Woody Plant Biology- Part 1

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Objectives for the Course

1. Identify tree structures and their functions
   - Diagramming various structures
   - Detailing their interaction
2. Detail the composition of a tree's vascular system
   - Outline water and carbohydrate movement
   - Important Hormones

Objectives

3. Outline the chemical and energy processes of photosynthesis and respiration
   - Identify affecting factors
4. Assess the interaction between genetic potential and the environment
5. Reproductive parts

What is a tree?

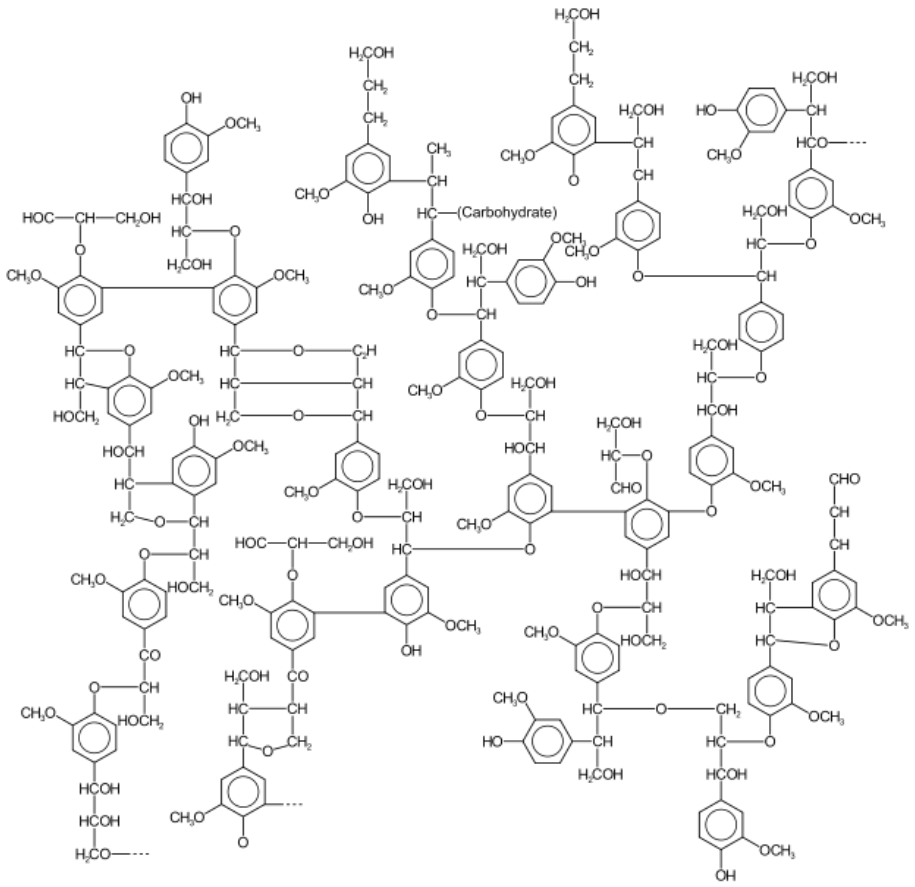
According to Wikipedia:

- Woody plant
  - Vascular plant with conducting tissues and individual cells grouped into specialized tissues
  - Secondary branches
  - Typically one single main stem or trunk with clear apical dominance
- Minimum height varying from 10-20'; some authors set a minimum of 4"trunk diameter
- Compared with most other plants, trees are long-lived, some living several thousand years and growing to up to 115 m (375 ft) high.

What is a tree?

- According to Dr. Alex Shigo:
  - Highly compartmented, woody, perennial that sheds
  - Long-lived and massive
  - Typically one trunk
  - Must defend itself against attack
    - Can add new tissue
  - Deserving of dignity, particularly in death

What is a tree?



- Autotroph-
  - Makes its own food using light, water and CO2
- Stores energy in living wood cells
- Connected system of living and dead cells
- Wood energy for other organisms
  - Cellulose = chains of glucose, most abundant organic compound
  - Lignin

What is tree biology?

- Study of life processes
  - Growth
  - Structure
  - Function

Cells, tissues and organs

LEAVES, STEMS, ROOTS, FLOWERS & FRUIT

ORGANS

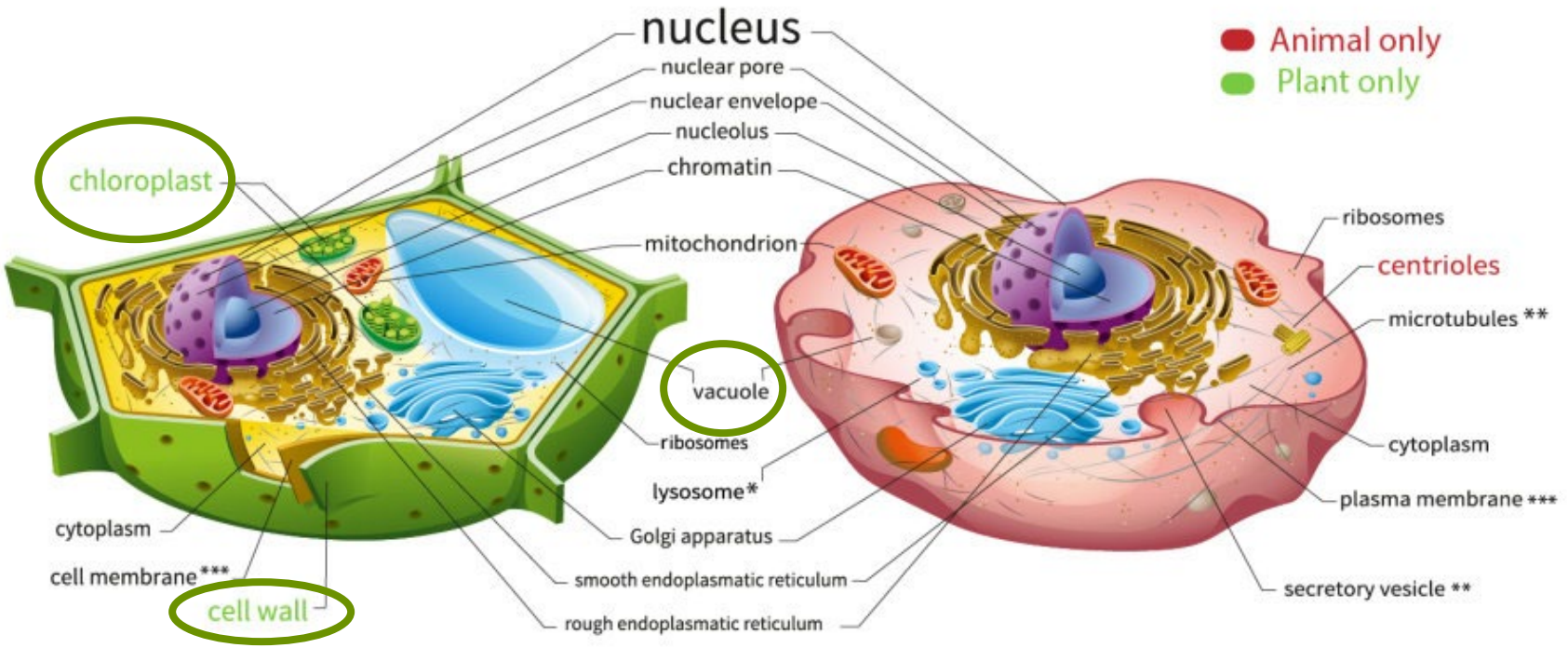
EXAMPLES- WOOD AND BARK

TISSUES

DIFFERENTIATION

CELLS

What makes plant cells different than animal cells?

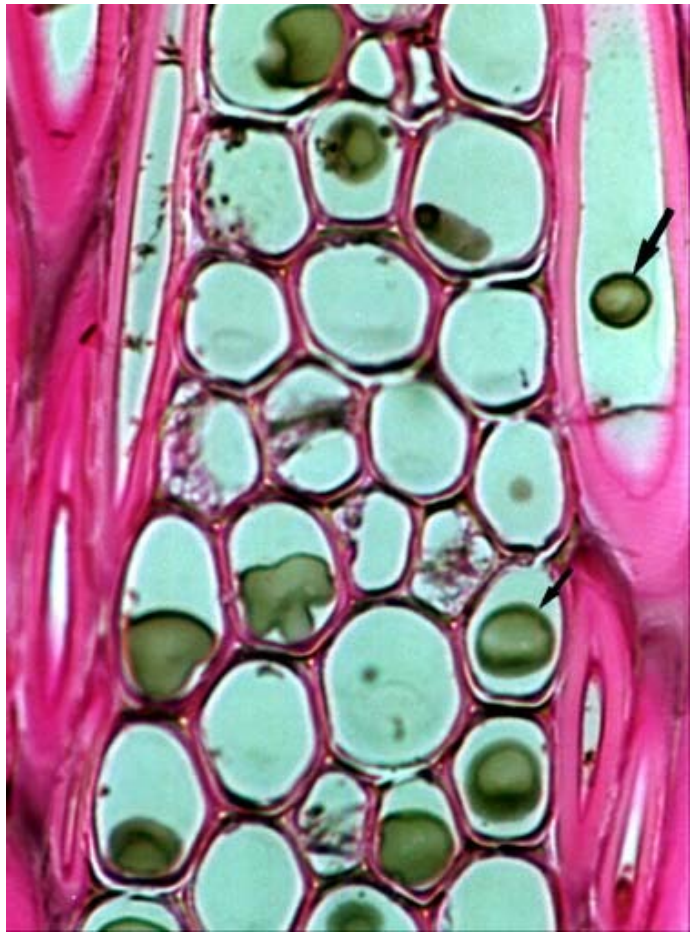


* Plants may have lytic vacuoles, which act like lysosomes in animal cells.

** Although they're not labelled here, plant cells have microtubules and secretory vesicles, too.

*** Cell membrane and plasma membrane are just different names for the same structure.

Parenchyma Cells



- Least specialized
- Thin flexible cell walls
- Living at maturity
- Most metabolic functions
- Large central vacuole
- Ability to differentiate into other cell types
  - During repair and replacement of organs after injury

Cell differentiation ➡ Tissues

- Changes their structure to fulfill functions
- Similar structured cells become tissues

Tissues organize into Organs

Leaves

Stems

Roots

Treehugger.com

Flowers

Fruit

Herbarium, NC
State University

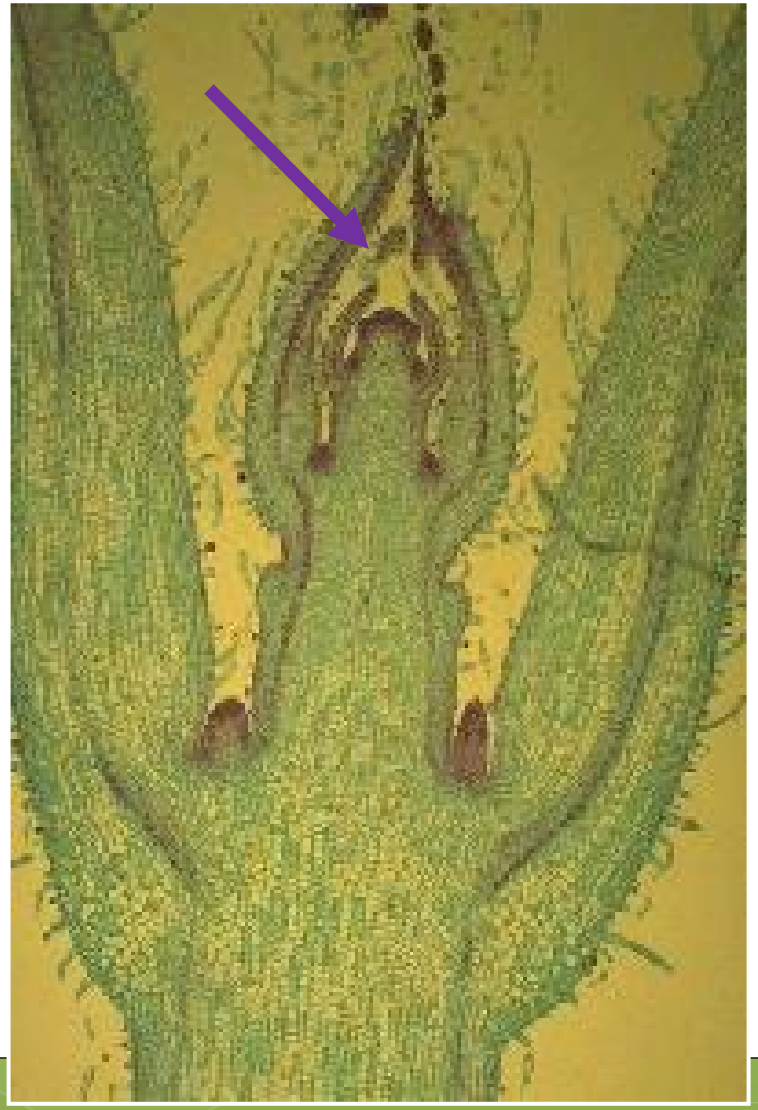
All Organs together = Trees

Photo- Wikipedia

Tree Anatomy: Terminology

- Meristem: primary and secondary
- Buds: apical, lateral, axillary and adventitious
- Nodes, internodes, leaf scar, bud scale
- Cambium
- Bark and outer bark
- Xylem- Sapwood and heartwood
  - Rays and growth rings
- Lenticels
- Phloem
- Structure- branch collar, branch bark ridge

Primary (apical) Meristems



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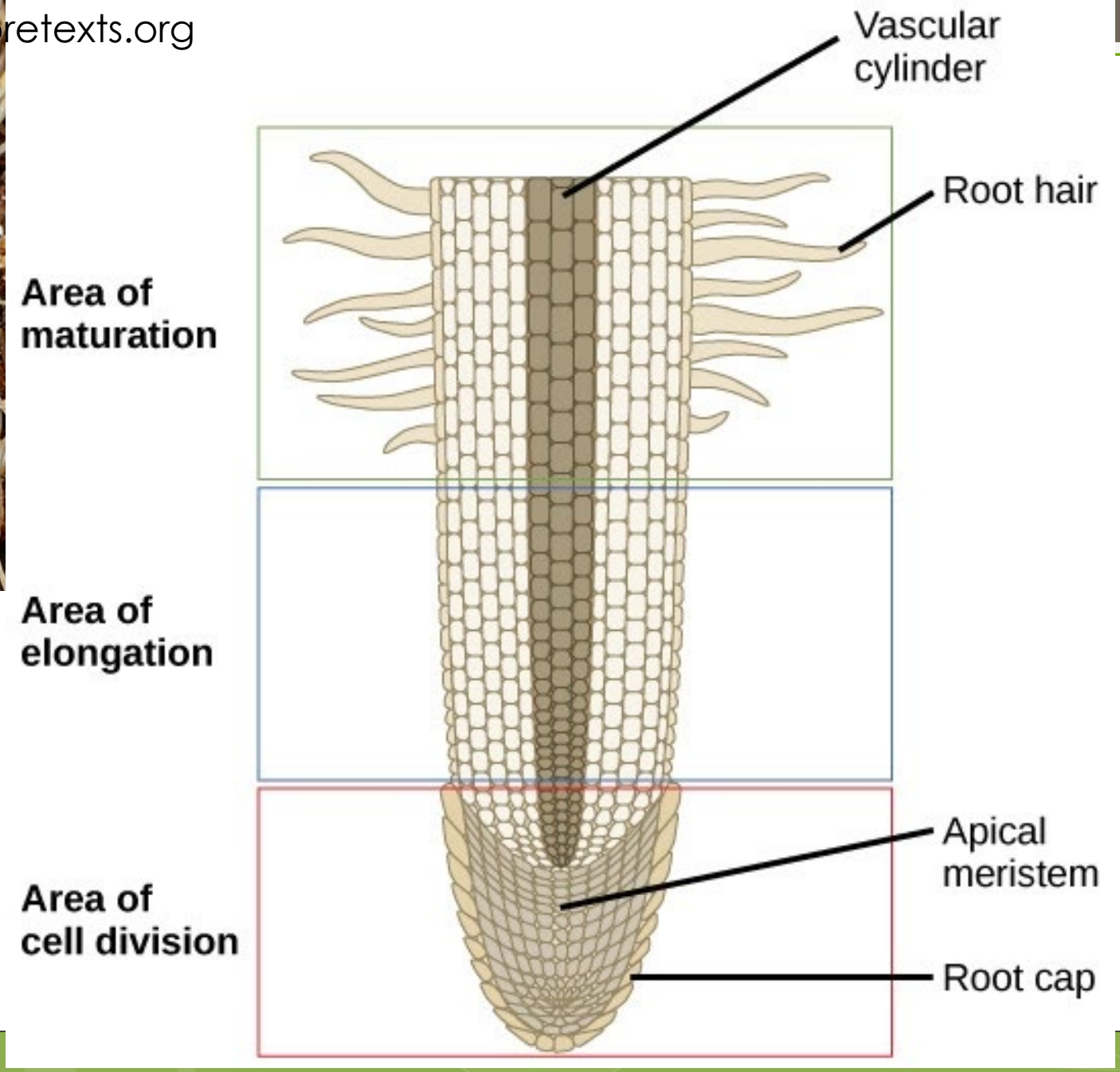
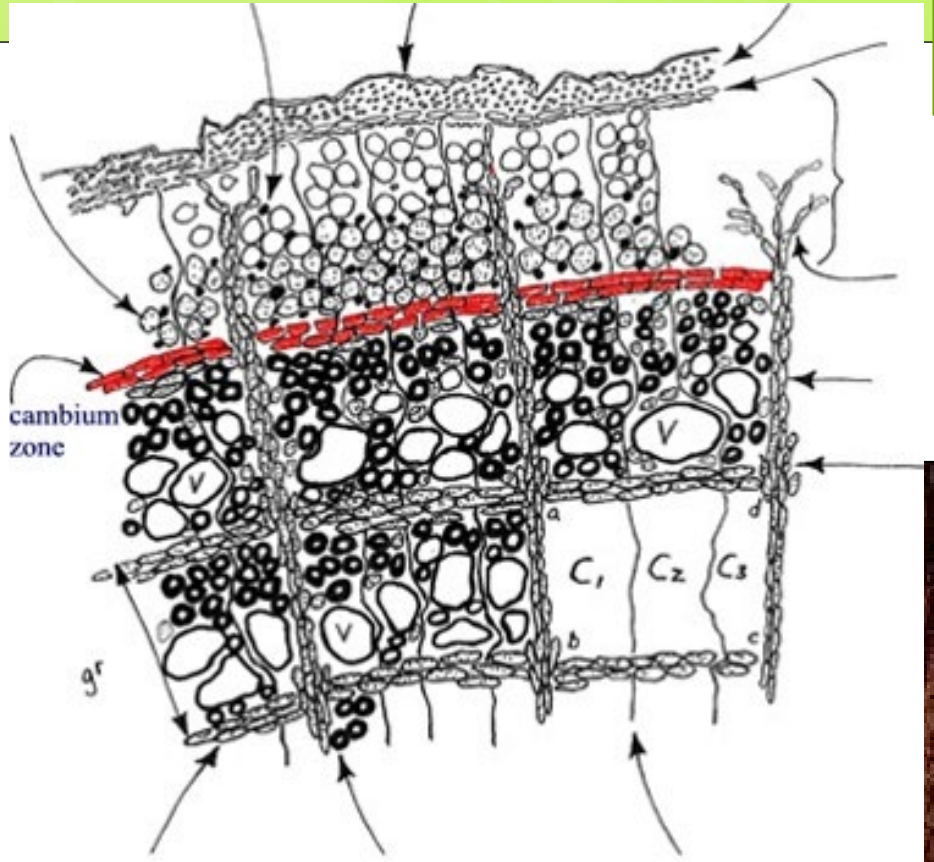


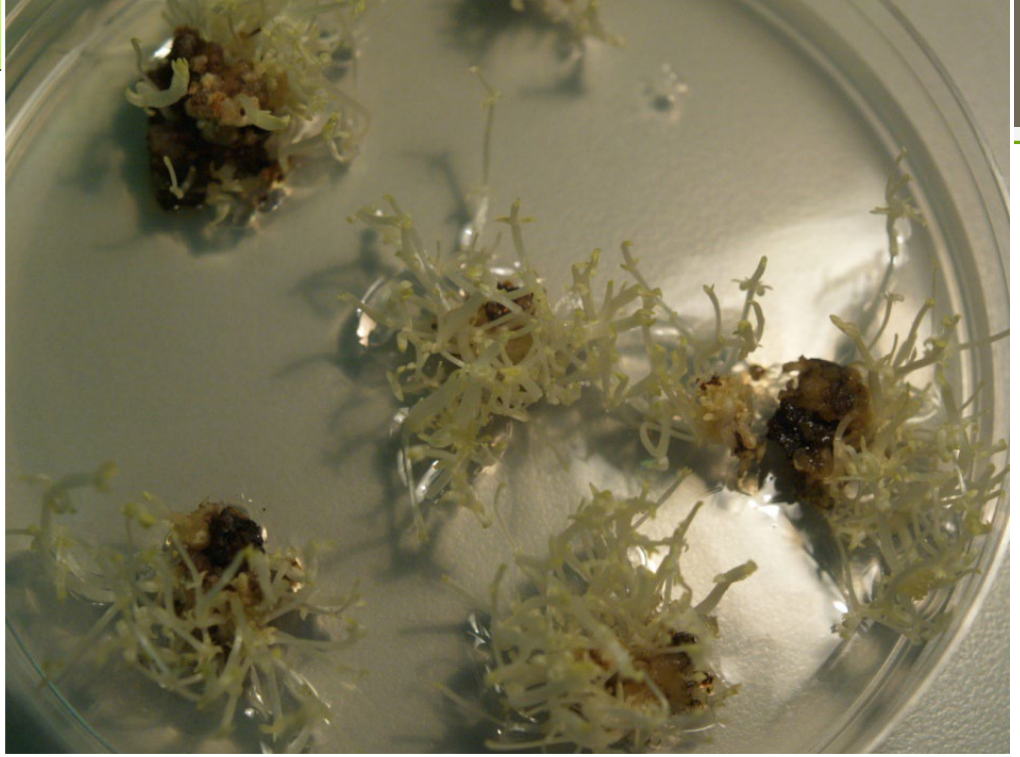
Secondary Meristems



↑ Cambium & Bark (periderm)

Buds types

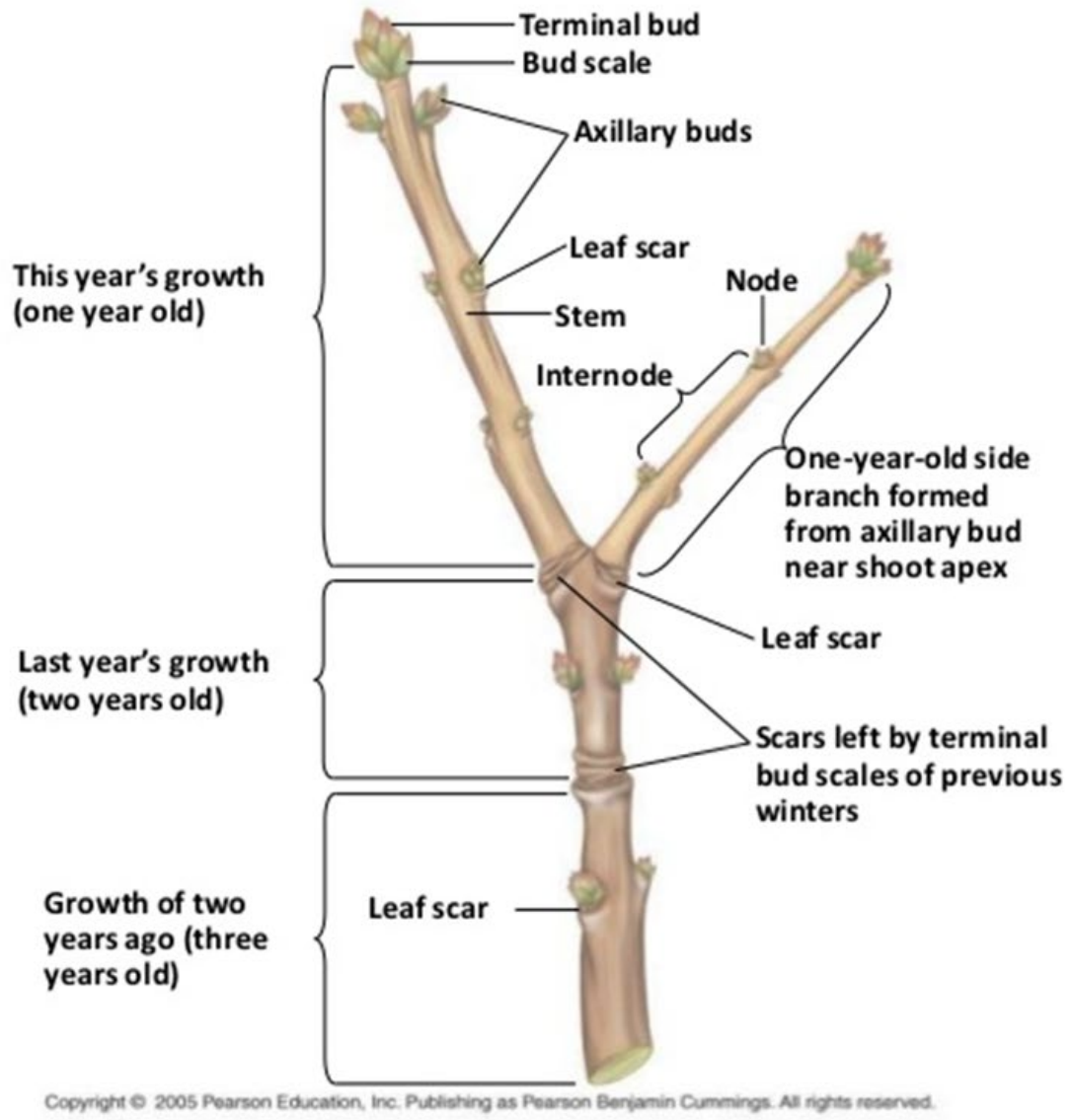
- Apical (terminal) bud- bud at the tip of a twig or shoot
- Lateral bud- vegetative bud on the side of a stem
- Adventitious bud- produced along stems or roots where meristems are not normally found
- Dormant buds- suppressed within growing tissues
  - Latent bud- bud held in dormancy for more than one year by hormones from terminal bud
- Epicormic shoot- arise from dormant buds elongating

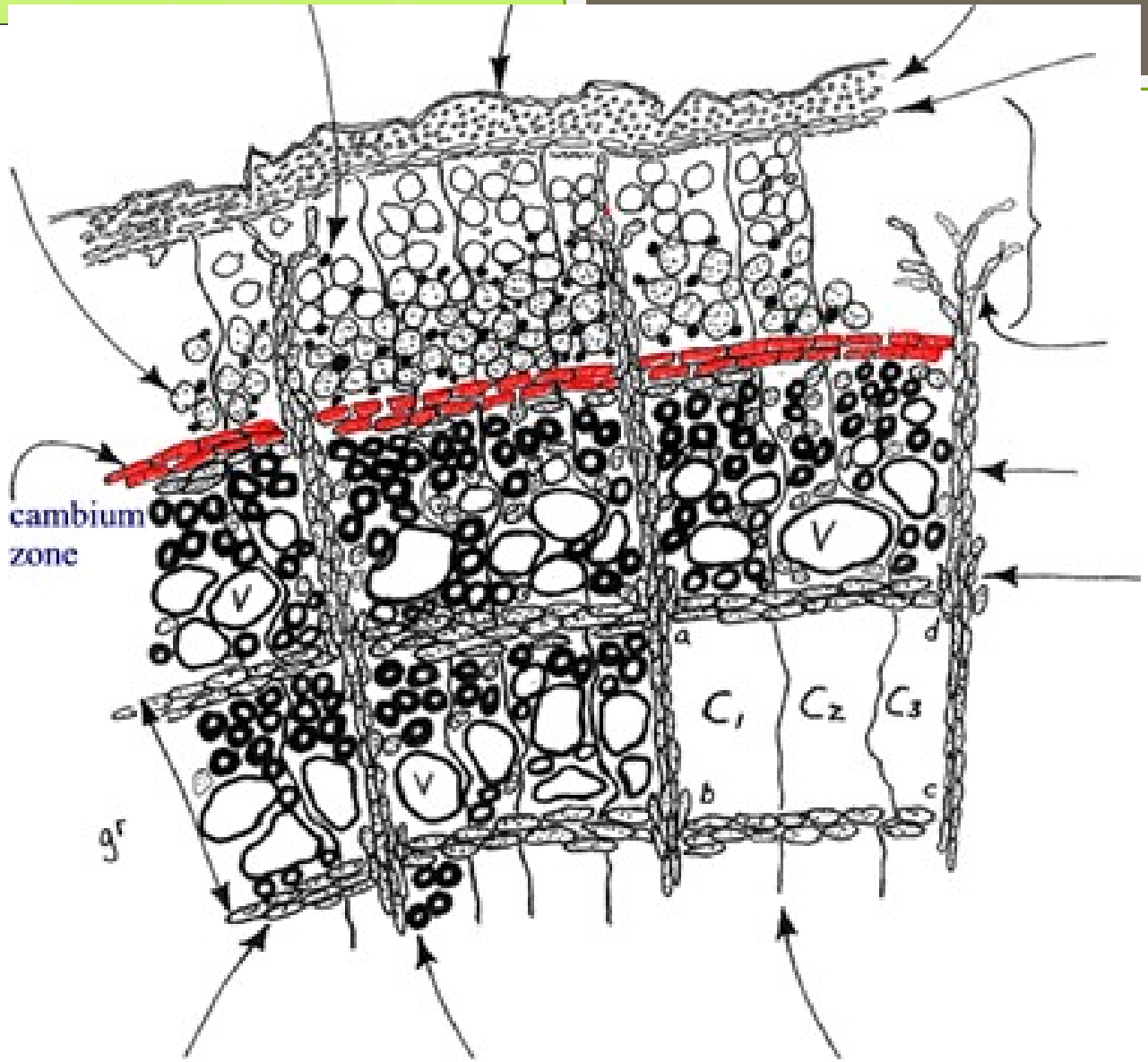


copse

Woody plants

- In woody plants, primary and secondary growth occur simultaneously but in different locations




cambium
zone
V
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V
a
d
C1
C2
C3
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c
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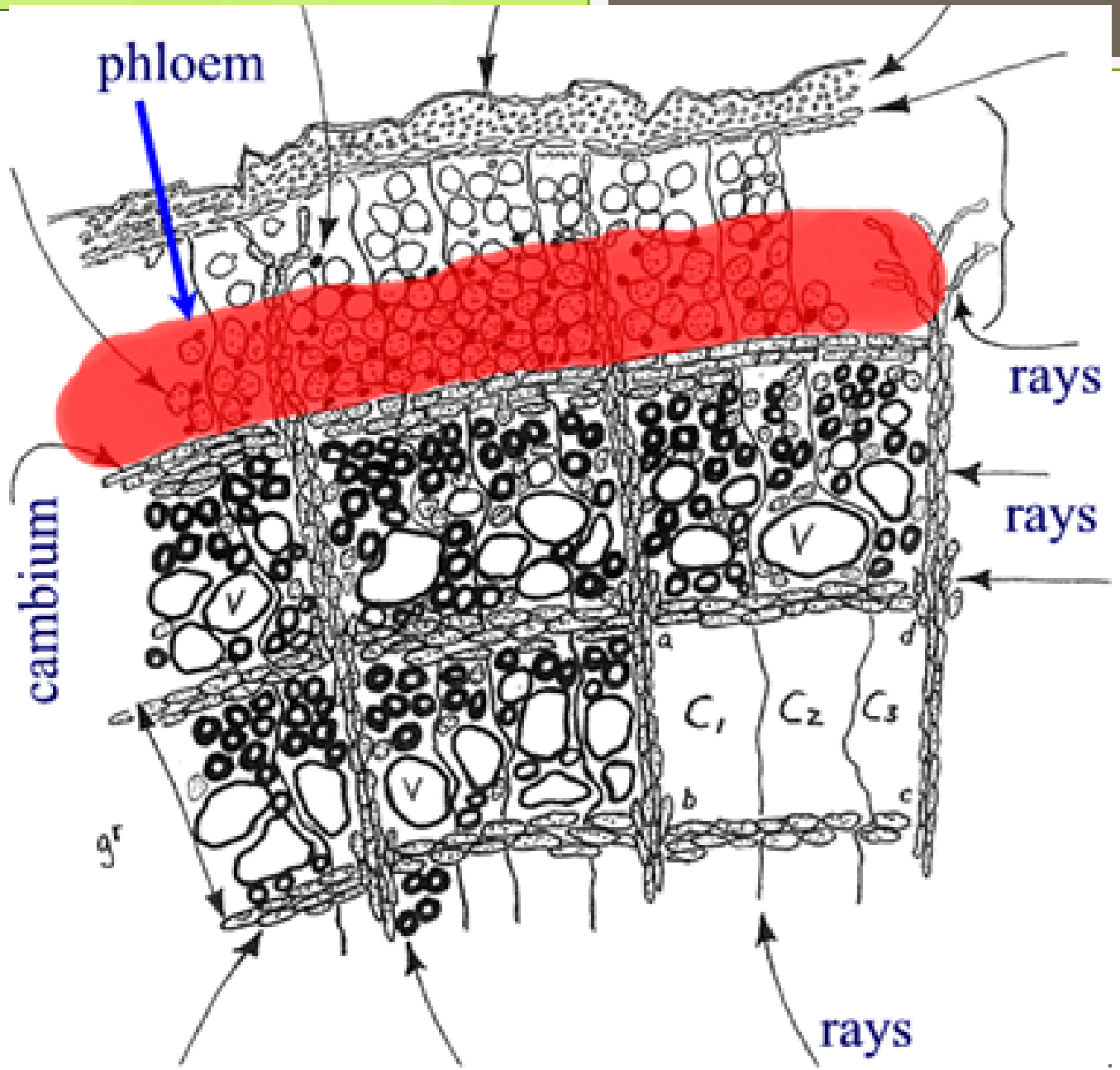
phloem
rays
rays
rays
cambium
V
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a
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b
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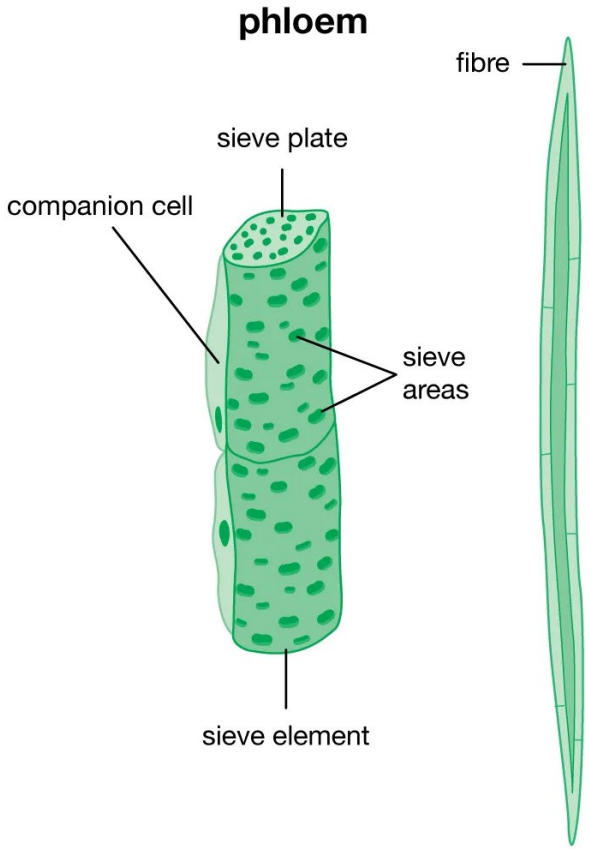
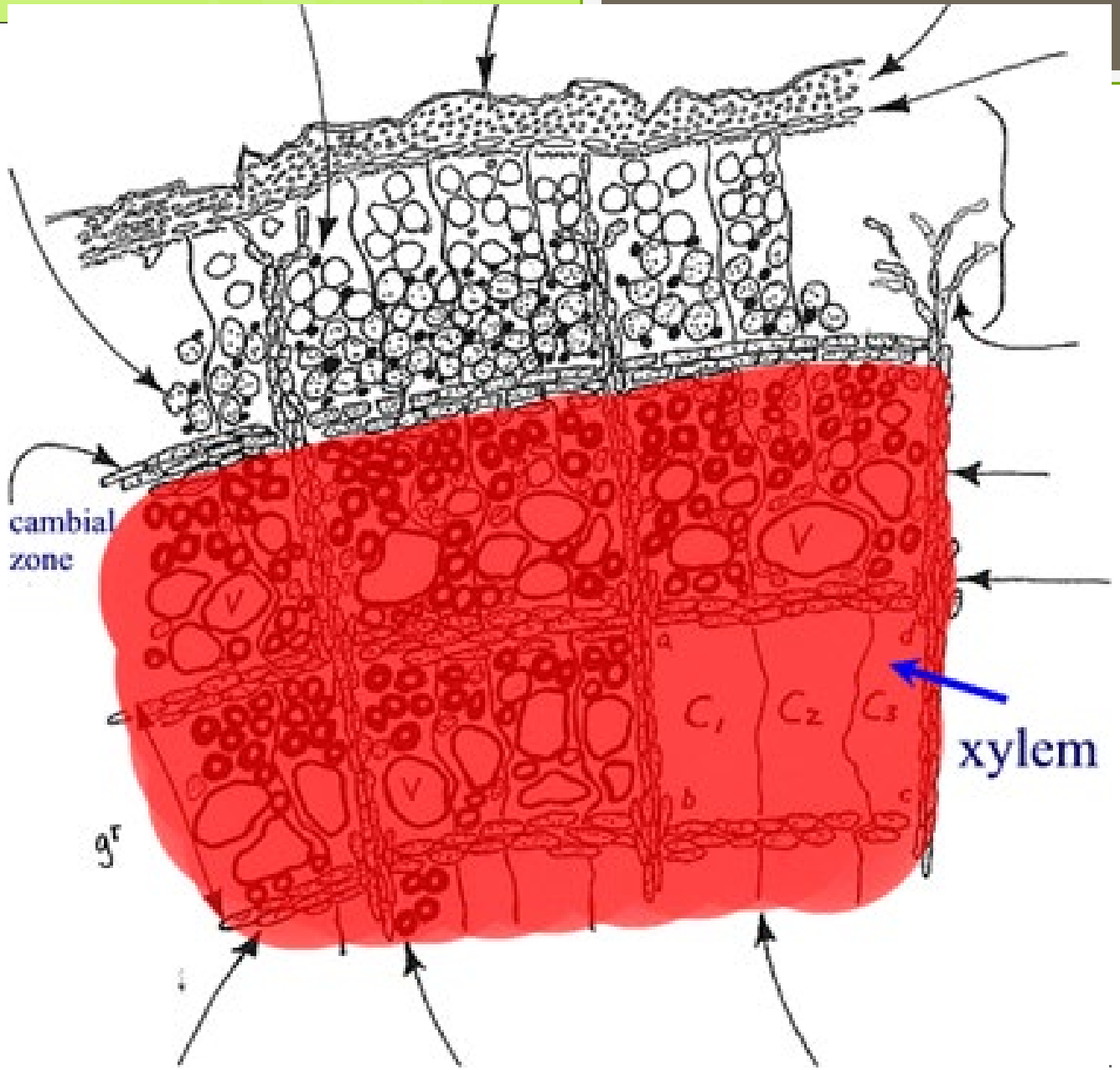
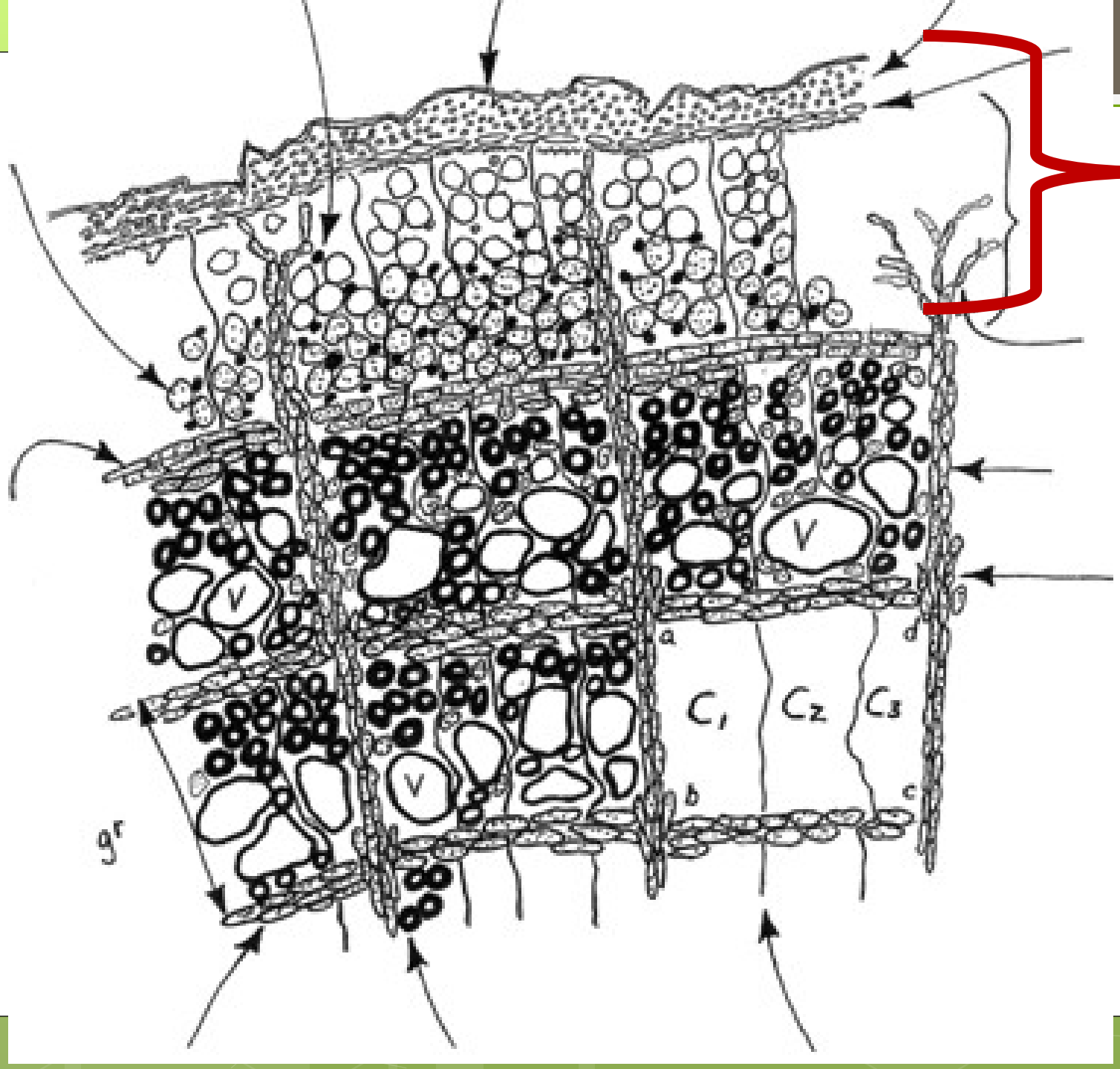
C1
C2
C3
gr

Phloem- sieve tubes




cambial
zone
xylem


BARK
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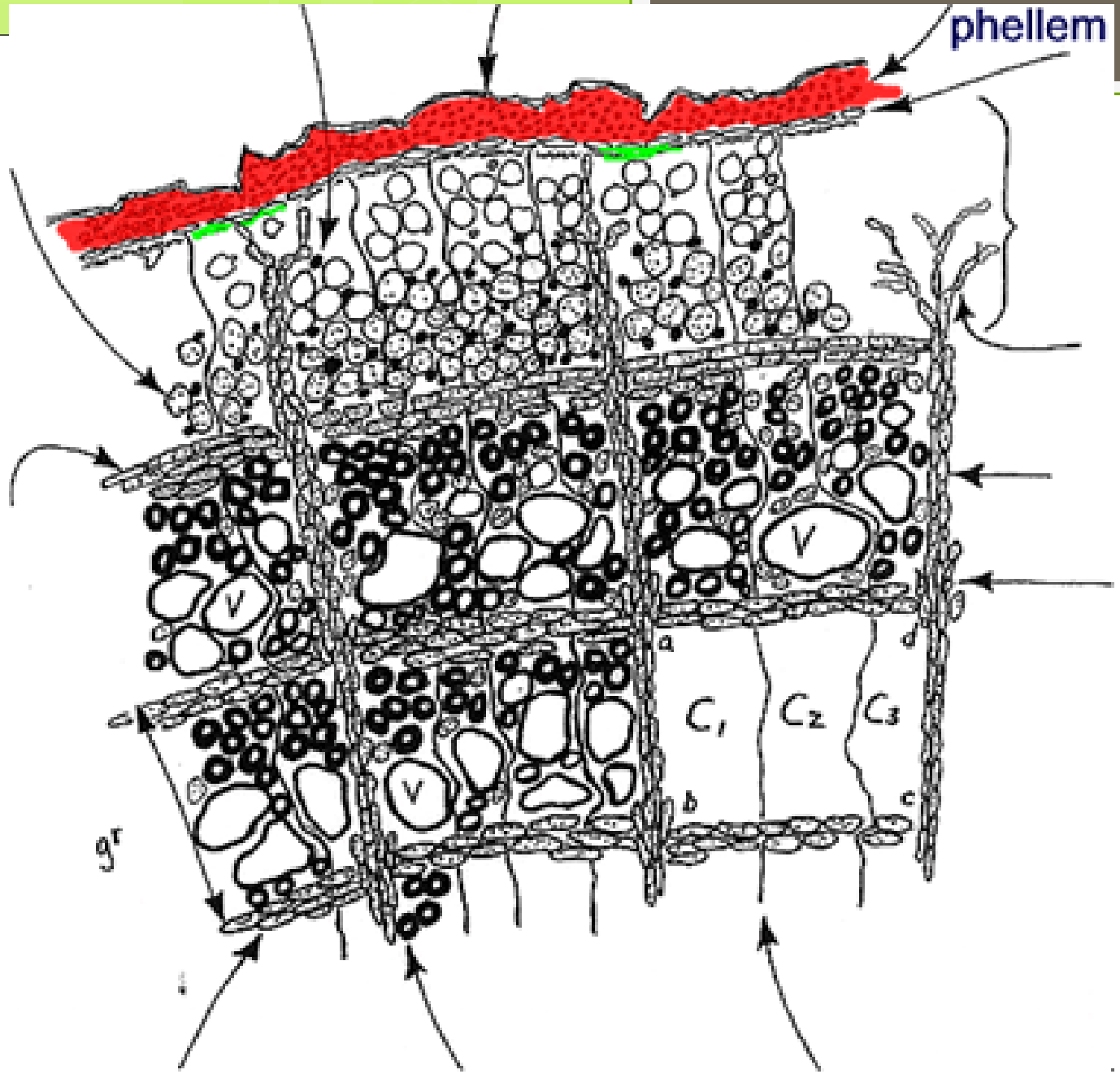
C2
C3
gr


phellem
V
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V
a
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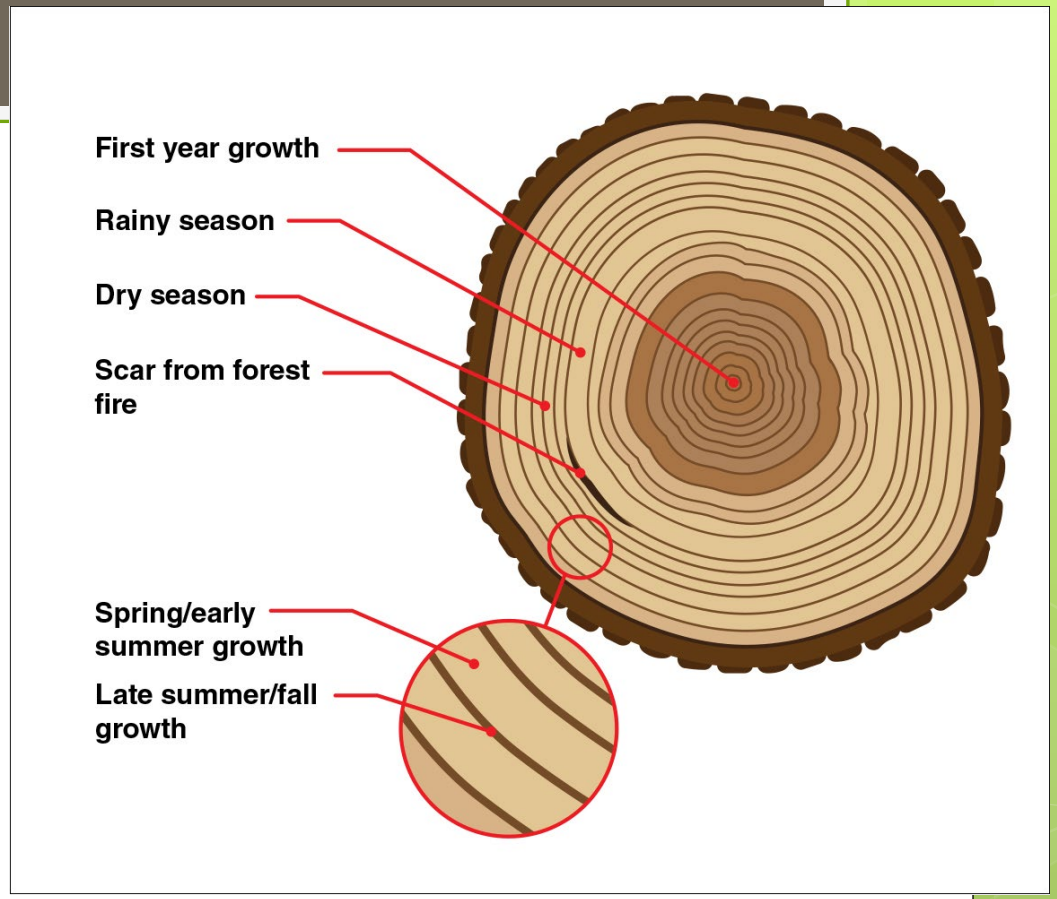
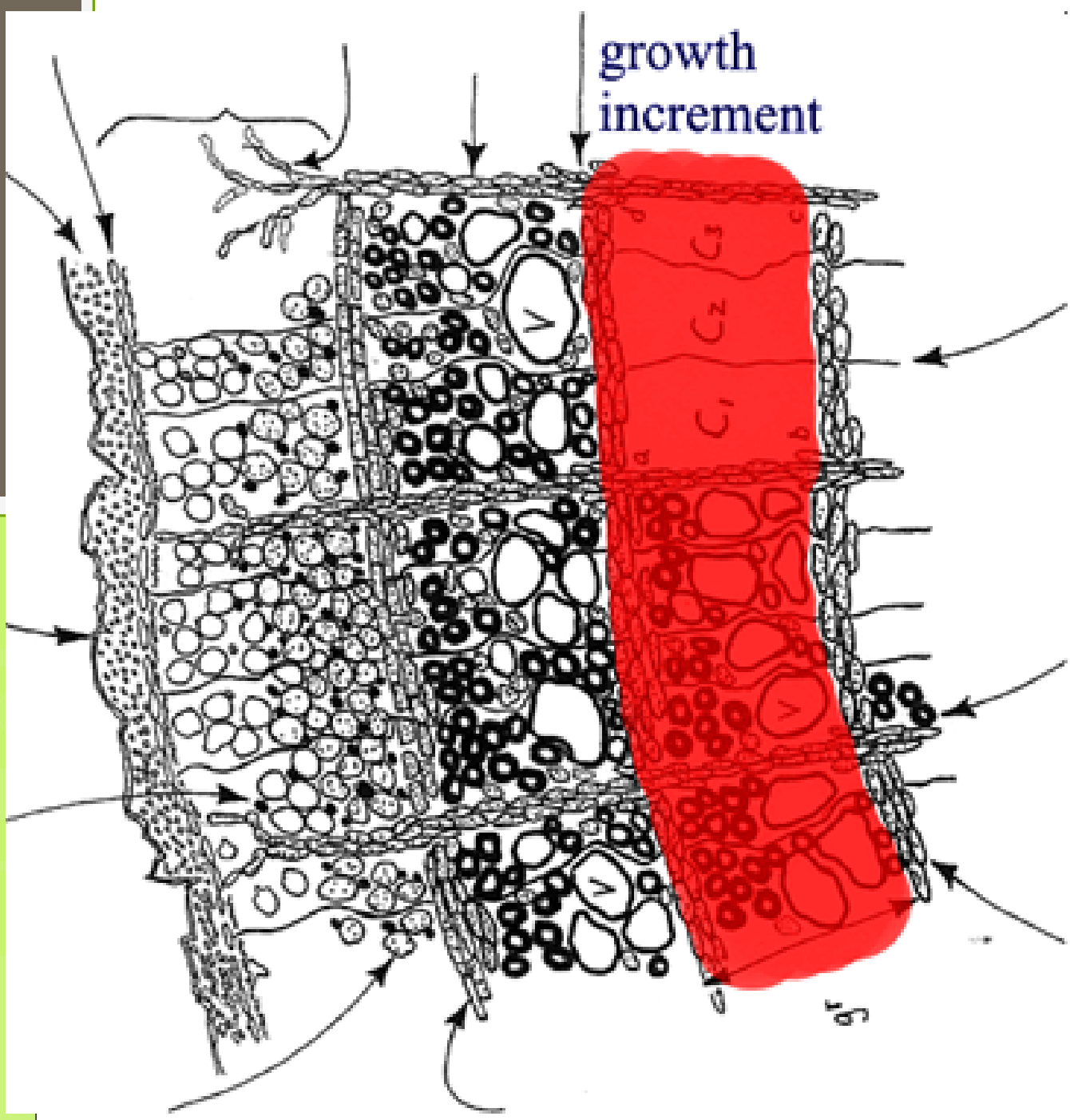
d
C1
C2
C3
gr

Xylem = Wood (both living and dead cells)

- Four main functions
  - Conducting water and nutrients (minerals from soil)
  - Support weight of tree storage of carbohydrate reserves
  - Defends against disease and decay

- Produce growth increments
  - Spring (earlywood) and summer (latewood)
- Sapwood and heartwood



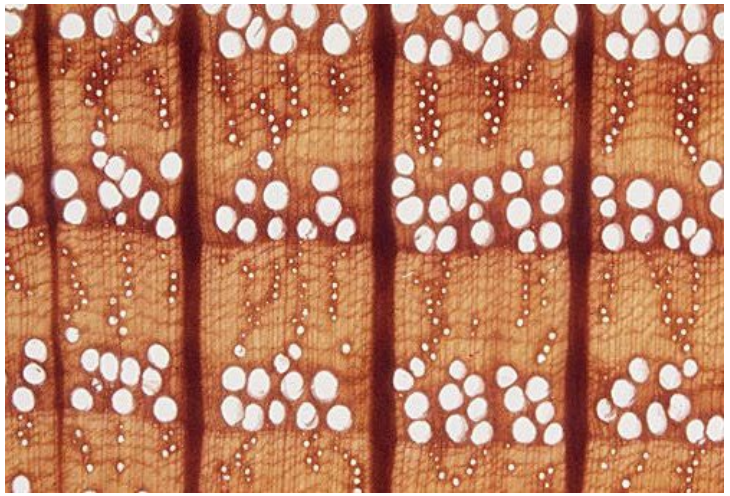

growth
increment

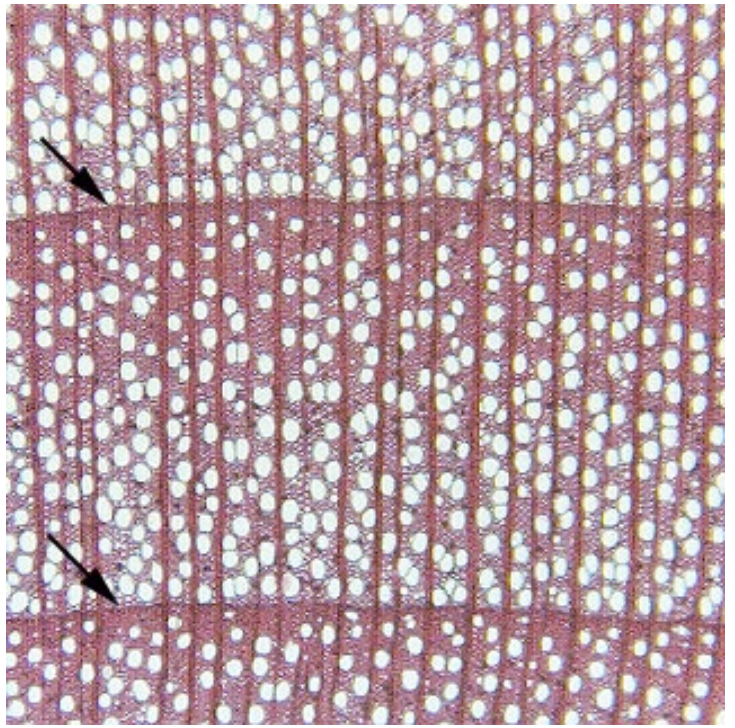
Sapwood vs. Heartwood

- Mostly alive
- Water conducting, with some movement of starches
- Retains reserve foods
- Lighter appearance
- Mostly symplast

- Chemically altered- mostly dead
- Non-conducting
- Loss of reserve foods
- Infiltration of wood by various substances-changes color
- Part of apoplast
- Not all trees produce heartwood
- NOT DECAYED WOOD

Ring porous versus Diffuse porous



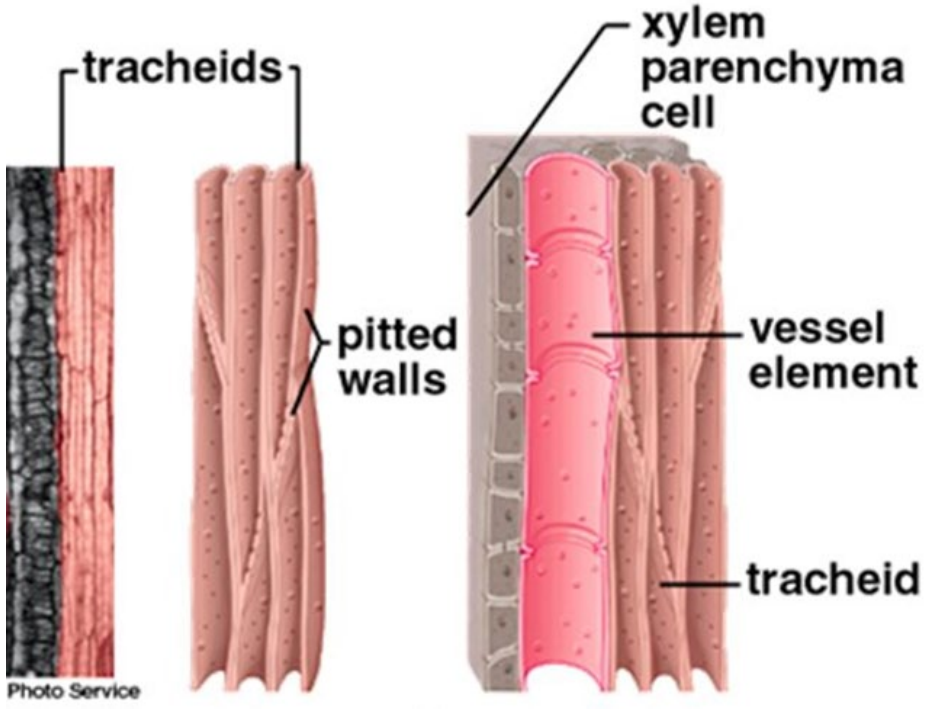


Ring porous- oak, elm, chestnut
Diffuse porous- maple, cherry, apple, beech, holly

Gymnosperms

- Present for > 200 M years
- Have no flowers or fruits
- Naked seeds
- Seeds found in cones
- Examples- pines, spruce, fir

Gymnosperm xylem- tracheids, fibers and parenchyma cells



- Tracheids conduct water and provide mechanical support- elongated cells with pointy ends and thick walls
- Fibers provide mechanical strength

Angiosperms

- Very diverse group of plants
- “Flowering” plants
- Seeds enclosed in fruit
- Includes trees, herbaceous plants, crops, etc.

Wild Harvests

Angiosperm xylem- vessels, fibers, tracheids and parenchyma cells

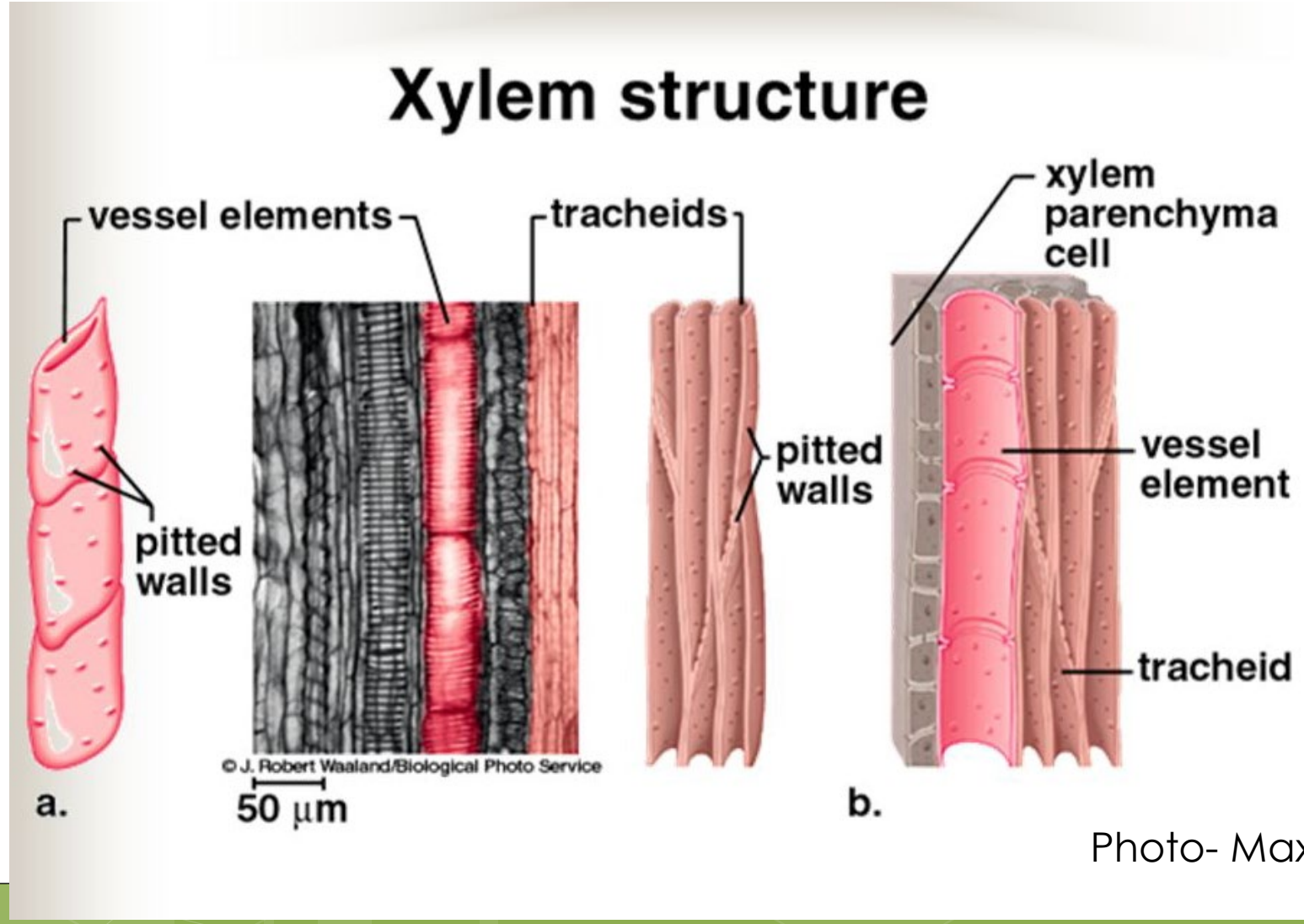
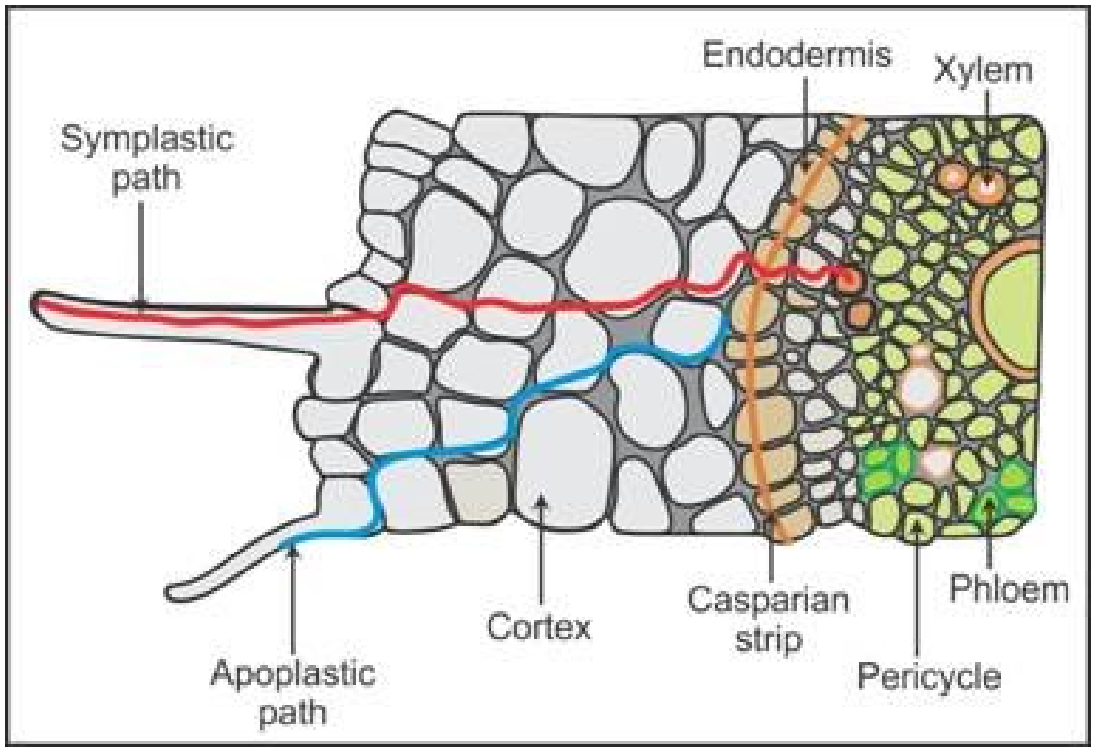
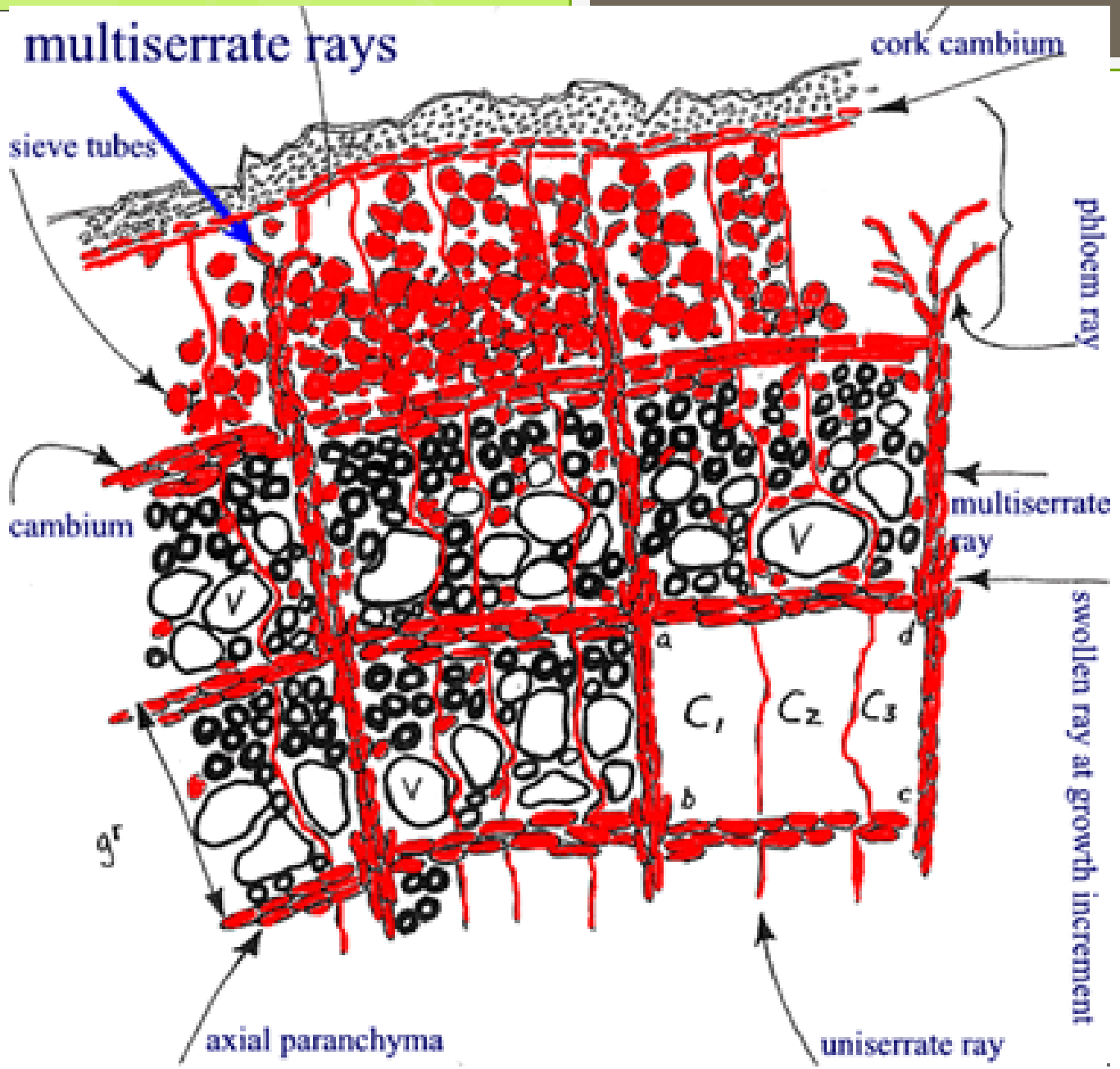


Photo- Maximillian Simon

Symplast – living network or pathway

- Inner portion of cell membrane
- Water and some solutes diffuse through
- Connects the "inner contents" of the cells




multiserrate rays
cork cambium
sieve tubes
phloem ray
cambium
multiserrate ray
swollen ray at growth increment
axial paranchyma
uniserrate ray
V
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V
a
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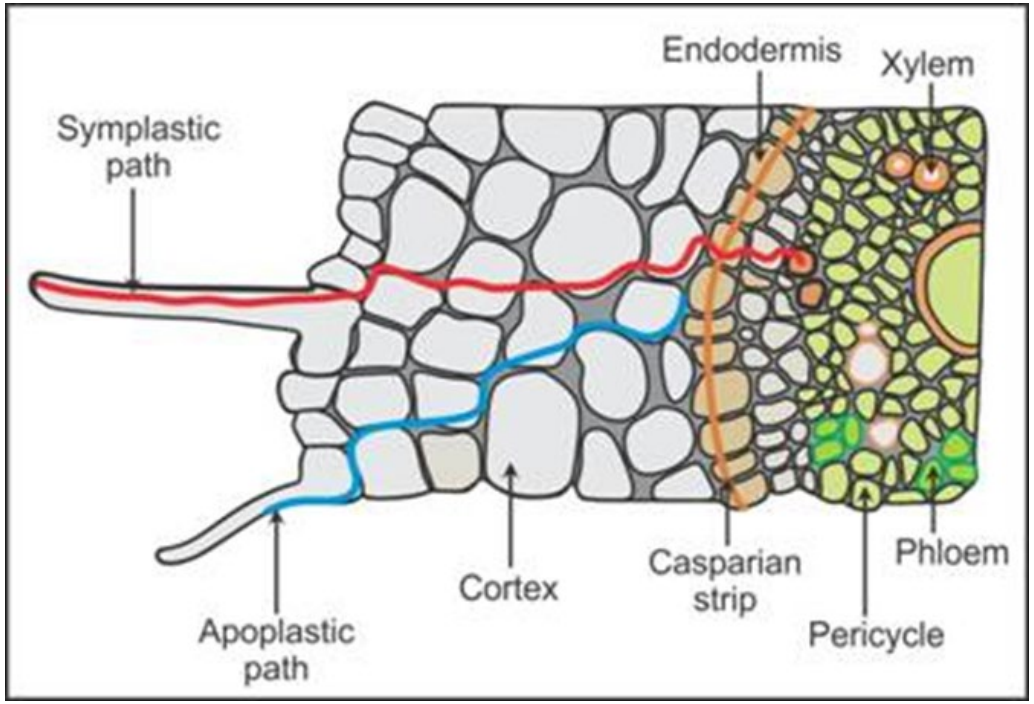
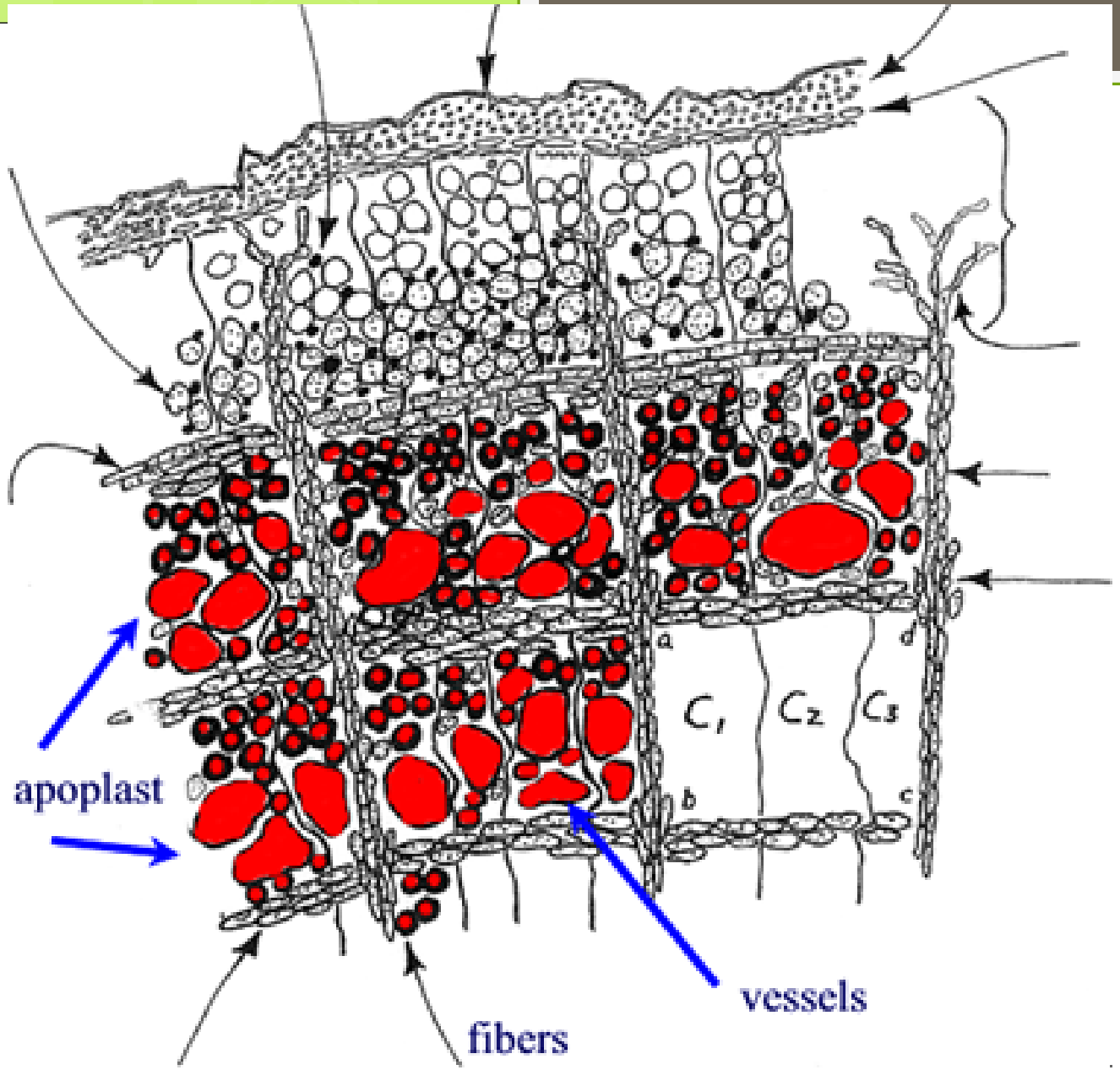
C2
C3
gr

Apoplast – nonliving cell network

- Intercellular spaces
- Filled with gases and water moving freely
- Most xylem is apoplast




apoplast
fibers
vessels
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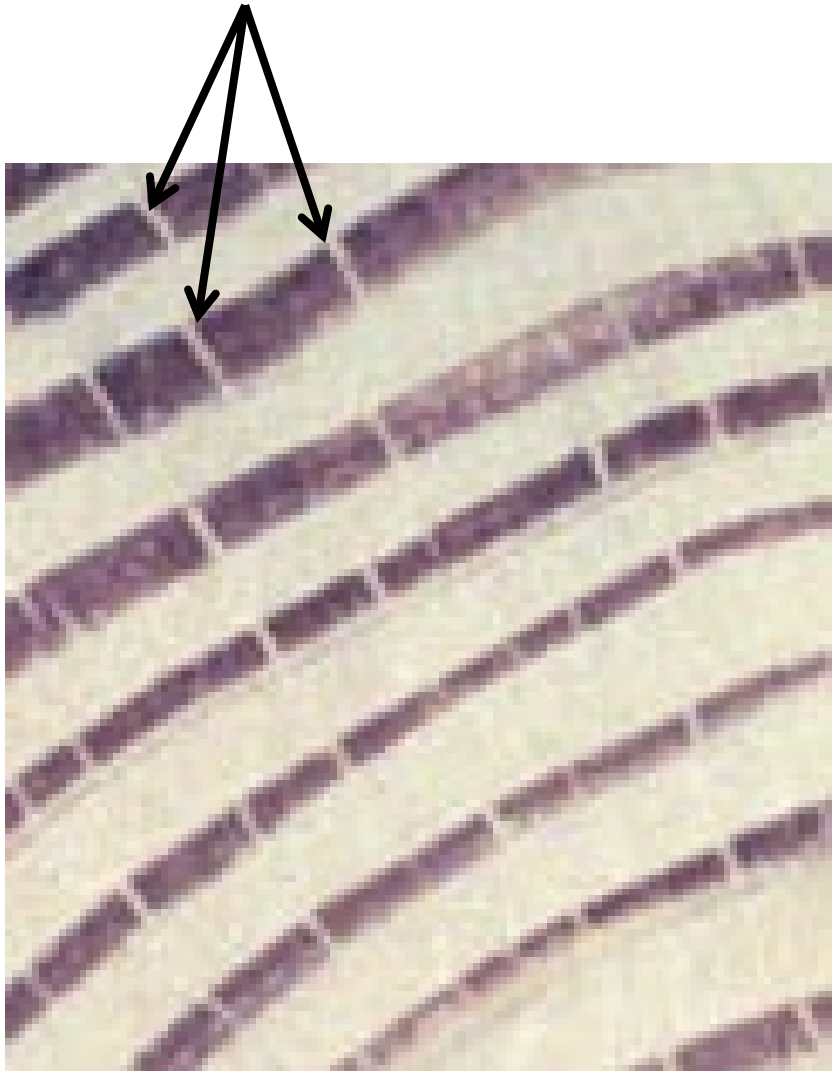
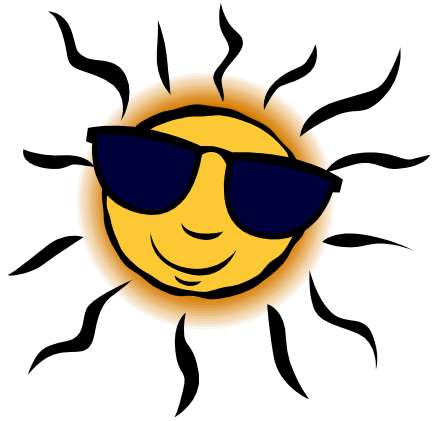
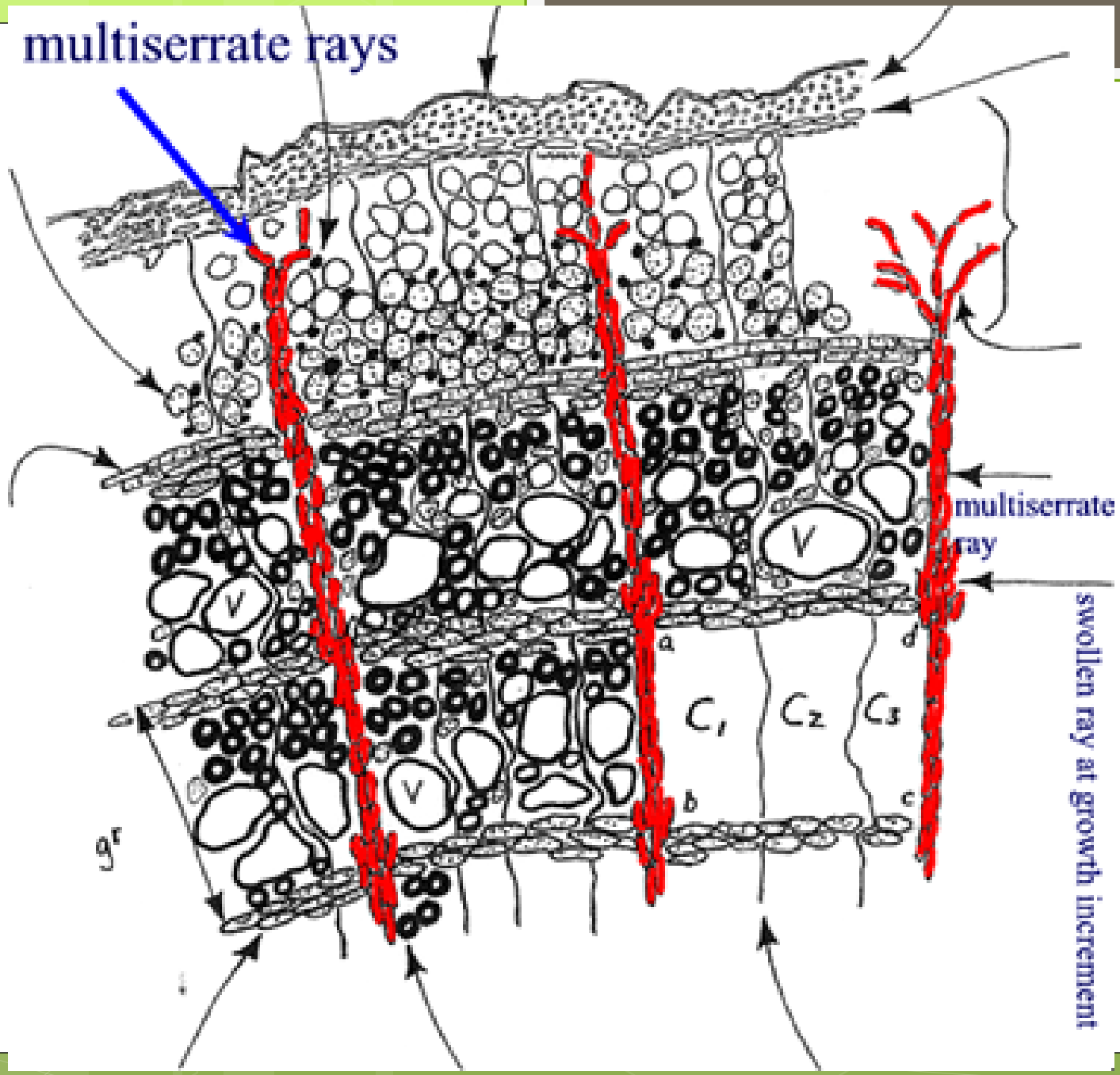
C1
C2
C3

Rays





- Transport sugars throughout trunk
- Store carbs as starch
- Aid in plant defense


multiserrate rays
multiserrate ray
swollen ray at growth increment
V
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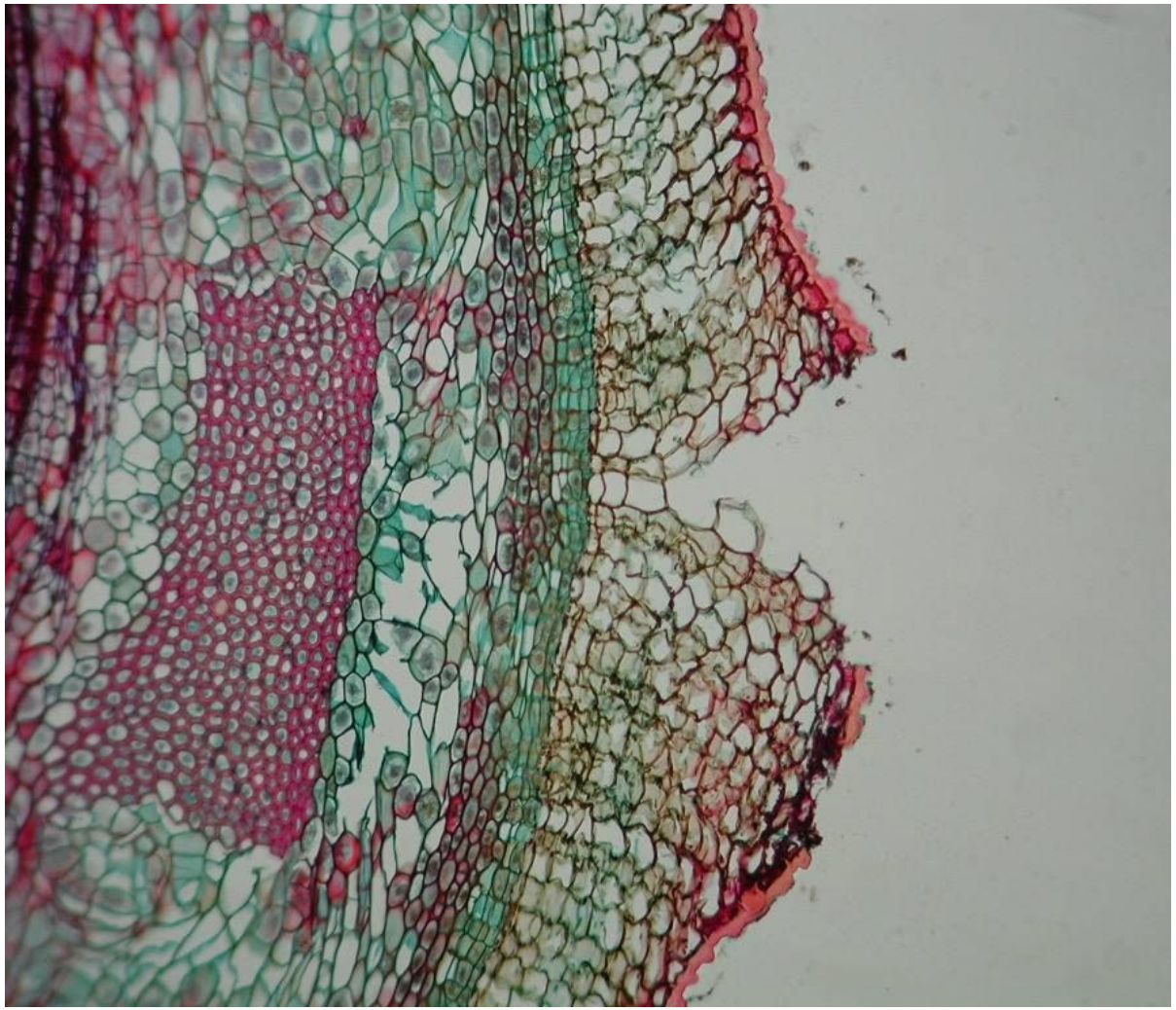
C1
C2
C3

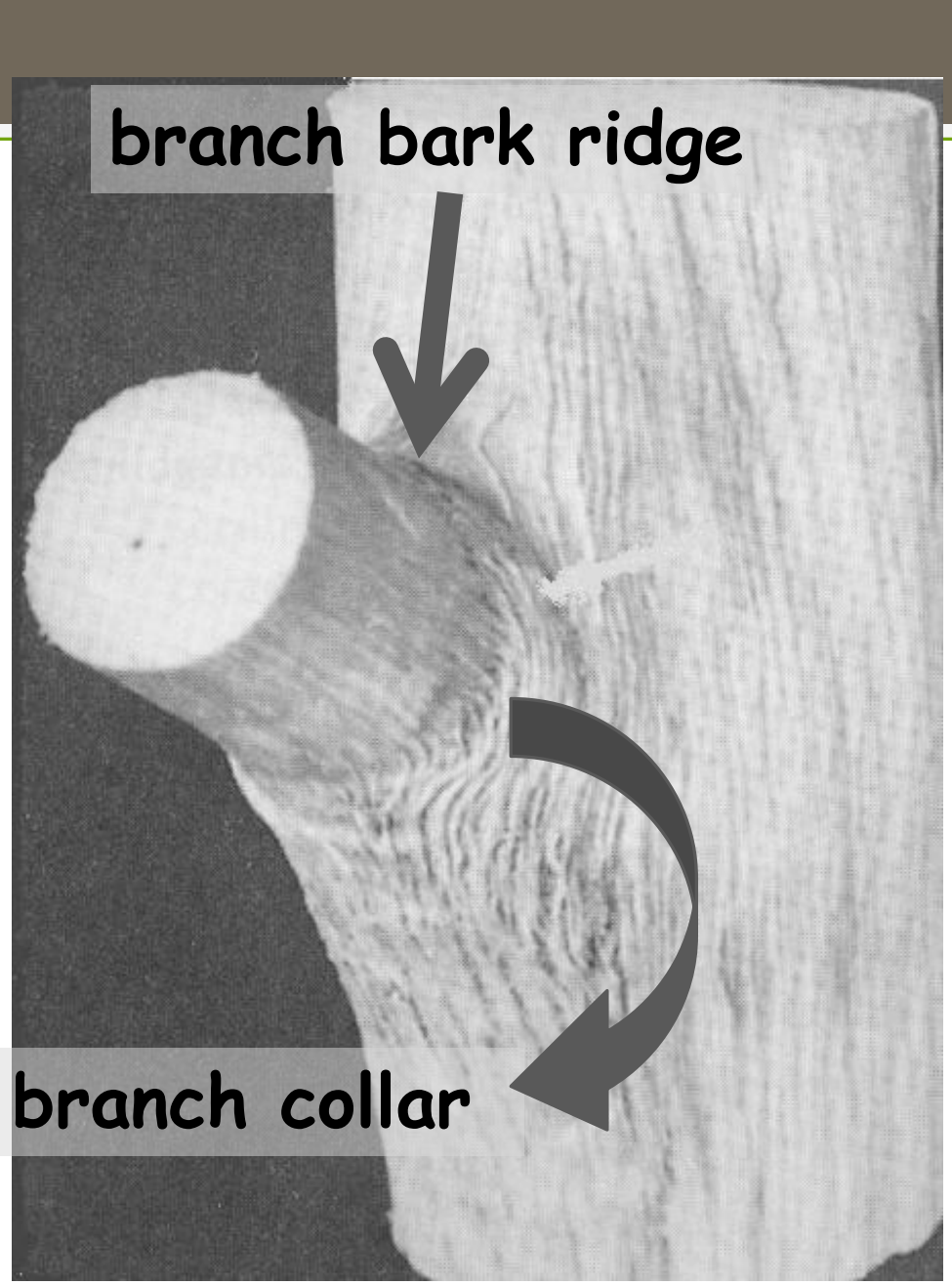
Lenticels



Tree Structure

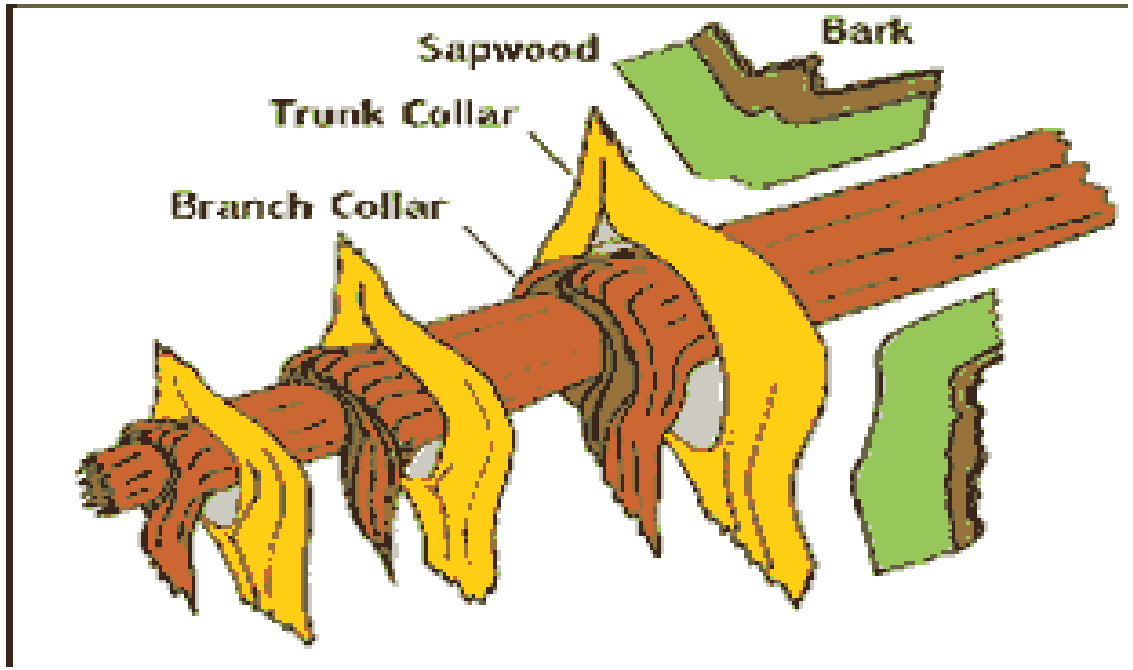
Branches

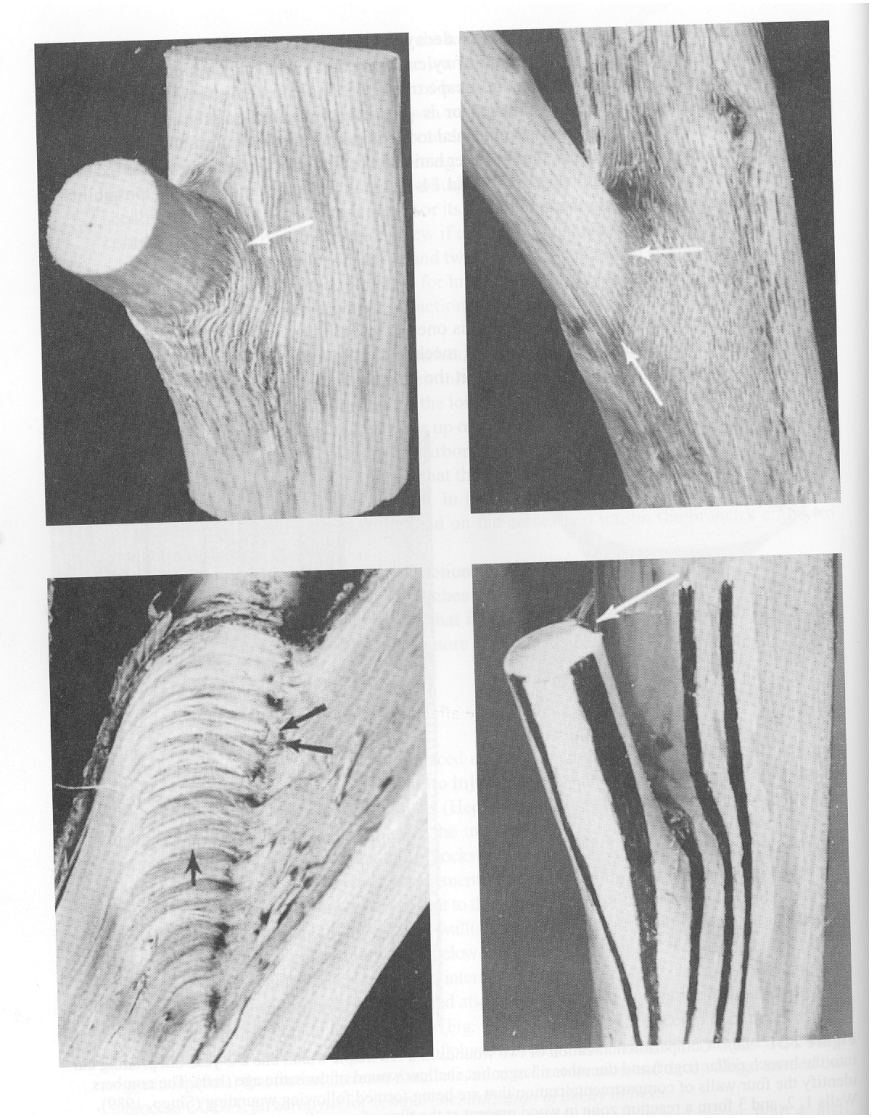
- Similar in structure & function to trunk
- Unique attachments
- Branch collar
  - Union of branch and trunk
  - Key to proper pruning
- Branch bark ridge
  - In crotch, branch and trunk expand against each other



Branch Orientation

Branch attachment





Potential defects

- Bark inclusion
- Low aggressive branches grow up into permanent crown
- Branches may sag

Apical Control vs Apical Dominance

- Apical control
  - Inhibition of growth of lateral branches by the terminal over many seasons
  - Excurrent form
- Apical dominance
  - Inhibition of lateral buds by terminal bud on currently elongating branch

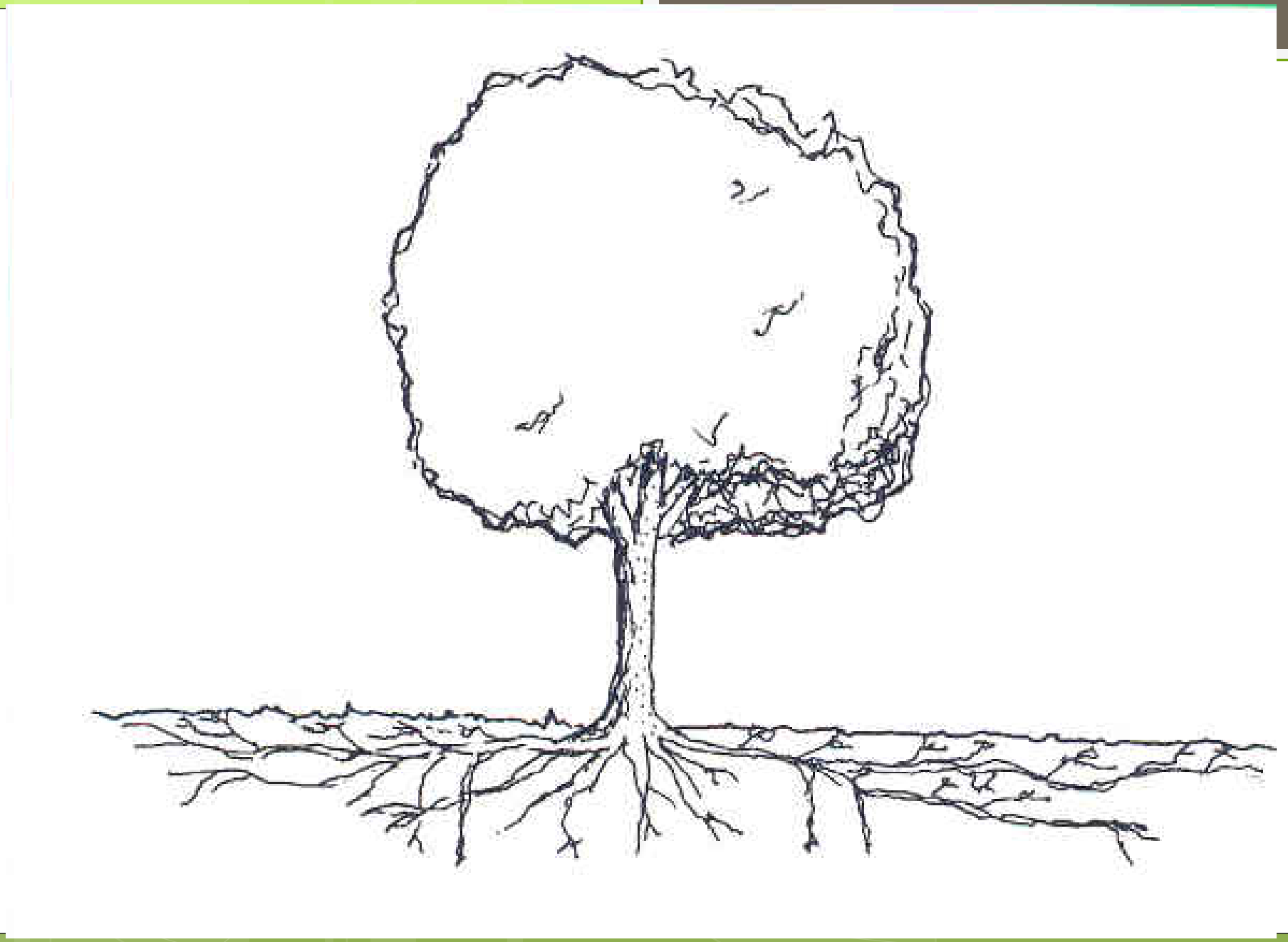
Tree Form

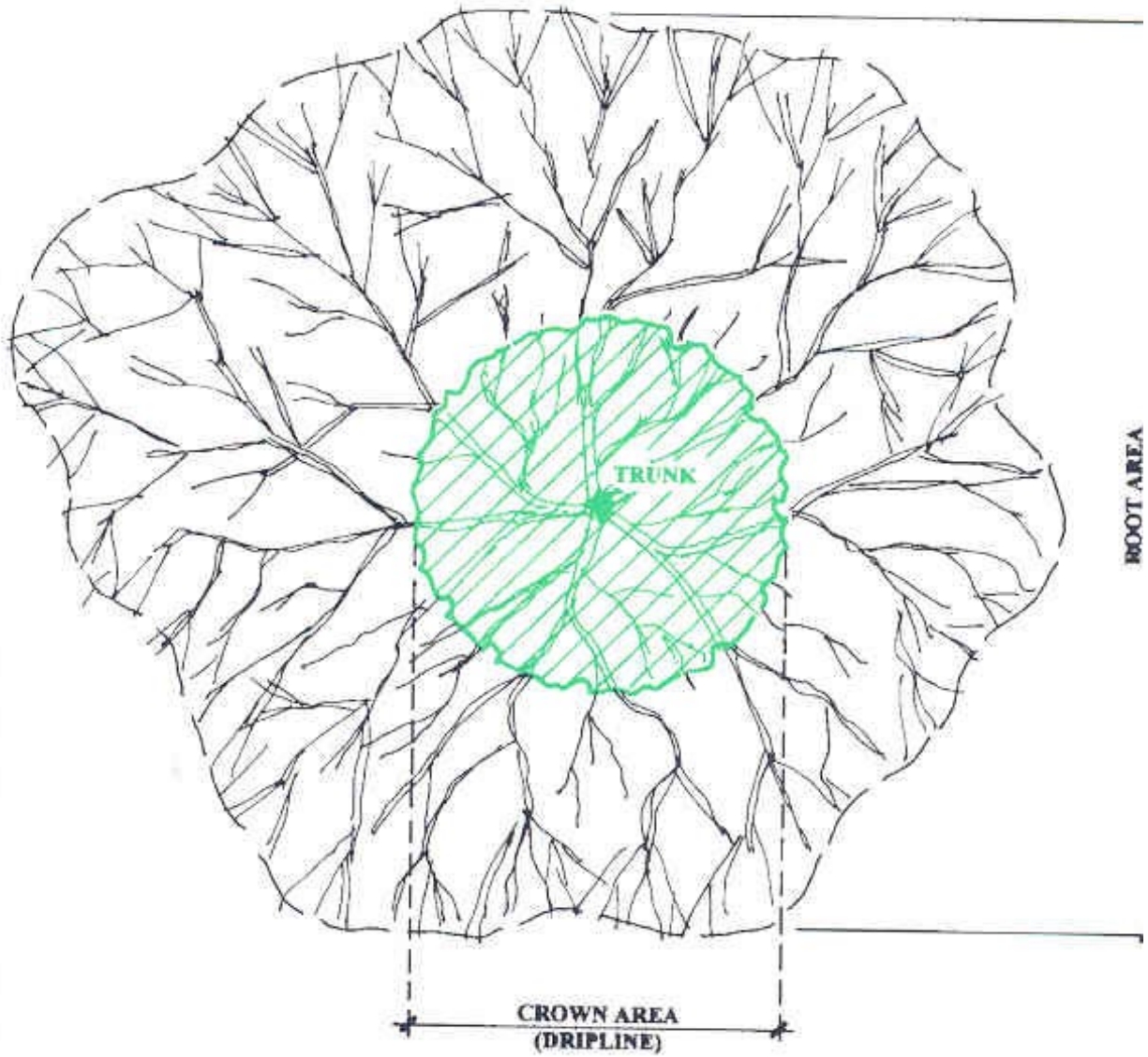
EXCURRENT AND DECURRENT

Roots

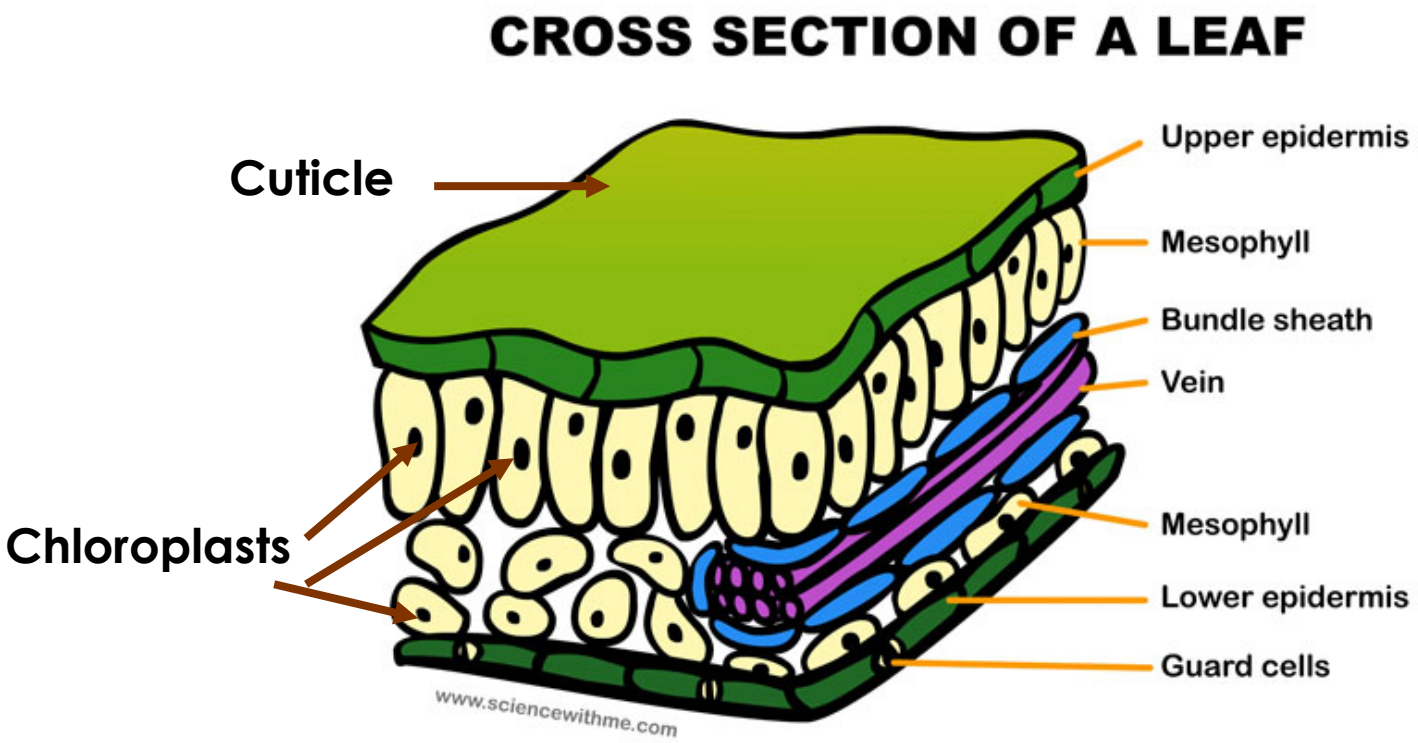
- Anchorage
- Storage
- Absorption and conduction
- Same structure as trunk and branches

- Absorbing roots
  - Fibrous, root hairs, roots tips w/meristematic tissue
  - Upper 12" of soil
- Lateral roots
  - Extend 2-3 times crown radius; top 18" of soil




TRUNK
ROOT AREA
CROWN AREA
(DRIPLINE)

Leaves


CROSS SECTION OF A LEAF
Cuticle
Upper epidermis
Mesophyll
Bundle sheath
Vein
Chloroplasts
Mesophyll
Lower epidermis
Guard cells
www.sciencewithme.com

Photosynthesis

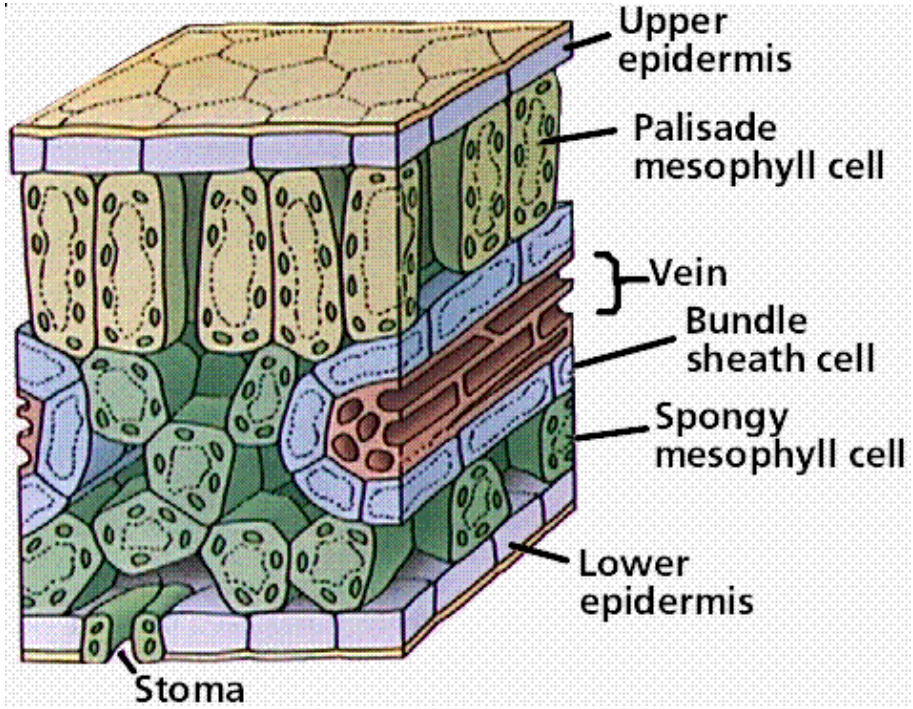
$$6\,CO_2 + 12\,H_2O \xrightarrow{\text{light}} 6\,O_2 + 6(CH_2O) + 6H_2O$$

- **WHERE?**

- **In the leaves:**
  - ✓ **In <u>Chloroplasts</u> via chlorophyll (pigment)**
  - ✓ **Converts light energy into chemical energy (sugar)**

Transpiration

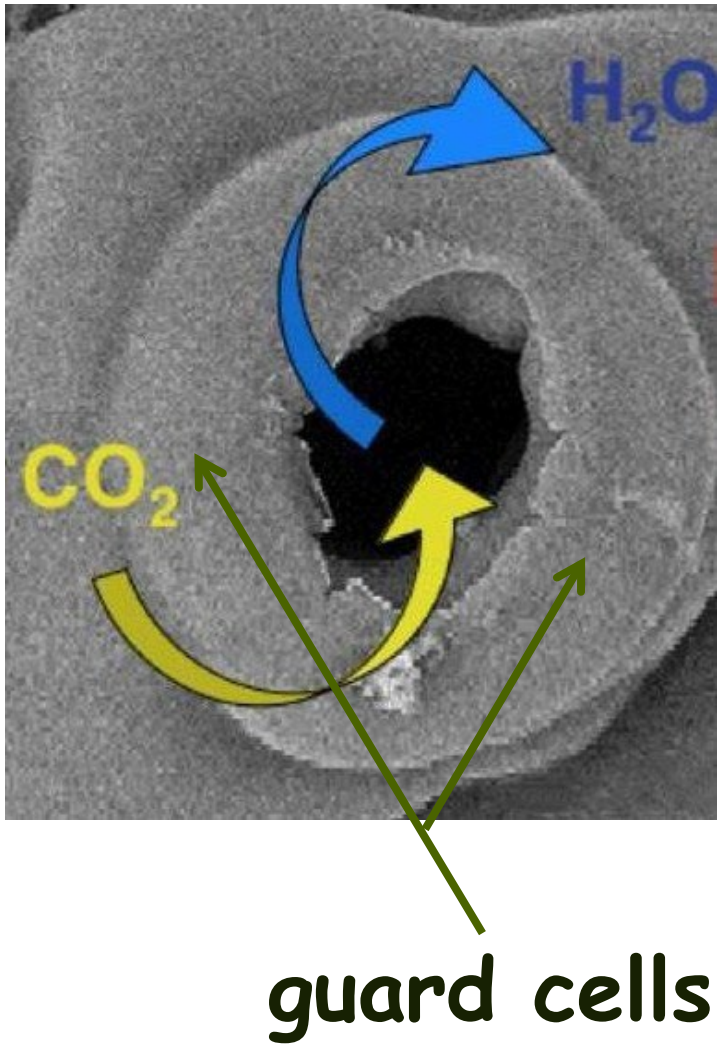
- Drives plant water uptake
- Cools plant
- Maintains cellular and plant turgidity
- Controlled by:
  - temperature, humidity and water availability
  - Anatomical features: cuticle thickness, presence of hairs, # and location of stomata



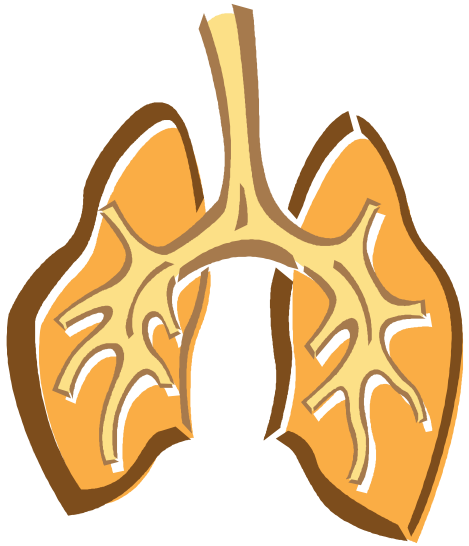
- https://youtu.be/tk5IwL2iNgU

Stomata

- Control photosynthesis and transpiration
- Guard cells control stomata opening/closing
  - Environmentally controlled: light, temperature, humidity
  - ABA (abscissic acid) regulated; roots and leaves



Respiration



- Chemical energy stored as starch/sugar are used by tree

- $CH_2O + O_2$ $\xrightarrow{\text{energy}}$ $CO_2 + H_2O$

- Photosynthesis:

  $6\ CO_2 + 12\ H_2O \xrightarrow{light} 6\ O_2 + 6(CH_2O) + 6H_2O$

- Respiration:

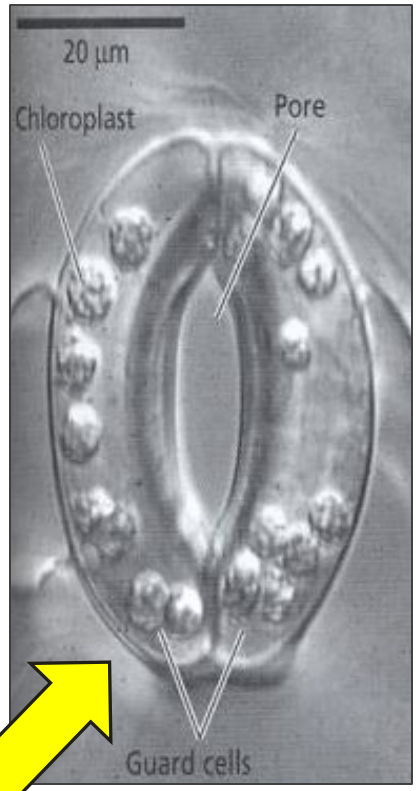
  $6(CH_2O) + O_2 \xrightarrow{energy} 6\ O_2 + 6H_2O$

NOTE: Photosynthesis < respiration- plant uses stored reserves

i.e. repeatedly defoliated, as with insects eating foliage or water stress leading to defoliation

Important Hormones

- Abscissic acid
  - Controls stomatal closure
  - Induces seeds to synthesize storage proteins
  - Plays role in dormancy
  - Found in roots and in leaves
  - "Signals" from roots to leaves, as soil dries



OPEN

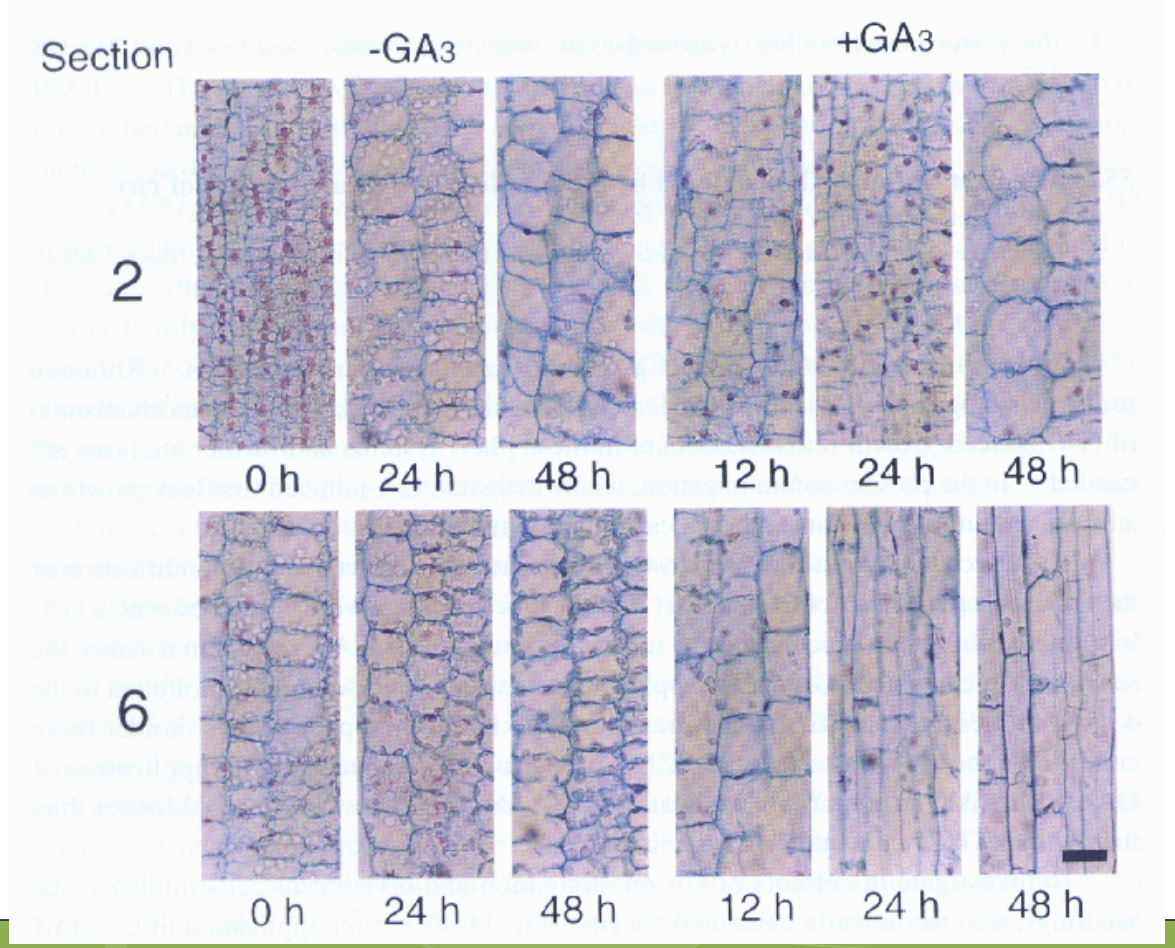
CLOSED

- Auxin
  - Controls tropism
  - Used for rooting
  - Controls apical dominance

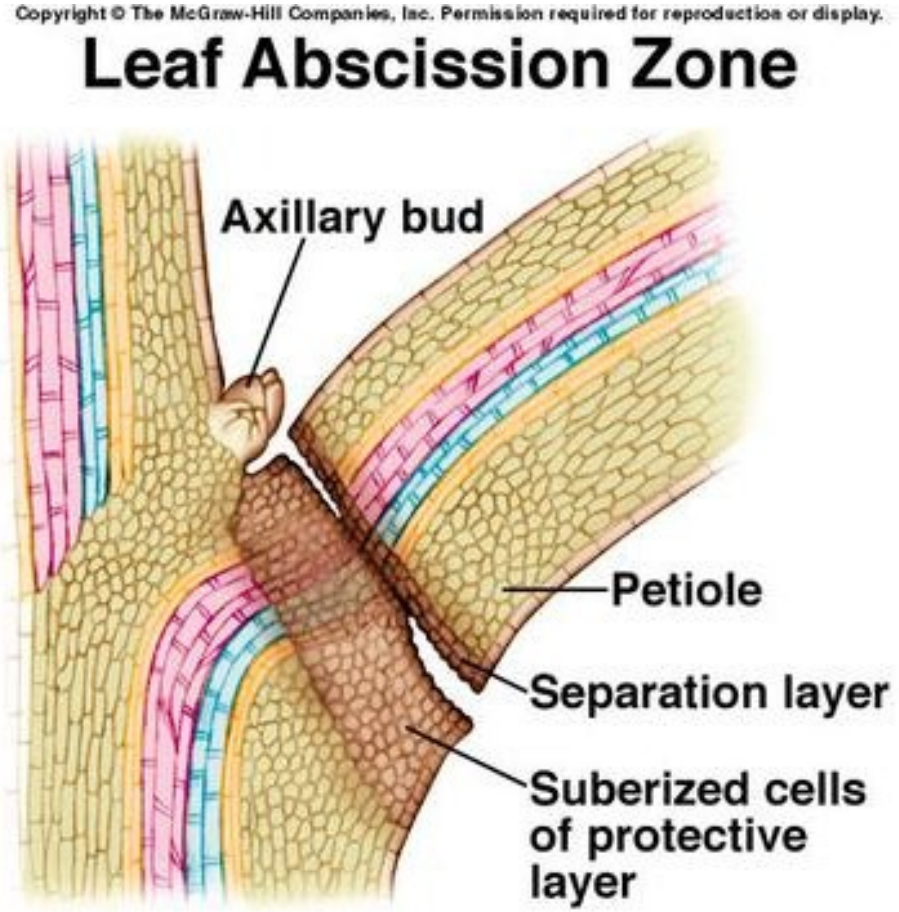
Photo- Britannica

Photo- Natural Navigator.com

- Cytokinin
  - Controls cell growth and division
- Gibberellins
  - Controls cell elongation



- Ethylene
  - Controls fruit ripening
  - Controls leaf abscission



- Enables leaf drop
- Protect region of stem

Energy Use

- Growth
- Maintenance
- Root production and exudates for associates
- Reproduction
- Storage and defense

Factors Limiting Growth

Production method

Soil conditions

Planting Technique

Plant Growth

- Genes
- Environmental stimuli:
  - Changing climate impacts
  - Light, gravity, temperature, water
  - Site conditions- soil, re-reflected heat, space
  - Humans- why, how and what we do???
- Hormones
- Maturity

Reproduction

- Angiosperms- reproductive parts in flower
- Gymnosperms- male and female cones, no flowers

Males and Females…

- Monecious
  - Male and female flowers on same plant
- Dioecious
  - Male and female flowers on different plants
- Use this to breed fruitless plants or just use males

Photo- ehow.com and Etsy

Flower types

Some male flowers

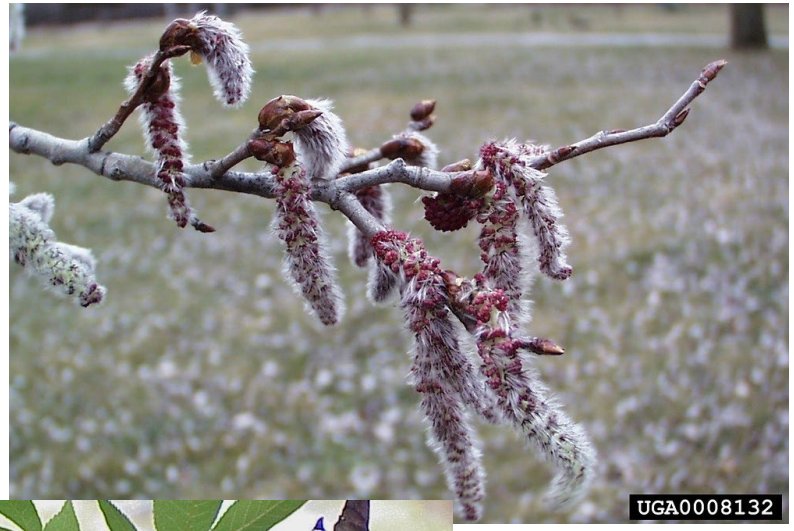


Photo- Sharons Florida

Photo- parksconservancy.org

Photo- Wikimedia Commons

Fruit

Photo- Gecko Green

Photo- Britannica

Photo- Earth.com

Photos: Go Botany- Native Plant Trust

Photo- https://artandscienceofhorticulture.weebly.com/

What does it all mean?

- Trees live longer and get much bigger than other plants
- Can respond to disease, insects, damage, and environmental stressors successfully
- LONG TERM INVESTMENT

Wrap Up

- Understanding tree Biology is key to understanding how to select, grow and maintain trees

- Questions?
- Contact Dr. Barbara Fair at bfair@ncsu.edu