On the Expansion of Bast Cells in Conifers.

By

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(With 2 Plates and 3 Text-figures)

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Introduction.

Alternation or crushing is common in the secondary phloem of mature stems. It is known that the outer phloem of dicotyledonous plants undergoes extensive sclerification of parenchyma, obliteration of sieve-tubes, or lateral flattening of ray cells. In Coniferous plants, we find modifications of bast cells, varying with species in the manner and the extent to which they modify. This may occur partly before a zone of periderm is formed in the bast, or later when the bast cells are dead. There is but little literature dealing with the subject of modifications undergone by the phloem of coniferous plants. The present article describes certain observations made by the writer during the period 1933–1935.

Material and Method.

The following material collected from Hokkaidō, Honshū, Shikoku, and Taiwan were studied.

Ginkgoales.
Ginkgoaceae......Ginkgo biloba L.

Coniferae.
Podocarpaceae...Podocarpus Nagi Zoll. et Moritz., P. macrophyllus D. Don.
Cephalotaxaceae...Cephalotaxus drupacea Sieb. et Zucc.

Pinaceae.
Observation.

1. Taxaceae, Podocarpaceae, Cephalotaxaceae and Ginkgoaceae.

In *Taxus*, *Podocarpus*, and *Cephalotaxus*, modification of bast cells accompanied by formation of periderm is not frequent. Only irregularly expanded bast cells are found in the outer bark (rhytidome) of *Torreya nucifera* the phellem of which is characterized by enlarged thick-walled cells. In *Ginkgo biloba*, collapsed bast cells are enclosed by well developed periderms.

2. Pinaceae.

Both isodiametric expansion and tangential enlargement of bast cells occur in plants of Pinaceae. Expansion of phloem parenchyma is common in the outer bark of *Abies*, *Tsuga*, *Picea*, *Larix*, and *Pseudotsuga*. Some species of *Abies*, *A. firma* and *A. homolepis* for example, have very irregularly enlarged parenchyma, while in *Larix* and *Pseudotsuga*, the expanded cells are evenly distributed throughout every outer bark (Phot. 2). In *Tsuga* and *Picea*, expansion occurs either radially along both sides of the rays (Text-fig. 1–C, Phot. 1), forming tangentially, a discontinuous row (Text-fig. 1–D), or irregularly among non-modified tissue.

In the sieve-tubes, which also expand as phloem parenchyma in the

MAXIM.


Taxodiaceae.


Cupressaceae.


Juniperoideae ....... *Juniperus rigida* Sieb. et Zucc., *J. sinensis* L.

Though material, such as *Abies frima*, *Larix Kaempferi* and *Pinus densiflora*, was directly sectioned by a sliding microtome, while the brittle one was treated by celloidin-imbedding. The sections were stained with safranin and haematoxylin.
outer bark of *Tsuga, Larix*, and *Pseudotsuga* (Phot. 12), sieve-plates are easily observed in transverse section (Text-fig. 1–A, B). Collapse of the sieve-tubes, shown by an irregular band of structureless wall substance, is clearly apparent in the outer bark of *Picea, Larix, Pseudotsuga*, and *Pinus* (Text-fig. 1–B). Expansion of ray cells occurs in the outer bark of *Tsuga* and *Picea* (Text-fig. 1–A), which however is not distinct in those of *Larix* and *Pseudotsuga*, although the fusiform rays of these three genera are tangentially flattened as the result of increase of parenchyma in horizontal canals.

Hard pine (*Diploxylon*), as *Pinus densiflora* and *P. Thunbergii*, has isodiametrically expanded bast cells and radially elongated parenchymatous cells; the former evently scattered among the outer bark, or, although rarely, showing tangential arrangement (Phot. 3); and the latter restricted to the interior of the phelloderm (Text-fig. 2–B, Phot. 4). In Soft pine (*Haploxylon*), as in *Pinus koraiensis*, the expansion of bast cells is not distinct, excepting some parenchyma inside the phelloderm, which cells often expand without any semblance of regularity (Text-fig. 2–A).

3. **Taxodiaceae.**

The bast elements of Taxodiaceae are regularly arranged in both tangential and radial directions. It differs from Pinaceae not only in the scaling and splitting of bark, but also in the mode of modification of bast cells.

Both bast parenchyma and sieve-tubes of *Sciadopitys* are always expanded to an extraordinary degree in the outer bark (Text-fig. 2–C, 3–B). If the expansion happens to be very great, almost all the parenchymatous
cells are modified, the outer bark being soft and swollen (Phot. 5); while in slightly expanded ones, modified cells are scattered among normal tissue (Phot. 6). In *Cunninghamia*, in which expansion of bast parenchyma is also common, these cells more elongate in a radial direction than in tangential (Text-fig. 3–D, Phot. 7, 13). Although the outer bark of *Cryptomeria* usually consists of non-modified bast cells, expanded parenchyma is sometimes found as in the foregoing genera. These expanded cells are extremely large, very thin walled, and irregular in shape (Phot. 9). This change is accompanied by, or followed sooner or later by, the formation of periderm.

4. **Cupressaceae.**

In Cupressaceae, the bast elements are arranged more regularly than in those of Taxodiaceae, the same regularity being retained in the outer
bark on account of there being only little modification of the bast cells. Although not as a rule, expansion of bast parenchyma occurs in the outer bark of *Thuja Standishii* (Text-fig. 3-C, Phot. 10) and *Chamaecyparis pisifera* (Text-fig. 2-D, Phot. 2, 8), as in Taxodiaceae.

Tangential enlargement of phloem cells, as referred to by Sinz, is observed in relatively young material of some species of Taxodiaceae and Cupressaceae, which however differs from the foregoing phenomenon.

**Summary.**

1) Modification of bast cells in the outer bark (rhytidome) of coniferous plants is an isodiametric enlargement and radial elongation of parenchyma cells, sieve tubes, and phloem ray cells in the Pinaceae, and an extraordinary expansion of bast parenchyma cells or sieve tubes in the Taxodiaceae and Cupressaceae.

2) Extraordinary expansion of bast cells in the outer bark, although common in *Sciadopitys verticillata* and *Cunninghamia lanceolata*, is less so in *Cryptomeria japonica*, *Thuja Standishii*, and *Chamaecyparis pisifera*.

In conclusion, the writer wishes to acknowledge his indebtedness to Mr. Torii Miyoshi of the Forest Experiment Station of the Imperial Household, for the material.

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**Literature.**


Explanation of Plates V–VI.

Figs. 1–10, Cross section of outer barks. × 30.
  Fig. 1, *Picea jezoensis*, showing radial expansion of bast cells.
  Fig. 2, *Pseudotsuga japonica*, showing evenly distributed expanded cells.
  Fig. 3, *Pinus densiflora*, showing tangential expansion of bast cells.
  Fig. 4, *Pinus densiflora*, showing radial elongation of bast cells inside the phelloderm.
  Fig. 5, *Sciadopitys verticillata*, showing extraordinary expansion of bast cells.
  Fig. 6, The same species, showing slightly expanded bast cells.
  Fig. 7, *Cunninghamia lanceolata*, showing expanded bast parenchyma.
  Fig. 8, *Chamaecyparis obtusa*, showing expanded bast parenchyma.
  Fig. 9, *Cryptomeria japonica*, showing expanded bast parenchyma among non-modified tissue.
  Fig. 10, *Thuja Standishii*, showing expanded bast parenchyma.

Figs. 11–14, Radial section of outer barks. 11, 13, × 30; 12, 14, × 60.
  Fig. 11, *Sciadopitys verticillata*, showing expanded bast cells.
  Fig. 12, *Larix Kaempferi*, showing expanded sieve-tubes.
  Fig. 13, *Cunninghamia lanceolata*, showing expanded bast parenchyma.
  Fig. 14, *Chamaecyparis pisifera*, showing expanded bast parenchyma and non-modified sieve-tubes.

Addendum.

Of fossil plants, the writer found the expanded bast-parenchyma in a *Cupressinoxylon*-type wood collected by Y. Imai from the Urakawa Series (Senonian) of Nami-kawa, Toyohara-mati, Karahuto. The expansion closely resembles that of *Chamaecyparis pisifera* occurring in some cells of the outer bark.

Tangential enlargement of phloem cells is observed in the branch of *Dadoxylon sidugawense* Shimakura from the Sidugawa Series (Liassic) of Sidugawa-mati, Miyagi-ken, a specimen of *Paraupressinoxylon*, which is thought to be a wood of *Cryptomeriodpis Stopes et Fuji* (*= Geinitzia of Jeffrey*), from the Urakawa Series of Karahuto (Russian Saghaline?) shows regularly arranged bast elements as in living Cupressacean plants (Cf. Holden, Bot. Gaz., Vol. LVIII). In *Cedroxyylon* cfr. *Yendoi* Stopes et Fuji from the same series of the Kawakami Coal Mine, Karahuto, the structure of bark quite resembles that of *Cedrus*, and the modification of bast cells to *Abies*.

With these facts in consideration, it may be concluded that the expansion or modification of bast cells is a phenomenon occurring in both living and fossil coniferous plants.