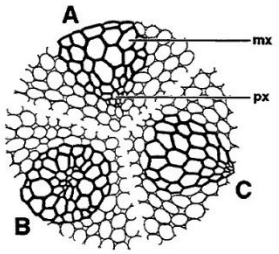
THE XYLEM

The xylem is the principal water-conducting tissue in a vascular plant. It is also involved in the transport of solutes, in support, and in food storage. Together with the phloem, the principal food-conducting tissue, the xylem forms a continuous vascular system extending throughout the plant body. As components of the vascular system, xylem and phloem are called vascular tissues.

The vascular tissues that differentiate in the primary plant body are the primary xylem and the primary phloem. The meristematic tissue directly concerned with the formation of these tissues, and which is their immediate precursor, is the procambium.

Primary xylem can be temporally and positionally divided into two categories of elements. Protoxylem is the initial primary xylem to differentiate and is identified by its position within the organ. Metaxylem is that primary xylem component that differentiates later. It is not uncommon for the protoxylem to consist of only one or two elements.



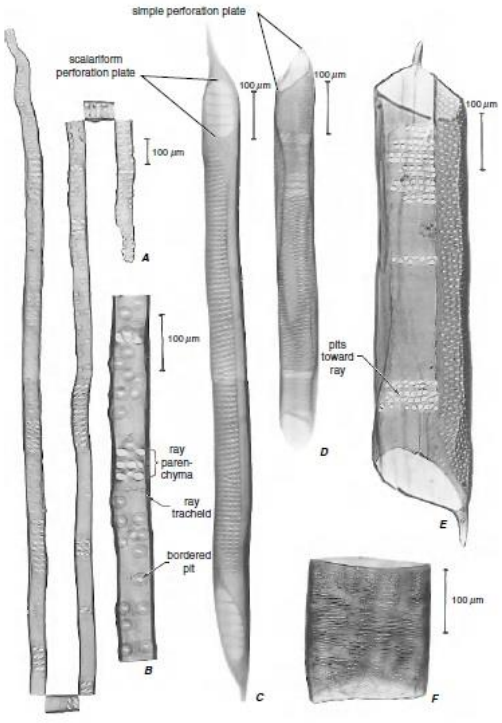
Relationship of protoxylem and metaxylem and types of primary xylem differentiation. (A) Endarch primary xylem. (B) Mesarch primary xylem. (C) Exarch primary xylem. Reprinted with permission of the publisher from THE ANATOMY OF WOODY PLANTS by E.C. Jeffrey: The University

CELL TYPES OF XYLEM

■ **Principal Cell Types in the Secondary Xylem** ■

Cell Types	Principal Functions
Axial system	
Tracheary elements	
Tracheids, Vessel elements	Conduction of water; transport of solutes
Fibers	
Fiber-tracheids, Libriform fibers	Support; sometimes storage
Parenchyma cells	
Radial (ray) system	Food storage; translocation of various substances
Parenchyma cells	
Tracheids in some conifers	

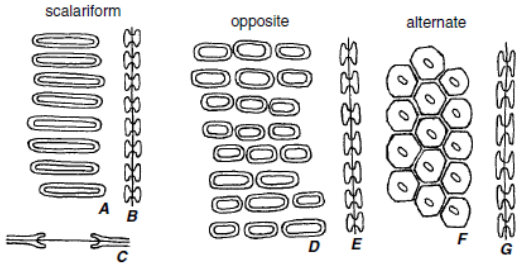
TRACHEARY ELEMENTS—TRACHEIDS AND VESSEL ELEMENTS—Two fundamental types of tracheary elements occur in the xylem, the **tracheids** and the **vessel elements**, or **vessel members .**Both are more or less elongated cells that have lignified secondary walls and are nonliving at maturity. They differ from one another in that tracheids are imperforate cells having only pit-pairs on their common walls, whereas vessel elements also have perforations, which are areas lacking both primary and secondary walls through which the vessel elements are interconnected. The part of the vessel element wall bearing the perforation or perforations is called the **perforation plate** A perforation plate may have a



Tracheary elements. **A**, earlywood tracheid of sugar pine (*Pinus lambertiana*). **B**, enlarged part of **A**. **C**–**F**, vessel elements of tulip tree, *Liriodendron tulipifera* (**C**), beech, *Fagus grandifolia* (**D**), black cottonwood, *Populus trichocarpa* (**E**), tree-of-heaven, *Ailanthus altissima* (**F**). (From Carpenter, 1952; with permission from SUNY-ESF.)

single perforation (***simple perforation plate***; or several perforations (***multiple perforation plate***). The perforations in a multiple perforation plate may be elongated and arranged in a parallel series (***scalariform perforation plate***) or in a reticulate manner (***reticulate perforation plate***) or as a group of approximately circular holes (***foraminate perforation plate)***

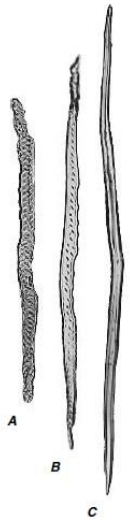
The Secondary Walls of Most Tracheary Elements Contain Pits. Simple and bordered pits are found in the secondary walls of tracheids and vessel elements of the latest formed primary xylem and of the secondary xylem. The number and arrangement of these pits are highly variable, Usually numerous bordered pit-pairs occur between contiguous tracheary elements (***intervascular pitting***); The bordered pits in tracheary elements show three main types of arrangement: scalariform, opposite, and alternate.



*[If the pits are elongated transversely and arranged in vertical, ladder-like series, the pattern is called **scalariform pitting** . Circular or oval bordered pits arranged in horizontal pairs or short horizontal rows characterize **opposite pitting** .If such pits are crowded, their borders assume rectangular outlines in face view. When the pits are arranged in diagonal rows, the arrangement is **alternate pitting]***

XYLEM FIBERS

Fibres are specialized as supporting elements in the xylem.These are long cells with secondary,commonly lignified, walls. The walls vary in thickness but are usually thicker than the walls of tracheids in the same wood. Two principal types of xylem fiber are recognized, the **fiber-tracheids** (which is thicker to libiform fiber but thinner than tracheid) and the **libriform fibers** (which resemble phloem fibers and the thinnest)

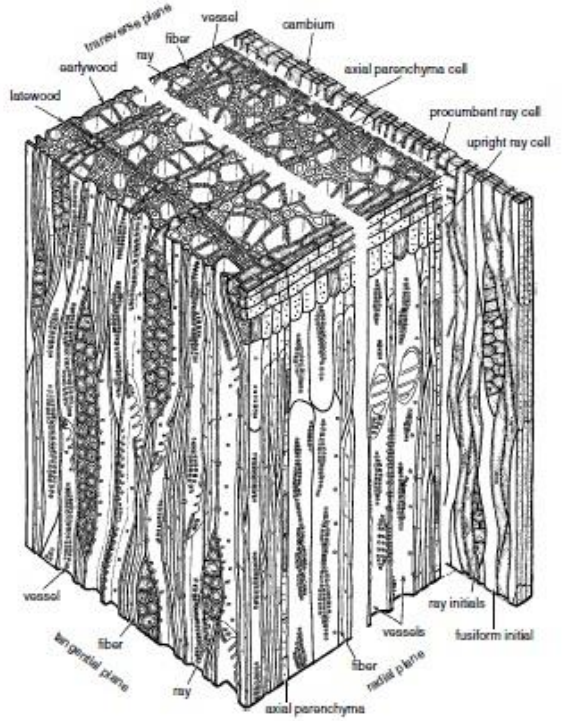


A, tracheid, B, fiber-tracheid, and C, libriform fiber

XYLEM PARENCHYMA

In the secondary xylem the parenchyma cells are commonly present in two forms: axial parenchyma and ray parenchyma. The axial parenchyma cells are derived from the elongated fusiform initials of the vascular cambium, and consequently their long axes are oriented vertically in the stem or root.

If the derivative of such a cambial cell differentiates into a parenchyma cell without transverse (or oblique) divisions, a fusiform parenchyma cell results. If such divisions occur, a parenchyma strand is formed. Parenchyma strands occur more commonly than fusiform parenchyma cells. Neither type undergoes intrusive growth. The ray parenchyma cells, which are derived from the relatively short ray initials of the vascular cambium, may have their long axes oriented either vertically or horizontally with regard to the axis of stem or root.



Block diagram of vascular cambium and secondary xylem of *Liriodendron tulipifera* L. (tulip tree), a woody angiosperm. The axial system consists of vessel elements with bordered pits in opposite arrangement and inclined end walls with scalariform perforation plates; fiber-tracheids with slightly bordered pits; and parenchyma strands in terminal position. The ray system contains heterocellular rays (marginal cells are upright, others procumbent), uniseriate and biseriate, of various heights. (Courtesy of I. W. Bailey; drawn by Mrs. J. P. Rogerson under the supervision of L. G. Livingston. Redrawn.)

TYLOSES- In the secondary xylem both the axial and the ray parenchyma cells located next to the vessels may form outgrowths through the pit cavities and into the lumina of the vessels when the latter become inactive and lose their internal pressure. These outgrowths are called **tyloses** (singular: tylose), and the parenchyma cells that give rise to them are referred to as **contact cells**.