CHAPTER 2 TERMINOLOGY

2.1 The project

Many wooden artifacts are made from different parts of a tree i.e., heartwood (wood), branch or root. Each tree part has a different anatomy, structural strength, and vulnerability to environmental and biological deterioration. Often the curator or archaeologist would like to know the genus or species and what part of the tree was used to help interpret the technology used in making the object, its provenience, and trade. Conservators of museum collections need the information to understand the physical vulnerability of the woody material so as to give it logical care. The purpose of this chapter is to familiarize one with the names and anatomy of the different tissues and cells in the different parts of branches, roots, and heartwood of some dicot and conifer trees and woody shrubs.

2.2 An introduction to terminology

The following is presented to familiarize the reader with anatomical terminology and the general differences between, tree trunk heartwood, branches, and roots. The glossary at the end of the chapters also assists in terminology.

Fig. 2.1 shows the growth changes in the different tissues in a generalized young plant or tree over a three year period of a woody dicot or conifer stem or branch. The salient terms are the in order from outside inwards: epidermis, periderm, cortex, primary phloem, 2nd phloem, vascular cambium, 2^{nd} xylem, primary xylem, and inner pith.

The top circle shows the youngest growth of primary tissues. The outer epidermis is the bark. It is a single layer of cells protected by a wax cutin. Next to it is the cortex in which starch is made and stored. In the very young stem it makes up the greatest amount of tissue. It is surrounded by separated bundles of primary xylem and primary phloem. Primary refers to the first years growth. The xylem and phloem are separated by a thin layer of cambium cells from which they are produced. The xylem is on the inside towards the center and phloem on the outside towards the bark. The xylem, in its early development, mainly transports nutrients and water to where ever it is needed. Xylem also gives the stem some strength. The phloem primarily makes starch and converts it to send to the xylem with water. In the center of the young stem is the pith. It is a group of air filled, sponge-like, cells that mainly gives the stem its strength, light weight, and flexibility. It may also be involved in starch storage.

The next stage of development is the formation of the vascular cambium that produces the vascular bundles of secondary (2^{nd}) xylem and phloem.

Fig.2.1 shows in the one year old stem that the vascular bundles have formed a complete ring. On its outside is 2^{nd} phloem (blue) separated from the inner 2^{nd} xylem (red), by the vascular cambium (yellow). The outside of the pith is lined with the primary xylem tissue bundles(purple) that give it a characteristic shape that can help in identification of species. It functions to give the branch lightness and flexibility. The one year old year old stem may slough off the epidermis and

a cork cambium embryonic cell replaces it with the periderm. The periderm may form new bark such as birch bark or cork. The cortex does not change.

The three year old stem shows the growth of three annual rings of the xylem now called 2nd xylem. The phloem also grows and shows annul rings. In some trees the bark develops further into a rough surface of 2nd phloem cells, called the rhytidome. At this age the 2nd xylem and 2nd phloem is called sapwood.

Sapwood goes through developmental stages i.e., embryonic, metabolic, and transition. The newly formed embryonic xylem tissue develops into its functional metabolic stage. After it is no longer functional it goes through a transition that forms into dead heartwood. Sapwood may remain for years at the metabolic stage, making and storing starch and transporting it. Some remain as sapwood up to eight years or more, depending on species. Then the metabolic sapwood 2nd xylem cells is converted to heartwood by sealing the cells with lignin and developing biocides called polyphenolic terpenes for protection against biological deterioration.

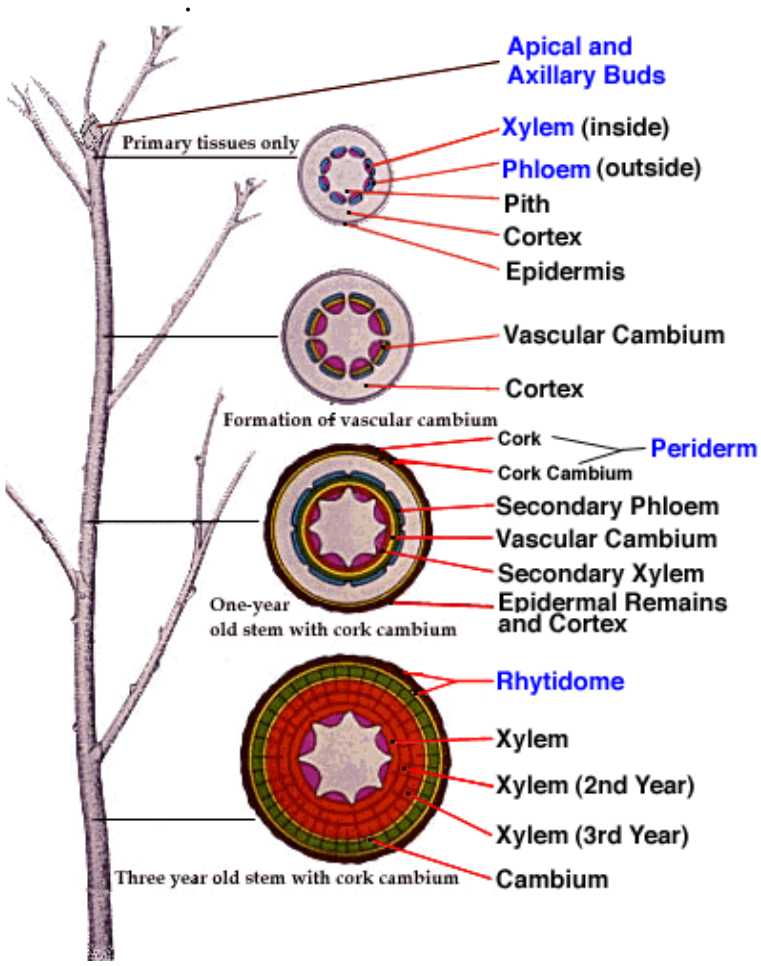

Fig.2.1

Fig.2.1 Shows the growth changes in a stem showing the development of the tissues and their positions. **With kind permission from . Kantharal Gowda gkraj-bg@yahoo.co.in**

Fig.2.2

Fig. 2.2 Crosscut rounds of a single tree showing characteristics of different ages. Each round has a light colored sapwood and central dark 2nd xylem, the wood.Public domain wiki

In Fig.2.2 the pieces of different sizes of a tree trunk show the variable amounts of the outer light colored sapwood and the central dark colored heartwood, depending on their age. It is characteristic to have relatively more sapwood in the younger part of the stem than the larger stems. Some of the rounds show branch traces developing from the center of the round. Branches are mainly with just sapwood.

With an archaeological artifact fragment of wood and cleaned splints of wood used in ethnographic artifacts, one does not know if the wood is tree trunk-heartwood, branch sapwood or root. The first step is to deterimed what strucvture it is. For identification of the species, heartwood is considered quite easy by just using established keys of the 2nd xylem (wood) developed for commercial wood. Branch sapwood and root structure are very different anatomically than heartwood. Branch meatabolic sapwood of dicot trees has many of the anatomical features used in identified of dicot heartwood, this is not the case with Coniferous branches. The few tissues and their names presented in Fig. 2.1 are common in, heartwood, branches and roots of all species, whicht makes the task easy. Their anatomy varies and is presented in the followng chapters.

The vascular tissue that circulates the sap is the xylem and phloem sapwood in branches... They both have tubes or connected cells that run the length of the tree from root to the top apical meristem bud. The tubes carry solutions to where ever nutrients, amino acids and minerals are needed. The contents are protoplasm, not just water. The branch phloem collects the nutrients – sugars and amino acids from the leaf and minerals and water from the roots and distributes it to all part in the tree. 2nd xylem moves water upwards. Phloem tissue moves the products from leaves into the tree trunk sapwood and down to roots. It also draws water up from the root. The process of this movement of nutrients and water, as mentioned, is based on simple diffusion gradients, caused by variable sugar concentrations. Water in 2nd xylem is moved by transpiration – evaporation of water from leaves. The phloem cells in which it is transported are the sieve cells or sieve tubes with sieve plates with holes that connect to all adjacent cells. These are shown in FIG.5.4b. They are species specific in shape and assist in species identification.

The sap is mentioned because the minerals, amino acids and sugars are still present when branches are used in artifacts, that may make them vulnerable to biodeterioration..

2.3 The three dimensioins of a round stem, branch and root

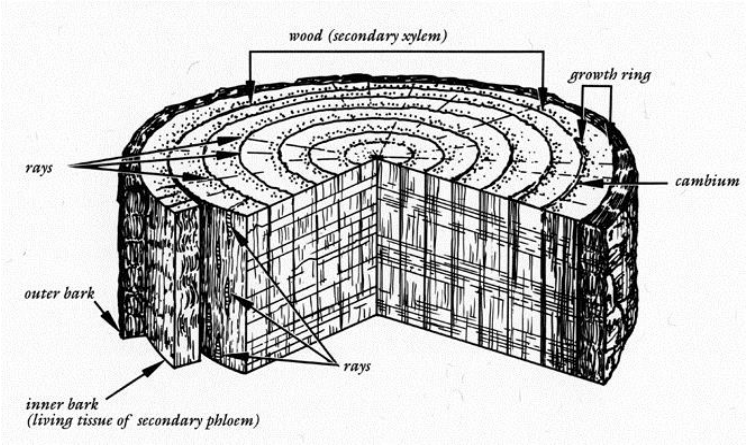

Fig.2.3a

Fig. 2.3b

Fig.2.3a The three-dimensional aspects of a young-6 year old- coniferous branch. The top surface is the transverse surface, the radial cuts are the radial surface and the circumfrence is the tangential surface. Originally published in Florian, Mary Lou, Dale Paul Kronkright, and Ruth E. Norton, *The Conservation of Artifacts Made from Plant Materials* (Los Angeles: The Getty Conservation Institute, 1990) p 14. © J. Paul Getty Trust. Reprinted by permission of the publisher.

Fig. 2.3b Trasverse surface of western red cedar (WRC) 2 year od branch. It shows from outside inwards-the outer dark brown bark complex, porous cortex, fingers of golden brown 2nd phloem, central sapwood of 2nd xylem and a portion of the central dark elongated pith surrounded by circular primary cell fragments. The phloem and sapwood are characteristically separated by the red thujaplicins biocide of western red cedar.
mlfphoto

In looking at samples from an artifact, because it is so small and one often does not know what surface is exposed it is essential to be able to recognize the tssiues on any surface. Fig. 2.3a shows the three-dimensional aspects of a round of a coniferous tree trunk. Custom has it that the description of the tissues and cells are according to these three surfaces.

The surface of a cross section of the round top, is the transverse surface, and shows the circular growth rings. If a longitudinnaly cut is taken down the bark region, it is the tangential surface of the round. In Fig.2.3a the cut on radial surfaces show the lines of the radial wood ray

that go radially into the round from the outer young growth ring to the older rings towards the center. The crosss section of these radial rays cells are shown on the cut on the tangentials surface as a short row of circular cells .

The order and arrangement of the tissues are the same in tree trunk, branch and root, but their amounts and anatomy vary. Again as convential has it , as shown in Fig.2.3a, the so called inner bark is 2nd phloem tissue and the outer bark contains true bark,cortex and primary phloem .

In branches and tree trunks (stems)- as observed on the transverse surface **(**Fig.2.3b), there are the cellular tissues from the outside inwards; true outer bark, and inner bark the primary and 2nd phloem, vascular cambium, and 2nd xylem and central primary xylem and pith.

The very center of the branch center is pith, but it becomes crushed and is not seen in large tree trunks. The 2nd xylem is in two colors (Fig.2.2), shown in the light colored outer living sapwood and inner dark brown dead heartwood. Fig. 2.3b is only sapwood in the branch because of its young age. The relative amounts of heartwood verses sapwood varies with age and different species.

The outer bark region is a complex (Fig.2.3b) of true bark, cortex, and phloem tissue. It is easily removed in ethnographic preparation of branches for use in artifacts. It naturally separates from the xylem at the layer of a very few delicate thin walled vascular cambium cells, that lies between the 2nd phloem and 2nd xylem.

In this archaeological project the bark cellular complex was not usually present and was not considered for species identification. But in some small branch samples where the bark complex cells were present, but was badly disorganized and deteriorated, significant anatomical bark features, such as isolated colored epidermal bark cells, resin canals, sclereid cells and crystals, were observed and assisted in species identification.

2.4 The samples and method of preparation for microscopy

The microscope slides were water mounts of dried or fresh material and histologically prepared stained slides.

The following method proved suitable for the author but may not be suitable for all and she takes no responsibility if you cut yourself.

For the dried and fresh material, the sample is placed on a microscope glass slide in a small drop of water and thin sections cut, free hand, with a single edged razor blade-the ones used to clean paint of windows from the hardware store.

The process used was as follows, the index finger nail -at an angle -holds the small sample down firmly on the glass slide with only a small- hardly seen-- portion protruding. The razor blade is firmly slid down the nail and cut the sample. Several –rapidly cuts-, one after the other, are made and at the same time slowly raise the angle of the index finger that exposing very slightly the sample. Keep cutting while this is happening. You should have done at least ten cuts or more. Some will be useless, but one or two will be usable for viewing. Many cuts can be made even if you cannot see the cuts.

Remove your index finger, check the slide for samples on it and push them with a suitable needle tool into the drop of water. The sample can also be teased apart to aid in observation of such small groups of cells. Occasionally when the sample seems to produce no observable results, it can be chopped with the razor blade at right angles with the slide,-into very small fragments. Commonly small fragments of radial rays remain and they are a major structure used for species identification. Pre soaking of dried material may assist cutting.

Permission is required from conservator or owner of the artifact to take a sample from an artifact. With archaeological artifacts rarely can tissue be removed specifically from radial, tangential, or transverse surfaces. Razor thin samples can be removed only on carefully selected spots that do not interfere with regions that showed human activity. The wet archaeological material is very soft and easily fragmented and placed in water. The tissues have an inherent color for contrast, thus, staining is not necessary. This method has been shown to be the most efficient and logical method with such material. The material even though fragmented, shows small groups of cells that by chance may be orientated as to transverse, radial, or tangential view and give significant information.

The term species identification is loosely used but in many cases it is the genera that are identified. Species identification, for example for spruce (Picea) there are many species. When dealing with archaeological material the palynolgy analysis- the study of buried pollen- will tell what species were shown to be present for that specific environment, and thus the species is assumed to be one of those and is a fairly good possibility.

For the following chapters, living known samples, for standards, of roots and branches of seven common Northwest Coast coniferous species were collected from the arboretum at Canadian Forestry Services, Pacific Forestry Institute, Victoria, BC Can. The surface lateral root samples were circa 5mm-1 cm in diameter and a few centimeters in length. One half was used for transverse section and the other piece was split in half. This was sectioned from the outer tangential bark surface to the true radial surface at the middle of the piece. This produced serial sections that allowed observation of all growth from bark through the 2nd xylem growth rings to the central primary tissue. These samples were prepared using standard histological technique.

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