THE OCCURRENCE OF INTERCELLULAR CANALS IN THE WOOD OF SOME SPECIES OF *FLINDERSIA.*

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(With Plate IX and four text figures.)

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The genus *Flindersia,* which yields some of the most valuable timbers Australia possesses, was placed provisionally in the Natural Order *Meliacæ* by Bentham and Hooker,[1] Engler and Gilg[2] place it in the Family *Rutaceæ,* though Hutchinson[3] still leaves it in the Family *Meliaceæ.* It apparently occupies a midway position between these two families, differing chiefly from the *Meliaceæ* in possessing pellucid, dotted leaves, a characteristic of the *Rutaceæ.*

According to White,[4] of the eighteen species known only three are found outside Australia, and six occur in New South Wales as well as in Queensland.

As pointed out by Record,[5] intercellular canals or secretory passages may be divided into two main classes, namely, longitudinal and radial, and the longitudinal class may again be subdivided into normal and pathological canals or passages. The common Philippine Maple or Borneo

[1]Bentham and Hooker, Genera Plantarum, i, 340, 1862-1867.

[2]Engler and Gilg, Syllabus der Pflanzenfamilien, p. 248, 1924.

[3]Hutchinson, J. The Families of Flowering Plants, i, 251, 1926.

[4]White, C. J. Notes on the genus Flindersia. Proc. Linn. Soc. N.S.W., xlvi, 324, 1921.

[5]Record, S. J. The Occurrence of Intercellular Canals in Dicotyledonous Woods, Tropical Woods, No. 4, p. 17, 1925.

Cedar, *Shorea* spp., belonging to the Family *Dipterocarpaceæ*, are examples of the normal type, the white lines seen on end section being due to the presence of well-developed resin passages. The second or pathological type usually results from the breaking-down of the wood structure, i.e., gummosis. Record also points out that, although "they provide a valuable diagnostic feature, but inasmuch as their presence is accidental, little or no significance can be attached to their absence in a given specimen.

Groom[6] has described in detail the occurrence of excretory glands in the secondary xylem of *Lovoa Klaineana* and in the erect pneumatophores of *Carapa moluccensis* var. *gangetica*.

Record[7] describes vertical canals (gummosis type) as occurring in the following genera belonging to the *Rutaceæ*: *Xanthoxylum, Esenbeckia, Balfourodendron, Euxylophora*, and in "Tropical Woods," l.c., adds the genus *Citrus*.

Solereder[8] mentions that mucilage cavities occur in the wood of *Evodia rutaecarpa* by the disorganisation of wood cells, and are arranged in concentric circles. Solereder does not mention the occurrence of secretory cavities in the wood of *Flindersia*.

Material was examined of *Flindersia acuminata*, White; *F. australis*, R.Br.; *F. Bennettiana*, F.v.M.; *F. Brayleyana*, F.v.M.; *F. Bourjotiana*, F.v.M.; *F. Ifflaiana*, F.v.M.; *F. laevicarpa*, White and Francis; *F. maculosa*, F.v.M.; *F. Oxleyana*, F.v.M.; *F. pubescens*, Bailey; *F. Schottiana*, F.v.M.

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[6]Groom, P. Excretory Systems in the Secondary Xylem of Meliaceæ. Ann. Botany, xl, 631, 1926.

[7]Record, S. J. Further Notes on Intercellular Canals in Dicotyledonous Woods. Jour. of Forestry, xix, 7, 1921.

[8]Solereder, H. Systematic Anatomy of the Dicotyledons, p. 181, Oxford, 1908.

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Intercellular passages were observed in *F. Bennettiana, F. Brayleyana, F. Oxleyana, F. Pimenteliana,* though it is very probable that an examination of further material would result in their being found in some of the other species; at any rate, in those in which metatracheal parenchyma is strongly developed.

These intercellular canals occur most commonly in the wood of *Flindersia Brayleyana,* known on the Sydney market as Queensland Maple. The timber is used very extensively in the cabinet trade for furniture and for office and shop fittings, three-ply, veneers, etc. The wood is diffuse porous, without prominent growth rings, and with irregularly spaced metatracheal parenchyma rings which vary from one to 40 cells or more in width. At times these parenchyma zones are so wide and crowded that they make up more than half of the volume of the wood and are easily visible with the naked eye, but this condition usually only obtains for a few centimetres radially. Frequently the lines of "soft tissue" are not visible without a lens, but even when easily visible are usually comparatively widely-spaced. They may appear reddish brown in colour on end section, but lighter than the ground mass of the wood, or they may occur as fine pale-coloured lines. Tangentially they may appear as prominent reddish brown markings, darker than the surrounding tissue, giving the wood a distinct figure.

The intercellular canals usually occur only in the metatracheal parenchyma, but the presence of this does not imply the occurrence of canals, as in some specimens in which soft tissue was especially prominent, no trace of canals was found. They were found in the sapwood in close proximity to the cambium and may evidently be formed at an early stage after the formation of the secondary xylem. The canals observed varied in size from about 5μ in dia-

meter or less to a tangential diameter of about 800μ and a radial diameter of 175μ. In transverse section they appear as a concentrically-arranged ring of cavities, occasionally extending from ray to ray, but never crossing them, or as small solitary cavities, or as a group of cavities often joined one with the other by small branches. They do not necessarily extend tangentially throughout the whole metatracheal zone, but may only occur for a distance of a few millimetres. Frequently there are considerable spaces between the canals in the same metatracheal zone.

Even the metatracheal zones may vary in width considerably, ranging from one to 40 cells in a distance of less than 10 mm. A considerable development of parenchyma may give rise to a zone of over 5 mm. in radial width, and in such cases more than one row of canals may occur. In such a broad parenchyma zone vessels and isolated groups or fibres may be included. Seasoning cracks may open up along these soft tissue areas and they are obviously a definite line of weakness in the wood. Even in these broad zones, however, canals have not been observed wider than 150μ when measured radially.

In radial section the canals usually appear as elongated passages, varying slightly in width, and often with short lateral projections conforming to the shape of the adjoining cells. They may be fusiform in shape or may narrow and widen again at intervals. The wider canals may have traversing them chains of short parenchymatous cells which may be partially disintegrated, leaving only the cell cavity distinct. Narrow, elongated canals occur between adjoining rows of cells, and these may be linked up with the main canal by short branches. Whereas the narrow canals may have distinct lateral limits, the borders of the wider passages may be indistinct, branches running out into the surrounding tissue.

Tangentially the canals usually show themselves to form an anastomosing network, with smaller branches radiating into the adjoining tissue, and without definite borders. The multiseriate rays appear to be unaltered, but as in a radial view, chains, groups and solitary cells are often present.

Contents.

The contents of the intercellular canals are usually clear and amorphous, ranging in colour from practically colourless to a deep orange, but may sometimes have fine, irregular markings. Occasionally the contents are slightly granular. The consistency appears to be firm and horny; it frequently shows minute scratches made by the razor in sectioning. Cracks and gaps sometimes occur. The secretory substance is insoluble in water, absolute alcohol, chloroform and ether, either boiling or cold. Even exposure of the wood to boiling 95% alcohol, under pressure, at a temperature of 190° C. for over an hour during the preparation of the wood for sectioning had no apparent effect. Aniline chloride causes the substance to become bright yellow, resembling in colour the lignified cell walls. It does not dissolve in a concentrated aqueous caustic potash solution, but becomes darker in colour. Alkannin or Sudan III give no reaction for resinous or oily bodies. It shows a strong affinity for lignin stains. Ferric chloride has practically no effect on the pale-coloured material, but darkens that which is more highly coloured. Potassium bichromate causes a slight darkening of the deeper-coloured material. Iodine solution has no effect. Iodine and sulphuric acid causes a slight darkening. Phloroglucin and hydrochloric acid give a reddish violet colour, usually lighter towards the edges and deeper in the centre; the colour appears to be similar to that of the surrounding lignified tissue.

A light yellow to reddish brown- coloured secretion sometimes occurs in the vessels of *Flindersia,* not always in close proximity to the canals and more often isolated from them. This secretion is usually clear and amorphous and generally resembles that occurring in the canals, except that it is usually (but not always) darker in colour. It may entirely fill the vessel cavity when seen in transverse section, or may form a fringe round the edge, or may form rounded projections into the cavity, resembling tyloses. In longitudinal sections it may extend for a considerable distance from vessel segment to segment, forming a more or less continuous plug which may be irregularly cracked (possibly as the result of seasoning of the wood), or may be confined to a small area near the simple end perforation of the vessels. It may also be found to form rounded projections into the vessel cavity, similar in appearance to those seen in transverse section. What appears to be a similar plugging substance is occasionally seen extending for short distances in the wood fibres, and it may occur in the parenchyma or rays of the heart-wood. The vessels may also be filled with a dark-coloured, opaque, granular deposit, but this is usually less common than the clear orange secretion.

The behaviour of this substance does not appear to differ very markedly from that found in the canals, although when the colour of the plugging material is reddish it is affected to a greater degree with ferric chloride; evidently the colouration is due at least in part to the presence of phlobaphene-like substances. It, too, is insoluble in those liquids which do not affect the secretory substance in the canals.

Occasionally the vessel secretion has a lighter yellow fringing material, whilst the inner part may be orange, but

this fringing material may only be found on one side of the vessel, and on the other side the darker-coloured substance is in direct contact with the cell wall.

The principal difference appears to be in its reaction to phloroglucin and hydrochloric acid, the colour ranging from reddish purple to reddish brown, whilst part of the plugging substance is frequently unaltered in colour; portions of the lighter-coloured material, however, give approximately the same colouration as that obtained from the canals.

Groom *l.c.* has shown that in *Lovoa*, the substances occurring in the canals and vessels does not correspond to cellulose, pectic substances, resin, swelling gums and mucilages, but that the outer part of the canal excretion shows lignin reactions, whilst the centre part does not, but contains tannin, and thus resembles the plugging substance found in the vessels. In *Flindersia* an almost similar condition was found as regards the reaction of the canal substance, and that occurring in the vessels, in so far as they show evidence of lignin and do not indicate cellulose, resin, mucilage, etc. The centre part of the canal substance shows a more definite lignin reaction than that found towards the periphery. Tannin or phlobaphenes are usually more pronounced in the vessels.

The general reactions of the substance are those of "wound gum," which is frequently found in vessels in the vicinity of wounds, and is evidently secreted by the adjacent parenchyma. There are, however, no signs of wounds in the vicinity of the vessels which are filled with this "wound gum," although from its tylosic appearance at times it is evidently secreted by adjacent parenchyma.

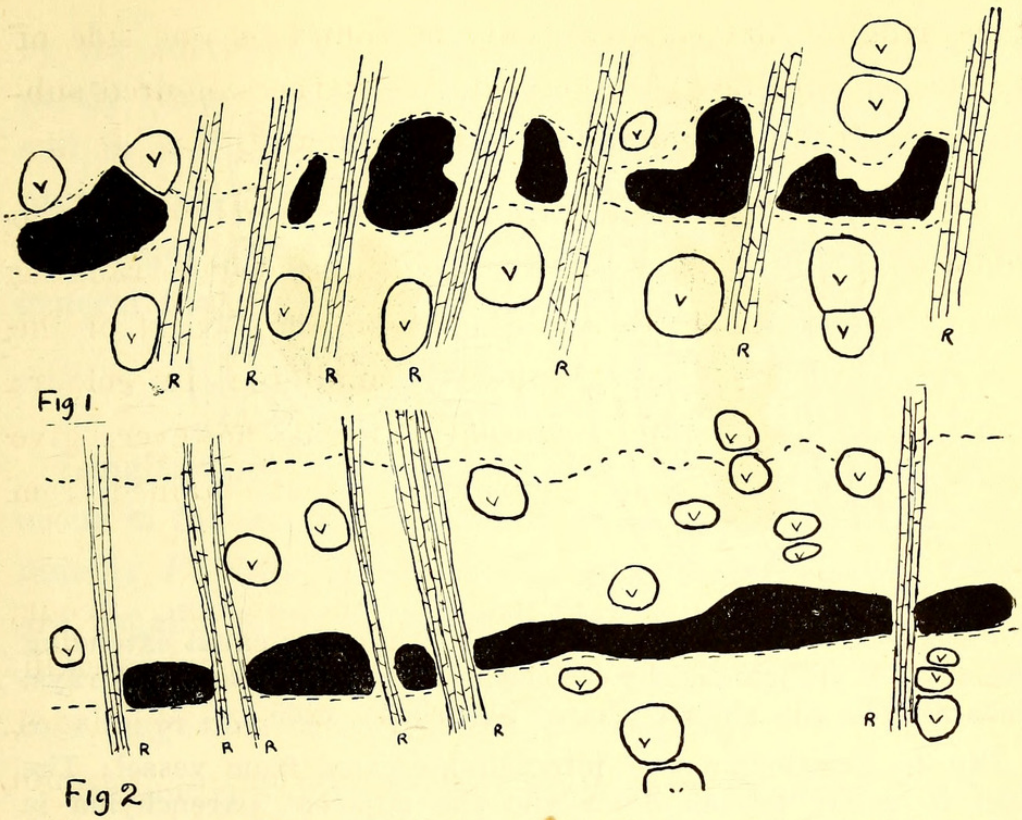


Fig 1.—A portion of arc of intercellular canals formed largely by breaking down of vessels and adjacent tissue. Metatracheal parenchyma (between dotted lines) is not largely developed. x40.

Fig. 2.—Portion of arc of intercellular canals showing restricted radial development even in a broad terminal zone of metatracheal parenchyma. The broad canal is exceptional and is only possible through the abnormal distance between rays. x40.

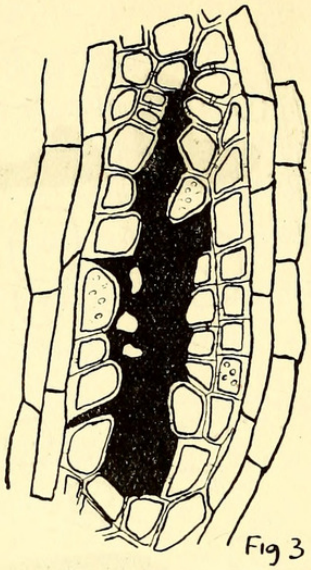
V = vessels.
R = rays.

Formation.

According to Groom *l.c.*, Janssonius* found that in *Cedrela febrifuga* var. *glabrior* (*Meliaceæ*) the intercellular canals take their origin in the vessels, and subsequently widen by the dissolution of the surrounding parenchyma cells. Groom does not record the initial stages of canal development in *Lovoa* and *Carapa* as occurring in the vessels.

In *Flindersia Brayleyana* there is undoubtedly evidence that the mode of formation noted by Janssonius may occur

*Groom gives the reference as Janssonius H. H., Mikrographie des Holzes der auf Java vorkommenden Baumarten Bd. ii, 1908. This publication was not available.



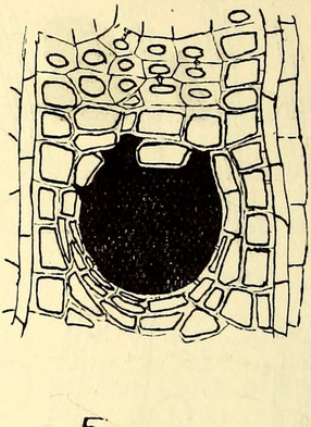


Fig 3.—An unusual form of schizo-lysigenous canal extending radially. It is bounded by wood parenchyma between two rays. Several cells are shown, almost absorbed. x265.

Fig 4.—Development of intercellular canal from vessel. The wall is partly broken down and the adjacent parenchyma is disappearing. x210.

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especially in the development of the larger canals, and in such cases the amount of metatracheal parenchyma may be small (c.f. Text Fig. 1).

As a rule, disintegration of the adjacent parenchyma follows quickly with the breaking-down of the vessel wall and the canal becomes irregular in shape (Text Fig. 4). This mode of formation is not always followed, and an examination of the photomicrograph. Fig 1, Plate IX, shows the typical development of the smaller canals in a comparatively narrow metatracheal parenchyma zone. It is evident that the initial stages are schizogenous, the amount of secretory substance produced by the parenchyma (clearly seen as a black mass) in several cases being little larger than the intercellular spaces. Further development is still schizogenous, the cavity becoming larger, but eventually disintegration of the cells which have been isolated

by the surrounding secretory substances occurs. Such a partly lysigenous cavity is seen on the right of the figure, and in it is an isolated cell cavity; the walls have been partly broken down, but the cavity has not been occluded. The larger canals may, therefore, be schizo-lysigenous. In general the formation resembles gummosis.

Summary.

Longitudinal intercellular canals of a gummosis type occur in the secondary wood of some species of *Flindersia*, notably *F. Brayleyana*, F.v.M., Queensland Maple. They are usually found in metatracheal parenchymatous bands and form a more or less anastomosing network extending in a tangential direction, but not radially.

The contents give lignin reactions, resembling "wound gum," and are in general similar to the contents of certain of the vessels.

The development of the smaller canals may be schizogenous, whilst the larger ones are schizo-lysigenous, due to the disintegration of the wood parenchyma. Canals may arise by the breaking-down of vessels and may be enlarged by the disintegration of the surrounding tissue.

The occurrence in the metatracheal parenchyma is irregular since they may frequently be wanting; nevertheless their recognition is undoubtedly a useful diagnostic character.

They are usually so small that they do not interfere with the utilisation of the wood; although when strongly developed they might exert a weakening effect, e.g., in lowering the resistance to longitudinal shear.

The insolubility of the contents is such that they are not likely to affect polish or other finishing materials.

Explanation of Plate.

Plate IX.

Fig. 1.—Transverse section of portion of heartwood of *Flindersia Brayleyana,* F.v.M., showing intercellular canals (dark coloured) occurring in a zone of metatracheal parenchyma which is bordered above and below by zones of wood fibres. Extending vertically are several multiseriate rays. On the right is a typical schizo-lysigenous canal, whilst towards the centre are several small schizogenous canals. x180.

Fig. 2.—Longitudinal radial section of same metatracheal parenchyma zone as Fig. 1, but at a narrower place. Small intercellular canals of this type are often more or less fusiform. To the right the canal is considerably narrowed. Towards the top is a zone of wood fibres, and at the bottom is portion of a vessel showing segments. x180.