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THE ANATOMY OF THE WOOD OF THE ANACARDIACEAE AND ITS BEARING ON THE PHYLOGENY AND RELATIONSHIPS OF THE FAMILY

by

Jeannette M. Kryn

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Abstract

THE ANATOMY OF THE WOOD OF THE ANACARDIACEAE AND ITS BEARING ON THE PHYLOGENY AND RELATIONSHIPS OF THE FAMILY

by Jeannette M. Kryn

The purpose of this investigation is to interpret the phylogeny of the Anacardiaceae from the point of view of anatomical structure. The microscopic anatomy of thirty-nine non-American genera was studied in detail, but the data for the American genera were obtained from published papers dealing with the structure of the group.

The introductory portion of this paper, presenting the taxonomic history of the family, indicates that certain genera, Blepharocarya, Rhodosphaera, Spondianthus, Juliania, and Toxicodendron, have been troublesome to the systematists. It also deals with the economic importance of the family. A detailed study of the wood of the thirty-nine non-American genera follows, with a summary of the characteristics of the American genera.

In the final section an attempt is made to apply the information obtained to taxonomic problems. The phyletic characters of the wood of the Anacardiaceae are determined. The structure of Blepharocarya, Rhodosphaera, Spondianthus, and Juliania is compared with that of the Anacardiaceae and with families to which the genera have at some time been assigned. Toxicodendron is evaluated as a genus. Last of all, the structure of the wood of all the families in Gundersen's Rutales is presented for comparison.

The following conclusions can be drawn from this study: (1) the Anacardiaceae are intermediate in specialization with respect to wood anatomy, being neither as little specialized as such a family as the Magnoliaceae nor as highly specialized as the Bignoniaceae; (2) Blepharocarya and Rhodosphaera should remain in the Anacardiaceae on the basis of wood structure; (3) Juliania resembles the Anacardiaceae but differs in many respects from the Juglandaceae and should remain with Orthopterygium in the family Julianiaceae, but in the same order as the Anacardiaceae; (4) Spondianthus should be placed with the Euphorbiaceae, on the basis of anatomical structure; (5) Toxicodendron, as delimited by Barkley, including the Venenatae (not Malosma) and Rhus trichocarpa Miq. of the Trichocarpaceae, probably differs sufficiently from the other species of Rhus to be regarded as a valid genus; (6) the families in Gundersen's Rutales seem to be closely related, with the exception of the Coriariaceae, which differ from the other families in having a more primitive anatomical structure. The Sapindaceae should also be included in the Rutales, however, for the reason that many of the anatomical characteristics of this family are similar to those of the Rutales. With the exclusion of the single genus indicated, and with the concept of the order expanded to include the Sapindaceae, the order Rutales would become a reasonably homogeneous group.

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INTRODUCTION

Objectives of This Study

The family Anacardiaceae is very gratifying to the wood anatomist, for it contains no herbaceous members. Marchand (1869) wrote that the Anacardiaceae constituted one of the most indefinite families in the plant kingdom. The small size of the flowers and their unisexual condition were cited as responsible for the difficulty in determining genera. He prepared his revision of the family to eliminate, on the one hand, the creation of genera which he considered merely new species of known genera, and to abolish, on the other hand, the fusion of very different types into one genus. Since the last decade of the nineteenth century most of the genera have been well established on the basis of floral as well as anatomical characteristics, but several have retained their questionable status, and four genera established since Marchand revised the family have proved troublesome to the systematists. Of the latter group, Blepharocarya was considered by Engler (1896) to be of uncertain position. It had been assigned to the Sapindaceae in the Index Kewensis (Hooker and Jackson, Vol. 1, 1893), although Dalla Torre and Harms (1900 - 1907) placed it in the tribe Rhoideae of the Anacardiaceae. Barkley (1942) omitted the genus in his key to the members of the Anacardiaceae because he assigned it to another family on the basis of floral morphology. The genus

Rhodosphaera, named by Engler in 1881 and considered to be anacardiaceous, has likewise been omitted by Barkley (1942) because of its floral structure. On the other hand, Spondianthus was named by Engler in 1905 and assigned to the Anacardiaceae, but Engler himself decided it had affinities with the Euphorbiaceae and later placed it in that family. Thus, although Dalla Torre and Harms (1900 - 1907) added the genus to the tribe Spondieae in accordance with Engler's original concept, Pax and Hoffmann (1922) described it in their monograph of the Euphorbiaceae. Barkley (1942), however, considered it a valid member of the Anacardiaceae. Dobinia was added to the Anacardiaceae by Engler in 1892 (Engler and Prantl, 1896). It had been placed in the order Acerineae of the class Acera by Endlicher (1836 - 1840), in the sub-family Acerineae of the Sapindaceae by Bentham and Hooker (1862), and in the family Aceraceae of the Sapindales by Hutchinson (1926). Barkley (1942) has not questioned its inclusion in the Anacardiaceae.

Of the genera that were included in the Anacardiaceae of the earlier classification systems but not in the modern ones, exclusive of the genera listed above, most were transferred to the families now considered closely related, particularly to the Burseraceae. One genus, Juliania, has caused much disagreement. It was considered a member of the Anacardiaceae by Bentham and Hooker (1862), but it was regarded by Engler and Diels (1936) as worthy of independent status in a separate family, the Julianiaceae, in the order

Julianiales near the Juglandales. Gundersen (1950) likewise places the genus in the Julianiaceae, but in his order Rutales, following the Burseraceae and the Anacardiaceae. Endlicher (1836 - 1840) had included Julianis in his order (family) Rutaceae, separated by six orders from the Anacardiaceae, but Dalla Torre and Harms considered it of uncertain position in the Anacardiaceae. Bessey (1915) placed the family Julianiaceae in the Sapindales with the Anacardiaceae, Juglandaceae, Betulaceae, and others. Hutchinson (1926) and Wettstein (1935) both included Julianis with the Juglandales as a separate family, the Julianiaceae.

The only other important problem involving the genera of the Anacardiaceae has been concerned with the genus Rhus. Barkley (1942), following ample precedent, divided the traditional genus into several genera: Actinocheita, Metopium, Malosma, Cotinus, Toxicodendron, Schmaltzia, and Rhus. This division was made on the basis of a purely taxonomic study.

In contrast to the rather clearly defined genera of the Anacardiaceae are the problems involved in assigning the family to an order and determining the closely related families. The approach to a solution of these problems will be made through a study of the wood anatomy of the Anacardiaceae and those families which taxonomists at some time have regarded as closely related.

A number of studies of the anatomy of the Anacardiaceae have been published. Solereder (1908) was one of the first writers to summarize the important anatomical details of the

woody axis, and this work has recently been amplified and modernized by Metcalfe and Chalk (1950). Moll and Janssonius (1908 - 1911) prepared a detailed report of the woody structure of nine genera native to Java. Garratt (1931) studied the wood anatomy of one genus, Dracontomelum. Record (1939) made a valuable study of all the American members of the family, and later Hess (1946) published a very similar paper. Webber (1941) and Heimsch (1942) incorporated a summary of certain outstanding features of the group as a whole in the larger works which they prepared. More recently, Dadswell and Ingle (1948) have analyzed the woody stem of the genera from the south-west Pacific area.

One might ask why another study is being presented when so many have already been made. The answer is that a completely satisfactory classification of the Anacardiaceae is still lacking, and the writer hopes that this detailed study of the entire family, from the point of view of both wood anatomy and phylogeny, might be of value to the taxonomists. Gundersen (1950, p. 217), who has accepted the work of the wood anatomists, yet has this to say:

> At present there remain many problems and uncertainties in the classification of the dicotyledons. The position of a family may often depend on our views about the relationships within a family; we should particularly know which genera may be considered primitive. In this connection the methods of cytotaxonomy and plant anatomy seem to be especially promising. Comparisons, from many points of view, are needed between families of suspected relationship, such as . . . Anacardiaceae and Juglandaceae. . . .

In this study the writer presents a critical analysis of the anatomy of the secondary xylem of the Anacardiaceae, with emphasis upon the non-American members of the family, together with a consideration of the structure of those families which have been regarded as closely related by the authors of the leading systems of classification. It is hoped that the information gained will help answer the following questions:

1. Do the tribes into which the family has been divided on the basis of floral structure form distinct groups on anatomical grounds?
2. Should Blepharocarya, Rhodosphaera, and Spondianthus be excluded from this family, and if so, to which families should they be assigned on the basis of wood structure?
3. What is the relationship between the Anacardiaceae and the Juglandaceae with regard to wood structure, and to which family is Julianis more closely related?
4. Is the genus Toxicodendron, as delimited by Barkley, supported by valid anatomical differences?
5. Do the Anacardiaceae resemble the Burseraceae, Julianiaceae, Simaroubaceae, Rutaceae, and Meliaceae to such an extent that they merit inclusion in the same order, separated from the Sapindaceae?

Taxonomic History of the Family

The family Anacardiaceae is composed exclusively of woody plants, trees, shrubs, and woody climbers, classified in from 58 to 73 genera by the more recent authors. Thus Engler (1896, 1900 - 1908) lists 68 genera with 500 species; Hegi (1907) and Record (1939) list 58 and 65 genera respectively; Barkley (1942) and Lawrence (1951) include 73 genera with 600 species; and Gundersen (1950) lists 60 genera. In almost every case, the difference in the number of genera is the result of the varying concepts of the generic limits of the Rhus complex.

Five genera included in all modern classifications were listed by Linnaeus (1754) in his "Ordo Generum." These genera are Rhus, Spondias, Anacardium, Schinus, and Pistacia. In 1759, Bernard de Jussieu (A. de Jussieu, 1789) placed in his Ordo Terebinti the five genera listed above and added Bursera, Juglans, and several present-day Rutaceae. Adanson (1763) divided his forty-fourth family, the Pistachiers, into two groups. In the first group of plants with pinnate leaves he included, among others, Monbin (Spondias), Molle (Schinus), Rus (Rhus), Pistakia (Pistacia), and Vernix (Toxicodendron); in the second group with simple leaves he listed Akajou (Anacardium), Mangas (Mangifera), and Kotimus (Cotinus). Other Adansonian genera are now included in the Rutaceae, Sapindaceae, and Meliaceae. Later, Antoine de Jussieu (1789) placed his twelfth order, the Terebinthaceae, near the end of his fourteenth class and divided it into five parts, of

which the final two contained "Genera Terebintaceis affinia." In his first part, in addition to several non-anacardiaceous genera, he listed Anacardium, Mangifera, and Rhus. The second part included Comocladia, Schimus, Terebinthus (Pistacia), Tapiria (Tapirira), Poupartia, and Spondias. Bursera was once more present. The final three parts contained such genera as Aylantus (Ailanthus), Zanthoxylum, Ptelea, and Juglans.

Marchand (1869), in discussing the history of the Anacardiaceae, notes that Robert Brown was the first to indicate, in 1818, the existence of a special group of plants similar to Anacardium which he believed merited family status. Brown proposed the name Anacardiaceae for this new family composed of genera which had been regarded as members of the larger group, the Terebinthaceae, since the time of Antoine de Jussieu. He selected as representative genera these members of the first two sub-orders of Jussieu: Anacardium, Semecarpus, Mangifera, and Rhus, and he added Buchanania and several other plants. The genera which remained of Jussieu's two sections served to form the Burseraceae, Connaraceae, and others. Kunth (1824) accepted the divisions proposed by Brown, but he retained the name Terebinthaceae for the family and added the following genera which the latter had regarded as belonging to the Burseraceae: Comocladia, Schimus, Pistacia, and Serindeia. He also added these new genera: Rhinocarpus, Cambessedea, Mauria, Duvaua, and Astronium.

Most of the terebinthaceous genera which he excluded from the family have never been returned to the Anacardiaceae.

Bentham and Hooker (1862) placed the Anacardiaceae with the Sapindaceae in the order Sapindales, and regarded the Burseraceae, Meliaceae, Rutaceae, and Simaroubaceae, some of whose genera had been considered terebinthaceous by the earlier writers, as distinct families in the Geraniales. They then divided the Anacardiaceae into two tribes: the Anacardieae with 35 genera, and the Spondieae with 11 genera, a total of 46, four of which they considered of uncertain position. All the members of the first tribe remain in the Englerian classification, occasionally, however, under synonyms, except Corynocarpus, which has been placed in a separate family, the Corynocarpaceae, in the Sapindales. Five genera of the second tribe remain in Engler's Anacardiaceae. Of the remaining six, Julianis has been placed in a separate family, the Julianiaceae, in the order Julianiales near the Juglandales; Hitzeria (Commiphora) has been assigned to the Burseraceae; and Lannecma, Rumphia, and Huertia have been variously placed. It is interesting to note, at this point, that authors of recent papers concerned with the anatomy of the wood of Julianis consider this genus to be closely related to the Anacardiaceae. Record (Record and Hess, 1943:201) says of the Julianiaceae: "This small tropical American family . . . might well be included in the Anacardiaceae. . . ." Heimsch (1942) cites papers of Fritsch, Kramer, and Copeland and Doyel to support

his belief that the affinities of the Julianiaceae, with reference to wood structure, are with the Anacardiaceae.

Baillon (1878) based his classification of the Terebinthaceae upon an earlier one of Triana and Planchon which had united the Burseraceae and Anacardiaceae in a single family. He made of these families three series, the Spondieae, Anacardieae, and Bursereae, and added two other series, the Mappieae and Phytocreneae. He thus divided his family into five tribes, only two of which contained genera of the present Anacardiaceae. Two genera of his Anacardieae series, Juliania and Corynocarpus, have been removed; but although the Bursereae have become a separate family, the Burseraceae, one of that series, Dasycarya, has remained in Engler's group as the synonymous Cyrtocarpa and another, Paiveusea (Paivaeusa), has been placed in the Euphorbiaceae. All of the Mappieae and Phytocreneae have been assigned to the Icacinaceae by Engler.

This brief account of the early history of the family serves to indicate the confusion that existed in the grouping of genera in families in the earlier classifications, but at the same time it emphasizes the closeness of the relationship of the Burseraceae, Anacardiaceae, Sapindaceae, and Juglandaceae and thus helps to explain the present-day difficulty in assigning the now relatively static families to acceptable orders.

Engler (1896) admitted the close affinities of the Burseraceae and the Anacardiaceae, but he placed them in separate orders; the former with the Rutaceae, Simaroubaceae,

and Meliaceae in the Geraniales because it possesses an anatropous ovule with a dorsal raphe, and the latter with the Sapindaceae in the Sapindales because it has an anatropous ovule with a ventral raphe. The separation was necessary because of his emphasis upon the importance of the seed character. Engler regarded his Anacardiaceae as a very natural family, for the position of the ovule and the presence of schizo-lysigenous resin ducts in the stem together served to separate the anacardiaceous genera from all others. He divided his family into five tribes differing primarily in the type of gynoecium possessed by the genera. Of the 33 genera of Engler not included by Bentham and Hooker, 20 were unknown at the time of publication of the Genera Plantarum; 11 were listed under synonyms; one, Thyrsodium (Garuga), was considered a member of the Burseraceae; and one, Dobinea, was placed by Bentham and Hooker in the Sapindaceae.

Hallier (1912) did not accept Engler's Geraniales and Sapindales. He divided them into the Gruinales, "Aesculines," and "Térébinthines." In the latter order were the Rutacées, Meliacées, Simarubacées, Térébinthacées (which included the Burséréés, Anacardiacées, Julianales Engl. and Juglandales Engl.), and the Acéracées and Amentacées.

Hutchinson (1926) distributed the previously mentioned members of Engler's Geraniales and Sapindales in the following three consecutively numbered orders: Rutales, including the Rutaceae, Simaroubaceae, and Burseraceae; Meliales, including the Meliaceae; and Sapindales, including the Sapindaceae and

Anacardiaceae. Then in the next order, the Juglandales, he placed the Juglandaceae and Julianiaceae, both of which had been present with the Anacardiaceae in several early classifications. These four orders were grouped together in the sub-phylum Pinnatae, which is characterized as possessing mostly pinnately or rarely palmately compound leaves. Hutchinson followed the lead of Bentham and Hooker in placing Dobinea in the Aceraceae of the Sapindales.

More recently Wettstein (1935) made the Anacardiaceae the tenth family of his Terebinthales, which included also the Rutaceae, Simaroubaceae, Burseraceae, Meliaceae, and Sapindaceae.

Gundersen (1950) has utilized the results of studies in cytology, wood anatomy, floral morphology, and paleobotany in developing his scheme of classification. His twenty-sixth order, Rutales, includes the Burseraceae, Anacardiaceae, Julianiaceae, Simaroubaceae, Rutaceae, and Meliaceae. It is followed by the Juglandales and Sapindales.

Thus, although modern systematists follow Engler rather closely in his delimitation of the family Anacardiaceae based upon the position of the ovule and the presence of resin ducts, they refuse to admit that the seed structure is of sufficient importance to require the separation of closely related families into different orders. This stand of the taxonomists is shared by the wood anatomists, for they have found that the families under discussion show many similar

features of wood structure, even though they differ sufficiently to remain distinct families. Webber (1941, 460 - 461), in discussing the affinities of the Burseraceae, presents the following summary of her conclusions in regard to the interrelationships of the families:

> It is evident that the woods of all five families have many structural features in common. However, certain structural features which are absent in the Burseraceae are shared by the more variable woods of the Anacardiaceae, Simarubaceae, Rutaceae, and Meliaceae, while among these families other features have been reported only in the Burseraceae and Anacardiaceae; or in the Burseraceae, Simarubaceae, Rutaceae, and Meliaceae; or in the Simarubaceae, Rutaceae, and Meliaceae. Hence it may be concluded that the wood s tructure of the Burseraceae, rather than presenting evidence for grouping this family with the Anacardiaceae instead of with the Simarubaceae, Rutaceae, and Meliaceae, is more suggestive of the probable common ancestry of all five families.

Economic Importance

The anacardiaceous plants constitute a family which might be characterized as being at the same time notable and notorious, for although its members furnish many edible fruits, valuable nuts, famous oriental lacquer, and are important sources of tannin, they often possess one or more poisonous principles such as that of American poison ivy which makes the use of their products dangerous. This poisonous substance is non-volatile, and ageing with oxidation does away with the danger of a serious dermatitis or internal poisoning. New lacquer ware, for instance, may be poisonous, but old is not.

One of the most important of all tropical fruits, the mango, is the product of Mangifera indica L. Other species also produce edible fruits, but they are inferior because of the turpentine flavor caused by substances in the resin canals of the tissues. Selection under cultivation seems to have eliminated the tendency of the fruits to be poisonous. Spondias dulcis Forst. is grown extensively for its fruit, and Spondias purpurea L. furnishes the Spanish plum of South America.

The cashew nut, the product of Anacardium occidentale L., is native to America, but it is widespread through cultivation. The seed is said to contain a volatile poison which is inactivated by roasting before the nut can be eaten. The oil in the seeds has been known for hundreds of years as a food oil. The pear-shaped, red-colored fruit stalk is utilized in the preparation of marmalades and alcoholic cashew wine. The sap in all parts of the plant darkens upon exposure to the air and can be used as a permanent black marking ink which cannot be removed by water. (Burkill, 1935). The poisonous black substance, cardol, from the shell of the seed, is used in bookbinding and for varnishing furniture and other household furnishings in India and South America because it affords protection against attacks of ants and other insects.

The pistachio nut, the fruit of Pistacia vera L., has been grown in the Mediterranean region for a long time. The

bark of Pistacia Lentiscus Linn. is tapped for an oleo resin which hardens into mastic. This was used as a perfume and in medicine in the past and enters into the preparation of a Turkish liqueur.

The oriental lacquer of commerce is a natural product, the white sap of any one of several anacardiaceous trees of the Malayan region and Japan. It turns black soon after it is collected, unless it is heated to destroy the enzymes, but it remains fluid for some time. Rhus vernicifera DC., and species of Melanorrhoea, Gluta, Swintonia, Semecarpus, and Buchanania yield almost identical substances (Burkill, 1935: 1436).

Record (1939) has described in detail the process by which tannin is extracted from the heartwood of quebracho (Schinopsis Lorentzii Engl. or S. Balansae Engl.), which contains from twenty to thirty per cent of tannin. Many other anacardiaceous plants also contain tannin in sufficient quantity to be of commercial value. The leaves of Rhus Coriaria L., second in importance to the wood of Schinopsis, must have been in common use for centuries, for Theophrastus made allusions to their use in tanning and in medicine in his Enquiry into Plants.

Although many of the members of this large family have a beautifully colored, lustrous, and durable heartwood, only three of the genera produce woods of more than local importance. One of these, Schinopsis, is so durable that

practically all the fence posts, telegraph poles, bridge timbers, and railway ties of large parts of South America are made of it. It is seldom cut into boards, however, because of a tendency of the thin lumber to check and warp, and because of difficulty in sawing (Record, 1939). The genus Astronium is the source of gonçalo alves, (A. fraxinifolium Schott., and A. graveolens Jacq.), which is used for veneers for fine furniture in the United States because of its lustrous light or dark reddish brown heartwood marked by vertical blackish bands. The wood of the third genus, Dracontomelum, has been introduced to the American market very recently. Garratt (1931) says that it is similar in general appearance and anatomy to the lighter-colored specimens of "orientalwood" from Queensland. The beautiful red woods of Melanorrhoea and Gluta are little used because the poisonous latex discourages felling of the trees by the natives; and other genera, such as Mangifera and Anacardium, produce timbers of a grade not sufficiently high to warrant the expense of exportation (Burkill, 1935).

VARIOUS SCHEMES OF CLASSIFICATION OF THE ANACARDIACEAE

Classification of the Genera According to Endlicher (1836 - 1840):

Class: Acera

Order:* Acerineae

Genus: 1. Dobinea

Class: Terebinthineae

Order: Juglandeae

Genus: 1. Juglans, etc.

Order: Anacardiaceae

Genera:
1. Pistacia
2. Dupuisia [(later placed in Sorindeia)]
3. Sorindeia
4. Comocladia
5. Cyrtocarpa
6. Odina
7. Pegia
8. Solenocarpus
9. Schimus
10. Duvaua [Schimus]
11. Mauria
12. Lithraea
13. Rhus
14. Styphonia [Rhus or Schmaltzia]
15. Botryocoras [Laurophyllus]
16. Loxostylis
17. Astronium
18. Melanorrhoea
19. Gluta
20. Stagmaria [Gluta]
21. Syndesmis [Gluta]
22. Holigarna
23. Mangifera
24. Anacardium
25. Semecarpus
26. Bouea
27. Buchanania

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*Endlicher's Order corresponds to the modern Family.

Spondiaceae
28. Spondias
29. Poupartia

Genera dubia

30. Heeria, etc.

Order: Burseraceae

Genus: 1. Tapiria [Tapirira]

Order: Rutaceae

Genus: 1. Juliania

According to Bentham and Hooker (1862):

Order: Sapindales

Family: Sapindaceae

Genera: 1. Dobinea, etc.

Family: Anacardiaceae

Tribe I: Anacardieae

Genera:
1. Rhus
2. Comocladia
3. Pistacia
4. Sorindeia
5. Pentaspadon
6. Loxopterygium
7. Mangifera
8. Anacardium
9. Bouea
10. Gluta
11. Buchanania
12. Loxostylis
13. Melanorrhoea
14. Swintonia
15. Schinus
16. Euroschinus
17. Smodingium
18. Haematostaphis
19. Solenocarpus
20. Tapiria [Tapirira]
21. Trichocypha
22. Odina
23. Astronium
24. Parishia
25. Semecarpus
26. Oncocarpus [Semecarpus]

27. Drimycarpus
28. Holigarna
29. Nothopegia
30. Campnosperma
31. ? Drepanospermum [Campnosperma]
32. Corynocarpus [Corynocarpaceae]
33. Botryoceras [Laurophyllus]
34. Mauria
35. Duvaua [Schinus]

Tribe II: Spondieae

Genera:
36. Spondias
37. Dracontomelum
38. Dasycarya [Cyrtocarpa]
39. Hitzeria [Commiphora - Burseraceae]
40. Sclerocarya
41. ? Harpephyllum
42. Lannecma [Poupartia]
43. ? Rumphia (?)
44. ? Huertia (?)
45. ? Enrila [Ventilago - Rhamnaceae]
46. ? Juliania

According to Baillon (1878):

Family: Terebinthaceae

Tribe I: Spondieae

Genera:
1. Spondias
2. Buchanania
3. Sclerocarya

Tribe II: Bursereae

Genera: 4. Dasycarya [Cyrtocarpa], etc.

Tribe III: Anacardieae

Genera:
5. Schinus
6. Sorindeia
7. Selenocarpus
8. Tapirira
9. Haematostaphis
10. Gluta
11. Swintonia
12. Melanorrhoea
13. Astronium

Tribe IV: Mappieae [Icacinaceae]

Tribe V: Phytocreneae [Icacinaceae]

According to Engler (1896):

Order: Sapindales

Sub-order: Anacardiineae

Family: Anacardiaceae

Tribe I: Mangifereae

Genera:
1. Buchanania
2. Mangifera
2a. Fegimanra
3. Anacardium
4. Gluta
5. Swintonia
6. Melanorrhoea
7. Bouea

Tribe II: Spondieae

Genera:
7a. Koordersiodendron
8. Spondias
8a. Antrocaryon
8b. Allospondias
9. Solenocarpus
10. Dracontomelum
11. Pleiogynium
12. Sclerocarya
13. Pseudospondias
14. Poupartia
15. Pegia
16. Harpephyllum
17. Calesium [Lannea; Odina]
17a. Spondiopsis
18. Cyrtocarpa
19. Haematostaphis
20. Tapirira

Tribe III: Rhoideae

Genera:
21. Haplorhus
22. Pistacia
23. Pentaspadon
24. Microstemon
25. Thyrsodium
26. Faguetia
27. Sorindeia
28. Trichocypha
29. Parishia
30. Protorhus
31. Baronia

32. Campnosperma
33. Euroschinus
34. Rhodosphaera
35. Mauria
36. Schinus
37. Lithraea
38. Cetinus
39. Loxostylis
40. Laurophyllus
41. Smodingium
42. Heeria
43. Comocladia
44. Metopium
44a. Mosquitoxylum
45. Pseudosmodingium
46. Rhus
47. Astronium
48. Loxopterygium
49. Schinopsis

Uncertain Genera of the Rhoideae

50. Micronychia
51. Veatchia [Pachycormus]

Fossil Genus: Possibly Belonging to the Rhoideae

52. Heterocalyx

Tribe IV: Semecarpeae

Genera: 53. Nothopegia
54. Melanochyla
55. Drimycarpus
56. Semecarpus
57. Catutsjeron [Holigarna]

Tribe V: Dobineae

Genera: 58. Dobinea

Genus of Doubtful Position

59. Blepharocarya

According to Dalla Torre and Harms (1900 - 1907):

Family: Anacardiaceae

I. Mangifereae

Genera:
1. Buchanania
1a. Androtium
2. Pegimamra
3. Mangifera
4. Anacardium
5. Gluta
6. Swintonia
7. Melanorrhoea
8. Bouea

II. Spondieae

Genera:
9. Koordersiodendron
10. Spondias
11. Antrocaryon
12. Spondiopsis
12a. Spondianthus
12b. Nothospondias
13. Solenocarpus
14. Dracontomelum
15. Pleiogynium
16. Sclerocarya
17. Pseudospondias
18. Poupartia
19. Pegia
20. Harpephyllum
21. Lannea [Odina]
22. Cyrtocarpa
23. Haematostaphis
24. Tapirira

III. Rhoideae

Genera:
25. Haplorhus
26. Pistacia
27. Pentaspadon
28. Microstemon
29. Thyrsodium
30. Faguetia
31. Sorindeia
32. Trichocypha
33. Parishia
34. Proterhus
35. Baronia
36. Campnosperma
37. Euroschinus
38. Rhodosphaera
39. Mauria
40. Schimus
41. Lithraea
42. Blepharocarya
43. Cotinus

44. Loxostylis
45. Laurophyllus
46. Smodingium
47. Heeria
48. Comocladia
49. Metopium
50. Mosquitoxylum
51. Pseudosmodingium
52. Rhus
53. Astronium
54. Loxopterygium
55. Schinopsis
56. Micronychia
57. Veatchia [Pachycormus]

IV. Semecarpeae

Genera: 58. Nothopegia
59. Melanochyla
60. Drimycarpus
61. Semecarpus
62. Holigarna

V. Dobineae

Genera: 63. Dobinea

Genera incertae Sedis

64. Juliania
65. Rumphia
66. Tricoros

According to Barkley (1942):

Family: Anacardiaceae

Section: Dobineae

Genus: Dobinia

Section: Mangifereae

Genera: Buchanania
Androtium
Bouea
Melanorrhoea
Gluta
Swintonia
Mangifera

Pegimanra
Anacardium

Section: Spondieae

Genera: Tapirira
Antrocaryon
Spondias
Spondianthus
Nothospondias
Solenocarpus
Dracontomelum
Haematostaphis
Cyrtocarpa
Spondiopsis
Pleiogynium
Sclerocarya
Pseudospondias
Odina
Poupartia
Harpephyllum
Koordersiodendron

Section: Semecarpeae

Genera: Semecarpus
Holigarna
Melanocumia
Glycycarpus [Nothopegia]
Melanochyla
Drimycarpus

Section: Rhoideae

Genera: Haplorhus
Pistacia
Pentaspadon
Microstemon
Thyrsodium
Faguetia
Parishia
Sorindeia
Trichocypha
Proterhus
Scassellatia
Campnosperma
Montagueia
Euroschinus
Mauria
Schinus
Pachycormus [Veatchia]
Lithraea

Loxopterygium
Schinopsis
Cotinus
Loxostylis
Laurophyllus
Smodingium
Mieronyehia
Astronium
Baronia
Comocladia
Metopium
Heeria
Mosquitoxylum
Pseudosmodingium
Ochoterenaea [Rhus]
Actinocheita [Rhus]
Rhus
Schmaltzia [Rhus]
Duckera [Rhus]
Searsia [Rhus]
Malosma [Rhus]
Toxicodendron [Rhus]

MATERIAL AND METHODS

Specimens Studied

In this study, 210 samples of 127 species in 39 genera are considered. They represent the members of the non-American genera of the Anacardiaceae available in accessible collections, with the exception of Juliania, a Mexican genus which is included because of its interesting taxonomic history, although it is no longer considered to be even a doubtful member of the family. Thirteen non-American genera have been omitted because specimens could not be located. These are: Dobinia, Drimycarpus, and Pegia from the Himalayan region; Baronia and Micronychia from Madagascar; Fegimanra, Laurophyllus, Loxostylis, Nothospondias, Smodingium, and Spondiopsis from Africa; and Androtium and Solenocarpus from Borneo and the East Indies, respectively. The anatomical characteristics of the 16 exclusively American genera are summarized from information in the literature.

Most of the specimens, 127, were made available from the collection of the Yale School of Forestry through the courtesy of the late Dean S. J. Record. Fifty-two samples of woods of the south-west Pacific area were contributed by Mr. H. E. Dadswell, of the Australian Division of Forest Products. The remaining specimens were obtained from the Chicago Museum of Natural History, the Imperial Forestry Institute of Oxford, England, Professor H. H. Bartlett's

collection of Sumatran woods, and members of the Wood Collectors Society. It is sometimes difficult to secure wood samples that correspond to definite citable herbarium specimens. For the sake of precise identification of material there should always be a voucher in the form of a good herbarium specimen. Older collectors, and some modern ones, have not always realized the importance of being able to check identifications, and, as a consequence, wood collections are full of specimens of which the identity cannot be verified. This is a defect of collections that will only be modified in the course of time. In the meantime, determinations of material have to be accepted unless there is some evidence of error. Very frequently samples are not closely localized, and one has to be content with a locality designation as vague as "East Indies" or "Southeast Asia." It would be highly desirable if there were greater precision in citation of collection data in such studies as the present one, and, as a move in the right direction, full citation is made of collector, locality, and number whenever herbarium specimens correspond to wood samples.

Methods

Microtechnique and illustration. -- More than 2500 permanent slides of stained macerated wood and transverse, radial, and tangential sections were prepared. Blocks of wood were boiled and cooled alternately until air was removed. The softer woods were sectioned without further treatment, using a Spencer sliding microtome. Hard woods, however, were

first softened by treatment with superheated steam directed upon the block in the microtome holder. The cut sections, 20 to 30 μ in thickness, were stained with safranin and in some cases counterstained with fast green, following the method outlined by Johansen (1940). Sections of very hard woods were cut by hand with a sharp razor blade. Although macroscopically unattractive in appearance, sections cut in such manner were free from tearing and had the advantage of presenting very thin and thick areas on one slide, for comparison. Slivers of the boiled wood were macerated according to the method of Jeffrey (Sass, 1940); the material was washed, stained in safranin or fast green (Franklin, 1937), and mounted in Canada balsam or "Permount."* At least 10 slides showing cross, radial, and tangential sections, and from 10 to 15 slides of macerated wood were prepared for each species. In addition, temporary slides showing all three sections unstained were made by mounting hand-cut sections of dry wood in a mixture of potassium acetate, glycerin, and alcohol. Such sections remained useful at least a week and were more instructive than permanent mounts in displaying pitting, crystals, and echimulate bodies.

The drawings showing typical vessel elements and those illustrating the distribution of parenchyma in certain genera were made with a microprojector. All other drawings

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*It is highly undesirable to use trade names which are likely or almost sure to become obsolete in the course of a few years, but the composition of this commercial mounting medium is unfortunately not indicated by the manufacturer or dispenser.

were prepared by means of a camera lucida. Calibrations were made with a stage micrometer and ruler. Photographs were taken with optical-bench photomicrographic apparatus, using a standard compound microscope and cut film.

Descriptions and terminology. -- The terminology used in the descriptions of the secondary wood of the anacardiaceous genera is essentially that approved by the Committee on Nomenclature of the International Association of Wood Anatomists (1933), but the distribution of parenchyma is described in accordance with the glossary prepared by Hess (1950), who defines terms used in this study as follows:

A. Apotracheal Parenchyma -- Wood parenchyma cell aggregates whose position is not determined by the vessels, or solitary wood parenchyma cells not in contact with vessels.

   1. Concentric parenchyma -- lines or bands of apotracheal parenchyma of sufficient length as to appear more or less continuous around the growth layer.

   2. Terminal parenchyma -- Lines or bands of marginal parenchyma, typically apotracheal, forming the outer layers of seasonal growth.

B. Paratracheal Parenchyma -- Individual parenchyma cells or aggregates of parenchyma cells in contact or association with vessel elements or vascular tracheids.

   1. Vasicentric parenchyma -- Paratracheal parenchyma forming vascular sheaths of variable width, and circular or oval in cross section.

   2. Aliform parenchyma -- Paratracheal parenchyma surrounding the vessels and extending wing-like laterally from them.

   3. Confluent parenchyma -- Paratracheal parenchyma surrounding the vessels and in connectant bands of variable width.

The rays are described according to the following classification proposed by Kribs (1935), with notations to indicate when rays differ slightly from the standard for the class:

I. Heterogeneous Type I

1. Uniseriate rays usually high, numerous, and composed of very large, vertically elongated cells which are unlike the cells of the multiseriate part of the multiseriate rays.

2. Multiseriate rays usually with parallel sides and with very large, vertically elongated uniseriate wings (long wings) which are composed of cells identical with those of the uniseriate rays. The cells of the multiseriate portion of the ray are oval, radially elongated, or vertically elongated.

II. Heterogeneous Type II

Uniseriate rays usually lower and composed of cells which are unlike those of the multiseriate part of the multiseriate rays.

A. 1. Uniseriate rays composed of rectangular, vertically elongated cells only.

2. Multiseriate rays with sides parallel or fusiform, the cells of the multiseriate portion being round to oval, radially elongated, and with uniseriate tips of large, vertically elongated marginals, one cell high.

B. 1. Uniseriate rays of two types; some of the uniseriates are composed of rectangular, vertically elongated cells; some are composed of cells which are nearly identical with those of the multiseriate part of the multiseriate rays.

2. Multiseriate rays with sides parallel or fusiform, the cells of the multiseriate portion being round to oval, radially elongated, and with medium to small, vertically elongated marginals, usually single, occasionally two cells high. If the uniseriate tips are longer, the cells are modified; that is, they are mostly square.

III. Homogeneous Type I

1. Uniseriate rays rather low, numerous to scarce, and composed of cells which are identical with those of the multiseriate rays.

2. Multiseriate rays mostly fusiform, the cells of the multiseriate portions being round to oval, radially elongated, and with long to short, uniseriate tips composed of cells identical with those of the multiseriate portion of the ray. Occasionally a multiseriate ray possesses very small, square marginals, one cell high, which occur sporadically.

IV. Homogeneous Type II

1. Uniseriate rays usually scarce to absent; when present, low, and composed of cells identical with those of the multiseriate rays.

2. Multiseriate rays fusiform, and composed entirely of small, round, radially elongated cells; uniseriate tips absent or extremely short.

V. Uniseriate rays only: Heterogeneous Type III.

VI. Uniseriate rays only: Homogeneous Type III.

The measurements presented are based on at least fifty of the elements under consideration when one species is available, but on one hundred elements for genera with more than two species. The range is given rather than the mean, for the material is too limited in amount to provide an accurate mean. Rendle and Clarke (1954a) have shown that variation in the size of cells in different parts of the tree is so great that a true mean could be attained only by measuring 25 vessels selected at random from each of five samples taken

from each of four trees. Although not statistically significant, the measurements do seem to correlate with morphological data and with the figures presented for certain genera by Dadswell and Ingle (1948), and Pearson and Brown (1932), and are therefore considered of value in this study.

Since most of the pores in transverse section are solitary or in radial multiples of 2 to 3, the multiples are regarded as units and counted as single pores, in accordance with the recommendation of Randle and Clarke (1934b). Pores of the ring-porous woods were not counted because of the great variation within a single growth ring; and pores of the diffuse-porous woods which showed distinct growth rings were counted in both early and late wood zones. The "total length" of the vessel elements, from tip to tip, was measured in macerated material, as recommended by Chalk and Chattaway (1934).

The classes used in describing the numerical distribution of the pores and rays and in describing the height of rays are those of Chattaway (1932); classes used in describing the length of the vessel elements and wood fibers are those approved by the Council of the International Association of Wood Anatomists (1937); classes used in describing the vessel diameter and ray width are likewise those approved by the Council (1939); and the classes used in describing the pits are those recommended by Record and Chattaway (1939).

DESCRIPTION OF THE WOODS OF THE ANACARDIACEAE

The Arrangement of the Genera

The genera of the Anacardiaceae represented by wood specimens in this study have been grouped in accordance with the classification system of Dalla Torre and Harms (1900 - 1907), and the anatomical descriptions of the woods have been numbered as shown in the following synopsis:

I. Mangifereae
   1. Buchanania
   2. Mangifera
   3. Gluta
   4. Swintonia
   5. Melanorrhoea
   6. Bouea

II. Spondieae
   7. Koordersiodendron
   8. Spondias
   9. Antrocaryon
   10. Spondianthus
   11. Dracontomelum
   12. Pleiogynium
   13. Sclerocarya
   14. Pseudospondias
   15. Poupartia
   16. Harpephyllum

17. Lannea

18. Odina

19. Haematostaphis

III. Rhoideae

20. Pistacia

21. Pentaspadon

22. Microstemon

23. Faguetia

24. Sorindeia

25. Trichocypha

26. Parishia

27. Proterhus

28. Campnosperma

29. Euroschinus

30. Rhodosphaera

31. Blepharocarya

32. Cotinus

33. Heeria

34. Rhus

IV. Semecarpeae

35. Nothopegia

36. Melanochyla

37. Semecarpus

38. Holigarna

Genus of Uncertain Position

39. Juliania

The Anatomical Characteristics of the Non-American Genera

I. Mangifereae

1. Buchanania Spreng. in Schrader, Journ. (1800) II. 234.
Type species, B. Lanzan Spreng. (India)

(1) Material

B. acuminata Blume: 1 sample, Sumatra
B. acuminatissima Merr.: 1 sample (Bur. Forestry of Manila, Pangil, Philippines, No. 29)
B. arborescens Blume: 1 sample, Java
1 sample, Borneo
2 samples, Malaya
1 sample, N. Australia
B. attenuata A. C. Smith: 1 sample (A. C. Smith, No. 1310, Fiji Islands)
B. florida Schau.: 1 sample, central Java
B. lanceafolia Roxb.: 3 samples, Burma
B. heterophylla K. Schum.: 1 sample (NGF. 1517, Lae area, New Guinea)
B. lucida Blume: 5 samples, Malaya
B. mollis Laut.: 1 sample (NGF. 2064, Dobodura area, New Guinea)
B. Muelleri Engl.: 2 samples, Australia
B. nitida Engl.: 1 sample, Camarines, P. I.
B. palawensis Laut.: 1 sample, Micronesia
B. sessilifolia Blume: 2 samples (H. E. Desch, Nos. 3993 and 5490, For. Res. Inst., Kepong, Selangor, Malaya)
B. solomonensis Merr. & Perry: 1 sample, N. Borneo

The genus Buchanania is represented by twenty species of trees or shrubs in Malaya, south-eastern Asia, New Guinea, Solomon Islands, Queensland, and northern Australia. Fourteen species were studied. The heartwood is pale pinkish brown or light gray, soft to moderately hard, with medium fine and uniform texture and rather high luster; straight grained.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with unaided eye, not numerous, evenly distributed, mostly solitary, but also in radial multiples of 2 to 3, occasionally more, or in very small clusters (Plate 7, Figs. 1, 2, 3); vessel lines always distinct and darker than the background. Rays scarcely visible without a lens, very fine and straight, closely spaced, always distinct on radial surface as red-brown, lustrous flecks. Parenchyma not visible macroscopically.

(3) Microscopic Structure

Vessels 2 to 6 per sq. mm. (4 to 10 in B. attenuata), thin-walled, oval to round in cross section. In pore multiples consisting of three or more cells, usually only one pore is of average size and the others are greatly reduced. Tangential diameters from 40 to 290 μ (mostly 76 to 200 μ).

Vessel elements medium-sized, 280 to 896 μ (mostly 480 to 760 μ) in length; ends oblique to nearly horizontal; often appearing as long, rather thick projecting tips; perforations simple. Thin-walled tyloses present in B. lucida, B. nitida, B. palawensis, and B. sessilifolia; sparse or lacking in other species.

Intervascular pit-pairs alternate, often crowded, medium-sized to large; apertures conspicuous, lenticular, horizontal, generally included; borders circular to hexagonal, depending upon crowding, 7.6 to 15 μ in diameter. Vessel-to-ray pit-pairs variable in size and shape, generally large, round to oblong or gash-like; half-bordered; 3 to 7 per crossfield. Vessel-to-wood parenchyma pit-pairs similar, often horizontally elongated and scalariformly arranged.

Fibers form more than half of the ground mass of the wood in transverse section; in regular radial rows; lumina large; walls relatively thin; squarish or rectangular (Plate 7, Fig. 4); some fibers septate, with inconspicuous septa; straight, tapering frequently abruptly to a long, needle-like end; 0.66 to 1.58 mm. long (mostly 0.94 to 1.28 mm.), 17 to 34 μ in diameter. Resin-like deposits in some fibers (Plate 7, Figs. 2 and 3).

Pit-pairs small but distinct, oval, indistinctly bordered, vertically arranged, often in single rows, not numerous and primarily on radial walls.

Parenchyma not abundant, paratracheal, vasicentric in a sheath one to several cells wide

in B. attenuata and B. florida, occasionally short-aliform and tangentially extended, scantily paratracheal in other species, not completely surrounding the pore, but occasionally with several cells at one side of the pore. Resin-like deposits abundant.

Rays 3 to 16 fiber widths apart in cross section; 3 to 8 per mm., usually straight or very slightly bent to conform to the pore outline, decidedly heterogeneous (Type II B) with fairly wide procumbent cells and usually single rows of square or tall upright marginal cells. In tangential section the rays are primarily 1 to 3 seriate. Normal rays 0.02 to 0.06 mm. wide, 2 to 36 cells (0.13 to 0.94 mm.) high. Horizontal intercellular canals present in certain rays of all species, but not abundant. Those fusiform rays containing canals often little wider than normal rays, rarely wider than triseriate (Plate 29, Fig. 2). Canals of B. nitida and B. sessilifolia larger, corresponding with abrupt widening of the ray at the center. Rays containing ducts 0.03 to 0.11 mm. wide, 12 to 44 cells (0.34 to 0.80 mm.) high.

Orange-brown resin-like deposits abundant in all cells. Crystals of calcium oxalate present in some marginal cells.

2. Mangifera [L., Fl. zeyl. (1747) 211] L., Spec. pl. ed. I. (1753) 200. Type species, M. indica L. (Ceylon)

(1) Material

M. altissima Blanco: 1 sample, Philippines
M. cassia Jack: 1 sample, Java
M. foetida Lour.: 2 samples, Malaya
M. indica L.: 1 sample, Siam
1 sample (Rahmat 5026, Sumatra)
3 samples, Madras, India
M. laurina Blume: 1 sample, Java
M. longipes Griff.: 1 sample, Java
M. minor Blume: 1 sample (J. H. L. Waterhouse, No. 153, Bougainville Island)
1 sample (NGF. 1274, Dobodura area, New Guinea)
M. monandra Merr.: 1 sample, unknown region
M. odorata Griff.: 1 sample, Java
M. solomonensis C. T. White: 2 samples, Guadalcanal
M. zeylanica Hook. f.: 2 samples, Ceylon

Mangifera, with about thirty species, occurs in India, Burma, Indonesia, New Guinea, Philippines, and the Solomon Islands. Mangifera indica L., however, is cultivated in all tropical lands. Eleven species were studied. The heartwood is grayish to reddish brown, often with darker brown stripes. The sapwood is usually wide with a more uniform and lighter color. The wood is moderately heavy to heavy, medium-hard, with fairly fine texture and moderately high luster. Many of the specimens have interlocked grain.

(2) Macroscopic Structure

Growth rings visible, marked by narrow to moderately wide bands of parenchyma. Pores

visible with unaided eye, evenly distributed, not numerous, mostly solitary, but also in radial multiples of 2 to 3, rarely more, and occasionally in small clusters. Vessel lines always distinct, darker than background. Rays scarcely visible, very fine and straight, closely spaced, usually distinct on radial surface as red-brown to tan lustrous flecks. Parenchyma faintly visible in some specimens, distinct with a lens in all; paratracheal, or apotracheal in the form of terminal bands.

(3) Microscopic Structure

Vessels 1 to 6 per sq. mm., thin-walled, round to elliptical in cross section. Tangential diameters from 80 to 304 μ (mostly 96 to 200 μ).

Vessel elements medium-sized, 288 to 752 μ (mostly 360 to 640 μ) in length; ends oblique; projecting tips short and thin or none, rarely long and thick; perforations simple with a narrow rim; tyloses thin-walled, abundant in heartwood. Resin-like deposits in some vessels.

Intervascular pit-pairs alternate, medium-sized to large (mostly large); apertures conspicuous, lenticular, horizontal, generally included; borders polygonal in outline, 7.6 to 19 μ in diameter. Vessel-to-ray pit-pairs large,

half-bordered, round to oblong or gash-like; 3 to 8 per crossfield. Vessel-to-wood parenchyma pit-pairs very large, horizontally elongated and frequently scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to long needle-like ends, but occasionally with a "heel;" 0.66 to 1.30 mm. long (mostly 0.81 to 1.16 mm.), 11 to 29 μ in diameter; lumina large; walls thin to moderately thin; non-septate. Many fibers contain resin-like deposits.

Pit-pairs small, indistinctly bordered, oval to slit-like, scattered evenly throughout the length of the fiber, on radial walls only.

Parenchyma moderately abundant, paratracheal, vasicentric in a rather wide sheath to aliform and often confluent in some species; apotracheal in short to long tangential bands, in apparently terminal bands one to six or more cells wide, and rarely diffuse (Plate 9, Fig. 1 and 2). Resin-like deposits abundant.

Rays 2 to 16 fiber widths apart in cross section; 6 to 9 per mm., usually straight or very slightly bent to conform to the pore outline, heterogeneous (Type II B) with many rows of

procumbent cells and one to several rows of square or short upright marginal cells. In tangential section the rays are predominantly uniseriate in M. solomonensis, M. foetida, M. laurina, M. odorata, and M. altissima (Plate 28, Fig. 2); mainly biseriate, rarely triseriate in the remaining species examined (Plate 29, Fig. 1). Rays 0.02 to 0.07 mm. wide, 2 to 24 cells (0.13 to 0.60 mm.) high. Horizontal intercellular canals absent; resin-like deposits in most cells, and large crystals abundant in both marginal and procumbent cells.

3. Gluta L., Mant. II (1771) 293.
Type species, G. Renghas L. (Java)

(1) Material

G. Renghas L.: 1 sample, central Java
G. tavoyana Wall.: 2 samples, Burma
G. travancorica Bedd.: 1 sample, India

Gluta includes about five tree species occurring in Malaya, Java, Sumatra, Burma, and southern India. Three species were studied. The heartwood is a beautiful dark orange-red to reddish brown, sometimes streaked with darker bands. The sapwood is much lighter in color, usually pinkish tan or gray. The specimen of G. Renghas is moderately soft and moderately light; the others are hard and moderately heavy. Texture fine to fairly coarse; grain somewhat interlocked. Wood with moderately high luster.

(2) Macroscopic Structure

Growth rings usually present, but they are difficult to identify because of the presence of bands of resin-filled fibers and long tangential bands of apotracheal parenchyma. Pores variable in size, visible with unaided eye, uniformly distributed, not numerous, predominantly solitary, but occasionally in radial multiples of 2 to 3, rarely more. Vessel lines distinct because of deposits of resin-like substance. Rays not visible to naked eye, very closely and

evenly spaced, distinct but not conspicuous on radial surface as light brown flecks. Parenchyma moderately abundant, sparsely paratracheal, and apotracheal in numerous irregularly spaced concentric bands, often discontinuous.

(3) Microscopic Structure

Vessels 1 to 4 per sq. mm., moderately thin-walled, round or oval in cross section, from 56 to 242 μ (mostly 112 to 192 μ) in tangential diameter.

Vessel elements barrel-shaped, medium-sized, 240 to 760 μ (mostly 408 to 576 μ) in length; ends slightly to decidedly oblique; projecting tips short or none, rarely very long and then thick; perforations simple with a narrow rim. Tyloses abundant, thin-walled, often filled with reddish brown resin-like deposits.

Intervascular pit-pairs alternate, large to very large, usually crowded; apertures conspicuous, lenticular, horizontal, included; borders angular in outline when crowded, otherwise round and somewhat flattened horizontally, 9.5 to 17 μ in diameter. Vessel-to-ray pit-pairs large, round to oblong or gash-like, half-bordered, 3 to 7 or more per cross field.

Fibers forming more than half the ground mass of the wood in transverse section, arranged

in regular radial rows; lumina very large; walls moderately thick; non-septate. Fibers straight, tapering gradually to long narrow ends, but sometimes tapering abruptly and forming an unequally forked tip; 0.57 to 1.41 mm. long (mostly 0.80 to 1.09 mm.), 9.5 to 25 μ in diameter. Resin-like deposits in many fibers.

Pit-pairs small, slit-like to oval; apertures nearly vertical, on radial walls only.

Parenchyma abundant; sparsely paratracheal, in a narrow vasicentric sheath which rarely completely encircles the pores because it is frequently interrupted by rays or fibers adjacent to the vessels; apotracheal in numerous, irregularly spaced tangential bands 1 to 6 cells wide, often discontinuous and occasionally coalescing (Plate 8, Fig. 3). Resin-like deposits abundant; crystals absent, but echinulate bodies (described by Pearson and Brown, 1932, p. 322) are present in all species except G. Renghas.

Rays 2 to 13 fiber widths apart in cross section; 7 to 11 per mm., straight, or bending slightly to conform to the pore outline, very weakly heterogeneous in G. taveyana and G. travancorica, with single rows of square marginal

cells of practically the same height as the procumbent cells. G. Ranghas, however, seems to fit best into Kribs' Homogeneous Type III classification, with the exception of the fusiform rays (Kribs, 1935), for the square marginal cells are of sporadic occurrence. In tangential section the normal rays are almost entirely uniseriate, only rarely biseriate, 0.02 to 0.04 mm. wide, 2 to 33 cells high (0.08 to 1.11 mm.). Many rays are united longitudinally. Horizontal intercellular canals are present in certain rays of all species, moderately abundant, fairly large and conspicuous, round or oval, surrounded by one or two rows of small, thick-walled epithelial cells. Fusiform rays 2 to 4 cells wide at center, occasionally with a rather long tail of uniseriate cells. Rarely there may be two canals in a single ray, particularly in G. tavoyana. Fusiform rays 0.03 to 0.09 mm. wide, 7 to 39 cells (0.20 to 0.97 mm.) high (Plate 27, Fig. 1).

Resin-like deposits abundant in all cells. Crystals absent. Echimulate bodies are very numerous in the cells of G. tavoyana and G. travancorica, sparse in G. Ranghas; larger than those found in the wood parenchyma, with the

largest 15 to 27 μ in tangential diameter (Plate 51, Fig. 2). Starch grains present in G. Renghas and G. tavoyana.

Notes

I. Pearson and Brown (1932, p. 322) thus describe the deposits found in the parenchyma cells: ". . . spherical or ellipsoidal, echinulate bodies resembling aggregate crystals occasional, solitary in the cells." The authors indicate that similar solitary echinulate bodies are very numerous in the ray cells and add, ". . . these may be aggregate crystals, but they failed to behave like crystals under polarized light. . . ."

II. Dadswell and Ingle (1948) identified the echinulate bodies as silica deposits, but they, too, failed to find them in the parenchyma of G. Renghas.

III. Moll and Janssonius (1908) do not mention the presence of the echinulate bodies, but they do indicate the starch grains seen in both the parenchyma cells and the ray cells of G. Renghas. These are also present in the specimen of that species examined by the writer.

4. Swintonia Griff. in Proc. Linn. Soc. I (1846) 283. Type species, S. floribunda Griff. (Burma)

(1) Material

S. floribunda Griff.: 1 sample, Burma
S. Griffithii Kurz: 2 samples, Burma
S. penangiana King: 1 sample, Fed. Malay States
S. Schwenkii Teys. & Binn.: 1 sample, Burma*
S. spicifera Hook. f.: 1 sample, Fed. Malay States

There are about eight species of Swintonia, limited in distribution to Burma and Malaya. Five species were studied. The heartwood is light gray to grayish brown, with a moderately high luster. The wood is moderately light and soft, straight-grained, rather fine textured in S. spicifera but fairly coarse textured in the other species.

(2) Macroscopic Structure

Growth rings indistinct. Pores readily visible with unaided eye except in S. spicifera, where they are just within limit of vision; variable in size, not numerous, mostly solitary, but also in radial multiples of 2 to 3, rarely more, occasionally in clusters. Vessel lines distinct, darker than background. Rays not distinct without a lens in S. penangiana, just within limit of vision in the other species,

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*One sample of S. Schwenkii Teys. & Binn. from the Yale University collection has not been used in this study because it seems to be incorrectly named.

very fine, closely spaced, usually distinct on radial surface as small, brown flecks. Parenchyma faintly visible without a lens, quite distinct with a lens; paratracheal, but more abundantly apotracheal in irregularly spaced bands which simulate growth rings.

(3) Microscopic Structure

Vessels 1 to 5 per sq. mm., thin-walled, round to elliptical in cross section. Tangential diameters from 64 to 304 μ (mostly 120 to 240 μ).

Vessel elements medium-sized, 408 to 808 μ (mostly 488 to 720 μ) in length; ends oblique; projecting tips short and narrow or none, rarely long and moderately thick; perforations simple with a narrow rim; tyloses moderately thick-walled, abundant in S. floribunda and S. penangiana, rather sparse in other species.

Intervascular pit-pairs alternate, sometimes crowded, large to very large; apertures conspicuous, lenticular, horizontal, included; borders round to polygonal in outline, 9.5 to 19 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round to horizontally elongated, 3 to 11 per crossfield. Vessel-to-wood parenchyma pit-pairs horizontally elongated and often scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to long needle-like ends; 0.70 to 1.47 mm. long (mostly 0.92 to 1.24 mm.), 9.5 to 31 μ in diameter; lumina large, walls moderately thin; non-septate.

Pit-pairs small, inconspicuously bordered, slit-like, in one or two vertical rows on radial walls only.

Parenchyma moderately abundant, paratracheal in a single layer, usually incompletely vasicentric; apotracheal in irregularly spaced concentric bands, in short to long tangential rows 2 to 6 cells wide, and in diffuse clusters (Plate 8, Fig. 1). Resin-like deposits frequent; small echinulate bodies present in all species with exception of S. penangiana, but rare in S. Schwenkii. Long crystalliferous strands of parenchyma frequent in S. penangiana, S. floribunda, and S. Schwenkii, rare in S. Griffithii, and absent in S. spicifera.

Rays 2 to 25 fiber widths apart in cross section; 3 to 8 per mm., straight, or slightly bent to conform to the pore outline, heterogeneous (Type II B) with a single marginal row of square cells, to almost homogeneous. In

tangential section the normal rays of S. floribunda and S. Schwenkii are predominantly biseriate, those of the remaining species mainly uniseriate. Normal rays 0.013 to 0.064 mm. wide, 2 to 29 cells (0.084 to 0.610 mm.) high. Horizontal intercellular canals present in occasional multiseriate rays, round, small, surrounded by 1 to 2 rows of very small epithelial cells. Fusiform rays 0.055 to 0.11 mm. wide, 11 to 52 cells (0.255 to 1.07 mm.) high. Resin-like deposits usually abundant, crystals absent, but echinulate bodies are conspicuous in all species except S. Schwenkii, where they are rare.

5. Melanorrhoea Wall., Pl. as. rar. I. (1829) 9 t. 11, 12.
Type species, M. usitata Wall. (Burma)

(1) Material

M. aptera King: 2 samples (H. E. Desch, Nos. 4622 and 5563, For. Res. Inst., Kepong, Selangor, Malay)
M. Curtisii Oliv.: 1 sample, Malaya
M. glabra Wall.: 2 samples, Burma
M. pilosa Lecomte: 2 samples (H. E. Desch, Nos. 4137 and 4715, For. Res. Inst., Kepong, Selangor, Malay)
M. torquata King.: 2 samples, Malaya
M. usitata Wall.: 1 sample, Siam
M. Wallichii Hook. f.: 3 samples, Malaya
M. woodsiana Scortech. ex King: 1 sample, N. Borneo

There are about ten species of Melanorrhoea occurring as trees in Burma, Indo-China, Malaya, Sumatra, Borneo, and New Guinea. Eight species were studied. The heartwood is orange-red to dark red, often streaked with deep brown or purple. The sapwood is pale pinkish or grayish tan, quite distinct from the heartwood. The wood is moderately heavy to heavy, moderately hard, with medium texture in M. torquata and M. pilosa, rather fine texture in other species; luster variable but never high. Many of the specimens have slightly interlocked grain.

(2) Macroscopic Structure

Growth rings indistinct. Pores visible with unaided eye in all species except M. usitata, evenly distributed, not numerous, predominantly solitary but also in radial multiples of 2 to 3,

rarely more, and then variable in size. Vessel lines distinct, glistening because of tyloses and resin-like deposits. Rays not visible without a lens, very fine, closely spaced, distinct on radial surface in sapwood, visible only because of luster in darker heartwood. Parenchyma faintly visible without a lens in some specimens, distinct with a lens in all; sparsely paratracheal, and apotracheal in irregularly spaced, occasionally discontinuous bands.

(3) Microscopic Structure

Vessels 2 to 5 per sq. mm., thin-walled, elliptical or round in cross section. Tangential diameters from 48 to 304 μ (mostly 128 to 232 μ).

Vessel elements medium-sized, 320 to 952 μ (mostly 480 to 720 μ) in length; ends moderately oblique; projecting tips short and thin or none, rarely long and thick; perforations simple with a narrow rim; tyloses moderately thick-walled in M. usitata, thin-walled in other specimens. Resin-like deposits abundant, frequently plugging the vessel.

Intervascular pit-pairs alternate, large; apertures conspicuous, lenticular, horizontal, included; borders polygonal in outline when crowded, otherwise round, 9.5 to 15 μ in diameter.

Vessel-to-ray pit-pairs large, half-bordered, round to irregular or gash-like; 2 to 5 per crossfield. Vessel-to-wood parenchyma pit-pairs large, horizontally elongated and frequently scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to long needle-like ends; 0.71 to 1.54 mm. long (mostly 0.81 to 1.16 mm.), 9.5 to 27 μ in diameter; lumina large; walls moderately thick; non-septate. Many fibers, particularly in the heartwood, are plugged with reddish brown, resin-like material and often alternate in bands with non-filled fibers.

Pit-pairs small, indistinctly bordered or simple, slit-like, scattered throughout the length of the fiber, on radial walls only.

Parenchyma moderately abundant, paratracheal, usually sparse to occasionally vasicentric; apotracheal in numerous, irregularly spaced bands up to eight cells wide, often discontinuous. Resin-like deposits abundant; small echinulate bodies present in some cells.

Rays 2 to 16 fiber widths apart in cross section; 6 to 11 per mm., usually straight or very slightly bent to conform to the pore outline,

practically homogeneous (Type III), with no true upright cells. In tangential section the normal rays are predominantly uniseriate, occasionally biseriate in part; 0.01 to 0.04 mm. wide, 2 to 24 cells (0.08 to 0.66 mm.) high. Horizontal intercellular canals present in occasional multiseriate rays, round or oval, moderately large, surrounded by 1 or 2 rows of small, thick-walled epithelial cells. Fusiform rays 0.04 to 0.13 mm. wide, 11 to 34 cells (0.20 to 0.69 mm.) high (Plate 27, Fig. 2). Resin-like deposits abundant, crystals absent, but echinulate bodies are present in many cells.

6. Bouea Meissn., Gen. (1837) 75. Type species, B. burmanica Griff. (Burma)

(1) Material

B. macrophylla Griff.: 1 sample, Java
3 samples (H. E. Desch, Nos. 3683, 5445, and 5960; For. Res. Inst., Kepong, Selangor, Malay)
B. microphylla Hook. f.: 1 sample (H. E. Desch, No. 4736, For. Res. Inst., Kepong, Selangor, Malay)
Bouea, sp.: 1 sample, Sumatra

There are four species of Bouea occurring as small trees in Malaya, Burma, Java, and the Moluccas. Two species were studied. The heartwood is pale brown with a pinkish or grayish tinge, moderately light in weight to moderately heavy, medium-hard, with fine texture and fairly high luster. Most of the specimens are straight grained.

(2) Macroscopic Structure

Growth rings indistinct. Pores visible with unaided eye, evenly distributed, not numerous, mostly solitary, but also in radial multiples of 2 to 3, or rarely in small clusters. Vessel lines distinct, darker than background. Rays not visible with unaided eye, very fine, closely spaced, distinct on radial surface as narrow brown flecks. Parenchyma faintly visible, paratracheal, and apotracheal in irregularly spaced bands.

(3) Microscopic Structure

Vessels 2 to 5 per sq. mm., moderately thin-walled, usually round in cross section. Tangential diameters from 56 to 210 μ (mostly 72 to 138 μ).

Vessel elements medium-sized, 272 to 784 μ (mostly 440 to 712 μ) in length; ends horizontal to moderately oblique; projecting tips long, blunt; perforations simple with a narrow rim; tyloses with somewhat thickened walls in B. microphylla, thin-walled and sparse in B. macrophylla. Resin-like deposits in some vessels.

Intervascular pit-pairs alternate, mostly medium-sized; apertures conspicuous, lenticular, horizontal, included; borders crowded, polygonal in outline, 6 to 13 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round to oblong or gash-like. Vessel-to-wood parenchyma pit-pairs similar, often scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, usually tapering gradually to blunt tips, but occasionally bifurcate at the end; 0.42 to 1.40 mm. long (mostly 0.58 to 1.00 mm.), 9.5 to 19 μ in diameter; lumina often small; walls moderately

thick to rather thin; non-septate; sometimes gelatinous.

Pit-pairs very small, indistinctly bordered, oval to slit-like, fairly numerous on radial walls only.

Parenchyma abundant, paratracheal, vasicentric to rarely aliform; apotracheal in irregularly spaced bands 2 to 8 or more cells wide (Plate 8, Fig. 2). Resin-like deposits abundant.

Rays 2 to 13 fiber widths apart in cross section; 6 to 10 per mm., straight, decidedly heterogeneous with square and tall-upright cells in one to several marginal rows or occasionally interspersed between procumbent rows. In tangential section the rays are uniseriate to biseriate; 0.01 to 0.05 mm. wide, 1 to 36 cells (0.08 to 0.96 mm.) high; sometimes fused vertically. Horizontal intercellular canals absent; resin-like deposits abundant; crystals present in marginal cells (Plate 28, Fig. 1).

II. Spondieae

7. Koordersiodendron Engl. in: Mededeel. uit Lands Plantentuin te Buitenzorg. XIX (1898) 410. Type species, K. celebicum Engl. (Celebes)

(1) Material

K. pinnatum (Blanco) Merr.: 2 samples, Philippines
1 sample, N. Borneo

Koordersiodendron occurs in the Philippines, Borneo, Celebes, and New Guinea. One species was studied. The heartwood is reddish brown, the sapwood pinkish tan and distinct from the heartwood; heavy to moderately heavy, hard, with medium texture and fairly high, golden luster. Grain sometimes interlocked. Mildly fragrant odor but no distinctive taste.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible to the naked eye, evenly distributed, moderately few, mostly solitary, but also in short radial multiples of 2 to 3 and rarely in tangential pairs. Vessel lines distinct, darker than background. Rays faintly visible with a lens, very fine, closely spaced, distinct but not conspicuous on radial surface, slightly darker than vertical elements. Parenchyma visible with lens when wood is moist, paratracheal.

(3) Microscopic Structure

Vessels 4 to 9 per sq. mm., thin-walled,

rounded in cross section. Tangential diameters from 64 to 200 μ (mostly 120 to 160 μ).

Vessel elements medium-sized, 384 to 1056 μ (mostly 416 to 792 μ) in length; ends nearly horizontal on larger elements, oblique on smaller ones; projecting tips short and narrow; perforations simple with a narrow rim; tyloses moderately thick-walled, abundant. Resin-like deposits present.

Intervascular pit-pairs alternate, large to very large; apertures lenticular, horizontal, included, rarely exserted and coalescent; borders 8 to 19 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, apertures rounded or horizontally elongated. Vessel-to-wood parenchyma pit-pairs indistinct.

Fibers forming more than half the ground mass of the wood in transverse section, somewhat twisted, tapering gradually to long, needle-like ends; 0.88 to 2.17 mm. long (mostly 1.00 to 1.60 mm.), 11 to 21 μ in diameter; lumina generally large; walls moderately thick; distinctly septate. Resin-like deposits abundant.

Pit-pairs small, simple, slit-like, on radial walls.

Parenchyma paratracheal, generally

incompletely vasicentric. Resin-like deposits abundant; crystals occasionally present.

Rays 3 to 10 fiber widths apart in cross section; 6 per sq. mm., usually bent to conform to the pore outline, heterogeneous (Type II B) with one to several rows of upright, chambered cells containing crystals, interspersed with tall, pointed cells without crystals (Plate 47, Fig. 2). In tangential section the rays are 1 to 3 seriate, 0.03 to 0.05 mm. wide, up to 39 cells (0.16 to 0.99 mm.) high. Horizontal intercellular canals present, infrequent, small, filled with deposits, surrounded by one to several rows of small, thick-walled epithelial cells. Fusiform rays 0.05 to 0.09 mm. wide, up to 19 cells (0.48 to 0.58 mm.) high. Resin-like deposits abundant, crystals usually in the chambered, upright marginal cells as described earlier.

8. Spondias [L., Gen. ed. 1 (1737) 365.] L., Spec. pl. ed. 1. (1753) 371. Type species, S. Mombin L. (Brazil)

(1) Material

S. dulcis Forst.: 1 sample (NGF. 1222, Aitape area, New Guinea)
1 sample (NGF. 1825, Wide Bay, New Guinea)
S. dulcis Forst. var. acida Engl.: 1 sample, E. Java
S. Mangifera Willd.: 1 sample, India
S. Mangifera Willd. var. javanica Koord. & Valet.: 1 sample, W. Java
S. pinnata (L.) Kurz: 1 sample (Waterhouse, No. 389, Cazelle Penins., New Britain)
1 sample, New Guinea

There are about twenty species of Spondias in the tropical regions of both the Old and the New World. Three species were studied. Heartwood pale gray or light grayish brown; sapwood not clearly defined; light, soft, moderately coarse-textured, without distinctive luster; straight grained.

(2) Macroscopic Structure

Growth rings faintly visible in most specimens, defined by denser bands of fibers. Pores visible with unaided eye, evenly distributed, not mmerous, mostly solitary, but also in radial multiples of 2 to 3, rarely in clusters of 3 to 7 (Plate 12, Figs. 1, 2, and 3). Vessel lines distinct but not conspicuous. Rays distinct without a lens, moderately coarse, distinct on radial

surface as broad, lustrous flecks little darker than the background. Parenchyma sometimes faintly visible with a hand lens, paratracheal.

(3) Microscopic Structure

Vessels 2 to 6 per sq. mm., thin-walled, generally round in cross section, but slightly angular in S. Mangifera. Tangential diameters from 80 to 345 μ (mostly 136 to 225 μ).

Vessel elements medium-sized, 320 to 864 μ (mostly 576 to 760 μ) in length; ends nearly horizontal to oblique; projecting tips short and narrow or occasionally long and thick; perforations simple with a narrow rim; tyloses usually present but not abundant, thin-walled.

Intervascular pit-pairs alternate, large to very large; apertures conspicuous, lenticular to slit-like, horizontal, included; borders crowded, often decidedly angular, 10 to 21 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, apertures oval to elongated; 4 to 9 per crossfield. Vessel-to-wood parenchyma pit-pairs similar, horizontally elongated and often scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to long, thin ends, but

sometimes with a distinct "heel"; 0.56 to 1.84 mm. long (mostly 1.20 to 1.50 mm.), 19 to 43 μ in diameter; lumina large; walls thin; septate, with numerous thin septa.

Pit-pairs small, simple, usually on radial walls only and in a single, vertical row.

Parenchyma paratracheal, vasicentric to aliform; not abundant. Crystals sometimes present.

Rays 4 to 20 fiber widths apart in cross section; 2 to 4 per mm., straight, heterogeneous, with 1 or 2 rows of upright marginal cells. In tangential section the rays are of two types: (a) uniseriate rays composed entirely of upright cells, 0.02 to 0.03 mm. wide, 2 to 12 cells (0.09 to 0.74 mm.) high, infrequent; (b) multiseriate rays 2 to 7 cells wide (0.03 to 0.22 mm.), 5 to 52 cells (0.19 to 1.52 mm.) high. Horizontal intercellular canals present in the larger multiseriate rays, 1 to 3 per ray, surrounded by 1 or 2 rows of small epithelial cells (Plate 30, Fig. 1); rare in S. Mangifera. Resin-like deposits present; crystals in both procumbent and marginal cells.

Note

One specimen, S. axillaris Roxb. (Yale No. 21948), has

been omitted from this discussion because it is synonymous with Poupartia axillaris (Roxb.) King & Prain, and it is described with the similar specimen of the latter genus.

9. Antrocaryon Pierre in Bull. Soc. Linn. Paris. Nouv. ser. (1898) 23. Type species, A. Klaineanum Pierre (W. trop. Africa)

(1) Material

A. Klaineanum Pierre: 1 sample, Gaboon, W. Africa

There are two species of Antrocaryon, both growing as tall trees in the tropical regions of West Africa. One species has been studied. Heartwood light brown, moderately light and moderately soft, with fine texture, fairly low luster. Straight-grained.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with unaided eye, fairly evenly distributed, not numerous, usually solitary, but also in radial multiples of 2 to 3, rarely in small clusters of 3 to 7. Vessel lines distinct. Rays not visible without lens, very fine, closely spaced, distinct but not conspicuous on radial surface. Parenchyma faintly visible with unaided eye; sparingly paratracheal, and apotracheal in numerous fine, closely spaced concentric bands.

(3) Microscopic Structure

Vessels 2 to 5 per sq. mm., thin-walled, round to elliptical in cross section. Tangential diameters from 80 to 207 μ (mostly 120 to 175 μ).

Vessel elements moderately long, 265 to

1008 μ (mostly 576 to 952 μ) in length; ends horizontal to oblique; projecting tips very short to long, rather thick; perforations simple with a narrow rim; tyloses absent; occasional resin-like deposits in vessels.

Intervascular pit-pairs alternate, small; apertures oval, horizontal, generally included; borders rounded in outline, 4 to 7 μ in diameter. Vessel-to-ray pit-pairs small, rounded, 25 per cross field. Vessel-to-wood parenchyma pit-pairs similar.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to long, thin ends; 0.67 to 1.97 mm. long (mostly 0.92 to 1.60 mm.), 10 to 23 μ in diameter; lumina large; walls thin to moderately thick; non-septate.

Pit-pairs small, indistinctly bordered, rather numerous, on radial walls only.

Parenchyma moderately abundant, paratracheal, usually incompletely vasicentric with one row of cells; apotracheal, with numerous concentric bands usually 2 to 3 cells wide (Plate 10, Fig. 3). Occasional resin-like deposits present. Crystalliferous strands with each chamber bearing a solitary rhombohedral crystal observed, rare.

Rays 1 to 8 fiber widths apart in cross section; 8 per mm., straight, curving only slightly when in contact with pores, heterogeneous (Type II B) with inner rows of procumbent cells and one to several rows of square marginal cells, the outermost row usually composed of tall upright cells. In tangential section the rays are uniseriate or biseriate, very rarely triseriate in part (Plate 32, Fig. 3). Rays 0.02 to 0.04 mm. wide, 1 to 21 cells (0.06 to 0.84 mm.) high. Horizontal intercellular canals absent; crystals lacking.

10. Spondianthus Engl. in Eng. Jahrb. xxxvi (1905). Type species, S. glaber Engl. (Tropical Africa)

(1) Material

S. Preussii Engl.: 1 sample (C. Vigne, No. 4301, Gold Coast, Africa)
S. ugandensis Hutch.: 3 samples (G. P. Cooper, Nos. 140, LL06, and 4108; Liberia, Africa)

There are about four species of Spondianthus, limited in distribution to tropical Africa. Two species were studied. The heartwood is light pinkish brown, dull, moderately light to moderately heavy, moderately soft to hard, coarse textured.

(2) Macroscopic Structure

Growth rings not evident. Pores readily visible without a lens, fairly uniform in size, moderately few, mostly solitary, but also in radial multiples of 2 to 3, rarely in very small clusters (Plate 12, Fig. 4). Vessel lines distinct but not conspicuous, scarcely darker than background. Rays readily distinct without a lens, rather wide, visible on radial surface as lustrous flecks of same color as background. Parenchyma not visible.

(3) Microscopic Structure

Vessels 6 to 8 per sq. mm., thin-walled, oval to round or angular in cross section. Tangential diameters from 48 to 262 μ (mostly 124 to 200μ).

Vessel elements long to very long, 600 to 1658 μ (mostly 1000 to 1380 μ) in length; ends decidedly oblique to horizontal; projecting tips short and thin, very long and thick, or none; perforations simple with a narrow rim. Some elements closely resemble tracheids in size and shape, but bear simple perforations. Tyloses and resin-like deposits absent.

Intervascular pit-pairs alternate, large to very large; apertures conspicuous, lenticular, generally included; borders polygonal to irregular in outline because of crowding, 11 to 24 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, usually round, but also irregular, 5 to 8 per crossfield. Vessel-to-wood parenchyma pit-pairs large, irregular in shape.

Fibers forming more than half the ground mass of the wood in transverse section, irregular in size, shape, and arrangement; usually straight, tapering gradually to long, needle-like ends; 1.16 to 2.86 mm. long (mostly 1.67 to 2.48 mm.), 22 to 46 μ in diameter; lumina moderately large, walls thick; septate.

Pit-pairs conspicuous, indistinctly bordered, numerous on radial walls.

Parenchyma paratracheal, sparsely vasicentric.

Rays 2 to 13 fiber widths apart in cross section; 3 to 6 per mm., usually straight, markedly heterogeneous (Type I), with up to 10 rows of marginal upright cells. In tangential section the rays are of two types: (a) uniseriate or biseriate rays composed entirely of upright cells, 0.01 to 0.05 mm. wide, 2 to 21 cells (0.20 to 1.85 mm.) high, numerous; (b) multiseriate rays 5 to 10 cells wide (0.13 to 0.18 mm.), 81 to 165 cells high (3 to 7 mm.); sheath cells sometimes present in multiseriate rays (Plate 30, Fig. 2). Horizontal intercellular canals absent; resin-like deposits abundant; crystals present in procumbent cells.

11. Dracontomelum Blume, Mus. bot. ludg. batav. I (1850) 231 t. 42. Type species, D. mangiferum Blume (Java)

(1) Material

D. dao M. & R.: 4 samples, Philippine Islands
D. edule (Blanco) Skeels: 1 sample, Philippine Islands
D. mangiferum Blume: 1 sample, Java
1 sample, New Guinea
1 sample, Malaya
D. vitiense Engl.: 1 sample (A. C. Smith, No. 943, Fiji Islands)

Dracontomelum, with about six species, occurs in Java, Malaya, New Guinea, Fiji Islands, and the Philippines. All species are medium sized to large trees. Four species were studied. The heartwood is variable, from medium grayish brown to light red-brown, irregularly marked with dark brown or black streaks. Sapwood usually distinct, pinkish tan or yellow. Wood moderately light to moderately heavy, medium hard, texture generally medium, fine in D. vitiense; luster moderately high. Grain straight or interlocked. Odor slightly sour, taste not distinctive.

(2) Macroscopic Structure

Growth rings not visible, but D. vitiense has alternating areas of fewer pores which might be the late wood portions of growth rings. Pores distinct with unaided eye, evenly distributed, not numerous, mostly solitary, but also

in radial multiples of 2 to 3, rarely more. Vessel lines always distinct, darker than background. Rays visible, fine and closely spaced, distinct on radial surface. Parenchyma paratracheal, vasicentric to aliform and occasionally confluent.

(3) Microscopic Structure

Vessels 1 to 4 per sq. mm., but up to 6 per sq. mm. in D. vitiense (young stem specimen), thin-walled, round to oval in cross section, often radially flattened. Tangential diameters from 40 to 320 μ (mostly 200 to 248 μ), but in D. vitiense 40 to 176 μ.

Vessel elements medium-sized, 128 to 896 μ (mostly 360 to 650 μ) in length; ends horizontal in larger elements, oblique in small ones; projecting tips short and narrow, or none; perforations simple with a narrow rim; tyloses abundant, thin-walled.

Intervascular pit-pairs alternate, large; apertures lenticular, horizontal, generally included, but sometimes exserted and coalescent; borders irregularly rounded to polygonal in outline, 11 to 17 μ in diameter. Vessel-to-ray pit-pairs large, oval to elongated, half-bordered to bordered. Vessel-to-wood parenchyma pit-pairs similar, often scalariform.

Fibers forming more than half the ground mass of the wood in cross section, straight, tapering gradually to long, narrow ends; 0.55 to 1.93 mm. long (mostly 0.90 to 1.40 mm.), 10 to 25 μ in diameter; lumina generally large, walls moderately thick; septate, with numerous septa, sometimes conspicuous because of resin-like deposits.

Pit-pairs small, simple, slit-like, scattered, confined almost completely to radial walls.

Parenchyma paratracheal, vasicentric in a sheath 1 to 7 cells wide, often forming aliform extensions (Plate 11, Fig. 1). One specimen of D. dao shows abundant aliform parenchyma often extended tangentially, and also several wide apotracheal concentric bands up to 10 cells in width. Resin-like deposits abundant; crystals sometimes present.

Rays 3 to 10 fiber widths apart in cross section, 5 to 7 per mm., usually in contact with a pore at some point and slightly bent to conform to the pore outline, heterogeneous (Type II B), with interior cells procumbent and marginal cells large, square to upright rectangular. In tangential section the rays are

1 to 5 seriate, mostly 3 to 5, 0.015 to 0.085 mm. wide, up to 38 cells (1.04 mm.) high. Horizontal intercellular canals absent. Resin-like deposits abundant; crystals common in marginal cells, but also present in procumbent cells.

Note

Garratt (1931) says the prominent septa in the fibers of Dracontomelum dao may be horizontal resin plates rather than true septa. He supports his contention by the observation that similar features are occasionally noted in the wood-parenchyma cells.

12. Pleiogynium Engl. in De Candolle, Monogr. Phaner. IV. (1883) 255. Type species, P. Solandri (Benth.) Engl. (Australia)

(1) Material

P. papuanum C. T. White: 1 sample, Solomon Islands
P. pilosum (Benth.) Engl.: 1 sample, Fiji Islands
P. Solandri (Benth.) Engl.: 1 sample (A. C. Smith, No. 1300, Fiji Islands)
2 samples, Queensland, Australia

There are about three species of Pleiogynium, all medium sized trees, occurring in New Guinea, Solomon Islands, Fiji Islands, and Queensland, Australia. Three species were studied. The heartwood is light to dark reddish brown, moderately heavy, hard, with moderately high luster and fine texture, generally straight grained. No distinctive odor or taste.

(2) Macroscopic Structure

Growth rings faintly visible because of denser bands of fibers. Pores just within the limit of vision with unaided eye except in P. pilosum (specimen is from very young stem), evenly distributed, moderately numerous, mostly solitary, but also in radial multiples of 2 to 3, occasionally in longer multiples or chains to 6 or 7 cells in length. Vessel lines usually distinct, but not conspicuous, lighter than the background. Rays indistinct without a lens,

very fine, closely spaced, distinct on radial surface only because of luster. Parenchyma visible with lens, paratracheal, vasicentric to occasionally aliform.

(3) Microscopic Structure

Vessels 10 to 19 per sq. mm., up to 25 per sq. mm. in the specimen of P. pilosum, thin-walled, round in cross section. Tangential diameters 40 to 125 μ (mostly 64 to 88 μ) in P. pilosum, 40 to 180 μ (mostly 80 to 120 μ) in other specimens.

Vessel elements medium-sized, 208 to 616 μ (mostly 440 to 552 μ) in length; ends horizontal to oblique; projecting tips short and narrow; perforations simple with a narrow rim; tyloses moderately abundant, thin-walled. Resin-like deposits present.

Intervascular pit-pairs alternate, medium-sized; apertures conspicuous, lenticular, horizontal, included; borders round to angular, 6 to 12 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round to horizontally elongated, 2 to 8 per crossfield. Vessel-to-wood parenchyma pit-pairs elongated, often scalariform.

Fibers forming at least half the ground

mass of the wood in transverse section, straight, tapering gradually to long, narrow pointed ends, but occasionally with a distinct "shoulder" and sometimes bifurcate at the ends; 0.39 to 1.42 mm. long (mostly 0.80 to 1.20 mm.), 10 to 25 μ in diameter; lumina variable, often small; walls moderately thick, gelatinous in part, sometimes flattened near the limits of the growth ring; septate with numerous septa in some specimens, sporadically septate in others. Fibers with resin-like deposits usually in concentric bands or zones.

Pit-pairs small, indistinctly bordered, on radial walls, rarely on tangential surface, with long axis vertical.

Parenchyma paratracheal, vasicentric in a sheath 1 to 2 rows wide, occasionally aliform. Resin-like deposits abundant.

Rays 2 to 8, occasionally to 14 fiber widths apart in cross section; 5 to 9 per mm., usually straight, heterogeneous, with 1 to 3 rows of upright and square marginal cells and frequent large, rounded, crystal-bearing cells interspersed. In tangential section the rays are uniseriate, predominantly biseriate, and rarely triseriate. Rays 0.015 to 0.04 mm. wide,

2 to 25 cells (0.09 to 0.47 mm.) high. Horizontal intercellular canals present, small, surrounded by 1 or 2 rows of small epithelial cells (Plate 33, Fig. 1). Fusiform rays 3 to 4 cells wide in part, 0.05 to 0.07 mm. wide, 13 to 31 cells (0.28 to 0.68 mm.) high. Resin-like deposits abundant; very large, rhombohedral crystals often completely fill the special cells mentioned above.

13. Sclerocarya Hochst. in Flora, xxvii (1844) Bes. Beil I. Type species, S. Birrea Hochst. (Abyssinia)

(1) Material

S. caffra Sond.: 2 samples (H. J. Schlieben, No. 406, Tanganyika, East Africa)

The three species of Sclerocarya occur as trees in tropical Africa. One species was studied. Heartwood medium pinkish brown, moderately heavy, moderately soft to hard, with fairly fine texture and moderately low luster. Grain somewhat interlocked.

(2) Macroscopic Structure

Growth rings distinct, indicated by bands of flattened fibers. Pores visible with unaided eye, evenly distributed, not numerous, mostly solitary, but also in radial multiples of 2 to 3, occasionally more, or rarely small clusters. Vessel lines distinct, darker than background. Rays indistinct without a lens, very fine and closely spaced, distinct but not conspicuous on radial surface. Parenchyma visible with lens, sparingly paratracheal.

(3) Microscopic Structure

Vessels 3 to 7 per sq. mm., thin-walled, round to oval in cross section. Tangential diameters from 48 to 207 μ (mostly 70 to 145 μ).

Vessel elements medium-sized, 264 to

568 μ (mostly 344 to 552 μ) in length; ends moderately oblique; projecting tips short to long, narrow; perforations simple with a narrow rim. Tyloses abundant, thin to moderately thick-walled. Resin-like deposits present.

Intervascular pit-pairs alternate, moderately large; apertures conspicuous, lenticular, horizontal, generally included; borders rounded to polygonal in outline, 7.5 to 19 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, irregular in size and shape but mostly oval or gash-like, 3 to 8 per crossfield. Vessel-to-wood parenchyma pit-pairs large, frequently scalariform, but sometimes smaller and irregular in outline.

Fibers forming more than half the ground mass of the wood in transverse section, sometimes straight and tapering abruptly to a needle-like end, but more frequently irregular in outline and forming a distinct "shoulder" before narrowing abruptly at the end; 0.56 to 1.37 mm. long (mostly 0.80 to 1.00 mm.), 17 to 38 μ in diameter; lumina large; walls thin to moderately thick and sometimes gelatinous; distinctly septate. Some fibers are plugged with resin-like deposit.

Pit-pairs small, indistinctly bordered, slit-like, numerous, primarily on radial walls.

Parenchyma paratracheal, sparingly vasicentric, often in but a single row and not completely encircling the pore. Resin-like deposits present.

Rays 2 to 14 fiber widths apart in cross section; 4 to 8 per mm., straight, heterogeneous (Type II B) with many rows of procumbent cells and one to several rows of square or short upright marginal cells. In tangential section the rays are almost entirely multiseriate, up to 4 cells wide but mostly 3 to 4; 0.03 to 0.08 mm. in width, 5 to 36 cells (0.12 to 0.69 mm.) in height. Horizontal intercellular canals present in some rays, small, surrounded, by one or two rows of small epithelial cells (Plate 33, Fig. 2). Fusiform rays may contain as many as three ducts, are up to 6 cells (0.05 to 0.10 mm.) wide, 12 to 43 cells (0.24 to 0.90 mm.) high. Resin-like deposits abundant; large, solitary rhombohedral crystals present in many marginal cells.

14. Pseudospondias Engl. in De Candolle, Monogr. Phaner. iv (1883) 258. Type species, P. microcarpa Engl. (Tropical Africa)

(1) Material

P. microcarpa Engl.: 2 samples (G. P. Cooper, No. 66, Liberia, Africa)

Pseudospondias is a monotypic genus occurring in tropical Africa. One species was studied. The heartwood is light pinkish to grayish brown, sometimes with a greenish tinge; sapwood light cream. The wood is moderately heavy, medium hard, with rather fine texture and moderately low luster; straight grained.

(2) Macroscopic Structure

Growth rings absent. Pores faintly visible without a lens, evenly distributed, not numerous, mostly solitary, but also in short radial multiples of 2 to 3, occasionally more. Vessel lines distinct but not conspicuous, slightly darker than background. Rays not visible without a lens, very fine, closely spaced, distinct but not conspicuous on radial surface as fine brown flecks. Parenchyma scarcely visible with lens, sparsely paratracheal.

(3) Microscopic Structure

Vessels 6 to 10 per sq. mm., thin-walled, round to elliptical. Tangential diameters from 48 to 175 μ (mostly 95 to 138 μ).

Vessel elements medium-sized, 408 to 776 μ (mostly 504 to 624 μ) in length; ends slightly to decidedly oblique; projecting tips short and thin or none, rarely long and thick; perforations simple with a narrow rim; tyloses rare; resin-like deposits absent.

Intervascular pit-pairs alternate, medium-sized; apertures conspicuous, horizontal, narrowly lenticular, generally included, but sometimes exserted and coalescent; borders round or horizontally elongated and angular, 6 to 13 μ in diameter. Vessel-to-ray pit-pairs moderately large, half-bordered, oval or horizontally elongated. Vessel-to-wood parenchyma pit-pairs similar, large, gash-like or scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to long, narrow ends, but some fibers irregular in shape; 0.66 to 1.58 mm. long (mostly 1.07 to 1.34 mm.), 10 to 27 μ in diameter; lumina generally large; walls thin to moderately thick, gelatinous in part; septate, with very thin septa. Resin-like deposits occur in some fibers.

Pit-pairs small, simple, slit-like, sparse, scattered primarily on radial walls.

Parenchyma paratracheal, incompletely vasicentric to aliform, often with a single wing on one side of the pore. Resin-like deposits abundant.

Rays 2 to 14 fiber widths apart in cross section; 4 to 9 per mm., usually straight, decidedly heterogeneous with low procumbent cells in the central portion, large square cells near the margin, and sometimes one or more rows of very high, narrow upright marginal cells (Plate 32, Fig. 2). In tangential section the rays are of two kinds: (a) uniseriate rays composed of oblong upright cells, 1 to 11 cells high (0.16 to 0.95 mm.) and 0.009 to 0.02 mm. wide; (b) multiseriate rays 2 to 3 cells wide (0.02 to 0.04 mm.), 6 to 33 cells (0.32 to 1.09 mm.) high. Horizontal intercellular canals present, infrequent, usually small, and the fusiform rays do not differ in size from normal multiseriate rays; rarely the canals are large, surrounded by small epithelial cells and the fusiform rays are up to six cells in width. Resin-like deposits abundant; crystals apparently absent.

15. Poupartia Comm. ex Jussieu, Gen. (1789) 372. Type species, P. borbonica J. F. Gmel. (Mauritius)

(1) Material

P. axillaris (Roxb.) King & Prain: 1 sample, China
1 sample, Japan
(Including Spondias axillaris Roxb.)

There are about eight species of Poupartia, all trees, occurring in the Amazon region of Brazil, south-eastern Asia, and Madagascar. One species was studied. The heartwood is light pinkish or grayish brown, the sapwood cream-white; moderately light, moderately soft, with rather coarse texture and fairly high luster; straight grained.

(2) Macroscopic Structure

Growth rings conspicuous, marked by concentric rows of large pores, ring-porous. Early wood pores visible readily without lens, in bands 2 to 4 cells wide, graduated in size from a single row of large pores at the beginning of the early wood zone to considerably smaller pores at the end, generally not crowded and frequently isolated by rays or fibers. Late wood pores not visible without lens, fairly evenly distributed, but often with a tendency toward arrangement in short, oblique rows, solitary, or in radial rows of 2 to 3, rarely more, and occasionally in small clusters. Vessel

lines distinct in early wood zone. Rays visible with naked eye, fine, closely spaced, distinct but not conspicuous on radial surface, lustrous, but same color as background. Parenchyma sparsely paratracheal.

(3) Microscopic Structure

Early wood vessels thin-walled, oval to round in cross section when solitary, graduated in size from beginning to end of zone, but without great difference in size. Tangential diameters from 140 to 320 μ (mostly 160 to 280 μ). Late wood vessels thin-walled, round or elliptical in cross section. Tangential diameters 48 to 160 μ (mostly 80 to 128 μ).

Vessel elements of early wood usually shorter than those of late wood; all elements 240 to 624 μ (mostly 320 to 544 μ) in length; ends of early wood elements nearly horizontal, projecting tips short and narrow, or occasionally long and thick; ends of late wood elements oblique, projecting tips short or long. All perforation plates simple, with a narrow rim; thin-walled tyloses present. Resin-like deposits in larger elements.

Intervascular pit-pairs alternate, large; apertures conspicuous, lenticular, horizontal,

included; borders polygonal when crowded, or round, 9.5 to 19 μ in diameter. Vessel-to-ray pit-pairs large, oval, often greatly elongated, half-bordered; 3 to 7 per crossfield. Vessel-to-wood parenchyma pit-pairs similar, often scalariform.

Fibers forming about half the ground mass of the wood in transverse section, larger in diameter in early wood, straight, tapering gradually to long, narrow ends, but occasionally with a distinct "shoulder"; 0.54 to 1.46 mm. (mostly 0.81 to 1.31 mm.) in length, 13 to 38 μ (rarely to 49 μ) in diameter; lumina large; walls thin; septate, with resin-like deposits on the septa. Fibers often flattened in bands 6 or more cells wide at the limits of the growth rings.

Pit-pairs minute, simple, oval, scattered on radial walls.

Parenchyma paratracheal, sparsely vasicentric, often in but a single row partially surrounding the pore; occasionally diffuse or terminal as scattered cells among the flattened fibers at the limit of the growth ring. Resin-like deposits sometimes present.

Rays 3 to 16 fiber widths apart in cross section; 3 to 4 per mm., straight, or slightly

bent to conform to the pore outline, heterogeneous (Type II B), usually with a single marginal row of square cells, but sometimes with 2 to 5 rows. In tangential section the rays are predominantly multiseriate, 2 to 4, sometimes 5 cells wide (0.02 to 0.07 mm.), 5 to 33 cells (0.11 to 0.65 mm.) high; rarely uniseriate composed entirely of upright cells up to 6 cells high (0.04 to 0.27 mm.), 0.009 to 0.02 mm. wide. Horizontal intercellular canals present in some rays, small, surrounded by 1 to 3 rows of very small epithelial cells. Fusiform rays up to 7 cells wide (0.05 to 0.11 mm.), 15 to 39 cells high (0.30 to 0.73 mm.). Some fusiform rays contain two resin canals. Large, solitary rhombohedral crystals occur in marginal cells of many rays; resin-like deposits common.

16. Harpephyllum Bernh. ex Krauss in Flora xxvii (1844) 349. Type species, H. caffrum Bernh. (S. Africa)

(1) Material

H. caffrum Bernh.: 1 sample (F. H. Ferreira, Pretoria, South Africa)*

Harpephyllum is a monotypic genus occurring in South Africa. The sapwood is white with a slight pinkish tinge, moderately light, moderately soft, with fine texture and fairly high luster. Grain slightly interlocked.

(2) Macroscopic Structure

Growth rings indicated by a band of denser fibers (stem only two years old). Pores visible without a lens, evenly distributed, moderately numerous, solitary, or in radial multiples of 2 to 4, rarely to 5, infrequently in small clusters. Vessel lines distinct, darker than background. Rays visible with lens, fine, very closely spaced, faintly visible on radial surface because of luster. Parenchyma not visible.

(3) Microscopic Structure

Vessels 14 to 17 per sq. mm., thin-walled, round in cross section. Tangential diameters from 28 to 145 μ.

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*A second specimen, No. 854 from the Yale University collection, has been omitted from this study because it is obviously incorrectly labeled and is not anacardiaceous. The specimen described in this paper is a portion of small stem 13 mm. in diameter, without heartwood.

Vessel elements small to medium-sized, 276 to 511 μ in length; ends slightly to decidedly oblique; projecting tips short and thin or thick, rarely moderately long and thick; perforations simple with a narrow rim; tyloses thin-walled.

Intervascular pit-pairs mostly alternate, but infrequently opposite or even scalariform in portions of elements, medium-sized to very large; apertures conspicuous, oblong, horizontal, included; borders rounded to angular in outline, 8 to 18 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval to irregular and scalariform. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming more than half the ground mass of the wood in transverse section, generally straight, tapering gradually to long, thin ends, but sometimes tapering abruptly; 0.35 to 1.45 mm. long (mostly 0.60 to 0.91 mm.), 14 to 34 μ in diameter; lumina large; walls thin; septate.

Pit-pairs small, indistinctly bordered, numerous, on radial walls only.

Parenchyma paratracheal, vasicentric, sparse. Resin-like deposits infrequent.

Rays 3 to 14 fiber widths apart in cross section; 9 to 13 per mm., straight, heterogeneous

(Type II B), with 1 to 4 rows of square or upright marginal cells. In tangential section the rays are 1 to 3 cells wide (0.02 to 0.06 mm.), 2 to 47 cells high (0.11 to 1.00 mm.). Horizontal intercellular canals present, small, surrounded by 1 or occasionally 2 rows of small epithelial cells. Fusiform rays 3 cells wide (0.04 to 0.07 mm.), 19 to 40 cells high (0.43 to 1.79 mm.). Resin-like deposits occasionally present; very large rhombohedral crystals abundant in both procumbent and marginal cells.

17. Lannea A. Rich. in Guillemin & Perrottet, Fl. Seneg. Tent. i. 153. t. 42 (1832). Type species, L. velutina A. Rich. (West Africa)

(1) Material

L. acida A. Rich.: 1 sample, Togo, West Africa
L. acidissima A. Chev.: 1 sample (C. Vigne, No. 1913, Gold Coast, Africa)
L. amaniensis Engl.: 1 sample (H. J. Schlieben, No. 529, Tanganyika, East Africa)
L. ambigua Engl.: 1 sample (H. J. Schlieben, No. 493, Tanganyika, East Africa)
L. Barteri (Oliv.) Engl.: 1 sample, Togo, West Africa
L. Buettneri Engl.: 1 sample, Togo, West Africa
L. egregia Engl.: 1 sample, Togo, West Africa
L. Stuhlmannii Engl.: 1 sample (H. J. Schlieben, No. 526, Tanganyika, East Africa)

There are about thirty species of Lannea, small to large trees, occurring in Africa from Sierra Leone to Abyssinia. Eight species were studied. The heartwood is not extensive, light pinkish to reddish brown; sapwood light yellow to grayish tan. The wood is light to moderately heavy, moderately soft to moderately hard, with fairly high luster, fine to medium texture, and straight to somewhat interlocked grain.

(2) Macroscopic Structure

Growth rings indistinct. Pores visible without a lens, evenly distributed, not very numerous, mostly solitary, but also in radial multiples of 2 to 3, sometimes 4 to 5, and in small clusters (Plate 10, Figs. 1 and 2). Vessel lines distinct, fine, darker than

background. Rays visible in cross section, moderately fine, closely spaced, distinct but not conspicuous on radial surface, slightly darker than background. Parenchyma sparingly paratracheal.

(3) Microscopic Structure

Vessels 4 to 11 per sq. mm., thin-walled, round to elliptical in cross section. Tangential diameters from 40 to 238 μ (mostly 96 to 160 μ), but in the young stem of L. ambigua, 40 to 158 μ (mostly 80 to 125 μ).

Vessel elements medium-sized, 240 to 856 μ (mostly 360 to 680 μ) in length; ends slightly to decidedly oblique; projecting tips short and narrow to long and thick; perforations simple with a narrow rim; thin-walled tyloses and resin-like deposits abundant.

Intervascular pit-pairs alternate, medium-sized to very large; apertures conspicuous, lenticular, horizontal, usually included, but sometimes exserted and coalescent in L. acida and L. Buettneri; borders rounded to polygonal in outline, 7.6 to 21 μ in diameter. Vessel-to-ray pit-pairs half-bordered, oval or gash-like; 2 to 8 per cross field. Vessel-to-wood parenchyma pit-pairs similar, often scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight to somewhat irregular in outline, tapering gradually to long, needle-like ends; 0.46 to 1.56 mm. long (mostly 0.76 to 1.20 mm.), 15 to 38 μ in diameter; lumina large; walls thin; septate, with thin septa. Resin-like deposits often present, particularly in vicinity of septa.

Pit-pairs small, simple, oval or round, numerous, usually on radial walls only.

Parenchyma very sparingly paratracheal, often only one or two isolated cells around pores; occasionally diffuse, in areas of flattened fibers.

Rays 2 to 16, occasionally to 23, fiber widths apart in cross section; 3 to 5 per mm. in L. acida, 4 to 6 per mm. in other species, usually straight or very slightly bent to conform to the pore outline, heterogeneous (Type II B). In tangential section the rays are rarely uniseriate, and then composed of a few upright cells; mostly multiseriate, 2 to 8 cells wide; mostly 4 to 8 in L. acida (Plate 32, Fig. 1), 3 to 5 in L. Buettneri and L. Barteri, and 2 to 3 in other species (Plate 31, Fig. 2); the largest rays 0.095 to

0.125 mm. wide, 20 to 30 cells (up to 0.82 mm.) high. Horizontal intercellular canals numerous, 1 to 3 per ray, very small, surrounded by a single layer of rather thick-walled epithelial cells (Plate 31, Fig. 1). Echimulate bodies present in many procumbent cells; occasional large, solitary crystals present in enlarged marginal cells, particularly in L. egregia; resin-like deposits present.

18. Odina Roxb. Hort. Beng. 29 (1814). Type species, O. Wodier Roxb. (E. India)

(1) Material

O. Wodier Roxb.: 2 samples, India
2 samples, Ceylon

There are two species of Odina, one widely distributed throughout India and Burma, the other occurring in New Guinea. One species was studied. The heartwood is light red to red-brown, the wide sapwood yellowish white to cream. The wood is moderately heavy, medium hard, with moderately fine texture and medium luster. The grain is usually interlocked.

(2) Macroscopic Structure

Growth rings scarcely distinct. Pores visible without a lens when the wood is moist, evenly distributed, not numerous, mostly solitary, but also in small radial multiples of 2 to 3, and clusters. Vessel lines distinct, slightly darker than the background. Rays just within the limit of vision without a lens, rather fine, closely spaced, distinct but not conspicuous on radial surface, lustrous, but almost the same color as background. Parenchyma scarcely visible with lens, paratracheal.

(3) Microscopic Structure

Vessels 5 to 9 per sq. mm., thin-walled, round to elliptical in cross section. Tangential

diameters from 40 to 200 μ (mostly 112 to 160 μ).

Vessel elements medium-sized, 336 to 800 μ (mostly 480 to 624 μ) in length; ends slightly to decidedly oblique; projecting tips short and narrow or long and thick; perforations simple with a narrow rim; tyloses thick-walled, abundant, intermingled with orange-brown, resin-like deposits.

Intervascular pit-pairs alternate, medium to very large; apertures lenticular, horizontal, included; borders polygonal in outline, 7.6 to 19 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval or round, often greatly elongated, 2 to 6 per crossfield. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming more than half the ground mass of the wood in transverse section, irregular in shape, tapering gradually to form long, thin ends or occasionally with a distinct "shoulder" or rarely bifurcate and with short, branch-like protuberances; 0.56 to 1.56 mm. long (mostly 0.82 to 1.28 mm.), 19 to 34 μ in diameter; lumina large; walls thin to moderately thick; septate, with depositions of orange-brown resin-like material on the thin septa.

Pit-pairs small, simple, oval, on radial walls.

Parenchyma sparingly paratracheal, usually as isolated cells around the pores. Resin-like deposits present.

Rays 2 to 13 fiber widths apart in cross section; 4 to 7 per mm., usually straight or slightly bent to conform to the pore outline, heterogeneous (Type II B) with many rows of procumbent cells and one or two rows of square or upright cells at margins. In tangential section the rays are multiseriate, 2 to 4 cells wide (0.03 to 0.077 mm.), up to 30 cells high (0.79 mm.). Horizontal intercellular canals present, one to three per ray, small, round, surrounded by one layer of rather thick-walled epithelial cells. Fusiform rays similar in size to normal rays. Echimulate bodies present in many ray cells; solitary crystals in enlarged marginal cells; resin-like deposits abundant.

19. Haematostaphis Hook. f. in Trans. Linn. Soc. xxiii (1860) 169 t. 25. Type species, H. Barteri Hook f. (Tropical Africa)

(1) Material*

H. Barteri Hook. f.: 1 sample, Togo, West Africa

Haematostaphis is a monotypic genus occurring in tropical Africa. The heartwood is brownish gray; sapwood cream. Wood moderately light and soft, with fine texture and low luster; interlocked grain.

(2) Macroscopic Structure

Growth rings indistinct. Pores visible with unaided eye, evenly distributed, not very numerous, solitary, or in radial multiples of 2 to 3, rarely more. Vessel lines distinct, darker than the background. Rays just within limit of vision without a lens, fine, closely spaced, distinct on radial surface. Parenchyma not distinct.

(3) Microscopic Structure

Vessels 4 to 9 per sq. mm., thin-walled, oval in cross section. Tangential diameters from 72 to 207 μ (mostly 90 to 145 μ).

Vessel elements medium-sized, 240 to

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*The one available specimen of Haematostaphis has been severely damaged by a fungous growth. Descriptions of the color, luster, and parenchyma distribution may be, therefore, somewhat inaccurate.

584 μ (mostly 344 to 504 μ) in length; ends nearly horizontal to moderately oblique; projecting tips short and thin or none; perforations simple with a narrow rim; tyloses thin-walled.

Intervascular pit-pairs alternate, large; apertures conspicuous, lenticular, horizontal, included; borders round to irregular in outline, 9.5 to 15 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round or oval, often horizontally elongated; 3 to 6 or more per cross field. Vessel-to-wood parenchyma pit-pairs not distinct.

Fibers forming more than half the ground mass of the wood in transverse section, irregular in shape, generally tapering gradually to long, narrow ends, but sometimes bifurcate; 0.74 to 1.84 mm. long (mostly 0.81 to 1.14 mm.), 17 to 40 μ in diameter; lumina large; walls thin; septate.

Pit-pairs small, simple, slit-like, on radial walls.

Parenchyma sparingly paratracheal, indistinct because of the poor condition of the specimen. Resin-like deposits and crystals present.

Rays 2 to 12 fiber widths apart in cross section; 5 to 8 per mm., straight, heterogeneous (Type II B) with central portion composed of procumbent cells and marginal layer of two or more rows of square or short upright cells. In tangential section the rays are multiseriate, up to four cells wide, with triseriate rays predominating; occasionally uniseriate with exclusively upright cells. Rays 0.04 to 0.08 mm. wide, 7 to 26 cells (0.13 to 0.95 mm.) high. Horizontal intercellular canals absent; resin-like deposits present in most cells; large, rhombohedral crystals abundant in cells of all parts of ray, solitary, or rarely two per cell.

III. Rhoideae

20. *Pistacia* Linn. Hort. Cliff. 456 (1737). Type species, *P. Terebinthus* Linn. (Southern Europe, Med. Reg.)

(1) Material

P. atlantica Desf.: 1 sample, Algeria
P. chinensis Bunge: 1 sample, Formosa
P. Lentiscus Linn.: 1 sample, Algeria
P. Terebinthus Linn.: 1 sample, Palestine
P. weimannifolia Poiss.: 1 sample, China

Pistacia, with about twelve species of small to medium-sized trees and shrubs, occurs in the Mediterranean region, India, China, Formosa, the Philippines, Mexico, and Texas. Five species were studied. The heartwood is olive-brown, often with narrow bands of darker brown, becoming a rich brown with age; sapwood cream or buff colored, often with a greenish tinge. The wood is moderately heavy to heavy, hard, with fine texture and low luster. Some specimens have interlocked grain.

(2) Macroscopic Structure

Growth rings visible, marked by concentric bands of larger pores; ring-porous to semi-ring-porous. The larger pores just within the limit of vision with the naked eye, in one to three more or less definite rows (mostly one), solitary, or in radial or tangential multiples of 2 to 3. The smaller or late wood pores in

long to short clusters arranged in an oblique pattern which is often visible without a lens. Vessel lines not conspicuous. Rays faintly visible without a lens, fine, closely spaced, distinct on radial surface because of luster. Parenchyma not distinct.

(3) Microscopic Structure

Vessels of two sizes, distributed as described above, thin to moderately thick-walled, round to oval when solitary, flattened at point of contact with other pores in clusters. Tangential diameters of early wood pores from 80 to 208 μ (mostly 100 to 172 μ); tangential diameters of late wood pores 24 to 88 μ (mostly 32 to 50 μ).

Vessel elements moderately short; early wood elements 104 to 311 μ in length; late wood elements 242 to 414 μ in length. Ends of all elements nearly horizontal to decidedly oblique; projecting tips short or long and thin, or none; perforations simple with a narrow rim; tyloses thin-walled, abundant in larger vessel elements. Resin-like deposits sometimes present.

Intervascular pit-pairs alternate, medium-sized; apertures lenticular, generally included; borders not crowded, round or oval in

outline, 7 to 10 μ in diameter. Vessel-to-ray pit-pairs medium-sized to large, half-bordered, round to irregular in outline. Pit-pairs from vessel to wood parenchyma not observed. Spiral thickenings present in all of the smaller vessel elements (Plate 34, Figs. 1 and 2).

Fibers forming about half the ground mass of the wood in transverse section, straight to irregular, tapering gradually to long needle-like ends; 0.24 to 1.03 mm. long (mostly .55 to .90 mm.), 14 to 22 μ in diameter; lumina moderately large; walls moderately thick to thick; occasionally septate.

Pit-pairs small, simple, or indistinctly bordered, on radial walls only.

Parenchyma paratracheal, sparse, crystals absent, resin-like deposits occasionally present.

Rays 4 to 12 fiber widths apart in cross section; 7 to 10 per mm., usually straight, or very slightly bent to conform to the large pore outline, heterogeneous (Type II B), with one or two rows of square or upright cells at margins. In tangential section the rays are 1 to 4 seriate, mostly 2 to 3 except in P. atlantica where they are mostly 3 to 5. Rays 0.018 to 0.07 mm. wide,

2 to 42 cells (0.08 to 0.55 mm.) high. Horizontal intercellular canals present, moderately large, surrounded by one or two rows of small epithelial cells, sometimes two canals per ray (Plate 34, Fig. 2). Fusiform rays often 5 to 6 cells wide at widest point, particularly in P. atlantica; 0.042 to 0.085 mm. wide, up to 48 cells high (0.55 mm.). Resin-like deposits in many cells; large crystals present in marginal cells.

21. Pentaspadon Hook. f. in Trans. Linn. Soc. xxiii (1860) 168. t. 24. Type species, P. Motleyi Hook. f. (Borneo)

(1) Material

P. minutiflora B. L. Burtt: 1 sample (J. H. L. Waterhouse, No. 13, Bougainville Island)
P. Motleyi Hook. f.: 1 sample, North Borneo
1 sample, Dutch East Indies
P. officinalis Holmes: 1 sample, Malaya

There are bout four species of Pentaspadon occurring from Malaya to New Guinea. Three species were studied. The heartwood is light pinkish brown; the sapwood pale yellow. Wood light to moderately heavy, moderately soft, with medium texture and fairly high luster. Generally straight grained.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible without a lens, evenly distributed, not very numerous, mostly solitary, but also in radial multiples of 2 to 3 (Plate 13, Fig. 3). Vessel lines distinct, darker than background. Rays visible without a lens, fine, fairly closely spaced, distinct but not conspicuous on radial surface, not much darker than background. Parenchyma sparse, paratracheal.

(3) Microscopic Structure

Vessels 9 to 16 per sq. mm. in P. minutiflora, 5 to 11 per sq. mm. in other species,

thin-walled, elliptical to round in cross section. Tangential diameters from 48 to 242 μ (mostly 117 to 166 μ, but larger in P. Motleyi, 145 to 195 μ).

Vessel elements medium-sized, 311 to 1021 μ (mostly 552 to 842 μ) in length; ends nearly horizontal to oblique; projecting tips short to long and thin, or none, rarely long and thick; perforations simple with a narrow rim; tyloses thin-walled, not abundant. Resin-like deposits occasionally present.

Intervascular pit-pairs alternate, medium-sized; apertures conspicuous, lenticular, included; borders round to irregular in outline, 8 to 10 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round to irregular in outline, often horizontally elongated. Vessel-to-wood parenchyma pit-pairs very large, frequently scalariform.

Fibers forming about half the ground mass of the wood in transverse section, irregular to straight in outline, tapering gradually to long needle-like ends, but occasionally with a "heel"; 0.45 to 1.45 mm. long (mostly 0.64 to 1.28 mm.), 14 to 26 μ in diameter; lumina rather large; walls moderately thin; septate, with distinct septa (Plate 34, Fig. 3).

Pit-pairs small, simple, on radial walls only.

Parenchyma sparse, paratracheal. Resin-like deposits sometimes present, not abundant.

Rays 2 to 15 fiber widths apart in cross section; 7 to 11 per mm., usually straight or very slightly bent to conform to the pore outline, heterogeneous with one to three rows of square or tall upright marginal cells. In tangential section the rays are multiseriate, 2 to 4 (mostly 2 to 3) cells wide (0.023 to 0.048 mm.), 3 to 38 cells (0.14 to 0.70 mm.) high (Plate 34, Fig. 3). Horizontal intercellular canals present, moderately large, surrounded by 1 or 2 rows of epithelial cells (Plate 36, Fig. 1). Fusiform rays 3 to 4 cells wide (0.05 to 0.07 mm.), 11 to 29 cells high (0.24 to 0.59 mm.). Resin-like deposits present; crystals present, mostly in marginal cells.

22. Microstemon Engl. Bot. Jahrb. i. (1881) 376. Type species, M. velutina Engl. (Malacca)

(1) Material

M. velutina Engl.: 3 samples (H. E. Desch, Nos. 3705, 4731, 4732; For. Res. Inst., Kepong, Selangor, Malay)

There are about three species of Microstemon recorded from the region of Malaya. One species was studied. The heartwood is light pinkish or yellowish brown, moderately light and moderately soft, with fine to medium texture and fairly high luster. Grain slightly interlocked.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with unaided eye, evenly distributed, not very numerous, mostly solitary, but also in radial multiples of 2 to 3. Vessel lines distinct but not conspicuous, scarcely darker than background. Rays visible without a lens, rather fine, closely spaced, distinct on radial surface because of luster, not darker than background. Parenchyma sparsely paratracheal.

(3) Microscopic Structure

Vessels 6 to 11 per sq. mm., thin-walled, round to elliptical in cross section. Tangential diameters from 69 to 207 μ (mostly 124 to 159 μ).

Vessel elements medium-sized, 400 to

966 μ (mostly 552 to 759 μ) in length; ends horizontal to slightly oblique; projecting tips short to long and thin, rarely long and thick; perforations simple with a narrow rim; tyloses thin-walled, not abundant.

Intervascular pit-pairs alternate, medium-sized to large; apertures conspicuous, lenticular, included; borders rounded to polygonal in outline, 9 to 12 μ in diameter. Vessel-to-ray pit-pairs large, rounded to often horizontally elongated, half-bordered. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming at least half the ground mass of the wood in transverse section, generally straight, tapering gradually to long needle-like ends; 0.55 to 1.73 mm. long (mostly 0.84 to 1.28 mm.), 15 to 34 μ in diameter; lumina large to moderately small; walls thin to moderately thick; septate, with distinct septa. Resin-like deposits occasionally present (Plate 11, Fig. 2).

Pit-pairs small, simple, slit-like, on radial walls.

Parenchyma paratracheal, sparse (Plate 11, Fig. 2).

Rays 4 to 14 fiber widths apart in cross

section; 5 to 9 per mm., straight, or slightly bent to conform to the pore outline, decidedly heterogeneous (Type II A) with 1 to 3 rows of marginal and interspersed upright cells. In tangential section the rays are 2 to 4 seriate (0.03 to 0.05 mm.), 5 to 24 cells (0.16 to 0.65 mm.) high. Horizontal intercellular canals present, small to moderately large, surrounded by 1 or 2 rows of epithelial cells (Plate 38, Fig. 1). Fusiform rays 4, rarely 5 cells wide (0.06 to 0.09 mm.), 15 to 34 cells (0.33 to 0.69 mm.) high. Resin-like deposits in most ray cells; large, rhombohedral crystals very abundant in marginal cells (Plate 47, Fig. 1).

23. Faguetia March. Rev. Anacard. 174 t. 2 (1869). Type species, F. falcata March. (Madagascar)

(1) Material

F. falcata March.: 1 sample, Madagascar

Faguetia is a monotypic genus occurring in Madagascar. The heartwood is reddish brown, often with narrow, purplish brown striping, moderately heavy, flinty hard, with fine texture and medium luster; interlocked grain.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with the naked eye, evenly distributed, moderately few, solitary, or in small radial multiples of 2 to 3, rarely more, or occasionally in small clusters. Vessel lines distinct but not conspicuous, not darker than background. Rays not visible without a lens, fine, closely spaced, Parenchyma paratracheal, vasicentric and occasionally aliform; infrequently apotracheal, in fine concentric bands.

(3) Microscopic Structure

Vessels 6 to 10 per sq. mm., moderately thick-walled, round to somewhat angular in cross section. Tangential diameters from 48 to 159 μ (mostly 83 to 124 μ).

Vessel elements medium-sized, 345 to 683 μ (mostly 462 to 587 μ) in length; ends

oblique to almost horizontal; projecting tips short or long and slender; perforations simple with a narrow rim; tyloses thin-walled, rather abundant. Resin-like deposits present.

Intervascular pit-pairs alternate, small; apertures not conspicuous, lenticular, generally included but sometimes exserted and coalescent; borders round to irregular in outline, 4 to 7 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round to gash-like. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming about half the ground mass of the wood in transverse section, straight, often twisted, tapering gradually to long needle-like ends; 0.57 to 1.31 mm. long (mostly 0.69 to 1.10 mm.), 8 to 23 μ in diameter; lumina moderately large; walls moderately thick; septate, in part.

Pit-pairs small, simple or indistinctly bordered, slit-like, on radial walls.

Parenchyma moderately abundant, paratracheal, vasicentric in a sheath 1 or 2 cells wide, occasionally aliform; apotracheal in some areas, in narrow discontinuous bands rarely more than one cell wide (Plate 13, Fig. 2). Resin-like deposits abundant.

Rays 3 to 13 fiber widths apart in cross section; 8 to 12 per mm., usually straight, decidedly heterogeneous (Type II B), often with many rows of square or upright cells at the margin or interspersed (Plate 55, Fig. 1). In tangential section the rays are 1 to 3 seriate, rarely 4, and the uniseriate rays are composed entirely of upright cells. Rays 0.02 to 0.07 mm. wide, 2 to 28 cells (0.15 to 1.42 mm.) high. Horizontal intercellular canals absent. Resin-like deposits abundant; large, rhombohedral crystals in marginal cells.

24. Sorindeia Dupetit-Thouars, Gen. Nov. Madag. 23 (1806). Type species, S. madagascariensis Dupetit-Thouars (Madagascar)

(1) Material

S. longifolia Oliv.: 1 sample, Liberia

About seven species of Sorindeia occur in tropical Africa and Madagascar. One species was studied. The heartwood is pinkish brown, the sapwood buff colored with a greenish yellow tinge. The wood is moderately heavy, hard, with medium texture and moderately low luster. Grain somewhat interlocked.

(2) Macroscopic Structure

Growth rings not distinct. Pores just within limit of vision without a lens, evenly distributed, moderately few, mostly solitary, but also in radial multiples of 2 to 3. Vessel lines distinct, conspicuous in sapwood because darker than background. Rays indistinct without lens, fine, closely spaced, distinct on radial surface only because of luster. Parenchyma not distinct without lens, paratracheal, sparse.

(3) Microscopic Structure

Vessels 7 to 14 per sq. mm., thin-walled, round to elliptical in cross section. Tangential diameters from 62 to 145 μ (mostly 83 to 124 μ).

Vessel elements medium-sized, 304 to 621 μ (mostly 442 to 490 μ) in length; ends oblique to nearly horizontal; projecting tips short or long and thin, rarely long and thick; perforations simple with a narrow rim; tyloses thin-walled, not abundant.

Intervascular pit-pairs alternate, small; apertures not conspicuous, lenticular, included, but often exserted and coalescent, forming a striated pattern; borders round to irregular in outline, 4 to 7 μ in diameter. Vessel-to-ray pit-pairs very large, half-bordered, gash-like and frequently scalariform. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming more than half the ground mass of the wood in transverse section, generally straight, tapering gradually to long, thin ends; 0.46 to 1.33 mm. long (mostly 0.86 to 1.25 mm.), 9 to 31 μ in diameter; lumina small to moderately large; walls moderately thick; septate, with thin septa.

Pit-pairs indistinct, simple, on radial walls.

Parenchyma paratracheal, sparse. Resin-like deposits present.

Rays 3 to 13 fiber widths apart in cross

section; 10 to 14 per mm., straight, decidedly heterogeneous, with relatively few rows of small procumbent cells and 1 to 3 marginal rows of square or tall upright cells; upright cells often interspersed, also. In tangential section the rays are almost entirely uniseriate, rarely biseriate in part, 0.014 to 0.037 mm. wide, 2 to 40 cells (0.15 to 1.33 mm.) high. Horizontal intercellular canals absent; resin-like deposits in most cells; large crystals present, not abundant.

25. Trichocypha Hook. f. in Benth. & Hook. f. Gen. i. 423 (1862). Type species, T. Mannii Hook. f. (Tropical Africa)

(1) Material

T. arborea A. Chev.: 2 samples, Liberia, Africa
T. ferruginea Engl.: 2 samples, Liberia, Africa
T. ulugurensis Mildbr.: 1 sample, Liberia, Africa

Trichocypha, with about sixteen species, occurs in tropical Africa. Three species were studied. The heartwood is light pinkish brown, the sapwood buff colored with a pinkish tinge. Wood moderately heavy, hard, with fine texture and moderately high luster. Grain interlocked.

(2) Macroscopic Structure

Growth rings not distinct. Pores just within limit of vision without a lens, evenly distributed, moderately few, mostly solitary, but also in radial multiples of 2 to 3. Vessel lines distinct but not conspicuous, very fine. Rays not visible without a lens, very fine, closely spaced, distinct but not conspicuous on radial surface, small, lustrous flecks. Parenchyma visible with lens, paratracheal.

(3) Microscopic Structure

Vessels 7 to 14 per sq. mm., thin to moderately thick-walled, mostly round in cross section. Tangential diameters from 62 to 173 μ (mostly 83 to 138 μ).

Vessel elements medium-sized, 304 to 725 μ (mostly 415 to 635 μ) in length; ends oblique to nearly horizontal; projecting tips short to long and thin, or none, rarely long and thick; perforations simple with a narrow rim; tyloses thin-walled, not abundant.

Intervascular pit-pairs alternate, generally small; apertures lenticular, included, but often exserted and coalescent, forming a striated pattern; borders rounded to irregular in outline, 4 to 8 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, gash-like or scalariform. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming about half the ground mass of the wood in transverse section, generally straight, tapering gradually to long needle-like ends; 0.52 to 1.56 mm. long (mostly 0.83 to 1.19 mm.), 12 to 32 μ in diameter; lumina moderately large; walls thin to moderately thick, occasionally gelatinous; non-septate.

Pit-pairs small, simple to indistinctly bordered, on radial walls.

Parenchyma moderately sparse, paratracheal, incompletely vasicentric to aliform, often with the wing-like extension on one side

only, rarely confluent. Resin-like deposits present.

Rays 3 to 20 fiber widths apart in cross section; 6 to 9 per mm., straight, heterogeneous (Type II A); procumbent cells small, round; marginal cells in 1 to 3 rows, very tall upright cells; upright cells occasionally interspersed. In tangential section rays 1 to 3 seriate, rarely 4 seriate, with uniseriate rays composed of exclusively tall upright cells. Rays 0.02 to 0.04 mm. wide, 2 to 31 cells high (0.21 to 1.10 mm.). Horizontal intercellular canals present in some rays, moderately small, surrounded by one row of epithelial cells. Fusiform rays 0.04 to 0.06 mm. wide, 23 to 33 cells high (0.55 to 0.80 mm.). Resin-like deposits present; echimulate bodies present in cells, not abundant; crystals apparently absent.

26. Parishia Hook. f. in Trans. Linn. Soc. xxiii (1860) 169. t. 26. Type species, P. insignis Hook. f. (Burma)

(1) Material

P. insignis Hook. f.: 2 samples, Burma
P. Malabog Merr.: 1 sample, the Philippines
P. oblongifolia Merr.: 1 sample, the Philippines
P. pubescens Hook. f.: 1 sample, Malaya

There are four species of Parishia occurring in Burma, Malaya, and the Philippines. Four species were studied. Heartwood light pinkish to grayish brown, sapwood almost white. Wood light to moderately light, moderately soft, with moderately coarse texture and medium luster. Grain straight to interlocked.

(2) Macroscopic Structure

Growth rings distinct in P. pubescens, marked by a line of denser fibers; not visible in other specimens. Pores visible without a lens, evenly distributed, moderately few, mostly solitary, but also in radial multiples of 2 to 3, occasionally to 4 or 5. Vessel lines distinct, darker than background. Rays just within limit of vision without a lens, fine, closely spaced, distinct on radial surface as fine flecks of red-brown color. Parenchyma visible with lens, paratracheal, vasicentric to aliform.

(3) Microscopic Structure

Vessels 4 to 16 per sq. mm., thin-walled,

round to oval in cross section. Tangential diameters from 62 to 200 μ (mostly 117 to 173 μ), but generally smaller in P. Malabog (mostly 62 to 117 μ).

Vessel elements medium-sized, 255 to 870 μ (mostly 345 to 683 μ) in length; ends oblique to nearly horizontal; projecting tips short and thin to long, or none; perforations simple with a narrow rim; tyloses thin-walled, rare.

Intervascular pit-pairs alternate, mostly medium-sized; apertures conspicuous, lenticular, horizontal, included; borders rounded to irregular in outline, 6 to 11 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval to irregular or gash-like. Vessel-to-wood parenchyma pit-pairs similar.

Fibers forming at least half the ground mass of the wood in transverse section, straight, tapering gradually to long, narrow ends; 0.31 to 1.45 mm. long (mostly 0.65 to 1.27 mm.), 15 to 37 μ in diameter; lumina medium to large; walls thin to moderately thick; non-septate. In P. pubescens bands of fibers at the end of the growth ring are flattened and have thicker walls.

Pit-pairs very small, possibly indistinctly bordered, on radial walls.

Parenchyma paratracheal, vasicentric in a uniseriate sheath, but sometimes aliform, and rarely confluent. Resin-like deposits present; starch grains abundant in the sapwood of P. Malabog.

Rays 2 to 14 fiber widths apart in cross section; 4 to 9 per mm., usually straight, decidedly heteregeneous with 1 or 2 rows of tall upright marginal cells. In tangential section the rays are 1 to 2 seriate, mostly biseriate in P. oblongifolia, up to 3 seriate in P. insignis, but primarily uniseriate in the others. Rays 0.02 to 0.06 mm. wide, 3 to 22 cells (0.21 to 0.79 mm.) high. Horizontal intercellular canals present in some rays, small to medium, surrounded by 1 or 2 rows of small epithelial cells. Fusiform rays 3 to 5 cells wide at largest portion (0.05 to 0.10 mm.), 18 to 32 cells high (0.44 to 0.70 mm.). Resin-like deposits present in most cells; crystals absent; echimulate bodies noted in a few ray cells; starch grains present in P. Malabog and P. insignis.

27. Protorhus Engl. in Engl. Bot. Jahrb. i. (1881) 420.
Type species, P.

(1) Material

P. sericea Engl. var. opaca H. Lec.: 1 sample, Madagascar

Protorhus, with nine species of trees and shrubs, occurs in Madagascar and Natal, South Africa. One species was studied. The heartwood is grayish brown with a reddish tinge, moderately heavy, moderately soft, with medium texture and low luster. Straight grained.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with unaided eye, evenly distributed, moderately numerous, mostly solitary, but also in radial multiples of 2 to 3. Vessel lines distinct, darker than background. Rays visible with a lens, very fine, closely spaced, distinct on radial surface as red-brown flecks. Parenchyma visible with lens, paratracheal.

(3) Microscopic Structure

Vessels 15 to 21 per sq. mm., thin-walled, round or oval in cross section. Tangential diameters from 48 to 138 μ (mostly 83 to 117 μ).

Vessel elements medium-sized, 435 to 890 μ (mostly 587 to 759 μ) in length; ends oblique; projecting tips short and thin to long

and thick; perforations simple with a narrow rim; tyloses not observed.

Intervascular pit-pairs alternate, mostly medium-sized; apertures conspicuous, lenticular, horizontal, included; borders rounded to elliptical in outline, 6 to 11 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, rounded to irregular. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming slightly less than half the ground mass of the wood in transverse section, generally straight, tapering gradually, rarely abruptly, to long, rather narrow ends; 0.52 to 1.50 mm. long (mostly 0.79 to 1.31 mm.), 12 to 37 μ in diameter; lumina moderately large; walls moderately thick to thick, occasionally gelatinous; rarely septate.

Pit-pairs small, indistinctly bordered, on radial walls.

Parenchyma paratracheal, vasicentric in a sheath 1 to 2 cells wide, mostly 1, sometimes aliform, rarely confluent. Resin-like deposits abundant.

Rays 2 to 16 fiber widths apart in cross section; 9 to 12 per mm., usually straight, heterogeneous (Type II B) with many rows of

small procumbent cells and 1 to several rows of square or upright marginal cells. In tangential section the rays are uniseriate and biseriate, rarely partially triseriate, 0.017 to 0.039 mm. wide, 3 to 49 cells (0.18 to 0.98 mm.) high. Horizontal intercellular canals absent; resin-like deposits abundant in most cells; crystals present, but not abundant, in marginal cells.

28. Campnosperma Thwait. in Hook. Kew Journ. vi. (1854) 65. t. I. Type species, C. zeylanica Thwait. (Ceylon)

(1) Material

C. arborescens Blanco: 1 sample (H. E. Desch, No. 3680, For. Res. Inst., Kepong, Selangor, Malay)
C. auriculata Hook. f.: 1 sample (Rahmat No. 7704, Sumatra)
1 sample, Sumatra
1 sample (NGF. 2074, Dobodura area, New Guinea)
C. brevipetiolata Volk.: 1 sample (NGF. 512, Aitape, New Guinea)
1 sample, Micronesia
C. macrophylla (Blanco) Hook. f.: 3 samples (H. E. Desch, Nos. 4149, 4722, 5375; For. Res. Inst., Kepong, Selangor, Malay)
C. minor Corner: 1 sample, Malaya
C. Wallichii King: 2 samples (H. E. Desch, Nos. 3693, 4035; For. Res. Inst., Kepong, Selangor, Malay)
1 sample, Vanikoro Island
C. zeylanica Thwait.: 1 sample, Ceylon

There are about ten species of Campnosperma occurring in the tropical regions of both the Old and New World. Seven species were studied. The heartwood is light grayish or pinkish brown; sapwood similar. Wood moderately light, moderately soft, with rather fine texture and low luster. Grain generally interlocked.

(2) Macroscopic Structure

Growth rings not evident. Pores just within limit of vision with the naked eye, evenly distributed, numerous, solitary, and in short radial rows of 2 to 3 (Plates 17 and 18). Vessel lines barely visible. Rays indistinct

with naked eye, fine, closely spaced, distinct on radial surface as low, reddish brown flecks. Wood parenchyma not evident.

(3) Microscopic Structure

Vessels 11 to 40 per sq. mm., thin-walled, oval to decidedly angular in cross section. Tangential diameters from 41 to 155 μ (mostly 76 to 110 μ, except in C. arborescens and C. Wallichii Yale 38717, where the diameters are mostly 97 to 131 μ).

Vessel elements moderately long, 580 to 1346 μ (mostly 890 to 1159 μ) in length; ends nearly horizontal to decidedly oblique; projecting tips short to long and thin, long and thick, or none; perforations simple with a narrow rim, or scalariform with 5 to 20 thin bars, rarely with 1 or 2 bars near the end of an otherwise simple perforation plate (Plate 49, Fig. 1); tyloses occasional, thin-walled. Resin-like deposits in some vessels.

Intervascular pit-pairs alternate, medium-sized to very large; apertures conspicuous, lenticular, horizontal, included; borders oval to irregular in shape, 8 to 17 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, gash-like to scalariform.

Fibers forming less than half the ground mass of the wood in transverse section, generally straight, tapering gradually to long, needle-like ends, occasionally with a "heel," but the widest fibers often tapering slightly to relatively broad, blunt ends; 0.55 to 1.73 mm. long (mostly 1.05 to 1.30 mm.), 14 to 46 μ in diameter; lumina large; walls thin to moderately thick; septate in part. Resin-like deposits present.

Pit-pairs small, conspicuous because rather numerous, indistinctly bordered to simple, mostly on radial walls.

Parenchyma generally absent, but occasionally very sparsely paratracheal.

Rays 1 to 18 fiber widths apart in cross section; 6 to 11 per mm., generally straight, heterogeneous (Type II A) with 1 to 3 rows of square or upright cells at margin. In tangential section the rays are 1 to 3 cells wide (0.015 to 0.04 mm.), 3 to 38 cells high (0.09 to 1.35 mm.). Horizontal intercellular canals present, moderately large, surrounded by 2 to 3 rows of very small epithelial cells (Plate 35, Fig. 3).. Fusiform rays 5 to 7 cells wide at widest portion (0.085 to 0.17 mm.), 22 to 46 cells high

(0.55 to 1.37 mm.). Resin-like deposits present in cells; crystals apparently absent.

29. Eurosehinus Hook. f. in Benth. & Hook. f. Gen. i. 422 (1862). Type species, E. falcatus Hook. f. (Australia)

(1) Material

E. falcatus Hook. f.: 3 samples, Queensland, Australia
1 sample, New South Wales. Australia
E. obtusifolius Engl.: 1 sample, New Caledonia
E. papuanus Merr. & Perry: 1 sample, New Guinea

Eurosehinus, with five species of medium to large trees, occurs in eastern Australia, New Guinea, and New Caledonia. Three species were studied. The heartwood is light pinkish brown, often with greenish yellow streaks, light to moderately light, moderately hard, with fine texture and medium luster. Grain somewhat interlocked.

(2) Macroscopic Structure

Growth rings indistinct. Pores more or less distinct without a lens, evenly distributed, rather numerous, particularly in E. papuanus, solitary, in short radial multiples of 2 to 4, and occasionally in small clusters (Plate 14, Figs. 1 and 2). Vessel lines usually distinct and darker than background. Rays visible without a lens, fine, closely spaced, distinct on radial surface, slightly darker than background. Parenchyma paratracheal, sparse, visible with lens.

(3) Microscopic Structure

Vessels 7 to 27 per sq. mm., generally thin-walled, round in cross section. Tangential diameters from 35 to 186 μ (mostly 69 to 117 μ).

Vessel elements medium-sized, 276 to 794 μ (mostly 450 to 656 μ) in length; ends slightly to moderately oblique; projecting tips short to long and thin, long and thick, or none; perforations simple with a narrow rim, rarely with modified scalariform plates in E. obtusifolius and E. falcatus (Plate 48, Fig. 1); tyloses rare.

Intervascular pit-pairs alternate, occasionally transitional, medium-sized to large; apertures conspicuous, lenticular, generally included; borders rounded to irregular in outline, 6 to 17 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval to horizontally elongated or scalariform, up to 13 per cross field. Pit-pairs from vessel to wood parenchyma not noted.

Fibers forming more than half the ground mass of the wood in transverse section, generally straight, tapering gradually to long, needle-like ends, but occasionally with a "heel" or

bifurcate; 0.38 to 1.15 mm. long (mostly 0.55 to 0.98 mm.), 12 to 39 μ in diameter; lumina large; walls fairly thin; sporadically septate in vicinity of vessels. Resin-like deposits in some fibers (Plate 14, Fig. 2).

Pit-pairs small, indistinctly bordered, not conspicuous, on radial walls only.

Parenchyma paratracheal, sparse; sometimes incompletely vasicentric and sporadically slightly aliform in E. falcatus and E. papuanus. Resin-like deposits present; small crystals in some cells.

Rays 4 to 20 fiber widths apart in cross section; 5 to 8 per mm., straight, heterogeneous (Type II B) with 1 to 3, occasionally 4 rows of square or upright marginal cells. In tangential section the rays are 1 to 3, rarely to 4 seriate, mostly 2 to 3 (0.01 to 0.54 mm.), 2 to 30 cells high (0.09 to 0.82 mm.). Horizontal intercellular canals present, often very large, surrounded by 2 to 4 rows of very small epithelial cells (Plate 36, Fig. 2). Fusiform rays up to 7 cells wide at broadest point (0.06 to 0.20 mm.), 11 to 37 cells high (0.10 to 0.83 mm.). Resin-like deposits present in most rays; crystals present in marginal cells, often in chambered upright

cells with as many as 4 chambers, each with a solitary crystal (Plate 48, Fig. 2); occasionally present in procumbent cells.

30. Rhodosphaera Engl. in Engl. Bot. Jahrb. i. (1881) 423.
Type species, R. rhodanthema Engl. (Australia)

(1) Material

R. rhodanthema Engl.: 1 sample, Queensland, Australia
1 sample, New South Wales, Australia

Rhodosphaera is a monotypic genus occurring in Queensland and New South Wales, Australia. The heartwood is greenish yellow or yellowish brown, often streaked with darker brown; the sapwood is light tan. The wood is moderately light to moderately heavy, moderately hard, with medium fine texture and rather high luster; straight grained.

(2) Macroscopic Structure

Growth rings not distinct, although they are simulated by concentric bands of darker colored fibers. Pores just within limit of vision with the naked eye, evenly distributed, moderately few, solitary, and in radial multiples of 2 to 4 (Plate 16, Fig. 1). Vessel lines not conspicuous. Rays faintly visible without a lens, fine, closely spaced, inconspicuous on radial surface, fine, lustrous flecks very slightly darker than background. Parenchyma not distinct.

(3) Microscopic Structure

Vessels 7 to 17 per sq. mm., moderately thin-walled, oval to round in cross section. Tangential diameters from 32 to 159 μ (mostly 83 to 131 μ).

Vessel elements medium-sized, 311 to 759 μ (mostly 476 to 683 μ) in length; ends nearly horizontal to decidedly oblique; projecting tips short and thin, or none; perforations simple with a narrow rim; tyloses thin-walled, rather abundant.

Intervascular pit-pairs alternate, medium-sized to large (mostly large); apertures conspicuous, slit-like, horizontal, included; borders generally angular, 9 to 18 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, round to oval or irregular (Plate 45, Fig. 1). Vessel-to-wood parenchyma pit-pairs absent.

Fibers forming at least half the ground mass of the wood in transverse section, generally straight, tapering gradually to narrow ends, occasionally with a "heel" or bifurcate; 0.38 to 1.24 mm. long (mostly 0.65 to 1.08 mm.), 9 to 39 μ in diameter; lumina large; walls thin to moderately thick; septate, especially in wide fibers surrounding vessels.

Pit-pairs small, indistinctly bordered, on radial walls primarily.

Parenchyma generally absent, rarely paratracheal, sparse.

Rays 2 to 16 fiber widths apart in cross section; 7 to 13 per mm., generally straight, heterogeneous (Type II A) with 1 to 3 rows of upright cells at margin (Plate 37, Fig. 1; Plate 45, Fig. 2). In tangential section the rays are primarily biseriate (0.01 to 0.04 mm.), 1 to 41 cells high (0.10 to 0.97 mm.). Horizontal intercellular canals present, infrequent, moderately small, surrounded by 1 to 4 rows of very small epithelial cells. Fusiform rays generally 3 cells wide (0.05 to 0.08 mm.), 19 to 26 cells high (0.29 to 0.61 mm.). Resin-like deposits in cells; large crystals abundant in both upright and procumbent cells.

31. Blepharocarya F. Mueller, Fragm. ix (1878) 15. Type species, B. involucrigera F. Mueller (Queensland, Australia)

(1) Material

B. involucrigera F. Muell.: 2 samples, Queensland, Australia

Blepharocarya is a monotypic genus occurring only in Queensland, Australia. The heartwood is light pinkish brown with a greenish tinge in some areas, moderately light, moderately hard, with fairly fine texture and golden luster; generally straight grained.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with the naked eye, evenly distributed, not numerous, mostly solitary, but also in radial multiples of 2 to 3, occasionally to 4 or 5 (Plate 15, Figs. 1 and 2). Vessel lines distinct, darker than background. Rays visible with a lens, fine, fairly closely spaced, distinct on radial surface as light, reddish brown flecks. Parenchyma just visible with lens, paratracheal, sparse.

(3) Microscopic Structure

Vessels 4 to 10 per sq. mm., thin-walled, round to oval in cross section. Tangential diameters from 46 to 228 μ (mostly 124 to 173 μ).

Vessel elements medium-sized, 414 to 911 μ (mostly 531 to 690 μ) in length; ends usually horizontal, occasionally oblique; projecting tips short and thin, long and thick, frequently none; perforations simple with a narrow rim (Plate 49, Fig. 2); tyloses thin-walled, not abundant.

Intervascular pit-pairs alternate, medium-sized; apertures lenticular, nearly horizontal, included; borders rounded to angular in outline, 7 to 10.5 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, rounded, irregular, horizontally or vertically elongated (Plate 44, Fig. 2). Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming more than half the ground mass of the wood in cross section, generally straight, tapering gradually to long, thin ends, or with a "heel"; widest fibers frequently very short with blunt ends; 0.43 to 1.26 mm. long (mostly 0.66 to 1.08 mm.), 12 to 34 μ in diameter; lumina large; walls thin; rarely septate, with very fine septa (Plate 37, Fig. 2).

Pit-pairs small, indistinctly bordered, not conspicuous, but rather numerous, on radial walls only.

Parenchyma paratracheal, incompletely vasicentric, sparse; resin-like deposits present.

Rays 2 to 14 fiber widths apart in cross section; 8 to 12 per mm., straight, heterogeneous (Type II B) with 1 to 3 rows of square or upright marginal cells. In tangential section the rays are predominantly biseriate, occasionally uniseriate (0.014 to 0.05 mm.), 1 to 35 cells high (0.05 to 1.00 mm.). Horizontal intercellular canals absent. Resin-like deposits present, but not abundant; crystals in marginal cells, infrequent.

32. Cotinus [Tourn.] Miller, Gard. Dict. abridged ed. 4 (1754). Type species, C. coggygria Scop. (Europe)

(1) Material

C. coggygria Scop.: 1 sample, Poland
1 sample, Transcaucasia, U.S.S.R.
C. coggygria Scop. var. cinera Engl.: 1 sample, China

There are two species of Cotinus, one occurring in Europe and Asia, the other in North America. One species was studied. The heartwood is deep golden yellow with a greenish tinge, often with orange streaks; the sapwood is very narrow, almost white. The wood is moderately heavy, medium-hard, with moderately coarse, uneven texture and high luster; straight grained.

(2) Macroscopic Structure

Growth rings distinct, marked by several rows of early wood vessels, visible with the unaided eye; late wood pores just within limit of vision with a lens, in radial multiples and clusters tending to form a somewhat oblique or flame-like pattern (Plate 16, Fig. 2). Vessel lines distinct in early wood zones, inconspicuous in late wood. Rays visible with lens, very fine, closely spaced, distinct on radial surface only because of luster, little darker than background. Parenchyma scarcely distinct with lens, paratracheal, sparse.

(3) Microscopic Structure

Vessels in: (a) early wood, solitary, or in radial or tangential multiples of 2 to 3, rarely more, in concentric bands 1 to 3 rows wide; moderately thick-walled, oval or round in cross section, flattened at points of contact; tangential diameters from 35 to 173 μ (mostly 90 to 138 μ); (b) late wood, longer multiples and clusters tending to form a wavy or oblique pattern, moderately thick-walled, mostly angular because of crowding within the clusters; tangential diameters from 12 to 69 μ.

Vessel elements extremely to moderately short, 152 to 366 μ in length; ends horizontal, especially in early wood elements, to decidedly oblique; projecting tips short to long and thin, occasionally long and thick, or none; perforations simple with a narrow rim; tyloses thin-walled, abundant.

Intervascular pit-pairs alternate, medium-sized to large; apertures conspicuous, lenticular, generally horizontal, included; borders round or oval in outline, 8 to 10.5 μ in diameter. Vessel-to-ray pit-pairs moderately large, half-bordered, round or oval. Pit-pairs from vessel to wood parenchyma not observed.

Spiral thickenings present in smaller vessel elements (Plate 38, Fig. 2; Plate 50, Fig. 1).

Fibers forming nearly half the ground mass of the wood in transverse section, straight, tapering gradually to long, thin ends, but often twisted, and rarely tapering abruptly to a pointed end; 0.19 to 0.66 mm. long, 9 to 23 μ in diameter; lumina large; walls moderately thick; non-septate.

Pit-pairs very small, simple or indistinctly bordered, inconspicuous, apparently on radial walls only.

Parenchyma paratracheal, incompletely vasicentric, sparse.

Rays 2 to 20 fiber widths apart in cross section; 12 to 18 per mm., straight, or slightly bent to conform to the pore outline, heterogeneous (Type II B), with 1 or 2 rows of square or upright marginal cells. In tangential section the rays are uniseriate and biseriate (0.009 to 0.03 mm.), 3 to 33 cells high (0.04 to 0.48 mm.). Horizontal intercellular canals absent; resin-like deposits abundant; large crystals in marginal cells.

33. Heeria Meissn. Gen. Comm. 55 (1837). Type species, H. argentea Meissn. (Africa)

(1) Material

H. macronifolia Engl.: 1 sample (H. J. Schlieben, No. 6167, Tanganyika, East Africa

There are about seven species of Heeria occurring in tropical and subtropical Africa. One species was studied. The heartwood is light pinkish brown, the sapwood grayish buff. The wood is moderately heavy and hard, with rather coarse texture and low luster. The grain is slightly interlocked.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with naked eye, evenly distributed, moderately few, solitary, or in radial multiples of 2 to 3, occasionally to 4, or in small clusters (Plate 13, Fig. 1). Vessel lines distinct, darker than background. Rays scarcely visible with a lens, very fine, closely spaced, distinct on radial surface as dark brown flecks. Parenchyma visible with lens, paratracheal, vasicentric to somewhat aliform and rarely confluent.

(3) Microscopic Structure

Vessels 12 to 16 per sq. mm., thin-walled, generally round in cross section. Tangential diameters from 62 to 173 μ (mostly 83 to 138 μ).

Vessel elements medium-sized, 304 to 966 μ (mostly 504 to 690 μ) in length; ends horizontal to moderately oblique; projecting tips short and thin, frequently very long and thick, or none; perforations simple with a narrow rim.* Tyloses present, thin-walled.

Intervascular pit-pairs alternate, medium-sized to large; apertures conspicuous, lenticular, horizontal, included; borders rounded or angular through crowding, 8 to 15 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval, horizontally elongated, or gash-like. Pit-pairs from vessel to wood parenchyma not observed.

Fibers forming about half the ground mass of the wood in transverse section, straight, tapering gradually to very long, needle-like ends; 0.40 to 1.60 mm. long (mostly 0.97 to 1.30 mm.), 12 to 23 μ in diameter; lumina rather large; walls moderately thick; septate. Many fibers contain resin-like deposits, particularly in the region of the septa.

Pit-pairs small, indistinctly bordered, not very conspicuous, on radial walls only.

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*Heimsch (1942) reports that Heeria argentea (E. Mey) O. Ktze. possesses some vessels with scalariform perforation plates, but these are not present in the material studied by the writer.

Parenchyma paratracheal, vasicentric, occasionally aliform and very rarely confluent. Resin-like deposits in cells.

Rays 2 to 16 fiber widths apart in cross section; 7 to 10 per mm., straight, heterogeneous (Type II B), with 1 to several rows of square or upright marginal cells. In tangential section the rays are 1 to 3 cells wide (0.01 to 0.05 mm.), 2 to 37 cells high (0.08 to 0.90 mm.), Horizontal intercellular canals absent; resin-like deposits abundant (Plate 35, Fig. 2), and crystals are present occasionally in upright cells.

34. Rhus [Tourn.] Linn. Gen. ed. I. 84 (1737). Type species, R. Coriaria L. (S. Europe)

(1) Material

R. australis*: 1 sample, Queensland, Australia
R. Engleriana Warb.: 1 sample (Waterhouse, No. 329, Nodup, New Britain)
R. japonica Buch. Ham.: 1 sample, Korea
R. semialata Murr.: 1 sample, Japan
1 sample, China
R. semialata Murr. var. sandwicensis Engl.: 1 sample, Hawaii
R. simarubaefolia A. Gray: 1 sample (Waterhouse, No. 184, Bougainville Island)**
1 sample (NGF. 1815, Kar Kar Island, New Guinea)**
1 sample, New Guinea
R. succedanea Linn.: 1 sample, China
1 sample, Japan
R. sylvestris Sieb. & Zucc.: 1 sample, Japan
R. trichocarpa Miq.; 1 sample, Japan

There are about one hundred and thirty species of Rhus, trees and shrubs, occurring throughout subtropical and warm temperate regions of the world. Eight species were studied. The heartwood is light pinkish brown streaked with gray, yellow, and green, or sometimes

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*This specimen from the Yale collection (No. 19424) has no author's name on its species card, nor is the writer able to find it listed in any publication concerned with the genus Rhus. It is so like specimens of Rhodosphaera rhodanthema Engl., however, that the writer is convinced it is the same, especially since Rhodosphaera also occurs in Queensland, Australia. Although Rhus australis is described with the genus Rhus, it is not included in the discussion because it is not a valid specimen. It is included in Table I, however, except for the matter of occurrence of intercellular canals, for its true identity was not realized until the table was completed.

**One specimen from the Yale collection, collected in New Guinea, and the specimen from Dr. Dadswell, collected on Bougainville Island, are listed as the synonymous Rhus taitensis Guillem.

olive green, or light orange-yellow in R. australis; the sapwood is almost white. The wood is light to moderately light, moderately soft to moderately hard, with medium to rather coarse texture and high luster. Grain straight to interlocked.

(2) Macroscopic Structure

a. Ring-porous woods: R. japonica, R. semialata, R. semialata var. sandwicensis, R. succedanea, R. sylvestris, R. trichocarpa.

Growth rings visible, formed by differences in pore size and occasionally by differences in color. Early wood pores visible without a lens, in wide bands, except in R. sylvestris, where they are in very narrow bands, fairly closely spaced at the beginning of the growth ring, uniformly and widely spaced throughout remainder of zone, mostly solitary, but also in radial multiples of 2 to 3, occasionally more. Late wood pores in small clusters of minute pores in R. japonica, R. semialata, and R. semialata var. sandwicensis; in long radial multiples or chains of up to 10 pores in R. succedanea; and solitary or in short radial multiples of 2 to 5 cells, rarely very small clusters, in R. trichocarpa and R. sylvestris (Plates 19 and 20).

Vessel lines distinct in early wood, darker than background. Rays faintly visible without a lens, very fine, closely spaced, distinct on radial surface as very fine flecks. Parenchyma not distinct.

b. Diffuse-porous woods: R. australis, R. Engleriana, R. simarubaefolia.

Growth rings not distinct. Pores visible with unaided eye, evenly distributed, moderately numerous, solitary, and in short radial multiples of 2 to 3, occasionally up to 5 or 6 (Plate 21, and Plate 22, Fig. 1). Vessel lines generally distinct, not conspicuous. Rays faintly visible without a lens, fine and closely spaced, distinct on radial surface as fine, light brown flecks. Parenchyma not visible.

(3) Microscopic Structure

Vessels 8 to 15 per sq. mm. (diffuse-porous woods), thin-walled except in R. succedanea and R. sylvestris, where moderately thick-walled; round in cross section in early wood, angular in late wood of ring-porous specimens, round to oval in diffuse-porous woods. Tangential diameters: (a) early wood, 55 to 248 μ (mostly 138 to 186 μ), with gradual decrease in size from beginning to end of zone; (b) late wood, mostly

smaller than 70μ, frequently less than 40μ; (c) diffuse-porous wood, 32 to 228μ (mostly 117 to 173μ).

Vessel elements short to medium-sized, 179 to 725 μ (mostly 331 to 587μ) in length; ends horizontal to oblique; projecting tips mostly short and thin, or none, occasionally moderately long and thick; perforations simple with a narrow rim; tyloses thin-walled, abundant in most species.

Intervascular pit-pairs alternate, small in R. succedanea and R. sylvestris; medium-sized to large in the others; apertures lenticular in larger pit-pairs, nearly round in small ones, confluent in R. succedanea and R. sylvestris, included in others; borders rounded to angular in outline, 5 to 9μ in diameter in R. succedanea and R. sylvestris, 8 to 15μ in the others. Vessel-to-ray pit-pairs half-bordered, round to elongated or gash-like. Pit-pairs from vessel to wood parenchyma not observed. Spiral thickenings in smaller vessels of R. japonica and R. semialata.

Fibers forming at least half the ground mass of the wood in transverse section, straight, tapering gradually to narrow ends, but occasionally the shorter elements taper slightly to

broad, rounded ends; 0.35 to 1.58 mm. long (mostly 0.59 to 1.00 mm.), 14 to 46 μ in diameter; lumina large, smaller near limit of early wood zone where fibers are always flattened; walls moderately thick in R. sylvestris, thin in others; septate in R. australis, R. succedanea, and R. sylvestris (Plate 38, Fig. 3), sporadically septate in R. trichocarpa; non-septate in others. Resin-like deposits occasionally present.

Pit-pairs very small, simple or indistinctly bordered, on radial walls.

Parenchyma paratracheal to vasicentric, sparse in most specimens. Resin-like deposits occasionally present, crystals infrequent.

Rays 2 to 24 (mostly 2 to 12) fiber widths apart in cross section; 5 to 14 per mm., generally straight, but bent slightly to conform to the outline of the larger pores, heterogeneous (Type II B), with 1 to 2 rows of square or upright marginal cells. In tangential section the rays are 1 to 4 cells wide (0.14 to 0.62 mm.), 3 to 75 cells high in R. trichocarpa (Plate 39, Fig. 2), 3 to 54 cells high in R. australis (Plate 39, Fig. 3) and R. semialata, and rarely more than 25 cells high (Plate 39, Fig. 1) in the others (0.15 to 1.42 mm. in R. trichocarpa

and R. australis, to 0.87 mm. in R. semialata, and rarely higher than 0.57 mm. in the others). Horizontal intercellular canals absent, except in R. australis, where they are exceedingly rare; resin-like deposits present in most cells. Rhombohedral crystals in many cells, crystal druses in some cells of all specimens except R. australis, R. succedanea, and R. sylvestris, and chambered marginal crystal-bearing cells in R. succedanea.

IV. Semecarpeae

35. Nothopegia Blume, Mus. Bot. Lugd. Bat. i. 203 (1850).
Type species, N. Colebrookiana Blume (E. India)

(1) Material

N. Colebrookiana Blume: 1 sample, Ceylon

There are about three species of Nothopegia occurring in eastern India and Ceylon. One species was studied. The heartwood is very light pinkish brown, with occasional streaks of yellowish green, moderately heavy, fairly hard, with fine texture and rather high luster; interlocked grain.

(2) Macroscopic Structure

Growth rings not distinct. Pores not visible without a lens, evenly distributed, fairly numerous, solitary, and in radial multiples of 2 to 4. Vessel lines not distinct. Rays visible with lens, very fine and closely spaced, distinct on radial surface as fine, light brown flecks. Parenchyma visible with lens, paratracheal, vasicentric and aliform, occasionally confluent.

(3) Microscopic Structure

Vessels 20 to 27 per sq. mm., fairly thick-walled, round to oval or somewhat angular in cross section. Tangential diameters from 35 to 97 μ (mostly 55 to 83 μ).

Vessel elements medium-sized, 380 to 711 μ (mostly 518 to 642 μ) in length; ends nearly horizontal to decidedly oblique; projecting tips short to long and very narrow, rarely long and thick, or none; perforations simple with a narrow rim; tyloses present, thin-walled.

Intervascular pit-pairs alternate, large; apertures conspicuous, lenticular, horizontal, generally included; borders rounded to angular through crowding, 10.5 to 14 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval to gash-like or scalariform. Vessel-to-wood parenchyma pit-pairs similar.

Fibers forming about half the ground mass of the wood in transverse section, straight, tapering gradually to very long, thin ends; 0.69 to 1.55 mm. long (Mostly 0.84 to 1.17 mm.), 11 to 17 μ in diameter; lumina moderately large; walls fairly thick; non-septate.

Pit-pairs very small, simple, on both radial and tangential walls.

Parenchyma moderately abundant; paratracheal, vasicentric to aliform and often confluent, connecting several pores in a tangential band; probably best described as transitional

between banded and aliform (Plate 25, Fig. 1). Resin-like deposits present.

Rays 2 to 12 fiber widths apart in cross section; 11 to 16 per mm., straight, heterogeneous (essentially Type II B), with one or occasionally more rows of tall upright marginal cells, and sometimes interspersed upright cells. In tangential section the rays are 1 to 3 seriate, mostly 2 to 3 seriate (0.01 to 0.05 mm.), 2 to 41 cells high (0.13 to 0.88 mm.) (Plate 42, Fig. 1). Horizontal intercellular canals absent; resin-like deposits in most cells; large solitary crystals abundant in both marginal and procumbent cells (Plate 46, Fig. 1; Plate 51, Fig. 1).

36. Melanochyla Hook. f. Flora Brit. Ind. ii. 38 (1876). Type species, M. tomentosa Hook. f. (Malacca)

(1) Material

M. bracteata King: 1 sample, Malaya
M. Kunstleri King: 2 samples (H. E. Desch, No. 3851, For. Res. Inst., Kepong, Selangor, Malay)
M. rugosa King: 1 sample, Fed. Malay States
M. tomentosa Hook. f. var. glabrescens Koord. & Valet.: 1 sample, W. Java

The six species of Melanochyla are confined to Malaya and Java. Four species were studied. The heartwood is light pinkish or yellowish brown, usually with a greenish tinge, moderately heavy to heavy, medium hard, with moderately coarse texture and medium luster. The grain is usually interlocked.

(2) Macroscopic Structure

Growth rings not distinct. Pores visible with unaided eye, evenly distributed, not numerous, mostly solitary, but also in radial multiples of 2 to 3 (Plate 25, Fig. 2). Vessel lines distinct, darker than background. Rays just within limit of vision without a lens, fine, closely spaced, distinct on radial surface as fine brown flecks. Parenchyma visible without a lens in M. tomentosa var. glabrescens, paratracheal, aliform to confluent.

(3) Microscopic Structure

Vessels 3 to 7 per sq. mm., thin-walled, round in cross section. Tangential diameters from 45 to 228 μ (mostly 104 to 173 μ).

Vessel elements medium-sized, 386 to 828 μ (mostly 545 to 690 μ) in length; ends horizontal to oblique; projecting tips short and thin, long and thick, or none; perforations simple with a narrow rim; tyloses thin-walled, common.

Intervascular pit-pairs alternate, medium-sized to large; apertures lenticular, horizontal, generally included; borders angular because of crowding, 8 to 13 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, rounded to irregular and horizontally elongated. Vessel-to-wood parenchyma pit-pairs similar.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually to very long, thin ends; 0.67 to 1.59 mm. long (mostly 0.96 to 1.31 mm.), 12 to 26 μ in diameter; lumina moderately large to large; walls moderately thick; non-septate.

Pit-pairs small, inconspicuous, indistinctly bordered, on radial walls only.

Parenchyma moderately abundant, paratracheal, aliform, often tangentially extended and sometimes confluent (Plate 25, Fig. 2). Resin-like deposits present.

Rays 2 to 16 fiber widths apart in cross section; 9 to 14 per mm., generally straight, but occasionally slightly bent to conform to the pore outline, heterogeneous (Type II B), with 1 or 2 rows of square or upright marginal cells. In tangential section the rays are 1 to 2 cells wide (0.014 to 0.06 mm.), 1 to 25 cells high (0.08 to 0.82 mm.). Horizontal intercellular canals present, small to medium-sized, surrounded by 1 or 2 rows of small epithelial cells (Plate 40, Fig. 2). Fusiform rays 4 to 8 cells wide at widest part (0.07 to 0.15 mm.), 16 to 31 cells high (0.43 to 0.79 mm.). Resin-like deposits in most cells; crystals in both marginal and procumbent cells of all specimens.*

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*Dadswell and Ingle (1948) report that crystals are absent in M. bracteata. In a specimen of that species received from Dr. Dadswell, however, the writer noted sparse crystals in both marginal and procumbent cells of the rays.

37. Semecarpus Linn. f. Suppl. 285 (1781). Type species, S. Anacardium L. f. (Tropical Asia and Australia)

(1) Material

S. Anacardium L. f.: 1 sample (Waterhouse, No. 71, Melanesia)
S. atra Vielle.: 2 samples, New Caledonia
1 sample (A. C. Smith, No. 1934, Fiji Islands; herb. mat. in N. Y. Bot. Gard.)*
S. heterophylla Blume: 1 sample, W. Java
S. laxiflora K. Schum. var. glabrescens Lauterb.: 1 sample (Waterhouse, No. 61, Melanesia)
S. lucens King: 2 samples (H. E. Desch, No. 3828, For. Res. Inst., Kepong, Selangor, Malay)
Semecarpus sp.: 1 sample (Rahmat 2905, Sumatra)

There are about forty species of Semecarpus, all medium-sized to large trees, occurring in the southwest Pacific area from the Philippines to New Caledonia. Five species were studied. The heartwood is light brown, usually with a pinkish tinge, or with streaks of pink or yellow, light, rather soft, with moderately fine to moderately coarse texture and medium luster; straight grained.

(2) Macroscopic Structure

Growth rings not distinct. Pores distinct to just within limit of vision without a lens, evenly distributed, not numerous, mostly solitary, but also in radial multiples

*This specimen from the Yale collection is listed as the synonymous Oncocarpus vitiensis A. Gray.

of 2 to 4. Vessel lines distinct, darker than background. Rays visible without a lens, moderately fine, closely spaced, distinct on radial surface as fine, lustrous brown flecks. Parenchyma visible without lens, abundant paratracheal, vasicentric, aliform to confluent.

(3) Microscopic Structure

Vessels 1 to 6 per sq. mm., thin-walled, round to somewhat angular in cross section. Tangential diameters from 124 to 373 μ in S. Anacardium, from 97 to 269 μ in S. atra and S. heterophylla, and from 48 to 193 μ in S. laxiflora and S. lucens.

Vessel elements mostly medium-sized, 297 to 752 μ (mostly 400 to 614 μ) in length; ends nearly horizontal to moderately oblique; projecting tips short to long and thick, or none; perforations simple with a narrow rim; tyloses thin-walled, not abundant.

Intervascular pit-pairs alternate, medium-sized to very large (mostly large); apertures conspicuous, lenticular, horizontal, included; borders angular in outline, 9 to 17 μ in diameter (Plate 43, Fig. 2). Vessel-to-ray pit-pairs very large, half-bordered to apparently simple, rounded to gash-like (Plate 44,

Fig. 1). Vessel-to-wood parenchyma pit-pairs similar, often scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, straight, tapering gradually or abruptly to long, thin ends; 0.51 to 1.87 mm. long (mostly 1.04 to 1.48 mm.), 17 to 45μ in diameter; lumina large; walls thin; non-septate.

Pit-pairs moderately small, indistinctly bordered, conspicuous because numerous, on radial walls only.

Parenchyma abundant (particularly in S. laxiflora), paratracheal, vasicentric, aliform to confluent (Plates 23 and 24). Resin-like deposits present.

Rays 1 to 14 fiber widths apart in cross section; 7 to 11 per mm., straight, heterogeneous (intermediate between Type II A and B), with 1 to 4 rows of square or upright marginal cells (Plate 41, Figs. 1 and 2). In tangential section the rays are 1 to 3 cells wide (mostly 2 to 3), rarely 4 (0.015 to 0.06 mm.), 1 to 35 cells high (0.13 to 0.88 mm.). Horizontal intercellular canals absent; resin-like deposits abundant; crystals present in some rays, rare.*

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*Dadswell and Ingle (1948) report crystals abundant in both marginal and procumbent cells, but the writer failed to observe them in the two specimens sent for study by Dr. Dadswell.

38. Holigarna Buch. Ham. ex Roxb. Hort. Beng. 22. (1814). Type species, H. longifolia Buch. Ham. (E. India)

(1) Material

H. Arnottiana Hook. f.: 1 sample (No. W. 6321, For. Res. Inst., Dehra Dun, India)
H. Beddomei Hook. f.: 1 sample, Dehra Dun, India
H. Helferi Hook. f.: 1 sample (No. B. 7169, For. Res. Inst., Dehra Dun, India)
H. longifolia Buch. Ham.: 1 sample (No. E. 6729, For. Res. Inst., Dehra Dun, India)

Holigarna, with five species, occurs in eastern India. Four species were studied. The heartwood is white to light gray, often with a yellowish tinge, light, soft, rather coarse textured, with moderately high luster; straight grained.

(2) Macroscopic Structure

Growth rings not distinct, although bands of thickened fibers occasionally simulate growth rings. Pores visible with unaided eye, evenly distributed, not numerous, mostly solitary, but also in radial multiples of 2 to 4, rarely more, or infrequently in small clusters. Vessel lines distinct, darker than background. Rays visible without a lens, fine and closely spaced, distinct on radial surface as fine brown flecks. Parenchyma abundant, paratracheal, vasicentric, aliform and occasionally confluent.

(3) Microscopic Structure

Vessels 1 to 5 per sq. mm., thin-walled, oval to round and occasionally angular in cross section (Plate 26, Fig. 2). Tangential diameters from 62 to 271 μ (mostly 138 to 200 μ).

Vessel elements medium-sized, 359 to 849 μ (mostly 421 to 650 μ) in length; ends horizontal to oblique; projecting tips short and rather thick or none; perforations simple with a narrow rim; tyloses thin-walled, often abundant. Resin-like deposits in some elements.

Intervascular pit-pairs alternate, large to very large; apertures conspicuous, lenticular, horizontal, included; borders rounded to polygonal or angular through crowding, 9 to 18 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, irregular to scalariform. Vessel-to-wood parenchyma pit-pairs similar, often scalariform.

Fibers forming more than half the ground mass of the wood in transverse section, generally straight, tapering gradually to long, narrow ends, or occasionally with a "heel"; 0.49 to 1.62 mm. long (mostly 1.04 to 1.35 mm.), 15 to 42 μ in diameter; lumina large; walls thin; non-septate.

Pit-pairs small, indistinctly bordered, with rounded apertures, conspicuous because numerous, on radial walls only.

Parenchyma generally abundant, paratracheal, vasicentric in a sheath 1 to several rows wide, often aliform and occasionally confluent (Plate 26, Figs. 1 and 2). Resin-like deposits present, not abundant.

Rays 2 to 16 fiber widths apart in cross section; 6 to 11 per mm., generally straight, heterogeneous (Type II B), with 1 to 5 rows of square or upright marginal cells. In tangential section the rays are 1 to 3 (mostly 2) cells wide (0.02 to 0.075 mm.), 2 to 55 cells high (0.16 to 1.46 mm.). Horizontal intercellular canals absent; resin-like deposits in many cells (Plate 40, Fig. 1). Small rhombohedral crystals and large crystal druses present in marginal and procumbent cells of H. Helferi, absent in all other specimens.

Genus of Uncertain Position

39. Juliania Schlecht. in Linnaea, xvii (1843) 746. Type species, J. adstringens Schlecht. (Mexico)

(1) Material

J. adstringens Schlecht.: 1 sample, Mexico

There are four species of Juliania occurring in Mexico, Guatemala, and Honduras. One species was studied. The wood is light yellowish buff, light, soft, with fine texture and moderately low luster; straight grained.

(2) Macroscopic Structure

Growth rings weakly defined, marked by bands of slightly flattened fibers. Pores visible with a lens, evenly distributed, moderately numerous, solitary or in radial multiples of 2 to 5, occasionally more, and in small clusters (Plate 22, Fig. 2). Vessel lines faintly visible, scarcely darker than background. Rays visible with naked eye, moderately fine, closely spaced, distinct on radial surface only because of luster. Parenchyma paratracheal, sparse.

(3) Microscopic Structure

Vessels 13 to 20 per sq. mm., thin-walled, rounded to angular in cross section. Tangential diameters from 29 to 166 μ (mostly 69 to 124 μ).

Vessel elements extremely to moderately short, 131 to 414 μ (mostly 262 to 386 μ) in

length; ends horizontal to oblique; projecting tips short and thin or thick to moderately long and thick, or none; perforations simple with a narrow rim* (Plate 50, Fig. 2); tyloses thin-walled.

Intervascular pit-pairs alternate and opposite (mostly alternate), medium-sized to very large; apertures conspicuous, horizontally elongated, included; borders rounded to angular in outline, 6 to 18 μ in diameter. Vessel-to-ray pit-pairs large, half-bordered, oval to horizontally elongated or gash-like (Plate 46, Fig. 2). Vessel-to-wood parenchyma pit-pairs similar.

Fibers forming slightly less than half the ground mass of the wood in transverse section, generally straight, tapering gradually to moderately long, thin ends, but frequently tapering abruptly and thus forming a distinct "shoulder"; 0.35 to 1.11 mm. long (mostly 0.56 to 0.91 mm.), 15 to 46 μ in diameter; lumina large; walls thin; septate, with numerous septa. Resin-like deposits occasionally present.

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*Stern (1952) reports that a few reticulate perforation plates were observed in each species examined. Neither Record and Hess (1943), Metcalfe and Chalk (1950), nor Heimsch (1942) noted them, however, nor were such perforations observed in the material available for this study.

Pit-pairs small, simple or indistinctly bordered, numerous, with rounded apertures, on radial walls only.

Parenchyma paratracheal, vasicentric, sparse. Resin-like deposits present.

Rays 2 to 16 fiber widths apart in cross section; 5 to 7 per mm., straight, heterogeneous (Type II B), approaching the homogeneous condition (Type I), with many rows of procumbent cells and 1 or 2 rows of square or low-upright marginal cells, the outermost often peaked or triangular in shape. In tangential section the rays are 1 to 5 cells wide, rarely 6 (0.017 to 0.11 mm.), 3 to 39 cells high (0.12 to 0.86 mm.) (Plate 42, Fig. 2). The uniseriate rays are infrequent and low. Horizontal intercellular canals present, infrequent, rarely of greater diameter than the procumbent cells, surrounded by a single layer of very small epithelial cells (Plate 43, Fig. 1). Fusiform rays are identical in size with the larger normal multiseriate rays. Resin-like deposits in most cells. Crystals abundant in marginal cells (Plate 46, Fig. 2).

TABLE I

SUMMARY OF ANATOMICAL CHARACTERISTICS OF THE GENERA

Genera	No. of Species Examined	PORES: At Least 10% Solitary	PORES: Short Radial Multiples	PORES: Small Clusters	PORES: Max. Tang. Diameter (μ)	PORES: Diam. of Pit Borders (μ)	PORES: Tyloses	RAYS: Width * No. of Cells	RAYS: Height No. of Cells	RAYS: Heterogeneous No. of Upright Cells	RAYS: Crystals: Marginal	RAYS: Crystals: Procumbent	RAYS: Echinulate Bodies	RAYS: Horizontal Resin Canals	PARENCHYMA: Vasicentric	PARENCHYMA: Aliform	PARENCHYMA: Apotracheal Bands	PARENCHYMA: Terminal	PARENCHYMA: Crystals	FIBERS: Septate
Antrocaryon	1	+	+ (2-3 pores)	Few	175-207	4-7	–	1-2(3)	< 21	+ (1-2)	–	–	–	–	+	–	+	–	Sparse	–
Blepharocarya	1	+	+ (2-3 occ. 5)	–	173-228	7-11	Sparse	(1), 2	< 35	+ (1-3)	Few	–	–	–	Sparse	–	–	–	–	Sparse
Bouea	2	+	+ (2-3)	Few	138-210	6-13	Sparse	1-2	< 36	+ (1-2)	+	–	–	–	+	Sparse	+	–	–	–
Buchanania	14	+	+ (2-3)	Few	200-290	8-15	Sparse in 1 sp. Sparse in most spp.	1-3	< 44	+ (1-2)	+	–	–	+	+	Sparse	–	–	–	Sparse
Campnosperma	7	+	+ (2-3)	–	110-155	8-17	Sparse	1-3	< 46	+ (1-3)	–	–	–	+	Sparse	–	–	–	–	Sparse
Cotinus	1	Ring-porous	+ Late Wood	Late Wood	69-138	8-11	+	1-2	< 33	+ (1-2)	+	–	–	–	Sparse	–	–	–	–	–
Dracontomelum	4	+	+ (2-3)	–	176-320	11-17	+	1, 2, 3-5	< 38	+ (1-2)	+	+	–	–	+	+	+ (In 1 sp.)	–	Sparse	+
Euroschinus	3	+	+ (2-4)	Few	117-186	6-17	Rare	1, 2-3(4)	< 37	+ (1-3)	+	Few	–	+	+	–	–	–	Occ.	Sporadic
Faguetia	1	+	+ (2-3)	Few	124-159	4-7	+	1-3(4)	< 28	+ (1-many)	+	–	–	–	+	Sparse	Sporadic	–	–	Sparse
Gluta	3	+	+ (2-3)	–	192-242	9-17	+	1	< 39	–	–	–	+	+	+	–	+	–	–	–
Haematostaphis	1	+	+ (2-3)	–	145-207	9-15	+	1, 2-3(4)	< 26	+ (2-4)	+	+	–	–	Sparse	–	–	–	+	+
Harpephyllum	1	+	+ (2-4)	Few	130-145	8-18	+	1-3	< 47	+ (1-4)	+	+	–	+	Sparse	–	–	–	–	+
Heeria	1	+	+ (2-3)	Few	138-173	8-15	+	1-3	< 37	+ (1-2)	Few	–	–	–	+	Sparse	–	–	–	+
Holigarna	4	+	+ (2-4)	Few	200-271	9-18	+	(1)-2(3)	< 55	+ (1-5)	+	+	–	–	+	Occ. confluent	–	–	–	+
Juliania	1	+	+ (2-5)	Few	124-166	6-18	+	1-5(6)	< 39	+ (1-2)	+ (1 sp.)	+ (1 sp.)	–	–	+	+	–	–	–	–
Koordersiodendron	1	+	+ (2-3)	–	160-200	8-19	+	1-3	< 39	+ (1-2)	+	–	–	+	Sparse	Occ. confluent	–	–	–	+
Lannea	8	+	+ (2-3 occ. 5)	Few	160-238	8-21	+	(1), 2-8	20-30	+ (1-2)	+	–	+	+	+	–	–	–	Sparse	+
Mangifera	11	+	+ (2-3)	Few	200-304	8-19	+	1-2(3)	< 24	+ (1-2)	+ Large	+	–	–	Sparse	–	–	–	–	+
Melanochyla	4	+	+ (2-3)	–	173-228	8-13	+	1-2	< 31	+ (1-2)	+	+	–	+	+	+	+	–	–	–
Melanorrhoea	8	+	+ (2-3)	–	232-304	9-15	+	1-(2)	< 34	+	–	–	+	+	+	+ (+ Confluent bands)	–	–	–	–
Microstemon	1	+	+ (2-3)	–	159-207	9-12	Sparse	2-4	< 34	Weakly + (1-3)	+	–	–	+	Sparse	+ Occ. confluent	+	–	–	–
Nothopegia	1	+	+ (2-4)	–	83-97	10-14	+	1, 2-3	< 41	+ (1-2)	+	+	–	–	Sparse	–	–	–	–	+
Odina	1	+	+ (2-3)	Few	160-200	8-19	+	2-4	< 30	+ (1-2)	+	–	+	+	+	+	–	–	–	–
Parishia	4	+	+ (2-3 occ. 5)	–	173-200	6-11	Rare	1-2(3)	< 32	+ (1-2)	– Large	–	+	+	Sparse	–	–	–	–	+
															+	±	–	–	–	–

* (1, 2 – 3 (4)) = Generally 2 to 3 cells wide, occasionally uniseriate and up to 4 cells wide.

TABLE I - Continued

Genera	No. of Species Examined	PORES: At Least 10% Solitary	PORES: Short Radial Multiples	PORES: Small Clusters	PORES: Max. Tang. Diameter (μ)	PORES: Diam. of Pit Borders (μ)	PORES: Tyloses	RAYS: Width * No. of Cells	RAYS: Height No. of Cells	RAYS: Heterogeneous No. of Upright Cells	RAYS: Crystals: Marginal	RAYS: Crystals: Procumbent	RAYS: Echinulate Bodies	RAYS: Horizontal Resin Canals	PARENCHYMA: Vasicentric	PARENCHYMA: Aliform	PARENCHYMA: Apotracheal Bands	PARENCHYMA: Terminal	PARENCHYMA: Crystals	FIBERS: Septate
Pentaspadon	3	+	+ (2-3)	–	166-242	8-10	Sparse	2-4	< 38	+ (1-3)	+	Few	–	+	Sparse	–	–	–	–	+
Pistacia	5	Ring-porous to semi-ring-porous	+ (2-3 in Early Wood)	+ (Late Wood)	88-208	7-10	+	1, 2-3(4)	< 42	+ (1-2)	+	–	–	+	Sparse	–	–	–	–	Sporadic
Pleiogynium	3	+	+ (2-3 Occ. 7)	–	125-180	6-12	+	1, 2(3)	< 25	+ (1-3)	+	–	–	+	+	+	–	–	–	Sporadic
Poupartia	1	Ring-porous	+ (Late Wood)	Few (Late Wood)	160-320	9-19	+	1, 2-4(5)	< 33	+ (1) Occ. 2-5	Large +	–	–	+	Sparse	–	–	Occ.	–	+
Protorhus	1	+	+ (2-3)	–	117-138	6-11	–	1-2(3)	< 49	+ (1-2)	Few	–	–	–	+	+ Occ. confluent	–	–	–	Rarely
Pseudospondias	1	+	+ (2-3)	–	138-175	6-13	Rare	1, 2-3	< 33	+ (1-4)	–	–	–	+	+	+	–	–	–	+
Rhodosphaera	1	+	+ (2-4)	–	131-159	9-18	+	(1)-2	< 41	+ (1-3)	+	+	–	+	Sparse	–	–	–	–	+
Rhus (Ring-porous, Early Wood)	5	+	+ (2-3)	–	186-248	5-15	+	1, 2-3(4)	< 25 (To 75 in 1 sp.; to 54 in 1 sp.)	+ (1-2)	+	+	–	–	+	–	–	–	+ (Rare)	+ (3 spp.)
(Ring-porous, Late Wood)		+ (In 1 sp.)	+ (2-5 in 2 spp. 2-10 in 1 sp.)	+	~70															
Rhus (Diffuse-porous)	3	+	+ (2-3 occ. 6)	–	173-228	5-15	+	1, 2-3(4)	< 25 (To 54 in 1 sp.)	+ (1-2)	+	+	–	–	+	–	–	–	+ (Rare)	+ (1 Sp.)
Sclerocarya	1	+	+ (2-3)	Few	145-207	7-19	+	2, 3-4	< 43	+ (1-2)	+	–	–	+	Sparse	–	–	–	–	+
Semecarpus	5	+	+ (2-4)	–	193-373	9-17	Sparse	1, 2-3	< 35	+ (1-4)	Few	–	–	–	+	+ Occ. confluent	–	–	Sparse	–
Soridoia	1	+	+ (2-3)	–	124-145	4-7	Sparse	1(2)	< 40	+ (1-3)	Few	–	–	–	Sparse	–	–	–	–	+
Spondianthus	2	+	+ (2-3)	Few	200-262	11-24	–	1-2, 5-10	< 165	+ (1-10)	Few	+	–	–	Sparse	–	–	–	–	+
Spondias	3	+	+ (2-3)	Few	225-345	10-21	Sparse	1, 2-7	< 52	+ (1-2)	+	+	–	+	+	+	–	–	Sparse	+
Swintonia	5	+	+ (2-3)	Few	240-304	9-19	+ (Sparse in 3 spp.)	1-2	< 52	+ (1) (Weakly)	–	–	+	+	+	–	+	–	+ (4 spp.)	–
Trichoscypha	3	+	+ (2-3)	–	138-173	4-8	Sparse	1-3(4)	< 33	+ (1-3)	–	–	+	+	+	+ Sparse, occ. confluent	–	–	–	–

* (1, 2 – 3 (4)) = Generally 2 to 3 cells wide, occasionally uniseriate and up to 4 cells wide.

Summary of the Anatomical Characteristics of the Non-American Genera of the Anacardiaceae

General discussion. -- The woods of the non-American genera of the Anacardiaceae are variable in color, but some are highly colored cabinet woods of distinctive appearance. Shades of brown from medium to deep red-brown are found in Gluta, Melanorrhoea, Koordersiodendron, Dracontomelum, Pleiogynium, Lannea, Odina, and Faguetia, often with streaks of darker brown or black, as in Dracontomelum. Rhodosphaera and Cotinus are bright yellow or yellowish brown, with a greenish tinge in the latter; Pistacia and Rhus (in part) are olive or greenish brown. The remaining genera are pale grayish or pinkish brown, or nearly white, often with streaks of yellow or green. The woods are light to heavy, soft to hard, with texture varying from fine to coarse, and luster apparently most pronounced in the paler woods, rather low in the darker colored specimens; grain straight to interlocked; without distinctive oder or taste.

Macroscopic structure. -- Ring-porous structure in Cotinus, Poupartia, Pistacia, and Rhus (in part); marked by larger pores in a narrow to wide band in the early wood zone, small to minute pores in late wood area in multiples, clusters, or solitary, often forming an oblique or flame-like pattern. Growth rings generally indistinct in diffuse-porous woods, although they are simulated in Mangifera, Gluta, Bouea, Melanorrhoea, and Swintonia, by irregularly spaced bands of apotracheal parenchyma, and in Pleiogynium, Spondias,

Sclerocarya, Harpephyllum, and Holigarna, by bands of flattened, often resin-filled fibers. Larger pores readily visible with naked eye, few to numerous, evenly distributed, predominantly solitary in most genera, but also in multiples of 2 to 5, rarely more, with multiples in largest number in Harpephyllum, Haematostaphis, Faguetia, Nothopegia, Juliania, Rhodosphaera, Rhus (in part), and Euroschinus; small clusters common in Pistacia, Cotinus, and Rhus (in part), infrequent in other genera. Vessel lines usually distinct, darker than background. Rays readily visible without a lens in Spondias, Spondianthus, Dracontomelum, Poupartia, Lannea (in part), and Juliania; commonly just within limit of vision or indistinct in the others. Parenchyma visible without a lens in Gluta, Melanorrhoea, Swintonia, Mangifera, Bouea, Dracontomelum, Semecarpus, Melanochyla, and Holigarna; paratracheal, vasicentric to aliform and confluent; apotracheal also in first five genera named; invisible without lens in remainder, generally sparse, paratracheal, vasicentric to short aliform or absent.

Microscopic structure. -- Vessels very few to numerous, 1 to 40 per sq. mm.; 1 to 6 in all the Mangifereae, Spondias, Antrocaryon, Dracontomelum, Semecarpus, and Holigarna; to more than 20 in Nothopegia, Euroschinus, and Campnosperma; walls usually thin, rounded or oval in outline when solitary, but occasionally angular in Faguetia, Campnosperma, Rhus (late wood), Nothopegia, Semecarpus, Holigarna, and Juliania; tangential diameters mostly medium-sized, large (many over 200μ)

in Mangifera (in part), Gluta, Swintonia, Melanorrhoea, Spondias, Dracontomelum, and Semecarpus (1 species), smallest (mostly 76 to 110 μ) in Campnosperma, Euroschinus, and Nothopegia. Vessel elements (Plate 2, Figs. 1 - 15; Plate 3, Figs. 1 - 16) mostly medium-sized, but long to very long in Spondianthus, moderately short in Cotinus and Juliania; ends decidedly oblique to horizontal; projecting tips short to long, narrow to thick, or none; perforation plates exclusively simple, except in Campnosperma, where scalariform and simple plates occur together, the scalariform sometimes predominating, with fine bars up to 20 in number, and in Euroschinus, where occasional modified scalariform or reticulate plates occur; tyloses absent only in Antrocaryon and Protorhus, rare or sparse in 14 genera, generally abundant in the remainder, thin-walled. Intervascular pit-pairs bordered, alternate, apertures lenticular to slit-like, included and generally horizontal, but sometimes exserted and inclined; borders rounded or angular because of crowding, diameters medium-sized (7 to 10 μ) in majority of genera, very large (many over 15 μ) in Dracontomelum, Rhodosphaera, Spondianthus, and Spondias, small (less than 7 μ) in Antrocaryon, Faguetia, Sorindeia, Trichocypha, and Rhus (in part); spiral thickenings in smaller vessels of Pistacia, Cotinus, and Rhus (in part). Vessel-to-ray pit-pairs typically large, half-bordered, the borders frequently indistinct and corresponding to the aperture, rounded to irregular and elongated vertically or

horizontally, gash-like, or scalariform in Harpephyllum, Sorindeia, Trichocypha, Campnosperma, Euroschimus, Nothopegia, Holigarna, and occasionally in Semecarpus.

Fibers (Plate 4, Figs. 1 - 13) with thick to thin walls, regularly septate in Dracontomelum, Haematostaphis, Harpephyllum, Heeria, Juliania, Koordersiodendron, Lannea, Microstemon, Odina, Pentaspadon, Poupartia, Pseudospondias, Rhodosphaera, Rhus (4 species), Sclerocarya, Sorindeia, Spondianthus, and Spondias, sparsely or sporadically septate in Blepharocarya, Buchanania, Campnosperma, Euroschinus, Faguetia, Pistacia, Pleiogynium, and Protorhus, non-septate in the remainder; pits generally small and inconspicuous, on radial walls primarily, except in Nothopegia, where they occur equally on tangential walls, simple or indistinctly bordered, sometimes filled with resin-like substance.

Parenchyma generally absent or very sparse in Campnosperma and Rhodosphaera; paratracheal, vasicentric in all other genera in varying amounts; aliform to confluent in Dracontomelum, Holigarna, Mangifera, Melanochyla, Nothopegia, Parishia, Pleiogynium, Protorhus, Pseudospondias, Semecarpus, Spondias, and Trichocypha; apotracheal in irregularly spaced bands, often discontinuous, narrow to moderately wide, in Antrocaryon, Bouea, Gluta, Mangifera, Melanorrhoea, and Swintonia (Plate 1, Figs. 1 - 5); crystals sparse in a few genera; resin-like deposits usually present.

Rays generally 1 to 10 cells wide in Spondianthus,

2 to 7 cells wide in Spondias and 1 species of Lannea, to 5 or occasionally 6 in Dracontomelum, Poupartia, and Juliania, uniseriate or partially biseriate in Bouea, Gluta, Melanorrhoea, Mangifera (in part), and Parishia (in part), but 2 to 3 seriate in the remainder; weakly to decidedly heterogeneous, with 1 to several rows of upright or square marginal cells in the majority of genera; more or less homogeneous in Gluta and Melanorrhoea; ray height variable from 165 cells in Spondianthus to a maximum of 21 cells in Antrocaryon, but the remainder rarely have a maximum greater than 50 or lower than 25: horizontal intercellular canals (Plate 5, Figs. 1 - 12; Plate 6, Figs. 1 - 9), variable in size between genera, observed in all genera except Antrocaryon, Blepharocarya, Bouea, Cotinus, Dracontomelum, Faguetia, Haematostaphis, Heeria, Holigarna, Mangifera, Nothopegia, Protorhus, Rhus, Semecarpus, Sorindeia, and Spondianthus, sometimes large and conspicuous with an epithelial lining of several rows of cells, but usually smaller: resin-like deposits abundant in most ray cells; crystals frequent, solitary, generally in marginal cells, sometimes in chambered upright cells or in special enlarged crystal-bearing marginal cells; druses observed in 5 species of Rhus; echinulate bodies present in rays of Gluta, Lannea, Melanorrhoea, Odina, Parishia, Swintonia, and Trichocypha.

Summary of the Anatomical Characteristics of the American Genera of the Anacardiaceae

The following account is based on the published descriptions by Record (1939), Record and Hess (1943), and Hess (1946). In addition, macroscopic examination of wood samples from the collections of the University of Cincinnati and the University of Michigan, as well as the personal collection of the writer, has been made. The American genera are: Anacardium, Astronium, Campnosperma, Comocladia, Cotinus, Cyrtocarpa (not included), Haplorhus (not included), Lithraea, Loxopterygium, Mauria, Metopium, Mosquitoxylum, Pistacia, Pseudosmodingium, Rhus (divided into Malosma, Toxicodendron, Actinocheita, and Rhus), Schinopsis, Schinus, Spondias, Tapirira, Thyrsodium, and Veatchia (Pachycormus; not included).

Woods variable in appearance. Color yellow with greenish cast to olive-green, frequently streaked, in Cotinus, Mauria (in part), Rhus (in part), and Toxicodendron; pink to light reddish orange in Mosquitoxylum and Rhus (in part); various shades of darker red in Astronium, Comocladia, Schinopsis, and Schinus (in part); light brown to dark reddish brown, often whitish or grayish brown with a pinkish tinge, frequently striped or variegated, in other specimens. Luster low, medium, or high. Odor may be present, not distinctive; taste of reddish woods occasionally astringent. In all of the other dry woods examined there was no distinctive odor or taste. Woods light to heavy, soft to hard, with fine to coarse texture and variable grain.

Growth rings present, sometimes indistinct, formed by differences in wall thickness or flattening of fibers in diffuse-porous woods. Ring-porous structure in some or all species of Cotinus, Rhus, Pistacia, and Toxicodendron; the early wood pores in a narrow to wide band, those in late wood often in diagonal or tangential bands of small to minute pores. Ulmiform (wavy) pattern in Schinus; in other diffuse-porous woods the pores are medium-sized or small, solitary, or in radial multiples of two to several pores each. Vessels with simple perforations; scalariform perforation plates with many narrow bars also present in some vessels of Campnosperma; spiral thickenings present in some or all vessels of Cotinus, Lithraea, Rhus, Schinus (in part), and Pistacia. Tyloses usually abundant in the heartwood. Intervascular pit-pairs typically rather large (mostly 9 or 10 μ), large or very large (12 to 20 μ) in Anacardium, Rhus (rarely), Spondias, and Tapirira; occasionally small (6 or 7 μ) in Rhus, Schinus, and Schinopsis; alternate, usually rounded, sometimes crowded and angular, commonly with included apertures. Fibers with thin to very thick walls; septate, at least in part, in Anacardium, Astronium, Campnosperma, Comocladia, Lithraea, Loxopterygium, Mauria, Metopium, Pseudosmodingium, Schinopsis, Schinus, Spondias, Tapirira, and Toxicodendron; pits small to minute, simple or indistinctly bordered. Parenchyma apparently absent in Campnosperma; sparingly vasicentric in the others; sometimes also terminal in a narrow

band, and occasionally diffuse (Lithraea and Mauria); often short aliform in Anacardium; crystalliferous strands present in a few genera (Lithraea and Mauria). Rays in part with small to large horizontal intercellular canals, with an epithelial layer composed of one to several rows of very small cells, in some or all species of Astronium, Campnosperma, Loxopterygium, Malosma, Metopium, Pistacia, Schinopsis, Schinus, Spondias, Tapirira, and Thyrsodium; other rays usually uniseriate and biseriate, or 1 to 3, occasionally to 4 or 5, rarely to 8 cells wide and mostly less than 30, occasionally to 50, rarely 100 cells high; weakly to decidedly heterogeneous; crystals common, often very numerous and sometimes large. Ray-to-vessel pit-pairs large, oval to greatly elongated, commonly irregular in shape, occasionally scalariform.

THE RELATIONSHIPS OF THE ANACARDIACEAE AS REFLECTED IN WOOD ANATOMY

Anatomical Characteristics of Phyletic Value

In modern times until very recent years, the classification of the flowering plants was based solely upon floral morphology. Fritsch (1903) points out that Radlkofer's monograph of the sapindaceous genus Serjania in 1875 was really the first important contribution towards systematic anatomy, since it involved the study of numerous specimens of each species and compared the relative values of the different anatomical features. Solereder, in 1885, was the first to make extensive application of anatomical features of wood in classification, but he did not attempt to show the importance of anatomical structure in phylogeny. Most modern taxonomists have been reluctant to use the data afforded by the study of wood anatomy, possibly because of the additional laborious effort required, but chiefly because insufficient work has been done to prove the reliability of the data. Now, however, with ever increasing interest in a truly phylogenetic classification of plants, the systematic botanists are seeking the aid of the cytologists, paleobotanists, plant geographers, comparative morphologists, and wood anatomists. As Lawrence (1952) points out, taxonomy is no longer a science dependent only on itself, but is rapidly becoming one of synthesis.

The study of wood anatomy has now progressed to the

point where certain phylogenetic principles have been established and are available for use by the taxonomist. Bailey (1951) notes that the development of vessels in angiosperms provides one of the most complete, extensive, and reliable phylogenetic trends of specialization known among either plants or animals, but he cautions that overemphasis upon their importance, with disregard of other characteristics of a plant, would result in as artificial a classification as one based upon the structure of the flower alone, because trends of evolutionary specialization in various organs, tissues, or parts of a plant commonly are not closely synchronized. Since this paper is concerned chiefly with the aid that study of mature secondary xylem may render taxonomists, I will present the following summary of the anatomical characteristics of phyletic value:

Vessels. -- Frost (1930a) has accepted the following theories derived from paleobotanical study and morphological evidence: (1) the tracheid is a more primitive structure than the vessel element, and (2) the vessel element is genetically related to and derived from the tracheid. He has proposed that the most primitive vessel elements are those most nearly resembling the tracheid in having great length, small cross-sectional area, angular outline, constant wall width with thin walls, and undeveloped or inclined end walls; diffuse distribution is primitive, whereas ring-porous structure is highly specialized. Further studies (Frost 1930b, 1931) have

indicated that scalariform perforation plates with complete borders, many bars (more than 15), and narrow openings between bars are the most primitive; horizontal simple plates the most advanced; with combinations of scalariform and simple plates or highly inclined simple plates occupying positions between the extremes. In addition, those elements with scalariform lateral pitting are primitive; those with alternate pitting advanced; and the elements with transitional or opposite pitting are intermediate in specialization. The evolutionary development of the vessel-to-parenchyma pitting follows that of intervascular pitting: fully bordered, half-bordered, or simple. Spiral thickenings in secondary vessel elements are an evidence of specialization; they do not occur in truly primitive woods.

Fibers. -- Bailey (1936) has noted that most primitive vessel elements tend to be associated with typical thick-walled tracheids forming the ground mass of the wood, but where vessel elements are highly specialized, the ground mass is composed of fibers having simple pits or pits with vestigial borders. The order of specialization, therefore, is tracheids, fiber-tracheids, and libriform wood fibers.

Parenchyma. -- Kribs (1937) has shown that the diffuse condition is primitive and abundant vasicentric parenchyma the most highly specialized. In evolutionary sequence the transitional types are (1) diffuse-aggregate (a mixture of diffuse parenchyma and parenchyma in short tangential arcs 2 to 10

cells long); (2) vasicentric scanty, apotracheal in narrow bands, and (3) apotracheal in wide bands. An absence of wood parenchyma indicates a primitive condition, but terminal parenchyma is a specialization resulting from reduction, since it occurs as an offshoot in practically every type of woody dicotyledonous stem.

Rays. -- Kribs (1935) attempted to establish certain phylogenetic ray types for use in descriptive work and phylogenetic investigations (outlined in this paper under the heading "Material and Methods"). Barghoorn (1940, 1941) has cautioned that although the ray types established by Kribs are convenient for use in descriptions, they must be used with discretion in phyletic discussions because phylogenetic specialization may be accelerated in different parts of the secondary xylem and in relation to the other structures of the secondary body; and, in addition, climatic factors are often correlated with parallel modifications of ray structure in unrelated families. One definite fact is established, however, namely, that heterogeneous rays with vertically elongated marginal cells and horizontally elongated procumbent cells are less specialized than homogeneous rays in which all the cells are horizontally elongated.

If we examine the Anacardiaceae in the light of the foregoing criteria, we find evidences of primitive structure as follows: (1) scalariform perforation plates with many fine, narrow bars in Campnosperma; (2) angular vessels of very small

diameter in Campnosperma and Nothopegia; (3) absence of parenchyma in Campnosperma and Rhodosphaera, and diffuse parenchyma in Lithraea and Mauria; (4) very long vessel elements and fibers in Spondianthus; (5) heterogeneous Type I rays in Spondianthus. Highly specialized structure is indicated by (1) ring-porous condition in five genera; (2) numerous vessels with transverse ends and simple perforation plates; (3) alternate intervascular pitting in most genera; (4) spiral thickenings in the smaller vessels of Cotinus, Rhus (in part), Pistacia, Lithraea, and Schinus; (5) libriform wood fibers with simple pits in some genera; (6) abundant vasicentric, aliform parenchyma, particularly in some genera of the Semecarpeae and Rhoideae; (7) homogeneous Type III rays in Gluta and Melanorrhoea. Since no single genus, with the possible exception of Campnosperma, combines very many of the primitive characteristics in its structure and no genus is entirely specialized, the family Anacardiaceae is probably best characterized as intermediate in specialization.

Relationships of the Tribes of the Anacardiaceae

Engler (1896) divided the family Anacardiaceae into five tribes based upon the nature of the ovary, as follows:

I. Mangifereae -- 5 free carpels or only 1; leaves always simple, entire.

II. Spondieae -- 5 or 4, seldom more, or fewer carpels, more or less united, extremely rarely only 1. Each carpel develops a locule in the ovary, which bears one seed from its upper end. Leaves seldom simple; pinnate or trifoliate.

III. Rhoideae -- 3 carpels, possibly only 1 in Pentaspadon; ovary with a single seed-bearing locule,

the 2 others very small or lacking; ovary and fruit free; leaves of various types.

IV. Semecarpeae -- 3 carpels; ovary with a single seed-bearing locule, the 2 others very small or lacking; ovary rarely free (Nothopegia), sunken in a cup shaped or tubular hollowed receptacle; leaves simple.

V. Dobineeae -- 1 carpel; female flower entirely naked; leaves simple, serrate, opposite.

Engler's division into tribes has been retained by modern taxonomists, and each tribe is so delimited that no genus has ever been transferred from one tribe to another. When this study was undertaken, the writer hoped that the anatomical characteristics of the tribes would present distinctions equally definite. This does not seem to be true.

We shall now examine in turn the occurrence in the tribes of each of the dominant features of the minute anatomy: vessels, septate fibers, parenchyma distribution, nature of the rays, and horizontal intercellular canals. The tribe Dobineeae has been omitted from the following discussion because no wood specimens have been obtained. Antrocaryon, although described with the Spondieae in this paper, has also been omitted from this discussion because the writer is convinced that the one sample studied (Yale No. 12851) has been incorrectly named. Its structure differs radically from the characteristics listed by Metcalfe and Chalk (1950) for that genus.

Vessels. -- The exceptions to the pattern for the Anacardiaceae are found in all tribes but the Mangifereae, where there are no angular pores, small pores, or scalariform

perforation plates. This distinction does not seem sufficient to segregate its genera, however, for the majority of the members of the other tribes adhere to the pattern also.

Septate fibers. -- This feature does seem to distinguish two of the tribes, for all the genera of the Spondieae have septate fibers and all those of the Semecarpeae lack them. It would be impossible to segregate unknown specimens on this basis alone, however, because most of the fibers in the Rhoideae are septate, and all but two of the Mangifereae have non-septate fibers.

Parenchyma distribution. -- Parenchyma is most uniform in the Semecarpeae, where abundant vasicentric, aliform, and occasionally confluent parenchyma is present in all genera studied. It is similar, however, in several genera of the Mangifereae, Rhoideae, and Spondieae. Although apotracheal banded parenchyma is present in some or all species of five genera of the seven Mangifereae that have been investigated, it occurs also in an American genus of the Rhoideae, Metopium. Most of the Rhoideae are characterized by sparse paratracheal parenchyma, and it is in that tribe that the only two genera of the family that lack parenchyma occur.

Rays. -- Although the only two genera with homogeneous rays belong to the Mangifereae, the remaining genera have heterogeneous rays similar to those of most of the family. Crystals are found in some members of all tribes, and echinulate bodies are present in the rays of seven genera representing all tribes but the Semecarpeae.

Horizontal intercellular canals. -- Canals are found in the rays of 35 genera distributed among all the tribes.

The structure of the wood, therefore, does not permit the segregation of the genera into tribes on the basis of anatomical characteristics.

The Status of Blepharocarya, Rhodosphaera, and Spondianthus

In the general introduction it has been indicated that four genera, Blepharocarya, Rhodosphaera, Spondianthus, and Dobinia have proved troublesome to the taxonomists. The first two genera have been excluded from the Anacardiaceae in the latest revision of the family by Barkley (1942), but he does not name the family to which he would assign them. Blepharocarya, however, was included in the Sapindaceae in the Index Kewensis (Hooker and Jackson, 1893); Rhodosphaera had never previously been considered as other than anacardiaceous. Although included by Barkley, Spondianthus was removed from the Anacardiaceae and placed in the Euphorbiaceae by Engler and most other taxonomists shortly after it was named: it is under that family that the wood specimens examined in this study are listed in the files of Yale University and the Imperial Forestry Institute of Oxford, England. No wood specimen of Dobinia was available to the writer for study.

Blepharocarya

The anatomy of the wood of Blepharocarya shows remarkable similarity to that of the Anacardiaceae in general.

The pores are similar in size, shape, wall thickness, and distribution. The vessel elements are medium-sized, have typical horizontal to oblique ends, simple perforation plates, medium-sized, alternate bordered pits with lenticular, included horizontal apertures, and even thin-walled tyloses are present. Vessel-to-ray pit-pairs follow the family pattern (Plate 44, Figs. 1 and 2). The fibers are thin-walled, rarely septate, with characteristic indistinctly bordered pits on radial walls only. Parenchyma is paratracheal, incompletely vasicentric, sparse, as in most of the Rhoideae. Rays are heterogeneous (Type II B), low, and predominantly biseriate. Horizontal intercellular canals are absent, but resin-like deposits and crystals are occasionally present.

The anatomy of Blepharocarya thus seems to justify the inclusion of this genus with the Anacardiaceae. Since Blepharocarya in the past has been assigned to the Sapindaceae, however, we shall next discuss the type of wood structure in that family and see whether the genus would fit into it.

Sapindaceae. -- The following description is based upon the work of Heimsch (1942), Record and Hess (1943), and Metcalfe and Chalk (1950), as well as upon macroscopic examination of the woods in the collection of the writer.

There are about 120 genera and more than 1000 species of trees, shrubs, and woody climbers in tropical and subtropical regions, particularly in the Old World. The heartwood is yellow to pinkish or reddish brown, usually without

sharp demarcation from the sapwood; moderately to decidedly hard and heavy, with coarse to fine texture and typically medium luster; grain variable. The family furnishes no timber of great importance.

Growth rings usually present, marked by variation in thickness of fiber walls, terminal parenchyma, or both. Some species of Sapindus and Koelreuteria are ring-porous. Pores typically small and indistinct without a lens, but medium-sized in 16 genera, 2 to 50 per sq. mm., usually thick-walled, rounded in outline, solitary, and with numerous multiples of 2 to 3, sometimes 4 to 6. Vessel elements very short to medium-sized (200 to 700 μ); perforation plates exclusively simple; resin-like deposits abundant; tyloses present only in Sapindus. Intervascular pit-pairs bordered, circular or hexagonal in outline, alternate, typically very small to minute, but medium-sized in 11 genera; apertures coalescent in species of 11 genera, resulting in striated appearance in vessel wall. Vessel-to-ray pit-pairs usually similar to intervascular pitting.

Fibers medium to very short; walls varying from medium to very thick, sometimes within the same growth ring; typically septate; pits simple or indistinctly bordered, more numerous on radial than on tangential walls.

Parenchyma usually paratracheal only and sparse, sometimes vasicentric, with isolated crystalliferous strands or diffuse parenchyma scattered among the fibers and occasionally

aliform and confluent, or in apotracheal confluent bands. Terminal parenchyma sometimes conspicuous.

Rays of most genera exclusively or predominantly uniseriate, but also up to 3 or even 6 cells wide in some genera, typically low, less than 25 cells or between 25 and 50 cells in height, rarely reaching 1 mm., mostly between 8 and 14 rays per mm., typically homogeneous (Types I and III, rarely II), with very small cells; some heterogeneous (Types II B and III), with 1 to 2 rows of upright marginal cells and sometimes interspersed square or upright cells in some species of 9 genera; crystals present in many species, sometimes abundant; chambered crystals in 3 genera; resin-like deposits often present. Storied rays in Diplokeleba.

Relationships. -- The Sapindaceae form a rather homogeneous family, similar in some respects to the Anacardiaceae, but very different in others. The chief differences in the Sapindaceae are: pores typically small and thick-walled; vessel elements very short to medium-sized with very small to minute pit-pairs; vessel-to-ray pit-pairs similar to intervascular pitting; fibers medium to thick-walled, typically septate; parenchyma sometimes diffuse and in conspicuous terminal bands; rays of most genera exclusively or predominantly uniseriate, typically homogeneous, storied in one genus; horizontal intercellular canals never present.

Although there are exceptions to all the family characteristics listed above, it is doubtful whether any single

genus of the Sapindaceae combines enough of the exceptional features to resemble a typical anacardiaceous genus. On the basis of stem anatomy, therefore, Blepharocarya should be retained in the Anacardiaceae.

Rhodosphaera

The anatomy of this genus is typical of the Anacardiaceae in most respects. The pores are slightly smaller than those of the majority of genera, but similar in shape, wall thickness, and distribution. Vessel elements are likewise similar, although the pit apertures are frequently slit-like rather than lenticular. Vessel-to-ray pit-pairs are large, but they are usually rounded rather than horizontally elongated and gash-like (Plate 45, Fig. 1). Rhus, however, usually shows a similar pattern. Fibers are septate. Parenchyma is usually absent, a condition found also in Campnosperma and therefore not unique for this family. The rays are more primitive than those of the majority of the genera, for they are heterogeneous Type II A rather than II B, but three other genera in the Rhoideae possess the same type. Horizontal intercellular canals are present, although infrequent. Crystals are abundant and resin-like deposits are present.

Relationships. -- Since Barkley has not assigned this genus to a specific family, we can merely assume that he would place it in one closely related to the Anacardiaceae. Two features of the anatomy of Rhodosphaera limit the choice of a possible family, namely, septate fibers and horizontal

intercellular canals. Only the Burseraceae regularly show these structures. None of the Burseraceae described in the literature, however, is entirely without some form of wood parenchyma, nor does any genus possess heterogeneous Type II A rays. There seems to be no basis, therefore, for excluding Rhodosphaera from the Anacardiaceae on anatomical grounds.

Spondianthus

The anatomical description of this genus duplicates that of the majority of anacardiaceous genera, until we note the measurements of the vessel elements, fibers, a nd rays. The vessel elements are almost 800 μ longer than the largest ones of the other genera, reaching to more than 1600 μ ; the fibers are more than 1200 μ longer (up to 3 mm. !), and the rays extend to 7 mm. in height, not to less than 1 mm. as in other Anacardiaceae. These sizes cannot be attributed to position in the stem or to environmental conditions, for variation is never that great, and in four samples of two genera studied the measurements are similar. In addition, the rays are decidedly heterogeneous Type I, with sheath cells in the multiseriate rays, a condition shown by no other anacardiaceous genus. No horizontal intercellular canals are present, but the fibers are septate. From the point of view of the wood anatomist, Spondianthus should be excluded from the Anacardiaceae.

We shall next examine the wood structure of the

Euphorbiaceae, in which family Spondianthus is placed at present by most taxonomists.

Euphorbiaceae. -- The following description of the minute anatomy is reproduced from the work of Metcalfe and Chalk (1950), with slight modifications. The macroscopic material is based on the work of Record and Hess (1943).

The family Euphorbiaceae includes about 285 genera and 7000 species of trees, shrubs, and herbaceous plants occurring throughout the world, but most abundant in the tropics. Heartwood variable in color, clear yellow, or pale to dark brown or red, or light to dark olive; sapwood may be sharply defined, or it may extend throughout stem. Wood light to very heavy, soft and spongy to hard, with very fine to coarse texture and usually very low luster, particularly in the darker woods which often have an oily appearance. The family is noted for Para rubber, obtained from the latex of Hevea; Tung oil, Castor oil, and tapioca are other important products of euphorbiaceous plants.

I. Phyllanthoideae

(a) Group A. Aporosa Type

Vessels variable in size even within genera, 50 to 210 μ mean tangential diameter (mostly 70 to 125 μ), typically with numerous multiples of 2 or 3 cells, often 4 or more, mostly 10 to 20 per sq. mm., but to 40 in 2 genera. Vessel elements moderately long

to very long (900 to 1600 μ); perforation plates scalariform, simple, or both. Intervascular pit-pairs opposite in one species, alternate and small to minute in the other genera. Vessel-to-ray pit-pairs large, elongated, and simple, except in Dicoelia.

Fibers typically with simple pits and very thick walls, very long (2.1 to 2.75 mm.).

Parenchyma abundant, apotracheal, diffuse, or in numerous short, uniseriate bands, commonly with chambered crystals.

Rays of 2 sizes, up to 4 to 17 cells wide, several millimeters high, markedly heterogeneous, often with more than 10 marginal rows of upright cells; sheath cells in larger rays; crystals sometimes present; resin-like deposits occur.

(b) Group B. Glochidion Type

Vessels generally small to moderately small in diameter (25 to 100 μ), but moderately large (100 to 200 μ) in 2 genera; solitary and in multiples of 2 to 3, occasionally 4; mostly 20 to 40 per sq. mm., but about 6 per mm. in Bischoffia. Vessel elements medium-sized to moderately long (500 to 1000 μ); perforation plates typically

simple, but scalariform in 1 genus, in part in several others; tyloses and solid deposits sometimes present. Intervascular pit-pairs alternate, bordered, minute to large. Vessel-to-ray pit-pairs large, almost simple, elongated, and often scalariform, but small in 2 genera.

Fibers with moderately thick walls in most species; septate; pits simple, more numerous on radial than on tangential walls; medium-sized to moderately long (1.1 to 2.2 mm.).

Parenchyma absent, or as rare cells touching the vessels.

Rays sometimes of two distinct sizes, up to 3 to 11 cells wide, often up to 2 mm. high, heterogeneous, sometimes decidedly so, with 10 or more rows of upright marginal cells; sheath cells common; resin-like deposits fill many ray cells; crystals present in 3 genera; silica reported in 2 genera.

II. Crotonoideae

Vessels typically medium-sized to large; solitary and in multiples of 2 to 3, often 4 or more cells; sometimes with a radial or oblique pattern; commonly fewer than 5 per sq. mm.,

rarely more than 17. Vessel elements moderately short to medium-sized (300 to 850 μ); perforation plates simple, except for 1 genus with exclusively scalariform plates and rare scalariform plates in a few species; tyloses often present, sometimes sclerotic. Intervascular pit-pairs typically medium-sized to large, often with apertures small and not extending to borders; almost scalariform or opposite in some genera. Vessel-to-ray pit-pairs mostly large, elongated, and often scalariform, but similar to intervascular pitting in some genera.

Fibers with moderately thin to moderately thick walls; medium-sized to moderately short; pits usually simple, but sometimes with small or distinct borders.

Parenchyma abundant, apotracheal, in diffuse to continuous concentric bands 1 to 2 cells wide, occasionally paratracheal in addition to apotracheal.

Rays typically 2 to 3 cells wide or exclusively uniseriate, sometimes 4 to 5 cells wide, usually more than 1 mm. high, but lower in several genera, decidedly heterogeneous, often with more than 10 rows of upright marginal cells and with more than 1 multiseriate part per ray,

sometimes with marked intercellular spaces; crystals common; resin-like deposits in many cells. Latex tubes sometimes present in the rays.

Relationships. -- The position of Spondianthus with regard to anatomical relationship with the Euphorbiaceae is clearly stated in the following paragraph reproduced from the discussion of the Euphorbiaceae by Metcalfe and Chalk (1950, Vol. II, p. 1230):

> Spondianthus, if it is correctly placed in the Euphorbiaceae, falls into this group [Group B. Glochidion Type] on account of its septate fibers; it differs from the other genera, but in the combination of its features rather than by the presence or absence of any one. Thus it has large rays typical of Group A, the intervascular pitting is similar to that of Antidesma [Group B], and the occurrence of vasicentric parenchyma suggests Bridelia [Group B]; only the pitting between vessels and rays cannot be matched, being large and usually circular.

Wood structure thus supports the inclusion of Spondianthus in the Euphorbiaceae.

The Status of Juliania

Juliania was included in the Anacardiaceae by Dalla Torre and Harms (1900 - 1907) as one of three "Genera incertae sedis." The other two were Rumphia L. and Triceros Lour., neither of which is represented by a wood specimen in the writer's collection. In the general introduction to this paper, the history of the genus Juliania is presented. Many studies concerned with its anatomy have been published in

recent years, always with the goal of aiding the taxonomists in establishing a definite place for the genus in systems of classification. The most recent publication is that of Stern (1952). The problem of Juliania is no longer that of its status within a family, for it is well established in its own family, the Julianiaceae, but rather that of the position of the Julianiaceae within an order. The presence of resin canals in the phloem and pith allies the family with the Anacardiaceae, and some taxonomists have therefore placed it in either the Sapindales or the Terebinthales with the latter family; the inflorescences of unisexual flowers, however, are similar to those of the Juglandaceae, and it has accordingly been assigned to the Juglandales by other investigators.

The wood structure of Juliania shows no characteristics that differ radically from those of the Anacardiaceae, although some features are not typical for the family. The vessel elements are short, but not shorter than those of Cotinus. Their occasionally angular outline occurs also in several other genera. The infrequently opposite pitting is matched by the pitting of Dobinea (not studied in this paper). The rays are Type II B, low, often with crystals and resin-like deposits as in most anacardiaceous genera. The two distinctive features of the family, septate fibers and horizontal intercellular canals, are both present in this genus.

The anatomy of the wood of Juliania, therefore, certainly supports the inclusion of the family Julianiaceae in

the same order with the Anacardiaceae. We shall next examine the structure of the secondary xylem of the Juglandaceae to see whether it is similar to that of Juliania and therefore might show relationship with the Anacardiaceae.

Juglandaceae. -- The following description is based on the published reports of Kribs (1927), Tippo (1938), Heimsch and Wetmore (1939), Record and Hess (1943), and Metcalfe and Chalk (1950).

The family Juglandaceae is composed of six genera with about 100 species of medium-sized to large trees and a few shrubs, occurring throughout the north temperate zone and in some mountainous regions of the tropics of both hemispheres. Heartwood light to dark brown, sometimes streaked or variegated; sapwood often abruptly demarcated, white or yellowish white. Woods light to heavy, hard to soft, with medium texture and mostly high luster; odor and taste distinctive in Juglans, but not pronounced, absent in other genera; grain generally straight. The best known genera are Carya (Hickory) and Juglans (Walnut).

Growth rings usually distinct, frequently conspicuous; ring-porous structure in Carya, Platycarya, and Juglans (in part). Pores medium-sized or slightly larger, not very numerous (2 to 5 per sq. mm.), thin to thick-walled, rounded or angular in outline, mostly solitary, but also in small multiples and clusters, with rather numerous multiples of up to 4 cells in some species of Engelhardtia and Platycarya, often

tending to have an oblique pattern. Vessel elements medium-sized to moderately long (400 to 900 μ); ends slightly to decidedly oblique; perforation plates exclusively simple, except in Alfaroa and Engelhardtia, where some scalariform plates with few bars also occur; thin-walled tyloses common. Intervascular pit-pairs alternate, bordered, small to medium-sized. Vessel-to-ray pit-pairs similar to intervascular pitting, or in part large and gash-like in Alfaroa and Engelhardtia. Spiral thickening in small vessels of Platycarya.

Fibers usually with moderately thick walls, thick in Carya and very thin in one species of Pterocarya, gelatinous layers frequently present; medium-sized (mean length 1.1 to 1.5 mm.); pits typically bordered (but small and apparently simple in Carya), limited to radial walls. Vascular tracheids present in Platycarya, with spiral thickening.

Parenchyma predominantly apotracheal, terminal, as short uniseriate bands to continuous concentric bands 2 to 3 cells wide, or diffuse, often with some paratracheal, vasicentric, or aliform and confluent parenchyma.

Rays 4 to 12 per mm.; 1 to 7 cells wide (mostly 2 to 4); less than 1 mm. high (4 to 75 cells); heterogeneous (Types I, in Alfaroa, and II A and B), with 4 or more, and sometimes more than 10, marginal rows of square or upright cells in species of 4 genera; almost homogeneous (Type I) in species of 3 genera. Crystals present in some ray cells.

Relationships. -- Although the pores resemble those of Juliania in shape and are solitary or in radial multiples (in diffuse-porous woods), they tend to form an oblique pattern. Vessel elements are longer in the Juglandaceae and show only alternate pitting. Fibers are typically fiber-tracheids with bordered pits, and they are never septate. Only in Carya are there simple pits. Parenchyma differs greatly, for it is predominantly apotracheal, in terminal, concentric bands, or diffuse, whereas Juliania has the sparse paratracheal parenchyma typical of the Anacardiaceae. Rays are similar in size and type in a few genera, but horizontal intercellular canals are never present.

Juliania differs in so many important features from the Juglandaceae, with respect to type of parenchyma, pitting of vessels, pitting and septation of fibers, and the presence of horizontal intercellular canals: but is so like the Anacardiaceae that there seems no justification for placing the Julianiaceae with the Juglandales. Wood structure likewise lends no support to the concept of a close relationship between the Juglandaceae and the Anacardiaceae.

The Status of Toxicodendron

Toxicodendron [Tourn.] Miller was first established as a genus by Tournefort in 1700, but taxonomists generally have refused to accept it as distinct from Rhus, and in most classification systems it is merely a section of the latter genus. Barkley (1937) admits that it is impossible to decide its

generic status in an absolute manner, but he thus states his reason for separating it from Rhus:

> The non-glandular pubescence when present on the fruit-coat, the ceriferous mesocarp, the consistently poisonous effluvium, and the paniculate inflorescence in Toxicodendron, as contrasted with the glandular pubescence always present on the fruit-coat, the non-waxy mesocarp, the constantly innocuous effluvium, and the thyrsoidal inflorescence of Rhus, as well as many minor characters consistently different between these elements, are characters that seem to the author sufficiently well marked to separate the two as distinct genera.

Engler (1896) divided the genus Rhus into four sections, Trichocarpae, Venenatae, Gerontogeae, and Melanocarpae, separated by fruit characters. Barkley has separated the genus Toxicodendron from Engler's great section Venenatae, not including Malosma, and one species from the Trichocarpae, Rhus trichocarpa Miq., which now becomes Toxicodendron trichocarpum (Miq.) Kuntze. In the present study, three of the species described under Rhus would belong in Barkley's Toxicodendron, namely, Rhus trichocarpa Miq. from section Trichocarpae; Rhus sylvestris Sieb. & Zucc. and Rhus succedanea L. from section Venenatae. If we examine the structure of their wood, we find that they differ from other members of Rhus in the following ways: they are all ring-porous, as are many of the genus Rhus, but in the late wood the pores are predominantly solitary or in small multiples, rather than clustered as is typical. Septate fibers are present in these three species and in no others of the genus examined, although septa are only of sporadic occurrence in R. trichocarpa. On the contrary, the three species differ among themselves in that

Rhus succedanea and R. sylvestris are moderately thick-walled, whereas R. trichocarpa is thin-walled; spiral thickenings are present in smaller vessels of R. trichocarpa but not in the others, and the intervascular pits in this species are slightly larger and with included apertures rather than with the coalescent apertures of the two other species; the rays are 1 to 4 cells wide (mostly 2 to 3) in all, but in R. trichocarpa they are often 75 or more cells high, whereas they are rarely more than 25 cells high in the other two species.

There are thus only two important differences between the three species that might belong to Toxicodendron and those of Rhus: (1) the presence of septate fibers and (2) late wood pores solitary or in small multiples rather than clusters. We shall now examine the description of the secondary xylem of the American species of Toxicodendron as presented by Hess (1946).

> Ring-porous, the pores in the early wood rather large (190 to 220 μ), distinct, and in narrow to wide band; pores in late wood grading from small (85 μ) to minute (35 to 17 μ), not very numerous, uniformly distributed, solitary and with few short multiples, sub-circular, thick-walled. Vessels with simple perforations; rather large (9 μ) intervascular pits; filled with tyloses in the heartwood. Largest rays 5 or 6, rarely 4 cells wide and up to 70 to 120 cells high; heterogeneous with many square cells; crystals and gum deposits numerous; pits to vessels rather large and oval to much elongated. Wood parenchyma sparingly vasicentric. Wood fibers septate in part; pits very small, simple or indistinctly bordered. No gum ducts observed.

If we compare Hess's description of Toxicodendron with his own

report on the structure of the American species of Rhus, we find the following differences in Rhus: (1) late wood pores in clusters; (2) spiral thickenings in the smaller vessels; (3) rays uniseriate and biseriate, up to 25 cells high; (4) non-septate fibers. Although the American representatives of the two genera are quite distinct, the non-American ones are not quite so clear-cut. Since the size of the rays is not of phylogenetic importance when the variation is small, as previously noted in the first section of this discussion, their lack of conformity here does not merit consideration. The distribution of the pores and the septate fibers are of phylogenetic importance, however, and since the three species belonging in Toxicodendron all possess those characters, they probably could be considered distinct from the other species of Rhus. This point of view is in accord with that of Heimsch (1940), who studied the pollen grains of American and Asiatic species of Toxicodendron and found them similar.

Other Families in Gundersen's Order Rutales

In order to determine the possible phylogenetic relationships of the family Anacardiaceae as indicated by wood structure, it is necessary to compare their characteristics with those of the other families considered closely related by the taxonomists. Gundersen's classification was chosen for study, chiefly because he is the only one of the later systematic botanists who has attempted to incorporate data from the analysis of other plant parts with the evidence from

floral morphology, but also because his scheme contains only families having woody representatives. If we select the eight families of his order Rutales, among which are the Anacardiaceae, we find that they have been differently arranged by Engler and Diels (1936), Hallier (1912), Bessey (1915), Hutchinson (1926), and Wettstein (1935). Synopses of their classification schemes follow.

One fact is immediately evident: all the taxonomic arrangements, with the exception of that of Hutchinson, combine the Cneoraceae, Rutaceae, Simaroubaceae, Burseraceae, and Meliaceae in the same order, even though the order might have a different name. Hutchinson has placed the Cneoraceae in the Celastrales, which he considers unrelated to the other families listed above, for the family has simple leaves and thus could not be included with the "Pinnatae." He separates the family Meliaceae also, and places it alone in the Meliales because its leaves are not gland-dotted as are those of his Rutales, and the stamens are connate into a tube, rather than free. Hutchinson's classification is not as different as it seems, however, for he has many more orders merely because of his separation of families into woody and herbaceous lines of descent, and he restricts his orders more narrowly. Both Hallier and Wettstein include the Anacardiaceae with the five families first mentioned, but Engler and Diels, Bessey, and Hutchinson place the family in the Sapindales, in accordance with the difference in the seed character, as explained in

the general introduction to this paper. The Coriariaceae are considered more primitive than the others by Hallier and Hutchinson. All other schemes, however, included the family either with the Sapindales or Terebinthales. The position of the Julianiaceae has already been discussed in the section concerned with the genus Juliania.

We shall next consider the structure of the secondary xylem of the families of Gundersen's Rutales, to see whether there is any basis upon which to decide closeness of relationship. The Anacardiaceae and Julianiaceae have been fully treated in the earlier sections of this study and have been omitted here. All of the anatomical descriptions which follow are based upon the published accounts by the leading authorities, supplemented when possible by macroscopic examination of wood specimens.

Synopsis of the order Rutales according to Gundersen (1950). -- Family: Burseraceae
Anacardiaceae
Julianiaceae
Coriariaceae
Cneoraceae
Simarubaceae
Rutaceae
Meliaceae

Distribution of the families in Gundersen's Rutales according to Engler and Diels (1936). --

Order 10. Julianiales

Family: Julianiaceae

Order 23. Geraniales

Family: Cneoraceae
Rutaceae

Simarubaceae
Burseraceae
Meliaceae

Order 24. Sapindales

Family: Coriariaceae
Anacardiaceae

Distribution of the families in Gundersen's Rutales according to Hallier (1912). --

Order 7. Hamamelidales

Family: Coriariaceae

Order 14. Terebinthales

Family: Rutaceae
Cneoraceae
Meliaceae
Simarubaceae
Terebinthaceae (including Burseraceae, Anacardiaceae, and Julianiaceae)

Distribution of the families in Gundersen's Rutales according to Bessey (1915). --

Order: Geraniales

Family: Cneoraceae
Rutaceae
Simarubaceae
Burseraceae
Meliaceae

Order: Sapindales

Family: Coriariaceae
Anacardiaceae
Julianiaceae

Distribution of the families in Gundersen's Rutales according to Hutchinson (1926). --

Order 25. Coriariales

Family: Coriariaceae

Order 51. Celastrales

Family: Cneoraceae

Order 55. Rutales

Family: Rutaceae
Simarubaceae
Burseraceae

Order 56. Meliales

Family: Meliaceae

Order 57. Sapindales

Family: Anacardiaceae

Order 58. Juglandales

Family: Julianiaceae

Distribution of the families in Gundersen's Rutales according to Wettstein (1935). --

Order 5. Juglandales

Family: Julianiaceae

Order 25. Gruinales

Family: Cneoraceae (incertae sedis)

Order 26. Terebinthales

Family: Rutaceae
Simarubaceae
Burseraceae
Meliaceae
Anacardiaceae
Coriariaceae (incertae sedis)

Characteristics of the Burseraceae

The following description is based on the published studies of Webber (1941), Record and Hess (1943), Heimsch (1942), and Metcalfe and Chalk (1950), and the macroscopic examination of the woods of the Burseraceae in the writer's collection.

The family Burseraceae includes seventeen genera with about 600 species of mostly resinous trees and shrubs occurring throughout the tropics and to a small extent, the subtropical regions of the world. The heartwood, when distinct, is brown or reddish brown, with sharp or gradual transition to the yellowish, pinkish, or nearly colorless sapwood; weight and hardness widely variable; texture fine to moderately coarse; luster fairly high; grain straight to interlocked; without distinctive taste, but sometimes fragrant. The trees are best known as sources of true frankincense, myrrh, gum elemi, and a commercial timber, West African Okoume (Aucoumea Klaineana Pierre).

Growth rings usually absent, but present in many American genera; woods exclusively diffuse-porous. Pores distinct to invisible without a lens, rather numerous but not crowded, 5 to 40 per sq. mm. (mostly 10 to 15), solitary, and in radial multiples of 2 to 8, but some irregular clusters are occasionally present, sometimes with a tendency to diagonal or zonate arrangement, in tangential diameter ranging from 40 to 205 μ (mostly 100 to 180 μ), thin-walled, rounded or angular in

outline. Vessel elements extremely short to medium-sized, 100 to 900 μ long (mostly 300 to 500μ); ends horizontal to oblique; projecting tips short to long, or none; perforations exclusively simple, sometimes with large, pitted rims. Intervascular pit-pairs alternate, bordered, numerous; borders rounded to hexagonal, small to very large, 4 to 17 μ in diameter (mostly 9 to 10 μ); apertures elliptic or slit-like, oblique, sometimes exserted. Vessel-to-ray pit-pairs half-bordered or simple, small to large, rounded to irregular or oblong and gash-like, sometimes unilaterally compound. Thin-walled tyloses common; resin-like deposits frequent.

Fibers extremely short to moderately long (300 to 1850 μ), 12 to 50 μ in diameter, generally thin-walled, but sometimes moderately thick-walled; septate, except for several questionable species: pits simple, small slit-like to almost round, more numerous on radial than on tangential walls; starch grains, crystals, and resin-like substance may be present.

Parenchyma sparingly paratracheal in all genera, completely or incompletely vasicentric in sheaths 1 to 3, rarely more, cells wide, reportedly apotracheal, diffuse or in irregular, broken concentric bands in some species; resin-like deposits present; silica noted in one species.

Rays exclusively uniseriate in some species of 7 genera, composed of upright cells; 2 to 3 cells wide in the majority of the remaining genera, and up to 6 cells wide in

a few species, 1 to 41 cells high (less than 1 mm.). Uniseriate rays few in species with multiseriate rays, composed of both upright and procumbent cells, mostly 4 to 6 multiseriate rays per mm., up to 12 per mm., in woods with uniseriate rays only; heterogeneous (Type II B and III), with 1 to 3 rows of square or upright marginal cells. Horizontal intercellular canals regularly present or sporadic in some species of 11 genera, small or large, surrounded by small epithelial cells. Resin-like deposits in ray cells; solitary crystals present, primarily in marginal cells, sometimes in specialized wider crystal-bearing cells; silica bodies in some species of 4 genera.

Characteristics of the Coriariaceae

The following description is based on the anatomical studies of Heimsch (1942), Record and Hess (1943), and Metcalfe and Chalk (1950).

This family contains one genus, Coriaria, with about eight species of shrubs widely but sparingly distributed in temperate regions and at high altitudes in the tropics. Wood pale brown, white when freshly cut, light but firm, with medium texture and moderate luster; grain straight; no distinctive odor or taste. Stems too small for commercial use.

Growth rings distinct or indistinct; sometimes ring-porous structure present. Pores just within limit of vision without a lens, small to medium-sized (up to 140 μ), solitary, or in numerous tangential pairs or small clusters that extend

tangentially, evenly distributed, rounded or angular in outline, thin-walled. Vessel elements very short (mean length 200 μ); perforation plates simple; tyloses absent. Intervascular pit-pairs alternate, bordered, small; borders round, 5.5 μ in diameter; apertures often coalescent. Vessel-to-ray pit-pairs small, round to oblong.

Fibers moderately to very short (mean length 600 to 800 μ), thin-walled, non-septate; pits simple or indistinctly bordered.

Parenchyma paratracheal, enclosing the vessel groups and often linking them; sparse in species with mostly solitary vessels, forming broad, irregularly confluent bands in others; cells sometimes fusiform, or storied.

Rays 15 or more cells wide, more than 150 cells high (over 4 mm.); uniseriate rays absent; heterogeneous, composed almost entirely of square or upright cells; sheath cells numerous; crystals present.

Characteristics of the Cneoraceae

The following report is based upon the anatomical studies made by Heimsch (1942), Record and Hess (1943), and Metcalfe and Chalk (1950).

This small family of one genus and three species of shrubs or treelets occurs in the Mediterranean and Carribean regions. The wood is pale brownish gray, without distinct heartwood, hard, rather heavy, with fine texture and medium to dull luster; grain straight; ripple marks present, irregular

and indistinct. No distinctive odor or taste. The wood is of no economic importance because of its scarcity and the small size of the trees.

Growth rings present; one species ring-porous. Pores not visible to unaided eye, usually evenly distributed but sometimes with tendency to tangential arrangement in early wood, fairly numerous, mostly in small multiples and clusters, thick-walled, angular or round in outline. Vessel elements extremely short, with oblique ends. Intervascular pitting alternate, minute (3 μ). Vessel-to-ray pit-pairs very small, often unilaterally compound.

Fibers very short, thick-walled, non-septate, with simple or indistinctly bordered pits most numerous near the "shoulders."

Parenchyma abundant, aliform to confluent in short bands, occasionally terminal; cells often in 2-celled strands or fusiform; storied.

Rays homogeneous in mature wood, weakly heterogeneous in twig specimens and then with tall, sometimes pointed, upright cells. In tangential section the rays are occasionally uniseriate, mostly biseriate, and up to 3 cells wide; generally less than 10 cells high. Horizontal resin canals absent.

Characteristics of the Simaroubaceae

The following description is based upon the published studies by Webber (1936), Heimsch (1942), Record and Hess

(1943), and Metcalfe and Chalk (1950), as well as upon macroscopic examination of the wood specimens from the collection of the University of Cincinnati and that of the writer.

The family Simaroubaceae includes about thirty genera with 200 species of shrubs and small to large trees, widely distributed throughout the world, although mainly tropical. Woods without distinct heartwood, nearly white to canary or greenish yellow throughout, sometimes light brown; light to moderately heavy, with fine to rather coarse texture and mostly high luster; grain generally straight; without odor, but with mildly to decidedly bitter taste. The principal uses of the woods are medicinal and utilize a bitter principle always present in the group Simarouboideae. Only one genus, Simarouba, is important as a source of timber.

Growth rings usually present, not always distinct; ring-porous structure in a few species. Pores variable in size and abundance, few to moderately numerous, faintly distinct to invisible without a lens, solitary, or in radial multiples of 2 to 10, or in small clusters; evenly distributed, but sometimes forming a radial or oblique pattern, usually round, thin to thick-walled, but angular and thin-walled in several species. Vessel elements mostly medium-sized, with exclusively simple perforations, except for occasional multiple perforations in late wood of Ailantus; ends oblique; tyloses absent to abundant, usually thin-walled; resin-like deposits often present. Intervascular pit-pairs alternate,

often wider horizontally than vertically, variable in size from large to minute; borders rounded or hexagonal, 7 to 10 μ in diameter in species of 9 genera, less than 4 and to 6 μ in 6 genera; apertures sometimes coalescent. Ray-to-vessel pit-pairs similar to intervascular pits where these are small; large, round to oblong or gash-like, unilaterally compound, or simple in woods with large intervascular pitting. Spiral thickening in smaller vessels of species of Ailantus, Castela, Holacantha, and Picramnia.

Fibers mostly medium-sized (mean length 0.9 to 1.7 mm.); walls thick to thin; pits simple or bordered, usually small and inconspicuous, but moderately distinct in Ailantus and Simarouba, primarily on radial walls, except in two genera where they are equally distributed on radial and tangential surfaces; commonly or occasionally septate in species of seven genera; lumina filled with resin-like substance in some fibers of Suriana and Cadellia. Vasicentric tracheids reported in Alvaradoa, Castela, and Holacantha.

Parenchyma extremely variable, ranging from very sparse or absent to abundant in broad bands; generally with at least some paratracheal, vasicentric parenchyma; apotracheal, diffuse or concentric in narrow bands predominant in a few species; terminal parenchyma sometimes present, storied in several species.

Rays multiseriate except in 3 genera, usually 2 to 4 cells wide, up to 7 in Alvaradoa, Castela, Holacantha,

Picrasma, and Simarouba, sometimes more than 10 cells wide in Ailantus; over 50 cells high (exceeding 1 mm.) in Ailantus and several other genera, 25 to 50 cells high or less than 25, in most of remaining genera, homogeneous (Types I, II, and III) in 17 genera, markedly heterogeneous (Type II A) with 4 or more rows of square or upright marginal cells in 4 genera, and moderately heterogeneous (Type II B) in the remainder; crystals occasionally present in cells of some species, not numerous; crystals in chambered cells in one genus; resin-like deposits sometimes present; storied rays in certain species of 9 genera.

Characteristics of the Rutaceae

The following description of the woods is based upon the published studies of Heimsch (1942), Record and Hess (1940), Record and Hess (1943), and Metcalfe and Chalk (1950).

This large family comprises 140 genera with about 1600 species, mainly trees or shrubs, occurring in the tropics and sub-tropics, except for a few species in temperate regions. The wood is yellow, whitish, brownish, or greenish, often without much contrast between heartwood and sapwood, although a few species have coppery, reddish, or dark brown heartwood; medium heavy to heavy, with fine to moderately coarse texture and medium to very high luster; oder distinctive in some species of Amyris and Zanthoxylum, taste bitter in two genera. The family is the source of the citrus fruits, but only two species, Zanthoxylum flavum Vahl. and Chloroxylon Swietenia DC.

furnish well-known timbers, the West and East Indian Satinwoods, respectively.

Growth rings usually distinct; ring-porous structure in Choisya, Cneoridium, Erithrochiton, Ptelea, Thamnosma, Zanthoxylum americanum L., and Zanthoxylum Clava-Herculis L. Pores mostly invisible without lens except in early wood of ring-porous genera, moderately to very small (25 to 100μ in mean tangential diameter) in majority of genera, sometimes extremely small (less than 25μ), medium-sized in about one-third of the genera, with never more than 200μ mean diameter, except in ring-porous species, never exclusively solitary, commonly radial multiples of 2 to 4 or more, the pores characteristically rounded even in multiples; clusters moderately common in 14 genera; sometimes pores form radial or oblique pattern, or ulmiform pattern in some genera; few to very numerous, but not crowded; commonly thick-walled. Vessel elements moderately short to medium-sized; perforation plates typically exclusively simple, but a few foraminate, reticulate, scalariform, and modified scalariform plates have been reported in some species; solid deposits common and sometimes abundant. Intervascular pit-pairs alternate, mostly small to minute, but moderately large in 13 genera; coalescent apertures frequent. Vessel-to-ray pit-pairs similar to intervascular pitting, occasionally unilaterally compound in some genera, or simple. Spiral thickening in some species of 15 genera.

Fibers very short to mostly medium-sized; walls moderately to very thick, sometimes mucilaginous, occasionally septate in a few genera; pits simple or indistinctly bordered, few to numerous on radial walls, rare on tangential walls; resin-like deposits sometimes present.

Parenchyma very sparse to very abundant, paratracheal, vasicentric, aliform and confluent in some genera, apotracheal, terminal frequently, occasionally reticulate and diffuse, often consisting only of chambered crystal cells; crystals numerous.

Rays exclusively uniseriate, or up to 2 to 4 cells wide, larger in a few genera, 2 to 100 cells high (mostly to 30), but usually less than 1 mm.; 4 to 14 (mostly 7 to 10) rays per mm., homogeneous (Types I and II) in 31 genera, homogeneous (Type III) in woods with exclusively uniseriate rays, decidedly heterogeneous with uniseriate margins of 4 or more rows, in species of 16 genera, weakly heterogeneous in several others. Chambered crystalliferous cells present in some species; silica in rays of 2 genera; storied structure in Chloroxylon.

Characteristics of the Meliaceae

The following anatomical description is based on the published reports of Kribs (1930), Panshin (1933), Record and Hess (1943), and Metcalfe and Chalk (1950) and the macroscopic examination of the wood samples in the collection of the writer.

The family Meliaceae comprises 40 genera and more than 1000 species of trees and shrubs, occurring primarily in the tropical and sub-tropical regions of America, Africa, and Asia, but also in New Zealand and the eastern coast of Australia. The woods are creamy white to dark chocolate brown, mostly red or reddish brown, light to heavy, soft to very hard, with high or dull luster; grain straight to decidedly interlocked; odor aromatic or not distinctive; ripple marks present in some genera. The family is best known for its woods of great beauty or utility, Mahogany, Spanish Cedar, Crabwood, African Mahogany, African Walnut, Toon, and others.

Growth rings distinct to apparently absent; one genus ring-porous, one with semi-ring-porous structure. Pores few to numerous, minute to large, invisible to distinct without lens, mostly round and thin-walled, solitary, or in radial multiples of 2 to 8, clusters occasionally present in some genera, evenly distributed. Vessel elements medium-sized, mean length 300 to 700μ; ends slightly to decidedly oblique; perforations exclusively simple; tyloses absent; yellow or red resin-like deposits and chalky white substance often filling lumina. Intervascular pit-pairs alternate, bordered, mostly minute, but large in 7 genera; apertures often coalescent. Vessel-to-ray pitting similar to intervascular pitting.

Fibers very short to moderately long, thin to very thick-walled; septate in majority, non-septate in 16 genera; pits simple, or with very narrow borders, confined almost entirely to radial walls; resin-like deposits sometimes present.

Parenchyma variable in type and amount in different genera and even in different species of single genera; paratracheal, vasicentric, aliform to confluent; apotracheal, terminal, diffuse, or broad concentric bands; diffuse parenchyma often consisting entirely of crystalliferous cells; storied in woods with storied rays and in some others; resin-like deposits sometimes present.

Rays homogeneous to decidedly heterogeneous, varying even within one genus, exclusively uniseriate in species of 15 genera, mostly 2 to 3 cells wide in the remainder, but up to 4 to 6 cells wide in species of 8 genera, and 7 to 9 cells wide in species of Khaya and in Melia, 2 to 150 cells high, mostly less than 30 cells, over 1 mm. high in some genera; resin-like deposits common; crystals present in marginal cells of the Swietenioideae. Rays storied in most specimens of Pseudocedrela, Ptaeroxylon, Swietenia, Xylocarpus, and in some species of 5 other genera.

The Relationships of the Rutales

All the families have pores which are solitary or in small multiples or clusters, except that the Cneoraceae have almost exclusively multiples and clusters. Pores are round in the Simaroubaceae, Rutaceae, Meliaceae; round or angular in the others; mostly small to medium-sized. Vessel elements are extremely short in the Cneoraceae and Coriariaceae, short to medium-sized in the others. Intervascular pitting is minute in the Cneoraceae, small in the Coriariaceae, minute

to large in the Meliaceae and Rutaceae, and small to large in the others. Perforations are exclusively simple in all but the Simaroubaceae and Rutaceae, where some multiples or scalariform plates are rarely present; ends are slightly to decidedly oblique.

Fibers all have simple or indistinctly bordered pits. Most genera of the Burseraceae and Meliaceae have septate fibers, and non-septate fibers are completely absent only in the Cneoraceae and Coriariaceae.

Parenchyma is variable, abundant to sparse, apotracheal to paratracheal or both. The Burseraceae, however, have typically sparse paratracheal parenchyma.

Rays are typically less than 1 mm. high (25 to 50 cells), but very low (less than 10 cells) in the Cneoraceae and very high (over 4 mm.) in the Coriariaceae; 1 to 4 cells wide in most rays, but over 15 cells wide in the Coriariaceae; exclusively homogeneous in the Cneoraceae, some genera homogeneous in the Rutaceae, Simaroubaceae, and Meliaceae, and heterogeneous, exclusively, in the Burseraceae and Coriariaceae. Horizontal intercellular canals are present only in the Burseraceae.

In comparing the anatomy of the families, we find that the only feature always present is the simple or indistinctly bordered pitting on the fibers. The Burseraceae, Anacardiaceae, and Julianiaceae form a distinct group immediately, however, because of the combination of septate fibers in most

genera, sparse paratracheal parenchyma, and horizontal intercellular canals. The Rutaceae, Simaroubaceae, and Meliaceae likewise form a unit because of the frequency of homogeneous rays. The Cneoraceae differ from all the others in the distribution of the pores (multiples and clusters), extremely short vessel elements, exclusively minute intervascular pitting, completely non-septate fibers, and very low, exclusively homogeneous rays. The differences may not be great, however, for the family consists of but one genus with three species, and would probably closely resemble at least one of the exceptional genera of each of the large families whose generalized descriptions have been given. The Coriariaceae also differ in the lack of septate fibers and in the presence of the extraordinarily high, wide rays. Such rays are far more primitive than those of the other members of the Rutales and the family probably should not be included in the order. It does not seem to belong with the rather primitive Hamamelidales to which Hallier assigned it on the basis of floral anatomy, but it seems rather unhappily placed among Gundersen's more specialized families.

From the point of view of wood anatomy, Gundersen seems to have developed an acceptable classification of the families related to the Anacardiaceae, with the exception of the Coriariaceae. The problem of the relationship of this group to the Sapindaceae still remains, and many taxonomists, as well as wood anatomists, would object to the separation of

the Sapindaceae from Gundersen's Rutales. Certainly its typically septate fibers, homogeneous rays, and solitary pores with occasional short multiples, are similar to structures found in most of the families in Gundersen's Rutales. Its inclusion would not be a radical innovation, for Wettstein (1935) has a similar grouping in his Terebinthales, and Gundersen's inclusion of the Julianiaceae and Cneoraceae would thus improve upon the scheme of Wettstein. In the opinion of the writer, therefore, the ideal arrangement would be to exclude the Coriariaceae from the Rutales of Gundersen but to add the Sapindaceae.

SUMMARY

1. The non-American genera of the Anacardiaceae, as delimited by Dalla Torre and Harms, have been studied and the macroscopic and microscopic structures of their secondary xylem has been described.
2. A summary of the anatomical characteristics of the American members of the Anacardiaceae is presented from the literature.
3. The family Anacardiaceae is intermediate in specialization with regard to features of phyletic importance, for no genus exhibits many primitive characteristics, nor is any genus entirely specialized.
4. Structure of the wood does not support the segregation of anacardiaceous genera into the tribes established by Engler.
5. Barkley's exclusion of Blepharocarya and Rhodosphaera from the Anacardiaceae is not supported by the evidence in wood anatomy.
6. Spondianthus should be retained in the Euphorbiaceae, as advocated by Engler and others, for its wood structure does not uphold Barkley's inclusion of the genus in the Anacardiaceae.
7. There is anatomical evidence for placing the Julianiaceae with the Anacardiaceae in the same order, but there is none for its inclusion with the Juglandaceae.

8. The Juglandaceae show no close anatomical relationship with the Anacardiaceae.
9. Wood structure supports the exclusion of *Toxicodendron*, as defined by Barkley, from the genus *Rhus*.
10. All of the families of Gundersen's Rutales, except the Coriariaceae, show a uniformity of structure which probably indicates relationship, but the Sapindaceae should be added to the group.

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PLATES

Plate 1

Apotracheal parenchyma in the Mangifereae

(Rays omitted)

Fig. 1. *Gluta Renghas* L.

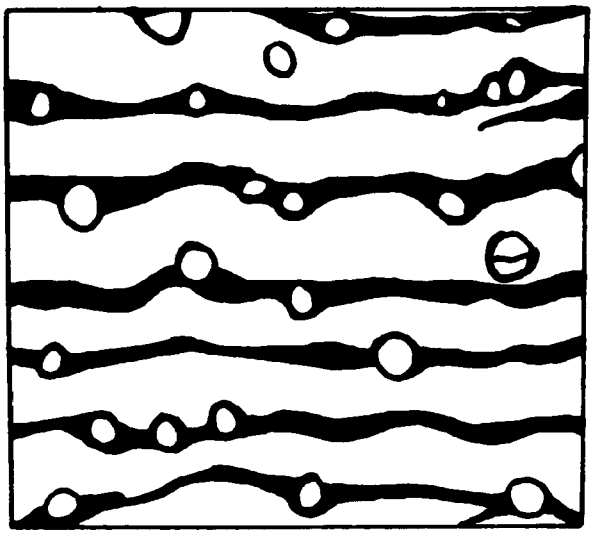
Fig. 2. *Melanorrhoea terquata* King

Fig. 3. *Bouea macrophylla* Griff.

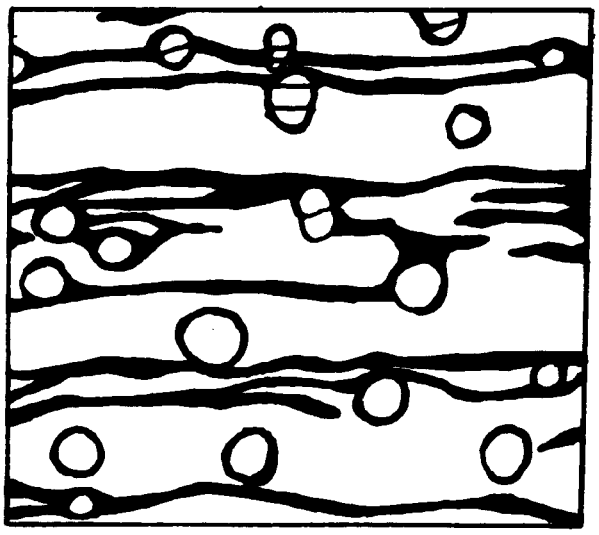
Fig. 4. *Mangifera laurina* Blume

Fig. 5. *Swintonia floribunda* Griff.

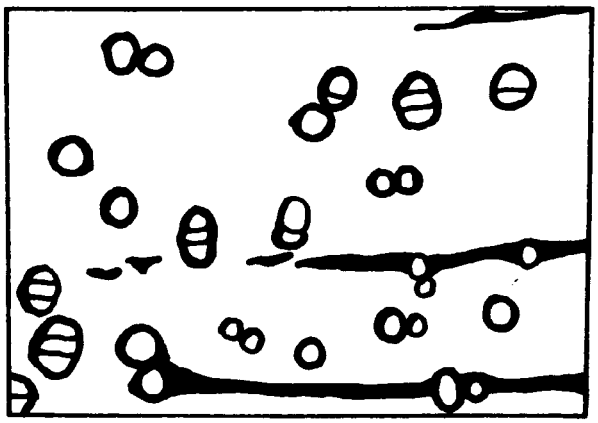
Plate 1



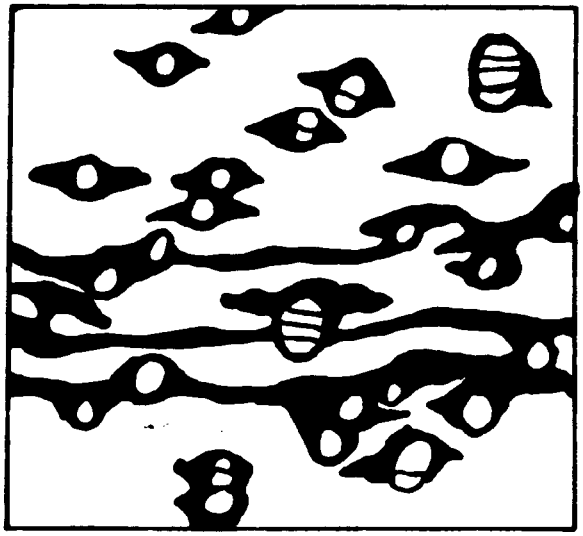
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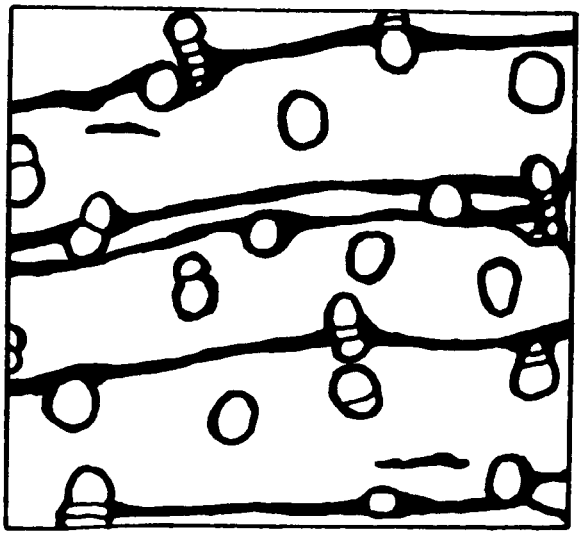
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5

1 mm.

Plate 2

Variation in size and shape, and types of perforation plates in vessel elements.

Figs. 1, 2, and 3. *Microstemon velutina* Engl.

Fig. 4. *Nothopegia Colebrookiana* Blume

Figs. 5 and 6. *Rhodosphaera rhodanthema* Engl.

Figs. 7, 8, 9, 10, and 11. *Blepharocarya involucrigera* F. Mueller

Figs. 12 and 13. *Heeria mucronifolia* Meissn.

Figs. 14 and 15. *Melanochyla Kunstleri* Hook. f.

Plate 2

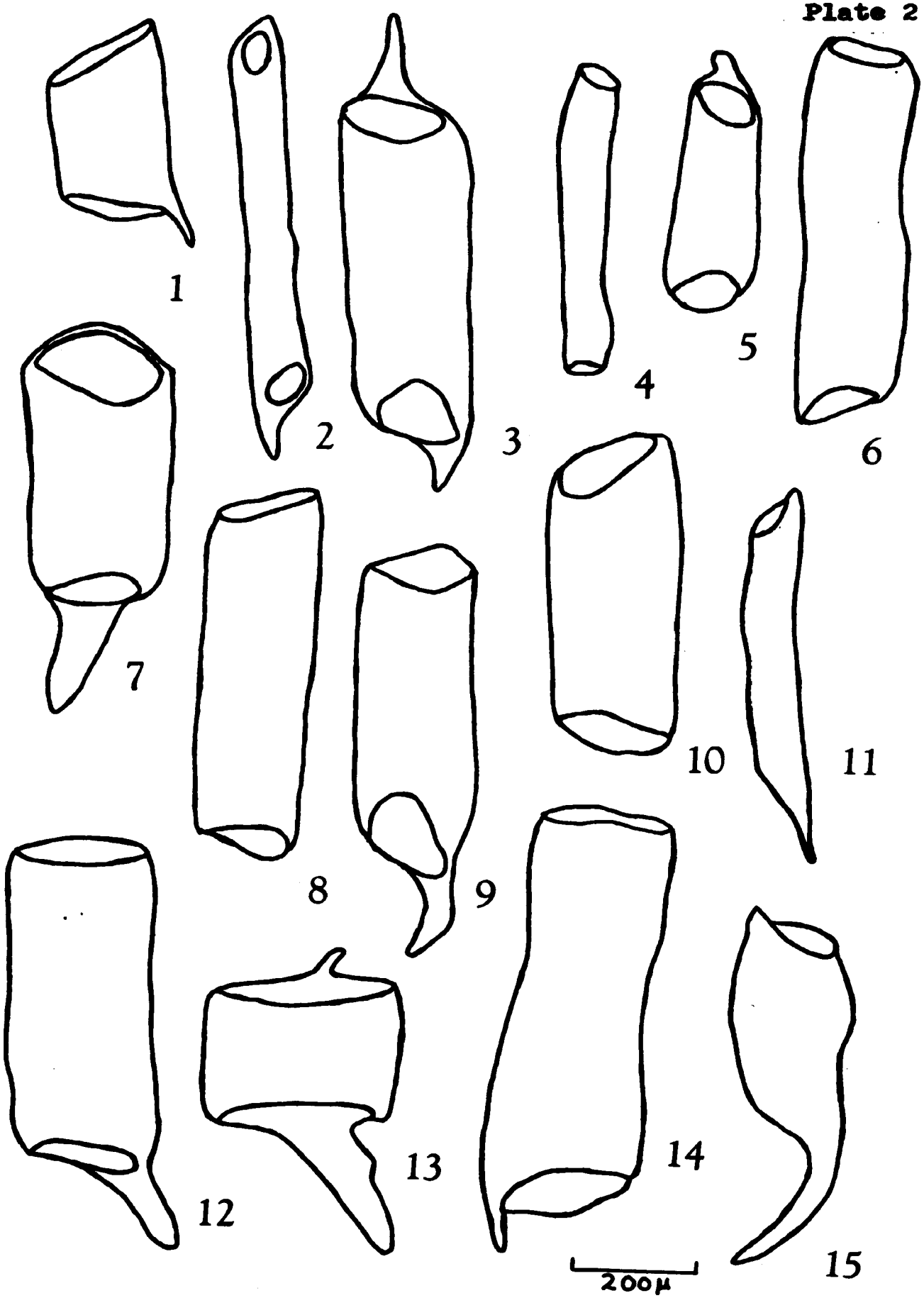


Plate 3

Variation in size and shape, and types of perforation plates in vessel elements.

Figs. 1, 2, 3, and 4. *Campnosperma Wallichii* King

Fig. 5. *Campnosperma macrophylla* (Blanco) Hook. f.

Fig. 6. *Campnosperma zeylanica* Thw.

Figs. 7 and 8. *Spondianthus ugandensis* Hutchinson

Figs. 9, 10, 11, and 12. *Cotinus coggygria* Scop.

Figs. 13, 14, 15, and 16. *Juliania adstringens* Schlecht.

Plate 3

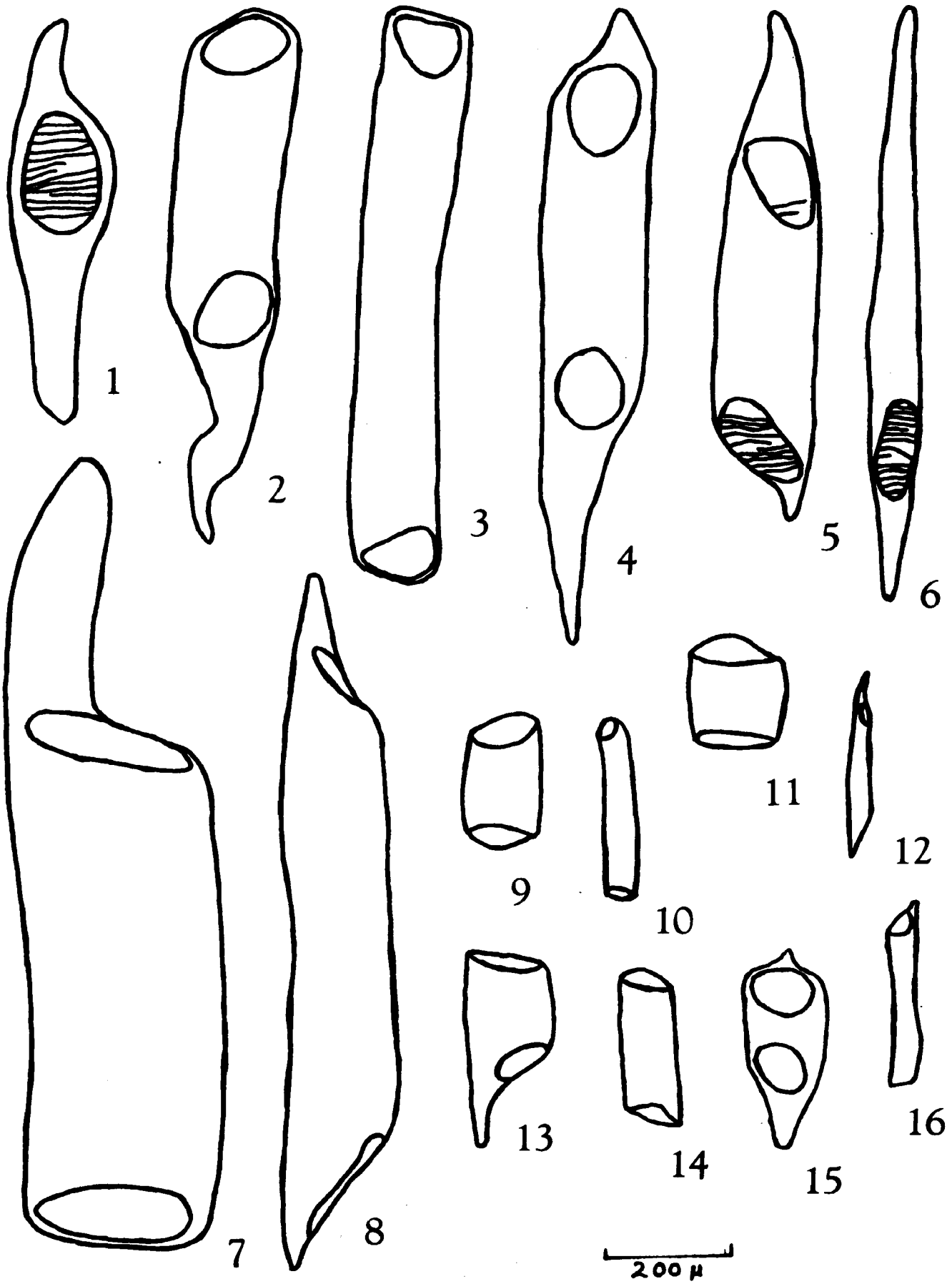


Plate 4

Types of fibers

Fig. 1. *Mangifera minor* Blume

Fig. 2. *Swintonia Griffithii* Kurz

Fig. 3. *Sclerocarya caffra* Sond.

Figs. 4 and 5. *Rhodosphaera rhodanthema* Engl.

Fig. 6. *Rhus semialata* Murr.

Fig. 7. *Cotinus coggygria* Scop.

Figs. 8 and 9. *Juliania adstringens* Schlecht.

Fig. 10. *Blepharocarya involucrigera* F. Mueller

Fig. 11. *Heeria mucronifolia* Meissn.

Fig. 12. *Nothopegia Colebrookiana* Blume

Fig. 13. *Semecarpus laxiflora* K. Schaum.

Plate 4

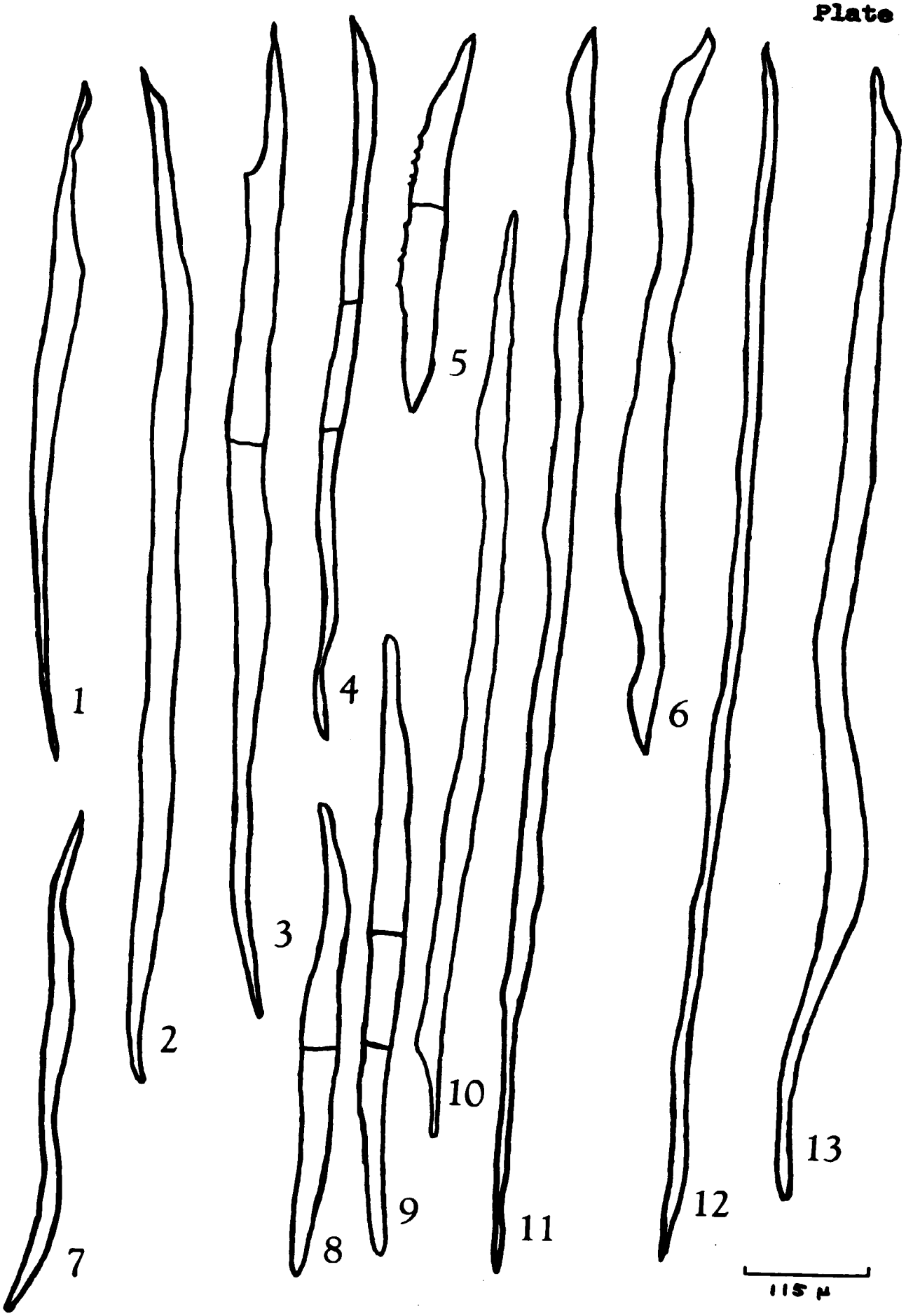


Plate 5

Intercellular canals in rays, tangential view.

Fig. 1. *Swintonia Griffithii* Kurz.

Fig. 2. *Gluta Renghas* L.

Fig. 3. *Melanorrhoea torquata* King

Fig. 4. *Buchanania attenuata* A. C. Smith

Fig. 5. *Koordersiodendron pinnatum* Engl.

Fig. 6. *Spondias dulcis* Forst. var. *acida* Engl.

Fig. 7. *Pleiogynium pilosum* (Benth.) Engl.

Fig. 8. *Poupartia axillaris* (Roxb.) King & Prain.

Fig. 9. *Sclerocarya caffra* Sond.

Fig. 10. *Pseudospondias microcarpa* Engl.

Fig. 11. *Odina Wodier* Roxb.

Fig. 12. *Lannea amaniensis* Engl.

Plate 5

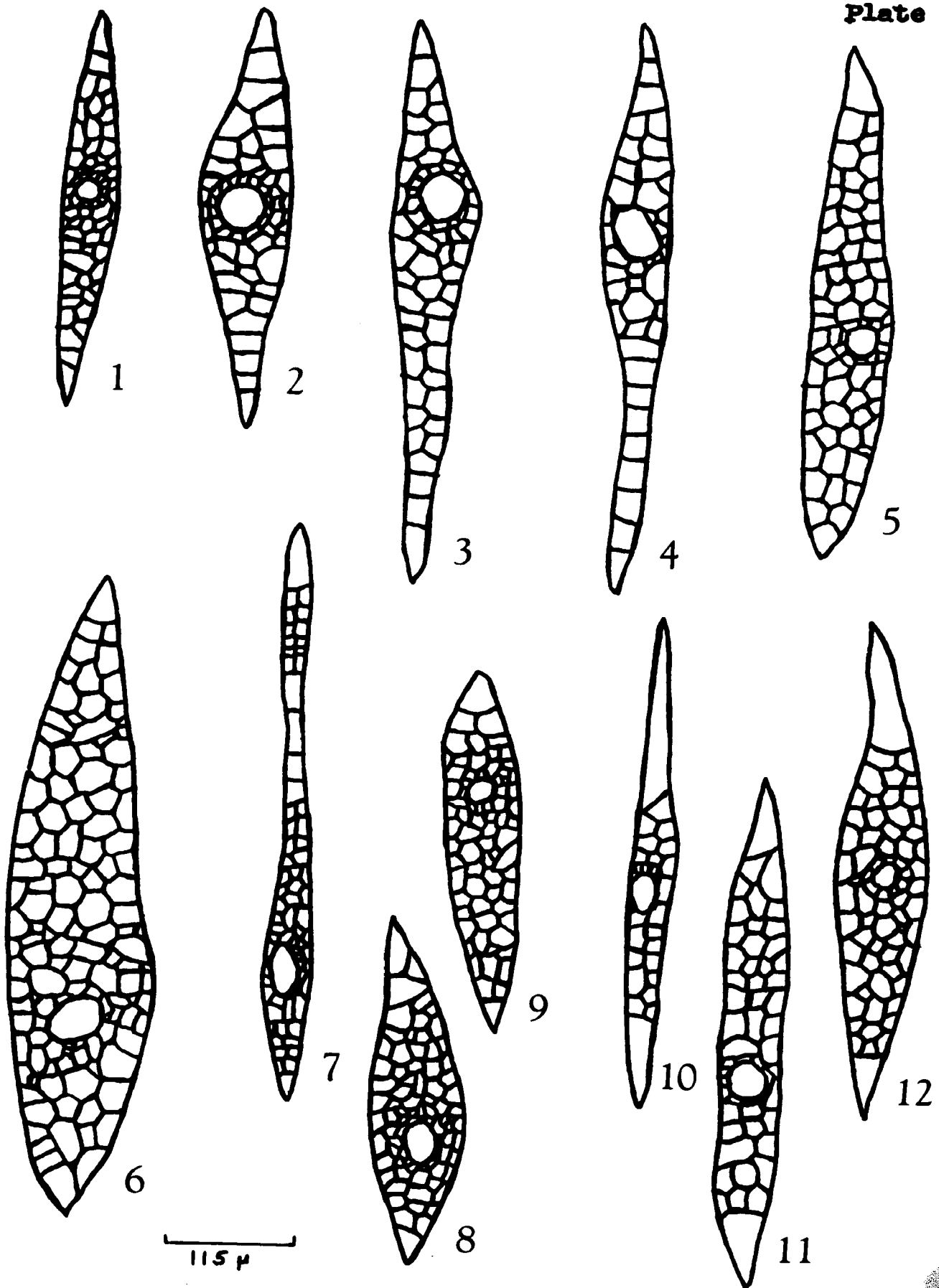


Plate 6

Intercellular canals in rays, tangential view.

Fig. 1. *Pistacia Lentiscus* L.

Fig. 2. *Pentaspadon Motleyi* Hook. f.

Fig. 3. *Microstemon velutina* Engl.

Fig. 4. *Trichocypha ferruginea* Engl.

Fig. 5. *Parishia Malabog* Merr.

Fig. 6. *Campnosperma Wallichii* King

Fig. 7. *Euroschinus falcatus* Hook. f.

Fig. 8. *Melanochyla Kunstleri* King

Fig. 9. *Rhodosphaera rhodanthema* Engl.

Plate 6

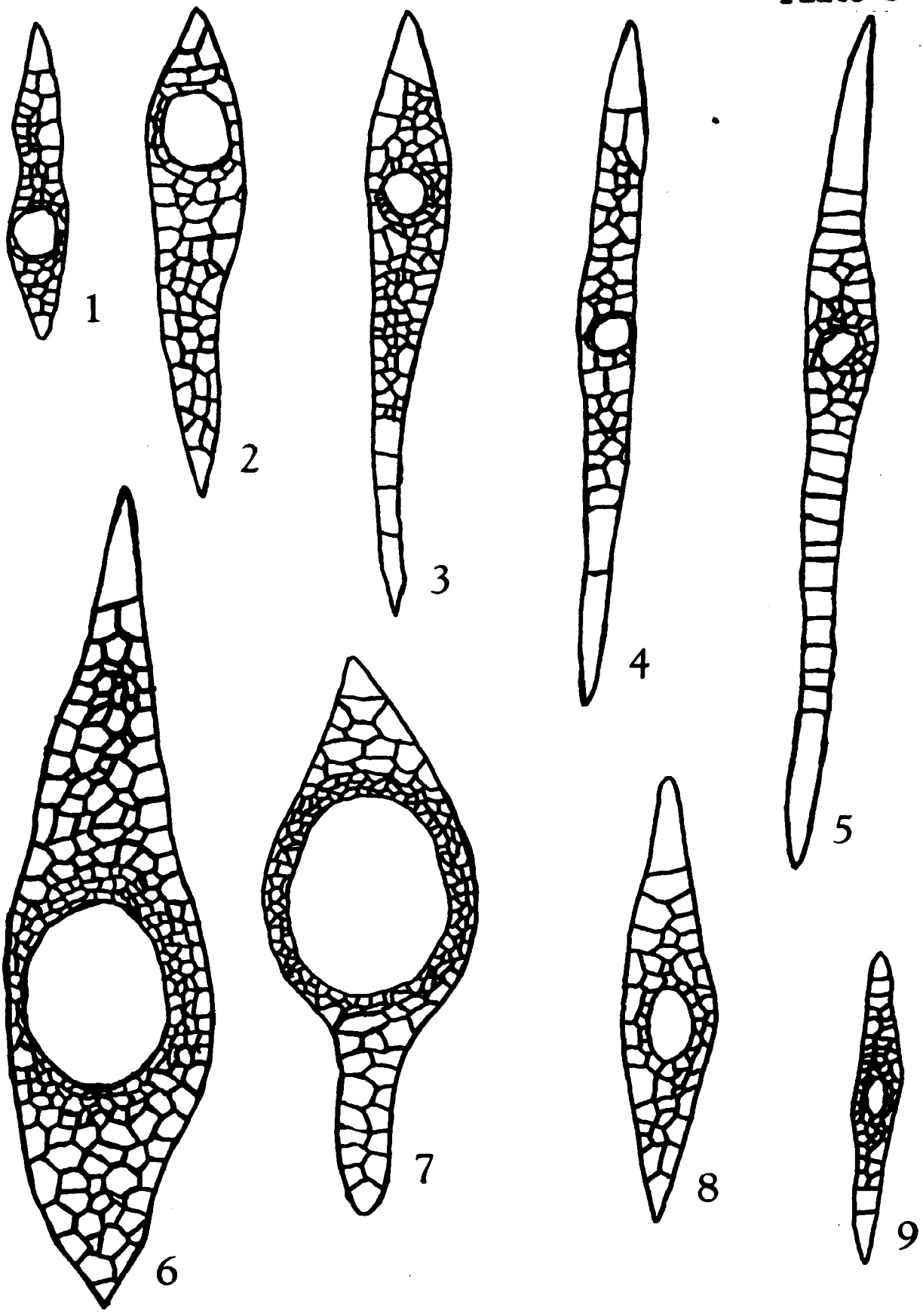


Plate 7

Fig. 1. Buchanania palawensis Laut. Transverse section showing size and arrangement of pores and absence of apotracheal parenchyma. x 27.

Fig. 2. Buchanania sessilifolia Blume. Transverse section showing size and arrangement of pores and paratracheal parenchyma. Note rows of fibers with resin-like deposits. x 27.

Fig. 3. Buchanania nitida Engl. Transverse section showing short radial multiples of pores, scanty paratracheal parenchyma, and resin-like deposits in fibers. x 27.

Fig. 4. Buchanania nitida Engl. Higher magnification of Fig. 3. Note thin-walled pores and fibers, rectangular outline and large lumina of fibers, and resin-like deposits in the rays.

Plate 7

Fig. 1. Buchanania palawensis Laut. Transverse section showing size and arrangement of pores and absence of apotracheal parenchyma. x 27.

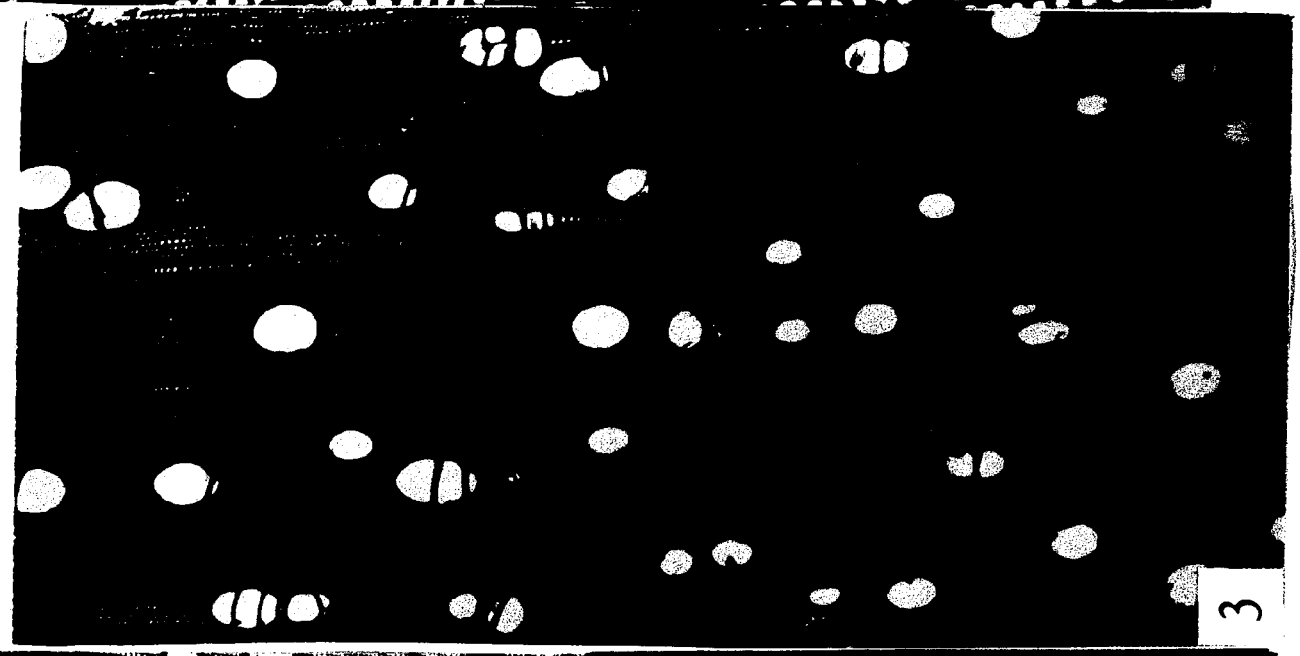
Fig. 2. Buchanania sessilifolia Blume. Transverse section showing size and arrangement of pores and paratracheal parenchyma. Note rows of fibers with resin-like deposits. x 27.

Fig. 3. Buchanania nitida Engl. Transverse section showing short radial multiples of pores, scanty paratracheal parenchyma, and resin-like deposits in fibers. x 27.

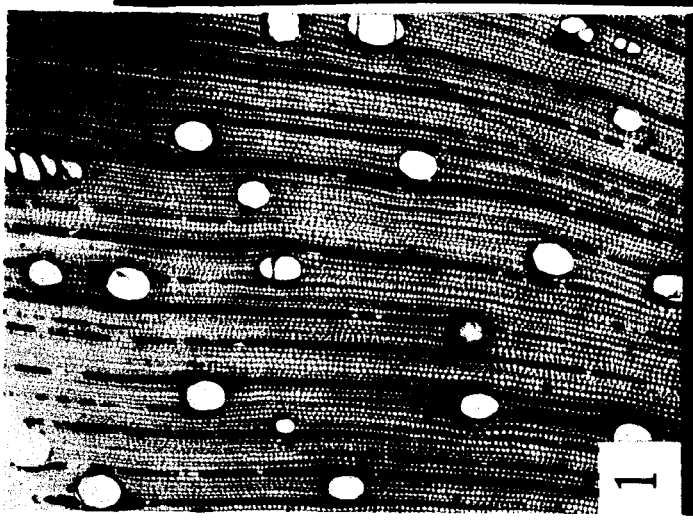
Fig. 4. Buchanania nitida Engl. Higher magnification of Fig. 3. Note thin-walled pores and fibers, rectangular outline and large lumina of fibers, and resin-like deposits in the rays.



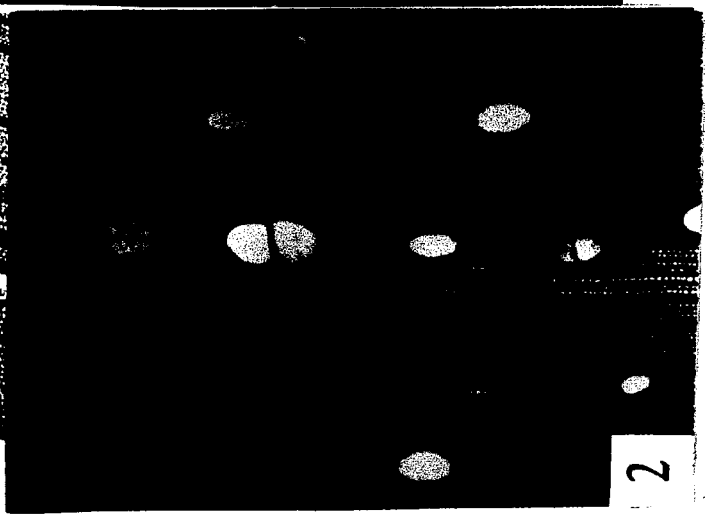
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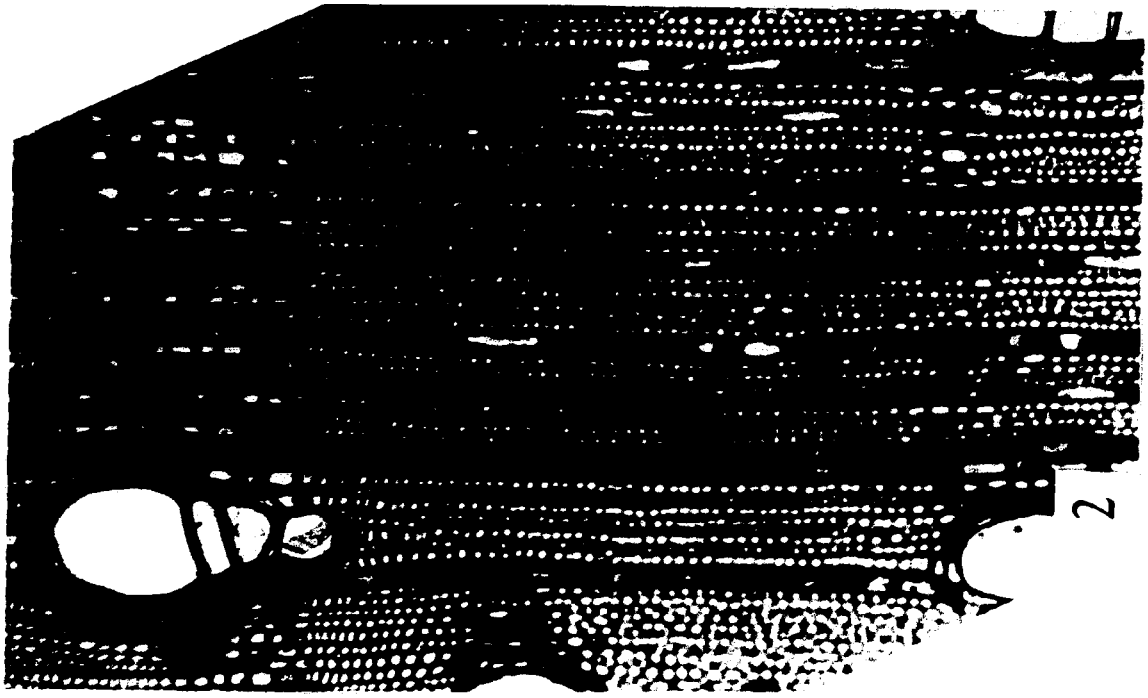
Plate 7

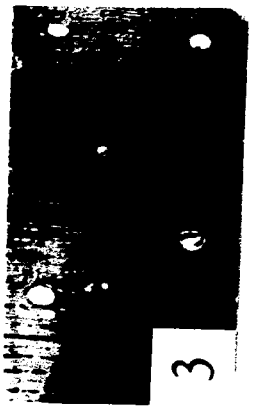
Plate 8

Fig. 1. Swintonia floribunda Griff. Transverse section showing size and arrangement of pores and concentric bands of apotracheal parenchyma. x 27.

Fig. 2. Bouea macrophylla Griff. Transverse section showing wide apotracheal parenchyma band. x 130.

Fig. 3. Gluta tavoyana Wall. Transverse section showing arrangement of pores and narrow, concentric bands of apotracheal parenchyma. x 20.





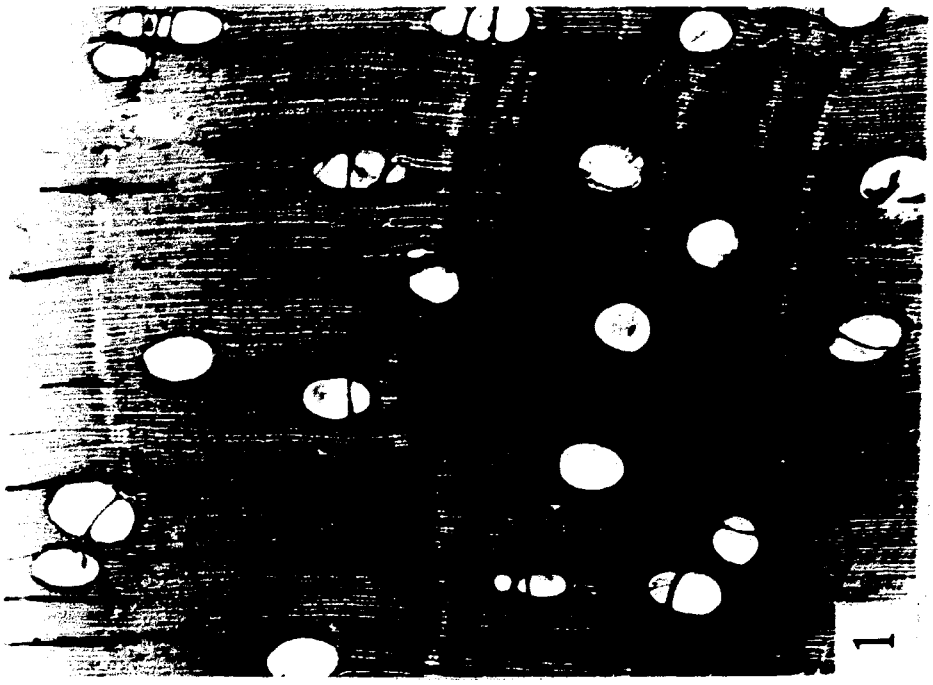


Plate 8

Plate 9

Fig. 1. Mangifera laurina Blume. Transverse section showing vasicentric, aliform parenchyma and several apotracheal bands. x 27.

Fig. 2. Mangifera laurina Blume. Higher magnification of Fig. 1. Note tyloses in vessels. x 130.



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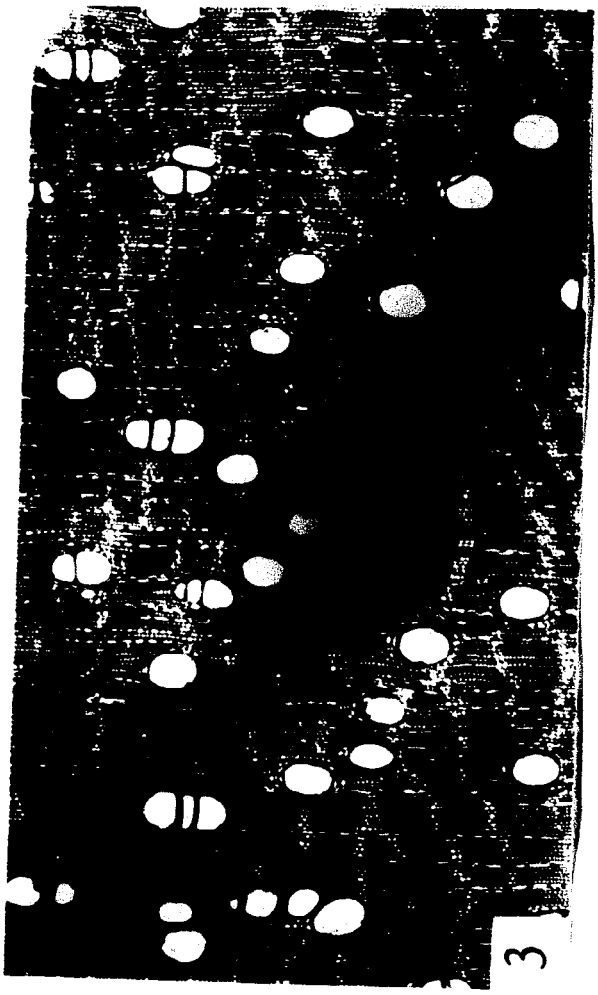
Plate 9

Plate 10

Fig. 1. Lannea acida A. Rich. Transverse section showing size and arrangement of pores and wide rays. x 27.

Fig. 2. Lannea amaniensis Engl. Transverse section showing size and arrangement of pores. Note abundant tyloses and resin-like deposits in the vessels. x 27.

Fig. 3. Antrocaryon Klaineanum Pierre. Transverse section showing size and arrangement of the pores and the numerous narrow bands of apotracheal parenchyma. x 27.





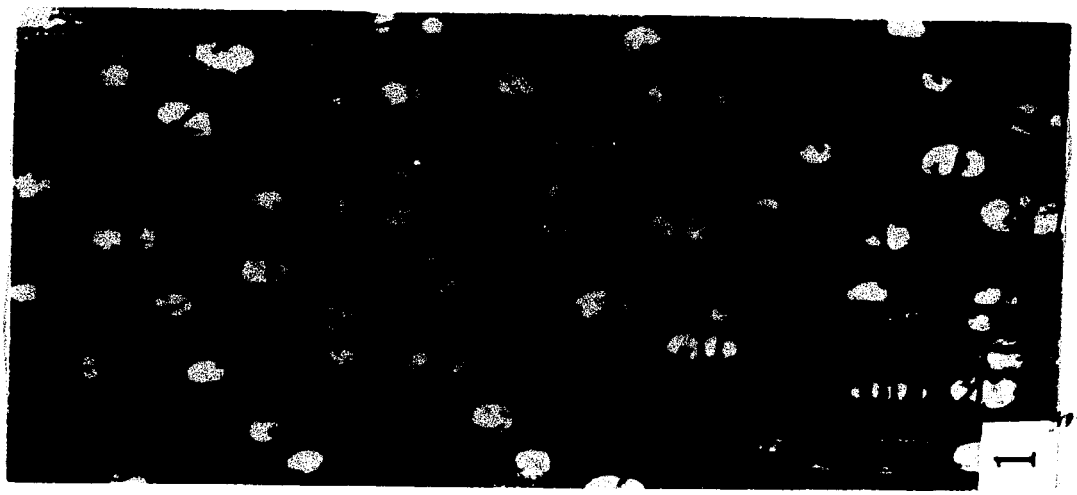
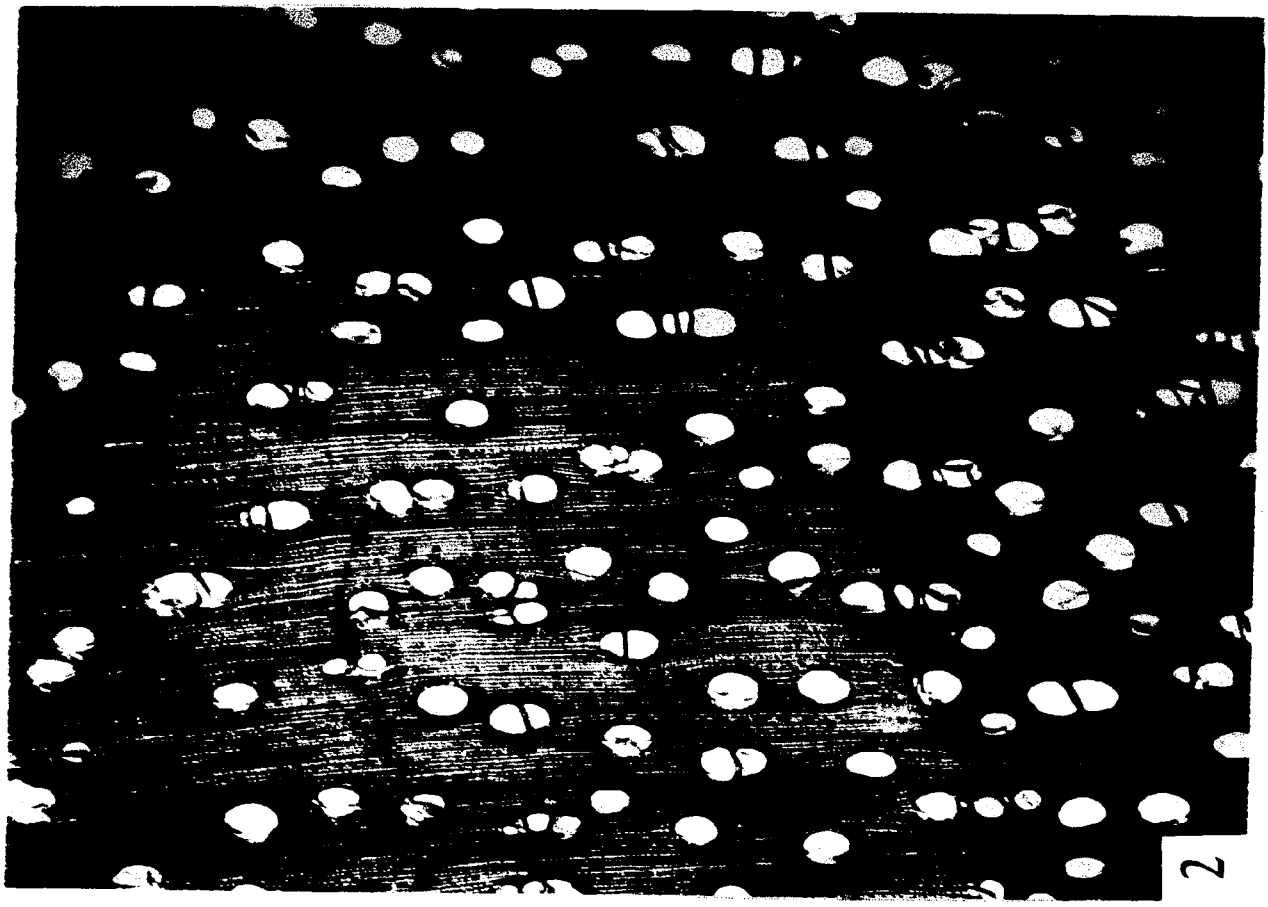


Plate 10

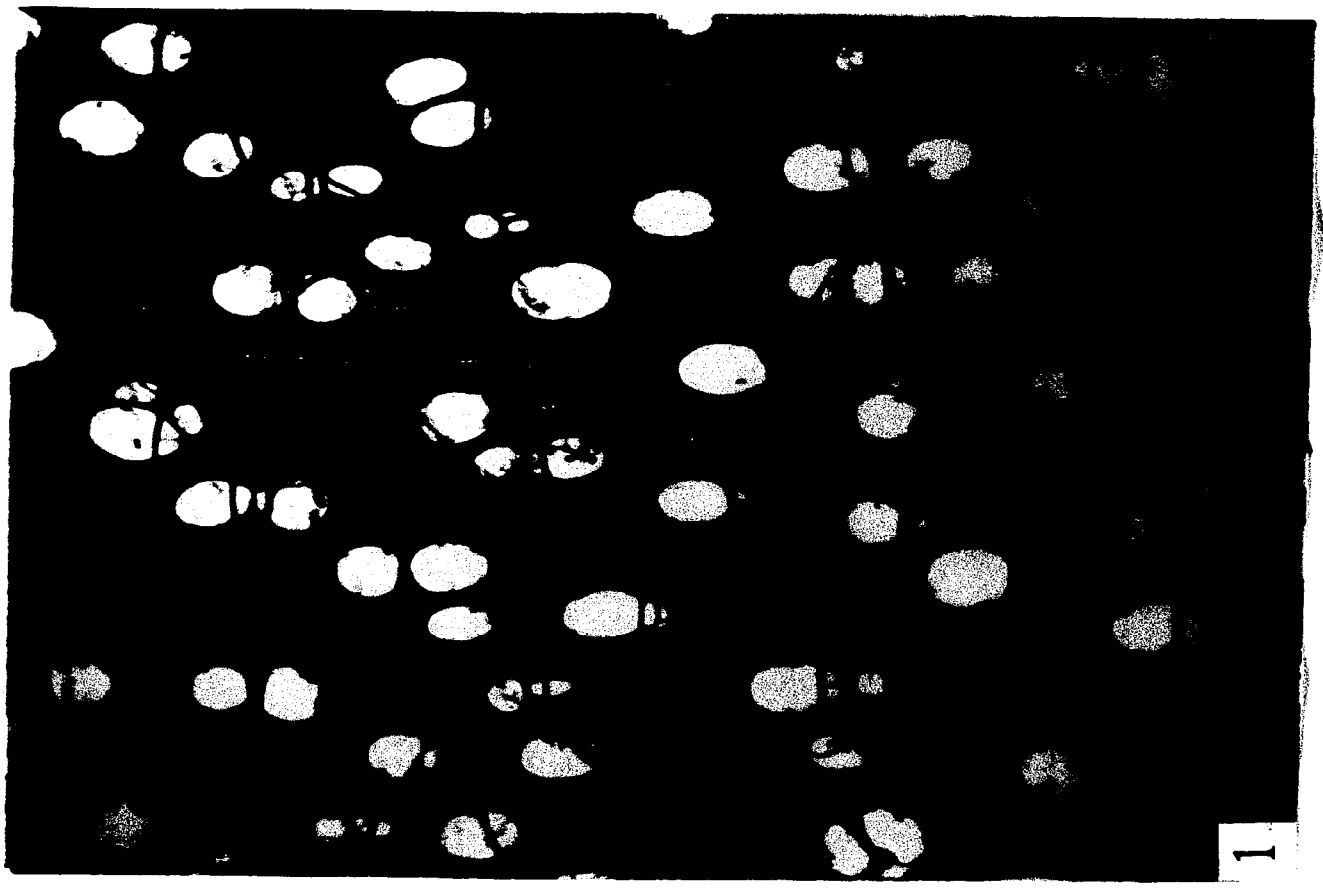
Plate 11

Fig. 1. Dracontomelum mangiferum Blume. Transverse section showing size and distribution of large pores, and vasicentric parenchyma with occasional aliform extensions. x 27.

Fig. 2. Microstemon velutina Engl. Transverse section showing size and arrangement of pores and sparse paratracheal parenchyma. Note bands of darker fibers filled with resin-like deposits. x 27.



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Plate 11

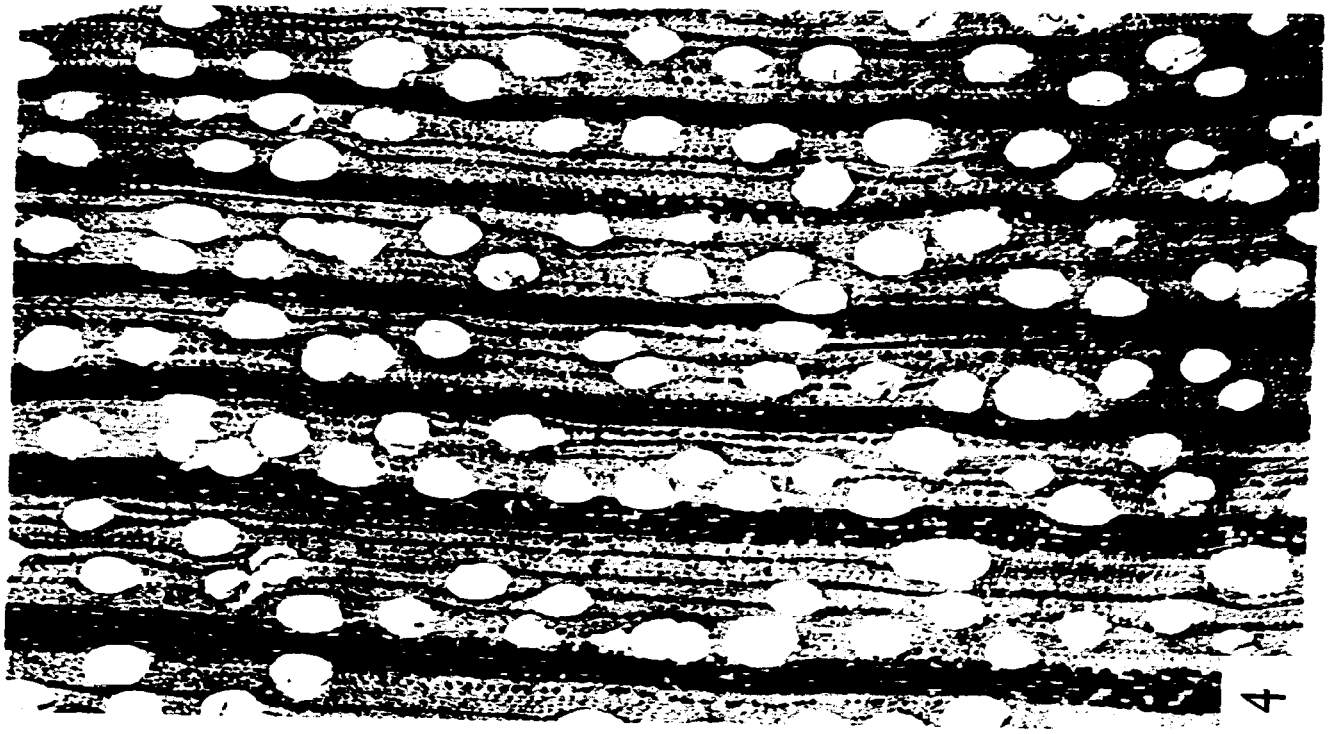
Plate 12

Fig. 1. Spondias Mangifera Willd. var. javanica Koord. & Valet. Transverse section showing arrangement of large pores, and wide rays. x 20.

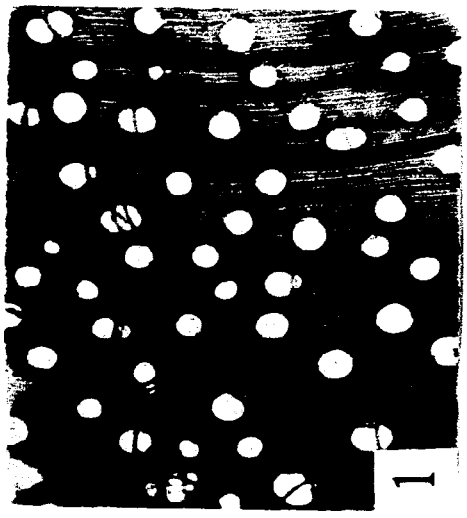
Fig. 2. Spondias Mangifera Willd. Transverse section showing several small clusters of pores. x 20.

Fig. 3. Spondias pinnata (L.) Kurz. Transverse section showing wide rays and thin-walled fibers with large lumina. x 27.

Fig. 4. Spondianthus ugandensis Hutch. Transverse section showing size and arrangement of pores and wide rays abundantly filled with resin-like deposits. x 27.







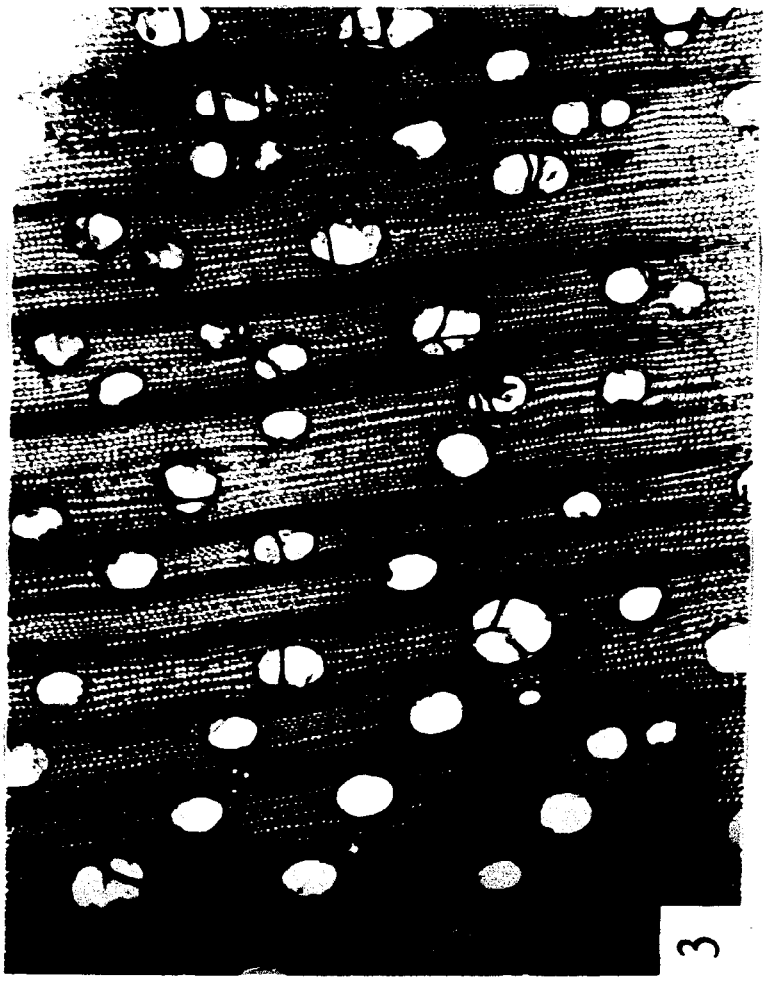


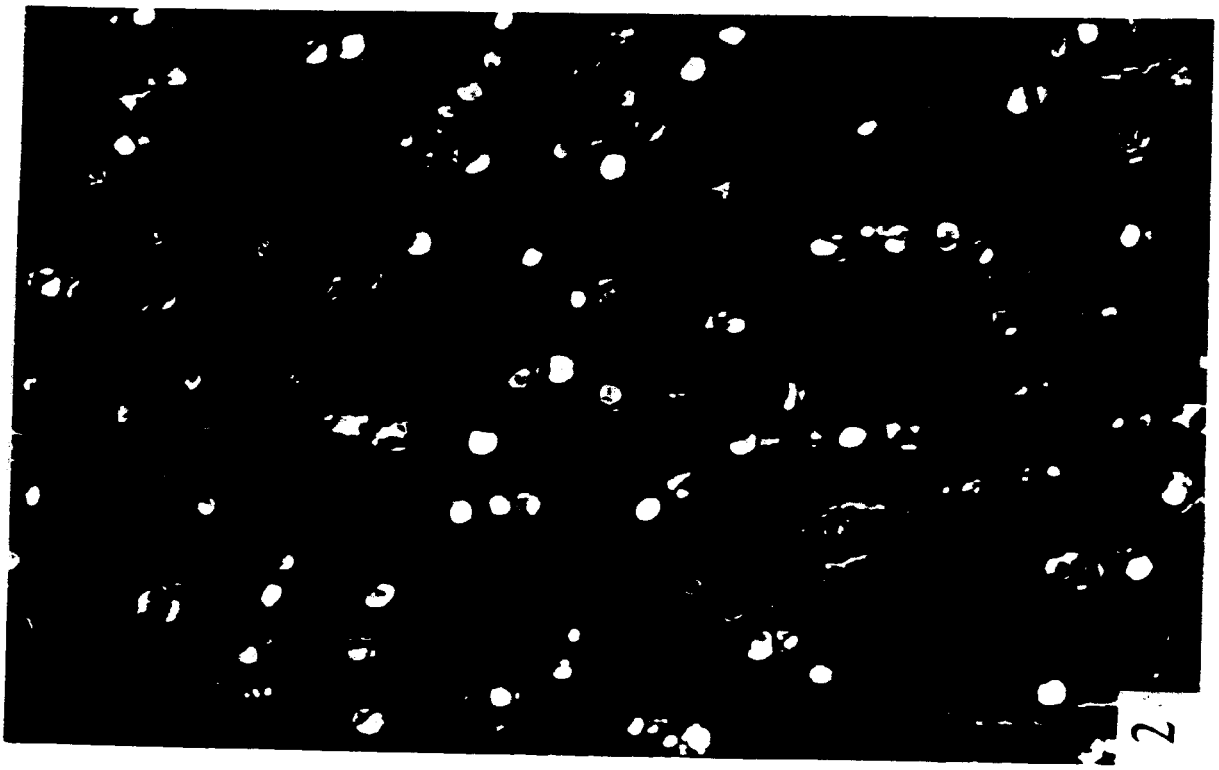
Plate 12

Plate 13

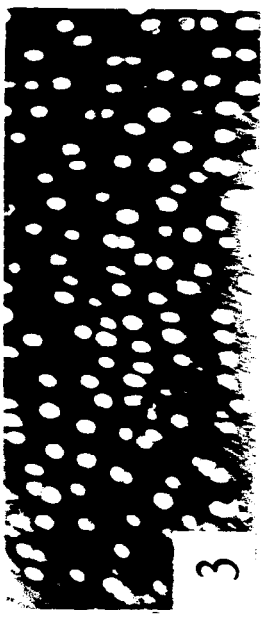
Fig. 1. Heeria mucronifolia Engl. Transverse section showing size and arrangement of pores. x 27.

Fig. 2. Faguetia falcata March. Transverse section showing size and arrangement of pores and narrow bands of apotracheal parenchyma. x 27.

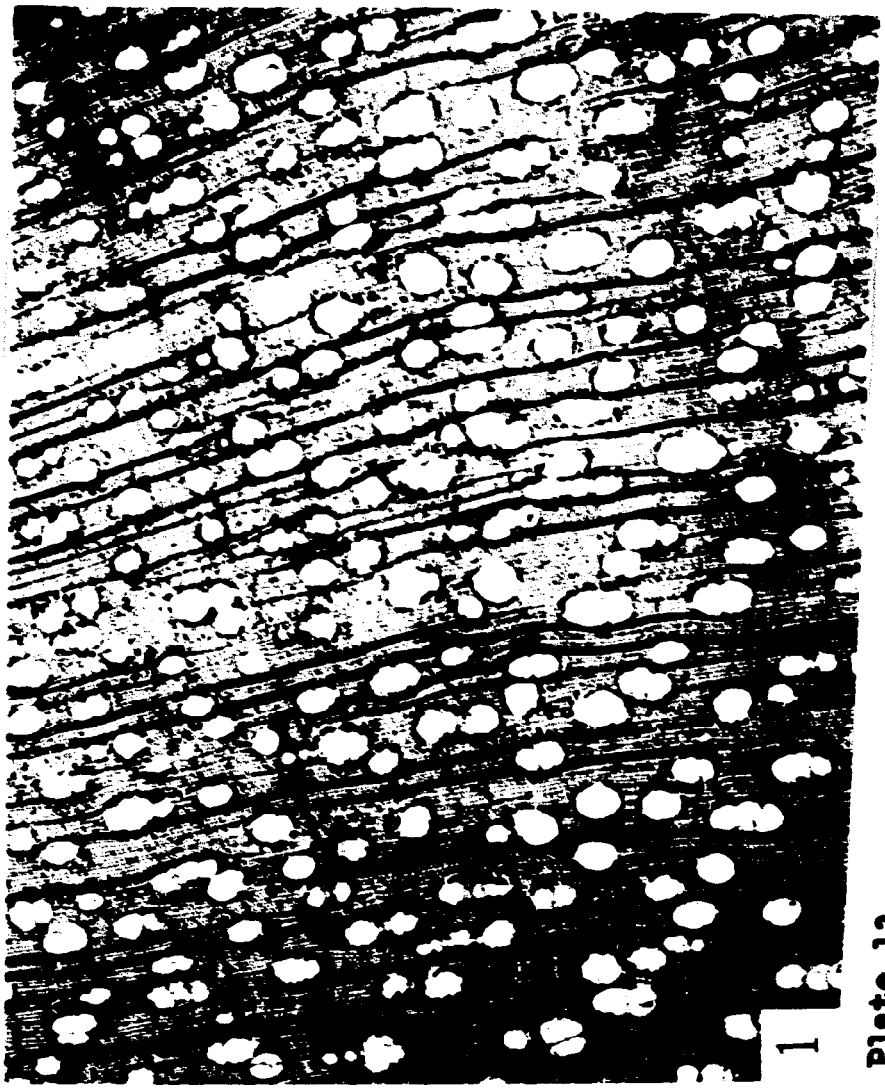
Fig. 3. Pentaspadon minutiflora B. L. Burtt. Transverse section showing size and arrangement of pores. x 20.



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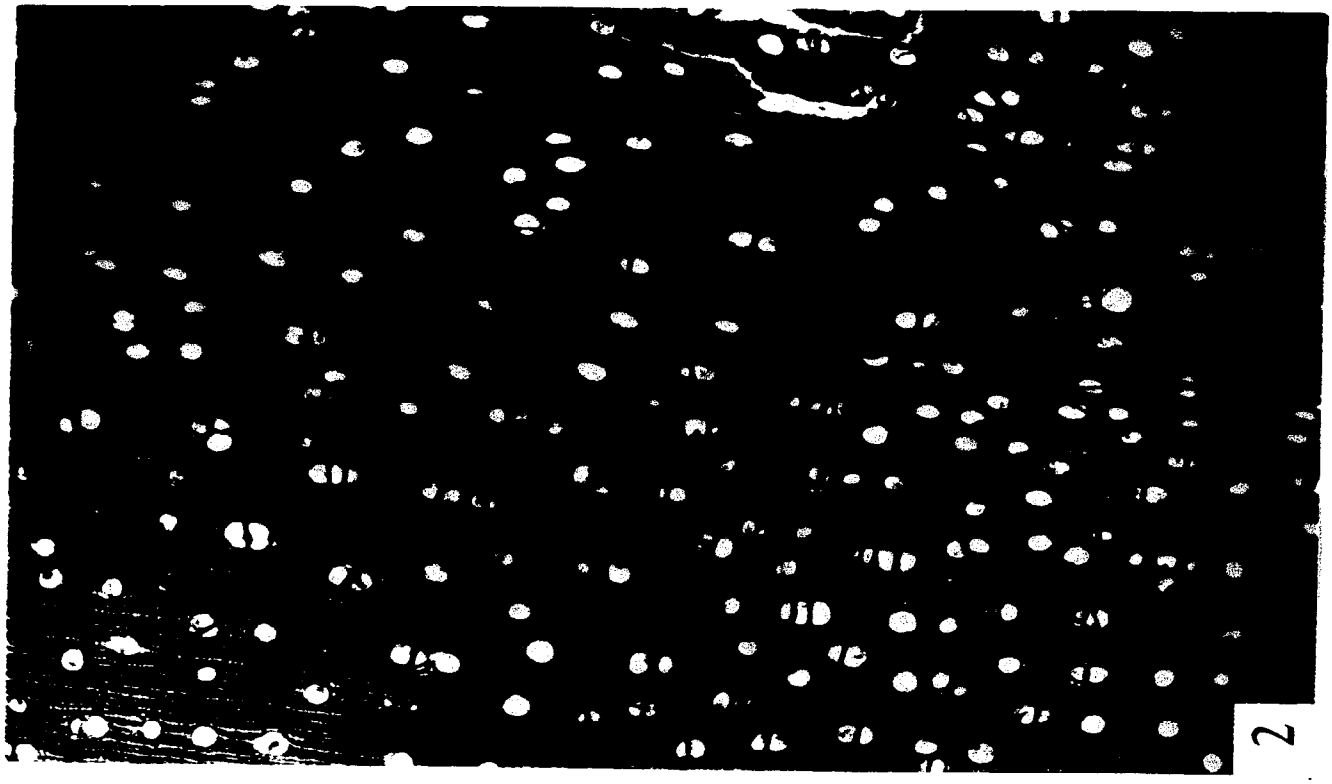
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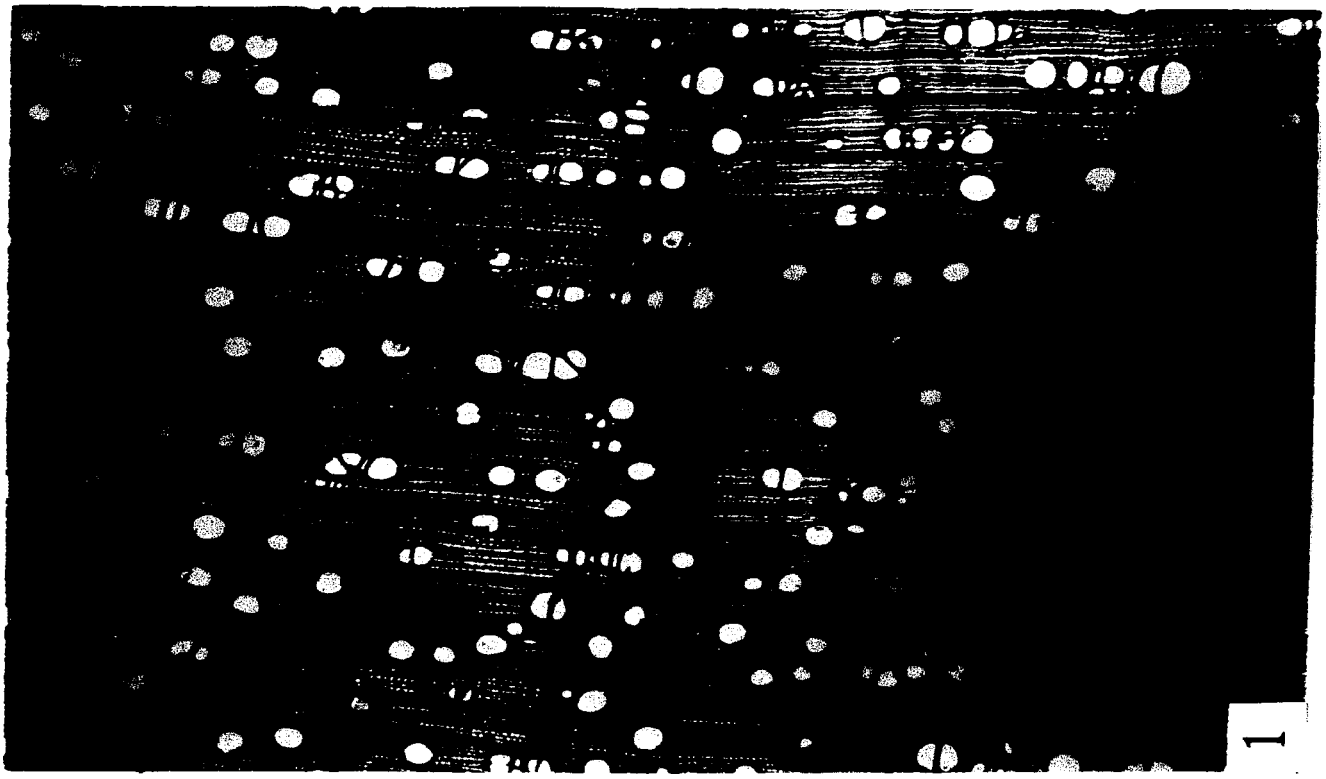
Plate 14

Fig. 1. Euroschinus falcatus Hook.f. Transverse section showing size and arrangement of pores and sparse parenchyma. x 27.

Fig. 2. Euroschinus obtusifolius Engl. Transverse section showing size and arrangement of pores and occasional rows of fibers with resin-like deposits. x 27.



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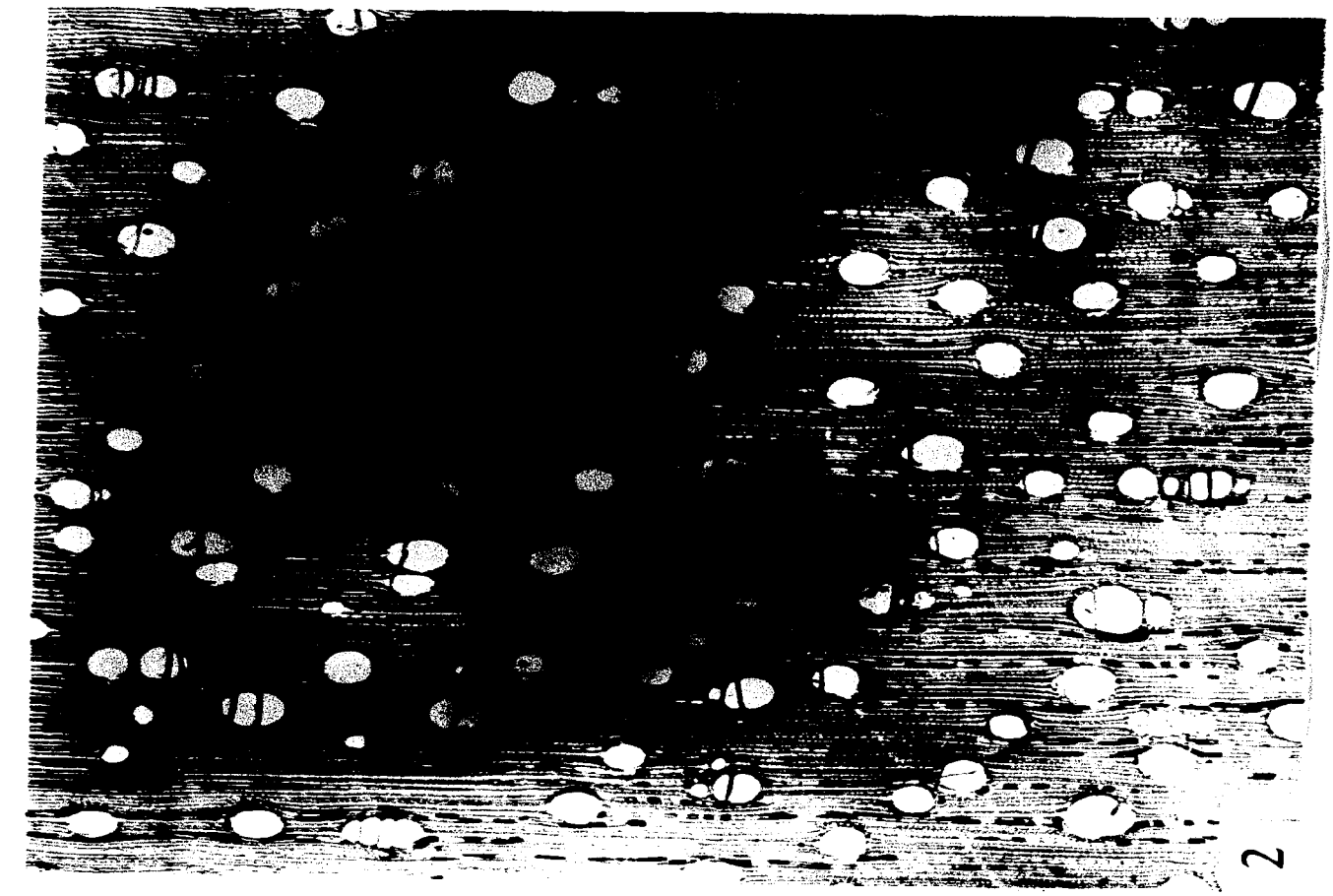
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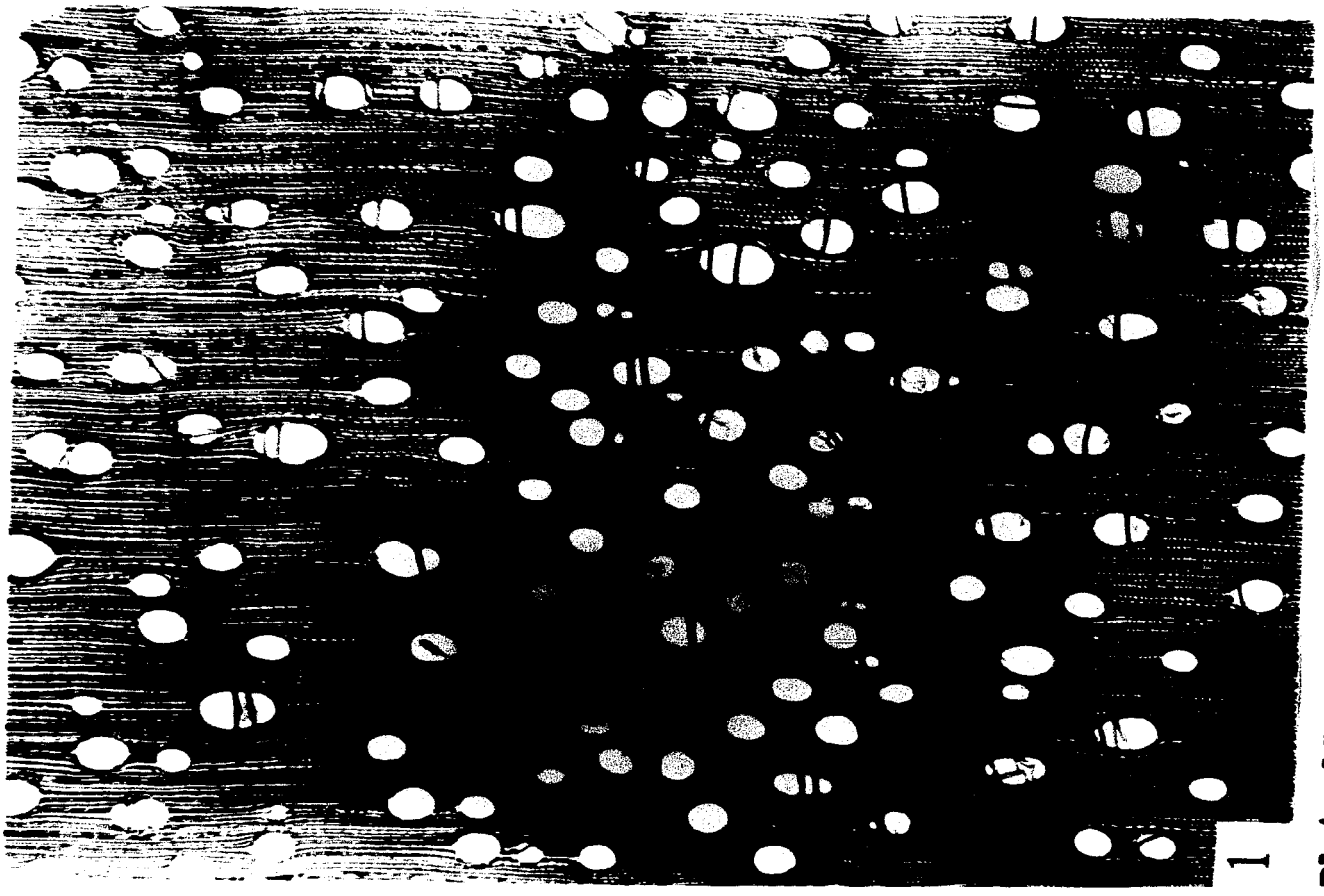
Plate 15

Fig. 1. Blepharocarya involucrigera F. Mueller. Transverse section showing the size and arrangement of the pores. x 27.

Fig. 2. Blepharocarya involucrigera F. Mueller. Transverse section of a different specimen of the same species as Fig. 1. Note the almost identical appearance of the two sections. x 27.



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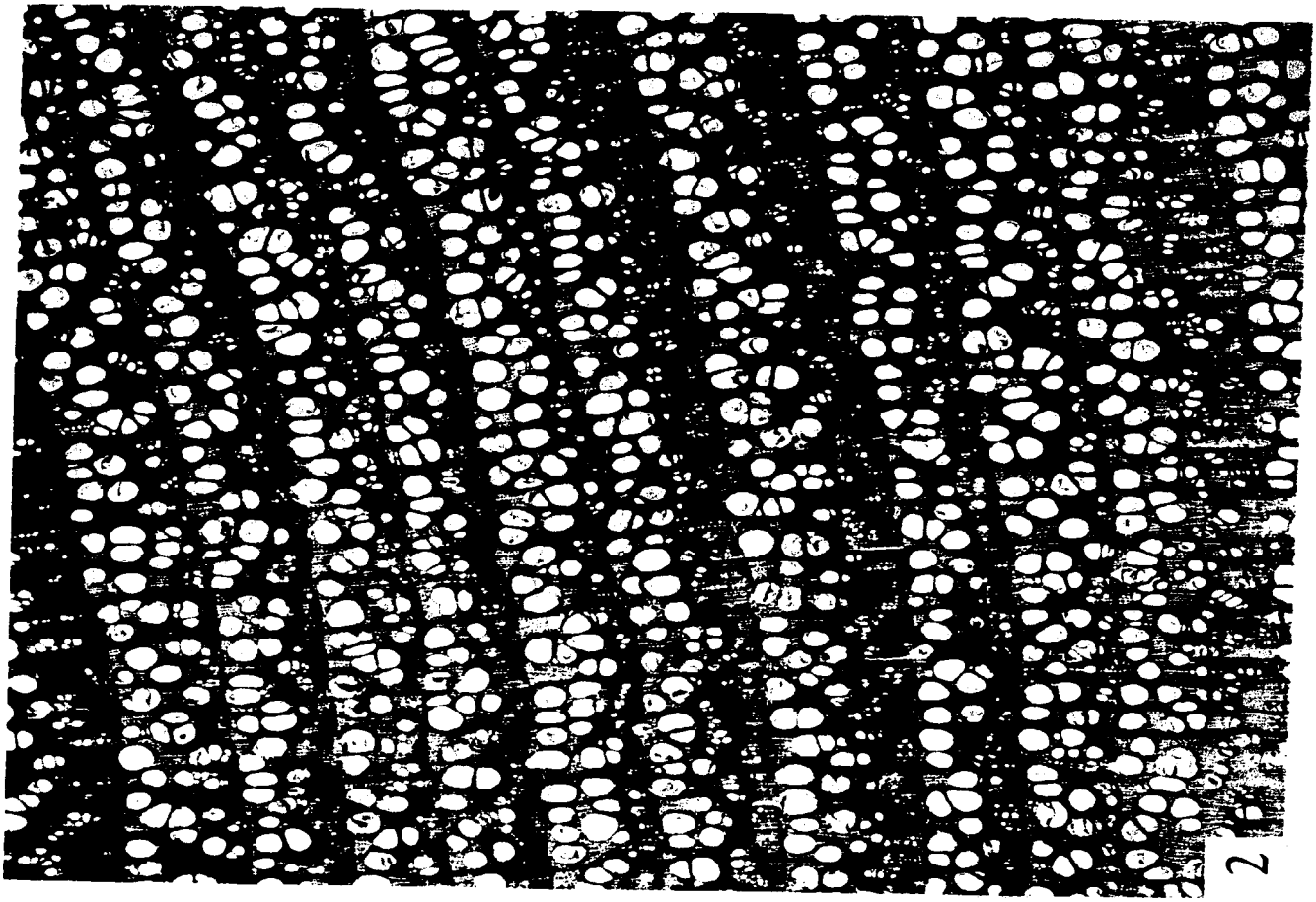
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Plate 15

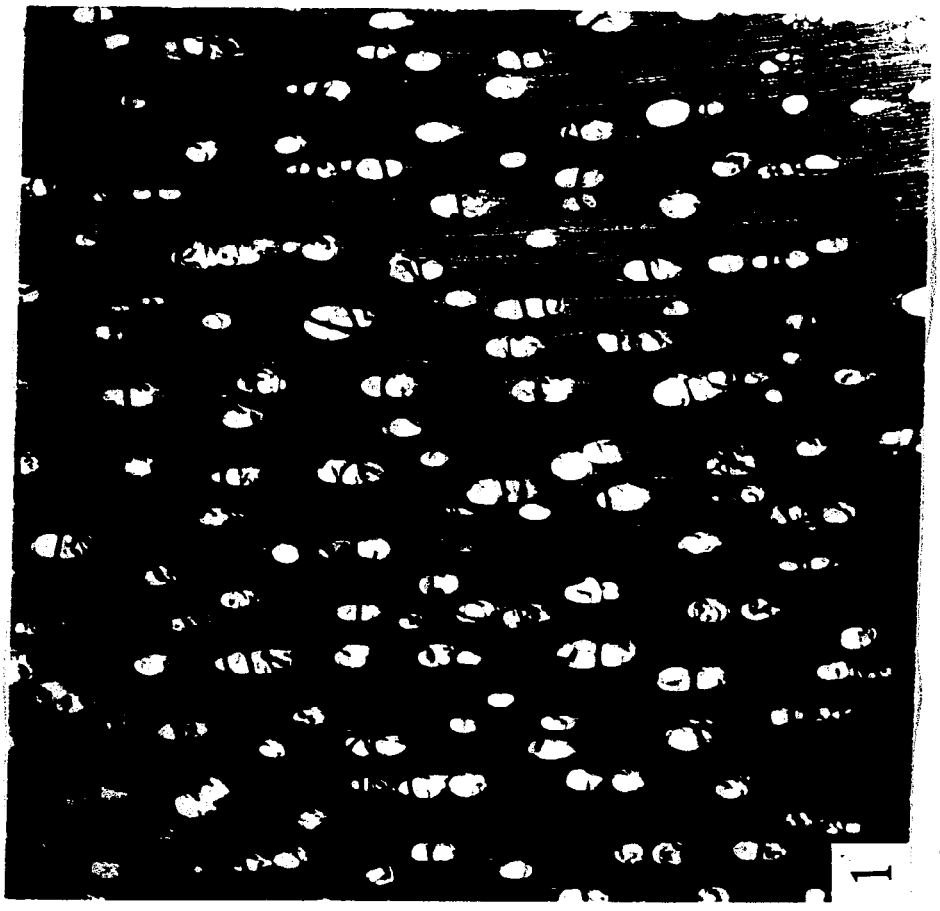
Plate 16

Fig. 1. Rhodosphaera rhodanthema Engl. Transverse section showing size and arrangement of the pores. x 27.

Fig. 2. Cotinus coggygria Scop. Transverse section showing the ring-porous arrangement of the pores. Note the similarity to Rhus semialata Murr., Plate 20, Figure 2. x 27.



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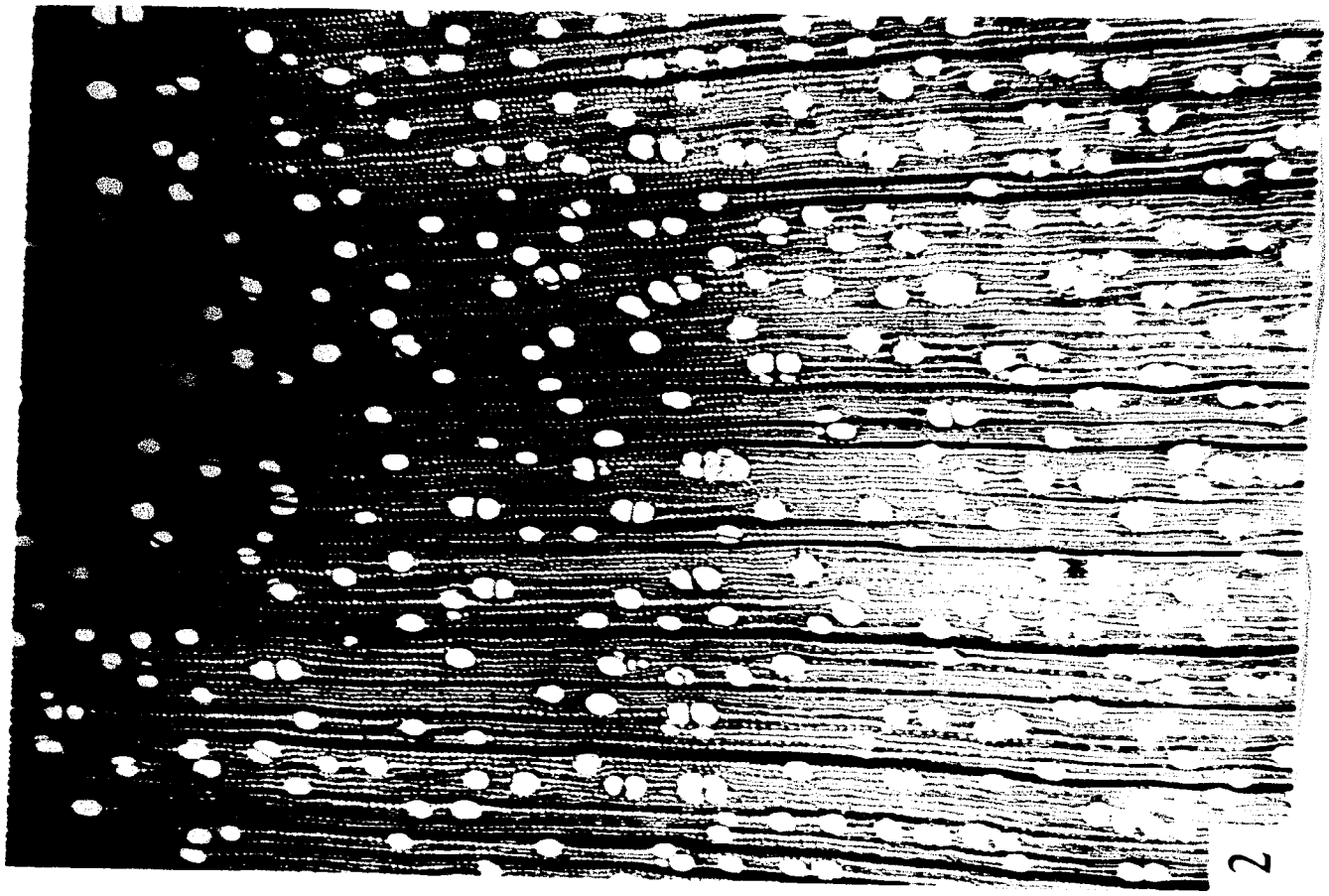
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Plate 16

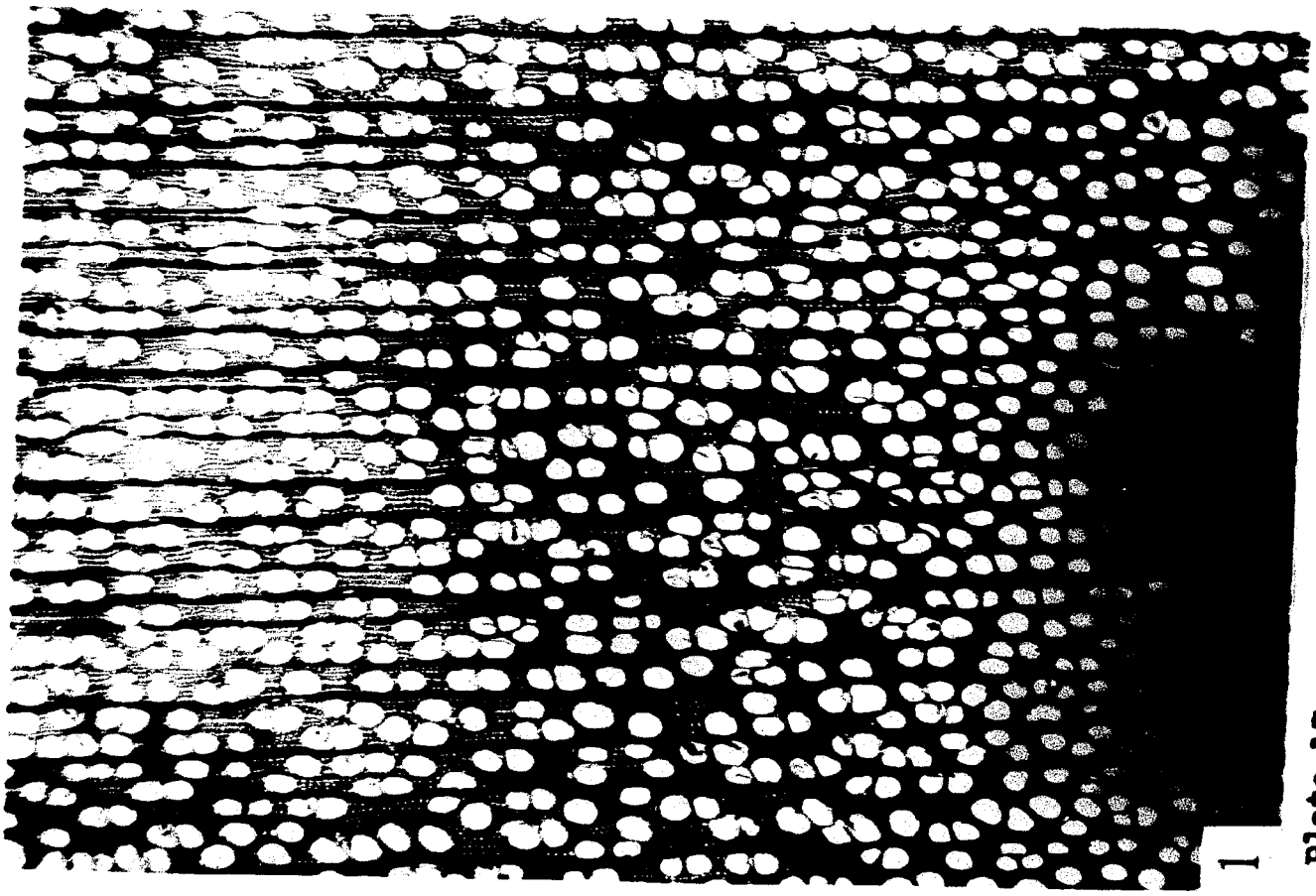
Plate 17

Fig. 1. *Campnosperma macrophylla* (Blanco) Hook. f. Transverse section showing the numerous, small pores and absence of parenchyma. x 27.

Fig. 2. *Campnosperma zeylanica* Thwait. Transverse section showing the size and arrangement of pores and the thin-walled fibers. x 27.



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Plate 17

Plate 18

Note the marked similarity between the species of Campnosperma.

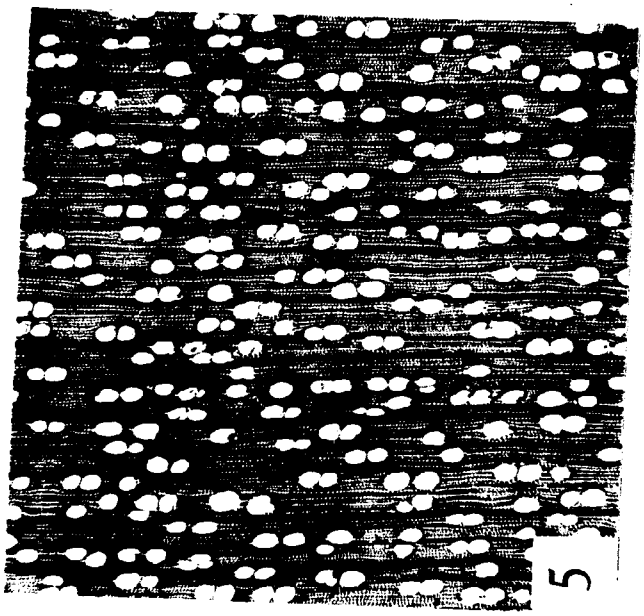
Fig. 1. Campnosperma brevipetiolata Volk. Transverse section. x 27.

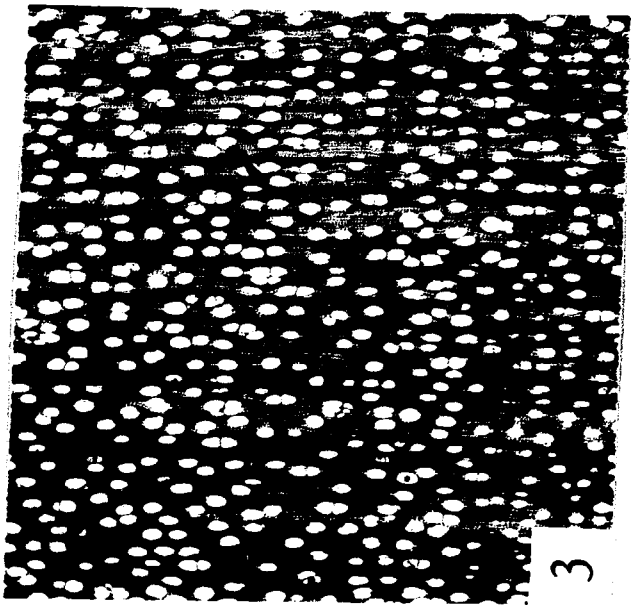
Fig. 2. Campnosperma Wallichii King. Transverse section. x 20.

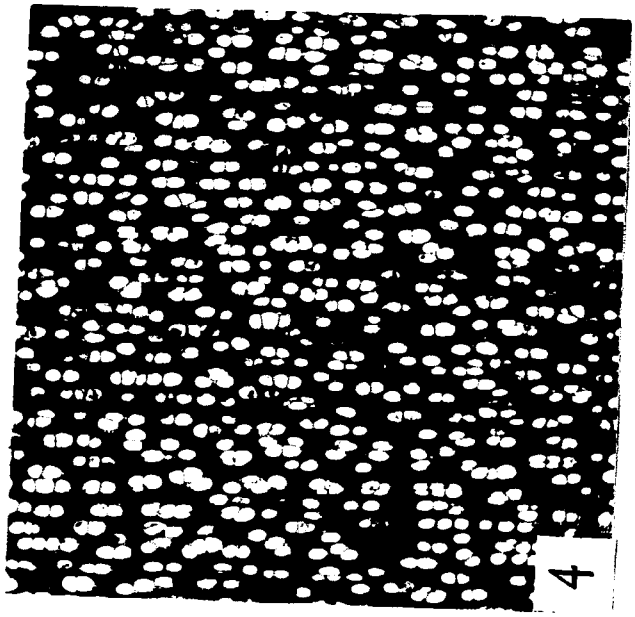
Fig. 3. Campnosperma Wallichii King. Transverse section of another specimen. x 20.

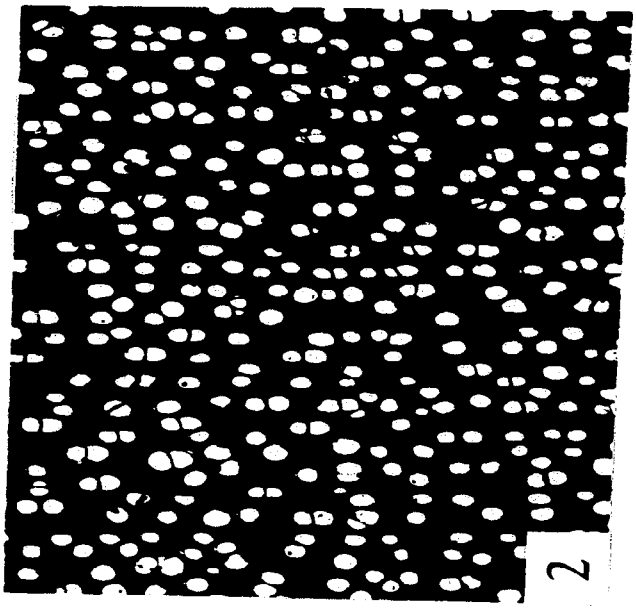
Fig. 4. Campnosperma auriculata Hook. f. Transverse section. x 20.

Fig. 5. Campnosperma arborescens Blanco. Transverse section. x 20.









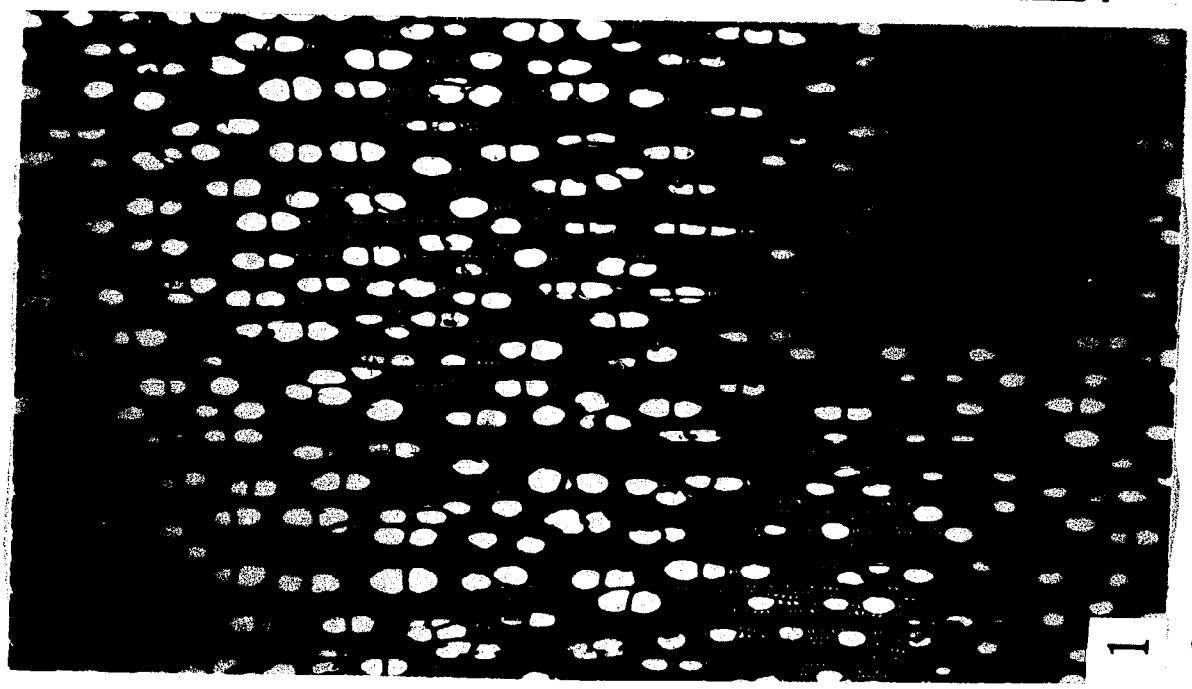
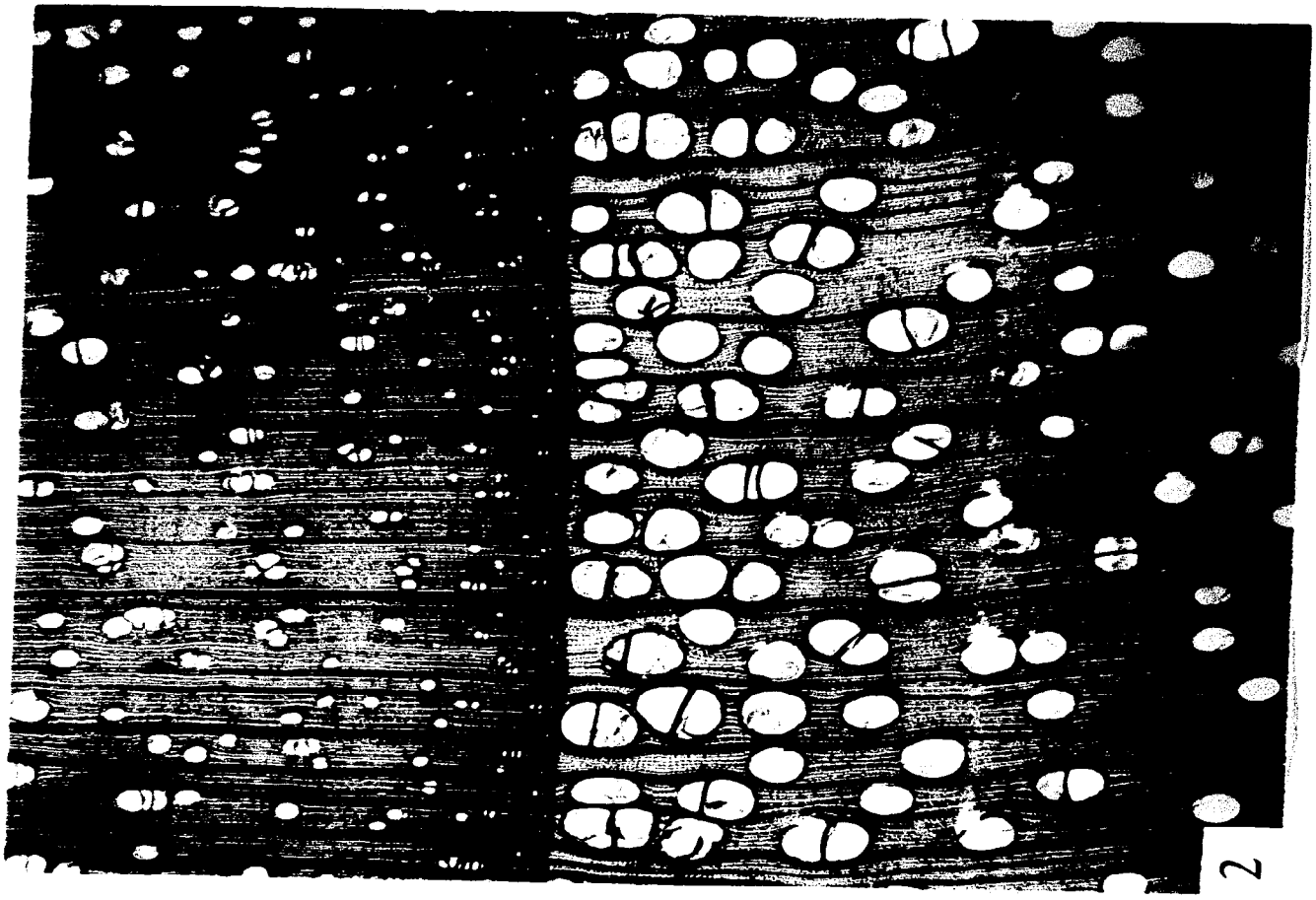


Plate 18

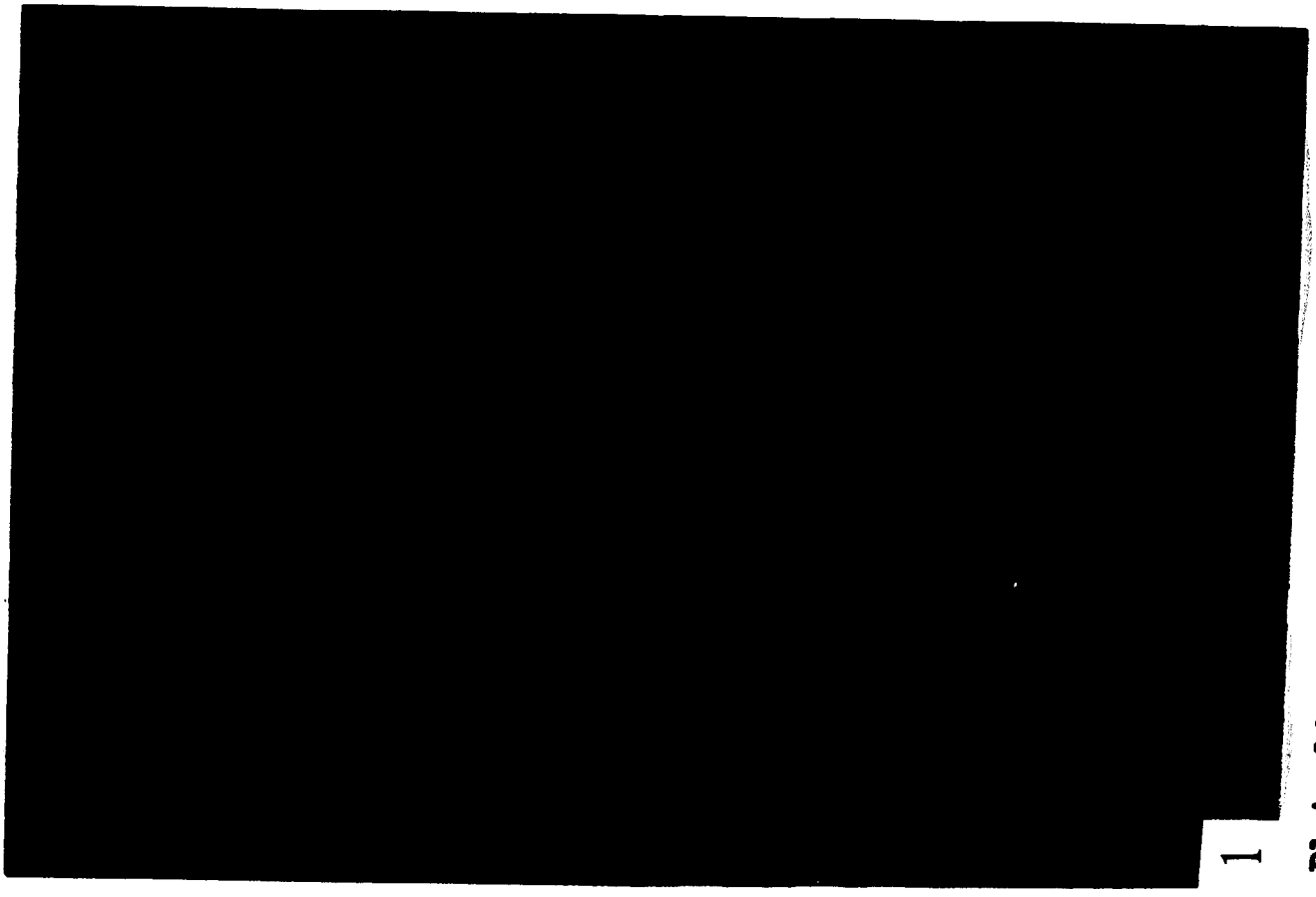
Plate 19

Fig. 1. Rhus semialata Murr. var. sandwicensis Engl. Transverse section showing the ring-porous arrangement of the pores. Note the wide early wood zone and the clusters of minute pores in the late wood. x 27.

Fig. 2. Rhus trichocarpa Miq. Transverse section showing ring-porous arrangement. The early wood pores are similar to those shown in Fig. 1, but note that the late wood pores are predominantly in short radial multiples and solitary. x 27.



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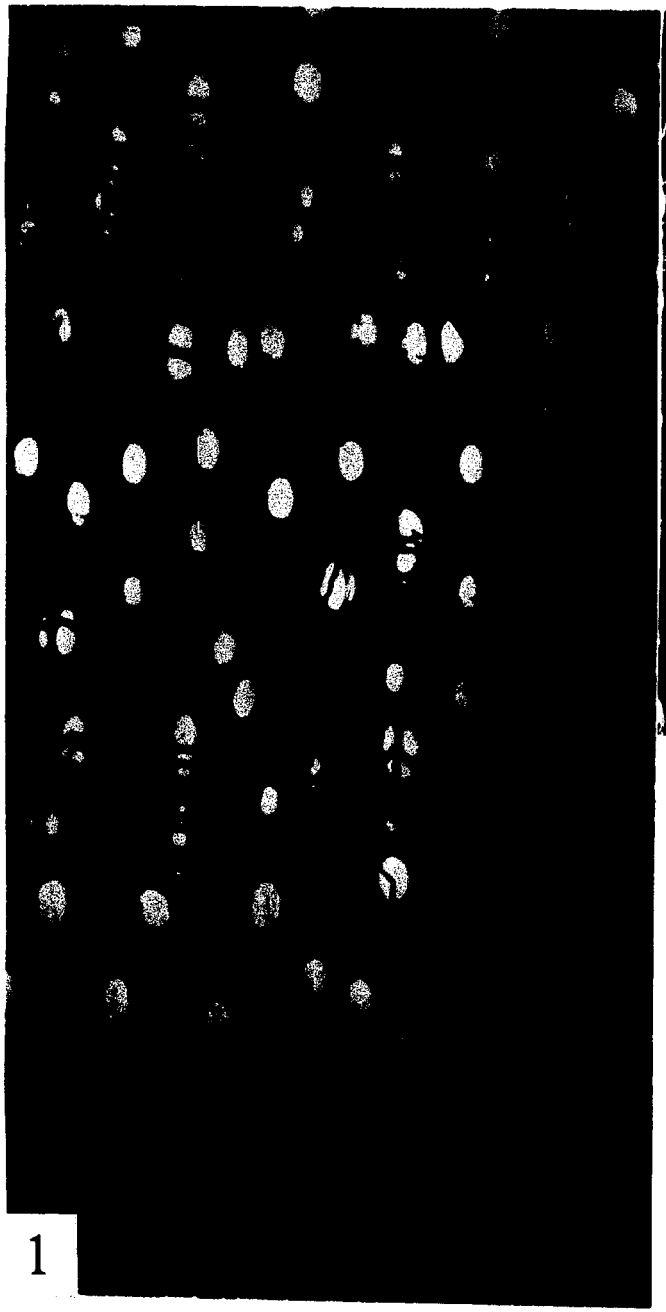
Plate 19

Plate 20

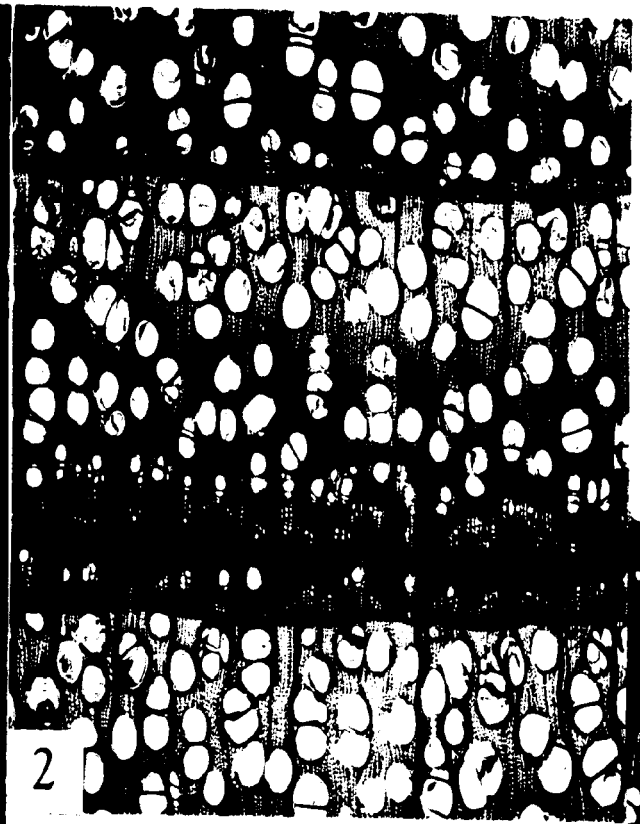
Fig. 1. Rhus succedanea L. Transverse section showing ring-porous arrangement. Note that the late wood pores are solitary or in multiples or long chains. x 27.

Fig. 2. Rhus semialata Murr. Transverse section showing ring-porous arrangement. Compare the arrangement of late wood pores with those of Cotinus coggygria Scop., Plate 16, Fig. 2. x 20.

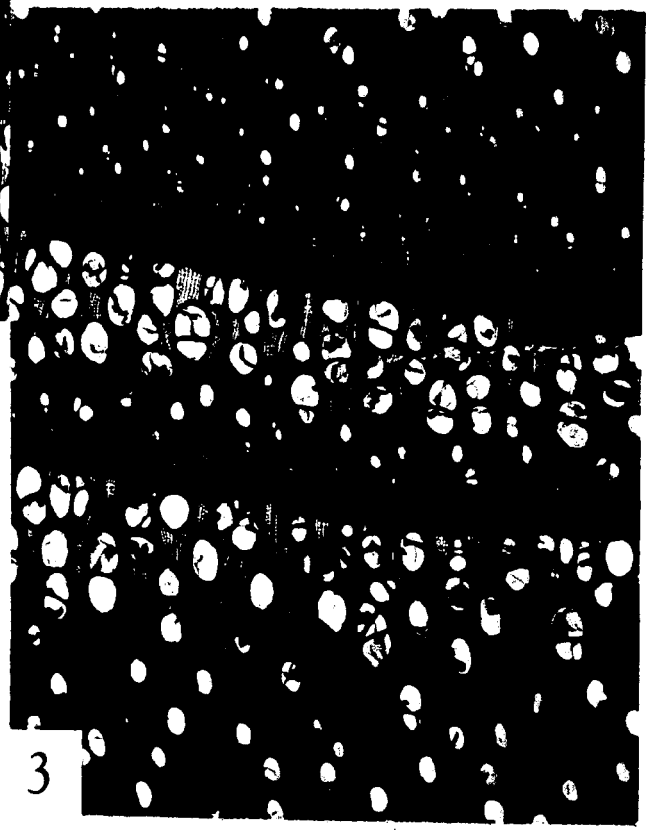
Fig. 3. Rhus japonica Buch. Ham. Transverse section showing ring-porous arrangement. Note the irregular tangential bands of minute pores in the late wood. x 20.



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Plate 20

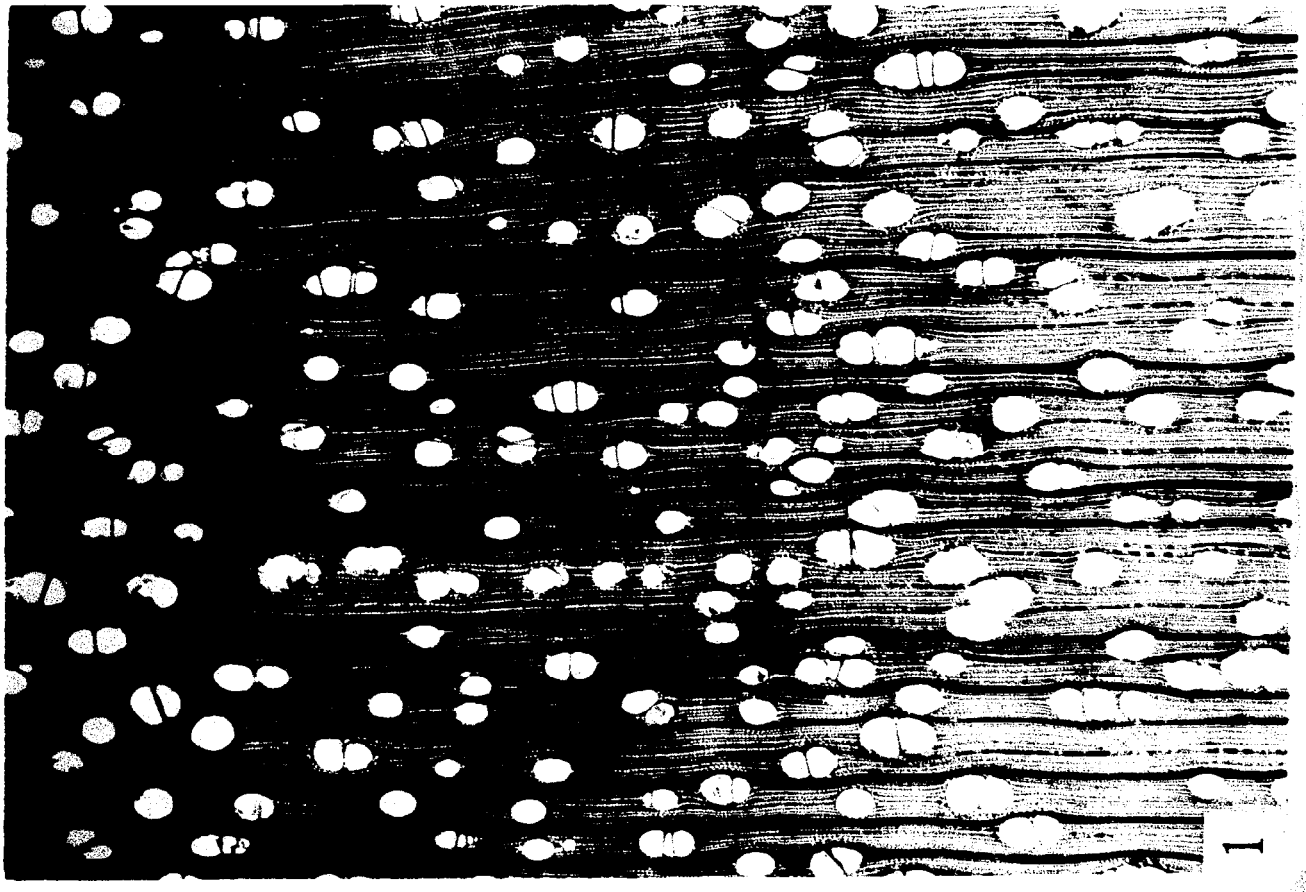
Plate 21

Fig. 1. Rhus Engleriana Warb. Transverse section showing size and arrangement of the pores. x 27.

Fig. 2. Rhus simarubaefolia A. Gray. Transverse section showing the size and arrangement of the pores. x 27.



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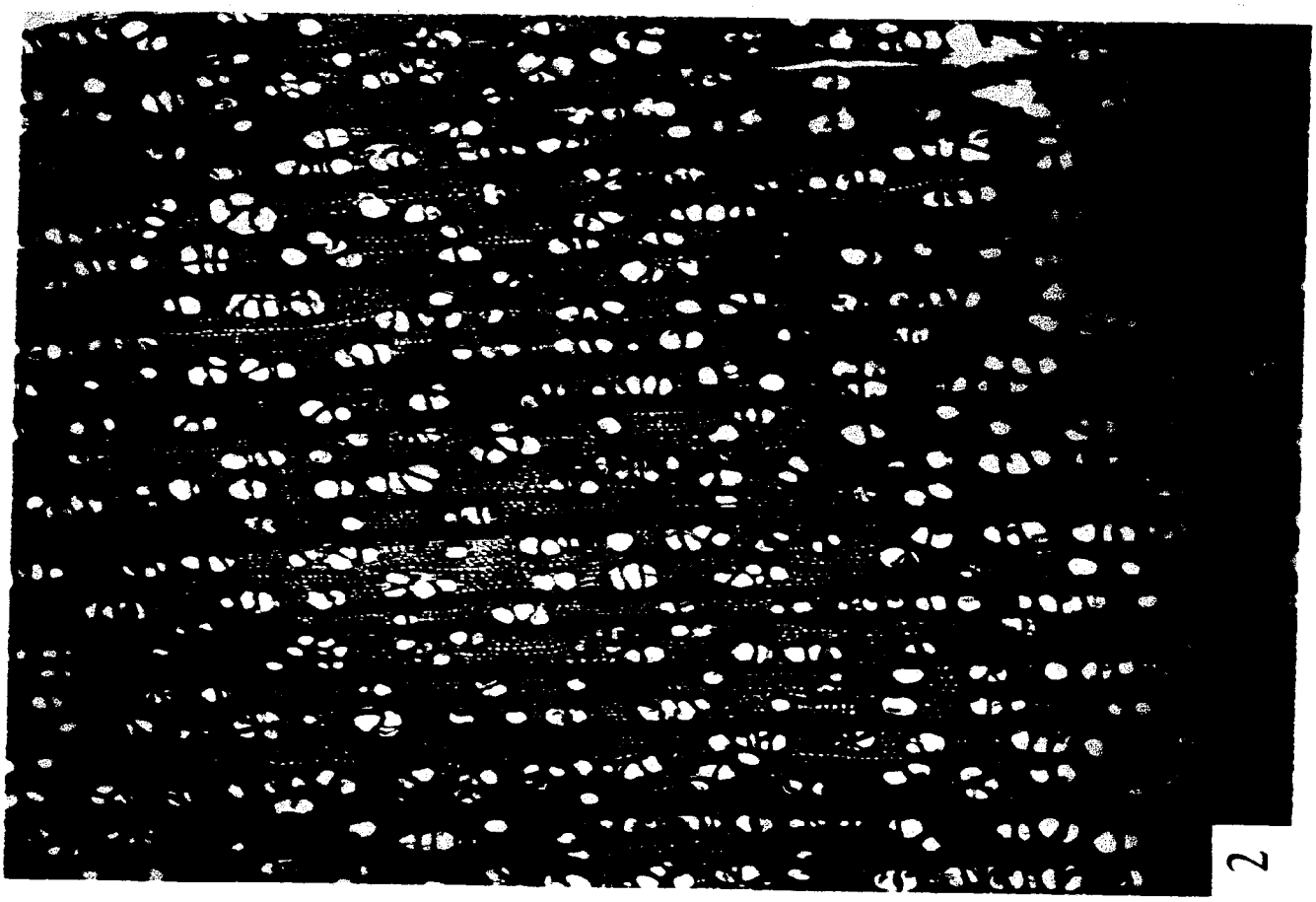
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Plate 21

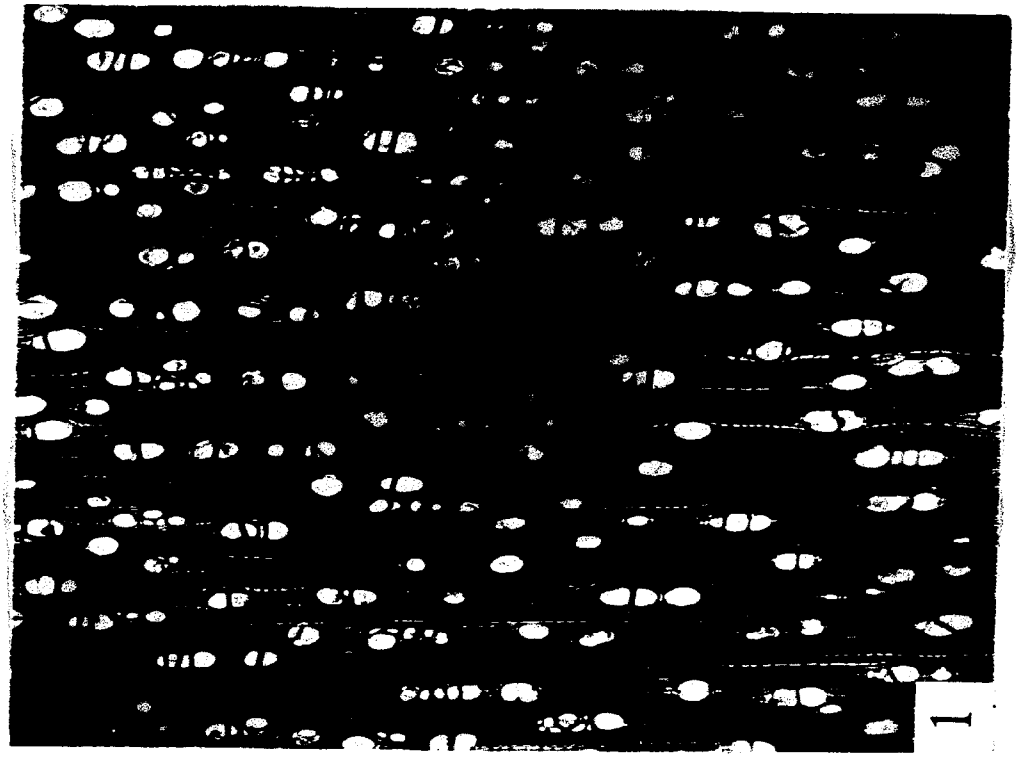
Plate 22

Fig. 1. Rhus australis Transverse section showing size and arrangement of the pores. x 27. Compare with Rhodosphaera rhodanthema Engl. (Plate 16, Fig. 1).

Fig. 2. Juliania adstringens Schlecht. Transverse section showing the size and arrangement of the pores. Note the relatively wide rays. x 27.



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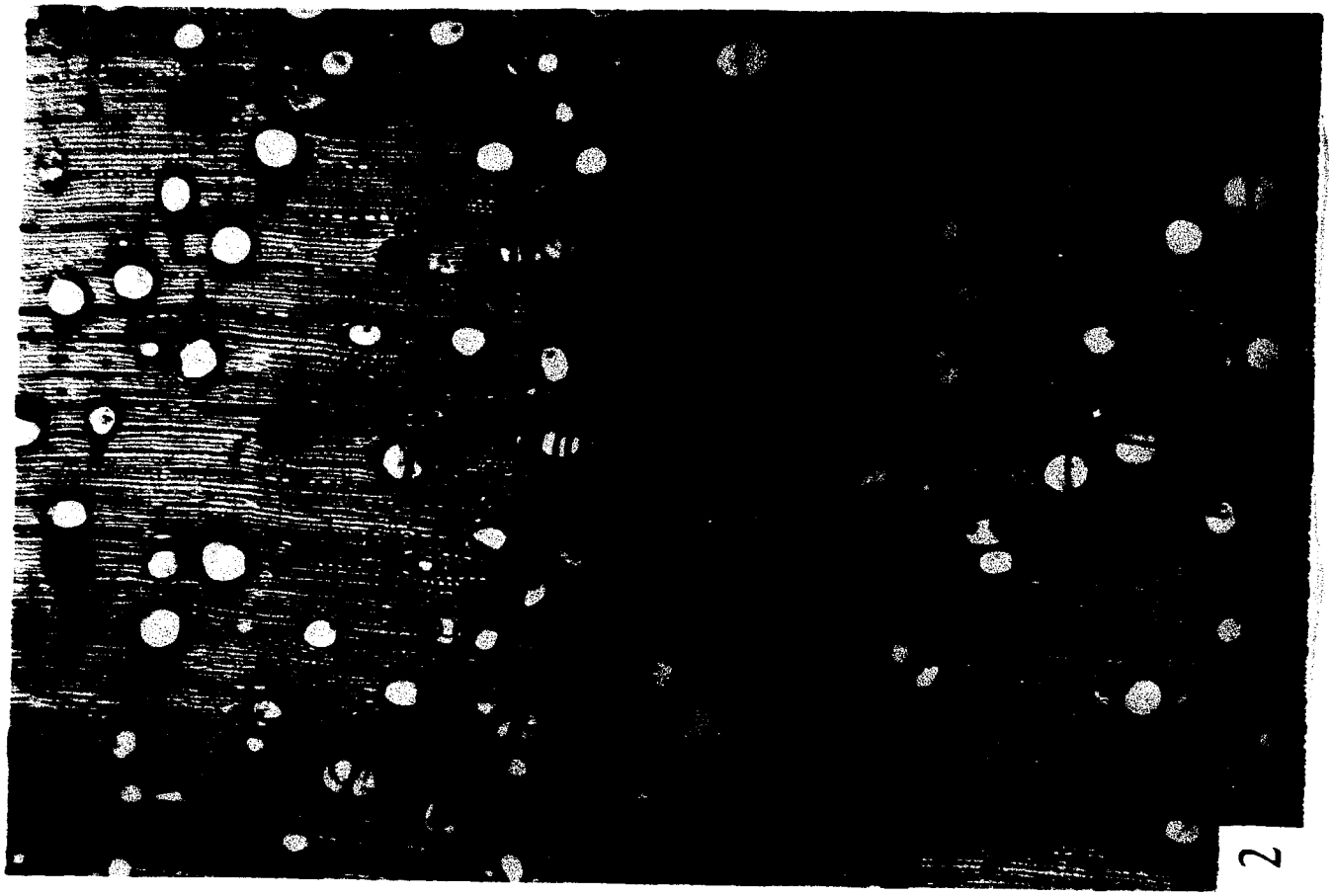
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Plate 22

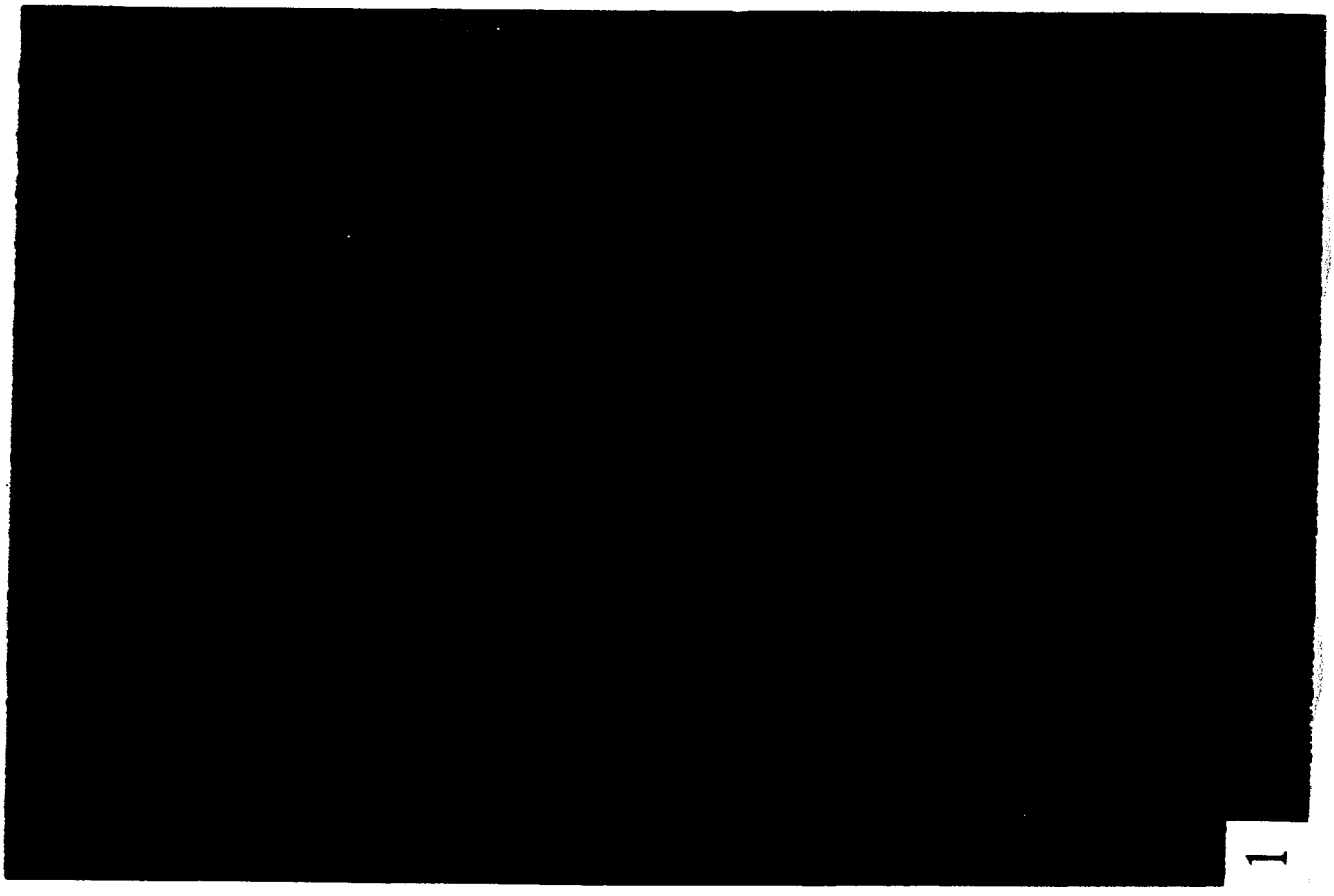
Plate 23

Fig. 1. Semecarpus lucens King. Transverse section showing size and arrangement of pores and the vasicentric, aliform to confluent parenchyma. Note the thin-walled fibers. x 27.

Fig. 2. Semecarpus atra Vielle. Transverse section showing size and arrangement of pores and conspicuous aliform parenchyma. The black material plugging some pores is not a resin-like substance. It appears to be masses of very fine, dark, fungous mycelium, under the highest power of the microscope. x 27.



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Plate 23

Plate 24

Fig. 1. Semecarpus laxiflora K. Schum. Transverse section showing abundant aliform confluent parenchyma. x 27.

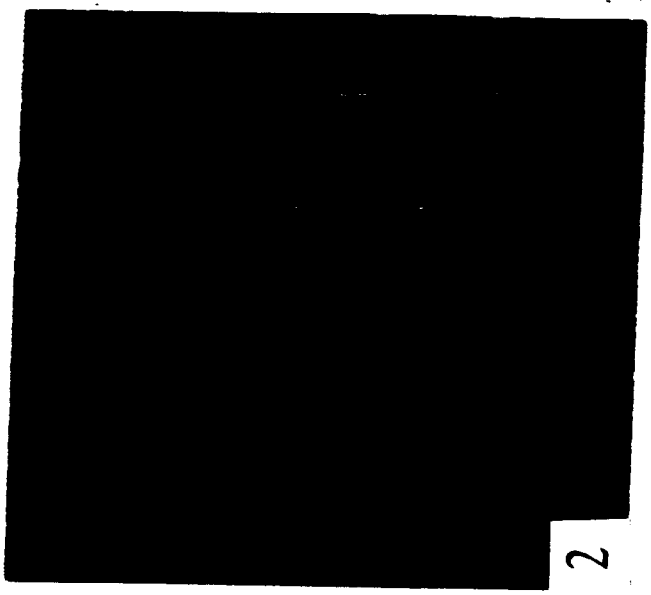
Fig. 2. Semecarpus heterophylla Blume. Transverse section showing primarily paratracheal, vasicentric parenchyma. x 20.

Fig. 3. Semecarpus Anacardium L. Transverse section showing very large pores in this species. x 20.

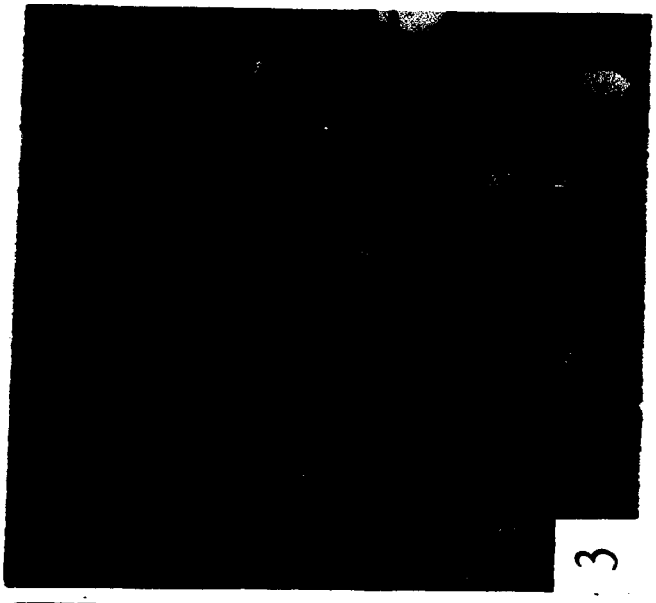
Fig. 4. Semecarpus atra Vielle. (Oncocarpus vitiensis A. Gray, Yale 28422). Transverse section showing aliform parenchyma. x 20.



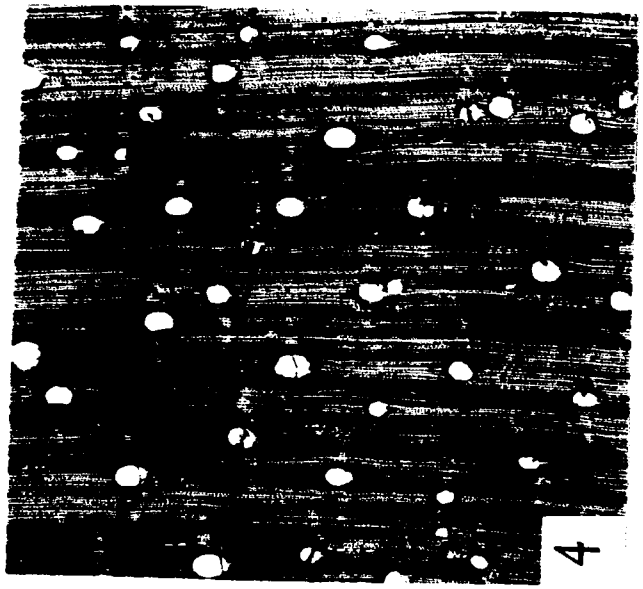
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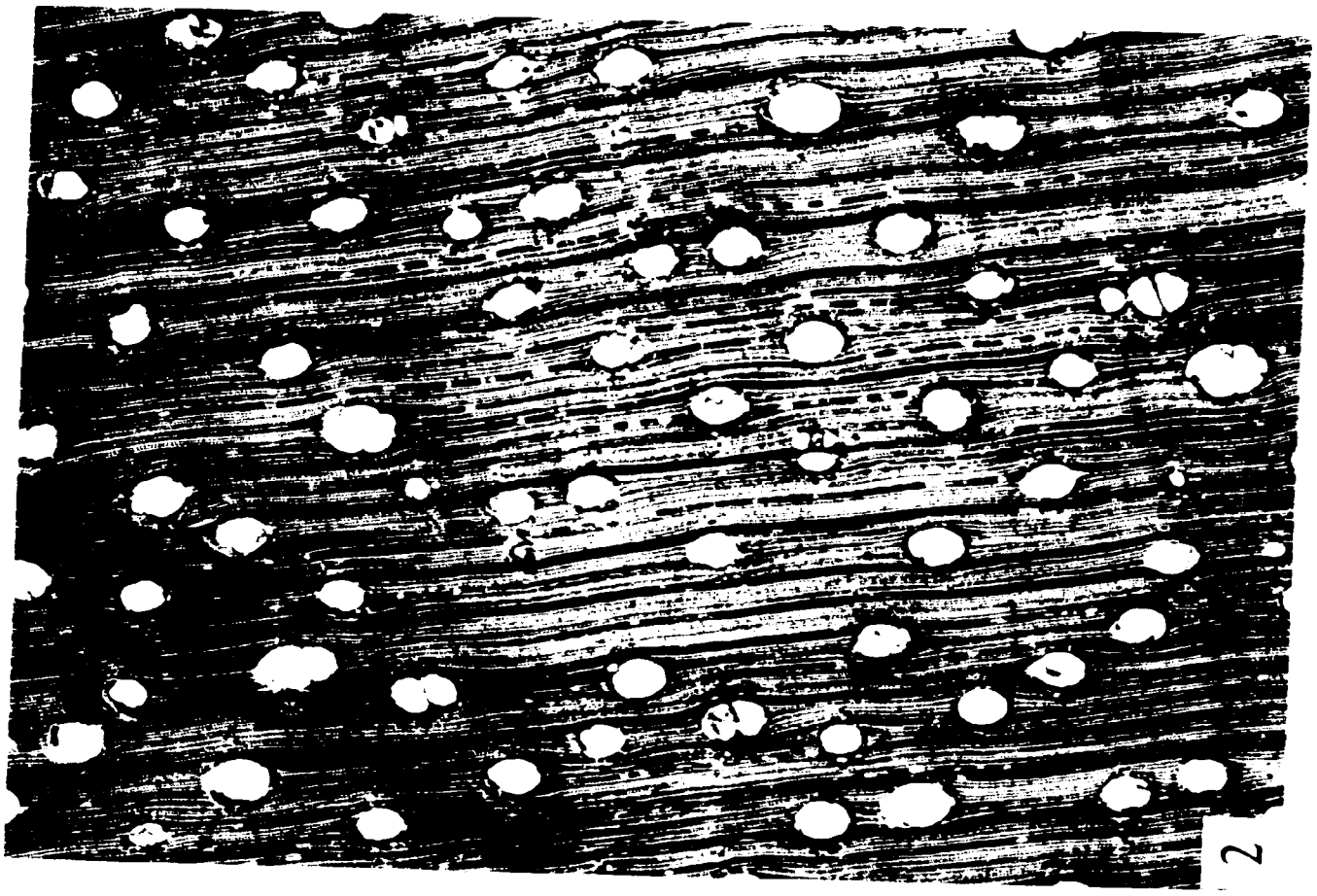
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Plate 24

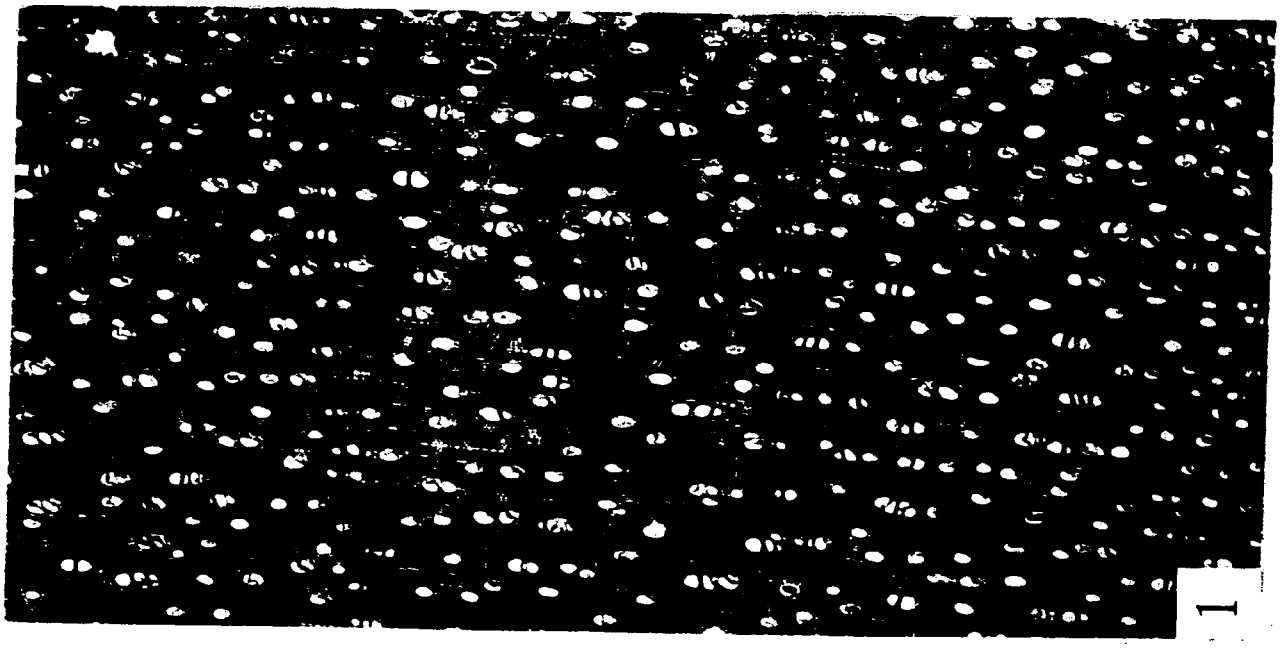
Plate 25

Fig. 1. Nothopegia Colebrookiana Blume. Transverse section showing distribution of the small pores and vasicentric, aliform, and often confluent parenchyma. x 27.

Fig. 2. Melanochyla Kunstleri King. Transverse section showing size and arrangement of the pores and aliform, occasionally confluent parenchyma. x 27.



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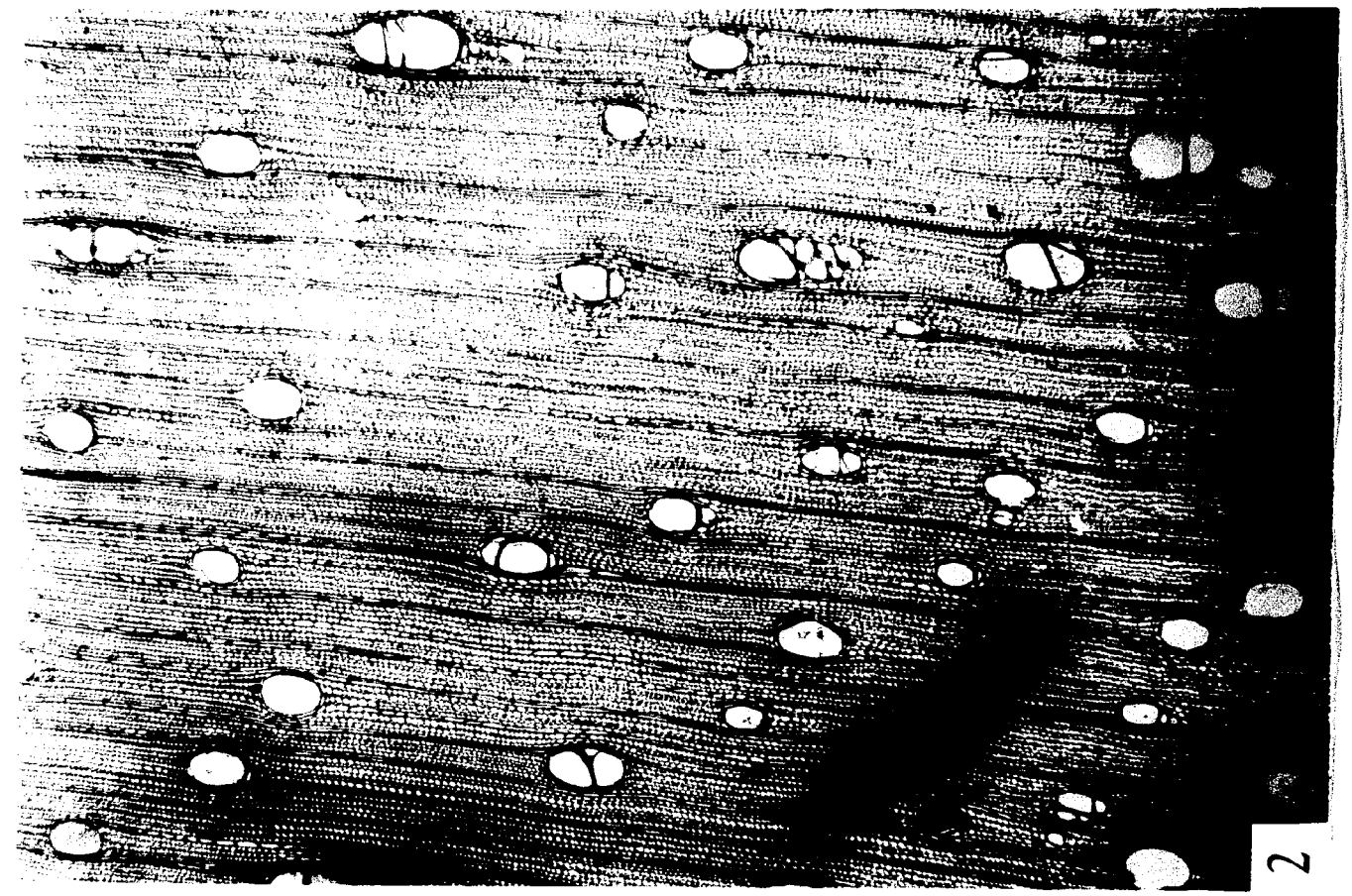
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Plate 25

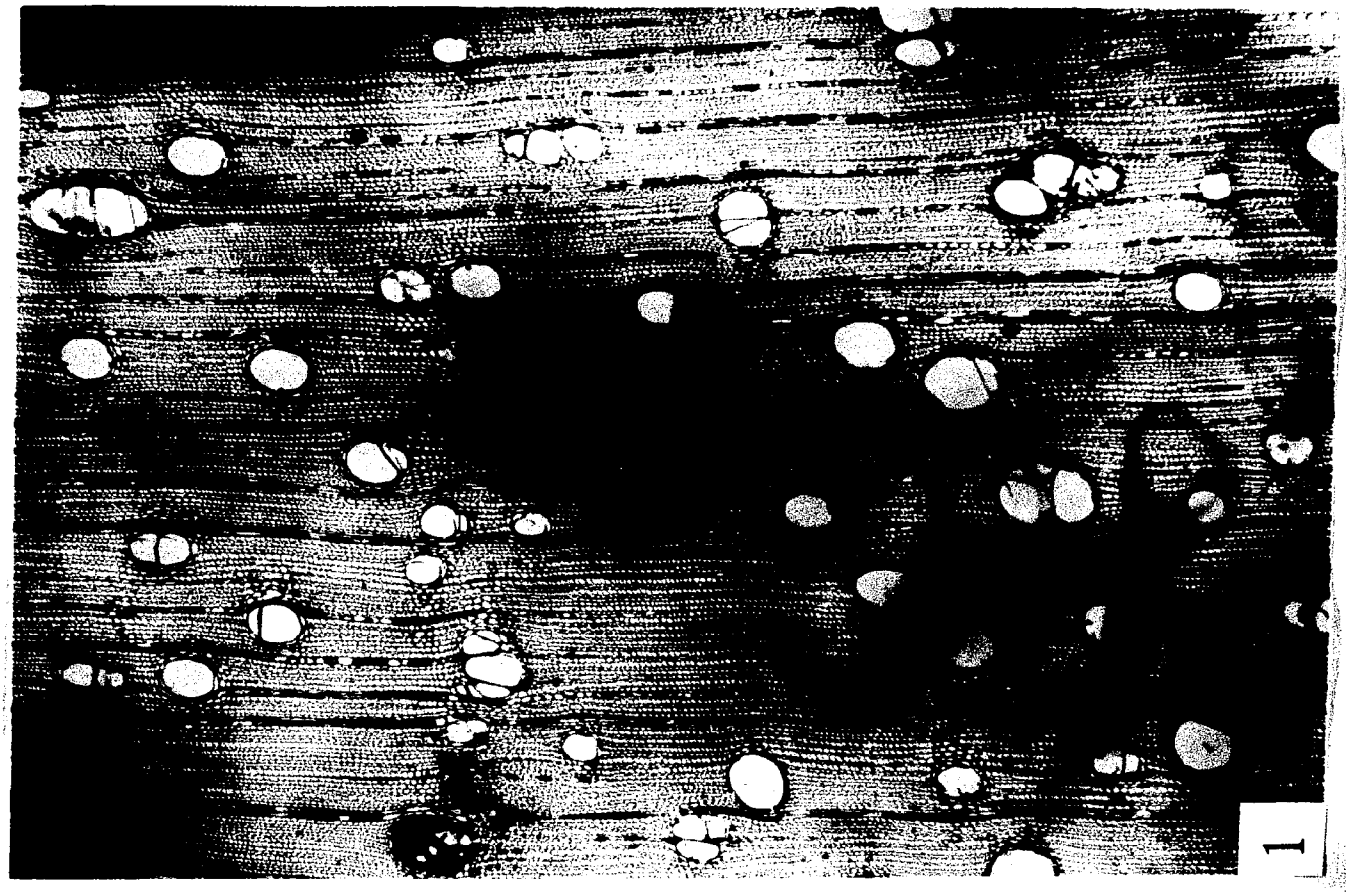
Plate 26

Fig. 1. Holigarna Helferi Hook. f. Transverse section showing size and arrangement of pores and vasicentric, aliform parenchyma. Note the pores at extreme upper left partially plugged with dark, resin-like substance. x 27.

Fig. 2. Holigarna Arnottiana Hook. f. Transverse section showing occasional angular pores and wide sheaths of vasicentric parenchyma. x 27.



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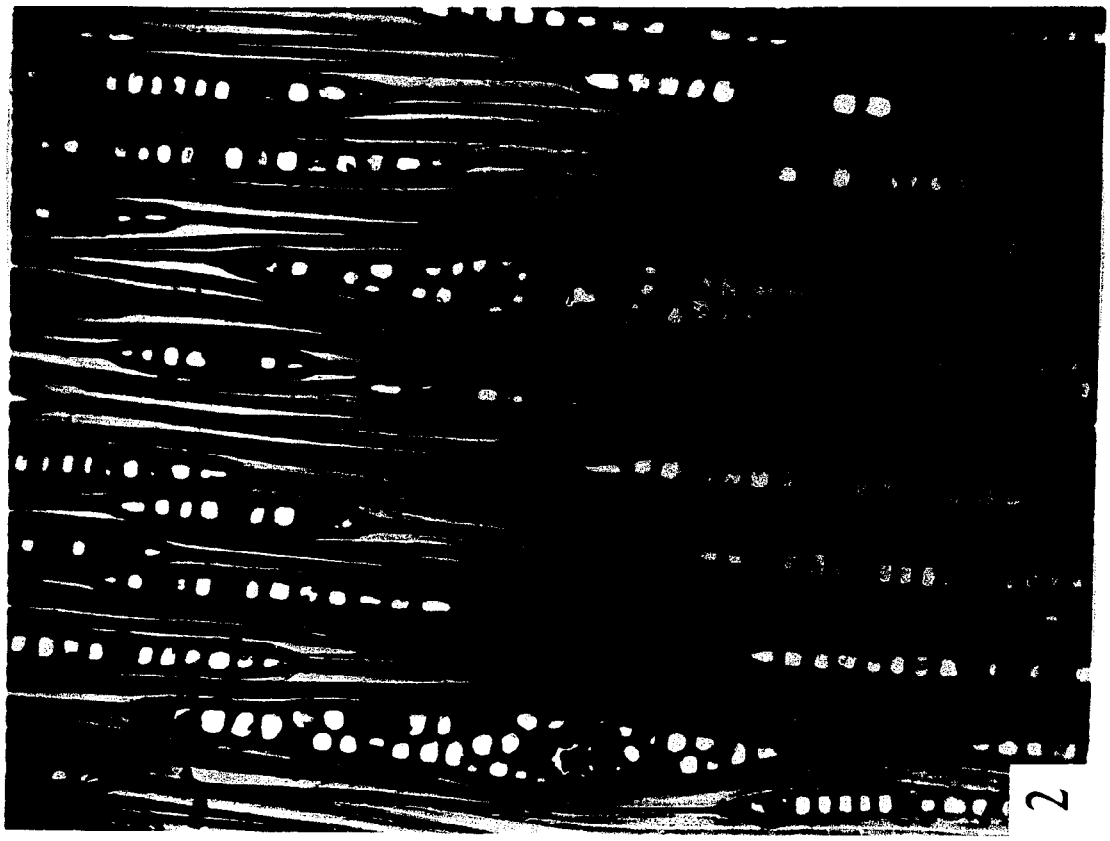
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Plate 26

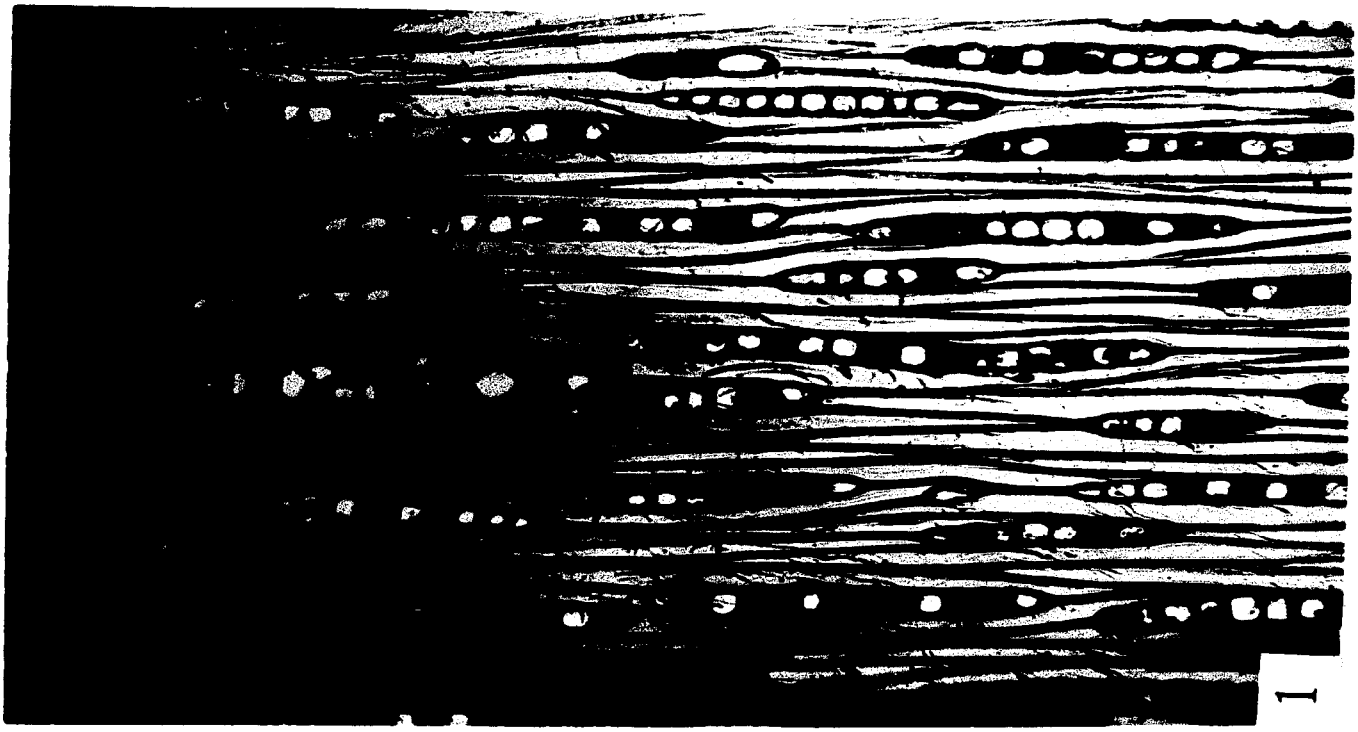
Plate 27

Fig. 1. Gluta Renghas L. Tangential section showing small horizontal intercellular canal in center ray. Note that all other rays are homogeneous and uniseriate, with the exception of the partially biseriate ray to the left of the one containing the canal. x 130.

Fig. 2. Melanorrhoea torquata King. Tangential section showing two small horizontal intercellular canals surrounded by thick-walled epithelial cells and essentially homogeneous, uniseriate normal rays. x 130.



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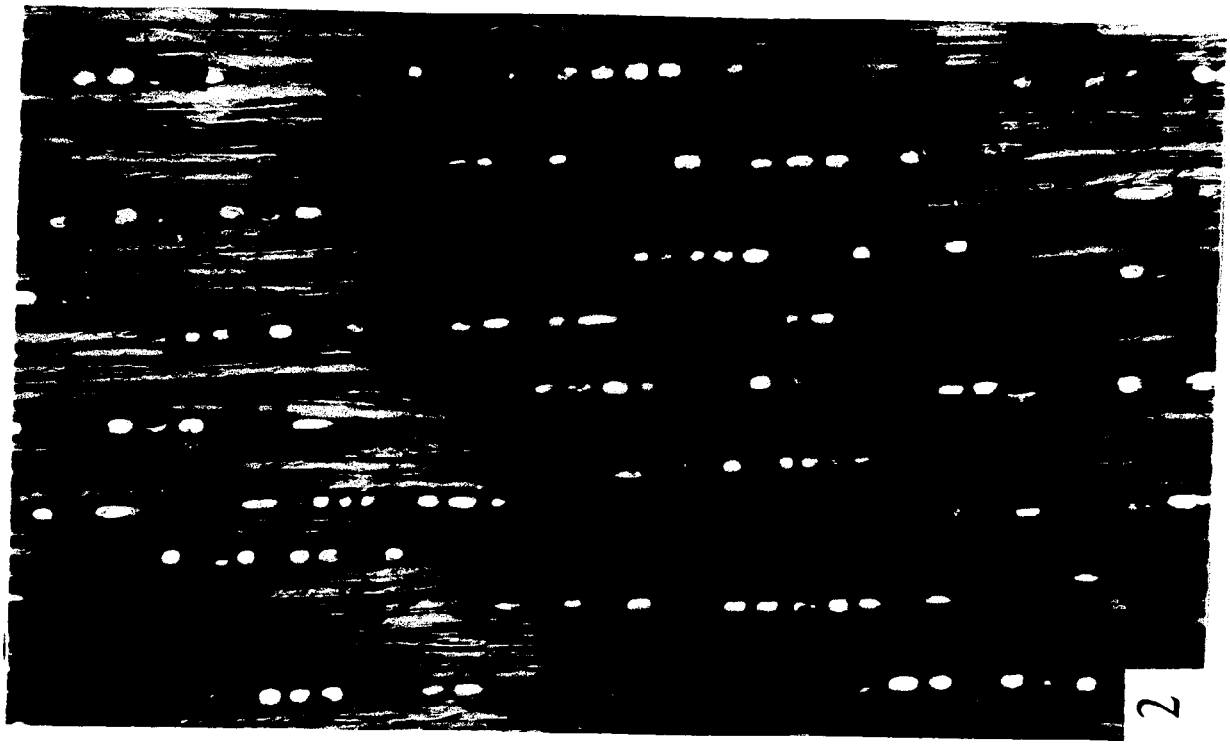
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Plate 27

Plate 28

Fig. 1. Bouea macrophylla Griff. Tangential section Showing uniseriate and biseriate rays. x 130.

Fig. 2. Mangifera foetida Lour. Tangential section showing uniseriate rays. x 130.



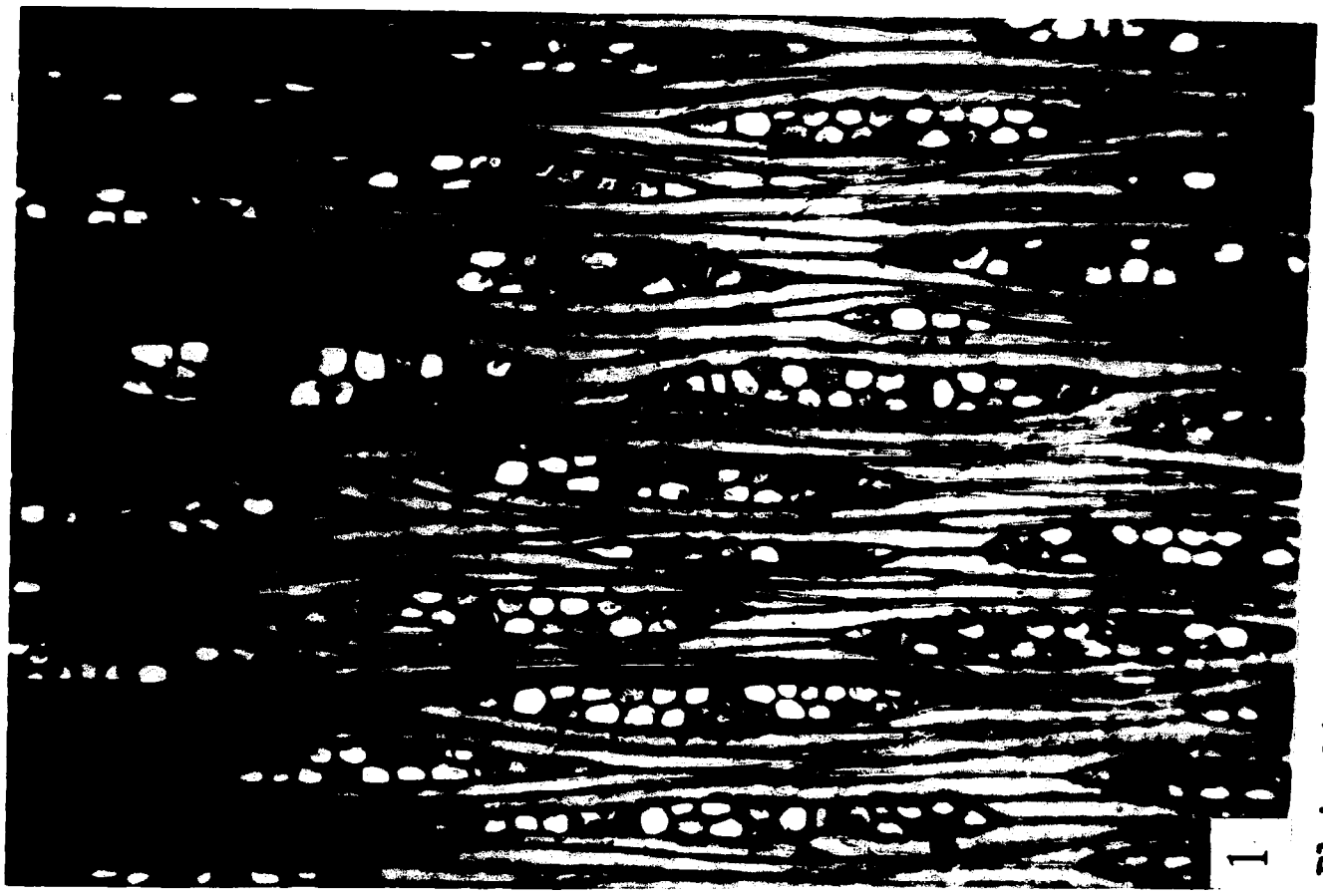
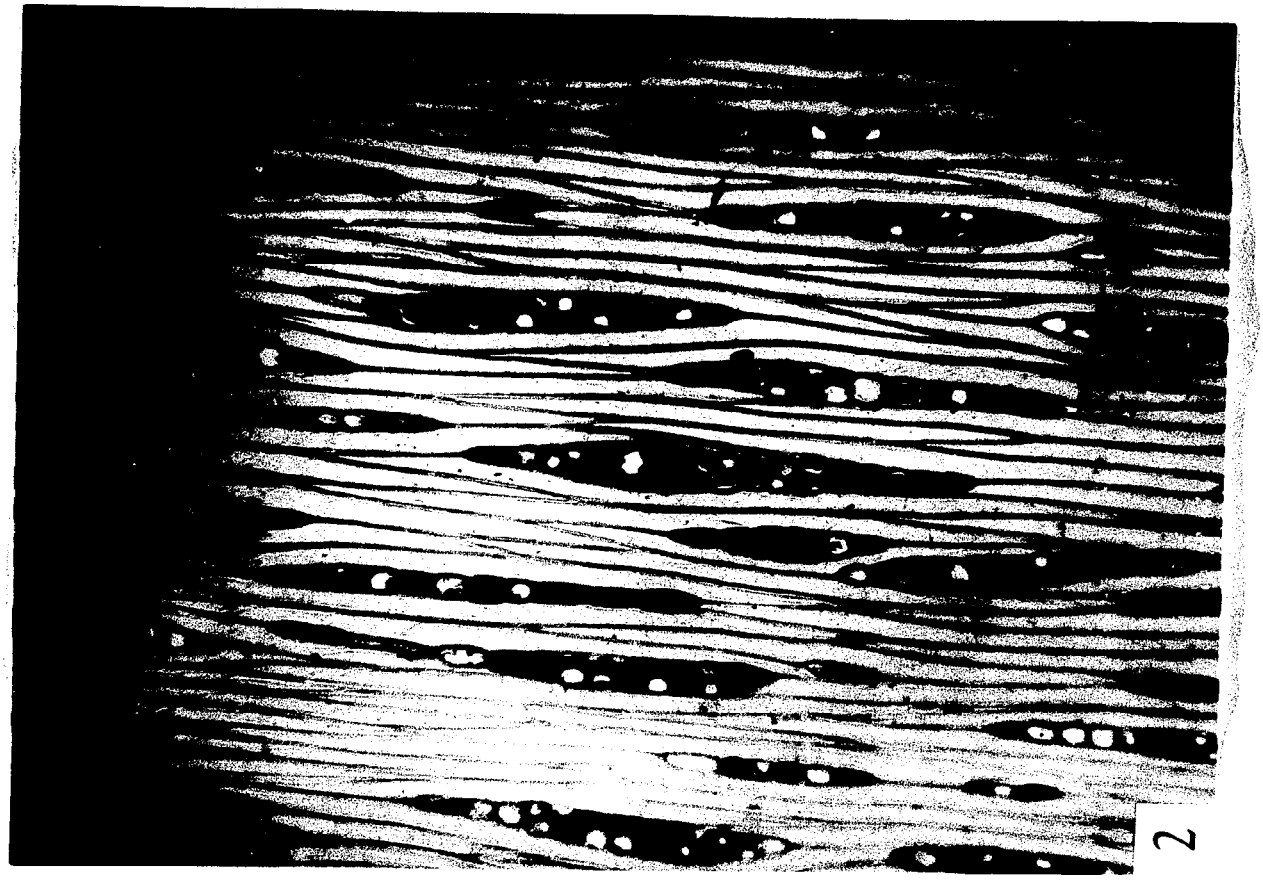


Plate 28

Plate 29

Fig. 1. Mangifera cassia Jack. Tangential section showing predominantly biseriate rays. x 130.

Fig. 2. Buchanania palawensis Laut. Tangential section showing one very small horizontal intercellular canal in center ray. x 130.



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Plate 29

Plate 30

Fig. 1. Spondias pinnata (L.) Kurz. Tangential section showing horizontal intercellular canal in large ray. Note the septate fibers. x 130.

Fig. 2. Spondianthus ugandensis Hutch. Tangential section showing portions of very large multiseriate rays. Note the sheath cells at the margins of the two rays on the right. x 130.



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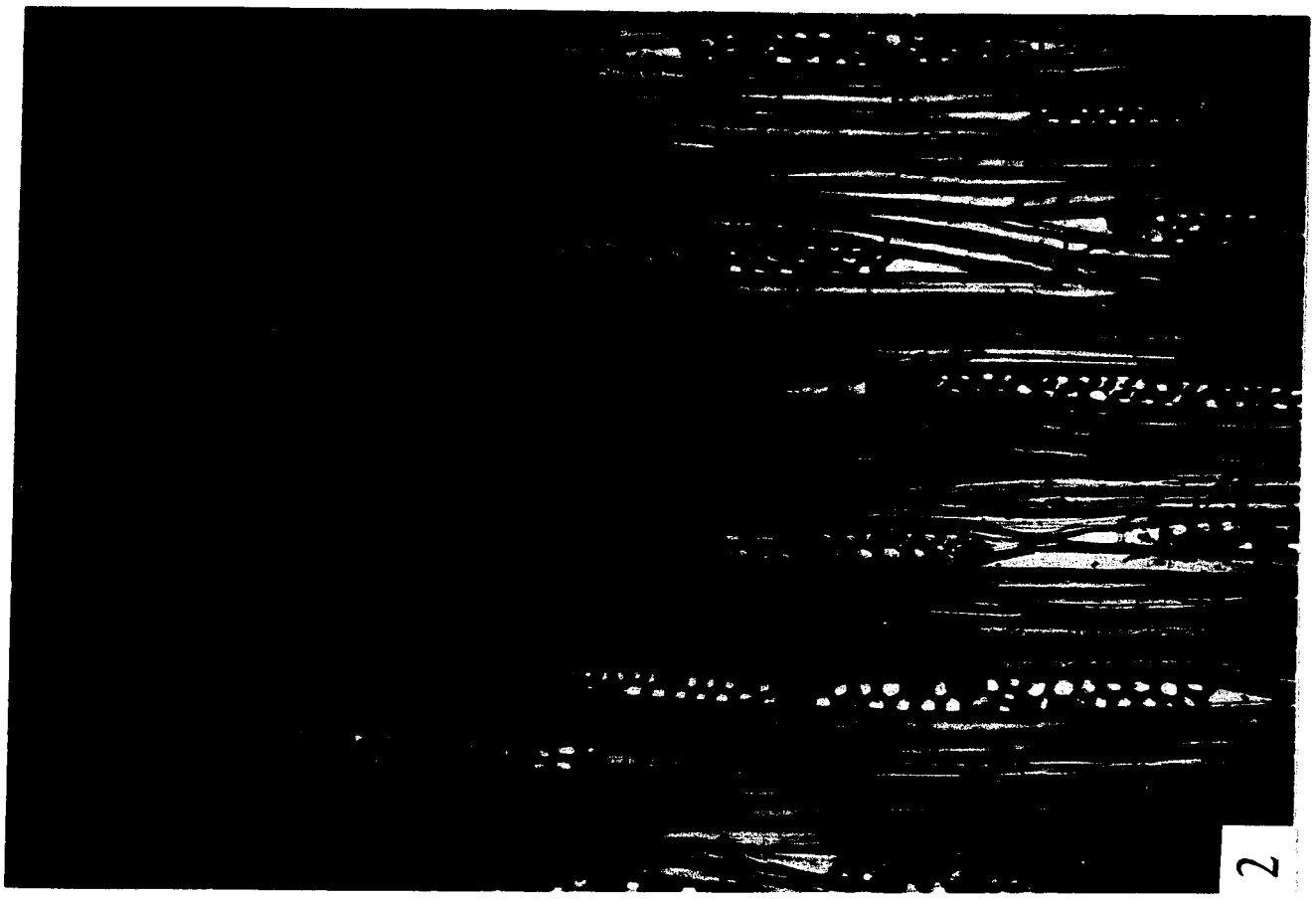
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Plate 30

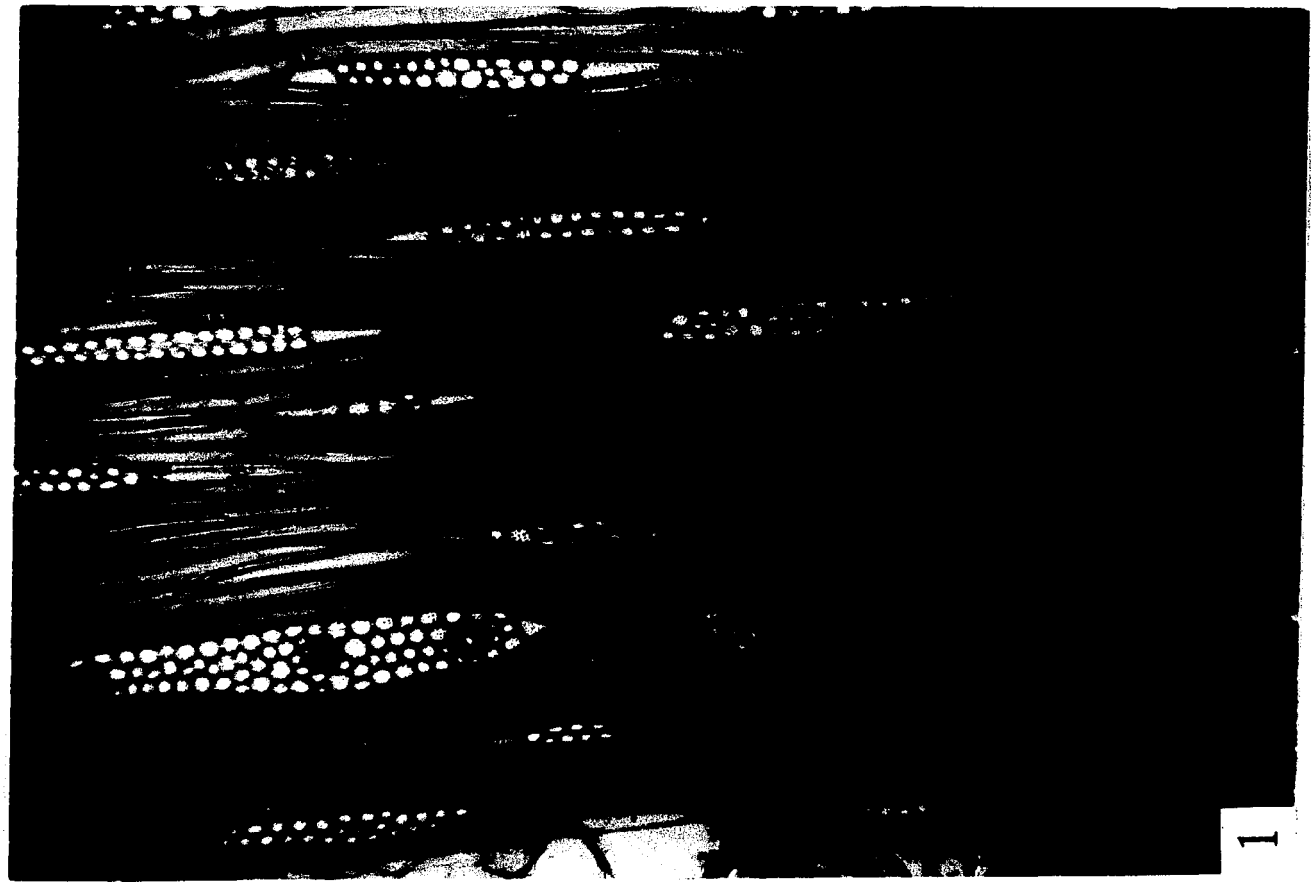
Plate 31

Fig. 1. Lannea amaniensis Engl. Tangential section showing very small horizontal intercellular canals surrounded by a single row of thick-walled epithelial cells. Note septate fibers. x 130.

Fig. 2. Lannea acidissima A. Chev. Tangential section showing biseriate and triseriate rays with tall upright cells. Note septate fibers. x 130.



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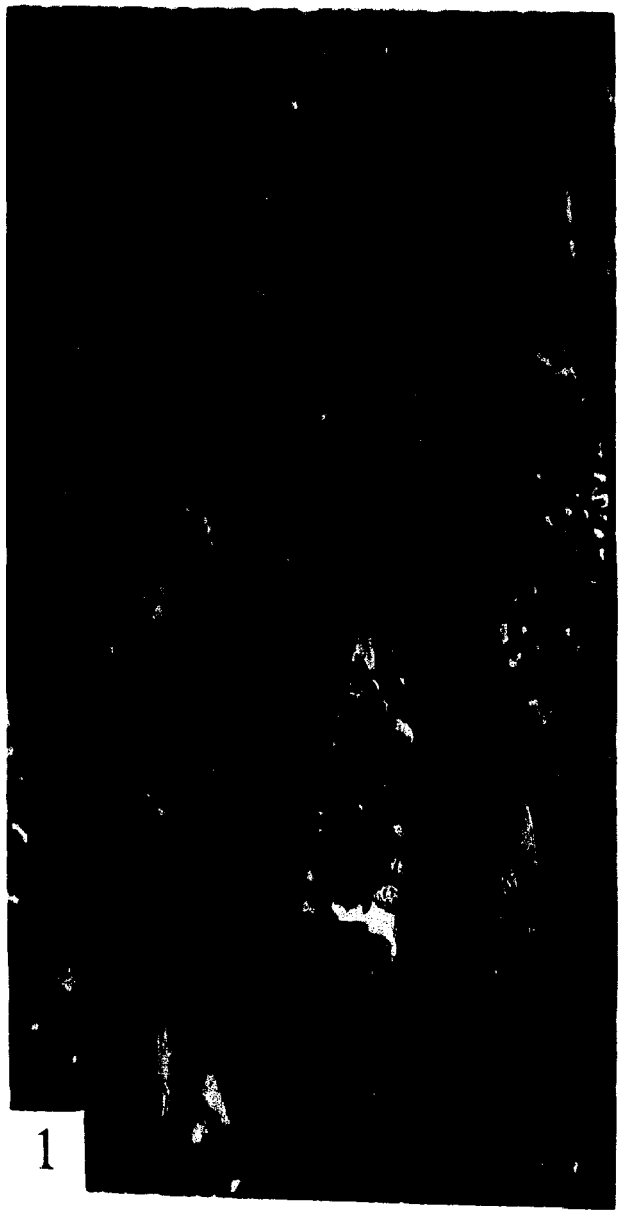
Plate 31

Plate 32

Fig. 1. Lannea acida A. Rich. Tangential section showing wide rays. Note septate fibers. x 130.

Fig. 2. Pseudospondias microcarpa Engl. Tangential section showing rays with tall upright marginal cells. Note vessel and longitudinal parenchyma. x 130.

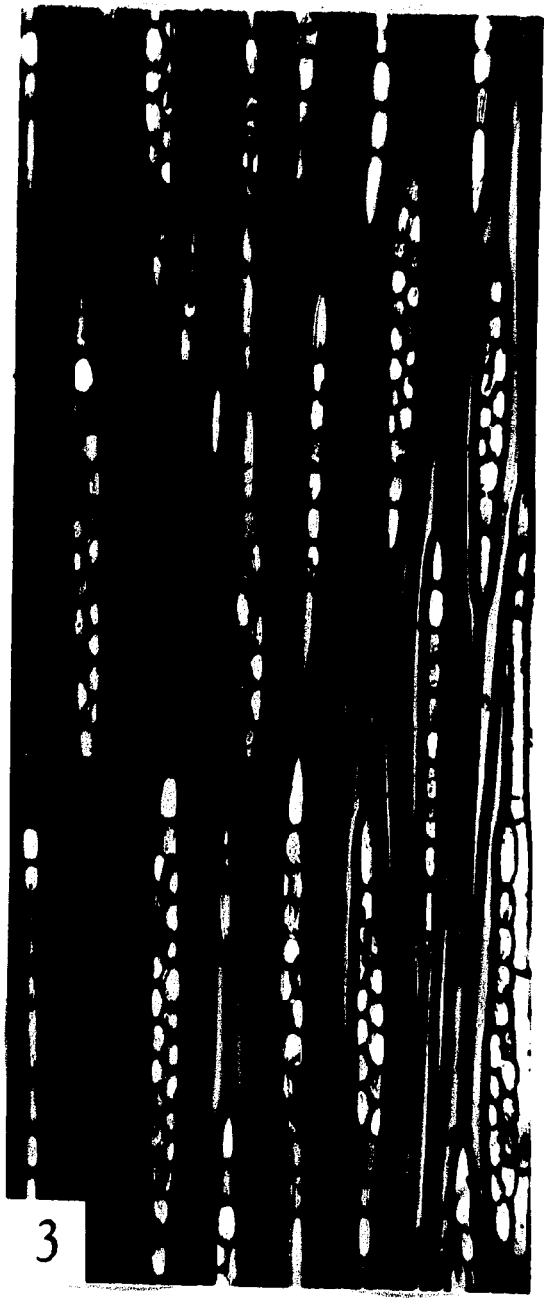
Fig. 3. Antrocaryon Klaineanum Pierre. Tangential section showing uniseriate and biseriate rays. Note absence of septate fibers. x 130.



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Plate 32

Plate 33

Fig. 1. Pleiogynium pilosum (Benth.) Engl. Tangential section showing horizontal intercellular canals in three rays, alternate bordered pitting on vessel, and parenchyma. Note the septate fibers. x 130.

Fig. 2. Sclerocarya caffra Sond. Tangential section showing small horizontal intercellular canal (wide ray at upper right) and abundant tyloses in large vessel. Note septate fibers. x 130.





Plate 33

Plate 34

Fig. 1. Pistacia atlantica Desf. Tangential section showing multiseriate rays, abundant tyloses in large vessel, and spiral thickenings in small vessels. x 190.

Fig. 2. Pistacia Weinmannifolia Poiss. Tangential section showing moderately large horizontal intercellular canal and spiral thickenings in small vessels. x 190.

Fig. 3. Pentaspadon Motleyi Hook. f. Tangential section showing distinctly septate fibers and normal rays. x 130.

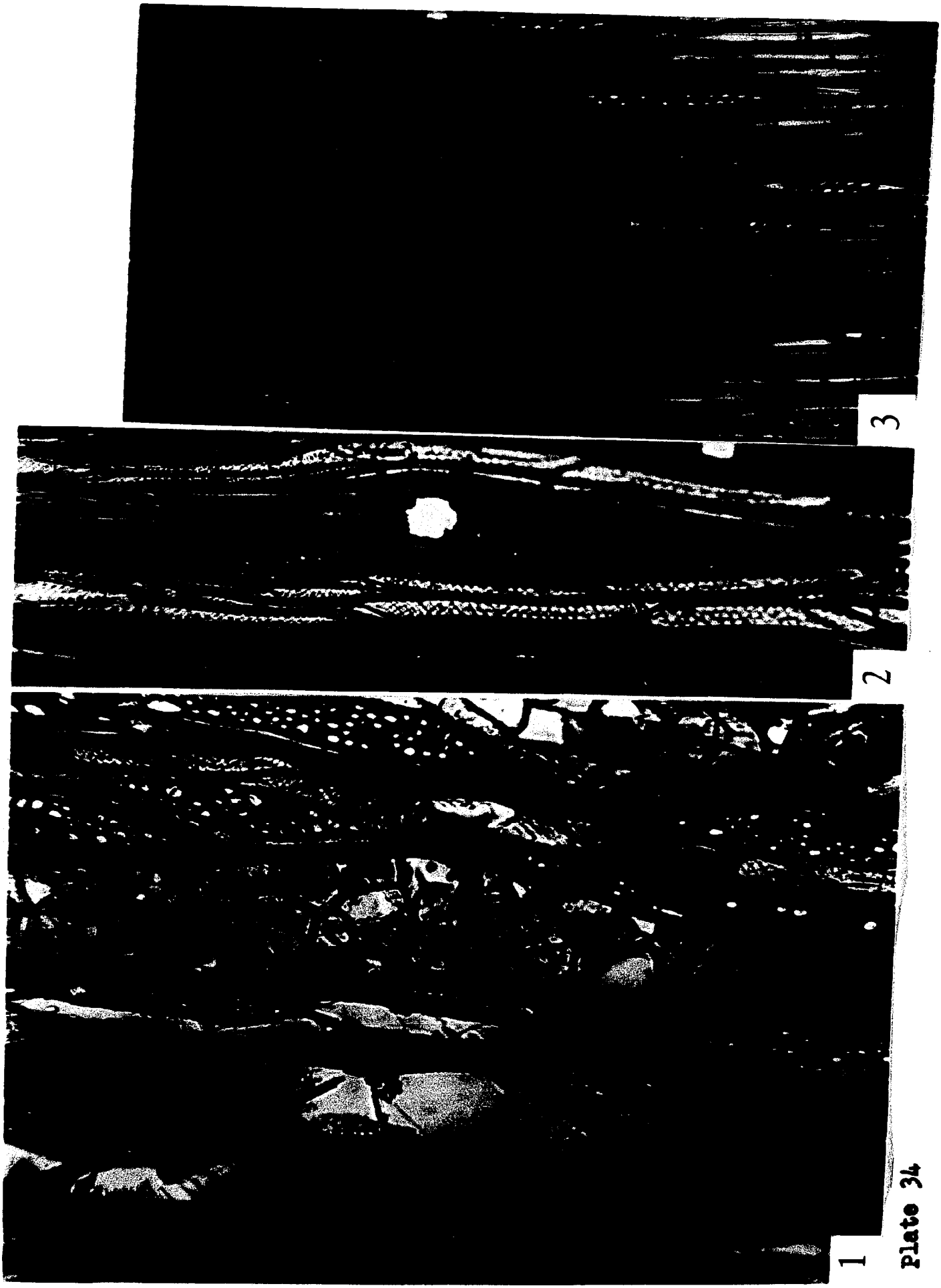


Plate 34

Plate 35

Fig. 1. Faguetia falcata March. Tangential section showing decidedly heterogeneous rays. x 130.

Fig. 2. Heeria mucronifolia Engl. Tangential section showing rays with abundant resin-like deposits. Note septate fibers. x 130.

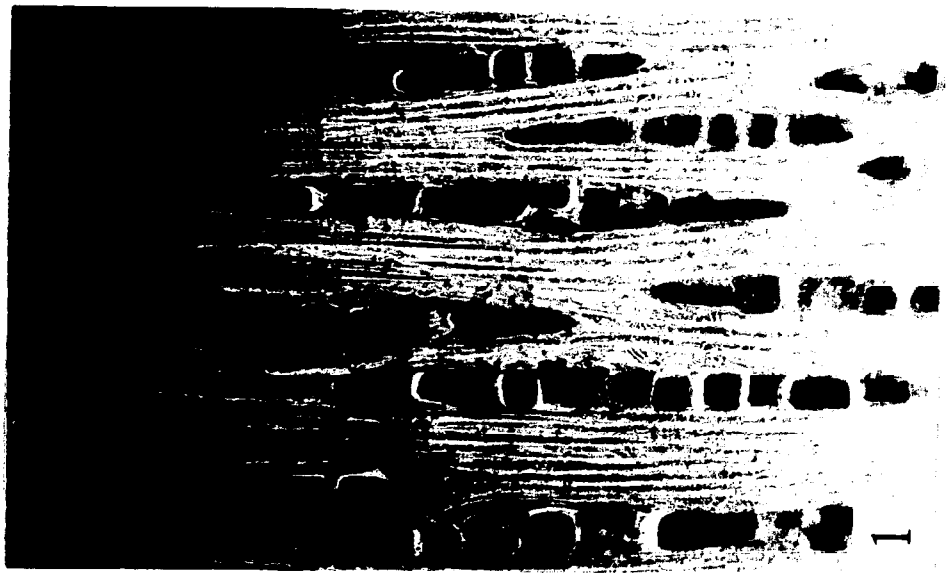
Fig. 3. Campnosperma macrophylla (Blanco) Hook. f. Tangential section showing large horizontal intercellular canal in fusiform ray. Note septate fibers. x 130.



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Plate 35

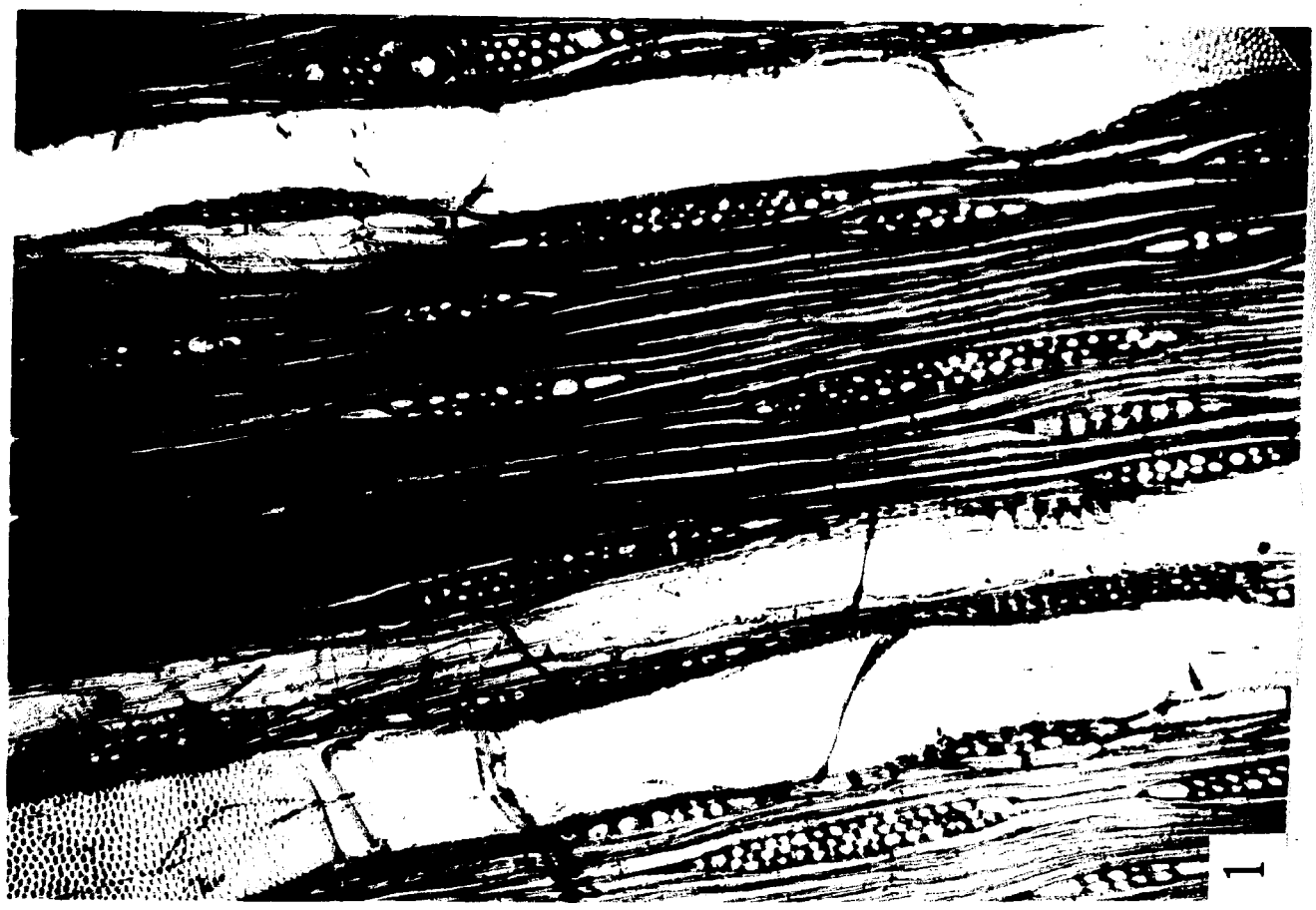
Plate 36

Fig. 1. Pentaspadon minutiflora B. L. Burtt. Tangential section showing small horizontal intercellular canal and alternate bordered pitting on vessels. Note septate fibers. x 130.

Fig. 2. Euroschinus falcatus Hook. f. Tangential section showing very large horizontal intercellular canal, surrounded by several rows of small epithelial cells. Note septate fibers. x 130.



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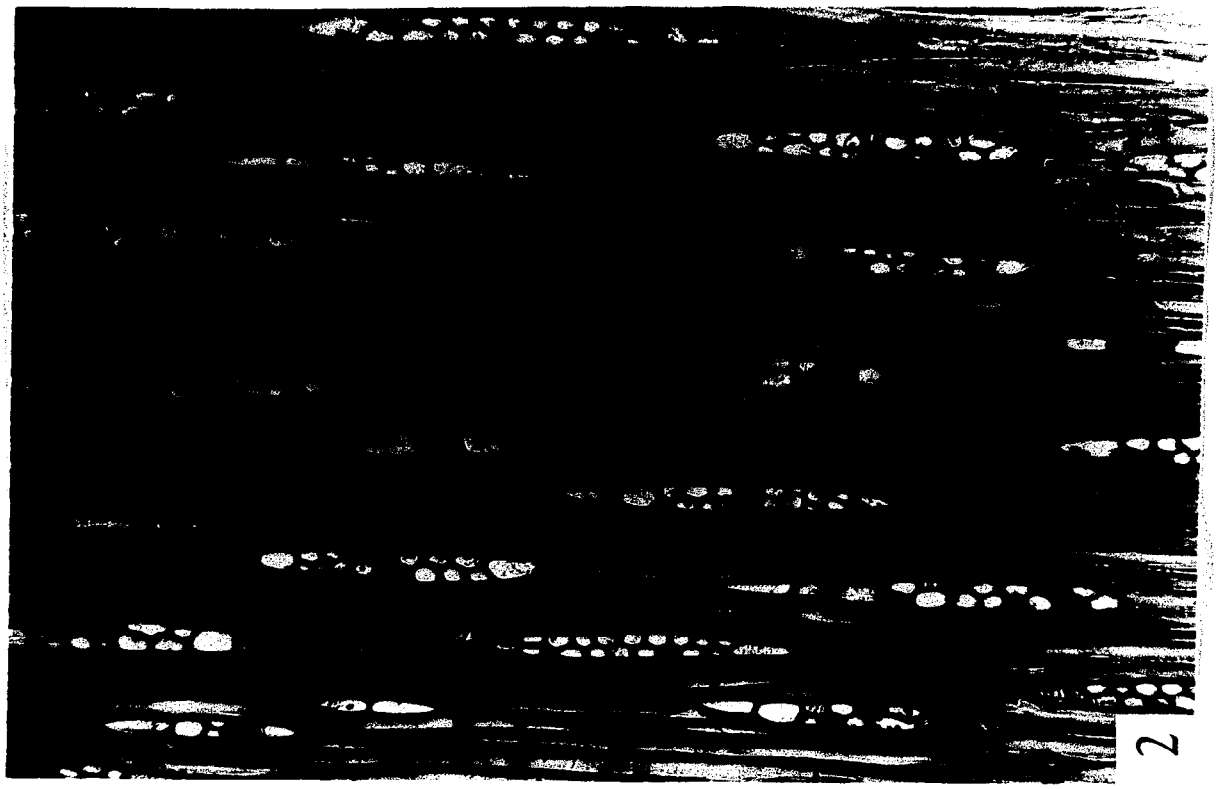
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Plate 36

Plate 37

Fig. 1. Rhodosphaera rhodanthema Engl. Tangential section showing biseriate rays, alternate bordered pitting on vessel, and septate fibers. x 130.

Fig. 2. Blepharocarya involucrigera F. Mueller. Tangential section showing uniseriate and biseriate rays and rare septate fibers. x 130.



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Plate 37

Plate 38

Fig. 1. Microstemon velutina Engl. Tangential section showing horizontal intercellular canal and marginal and upright cells. Note septate fibers and crystals in some ray cells. x 130.

Fig. 2. Cotinus coggygria Scop. Tangential section showing rays and spiral thickenings in very small vessels. x 130.

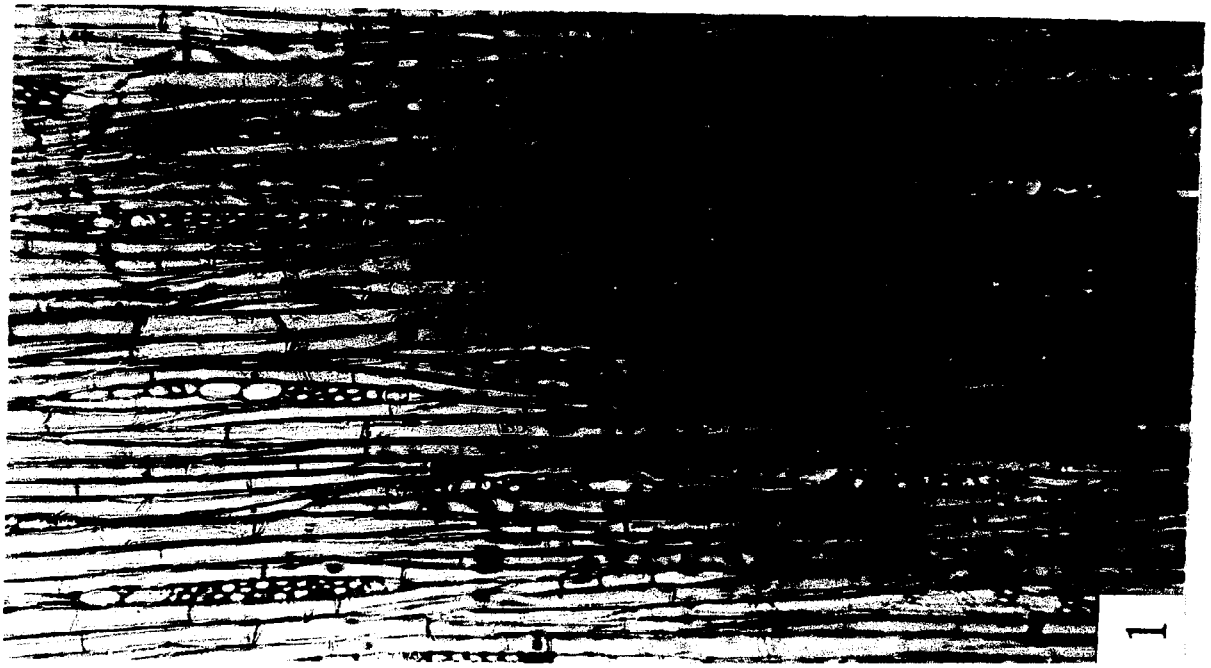
Fig. 3. Rhus succedanea Linn. Tangential section showing septate fibers. x 130.



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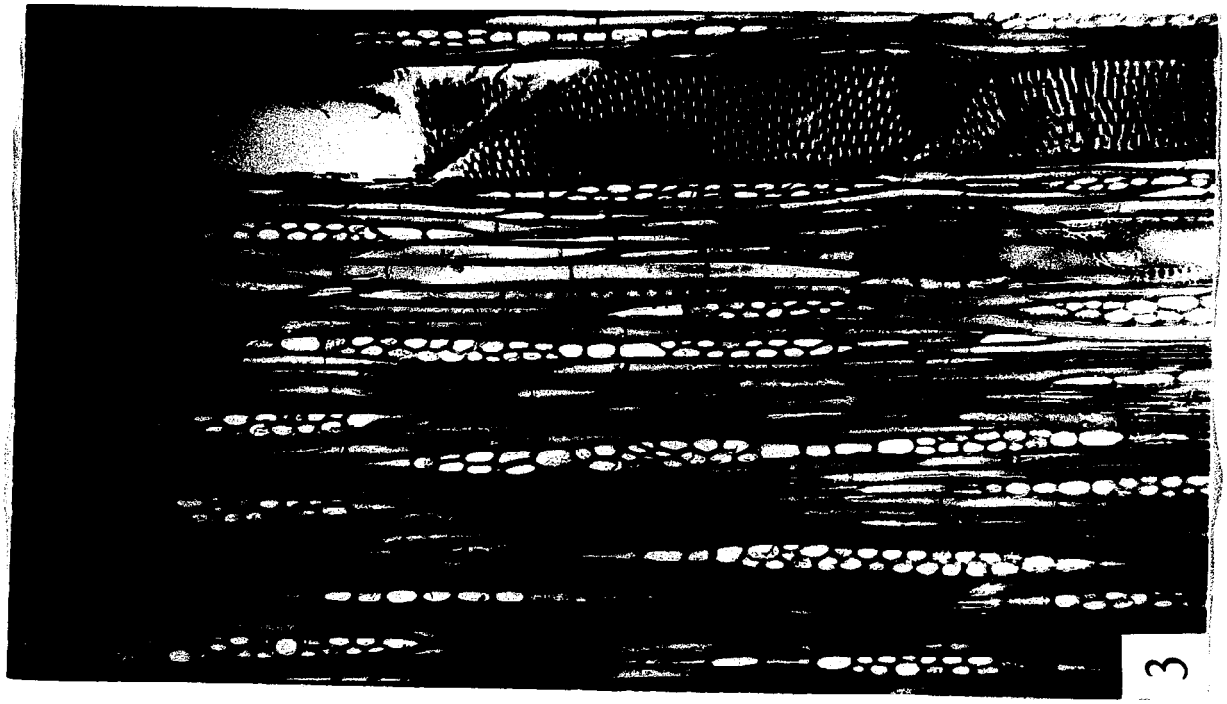
Plate 38

Plate 39

Fig. 1. Rhus semialata Murr. var. sandwicensis Engler Tangential section showing low rays and non-septate fibers. x 130.

Fig. 2. Rhus trichocarpa Miq. Tangential section showing moderately high rays and sporadically septate fibers. x 130.

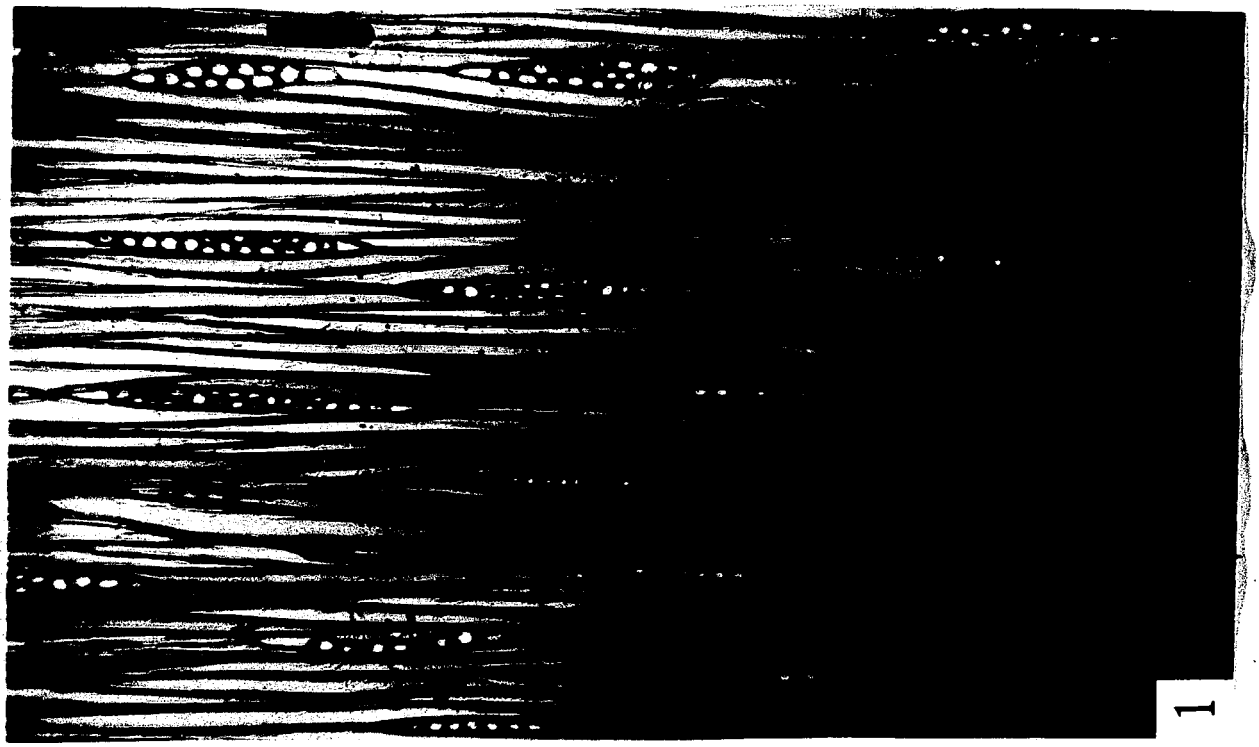
Fig. 3. Rhus australis Tangential section showing moderately high rays, septate fibers, and large bordered pits in the vessel. x 130. Compare with Rhodosphaera rhodanthema Engl. (Plate 37, Fig. 1).



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Plate 39

Plate 40

Fig. 1. Holigarna Helferi Hook. f. Tangential section showing rays. x 130.

Fig. 2. Melanochyla Kunstleri King. Tangential section showing horizontal intercellular canal in ray. x 130.



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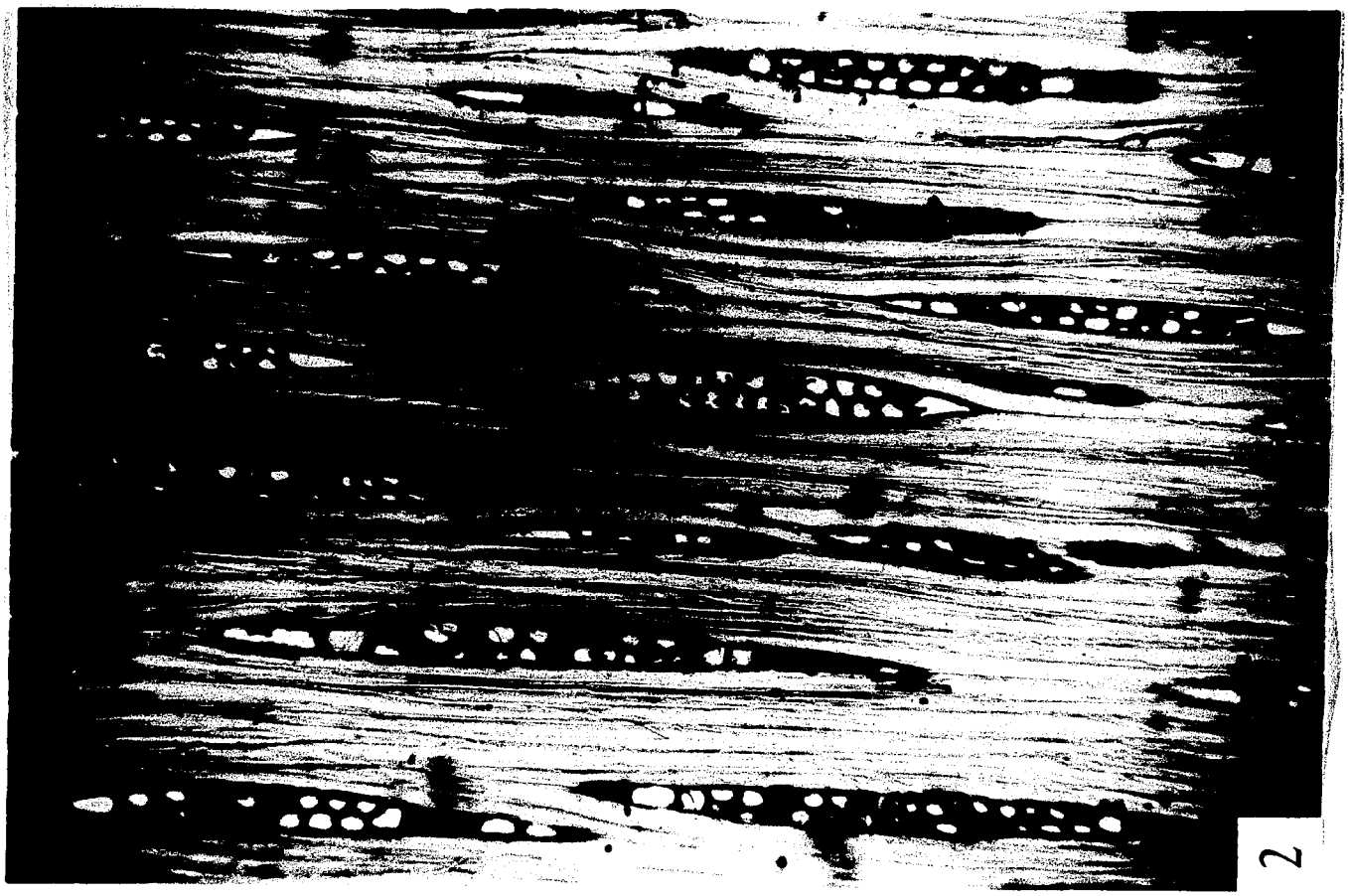
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Plate 40

Plate 41

Fig. 1. Semecarpus lucens King. Tangential section showing rays. x 130.

Fig. 2. Semecarpus atra Vielle. Tangential section showing rays. x 130.



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Plate 41

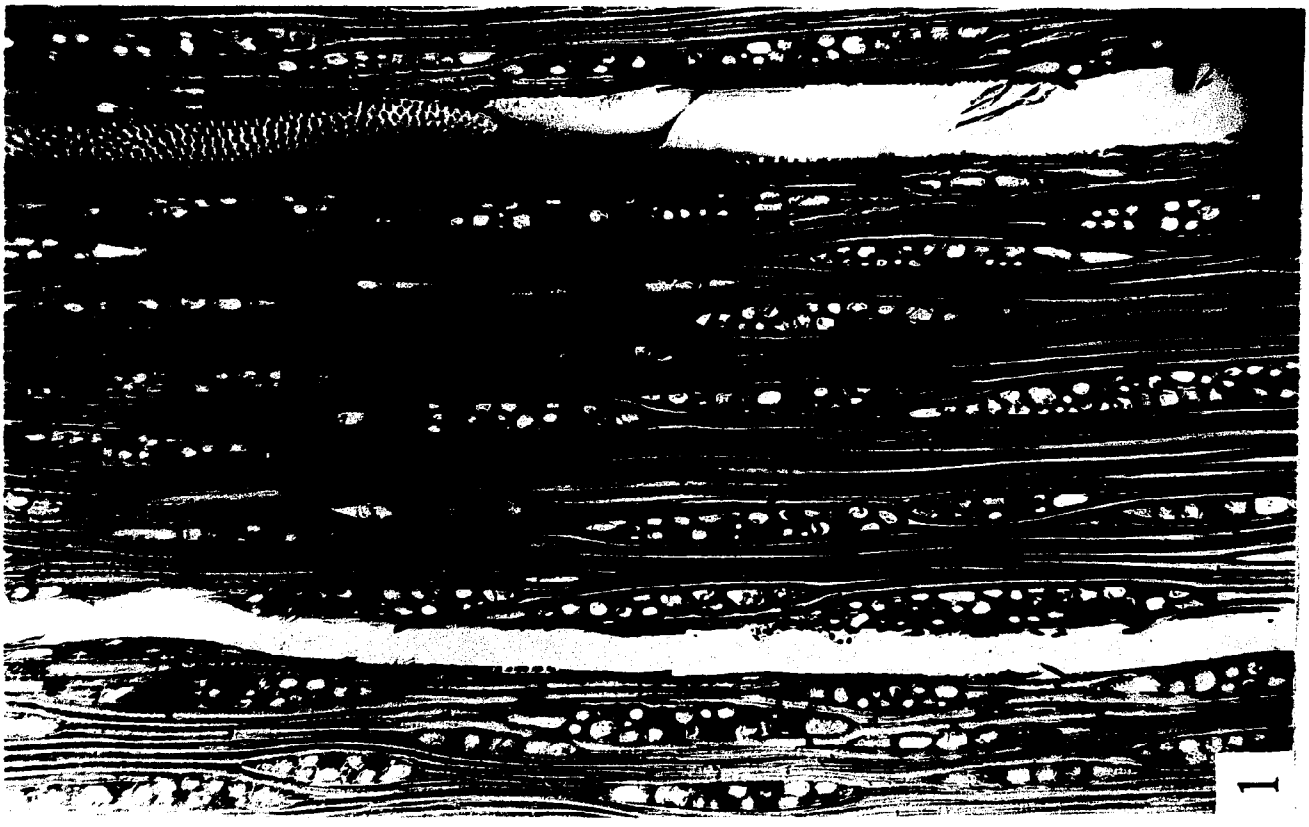
Plate 42

Fig. 1. Nothopegia Colebrookiana Blume. Tangential section showing rays and large, alternate bordered pitting in the vessel at right. x 130.

Fig. 2. Juliania adstringens Schlecht. Tangential section showing multiseriate rays and alternate bordered pitting in the vessels. x 130.



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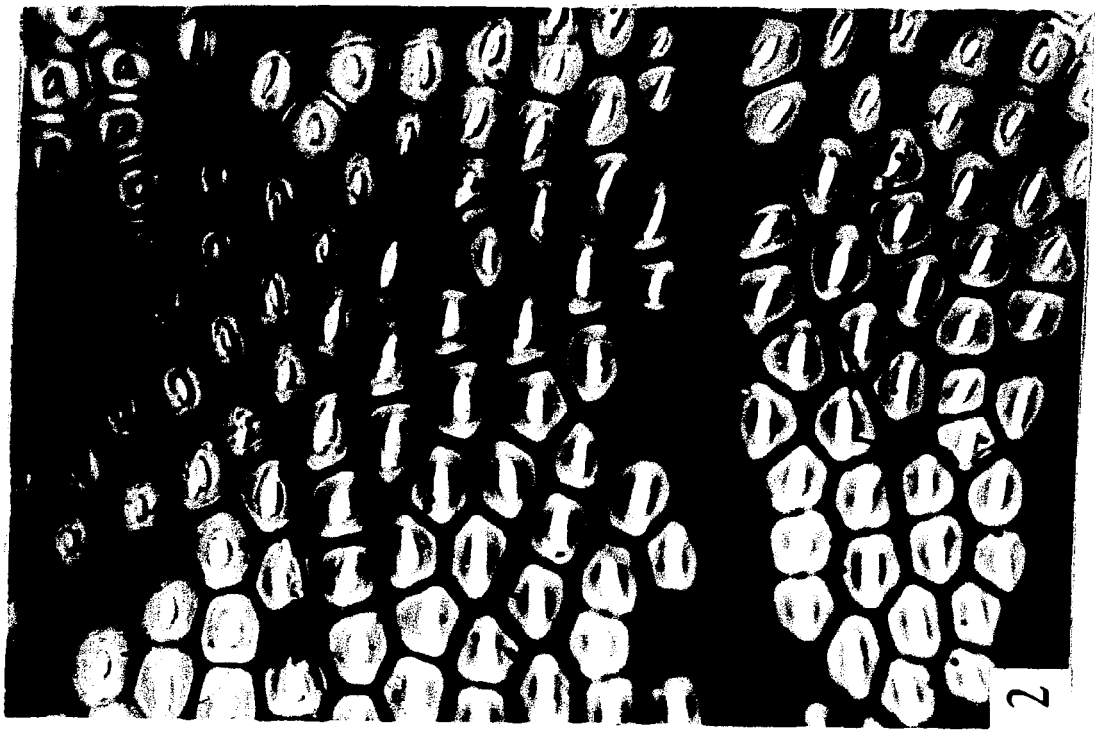
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Plate 42

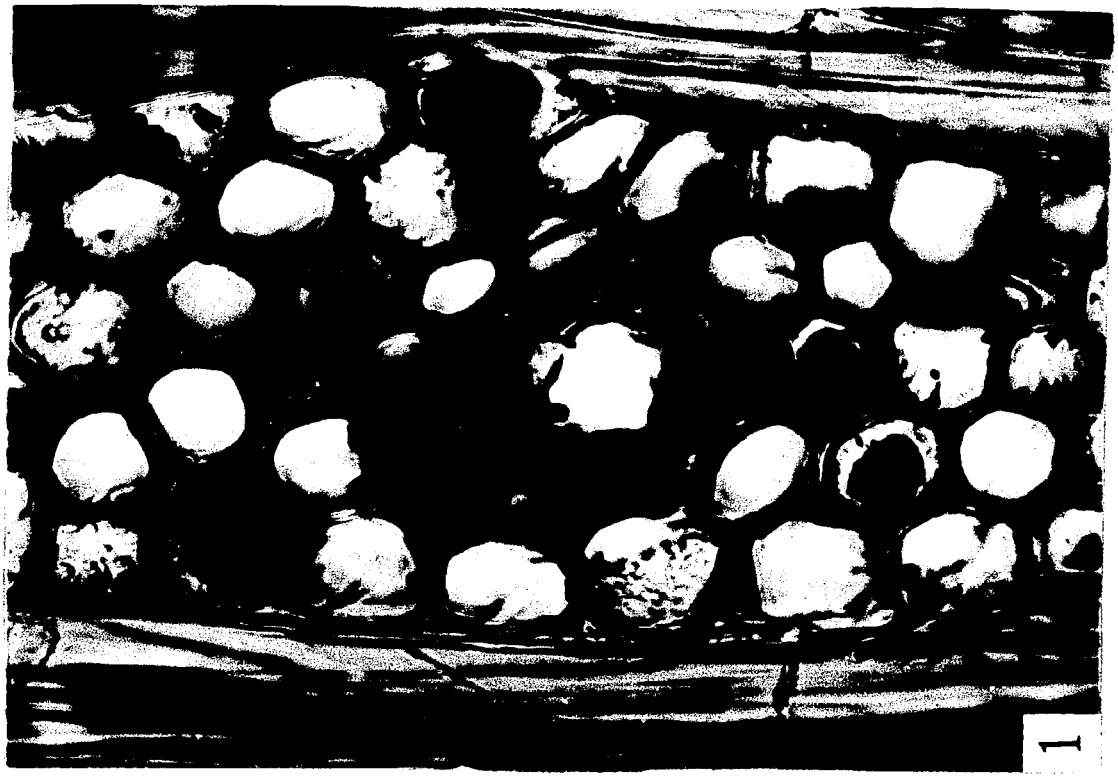
Plate 43

Fig. 1. Juliania adstringens Schlecht. Tangential section showing part of a ray containing a very small horizontal intercellular canal, surrounded by a single row of epithelial cells. Note the septate fibers. x 700.

Fig. 2. Semecarpus heterophylla Blume. Radial section showing alternate, angular bordered pits on portion of a vessel. Note the lenticular, horizontal apertures. x 700.



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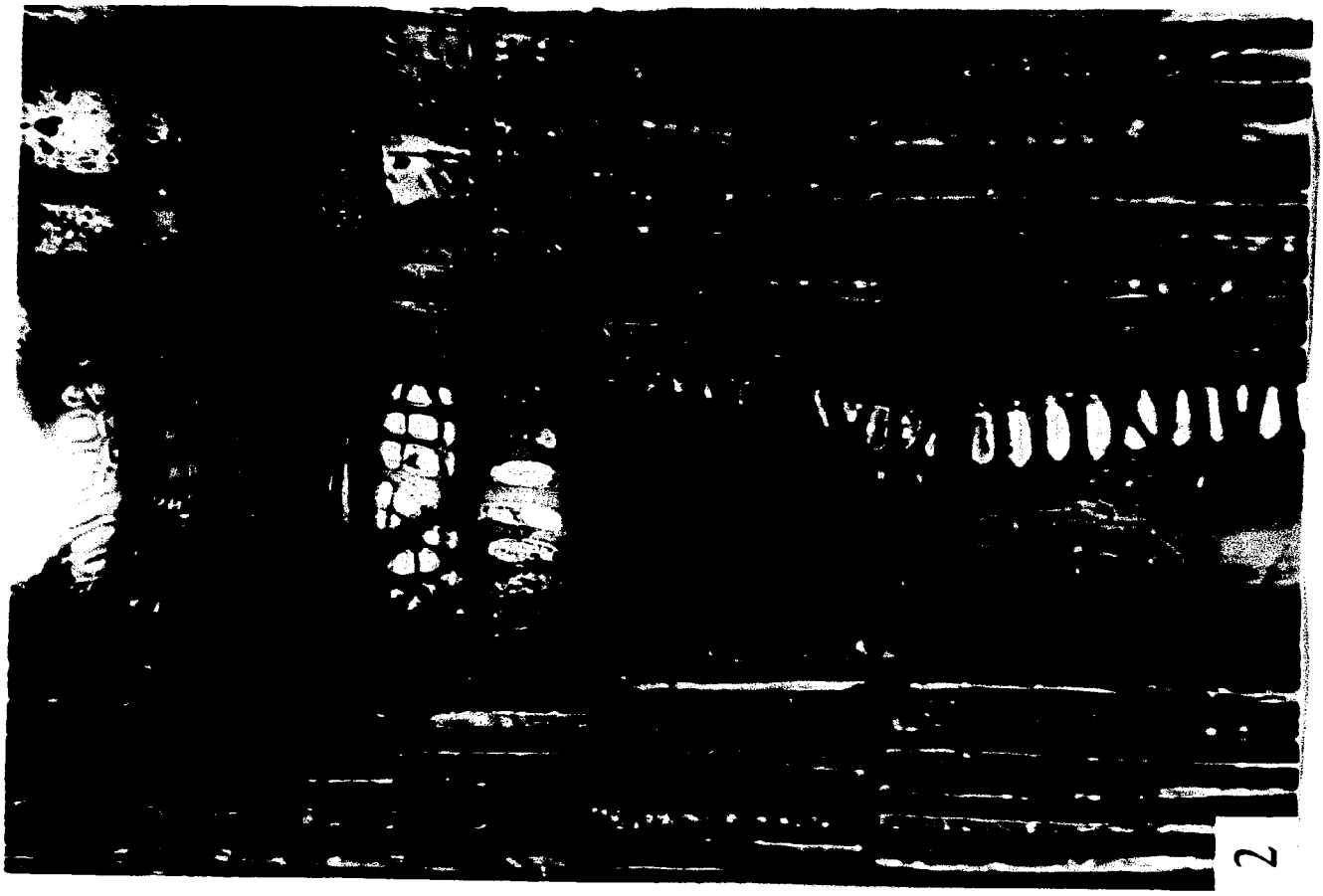
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Plate 43

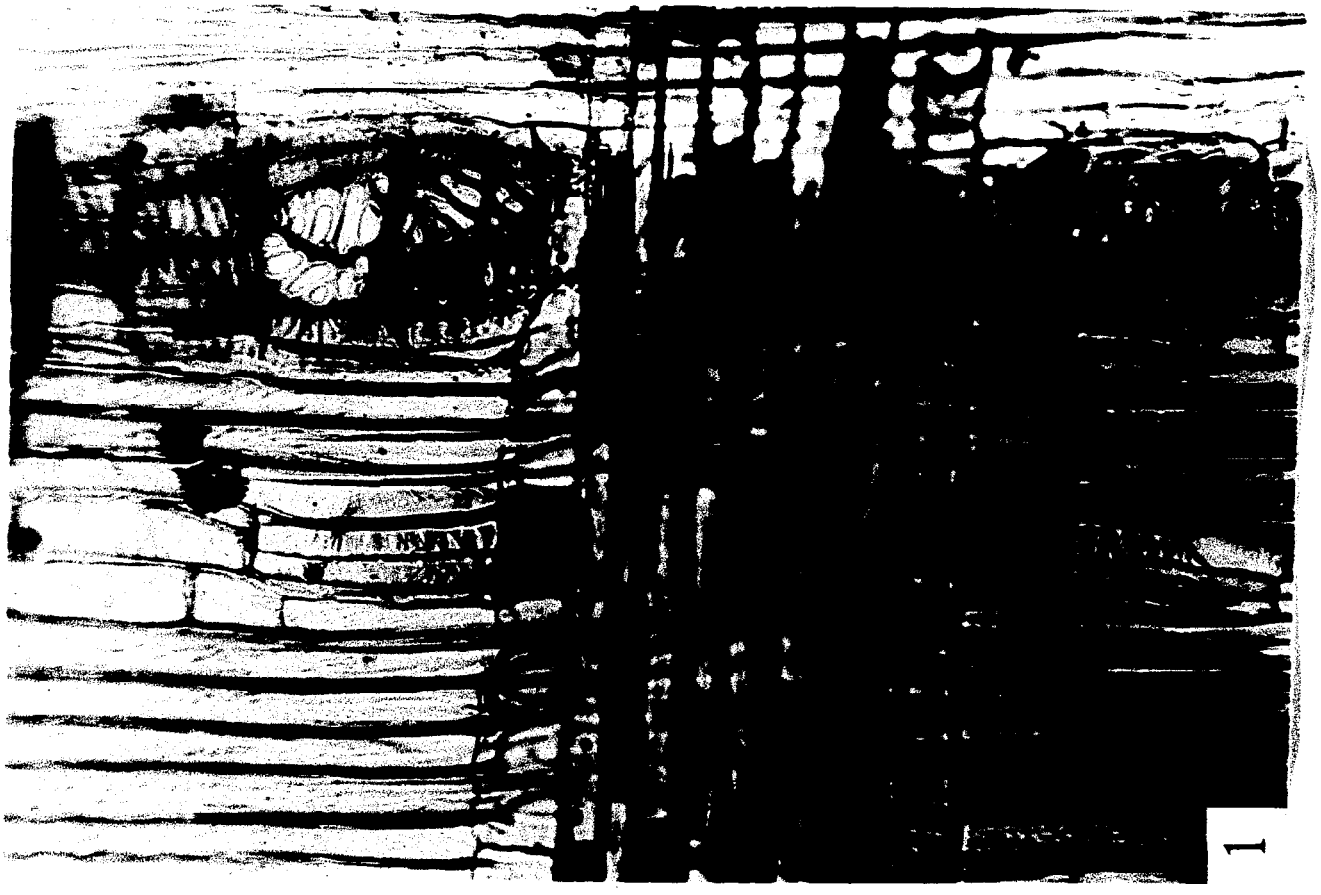
Plate 44

Fig. 1. Semecarpus heterophylla Blume. Radial section showing ray to vessel, half-bordered pitting characteristic for this species and for most of the Anacardiaceae. x 190.

Fig. 2. Blepharocarya involucrigera F. Mueller. Radial section showing characteristic ray to vessel pitting. Note the numerous, indistinctly bordered pits on the fibers. x 185.



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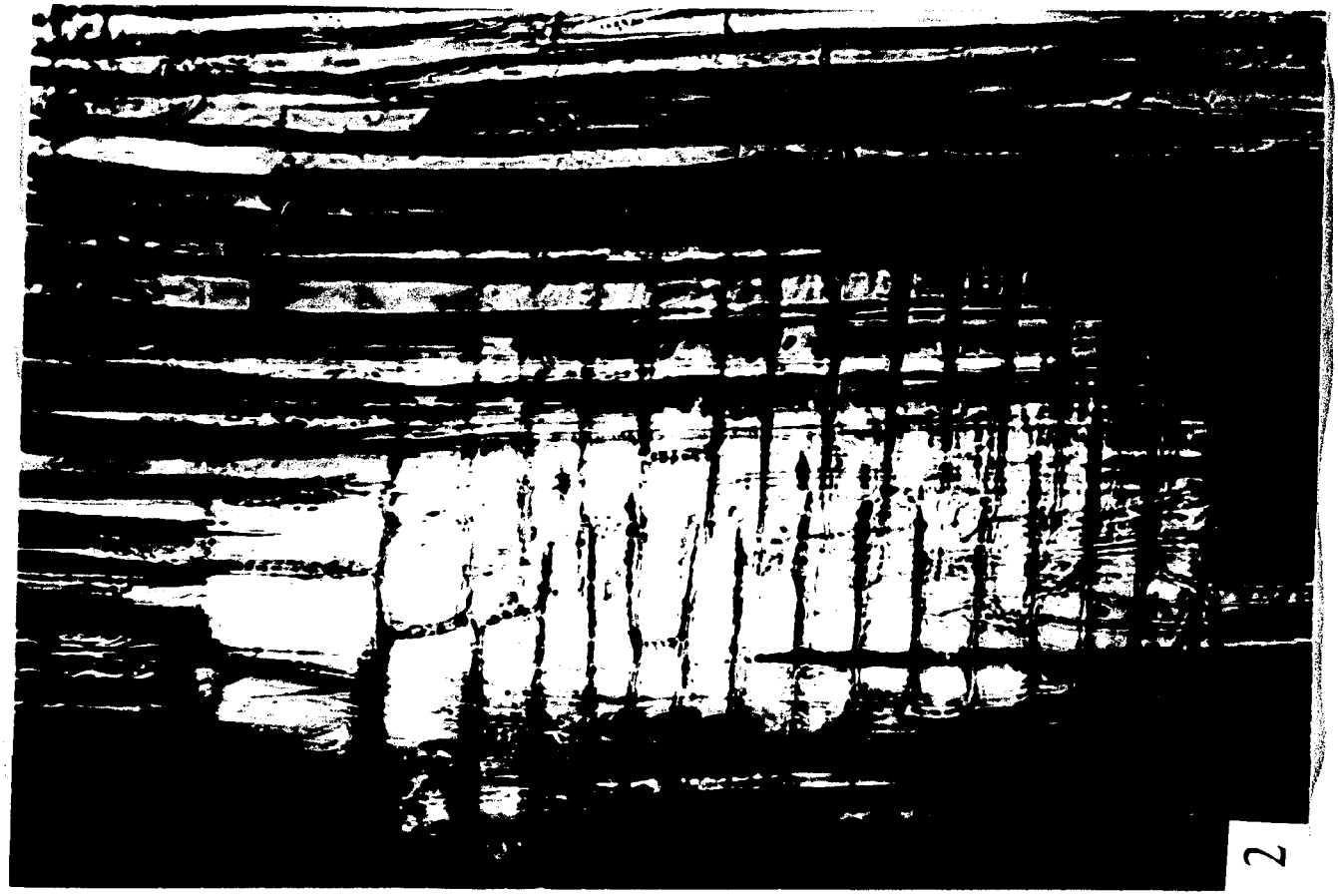
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Plate 44

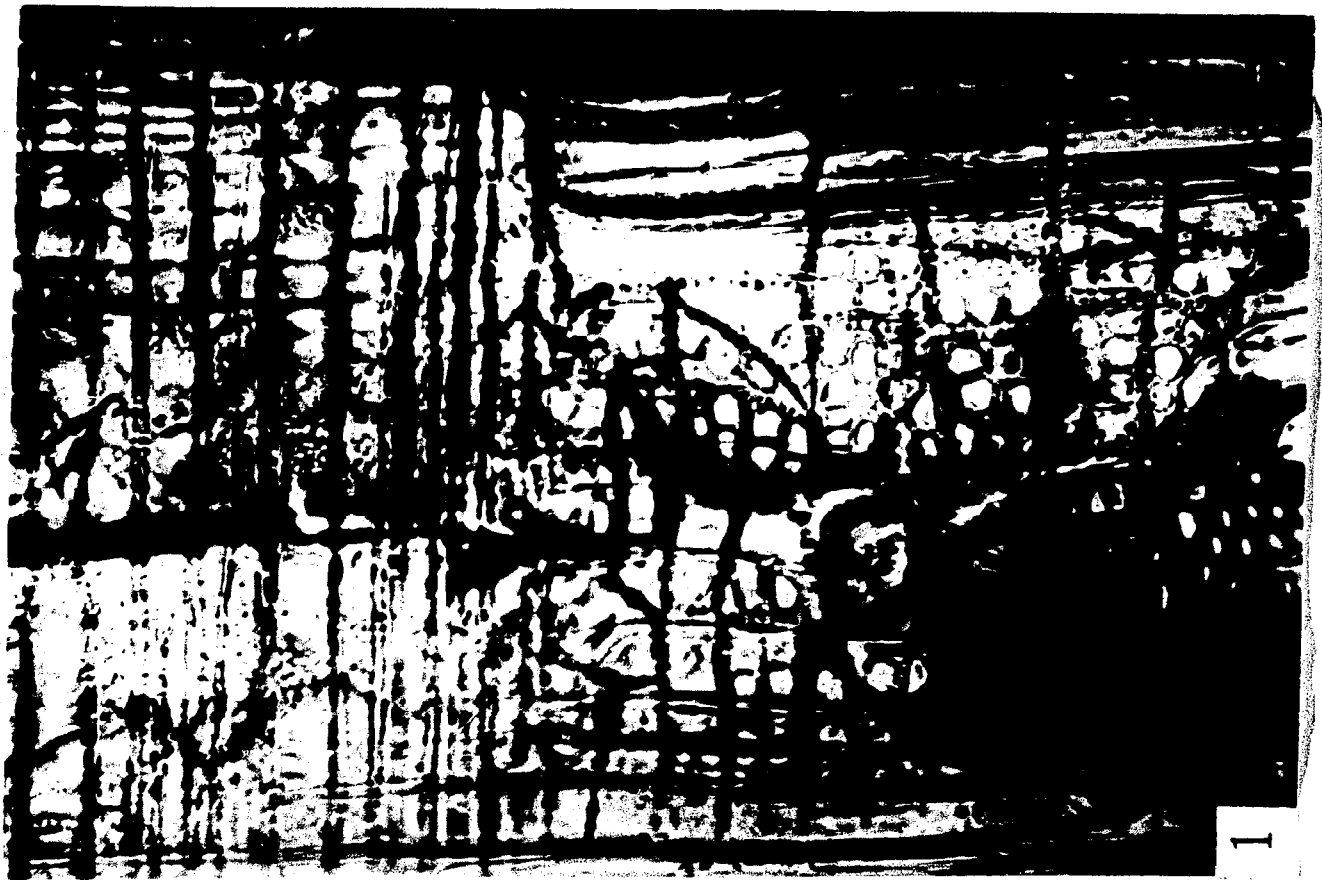
Plate 45

Fig. 1. Rhodosphaera rhodanthema Engl. Radial section showing large, rounded ray to vessel pitting. x 185.

Fig. 2. Same section, showing upright marginal cells and uniform procumbent cells. Note three crystals at lowest portion of ray. x 185.



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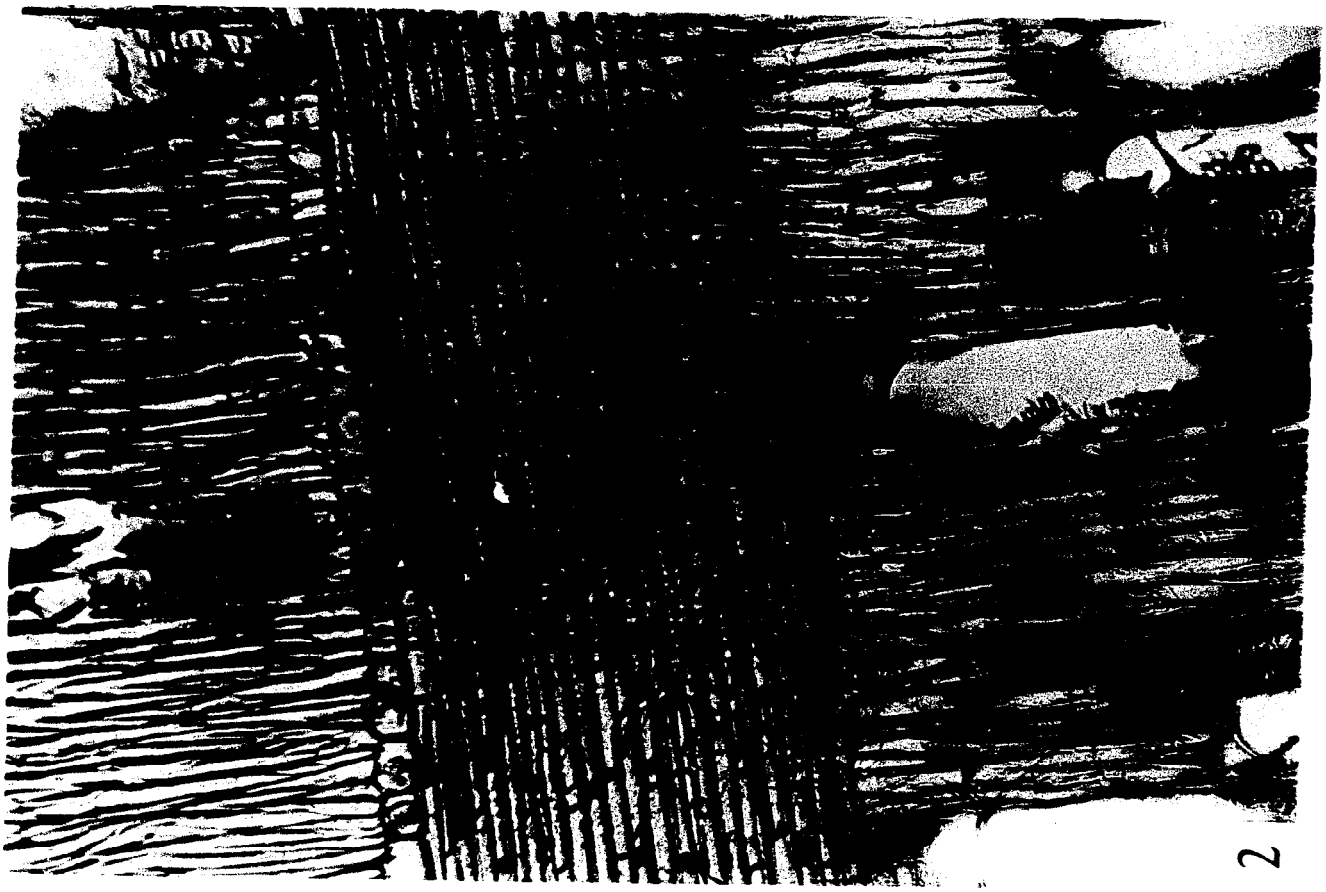
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Plate 45

Plate 46

Fig. 1. Nothopegia Colebrookiana Blume. Radial section showing tall upright marginal cells, resin-like deposits in rays, and crystals in both marginal and procumbent cells. x 130.

Fig. 2. Juliania adstringens Schlecht. Radial section showing single row of low upright marginal cells. Note vessel to ray pitting in upper right corner, above the ray, and note crystals in marginal cells only. x 130.



2



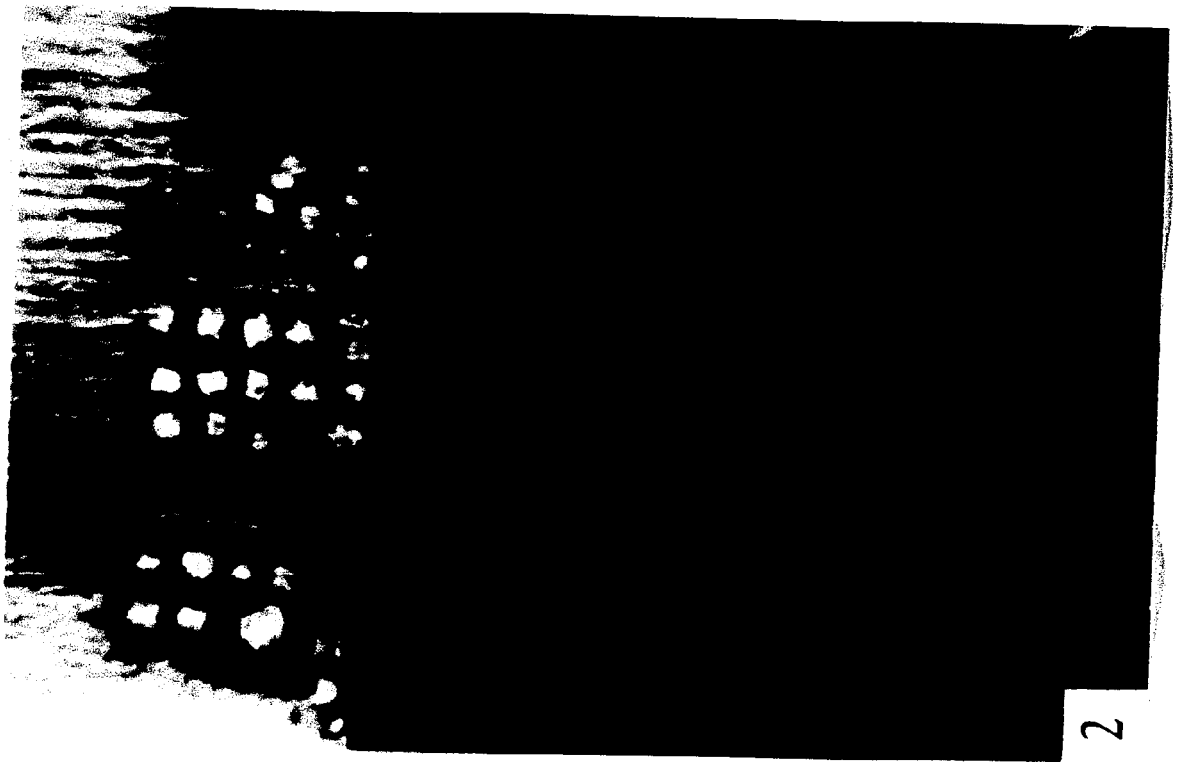
1

Plate 46

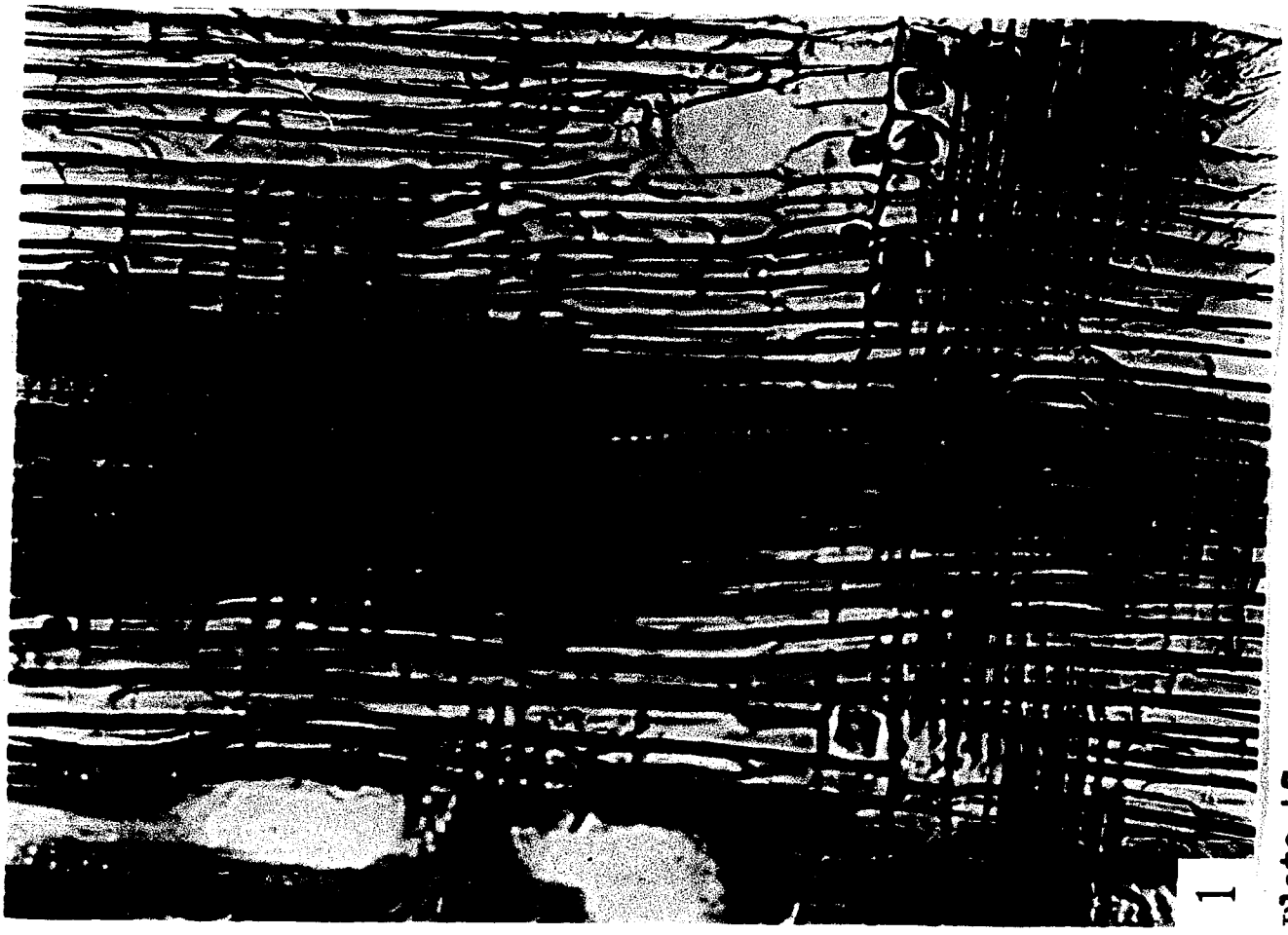
Plate 47

Fig. 1. Microstemon velutina Engl. Radial section showing large, rhombohedral crystals in marginal cells. x 190.

Fig. 2. Koordersiodendron pinnatum (Blanco) Merr. Radial section showing crystals in chambered upright ray cells. Note the tall, pointed upright cell filled with dark, resin-like substance, in the upper margin of the ray. (The procumbent cells appear solid black because of the thickness of the section and the abundance of resin-like material in the cells.) x 190.



2



1

Plate 47

Plate 48

Fig. 1. Euroschimus obtusifolius Engl. Macerated wood showing end of a vessel element showing portion of a modified scalariform or reticulate perforation plate. x 700.

Fig. 2. Euroschimus obtusifolius Engl. Radial section showing portion of ray with chambered upright marginal cells containing crystals. x 700.

2

1

Plate 48

Plate 49

Fig. 1. Campnosperma Wallichii King. Macerated wood showing vessel element with scalariform perforation plate, long tips, alternate bordered pits, and irregular or scalariform pits at portion crossed by a ray. Note pits in fibers. x 190.

Fig. 2. Blepharocarya involucrigera F. Mueller. Macerated wood showing large vessel element with nearly horizontal ends, simple perforation plates, and a long, thick projecting tip at the left. Note pits in fibers. x 190.

1

2

Plate 49

Plate 50

Fig. 1. Cotinus coggygria Scop. Macerated wood showing small vessel elements with oblique ends, simple perforation plates, and spiral thickenings. Note larger elements in shadow at lower portion of photograph with nearly horizontal ends. x 190.

Fig. 2. Juliania adstringens Schlecht. Macerated wood showing horizontal or slightly oblique ends and simple perforation plates. Note fibers at left with septa and numerous pits. x 190.

2

1

Plate 50

Plate 51

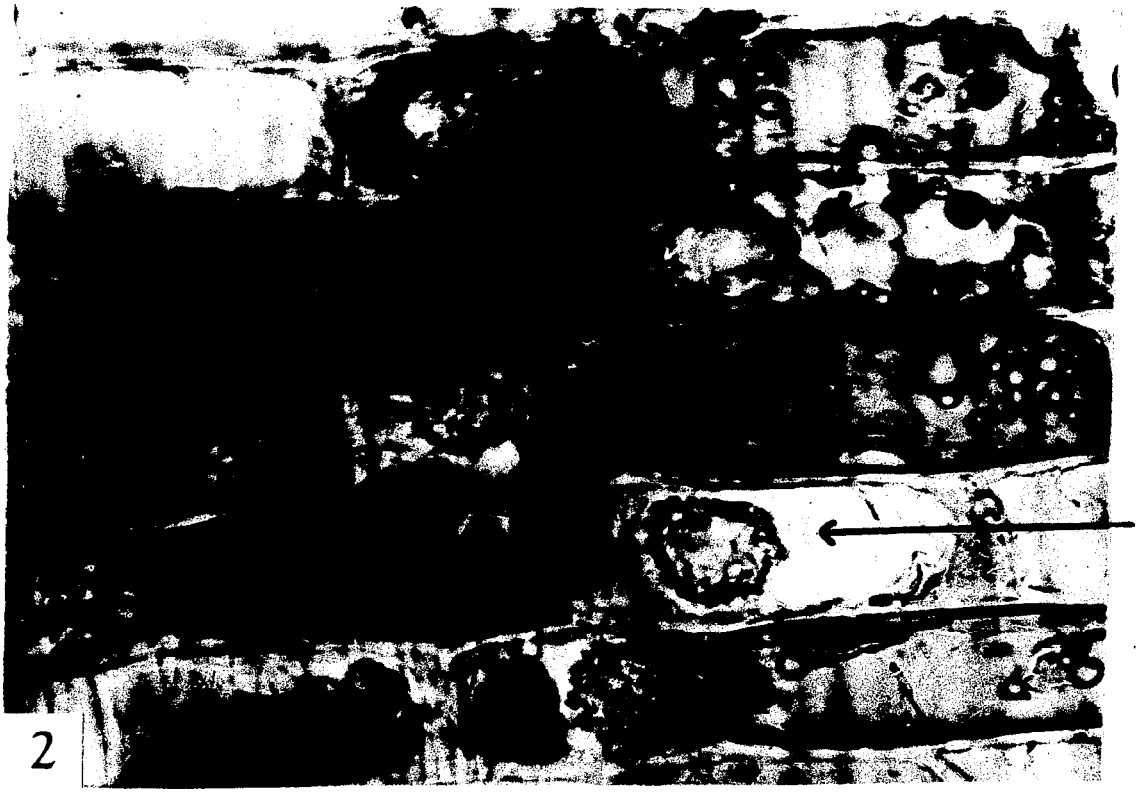
Fig. 1. Nothopegia Colebrookiana Blume. Radial section showing large, rhombohedral crystals in both marginal and procumbent cells. Note deposits of dark, resin-like material. x 700.

Fig. 2. Gluta tavoyana Wall. Radial section showing portion of ray with large, white, echinulate bodies in the cells (see arrow). Small starch grains and masses of dark, resin-like substance are also present x 700.

Plate 51



1



2