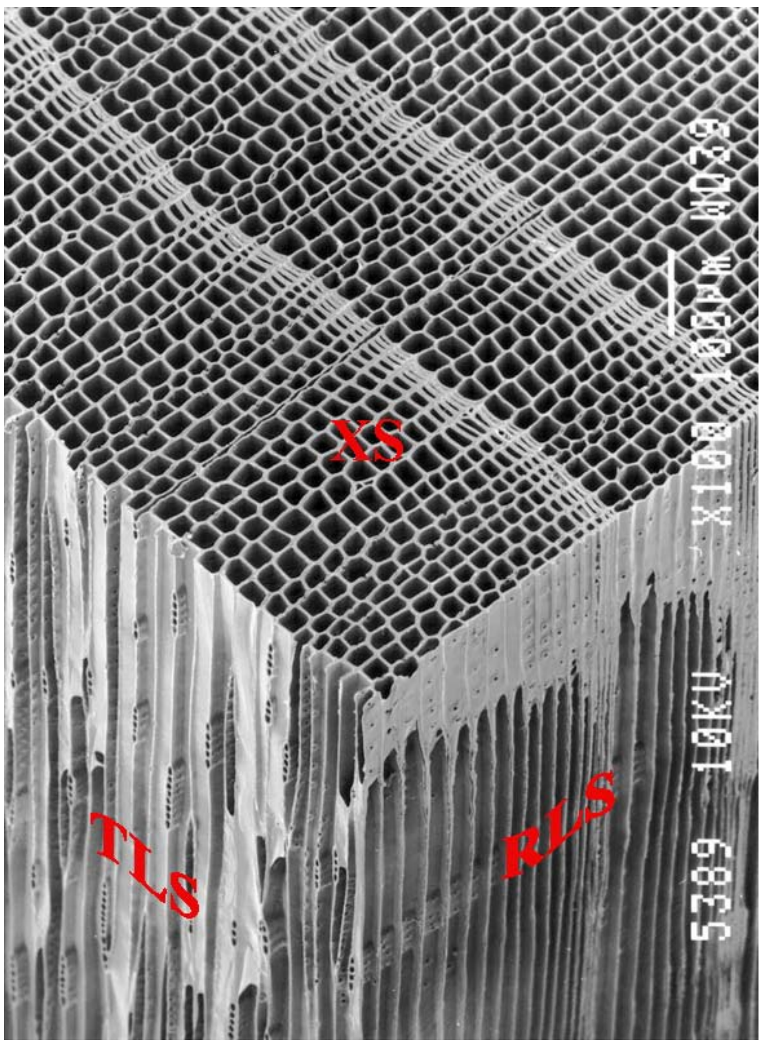
Part 3
GLOSSARY

Sections (transverse, radial, tangential)

For identification, various features of the wood are viewed in three different planes. This glossary will provide basic descriptions of some of the major features, with reference to which plane(s) they can be viewed in.

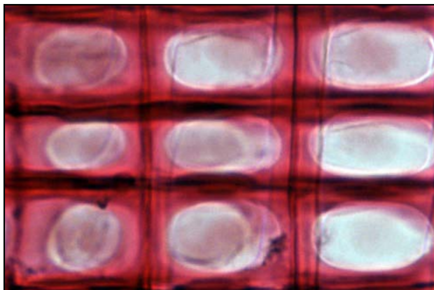
The transverse or cross section is the plane perpendicular to the long axis of the trunk. It is the same view as you would see if you were looking down at the top of a stump after a tree had been cut down. The radial section is the vertical plane from the pith at the center of the tree heading out towards the bark. The tangential section is the plane perpendicular to the long axis of the rays and tangential to the growth rings.



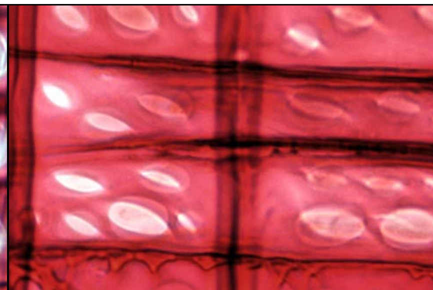
Scanning Electron Microscope photograph of hinoki cypress wood (*Chamaecyparis obtusa*) showing the three planes of reference used in wood identification. XS = transverse or cross section; RLS = radial section; TLS = tangential section.

Cross-field pits

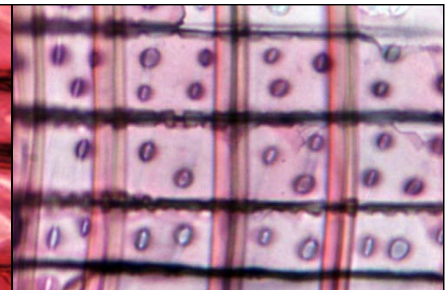
Feature found in conifers, and visible (when preserved) in radial section at relatively high magnification. These are pits in the cell walls of ray parenchyma that allow communication between the ray cells and the adjacent axial tracheids. The appearance of cross-field pits is an important diagnostic feature that helps in identification of conifers. Unfortunately, this feature is not often well preserved in woods of the Columbia River Basalts. Examples of the various cross-field pit types are shown below:



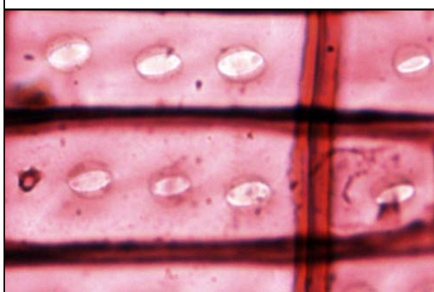
Window-like pits in eastern white pine (*Pinus strobus*)



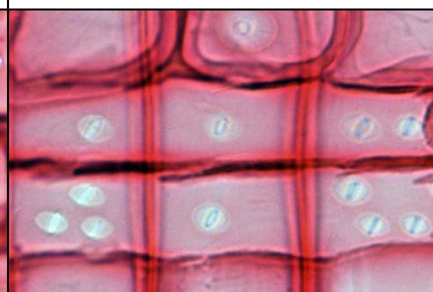
Pinoid pits in lodgepole pine (*Pinus contorta*)



Piceoid pits in white spruce (*Picea glauca*)



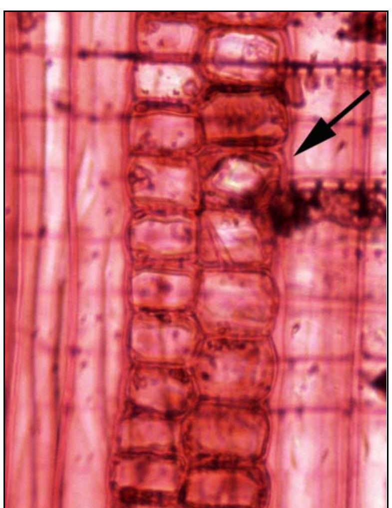
Taxodioid pits in coastal redwood (*Sequoia sempervirens*)



Cupressoid pits in Taiwan cypress (*Chamaecyparis taiwanensis*)

Crystals

Crystals are mineral inclusions that can be found in both conifers and hardwoods, but they are less common in the conifers. They are also found in *Ginkgo*. Depending on the wood type, they can be located in axial parenchyma or in ray cells and the cells that contain them are often enlarged. When present, crystals may be observed in either radial or tangential sections.

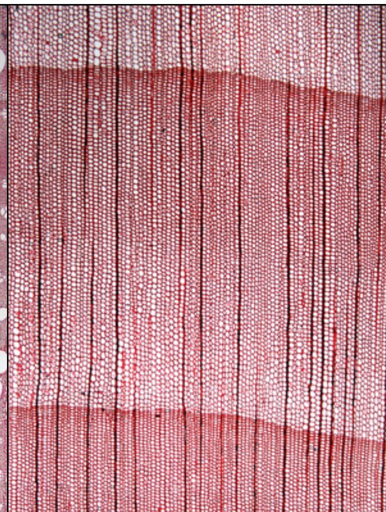


Crystal-bearing parenchyma strands in radial section of bigleaf maple (*Acer macrophyllum*)

Earlywood/Latewood

Terms describing seasonal growth of wood, especially in temperate zones. Also sometimes called springwood and summerwood. In the early part of the growing season, the wood is often less dense with larger vessels (hardwoods) or tracheids (softwoods). Towards the end of the growing season, the wood becomes denser and vessels or tracheids are often smaller. The transition from earlywood to latewood can be gradual or abrupt, depending on the species.

Growth ring of netleaf hackberry (*Celtis reticulata*) showing relatively distinct earlywood and latewood zones.



An example of a conifer (*Calocedrus decurrens*) with a gradual transition from earlywood to latewood.

An example of a conifer (*Pseudotsuga sinensis* var. *sinensis*) with an abrupt transition from earlywood to latewood.

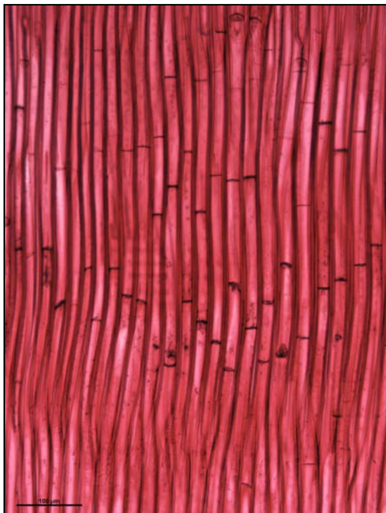
Epithelial cells

Specialized parenchyma cells that surround resin canals in certain conifers (some members of the pine family). They are best seen in transverse or tangential section, and are useful in identification. Important characteristics are the number and shape of the cells and whether they are thin or thick walled.

Epithelial cells surround a horizontal resin canal in a fusiform ray of Douglas fir (*Pseudotsuga menziesii*) - tangential section

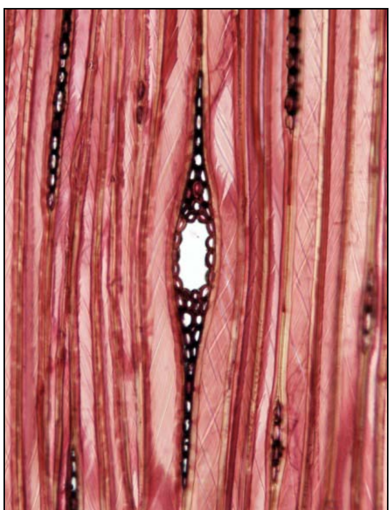
Fiber (Septate, non-septate)

Fibers are the most common cell type in hardwoods. Their function is to provide structural support for the plant. Certain features of them can be useful for identification, including the type of pits (simple or bordered), whether they are septate or non-septate, and the wall thickness. Septate fibers are those which have one or more transverse dividing walls inside the cells and function in storage in the sapwood. Various aspects of fibers can be viewed in each of the three sections.

	
Septate fibers in radial section of gumbo limbo (*Bursera simaruba*)	**Non-septate fibers in radial section of yellow buckeye (*Aesculus flava*)**

Fusiform ray

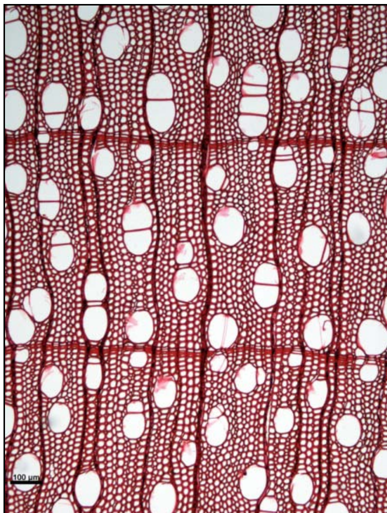
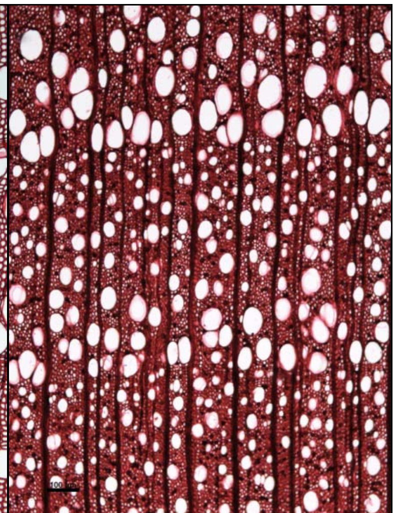
This term describes the shape of some rays as viewed in tangential section, where they are wide in the middle and taper towards both ends. This term is generally applied to rays that contain horizontal resin canals, although it is sometimes also used to describe the appropriately shaped multiseriate rays in hardwoods.



Fusiform ray with horizontal resin canal in tangential section of tamarack larch (*Larix laricina*)

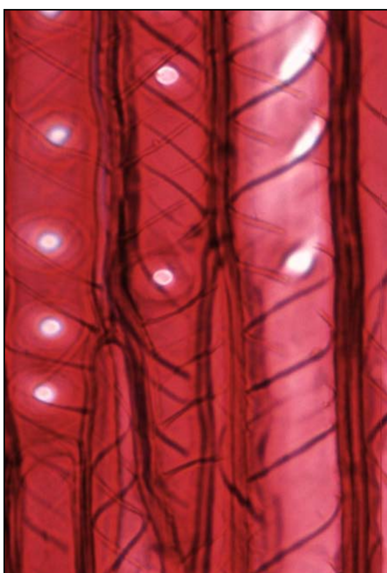
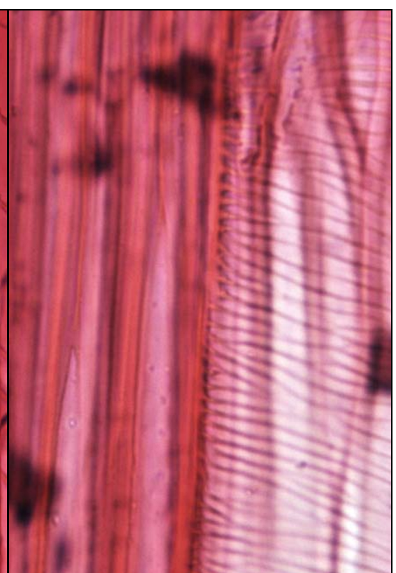
Growth ring

An annual growth increment in hardwoods or softwoods best viewed in transverse section. Woods from temperate zones typically have distinct boundaries between growth increments due to the seasonality of growth. Woods from more tropical regions are likely to have growth occurring throughout the year and thus the boundaries between growth increments may be difficult or impossible to detect.

	
Birch (*Betula* sp.) with distinct growth ring boundaries.	**Bitterbrush (*Purshia tridentata*) with indistinct growth ring boundaries**

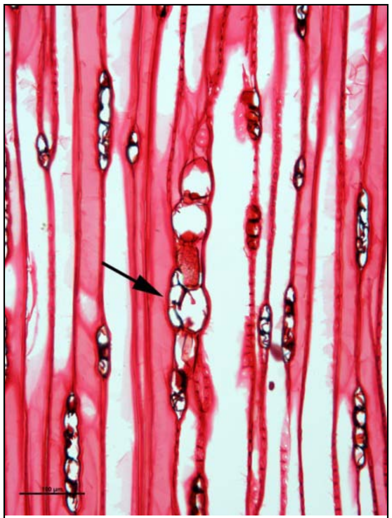
Helical thickenings

Also known as spiral thickenings. This feature is seen in radial or tangential sections and is present in some softwoods and some hardwoods. In softwoods, helical thickenings may occur in axial tracheids or ray tracheids of some species. In hardwoods, helical thickenings most often occur in vessels, although they can also occur in fibers of some species. The presence and distribution of helical thickenings is an important diagnostic feature.

	
Helical thickenings in axial tracheids of Pacific yew (*Taxus brevifolia*)	**Helical thickenings in vessel of red maple (*Acer rubrum*)**

Idioblasts

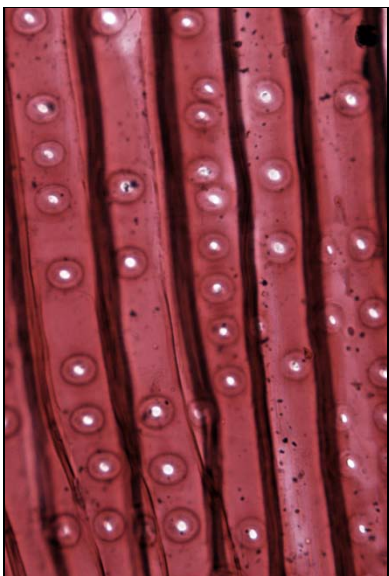
Plant cells that differ from adjacent tissue and contain various non-living materials. Idioblasts can occur in both hardwoods and softwoods. *Ginkgo* has idioblasts with crystals in them. Best viewed in longitudinal sections.



Idioblasts in tangential section of *Ginkgo biloba*

Intertracheary pits

This term refers to pits in conifer tracheids that allow water flow between adjacent tracheids. Pits are found as uniseriate, biseriate, or multiseriate rows along the length of the tracheid. Best viewed in radial section of earlywood tracheids.

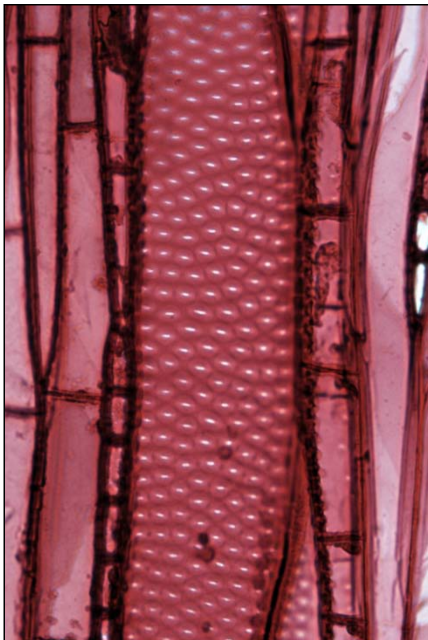


Uniseriate intertracheary pits in giant redwood (*Sequoia gigantea*)

Rows of uniseriate and biseriate intertracheary pits in coffin tree (*Taiwania cryptomerioides*)

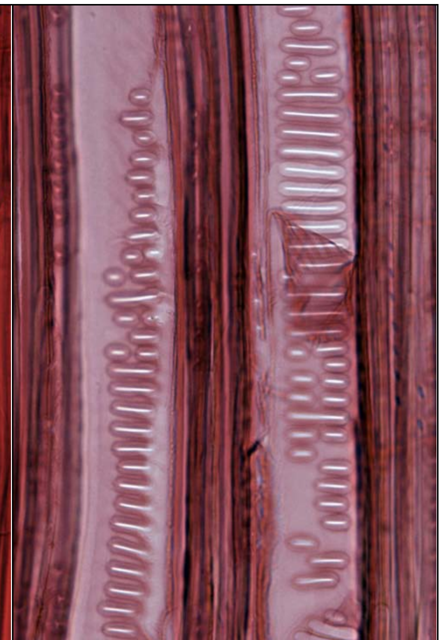
Intervessel pits

Intervessel pits are pits that occur in the vessel element walls between adjacent vessels. They come in a variety of shapes, sizes and arrangements, and are an important diagnostic feature of hardwoods. They can be viewed in either radial or tangential section. Often poorly preserved in fossil woods.



Alternate intervessel pit arrangement in tangential section of butternut (*Juglans cinerea*)

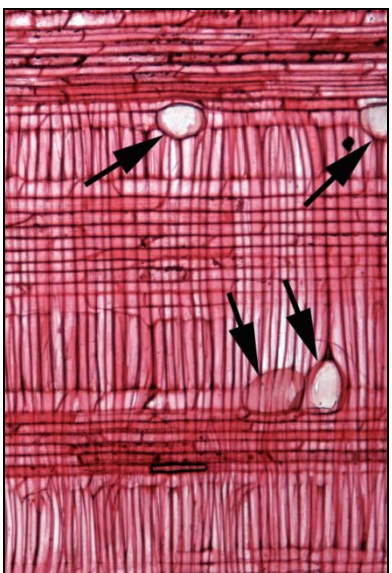
Opposite intervessel pit arrangement in radial section of water tupelo (*Nyssa aquatica).* Note how the pits are arranged in horizontal rows.



Scalariform intervessel pit arrangement in radial section of witch-hazel (*Hamamelis virginiana*)

Oil cells

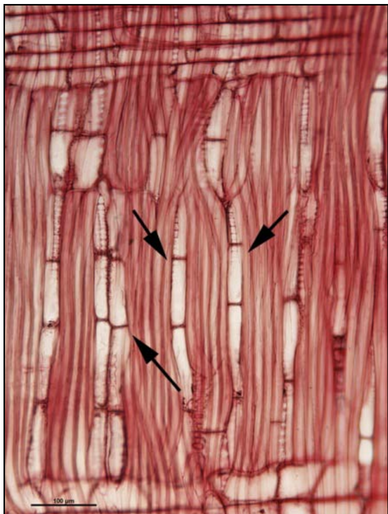
Enlarged cells filled with oil. Can be associated with ray parenchyma or axial parenchyma. These occur in relatively few woods and thus are important for identification. Many species in the laurel family (Lauraceae) exhibit this feature, such as *Richteroxylon* from Vantage.



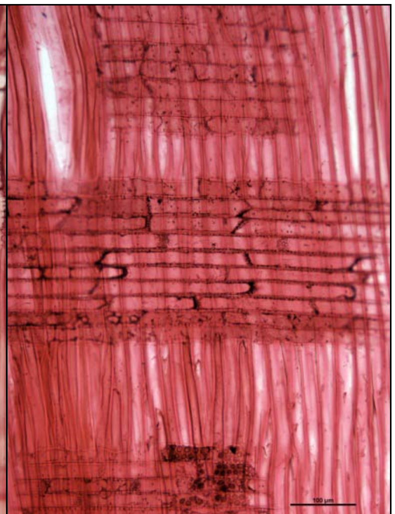
Oil cells along margin of rays in sassafras (*Sassafras albidum*)

Parenchyma

Parenchyma are specialized cells the plant uses for storage and conduction of nutrients. They occur in both hardwoods and softwoods. Axial strands of parenchyma cells are an important feature in many plant species. Additionally, wood rays are largely made up of parenchyma cells.



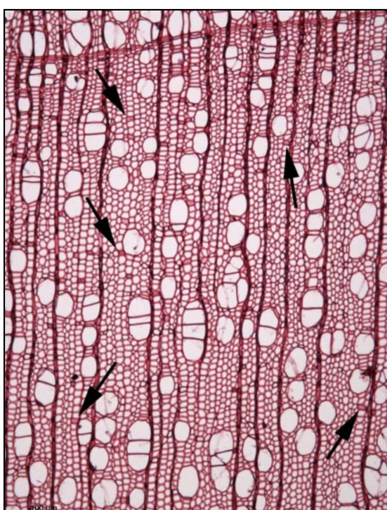
Strands of axial parenchyma in radial section of persimmon (*Diospyros virginiana*)



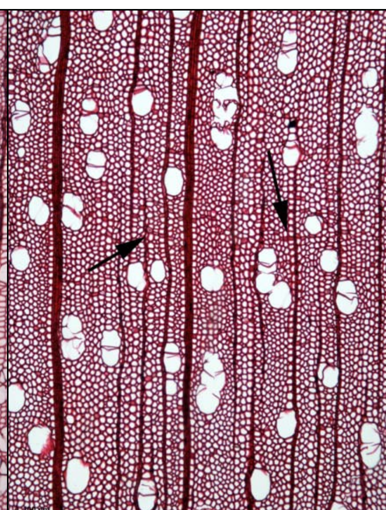
Rays are typically made up of parenchyma cells. Radial section of cottonwood (*Populus balsamifera*)

The presence, absence, abundance and distribution of axial parenchyma in a wood are very useful for identification. Parenchyma distribution patterns are best seen in transverse view, while individual strands are usually visible in radial or tangential sections. Parenchyma can either be scattered throughout the growth ring, occur at the growth ring boundaries, occur in association with the vessels in hardwoods, or be in some combination of the above.

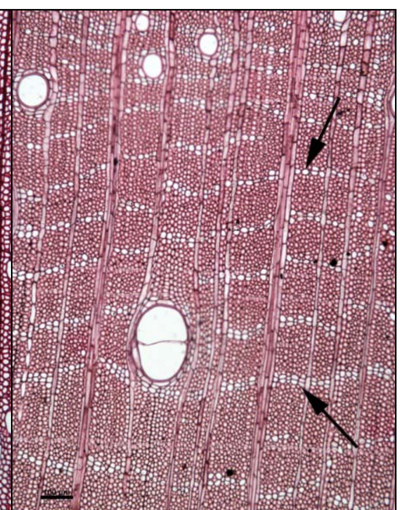
Parenchyma that are not associated with vessels are known as apotracheal parenchyma. They can be scattered individually (diffuse), occur in small groups that are oriented tangentially (diffuse-in-aggregate), or form nearly continuous tangential bands in portions of the growth ring.



Diffuse parenchyma in cross section of red alder (*Alnus rubra*). Parenchyma appear as darker cells scattered among the fibers.



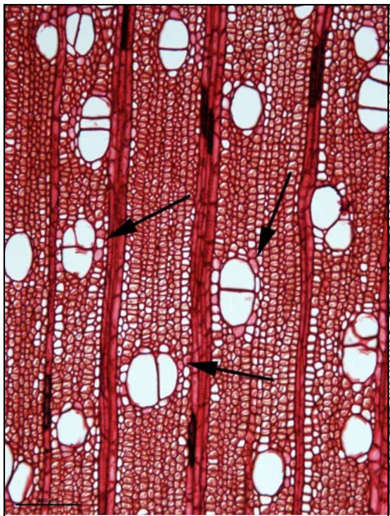
Gray birch (*Betula populifolia*) with both diffuse and diffuse-in-aggregate parenchyma. Arrows point to short tangential chains of parenchyma.



Some woods have parenchyma that form nearly continuous tangential bands, as in this sample of red hickory (*Carya ovalis*).

Paratracheal parenchyma are in direct contact with vessels. They are categorized into several types:

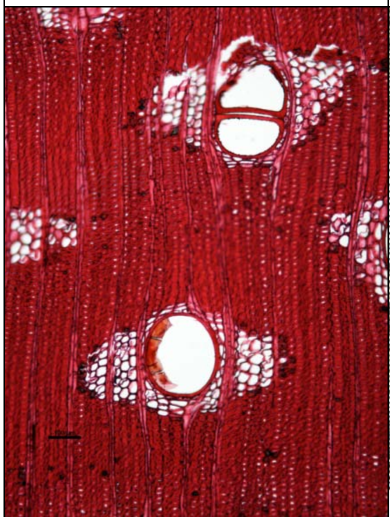
- scanty paratracheal: few parenchyma strands in proximity to the vessels. They can be individual or form an incomplete ring around the vessel.
- vasicentric: parenchyma cells form a complete sheath around the vessel.
- aliform: parenchyma form a ring around the vessel and extend laterally into the surrounding tissue.
- confluent: Two or more vessels with vasicentric or aliform parenchyma that merge and connect the vessels. This can result in irregular bands when viewed in cross section.
- lozenge-aliform: a type of aliform parenchyma with lateral extensions that form a lozenge or diamond shape when viewed in cross section.
- winged-aliform: a type of aliform parenchyma with elongated extensions that appear somewhat wing shaped when viewed in cross section.



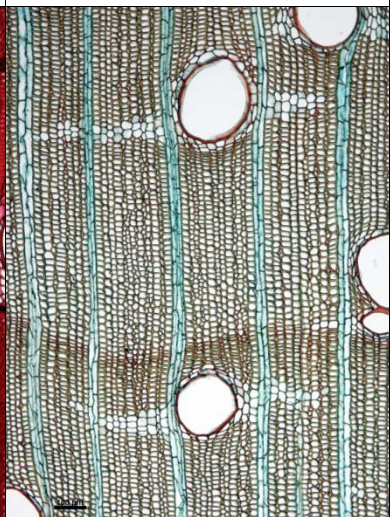
Scanty paratracheal parenchyma in cascara (*Frangula purshiana*). Axial parenchyma form an incomplete sheath around the vessel.

Vasicentric parenchyma in sassafras (*Sassafras albidum*). Axial parenchyma completely surround the vessel.

Confluent aliform parenchyma in honey locust (*Gleditsia triacanthos*). Axial parenchyma surrounding vessels merge, forming irregular bands.



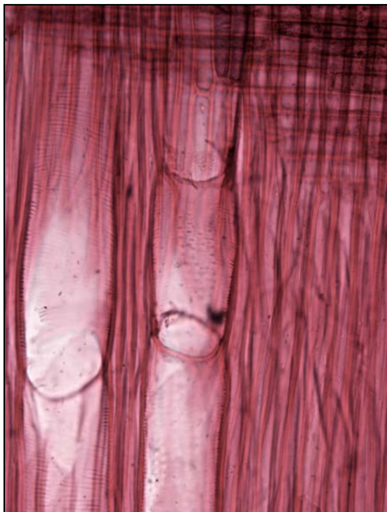
Lozenge-aliform parenchyma in tindalo (*Afzelia rhomboidea*) form a characteristic diamond shape around the vessels.



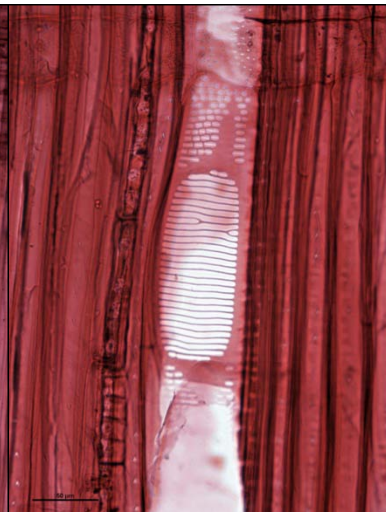
Winged-aliform parenchyma in copaia (*Jacaranda copaia*), showing long winglike extensions from the vessels.

Perforation plate

Perforation plates are the openings in the end walls of adjacent vessel elements in hardwoods. They allow fluids to pass from one vessel element to another along the length of the vessel. Simple perforation plates have a single opening, whereas scalariform perforation plates consist of a series of parallel openings separated by bars. The bars may be branched and can vary in number. Perforation plates are best viewed in radial or tangential sections. Some woods have exclusively one or the other type, while other species may have a mix of simple and scalariform perforations.



Simple perforation plates in radial section of red maple (*Acer rubrum)*



Scalariform perforation plate with many bars in radial section of water tupelo (*Nyssa aquatica)*

Scalariform perrforation plates with few bars in radial section of madroño (*Arbutus peninsularis)*

Porosity

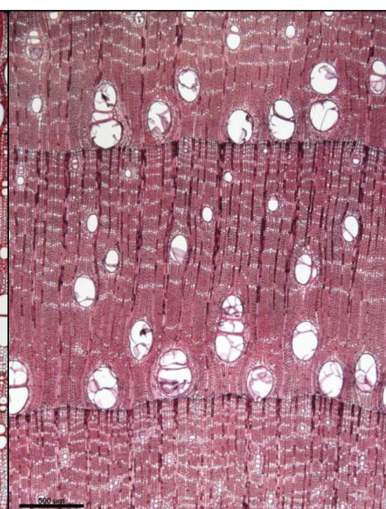
When viewed in cross section, the arrangement of pores (vessels) in hardwoods is described by three categories based on the differences in pore diameter throughout the growth ring.

Ring porous: Earlywood pores are distinctly larger than the pores in the latewood, with a relatively abrupt transition in sizes.

Semi-ring porous: Earlywood pores are larger than latewood pores, with a gradual transition in pore size through the growth ring.

Diffuse porous: Pore diameter does not change significantly from earlywood to latewood.

Ring porous wood: American ash (*Fraxinus americana)*



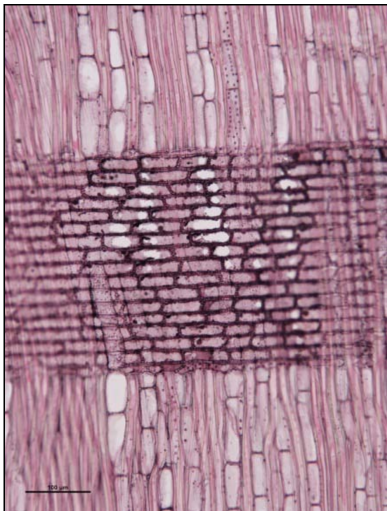
Semi-ring porous wood: shagbark hickory (*Carya ovata*)

Diffuse porous wood: sugar maple (*Acer saccharum*)

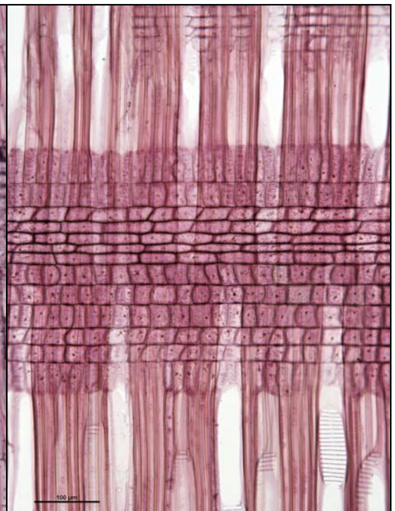
Rays

Rays are present in both hardwoods and softwoods, and serve the function transporting fluids and nutrients laterally within the plant stem. They are ribbon-like aggregates of mostly parenchyma cells, extending from the bark towards the pith. Depending on the species, rays can be anywhere from one cell to over twenty cells thick. Rays exhibit a number of features that are important for wood identification, some of which are defined below.

- Homocellular: Rays that are made up of only one cell type.
- Heterocellular: Rays that are made up of more than one cell type. This usually involves procumbent (radially elongated) and square or upright cells in hardwoods, or procumbent cells and ray tracheids in softwoods. The square or upright cells are often seen along the margin of the rays, but can also be found in the body of the ray in some species.



Homocellular ray of willow oak (*Quercus phellos*) viewed in radial section



Heterocellular ray of witch-hazel (*Hamamelis virginiana*) viewed in radial section

- Uniseriate rays: rays that are only one cell wide.
- Multiseriate rays: rays that are multiple cells wide.
- Aggregate or composite rays: Thick rays that are made up of a number of closely spaced smaller rays intermixed with fibers (and occasionally small vessels). This feature is rare, thus its presence is an important diagnostic feature.

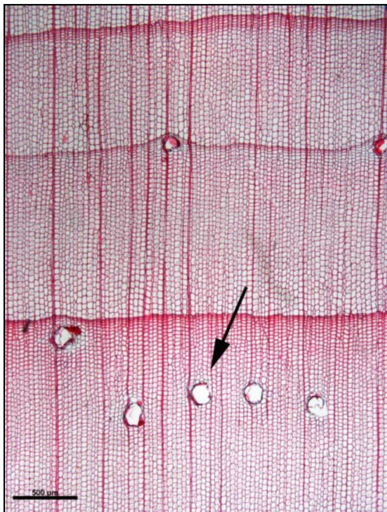
Uniseriate and biseriate rays of shamel ash (*Fraxinus uhdei*) viewed in tangential section

Large multiseriate rays of American sycamore (*Platanus occidentale*) viewed in tangential section

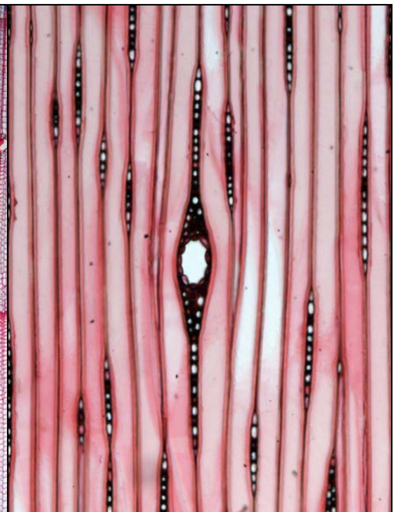
Aggregate ray of American hornbeam (*Carpinus caroliniana*) viewed in tangential section

Resin canals

Resin canals occur in some conifers. They are surrounded by epithelial cells which secrete the resin. They can be oriented either vertically or horizontally in the wood. They may occur singly or in small groups or chains.



Vertical resin canals in eastern white pine (*Pinus strobus*) viewed in transverse section



Horizontal resin canal in fusiform ray of Sitka spruce (*Picea sitchensis*) viewed in tangential section

Tracheid

Tracheids are elongated cells that function in upward transportation of fluids and for support. They are the principal cell type in softwoods, but are also found in some hardwoods. Tracheids have bordered pits to allow communication with adjacent cells (see intertracheary pits).

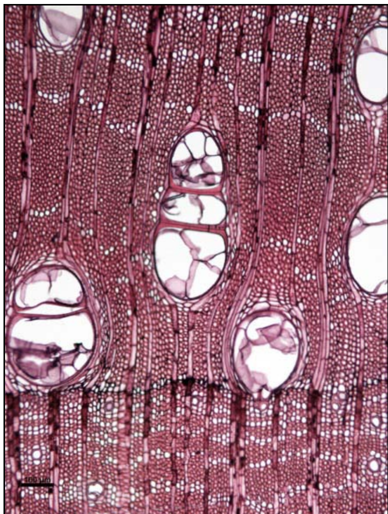
The axial cells in this section of incense cedar (*Calocedrus decurrens*) are primarily tracheids.

The light areas surrounding the vessels of this black oak *(Quercus velutina*) contain a mixture of tracheids and axial parenchyma, while the darker areas away from the vessels consist mostly of thick walled fibers.

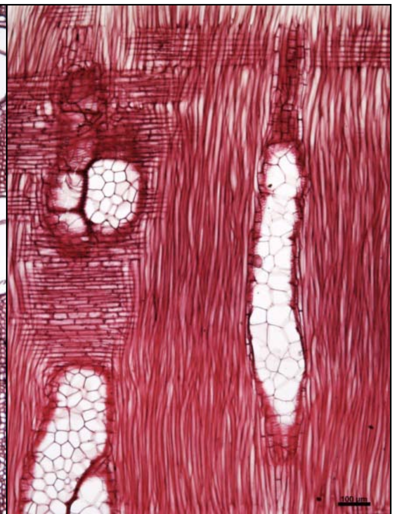
Radial section of white oak (*Quercus alba*) showing tracheids and axial parenchyma. The arrows point to bordered pits in the vascular tracheids.

Tyloses

Bubble-like structures found in the vessels of some woods. Their presence may help in wood identification. They can typically be seen in all three sections under the microscope.



Vessels with tyloses in cross section of shagbark hickory (*Carya ovata*)



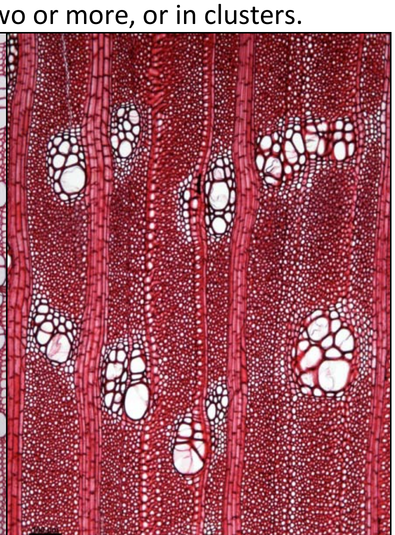
Tylose filled vessels seen in radial section of black locust (*Robinia pseudoacacia*)

Vessels

Vessels are axial tubes within a hardwood that function to allow movement of fluids and nutrients vertically within the plant stem. They are constructed of a series of interconnected vessel elements. When viewed in cross-section, vessels are often referred to as 'pores'.

The cross sectional arrangement of vessels is an important diagnostic feature. Vessels can be solitary, in radially arranged multiples of two or more, or in clusters.

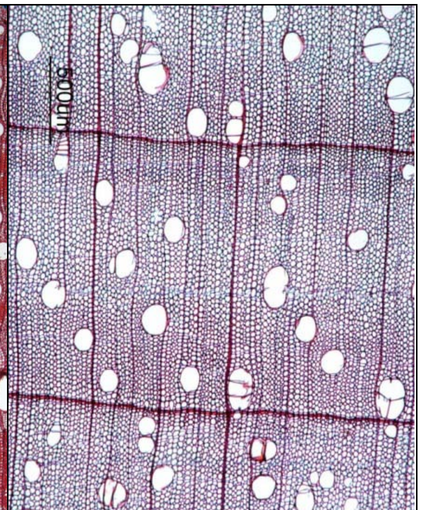
Transverse section of red maple (*Acer rubrum*) showing solitary vessels and vessels in radial multiples.



Transverse section of black locust (*Robinia pseudoacacia*) showing latewood with vessels in clusters.

In some woods, the vessels can form a distinct pattern, such as the dendritic (branching) arrangement of vessels in some oaks, or the diagonal arrangement in woods such as *Pterocarya*.

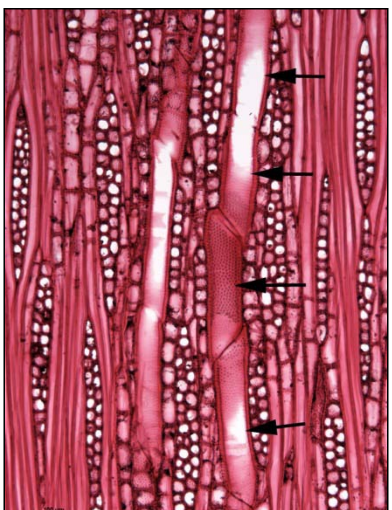
Transverse section of northern red oak (*Quercus rubra*) showing radial pore arrangment.



Transverse section of Chinese walnut (*Pterocarya rhoifolia*) showing diagonal pore arrangement (FFPRI TWTw 18460 from the Inside Wood database, http://insidewood.lib.ncsu.edu/search)

<u>Vessel element</u>

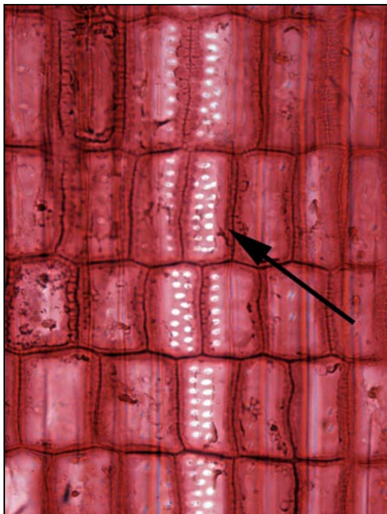
Vessel elements are the individual cells that make up vessels in hardwoods. They are arranged in a vertical stack with the individual vessel elements connected by perforation plates. They can also communicate with adjacent vessels by means of intervessel pits, or with rays through vessel-ray pits.



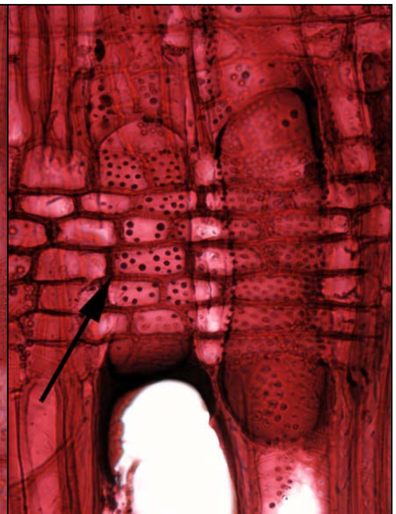
Vessel in American ash (*Fraxinus americana*) seen in tangential section. Arrows point to individual vessel elements.

Vessel-ray pits

Pits in the cell walls between vessel elements and adjacent ray parenchyma. The size and form of these pits can be of diagnostic value. This feature is viewed in radial section, although it is often poorly preserved or not visible in the fossil woods of the Columbia River Basalts.



Vessel-ray pits in radial section of Pacific dogwood (*Cornus nuttalli*)



Vessel-ray pits in radial section of bitter cherry (*Prunus emarginata*)