CHAPTER THREE

THE STRUCTURE OF WOODY PLANTS: SOFTWOODS

Gymnosperms evolved on earth before angiosperms, and conifers retain a relatively primitive cell structure compared with the more specialized and complex anatomy of hardwoods. Because coniferous anatomy is simpler, softwoods will be discussed first. Their simplicity does, however, mean that there are fewer differences to distinguish one softwood from another, particularly at a macroscopic level. This contrasts with hardwoods, whose greater diversity of cell type, cell size and other features often makes identification possible even without a microscope. Thus, in the identification chapters, hardwoods are presented first because their greater anatomical complexity actually makes them easier to differentiate.

To accommodate readers who do not wish to use a microscope, this chapter first describes what can be seen without one. But, as mentioned, the primitiveness of softwood anatomy makes the microscope very important in finding features that separate one softwood from the next. You should, at the very least, read through the descriptions of the microscopic features and study the photographs taken at microscopic level.

An Introduction to the Softwoods: Eastern White Pine

We begin by examining a typical softwood, eastern white pine, which illustrates most of the features that are explained in detail in the pages that follow.

The oblique view of a cube of eastern white pine (facing page) was photographed with a scanning electron microscope. The circular insets show thin transverse, radial and tangential sections of the cube as they appear magnified 75 times under an ordinary microscope with transmitted light.

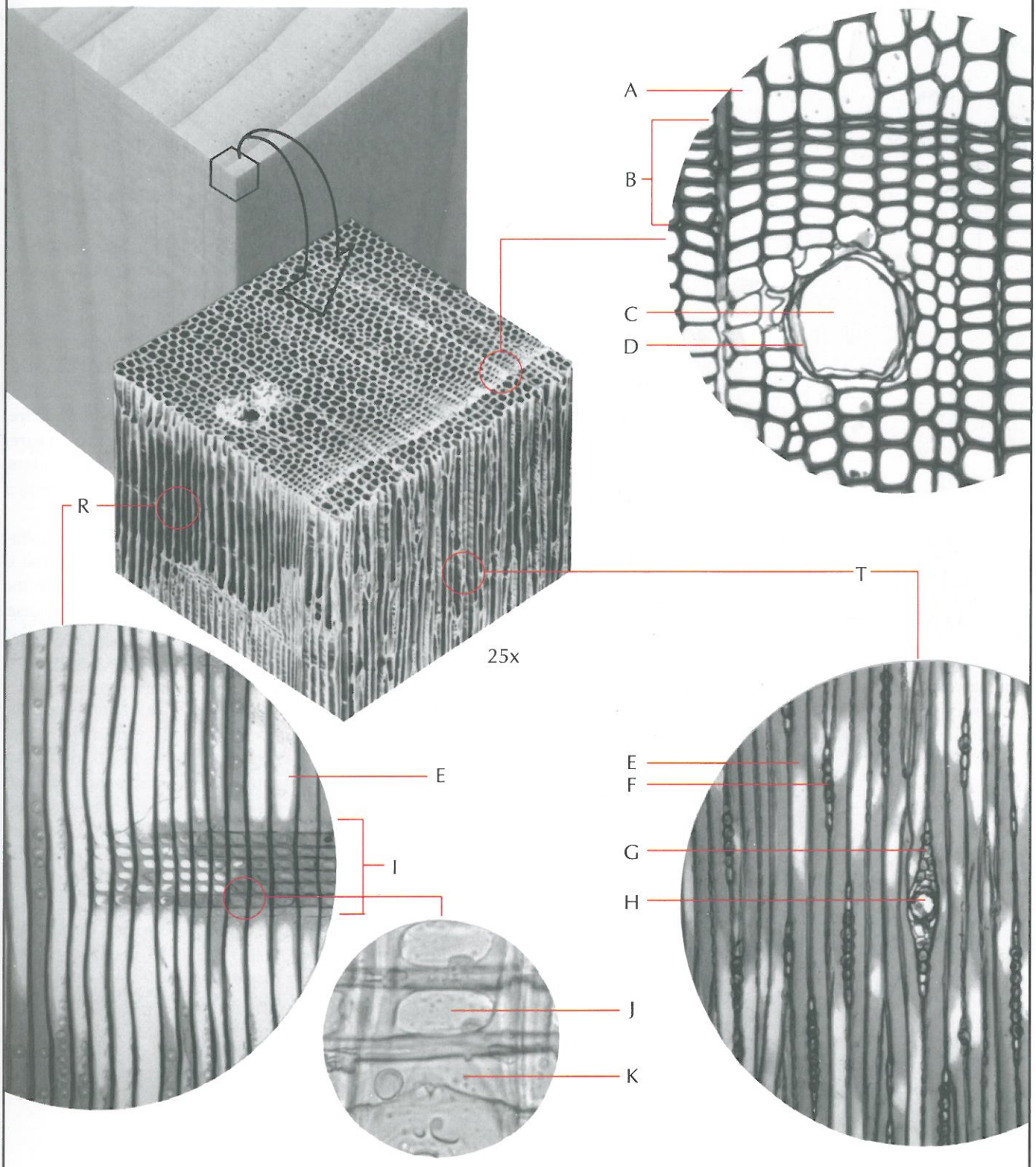
The wood tissue is composed mainly of **tracheids** (A), which are arranged in radial fashion and are fairly uniform in tangential diameter. The denser latewood (B) is the result of the tracheids' smaller radial diameter and flattened shape as well as their slightly thicker walls. In the transverse view we see a gradual transition from earlywood to latewood. Rays appear as narrow lines extending across the growth rings at right angles. The larger, rounded openings are **resin canals** (C), which are surrounded by thin-walled **epithelial cells** (D).

In tangential view, the elongated form of the tracheids (E) is evident; their length is 75 to 100 times their diameter. We see scattered rays, which appear as vertical tiers of small, rounded cells (F); we are actually looking into the ends of them. An occasional **fusiform ray** (G) is enlarged in the central position and has a resin canal (H) running through it horizontally.

The radial view also shows the elongated shape of the tra-

PRINCIPAL SURFACES OF EASTERN WHITE PINE

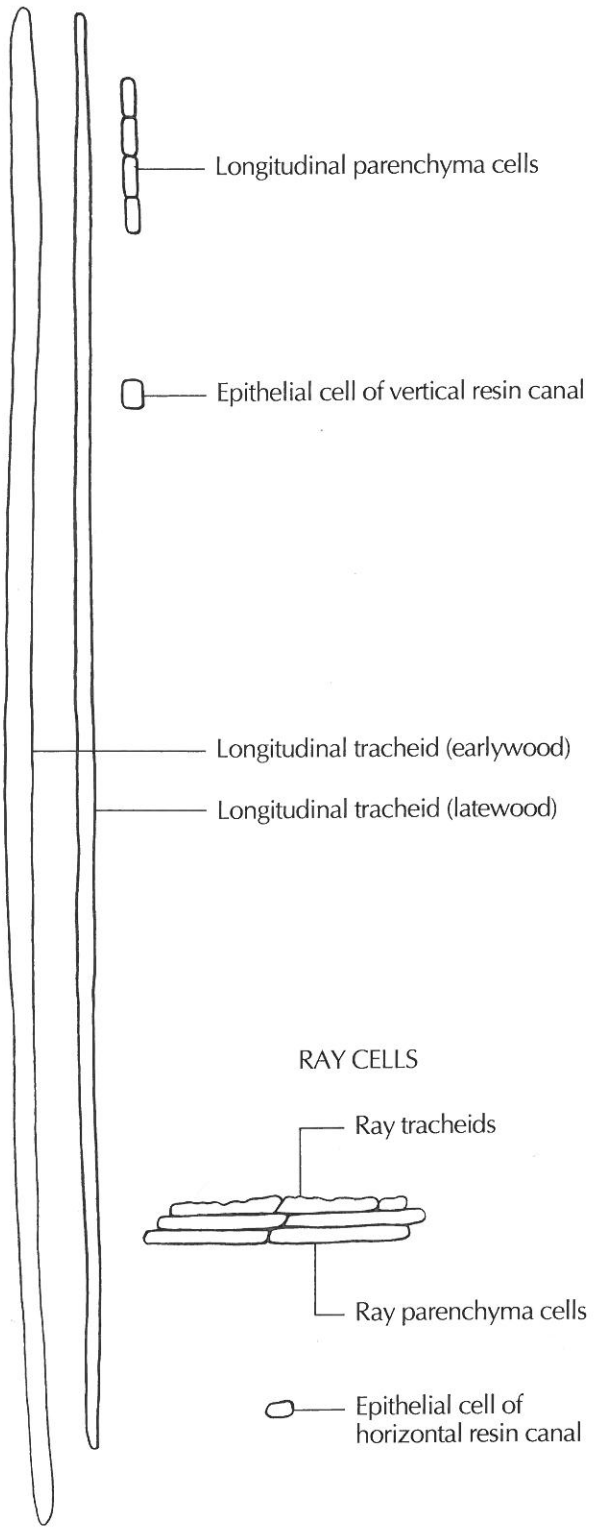
Cross-sectional (X), radial (R) and tangential surfaces of eastern white pine. The cube in the center has been magnified 25 times with an electron microscope. The large circular insets show typical hand-cut sections of these three surfaces magnified 75 times with a standard microscope. The small inset at the bottom shows the radial surface magnified 200 times. The letters correspond to features described in the text.



Center photo by Wilfred Côté

CONIFER CELL TYPES

This diagram shows the relative sizes and shapes of longitudinal cells and ray cells in conifers.



cheids. We see a ray (I) composed of seven rows of ray cells — both ray tracheids and ray parenchyma — that has been split by the sectioning. Where the ray parenchyma cells cross the longitudinal tracheids, rounded windowlike pitting occurs (J). The upper and lower rows of ray cells are ray tracheids (K).

These characteristics of eastern white pine are typical, in a general way, of most conifers. However, there are some specific points of variation as well as additional features in other conifers, and these are what provide a basis for species separation.

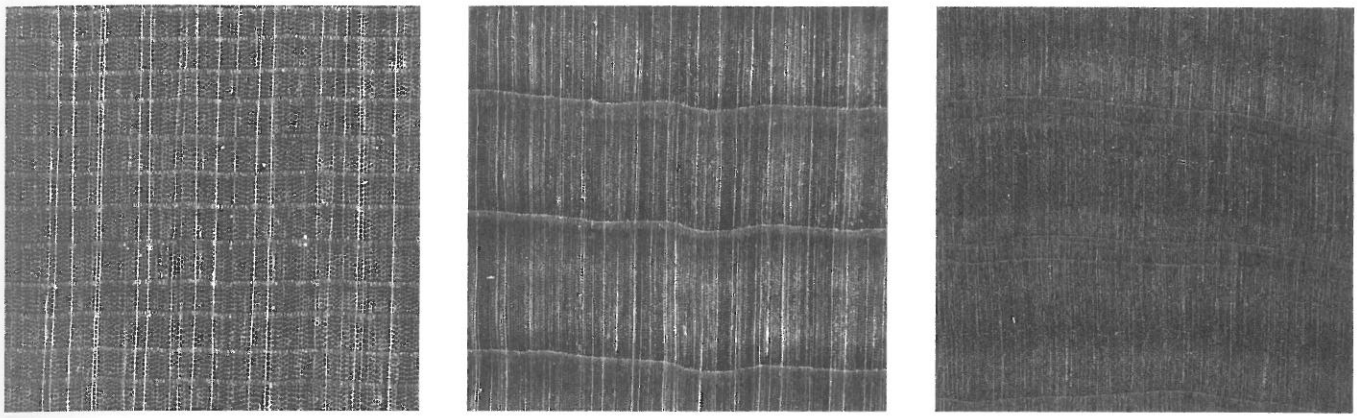
Tracheids and Texture

Although the general shape and proportions of longitudinal tracheids among conifers are so similar that they are of little value in identification, the actual dimensions can be valuable. Tracheid length is very difficult to measure in solid wood or in sections, so it is not often used in identification. But tracheid diameter is very informative since it has a bearing on the texture of softwoods (see the photos on the facing page).

The radial diameter varies with the tracheids' position in the growth ring, but the tangential diameter remains fairly constant and is therefore a useful identification feature. Among coniferous woods, tracheid diameter provides a basis for judging the coarseness or fineness of the wood's texture. The larger the tracheid diameter, the coarser the texture. Table 3.1 lists typical tracheid diameters for various conifers, and enables you to correlate the texture of a sample with a certain group of softwoods.

For example, eastern redcedar, with its small-diameter tracheids, is fine-textured. But redwood, at the opposite extreme, is coarse-textured. Douglas-fir and western redcedar fall in the middle. With a little practice, you will learn to estimate coarse, medium and fine textures. It is useful to have a set of labeled wood samples to help calibrate your eye. Sources for such sets are listed in Appendix V.

When transverse surfaces are viewed with a hand lens, individual tracheids can usually be seen clearly in coarse-textured species; they are virtually invisible in fine-textured woods. Just how "invisible" they are is subjective — it depends on your eyesight. Most people can see tracheids clearly in baldcypress, just barely in white pine and not at all in redcedar. How well you can see and judge texture with a hand lens also depends on how well you cut the transverse surface (this is discussed in Chapter 7). A microscope fitted with measuring scales can also be used to determine texture by measuring tracheid diameters directly.

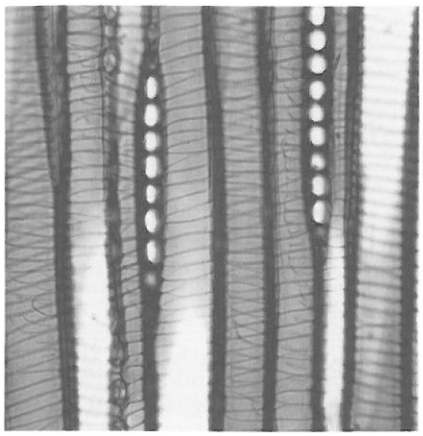


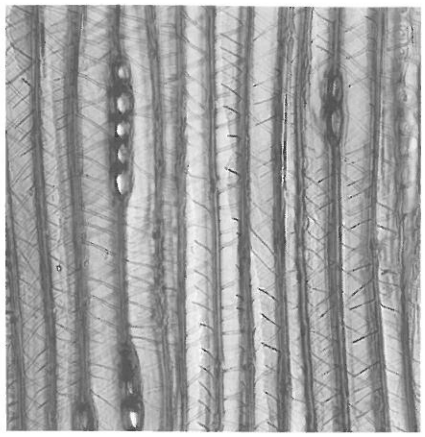
TEXTURE IN CONIFERS
In conifers, 'texture' is a measure of relative tracheid diameter. In redwood (left), a coarse-textured conifer, individual tracheids are distinct when viewed with a hand lens. In a medium-textured wood, such as western redcedar (center), tracheids are barely discernible, and in fine-textured woods, such as eastern redcedar (right), individual tracheids cannot be seen clearly.

TABLE 3.1: DIAMETERS OF LONGITUDINAL TRACHEIDS IN VARIOUS SOFTWOOD SPECIES

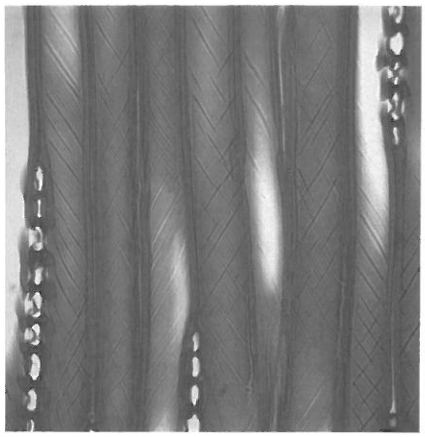
Scientific Name	Common Name	Tracheid dia.*
Abies	(true) fir	
A. amabilis	Pacific silver fir	40-60
A. balsamea	balsam fir	30-50
A. concolor	white fir	35-50
A. lasiocarpa	subalpine fir	35-45
A. magnifica	California red fir	35-45
A. procera	noble fir	40-60
Chamaecyparis	white-cedar	
C. lawsoniana	Port-Orford-cedar	35-50
C. nootkatensis	Alaska-cedar	25-40
C. thyoides	Atlantic white-cedar	25-40
Juniperus virginiana	eastern redcedar	20-35
Larix	larch	
L. laricina	tamarack	30-45
L. occidentalis	western larch	40-60
Libocedrus decurrens	incense-cedar	35-50
Picea	spruce	
P. engelmannii	Engelmann spruce	25-35
P. glauca	white spruce	25-35
P. mariana	black spruce	25-30
P. rubens	red spruce	25-35
P. sitchensis	Sitka spruce	35-55
Pinus	pine	
P. albicaulis	whitebark pine	20-35
P. contorta	lodgepole pine	35-55
P. echinata	shortleaf pine	35-60
P. elliottii	slash pine	40-60
P. lambertiana	sugar pine	40-65
P. monticola	western white pine	35-60
P. palustris	longleaf pine	35-60
P. ponderosa	ponderosa pine	35-60
P. resinosa	red pine	30-45
P. strobus	eastern white pine	25-45
P. taeda	loblolly pine	35-60
Pseudotsuga menziesii	Douglas-fir	35-55
Sequoia sempervirens	redwood	50-80
Sequoiadendron giganteum	giant sequoia	45-60
Taxodium distichum	baldcypress	45-70
Taxus brevifolia	Pacific yew	15-25
Thuja	thuja	
T. occidentalis	northern white-cedar	20-35
T. plicata	western redcedar	30-45
Tsuga	hemlock	
T. canadensis	eastern hemlock	30-45
T. heterophylla	western hemlock	30-50

* Approximate range in micrometers
(1 micrometer = 1μm = 0.001 mm)





SPIRAL THICKENINGS
In Douglas-fir (left), which has resin canals, spiral thickenings are nearly perpendicular to the tracheid axis. In yew (right), which lacks resin canals, spiral thickenings form a less regular pattern and a steeper spiral. (200x)



SPIRAL CHECKING
The spiral checking in the longitudinal tracheids of this eastern white pine sample is associated with reaction wood. (200x)

Spiral Thickenings

Because tracheids are conductive cells, they are devoid of contents and usually have relatively smooth inner walls. In a very few conifer species, however, their walls have **spiral thickenings** (see the photos above). These thickenings are visible only with a microscope, appearing in radial or tangential section as fine-lined, helically arranged ridges.

This feature is found in only two conifers, so its presence is important in identifying them. Spiral thickenings in conjunction with resin canals indicate Douglas-fir; spiral thickenings in the absence of resin canals indicate yew.

Spiral Checking

Spiral checking (see the photo above right), also seen in some tracheids, refers to the minute separations or checks that may appear in tracheid walls. They are seen microscopically as helical lines. Because spiral checking occurs among a variety of conifers, it is not particularly useful as an identification feature; it is mentioned here to avoid confusion with spiral thickenings.

Spiral checking can result from severe seasoning stresses and is most common in conifers with thick-walled tracheids; it is also associated with an abnormality known as reaction wood, which is described in Chapter 6. Spiral checks follow the cellulose orientation in the tracheid walls and are oriented at an angle of 45° or less with the tracheid axis. Note that the spiral thickenings in the photos above are more nearly perpendicular to the tracheid axis than the spiral checking in the photo above right — this will help you tell the two apart.

Pits and Pit Pairs

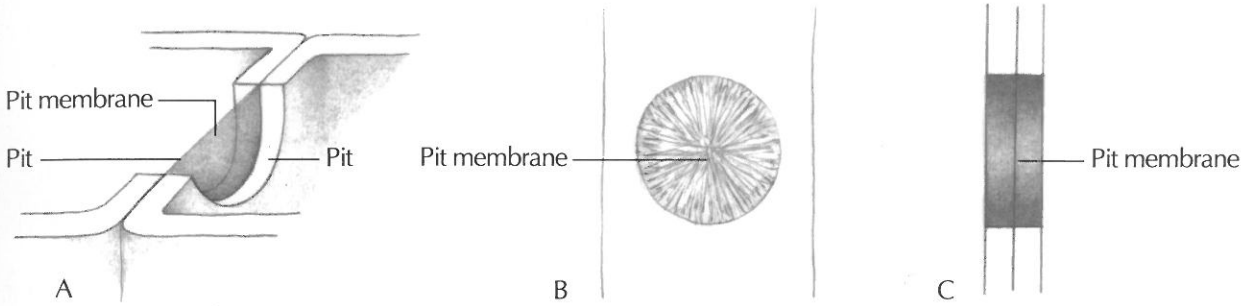
Voids in the secondary walls of cells are called **pits**. A pit in one cell occurs opposite a pit in an adjacent cell, forming a **pit pair**. The pits of a pair are separated by a sievelike **pit membrane**, which is the remnant of the original primary walls of the cells before the secondary wall was added. Pit pairs are the principal avenues through which fluids pass from cell to cell. When seen under a microscope, the face view of these pits (and sometimes the section view) can be extremely telling in identification.

If the pit looks like a plug removed from the cell wall, it is called a **simple pit.** Pits found in the walls of longitudinal or ray parenchyma cells in conifers are usually simple pits. Pits in tracheids have more elaborate, domelike shapes and are called **bordered pits.**

Bordered pits are abundant along the radial walls of coniferous tracheids. They look like circular targets or doughnuts when viewed radially. Since they are always present, their occurrence is not helpful for identification. But the number of these pits across a radial wall of earlywood tracheids can be very meaningful (see the photos on the facing page). For example, in larch, pits are commonly paired; in spruce, they are usually single; and in redwood and baldcypress, there may be up to four pits.

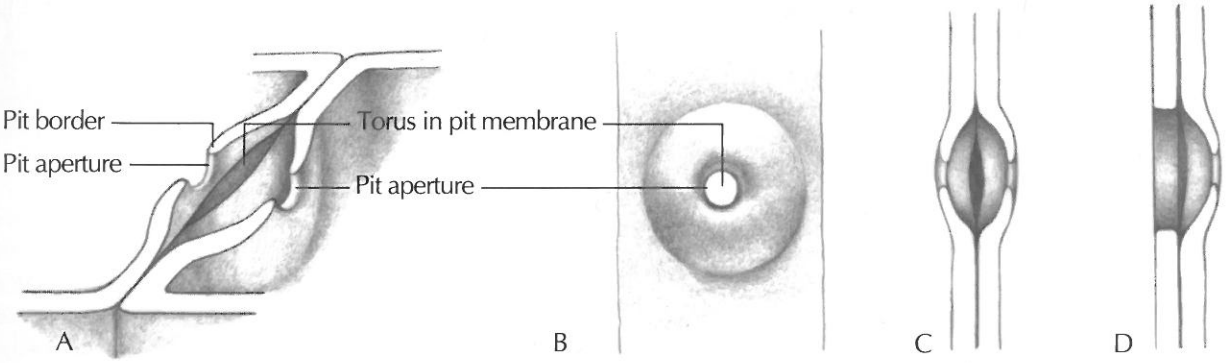
SIMPLE PITS

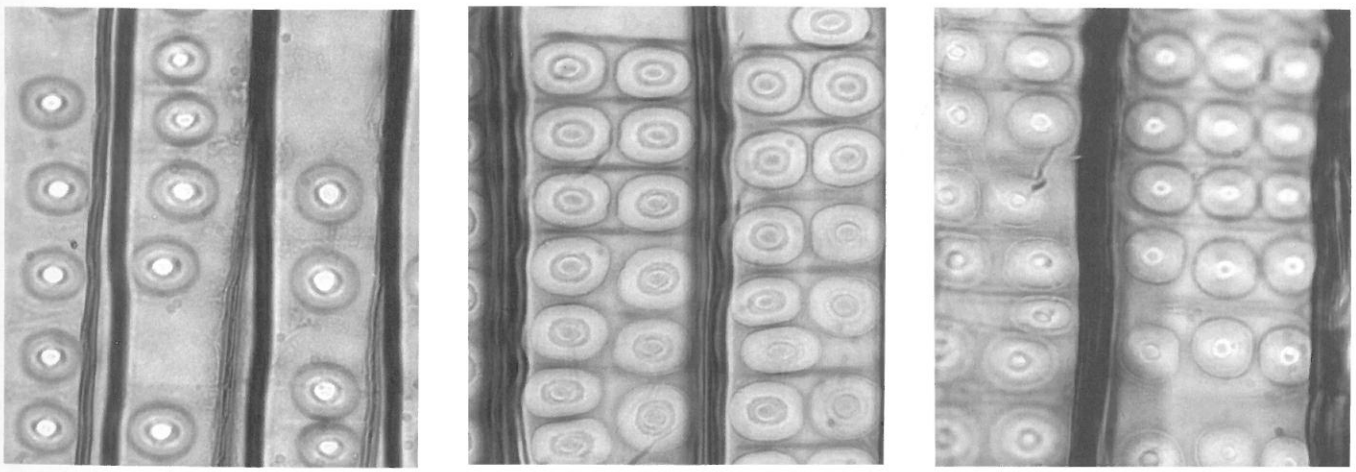
In this pair of simple pits of two adjacent cells (A), each simple pit is a more or less uniform-diameter void in the walls. In face view (B), we see the pit in outline. In sectional view (C), the pit membrane may be visible.



BORDERED PITS

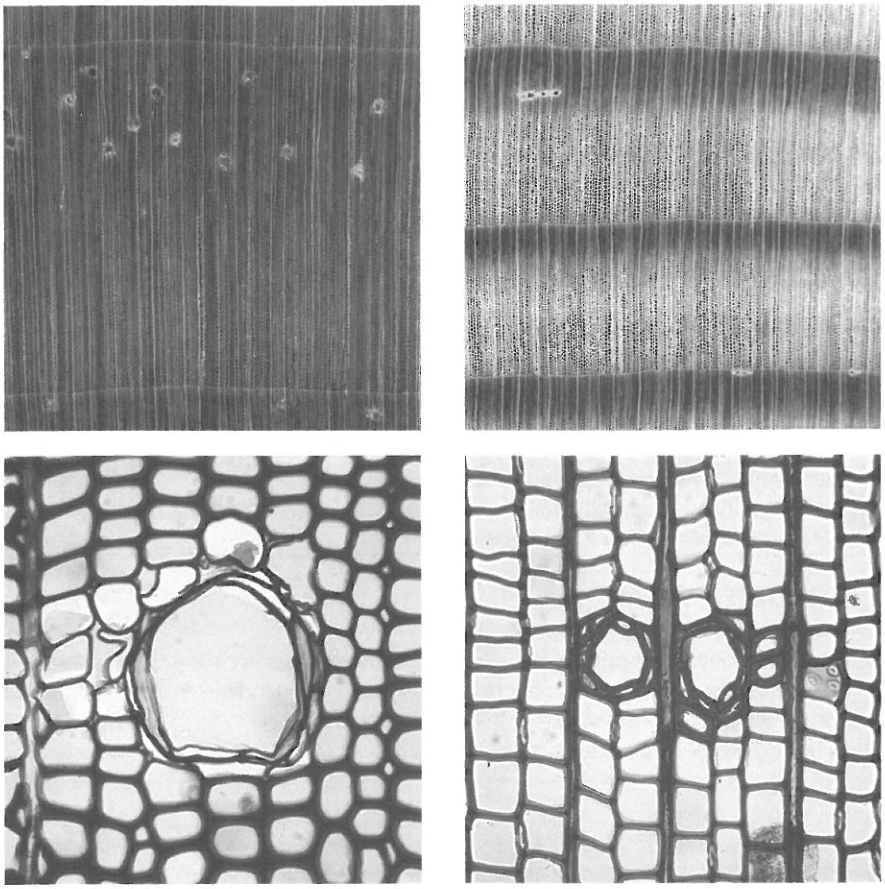
These bordered pit pairs typically form between two coniferous tracheids (A). In face view (B), they appear as doughnutlike structures. In sectional view (C), the domed borders are apparent. A half-bordered pit pair (D) is found where a bordered pit joins with a simple pit.





RADIAL WALL PITTING IN EARLYWOOD TRACHEIDS

The number of bordered pits across the radial wall of earlywood tracheids has some diagnostic value. For example, in spruce (left) there is rarely more than one bordered pit, whereas in larch (center), pits are commonly paired. In redwood (right), as many as four bordered pits may occur. (450x)



RESIN CANALS
In pines (top row, left [10x]), resin canals are usually larger, numerous and quite evenly distributed, occurring singly; the epithelial cells (bottom row, left [200x]) are thin-walled. In Douglas-fir (top row, right [10x]), spruces and larches, resin canals are usually smaller, fewer in number and erratically distributed, occurring singly or in tangential groups of four to several; the epithelial cells (bottom row, right [200x]) are thick-walled.

Resin Canals

Resin canals are tubular passages in wood that are actually intercellular spaces surrounded by special parenchyma cells called **epithelial cells**. The epithelial cells exude **pitch** or **resin** into the canals. The canals apparently serve a protective function for the tree by exuding pitch to seal off wounds caused by mechanical damage or boring insects. Resin canals occur in all species of four genera within the family *Pinaceae:* pines (*Pinus* spp.), spruces (*Picea* spp.), larches (*Larix* spp.) and Douglas-fir *(Pseudotsuga menziesii),* as shown in the photos above.

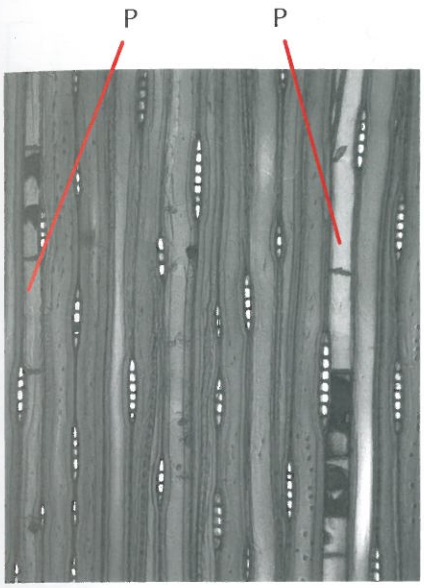
The presence of resin canals provides an initial basis for separating the pines, spruces, larches and Douglas-fir from the balance of the conifers. In some species, resin canals are readily visible with the naked eye, but the smallest resin canals in other species can be seen only with hand-lens magnification.

In pines, resin canals are relatively large and numerous. They are usually present in all growth rings and are evenly distributed throughout the rings. They tend to occur singly, and, as can be seen microscopically, they have thin-walled epithelial cells. These cells sometimes bulge out and seem to block or fill the resin canal. Such protrusions are called tylosoids. Thin-walled epithelial cells are easily damaged during sectioning of a sample and therefore may not be clearly defined when viewed microscopically.

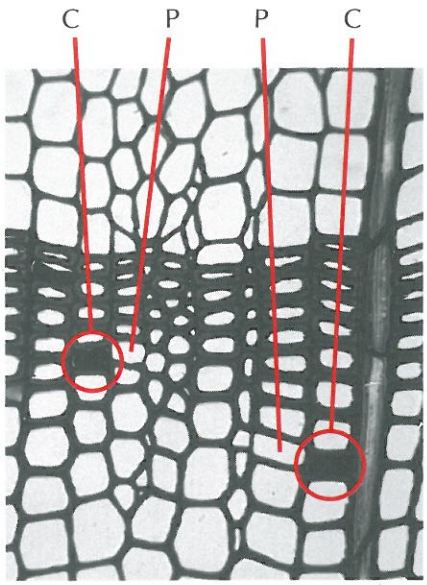
In spruces, larches and Douglas-fir, the resin canals are smaller, fewer and less uniformly distributed. They may appear to be absent from some growth rings. They commonly occur in groups of two to several, arranged tangentially to one another. As seen with a microscope, the epithelial cells are thick-walled and usually distinct.

The appearance of resin canals is variable, and, consequently, so is one's ability to locate them. Some caution is in order here. Their distinctness depends not only on size, but also on the condition of the pitch or resin within them. When a resin canal is empty, it appears as a minute pinhole in transverse view. In some instances, however, the canal is filled with yellowish or amber resin in a liquid state. In other instances, the resin may permeate surrounding tracheids or migrate onto the adjacent wood surface and produce dark spots far larger than the resin-canal diameter. This is easy to see but can be very misleading.

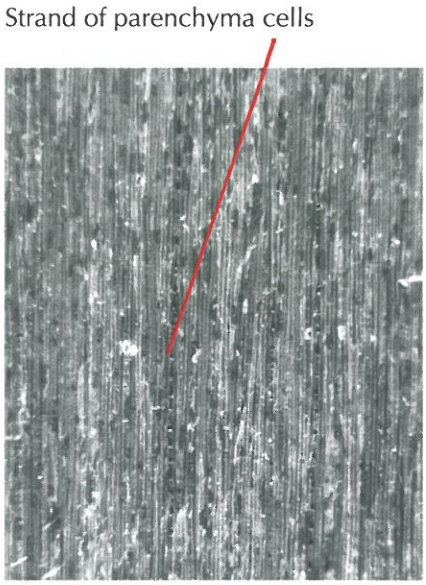
In still other cases, the resin forms sugary crystals in the canal and appears as white or yellow specks. I have the greatest difficulty finding resin canals in certain pieces of eastern spruce, where even with a hand lens the canals often appear only as scattered white specks, barely distinguishable from cutting debris and dust particles. One trick that helps in deciding whether or not a doubtful speck is a resin canal is to slice a new section from the same area (the method for doing this is de-



PARENCHYMA CELLS: LONGITUDINAL VIEW
Longitudinal parenchyma cells are of approximately the same cross-sectional dimensions as the surrounding longitudinal tracheids, but are short and occur in strands. Cross walls clearly separate them, and darkened contents also help make them visible. (50x)



PARENCHYMA CELLS: CROSS-SECTIONAL VIEW
In cross section, longitudinal parenchyma cells can be distinguished by their thin walls (P) and, in some cases, by their dark cell contents (C). (100x)



PARENCHYMA CELLS: LONGITUDINAL VIEW WITH HAND LENS
When longitudinal parenchyma cells are abundant, as in redwood, the strands of cells are just barely visible with a hand lens on split longitudinal surfaces. They appear as minute dashed lines due to the dark contents in the cells.

scribed in Chapter 7). If the speck disappears, it was a dust particle. But if it is a resin canal, it will still be in the same location after the next cut.

Longitudinal resin canals show up to varying degrees on radial and tangential surfaces. Their clarity depends on how closely the plane of the cut coincides with the axis of the canal, the size of the canal and the color and condition of the canal's contents. In species like soft pines, particularly sugar pine, they appear as distinct dark-brown lines; in spruce, they are either invisible or show only as fine, faint yellow lines.

Smaller transverse resin canals located within certain rays are also found in those species that have normal longitudinal resin canals. Transverse resin canals are discussed below under rays.

Finally, it should be noted that resin canals occasionally form as a response to environmental stress or injury in species that normally do not have them. These are called **traumatic resin canals**. They appear in transverse view as a single continuous line extending for a considerable distance along a growth ring, and are usually absent elsewhere. They are very small, barely larger than the tracheid diameter. Fortunately, they are rare and should cause little confusion since they are easily recognized and so different from normal resin canals.

Longitudinal Parenchyma

Although almost all longitudinal cells in conifers are tracheids, a few cells in certain species are longitudinal parenchyma. These cells have about the same cross-sectional dimensions as tracheids, and therefore are not individually distinct to the unaided eye. Viewed microscopically in longitudinal section, parenchyma cells are relatively short and occur in vertical series or strands — hence the term **strand parenchyma**.

In longitudinal (either radial or tangential) section (see the photo above left) parenchyma cells are easily distinguished microscopically because of their cross walls. In cross section (above center) they are about the same size as tracheids, but are always thin-walled, whereas tracheids can be thin- to thick-walled.

In sapwood, the parenchyma cells are alive and have cell contents. When the transition to heartwood occurs and the cells die, they often retain enough contents to fill the cell cavity partially or completely. The contents may also appear as scattered globules. The contents range in color from yellow to orange, red or amber, or they can be opaque.

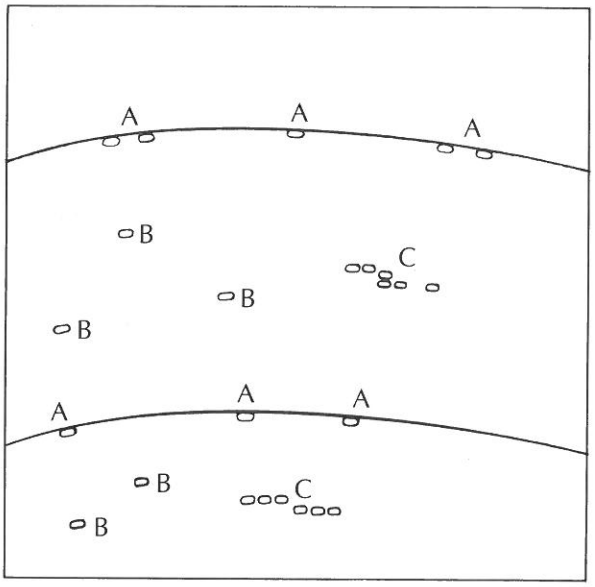
Microscopically, contents may cause parenchyma cells to appear as darkened cells. With a hand lens, they are seen in coarse-textured woods like redwood and baldcypress (above right) as fine, dark, broken lines on longitudinal surfaces. These lines are a series of the same darkened individual cells that are visible through the microscope.



NODULES
Nodules appear in association with simple pitting on the end walls of longitudinal parenchyma in tangential view in some species, such as the baldcypress shown here. (300x)

PARENCHYMA CELLS: CLASSIFICATION OF ARRANGEMENT

Parenchyma arrangement is described according to the placement of the parenchyma within the growth ring, as shown in these cross-sectional views. Parenchyma at the growth-ring boundary (A) is termed marginal or terminal parenchyma. If it occurs singly within the ray (B), it is called diffuse parenchyma, and if it is concentrated in a tangential arrangement (C), it is referred to as metatracheal or zonate parenchyma.



Simply noting the presence or absence of longitudinal parenchyma cells assists in identification; sometimes estimating their number is of value. For example, they are absent in the genera *Pinus* and *Picea*, but they are always abundant in *Sequoia* and *Taxodium*. In other genera they occur to varying degrees, consistently in some, sporadically in others.

Noting their position and distribution within the growth ring as seen in cross section is also very helpful, as shown in drawing above. We use the term **diffuse** to describe single cells that are scattered throughout the growth ring. **Terminal** or **marginal parenchyma** denotes cells that are located at the growth ring boundary. And **zonate parenchyma** are cells that are numerous enough in one area of the growth ring to be obvious.

The abutting horizontal walls of adjacent longitudinal parenchyma cells within a strand sometimes show pronounced simple pit pairs. Where multiple pairs occur, as viewed microscopically in tangential section, the remaining walls may appear as bumps in the cross wall. These are known as **nodular end walls,** or nodules (see the photo above).

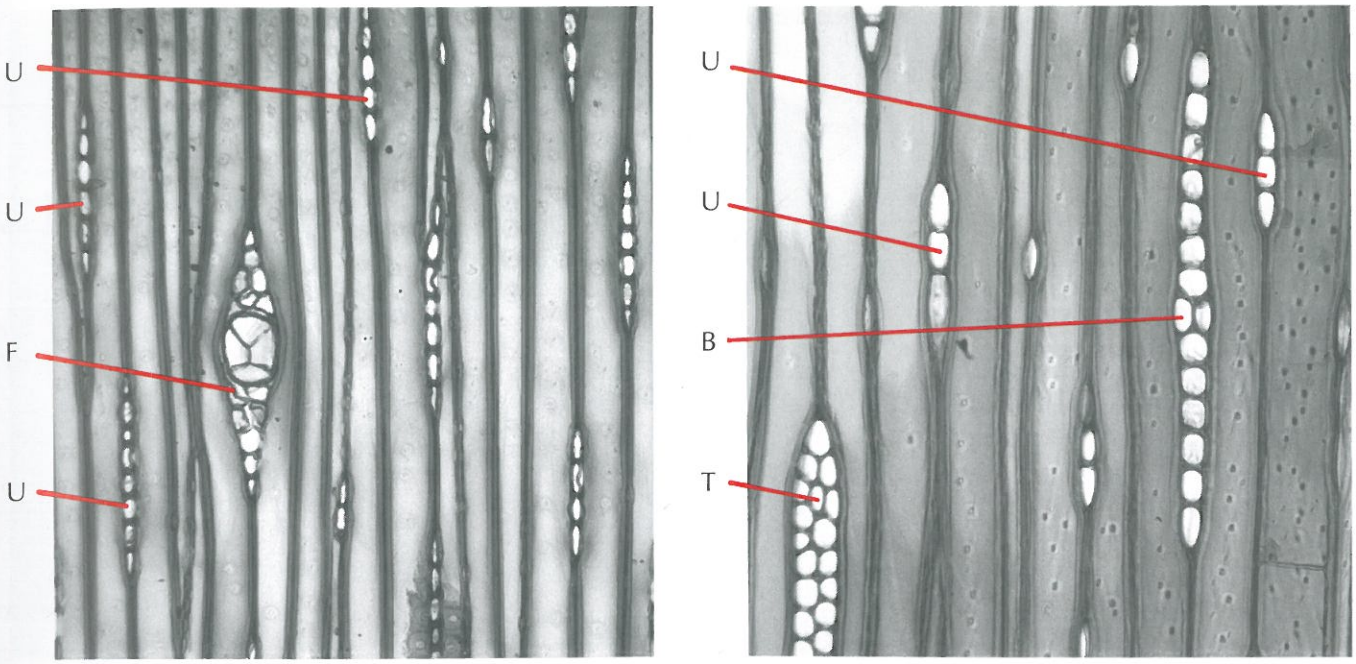
Nodules are useful in identification. Their presence in baldcypress, for example, distinguishes it from redwood, whose longitudinal parenchyma cross walls lack nodular thickenings. Determining microscopically whether nodules are present or absent can be very difficult where dark contents are present in the parenchyma cells; end walls show up much more clearly in cells whose cavities are devoid of contents.

Rays

Rays are important identification features in conifers when viewed microscopically, since magnification produces valuable information on how many cells high or wide a ray is, what type or types of cells compose the ray and what sort of pitting or sculpting is evident on the cell walls.

Seriation refers to the width of a ray as measured in cells (see the top photos on the facing page). Viewed tangentially, most rays in any conifer are **uniseriate;** that is, they consist of a single vertical tier of cells. A few species — redwood, for example — commonly have rays that are two cells wide, at least at some points along the ray. These are **biseriate** rays. Both uniseriate and biseriate rays are considered narrow rays.

The maximum height of the rays, as defined by a cell count in



RAYS: TANGENTIAL VIEW
Conifers have narrow rays that are mostly uniseriate (U), that is, one cell wide, as seen in these tangential views. But occasionally the rays are biseriate (B) or triseriate (T). Species that have resin canals have fusiform rays (F), specialized rays that contain horizontal resin canals. (150x)

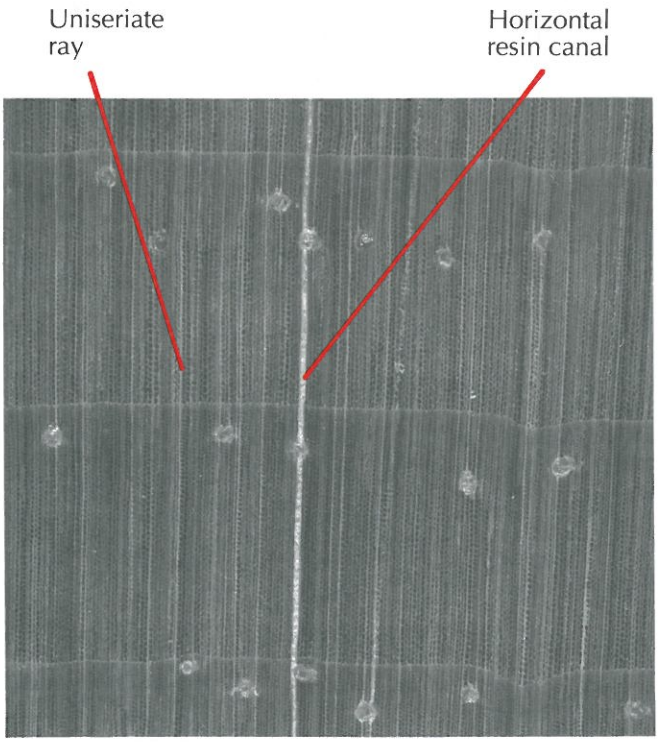
tangential section, also helps identify the wood. Species that have normal longitudinal resin canals also have horizontal resin canals; these small canals occur in the middle of specialized rays called **fusiform rays** (F in the photo above left).

As with vertical resin canals, the epithelial cells surrounding horizontal resin canals are either thin-walled, as in pines, or thick-walled, as in spruces, larches and Douglas-fir.

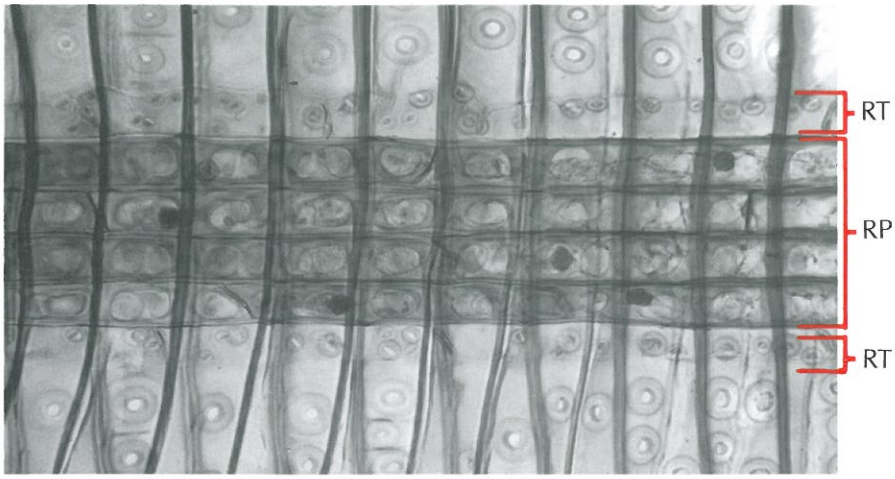
On a transverse surface as viewed with a hand lens, a sectioned horizontal canal in a fusiform ray will stand out as a bright yellow or white line (photo at right). Fusiform rays are often similarly apparent on radial surfaces, as long as the cuts are precisely radial. Generally these rays are invisible with a hand lens on tangential surfaces, although in soft pines, where they are larger, they may appear as minute dark specks.

Fusiform rays are extremely valuable as microscopic identification features. For example, a sliver of wood might not show any longitudinal resin canals with the eye or hand lens. But finding a fusiform ray on a tangential section with the microscope would indicate that the wood was one of the four genera of *Pinaceae* that do have normal longitudinal resin canals. Evaluating the thickness of the walls in epithelial cells would immediately place the unknown sample into either the pine or the spruce-larch-Douglas-fir group.

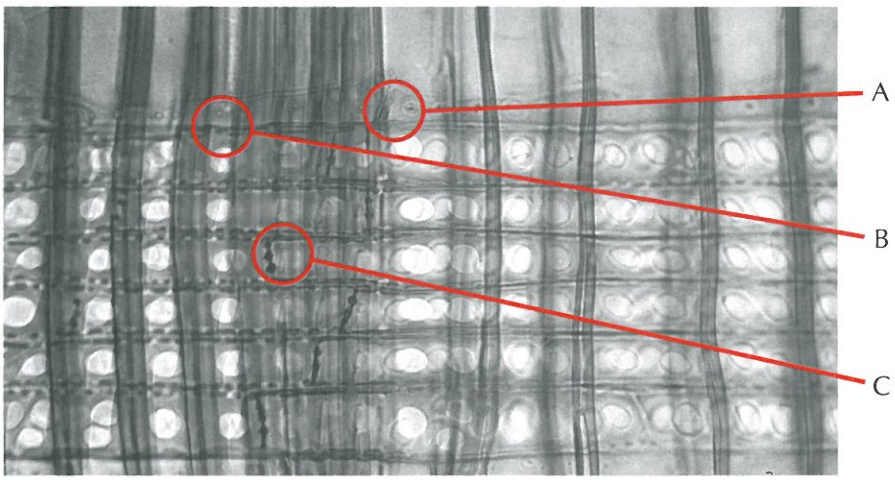
Most narrow rays contain two types of cells, **ray tracheids** and **ray parenchyma**. Typically, the ray parenchyma is in the central portion of the ray and the ray tracheids are in one or more rows along the upper and lower margins of the ray. But ray tracheids may also occur in the central portion of the ray.



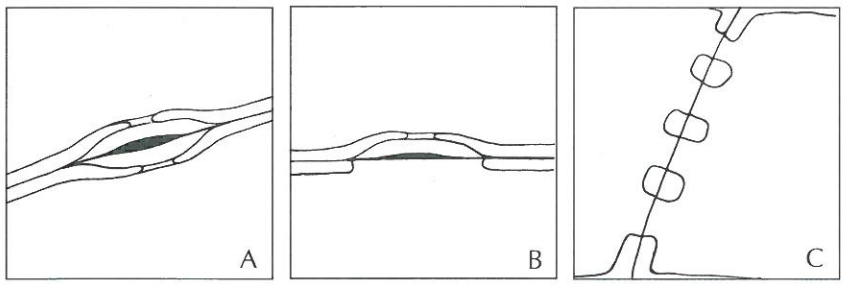
HORIZONTAL RESIN CANALS
A fusiform ray in this cross-sectional view of eastern white pine has been sectioned through its horizontal resin canal. The fusiform ray shows as a conspicuous radial line, distinct from the barely visible uniseriate rays. (15x)

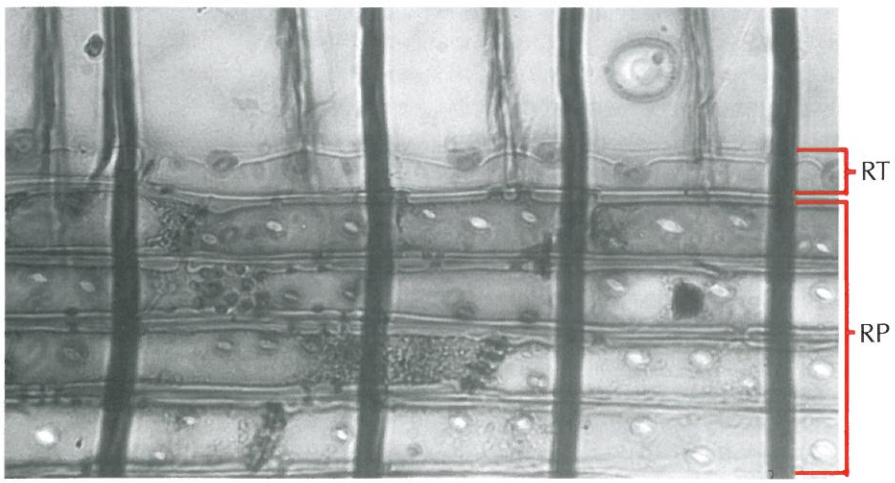


HETEROCELLULAR RAYS
Heterocellular or heterogeneous rays are rays that are composed of both ray tracheids (RT) and ray parenchyma (RP), as seen in this radial view of eastern white pine. (250x)

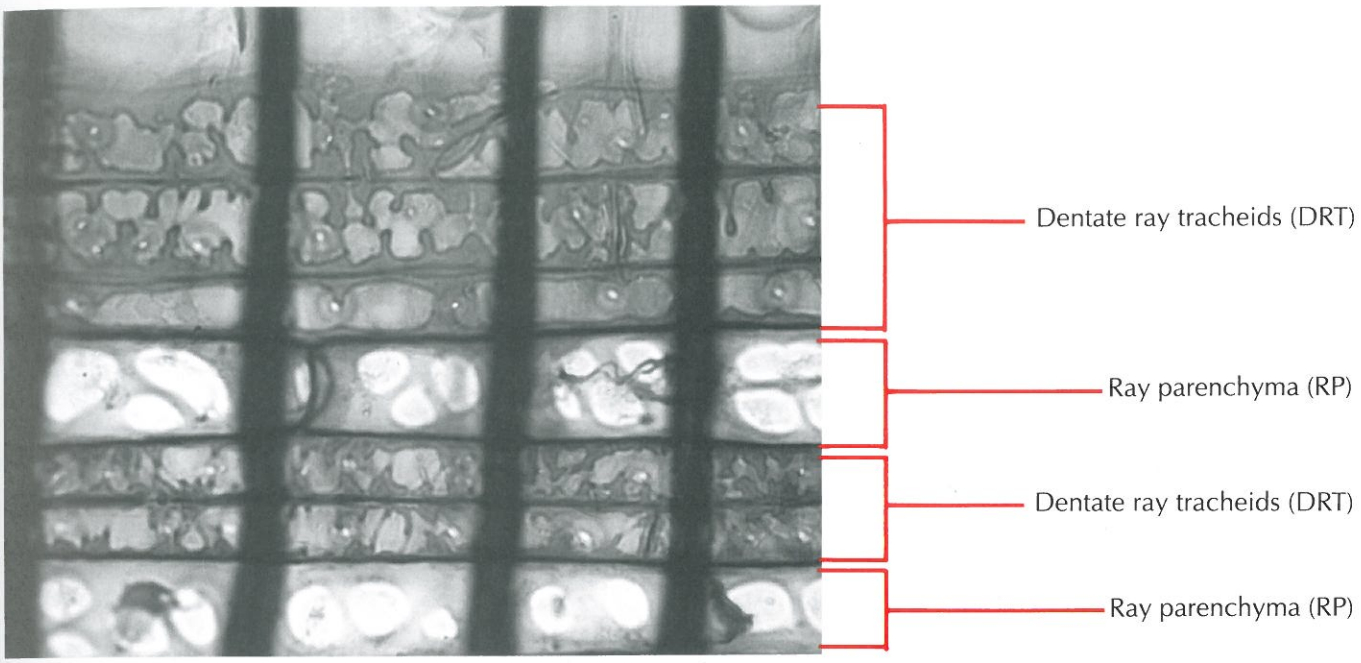


RAY CELL PITTING
Ray tracheids can be distinguished by the bordered pit pairs (A) that separate adjacent cells. Half-bordered pit pairs (B) occur between ray tracheids and ray parenchyma. Simple pit pairs (C) are found between ray parenchyma cells. (250x)





NARROW RAY TRACHEIDS IN HEMLOCK
In hemlock, ray tracheids (RT) may be difficult to see, sometimes appearing only faintly compared with ray parenchyma cells (RP). (550x)



DENTATE RAY TRACHEIDS IN HARD PINES
In hard pines, ray tracheids have jagged inner walls and are called dentate ray tracheids (DRT). Ray parenchyma (RP) are also visible. (600x).

A ray with both types of cells is **heterocellular** or **heterogeneous** (facing page, top photo). A ray composed of either ray tracheids or ray parenchyma is **homocellular** or **homogeneous**. Some species, such as true firs and cedars, have only homogeneous parenchyma rays. Alaska yellow cedar has homogeneous rays composed of either all ray parenchyma or all ray tracheids.

Ray tracheids are distinguished by their bordered pits (facing page, center photo). In radial view, where rays cross longitudinal tracheids, small, rounded bordered pits can be seen. At abutting end walls, bordered pit pairs can be seen in section. Ray tracheids at the ray margin may be exceptionally narrow, irregular along the outer edge or very faint (facing page, bottom photo).

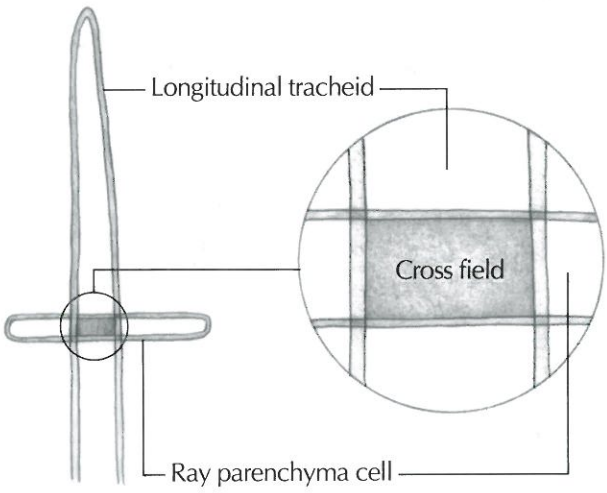
In most species ray tracheids are smooth-walled. In the hard pines, however, ray tracheids have irregular walls. In radial view these tracheids have toothlike projections and are consequently called **dentate ray tracheids** (photo above).

Ray parenchyma cells have simple pits. Viewed radially, these pits are sometimes evident along horizontal walls or on end walls. Where multiple simple pits occur on the end walls of ray parenchyma cells, the cell wall remnants may appear knobby and are called nodules.

An important identification feature in conifers is the pitting that occurs between ray parenchyma cells and earlywood longitudinal tracheids. As viewed radially at higher magnifications, the common wall between these cells is delineated above and below by the horizontal walls of a ray parenchyma cell, and along the sides by the lateral walls of the longitudinal tracheid. This area of pitting is called a **cross field** or **ray crossing**.

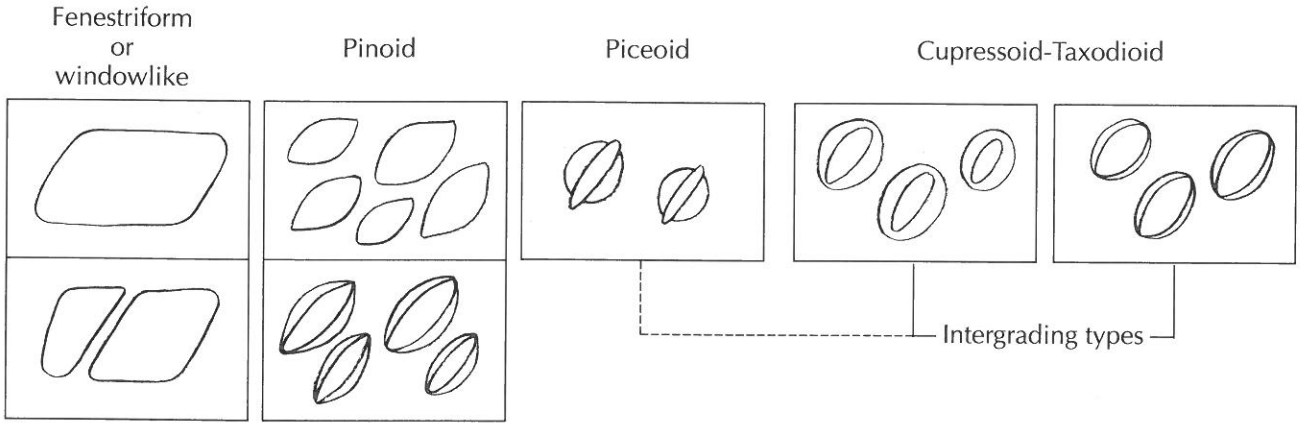
CROSS FIELD

The common wall joining a ray parenchyma cell and an earlywood longitudinal tracheid, as seen in radial view, is called a cross field or ray crossing.



TYPES OF CROSS-FIELD PITTING

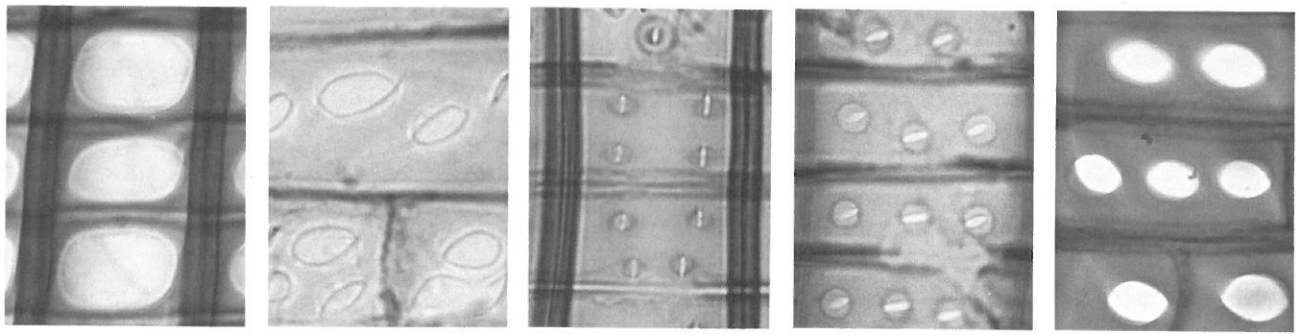
This chart summarizes the major classifications of cross-field pitting types. There is considerable intergrading between taxodioid and cupressoid pitting and, to some extent, between piceoid and cupressoid pitting. The photos show radial views.



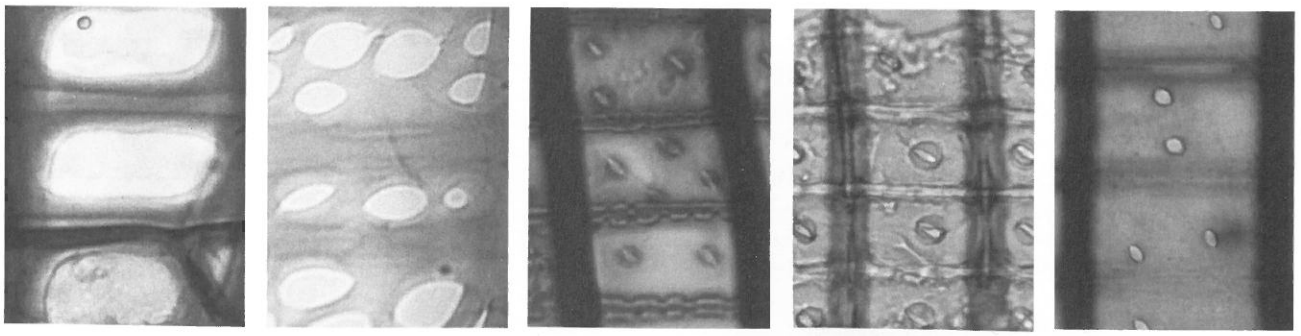
SPECIES WITH RESIN CANALS

SPECIES LACKING RESIN CANALS

Soft pines Red pine Scots pine	Hard pines (other than red pine and scots pine)	Spruce Larch Douglas-fir		
Windowlike	Pinoid	Piceoid	Cupressoid	Taxodioid



EASTERN WHITE PINE (750x) | SOUTHERN YELLOW PINE (750x) | EASTERN SPRUCE (750x) | INCENSE-CEDAR (750x) | REDWOOD (750x)



RED PINE (750x) | SHORTLEAF PINE (750x) | RED SPRUCE (750x) | EASTERN REDCEDAR (750x) | WHITE FIR (750x)

TABLE 3.2: SUMMARY CHECKLIST OF ANATOMICAL FEATURES FOR SOFTWOOD IDENTIFICATION

Sapwood/Heartwood:
- Color/visual contrast
- Width of sapwood

Growth Rings:
- Width (rate of growth)
- Evenness of grain
- Abruptness of earlywood-to-latewood transition

Tracheids:
- Diameter/texture
- Radial wall pitting

Resin Canals:
- Present/absent
- Size
- Number/distribution
- Epithelial cell wall thickness

Longitudinal Parenchyma:
- Present/absent
- Abundance
- Plain/nodular end walls
- Contents
- Location:
  - Terminal or marginal
  - Diffuse
  - Metatracheal or zonate

Rays:
- Height
- Seriation
- Homocellular or heterocellular
- Fusiform rays:
  - Present/absent
  - Epithelial cell walls: thick or thin
- Ray tracheids:
  - Smooth or dentate
- Ray parenchyma:
  - Cross-field pitting: windowlike, pinoid, piceoid, cupressoid or taxodioid
  - End walls: smooth or nodular
  - Contents

Latewood tracheids are narrow in radial diameter and therefore form narrow cross fields. To evaluate the cross-field pitting types discussed below, cross fields formed at earlywood tracheids should be examined. The drawing on the facing page shows the various types of cross-field pitting found in coniferous woods. As you will see, cross-field pitting can be an extremely important feature for identifying softwoods.

Generally speaking, **fenestriform** or **windowlike pitting** is seen in soft pines and red pine, **pinoid pitting** in hard pines, **piceoid** or **piciform pitting** in spruces, larch, and Douglas-fir, **cupressoid pitting** in hemlock and cedars (except *Thuja*) and **taxodioid** pitting in redwood, firs, *Thuja* and cypress. Among the last three types, pitting is not consistent for every sample of certain species.

Fenestriform and pinoid pitting are relatively easy to discern. Pinoid pitting is made even easier to recognize by the fact that it occurs only when dentate ray tracheids are also present. But the other three types—piceoid, cupressoid and taxodioid—are smaller and more difficult to see, and they intergrade with one another. You should consider them in conjunction with other features. For example, piciform pitting is associated with three genera that also have resin canals; cupressoid and taxodioid pitting is associated with species that usually have fairly abundant longitudinal parenchyma. Cupressoid and taxodioid pitting are the most confusing.

Summary

Although the softwood features that you observe with your eye and hand lens will help suggest some of the possibilities for identification, there are only a few species that can be identified consistently without microscopic examination. Any serious involvement with softwood identification requires microscopic examination. And, as you shall see later in the softwood identification section, even microscopy will fail to separate all species of certain softwood genera.

The checklist at left summarizes what we have just covered on softwood identification.