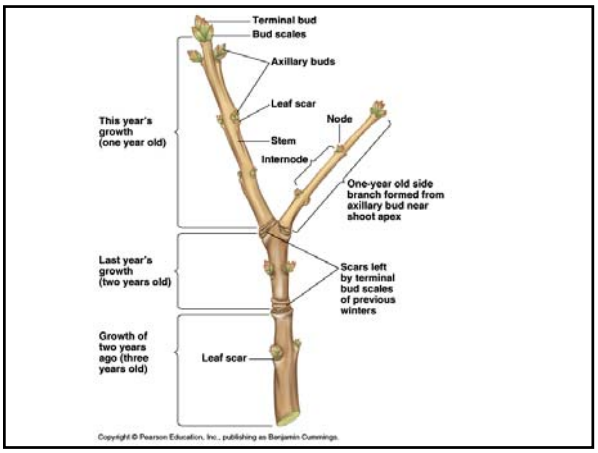
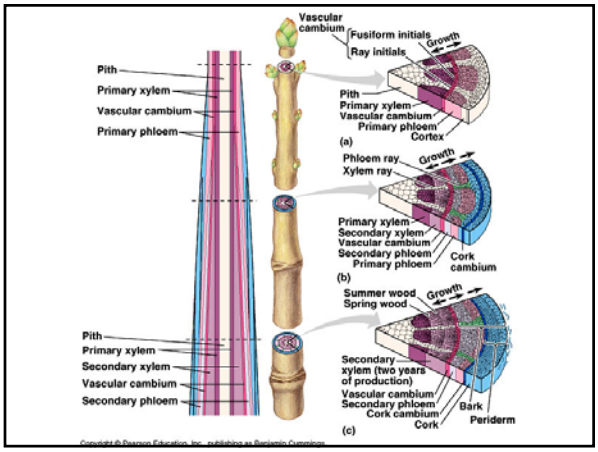
Lecture 18. Mini-review and Secondary Phloem

- **Secondary Stem Growth** – secondary phloem





Reasons for secondary growth in stems vs. roots

1. **Method of satisfying the demand during growth**
2. **In dicot perennials & gymnosperms new yearly leaves & needles need new vascular systems**
3. **Greater herbage (topside) requires greater support**

Type of secondary growth
- Continuous vascular cylinder (most common - angiosperms)

a) **Leftover procambium produces cells - becomes fascicular cambium**
b) **Parenchyma between bundles becomes interfascicular cambium**
c) **Both fascicular and interfascicular cambium produce secondary phloem and secondary xylem - they become or behave as a vascular cambium**

Distribution of secondary vascular tissues

A. **Usually 5x more xylem produced than phloem**
B. **More xylem because of high demand for water**
C. **Xylem in trees forms conspicuous rings because the vascular cambium produces different sized cells (small in the Fall and large in the Spring)**
D. **Phloem doesn't form distinguishable rings because it doesn't form a secondary wall - old phloem gets squashed**
E. **Vascular system last for only one year - then an new system is provided**

The cambial zone: theoretically thought to be one layer

A. Axial system

1. Vascular cambium: gives rise to tracheids & sieve cells, vessels & sieve tube members - fibers and sclerids come out of this too

2. Fusiform initials - make axial phloem (usually sieve cells) and xylem (usually tracheids) elements

3. Sometimes a fusiform initial can become a ray initial

B. Transverse (ray) system

1. Ray initials - make xylem and phloem rays as well as ray parenchyma

2. Purposes of ray system

a) Storage (starch grains)

b) Produce tyloses

c) Absorb air bubbles

d) Produce callose

The Vascular Cambium

Definitions

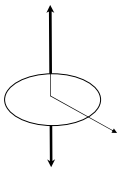
AXIAL: Along the axis of the organ, or organism

RADIAL: At right angles to the axis, i.e., along a radius

Tangential: At right angles to a radius.

Ray Initial: Meristematic cambial cell. Forms a file of cells (one or more wide) that is composed of parenchyma. Orientated ALONG a RADIUS. Contributes to the **RADIAL** transport system

Fusiform Initial: Meristematic cambial cell. Forms new secondary xylem and secondary phloem and associated cells.
Contributes to the **AXIAL** transport system.



THE VASCULAR CAMBIUM

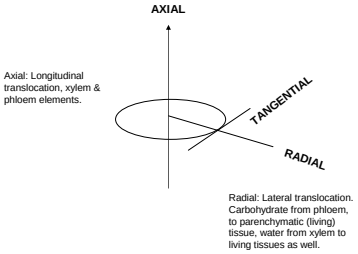
The vascular cambium is unlike the primary meristems of the plant (root and shoot apex) in that:

- it produces new cells and tissues which add to the axial system (i.e. the conducting system) as well as to the radial system (i.e. the lateral transport pathway), whereas the apical meristems of the shoot and root add only to the axial system.
- Thus the cells of the vascular cambium do not fit the regular concept of meristematic cells (i.e. small dense, with large nuclei, and of isodiametric shape).
- Cambial cells are usually highly vacuolate and occur in two forms, namely fusiform cells and ray cells.

1. The term fusiform implies that the cell is shaped like a spindle, but it is approximately prismatic and wedge-shaped at both ends.
2. Ray cells on the other hand, are short squat cells.
3. Tangentially, both cell types are wider than they appear in radial section or view.
4. These two different cell types (fusiform and ray cells) have unique functions.
   - Fusiform cells usually only produce cells associated with the axial system that is they produce either new elements of the xylem, or elements of the phloem, and thus add to the AXIAL conducting system.
   - Ray cells on the other hand, produce under normal circumstances, ONLY ray cells and thus add to the RADIAL system of the plant

***Robinia* cambium: tangential section**

Axial vs. Radial directions

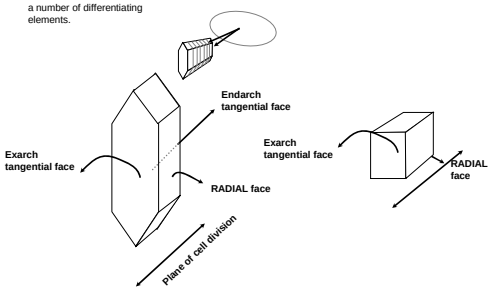


Axial: Longitudinal translocation, xylem & phloem elements.

Radial: Lateral translocation. Carbohydrate from phloem, to parenchymatic (living) tissue, water from xylem to living tissues as well.

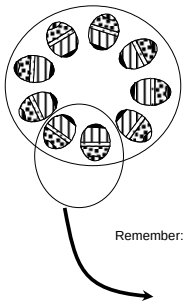
Fusiform vs. ray initials

Fusiform and ray cells form FILES of cells – each file contains a number of differentiating elements.



Division planes

Development of secondary vascular tissues

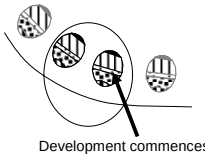


During primary growth, the vascular bundles produce **PRIMARY** vascular tissue.

These are the **primary phloem** (proto + meta) and **primary xylem** (proto and meta).

The **fascicular cambium separates the two tissues.**

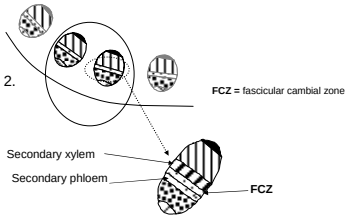
Remember: a ***fascicle*** is a vascular bundle



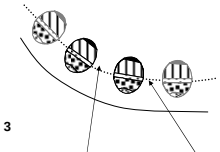
1.

Development commences at the fascicular cambium

First activity is in the vascular bundle

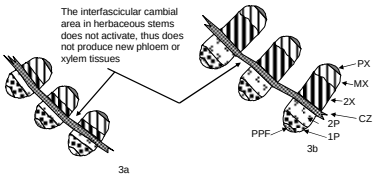


Secondary xylem and phloem are produced by the **fascicular cambium**

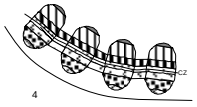


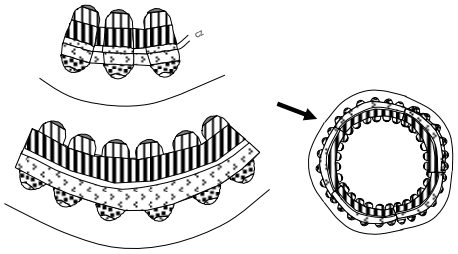
3

The interfascicular regions begins to develop a cambium.



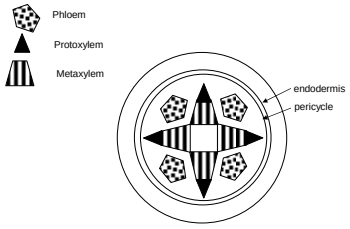
A widening band of secondary vascular tissue results.





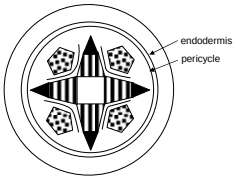
The ring of secondary tissue is Complete. The **interfascicular** and **fascicular cambia** together form a **vascular cambium**

Cambial activity in the root.



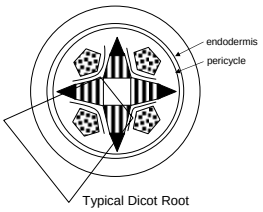
Typical Dicot Root, end of primary growth (cambial activity in Gymnospermous roots is very similar).

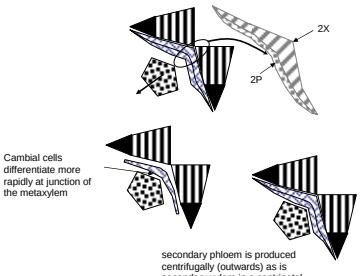
Formation of the cambium. Stage 1.



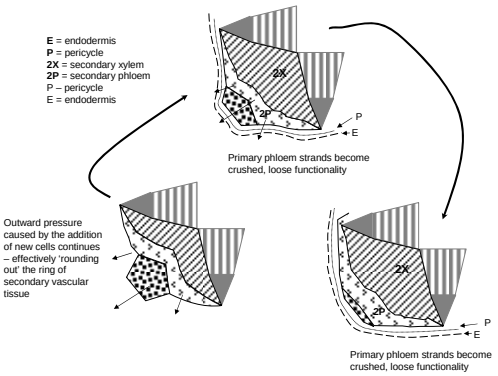
Typical Dicot Root

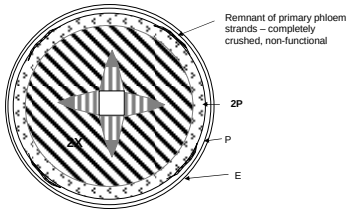
Formation of the cambium. Stage 2.





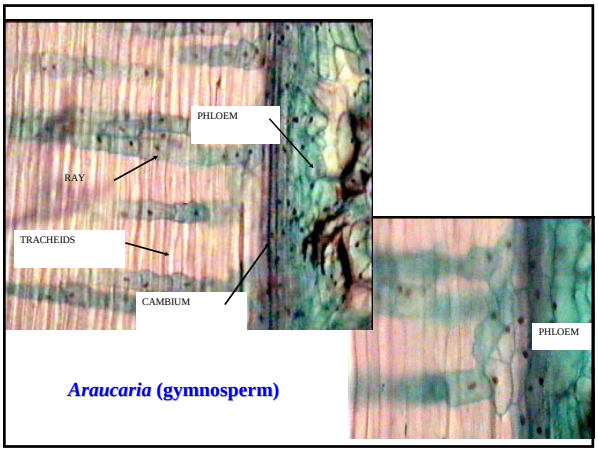
secondary phloem is produced centrifugally (outwards) as is secondary xylem in a centripetal (inward) direction. Outward pressure begins to be applied to the primary phloem strands. These strands are gradually forced outwards, to make way for the newly-added secondary vascular tissues.



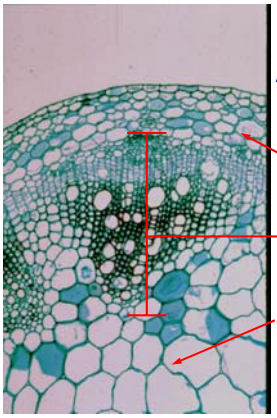


E = endodermis
P = pericycle
2X = secondary xylem
2P = secondary phloem
P – pericycle
E = endodermis

The root will retain its primary xylem, which will be visible and may be functional



***Araucaria* (gymnosperm)**

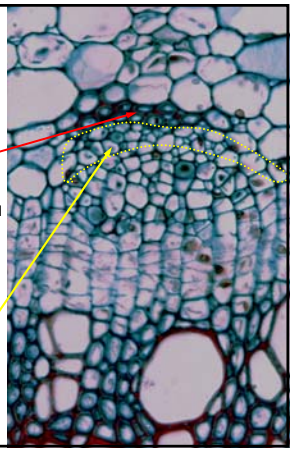


All Stems are divided into..

a cortex

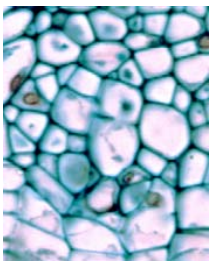
A zone of vascular tissue

A pith (parenchymatous in young stems like this one)

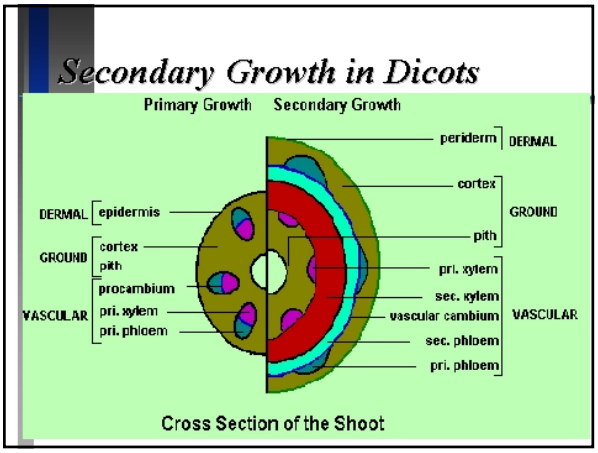


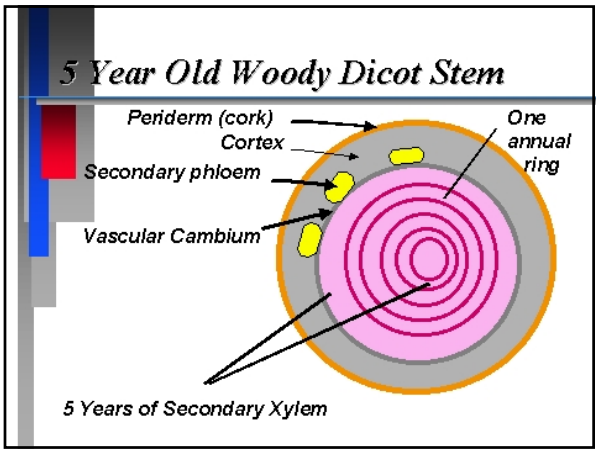
Primary phloem fibers - derived from the protophloem. This forms the outer tissue (these cells should be stained red in the Fabil section) of each vascular bundle - they may be hardly visible in your section

The protophloem is formed first.



Metaphloem - small cells (stained blue) lying between the phloem fibers and the xylem. Note very small, deeply-stained companion cells and the rather wider sieve tubes.




5 Year Old Woody Dicot Stem
Periderm (cork)
Cortex
Secondary phloem
Vascular Cambium
One annual ring
5 Years of Secondary Xylem


Three Year Old Tree