whitish to reddish-brown colour with prominent, lustrous rays which in a tangential section make small but clear, brown "ermine" markings. Rather hard and heavy. The sapwood gradually merges into the darker, central wood.

Transverse section. Boundary, a line of contrast in density between successive rings, often rather vague to the unaided eye, but clear with lens. Contour crenate or notched between the rays (i.e. arched towards the bark).

Parenchyma not visible with lens.

Vessels visible with lens, small, diminishing regularly towards the outer side of the ring, apparently crowded (lens), and occupying most of the section.

Rays of more than one size (uni- and multiseriate) very bright and evident, irregular in size and spacing, the larger widely separated, light brown, lighter than the ground: harder than the fibres.

Radial section. Boundaries fairly distinct, always sharp: vessels just visible: rays conspicuous and lustrous. Parenchyma (b) in zones of one cell wide, not visible except with microscope in transparent section.

Tangential section. As the radial, but the boundaries more evident as loops: rays dark, spindle-shaped bodies, small and widely separated, but very distinct.

May be confused with:

Plane-tree (rays dull though very conspicuous in radial section: in tangential section they are obscure, very numerous, and close together producing a matt surface: small rays rare: no concentric parenchyma (b)).

Alder (large rays dull and rare, very high in tangential section, from an inch to many inches).

May be distinguished by:

Rays very bright in all sections: in tangential section they are widely separated and clear though small: small rays abundant. Parenchyma (b) present.

As above: height of rays not exceeding $\frac{1}{2}$ inch.

WILLOWS

Salix alba, capræa, fragilis and *cærulea*. Salicaceæ.

Light-coloured, diffuse-porous, pinkish-brown wood; very soft and light in weight and very fine in the grain.

Transverse section. Boundary vague yet clear with lens, sometimes a line of parenchyma of flattened cells.

Parenchyma not otherwise visible with lens (probably not present except in the boundary line).

Vessels extremely small, visible with lens, never with the naked eye: diminishing in size a little on the outer side of the ring: scattered (or sometimes in oblique lines as in the Birch, but much less pronounced): sub-divided groups numerous but short (rarely more than three pores to the group).

Rays visible with lens only: of one kind: regular in size and spacing at intervals of the width of about a large vessel apart: almost too thin to taper: of a rather darker shade than the wood.

Radial section. Vessels visible yet very fine: rays just visible as minute, brown, very narrow lines: boundaries traceable, clear, but not prominent. Mr J. Line, of the School of Botany, believes that he has found a distinction between *Salix* and *Populus* in the number and shape of the pits on the vessels at the point where the ray-cells form a cross-field. If this is constant it will be a valuable and much needed adjunct (see below).

Tangential section, as the radial, but the boundaries rather clearer as loops: rays scarcely visible, uniseriate.

May be confused with:

Lime, Birch, Sycamore, Tulip-tree (all of these have multiseriate rays and a colour which never approaches pinkish-brown though it may be whitish or brownish).

Pear-tree and Alder (colour sometimes pinkish-brown but rays multiseriate).

Poplar (the heartwood of *P. alba* syn. *P. canescens*, which is medium in weight).

P. fastigiata, tremula, nigra, i.e. the white-wooded Poplars, and Horse Chestnut.

Poplars generally (two, sometimes three rows of rounded pits in the cross-fields of most of the ray-cells which are all prostrate: constant?)

Horse Chestnut: no distinction except in size of elements, weight, colour, etc. 5 to 8 rows of pits: ray cells all prostrate: spiral thickenings in the vessels.

May be distinguished by:

Pinkish-brown colour and uniseriate rays.

Uniseriate rays: light weight.

Difference in weight, coarseness of grain and hardness: no other certain difference.

Pinkish-brown colour: no other certain difference.

Willows generally (3-6 rows of angular pits in the cross-fields of the erect edge-cells only: constant?)

Pinkish-brown colour. Pits as above. No spirally thickened vessels.

POPLARS

Populus. Salicacæ.

Diffuse-porous woods of medium weight and hardness and of uniform colour and structure: not easily distinguishable from each other (except as regards *Populus alba* (syn. *P. canescens*) which forms a pinkish-brown heartwood). The others are white. *P. italica* is generally full of knots. *P. nigra* is fine-grained and very light in weight. All are difficult to smooth in vertical section with cutting tools though they cut cleanly across grain when they appear silvery-grey.

Transverse section. Boundary a fine line of parenchyma: the varying density of the rings also provides a line of contrast.

Parenchyma as above, otherwise nil.

Vessels visible with lens, small, apparently crowded, diminishing a little in size and numbers from the Spring to the Autumn wood. Where widely spaced, as happens in very well-developed rings, there is a tendency to form short, loose arcs.

Rays visible with lens, very fine, numerous, sinuous (wriggling between the vessels): very regular in spacing, at intervals of the width of a large vessel apart: colourless or of the same colour as the fibres: uniseriate.

Radial section. Boundaries traceable but not prominent: vessels clearly visible but rather fine: silver-grain hardly visible (except in *P. canescens* and perhaps in *P. nigra*). See note to Willow for microscopic details.

Tangential section. As the radial, but the boundaries generally show feeble fringes and sometimes zigzag markings in the cross-grain, as in the Birch but feebler.

The white-wooded Poplars may be confused with:

Horse Chestnut (exceedingly fine grain, hence smooth surface when planed: very light weight: often with a yellow tinge).

Lime and Birch (multiseriate rays at rather irregular intervals in transverse section).

Tulip-tree and Sycamore (rays very clearly visible: multiseriate).

They may be distinguished by:

No certain character, at least as regards *Populus nigra* which is nearly as light in weight and has small pores. From the others their coarseness of grain and greater weight are the only distinguishing features.

Uniseriate rays at regular intervals of the width of a large vessel.

Rays uniseriate, need lens.

Alder, when white, and in the absence of wide rays as may happen in small pieces (vessels scanty in the Autumn wood: a minute, brown, secondary silver-grain produced in radial section by the small rays, which are multiseriate).

Poplars making brown heartwood may be confused with:

Alder, when brown, as above.

Willows (light in weight: colour pinkish-brown: grain fine: watery extract red, deeper in colour than the wood itself)*.

Pear-tree (wood very compact and solid, surface extremely smooth, rays multiseriate).

Vessels abundant in the Autumn wood though less so than in the Spring: silver-grain if evident, then of much the same colour as the ground. Rays uniseriate.

Rays uniseriate.

No certain feature but the grain much coarser, weight greater: absence of pinkish colour in the white kinds. Watery extract very pale yellow.

Rays uniseriate.

* See also note under "Radial section" to Willow, No. 6712.

II. CONIFERS

(Note. The following applies to those woods only, which are prescribed for the course in Forestry at Cambridge.)

All the coniferous woods that concern us *at present*, exhibit a pronounced difference in density between the inner and outer zones of the same annual ring, hence in transverse section the rings are sharply marked off and in longitudinal section (on the plank-face) the wood is definitely and sometimes boldly striped. In many of the Cupressineæ, the distinction of the zones of the ring is reduced to a line of denser tissue at the extreme boundary of the ring or may be altogether wanting as in some species of Podocarpus.

Woods either without pores of any kind or, if pores be present (in the form of resin-canals), they are **never in the inner (Spring) zone** of the annual ring (compare Figs. 1-3). The resin-canals are often present in the middle of the ring where the tissue is still soft, lax and light-coloured. In comparison with the vessels of the Broad-leaved trees, they are exceedingly few in numbers, often far apart and rarely, if ever, in more than one or at most two, very imperfect rows. These rows are interrupted in the most irregular manner, sometimes inches of arc being without them. They never exceed 50 to the inch of arc in any ring, whereas in the wood of the Broad-leaved trees the vessels are never less than a hundred (generally many hundreds), in that distance. The resin-canals may appear on a transverse section as white points, sometimes visible to the unaided eye, but always with ease with the lens unless their colour renders them obscure, that is to say, they are never so very small as are sometimes the vessels of the Broad-leaved trees. The species included in the course, that have such vertical resin-canals are: *Pinus sylvestris*, the Scots Fir; *Pinus Strobus*, the White Pine of America known as the Weymouth Pine in England; *Pinus palustris*, the American Pitch Pine of export; *Picea excelsa*, the Common Spruce; *Larix europæa*, the Larch; and *Pseudo-Tsuga Douglasii*, the Douglas Fir.

Inasmuch as horizontal resin-canals occur in the larger rays of all our present species which present vertical resin-canals, the presence of the one can be predicted from that of the other. This is important as the vertical resin-canals of the Spruce are exceedingly rare at times, and may be overlooked whereas in the Silver Fir (a species generally confused with the Spruce), there are no resin-canals of any kind. The species of Conifers lacking resin-canals are: *Abies pectinata*, the Silver Fir (except after wounding); *Taxus baccata*, the Yew-tree; *Sequoia sempervirens*, the Giant Redwood (except after wounding); and *Juniperus virginiana*, the Pencil Cedar.

CONIFERS

A knowledge of the *use* of the key will only be required of third year students, but it is to be understood that such keys are useless as soon as fresh species are added.

Conifers, in imperfectly prepared specimens, may be confused with:

Broad-leaved woods with small vessels [vessels abundant in Spring (inner) zone of the ring, not less than 100 per inch of arc of the whole ring, often many hundreds]. See page 2, Key, page 50, Figs. 2, 3 and 10-12.

Conifers [no pores of any kind in the inner (Spring) zone of the rings. If pores are present in the middle or outer zones, then they never exceed 50 per inch of arc of the whole ring]. See page 1, Key, page 48, Figs. 1 and 4-9.

SCOTS FIR

Pinus sylvestris Linn. Coniferæ. Abietinæ.

A rather soft whitish to whitish-brown wood striped boldly with resinous-brown belts. In extreme cases it may be very nearly white (the sapwood), or as dark-coloured and resinous as Pitch Pine. A sapwood tree, but the heart is not apparent when freshly felled; it develops on drying. Sapwood very wide. Watery extract nearly clear and limpid: potash causes little change: with perchloride of iron, clear brown solution (constant?).

Transverse section (compare Fig. 1). Boundaries always very well defined by the more resinous Autumn wood on the outer side of the ring. Contour regular.

Pores or vertical resin-canals present, but never in the innermost zone of the ring (i.e. the side towards the pith). The resin-canals are abundant in the dark hard Autumn wood and occasionally stray a little beyond it into the softer wood in the middle of the ring but this is quite exceptional in our species. The lining-cells or epithelial-cells which clothe the interior of these canals, is thin-walled in comparison with those of the Spruce, i.e. less in thickness than the walls of the tracheids surrounding the canals.

Rays of two kinds, large and small (uni- and multiseriate). See tangential section below.

Ground-tissue of tracheids having bordered pits.

Pith large, up to about $\frac{3}{16}$ inch, grey or brown.

Radial section (compare Fig. 6). Rays very inconspicuous. Under the microscope they are seen to be composed of two kinds of cells, the uppermost and lowermost are tracheids having *very jagged walls*. The middle cells (generally in several rows), are of parenchyma. They cross the vertical tracheids of the ground-tissue at right angles and the point where their walls mutually mark off a minute rectangular space is called the "cross-field." In the cross-field of this species there is a large simple (unbordered) pit of a somewhat rhomboidal shape, which occupies practically the whole of the available space. Very occasionally there may be two such pits present, but they are exceptional and very rare. This point must be grasped, as the number and size of these pits in the cross-field form one of the very scanty *points d'appui* that we have for distinguishing the various genera of the Conifers.

Tangential section (compare Figs. 7-9). The larger rays appear as minute spindle-shaped bodies that are only exceptionally visible with the lens. They are expanded in the middle of their length to accommodate a horizontal resin-canal which in this species occupies the whole *transverse width of the ray* (compare Douglas Fir in which this is not the case).

The smaller rays are of one row of cells only and do not contain a resin-canal. The larger kind are called "lenticular rays" and the latter, or smaller, "linear rays." The larger rays have two rows of cells, only in the middle height; at the ends they are one-rowed. In point of height they may be of as many as fifteen cells or less, rarely more (at least in this species).

Pinus sylvestris Linn. may be, and generally is, confused with other species of Pine, with the Douglas Fir, with the Spruce, with the Silver Fir, and with the Larch. It may be distinguished as follows:

From the Spruce, by the rarity of the vertical resin-canals in that wood which also has more than one (small) pit in the cross-field, and thick-walled epithelial cells.

From the Larch, which has several small pits in the cross-field, frequently in two rows one above the other; smooth walls to the ray-tracheids or edge-cells, and thick-walled epithelial cells. Smell, none when worked (at least when the wood is dry). Reaction with perchloride of iron on watery extract, inky.

From the Douglas Fir, which, in tangential section, has rays that are rather short, lanceolate or boat-shaped, in the middle of which the resin-canal occupies only a portion of the transverse diameter of the ray (i.e. there are one to two layers of cells between the canal and the surrounding ground-tissue: the tracheids have spiral thickenings. Smell, none when worked (at least when the wood is dry). Reaction as for Larch, inky.

From the Yew, which has no resin-canals whatever, but has spiral-thickenings in the tracheids. Reaction of watery extract with perchloride of iron, none.

From the Silver Fir, by the absence of resin-canals of either kind in that wood which has, however, two or more small pits in the cross-field.

From the Weymouth Pine, which has smooth-walled tracheids and proportionately higher lenticular rays (tangential section).

PITCH PINE

Pinus palustris Mill. Coniferæ. Abietinææ.

A hard heavy wood very heavily charged with resin which gives it a peculiar transparence. The resin is in a solid condition and the wood does not bleed. Smell when worked, powerful and vinous. Reaction with perchloride of iron, brown precipitate.

Structure, much as in *Pinus sylvestris*. Resin-canals abundant.

Pits in the cross-field always more than one, frequently four, but they are still proportionately large and occupy the whole space (not as in *Abies*). Walls of the ray-tracheids exceedingly rugged and projecting so much inwards as to make it difficult to see the pits.

Rays of two kinds as in the Pines generally and of much the same shape and structure as in Scots Fir, i.e. spindle-shaped, slender, and long-drawn-out (acicular or rat-tailed).

May be confused with:

Scots Fir when the latter is heavily charged with resin (one large pit in the cross-field, seldom two).

May be distinguished by:

Three or four large pits in the cross-field, seldom two.

Note. There are other species which pass under the name of Pitch Pine in the U.S.A. and even *P. sylvestris* is occasionally so-called. The present species (*P. palustris*) is supposed to furnish the Pitch Pine of commerce as described above, but the only justification until recently seems to be that *P. palustris* is the only one exported from U.S.A. to Europe.

Mr V. Braid, who kindly undertook the investigation of all the specimens in the collection of the School of Forestry, has proved that this supposition is correct. Prof. Record, of Yale, when writing of Pitch Pine, refers to it as the Longleaf or Georgia Pine. (See *Archives of the Cambridge Forestry Association*, No. 2, 1920.)

WEYMOUTH PINE OR AMERICAN WHITE PINE

Pinus Strobus Linn. Coniferæ. Abietinææ.

A very light soft wood of a whitish colour sometimes tinged with red. The striping is not by any means boldly marked and the distinctions between the Spring and Autumn wood are, if anything, less pronounced than in the Spruce which it much resembles.

Smell when worked feeble or none. Lustre, micaceous or silky. Reaction with potash on the citron-coloured watery extract, clears to a beautiful bright green. With perchloride of iron, a cloudy, brandy-coloured solution that does not clear readily (constant?).

Structure as that of the Spruce from which it is difficult to distinguish. The great abundance of the vertical resin-canals in the present species and the rarity in the Spruce are sufficient in most cases. Structure as in the Pines generally (compare Figs. 1, 4, 7).

Resin-canals abundant, often as many as 40 to the inch of arc.

Pits in the cross-field, one large one only, according to Bauschinger: one, two or three, according to W. S. Jones. Our specimen shows one in the Autumn and two in the Spring wood.

Walls of the ray-tracheids, smooth.

Large rays similar to those of *P. sylvestris*, but considerably larger in tangential section, while the small linear rays remain about the same size in both.

Pith large (up to $\frac{1}{4}$ inch diameter), soft, much lighter in colour than the wood, conspicuous.

Weymouth Pine may be confused with all those with which *P. sylvestris* may also be confounded.

It may be distinguished from P. sylvestris by the height of the lenticular or large rays (Fig. 7), the abundance of pairs of pits in the cross-field of the Spring wood and the smooth-walled ray-tracheids. The lenticular rays are multiseriate for the greater part of their height. From the other species as *P. sylvestris*, which see.

LARCH

Larix europæa DC. Coniferæ. Abietinææ.

A moderately hard and heavy wood of a brownish-white, striped very broadly with darker resinous-brown bands. In the lighter coloured wood it resembles Scots Fir, in the darker, Douglas Fir, and in such cases it is impossible to distinguish it except by the structure. Smell, none when worked, at least when the wood is quite dry (compare Scots Fir, which has a powerful resinous smell when worked). The smell is revived by warming. Reaction with perchloride of iron, inky.

Structure, much as *Pinus sylvestris*. Must be observed by the microscope. Resin-canals abundant: epithelium thick-walled.

Spiral thickenings to the vertical tracheids either absent or weak.

Rays with their horizontal resin-canals, slender, attenuated, acicular, spindle-shaped in tangential section as in *P. sylvestris* (compare Douglas Fir in which they are stout and boat-shaped), see Figs. 7-9. In the Larch the horizontal canal occupies the whole width of the ray (compare Douglas Fir in which it does not).

Pits in the cross-field, two or more small ones of a somewhat slit shape occupying but little of the space.

Walls of the ray-tracheids, smooth.

Pith minute, obscure.

May be confused with:

Scots Fir when dark-coloured (pits in the cross-field, one large one, rarely two).

Douglas Fir (spiral thickenings in the vertical tracheids: rays broad and short).

May be distinguished by:

Many small pits in the cross-field.

Spiral thickenings rare: rays narrow and rat-tailed.

SPRUCE

Picea excelsa Link Coniferæ. Abietinææ.

A soft wood, light in colour and in weight resembling Silver Fir, from which it is difficult to distinguish. Although plainly and definitely striped, the difference in the colour of the Autumn and Spring wood is small. Smell when worked, little or none (dry wood). Lustre crystalline or satiny.

Structure, as in the Pines, more or less.

Resin-canals present, the vertical ones being casual and sometimes absent over long lengths of arc (even as much as 15 inches). When in doubt the horizontal canals must be carefully searched for.

Reaction of watery extract with potash, none: with perchloride of iron, yellow (otherwise the colour of the perchloride only).

Rays of two kinds: horizontal resin-canals abundant. They are of the same character as those of the Scots Fir and of the Larch, and of the same slender shape as those of the latter.

Pits in the cross-field, usually two or more small ones which occupy but a minute portion of the area.

Ray-tracheids with processes projecting inwards.

Epithelial cells of the vertical resin-canals, thick-walled, i.e. about as thick as those of the tracheids around them.

The shavings are soft and silky to the touch.

Pith large, up to $\frac{1}{4}$ inch diameter, conspicuous, soft.

May be confused with:

Silver Fir (no resin-canals, no tracheids in the rays).

Weymouth Pine (one or two large pits in the cross-field).

Sapwood of Scots Fir (one large pit in the cross-field).

May be distinguished by:

Resin-canals of both kinds present: tracheids in the rays.

Two or several small pits in the cross-field.

As above.

DOUGLAS FIR

Pseudo-Tsuga Douglasii Carr. Coniferæ. Abietinææ.

A moderately heavy, brownish-white wood, striped very broadly with darker resinous-brown bands. It much resembles Larch and also the darker sorts of Scots Fir from both of which it is difficult to distinguish except with the microscope. Smell not resinous when worked, at least when the wood is dry. It is rather unpleasant though not strong, and is not revived by warming. Reaction with perchloride of iron, inky. The resin remains fluid, the canals bleed and often stain the surface.

Structure much resembling that of *Pinus sylvestris*. Must be observed in thin section by the microscope.

Vertical resin-canals abundant. Spiral thickening of the tracheids, pronounced?

Horizontal resin-canals in tangential section stout and somewhat of the outline of a boat (see Fig. 9). The canal in the middle height occupies only a portion of the transverse diameter, i.e. there are one or two rows of cells which separate it from the surrounding ground tissue.

Pits in the cross-field, several, small, and slit-like.

Pith small, about 1.5 mm. diameter.

May be confused with:

Scots Pine (one large pit in the cross-field, slender rays in tangential section which contain a resin-canal that occupies the whole transverse diameter (compare Figs. 8, 9). No spiral thickenings in the tracheids).

Larch [rays as in Scots Fir, but still more attenuated (compare Figs. 8, 9). Spiral thickenings rarely seen].

May be distinguished by:

Two or several small pits in the cross-field: wide rays in tangential section with small resin-canal in centre. Spiral thickenings usually evident.

As above.

SILVER FIR

Abies pectinata DC. Coniferæ. Abietinææ.

A soft wood, light in colour and in weight resembling Spruce, from which it is difficult to distinguish. This is more especially the case when the resin-canals (vertical) are rare in the Spruce. Although plainly striped, the difference in colour of the Spring and Autumn wood is not very great. Smell when worked, none (dry wood). Lustre crystalline or satiny.

Reaction of watery extract with potash, greenish: with perchloride of iron, brown precipitate (Constant?).

Structure. Resin-canals absent. Occasionally traumatic canals occur, but these are then in arcs of some length tangentially and the component canals are of various sizes and irregular in appearance.

Rays of one kind only (the smaller) uniseriate. In tangential section they are seen to be up to about 30 cells in height or less. At times the rays seem to be superposed one over the other in a vertical direction as though on the point of being split into two or more. *No tracheids in the rays.*

Pits in the cross-field, several, small; occupying very little of that area.

Pith minute.

The shavings are crisp to the touch.

May be confused with:

Spruce (resin-canals, especially the horizontal canals in the rays, present: tracheids in the rays).

Weymouth Pine (one or two large pits in the cross-field: resin-canals abundant).

Sapwood of Scots Pine (as Weymouth, but only one large pit).

May be distinguished by:

Absence of both kinds of resin-canals. No tracheids in the rays.

Two or several small pits in the cross-field. No resin-canals.

As above.

GIANT REDWOOD

Sequoia sempervirens Rndl. Coniferæ. Taxodinæ.

A very soft, light, wood of a beautiful crimson-red colour; sometimes purple. Darkens considerably and becomes brown on exposure to the light. No smell.

Transverse section. Boundaries of the rings well very defined by the much darker Autumn zone, which latter may vary in breadth from a mere line to a considerable band.

Resin-canals absent. Resin-cells present, but by no means abundant; scattered rather than in zones.

Rays of one kind only, uniseriate, similar to those of the Pencil Cedar but sometimes attaining a height of 25 cells. The rays at times seem to be superposed one over the other to as many as three, as though they composed a single high ray with constrictions at intervals.

Giant Redwood is not easily confused with any other wood, except *S. gigantea* and perhaps Pencil Cedar when there is no opportunity of remarking the smell of the latter.

Pencil Cedar [rays in tangential section seldom 15 cells high (microscope): resin-cells abundant, often visible in transverse section with lens as vague dark-coloured zones].

Redwood, rays in tangential section up to 25 cells high: resin-cells rare, an occasional one here and there. No smell.

PENCIL CEDAR

Juniperus virginiana Linn. Coniferæ. Cupressineæ.

A very soft, light wood of a beautiful rose colour, an agreeable aroma and sweet taste. It is hardly possible to mistake it for any other wood.

Transverse section. Ring-boundaries very distinct on account of the difference in density of the Autumn wood, the breadth of which may vary from a mere line to a narrow band.

Resin-canals absent. Resin-cells frequent, often arranged in zones which may be visible with the lens.

Rays of one kind only, uniseriate, low, rarely being more than fifteen cells high and for the most part under ten. No tracheids in the ray.

May be confused with Giant Redwood (see preceding species), when no opportunity occurs of remarking the smell.

YEW-TREE

Taxus baccata Linn. Taxaceæ.

A hard, heavy wood of a deep reddish-brown colour and rather cold to the touch. The colour of the Autumn and Spring wood is not very different though the limits are distinct enough. Smell, none.

Structure very simple, consisting of rays and tracheids only. Vertical parenchyma sometimes occurs, but most observers assert that it is absent.

Resin-canals, or resin-cells, none. Spiral thickenings to the tracheids present.

The Yew is not easily confused with any other wood but if doubt arises between this species and the Larch and Douglas Fir, they may be distinguished by the presence of resin-canals in both of the latter and also by their watery extracts which are very pale yellow. The Yew yields an extract of the colour of sherry.

KEY TO THE WOODS OF THE BROAD-LEAVED TREES INCLUDED IN THE COURSE

Note. When the visibility of any tissue is in doubt, run down both alternatives.

- | | | |
|-------|---|------------------|
| 1. | Woods having a pore-ring in the innermost part of the annual ring (including those that have a scanty row of pores made more visible by the parenchyma with which they are packed) | 2 |
| 1 a. | Woods having no pore-ring | 14 |
| 2* | Pores of the Autumn zone arranged in radial streams or lines | 3 |
| 2 a. | Pores of the Autumn wood connected by parenchyma into festoons, lines, arcs, angles or scraps (tangentially or obliquely) | 5 |
| 2 b. | Pores scattered, not joined by parenchyma, not even in the late Autumn wood | 11 |
| 3. | Rays prominent in transverse section | 4 |
| 3 a. | Rays obscure in transverse section | Chestnut |
| 4. | Wood with stripes of a pinkish or pinkish-brown colour: watery extract at first nearly colourless | American Red Oak |
| 4 a. | Wood uniformly brown | 25 |
| 5. | Pores of the pore-ring very much larger than those immediately outside it in the Summer wood | 6 |
| 5 a. | Pores of the pore-ring but little larger than those following | 9 |
| 6. | Pore-ring of one row of pores only | American Elm |
| 6 a. | Pore-ring of more than one row | 7 |
| 7. | Rays obscure and light-coloured: pores of the Autumn wood joined by parenchyma to short lines, arcs or angles, only | Ash |
| 7 a. | Rays brown, quite evident though small: pores in the Autumn wood in practically continuous, concentric lines | 8 |
| 8. | The half-tone effect produced by the rays in tangential section, obscure: rays (microscope) appear of the shape of a slender skiff (Fig. 11): reaction of watery extract with perchloride of iron, golden, no precipitate (constant?) | Wych Elm |
| 8 a. | Half-tone effect pronounced: rays in tangential section having the outline of a broad-beamed boat (see Fig. 10): watery extract with perchloride of iron gives a slight brown precipitate (constant?) | Common Elm |
| 9. | Parenchyma in tangential section (microscope), arranged alternately: wood whitish or greenish-white within | Mulberry |
| 9 a. | Parenchyma in tangential section in palisade (see Fig. 12) | 10 |
| 10. | Pores choked with thyloses which are visible with the lens: rays comparatively low in tangential section (microscope) (see Fig. 12) | False Acacia |
| 10 a. | Thyloses few and difficult to find: rays high in tangential section (microscope): wood becomes very dark-coloured | Laburnum |
| 11. | No minute bars of parenchyma between ray and ray | 13 |
| 11 a. | Cross-bars present (sometimes very difficult to find) | 12 |
| 12. | Cross-bars of parenchyma very clear and unmistakable | Hickory |

* Note that there are more than two alternatives here.

KEY TO THE BROAD-LEAVED TREES

- 12 a.** Cross-bars very obscure (need careful search in the Autumn wood) **Walnut**
- 13.** Wood deep brown: pore-ring feeble, shown up by light-coloured parenchyma: evil smell when worked **Teak**
- 13 a.** Wood whitish (brown in Hungarian Ash): no smell: pore-ring strong **Ash**
- 14*.** Rays very large or prominent, hence silver-grain broad **15**
- 14 a.** Rays in transverse section not prominent but still visible at arm's length: silver-grain narrow but often very marked **18**
- 14 b.** Rays visible with attention: silver-grain very inconspicuous yet still visible **19**
- 14 c.** Rays needing lens in transverse section: silver-grain very obscure in the light-coloured woods though prominent enough in Mahogany **21**
- 15.** Rays casual, occurring in groups at one place (transverse section) and leaving rayless spaces at others **16**
- 15 a.** Rays abundant and evenly distributed **17**
- 16.** Rays white: wood hard, heavy **Hornbeam**
- 16 a.** Brown rays, obscure on transverse section unless wetted: wood soft, white to brownish **Alder**
- 17.** Rays in transverse section, dull: silver-grain dull also . **Plane-trees**
- 17 a.** Rays in transverse section bright: silver-grain bright . . . **Beech**
- 18.** A half-tone effect produced by the rays in tangential section very evident **Sycamore**
- 18 a.** No half-tone effect **Tulip-wood**
- 19.** Pores arranged in oblique lines in transverse section (see Fig. 2) **Birch**
- 19 a.** Pores not arranged in oblique lines (though minute arcs may occasionally be indicated) (see Fig. 3). **20**
- 20.** Silver-grain consists of brown flakes occupying about half of the surface: watery extract rich red **Pear-tree**
- 20 a.** Silver-grain pale brown, obscure: watery extract pale yellow . **Lime**
- 21*.** Wood deep, rich brownish-red: heavy **22**
- 21 a.** Wood pinkish-brown: light to medium in weight **23**
- 21 b.** Wood black or brown with black stripes **Ebony**
- 21 c.** Woods white or yellow **24**
- 22.** Cross grain: rays in tangential section (microscope) distorted (as in Fig. 10): much white deposit . . . **Cuban Mahogany**
- 22 a.** Wood straight-grained: rays symmetrical in tangential section (as in Fig. 11): little white deposit if any **Honduras and Tabasco Mahoganies**
- 23.** Wood very light in weight, fine-grained **Willow**
- 23 a.** Wood medium heavy and moderately coarse-grained . *Populus alba*
- 24*.** Wood exceedingly fine-grained and very light in weight **Horse Chestnut**
- 24 a.** Wood medium-grained, moderately heavy **Poplars** (the white woods)
- 24 b.** Wood very heavy (generally sinks in water), colour yellow **Boxwood**
- 25.** Woods of a warm brown colour: thyloses few . . . **English Oaks**
- 25 a.** Wood of a neutral brown colour: vessels packed with thyloses . **American White Oak**

* Note that there are more than two alternatives here.

KEY TO THE CONIFEROUS WOODS INCLUDED IN THE COURSE

- | | | |
|-------|---|--------------------------------|
| 1. | Wood with a sweet aroma (at least when worked) | Pencil Cedar |
| 1 a. | Woods which are either scentless or have a balsamic or resinous odour | 2 |
| 2. | A scentless wood of a rich red colour, very soft and light, resin-cells present but rare | Giant Redwood |
| 2 a. | Woods either scentless or having a balsamic odour but in any case having no resin-cells | 3 |
| 3. | No resin-canals either vertical or horizontal | 4 |
| 3 a. | Resin-canals of both kinds present (make sure of the horizontal canals) | 5 |
| 4. | Wood very heavy and hard: colour dark brown, very little difference between the Spring and Autumn wood | Yew-tree |
| 4 a. | Wood very light in colour and in weight: colour whitish or yellowish | Silver Fir |
| 5. | Wood light in weight and colour | 6 |
| 5 a. | Wood medium to heavy: colour (of the Autumn wood at least), dark brown or reddish | 7 |
| 6. | One large pit, or at most two, pits in the cross-field | 9 |
| 6 a. | Two or more small pits in the cross-field: vertical resin-canals rare and casual | Spruce |
| 7*. | One (or but rarely two) large pits in the cross-field: balsamic smell (worked). Reaction with perchloride of iron slight or none | Scots Pine (heart) |
| 7 a. | More than one large pit in the cross-field (mostly two, but even three or four) | 10 |
| 7 b. | More than one small pit in the cross-field (never one large one only: no smell when worked (dry)). Reaction with perchloride of iron, inky | 8 |
| 8. | Rays in tangential section, stout; the horizontal resin-canal within them does not occupy the whole width of the middle: spiral tracheids present | Douglas Fir |
| 8 a. | Rays in tangential section, long drawn-out, slender: the canal within them occupies the whole width of the middle: tracheids not spirally thickened as a rule | Larch |
| 9. | Wood very soft and light, feebly resinous; smell when worked, feeble: generally two large pits in the Spring cross-fields and one in the Autumn | Pinus Strobus |
| 9 a. | Wood moderately hard: smell when worked, powerfully resinous: one large pit in all cross-fields, very rarely two | P. sylvestris (sapwood) |
| 10. | Wood light in weight and colour: one or two large pits in the cross-field | P. Strobus |
| 10 a. | Wood heavy and highly charged with resin: often four large pits in the cross-field | P. palustris |

* Note that there are more than two alternatives here.

EXPLANATION OF THE PLATES

The scale of magnification is about 50 diameters and is the same for all figures.

Fig. 1. Weymouth Pine, *Pinus Strobus*: transverse section. A typical Conifer with resin-canals (three only shown). Note the scarcity of these in comparison with the vessels of Broad-leaved woods, such as are shown in Figs. 2 and 3. One of the resin-canals is in the middle zone of the ring. A part of the Spring zone of the succeeding ring is represented by the large-celled portion above. Note also that the cells are strictly in rank and file. The rays are the denser, darker lines running between rows of cells from the top to the bottom of the figure. The resin-canals are lined with epithelial cells: the one towards the right of the figure is filled with thyloses. The cells are flattened on the outer edge of the lower ring, the lumina becoming smaller in proportion to the wall-substance, hence the wood is denser. The contrast between the flattened cells and the lax cells that succeed them, forms a "line of contrast" that serves as the ring-boundary.

Fig. 2. Birch, *Betula alba*, transverse section. Pith side downwards. This shows a portion of two rings with a boundary of flattened cells also a number of vessels most of which are in "mother and daughter" groups. Note the relative isolation of these groups and their tendency to arrange themselves in oblique lines, and that the vessels of the Spring zone (above the boundary) are larger than those in the preceding Autumn zone (below). There are about 30 groups (including single pores) shown in the figure. Compare this number with that of the pores in the next figure of the Lime, where it is some ten times as great, and many of the groups have a quite different aspect. The relative transparency of the rays (running from top to bottom of the figure) should be ignored as it is due to the methods of preparation.

The cells are more or less in rank and file, but they do not show the exquisite regularity of the Coniferous woods. Their density, between that of the Spring (above) and the Autumn (below) wood, does not differ much.

Fig. 3. Lime-tree. Transverse section. Pith side downwards. A portion of two rings shown, the broadest being above. Compare preceding figure and note that the vessels tend to arrange themselves in loops or undulating lines, rather than in oblique lines and that they are more crowded and larger in the Spring zone than in the Autumn zone adjoining. The cellular tissue (wood-fibres) is relatively dense but the abundance of the vessels counterbalances this, hence the wood is not so heavy as the Birch.

Fig. 4. Weymouth Pine, *Pinus Strobus*, radial section. The long-pointed, vertical cells are tracheids which should show the characteristic bordered pits in this section. The mass of rounded cells (top, middle of photo), are thyloses filling a vertical resin-canal. Immediately below these, the rectangular square-ended parenchymatous lining-cells of the epithelium are seen. The bands of cells passing horizontally across the figure are small linear rays. At the points where their walls and those of the tracheids form little rectangular spaces (cross-fields) large unbordered pits may be obscurely seen. The zone of narrow tracheids represents the Autumn (Summer) wood: the zone of the wide ones, the Spring wood.

Fig. 5. Larch, *Larix europæa*. Details as for previous figure except that there is a horizontal resin-canal, shown in the upper ray and that there are two or more small pits in the cross-fields where they appear as minute dots occupying but a small amount of the space of the rectangle.

EXPLANATION OF THE PLATES

- Fig. 6. Scots Pine, *Pinus sylvestris*, radial section. Details as in Figs. 4 and 5, but here again we have but one pit in the cross-field.
- Fig. 7. Weymouth Pine. Tangential section showing many small (linear or uniseriate) rays and one large lenticular ray having in the middle a resin-canal filled with thyloses. Note that the canal occupies the whole of the transverse diameter of the ray (compare Fig. 9), and that the large rays are higher than those of the Larch (and also of the Scots Pine), although the small rays in both species are relatively of the same height. The elongated cells amongst which the rays are imbedded are tracheids. Compare, also, the shape of the lenticular rays in Fig. 9.
- Fig. 8. Larch, tangential section. Details as in preceding figure. Note that the lenticular rays are slender because the greater part of the height consists of one row of cells only. The resin-canal, with its epithelial cells, occupies the whole of the transverse diameter of the middle of the ray (compare Fig. 9 of the Douglas Fir, where there is a row of parenchyma-cells surrounding the epithelial lining which makes the resin-canal appear small).
- Fig. 9. Douglas Fir, *Pseudo-Tsuga Douglasii*, tangential section. Details as for Figs. 7 and 8, but the lenticular rays are of stouter build. They appear, however, too blunt in the photo as the edge-cells are not shown, but in any case they are of two or more rows of cells for the greater part of their height. The spiral thickenings of the tracheids does not come out.
- Fig. 10. Common Elm, *Ulmus campestris*, tangential section. The stout oval bodies composed of cells of circular section are multiseriate or compound rays. These have been distorted here and there by strands of fibres passing through them. This form is called "unsymmetrical." The square-ended cells appearing in small quantity, are vertical parenchyma which we may call "muriform," i.e. resembling bricks, as contrasted with the "palisade" in Fig. 12. The light-coloured channels are vessels and the darker elongated cells are wood-fibres.
- Fig. 11. Wych Elm, *Ulmus montana*, tangential section. Details as for preceding figure. Note that the rays, though of approximately similar height, are narrower and are composed of smaller cells.
- Fig. 12. False Acacia, *Robinia Pseud-Acacia*, tangential section. The large, wide, white strips are vessels filled with thyloses. The latter are so tightly packed that they become angular in outline. The short-pointed cells in rows are parenchyma "in palisade." The very irregular bodies composed of cells which are round in section are the rays: they are seen in this photo imbedded in the parenchyma. There are but few fibres shown, as the specimen is from the Spring zone of the wood: in the denser wood they form the major part of the tissue whereas the parenchyma is correspondingly scarce.

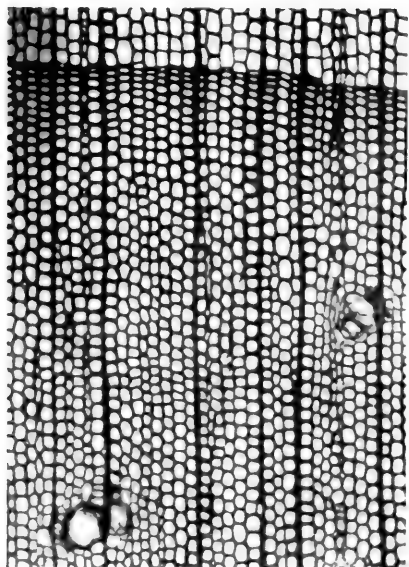


Fig. 1

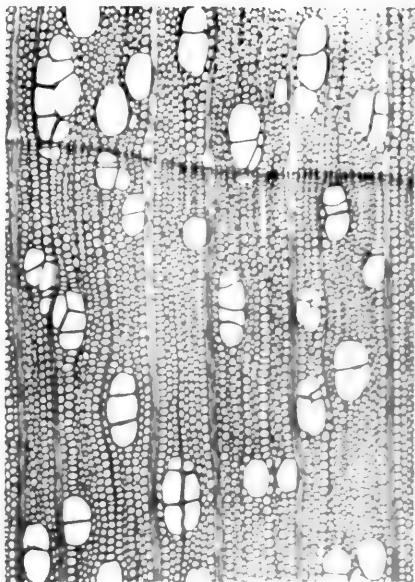


Fig. 2

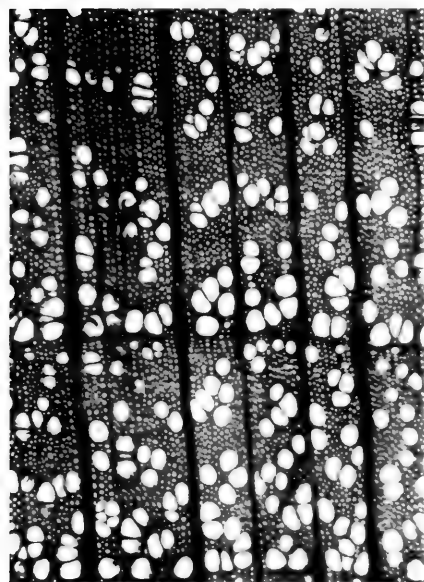


Fig. 3

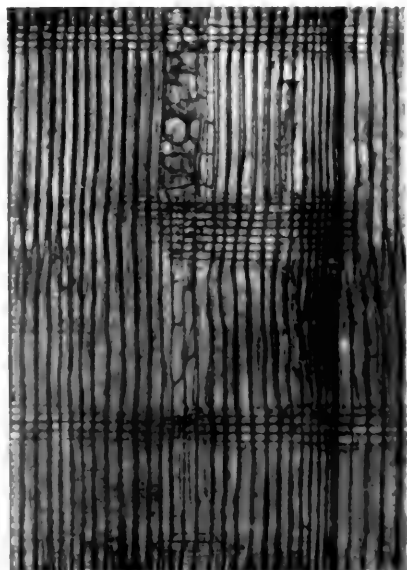


Fig. 4



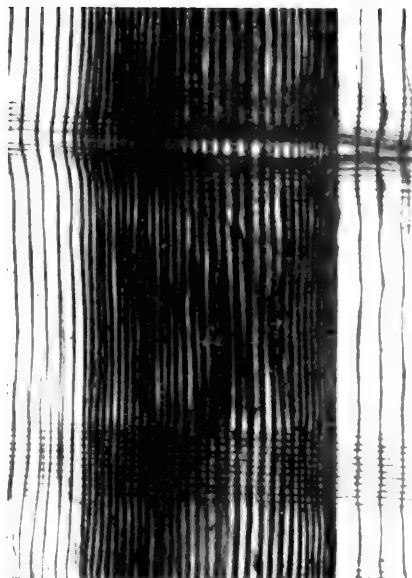


Fig. 5

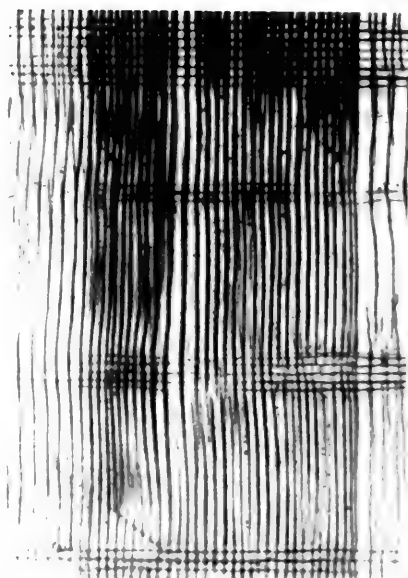


Fig. 6

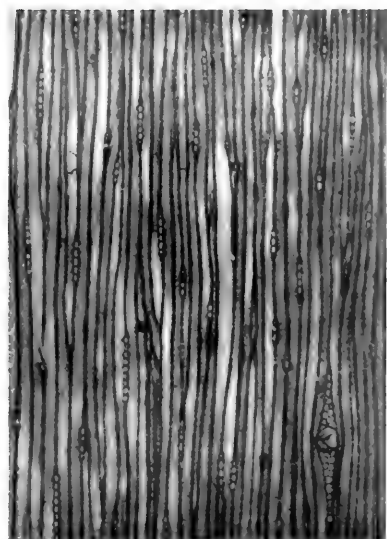


Fig. 7

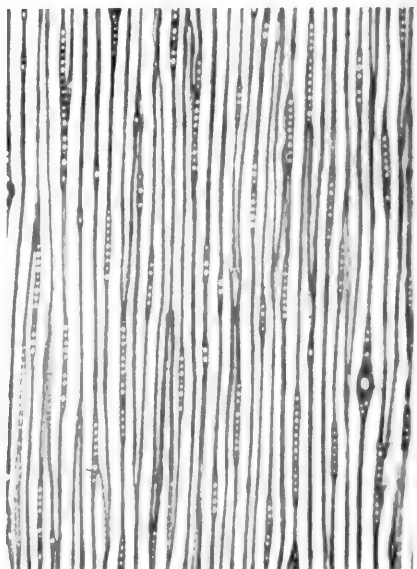


Fig. 8



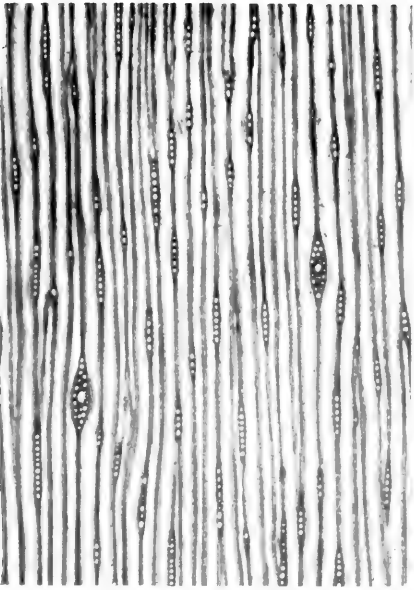


Fig. 9

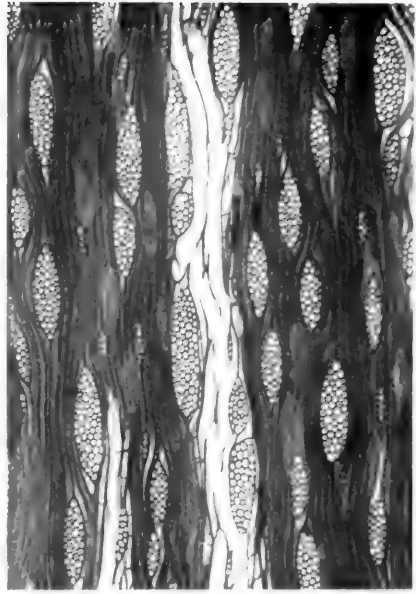


Fig. 10

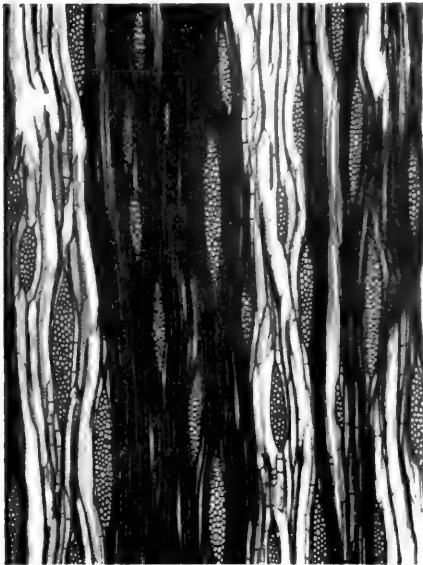


Fig. 11

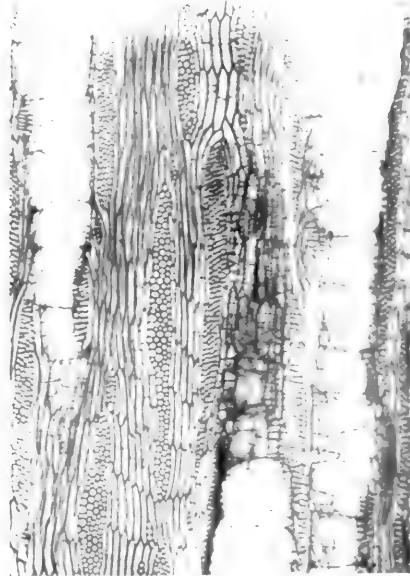
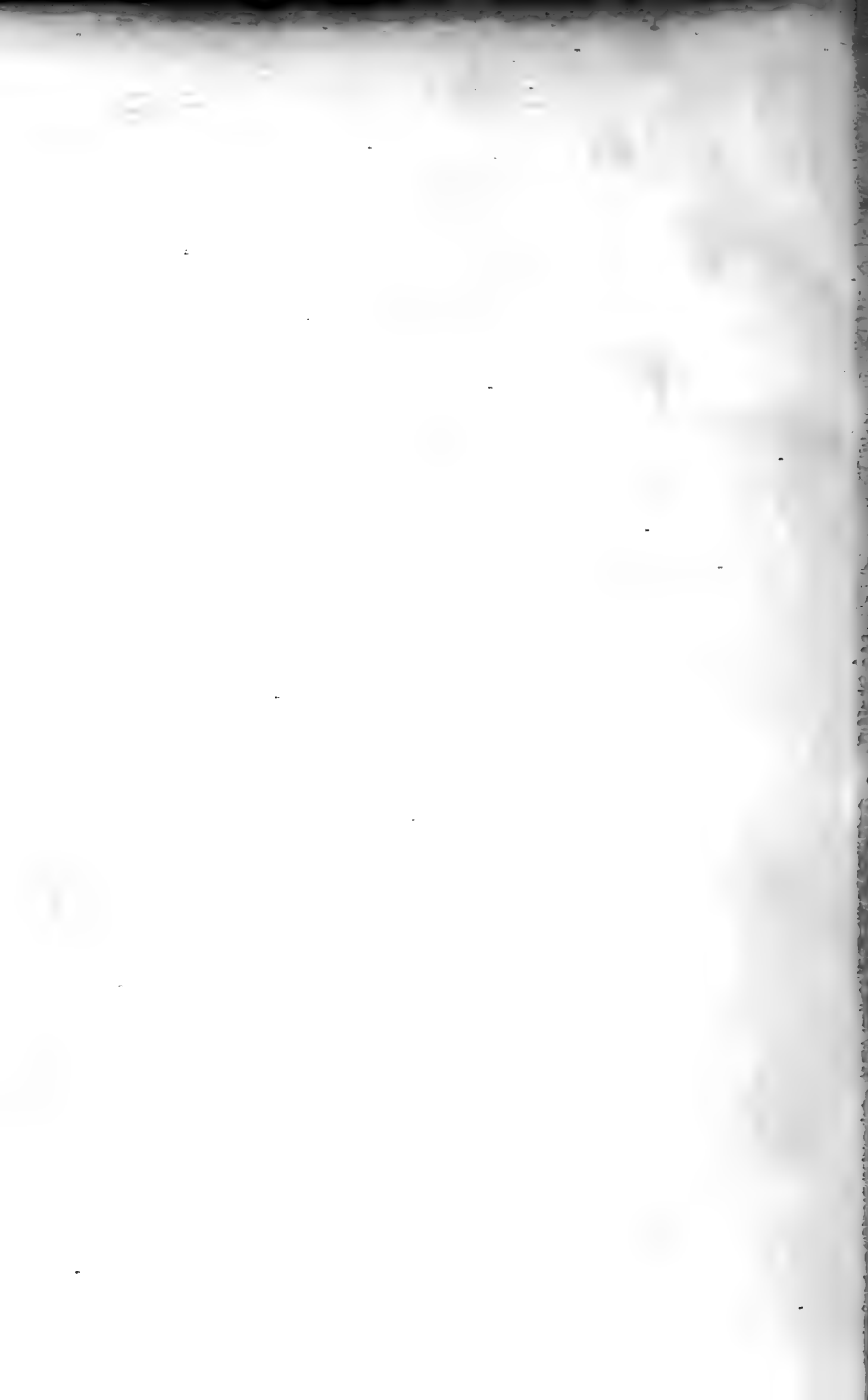


Fig. 12







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