FIELD IDENTIFICATION OF SELECTED TIMBERS OF INDIA

A HANDBOOK

Indian Council of Forestry Research & Education

(An autonomous body of Ministry of Environment, Forest & Climate Change, Government of India)

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INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
P.O. New Forest, Dehradun - 248 006

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Foreword

Dr. Suresh Gairola, IFS
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ICFRE with its Headquarters at Dehradun is an apex body in the national forestry research system that promotes and undertakes need based forestry research and extension. The Council that came into being in 1986 has a pan India presence with its 9 Regional Research Institutes and 5 Centers in different bio-geographical regions of the country. Since then research in different fields of forestry has been a major focus of ICFRE.

There is an earnest need to present its research finding to the stakeholders in a simple and lucid manner to improve the visibility and relevance of ICFRE. Therefore, it was decided that the information available on the technologies, processes, protocols and practices developed by ICFRE be published in the form of operational manuals/user manuals. It is also desirable that the manual should be a comprehensive national level document depicting extent of knowledge in applicable form.

Accordingly, 18 scientists of ICFRE were nominated as National Subject Matter Coordinators (NSMCs) to carry out the task on the specified subject. These NSMCs were assigned the task to select and nominate nodal officers from other Institutes of ICFRE as well as other organizations if necessary, collect and collate the information on the subject from various sources in coordination with the nodal officers of ICFRE institutes.

The present handbook 'Field Identification of selected timbers of India' with information on methodology for assessment of physical features and description of macroscopic features of fifty commercial timbers of India, along with the photograph of their transverse view will be useful in field identification of these timber species and will be of immense use as a practical guide to wood science students, teachers and researchers, traders, wood based industries and forest officers.

I hope that the guidebook will provide useful information to the diverse stakeholders and prove to be helpful literature for planning future programmes.

Dr. Suresh Gairola

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Dr. (Ms.) Sangeeta Gupta

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Wood Anatomy Discipline

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Preface

The present revision of the renowned book 'Field Identification of fifty important timbers of India' by K. Ramesh Rao & K.B.S. Juneja was the need of the hour as it was written in 1972, and required review. It was therefore decided to amend this book by excluding species that are, now either rare or under CITES and by including species that are in large scale plantations in India.

It is hoped that this general text book giving methodology for assessment of physical features and description of macroscopic features of timber, would serve as practical guide to wood science students, teachers and researchers. The unique combination of features useful in field identification of common fifty timbers should be useful for traders, wood based industries and Forest officers specially those in charge of Forest Corporation depots. This book is not intended for species level timber identification as microstructure studies are a must to identify a wood up to species level. However, this book would certainly assist in teaching and understanding various macroscopic wood anatomical features associated with fifty common timbers of India. So far, timber identification is concerned, the description and photograph given for fifty timbers shall assist the user, to quite an extant, in determining whether the supplied timber is the desired one or not.

The book starts with a brief introduction followed by description of physical and macroscopic features of wood. Since these chapters required no change therefore they have been kept same as in the original publication. The book then covers the unique combination of physical and macroscopic structure of fifty commercial timbers of India. The descriptions of these fifty timbers have been taken from already published data mentioned under references. The photographs of the transverse view as seen through hand lens have been taken through stereozoom microscope and it has been our endeavour to cover two to three growth rings of them so as to give a broader transverse view. A dichotomous species key has been prepared for the identification of fifty timbers. This key, however, should be used with great caution as many related species may have the same features and therefore it is helpful if one is sure that the unknown timber is among these fifty timbers only.

Acknowledgments: My gratitude to Dr. Suresh Gairola, Director-General, ICFRE for his valuable foreword and Shri A.S. Rawat, Director, FRI for encouragement and active support; Mr. Rajat Sharma, Artist, Wood Anatomy Discipline, FRI for the lucid illustrations; Ms. Prachi Gupta, Senior Research Fellow, for assisting me in typing and template preparation; and Mr. Rahul Rana, M.Sc. student, for his assistance in taking snapshots.

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Contents

1 INTRODUCTION

IDENTIFICATION OF TIMBER AND ITS IMPORTANCE

Timber, that means wood of commercial importance, is one of the most valuable and versatile raw materials used by man and play a vital role in the economic and industrial development of a nation. Wood is of plant origin and cellular in structure, being produced by thousands of different kinds of trees like the Mango (*Mangifera indica*), Teak (*Tectona grandis*), Sal (*Shorea robusta*), etc., each with its distinctive features. Like the trees, the woods produced by them also differ considerably in their appearance, structure and properties. In India alone we have well over 1600 different woods, which show a remarkably wide range of variation in their physical properties such as colour, texture, grain, weight, hardness, etc., as well as in their anatomical structure. Depending upon its structure and properties, timber is put to a variety of different uses, and there is hardly any industry or field which does not involve the use of wood in one form or the other.

Because of its variability in different species, one of the fundamental things to remember in timber utilization is that the choice of species should not be made indiscriminately on account merely of easy availability, cheapness and other considerations. With the proper technical know-how and some care, it is always possible to select the right timber for any job requiring the use of wood, if only its correct identity is known. Before a timber is put to any specific use, the first and most essential step is therefore to know exactly what species it belongs to and what properties it possesses. In other words, correct identification is the only true basis for the efficient utilization of this important raw material.

Timber identification is a highly specialized and fascinating field of study. It is not always an easy matter, especially when we have to deal with a large number of species. The unsystematic and haphazard manner in which they are handled, due mostly to ignorance and carelessness, and the tendency of some unscrupulous dealers to pass off inferior timbers under the name of reputed ones like Teak (*Tectona grandis*), Deodar (*Cedrus deodara*) etc., add further to the difficulties of timber users. Consequently, there is often the risk of inferior or even totally unsuitable woods being supplied. Use of wrong timber arising out of such mistakes or fraud may sometimes lead to serious loss of money, material and even human life. This can easily be avoided if the importance of correct identification of timber is realized by all those who have to deal with timber.

COMMON METHODS OF IDENTIFICATION

People who have occasion to handle timber frequently like carpenters, timber dealers, etc., may often be able to spot common timbers such as Teak (*Tectona grandis*), Deodar (*Cedrus deodara*) and Sal (*Shorea robusta*) from their mere look, smell or feel. The appearance of a timber, which depends on general properties like colour, lustre, grain, texture and figure, is no doubt suggestive and often gives a clue to its probable identity. Similarly, the weight, hardness, odour and feel may also be of some help when we have to deal with only a few timbers. But this procedure based only on physical characteristics is neither easy nor practical when hundreds of timbers are involved.

Experience has shown that colour, weight, hardness, etc., are not always reliable as they may vary in the same timber because of several factors like exposure, age, moisture content, etc. Further, widely different timbers may sometimes be similar in general appearance or made to look alike by artificial treatment. Therefore, identification of timbers from their appearance and general properties is at best only a hit-or-miss method on which much reliance cannot be placed when we have to deal with a large number of timbers as in our country.

Experienced foresters, wood-cutters and local tribesmen may often be able to identify standing timber and newly-felled logs from the external characteristics of the bark and peculiarities of the blaze but this method is not of much practical value, as timber in the form it is commonly sold in the market is usually devoid of bark.

Besides the above, laboratory procedures like chemical analysis, micro-chemical tests and physico-chemical methods have also been tried and found to be of some help. But, for obvious reasons, they are of limited value and capable of application only in a few special cases.

Therefore, the only method which is reliable and, to be of common application both in the field and in the laboratory is the one based on the anatomical structure of wood. The wood structure is different in different species, depending on the proportions, size and distribution of various cell elements like vessels, fibres, parenchyma, etc. No two woods have exactly the same structure and the structural patterns are like the finger-prints by which the identity of any timber can be established. Though detailed study of the microscopic structure of wood from specially prepared slides is possible only in a well-equipped laboratory, the main structural patterns which are of diagnostic value can be made out in the field itself and afford a reliable basis for timber identification.

EQUIPMENT FOR FIELD IDENTIFICATION

A sharp pocket knife and a pocket magnifier or hand lens of linear magnification of 10 or 20 times preferably with LED lamp is required for identification of timber in the field, through its macroscopic anatomical structure.

In cases where the timber to be examined is in large sizes or forms part of permanent structures and fittings, small pieces of a size convenient for examination needs to be chiseled out with the help of electric saw or a small saw, a chisel and a hammer. For timbers, that are very soft or badly attacked by rot, safety-razor blades may be used.

PROCEDURE FOR EXAMINATION OF WOOD SAMPLE

The first step in the proper identification of timber is to take out a sample and then prepare on it a suitable surface for examination under the hand lens. The timber sample to be examined should be of a size convenient for easy handling and manipulation. A rectangular piece of 2 to 3 cm square across the grain, and about 5 cm in height along the grain, is a good and convenient size to work with, though, due to unavoidable circumstances it may sometimes not be possible to take out such a sample and identification will have to be based on a much smaller piece. The sample selected or taken out for examination should first be trimmed in the vertical direction along the grain so that at least, one longitudinal surface is tangential (flat-sawn) and one is radial (quarter-sawn). However, for identification the most revealing and important surface to be examined is the end or transverse surface. For suitably preparing this surface for examination under the hand lens, the trimmed sample is held tightly in the left hand in a vertical position, with the end surface facing upwards and the pith side pointing inwards towards the holder. The knife is held firmly in the right hand, with the thumb pressed hard against the inner side of the sample. To make a good clean cut, the blade should be slightly tilted downwards at an angle and then drawn inwards, across the grain. While doing so care should be taken to see that the right thumb is kept well below the upper edge of the sample, lest any accidental slipping of the knife should give a nasty cut to the thumb. A little practice and experience will be necessary to know exactly how much pressure is to be applied to the knife blade for making a clean and perfect cut. For the purpose of examination, it is not necessary that the entire end surface of the sample should be exposed by making several cuts. In most cases, a single cut exposing an area about a centimeter square will be found sufficient, provided it is clean and sharp and made in the proper plane. A good cut is most important as even the slightest crushing of tissues resulting from a blunt knife or a bad cut is likely to obliterate some of the structural details so important for correct identification. It is for this reason that it is sometimes preferable to use a sharp and thin razor blade rather than a knife for making the cut particularly when the timber is extremely soft and brittle due to natural and other causes.

Once a good cut has been made, the next step is to examine the exposed area under the lens. For doing this, the lens is held close to the eye in one hand and the specimen slowly raised towards it with the other so that the cut area on the end surface comes sharply into focus, showing clearly all the structural details. For accuracy in identification work, it is desirable that examination of the specimen is always done in a good light, and the specimen held in such a way that the surface to be examined catches all the light. Experience has shown that, usually, structural features like rays, parenchyma, and resin canals stand out more clearly when the surface is moistened with water. But in some timbers application of water appears to have an opposite effect making some of the structures less distinct. It is therefore advisable to try both ways for accurate results.

Though most structural details, of diagnostic value are visible on the end surface, some features like ripple marks, horizontal resin canals, etc., can be observed only on the longitudinal surfaces, particularly the tangential surface. Therefore, no examination of timber samples can be considered complete unless the longitudinal surfaces are also carefully observed under the lens. Here again, the surfaces to be examined should be truly tangential and truly radial as, otherwise, they may give a wrong impression. Besides the structural pattern that can be seen under a lens, certain other features like colour, lustre, hardness, fluorescence, etc., are also of some importance in identification, particularly when taken in conjunction with the structural pattern. The combination of both physical and macroscopic features together should than be used for identification of a timber.

2 DIAGNOSTIC FEATURES OF WOOD

Timber identification may be grouped broadly under two heads, viz., (I) Physical features and (2) macroscopic anatomical features. The former includes features like colour, weight, hardness, lustre, etc., the study of which does not call for any special knowledge or technical experience. The latter on the other hand can be studied only under a hand lens and require basic knowledge regarding the macrostructure of wood.

PHYSICAL FEATURES

The most common physical properties that need to be assessed in a sample of timber are colour, hardness, weight, odour, lustre, feel, grain and texture. These physical attributes, though by themselves not so reliable as anatomical features, are often useful supplementary aids in the field identification of timbers and are therefore dealt with here.

Colour

Colour in wood shows a wide range of variation depending upon a number of factors; all the same, it is sometimes useful in the field identification of timbers. In most woods the logs when cut across show two more or less distinct regions based on colour – an outer lighter-coloured zone of varying width known as sapwood and an inner or central darker-coloured portion known as *heartwood*. The colour distinction between the sapwood and heartwood is sometimes of diagnostic value. It may be sharp and well-defined in some timbers like Chir (*Pinus roxburghii*), Sissoo (*Dalbergia sissoo*) and Kokko (*Albizia lebbeck*) or somewhat less defined and gradual as in Sal (*Shorea robusta*) and Haldu (*Adina cordifolia*) while others like Spruce (*Picea smithiana*), Fir (*Abies pindrow*), Kanju (*Holoptelea integrifolia*) and Gamari (*Gmelina arborea*) do not show any such distinction at all, the wood being of the same colour throughout.

The colour of the wood may be uniform, mottled, streaked or variegated. It ranges from almost creamy-white to jet-black through varying shades of grey, yellow, pink, red, brown and purple, and has occasionally even a greenish tinge. The term `light-coloured' is usually applied when the wood is pale yellowish-white or straw-coloured, pale pink, oatmeal, greyish-white, yellowish-grey, pinkish-grey, etc. Within certain limits the colour, whether light or dark may be fairly constant in certain timbers. In such cases it is of help in identification, particularly in distinguishing timbers, otherwise similar in structure like Bijasal (*Pterocarpus marsupium*) and Padauk (*Pterocarpus dalbergioides*).

The colouring matter and other extractives present in wood are often soluble in water and may come off in contact with water. In such cases the water extract of some timbers may show distinct fluorescence as in Bijasal (*Pterocarpus marsupium*) and Padauk (*Pterocarpus dalbergioides*). This is often helpful in their identification.

Hardness

Hardness refers to the resistance offered by wood to indentation or penetration by another body. For the purpose of field identification some idea of the hardness can be obtained from the extent to which woods can or cannot be indented with the finger-nail, and the comparative resistance offered by them to cutting across the grain with a sharp knife. This feature is at times helpful to distinguish woods with somewhat similar anatomy but different hardness Based upon these estimates, it is generally possible to group timbers into three broad classes in the field.

- Soft to very soft – readily indented by finger-nail e.g. Semul (*Bombax ceiba*), Papita (*Pterocymbium tinctorium*) etc.
- Moderately hard – not easily indented by finger-nail but readily cut with knife. Teak (*Tectona grandis*), Mango (*Mangifera indica*) etc.

- Hard to very hard – not indented by finger-nail and cut with considerable difficulty with knife Mesua (*Mesua ferrea*), Sal (*Shorea robusta*) etc.

Weight

Like hardness, weight of wood also varies considerably in different timbers depending on a number of factors like moisture content, amount of infiltration, etc., and as such, is of only limited application in field identification. However, occasionally it may be possible to distinguish two woods of similar structure on the basis of weight. Therefore, based on the field assessment of weight, timbers have been grouped into three classes.

- Light to very light (below 550 kg/m3 or 34 lb/ft3), e.g. Papita (*Pterocymbium tinctorium*), Semul (*Bombax ceiba*), Fir (*Abies pindrow*) etc.
- Moderately heavy (550-750 kg/m3 or 34-46 lb/ft3), e.g. Teak (*Tectona grandis*), Mango (*Mangifera indica*), Deodar (*Cedrus deodara*) etc.
- Heavy to very heavy (more than 750 kg/m3 or 46 lb/ft3), e.g. Mesua (*Mesua ferrea*), Sal (*Shorea robusta*) etc.

Odour

Most woods are devoid of any pronounced scent sufficiently characteristic to be of diagnostic value. This feature should therefore be used with caution, especially because practically all woods have some smell or other when freshly felled and cut, which disappears later. However, in the heartwood of a few timbers the odour is so strong and lasting and, at the same time, so distinctive and well defined that it is of practical value in field identification. Among some of the more important Indian timbers possessing such distinctive and easily detectable odour are Deodar (*Cedrus deodara*) with its pungent aromatic scent, Teak (*Tectona grandis*) with its characteristic smell of old leather.

Lustre

By lustre in wood is meant the ability of wood surfaces to reflect light when viewed from different angles. It is not possessed to the same degree by various timbers, and is thus occasionally of some value in their identification in the field. Timbers like Mulberry (*Morus alba*), Gamari (*Gmelina arborea*) are usually very bright and lustrous while others like Gurjan (*Dipterocarpus* spp.) Jaman (*Syzygium cumini*) are invariably dull. Lustre is best seen on freshly planed or split longitudinal surfaces, particularly the radial surface.

Apart from variation in lustre in different timbers, the ability to reflect light is not present to the same extent in all cells. Among all wood tissues, the rays are known to possess this ability to a remarkable degree. Consequently, in timbers with usually high and conspicuous rays, they appear as lustrous plates or broken ribbons producing the effect commonly known as `silver grain' e.g. Oak (*Quercus* spp.) and Silver oak (*Grevillea robusta*) while it is also seen to some extent in Semul (*Bombax ceiba*) and Papita (*Pterocymbium tinctorium*).

Texture

The term `texture' as applied to wood is generally confused with `grain'. Texture of wood depends upon the size of the cells and the distribution and proportion of the various types of cells. Thus, in hardwoods or porous woods it is primarily related to the size and frequency of the vessels or pores as well as the size and distribution of the rays, while in coniferous or non-porous woods it depends largely on the diameter of the tracheids which constitute the bulk of the wood. Based upon texture, woods can be classified under three classes, though some timbers may show considerable range of variation between any two of them.

- Fine-textured, e.g. Haldu (*Adina cordifolia*), Gardenia (*Gardenia* spp.).
- Medium coarse-textured, e.g. Kanju (*Holoptelea integrifolia*), Pali (*Palaquium ellipticum*).

- Coarse-textured, e.g. Semul (*Bombax ceiba*), Gurjan (*Dipterocarpus* spp.).

While the majority of the woods are even-textured, some timbers show appreciable differences in texture in different portions of the same growth ring. This is generally the case in ring-porous hardwoods like Teak (*Tectona grandis*), Toon (*Toona ciliata*) and Mulberry (*Morus alba*) etc. and in coniferous woods with conspicuous latewood like Chir (*Pinus roxburghii*). Such woods are described as uneven-textured.

The way a timber feels to the touch when rubbed depends to a large extent on its texture. Coarse-textured woods as a rule are rough on the surface, while fine-textured ones like Gardenia (*Gardenia* spp.) and Axlewood (*Anogeissus latifolia*) give a smooth feel. However, as distinct from this, some timbers may show a characteristic oily or greasy feel due to the presence of infiltration products like oils, waxes and gums e.g. Teak (*Tectona grandi*s).

Grain

Grain in wood refers to the general direction or alignment of cells, and as such should not be confused with texture. Depending on the actual alignment of the wood elements the grain may be straight, spiral, interlocked, wavy or irregular. Though not of much significance from the point of field identification of timbers, the nature of grain vitally affects the strength, seasoning and other properties of timbers and, as such, is of great importance in timber utilization. Occasionally, however, a particular type of grain may usually be associated with a timber, as interlocked grain in Sal (*Shorea robusta*).

MACROSCOPIC ANATOMICAL FEATURES

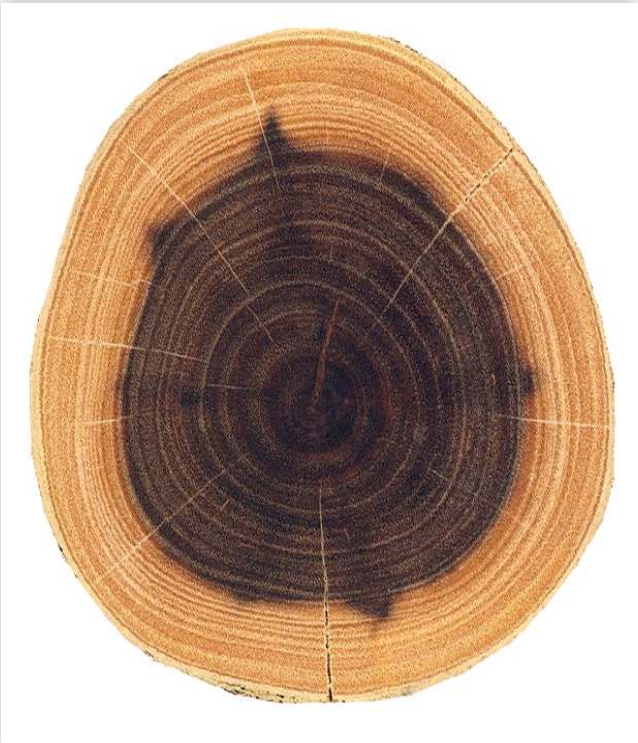
In most woods the logs when cut across show two more or less distinct regions based on colour – an outer lighter-coloured zone of varying width known as Sapwood and an inner or central darker-coloured portion known as Heartwood (Plate-1, A). It may be sharp and well-defined in some timbers like Chir (*Pinus roxburghii*) and Sissoo (*Dalbergia sissoo*) or somewhat less defined and gradual as in Sal (*Shorea robusta*) and Haldu (*Adina cordifolia*) while in others there may be no such distinction at all (Plate-1, B) like Spruce (*Picea smithiana*), Fir (*Abies pindrow*), Kanju (*Holoptelea integrifolia*) and Gamari (*Gmelina arborea*) etc., the wood being of the same colour throughout.

Sapwood, is the area where conduction of water and minerals takes place. Since it has huge moisture content, therefore it is more vulnerable to decay and fungi attack. It also has much more tendency to shrink than heartwood and is unstable when dried. Heartwood, is usually the non-conducting or the dead part of the tree and contains less moisture and therefore less prone to decay and fungi. It is stronger and more durable than sapwood due to its cells being clogged with extractives like gums, tannins, oils, resins and therefore has different chemical buildup.

Growth Ring

Apart from sapwood and heartwood, most woods show on the cut end surface of the logs a number of concentric lines or marks, this may be either faint and barely visible, or distinct and prominent. These are the Growth Marks. The interval, or layer, between two such consecutive growth marks represents the wood laid down by the tree during a growing season and is known as a Growth Ring. Within a growth ring the wood towards the inside, which is formed in the early part of the growth season, and is comparatively lighter in colour is termed as Earlywood, and the wood towards the outside, which is laid down in the later part of the season, and is comparatively darker in colour than earlywood is known as Latewood. Earlywood and latewood may differ to a varying extent in structure, texture, or both. The greater the difference between earlywood and latewood the more prominent are the growth rings. Growth rings are very conspicuous in conifers, while in Dicot woods, they may vary from indistinct (Plate-1, D) to distinct or prominent (Plate-1, C).

PLATE - 1



Sapwood and Heartwood colour distinct

Sapwood and Heartwood colour indistinct

Growth rings prominent or distinct

Growth rings indistinct

Based on the macrostructure, timbers are classified under two main groups: Porous and Non-porous.

Porous Woods

These are produced by dicotyledonous, or broad-leaved, trees like Teak (*Tectona grandis*), Sal (*Shorea robusta*), Mango (*Mangifera indica*) and Semul (*Bombax ceiba*), and are known as 'hardwoods'.

Non-Porous Woods

These are produced by coniferous, or needle-leaved, trees such as Deodar (*Cedrus deodara*), Chir (*Pinus roxburghii*), Spruce (*Picea smithiana*) and Fir (*Abies pindrow*), and are known as 'softwoods'.

These two terms 'hardwood' and 'softwood' have no relation to the relative hardness or softness of timber, and are only applicable to porous and non-porous woods respectively, irrespective of their softness or hardness. Thus, Semul (*Bombax ceiba*) and Papita (*Pterocymbium tinctorium*), though soft to very soft are classified as hardwoods as they are porous woods while Deodar (*Cedrus deodara*) and Chir (*Pinus roxburghii*), which are much harder, are classified as softwoods as they are non-porous. Thus, the term `hardwood' and `softwood' are often used in trade in our country rather vaguely or loosely, even by professionals.

The woods of the two groups differ markedly in their structure, hardwoods (*porous woods*) being much more complex than softwoods (*non-porous woods*). The various anatomical features of diagnostic value, peculiar to each group are described as follows-

POROUS WOODS

Porous woods or hardwoods are made up of a number of tissues or wood elements like the Vessel or Pores, Parenchyma, Fibre, Rays etc., which are adapted to perform certain specific functions in the living tree. The macroscopic anatomical features associated with each of these wood elements are explained below-

Pores or vessels

Vessels are long tubular elements running in a vertical direction and serve to conduct water and mineral nutrients from the soil to the crown. On the longitudinal surfaces, the vessels frequently show up as long fine lines or grooves, commonly described as vessel lines. When cut across, they appear on the end surface of wood as small circular or somewhat oval openings or holes usually visible to the eye or under a hand lens, and are known as 'pores'. The occurrence of pores or vessels is a constant feature of all broad-leaved trees and it is for this reason that hardwoods are classified as 'porous woods' (woods with pores). Conifers or softwoods on the other hand are classified as 'Non-porous' as vessels or pores are entirely absent in them. Apart from the presence or absence of pores, which is the basis for the classification of timbers into these two groups, many other characteristics of pores like their size, number or frequency, the way they are arranged or grouped and even their contents are of diagnostic value in the identification of hardwoods.

Pore size

Pores vary considerably in size from very small or minute visible only with the aid of a lens, to very large clearly visible to the eye. Further, the difference in pore size in different timbers may be of sufficient significance to be of value in their identification. Though actual measurement of the size of the pores is not possible without the aid of a compound microscope, some estimate of their relative size can be obtained in the field on the basis of their visibility according to the classification given below.

Size class	Visibility	Examples
Very large	Clearly visible to the eye; outlines distinct	Kokko (*Albizia lebbeck*), Semul (*Bombax ceiba*)
Large to medium-sized	Just visible to the eye; outlines not very distinct	Kanju (*Holoptelea integrifolia*), Vellapine (*Vateria indica*)
Small to very small	Not visible to the eye	Haldu (*Adina cordifolia*), Gardenia (*Gardenia* spp.)

Pore Number

The frequency of pores or the number of pores per unit area as seen on the end surface, varies considerably in different timbers and is of some value in timber identification. Accurate counts are, however, not possible in the field, though a rough grouping into three classes as given below is to some extent feasible and may be of help.

Pore Frequency	Pores per unit area	Examples
Scanty	Can usually be counted without using a lens (usually less than 10 per 4 sq. mm)	Semul (*Bombax ceiba*), Papita (*Pterocymbium tinctorium*), Fig (*Ficus* spp.), Aini (*Artocarpus hirsutus*)
Moderately numerous	Can be counted only under a lens (mostly 20-80 per 4 sq.mm)	Kanju (*Holoptelea integrifolia*), Vellapine (*Vateria indica*), Sal (*Shorea robusta*), Babul (*Acacia nilotica*), White cedar (*Dysoxylum malabaricum*).
Very numerous	Not possible to count even under a lens (over 80 per 4 sq. mm)	Haldu (*Adina cordifolia*), Boxwood (*Buxus sempervirens*)

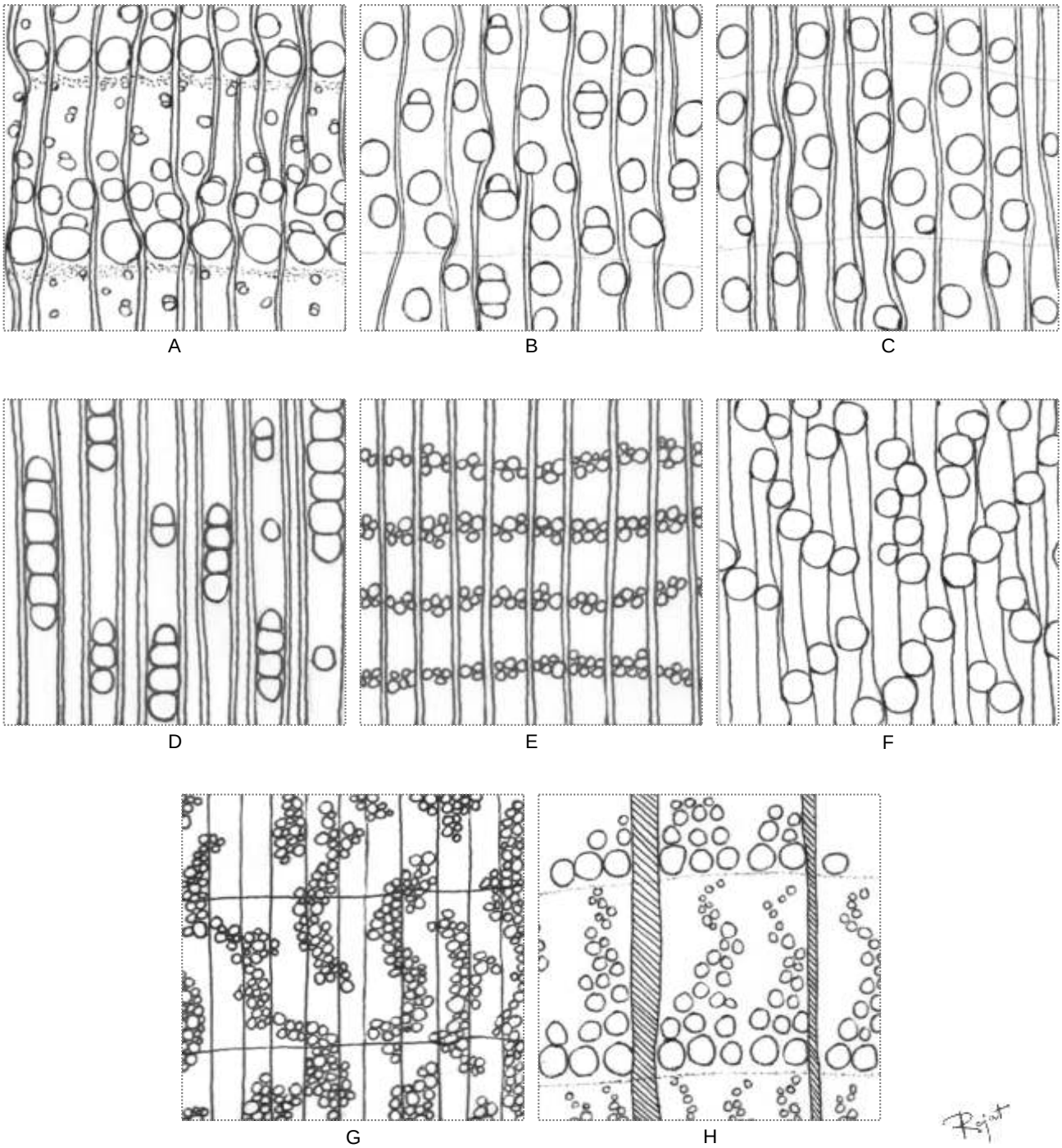
With a little practice and some training, even approximate counts can be made by using a piece of black paper or a thin metal foil in which a small square 2 mm x 2 mm has been cut out and counting the number of pores included in the square when it is superimposed on the cleanly cut end surface of the wood under examination.

Pore arrangement (Plate 2, A-H)

The way in which pores are arranged in a wood constitutes one of the most important features of diagnostic value in the field identification of timbers. Depending on the general pattern of distribution of pores within a growth ring, porous woods can be classified under two main groups, ring-porous and diffuse-porous, within each of which the pore arrangement is of diverse types, the most common one being solitary interspersed with short radial multiples.

PLATE - 2

ANATOMICAL FEATURES OF WOOD- PORE ARRANGEMENT.



A). Ring-porous with pores solitary and in short radial multiples. B). Diffuse-porous with pores solitary and in short radial multiples.
C). Exclusively solitary. D). Long radial multiples. E). Tangential clusters. F). Oblique groups.
G). Flame-like and Diffuse-porous. H). Flame-like and ring-porous.

Ring-porous to semi-ring-porous

When pores of the earlywood are distinctly larger than those of the latewood and are arranged to form a sort of conspicuous ring or belt at the beginning of the growth ring as in Mulberry (*Morus alba*), Teak (*Tectona grandis*) and Toon (*Toona ciliata*), the woods are described as ring-porous. Woods in which the ring-porous character is present but is not very distinct or conspicuous are described as semi-ring-porous, e.g. Benteak (*Lagerstroemia lanceolata*). For purpose of field identification, it is convenient to group ring-porous and semi-ring-porous woods together.

Diffuse-porous

The great majority of Indian hardwoods, however, do not show any appreciable difference in the size of earlywood and latewood pores, which are all, distributed more or less uniformly throughout the growth ring, and are classified as diffuse-porous woods.

Exclusively solitary

Pores are said to be solitary when they occur singly, without abutting on or coming into contact with other pores near them. In most hardwoods, the predominating pattern is one where such solitary pores are somewhat evenly interspersed with short radial multiples. However, there are a few timbers like *Dillenia* spp. and *Dipterocarpus* spp., in which the pores are almost exclusively solitary. This feature therefore, is of considerable help in their identification.

Long radial chains or multiples

Here the pores are so arranged as to form long, radial rows of 3-6 or more. When the contiguous pores within a row are merely in contact with or just touch each other, they form what is called a 'pore chain'. However, in many cases the walls of contact between the pores may become pressed or flattened, so as to give the impression of a single pore having subdivided several times. Such a radial arrangement is known as a long radial multiple. Long radial chains or multiples are a distinctive feature of a number of woods like Satinwood (*Chloroxylon swietenia*), Pali (*Palaquium ellipticum*) and Ebony (*Diospyros* spp.).

Tangential clusters or festoons

When most of the pores tend to form tangentially aligned groups or clusters they give rise to a pattern which is at once striking. Sometimes in such cases the tangential groups may be somewhat curved or arched giving the impression of pore-festoons connecting the rays. Among woods which show such characteristic tangential pattern may be mentioned Silver oak (*Grevillea robusta*) and Elm (*Ulmus wallichiana*).

Oblique groups

In some timbers, the predominant pattern may be somewhat diagonal, with most of the pores arranged in long or short, radially-oblique groups. Usually in such oblique groups, the individual pores are for the most part solitary. Yon (*Anogeissus acuminata*), Poon (*Calophyllum* spp.), and Oak (*Quercus* spp.) are good examples of timbers with oblique or diagonal pore pattern.

Flame-like

The pore pattern is described as `flame-like' when the pores (usually small) are arranged in somewhat sinuous, radially-oblique, triangular patches, resembling the flame of a candle. It is a rather rare and unusual feature and is found in only a few woods like *Rhamnus* and some Oaks (*Quercus* spp.).

Inclusions

The pores are as a rule open and devoid of any contents in the sapwood, but in the heartwood they may very often become filled with inclusions of various types. The presence, nature and colour of these inclusions are sometimes of help in identification.

Coloured deposits (Plate-4, B) -

These are mostly gums or other infiltration products and may be yellowish, reddish, brownish, or even blackish in colour. Dark reddish-brown deposits are characteristic of Toon (*Toona ciliata*) and Irul (*Xylia xylocarpa*), while in Teak (*Tectona grandis*) they are somewhat yellowish.

White or chalky deposits

These inclusions appear to be some kind of organic or mineral substances, which may sometimes completely occlude the vessels. White or pale yellowish-white chalky deposits are a characteristic feature of some well-known commercial timbers like Kanju (*Holoptelea integrifolia*) and Aini (*Artocarpus hirsutus*) and serve to distinguish them easily in the field.

Tyloses (Plate-4, A)

Unlike deposits which are mostly infiltration products, tyloses are formed by ingrowths of adjoining parenchyma cells into the pore cavity when the vessels cease to be functional. Often, they may be developed profusely, forming a glistening foam-like mass completely occluding practically all vessels in the heartwood, as in Sal (*Shorea robusta*) and Gamari (*Gmelina arborea*). In such cases, they are very useful in identification.

Parenchyma or soft tissues

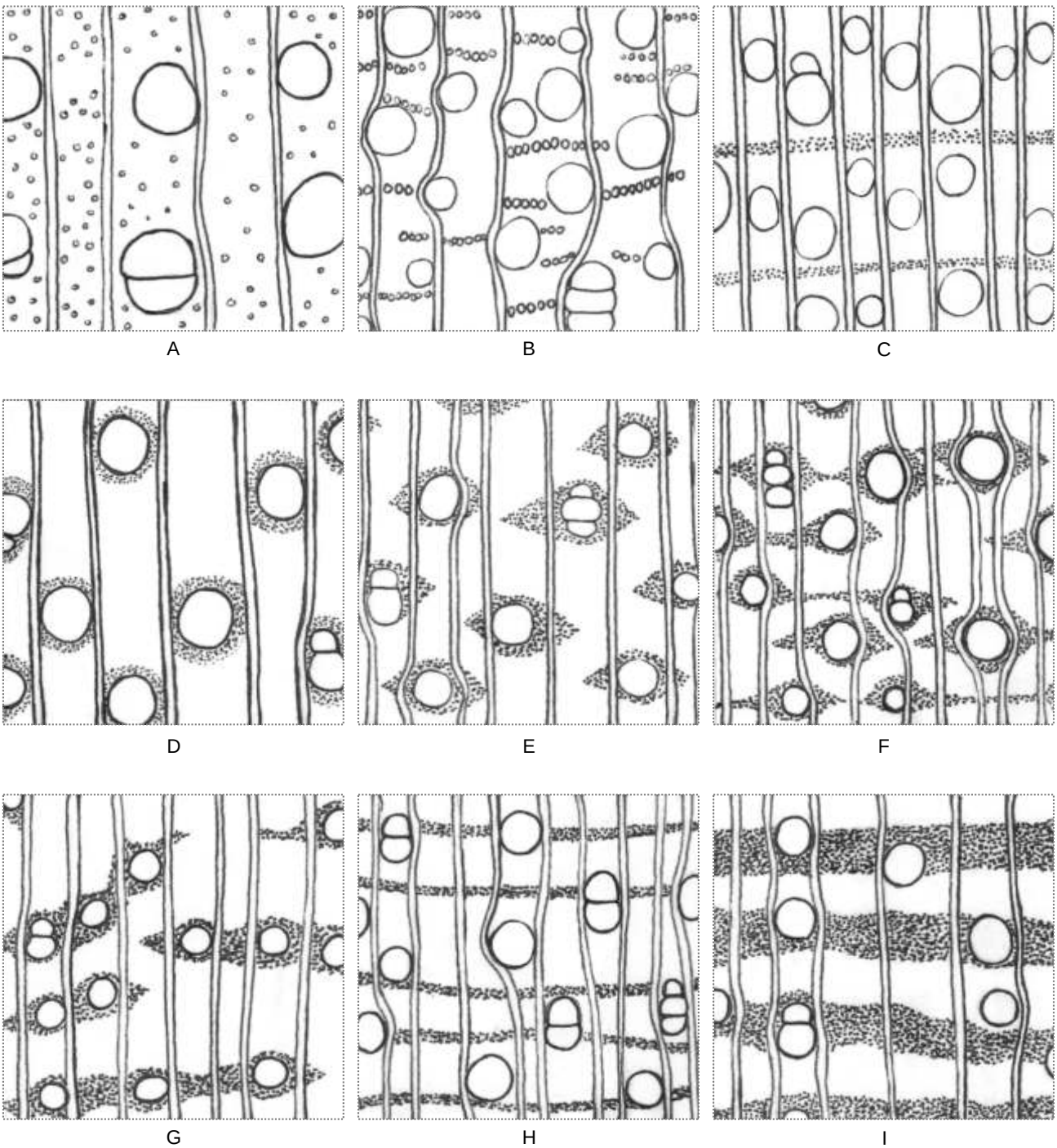
Parenchyma are small, thin-walled, rectangular or brick-shaped cells, which run vertically and mainly serve as storage tissue in the living tree. They are very much softer and easier to cut than the rest of the woody tissues and are also commonly known as *'soft tissues'*. Unlike vessels, the parenchyma cells being very small are not individually distinct even under the hand lens, but, collectively or *en masse* they often form characteristic patterns, which are clearly visible with a lens and sometimes even to the un-aided eye, on the end surface of wood. The distribution and arrangement of parenchyma are therefore of very great importance and practical value in the field identification of timber. The various types of parenchyma patterns met within hardwoods are described below. They are commonly referred to as apotracheal, when the parenchyma distribution is independent of the pores or vessels and paratracheal when associated with the vessels.

Indistinct or absent

It is only very rarely that parenchyma or soft tissues are found to be entirely wanting or absent in hardwoods as in *Homalium* spp. and *Sonneratia* spp. However, there are a number of timbers like Salai (*Boswellia serrata*) and Garuga (*Garuga pinnata*) where the soft tissues, though present, are so sparse or scanty as not to be visible even under the hand lens. For all practical purposes, these two types are indistinguishable in the field and are therefore considered together.

PLATE - 3

ANATOMICAL FEATURES OF WOOD- PARENCHYMA DISTRIBUTION



A B C

D E F

G H I

A). Diffuse or scattered. B). Diffuse-in-aggregates or fine lines. C). Delimiting growth rings. D). Vasicentric. E). Aliform. F). Confluent-narrow. G). Confluent-broad. H). Banded-narrow. I). Banded- broad.

Diffuse or scattered (Plate-3, A)

When parenchyma occur as isolated cells or short tangential aggregates, appearing under the hand lens as whitish or light-coloured dots against the darker coloured fibrous ground mass, the parenchyma distribution is described as 'diffuse' or 'scattered'. Diffuse parenchyma is found in Haldu (*Adina cordifolia*), but is not always easy to make out, requiring considerable practice and a sharp, trained eye.

Diffuse-in-aggregates or fine lines (Plate-3, B)

When the parenchyma occur in the form of fine evenly spaced tangential lines, which may be broken or fairly continuous, they are referred to as diffuse-in-aggregates or fine lines. Often, together with the rays, especially when the latter are fine, they give rise to a characteristic pattern closely resembling the meshes of a net and are described as 'reticulate' or 'net-like'. Such a reticulate pattern is usually clearly visible under a lens as in Pali (*Palaquium ellipticum*) and Ebony (*Diospyros* spp.). In the typically reticulate structure, the lines of parenchyma are more or less continuous and approximately of the same width as the rays. However, sometimes they may be somewhat broken or interrupted and associated with relatively broader rays as in Semul (*Bombax ceiba*).

Delimiting growth rings (Plate-3, C)

In some hardwoods, parenchyma may occur as a fine continuous line or a narrow band, which may be formed either at the beginning or end of the growth season. Such initial or terminal bands of parenchyma as a rule sharply demarcate or delimit the growth rings. When well-developed they are clearly visible to the naked eye, e.g. Champa (*Michelia champaca*), White cedar (*Dysoxylum malabaricum*) while in others like Laurel (*Terminalia tomentosa*), they may be very fine and visible only under the lens. As the presence of parenchyma delimiting growth rings is a constant feature of some woods, it is very useful in their identification.

Vasicentric (Plate-3, D)

Here the parenchyma are closely associated with the pores, forming a fairly uniform whitish or light-coloured sheath or halo round them, which is distinctly visible under the lens and sometimes even to the un-aided eye as in Babul (*Acacia nilotica*)

Aliform (Plate-3, E)

When the parenchyma surrounding the vessels extends sideways in the form of wing-like lateral projections, it is described as 'aliform' or 'eyelet' type of distribution. Aliform pattern is very distinct in Kokko (*Albizia lebbeck)*, Mango (*Mangifera indica*), Aini (*Artocarpus hirsutus*) and Kanju (*Holoptelea integrifolia*) and may often be found associated either with the vasicentric condition or the aliform confluent type described below.

Aliform confluent (Plate-3, F & G)

This is only a further development of the aliform type, in which the wing-like extensions of adjacent pores become confluent or connected together laterally. It is usually found in association with the aliform type. For purposes of field identification, it is often convenient to classify the aliform confluent type under two sub-types, namely *confluent-narrow* and *confluent-broad* depending on whether the confluent parenchyma connecting adjacent pores is thin and narrow as in Kanju (*Holoptelea integrifolia*) or relatively broad as in Sandan (*Ougeinia oojeinensis*).

Banded (Plate-3, H & I)

When parenchyma form relatively conspicuous tangential bands, occurring at frequent intervals throughout the growth ring, they are described as `banded'. The bands of parenchyma may be straight or wavy and either confluent or independent of the pores, though the latter is often difficult to make out. Here again two subtypes may be recognized for convenience in field identification. The term Banded-broad may be applied when the bands are broad and conspicuous, being more or less of the same width as the fibre layers separating them, e.g., Fig (*Ficus* spp.) and Narikel (*Pterygota alata*). It may be described as Banded-narrow when the parenchyma bands are fine and narrow as compared with the alternating fibre layers, e.g., Poon (*Calophyllum* spp.).

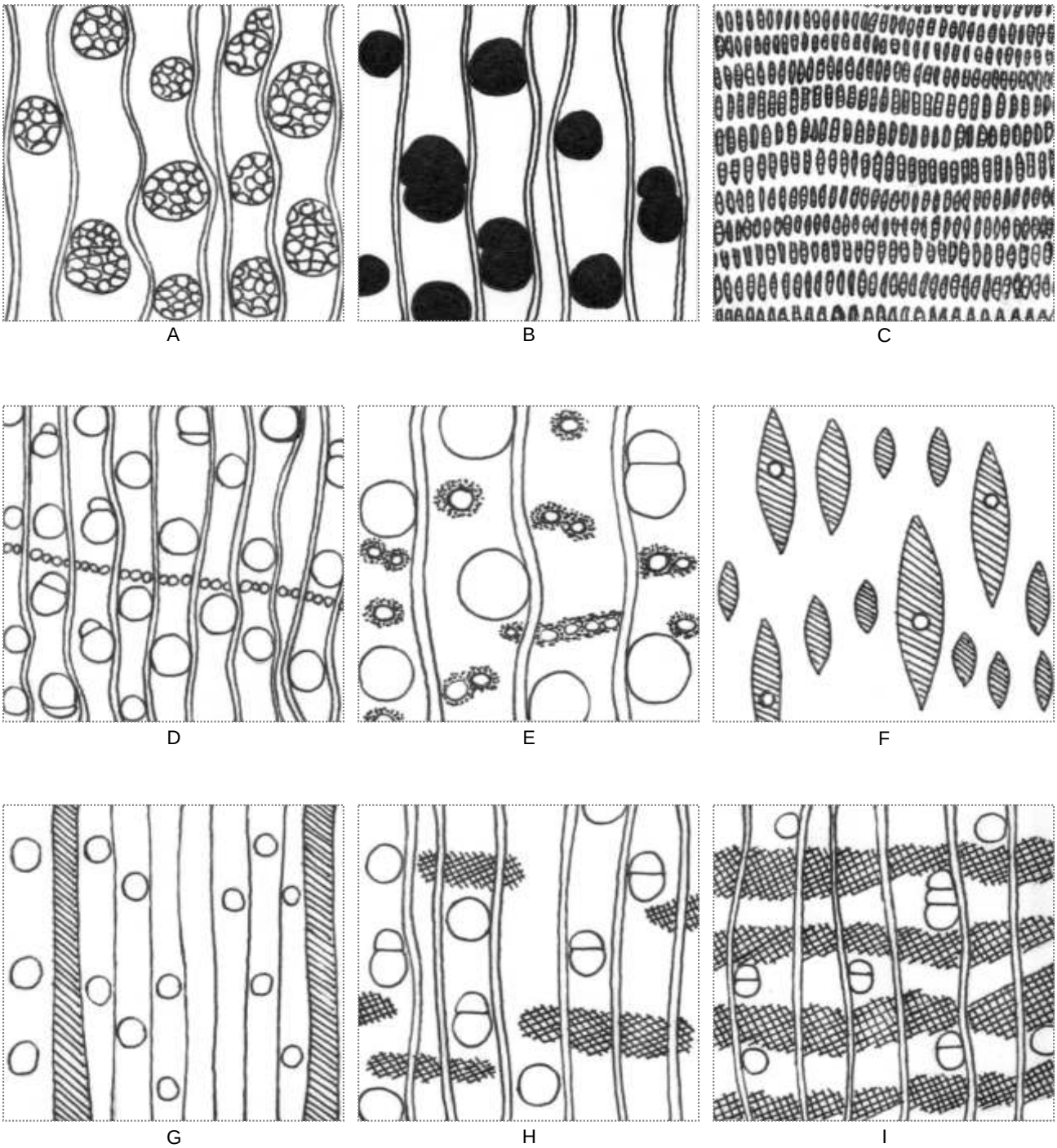
Rays (Plate-4, G)

Rays are groups or strips of horizontally aligned parenchyma cells running in a radial direction from the pith or centre of the log to the bark or periphery, and are meant mainly for radial conduction and storage. They are present in all woods and are visible on the end surface as numerous, fine, whitish or light-coloured parallel lines at right angles to the growth marks. On the tangential surfaces they appear as spindle-shaped bodies, somewhat darker than the background, arranged with their long axis vertical. On the radial surface the rays are ribbon-like and more lustrous than the rest of the tissues, giving rise to the effect known as `silver grain'. The width of the rays as seen on the end surface and their frequency and distribution vary considerably in different timbers and are therefore of considerable diagnostic value. Though exact measurement of ray width is not possible in the field, an approximate idea of the relative width of rays can be obtained on the basis of their visibility. For purposes of field identification of timber, the following classification based on visibility and frequency has been found very helpful and is therefore adopted here.

- Broad to very broad – Rays mostly prominent to the eye, e.g., Semul (*Bombax ceiba*), Papita (*Pterocymbium tinctorium*).
- Moderately broad- Rays mostly clearly visible to the eye and prominent under the lens, e.g. Gurjan (*Dipterocarpus* spp.), Sal (*Shorea robusta*), Teak (*Tectona grandis*).
- Fine to very fine- Rays not visible or indistinct to the eye and visible only under the lens, e.g., Benteak (*Lagerstroemia lanceolata*), Laurel (*Terminalia tomentosa*), Ebony (*Diospyros* spp.).
- Broad and fine - A few, rather widely-spaced rays distinct or prominent to the eye, interspersed with numerous closely-spaced, fine rays visible only under the lens, e.g. Semul (*Bombax ceiba*).
- Numerous, closely spaced- When the rays are 10 or more per mm, e.g. Benteak (*Lagerstroemia lanceolata*), Ebony (*Diospyros* spp.).
- Few, widely spaced- When the rays are less than 5 per mm, e.g., Papita (*Pterocymbium tinctorium*), Semul (*Bombax ceiba*).

PLATE - 4

ANATOMICAL FEATURES OF WOOD



A). Tyloses in vessels. B). Coloured deposits in vessels. C). Ripple marks. D). Intercellular canals in long tangential bands.
E). Intercellular canals in short tangential groups. F). Radial intercellular canal in rays. G). Broad and fine rays.
H). Included phloem. I). Included phloem.

Fibres

In addition to vessels, parenchyma and rays, there is another type of tissue, consisting of elongated, vertically-aligned, thick-walled elements with pointed tapering ends, which makes up the bulk of the wood by weight, in most hardwoods. These elongated, thick-walled cells are the fibres, whose main function is to give mechanical support to the tree. The fibres are individually indistinct even under the lens and are therefore not of much help in field identification, but collectively they form, as it were, the darker-coloured ground mass or matrix in which the pores and the usually lighter-coloured parenchyma and rays are arranged, giving rise to various end-grain patterns characteristic of different porous woods.

Other anatomical features

Besides pores, parenchyma and rays described above, there are certain unique or special anatomical features like ripple marks, intercellular canals and included phloem which are found only in a few timbers. Because of their very nature and rather limited but constant occurrence, they are most valuable in spotting those timbers in which they are normally present.

Ripple marks (Plate-4, C)

Some woods when viewed from the tangential surface, show a series of fine, equidistant, more or less straight to wavy lines or striations running at right angles to the grain. On account of their resemblance to ripple-like markings on sand caused by action of wind or water, they are known as `ripple marks'. They are mostly due to rays of more or less the same height being arranged in horizontal rows or series, and are clearly seen in Bijasal (*Pterocarpus marsupium*), and Kanju (*Holoptelea integrifolia*). Sometimes, along with the rays, one or more of the vertical elements like parenchyma and fibres may also show a storied or tier like arrangement, making the ripple marks even more conspicuous. Occasionally, however, only the longitudinal elements may be storied, in which case the ripple marks are invariably faint and inconspicuous, as in some samples of Semul (*Bombax ceiba*) and Dhaman (*Grewia tiliifolia*.). Ripple marks are thus of great importance in identification.

Intercellular canals (Plate-4, D, E & F)

Intercellular canals are long tubular cavities in wood which may run either vertically or in horizontal direction. The former are known as vertical canals and are distinguished from vessels by the fact that they have no walls of their own. The horizontal canals are similar to the vertical ones but run in a radial direction and are therefore described as radial canals. Both vertical and horizontal canals serve as repositories for various kinds of gums, resins and mucilaginous substances and are accordingly referred to as gum ducts, resin canals and mucilage canals. In hardwoods they are found only in a few timbers and, being visible under a lens, are of great diagnostic value.

Vertical Canals

When present may be arranged in two ways. In the first type, they are scattered either singly or in short tangential groups of 2-6, rarely more. Predominantly solitary canals are a characteristic feature of Vellapine (*Vateria indica*) while short tangential groups are typical of Gurjan (*Dipterocarpus* spp.). Piney (*Kingiodendron pinnatum*) shows solitary canals as well as short tangential groups. In the second type, the vertical canals are arranged in long tangential lines or bands, somewhat resembling growth marks. Sal (*Shorea robusta*) and Hopea (*Hopea parviflora*) are good examples of such distribution.

Radial or horizontal canals

Runs radially through the rays and are usually somewhat more difficult to make out than the vertical canals. However, with some practice they can be seen on the tangential surface of the wood as small, reddish-brown or blackish, circular openings in the middle of the rays, e.g. Garuga (*Garuga pinnata*), Jhingan (*Lannea grandis*) and Salai (*Boswellia serrata*).

Included phloem (Plate-4, H & I)

Phloem normally occurs in the inner bark of the tree and serves mainly to translocate elaborated food materials to the growing parts. Both structurally and functionally it is quite distinct from wood. However, there are a few rare instances of woods in which phloem tissues form a regular feature of the normal wood structure, occurring as pockets or islands embedded in the wood, e.g. *Strychnos* spp., *Memecylon edule* and *Aquilaria agallocha*. Such islands or stands of phloem occurring within the wood are known as *included phloem* and when present are of great diagnostic value. The included phloem strands run vertically and, being liable to disorganize and dry up easily, they form a conspicuous features of the woods in which they occur, appearing on the end surface as fairly large circular or oval cavities containing collapsed and broken tissues. The pockets containing partially disorganized phloem tissue may be isolated and scattered as in *Strychnos* spp., or they may be arranged in tangential or concentric bands as in *Avicennia* spp. On the longitudinal surface they look somewhat like coarse and very conspicuous vessel lines, giving the wood a very rough appearance.

NON-POROUS WOODS

Non-porous woods or softwoods are relatively very much simpler in structure than porous woods, and consist of only a few types of cells. Pores or vessels and fibres are entirely absent, the wood being made up mostly of tracheids which serve both for conduction and for support. Parenchyma or longitudinal parenchyma are usually absent or poorly developed and are, as a rule, not visible even under a lens. Therefore, except in a few cases they are not of much practical value in the field identification of conifers. Similarly, the rays also are very fine, visible only with a lens, and offer no scope for any classification that would be helpful in the field. From the foregoing it will be seen that, unlike porous woods, non-porous woods show comparatively few anatomical features that are of diagnostic value in the field. Nevertheless, there are some features associated with growth rings, earlywood, latewood, intercellular canals, etc., which, being visible to the eye or under a lens, are often of considerable help in the field identification of conifers, and are described below.

Growth rings indistinct

As already stated earlier, in non-porous woods as a rule growth rings are distinct or prominent on all the three surfaces. However, there are some notable exceptions like *Agathis, Araucaria* and *Podocarpus*, in which the woods do not show any marked contrast between the earlywood of one year and the latewood of the preceding year and as a result, the growth rings tend to be indistinct or faint, particularly on the longitudinal surfaces. Among Indian conifers, *Podocarpus wallichianus* usually shows such indistinct or faint growth rings that are practically impossible to make out on the longitudinal surfaces.

Transition from earlywood to latewood (Plate-5, A & B).

Though usually there is distinct contrast between the latewood of one year and the earlywood of the succeeding year, within the same growth ring they may not always be clearly demarcated. This is often made use of in the field

identification of conifers. When the transition from earlywood to latewood within a growth ring is abrupt, the latewood is sharply delimited and stands out prominently, as in Cypress (*Cupressus torulosa*) and Chir (*Pinus roxburghii*). On the other hand, in many conifers like Kail (*Pinus wallichiana*), Yew (*Taxus baccata*) and Thitmin (*Podocarpus neriifolius*) the transition from earlywood to latewood is more or less gradual and in consequence the latewood is never well marked or conspicuous, as in the first group. Occasionally, however, some timbers like Spruce (*Picea smithiana*) and Deodar (*Cedrus deodara*) may show both types of transition.

Resin canals (Plate-5, C-E)

These are intercellular canals containing resin and may be vertical or horizontal, usually both types occurring in the same wood. Resin canals are a characteristic feature of a number of Indian conifers like, Chir (*Pinus roxburghii*), Kail (*Pinus wallichiana*), Spruce (*Picea smithiana*) and Deodar (*Cedrus deodara*), while they may be entirely absent in others like Fir (*Abies*), Cypress (*Cupressus torulosa*), Juniper (*Juniperus* spp.) and Yew (*Taxus baccata*). Further, when present, they may show considerable variation in their size and arrangement in different timbers and are therefore most useful in the identification of conifers. The vertical canals are usually larger and more prominent than the horizontal or radial ones and may sometimes show up on the board faces as resin streaks which are long conspicuous lines or grooves along the grain filled with resin, e.g. Chir (*Pinus roxburghii*). Their arrangement as seen on the surface of the wood is of two types. Usually they are just a few in number, and occur scattered, either singly or in short tangential groups of two to three. Such distribution usually referred to as `scattered' is typically seen in Chir (*Pinus roxburghii*), Spruce (*Picea smithiana*) and Kail (*Pinus wallichiana*). In the second type, which is not so common, the vertical canals are arranged in long tangential bands. Among Indian conifers, only Deodar (*Cedrus deodara*) shows such concentric bands of resin canals. Apart from their distribution, the size and visibility of the vertical canals is also of diagnostic value. They are described as `large' when they are clearly visible to the eye as in Chir (*Pinus roxburghii*) and Kail (*Pinus wallichiana*), and as 'minute' when they are visible only under a lens as in Spruce (*Picea smithiana*).

Radial canals (Plate-5, F)

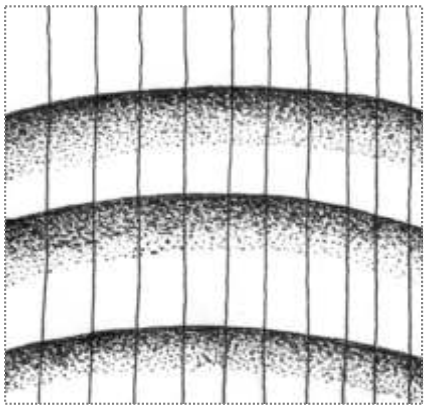
are as a rule very much smaller than vertical canals, and are therefore, not usually visible. But occasionally they can be seen on the tangential surface in the middle of some of the rays, as in Deodar (*Cedrus deodara*).

Parenchyma (Plate-5, G)

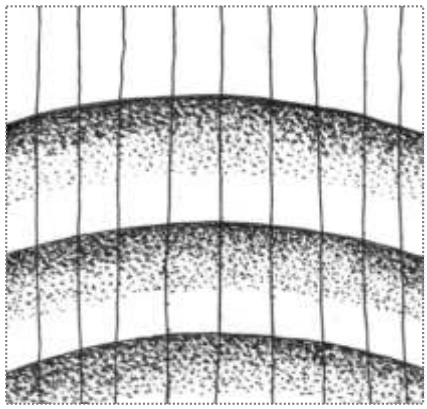
As stated earlier, these are mostly very sparse or absent in conifers, and not discernible without the help of a microscope. Occasionally, however, the longitudinal parenchyma may be sufficiently well developed to be just visible under a lens as minute, brownish-black dots or specks, irregularly scattered in the lighter-coloured ground mass, generally with a tendency to be arranged in tangentially oriented tracts. Thitmin (*Podocarpus neriifolius*) and Cypress (*Cupressus torulosa*) are good examples, the growth rings sometimes presenting a dark punctate appearance.

PLATE - 5

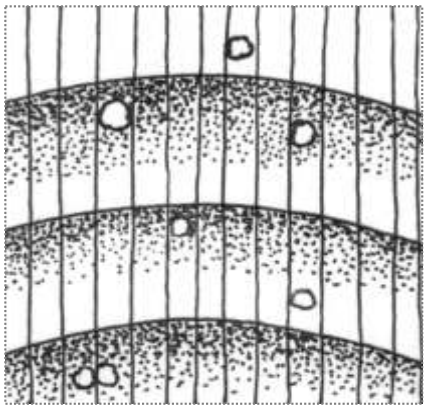
ANATOMICAL FEATURES OF WOOD



A



B



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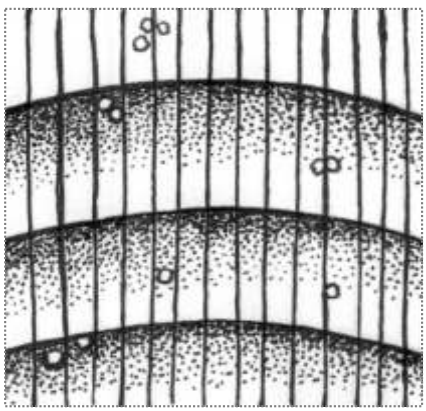
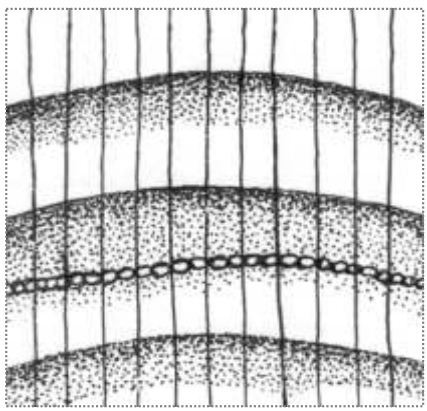
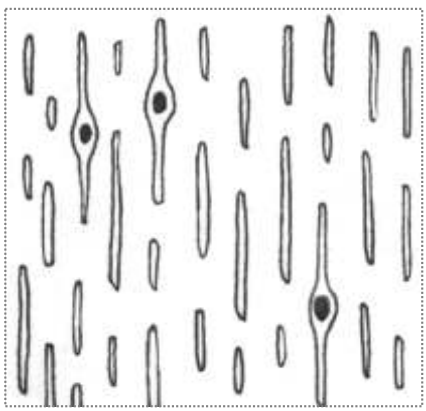


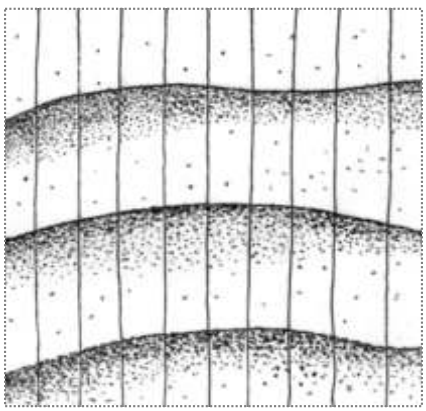
D



E



F



G

A). Transition from earlywood to latewood abrupt. B). Transition from earlywood to latewood gradual. C). Resin canal large and scattered. D). Resin canal minute and scattered E). Resin canals in a long tangential band. F). Radial canals in rays. G). Scattered parenchyma.

3 A DICHOTOMOUS KEY FOR THE IDENTIFICATION OF FIFTY IMPORTANT COMMERCIAL TIMBERS OF INDIA

1.	Wood non-porous (without vessels)	2
1.	Wood porous (with vessels)	7
2.	Resin canals absent	3
2.	Resin canals present	4
3.	Wood without any odour, white and very soft. No colour distinction between sapwood and heartwood	Fir, *Abies pindrow*
3.	Wood with pungent odour, light yellowish-brown, moderately hard. Sapwood and heartwood distinct	Deodar, *Cedrus deodara*
4.	Resin canals scattered	5
4.	Resin canals is long tangential bands, wood with pungent odour	Deodar, *Cedrus deodara*
5.	Resin canals minute appearing as white dots, visible only under the lens. Wood without any odour	Spruce, *Picea smithiana*
5.	Resin canal large, distinctly visible to the eye. Wood with strong resinous odour	6
6.	Wood yellowish to pale reddish-brown. Moderately hard, medium coarse-textured. Transition from early wood to latewood often abrupt	Chir, *Pinus roxburghii*
6.	Wood light pinkish-red to light-red, rather soft, fine-textured. Transition from earlywood to latewood gradual	Kail, *Pinus wallichiana*
7.	Wood ring-porous to semi-ring-porous	8
7.	Wood diffuse-porous	16
8.	Rays distinctly of two types- extremely broad and very fine, the former prominent to the eye on all the three surfaces	Indian Oak, *Quercus* spp.
8.	Rays all of one type, not prominent to the eye	9

9.	Earlywood pore-zone broad changing abruptly to latewood. Latewood pores arranged in tangential groups in zig-zag fashion	10
9.	Earlywood pore-zone narrow, showing gradual transition to latewood. Latewood pores mostly solitary or in short radial multiples	11
10.	Wood light brown to golden-brown to walnut-brown	Elm, *Ulmus wallichiana*
10.	Wood reddish-brown,	Persian Lilac-Bakain, *Melia azedarach*
11.	Semi-ring porous, tendency towards oblique arrangement, wood greyish-brown to dark brown with dark irregularly smoky streaks sometimes beautifully mottled	Walnut, *Juglans regia*
11.	Ring porous, no tendency towards oblique arrangement	12
12.	Parenchyma round the pores abundant and conspicuous, predominantly aliform to confluent	13
12.	Parenchyma round the pores scanty and inconspicuous, mostly vasicentric	14
13.	Confluent parenchyma in the latewood very conspicuous. Wood usually pinkish-brown to light reddish-brown	Jarul, *Lagerstroemia speciosa*
13.	Confluent parenchyma in the latewood relatively less conspicuous. Wood usually greyish to light-reddish or walnut-brown	Benteak, *Lagerstroemia lanceolata*
14.	Wood usually light coloured, creamy, white to pale yellowish-grey or buff. Tyloses abundant and conspicuous	Gamari, *Gmelina arborea*
14.	Wood reddish-brown or golden brown. Tyloses absent or scanty and inconspicuous	15
15.	Wood pinkish or reddish-brown with cedary smell, rather lustrous. Pores often filled with dark reddish-brown gummy deposits	Toon, *Toona ciliata*
15.	Wood golden-brown with characteristic smell of old leather, dull. Pores partly filled with tyloses	Teak, *Tectona grandis*
16.	Vertical gum ducts present	17

16.	Vertical gum ducts absent	22
17.	Gum ducts scattered singly or in short tangential groups of 2-4 or more	18
17.	Gum ducts in long tangential lines	20
18.	Pores usually large, clearly visible to the eye. Wood usually pinkish or reddish-brown	19
18.	Pores usually small, individually indistinct to the eye. Wood usually greyish-white	Vellapine, *Vateria indica*
19.	Growth rings distinct, delimited by a fine line of parenchyma. Rays fine to very fine, indistinct to the eye. Pores often filled with dark gummy deposits. Resin streaks on longitudinal surfaces prominent	Piney, *Kingiodendron pinnatum*
19.	Growth rings absent or indistinct. Rays moderately broad visible to the eye. Pores partly filled with tyloses	Gurjan, *Dipterocarpus* spp.
20.	Pores large, distinctly visible to the eye and heavily plugged with tyloses. Wood rather coarse-textured	Sal, *Shorea robusta*
20.	Pores small, hardly visible to the eye partly filled with tyloses. Wood medium to fine textured	21
21.	Parenchyma mainly diffuse to net-like; paratracheal parenchyma inconspicuous. Wood hard, moderately heavy to heavy	Thingan, *Hopea odorata*
21.	Parenchyma mainly paratracheal, often connecting adjacent pores; diffuse parenchyma scanty and inconspicuous. Wood very hard and very heavy	Hopea, *Hopea parviflora*
22.	Ripple marks present	23
22.	Ripple marks absent	24
23.	Wood light yellow or yellowish-grey. Pores often filled with white chalky deposits	Kanju, *Holoptelea integrifolia*
23.	Wood golden brown, Pores often filled with gummy deposits	Sissoo, *Dalbergia sissoo*
24.	Pores in long radial chains or oblique groups	25

24.	Pores not in long radial or oblique groups	30
25.	Rays distinctly of two types, extremely broad and very fine	26
25.	Rays of one type rather fine, not visible to the eye	27
26.	Heartwood greyish brown to reddish brown, wood hard to very hard, heavy to very heavy	Indian Oak, *Quercus* spp.
26.	Wood creamy-white to greyish-brown, very soft to soft; very light to light	Semul, *Bombax ceiba*
27.	Pores in long radial multiples of 2-6, parenchyma net like, Wood red to reddish brown moderately hard, moderately heavy	Pali, *Palaquium ellipticum*
27.	Pores exclusively solitary, in oblique groups	28
28.	Growth rings delimited by narrow line of parenchyma and darker latewood fibrous tissues, Semi-ring porous, wood greyish-brown to dark brown with dark irregularly smoky streaks sometimes beautifully mottled	Walnut, *Juglans regia*
28.	Growth rings not delimited by narrow line of darker latewood fibrous tissues, Wood light reddish-brown	29
29.	Wood hard to very hard, heavy to very heavy, Heartwood light reddish-brown when fresh, darkening on exposure	Casuarina, *Casuarina equisetifolia*
29.	Wood soft to moderately hard, light to moderately heavy. Heartwood pale brown to reddish brown	Blue gum, *Eucalyptus tereticornis*
30.	Pores minute to small, visible only under the lens	31
30.	Pores mostly medium-sized to large visible to the eye	36
31.	Growth rings delimited by a distinct band of parenchyma or fibre	32
31.	Growth rings not delimited by a band of parenchyma	34
32.	Wood soft Heartwood light brown turning to greyish-brown or reddish-brown, rather lustrous with a silky sheen when first exposed but becoming dull with age, soft, light, vessels usually open	Willow, *Salix* spp., Poplar, *Populus* spp.
32.	Wood moderately hard	33

33.	Heartwood greyish-red to pinkish grey ageing to greyish-brown, vessels open	Birch, *Betula* spp.
33.	Heartwood yellowish olive-green to olive-brown soft to moderately hard, light to moderately heavy occasionally filled with tyloses and whitish deposits	Champa, *Michelia champaca*
34.	Parenchyma paratracheal, forming thin sheaths or eyelets round the pores, often confluent connecting adjacent pores	Axlewood, *Anogeissus latifolia;* Yon, *A. acuminata*
34.	Parenchyma apotracheal, diffuse or in fine lines forming distinct network with the rays	35
35.	Parenchyma in fine lines forming distinct network with the rays. Wood soft and light, vessels partially filled with tyloses	Rubber wood, *Hevea brasiliensis*
35.	Parenchyma apotracheal diffuse, rather inconspicuous under the hand lens, wood deep yellow to brownish-yellow, moderately hard	Haldu, *Adina cordifolia*
36.	Parenchyma usually inconspicuous or not visible even under the lens	37
36.	Parenchyma usually distinct to the eye or under the lens	38
37.	Radial or horizontal gum ducts present visible under the lens on tangential surface as dark dots in some of the rays. Sapwood and heartwood distinct, the former dirty greyish-white, and the latter brown to greenish-brown. Wood moderately hard and moderately heavy	Salai, *Boswellia serrata*
37.	Radial or horizontal gum ducts absent. Sapwood and heartwood indistinguishable. Wood white when fresh, turning pale yellowish-grey, very soft and very light	Maina, *Tetrameles nudiflora*
38.	Growth rings delimited by a distinct band or a line of parenchyma	39
38.	Growth rings not delimited by a distinct band or line of parenchyma	47
39.	Parenchyma delimiting growth rings usually in marginal bands, distinctly visible to the eye	40
39.	Parenchyma paratracheal delimiting growth rings usually in fine lines, visible only under the lens	42
40.	Wood usually soft, greenish-brown without any characteristic odour. Pores open or occasionally filled with tyloses	Champa, *Michelia champaca*

40.	Wood moderately hard	41
41.	Heartwood pale yellowish or brownish-grey with a distinct sweet smell. Pores partly filled with yellowish-brown gummy deposits	White cedar, *Dysoxylum malabaricum*
41.	Heartwood greyish-red to pinkish grey ageing to greyish-brown, pores open	Birch, *Betula* spp.
42.	Parenchyma round the pores mostly vasicentric to aliform	43
42.	Parenchyma round the pores predominantly confluent	46
43.	Wood usually light coloured and soft to moderately hard	44
43.	Wood usually dark coloured, hard to very hard	45
44.	Tyloses abundant and conspicuous. Rays broad to moderately broad, widely-spaced. Wood creamy white to pale yellowish-grey	Gamari, *Gmelina arborea*
44.	Tyloses scanty and inconspicuous. Rays rather fine and closely-spaced. Wood yellowish-white or pinkish-brown	Mango, *Mangifera indica*
45.	Wood dark reddish-brown, medium fine-textured. Pores usually filled with dark gummy deposits	Irul, *Xylia xylocarpa*
45.	Wood greyish-brown, coarse-textured. Pores partly filled with tyloses	Laurel, *Terminalia tomentosa*
46.	Wood golden brown to brown	Sissoo, *Dalbergia sissoo*
46.	Wood yellowish-grey	White chuglam, *Terminalia bialata*
47.	Parenchyma predominantly apotracheal, diffuse-in-aggregates or fine lines or wavy bands. Wood soft to very soft and light	48
47.	Parenchyma predominantly paratracheal, vasicentric to aliform Wood moderately hard to hard, moderately heavy to heavy	51
48.	Rays not of two sizes, fine to very fine	Rubber wood, *Hevea brasiliensis*
48.	Rays of two sizes, very broad to moderately broad and fine	49

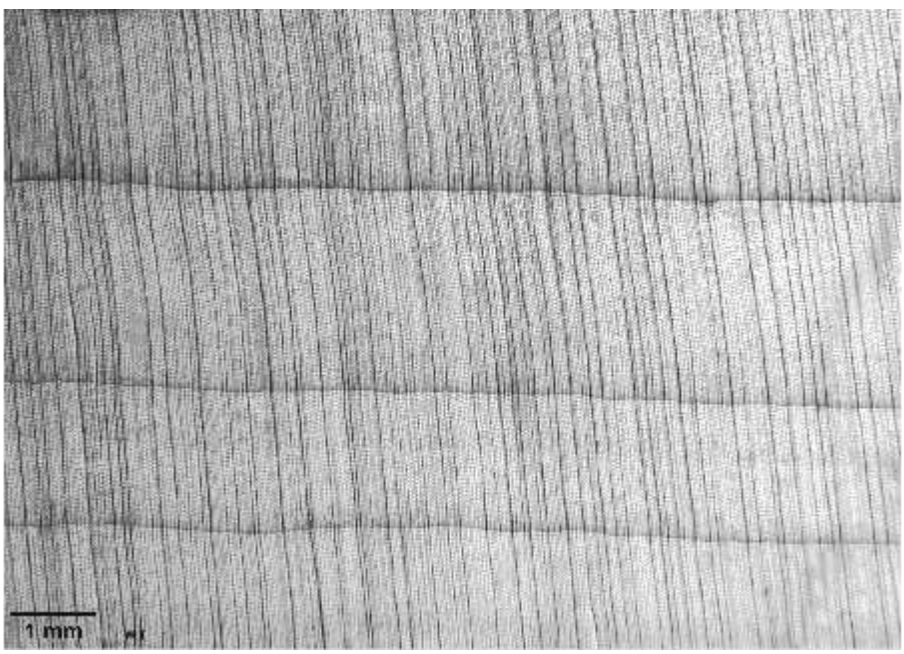
49.	Parenchyma prominent, arranged in broad wavy or fairly straight tangential bands	Narikel, *Pterygota alata*
49.	Parenchyma visible only under the lens, diffuse-in-aggregates or fine lines	50
50.	Parenchyma round the pores present, visible only under the lens	Papita, *Pterocymbium tinctorium*
50.	Parenchyma round the pores absent or indistinct under the lens, diffuse-in-aggregate	Semul, *Bombax ceiba*
51.	Parenchyma predominantly aliform forming conspicuous eye-lets	52
51.	Parenchyma predominantly vasicentric forming thin sheaths round the pores	54
52.	Wood usually not dark coloured yellowish-white or pinkish-brown. Rays rather fine and closely-spaced	Mango, *Mangifera indica*
52.	Wood usually deeply coloured, golden yellow to dark brown	53
53.	Rays rather broad and prominent. Wood golden yellow with darker streaks	Aini, *Artocarpus hirsutus;* Kathal, *Artocarpus heterophyllus*
53.	Rays rather fine, not distinct. Wood brown to dark brown or chocolate	Kokko, *Albizia lebbeck* Safed-siris, *Albizia procera*
54.	Wood creamy white to pale yellowish-grey or greyish brown	55
54.	Wood pinkish to reddish-brown, Tyloses absent or inconspicuous	56
55.	Tyloses abundant and conspicuous	Gamari, *Gmelina arborea*
55.	Wood vessels usually open tyloses only in heartwood	Jaman, *Syzygium cumini*
56.	Rays fine to moderately broad. Pores occasionally filled with inconspicuous tyloses	Dhaman, *Grewia tiliifolia*
56.	Rays moderately broad. Pores filled with gummy deposits	Babul, *Acacia nilotica*

4 DESCRIPTION OF TIMBERS

1. *Abies pindrow* (Royle ex D.Don) Royle (Fir)

PHYSICAL PROPERTIES

Wood creamy-white to pale yellow turning light brown on exposure, soft to moderately hard; light to moderately heavy (sp. gr. 0.37-0.46 air-dry); average weight 370-460 kg/m3 (23-28 lb./ft3) somewhat lustrous when fresh, medium fine textured and straight-grained; alcohol extract colourless to pale yellow.

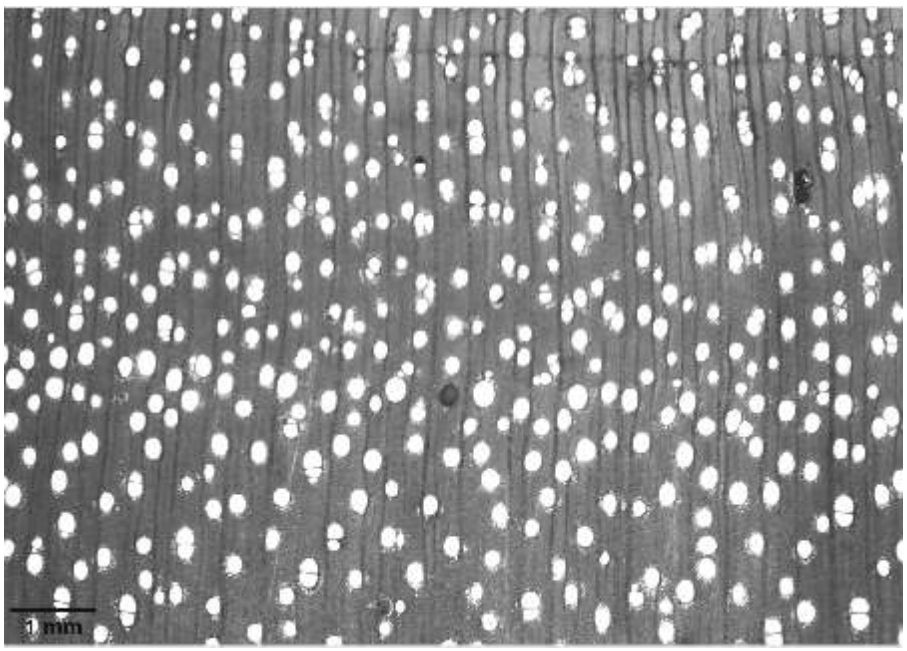


- Macroscopic structure: A non-porous wood.
- Growth rings distinct on all the three surfaces, delimited by a dense band of latewood tracheids, 3-5 per cm. Transition from earlywood to latewood gradual.
- Resin canals absent.
- Parenchyma not visible.
- Rays very fine, not visible to the eye but seen under the hand lens as fine closely spaced-lines.

2. *Acacia nilotica* (L.) Delile (Babul)

PHYSICAL PROPERTIES

Sapwood sharply demarcated from the Heartwood, wide, whitish, turning pale yellow on exposure; heartwood pinkish-brown ageing to reddish-brown; moderately heavy to heavy (sp. gr. 0.71-0.90 air-dry); lustrous; straight interlocked-grain; medium coarse-textured.

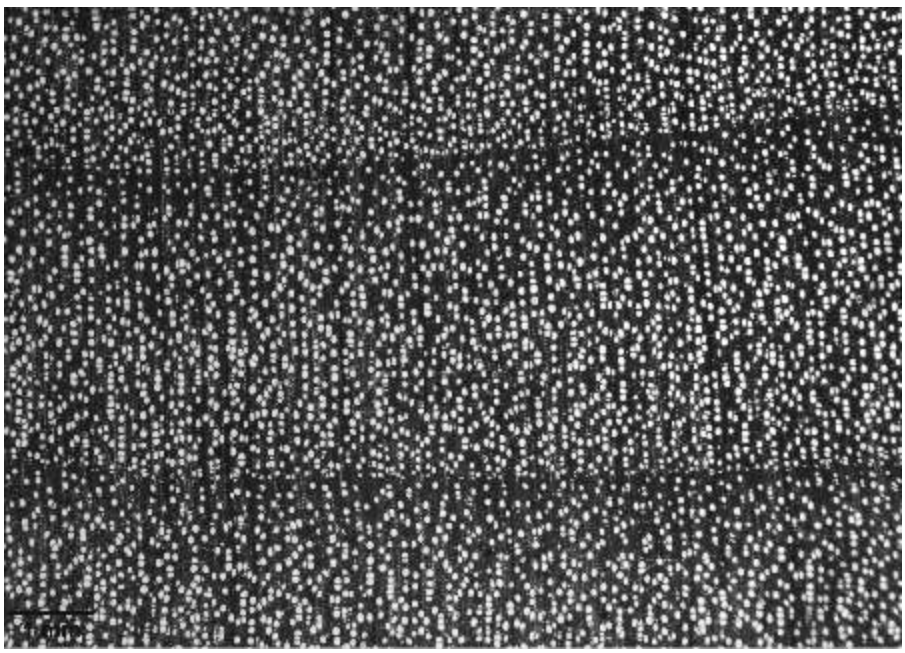


- Macroscopic structure : A diffuse-porous wood.
- Growth rings very variable, absent or indistinct in most samples, but visible under the hand lens, delimited by denser fibres and scattered parenchyma, occasionally accentuated by somewhat larger vessels.
- Vessels usually moderately large to small, visible to the eye, few to moderately few (3-12 mm^2), even to somewhat unevenly distributed, usually solitary or in radial multiples of 2-3, sometimes more, occasionally in clusters, usually oval in outline and filled with dark-brown gummy deposits in the heartwood; vessel lines fairly conspicuous.
- Parenchyma visible to the eye as thin to moderately thick sheaths round the vessels, sometimes enclosing or connecting two or more adjacent vessels tangentially or obliquely and occasionally as scattered parenchyma cells delimiting growth rings.
- Rays almost of the same colour as the background or slightly lighter in colour, moderately broad to fine, the former distinct to the eye and rather widely and irregularly spaced, the latter visible only under the lens.

3. *Haldina cordifolia* (Roxb.) Ridsdale syn. *Adina cordifolia* (Roxb.) Hook. f. (Haldu)

PHYSICAL PROPERTIES

Sapwood pale yellowish-white merging into the heartwood. Heartwood deep yellow when fresh, turning brownish or dull yellow on exposure. Wood moderately hard, moderately heavy (sp.gr. 0.58-0.73 air-dry); lustrous; usually straight-grained but sometimes broadly interlocked, fine-textured.

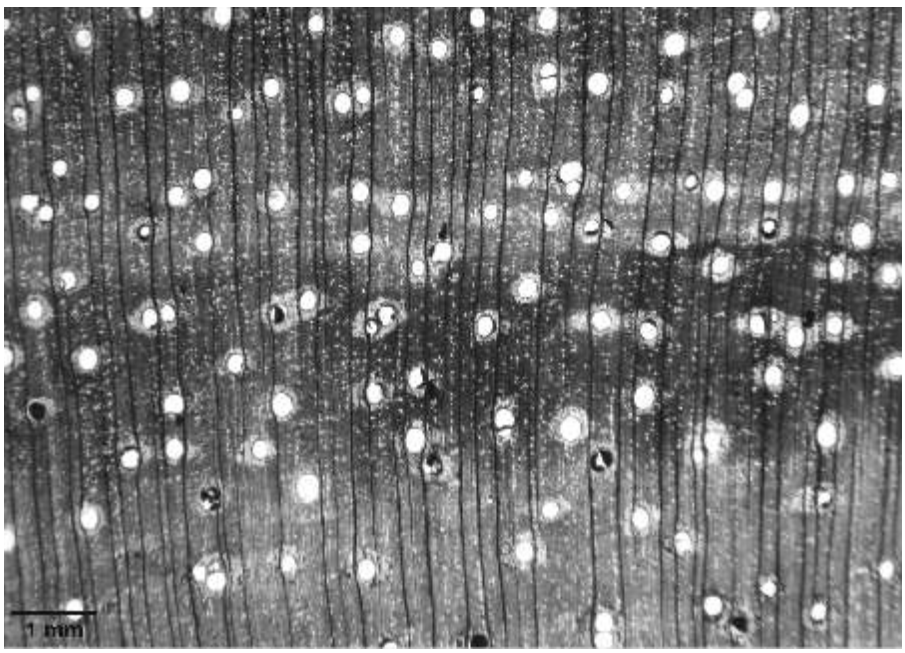


- Macroscopic structure : A diffuse-porous wood.
- Growth rings usually indistinct.
- Vessels small to very small, not visible to the eye, distinct under the lens, numerous to very numerous (25-45 per mm^2), evenly distribution, predominantly solitary (> 85 per cent) oval in outline, open, vessel lines indistinct.
- Parenchyma not visible under the lens, diffuse to diffuse-in-aggregates.
- Rays fine to very fine, distinct only under the lens, closely spaced.

4. *Albizia lebbeck* (L.) Benth. (Kokko)

PHYSICAL PROPERTIES

Sapwood sharply differentiated from the heartwood, usually wide, white or yellowish-white, turning yellow or greyish-yellow on ageing, often discolored due to sap stain; heartwood usually brown to dark brown, sometimes with purplish tinge and beautifully streaked with darker and lighter markings; moderately hard to hard, mostly moderately heavy to heavy (sp. gr. 0.55-0.88 air-dry), lustrous, straight to somewhat interlocked-grained; coarse, even-textured.

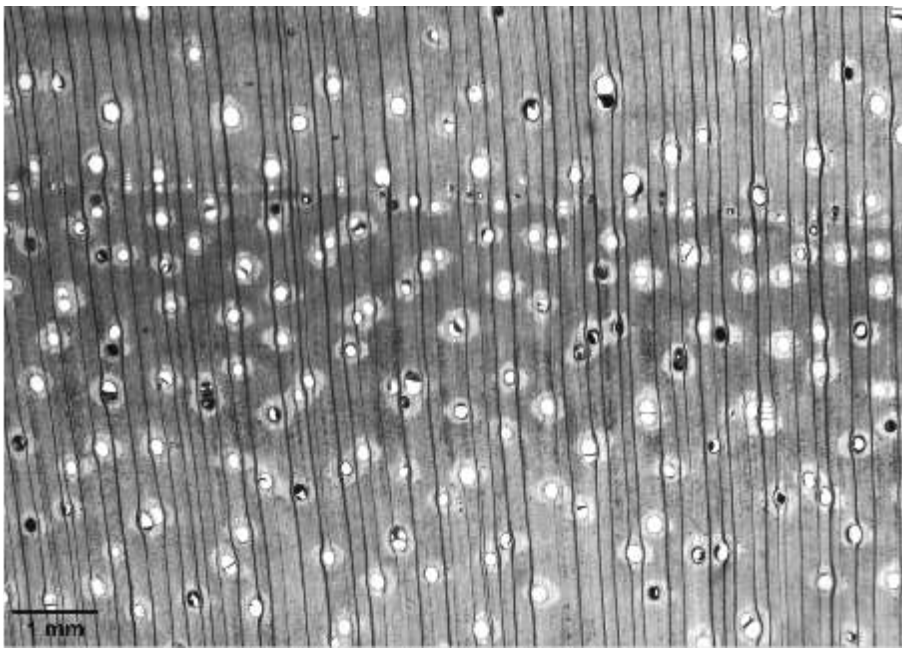


- Macroscopic structure : A diffuse-porous wood.
- Growth rings distinct to indistinct generally inconspicuous, delimited by radially flattened thin-walled fibres associated with parenchyma which may vary from a few scattered cells to a fairly continuous line, 1-5 per cm.
- Vessels large to moderately large, and distinctly visible to the eye, very few to moderately few (less than 1 to 8 per mm^2), more or less evenly distributed, solitary or in radial multiples of 2-3 or more, occasionally in small clusters, round to oval in outline, often filled with dark brown or black gummy deposits; vessel lines conspicuous.
- Parenchyma visible to the eye as distinct 'eyelets' round the vessels or vessel groups occasionally extending laterally to connect two or more adjacent vessels, and forming a very much interrupted to fairly continuous line delimiting the growth rings visible only under the lens, also sparsely diffuse and occasionally just visible under the hand lens as minute scattered white dots.
- Rays fine to indistinct, distinct under the lens as light-coloured lines of varying thickness which appear to run out after a short distance, usually somewhat widely spaced to fairly closely spaced.

5. *Albizia procera* (Roxb.) Benth. (Safed-siris)

PHYSICAL PROPERTIES

Sapwood sharply differentiated from the heartwood, usually wide, white or yellowish-white, turning yellow or greyish-yellow on ageing, often discolored due to sap stain; heartwood usually brown to dark brown, sometimes with purplish tinge and beautifully streaked with darker and lighter markings, occasionally golden brown; moderately hard to hard, mostly moderately heavy to heavy (sp. gr. 0.55-0.78 air-dry); lustrous, straight to somewhat interlocked-grained, coarse, even-textured.

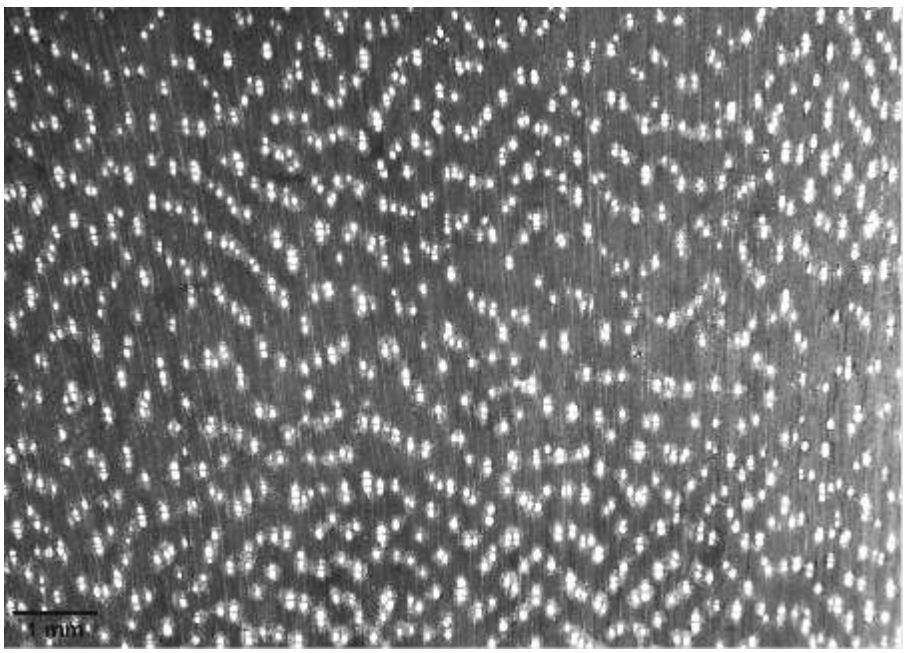


- Macroscopic structure : A diffuse-porous wood but occasionally a slight tendency for semi-ring-porousness.
- Growth rings distinct to indistinct generally inconspicuous, delimited by radially flattened thin-walled fibres associated with parenchyma which may vary from a few scattered cells to a fairly continuous line, 1-5 per cm.
- Vessels large to moderately large, and distinctly visible to the eye, very few to moderately few (less than 1 to 8 per mm^2), more or less evenly distributed, solitary or in radial multiples of 2-3 or more, occasionally in small clusters, round to oval in outline, often filled with dark brown or black gummy deposits.
- Parenchyma visible to the eye as distinct 'eyelets' around the vessels or vessel groups occasionally extending laterally to connect two or more adjacent vessels, and forming a very much interrupted to fairly continuous line delimiting the growth rings visible only under the lens, also sparsely diffuse and occasionally just visible under the hand lens as minute scattered white dots.
- Rays fine to indistinct to just visible to the eye, distinct under the lens as pinkish or light-coloured lines of varying thickness which appear to run out after a short distance , usually somewhat widely spaced to fairly closely spaced.

6. *Anogeissus acuminata* (Roxb. ex DC.) Wall. ex Guillem. & Perr. (Yon)

PHYSICAL PROPERTIES

Sapwood pale yellow to yellowish-grey or olive-grey, turning greyish-brown with age; heartwood small and usually not present except in large trees, chocolate or purplish-brown often with darker streaks. Wood usually hard and heavy (sp. gr. 0.87-1.04 air-dry); slightly interlocked-grained and fine to very fine-textured.

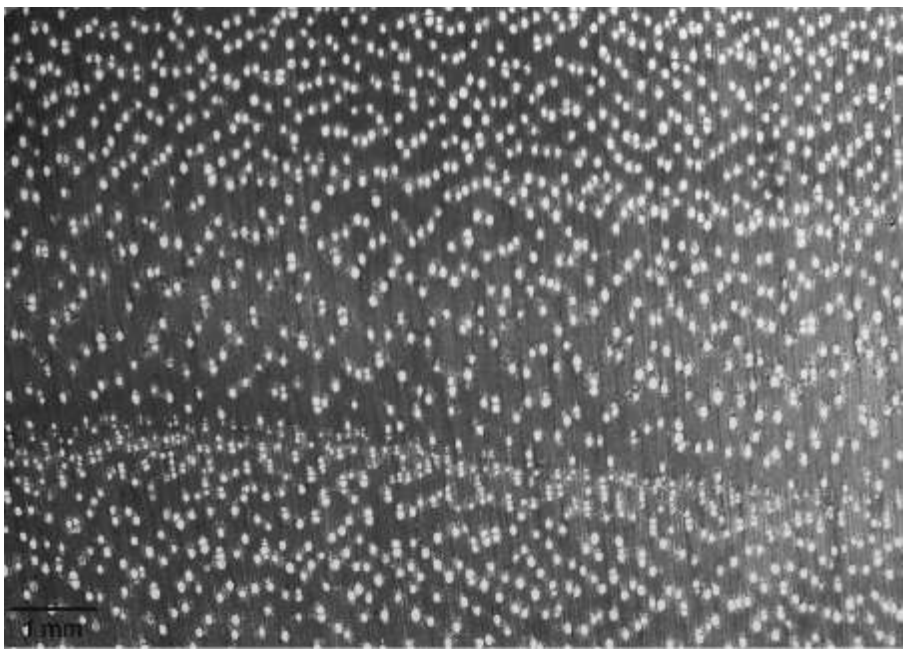


- Macroscopic structure : A diffuse-porous wood.
- Growth rings usually inconspicuous, when distinct demarcated by dark-coloured latewood fibres with fewer and smaller vessels and occasionally by a thin interrupted line of parenchyma, 1-8 per cm.
- Vessels small to very small and moderately numerous to numerous (12-37 mm^2), more or evenly less distributed but sometimes fewer in the latewood, solitary or in radial multiples of 2-4 sometimes more, often arranged in short tangential or oblique groups, round to oval in outline, mostly open; vessel lines inconspicuous.
- Parenchyma variable in amount and visibility, inconspicuous to barely visible to the naked eye, predominantly paratracheal, forming a thin sheath or 'eyelet' round the vessels or vessel groups, often connecting the tangentially or obliquely arranged vessels; also sometimes in thin interrupted lines delimiting growth rings.
- Rays very fine not visible to the naked eye, often with shining whitish deposits, closely spaced and evenly distributed.
- Traumatic gum canals occasionally present in tangential rows.
- Pith flecks rarely present.

7. *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr. (Axlewood – Bakli)

PHYSICAL PROPERTIES

Sapwood pale yellow to yellowish-grey or olive-grey, turning greyish-brown with age; heartwood small and usually not present except in large trees, chocolate or purplish-brown often with darker streaks. Wood usually hard and heavy (sp. gr. 0.87-1.04 air-dry); slightly interlocked-grained and fine to very fine-textured.

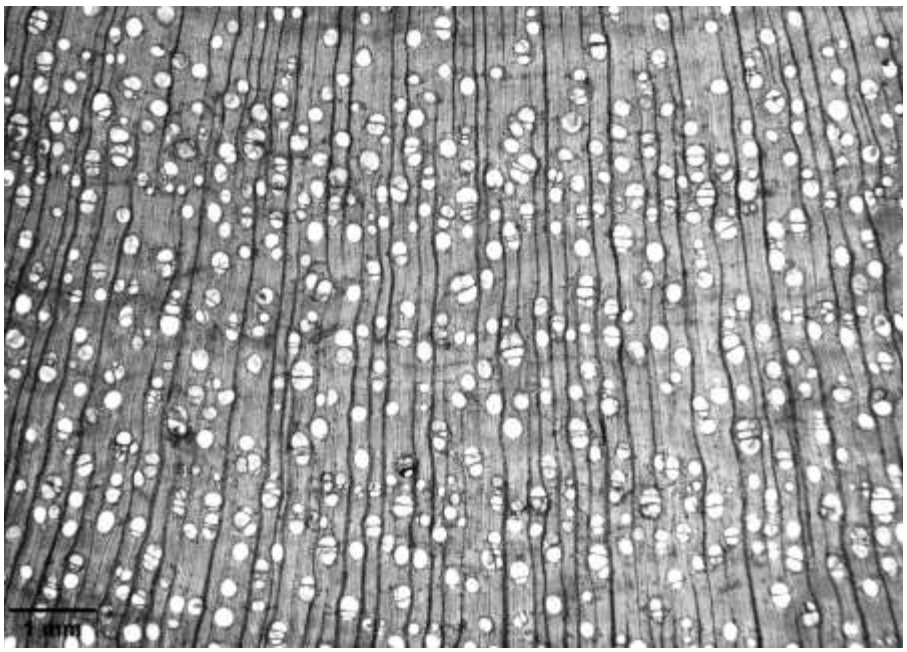


- Macroscopic structure : A diffuse-porous wood.
- Growth rings usually inconspicuous, when distinct demarcated by dark-coloured latewood fibres with fewer and smaller vessels and occasionally by a thin interrupted line of parenchyma, 1-8 per cm.
- Vessels small to very small and moderately numerous to numerous (12-37 mm^2), more or evenly less distributed but sometimes fewer in the latewood, solitary or in radial multiples of 2-4 sometimes more, often arranged in short tangential or oblique groups, round to oval in outline, mostly open; vessel lines inconspicuous.
- Parenchyma variable in amount and visibility, inconspicuous to barely visible to the naked eye, predominantly paratracheal, forming a thin sheath or 'eyelet' round the vessels or vessel groups, often connecting the tangentially or obliquely arranged vessels; also sometimes in thin interrupted lines delimiting growth rings.
- Rays very fine not visible to the naked eye, often with shining whitish deposits, closely spaced and evenly distributed.
- Traumatic gum canals occasionally present in tangential rows.
- Pith flecks rarely present.

8. *Artocarpus heterophyllus* Lam. (Kathal)

PHYSICAL PROPERTIES

Sapwood yellowish-white to greyish-white or grey; heartwood yellowish-brown to golden-brown with darker streaks, turning dark brown on exposure, lustrous when fresh, soft to moderately hard to hard, light to moderately heavy or heavy (sp.gr. 0.33-0.85 air-dry), straight to interlocked-grained and coarse-textured.

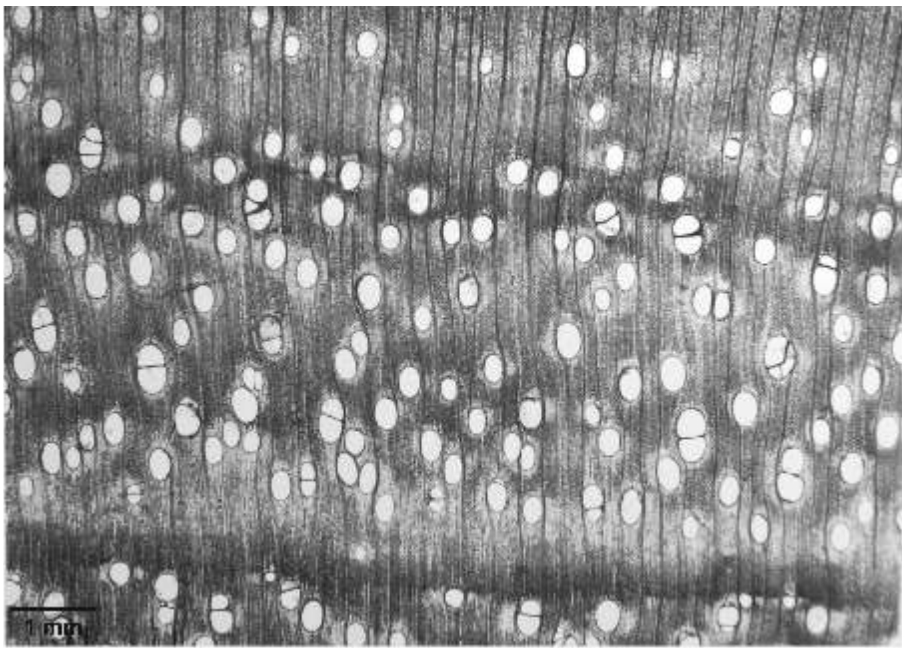


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct to distinct, when distinct demarcated by slightly denser and darker coloured latewood fibrous tissues, 2-4 per cm.
- Vessels large to medium sized, sometimes very large, distinct to eye, very few to few, sometimes moderately few (1-4 but often up to 8 per mm^2), solitary or in radial multiples of 2-3, evenly distributed, oval to round in outlines, sometimes filled with white chalky deposits, tyloses present, vessel lines distinct.
- Parenchyma visible to eye, distinct under the hand lens, forming light coloured haloes or eye-lets round the vessels often extending sideways joining similar extensions.
- Rays moderately broad and also fine at places, rather widely spaced and uniformly distributed, forming distinct or inconspicuous flecks on the radial surface.

9. *Artocarpus hirsutus* Lam. (Aini)

PHYSICAL PROPERTIES

Sapwood yellowish-white to greyish-white or grey; heartwood yellowish-brown to golden-brown with darker streaks, turning dark brown on exposure, lustrous when fresh, soft to moderately hard to hard, light to moderately heavy or heavy (sp.gr. 0.33-0.85), straight to interlocked-grained and coarse-textured.

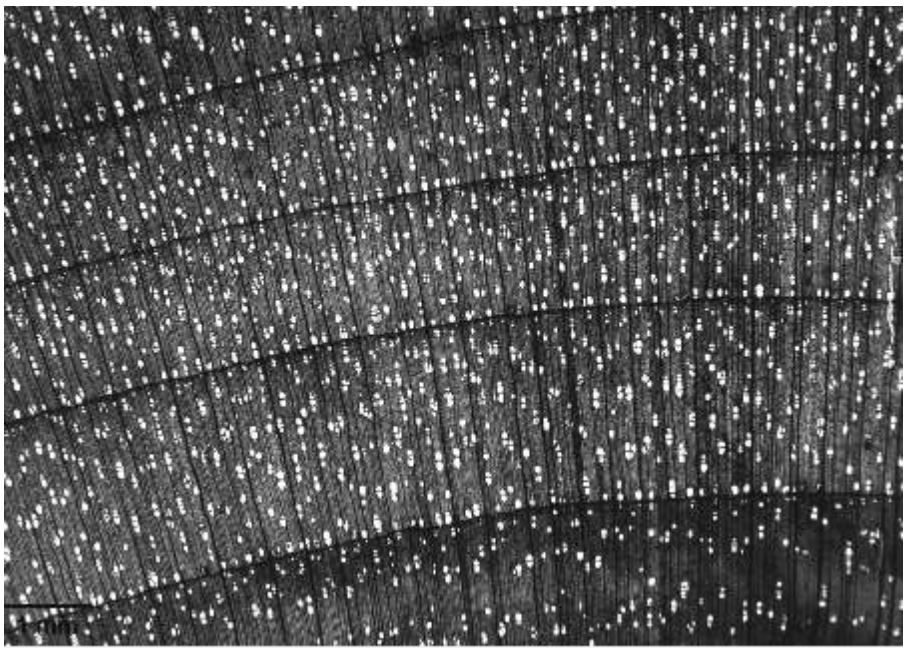


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct to distinct, when distinct demarcated by slightly denser and darker coloured latewood fibrous tissues, 2-4 per cm.
- Vessels large to medium sized, sometimes very large, distinct to eye, very few to few, sometimes moderately few (1-4 but often up to 8 per mm^2), solitary or in radial multiples of 2-3, evenly distributed, oval to round in outlines, sometimes filled with white chalky deposits, tyloses present, vessel lines distinct.
- Parenchyma visible to eye, distinct under the hand lens, forming light coloured haloes or eye-lets round the vessels often extending sideways joining similar extensions.
- Rays moderately broad and also fine at places, rather widely spaced and uniformly distributed, forming distinct or inconspicuous flecks on the radial surface.

10. *Betula* spp. (Birch)

PHYSICAL PROPERTIES

Sapwood distinct to indistinct, white or nearly so, heartwood light greyish-red or pinkish-grey when first exposed, ageing to light greyish-brown; moderately hard to hard, light to heavy (sp.gr.- 0.44-0.80 air-dry), lustrous when fresh, straight-grained and medium fine textured.

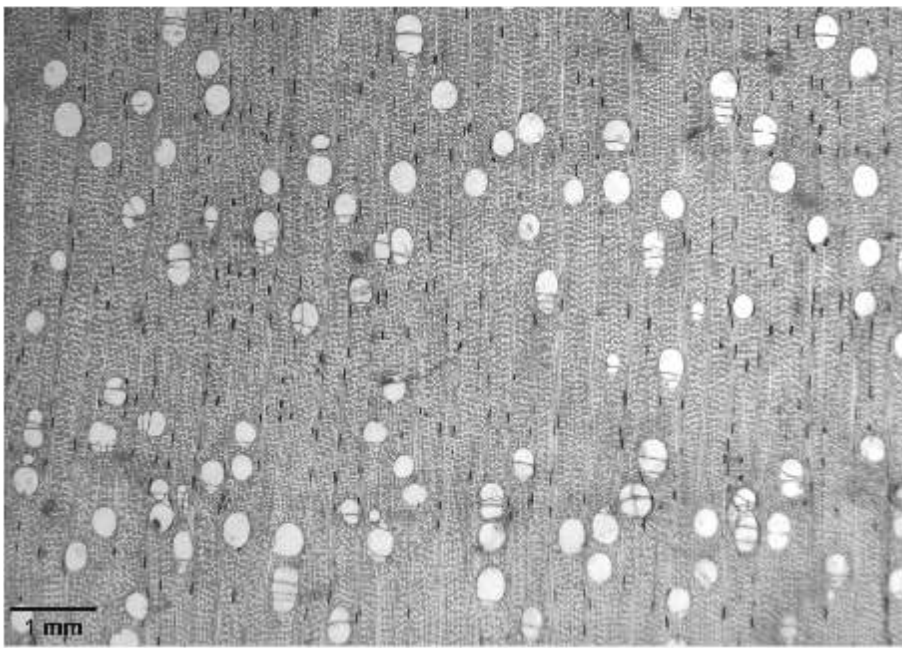


- Macroscopic structure : A diffuse-porous wood.
- Growth rings distinct, delimited by fine lines of parenchyma and sometimes by latewood fibrous tissue, 2-4 per cm.
- Vessels small to medium-sized, distinct under the hand lens (6-12 per mm^2), evenly distributed, mostly solitary and in short radial multiples, rather oval in outline, open, vessel lines distinct on longitudinal surfaces.
- Parenchyma distinct only under hand lens, delimiting growth rings and diffuse to diffuse-in-aggregates.
- Rays rather fine, closely spaced and evenly distributed, darker against the background.
- Pith flecks sometimes present.

11. *Bombax ceiba* L. (Semul)

PHYSICAL PROPERTIES

Wood creamy-white when freshly cut, becoming pale yellowish-brown to greyish-brown on exposure; usually no colour difference between sapwood and heartwood, but occasionally some logs show a darker coloured pinkish-brown to reddish-brown centre; very soft to soft; very light to light (sp. gr.0.26-0.50 air-dry), often lustrous showing silver effect on radial surface; coarse.

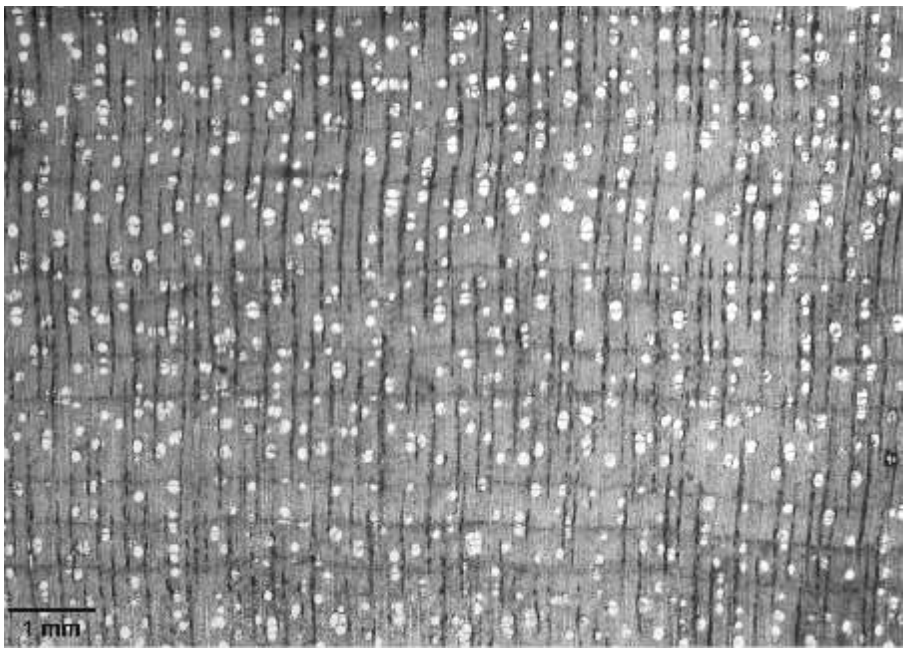


- Macroscopic structure : A diffuse-porous woods.
- Growth rings not always distinct to the eye.
- Vessels very large to large, clearly visible to the eye, very few to few (less than 1 to 4 per mm^2), usually more or less evenly distributed, with little difference in size throughout the growth ring, mostly solitary or in radial multiples of 2-7, oval in outline, usually open or partly filled with tyloses.
- Parenchyma, predominantly apotracheal, visible only under the lens diffuse to diffuse-in-aggregates appearing as fine, closely-spaced, somewhat interrupted tangential lines, forming a reticulum with the rays; lines of parenchyma about the same width as or wider than the fibre layers, 10-15 per mm. and often extending across two or more rays.
- Rays broad to fine, widely spaced; the broader rays very few but prominent to the eye, 1-5 mm or occasionally more in height, forming a conspicuous lustrous fleck on the radial surface; the narrower or fine rays few, just visible or indistinct to the eye, distinct only under lens, interspersed with broader rays sometimes tending to be storied.

12. *Boswellia serrata* Roxb. ex Colebr. (Salai)

PHYSICAL PROPERTIES

Heartwood sharply demarcated from the sapwood. Sapwood white, white to dirty white but very often discoloured due to fungal stain; heartwood small and except in large logs not always present, brown to greenish-brown sometimes with pleasing darker stripes. Wood dull with unpleasant smell when fresh; moderately hard and moderately heavy but heartwood hard and heavy (sp. gr. 0.57-0.88 air-dry); straight to somewhat interlocked-grained and coarse-textured.

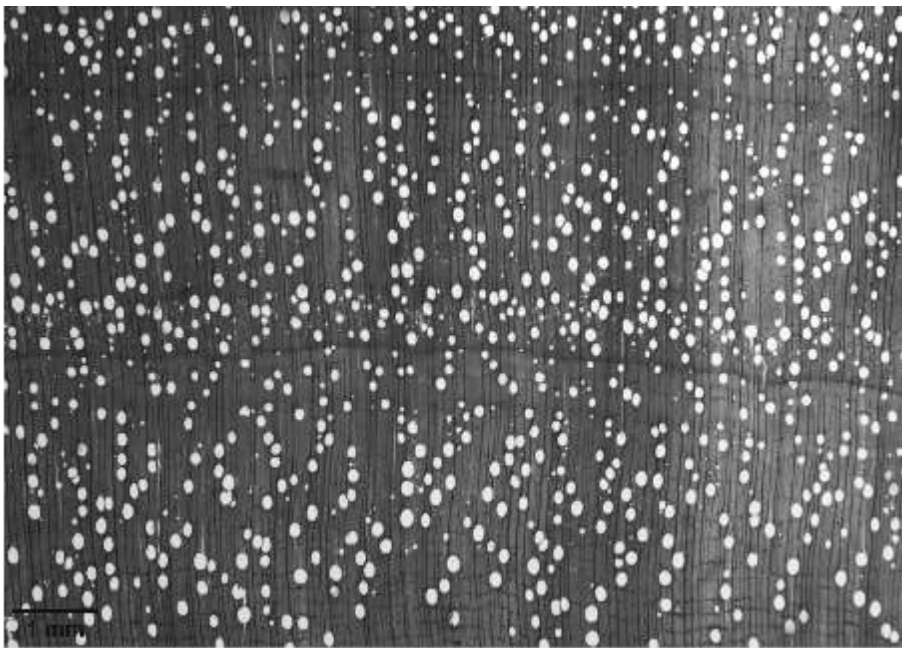


- Macroscopic structure : A diffuse-porous wood.
- Growth rings absent, but occasionally denser fibrous tissues may give the impression of growth marks.
- Vessels usually moderately large to moderately small, fairly distinct to the naked eye, moderately few to moderately numerous (7-13 per mm^2), uniformly distributed, solitary or in radial multiples of 2 to 4, and sometimes in small clusters, round to oval in shape; heartwood vessels plugged with tyloses and also brownish-yellow deposits; vessel lines distinct.
- Parenchyma not distinct even under the hand lens.
- Rays just visible to the eye, moderately broad under lens, usually short and not closely spaced; ray-flecks rather inconspicuous.
- Radial gum canals present. Sometimes visible on the tangential surface as black-dots to the naked eye and usually distinct under the hand lens.

13. *Casuarina equisetifolia* L. (Casuarina)

PHYSICAL PROPERTIES

Sapwood pale-brown gradually merging into heartwood. Heartwood light reddish-brown when fresh, darkening on exposure, hard to very hard, heavy to very heavy (sp. gr. 0.80-1.01 air-dry), more or less straight-grained and rather fine-textured.

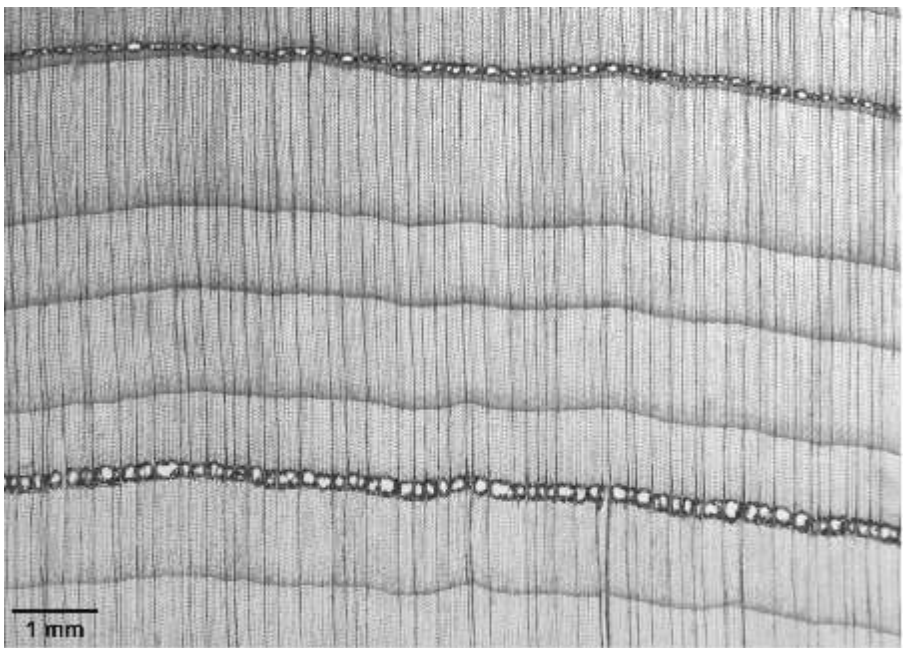


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct to somewhat distinct, when distinct delimited by dark coloured latewood fibrous tissue and a fine rather interrupted line of parenchyma, less than 1-3 per cm.
- Vessels medium-sized to small, just or hardly visible to eye, moderately few to moderately numerous (5-13 per mm^2), rather unevenly distributed, arranged radially or obliquely, exclusively solitary, rarely in pairs, oval in outline and mostly open, vessel lines distinct on the longitudinal surfaces.
- Parenchyma distinct only under the hand lens, predominantly as apotracheal fine, continuous or interrupted bands at regular intervals forming network with the rays.
- Rays fine to very fine, closely spaced and uniformly distributed.

14. *Cedrus deodara* (Roxb. ex D. Don) G.Don (Deodar)

PHYSICAL PROPERTIES

Sapwood and heartwood distinct. Sapwood white, heartwood light yellowish-brown, turning brown on exposure, mottling along the grain denoting growth rings, sometimes broad brown lines occur due to traumatic longitudinal resin canals, dull with an oily feel, strong and characteristic pungent resinous odour, soft to moderately hard, light to moderately heavy (sp. gr. 0.46-0.61 air-dry) average weight 460-610 kg/m3 (28-38 lb/ft3) straight grained and medium fine textured, alcohol extract yellow to orange-yellow.

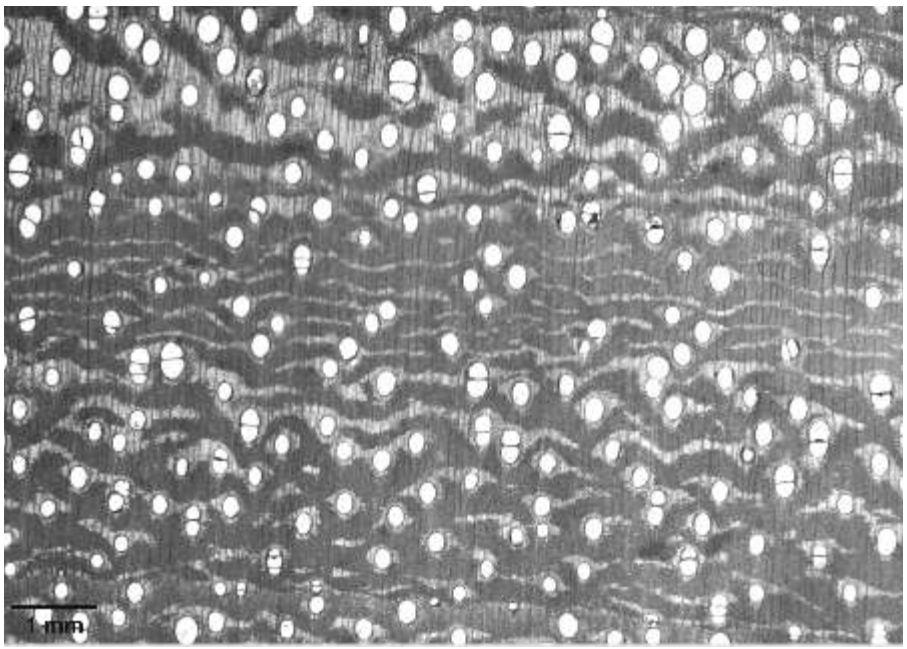


- Macroscopic structure : A non-porous wood.
- Growth rings distinct on all the three surfaces, delimited by dense latewood tracheids, 2-10 per cm. Transition from earlywood to latewood gradual.
- Resin canals not always present, when present arranged in long tangential rows showing up as dark brown lines on longitudinal surfaces.
- Parenchyma not visible.
- Rays very fine, not visible to the eye but seen under the hand lens as fine numerous, closely spaced-lines.

15. *Dalbergia sissoo* Roxb. (Sissoo)

PHYSICAL PROPERTIES

Heartwood sharply differentiated from the sapwood. Sapwood yellowish-white or pale brownish, narrow, heartwood golden brown to deep brown with darker streaks often showing attractive figure; hard, moderately heavy to heavy (sp. gr. 0.63-0.83 air-dry); straight to shallowly interlocked-grained and medium coarse-textured.

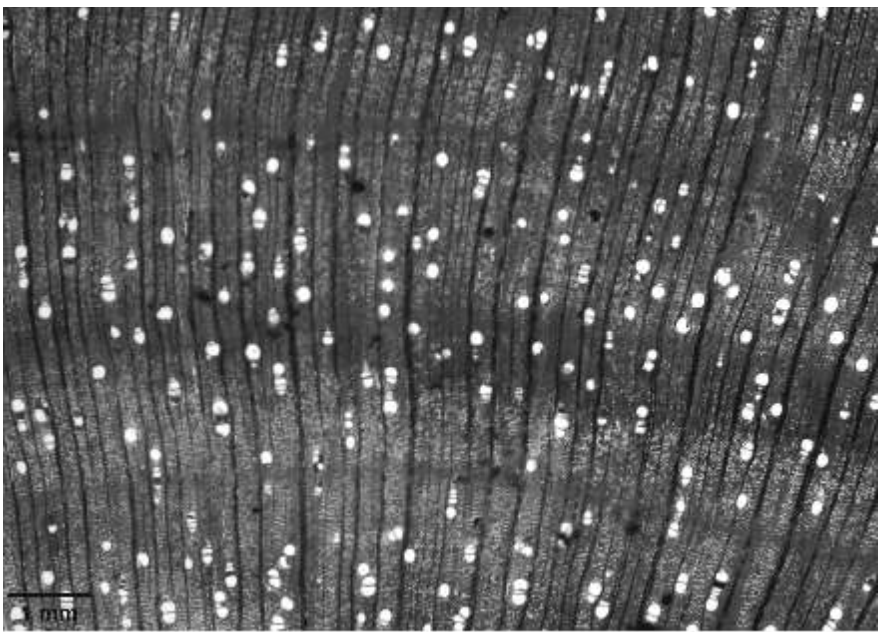


- Macroscopic structure : A diffuse-porous wood, occasionally with a tendency towards semi-ring-porousness.
- Growth rings indistinct or inconspicuous, barely visible under the lens, delimited by an extremely fine somewhat interrupted to more or less continuous line of parenchyma which can be made out only with difficulty, 2-6 per cm.
- Vessels large to small, few to moderately few (2-7 per mm^2), rather unevenly distributed, somewhat larger and comparatively more numerous in the middle or early part of the growth ring, mostly solitary or in short radial multiples, occasionally filled with white or dark gummy deposits, round to oval in outline.
- Parenchyma abundant, just visible to the eye, distinct under the hand lens, as sheaths or 'eyelets' round the vessels with short or long narrow, wing-like lateral extensions often connecting adjacent vessels with a tendency to form fairly straight to wavy irregular lines particularly in the latewood, also diffuse or diffuse-in-aggregates and as an extremely fine line delimiting the growth rings.
- Rays fine to very fine, not visible to the eye, closely spaced and uniformly distributed.
- Ripple marks present, distinct to somewhat inconspicuous under the hand lens being generally more distinct in the sapwood, 65-75 per cm.

16. *Dipterocarpus* spp. (Gurjan)

PHYSICAL PROPERTIES

Sapwood and heartwood fairly well demarcated; sapwood dirty white to greyish to pale yellowish-brown, heartwood pale-red to reddish-brown, sometimes with an orange tinge darkening to red on exposure, occasionally with reddish streaks, often with gummy exudation on the end surface; moderately hard; moderately heavy to heavy (sp.gr.0.59-0.91 air-dry), straight to interlocked-grained; coarse textured.

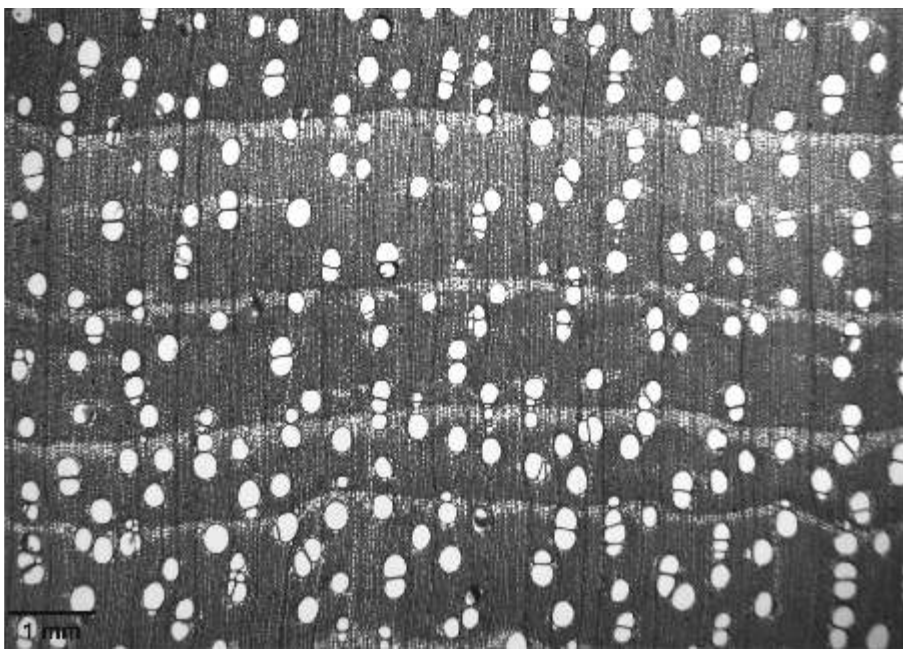


- Macroscopic structure : A diffuse-porous wood.
- Growth rings usually indistinct, occasionally faint marks delimited by narrow bands of thick-walled flattened fibres, about 2-3 per cm.
- Vessels in most cases moderately large to large, few to moderately numerous (4-13 per mm^2), solitary, a few in radial or oblique pairs, oval to round in shape; open or tyloses fill up the vessels partially or completely.
- Parenchyma usually visible only under lens, scanty to fairly abundant (a) apotracheal parenchyma diffuse to very short or broken fine tangential lines, sometimes visible under lens as white dots within the fibrous tissue; (b) paratracheal vasicentric round the vessels forming a thin layer, usually not conspicuous; (c) fairly conspicuous round the gum ducts forming a several seriate layer, occasionally looking like 'eye-let' pattern and often connecting tangential groups of gum-ducts with the rays and vessels.
- Rays moderately broad to fine, brownish in colour, not closely spaced, evenly distributed, showing a conspicuous silver grain effect on the radial surface.
- Gum ducts vertical, size rather variable, usually smaller than the vessels; fairly uniformly distributed, usually in tangential groups of 2-10 and may be connected with the vessels and rays; white deposits sometimes fill up the cavity of the ducts.
- Pith-flecks occasionally present.

17. *Dysoxylum malabaricum* Bedd. ex C. DC. (White cedar)

PHYSICAL PROPERTIES

Sapwood and heartwood not very sharply demarcated. Sapwood usually narrow whitish or pale grey with yellow cast, sometimes discoloured by sap stain and turning darker on exposure. Heartwood usually straw-yellow when fresh, turning golden yellow or yellow-brown on ageing; wood lustrous with faint, sour, cedary odour which persists for long. Wood moderately hard, moderately heavy (sp. gr. 0.66-0.77 air-dry), straight to somewhat interlocked-grained, even and fine-textured with a greasy or oily feel. A pleasing striped figure due to parenchyma bands and also sometimes due to interlocking of the grain is noticeable on the longitudinal surfaces.

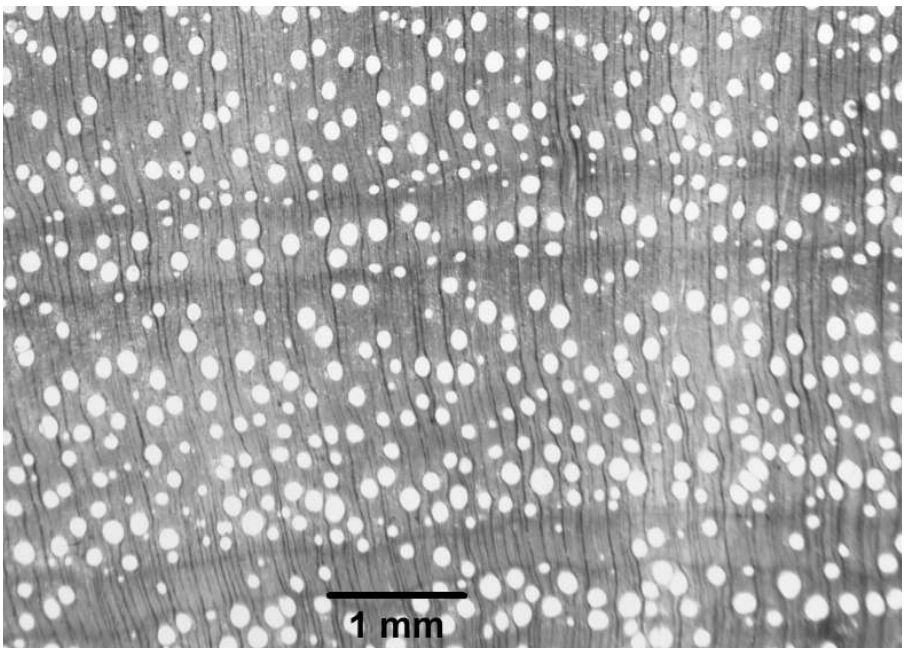


- Macroscopic structure : A diffuse-porous wood.
- Growth rings distinct, delimited by fairly thick, whitish, concentric lines of parenchyma (initial) 3-12 per cm; false growth marks are often met with.
- Vessels small, just visible to the eye but usually more distinct in the heartwood due to the deposits in them; moderately numerous (9-22 per mm^2), more or less evenly distributed, solitary or in radial multiples of 2-3; round to oval in shape and often plugged with pale yellow or brownish-yellow deposits; vessel lines fine but sometimes very conspicuous in seasoned timber, due to darkish gummy or oily deposits which may extend along the vessel lines as dark streaks, occasionally also staining the adjoining tissues.
- Parenchyma (a) whitish and distinct to the eye as fairly thick concentric lines delimiting the growth rings; frequently also in short tangential lines at very irregular distances; (b) vasicentric, forming a very thin sheath round the vessels multiples, visible only under lens.
- Rays fine, barely visible to unaided eye, almost of the same colour as the background, fairly closely spaced; ray-flecks inconspicuous.

18. *Eucalyptus tereticornis* Sm. (Blue gum)

PHYSICAL PROPERTIES

Sapwood light greyish-brown, gradually merging into pale brown to reddish-brown heartwood, moderately hard; moderately heavy (sp. gr. 0.69-0.84 air-dry); lustrous; straight to shallowly interlocked or wavy-grained and medium coarse-textured.

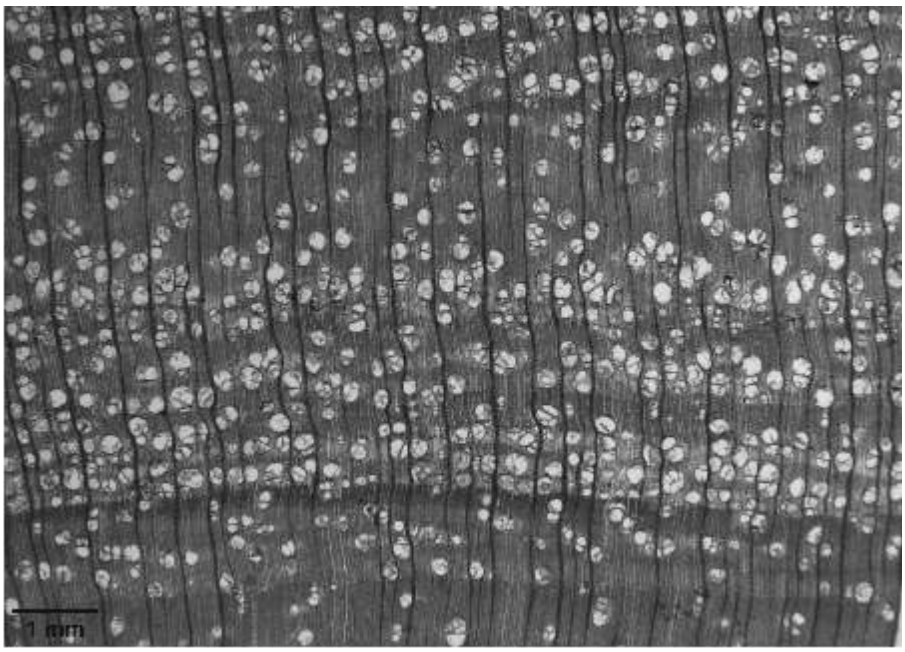


- Macroscopic structure : A diffuse porous wood.
- Growth rings indistinct.
- Vessels moderately large to small, visible to the eye, moderately numerous (5-20 per mm^2), exclusively solitary or nearly so, rather evenly distributed with a distinct tendency to be arranged in oblique groups, round to oval, open or filled with abundant tyloses, vessel lines distinct to the eye.
- Parenchyma indistinct to distinct to the eye, distinct under hand lens forming thin sheaths round the vessels, and diffuse to diffuse-in-aggregates.
- Rays fine, closely and more or less evenly spaced.

19. *Gmelina arborea* Roxb. (Gamari)

PHYSICAL PROPERTIES

Heartwood not distinct from sapwood in colour. Wood pale yellow to cream coloured or pinkish-buff when fresh, turning yellowish-brown on exposure; soft to moderately hard, light to moderately heavy (sp.gr. 0.39-0.66 air-dry) lustrous when fresh, usually straight to irregular or rarely wavy-grained and medium coarse-textured.

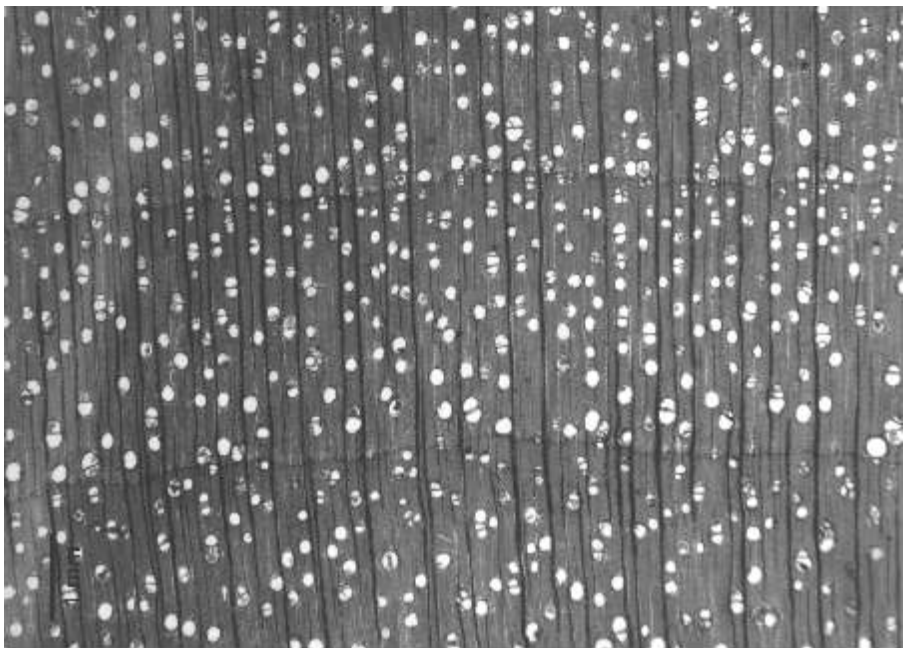


- Macroscopic structure : A diffuse-porous wood but often exhibiting a tendency towards semi-ring porosity.
- Growth rings distinct to somewhat indistinct, very variable even within the same sample, when distinct, delimited by comparatively larger earlywood vessels and fine lines of parenchyma.
- Vessels large to moderately large, distinct to fairly distinct to the eye, rather unevenly distributed, with a tendency to be larger and more numerous in the earlywood, mostly solitary and in radial pairs, rounded in outline and heavily plugged with tyloses; vessel lines distinct on longitudinal surfaces.
- Parenchyma visible to the eye prominent under the hand lens, forming thin or thick sheaths round the vessels sometimes also connecting them and often also in fine interrupted lines delimiting the growth rings.
- Rays moderately broad, distinct to the eye, somewhat widely spaced and uniformly distributed.

20. *Grewia tiliifolia* Vahl (Dhaman)

PHYSICAL PROPERTIES

Sapwood pale yellowish-white to yellowish-grey to light greyish-brown, distinct from the heartwood, which is reddish-brown to brown with darker coloured streaks; moderately hard to rather hard and moderately heavy (sp.gr.0.67-0.88 air-dry) dull, sometimes with a faint smell mildly suggestive of teak, medium to medium-coarse-textured.

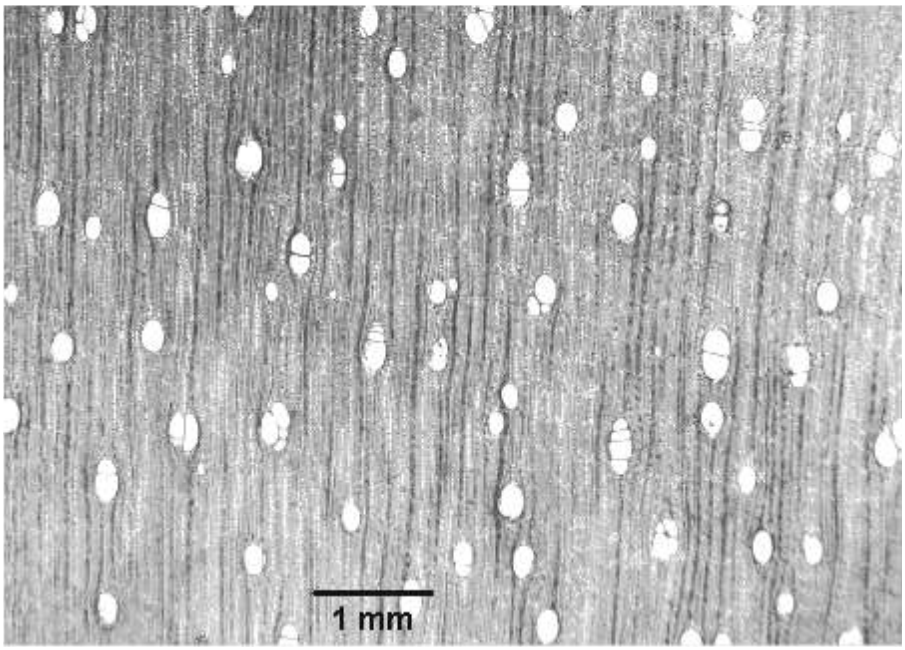


- Macroscopic structure : A diffuse-porous woods with occasional semi-ring porous tendency.
- Growth rings distinct, delimited by denser and darker latewood, 2-5 per cm.
- Vessels fairly distinct to just visible to the eye, moderately large or medium-sized to small, mostly moderately few to moderately numerous (6-19 per mm^2); evenly to somewhat unevenly distributed, mostly solitary or in short radial multiples of 2-3, occasionally in clusters of 3-5 or more, often round rather than oval in outline, filled with tyloses or chalky white deposits; vessel lines distinct.
- Parenchyma predominantly paratracheal, visible under the lens as narrow vasicentric sheaths or haloes round the vessels, sometimes also with a little diffuse parenchyma, which is indistinct or barely visible even under lens.
- Rays apparently of two size classes, moderately broad to fine and very fine, the largest in the former class visible to the eye, the latter visible only under lens, fairly wide apart to rather closely spaced; the small rays comparatively few with just a tendency to storied arrangement.
- Ripple marks present, due to the storied arrangement of small rays and longitudinal elements, rather faint and indistinct, often just a suggestion, 35-45 per cm.

21. *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg. (Rubber wood)

PHYSICAL PROPERTIES

Wood white or greyish-white when fresh, often showing grey discolouration, turning to dirty greyish-white or dirty creamy-white on ageing, soft or light (sp. gr. 0.46-0.51 air-dry), straight-grained, even and medium-textured.

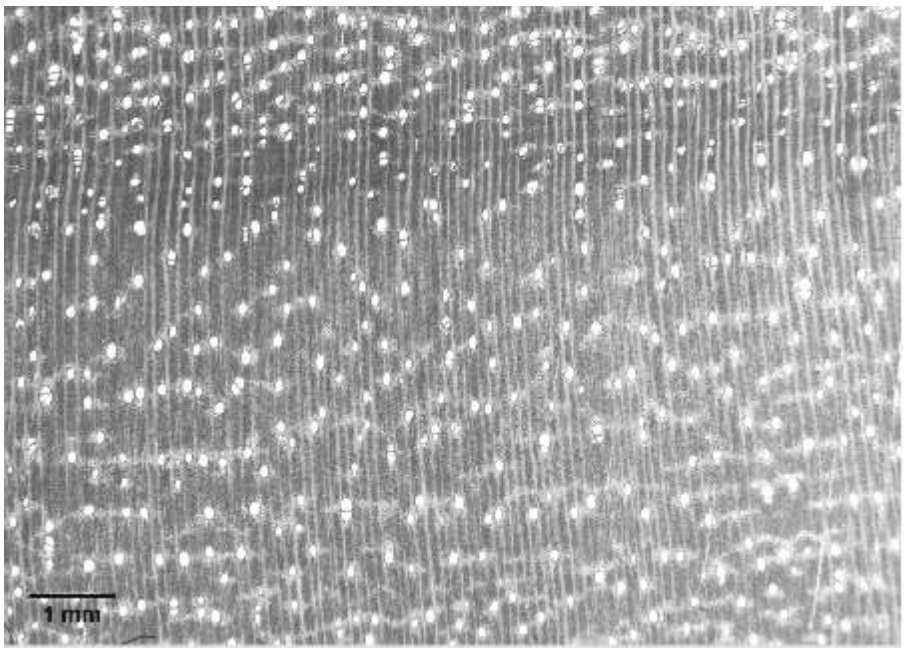


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct, but sometimes appearing faint impressions due to comparatively thick-walled fibrous tissue.
- Vessels moderately large to small, just visible to the eye, very few to few (1-4 per mm^2), evenly distributed, mostly solitary and in radial multiples of 2-4, sometimes more, open or partially filled with tyloses, oval in outline, vessel lines distinct on longitudinal surfaces.
- Parenchyma distinct under hand lens as narrow and closely spaced fine interrupted lines, also touching the vessels.
- Rays fine to very fine distinct under the lens, light in colour, uniformly distributed and closely spaced.

22. *Holoptelea integrifolia* Planch. (Kanju)

PHYSICAL PROPERTIES

Wood light yellow to yellowish-grey with no distinction of sapwood and heartwood. The grey tinge seen occasionally is due to sap stain; moderately large, moderately heavy (sp. gr. 0.56-0.68 air-dry), lustrous when fresh but still retaining its character for a long time, medium to fine-textured with somewhat interlocked-grain.

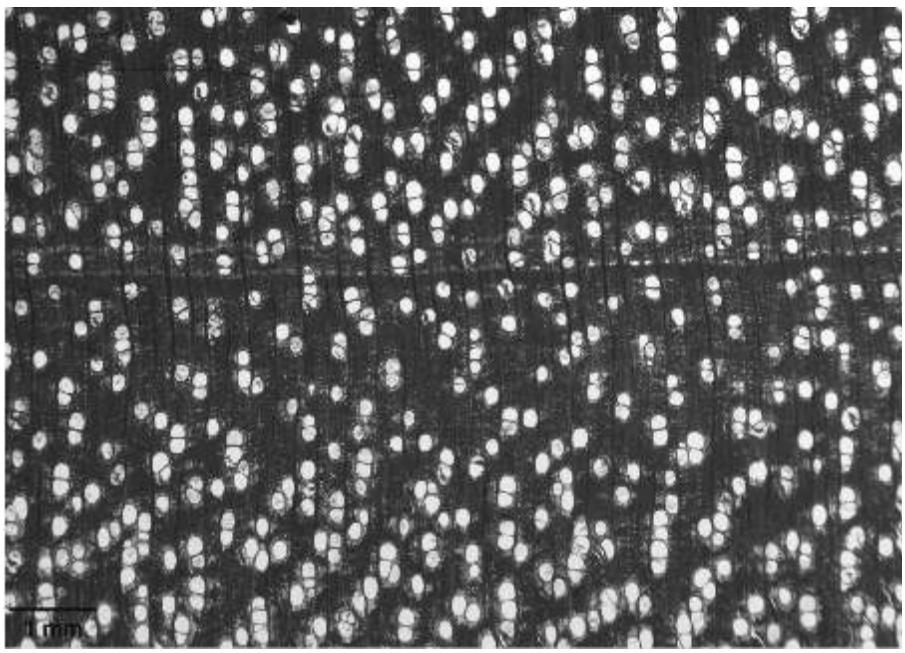


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct to distinct, delimited by fibres, 4-5 per cm.
- Vessels medium-sized to small, just visible to the eye, distinct under the hand lens, moderately numerous (11 per mm^2), solitary and in short radial multiples of 2-3, rarely more, round to oval, often filled with white chalky deposits appearing as dots; vessel lines fine, distinct on longitudinal surface.
- Parenchyma aliform to confluent, just visible to the eye, prominent under the hand lens as light coloured sheaths round the vessels often with narrow wings-like extensions, connecting adjacent vessels.
- Rays moderately fine to moderately broad, distinct under the hand lens, rather numerous somewhat closely-spaced.
- Ripple marks present just visible to the eye, prominent under the lens, about 40 per cm.

23. *Hopea odorata* Roxb. (Thingan)

PHYSICAL PROPERTIES

Sapwood pale yellow or greyish-yellow turning pale brown on exposure, heartwood yellowish-brown to brownish-red sometimes with darker streaks; hard to very hard; moderately heavy to very heavy (sp. gr. 0.62-0.93 air-dry); interlocked-grained; medium to medium fine-textured.

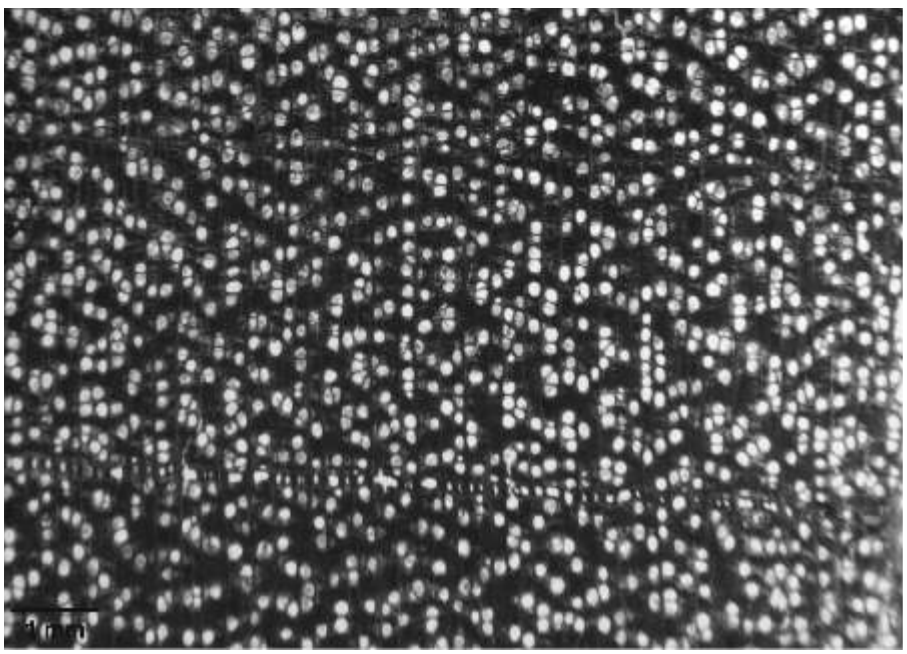


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct.
- Vessels small to medium-sized or usually larger, varying from just visible to fairly distinct to the eye, moderately few to moderately numerous (6-14 per mm^2), rather uniformly distributed, solitary, or more often in radial multiples of 2-4 or in groups of 3-6, usually round to oval, open or plugged with tyloses; vessel lines often distinct.
- Parenchyma visible only under the lens, scanty to fairly abundant; (a) apotracheal, diffuse in irregular fine net-like structure; (b) paratracheal, inconspicuous, as thin layers round the vessel or vessel groups (c) in tangential lines usually associated with bands of gum canals at irregular intervals.
- Rays rather fine, hardly visible to the eye, not closely spaced, evenly distributed, often showing ray flecks on the radial surface.
- Gum ducts vertical, small to very small usually distinct under lens, often in long tangential lines simulating growth marks, very irregularly distributed; also in short or broken interrupted rows; duct orifices sometimes filled with whitish-yellow deposits and show up conspicuously on the longitudinal surface.
- Ripple marks indistinct to absent.

24. *Hopea parviflora* Bedd. (Hopea)

PHYSICAL PROPERTIES

Sapwood and heartwood not very distinct, wood pale-yellow brown to bright reddish-brown with a yellowish tinge darkening on exposure to deep reddish-brown often with a purplish cast; hard to very hard; heavy to very heavy (sp. gr. 0.87-1.11 air-dry), interlocked-grained; fine and even-textured.

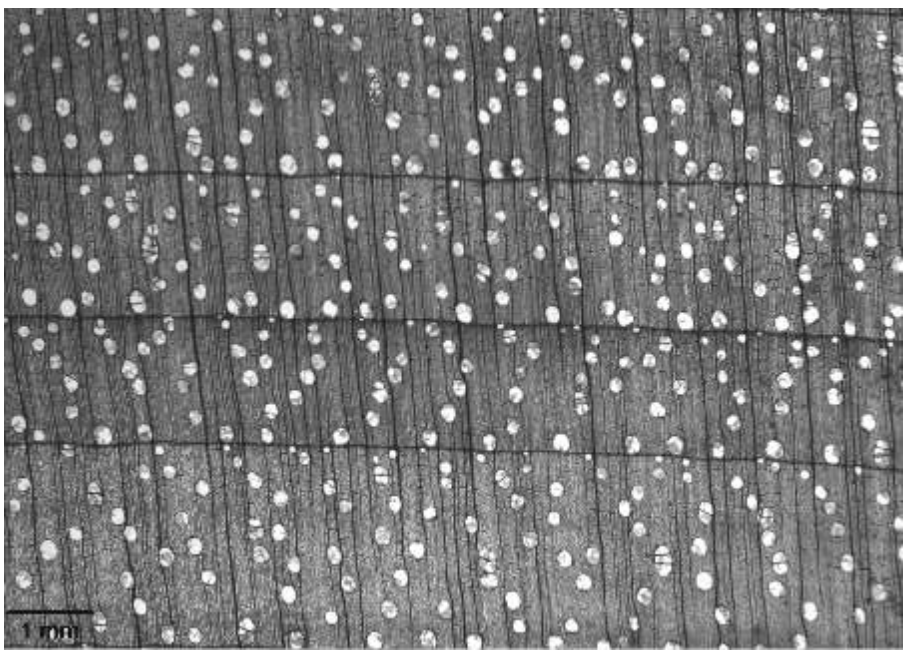


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct to fairly distinct, delimited usually by narrow bands of fibrous tissue devoid of vessels, 3-4 per cm, concentric bands of gum canals may often be mistaken for true growth rings.
- Vessels moderately small, sometimes medium-sized and moderately numerous (11-16 per mm^2), uniformly distributed; solitary to radial multiples of 2-5 or in oblique grouping which may be locally distinct; tyloses may partially fill up the vessels; vessel lines usually indistinct.
- Parenchyma not conspicuous, usually distinct under hand lens, (a) apotracheal, scattered or diffuse-in-aggregates, (b) paratracheal rather abundant, vasicentric to aliform, usually less conspicuous as a thin layer; inconspicuously confluent and rarely in wavy bands which are present locally in (c) thin concentric tangential lines, initial or terminal parenchyma irregularly distributed; short or long tangential lines to parenchyma embedding the gum canals are usually distinct under lens but often so irregularly spaced that these may be overlooked if casually examined.
- Rays moderately broad to fine, closely spaced, scarcely visible to the eye.
- Gum ducts vertical, small to very small, distinct under lens, often in long tangential lines, very irregularly and widely spaced, whitish-yellow deposits present in the canals, sometimes noticeable on the longitudinal surfaces.

25. *Juglans regia* L. (Walnut)

PHYSICAL PROPERTIES

Sapwood greyish-white and often broad, heartwood variable in colour from light brown or greyish-brown to dark brown with few or no markings or marked with dark irregularly smoky streaks sometimes beautifully mottled, moderately hard, light to moderately heavy (sp. gr. 0.33-0.68 air-dry), rather lustrous when fresh and beautifully figured particularly near the central zone, straight to sometimes interlocked-grained and medium coarse-textured.

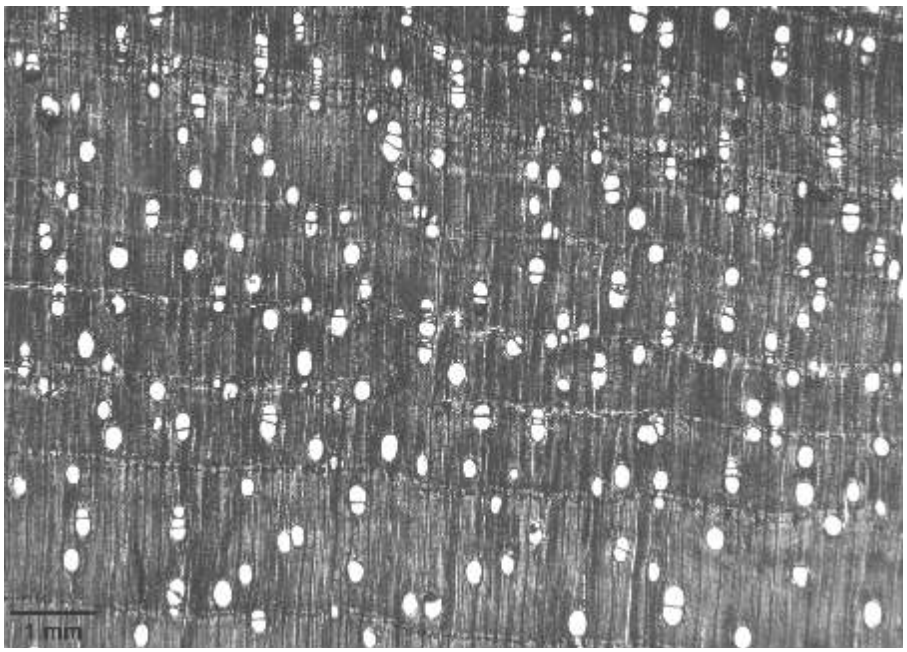


- Macroscopic structure : A diffuse-porous wood with a tendency towards semi-ring porosity.
- Growth rings inconspicuous to distinct, delimited by narrow line of darker latewood fibrous tissues, 1-6 per cm.
- Vessels moderate size to small, visible to the eye, distinct under the lens, moderately few to moderately numerous (6-12 per mm^2), somewhat evenly distributed, unevenly distributed in semi-ring porous samples having more numerous vessels on the latewood portion, mostly solitary, sometimes in radial multiples of 2-3, rarely more, with a tendency towards oblique arrangement, oval to round in outline, often filled with tyloses, vessel lines just distinct.
- Parenchyma not visible to eye, distinct under the lens on moist surface, apotracheal, diffuse-in-aggregates and inconspicuously scanty paratracheal around certain vessels as restricted sheaths. Also terminal forming a continuous uniseriate line.
- Rays fine to moderately broad, distinct under the hand lens, somewhat widely spaced and uniformly distributed.

26. *Kingiodendron pinnatum* (DC.) Harms (Piney)

PHYSICAL PROPERTIES

Sapwood and heartwood sharply differentiated. Sapwood white, greyish-white, heartwood light reddish-brown sometimes with a purplish cast, often blotched due to exudation of resin. Wood moderately hard, moderately heavy (sp. gr. 0.58-0.73 air-dry), somewhat lustrous; straight to interlocked-grained and medium coarse-textured.

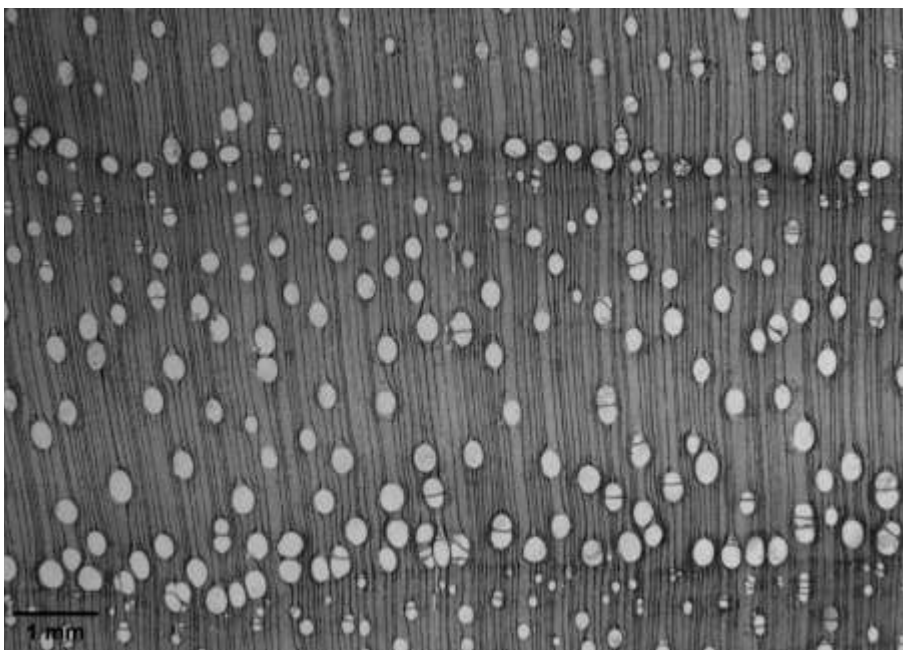


- Macroscopic structure : A diffuse-porous wood.
- Growth rings just visible to the eye, distinct under the lens, often discontinuous with numerous false marks indistinguishable from the true growth marks, delimited by a fine line of parenchyma.
- Vessels moderately large to small, visible to the eye, distinct under the lens, moderately few to few (3-8 per mm^2), evenly distributed, mostly solitary and in radial multiples of 2-3, usually open, a few plugged with greyish-white to yellowish-brown deposits; vessel lines distinct to rather conspicuous.
- Parenchyma indistinct or barely visible to the eye, occurring usually as a thin sheath round the vessels but occasionally forming 'eyelets' with short lateral extensions, connecting adjacent vessels, and also as a fine tangential line delimiting growth rings.
- Rays fine to very fine, distinct only under the hand lens, evenly distributed, closely spaced, giving a distinct radial fleck.
- Gum ducts present, scattered, almost of the same size as the vessels from which they are not easily distinguishable under the hand lens.

27. *Lagerstroemia lanceolata* Wall. (Benteak)

PHYSICAL PROPERTIES

Sapwood greyish-white, heartwood light-red to reddish-brown, darkening on exposure, moderately hard to moderately heavy (sp. gr. 0.59-0.76 air-dry) slightly to fairly lustrous; mostly straight-grained, occasionally cross-grained (one sample only), rather coarse-textured.

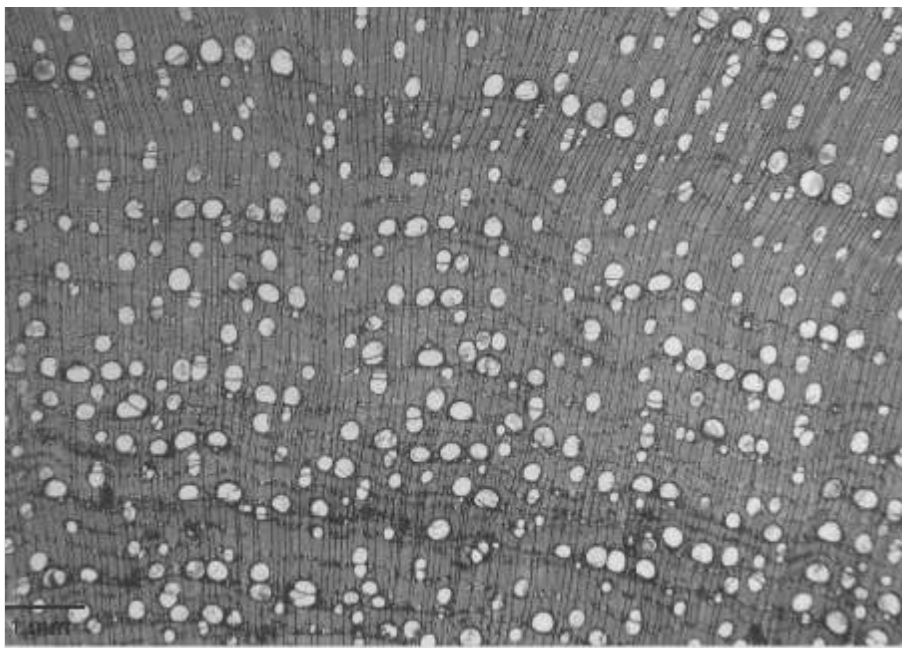


- Macroscopic structure : A semi-ring porous wood.
- Growth rings distinct, demarcated by large earlywood vessels and fine to fairly broad parenchyma bands 2-5 per cm, up to 8-9 per cm in slow grown samples.
- Vessels very large to large in the earlywood, distinct to the eye, solitary sometimes in multiples of two, usually plugged with tyloses, round to oval, transition from early to latewood gradual or nearly so, latewood vessels moderately large to small, visible to not visible to the eye, solitary or in multiples of 2-3, sometimes clustered or in long multiples in slow grown samples, round to oval, open; or frequently filled with tyloses, vessel lines distinct.
- Parenchyma fairly abundant, distinct to the eye, mainly as 'haloes' or eyelets round the vessel or vessel groups, occasionally extended laterally to connect a few adjoining vessels, rarely giving rise to interrupted short bands in the extreme latewood.
- Rays not visible to the eye, visible only under the hand lens, fine and closely spaced.

28. *Lagerstroemia speciosa* (L.) Pers. (Jarul)

PHYSICAL PROPERTIES

Heartwood generally not demarcated from the sapwood except in rare samples, wood greyish-white to pinkish-grey, heartwood when present, reddish-brown darkening on exposure; soft to moderately hard and light to moderately heavy, (sp. gr. 0.52-0.74 air-dry), slightly lustrous, usually straight to slightly interlocked-grain, medium coarse to coarse-textured.

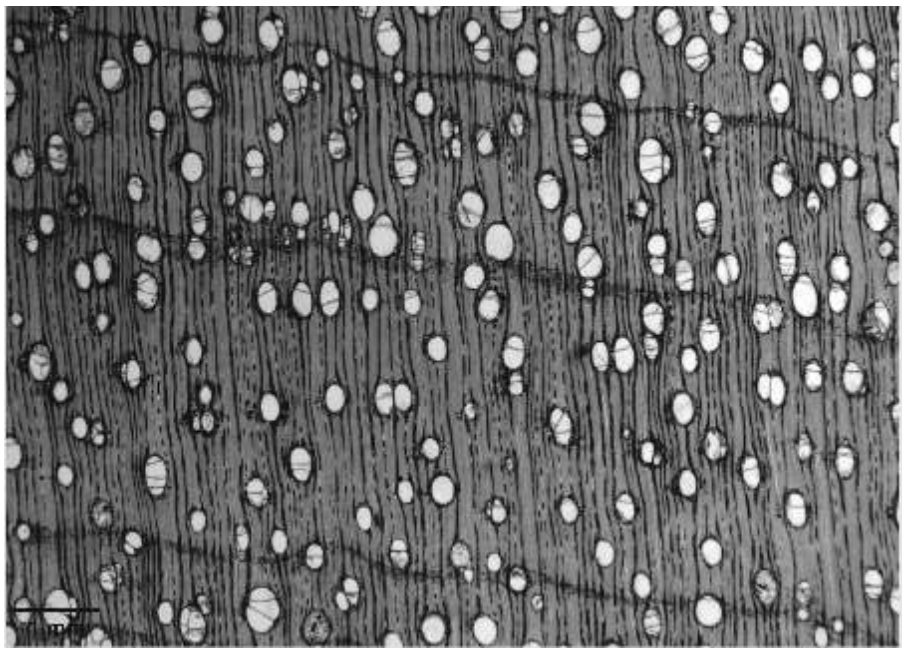


- Macroscopic structure : A semi-ring porous wood.
- Growth rings distinct, demarcated by earlywood vessels and fine to fairly broad parenchyma bands, 1-3 per cm, but up to 8 or more in some samples. Vessels large in the earlywood, distinct to the eye, usually solitary to sometimes in multiples of two, round to oval, usually heavily tylosed, transition from early to latewood gradual to sometimes rather abrupt, latewood vessels moderately large to small, visible to not visible to the eye, solitary or in multiples of 2-3, sometimes more or in small clusters, round to oval, usually filled up with tyloses, vessel lines distinct.
- Parenchyma fairly abundant to abundant, distinct to the eye, aliform to aliform confluent with short wavy extensions, connecting a few vessels in the earlywood but usually with fairly thick and more or less continuous bands in the latewood.
- Rays not visible to the eye, visible only under the lens, fine and closely spaced.
- Pith flecks small, occasionally present in some samples.

29. *Mangifera indica* L. (Mango)

PHYSICAL PROPERTIES

Sapwood not always distinct from heartwood but sometimes a fairly large and distinct brown to dark brown heartwood with light and dark streaks. Wood usually whitish-yellow, greyish-brown to buff in colour, often with a pinkish tinge, frequently discoloured by sap stain; soft to moderately hard; light to moderately heavy (sp. gr. 0.52-0.68 air-dry); straight to interlocked-grained occasionally with wavy or curly grain giving rise to beautiful ribbon figure, and quilted appearance on the longitudinal surfaces; medium to coarse-textured; rather lustrous when first exposed.

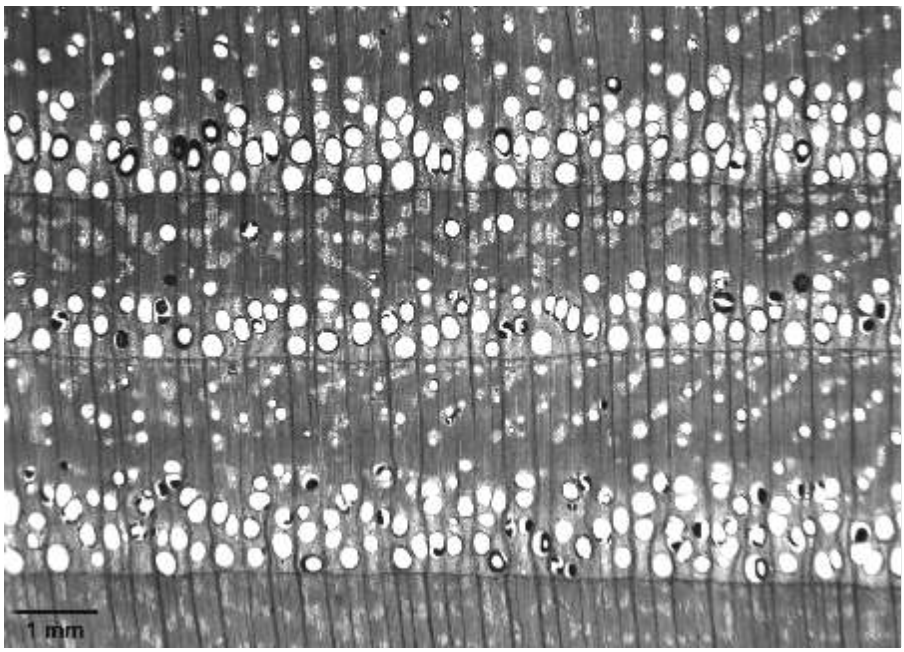


- Macroscopic structure : A diffuse-porous wood.
- Growth rings usually indistinct, but sometimes long tangential bands of parenchyma at more or less regular intervals give the impression of growth marks.
- Vessels large to small, distinct to the eye to just visible, very few to moderately numerous (1-10 per mm^2), more or less evenly distributed, usually solitary or in radial multiples of 2-3 or more, sometimes also in clusters, round to oval in outline, open or filled with tyloses.
- Parenchyma very variable, abundant to scanty, distinct to inconspicuous to the eye; (a) paratracheal, usually aliform and visible to the eye, sometimes with fine wing-like extensions; also vasicentric forming thin inconspicuous sheaths round the vessels; occasionally aliform-confluent in some samples (b) apotracheal, in thin tangential lines simulating growth marks and also ending abruptly.
- Rays moderately broad to fine, just visible to the eye but distinct under hand lens, brownish in colour, closely spaced, often showing inconspicuous ray-flecks on the radial surfaces.
- Pith flecks occasionally present as small lighter coloured patches.

30. *Melia azedarach* L. (Persian Lilac-Bakain)

PHYSICAL PROPERTIES

Sapwood yellowish-white; heartwood red or reddish-brown, the colour usually darkening on exposure. Moderately hard and moderately heavy (sp. gr. 0.55-0.61 air-dry); somewhat lustrous, without any characteristic odour or taste; straight-grained, coarse and uneven-textured.

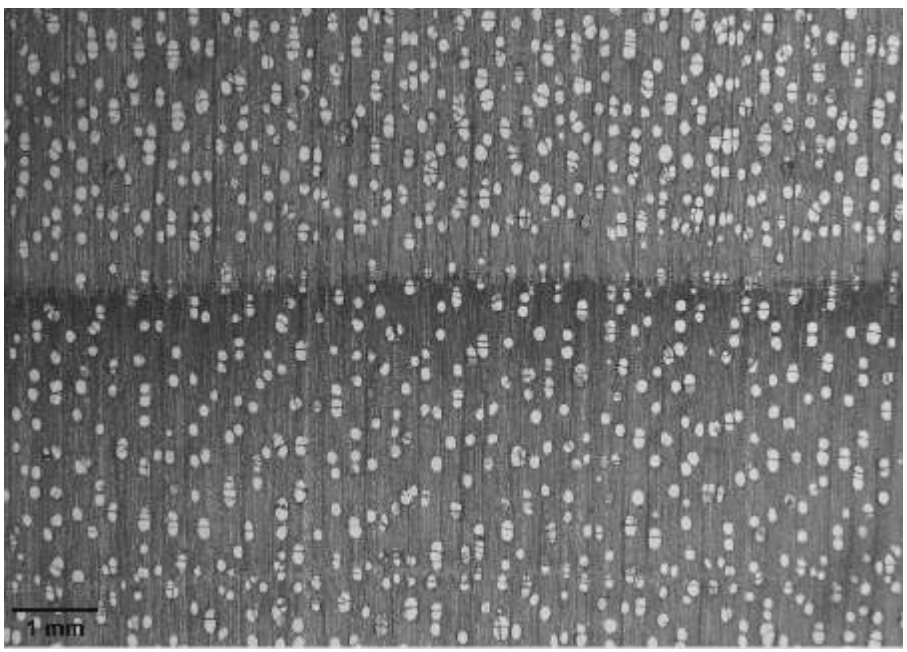


- Macroscopic structure : The wood is distinctly ring-porous.
- Growth rings distinct, 1-4 per cm.
- Vessels large to very small; earlywood vessels large, crowded and appearing as a conspicuous belt consisting of 4-8 or more rows; solitary or in radial pairs or appearing as crowded groups; transition from early to latewood abrupt; latewood vessels minute, hardly distinct individually under the hand lens but visible as numerous, small irregular groups associated with parenchyma, often forming a characteristic flame-like, zig-zag, or oblique pattern, occasionally also in narrow tangential bands across the rays. Vessels round and often filled with reddish-brown or blackish gum-like deposits.
- Parenchyma not abundant; (a) paratracheal round the vessels as light coloured tissue, comparatively more in the earlywood than in latewood; all the light coloured patches appearing as parenchyma under hand lens are not, however, of parenchyma, but consist of small vessels mixed with true parenchyma cells. These small vessels are particularly abundant both in the earlywood and latewood; in the earlywood, parenchyma (together with the small vessels) almost embed the large vessels, whereas in the middle of the ring, parenchyma forms thin sheath round the vessels but in the latewood it is in irregular patches round the vessel groups, often joining similar patches to form a zig-zag, flame-like, oblique or irregular tangential pattern; (b) also delimiting growth rings along with smaller vessels. Rays moderately broad, rather widely spaced, brownish in colour. Gum canals traumatic, occasionally present in tangential rows filled with dark contents.

31. *Magnolia champaca* (L.) Baill. ex Pierre. syn. *Michelia champaca* L. (Champa)

PHYSICAL PROPERTIES

Sapwood white to greyish-white, heartwood yellowish olive-green to olive-brown, soft to moderately hard, light to moderately heavy (sp.gr. 0.44-0.73 air-dry), usually straight-grained, medium fine-textured.

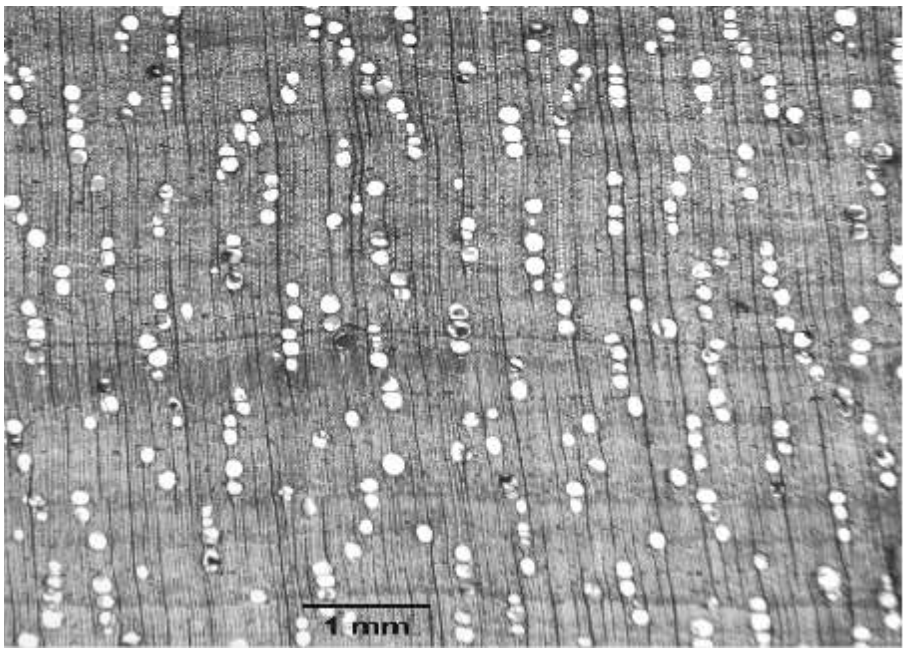


- Macroscopic structure : A diffuse-porous wood.
- Growth rings delimited by concentric bands of terminal parenchyma, 1-5 per cm.
- Vessels small to moderately large, evenly distributed but sometimes larger in earlywood few to very numerous (9-40 per mm^2), solitary (50-70%) and in radial multiples of 2-4, round to oval, occasionally filled with tyloses and whitish deposits, vessel lines inconspicuous.
- Parenchyma in narrow concentric bands, delimiting growth rings, sometimes forming a false growth marks.
- Rays fine, fairly closely spaced, evenly distributed.

32. *Palaquium ellipticum* (Dalzell) Baill. (Pali)

PHYSICAL PROPERTIES

Sapwood sharply differentiated from the heartwood, fairly large, pinkish white; heartwood light red to reddish-brown, moderately hard, moderately heavy (sp.gr. 0.59 – 0.76 air-dry), fairly straight to somewhat interlocked-grained and medium coarse- textured.

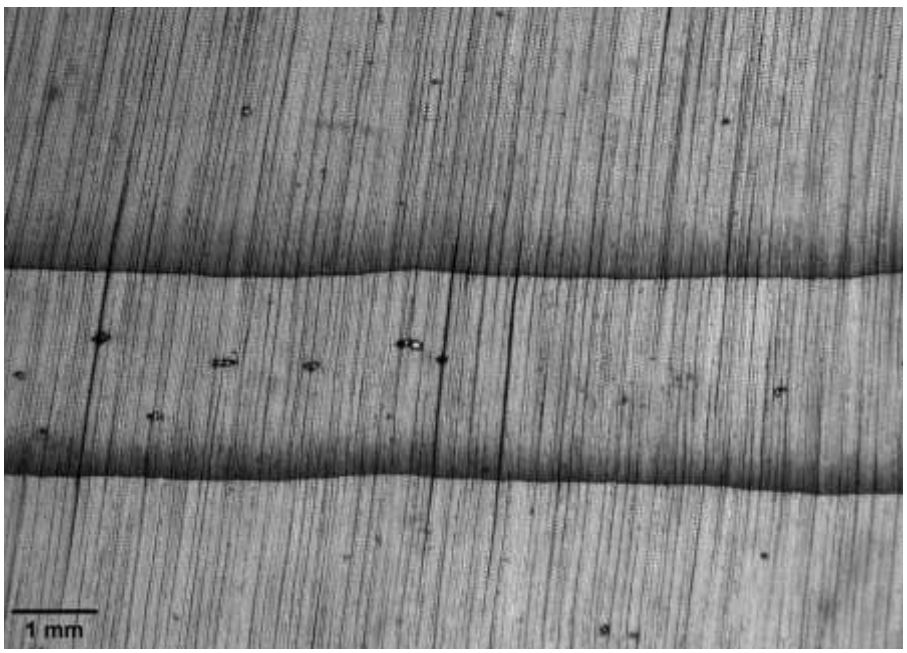


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct.
- Vessels moderately large to small, visible to the eye, moderately few to moderately numerous (6-12 per mm^2), more or less evenly distributed but with a tendency to be aligned obliquely, mostly in radial multiples of 2-6 sometimes more, oval in outline partly filled with tyloses and sometimes also with gum; vessel lines distinct on longitudinal surfaces.
- Parenchyma not visible to the eye but distinct under the lens, usually occurring as fine, closely spaced interrupted tangential lines forming an irregular reticulum with the rays.
- Rays fine to very fine, distinct only under the lens, fairly closely spaced and uniformly distributed.

33. *Picea smithiana* (Wall.) Boiss. (Spruce)

PHYSICAL PROPERTIES

Wood creamy white to pale buff turning greyish on exposure, true heartwood is absent but in larger trees the central zone becomes dull red, lustrous when fresh, often discoloured by sap stain without characteristic odour or taste, soft, light (sp. gr. 0.46-0.50 air-dry) average weight 460-500 kg/m^3 (29-31 lb/ft^3) straight-grained, fine and even-textured, alcohol extract colourless.

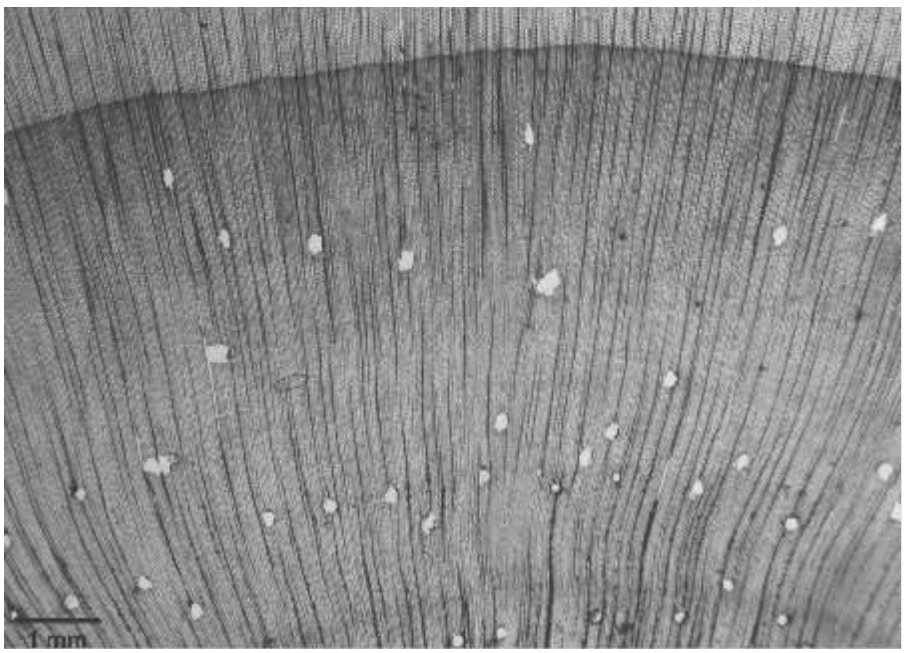


- Macroscopic structure : A non-porous wood.
- Growth rings distinct on all the three surfaces, demarcated by a somewhat dark band of thick-walled latewood tracheids, 3-7 per cm. Transition from earlywood to latewood gradual to abrupt.
- Resin canals vertical, small, visible under the lens, few, irregularly distributed either singly or in short tangential groups of 2-3 appearing as white dots.
- Parenchyma not visible.
- Rays fine to very fine, visible under the lens as numerous closely spaced lines.

34. *Pinus roxburghii* Sarg. (Chir)

PHYSICAL PROPERTIES

Sapwood is white to cream coloured, heartwood yellowish-brown turning light reddish-brown on exposure, with characteristic resinous odour when fresh, dull, moderately hard, moderately heavy (sp. gr. 0.55-0.68 air-dry) average weight 550-680 kg/m^3 (34-42 lb/ft^3) medium and uneven-textured and straight to spiral or twisted-grained, alcohol extract pale coloured.

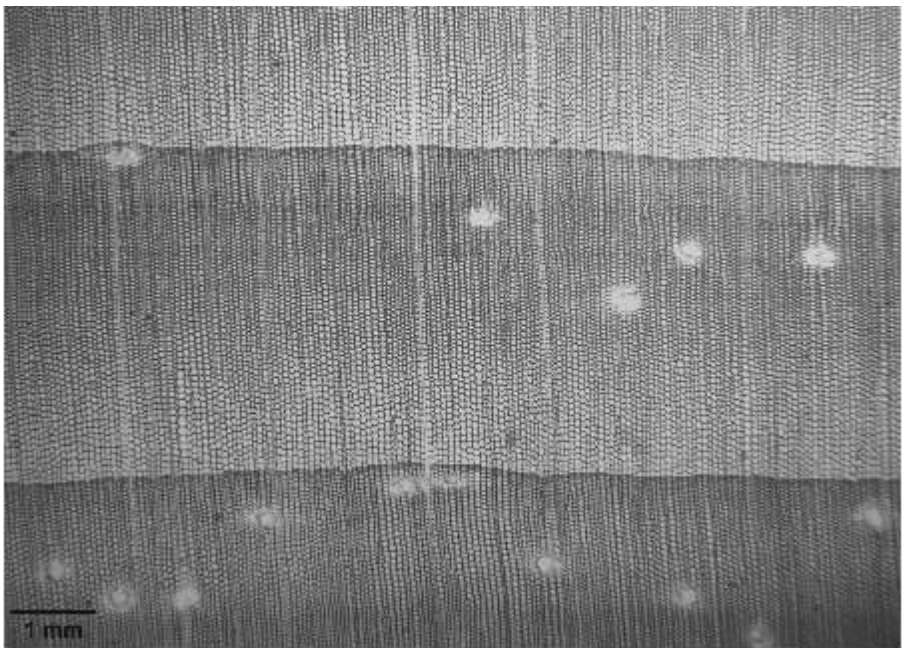


- Macroscopic structure : A non-porous wood.
- Growth rings distinct on all the three surfaces, due to thick-walled latewood tracheids, variable in width, 1-8 per cm. Transition from earlywood to latewood usually rather abrupt with conspicuous denser latewood.
- Resin canals of vertical type, scattered, large, distinct to the eye appearing as dark lines or resin streaks on longitudinal surfaces.
- Parenchyma absent.
- Rays very fine, not visible to the eye but visible under the lens as fine, numerous, closely spaced lines.

35. *Pinus wallichiana* A. B. Jacks. (Kail)

PHYSICAL PROPERTIES

Sapwood white to yellowish-white, heartwood light pinkish-red to light red with resinous odour when fresh, somewhat lustrous when fresh, dull, soft and light (sp. gr. 0.40-0.50 air-dry) average weight 400-500 kg/m^3 (25-31 lb/ft^3) straight-grained, medium fine and even-textured, alcohol extract pale-yellow to yellow.

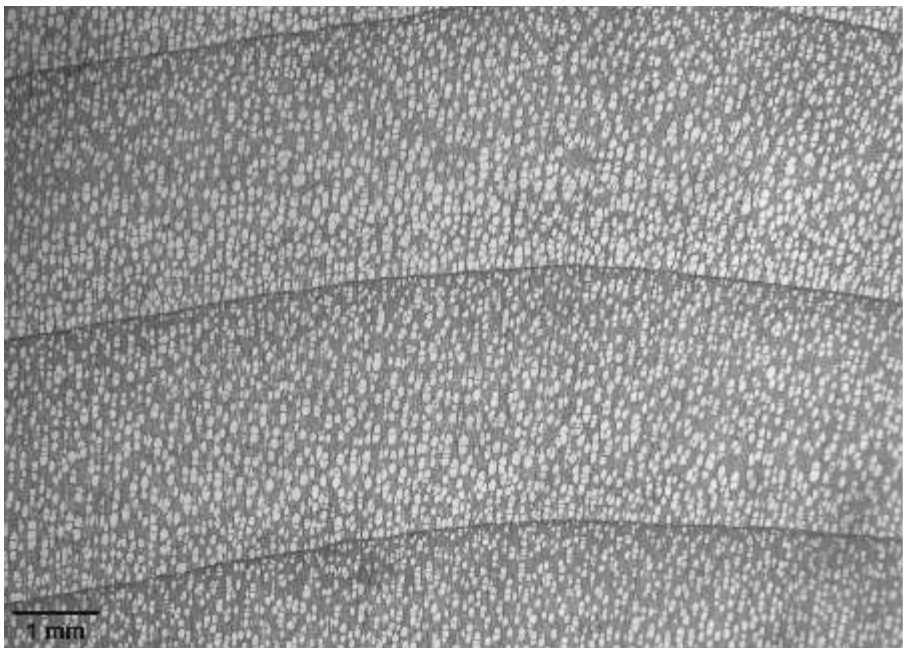


- Macroscopic structure : A non-porous wood.
- Growth rings distinct on all the three surfaces, due to thick-walled latewood tracheids variable in width, 2-8 per cm, transition from earlywood to latewood gradual.
- Resin canals of the vertical type scattered, large, distinct to the eye, appearing as dark lines or resin streaks on longitudinal surfaces.
- Parenchyma not visible.
- Rays very fine, not visible to the eye but seen under the lens as fine, numerous closely spaced lines.

36. *Populus* spp. (Poplar)

PHYSICAL PROPERTIES

Sapwood nearly white, broad, heartwood pale yellowish-white, turning yellowish-grey or brownish-grey, rather lustrous with a silky sheen, becoming dull with age, smooth, soft, very light to moderately heavy (sp. gr. 0.37-0.54 air-dry), straight to irregularly interlocked-grained, medium fine and uneven-textured.

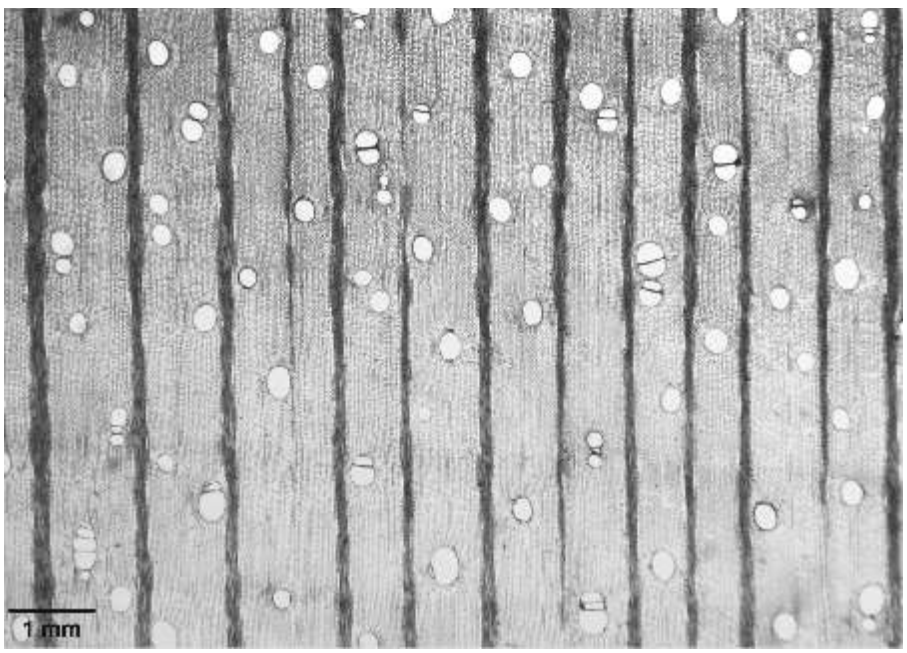


- Macroscopic structure : A diffuse-porous wood.
- Growth rings generally distinct to the eye, delimited by denser latewood fibres with fewer vessels, 1-4 per cm.
- Vessels small to very small, large to numerous at the beginning of the growth ring forming narrow or broad band, rather unevenly distributed, numerous (30-40 per mm^2), mostly in radial multiples of 2-4, open, vessel lines inconspicuous.
- Parenchyma marginal, not conspicuous.
- Rays very fine, numerous closely spaced, distinct only under the hand lens.

37. *Pterocymbium tinctorium* Merr. (Papita)

PHYSICAL PROPERTIES

Sapwood and heartwood not distinct. Wood creamy-white to oat-meal coloured, often showing dirty grey discoloration; soft to very soft, often easily dented with a finger nail, very light (sp. gr. 0.21-0.34 air-dry), lustrous on radial surface when not discoloured; straight-grained, even and coarse-textured.

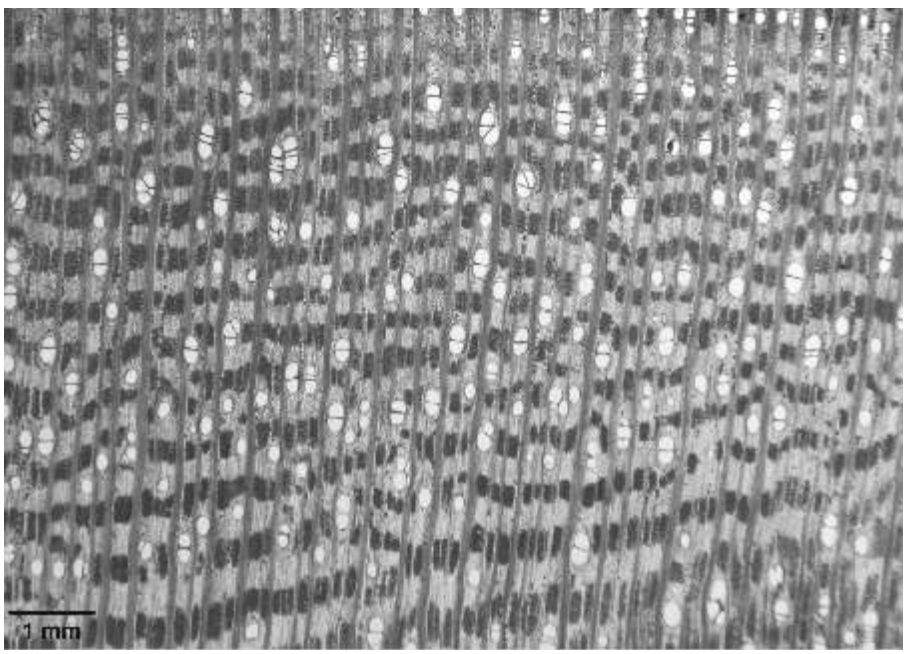


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct.
- Vessels large to moderately large, distinctly visible to the eye, few (2-4 per mm^2), more or less evenly distributed, mostly solitary, but sometimes in short radial multiples of 2-3 rounded to oval in outline, open.
- Parenchyma indistinct to the eye, but visible under the lens vasicentric forming a more or less well-defined sheath or halo round the pores; also diffuse, and diffuse-in-aggregates indistinct or not visible even under lens, due to the extremely thin-walled fibres, which can often to be seen individually with a lens.
- Rays of two sizes, very broad to moderately broad and fine, the former prominent to the eye, the largest being of the same width or occasionally even wider than an average sized pore, widely spaced forming a conspicuous lustrous fleck on the radial surface about 2.5 mm or more in height and the latter very few and visible only under the lens; not storied.
- Ripple marks indistinct or not visible to the eye, rather faint and irregular even under lens, sometimes just a tendency due to the storied arrangement of the fibres, parenchyma and vessel elements.
- Vertical Gum ducts occasionally present, traumatic and arranged in long tangential bands.

38. *Pterygota alata* (Roxb.) R.Br. syn. *Sterculia alata* Roxb. (Narikel)

PHYSICAL PROPERTIES

Sapwood and heartwood not distinct, wood greyish or pale yellowish-white to light greyish-brown often showing greyish-black discoloration, due to sap stain, soft to moderately hard and light to moderately heavy (sp. gr. 0.42-0.62 air-dry) somewhat lustrous on the radial surface when not discolored, usually straight-grained and coarse-textured.

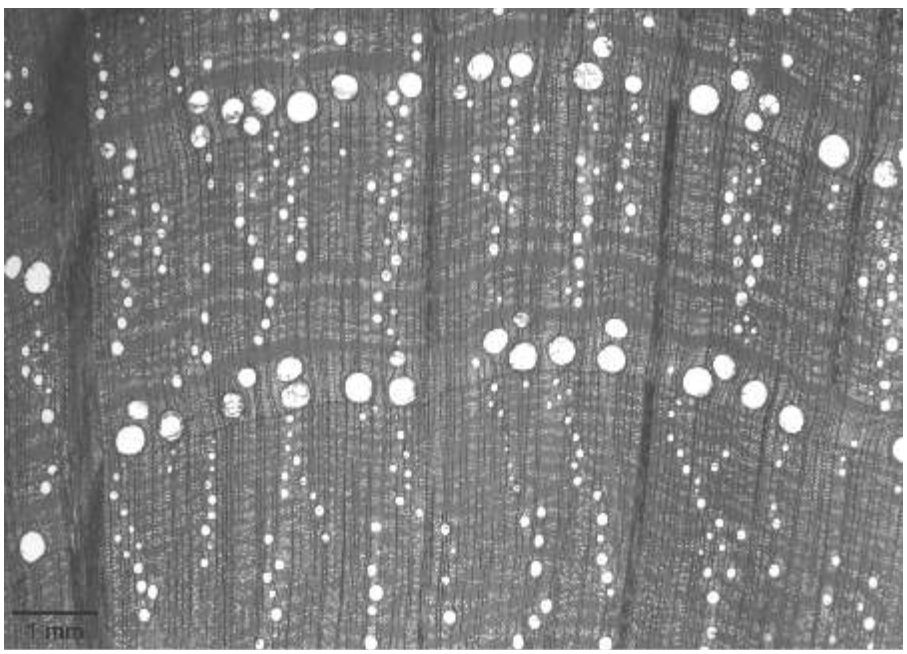


- Macroscopic structure : A diffuse-porous wood.
- Growth rings distinct to indistinct, when present demarcated by somewhat denser and darker latewood, 1-2 per cm.
- Vessels large to moderately large, few to very few (1-5 per mm^2), solitary and in short radial multiples of 2-3, occasionally in large multiples and clusters, rounded in outline, open, vessel lines distinct to conspicuous.
- Parenchyma distinctly visible to the eye, conspicuous under the lens, arranged in broad wavy or fairly straight tangential bands, slightly narrower than the darker fibre layers between them.
- Rays of two sizes, broad to moderately broad and fine, the former distinct and sometimes very prominent to the eye, widely spaced forming conspicuous fleck on the radial surface, the latter very few and visible only under the lens, not storied.
- Ripple marks indistinct or faint, often just a suggestion due to storied arrangement of the parenchyma.

39. *Quercus* spp. (Indian Oak)

PHYSICAL PROPERTIESs

Sapwood and heartwood distinct to indistinct. Sapwood greyish-yellow or greyish-brown to pale reddish-brown. Heartwood greyish-brown to reddish-brown, wood hard to very hard, heavy to very heavy (sp. gr. 0.77-1.02 air-dry), mostly straight grained but also irregular to wavy grained, medium-coarse and coarse-textured. Lustrous, radial flecks are prominent in *Q. lineata.*

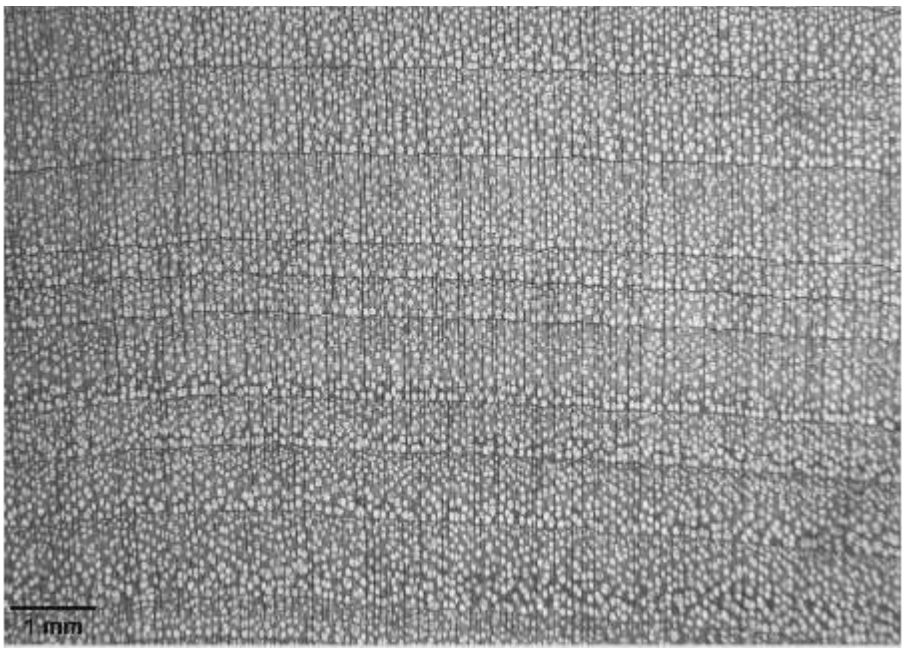


- Macroscopic structure : A diffuse-porous wood or ring-porous wood.
- Growth rings usually distinct, delimited by a more or less wavy zone of latewood fibrous tissues, 2-4 per cm in *Q. ilex*, indistinct in *Q. lamellosa, Q. leucotrichophora,* and *Q. lineata*.
- Vessels small to moderately large, distinct under the hand lens, mostly solitary, arranged obliquely or radially, few to moderately numerous (4-10 per mm^2) but few to moderately numerous (5-12 per mm^2) in *Q. ilex* and *Q. leucotrichophora,* round to oval mostly open or occluded with tyloses or white or red coloured deposit, vessel lines distinct on longitudinal surface.
- Parenchyma abundant, apotracheal, diffuse to diffuse-in-aggregates or as numerous wavy interrupted lines and also as thin sheath around the vessel.
- Rays of two distinct sizes: (a) Simple, fine to very fine numerous, visible only under the hand lens, closely spaced between broad rays; (b) Broad rays, visible to naked eye, regular, rather widely spaced (2-5 per cm) and more than 1.0 mm in width in *Q. lamellosa, Q. leucotrichophora* and *Q. lineata* and rather closely spaced (2-9 per cm) and less than 1.0 mm in width in all other species

40. *Salix* spp. (Willow)

PHYSICAL PROPERTIES

Sapwood white or light grey merging into heartwood; heartwood light brown turning to greyish-brown or reddish-brown, rather lustrous with a silky sheen when first exposed but becoming dull with age without characteristic odour or taste, soft, light (sp. gr. 0.39-0.59 air-dry), medium fine and uneven-textured.

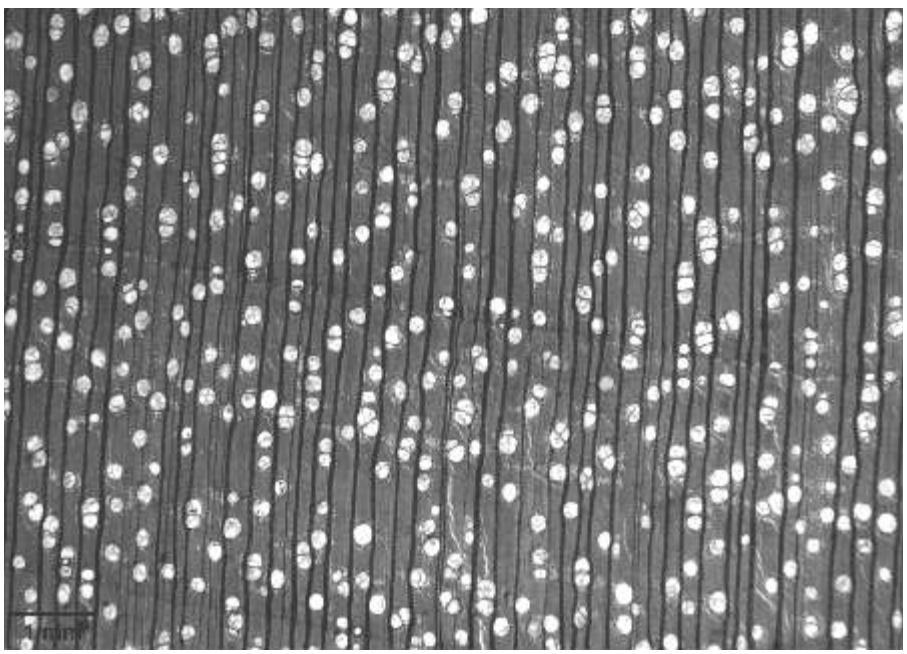


- Macroscopic structure : A diffuse-porous wood.
- Growth rings distinct to inconspicuous to the naked eye, 1-4 per cm.
- Vessels small to very small, distinct under the lens, generally slightly larger and numerous at the beginning of the growth rings, but not exhibiting any great variation in size, mostly in radial multiples of 2-4, very numerous (> 40 per mm^2), open, vessel lines distinct.
- Parenchyma marginal/terminal and diffuse but not distinct.
- Rays fine to very fine, not distinct to the eye, distinct under the lens, numerous and closely spaced.

41. *Shorea robusta* Gaertn. (Sal)

PHYSICAL PROPERTIES

Sapwood and heartwood usually distinct; sapwood when fresh, pale white with a brownish tinge, narrow; if left unprotected, often turns to almost black colour due to fungus attack. Wood dull; hard to very hard; usually heavy to very heavy (sp. gr. 0.62-1.00 air-dry); interlocked-grained, often showing characteristic ribbon bands; medium to coarse-textured.

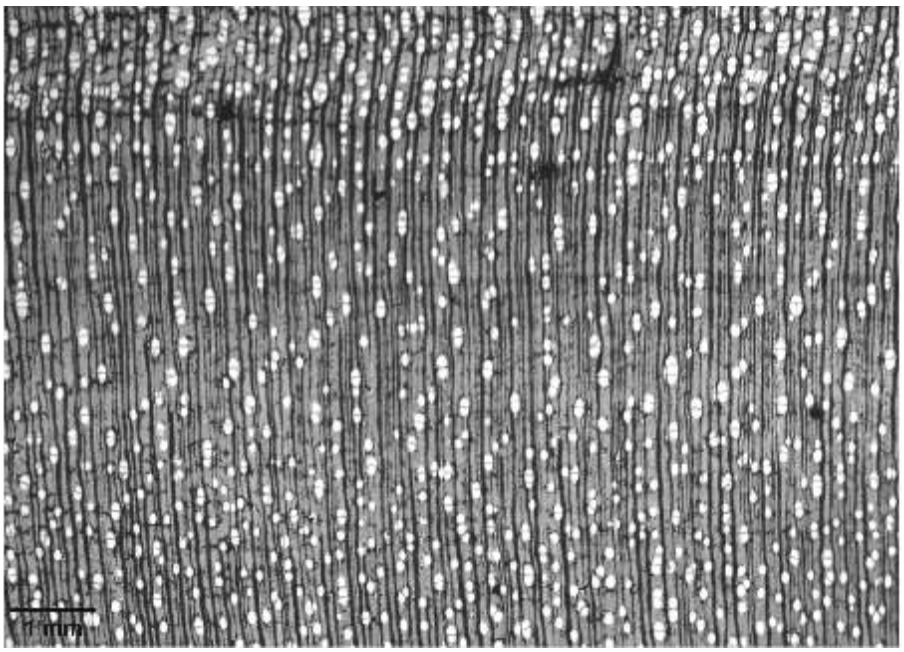


- Macroscopic structure : A diffuse-porous wood.
- Growth rings distinct to indistinct, demarcated by darker flattened fibres and sometimes also due to concentric band of parenchyma, 3-5 per cm.
- Vessels moderately large to small, just visible to eye, distinct under the hand lens, few to moderately few (5-9 per mm^2), more or less uniformly distributed, mostly solitary with few in short radial multiples of 2-3, round in shape, heavily plugged with tyloses, vessel lines distinct.
- Parenchyma scanty to abundant just visible to eye, distinct under the lens, vasicentric, aliform and confluent, forming narrow sheath around the vessels and occasionally extending sideways and joining similar extensions from other vessels, also diffuse and diffuse-in-aggregates, occasionally also delimiting growth rings.
- Rays fine to moderately broad, the latter distinct under the lens, rather few and somewhat widely-spaced.
- Vertical gum ducts usually present in long tangential bands appearing as white concentric lines at irregular intervals.

42. *Syzygium cumini* (L.) Skeels (Jaman)

PHYSICAL PROPERTIES

Heartwood not sharply demarcated from the sapwood, wood of the outermost region pale grey or greyish brown, grading gradually into dark brown or reddish brown wood towards the centre; true heartwood (with heavily tylosed vessels) usually not present except in very large logs, commonly moderately hard to hard, moderately heavy to heavy (sp. gr. 0.62-0.77 air-dry) but heartwood samples heavy to very heavy (sp. gr. 0.89-1.01 air-dry); usually shallow interlocked sometimes wavy grained, medium coarse-textured.

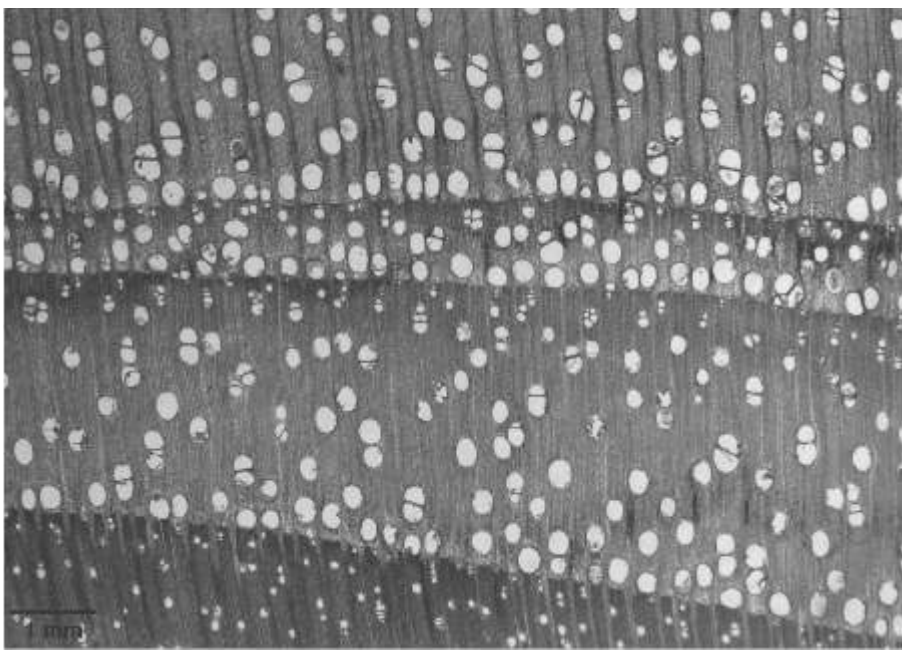


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct, but sometimes broken bands of parenchyma and bands of thick walled fibres may give the impression of growth rings.
- Vessels vary widely in size and frequency within a species, mostly moderately large and visible to the eye to small and indistinct to the eye, moderately few to moderately numerous (5-20 rarely up to 25 per mm^2) evenly distributed, solitary and in radial multiples of 2-3, occasionally up to 5, round to oval in outline mostly open or only occasionally partially filled with tyloses, usually indistinct under the hand lens, but in samples from the central portion of the large logs plugged with abundant tyloses, occasionally also filled with whitish powdery deposits; vessel lines distinct to inconspicuous.
- Parenchyma varying from scanty and distinct only under the hand lens to abundant and very distinct to the eye, mostly paratracheal, vasicentric to aliform confluent, sometimes forming broken bands and also diffuse.
- Rays fine to medium, evenly and closely spaced.

43. *Tectona grandis* L.f. (Teak)

PHYSICAL PROPERTIES

Sapwood and heartwood sharply demarcated. Sapwood white or pale yellow; heartwood light golden-brown when fresh, turning brown or dark brown on exposure, often with darker streaks; (the colour and markings of the heartwood vary considerably with locality), with an oily feel and characteristic odour reminiscent of old leather when fresh, moderately hard, moderately heavy (sp. gr. 0.51-0.77 air-dry); usually fairly straight-grained but the samples from the drier regions often exhibit rather irregular grain; coarse and uneven-textured.

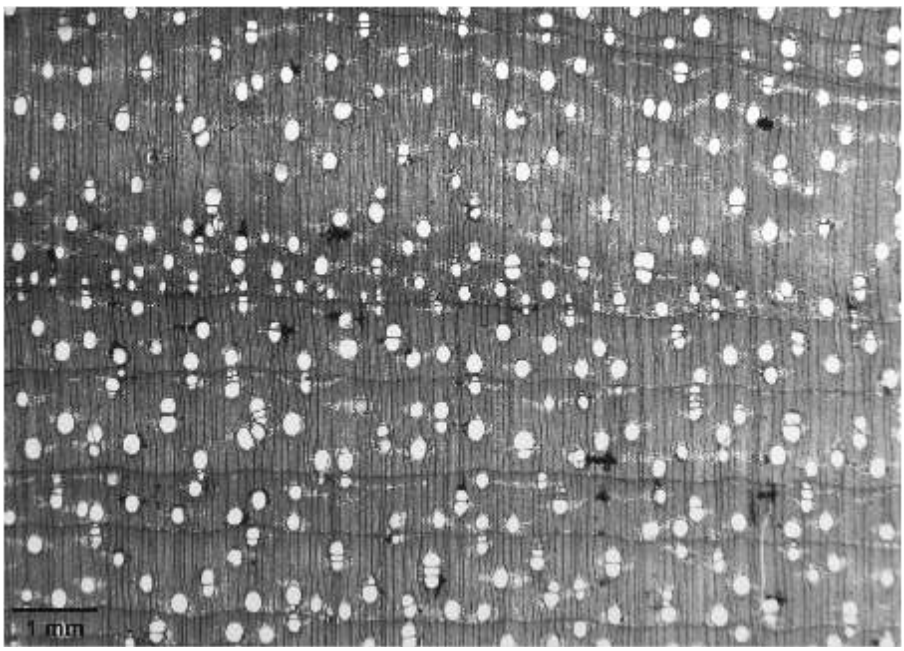


- Macroscopic structure : A ring-porous wood.
- Growth rings distinct, generally conspicuous to naked eye except in extremely slow grown samples, delimited by a narrow lighter coloured zone of large earlywood vessels enclosed in parenchymatous tissues, less than 1 to 6 per cm.
- Vessels in the earlywood large, distinctly visible to the eye, mostly solitary, oval in outline, partly filled with tyloses and sometimes with white powdery deposits, gradually becoming smaller towards the latewood; latewood vessels moderately large to small, mostly solitary or in radial pairs, round to oval in outline, vessel lines of the earlywood zone conspicuous on longitudinal surfaces.
- Parenchyma forming thin sheaths round the vessels distinct only under the hand lens but distinct to the eye in the earlywood forming a continuous zone enclosing the vessels along with initial band of parenchyma delimiting the growth rings.
- Rays visible to the eye, distinct under the lens, moderately broad, somewhat widely spaced and uniformly distributed.

44. *Terminalia bialata* (Roxb.) Steud. (White chuglam)

PHYSICAL PROPERTIES

Wood usually creamy-yellow, turning brownish on exposure. Some logs show a small to fairly large darker-coloured central portion of an attractive nut-brown or olive-brown shade with darker streaks, which furnishes the "silver grey wood" of commerce. The outer lighter coloured wood is commonly known as "White chuglam" in the trade. Wood moderately hard, moderately heavy (sp. gr. 0.55-0.76 air-dry); straight-grained, coarse-textured.

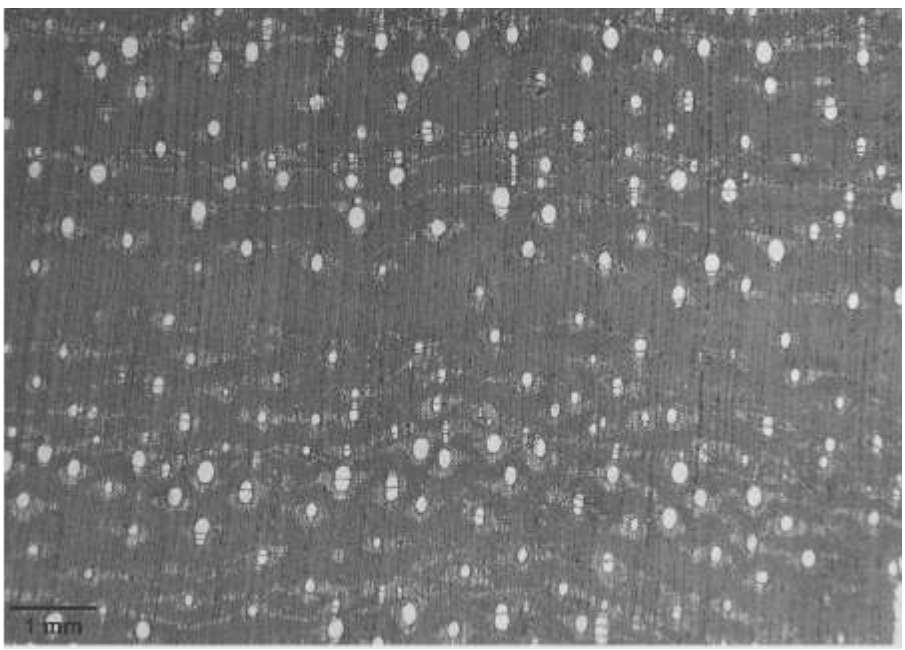


- Macroscopic structure : A diffuse-porous wood.
- Growth rings fairly distinct to the eye, delimited by dark-coloured latewood fibres and often also by a fairly straight thin interrupted line of parenchyma, usually 4-8 per cm.
- Vessels large to moderately large, few to moderately few (3-6 per mm^2), solitary or in radial multiples of 2-3, round to oval in outline, open; vessel lines distinct.
- Parenchyma visible to the eye, aliform to aliform confluent, occasionally tending to form broken wavy or straight tangential bands.
- Rays fine to very fine, indistinct to the eye, closely and evenly spaced.

45. *Terminalia tomentosa* Wight & Arn. (Laurel)

PHYSICAL PROPERTIES

Heartwood sharply differentiated from the sapwood. Sapwood pinkish-white to pinkish-grey or pale grey; heartwood walnut brown to deep brown sometimes with darker streaks giving a handsome figure; hard to very hard, heavy to very heavy, rarely moderately heavy (sp. gr. 0.71-1.16 air-dry), straight to somewhat interlocked-grained, coarse-textured.

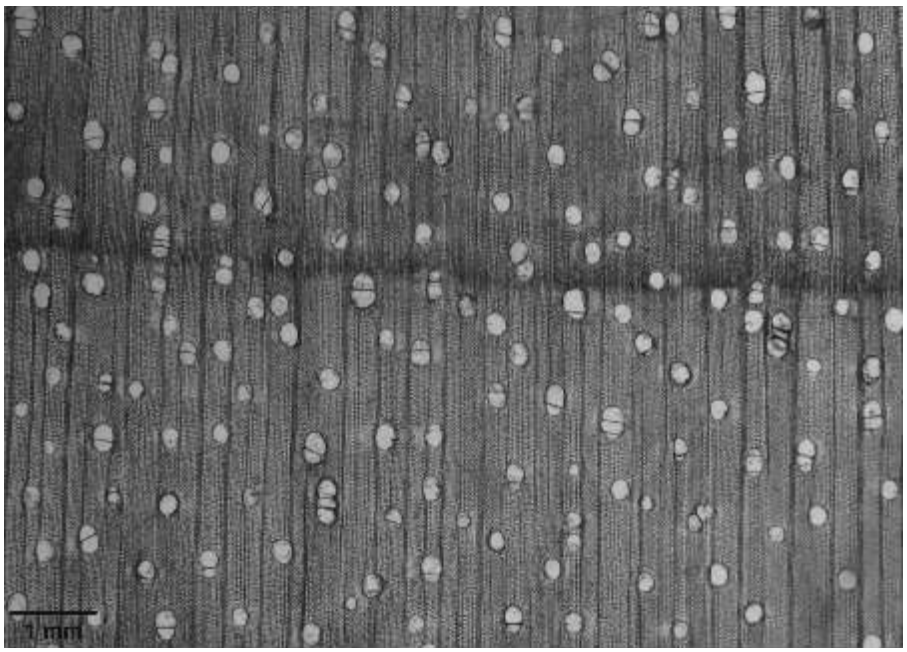


- Macroscopic structure : A diffuse-porous wood occasionally showing tendency towards semi-ring-porousness.
- Growth rings usually distinct only under the hand lens delimited by a fine line of parenchyma (initial), 2-22 per cm.
- Vessels large, distinct to the eye, usually somewhat smaller in the latewood specially in wider rings, few to moderately few (2-8 per mm^2), more or less evenly distributed, solitary or in radial multiples of 2-3, round to oval in outline, open or partially filled with tyloses and sometimes also with reddish-brown gum; vessel lines conspicuous.
- Parenchyma variable in the eye, predominantly aliform with short lateral extensions, sometimes confluent, connecting adjacent vessels, commonly aliform confluent in the samples from the west coast but typically aliform in those from the foothills of the Himalayas; and also as a fine undulating line delimiting growth rings, usually distinct only under the hand lens; commonly filled with whitish deposits.
- Rays fine to very fine, distinct only under the hand lens, closely and evenly spaced.
- Traumatic gum canals in tangential rows rarely present.

46. *Tetrameles nudiflora* R. Br. (Maina)

PHYSICAL PROPERTIES

No colour differentiation between sapwood and heartwood in any of the samples studied. Wood white or straw coloured when fresh, rapidly changing to pale yellowish-buff or yellowish-grey on exposure; soft to very soft; light to very light (sp. gr. 0.26-0.49 air-dry); lustrous when fresh; usually interlocked-grain and coarse-textured.

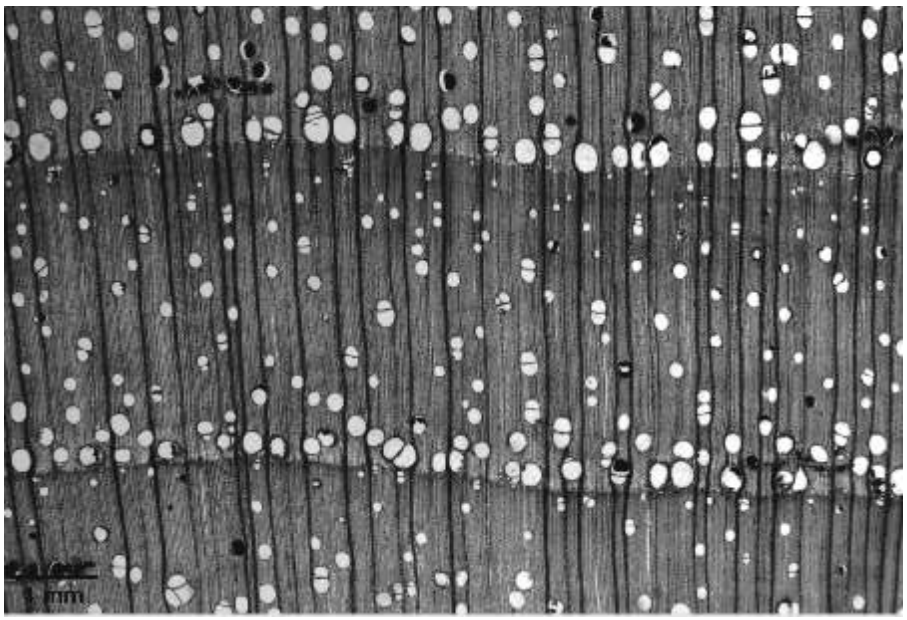


- Macroscopic structure : A diffuse-porous wood.
- Growth rings usually indistinct or absent.
- Vessels large to very large, visible to the naked eye, few to moderately few (2-7 per mm^2) evenly distributed, solitary and in short radial multiples of 2-3 rarely more, round to oval in outline, usually open; vessel lines conspicuous on longitudinal surfaces.
- Parenchyma distinct only under the hand lens as vasicentric thin sheaths round the vessels and rarely with short lateral inconspicuous extensions.
- Rays moderately broad, visible to the eye, somewhat widely spaced and uniformly distributed with distinct radial flecks.

47. *Toona ciliata* M. Roem. (Toon)

PHYSICAL PROPERTIES

Sapwood pinkish, pale brown or yellowish-grey. Heartwood usually pinkish to brick-red when fresh or sometimes light brown with yellow or orange cast, often turning darker with age; usually soft and light, but may also be moderately hard and moderately heavy (sp. gr. 0.37-0.61 air-dry); often lustrous, straight-grained or narrowly interlocked-grained; moderately fine and slightly uneven textured, with pleasing figure due to growth rings and ray-flecks, characteristic and pleasant cedary odour, when fresh.

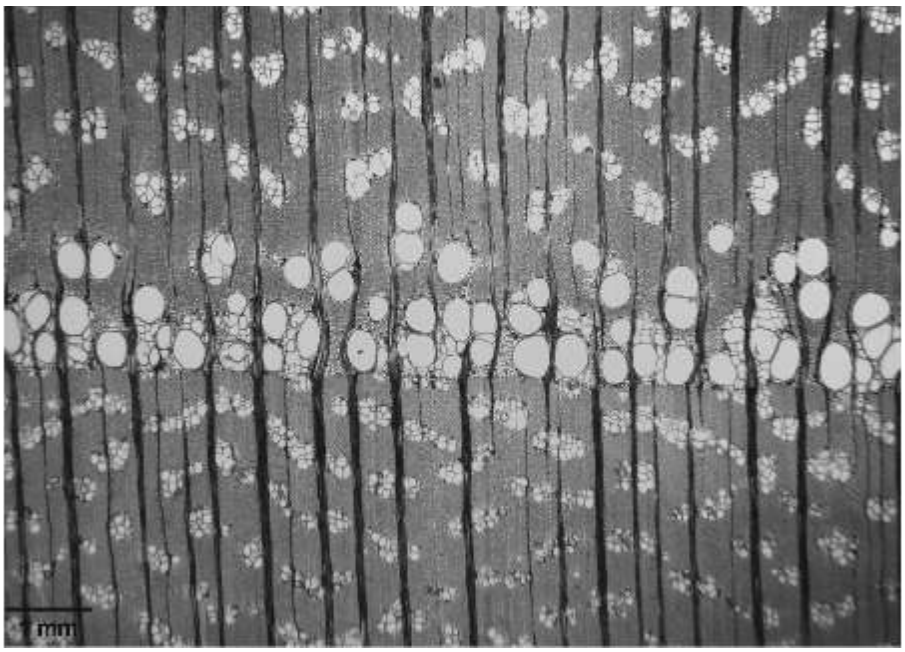


- Macroscopic structure : Usually semi-ring-porous, occasionally ring-porous or diffuse-porous.
- Growth rings distinct, not always conspicuous, usually delimited by concentric lines of initial parenchyma as well as by larger vessels arranged on the face of the growth marks, less than 1-5 rings per cm.
- Vessels of the earlywood often moderately large and arranged in a single row tangentially, but not crowded, visible to the eye, solitary or in radial pairs, round to oval, sometimes plugged with dark brown gummy substance; transition from early to latewood gradual; latewood vessels small, hardly visible to the eye, moderately few, majority solitary but some also in short radial multiples of 2-3, round to oval, vessel lines often distinct in the earlywood.
- Parenchyma inconspicuous, visible only under hand lens, brownish in colour delimiting growth rings and vasicentric, forming thin sheaths round the vessels.
- Rays inconspicuous to visible to the eye, reddish-brown in colour, fine to moderately broad, rather widely spaced; ray-flecks low but fairly conspicuous.
- Gum canals of traumatic origin occasionally present in long or short concentric rows with reddish-brown or blackish gummy deposits.
- Pith flecks sometimes present.

48. *Ulmus wallichiana* Planch. (Elm)

PHYSICAL PROPERTIES

Sapwood pale brownish-white to light greyish-brown, wide, heartwood light brown to golden-brown to walnut-brown with darker streaks, moderately hard to hard, light to moderately heavy (sp. gr. 0.38-0.63 air-dry), lustrous to non-lustrous, straight to twisted grain, medium-coarse and uneven-textured.

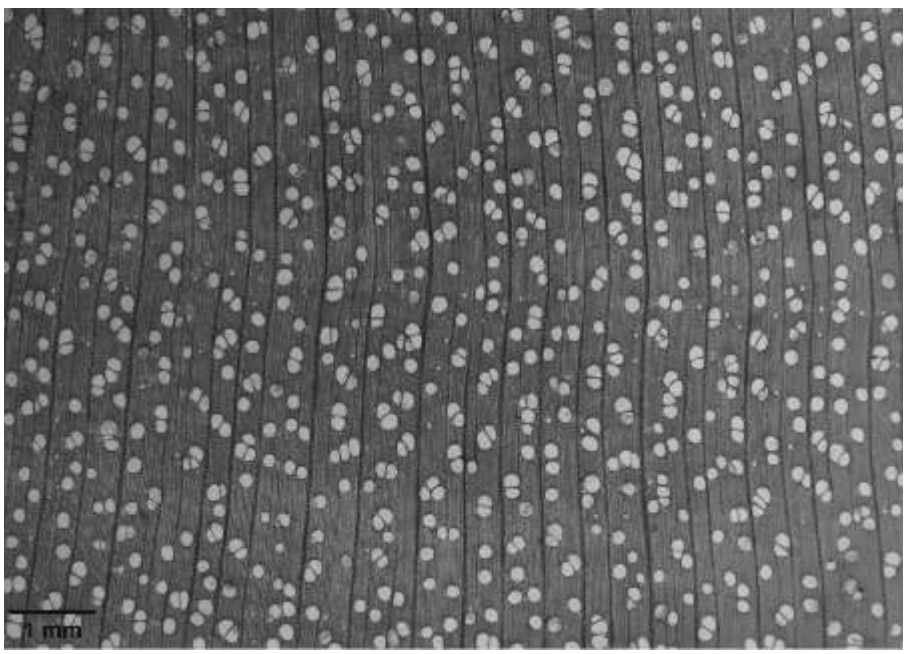


- Macroscopic structure : A ring-porous wood.
- Growth rings distinct, delimited by large earlywood vessels, 6-8 per cm. Earlywood vessels usually in single rows.
- Vessels of two distinct sizes, those in earlywood distinctly visible to the eye, forming a conspicuous zone of 1-3 rows on the face of the growth rings, transition from earlywood to latewood generally abrupt, latewood vessels small and in clusters arranged in wavy, ulmiform, tangential groups or bands, visible to the eye, round or oval, mostly open but with occasional white deposits; vessel lines distinct in tangential surface with white deposits.
- Parenchyma visible to the eye, abundant, embedding large earlywood vessels, scanty vasicentric round the vessel clusters in latewood.
- Rays medium fine to moderately broad, visible under the hand lens, rather widely spaced.

49. *Vateria indica* L. (Vellapine)

PHYSICAL PROPERTIES

Sapwood usually white or creamy in colour but sometimes dirty grey, heartwood whitish-grey or light yellowish-buff turning brownish or pinkish-buff on exposure, wood with resinous smell when fresh, soft to moderately hard, moderately heavy (sp. gr. 0.53-0.68 air-dry), often interlocked grained, medium-coarse and even-textured, somewhat lustrous when freshly cut with conspicuous ray flecks on the radial surface.

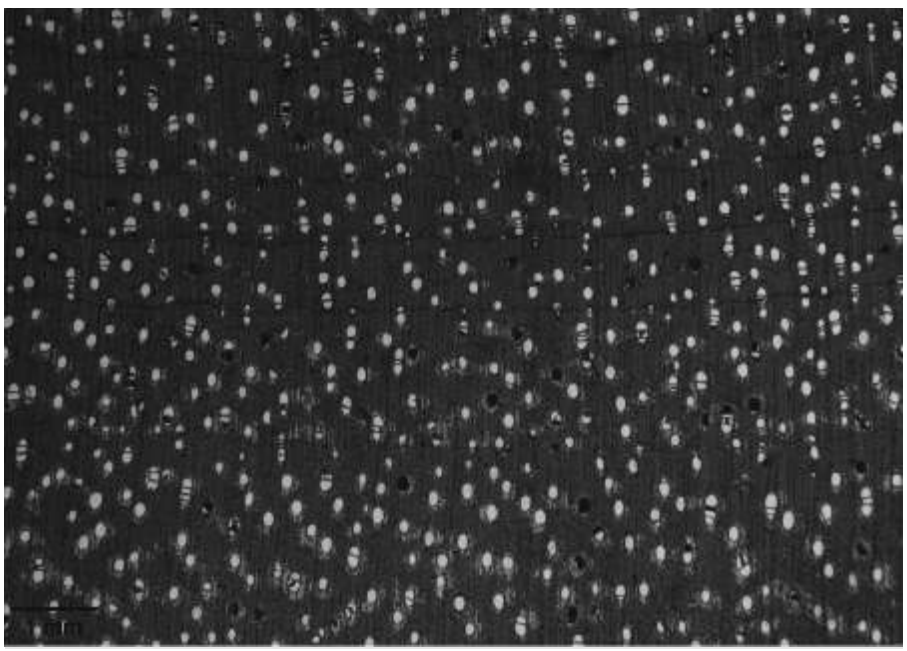


- Macroscopic structure : A diffuse-porous wood.
- Growth rings indistinct.
- Vessels moderately large to small, sometimes hardly visible to the eye, moderately few to numerous (5-25 per mm^2), evenly distributed, solitary or in pairs or sometimes in clusters of 2-5, round to oval, mostly open, occasionally filled with gum or tyloses.
- Parenchyma inconspicuous to the eye but visible only under hand lens, Vasicentric round the vessel or vessel groups, also faintly noticeable around the gum ducts as a thin layer.
- Rays moderately broad, visible under the hand lens, rather widely spaced, often brownish in colour and shows silver grain effect on the radial surface.
- Gum ducts minute, usually attracts attention as white specks to the naked eye, distinctly visible with a lens, uniformly scattered, mostly single, rarely in tangential rows, white gummy deposits often fill up the cavity of the ducts.

50. *Xylia xylocarpa* (Roxb.) Taub. (Irul)

PHYSICAL PROPERTIES

Sapwood narrow, brownish or pinkish-white; heartwood reddish-brown, frequently with darker streaks, turning deep reddish-brown on ageing, rather dull. Very hard, heavy to very heavy (sp. gr. 0.75-1.13 air-dry), usually with interlocked or wavy grain, even and medium to medium fine-textured.



- Macroscopic structure : A diffuse-porous wood.
- Growth rings fairly distinct to inconspicuous or indistinct under the hand lens, demarcated by a very fine interrupted line of parenchyma, 1-8 per cm.
- Vessels moderately large to rather small, visible to the eye, moderately few to moderately numerous (5-17 per mm^2), more or less evenly distributed, solitary or in radial multiples of 2-4, rarely more, occasionally also in clusters, oval in outline and usually filled with orange brown or dark reddish-brown gummy deposits in the heartwood; whitish deposits may also be present, vessel lines rather fine.
- Parenchyma sparse to fairly abundant, usually distinct only under the hand lens, forming thin to thick lighter-coloured patches or sheaths round the vessels, sometimes connecting them obliquely or tangentially, also as scattered cells or as a broken line delimiting growth rings, often inconspicuous even under the hand lens.
- Rays fine, visible only under the lens, closely and evenly spaced.

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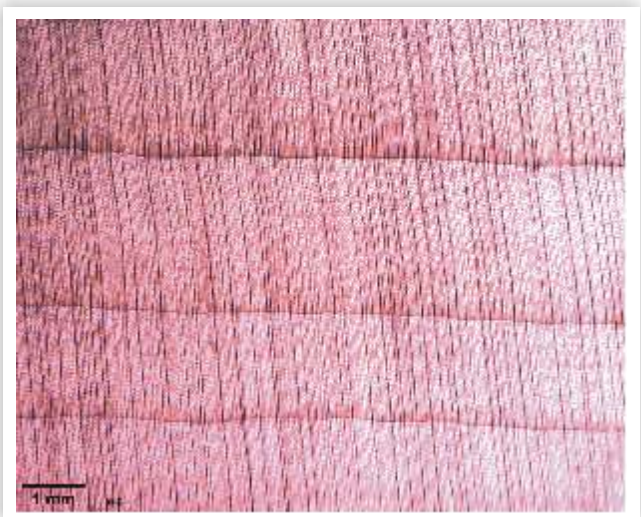

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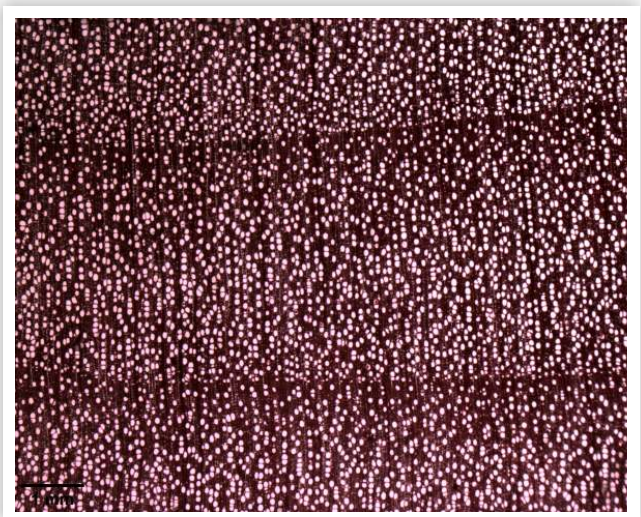

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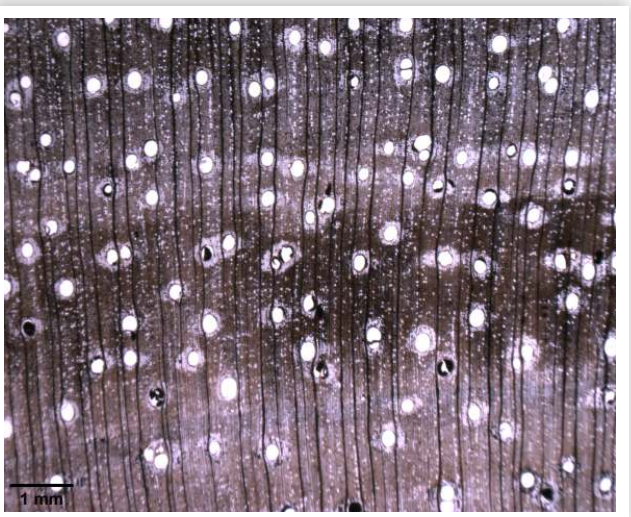

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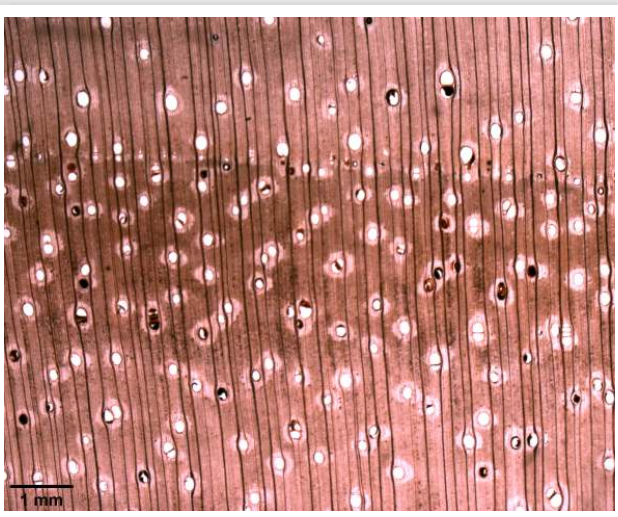

5. *Albizia procera*

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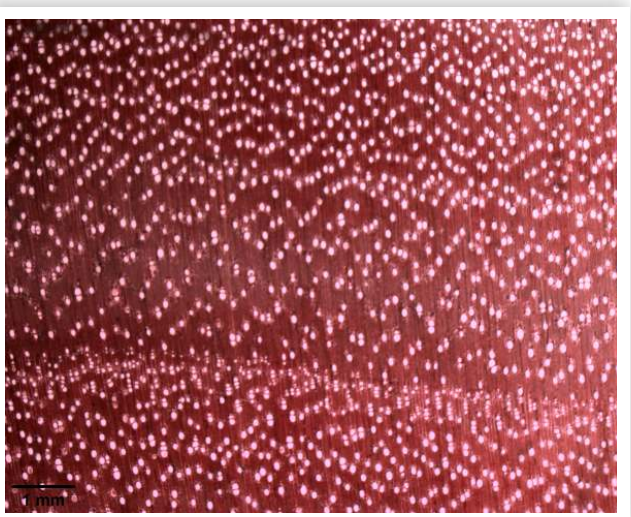
6. *Anogeissus acuminata*



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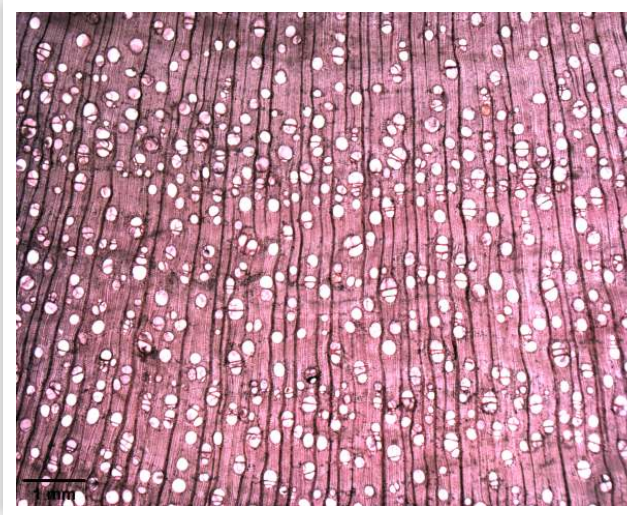

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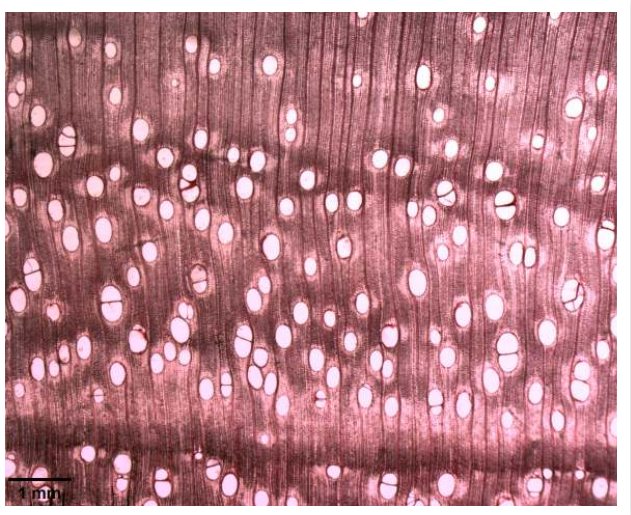

9. *Artocarpus hirsutus*

10. *Betula* spp.

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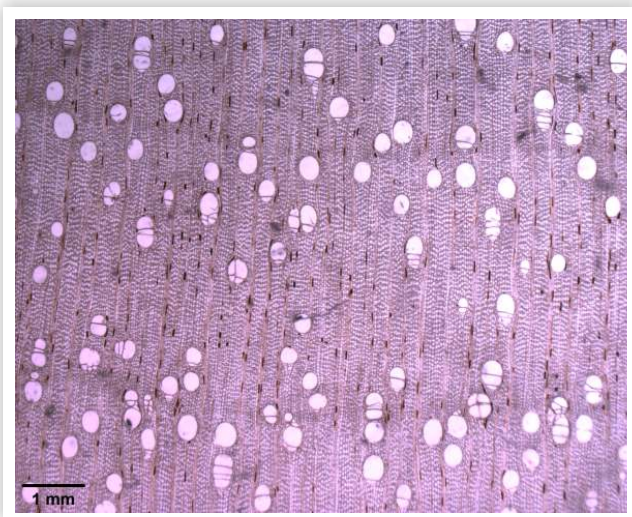

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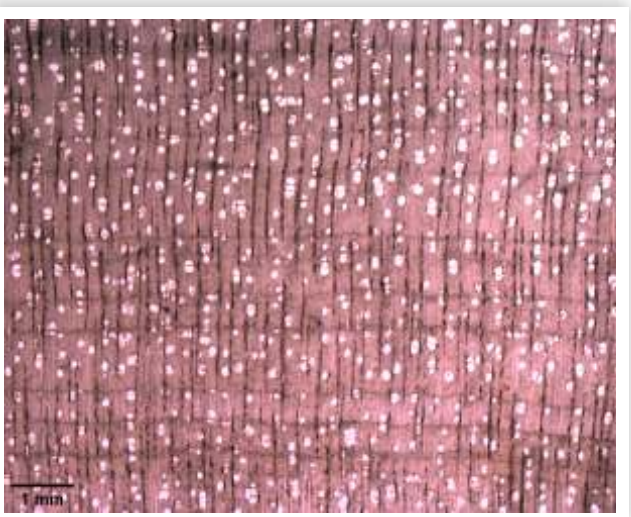
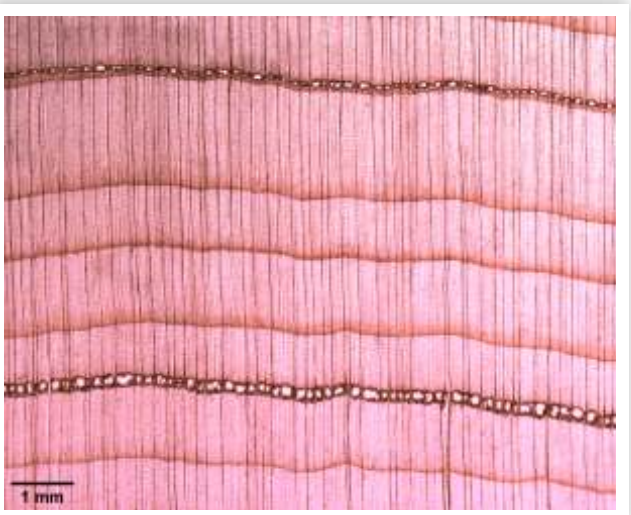


12. *Boswellia serrata*

13. *Casuarina equisetifolia*



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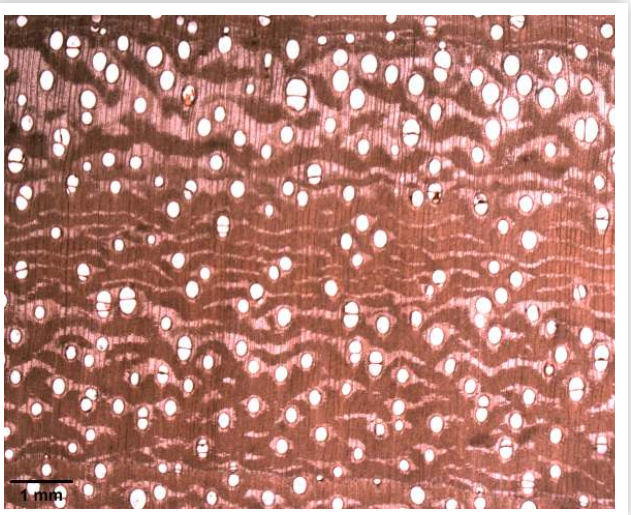

15. *Dalbergia sissoo*

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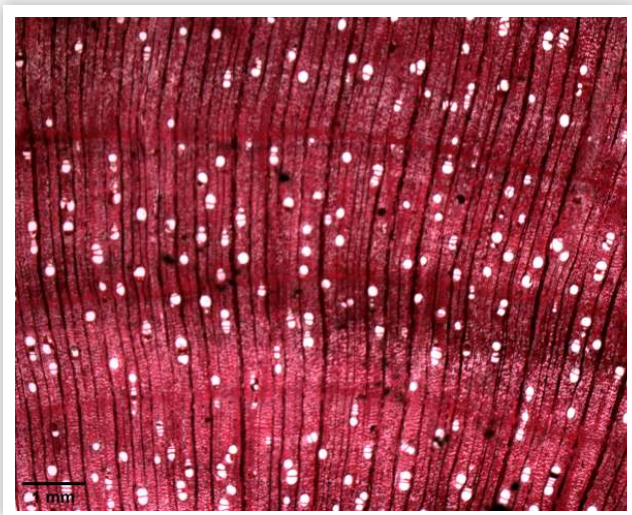
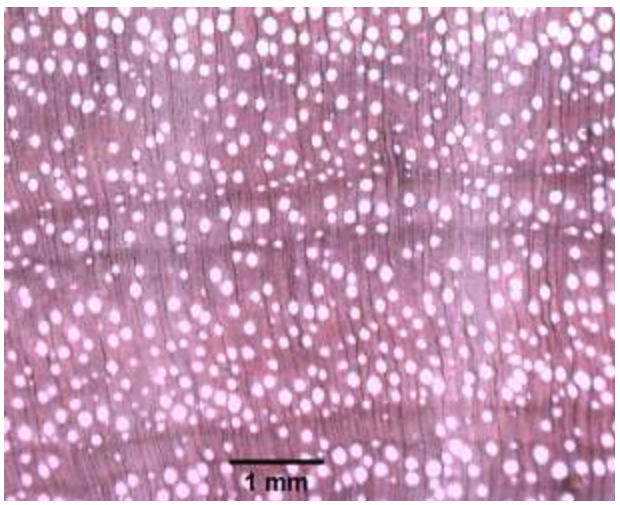


16. *Dipterocarpus* spp.

17. *Dysoxylum malabaricum*



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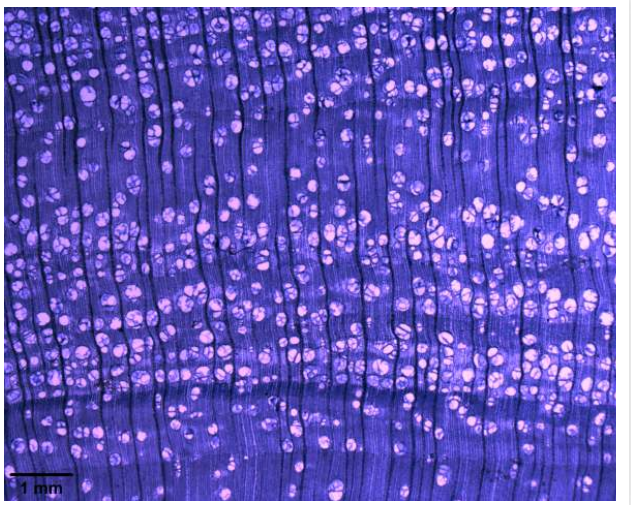

19. *Gmelina arborea*

20. *Grewia tiliifolia*

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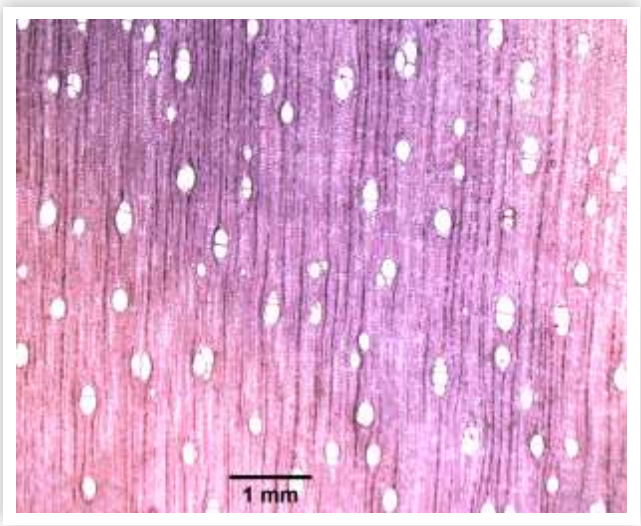

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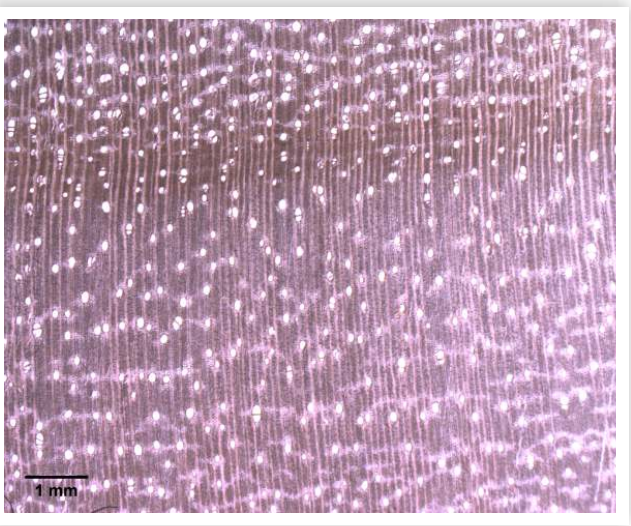

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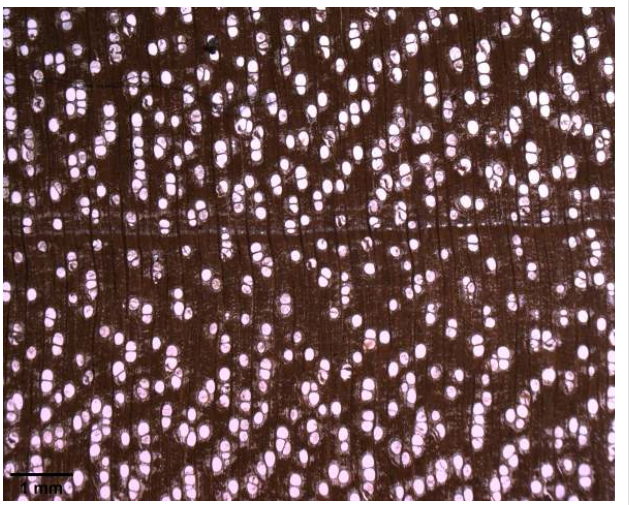

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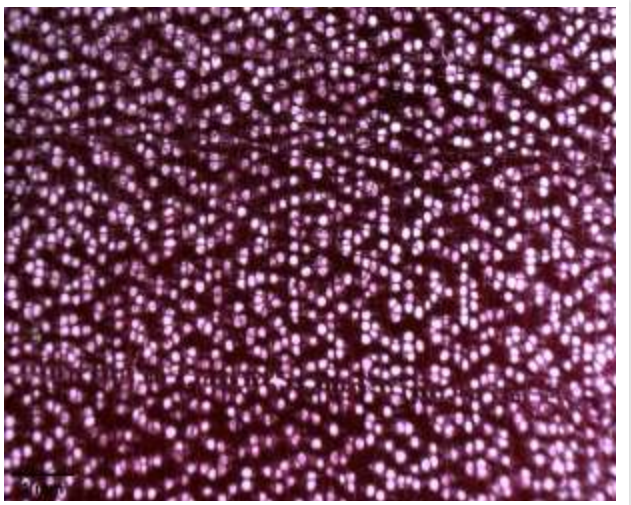

24. *Hopea parviflora*

25. *Juglans regia*

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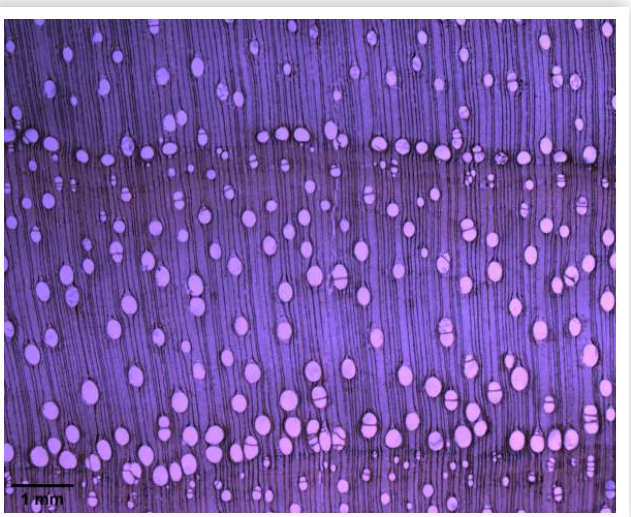
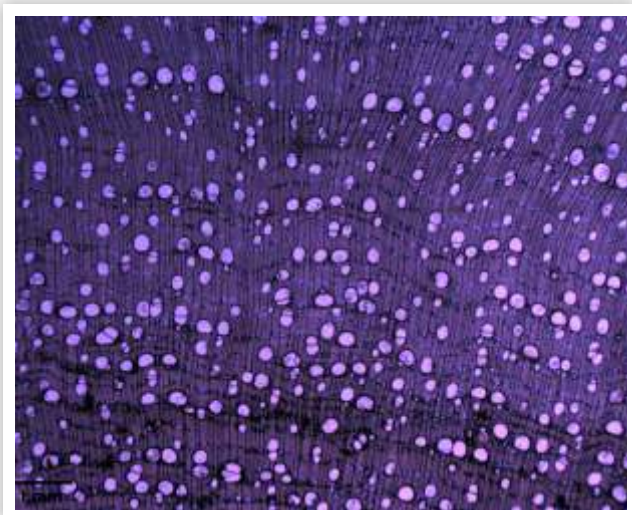
26. *Kingiodendron pinnatum*



27. *Lagerstroemia lanceolata*



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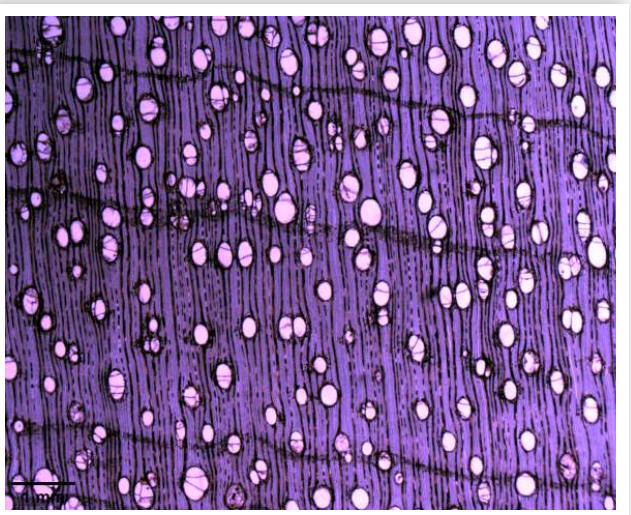

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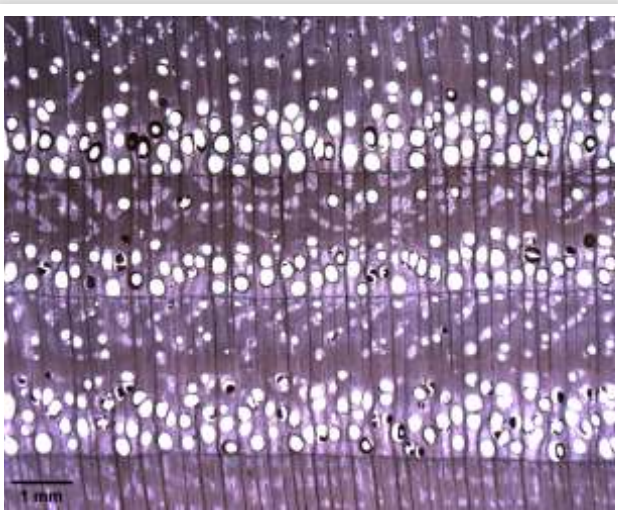

30. *Melia azedarach*

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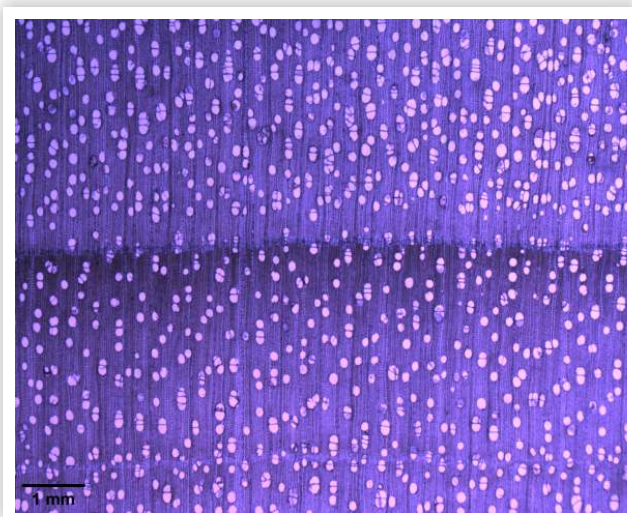

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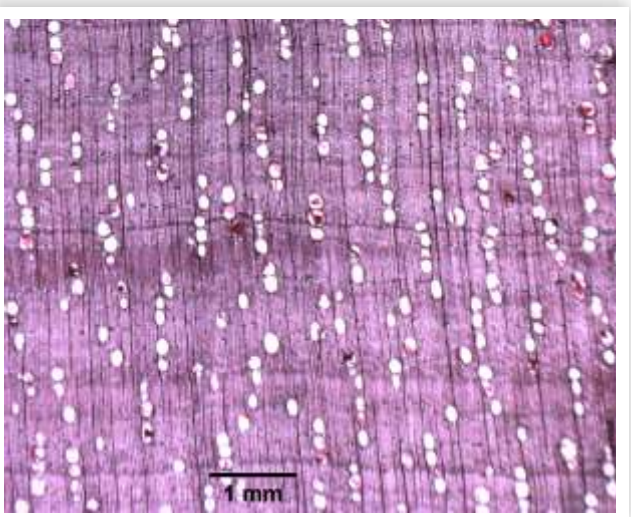

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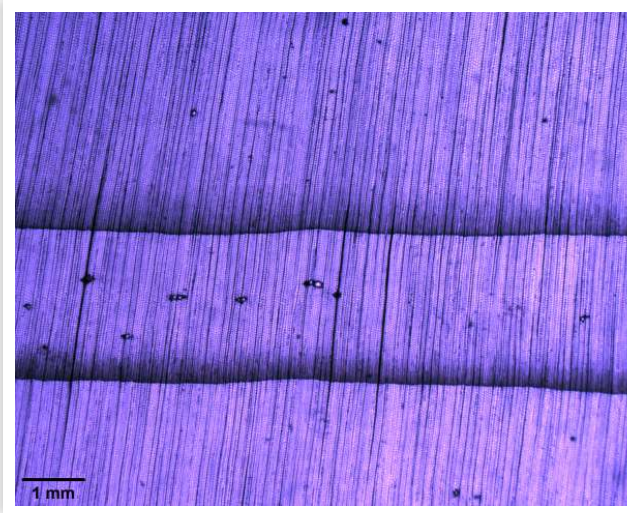

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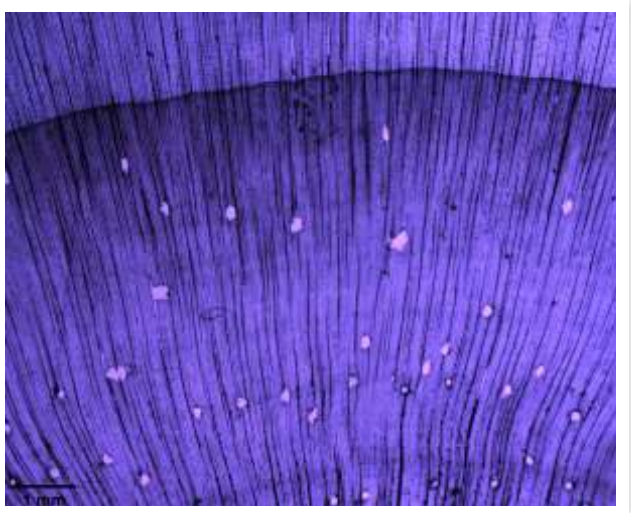

34. *Pinus roxburghii*

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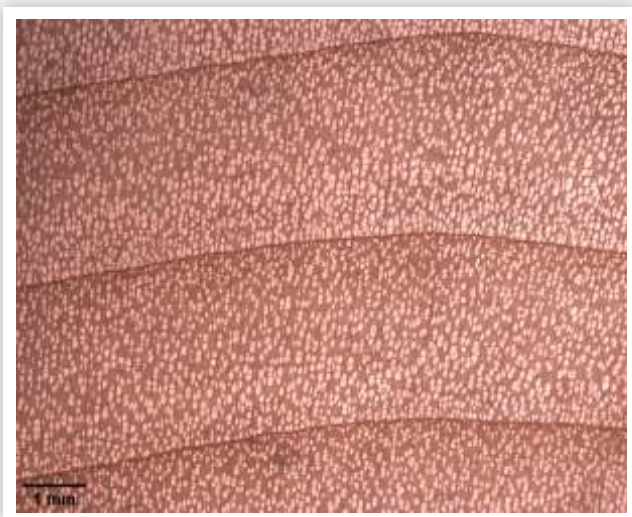

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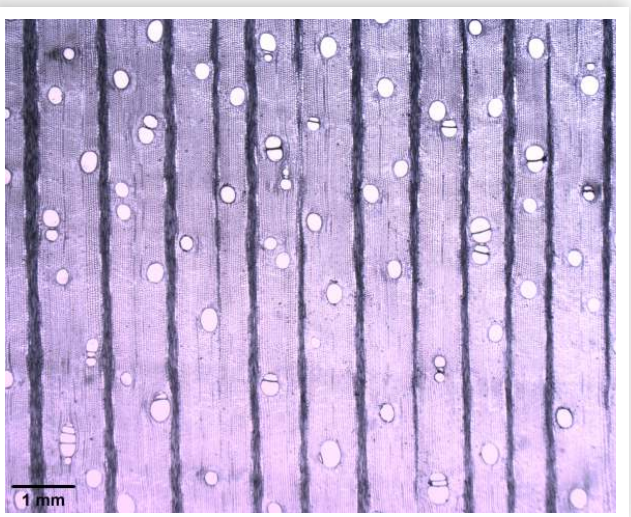
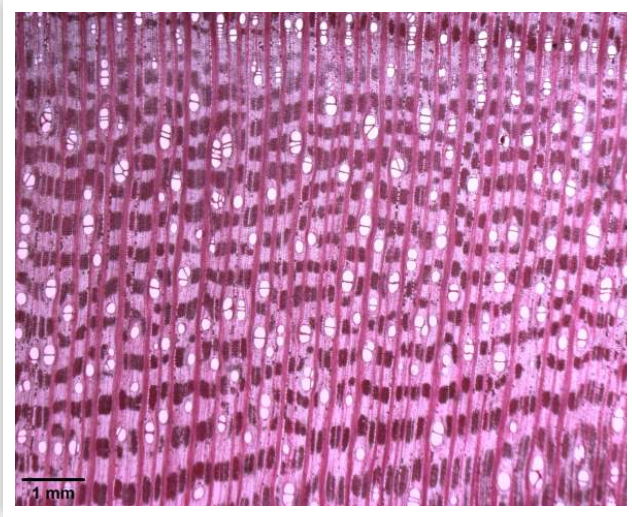


37. *Pterocymbium tinctorium*



38. *Pterygota alata*

39. *Quercus* spp.

40. Salix spp.

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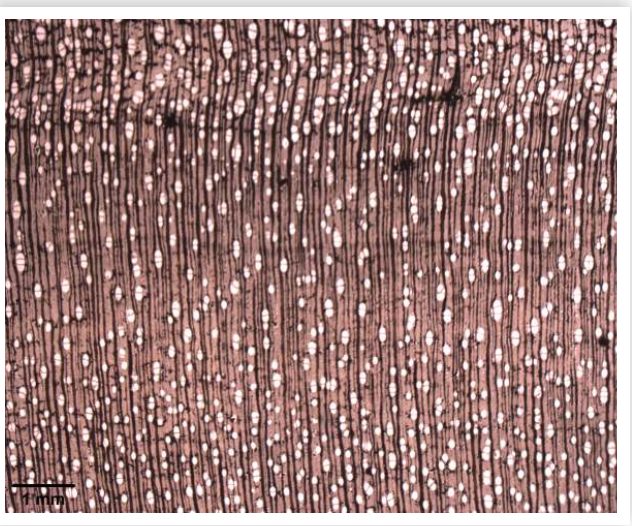
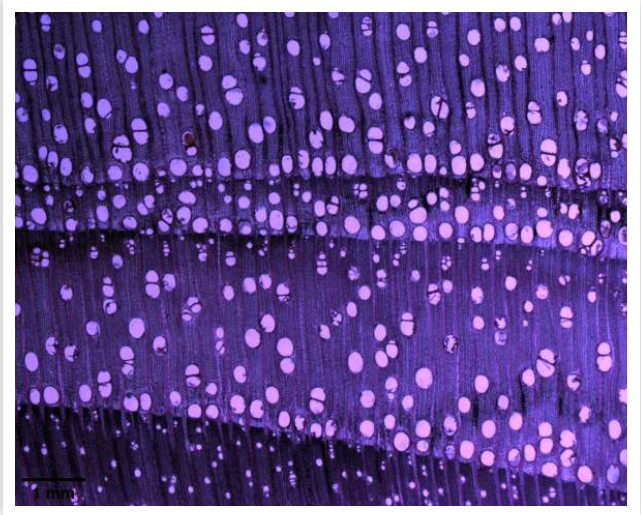
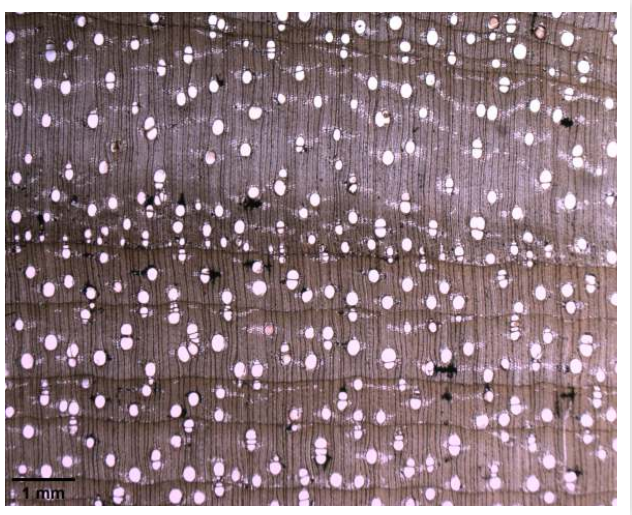
41. *Shorea robusta*



42. *Syzygium cumini*



43. *Tectona grandis*



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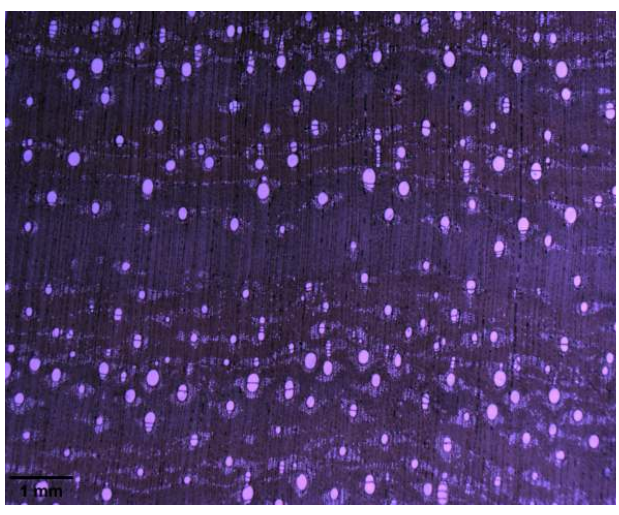

45. *Terminalia tomentosa*

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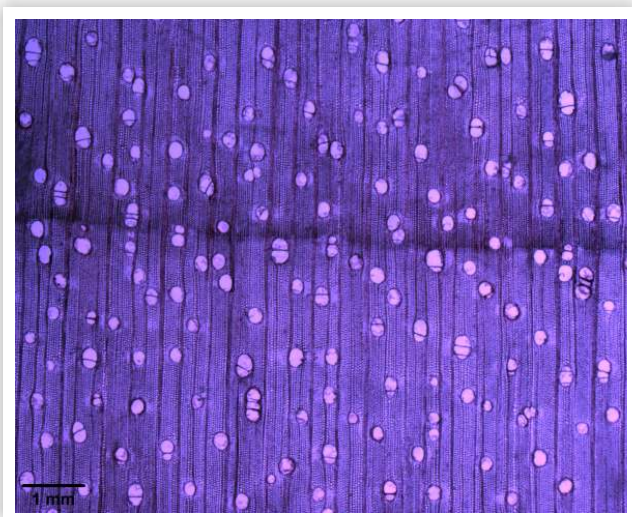

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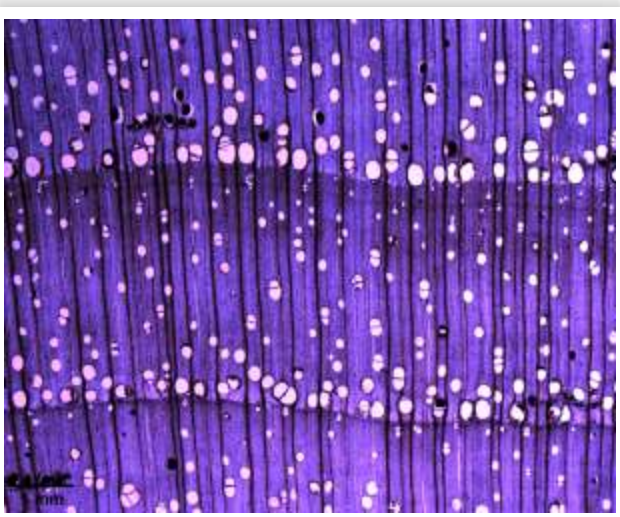

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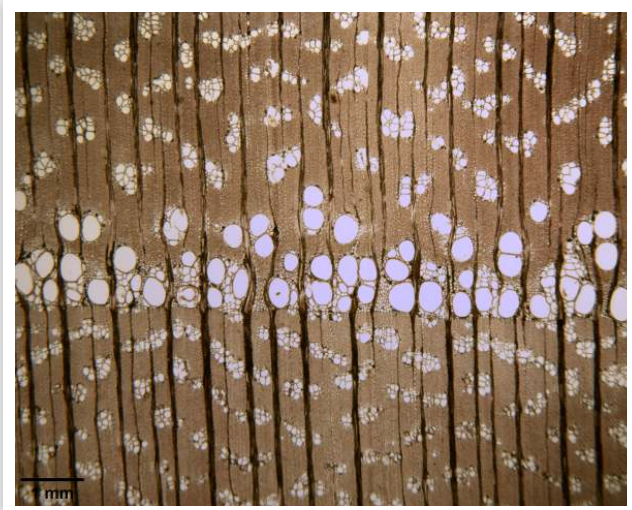

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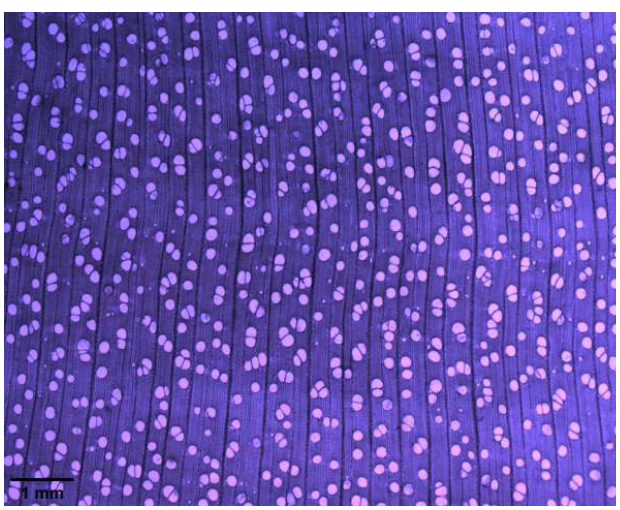
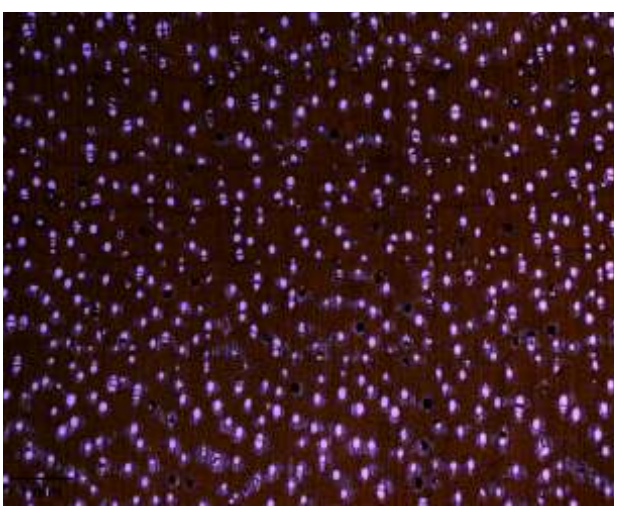


49. *Vateria indica*



50. *Xylia xylocarpa*

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