CHAPTER 4 : BARK ON BRANCHES OF SOME COMMON NORTH AMERICAN, NORTH WEST COAST GYMNOSPERMS (CONIFERS)USED IN ETHNOGRAPHIC ARTIFACTS. FIG. 4.1A- 4.7C

4.1 Introduction

The following text and illustrations are a guide of the anatomy of barks on branches of some common North West Coast (NWC), coniferous gymnosperm. An introduction to branch bark anatomy is presented in Chapter 3.

Coniferous branches of many species had many ethnological uses. Branches were used; in making withes for weaving and basketry; for flooring; preparations in cooking; in construction of fishing weirs and fish drying frames; in collecting herring spawn in waters; and many other utilitarian purposes. In some branches the bark may remain. If so, it could assist in identification of the branch species. The information of the species is of curatorial significance and the anatomy and inherent weaknesses significant for conservators. Knowing the bark anatomy will help identify the plant part as well as species of deteriorated archaeological woody fragments.

There are reports of traditional use of specific species of branches used in specific artifacts. It would not be surprising if nearby available endemic species were also commonly used. Species identification would assist in such cases.

In the anatomy of barks of the coniferous branches species the same tissues are present but in different amounts and cell shapes. In the terminology of bark, the colloquial terms inner and outer bark are used. The outer bark includes the epidermis and periderm and the inner bark the phloem. Fig.4.1a is an example of bark, seen in the cross section, of the branch of Pacific silver fir (A*bies amabalis*) starting from the outside inwards: the outer bark is made up of the epidermis and the periderm; and the inner bark of phloem tissues. The periderm is made up of the outer phellem and inner phelloderm separated by a layer of a few cells of cambium called phellogen. Between the periderm and primary phloem is the cortex. Each one of the tissues has specific cell shapes.

The anatomy of bark on branches and tree trunks is different. Many of the coniferous tree trunks-not branches- for example, yellow cedar and western red cedar (WRC), produce what is called bark, but it is inner secondary phloem tissue: it is discussed in Chapter 5. On a tree trunk it starts out like the young bark but develops further with age. Mature tree trunk bark may have an extensive growth of outer phellem cells, such as in birch bark, or secondary 2nd phloem cells such as in Western Red Cedar and Yellow Cedar bark. In the latter two species, the epidermis and periderm is sloughed off with age and the remaining bark is made up of layers of disorganized phloem fibers and is called the rhytidome. It is made up of dead, rough and fragmented phloem fibers on the surface but the 2nd phloem tissue close to the vascular cambium and 2nd xylem, is still living, organized 2nd phloem. This phloem bark is discussed under 2nd phloem in Chapter 5.

The anatomy of coniferous branch bark is different from dicot branch bark (Chapter 3). In coniferous branches there is a small amount of primary and secondary phloem fibers where as in the dicot branch there is significant primary fibers bundles encircling the branch. These fibers bundle are commonly called bast fibers.

In the following examples of branch bark of some common NWC trees, the family name is presented. Also the species in the text are placed in groups of their family. In many cases specific anatomical features, such as resin canals or ducts are common in families and genera

that also assist in the identification process. Such specific anatomical features are suggested for identification. The majority of the images are from slides stained with safranin O and fast green. In taxonomic identification literature, the common morphological characteristics such as needle and cone structures are used for identification thus of no value with woody material.

4.2 *Abies amabalis* (Pacific silver fir) branch bark. Pinaceae family Figs.4.1a-c

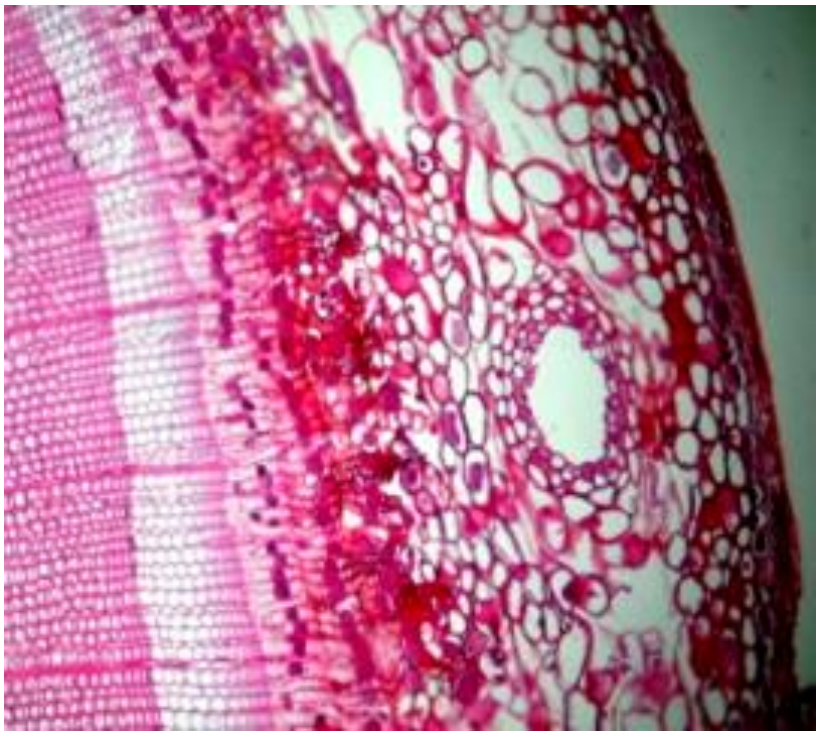


Fig.4.1a

Fig.4.1a Cross section of small branch of *Abies amabilis* showing of inner and outer bark.
PhotoMLFlorian

Fig.4.1a shows from outside right inwards: a narrow compact layer of a few layers of epidermal cells. Then a few rows of thick walled phellem cells and then an extensive region of loosely organized variable shaped cells of the phelloderm region. The phellem and phelloderm are separated by a few rows of delicate embryonic tissue the phellogen- it is too narrow to be seen. The large resin duct is in the cortex. Below the cortex are groups of dark red phloem fibers cells adjacent to the left 2nd xylem. Between these are sclereids shown under polarized light in detail in Figs. 4.1b and c. The ring of black cells is probably vascular cambium.

The elongated, oval shaped resin ducts have 2-3 layers of cells. Inner most layer is resin secretary cells. The resin duct may eventually develop into resin blisters on the outside surface of the bark; they are not axial resin canals. In *Abies* species, the 2nd xylem sap wood and dead heartwood are without axial resin canals.

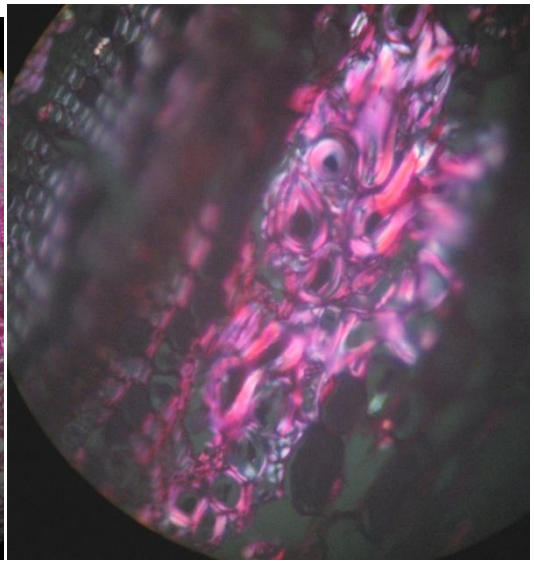


Fig.4.1b Fig.4.1c

Fig.4.1b – *Abies amabilis* cross section of branch bark under polarizing light shows a group of birefringent (shiny) irregular shaped sclereids in groups. The birefringence -bright color- is due to cellulose and lignin in the cell walls under polarizing light (see glossary). Below the 2nd phloem is a row of large cells with dark contents that may be albuminious mucus cells or cambium. PhotoMLFlorian

Fig.4.1c – *Abies amabilis* cross section at higher magnification of branch bark under polarized light showing tangled groups of irregular shaped sclereids of primary phloem origin. Their presence is a species identification characteristic. PhotoMLFlorian

The salient identifying features as shown in the Figs 4.1a-c, of the *Abies amabilis* branch bark in the cortical region are the presence of the resin ducts and tangled groups of sclereids. In archaeological water logged material the sample may not still have the orientation of the tissues but isolated groups of sclereids may be observed.

4.3 *Picea sitchensis* (Sitka spruce) branch bark. Pinaceae family Figs 4.2a-d

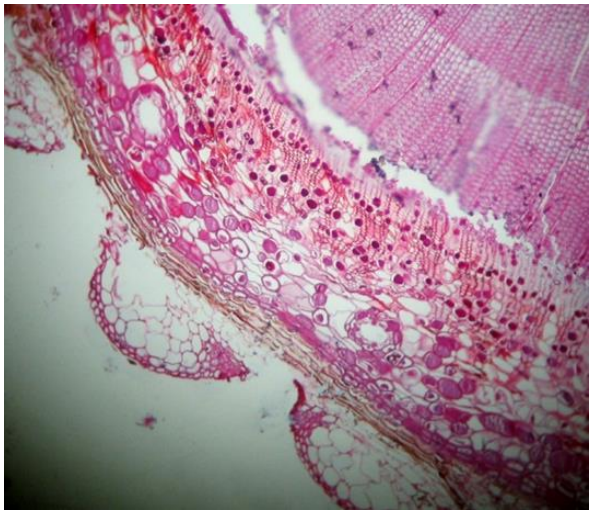


Fig.4.2a

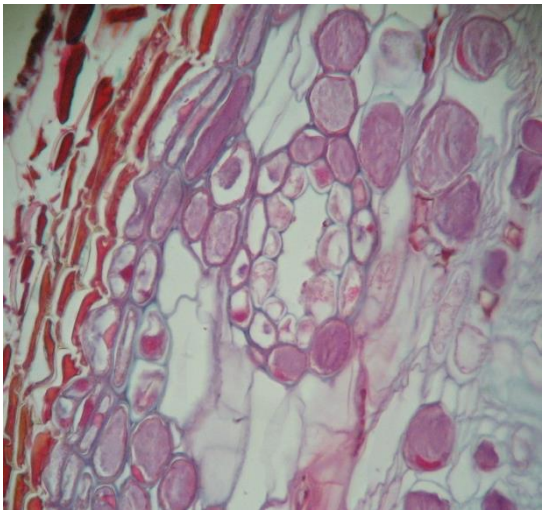


Fig.4.2b

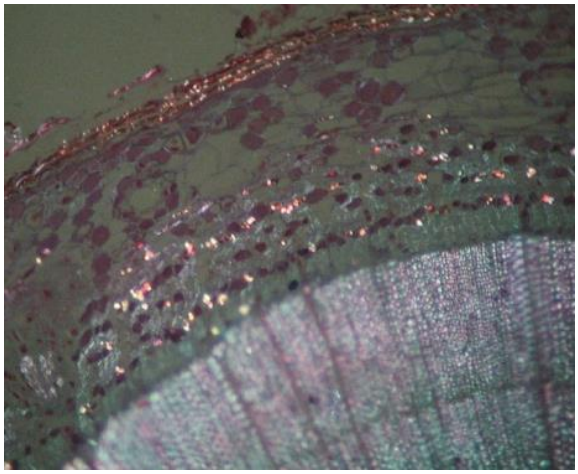


Fig.4.2c

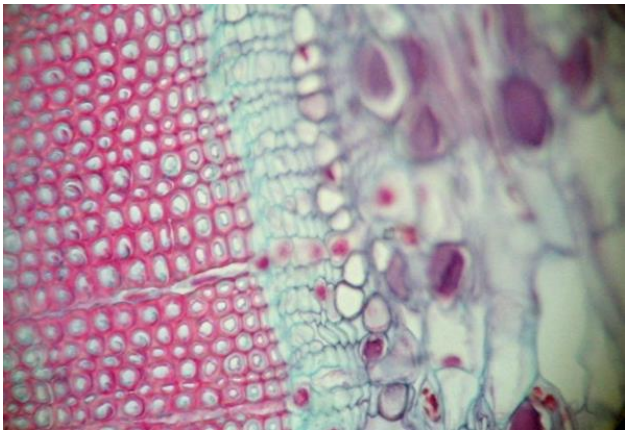


Fig.4.2d

Fig.4.2a- *Picea sitchensis* (Sitka spruce) branch bark cross section showing black large parenchyma cells separating growth rings of phloem. The dark color signifies the presence of protoplasm of cell contents or albumen. There are two small resin ducts in the cortex region. The bubble-like structures on the outer surface are structures of lichen. **PhotoMLFlorian**

Fig.4.2b- *Picea sitchensis* (Sitka spruce) branch bark shows the details of the epidermis. The epidermal cells are elongate in shape. The common small resin ducts have two layers of cells, the inner layer of cells are glandular epithelial cells. **PhotoMLFlorian**

Fig.4.2c- *Picea sitchensis* (Sitka spruce) cross section of branch bark the phloem shape is continuous in around the branch and not pyramidal, birefringent cellulose cells and a few

calcium oxalate crystals under polarizing light, in the ring of dark celled 2nd phloem. Phloem tissue commonly has calcium oxalate crystals a result of metabolic activity, age or insect activity. The presence of calcium oxalate is in 2nd phloem. There is no evidence of the presence of sclereids. PhotoMLFlorian

Fig.4.2d- *Picea sitchensis* (Sitka spruce) branch bark shows the details of the phloem cell pattern. The single row of large cells that delineate periderm and phloem is characteristic of this species. PhotoMLFlorian

Salient identifying features of the Sitka spruce are the elongate shape of epidermal cells, many small resin ducts in the cortex, a few small calcium oxalate crystal in the 2nd phloem, a single row of large primary phloem cells and lack of sclereids.

Calcium oxalate as mentioned may be present due to age, metabolic state or insect activity. It is reported that the greater the bark beetle infestation the greater amount of calcium oxalate and is thus considered as a defense mechanism. It is insoluble in water except under high acidity.

The 2nd phloem is in a continuous ring of linear groups not in pyramidal form. It is probable that as the branch grows pyramidal groups are formed.

4.4 *Pseudosuga menzeisii* (Douglas fir) branch bark. Pinaceae family Figs.4.3a-d

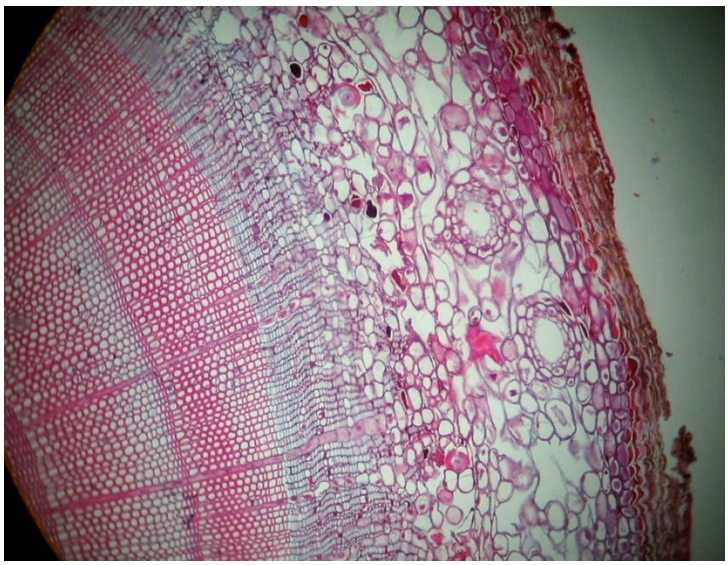
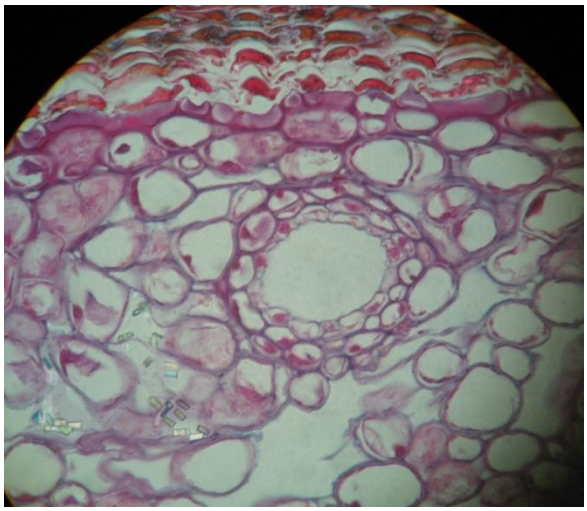


Fig.4.3a

Fig.4.3a- *Pseudosuga menzeisii* (Douglas fir) branch bark shows outer rows of brown epidermal cells and narrow phellem. The cortex has large cortical cells and a few near circular resin ducts. Below the cortex are bands of light blue phloem with regular rows of cells. PhotoMLFlorian



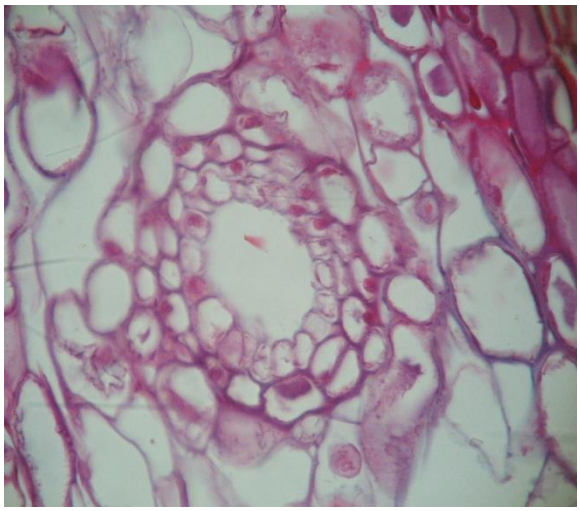


Fig.4.3b Fig.4.3.c

Fig.4.3b- *Pseudosuga menzeisii* (Douglas fir) branch bark shows a typical near circular resin duct with two to three layers of cells. A few rectangular crystals are present in far bottom left corner. **PhotoMLFlorian**

Fig.4.3c *Pseudosuga menzeisii* (Douglas fir) branch bark shows a resin duct similar to Fig. 4.3b, but with three layers of cells. This suggests a difference in stage of development. **PhotoMLFlorian**

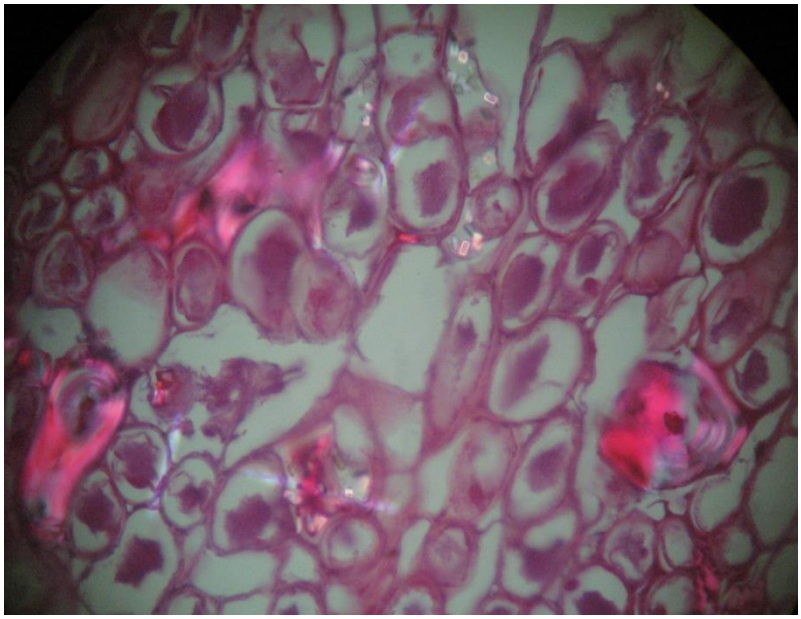


Fig. 4.3d

Fig.4.3d- *Pseudosuga menzeisii* (Douglas fir) branch bark shows a few isolated, irregular shaped, sclereids and minute rectangular crystal in the phelloderm/cortex region. The sclereids are not much larger than phelloderm cells. PhotoMLFlorian

The salient features of the Douglas fir branch bark are small circular resin ducts in phelloderm, narrow amount of phloem, irregular shaped small sclereids and a few rectangular, minute crystals in phelloderm region.

4.5 *Tsuga heterophylla* (hemlock) branch bark. Pinaceae family Figs.4.4a-ci and cii, and di and dii

Fig. 4.4a

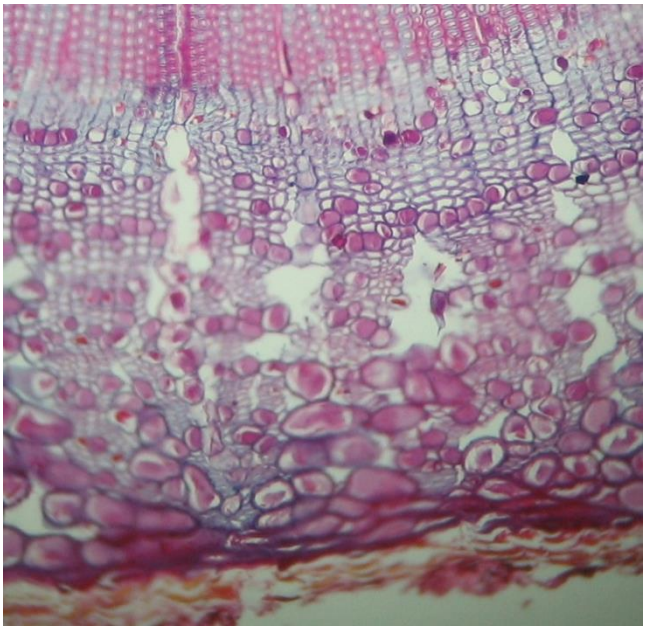


Fig.4.4 b

Fig.4. 4a- *Tsuga heterophylla* (hemlock) cross section branch. The bark -epidermis to phloem- takes up over 1/3 of the branch. Photomlflorian

Fig. 4.4b- *Tsuga heterophylla* (hemlock) cross section branch shows cellular details in the bark. Just below the xylem there are rows of regular shaped 2nd phloem groups that narrow down when in the phelloderm region. Between these groups there are large cells of radial ray origin without contents, some have fractured. The brown epidermis is present and above it thick walled elongate phellem cells. Photomlflorian

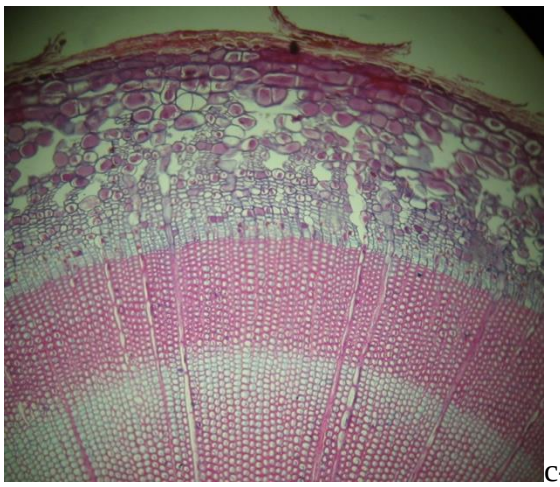
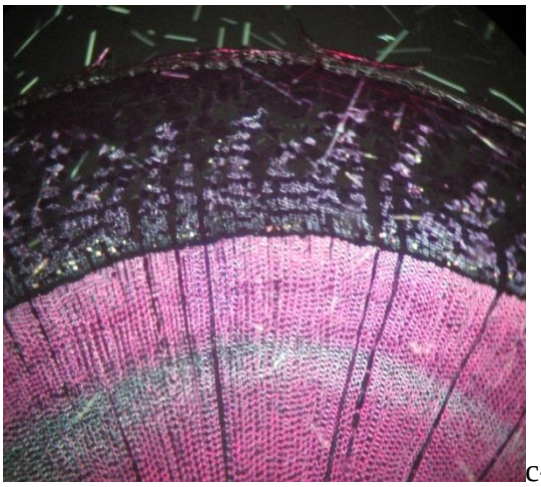

c-i

c-ii

Fig.4.4ci and cii- *Tsuga heterophylla* (hemlock) cross section branch shows the same image. The polarized image (cii) shows the 2nd phloem fibers in a pyramidal pattern in the cortex of periderm. The tips of the phloem fibers are well into the phelloderm region. There are very few calcium oxalate crystals that are commonly present in phloem. Photomlflorian

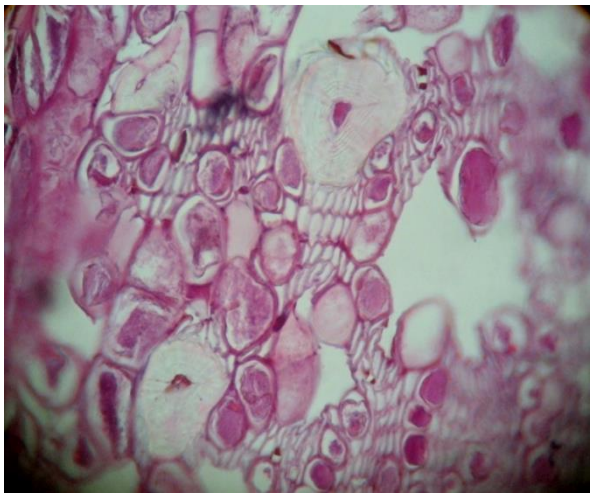
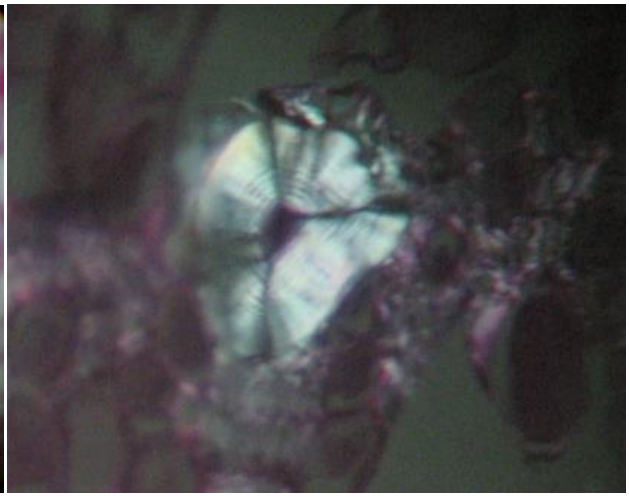



Fig. 4.4 di Fig.4.4dii

Fig. 4.4di- *Tsuga heterophylla* (hemlock) cross section branch shows many large sclereids with a central dark spot, in the phelloderm region. The bands of small rectangular thin walled cells amongst the cortical cells are phloem fiber groups. Photomlflorian

Fig. 4.4dii- *Tsuga heterophylla* (hemlock) cross section branch shows under polarized light the various shapes of the sclereids and characteristic layer lines. Photomlflorian

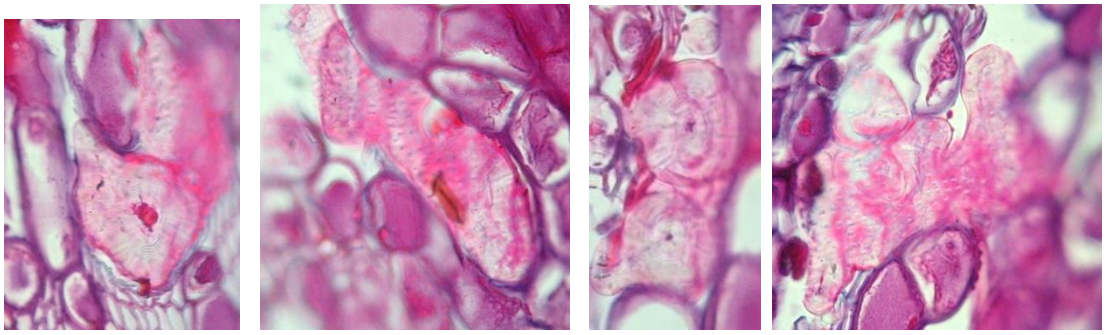


Fig. 4.4e (1-4)

Fig. 4.4e (1-4) ***Tsuga heterophylla*** **(hemlock) cross section branch shows a variety of pink sclereid (pink) shapes and sizes. These variable shapes are the result of cuts through a sclereid at different regions. In a three dimensional view the intact sclereid cell would have narrow, irregular extensions. Some show fine circular lines and pitting-common in sclereids. They are much larger than the cortex or phelloderm cells.** **PhotomIflorian**

The salient features of the hemlock are the lack of resin ducts, large irregular sclereids with black centers, pyramidal 2nd phloem under polarizing light, rectangular shape of thin walled 2nd phloem cells.

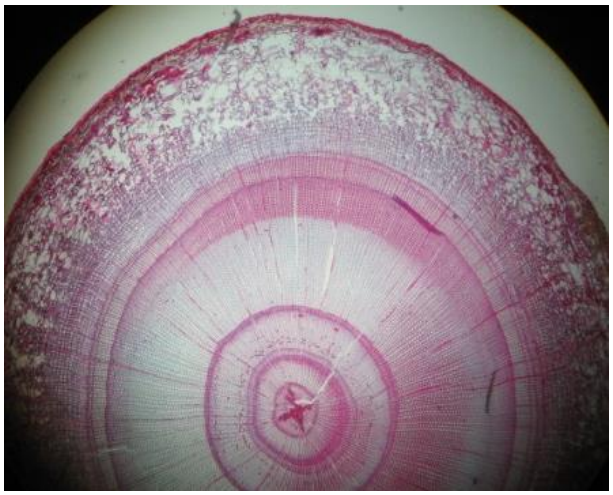
In summary: in comparison of the four species of the Pinaceae family, Abies (True fir), Sitka spruce, Doug fir and hemlock), can be separated from each other by salient anatomical features in the bark.

1. The three species of the family Pinaceae- excluding hemlock- have resin ducts in the phelloderm/cortical region.

2. Under polarizing light, Sitka spruce is without sclereids. *Abies* shows large groups of tangled sclereids, Hemlock has some isolated extremely large individual sclereids: Doug fir has a few isolated small sclereids the size of cortical cells. Sclereid can also be seen under light microscopy as well under polarizing light. Because they are lignified they may be still present in archaeological material. Hemlock sclereids in 10,000 year old water leached archaeological material were observed.

3. Also under polarizing light, Sitka spruce has a large amount of crystals that are regularly placed in the phloem and Doug fir has just a few isolated crystals seen under polarizing light and Abies and WRC and yellow cedar are without crystals. It is not sure if the presence or absence of phloem calcium oxalate crystals is a species specific characteristic or a reflection of age, physiology or the presence of bark beetles infestation, thus may not be useful as a salient feature for identification.

4.6 *Thuja plicata* (Western Red Cedar -WRC) branch bark. Cupressaceae family. Figs.4.5a-h



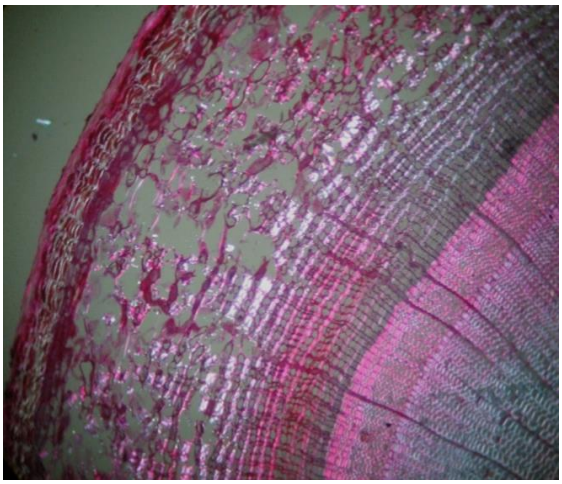


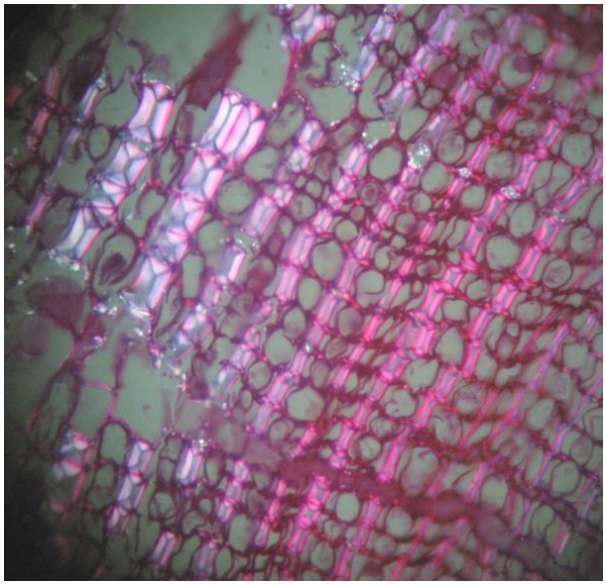
Fig.4.5a Fig. 4.5b

4.5c

Fig.4.5 a-cross section of 5 year old WRC branch. It shows the relatively large amount of bark as compared to the xylem and pith, approximately 1/3. In the lower left the cells are is normal wood in and the upper right shows a large region of darker stained cells due to denser and thicker walled cells. Compression wood is common in all branches. There are no resin ducts in the bark or wood. Sclereids were not observed. photomlflorian

Fig.4.5b.cross section of WRC branch bark of none compression wood region under polarized light. It shows from left inward, the outer epidermis, a region of brownish phellem cells a large porous region of phelloderm and groups of regular sized, radially organized large birefringent primary phloem fibers. The phloem cells variability in size, i.e., smaller inwards is due to younger age. Crystals were not observed. photomlflorian

Fig.4. 5c cross section of dead WRC branch bark. The brown color is due to oxidation of the natural polyphenolics present. It shows well the pyramidal shape of the 2nd phloem which is also shown in hemlock Fig. 4.4cii.



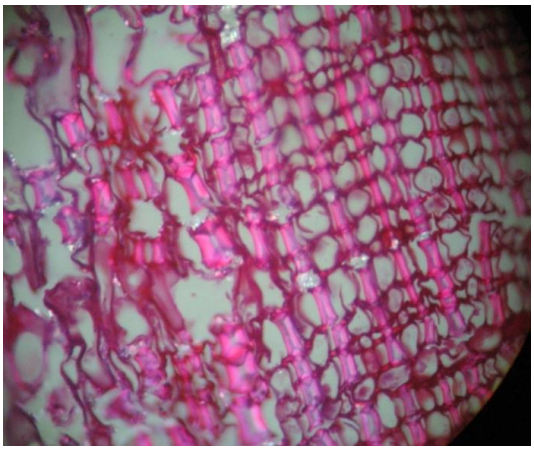
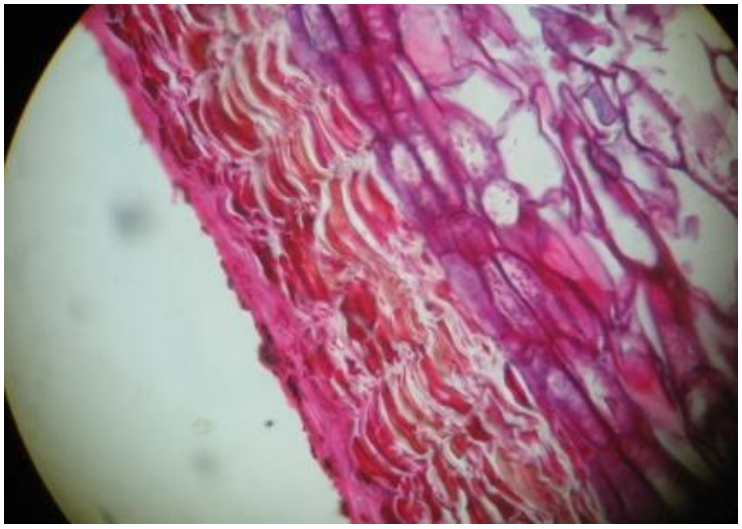


Fig.4.5d Fig.4.5e

Fig. 4.5d- cross section of 5 year old WRC bark branch phloem tissue of normal -as compared with compression wood (ig.4.5e)- Under polarizing light showing the rectangular shape and birefringence of the large phloem fibers. Calcium oxalate crystals are not present. The fibers are in pyramidal groups and in regular rows. The fibers are separated by large near circular sieve cells and very small linear parenchyma cells that appear to cross at right angles to the fibers. In this species the phloem is the inner bark of the branch. photomlflorian

Fig.4.5e-shows the cross section of the same 5 year old WRC branch but showing compression wood, under polarizing light. In comparison with Fig.4.5d, the compression wood shows that the early developed primary phloem cells are disorganized. The inner phloem fibers are longer and thinner and appear collapsed. Fig. 4.5d. photomlflorian



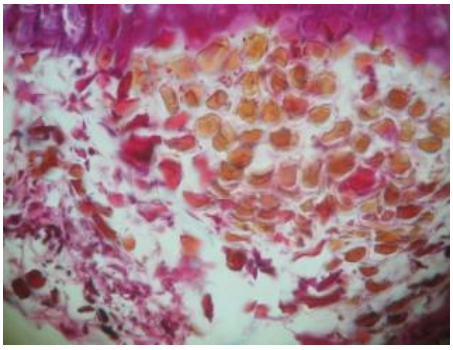
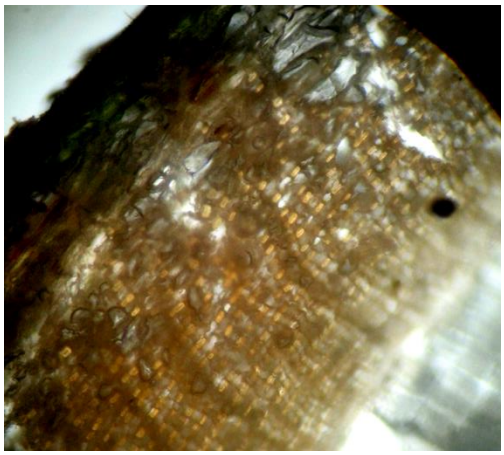


Fig. 4.5f Fig.4.5g

Fig.4.5f-cross section of epidermal region of WRC branch bark. The left outer clear surface is a cutin membrane over the epidermis. The epidermis shows the dense grouping of normal cup shaped epidermal cells. Next to it are a few layers of elongated phellem cells followed by large irregular shaped cortical cells. photomlflorian

Fig.4.5g- shows the tangential surface shape of epidermal cells of WRC branch bark. photomlflorian



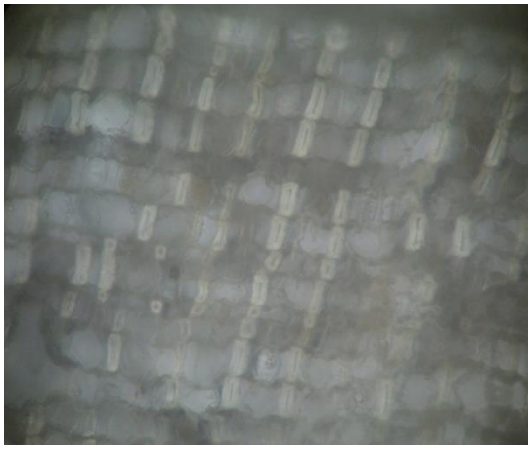


Fig.4.5h Fig.4.5i

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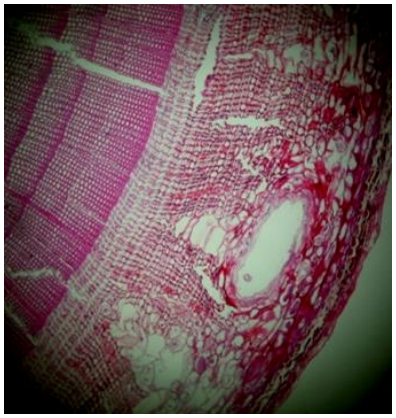
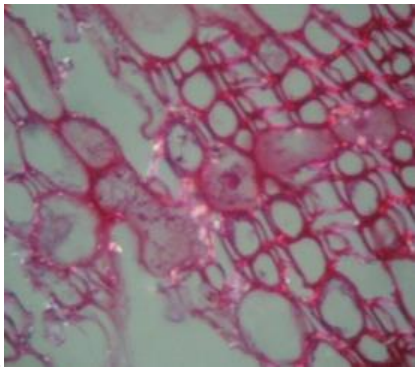
Fig.4.5h- is fresh WRC branch bark show under normal light, the phloem region and the normal golden yellow phloem fibers. The outerbark is periderm tissue. The green color is due to photosyntheic chloroplasts in the cells, that are common in young branches. In mature tree trunks of this speices the outer bark is completly replaced by 2nd phloem tissue
photomlflorian

Fig.4.5i-shows in fresh WRC branch bark the phloem fibers shown under polarizing light.
photomlflorian

The salient features of WRC branch bark are the lack of resin canals, and sclerieds. It has outstanding phloem fibrer regular pattern, with large primary phloem fibers and smaller regular shaped 2nd phloem fibers.

4.7 *Cupressus nootkatensis* (Chamaecyparis), (yellow cedar) branch bark. Cupressaceae family. Figs 4.6a-c.





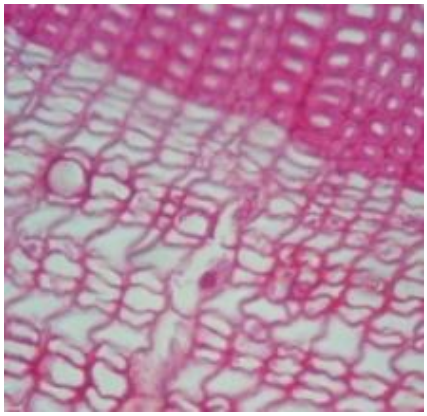


Fig.4.6a Fig.4.6b Fig.4.6c

Fig.4.6a- *Cupressus (Chamaecyparis)nootkatensis* (yellow cedar) cross section of branch bark showing large, broad, slightly pyramidal shaped groups of 2nd phloem similar to WRC in shape. Both species are in the same family. The groups of phloem are separated by large distorted ray cells. A few extremely large, elongated, oval, resin ducts are present in the cortical region. PhotoMLFlorian

Fig.4.6b- *Cupressus (Chamaecyparis) nootkatensis* (yellow cedar) cross section of branch bark showing very few minute crystals in phelloderm region under polarizing light. No sclereids are present or calcium oxalate crystals in the phloem. PhotoMLFlorian

Fig.4.6c- *Cupressus (Chamaecyparis) nootkatensis* (yellow cedar) cross section of branch bark. The phloem cell pattern shows groups of three cells made up of a central sieve element between two parenchyma cell. The groups are- separated by a large thin walled squarish phloem fiber. The irregular shape of the cells is due to their collapsing due to dehydration. The phloem fiber cells have thin walls as compared to the thick walled cells in WRC. photoMLFlorian

The salient features of *Cupressus (Chamaecyparis) nootkatensis* (yellow cedar) branch bark are the large, elongated resin ducts and the broad pyramidal groups of phloem. These groups are isolated by large distorted ray cells. The phloem has the pattern, seen in cross section of two parenchyma cells surrounding a sieve cell and these groups are separated by large thin walled phloem fiber. The species is in the same family as WRC that has a similar phloem pattern except the phloem fibers in WRC are rectangular and thick walled as compared to square and thin walled in Yellow cedar. No crystals or sclereids are present.

4.8 *Taxus brevifolia* (yew) branch bark. Taxaceae family. Figs.4.7a-b.

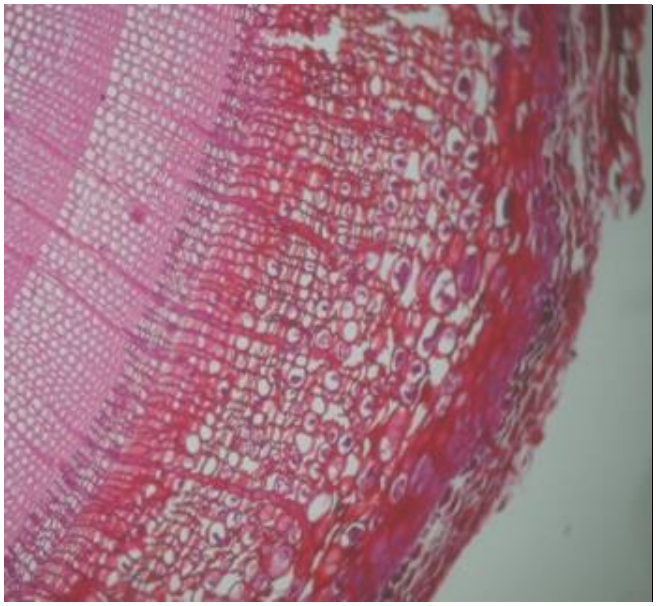


Fig. 4.7a

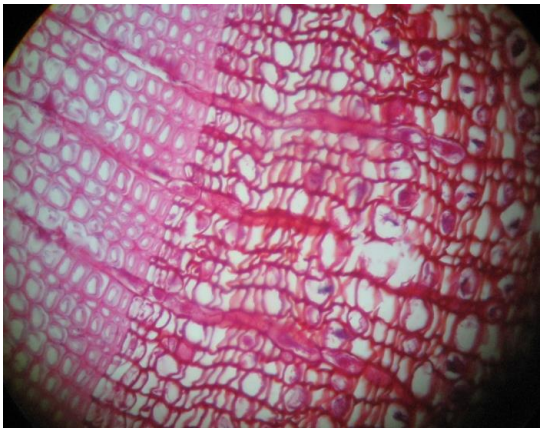


Fig.4.7b

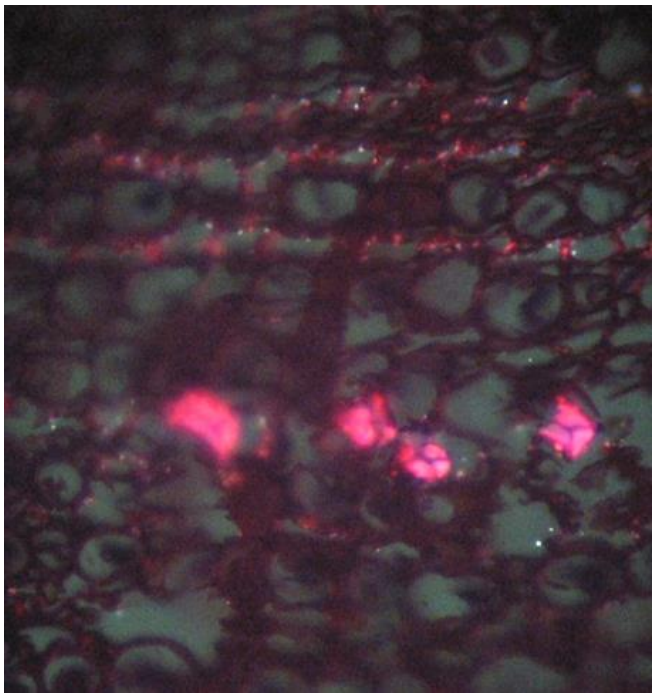


Fig.4.7c

Fig. 4.7 cross section of *Taxus brevifolia* branch bark showing thick epidermis, dense periderm of phellem and narrow phelloderm, large celled cortex and extensive phloem region. There are distictive broad radial ray parenchyma continuious from the 2ndxylem into the phloem. photomlflorian

Fig. 4.7b cross section compressiom wood are of *Taxus brevifolia* branch bark showing the broad ray parenchyma passing from xylem through the phloem. photomlflorian.

Fig.4.7c cross section of *Taxus brevifolia* branch bark under polarizing light show mimute sclereids that are smaller than phelloderm cells and small crystals in rows of phloem cells. photomlflorian

The salient features are the broaad ray parenchym passing through the xylem and phloem. The phelloderm is narrow. The epidermis is thick made up pf many layers. The sclereids are extremly small, smaller than phelloderm cells.

4.8 Table 4.1 a summary of salient anatomical features. There were no axial resin canals present in the branch 2nd xylem in all species sampled.

species	axial resin ducts in periderm	sclereids	phloem pattern and other features
4.2.Abies amabilis (Pacific silver fir) Family Pinaceae	many small, 3 layers of cells, nearly round-form blisters	groups of small irregular shaped tangled in cortex/phelloderm	row of large cells with contents at region of vascular cambium – phloem in a ring
4.3 Picea sitchensis (Sitka spruce) Family Pinaceae	small, many 2 rows of cells	absent	phloem in a ring –not pyramidal
4.4.Pseudotsuga menzeisii (Douglas fir). Family Pinaceae	oval-round, 2-3 layers	few	phloem in ring
4.5.Tsuga heteropylla (hemlock) Family Pinaceae	absent	present really large irregular shape	phloem plus/minus pyramidal
4.6.Thuja plicata (western red cedar) Family Cupressaceae.	absent	absent	phloem pyramidal, phloem fibers thick walled , and regular rectangular shape
4.7. Chamaecyparis nootkatensis (yellow cedar) Family Cupressaceae.	resin ducts -large oval to elongate,	absent	phloem group pyramidal , phloem fibers thin walled. extremely broad rays
4.8.Taxus brevifolia(Yew) Family Taxaceae	absent	a very few small sclereids	radial rays large enter from 2nd xylem to outer bark/ tissue dense/ thick epidermis

4.9 An example of a possible dichotomous key approach to identification of the above gymnosperm species branch bark anatomy and the presence or absence of axial resin ducts (canals)and sclereids in phelloderm

1. Axial resin ducts absent in phelloderm (hemlock, T*axus*, WRC)
    - 1.1 sclereids present
        - 1.1a sclereids large irregular shaped present-T*suga heterophylla*
        - 1.1b.very few minute rectangular isolated sclereids –Taxus
    - 1.2 Sclereids absent – *Thuja plicata*
2. Axial resin ducts present in periderm of coniferous tree branches,
    - 2.1 Resin ducts large and elongate- *Chamaecypari*s,
    - 2.2 Resin ducts round/oval -P*icea sitchensis, Abies amabilis, Pseudotsuga menzeisii*
        - i. Sclereids absent - P*icea sitchensis*
        - ii. Sclereids present- *Abies amabilis, Pseudotsuga menzeisii*
            - ii a Sclereids in large groups--*Abies amabilis*
            - ii b. Sclereids few isolated- *Pseudotsuga menzeisii*