Welcome to Arboriculture 101

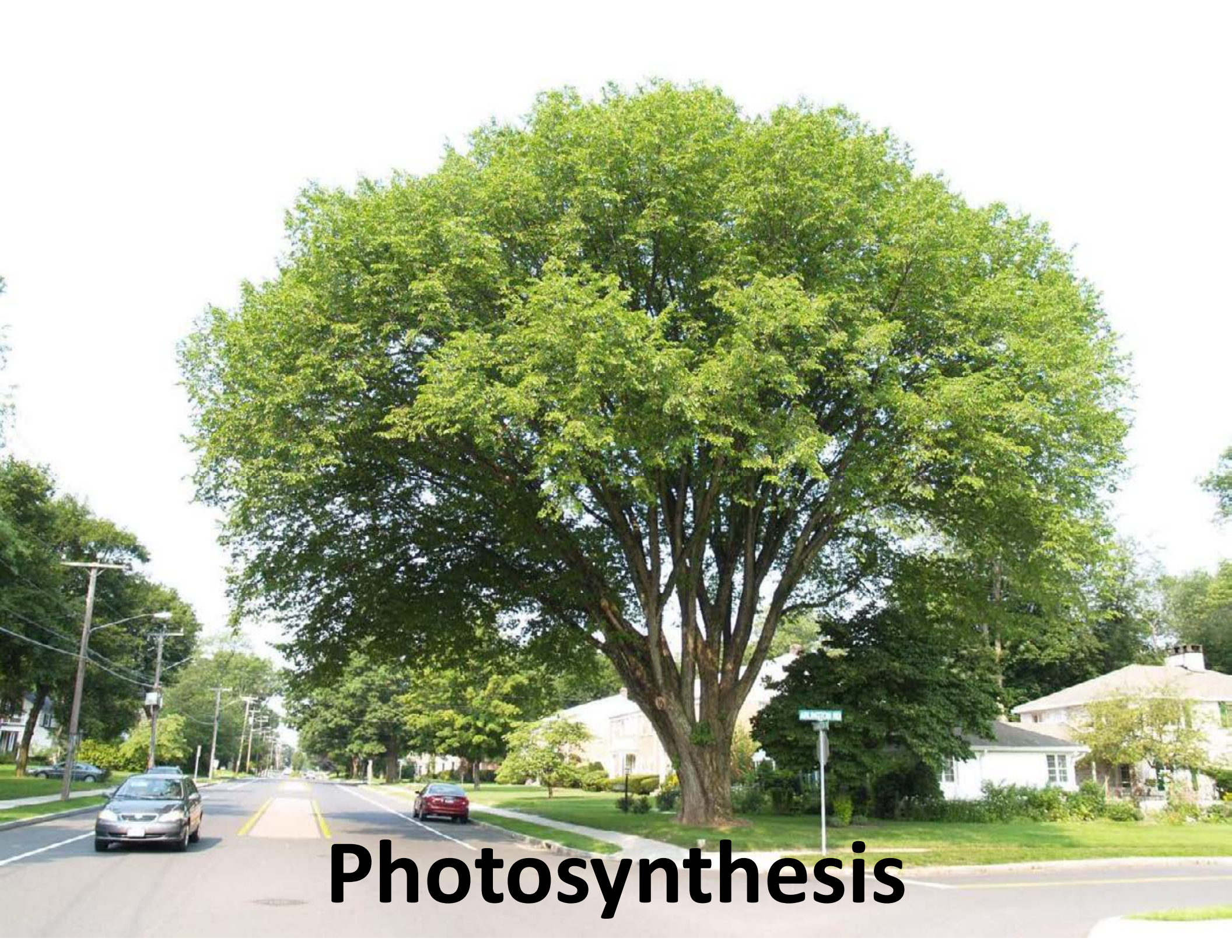
www.ctpa.org/arboriculture101.html

Introduction to Tree Biology

or, how the tree functions as a set of systems

Nine Systems

- Photosynthesis
- Hydrologic
- Structural
- Growth
- Response
- CODIT
- Reproductive
- Chronological
- Death and Shedding



Photosynthesis

Photosynthesis

Carbon Dioxide + Water → Oxygen + Sugar

energy in = sunlight

Photosynthesis

Carbon Dioxide + Water → Oxygen + Sugar

(6) CO_2+ (6) H_2O → (6) O_2 + $C_6H_{12}O_6$

energy from sunlight is now stored in the sugar

Respiration

Oxygen + Sugar → Carbon Dioxide + Water

energy out = metabolism

Sugars are the Building Blocks

Plants will use sugars to make:

Starches, Proteins, Fats, Oils,…

Which then become Cellulose, Lignins, Wood,

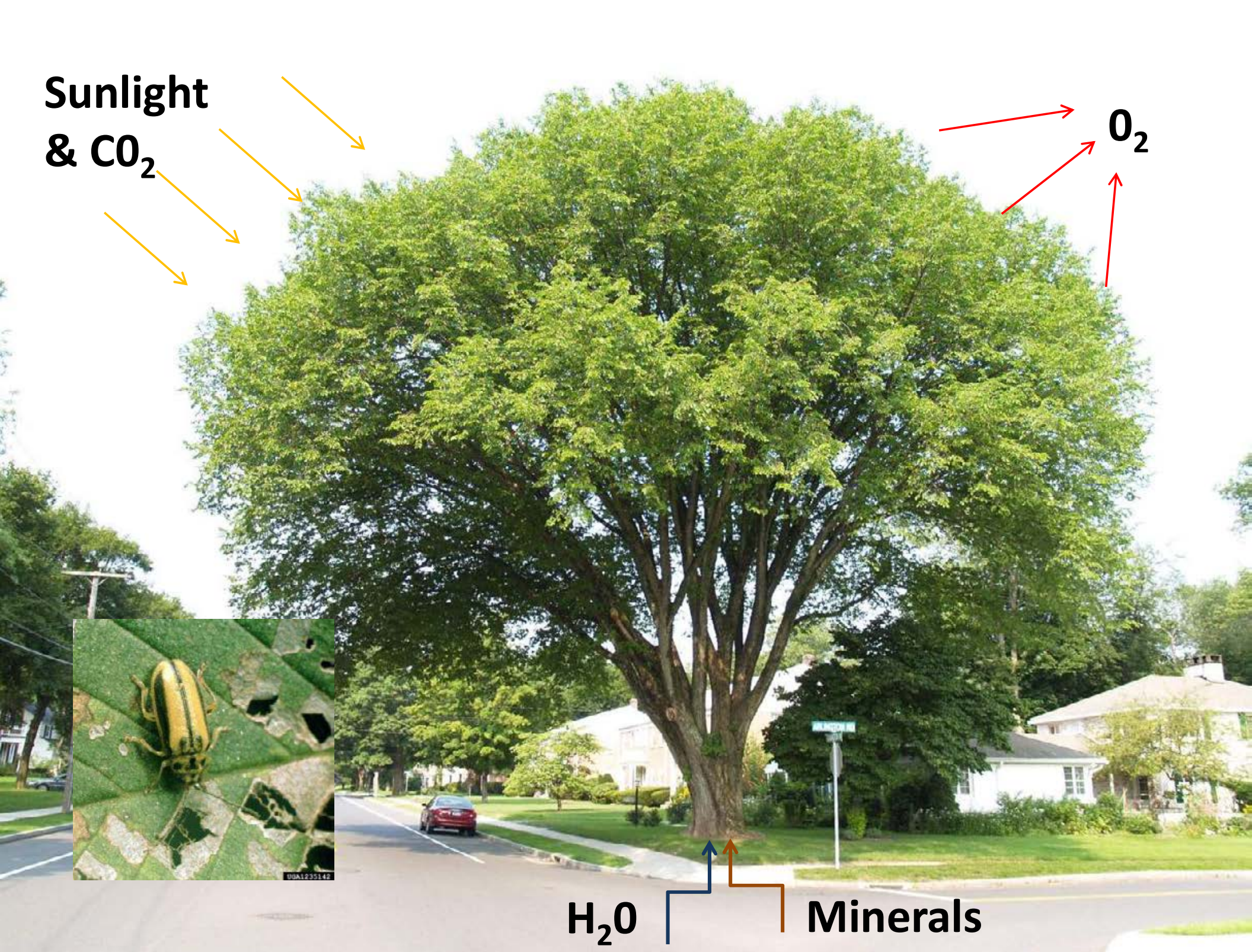
Which then become Bark, Leaves,…

and so on….

From simple sugars to ever more complex compounds….

All of which sounds good to the rest of us who are alive on this planet…


Photosynthesis =
Chlorophyll =
Green ≠ Leaves
(not always)


Sunlight
& CO_2
O_2
H_2O
Minerals

Hydrologic (Circulatory)


Transpiration

Parts of the trunk of a tree.

Bark

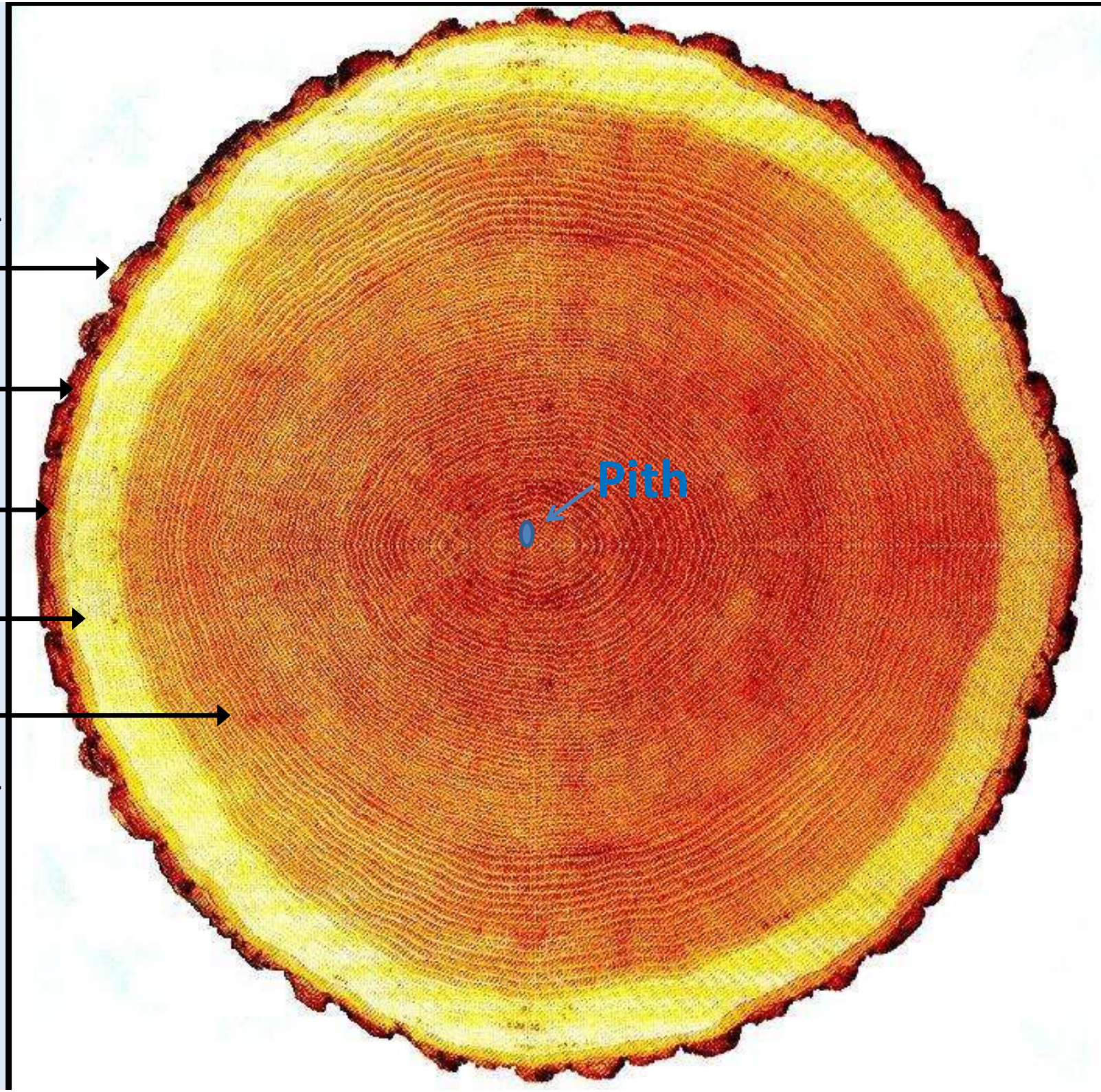
Inner Bark

Cambium

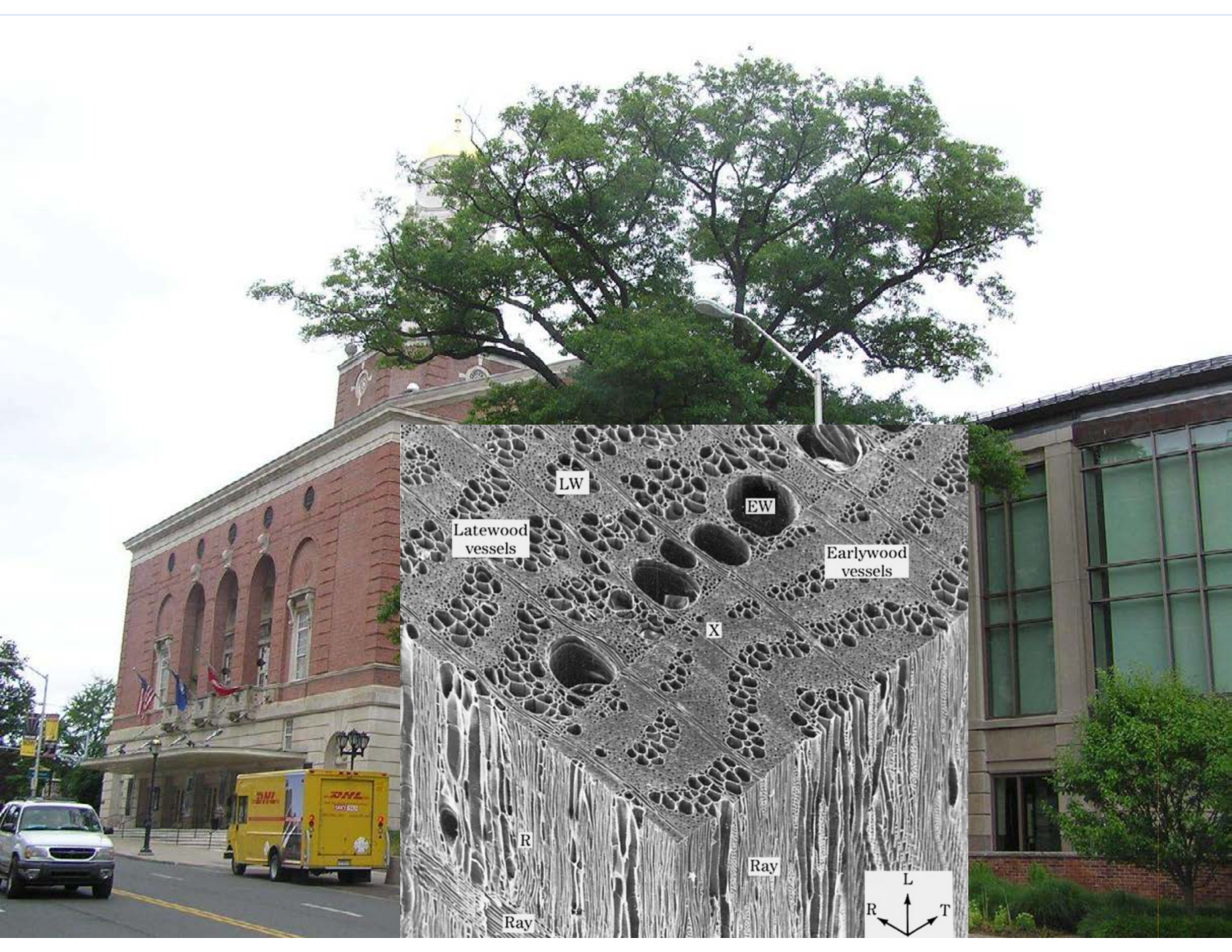
Sapwood

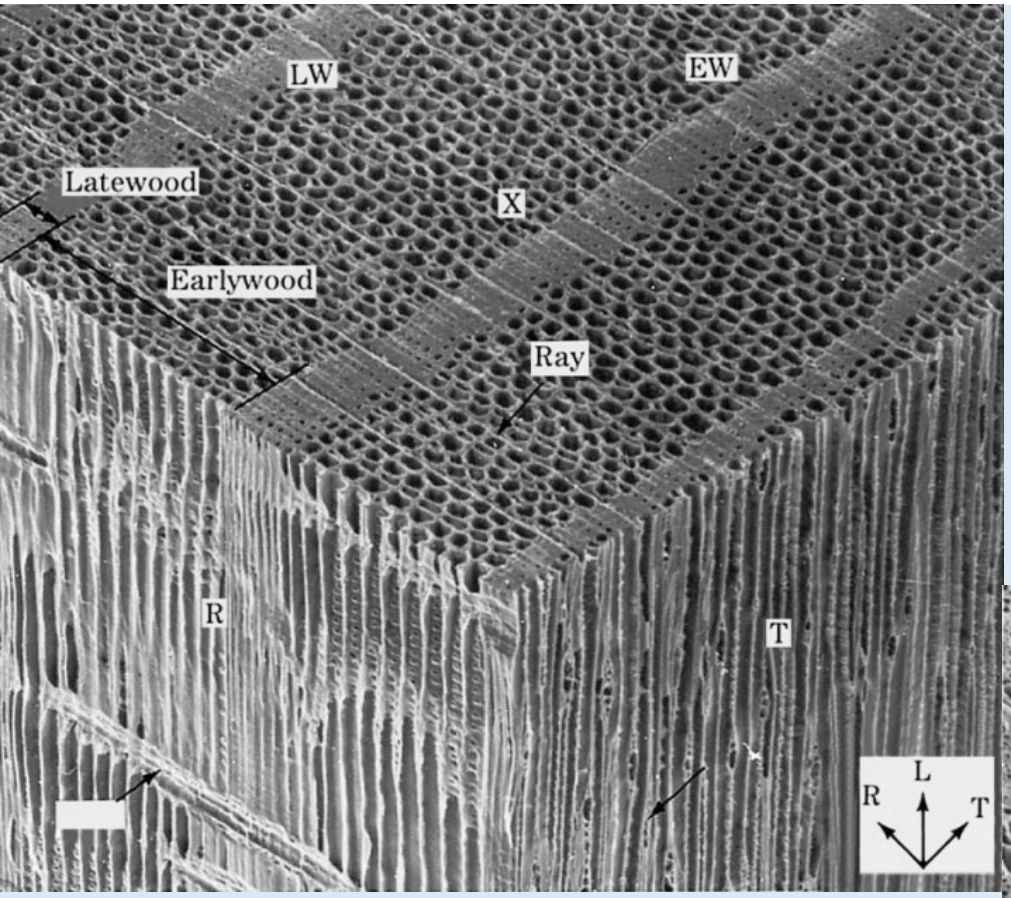
Heartwood

Inner bark contains phloem; wood is largely made up of xylem



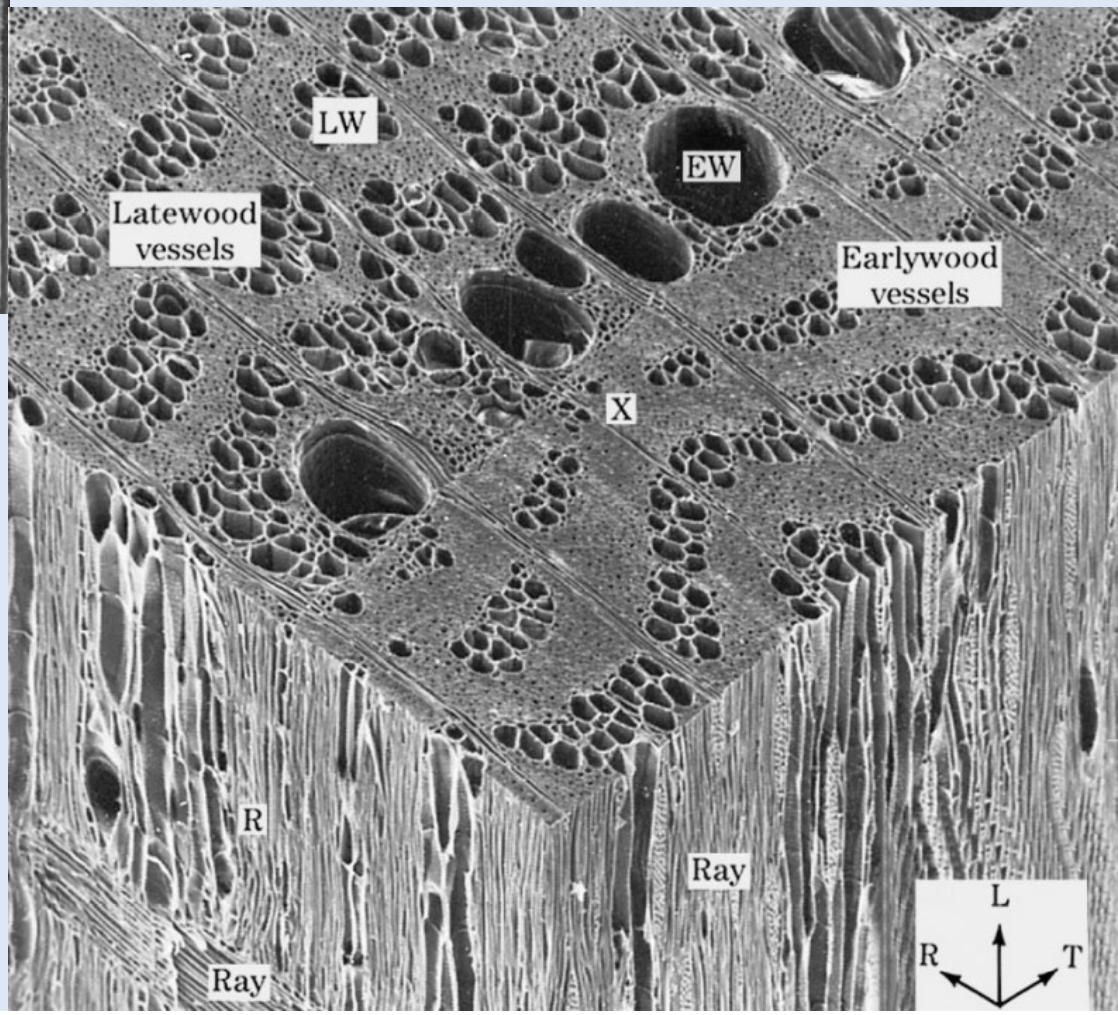
What is wood, really?

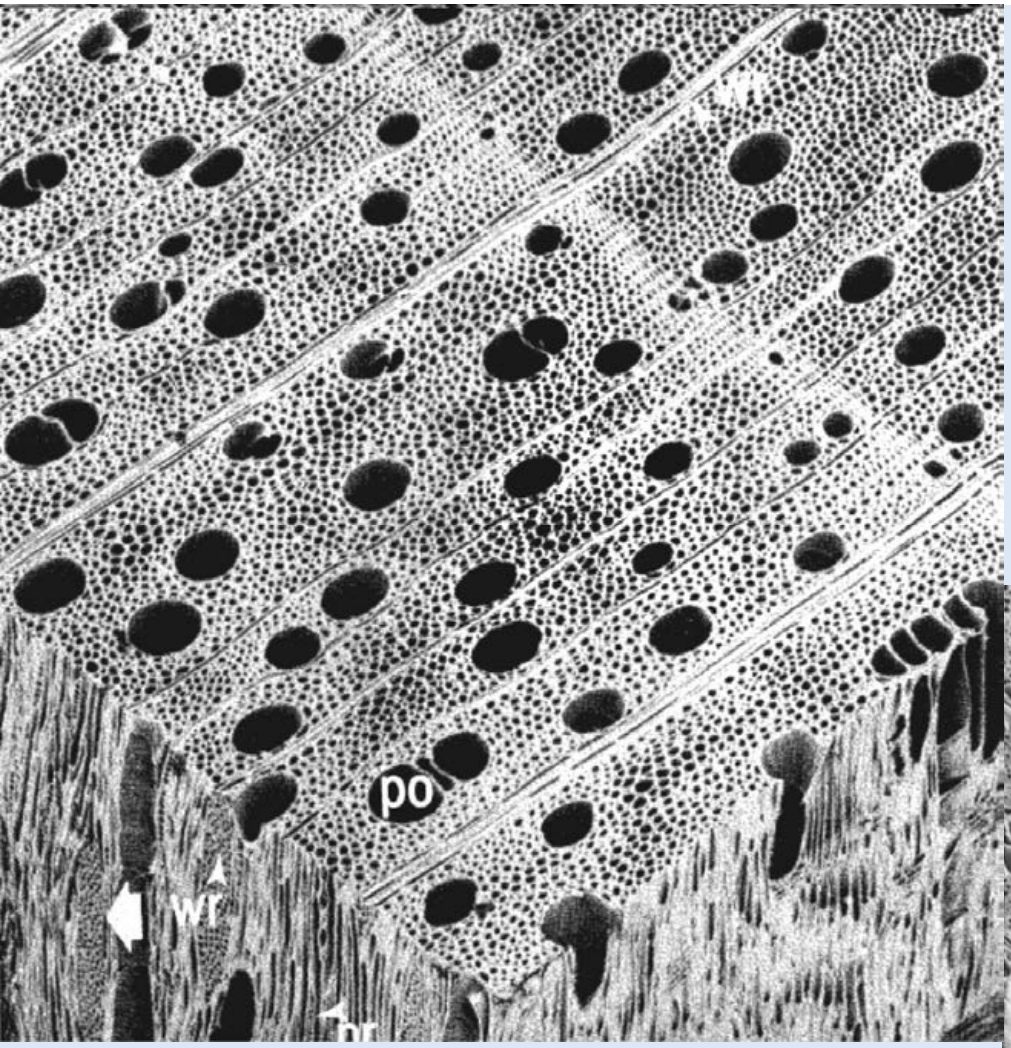

LW
EW
Latewood vessels
Earlywood vessels
X
R
Ray
Ray
L
R
T



← *Conifer (pine)*

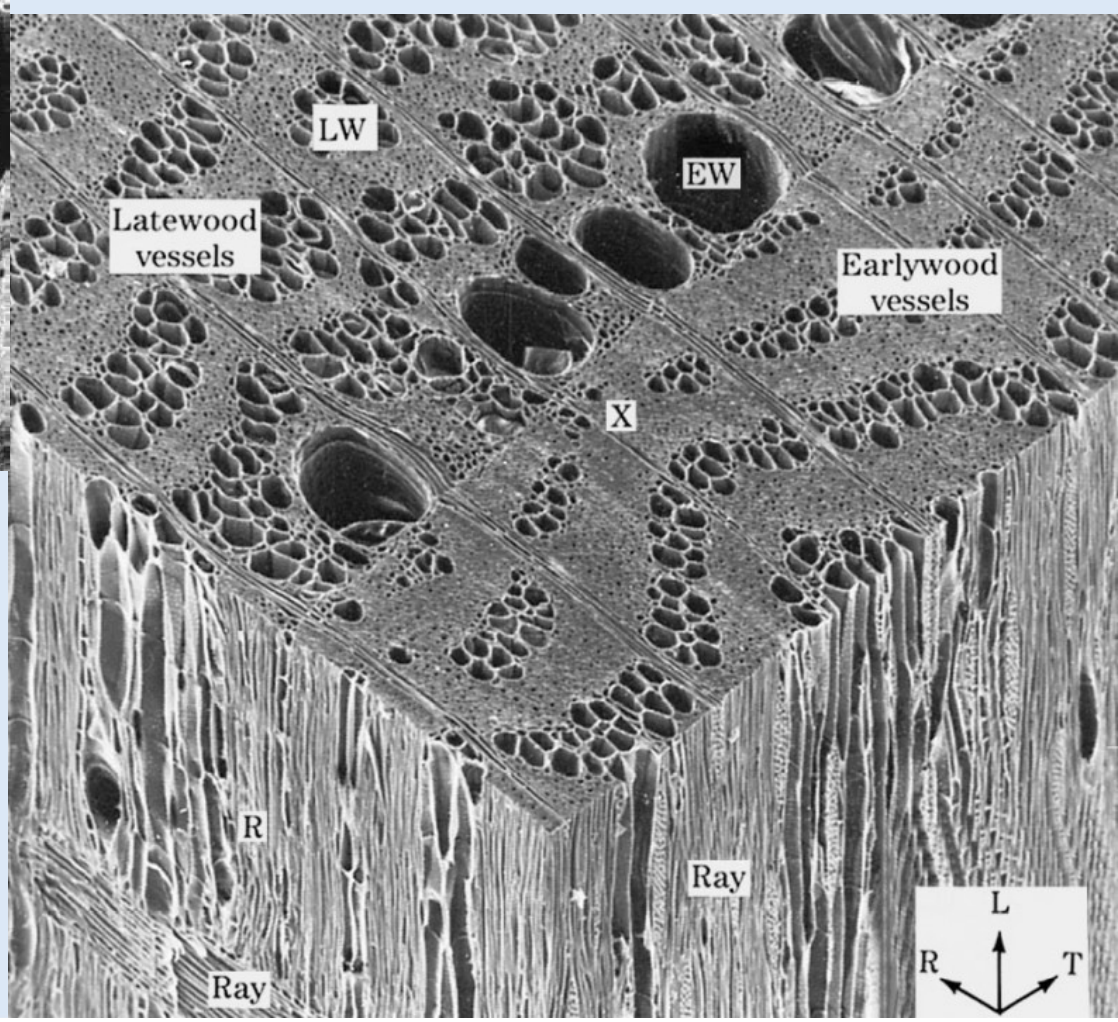
Hardwood (red oak) →

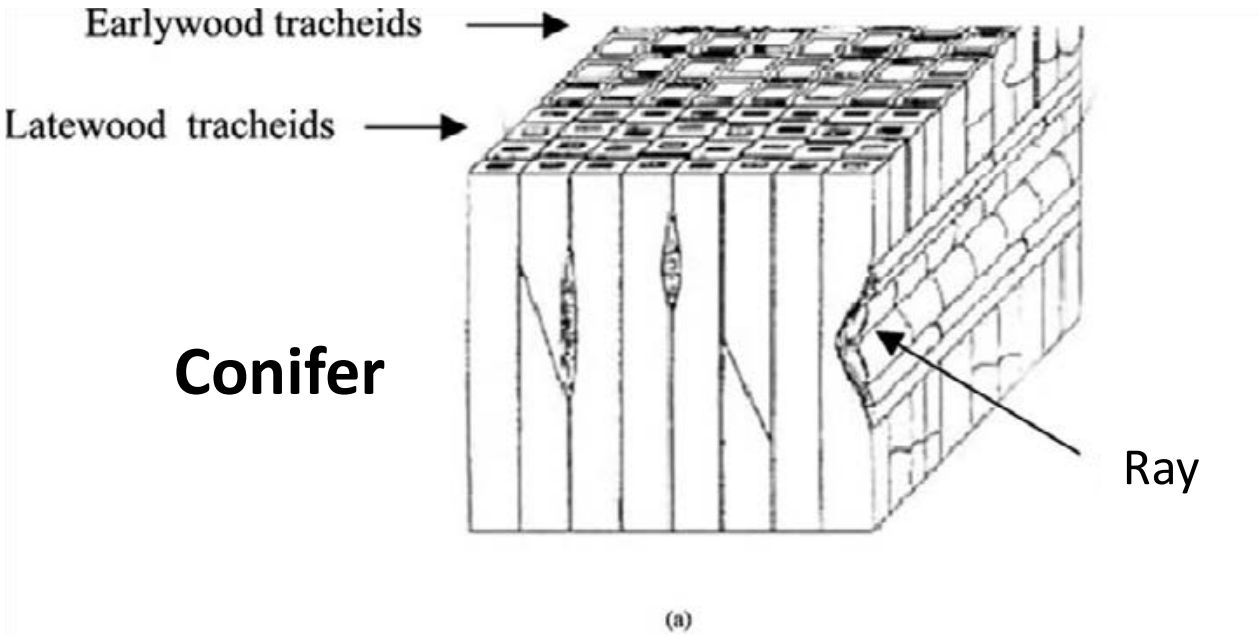




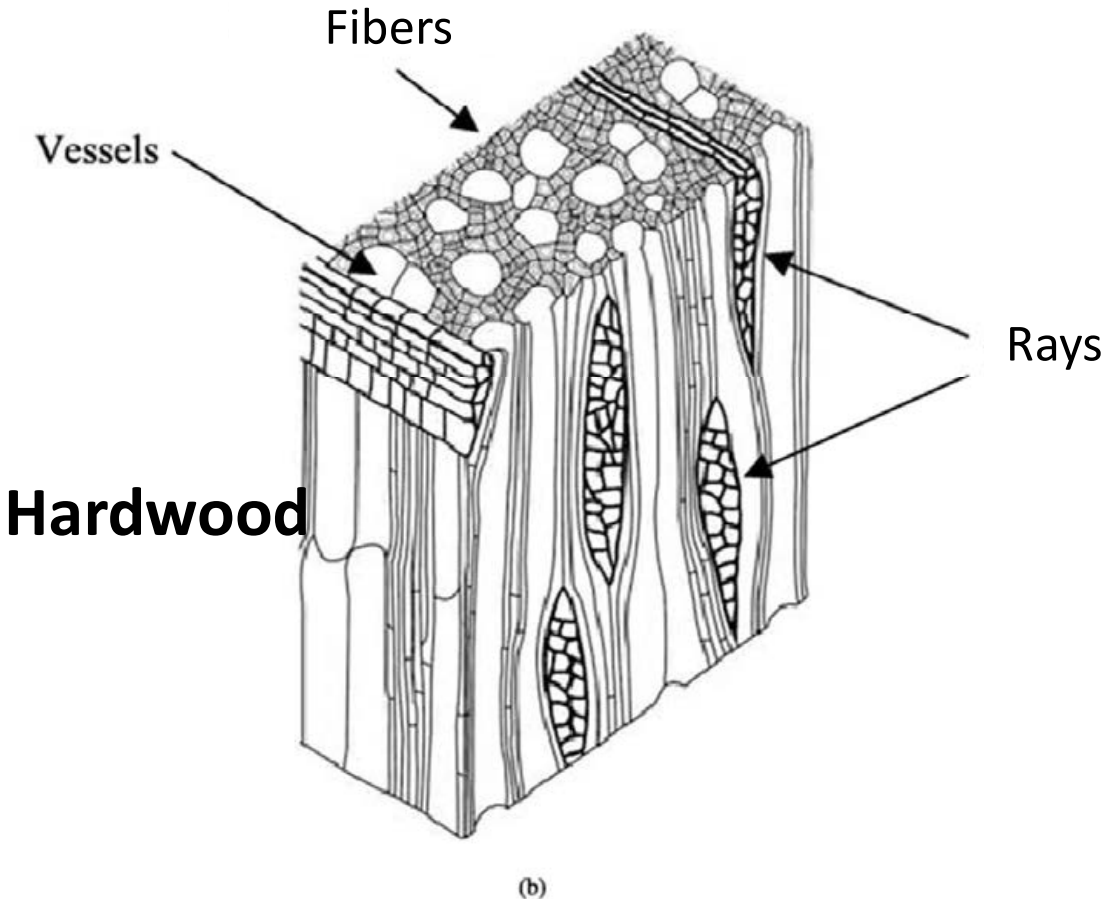
← *Diffuse Porous Hardwood (sugar maple)*

Ring Porous Hardwood (red oak) →





Conifer



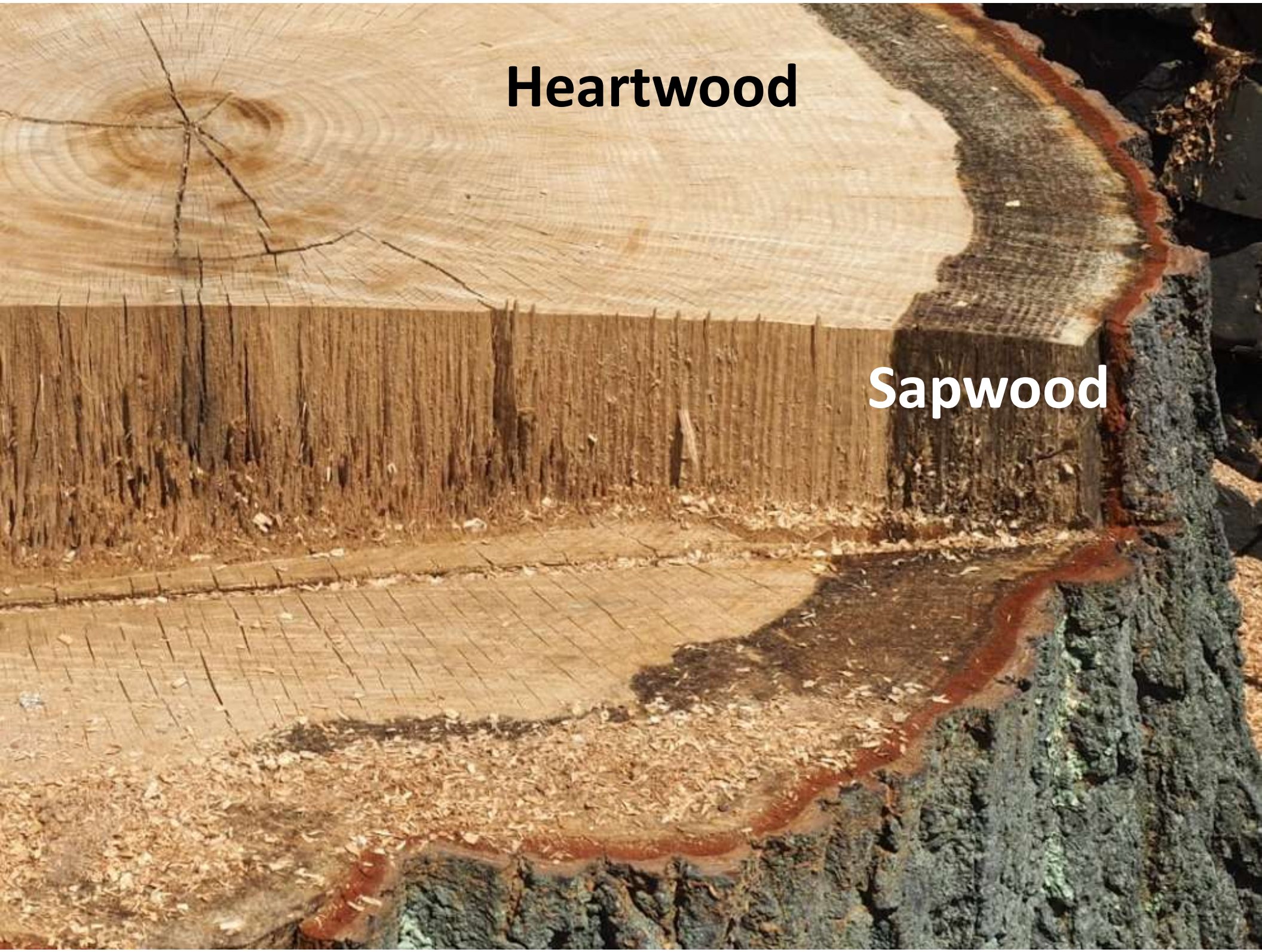
Hardwood

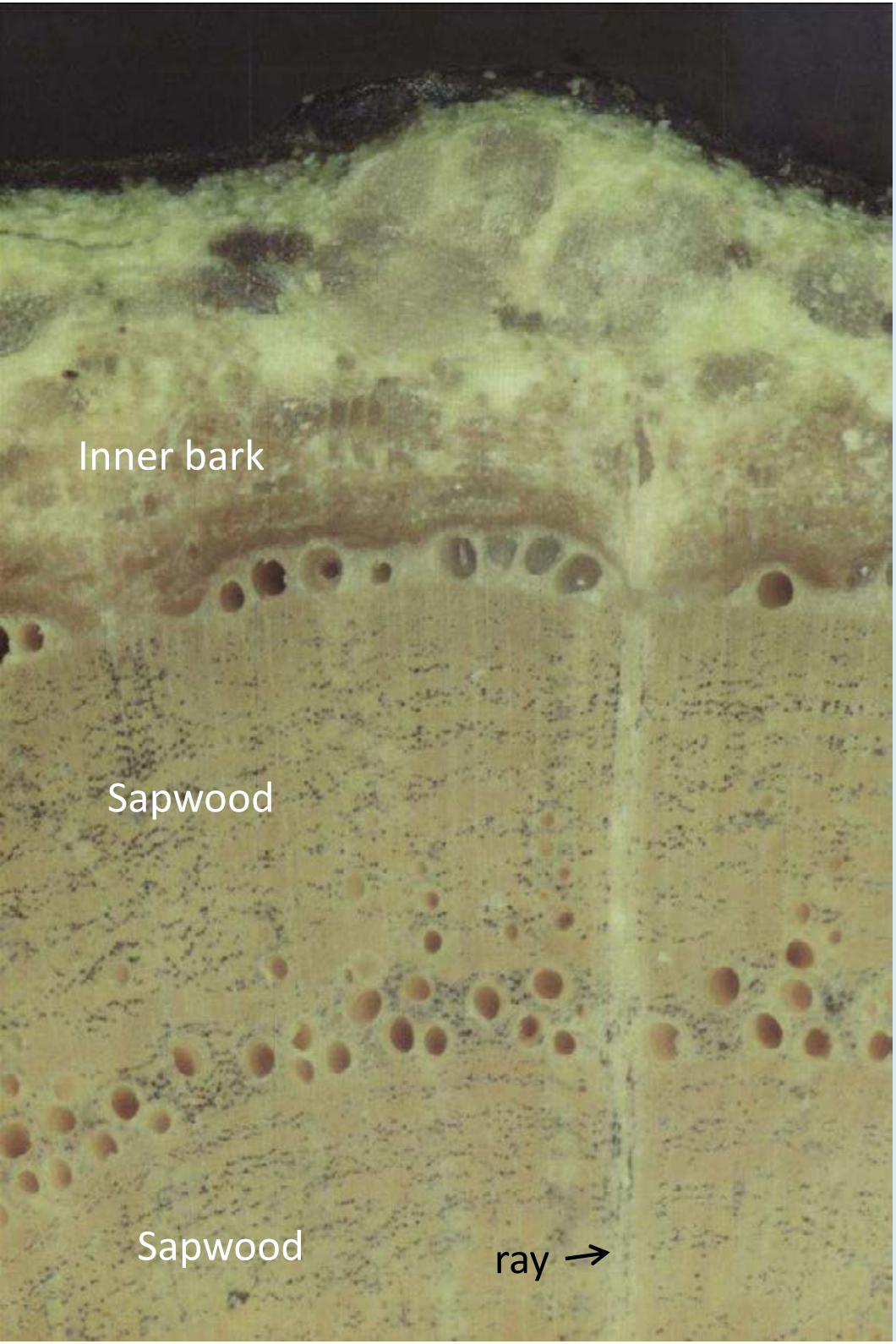

Douglas fir
(conifer)
Bark side
White ash
(ring porous hardwood)
Summer Wood
Spring Wood
Summer Wood
Spring Wood
Pith side

Explanatory Notes:

- X = xylem
- Conifers have tracheids
- Hardwoods have fibers and vessels
- Early Wood equals Spring Wood
- Late Wood equals Summer Wood
- Tracheids, fibers and vessels run lengthwise (up and down)
- Rays run across (vertical)

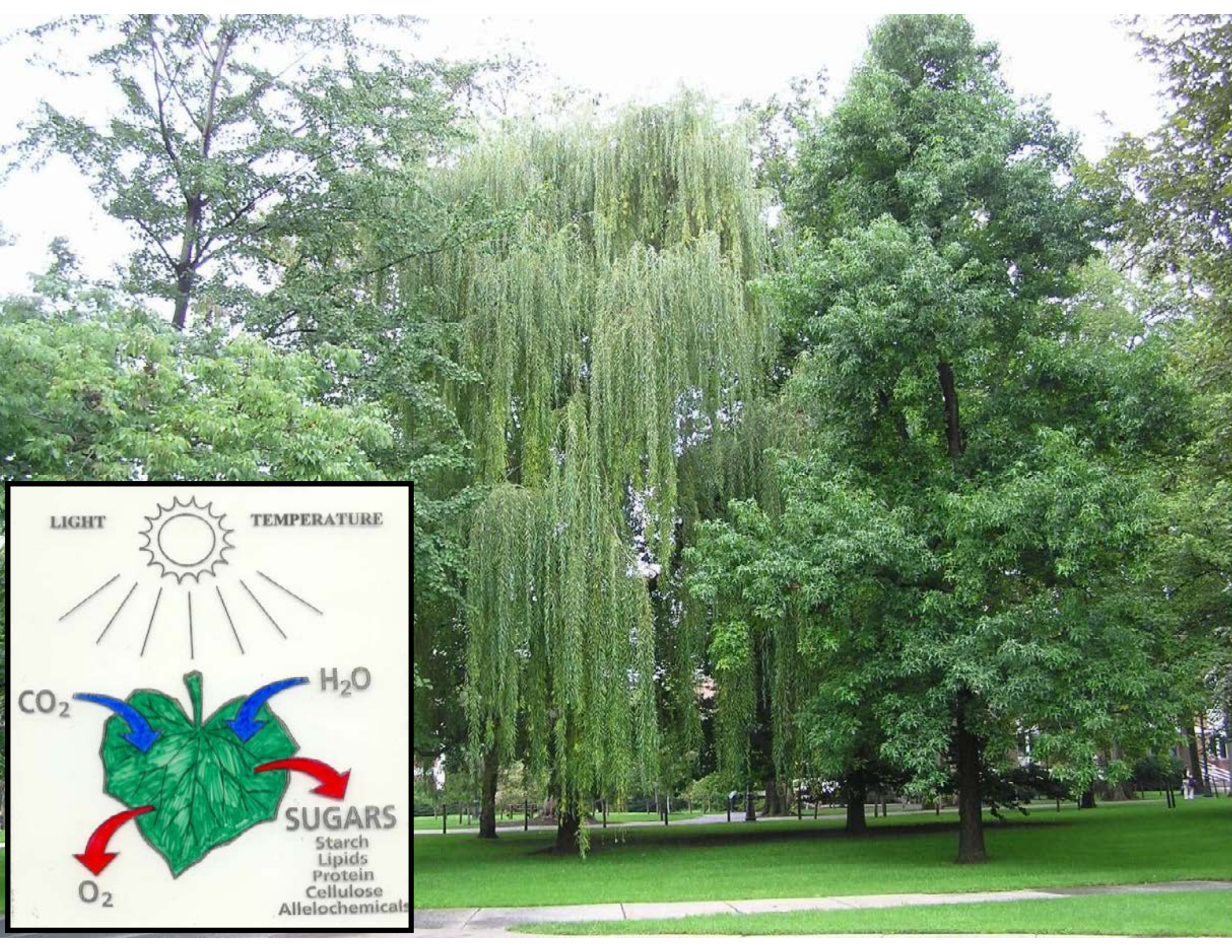

rays

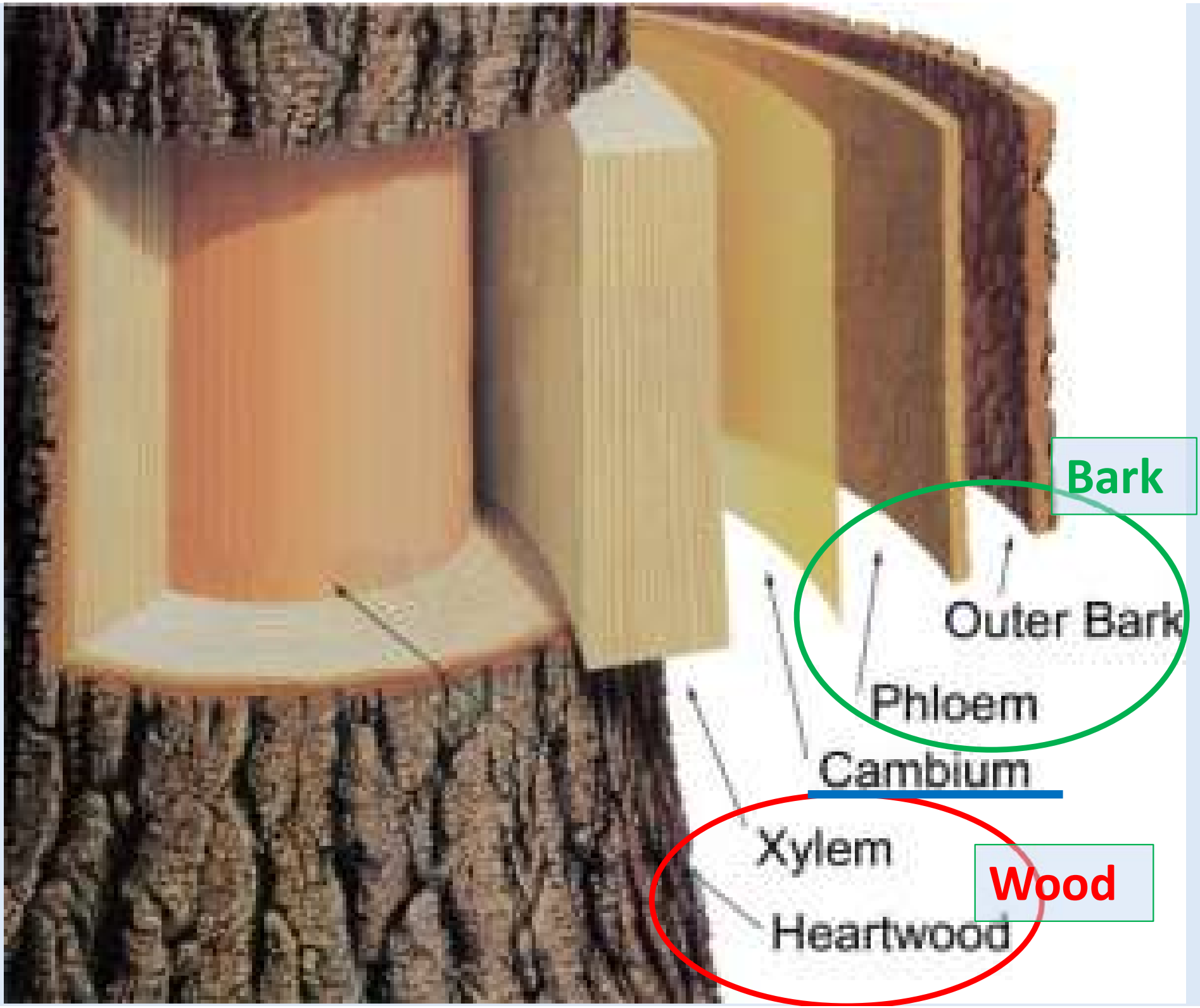

Heartwood
Sapwood



This photo by Alex Shigo shows a section of red oak that has been treated with iodine. The black specks that you see throughout the wood are starches – iodine turns starches black or dark blue.

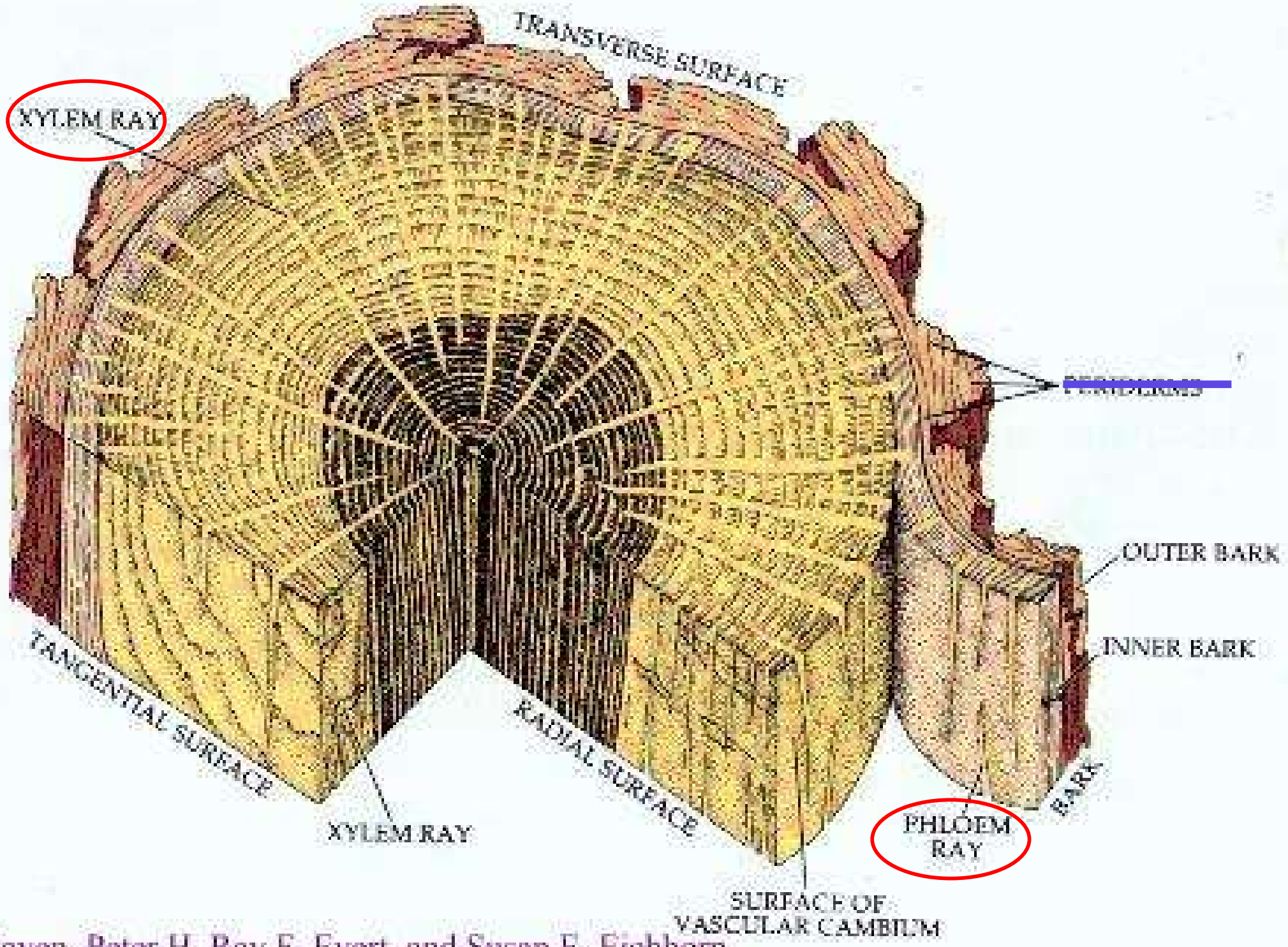
This is another major function of wood – it helps store the food supply of the tree – starches and fats (oils). The ray cells aid with transportation within the living part of the wood.


LIGHT
TEMPERATURE
CO_2
H_2O
O_2
SUGARS
Starch
Lipids
Protein
Cellulose
Allelochemicals


Bark
Outer Bark
Phloem
Cambium
Xylem
Wood
Heartwood

Important Notes – on bark:

- Outer bark provides the inner tree with protection from temperature changes, fire, dessiccation, insect and disease attack.
- Outer bark is made from the crushed remnants of inner bark and cells generated by the cork cambium that gives each species of tree its characteristic look.
- Inner bark is where the phloem tissue is housed.
- Phloem tissue is how the sugars produced in the leaves and elsewhere are moved throughout the tree.
- Unlike individual xylem cells, individual phloem cells are alive, which means that they are much better able to direct where these sugars go.
- Inner bark has ray cells – these ray cells are connected to the ray cells in the wood (or xylem).
- Both xylem cells (wood) and phloem cells (inner bark) are produced by the vascular cambium layer, which is found just beneath the bark.



Raven, Peter H, Ray F. Evert, and Susan E. Eichhorn.


Structural

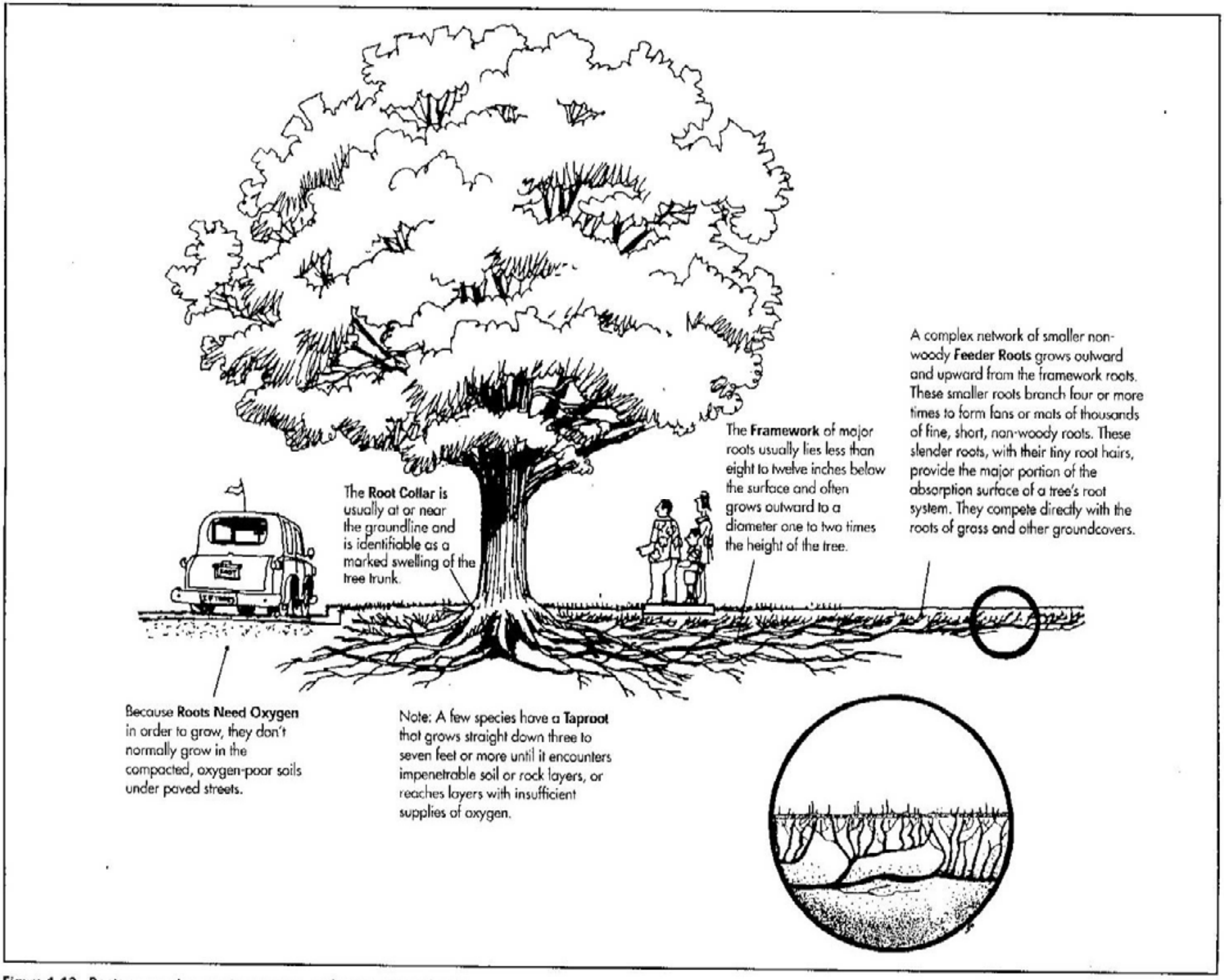


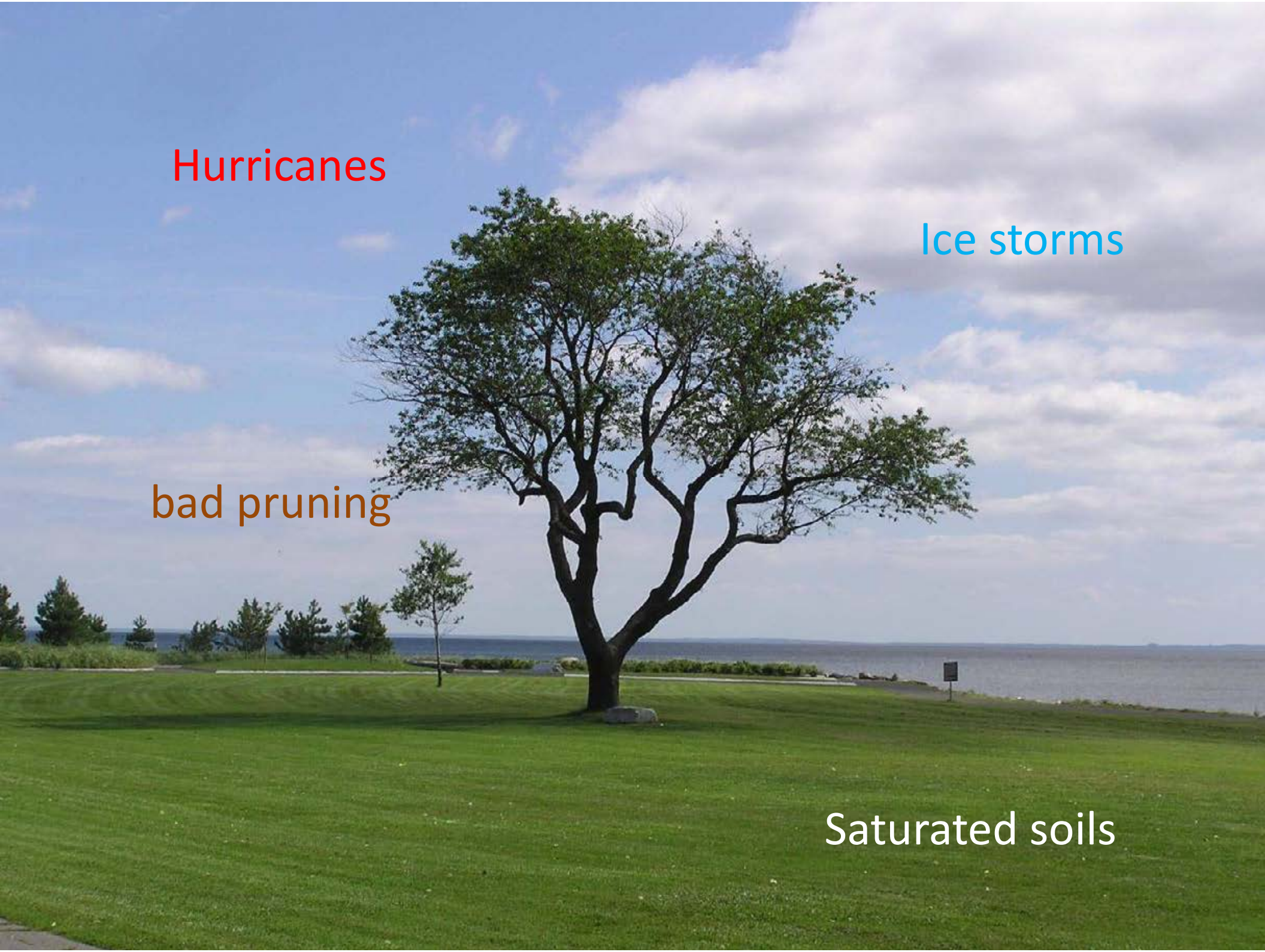
Figure 1.12 Roots grow where water, oxygen, and space are available.

Ceiba Tree, aka Silk Tree, Kapok Tree, Silk Floss Tree
Ceiba pentandra

Can grow up to 250 feet tall.

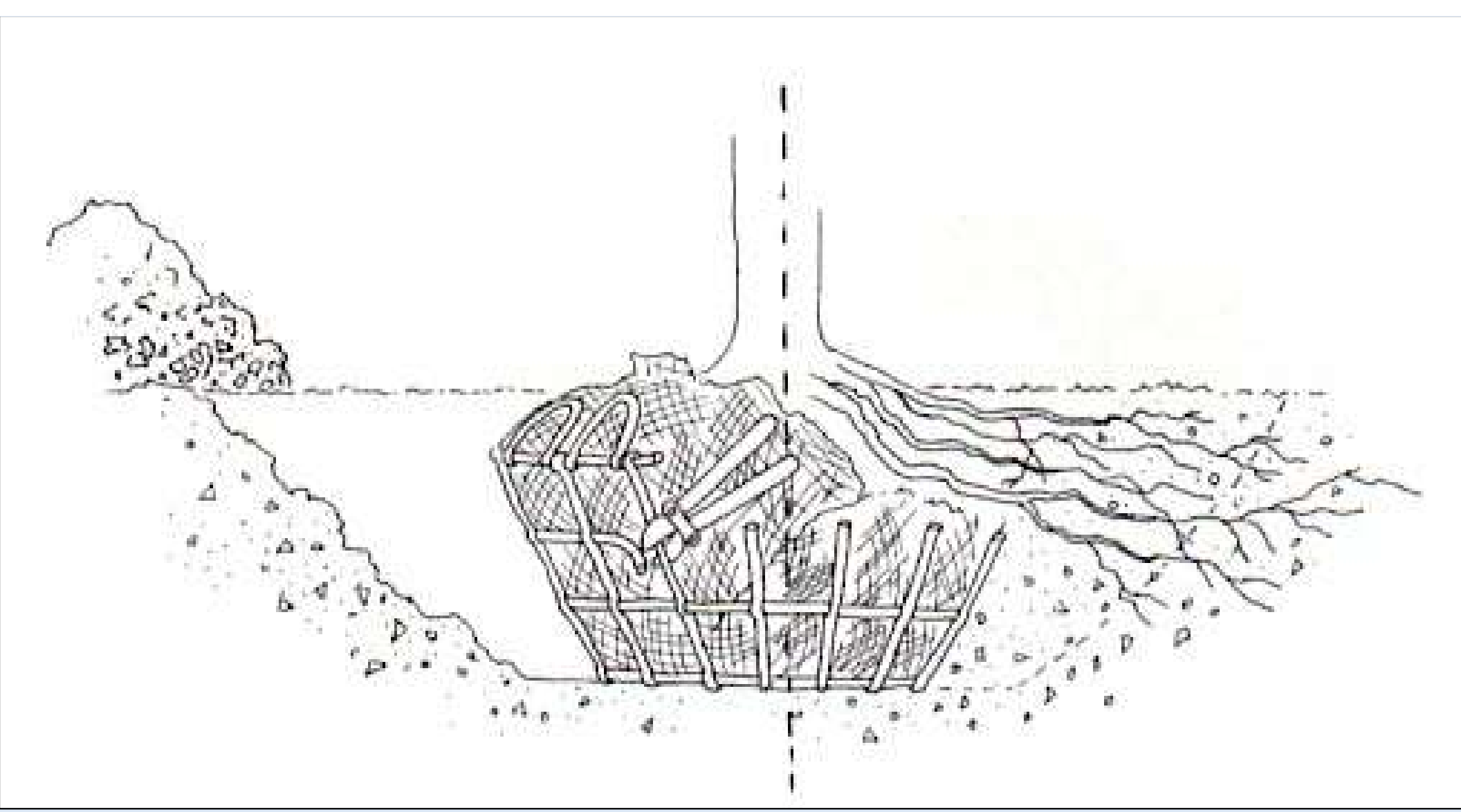
Santarem, Brazil, near to the Amazon River


1/2
MILE


Hurricanes
Ice storms
bad pruning
Saturated soils

Growth

The above ground parts of the tree grow in length from the buds at the tips of the branches and to the side from buds at the base of the leaves.



Tree roots grow from the tips, in the top 18 inches or so of the soil. When planting a tree, it is important to remove the burlap and wire from the upper 18 inches of the root ball, after the root ball has been placed in the hole!

Tree roots do branch, but the branching does not occur from buds in the same way as it occurs above ground. Roots do not have buds.

Meristem:

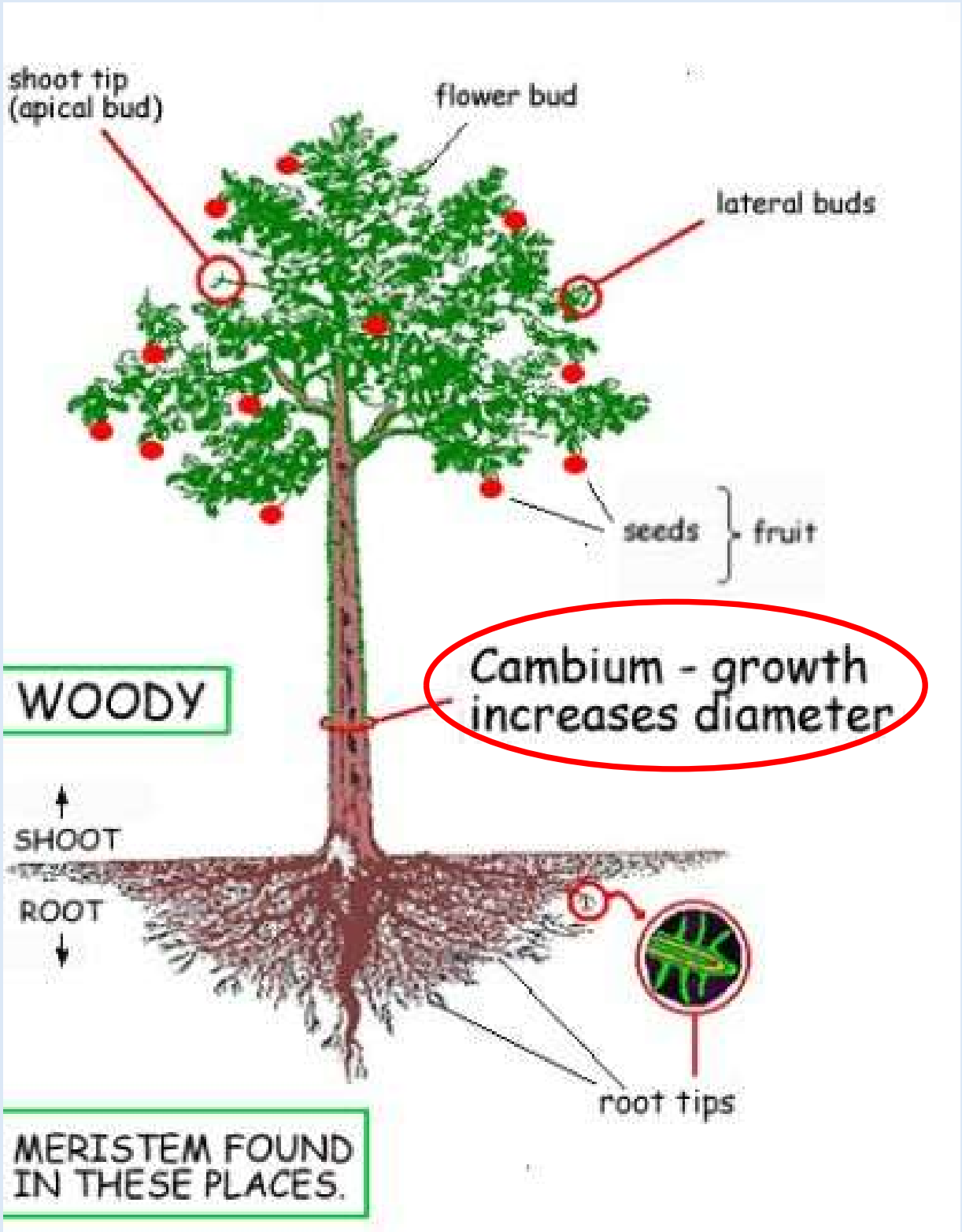
Tissue with undifferentiated cells that are able to divide and produce other types of cells.

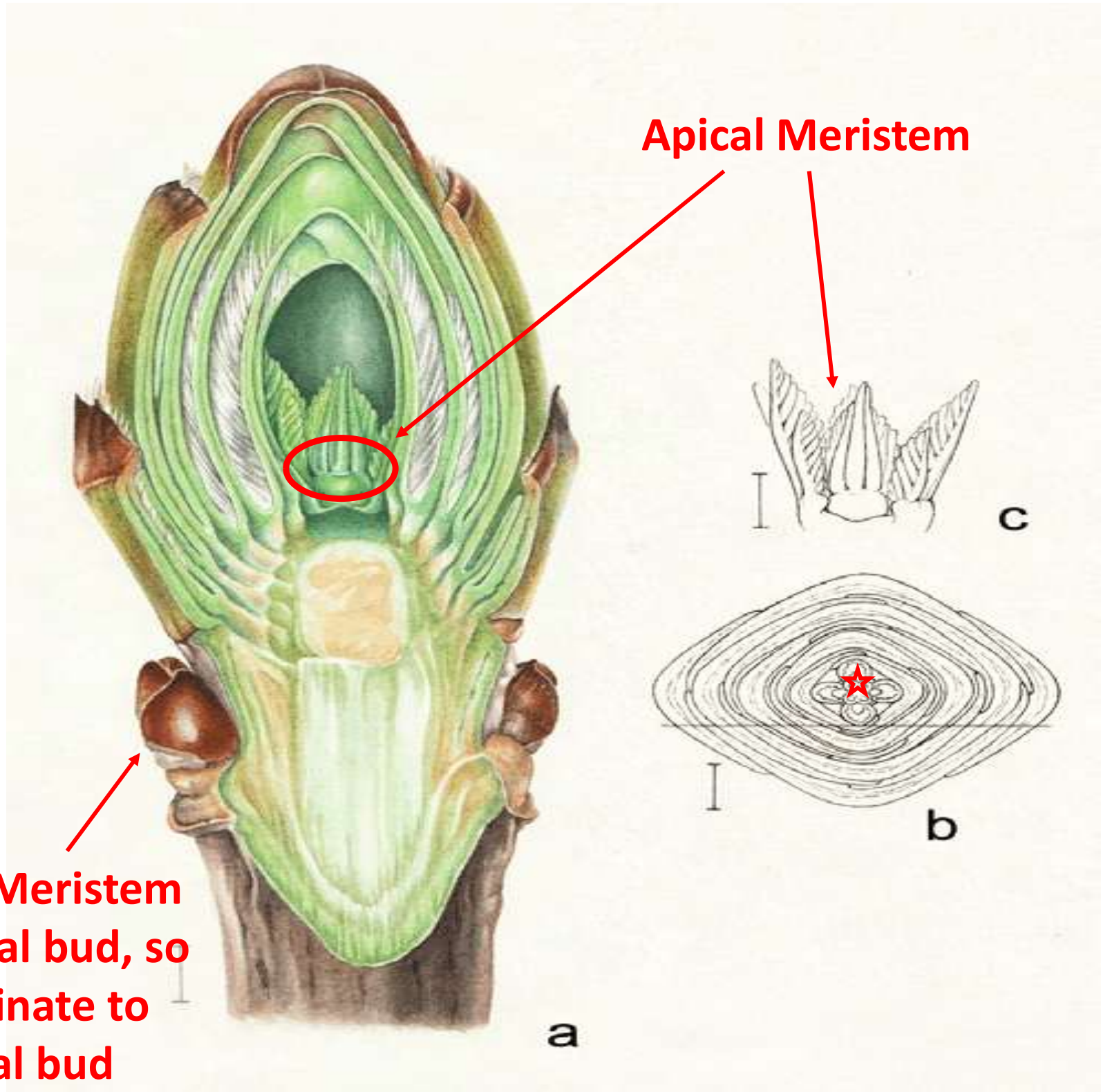
Examples:

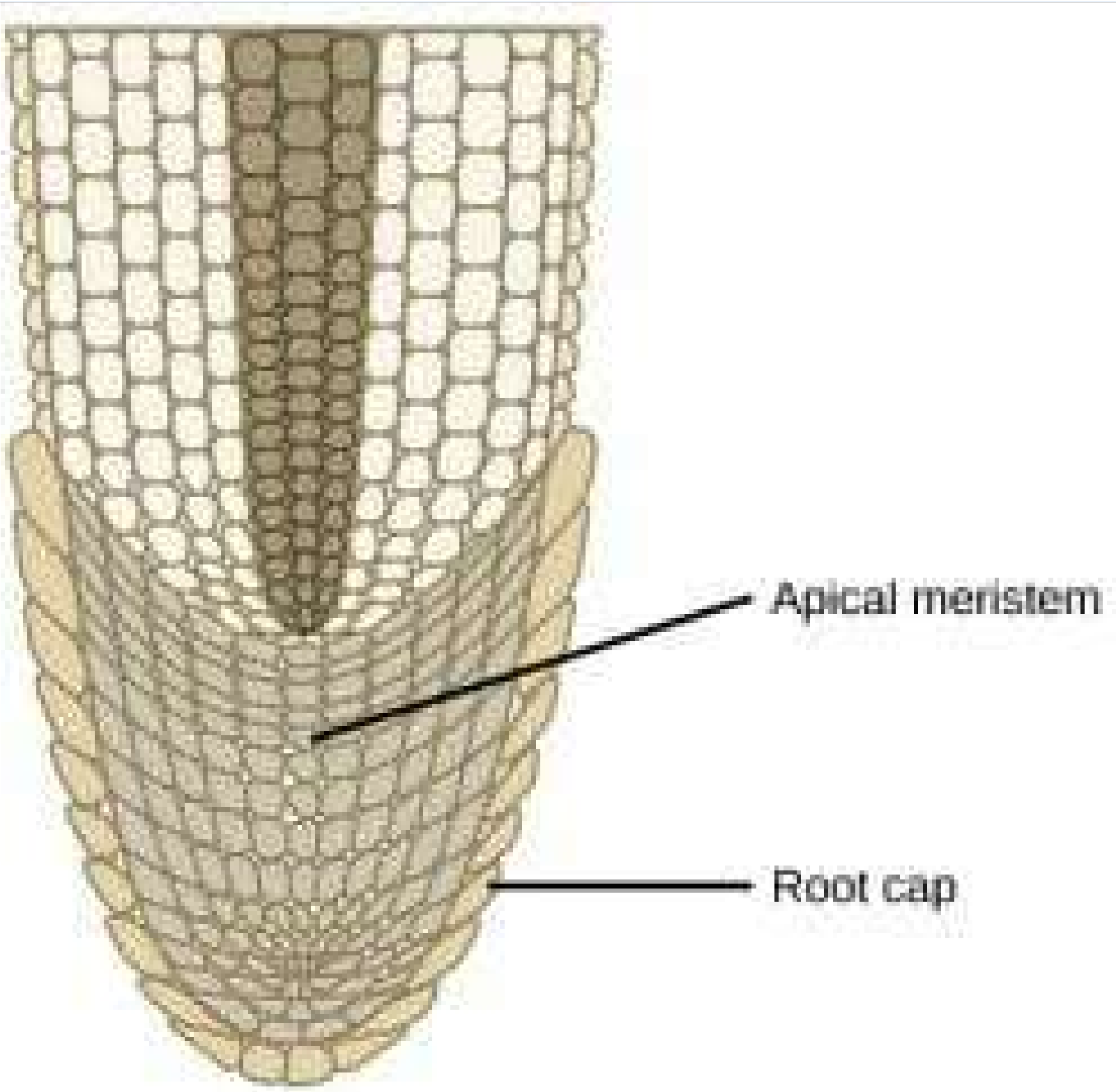
Apical meristem – present in the aboveground buds and also in the root tips. It is from the apical meristem in the bud that all of the parts of the tree aboveground comes. It is from the apical meristem in the root tips that all of the parts of the root comes.

Lateral meristem – aka **vascular cambium** – present as a thin layer of cells between the bark and the wood of the tree that produces phloem cells to the outside and xylem cells to the inside.

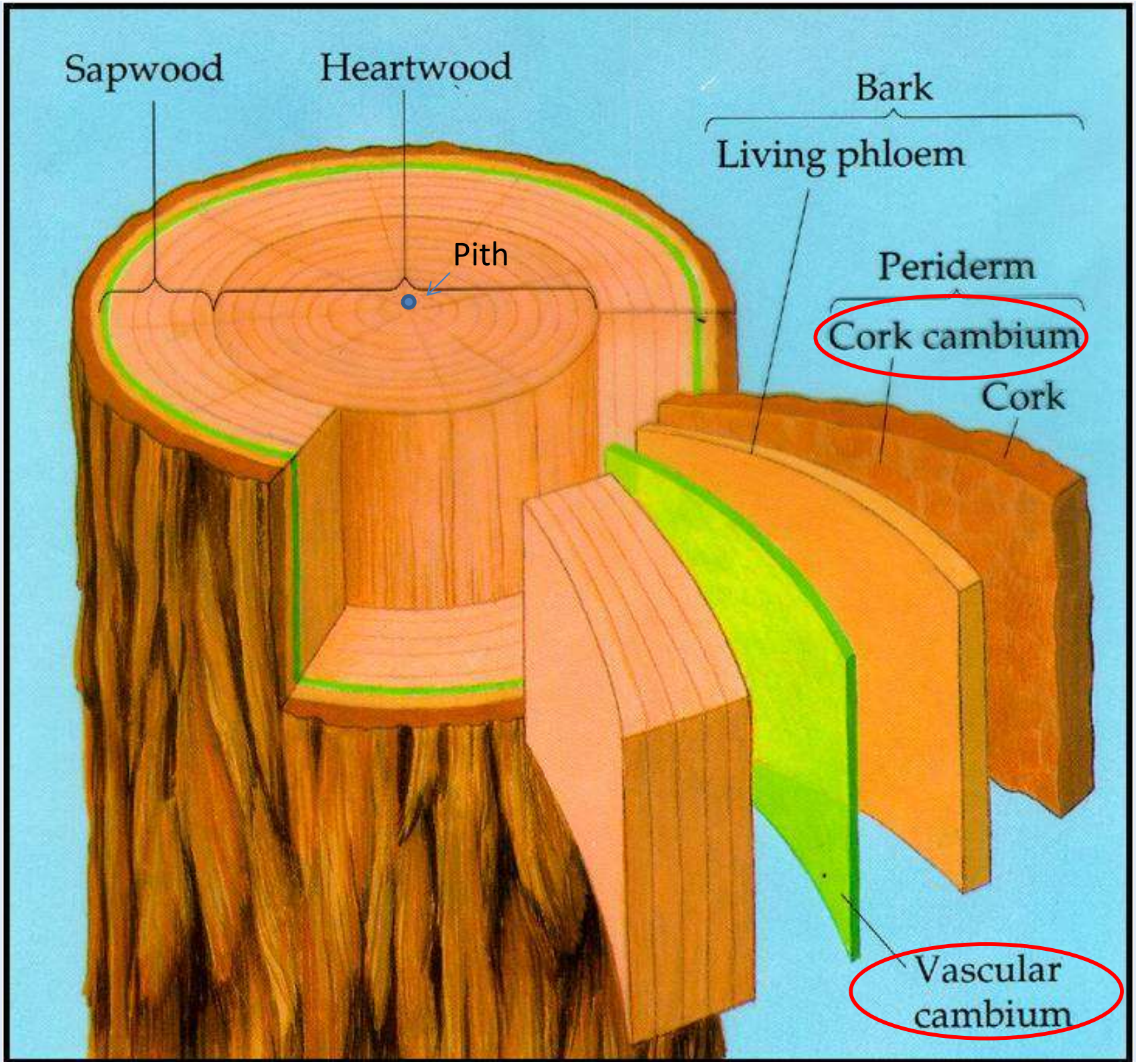
Cork cambium – strips of meristematic tissue within the outer bark that contributes to the production of outer bark cells. The cork cambium helps give the bark of the tree the structure typical to the species of tree.


shoot tip
(apical bud)
flower bud
lateral buds
seeds
fruit
WOODY
Cambium - growth
increases diameter
SHOOT
ROOT
root tips
MERISTEM FOUND
IN THESE PLACES.


Apical Meristem
c
b
a
Apical Meristem
In lateral bud, so
subordinate to
terminal bud


Apical meristem
Root cap

Trees grow in girth by means of the growth layer (vascular cambium) that is located underneath the bark of the tree, including around the trunk and branches and around the roots.

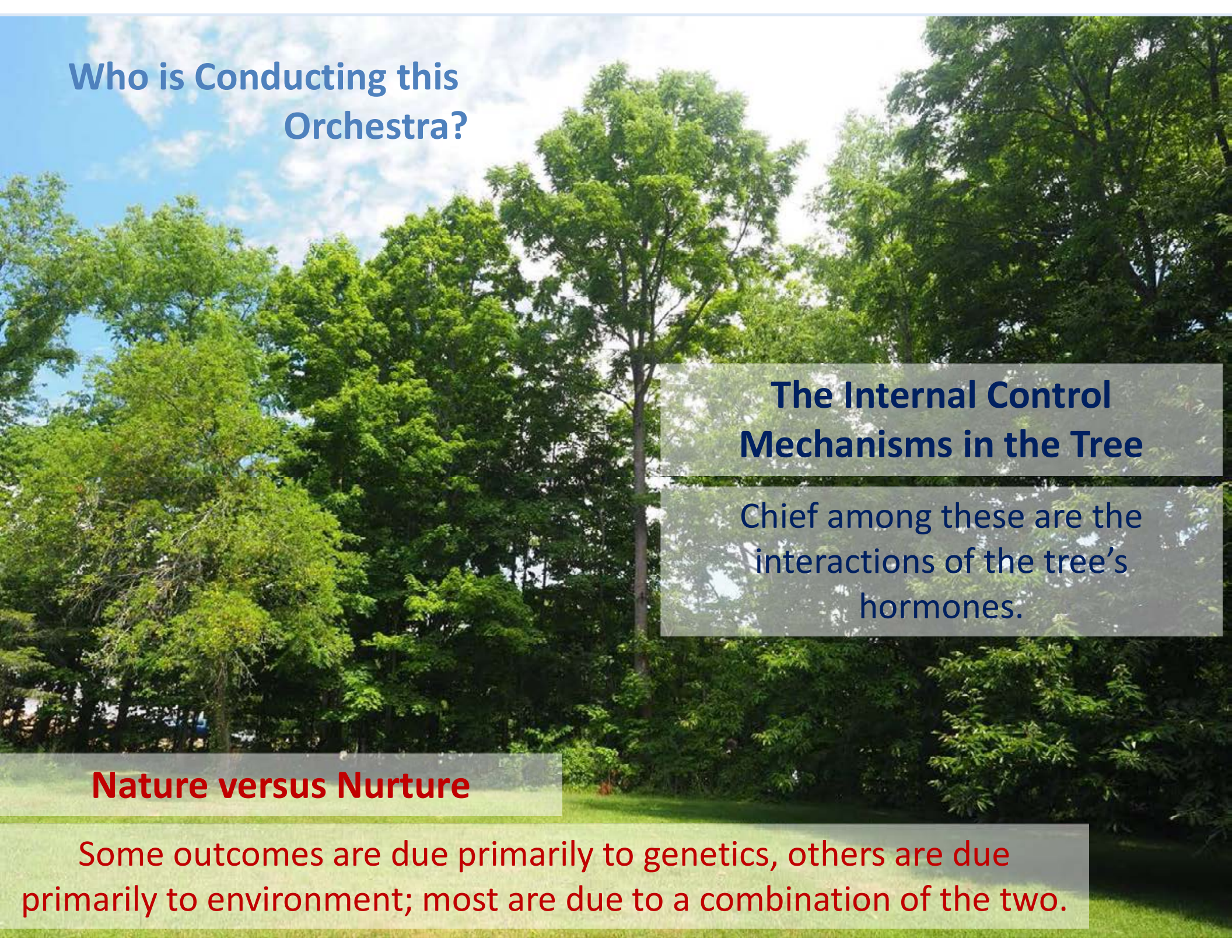

Sapwood
Heartwood
Bark
Living phloem
Pith
Periderm
Cork cambium
Cork
Vascular cambium

Response


7 6
7 5
7 4
IN TERMS OF INCHES AND TENTHS OF INCHES
MADE IN GERMANY


DEWEY-GRANBY OAK
"450 years ago, a tiny acorn..."
Under the permanent care and
preservation of the Granby Land Trust
for the pleasure of all.
1997


The Search for Access to Light
The Genetics of the Tree Itself,
Including What kind of Tree It Is
The Legacy of Environmental Influences
The Need to be Structurally Strong



Who is Conducting this Orchestra?

The Internal Control Mechanisms in the Tree

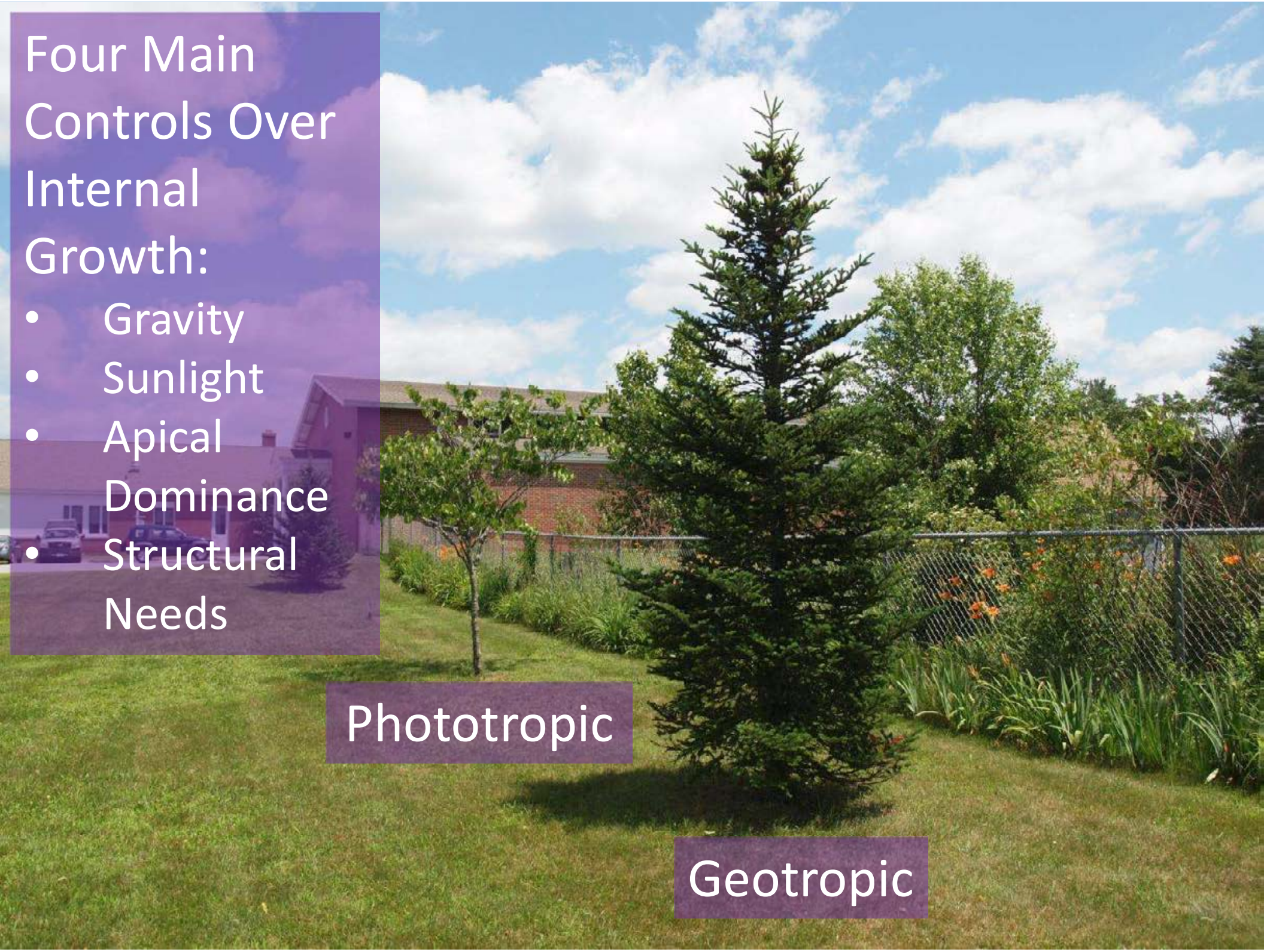
Chief among these are the interactions of the tree's hormones.

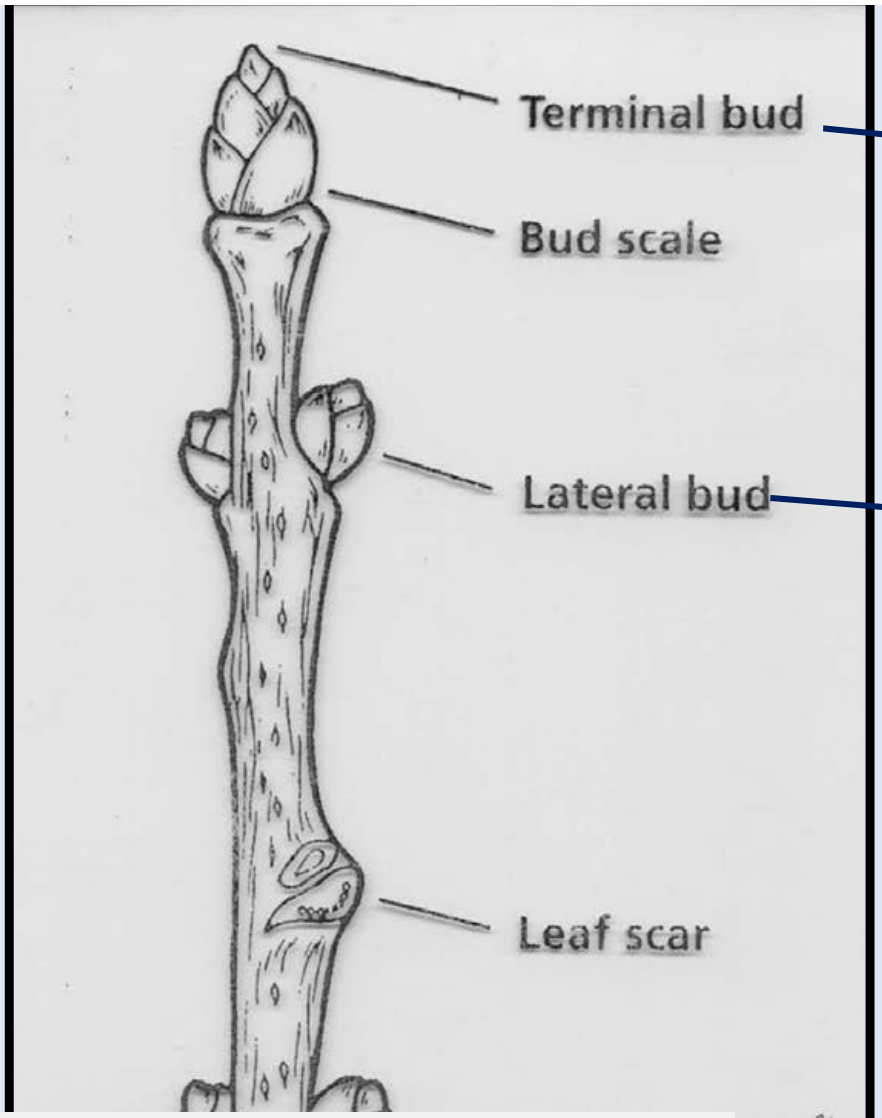
Nature versus Nurture

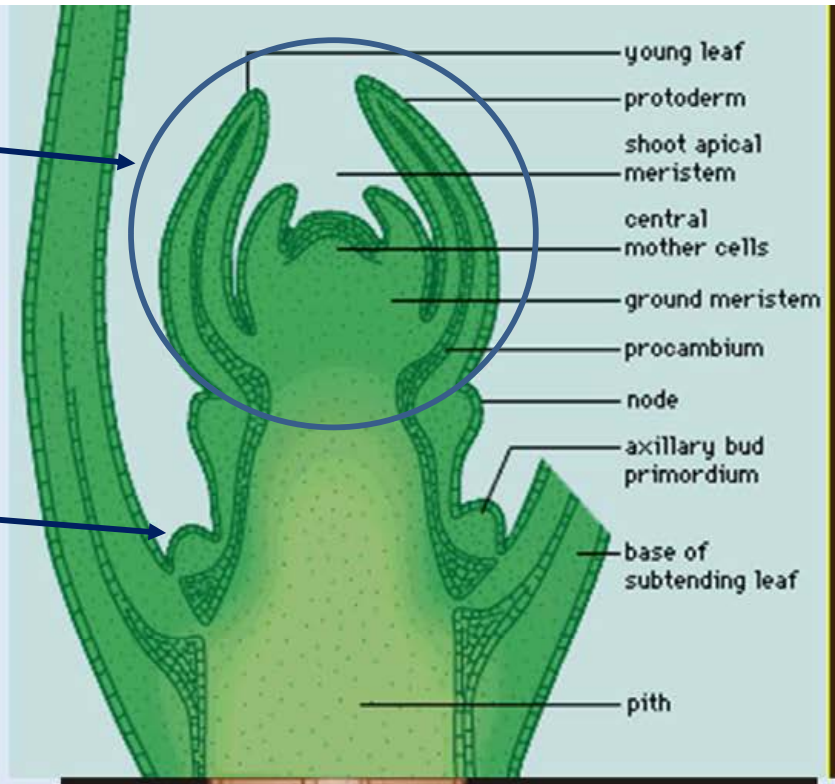
Some outcomes are due primarily to genetics, others are due primarily to environment; most are due to a combination of the two.

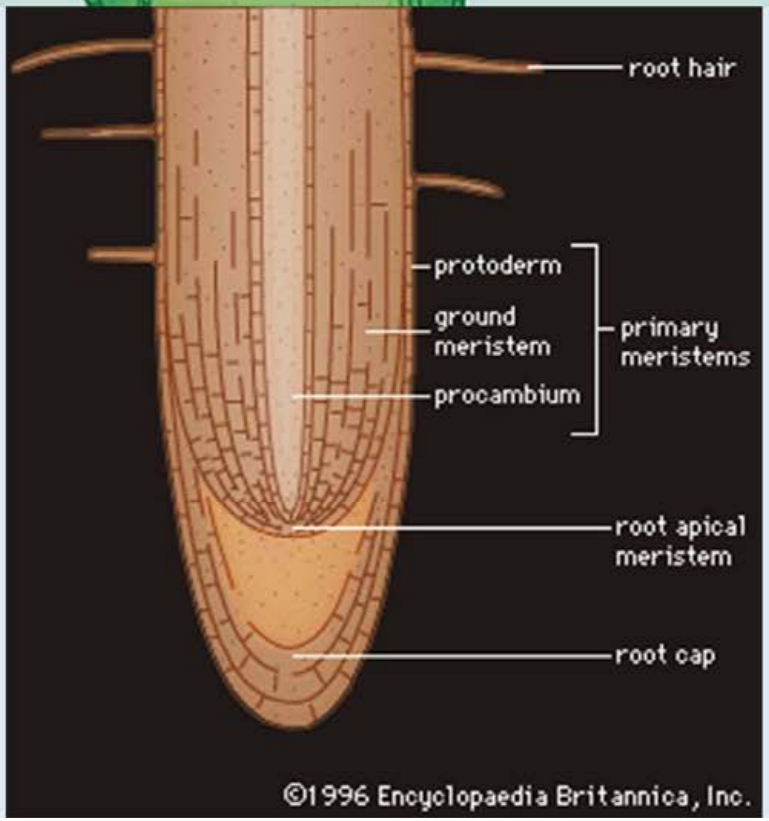
excurrent form ↑↑↑

decurrent form ↓↓↓


Four Main Controls Over Internal Growth:
• Gravity
• Sunlight
• Apical Dominance
• Structural Needs
Phototropic
Geotropic

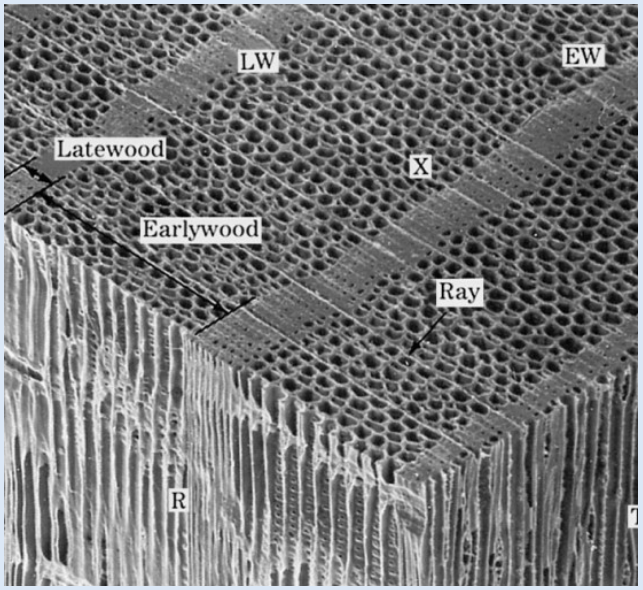


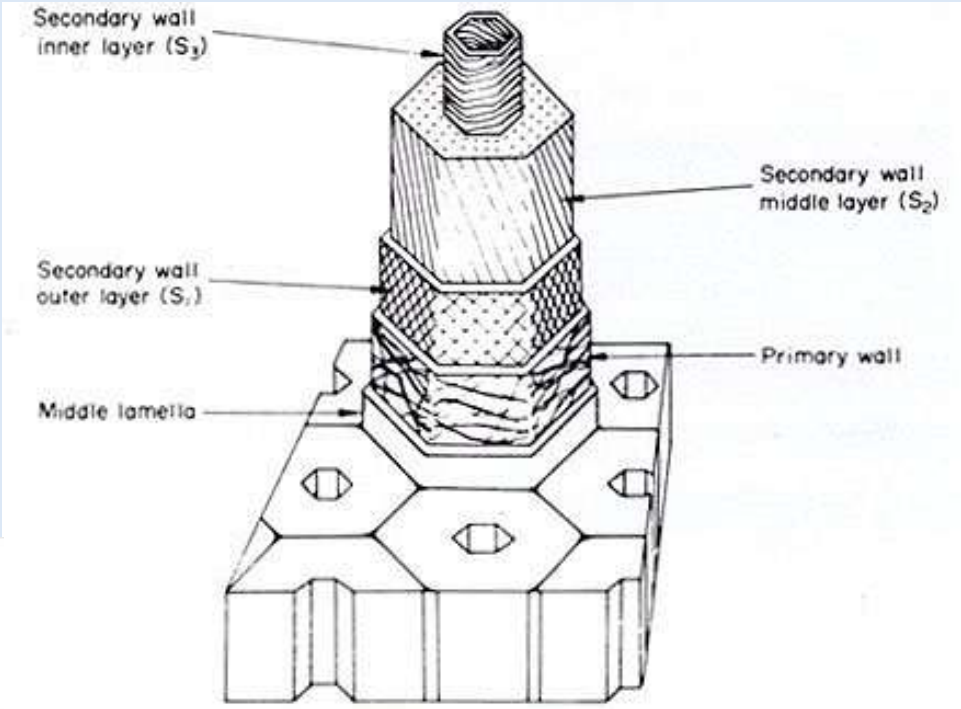




Major Plant Hormones:

- Auxins (shoots)
- Cytokinins (roots)
- Gibberellins





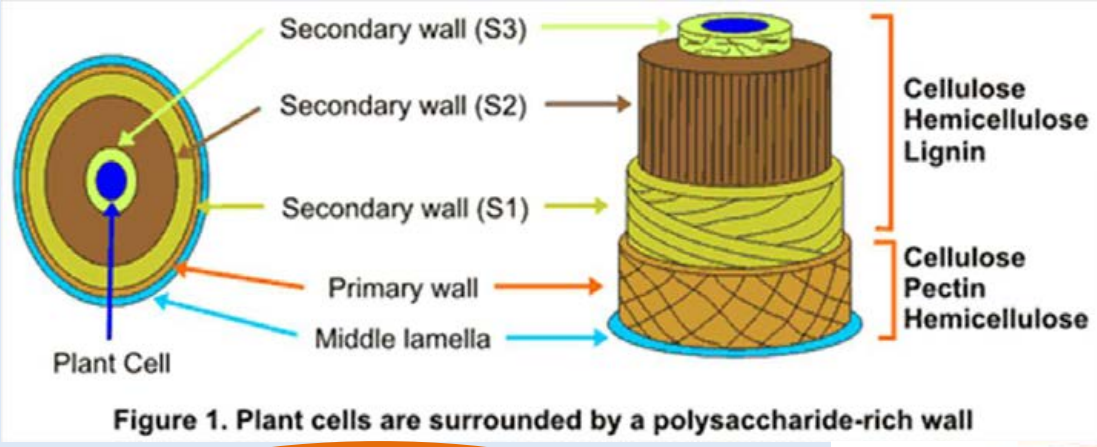
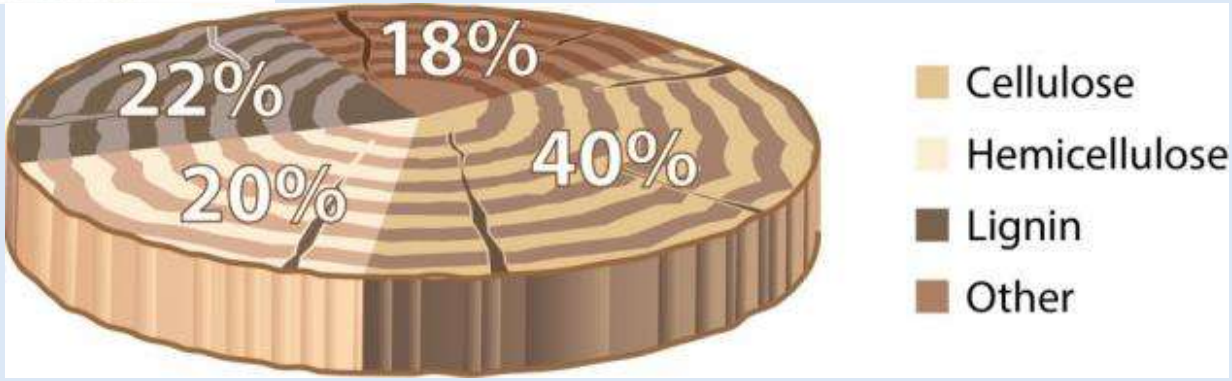
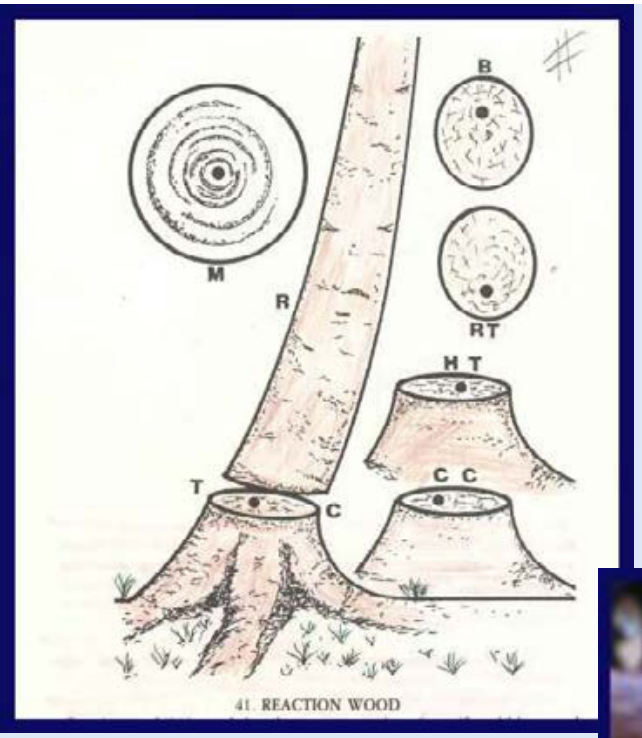
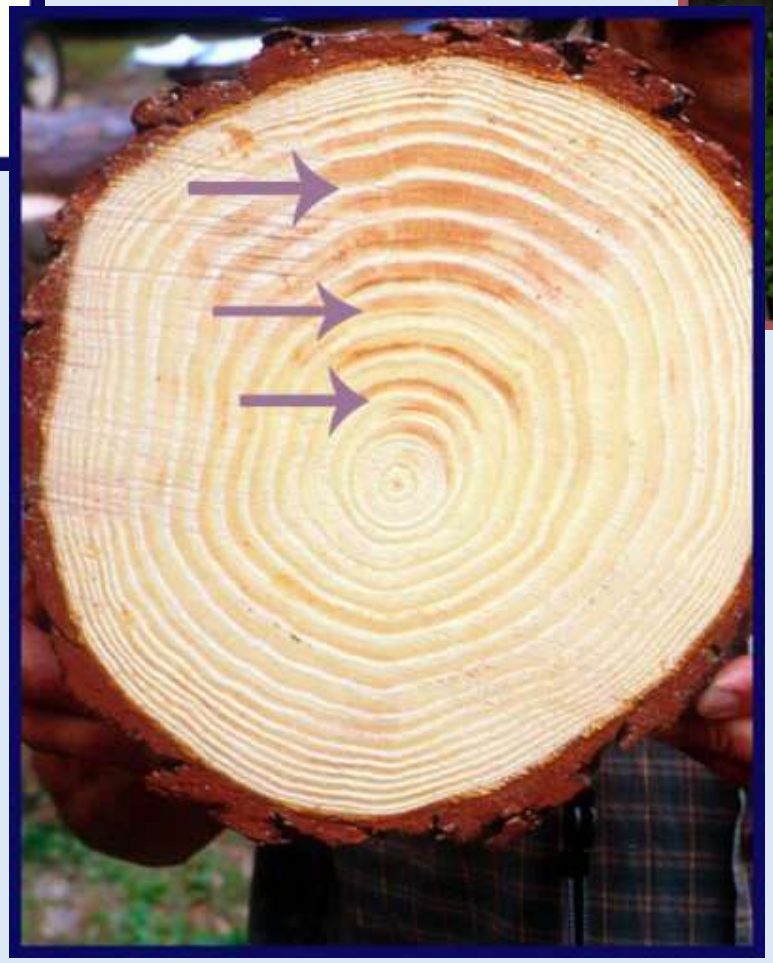


Figure 1. Plant cells are surrounded by a polysaccharide-rich wall

Lignin = stack of bricks
Cellulose = length of rope
Hemicellulose and Pectins = glue







Compression Wood: Conifers

Tension Wood: Hardwoods

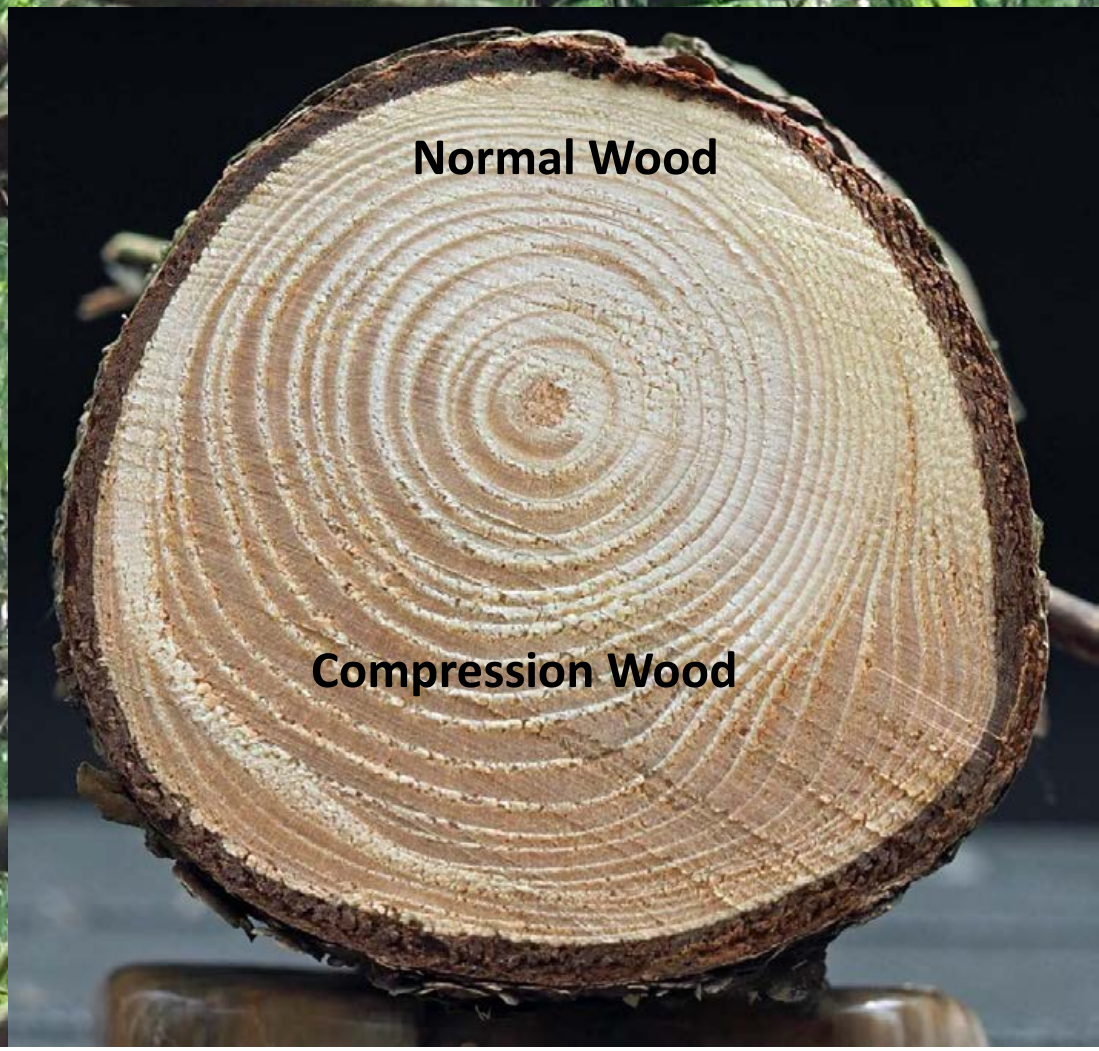
Branch Wood

Tension Wood – upper part of the limb. Increased cellulose content.

Sugar Maple

Branch Wood

Compression Wood – lower part of the limb. Increased lignin content.



Terms

- Excurrent – strong central leader (e.g. pin oak)
- Decurrent – spreading branches (e.g. sugar maple)
- Geotropic – guided by gravity (most conifers)
- Phototropic – guided by access to light (most hardwoods)
- Apical Dominance – the hormonal control over bud development and shoot growth played by the terminal bud
- Tension Wood – formed in angiosperms. Wood that is higher in cellulose and constructed in such a way that it increases the ability of the wood to carry load in tension.
- Compression Wood – formed in gymnosperms. Wood that is higher in lingin and constructed in such a way that it increases the ability of the wood to carry load in compression.

CODIT

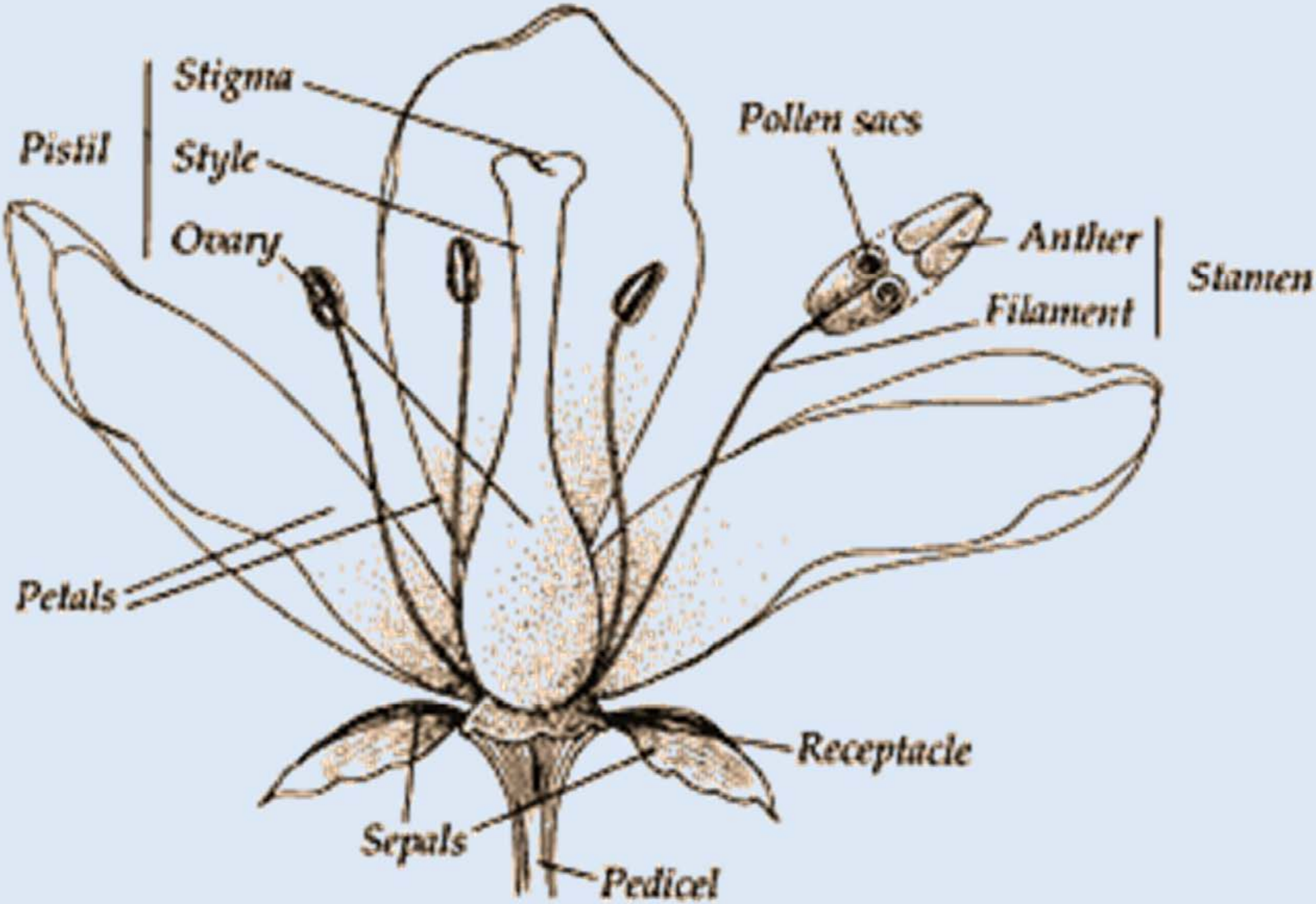
Compartmentalization of Decay in Trees

Reproduction

Why you need to know about reproduction in trees

- Floral display (ornamentals especially)
- Fruits and fruiting issues
- Pollen (increasingly a problem in cities!)
- Pollinators – of concern for several reasons
- Asexual reproduction – e.g. suckering

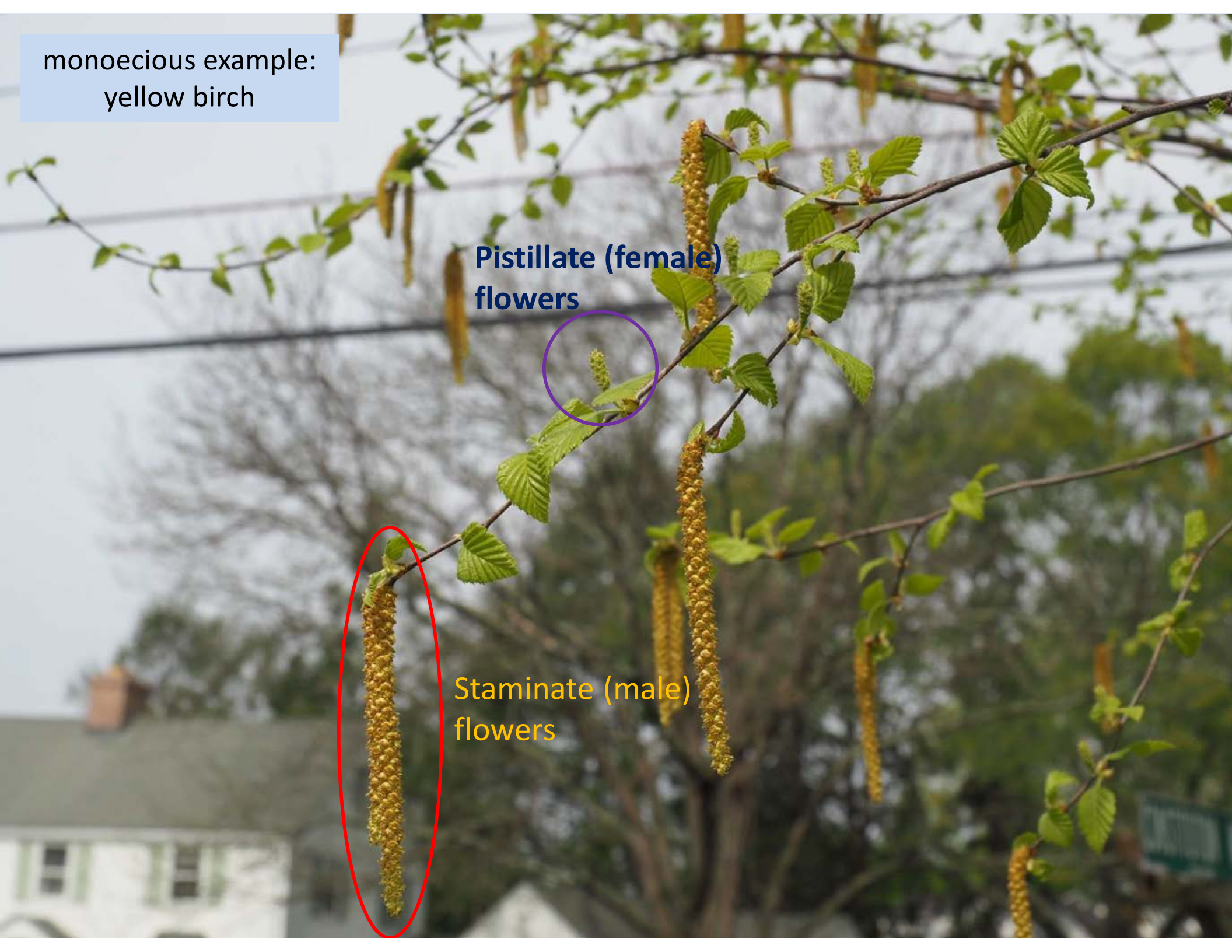
Perfect or two-sexed flower




Red Maples
in spring

Male and Female Trees??

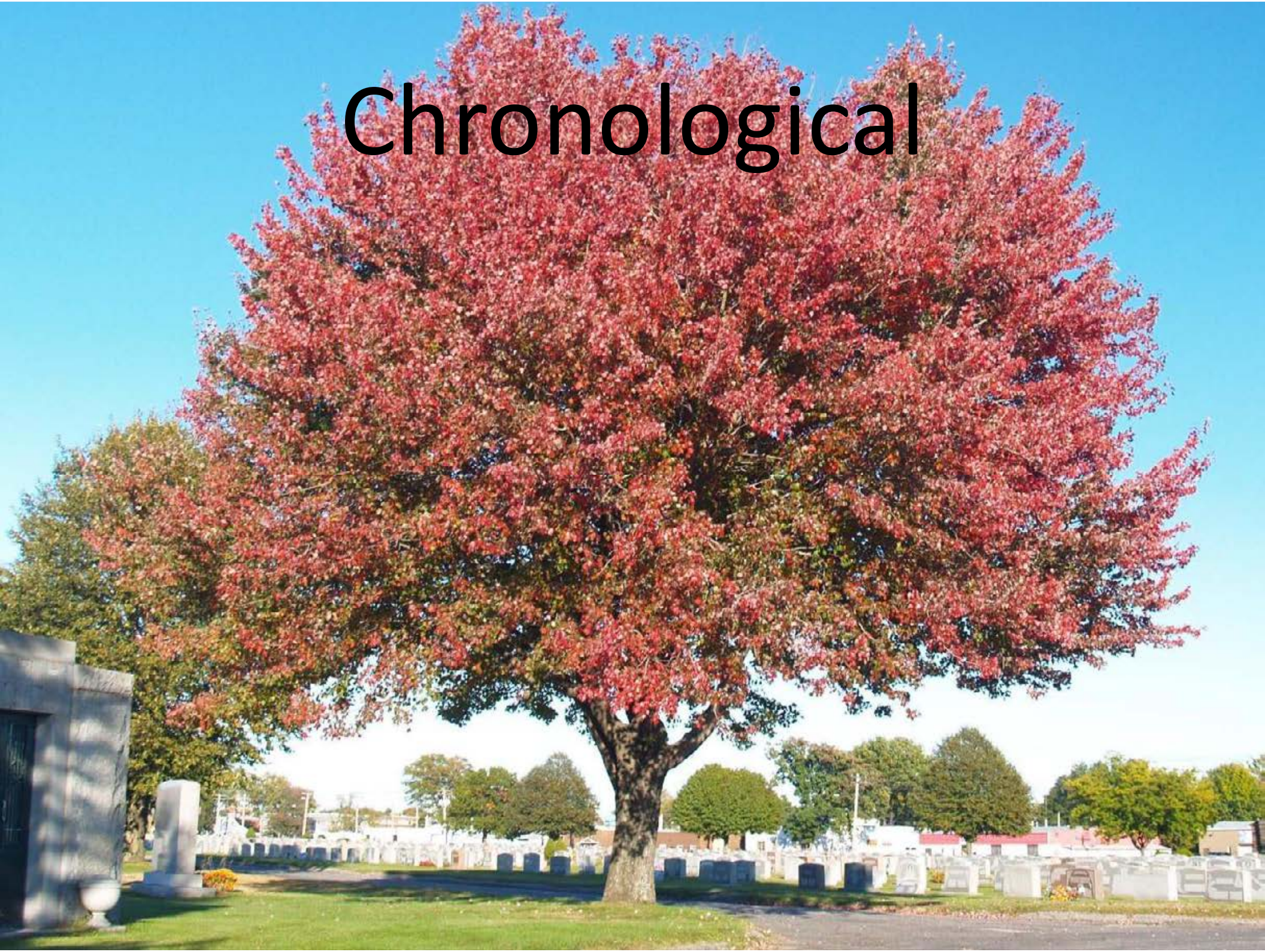
- Monoecious Trees: “one house” – individual male and female flowers on the same tree.
- Dioecious Trees: “two houses” – male and female flowers on different trees.
- Synecious Trees – trees with ‘perfect’ flowers (the pawpaw (*Asimina triloba*) the tulip poplar (*Liriodendron tulipifera* are examples).

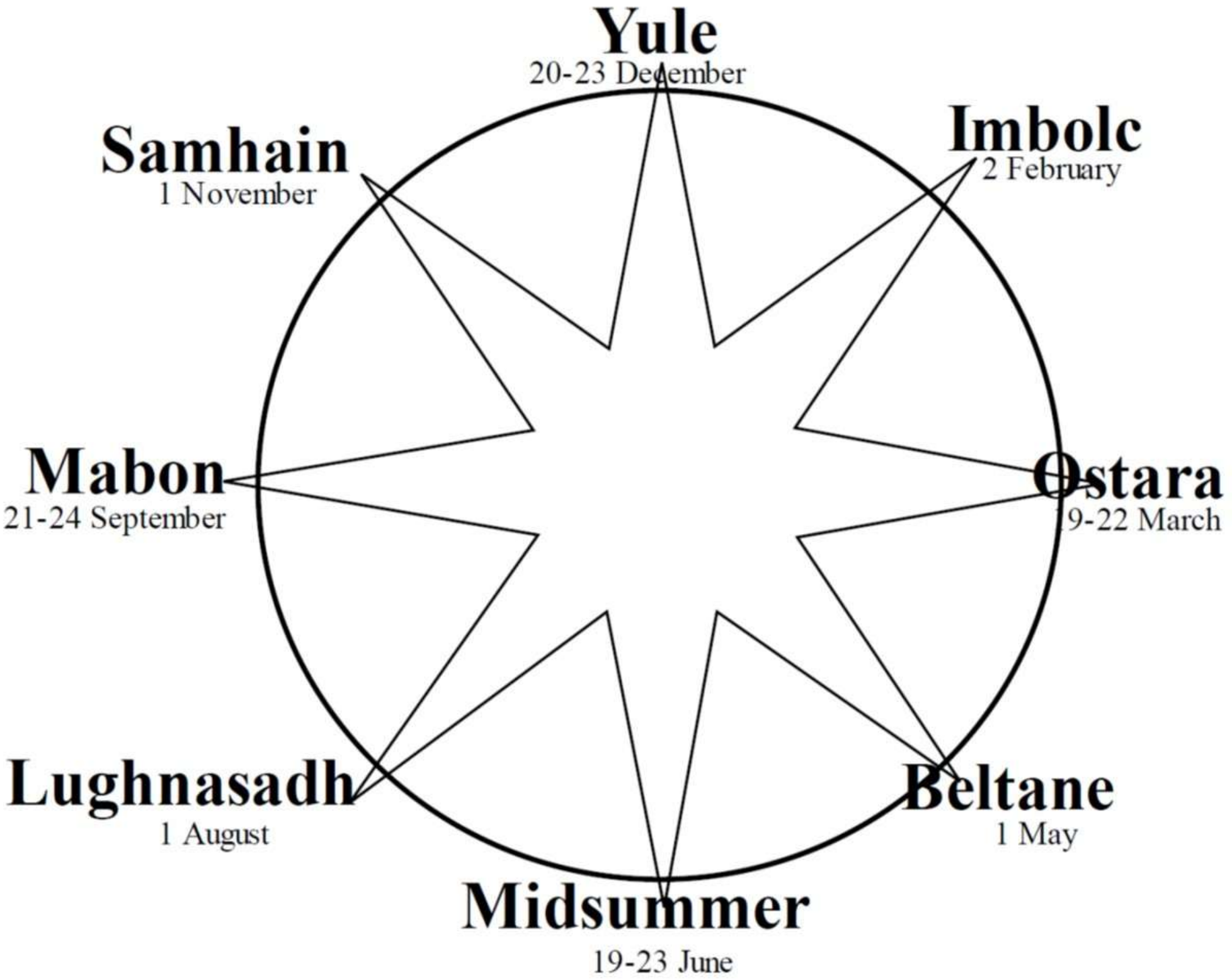

monoecious example:
yellow birch
Pistillate (female) flowers
Staminate (male) flowers

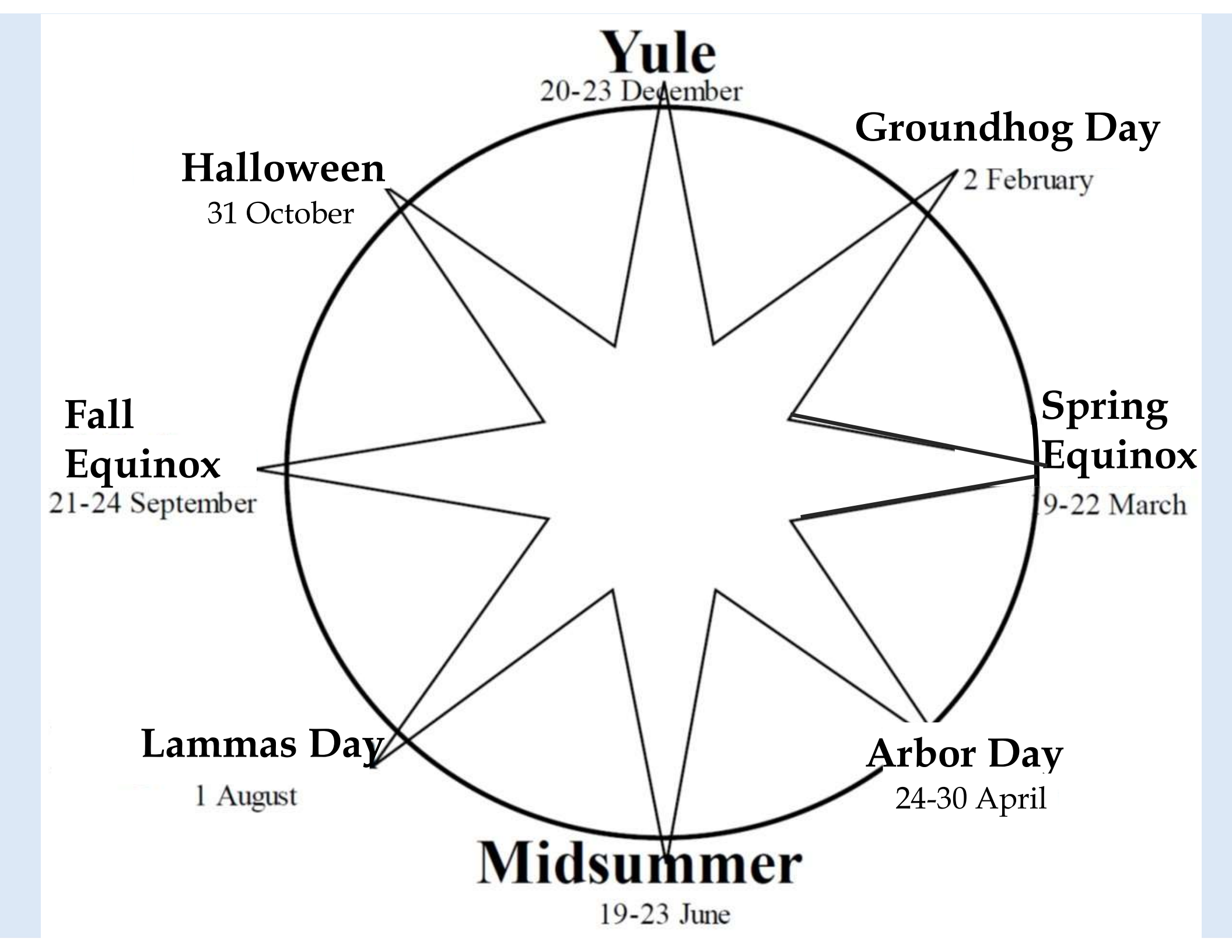

diecious example:
red maple
Female flowers


diecious example:
red maple
Male flowers

Chronological



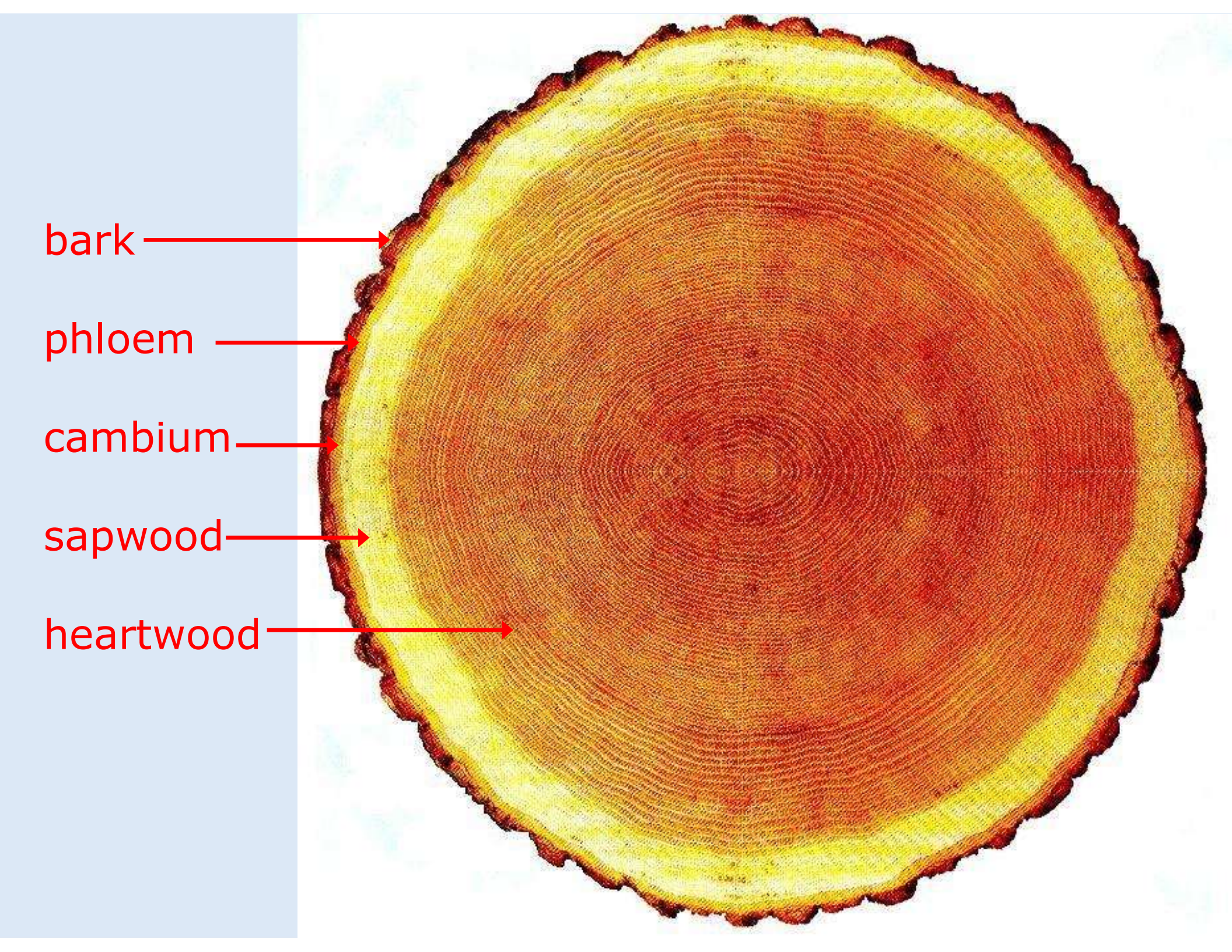

Yule
20-23 December
Imbolc
2 February
Samhain
1 November
Mabon
21-24 September
Ostara
9-22 March
Lughnasadh
1 August
Beltane
1 May
Midsummer
19-23 June


Yule
20-23 December
Groundhog Day
2 February
Halloween
31 October
Fall
Equinox
21-24 September
Spring
Equinox
9-22 March
Lammas Day
1 August
Arbor Day
24-30 April
Midsummer
19-23 June


CAS
OVERFLOW
PARKING

Death & Shedding


WAVE
a gallery


bark
phloem
cambium
sapwood
heartwood

Summary

Trees are woody, highly competitive, highly organized organisms that photosynthesize, and use the products of photosynthesis to develop a variety of structures and conduct a variety of functions that are necessary to keep it alive.


Questions?