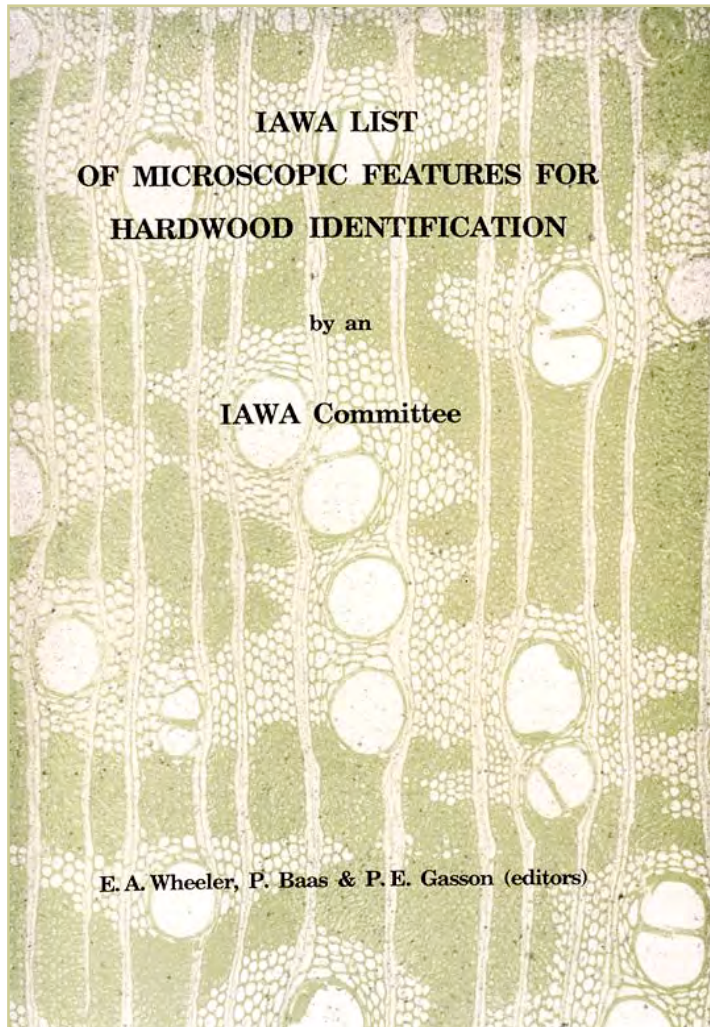




Order form at
International Association of Wood
Anatomists Web Site

<http://bio.kuleuven.be/sys/iawa>

IAWA Hardwood Feature List

Definitions and Illustrations

Features 96-122. Rays, Storied Structure

Numbered photographs from:
IAWA Committee. 1989. IAWA List of
Microscopic Features for Hardwood
Identification. IAWA Bulletin n.s. 10(3):
219-332.

Photographs without numbers are associated
with the InsideWood website hosted by N.C.
State University Libraries.

<http://insidewood.lib.ncsu.edu/search>

Photographs copyright of the individual
photographers credited.

Slide Set Assembled by E.A.Wheeler

**RAY WIDTH = ray width in cell numbers
as per feature description.**

Determine ray width on the **tangential section** by counting the number of cells in the widest part of the rays, perpendicular to the ray axis.

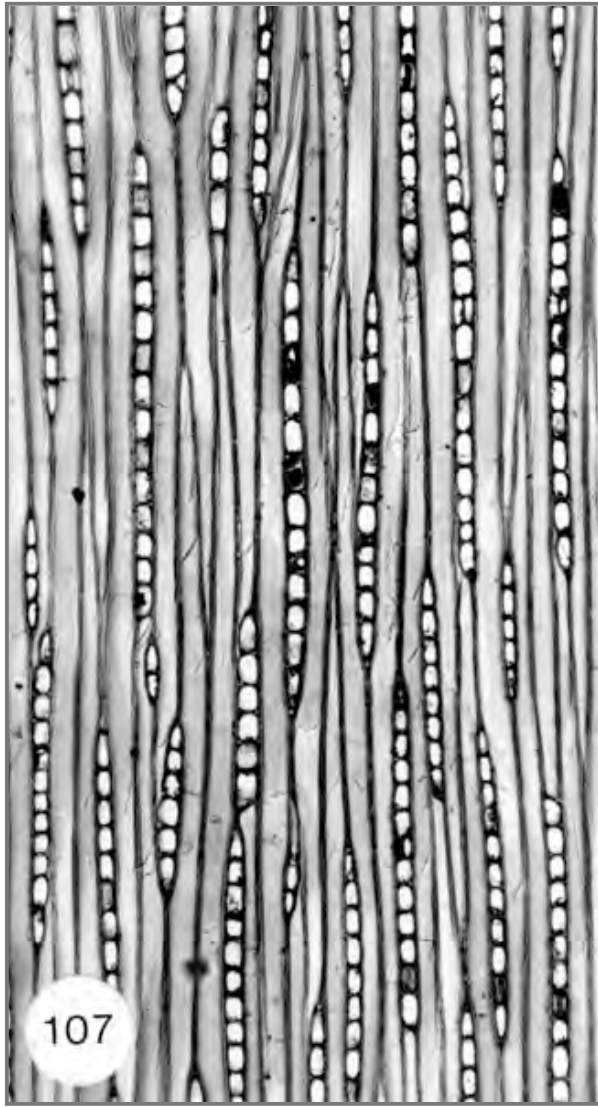
When rays are of two distinct sizes (feature 103), [use] the width of the larger size class.

These features for ray width do **not** apply to rays containing radial canals (feature 130) or to the rays composing an aggregate ray (feature 101).

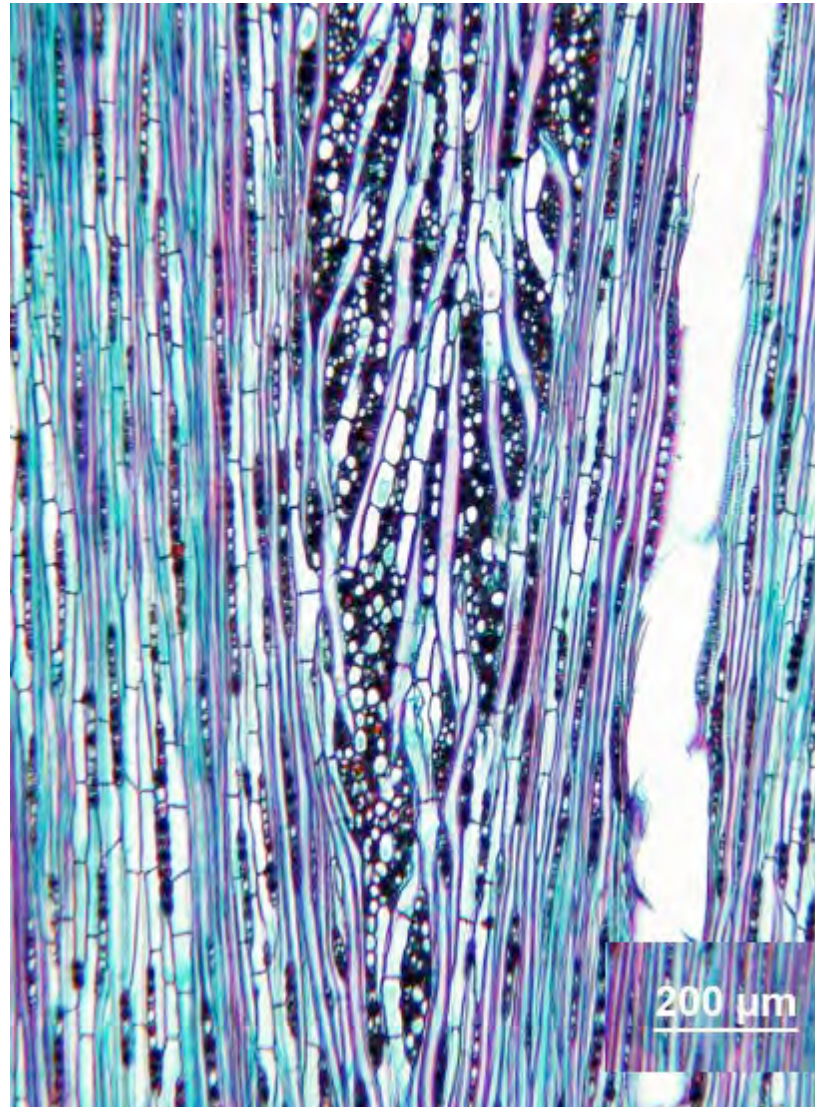
Examples follow.

Feature 96. Rays exclusively uniseriate

Lithocarpus (right) has exclusively uniseriate rays aside from the aggregate rays, features 96 and 101 (aggregate rays) are both present.



Lophopetalum beccarianum
(Celastraceae) K. Ogata



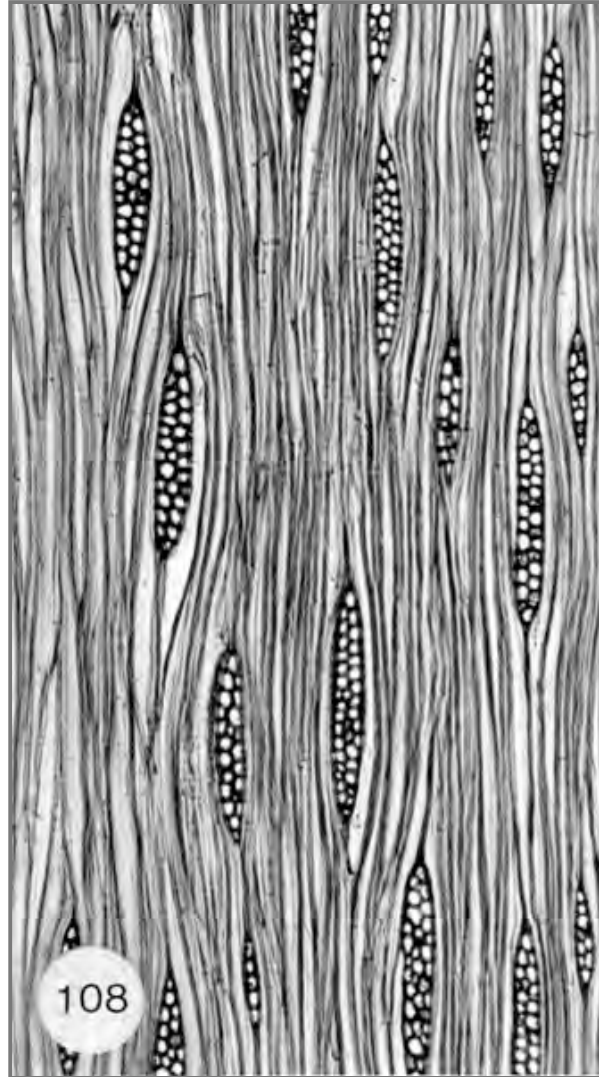
Lithocarpus edulis (Fagaceae)
E. A. Wheeler

Feature 97. Ray width 1 to 3 cells

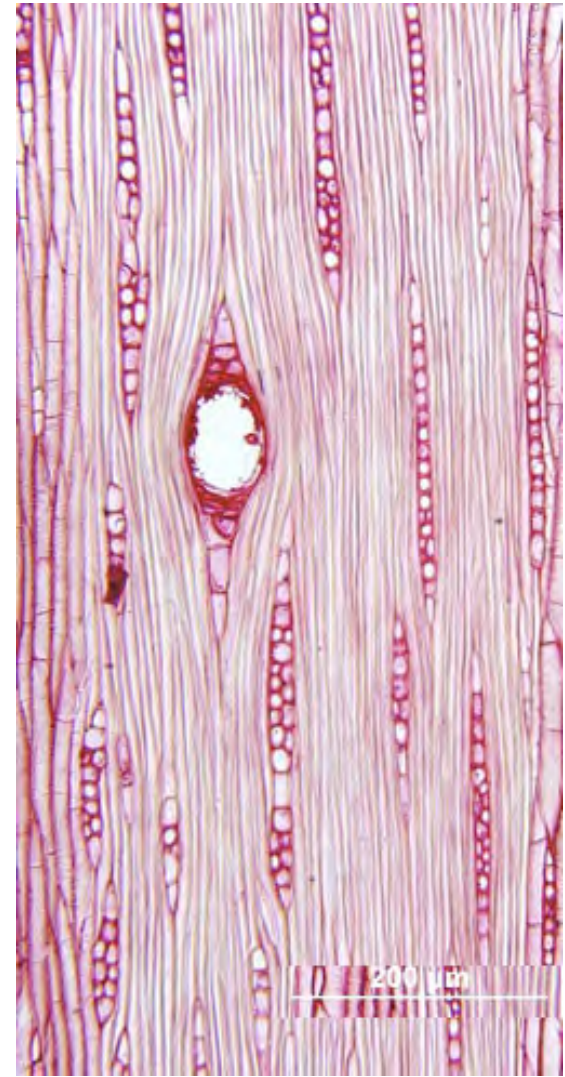
In *Rhus microphylla*, except for the ray with a radial canal, most rays are 2 cells wide, so features 97 and 130 apply.



Nothofagus antarctica
(Nothofagaceae) I. Poole

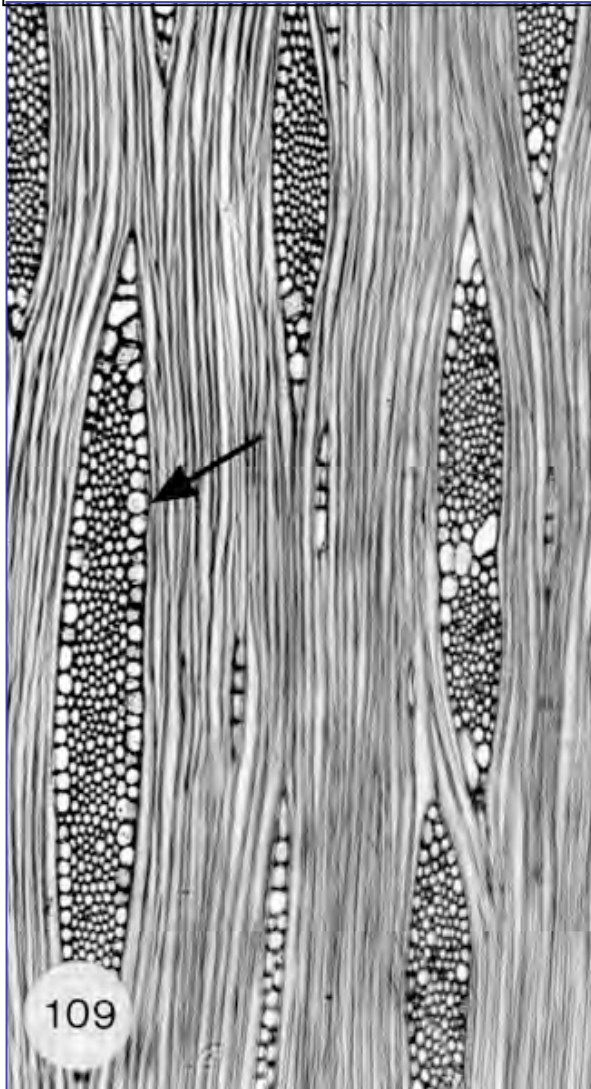


Albizia (Samanea) saman
(Mimosoideae) K. Ogata



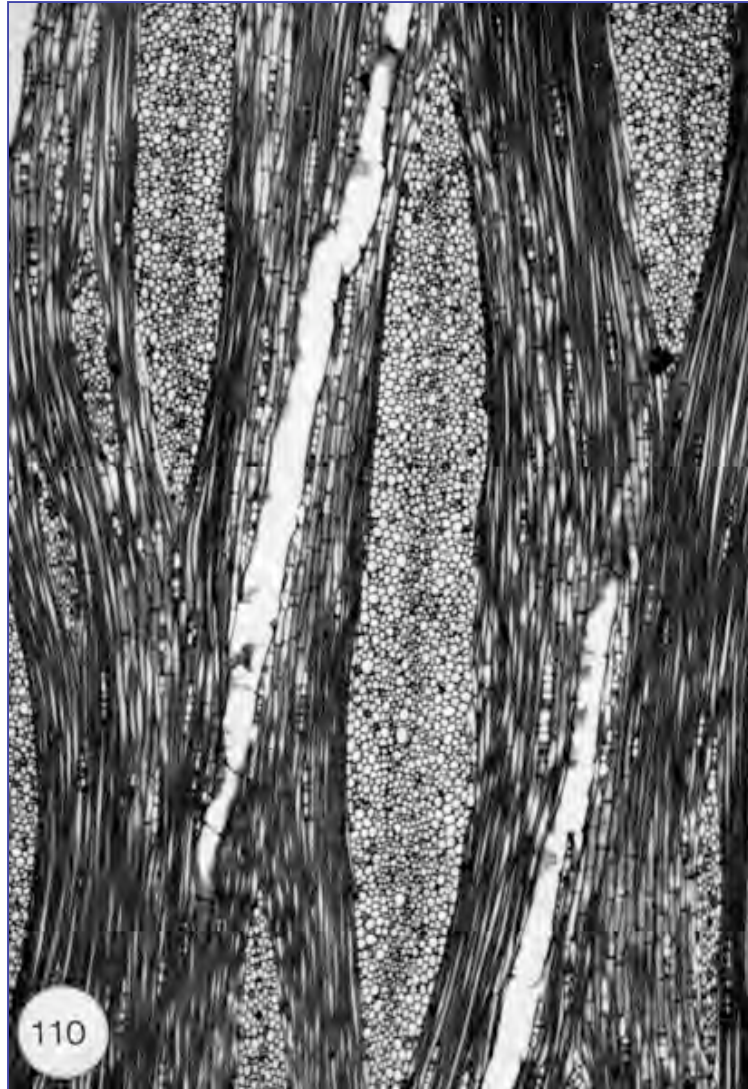
Rhus microphylla
(Anacardiaceae) E.A. Wheeler

Feature 98. Larger rays commonly 4- to 10-seriate.

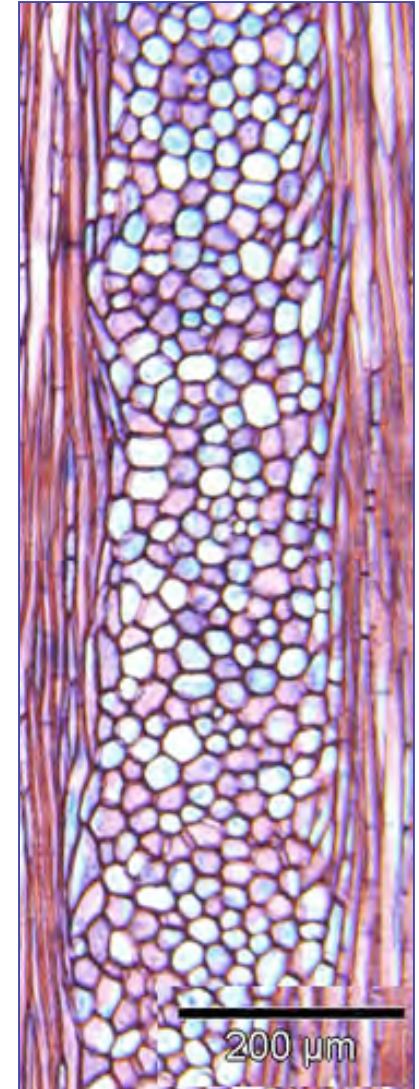


Celtis sinensis. K. Ogata
Arrow points to sheath cells, feature 110 (Cannabaceae)

Feature 99. Larger rays commonly > 10 seriate

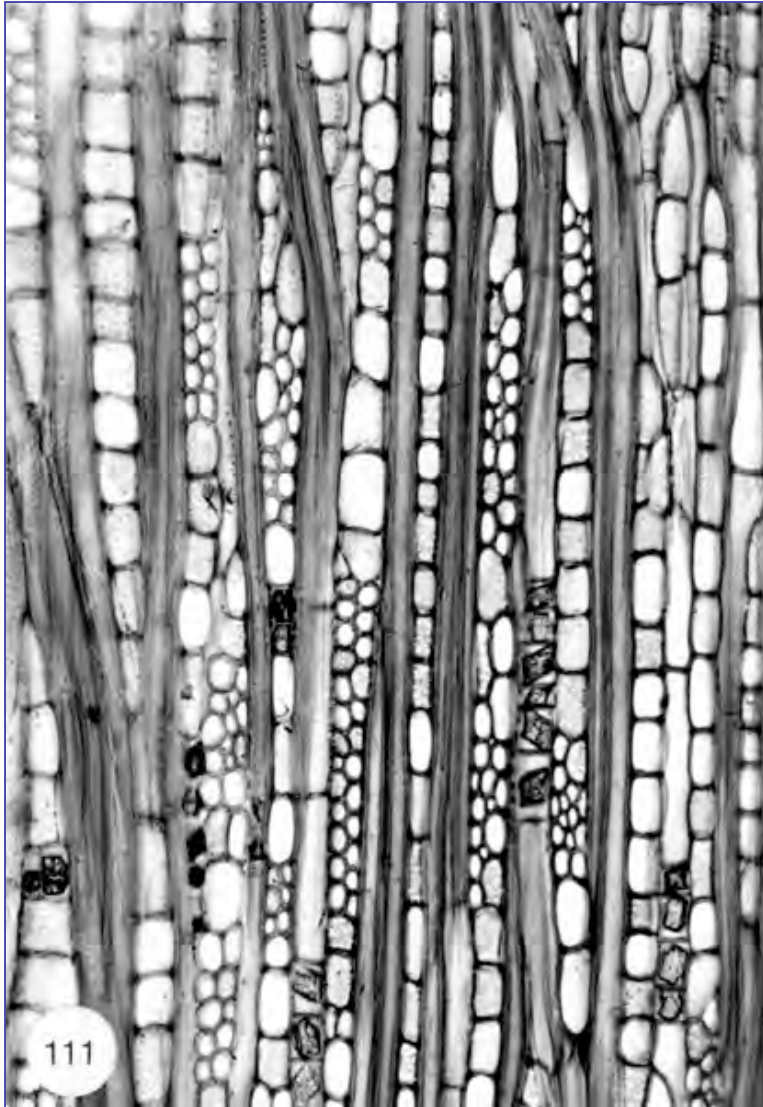


Cardwellia sublimis
E.A. Wheeler (Proteaceae)

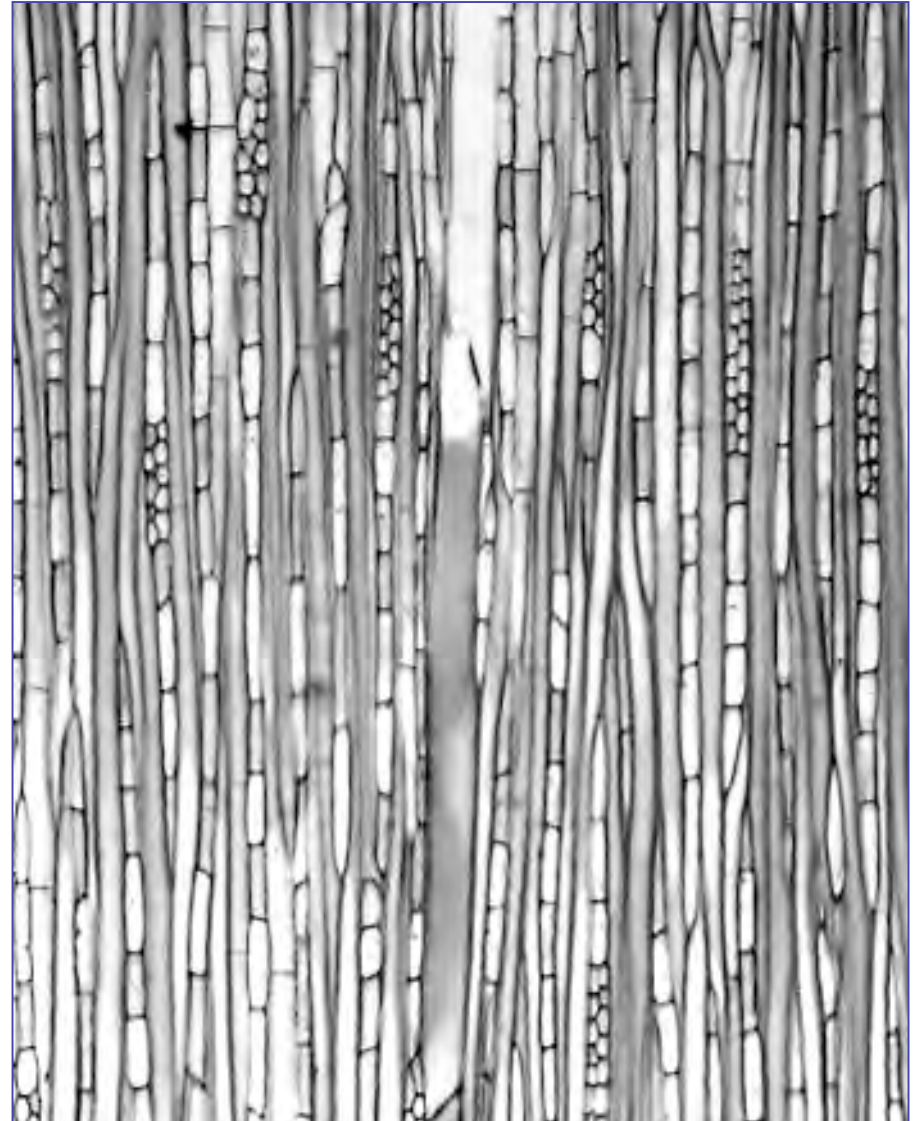


Agapetes saligna
F. Lens (Ericaceae)

Feature 100. Rays with multiseriate portion(s) as wide as uniseriate portions.

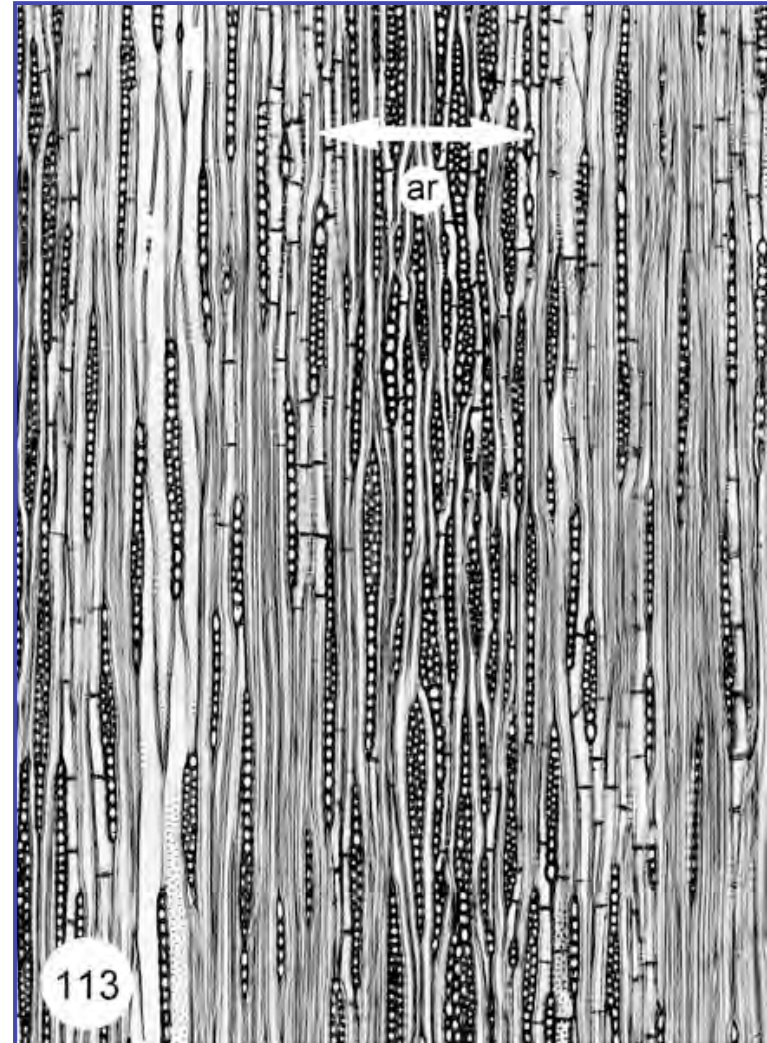
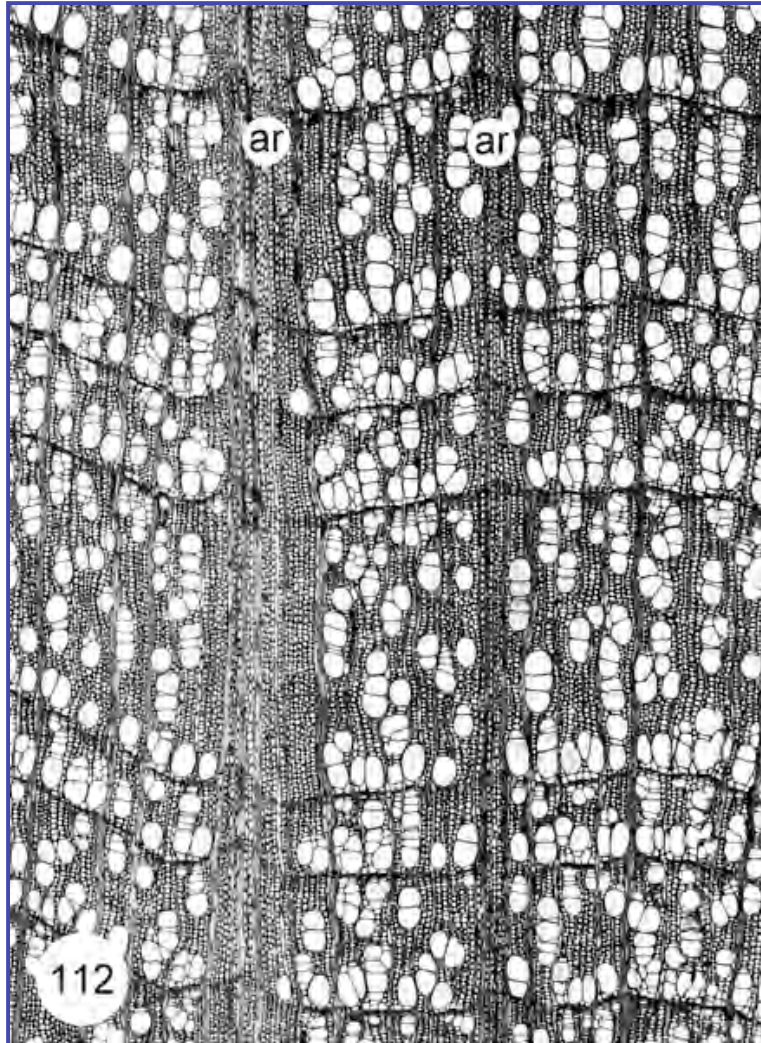


Caryocar costaricense. P.E. Gasson
(Caryocaraceae)



Ambelania acida. Els Bakker
(Apocynaceae)

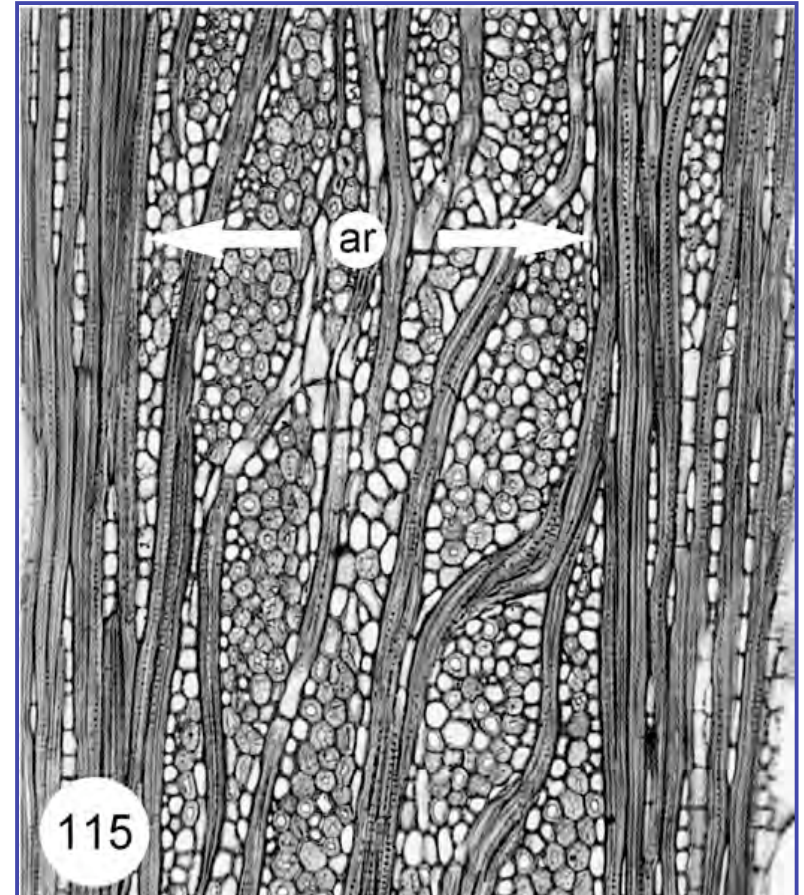
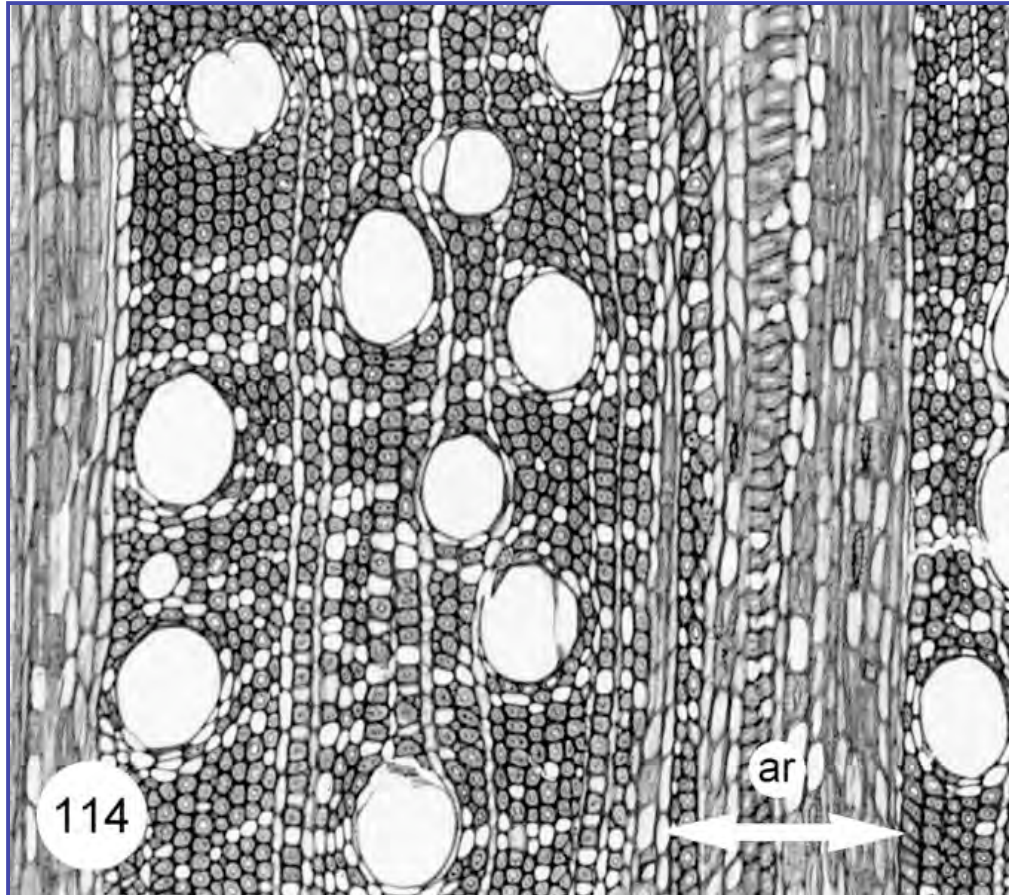
Feature 101. Aggregate ray = a number of individual rays so closely associated with one another that they appear macroscopically as a single large ray. The individual rays are separated by axial elements.



Carpinus betulus, aggregate rays (ar) composed of narrow rays. D. Grosser (Corylaceae)

AGGREGATE RAYS

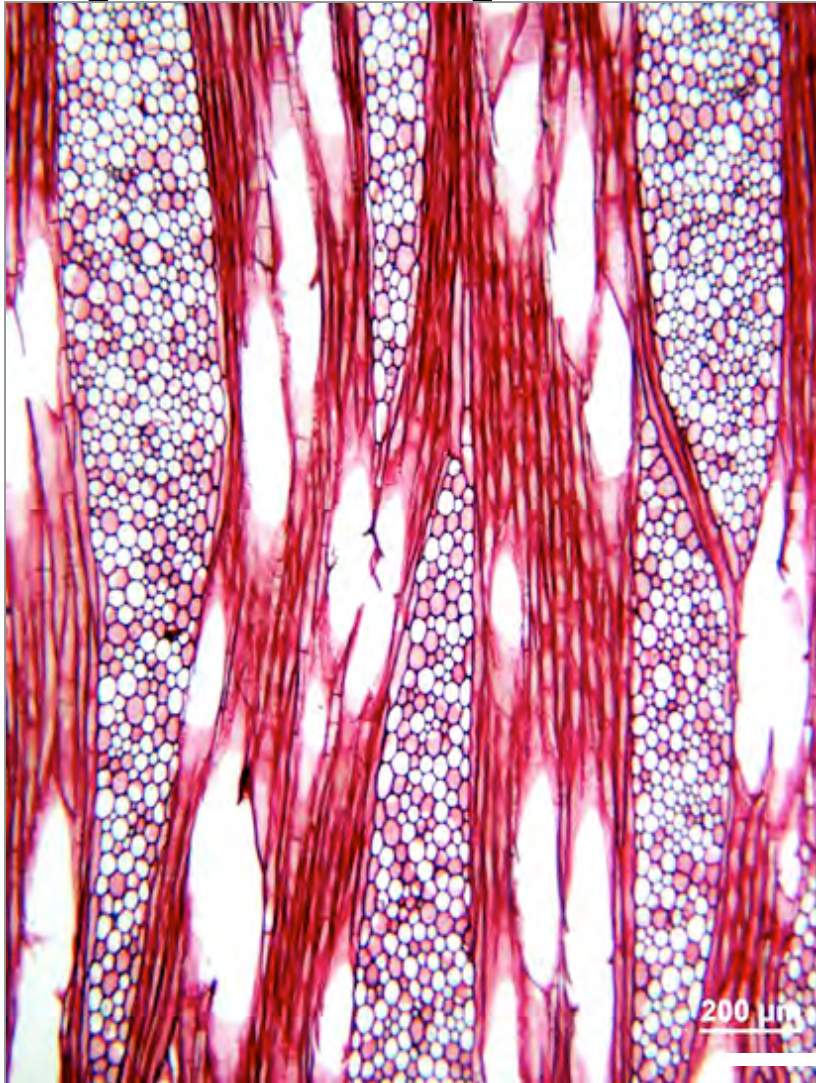
Feature 101. Aggregate ray



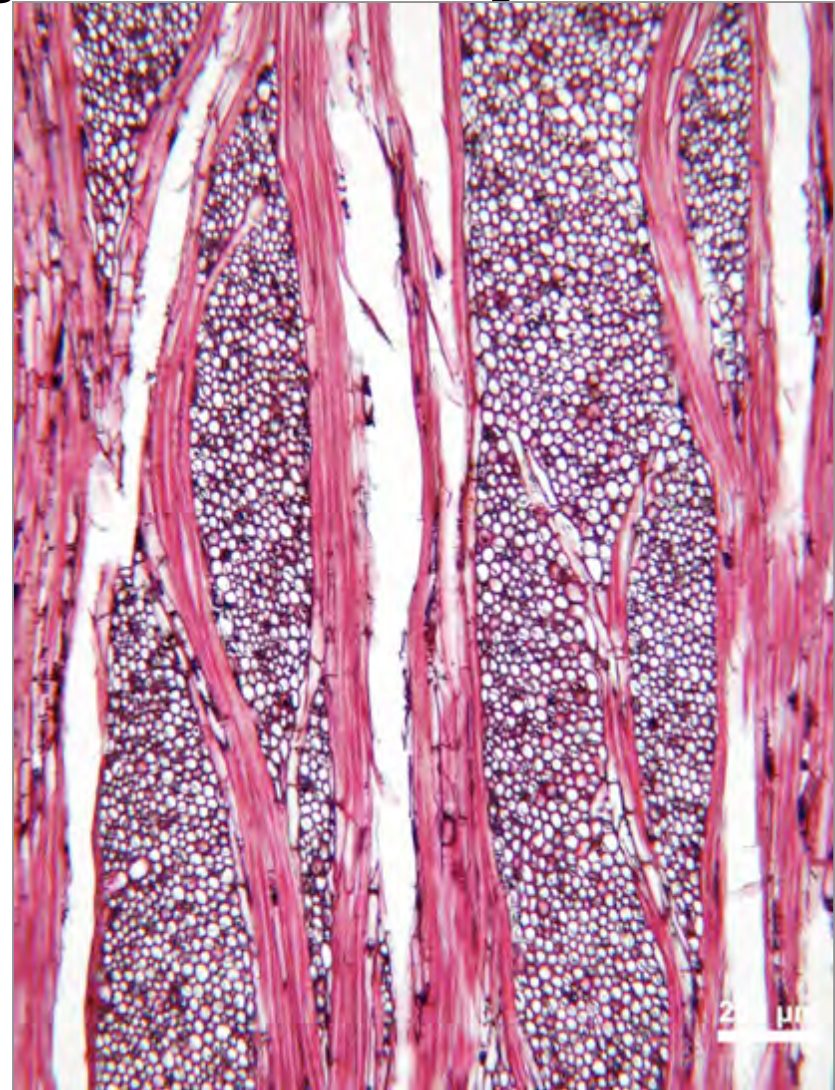
Emmotum orbiculatum, aggregate ray (ar) composed of multiseriate rays.
P.E. Gasson (Icacinaceae)

RAY HEIGHT

Feature 102. Ray height > 1 mm = the large rays commonly exceeding 1 mm in height.



Akania lucens. E.A. Wheeler (Akaniaceae)



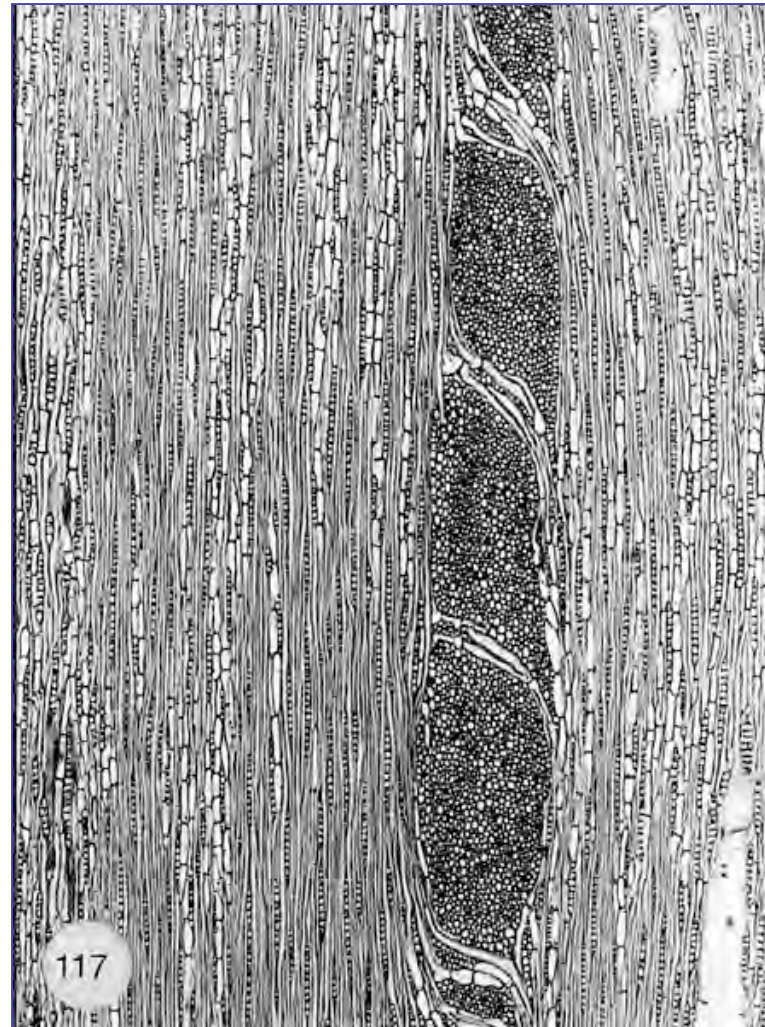
Platanus kerri. E.A. Wheeler (Platanaceae)

RAYs OF TWO DISTINCT SIZES

Feature 103. Rays of two distinct sizes = when viewed in **tangential** section, rays form two distinct populations by their width and usually also by their height.



Ternstroemia sp. P.E. Gasson
(Pentaphylacaceae)



Quercus gilva. K. Ogata (Fagaceae)

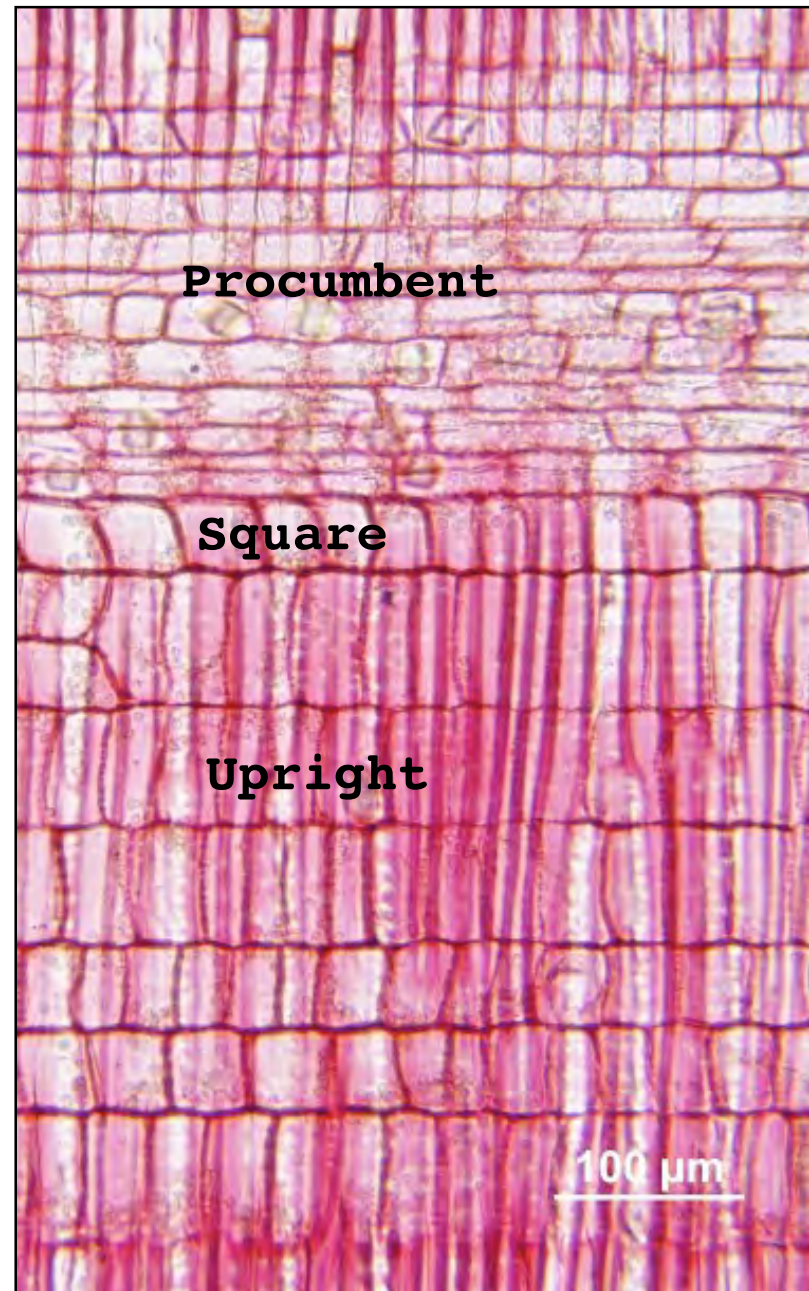
RAYs: CELLULAR COMPOSITION

Procumbent ray cell = a ray parenchyma cell with its longest dimension radial as seen in radial section.

Square ray cell = a ray parenchyma cell approximately square as seen in radial section.

Upright ray cell = a ray parenchyma cell with its longest dimension axial as seen in radial section.

Alangium villosum. (Alangiaceae)
E.A. Wheeler



RAYs: CELLULAR COMPOSITION

Procedure:

Use radial sections to determine the cellular composition of rays because types of ray cells are defined on the basis of their appearance in radial section.

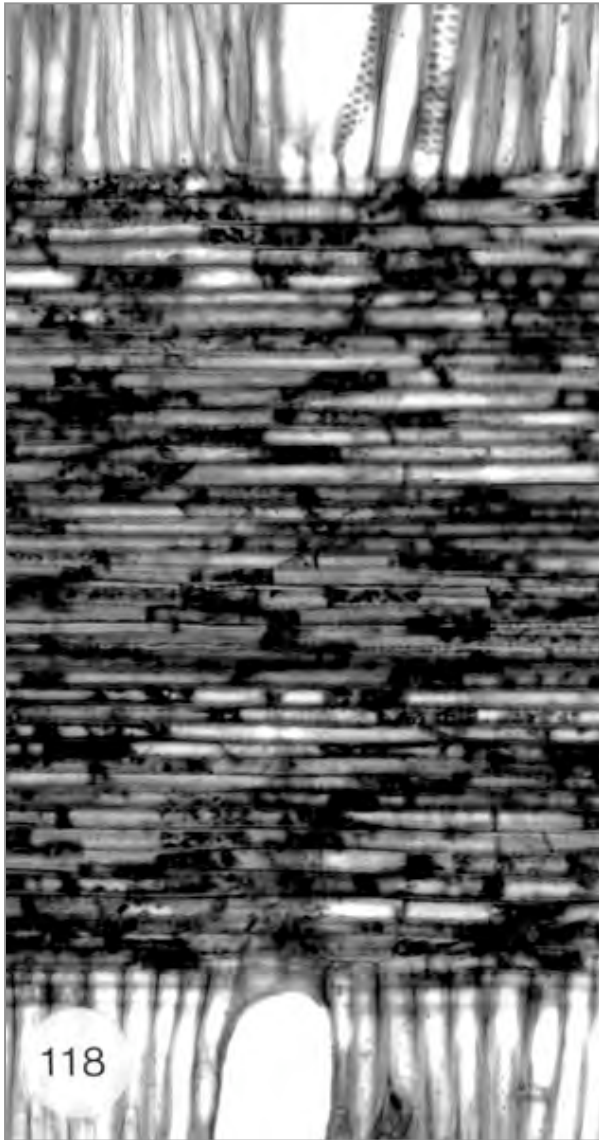
In woods with uniseriate and multiseriate rays -- **describe** the cellular composition of the **multiseriate rays**, not the uniseriate rays.

Comments:

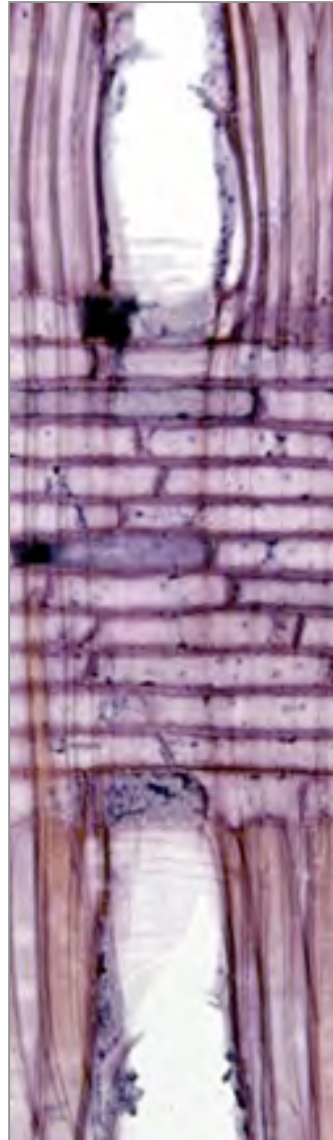
Some woods have more than one category of ray type with respect to cellular composition (e.g., features 104 and 106, 107 and 108).

The cellular composition of the multiseriate and uniseriate rays in the same wood is not necessarily the same.

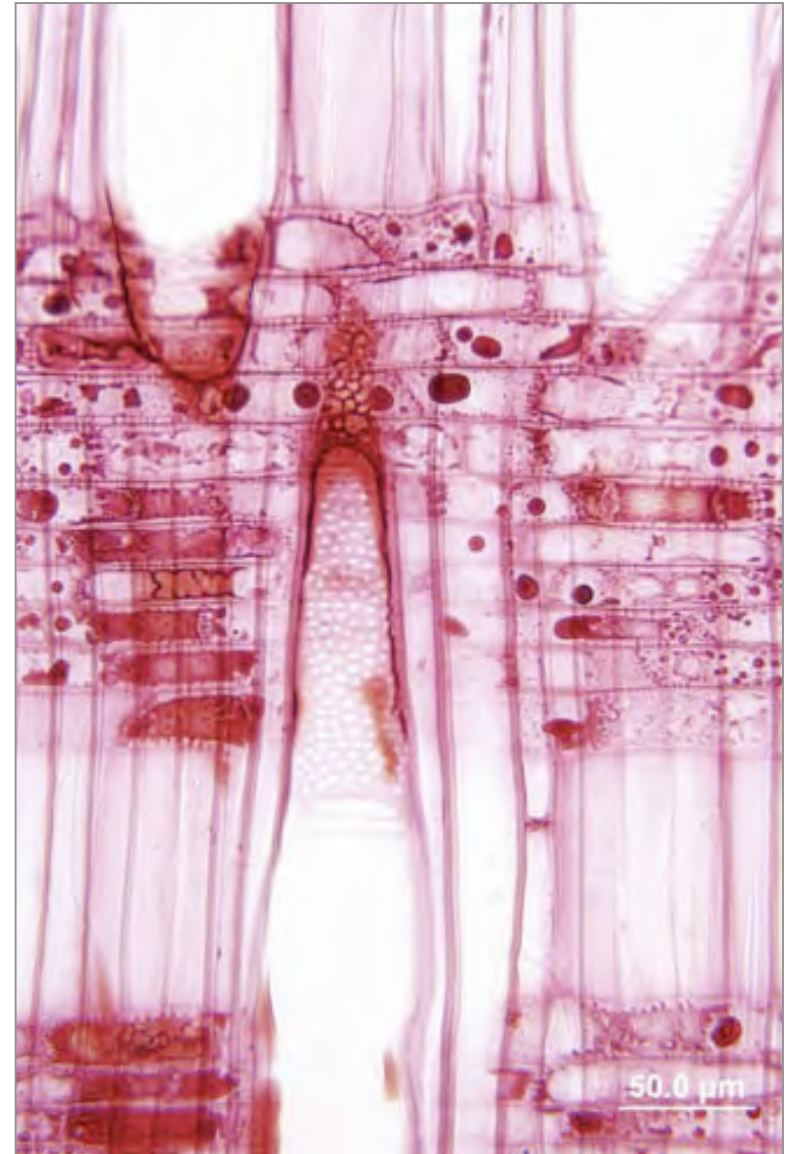
Feature 104. All ray cells procumbent



Acer campestre (Sapindaceae).
P.E. Gasson

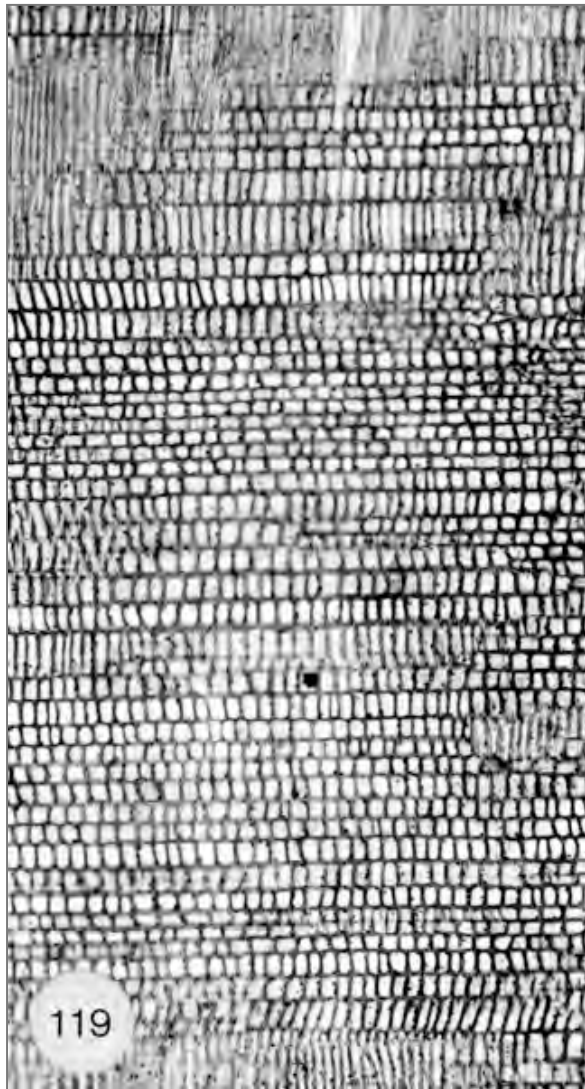


Aesculus turbinata
(Sapindaceae)
FFPRI, Tsukuba, Japan



Alnus tenuifolia (Betulaceae).
E.A. Wheeler

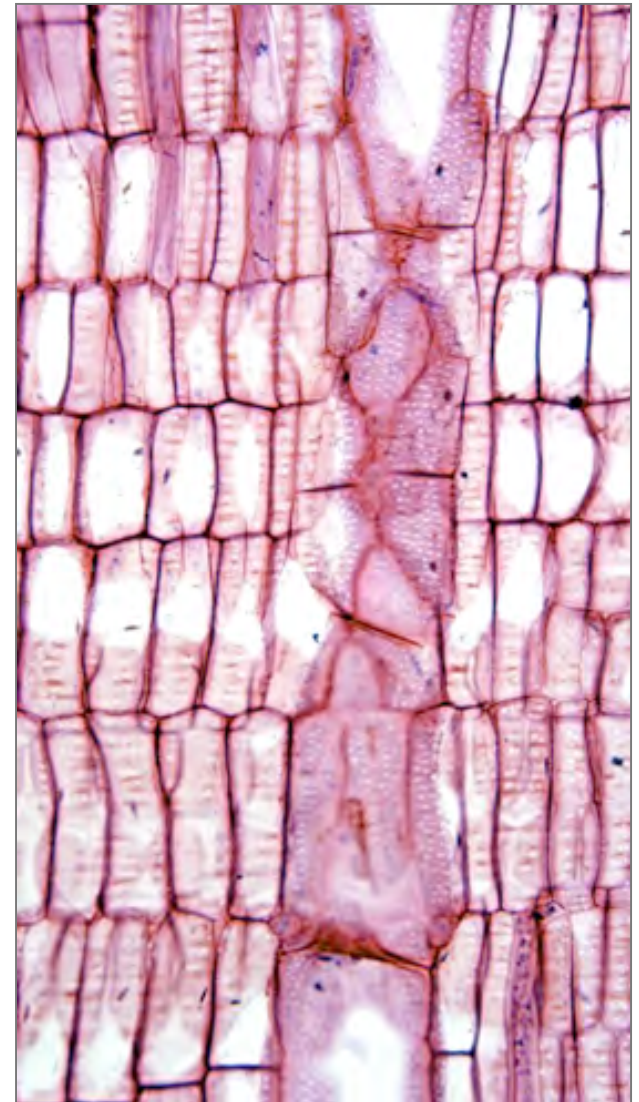
Feature 105. All ray cells upright and/or square



Aucuba japonica.
K. Ogata (Garryaceae)



Grammadenia parasitica.
F. Lens (Myrsinaceae)

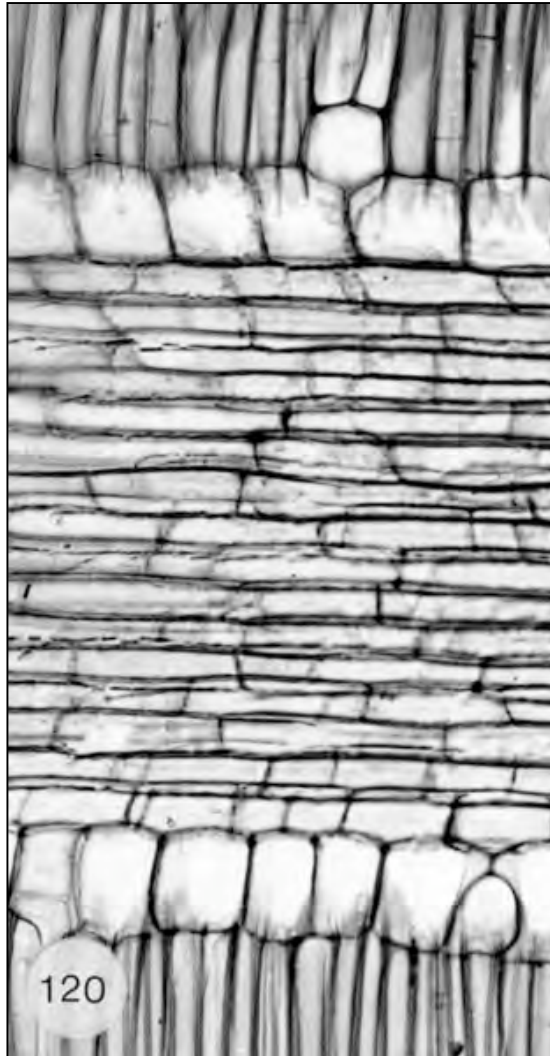


Scaevola sericea. FFPRI,
Tsukuba, Japan (Goodeniaceae)

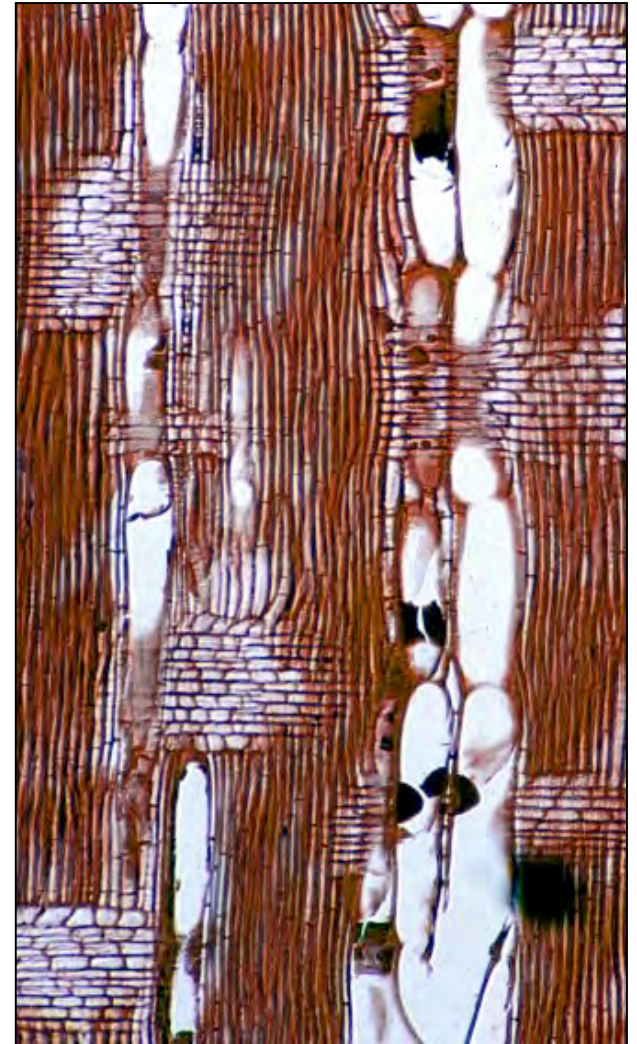
Feature 106. Body ray cells procumbent with one row of upright and/or square marginal cells



Melia azedarach (Meliaceae)
FFPRI, Tsukuba, Japan

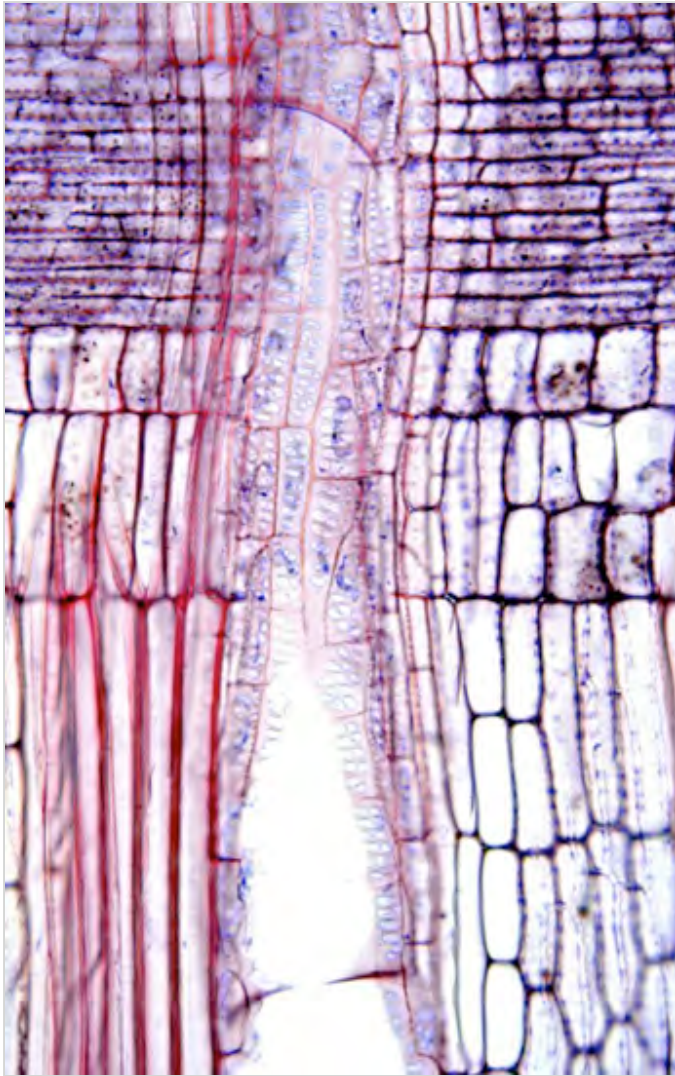


Pseudocedrela kotschyi.
(Meliaceae) P.E. Gasson



Exothea diphylla (Sapindaceae)
R. Klaassen

Feature 107. Body ray cells procumbent with mostly 2-4 rows of upright and/or square marginal cells



Ficus benguetensis
(Moraceae) FFPRI, Tsukuba,
Japan

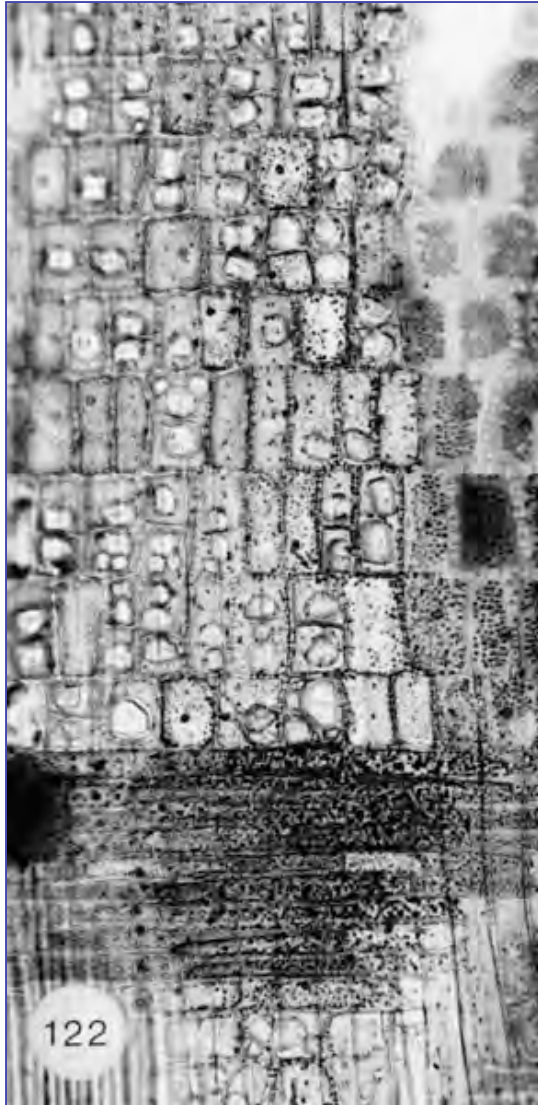


Carapa guianensis
(Meliaceae) E.A. Wheeler

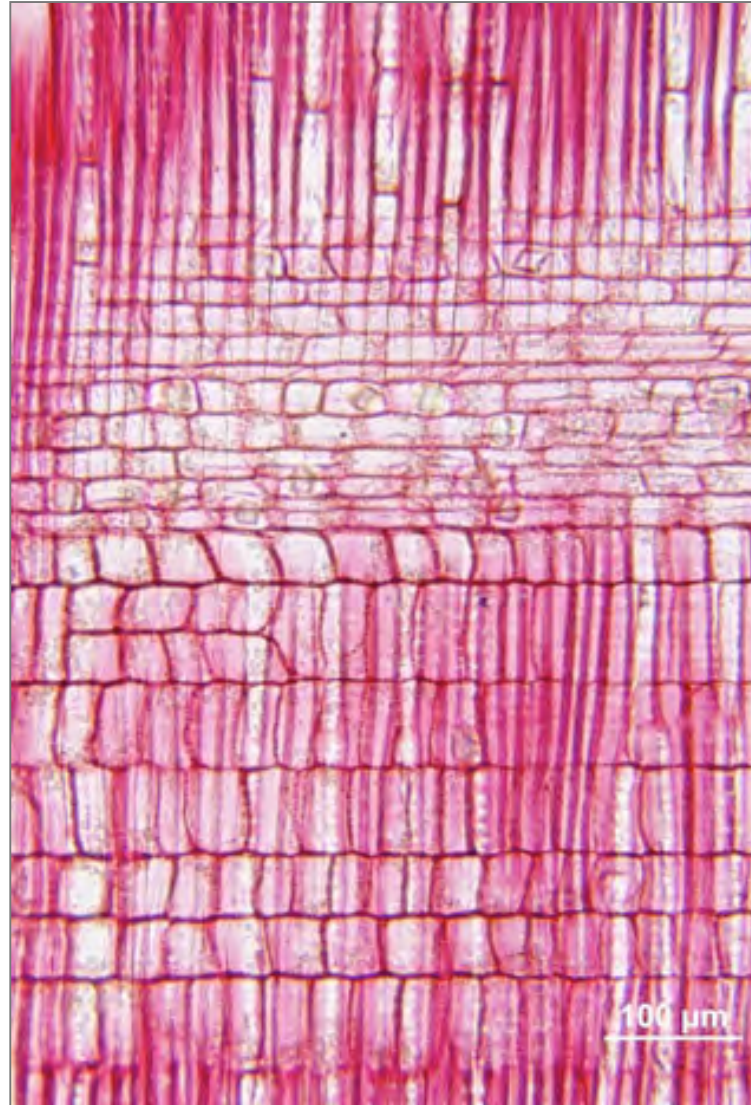


Diospyros maritima
(Ebenaceae) FFPRI, Tsukuba,
Japan

Feature 108. Body ray cells procumbent with over 4 rows of upright and/or square marginal cells

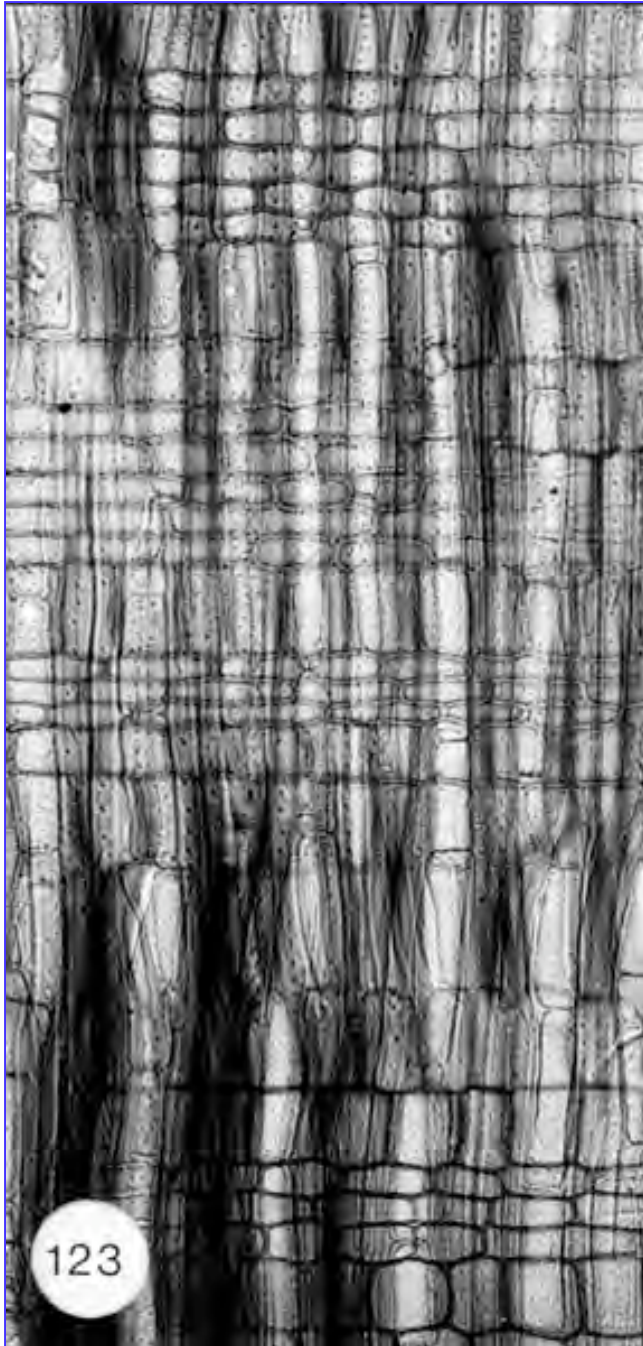


Homalium foetidum
(Salicaceae) P.E. Gasson



Alangium villosum (Alangiaceae) E.A. Wheeler



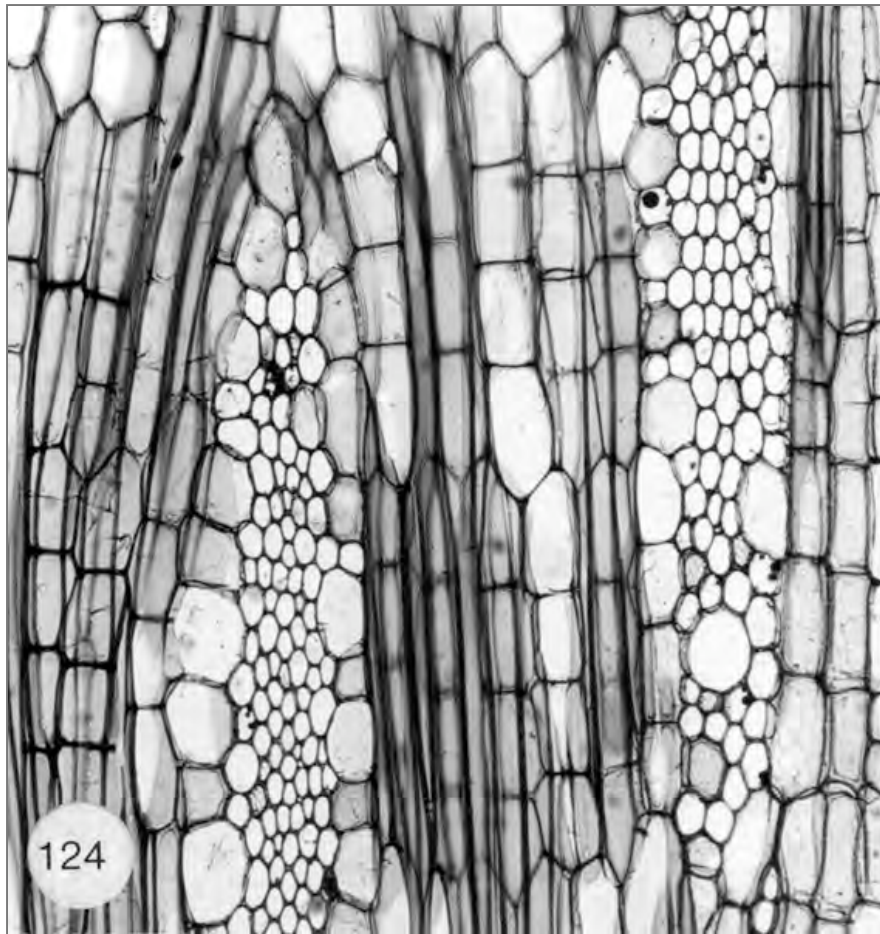


**Feature 109. Rays
with procumbent,
square and upright
cells mixed
throughout the ray.**

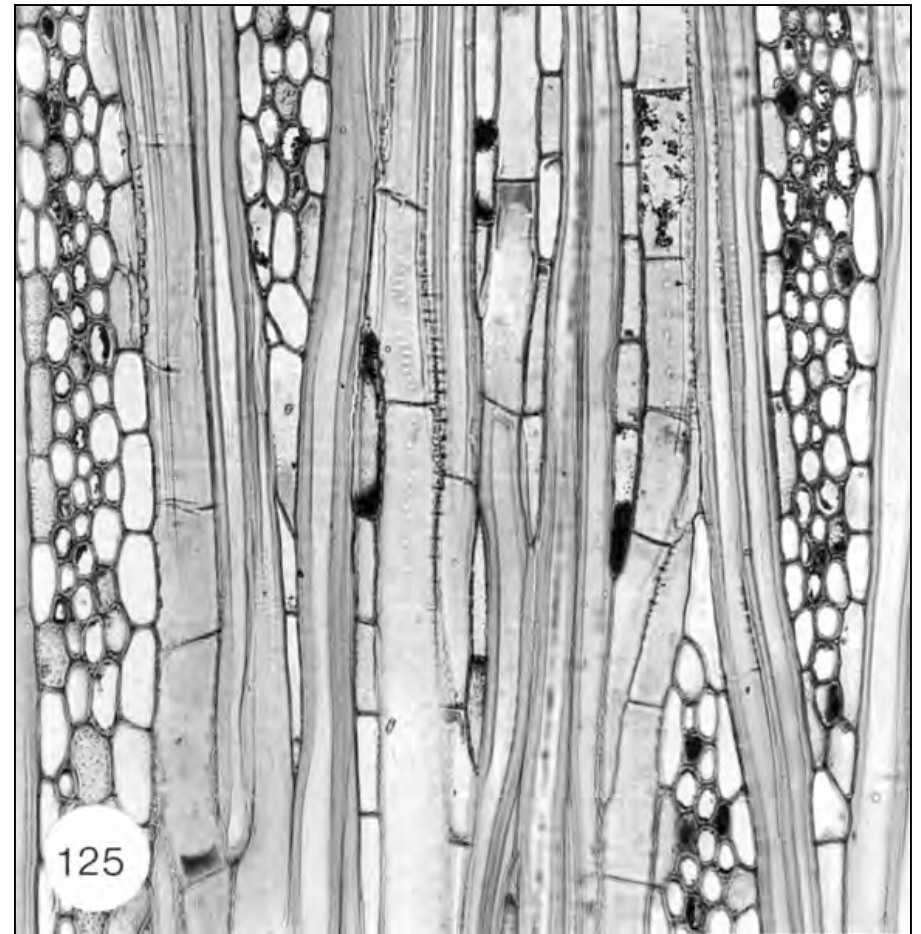
Xanthophyllum lanceatum (Polygalaceae).
Bridgwater & Baas 1982. IAWA Bull

SHEATH CELLS

Feature 110. Sheath cells = ray cells that are located along the sides of broad rays (>3-seriate) as viewed in tangential section and are larger (generally taller than broad) than the central ray cells.



Ceiba pentandra (Malvaceae / Bombacaceae)
K. Ogata



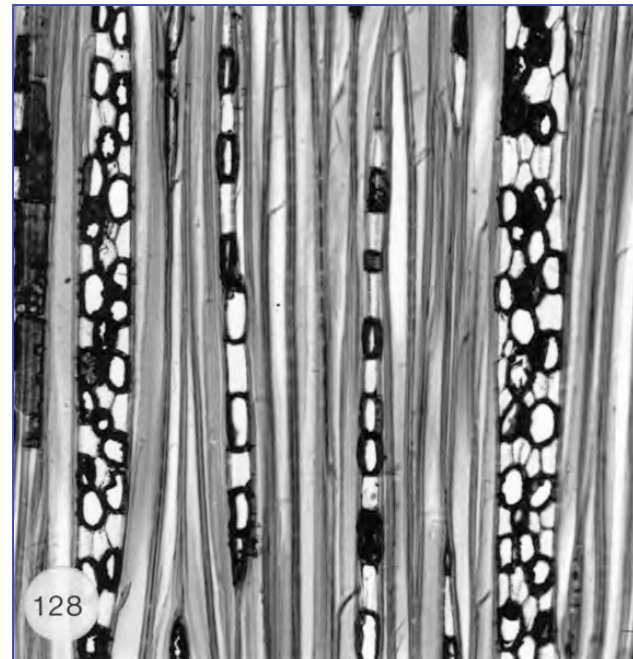
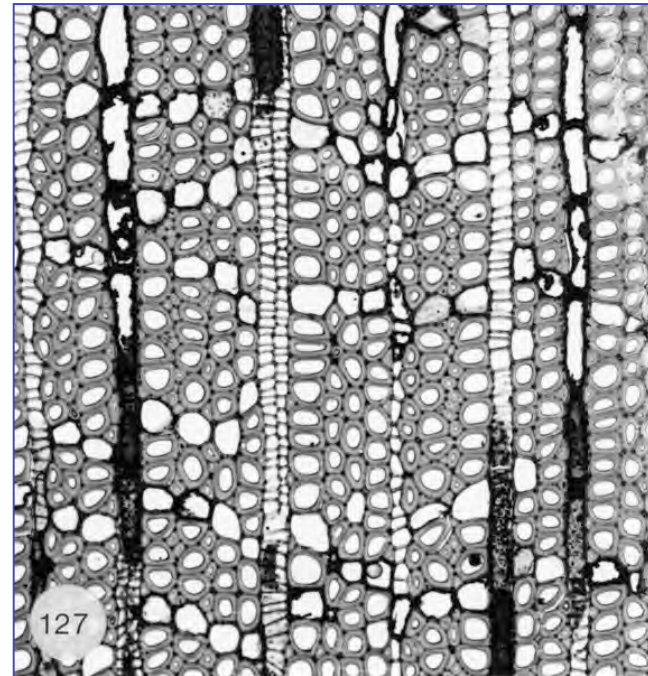
Stemonurus luzoniensis
(Stemonuraceae) K. Ogata

TILE CELLS

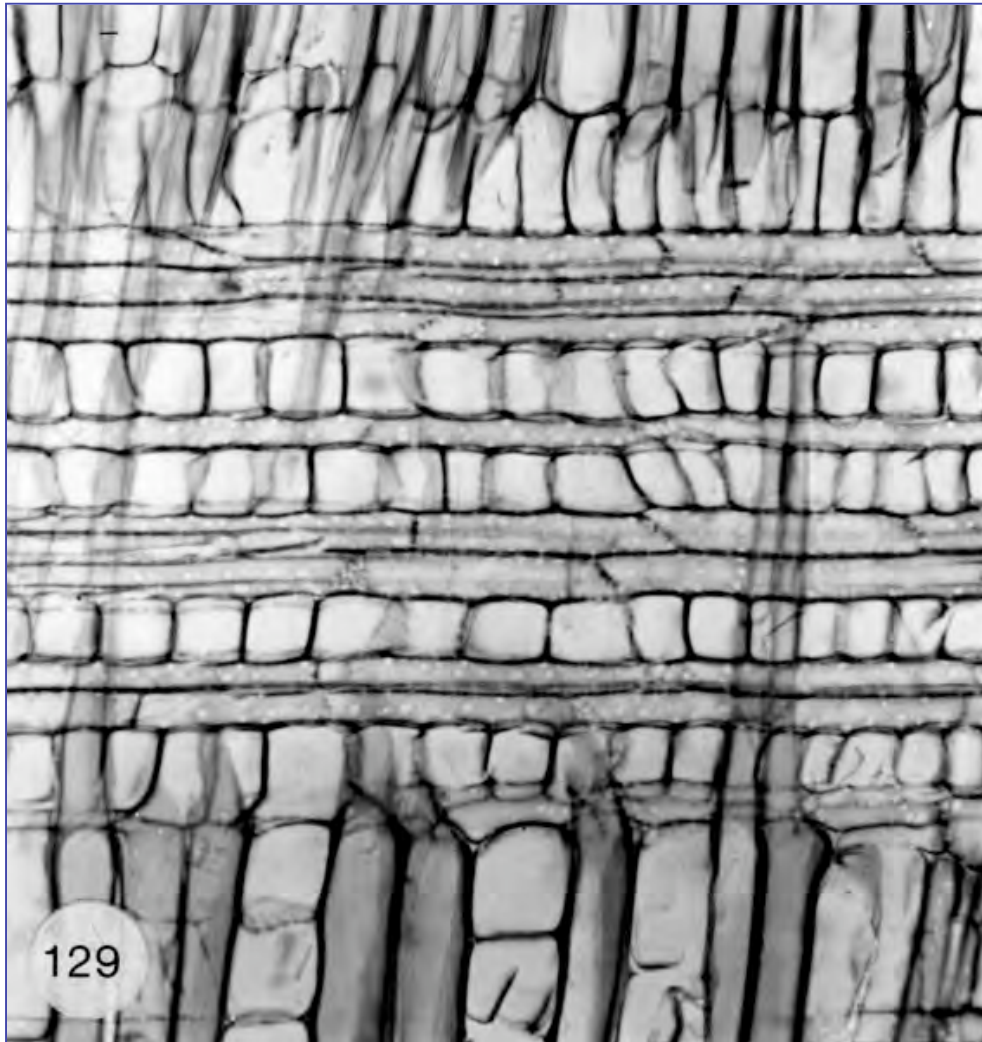
Feature 111. Tile cells = apparently empty upright (rarely square) ray cells occurring in intermediate horizontal series usually interspersed among the procumbent cells.



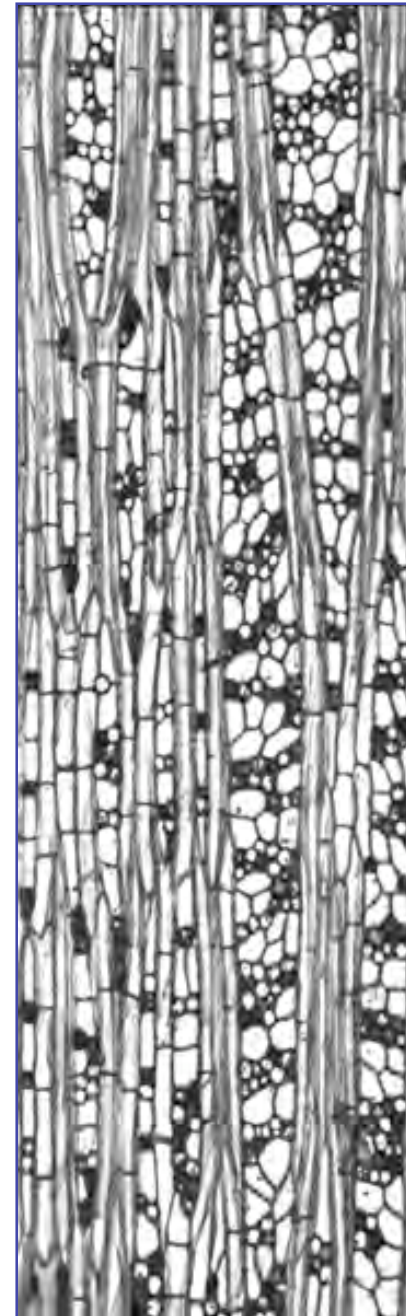
Neesia altissima (Malvaceae / Bombacaceae)
P.E. Gasson



Feature 111. Tile cells



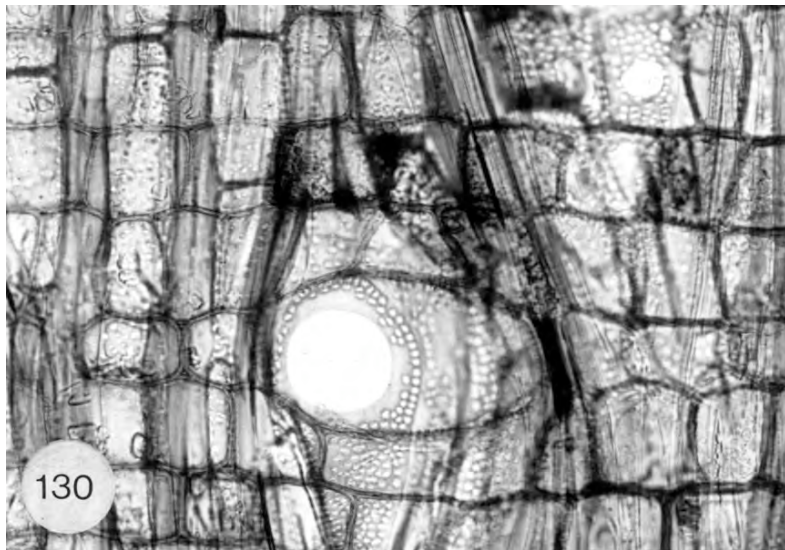
Pterospermum grewiaefolium (Malvaceae / Sterculiaceae)
P. Détienne



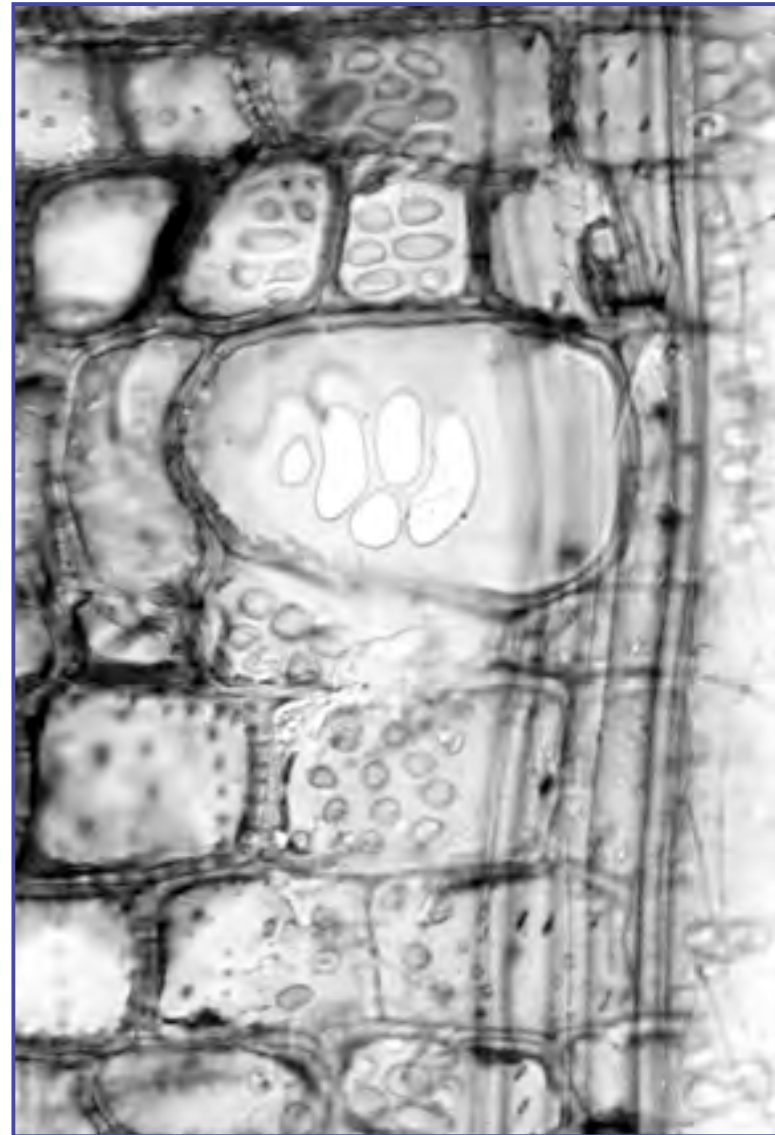
Pterospermum heterophyllum
S.M. Manchester

PERFORATED RAY CELLS

Feature 112. Perforated ray cells = ray cells of the same dimensions or larger than the adjacent cells, but with perforations, which generally are on the side walls connecting two vessels on either side of the ray.

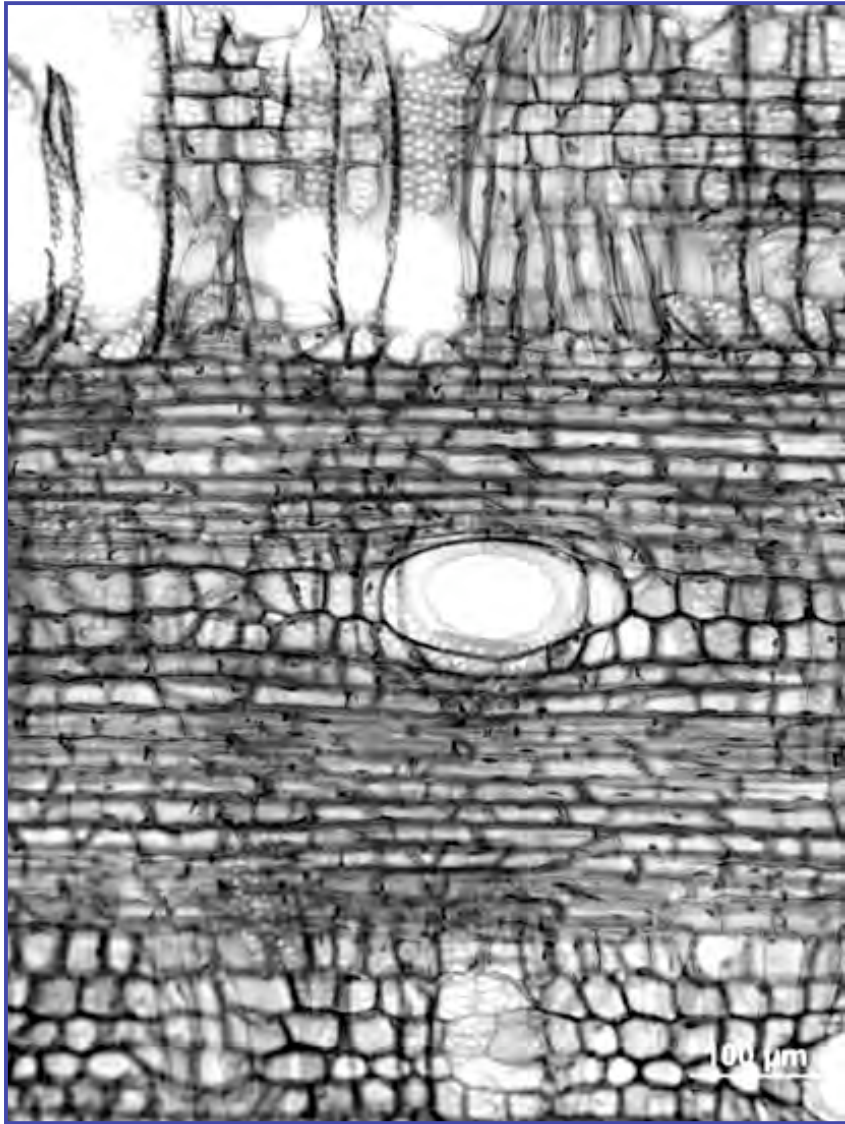


Chaunochiton breviflorum (Olacaceae)
Simple perforation in radial wall.
P.E. Gasson

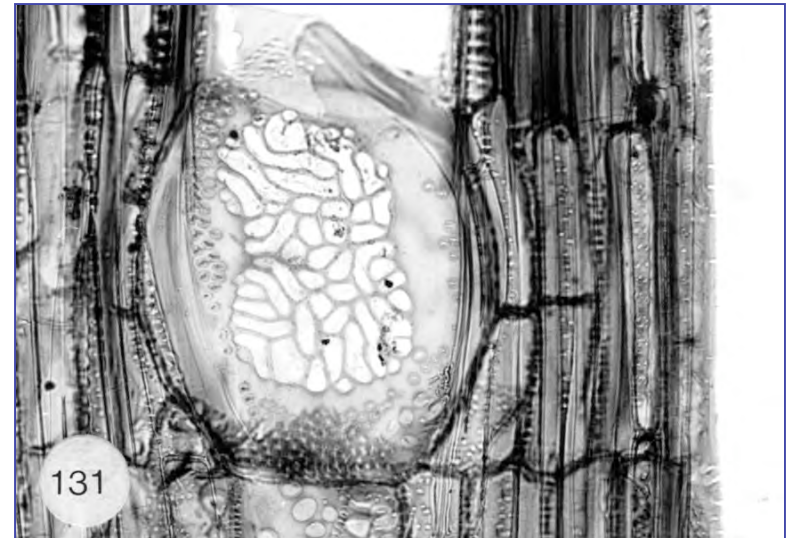


Carpotroche brasiliensis
(Achariaceae) Multiple perforation
in radial wall. R.B. Miller

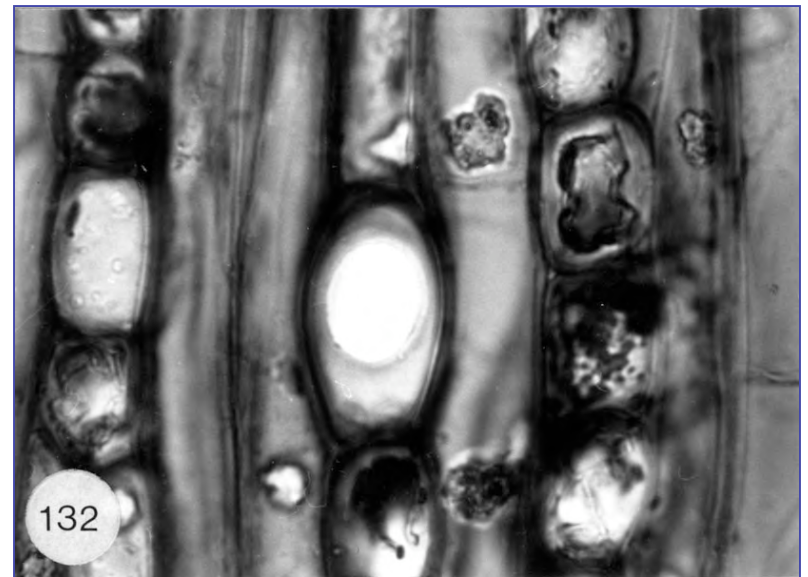
Feature 112. Perforated ray cells



Sambucus cerulea (Adoxaceae) Simple perforation in radial wall. E.A. Wheeler



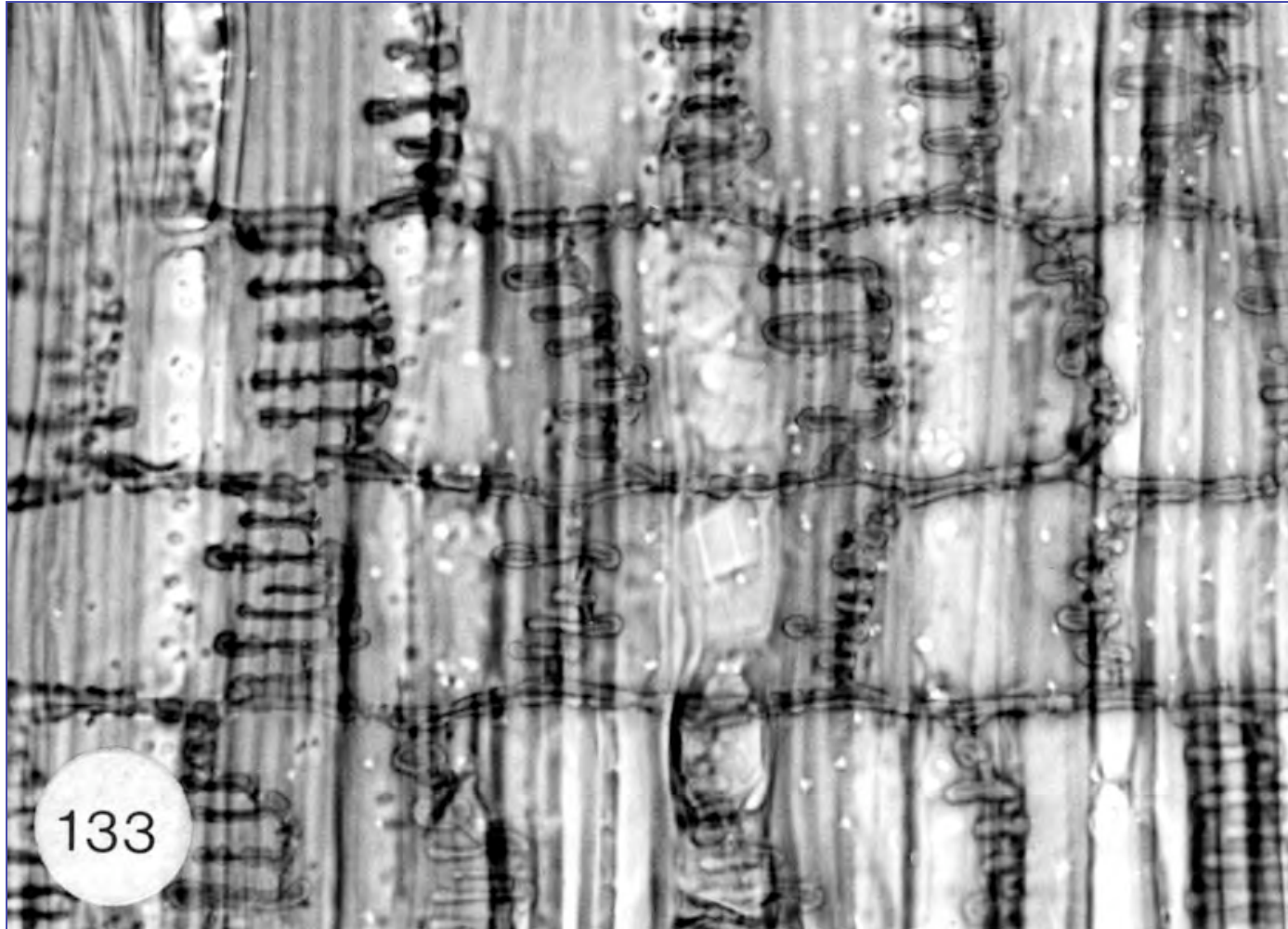
Richeria racemosa (Phyllanthaceae) Reticulate perforation in radial wall. P.E. Gasson



Combretum leptostachium (Combretaceae) Simple perforation in tangential wall. P.E. Gasson

DISJUNCTIVE RAY PARENCHYMA CELL WALLS

Feature 113. Disjunctive ray parenchyma cell walls = ray parenchyma cells partially disjoined but with contacts maintained through tubular or complex wall processes.



Malpighia incana (Malpighiaceae) P.E. Gasson

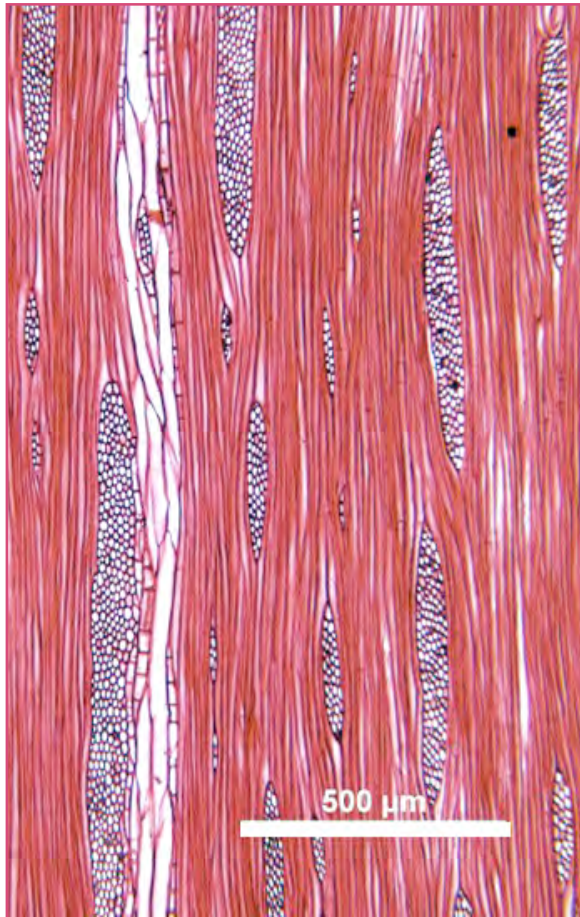
RAYs PER MILLIMETRE

114. $< 4 / \text{mm}$

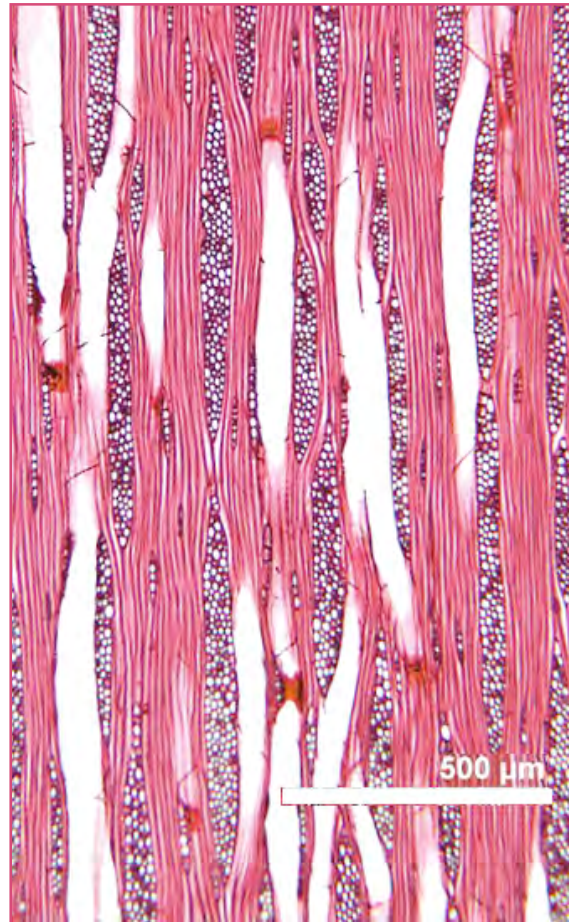
115. $4-12 / \text{mm}$

116. $> 12 / \text{mm}$

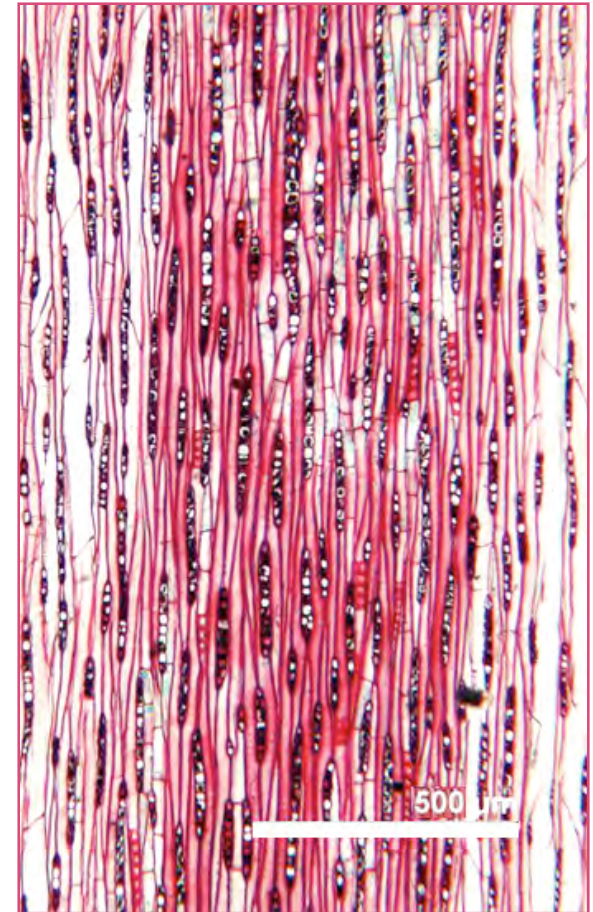
The number of rays per linear unit is best determined from a tangential section along a line perpendicular to the ray's axis; it can also be determined from a cross section.



Ailanthus altissima: E.A.Wheeler
(Simaroubaceae)



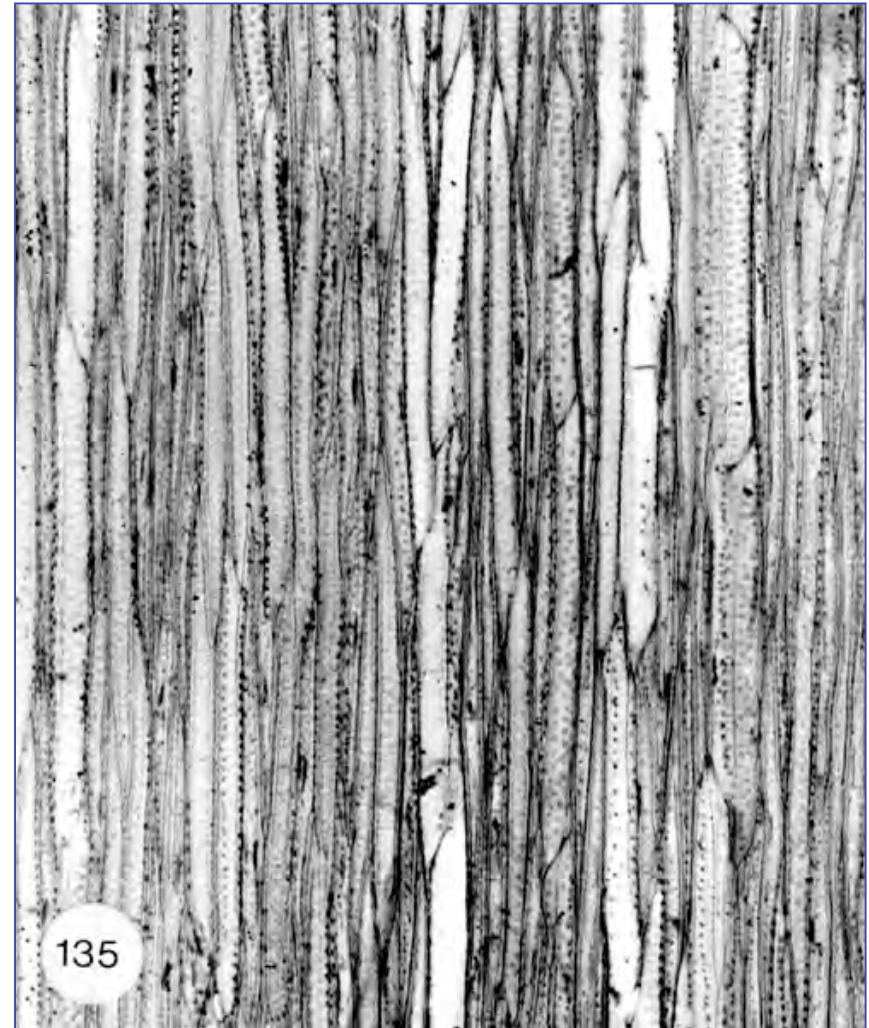
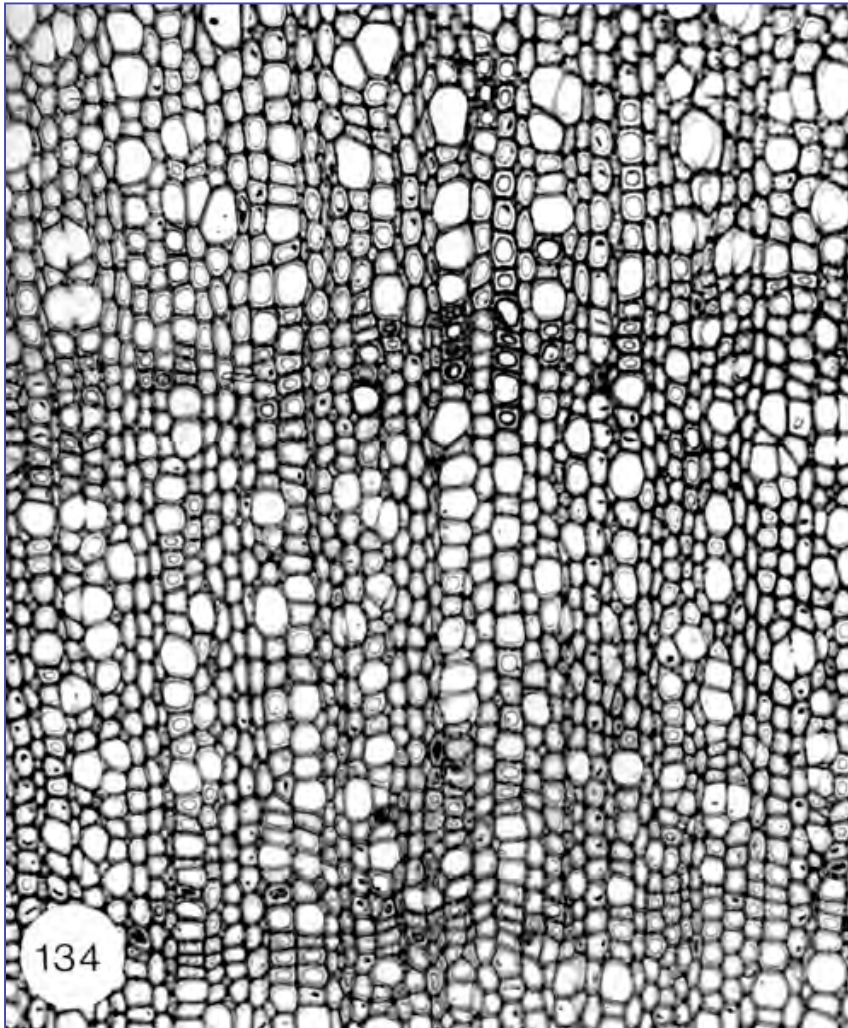
Prunus serotina: E.A.Wheeler
(Rosaceae)



Castanopsis sclerophylla
E.A.Wheeler (Fagaceae)

WOOD RAYLESS

Feature 117. Wood rayless = wood with only axial elements.



Veronica traversii (Plantaginaceae) P.E. Gasson

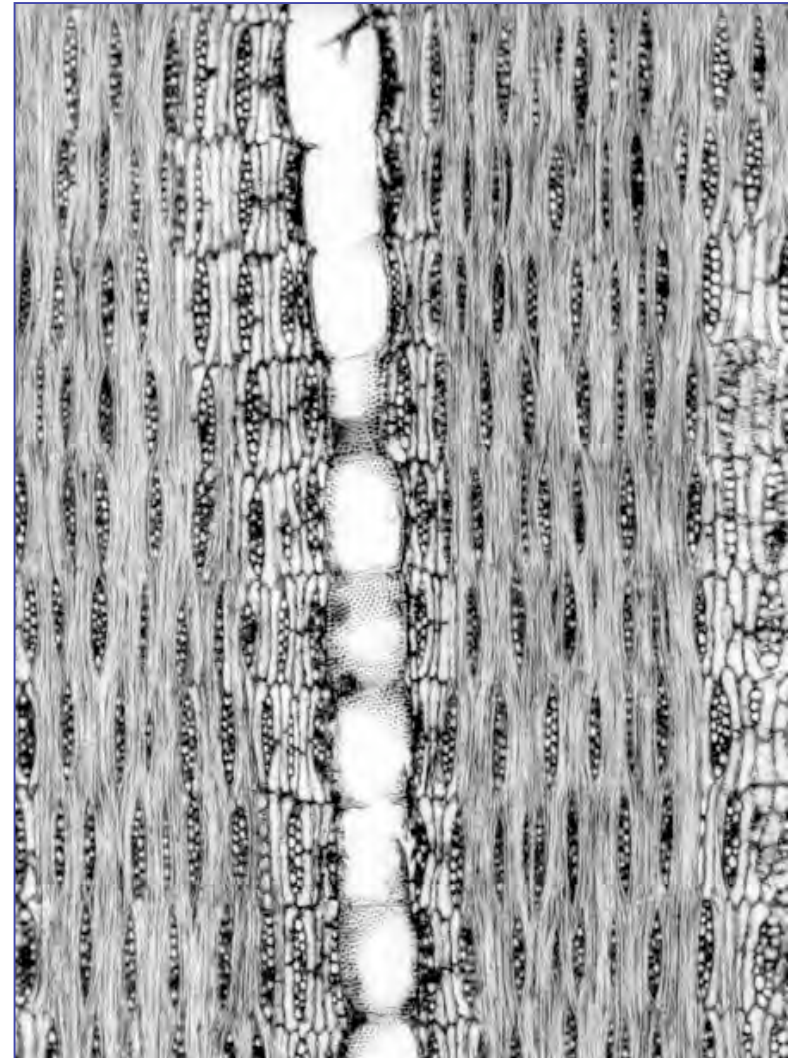
STORIED STRUCTURE = cells arranged in tiers
(horizontal series as viewed on the **tangential** surface).

Feature 118. All rays storied.



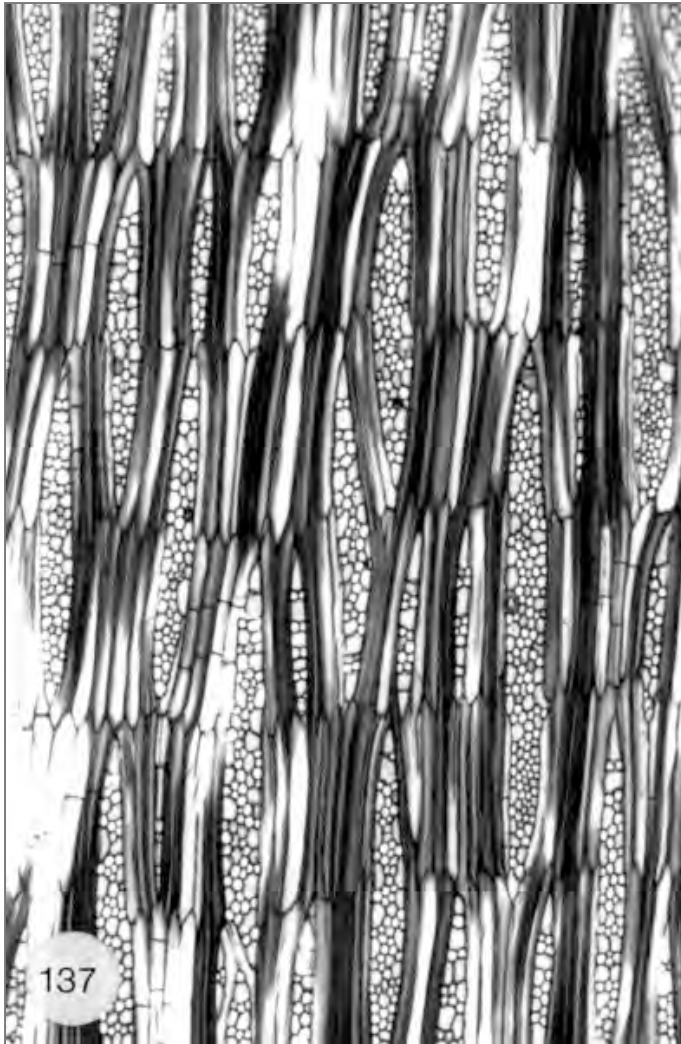
Tiers of rays visible with hand lens

Pterogyne nitens: L.Y.T. Westra
(Leguminosae - Caesalpinoideae)

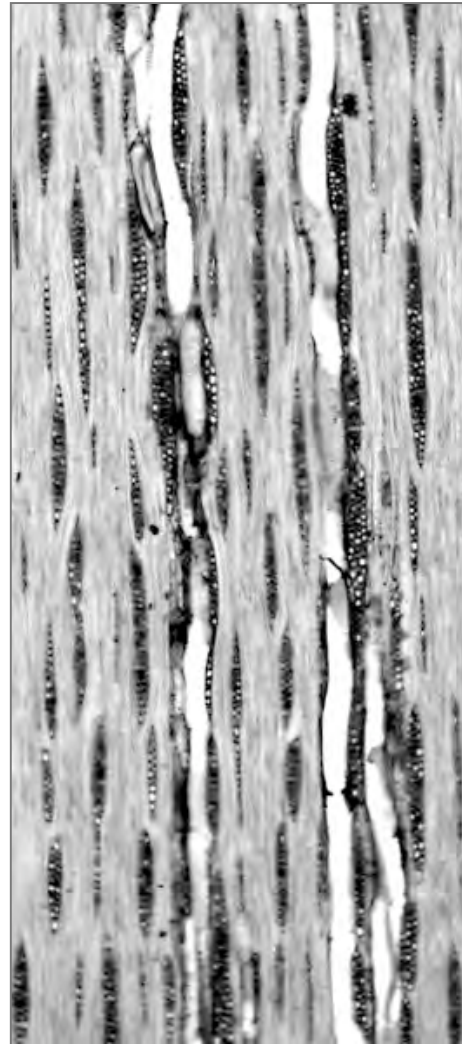


Bergeronia sericea: P.E. Gasson
(Leguminosae - Papilionoideae)

Feature 119. Low rays storied, high rays nonstoried.



Triplochiton sp. P.E. Gasson
(Malvaceae / Sterculiaceae)

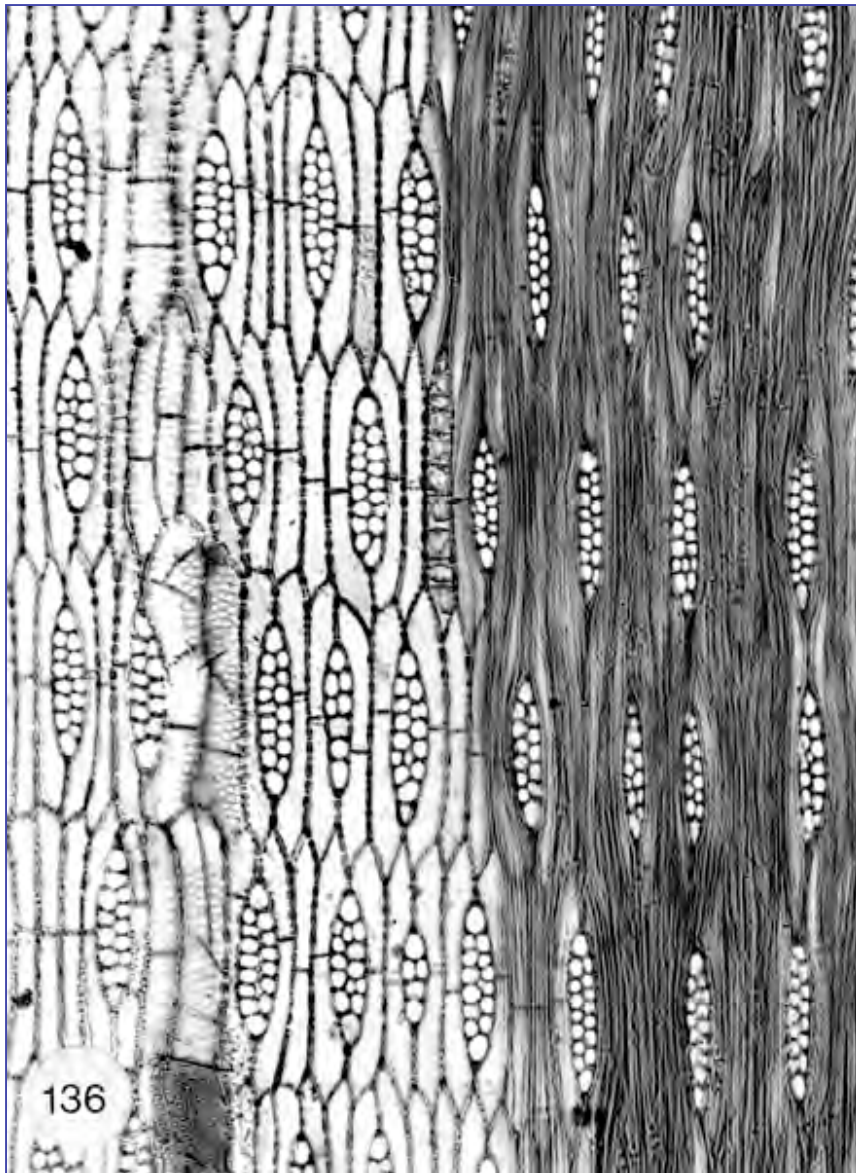


Cercis canadensis
P.E. Gasson
Leguminosae - Caesalpinioideae

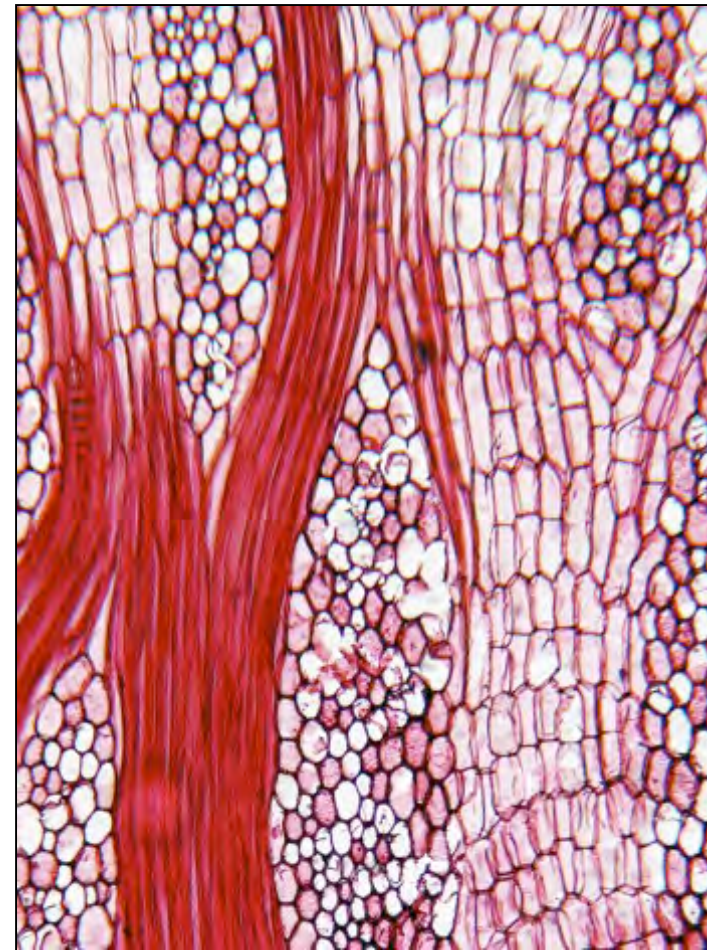


Cercis siliquastrum
A.P.M. Mennega

**Feature 120. Axial
parenchyma and/or
vessel elements
storied.**

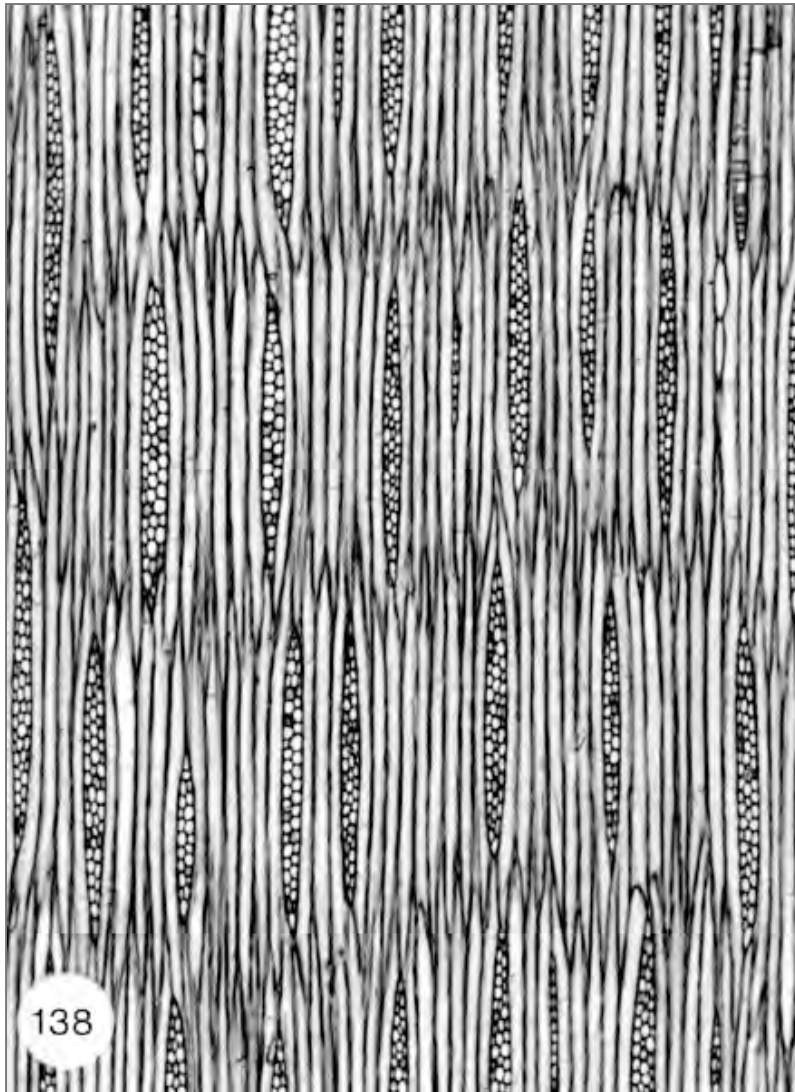


Dalbergia bariensis. K. Ogata. Note: All rays storied also present (Leguminosae - Papilionoideae)

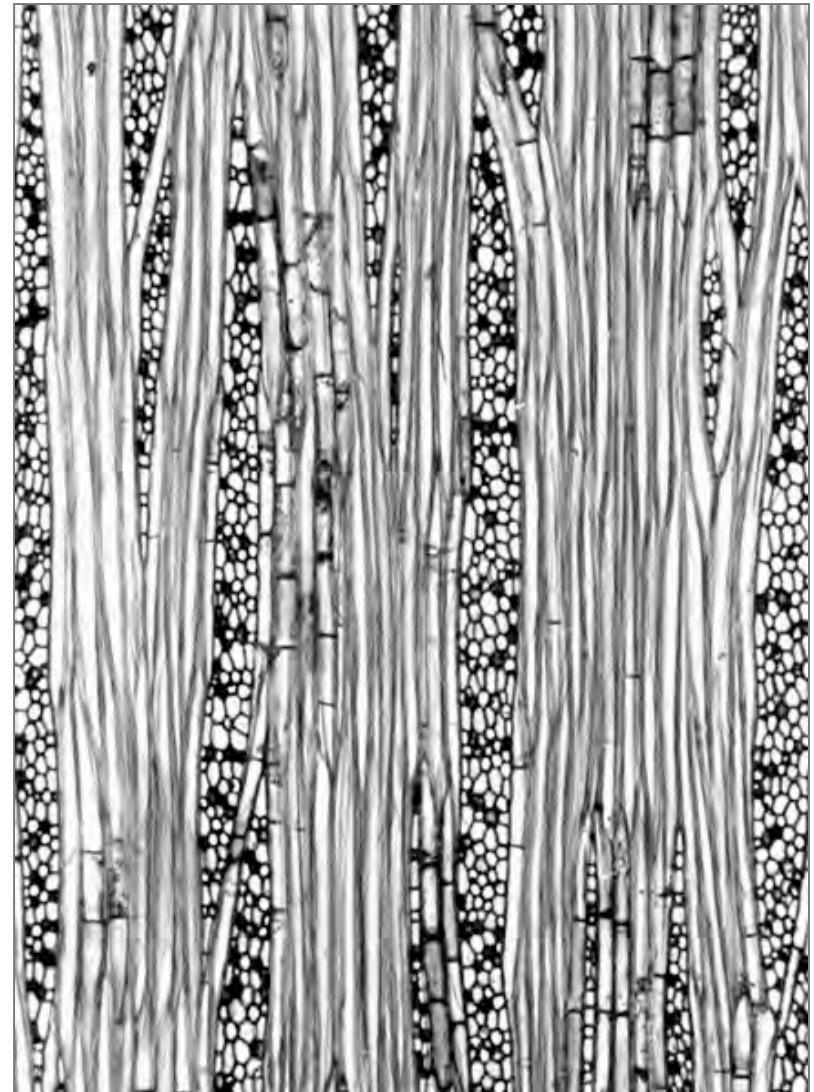


Erythrina herbacea. E.A. Wheeler
(Leguminosae - Papilionoideae)

Feature 121. Fibres storied

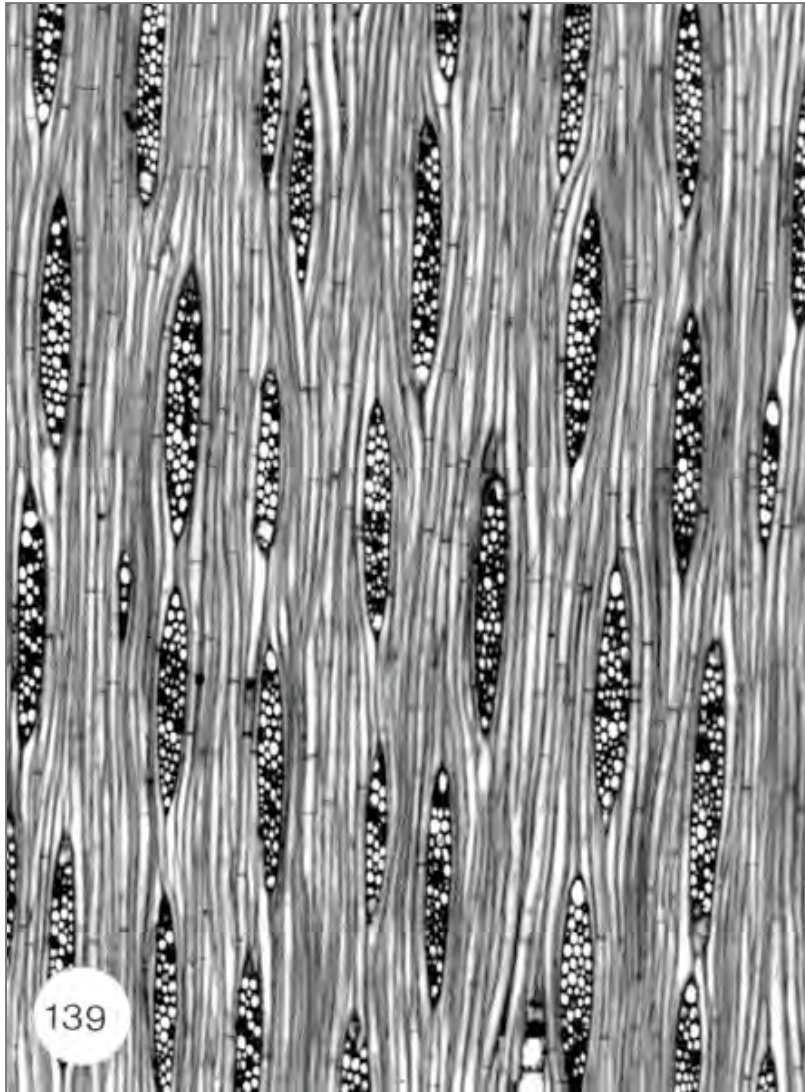


Quassia amara. P.E. Gasson
(Simaroubaceae)
Note: All rays storied also present

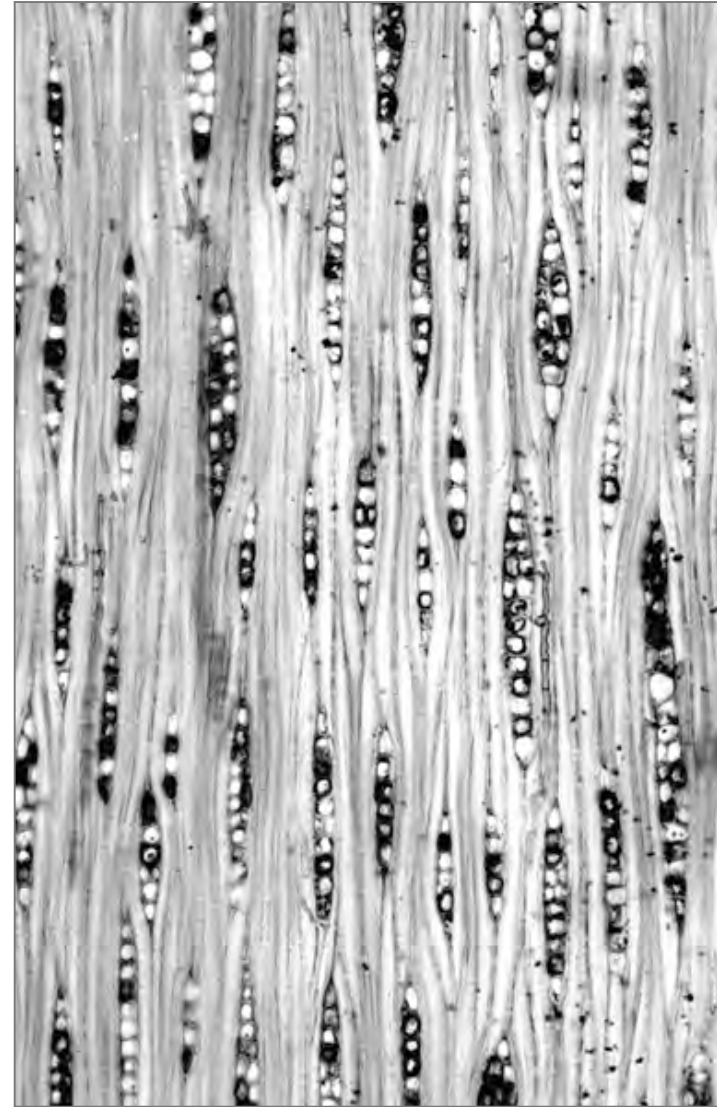


Guazuma crinita. S.M. Manchester
(Malvaceae / Sterculiaceae)

**Feature 122. Rays and/or axial elements
irregularly storied.**



Entandrophragma cylindrium. P.E. Gasson
(Meliaceae)



Brachystegia spiciformis. P.E. Gasson
(Leguminosae - Caesalpinioideae)