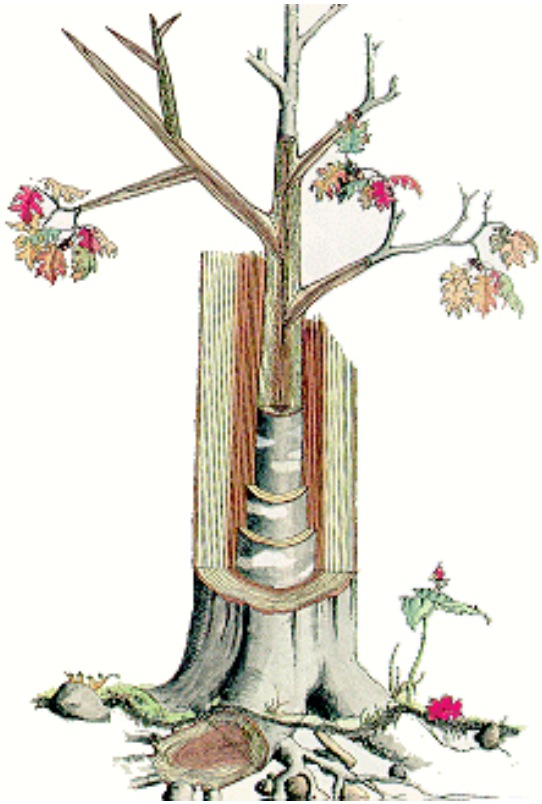
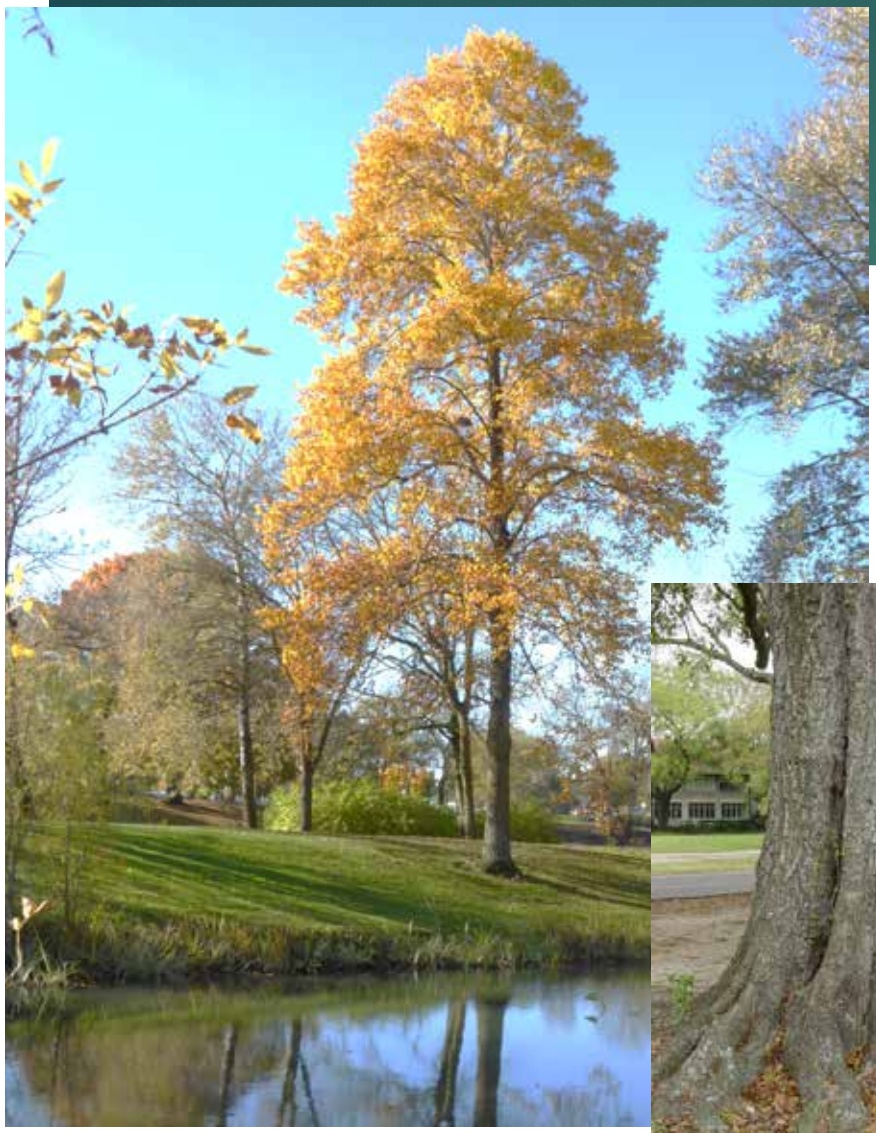
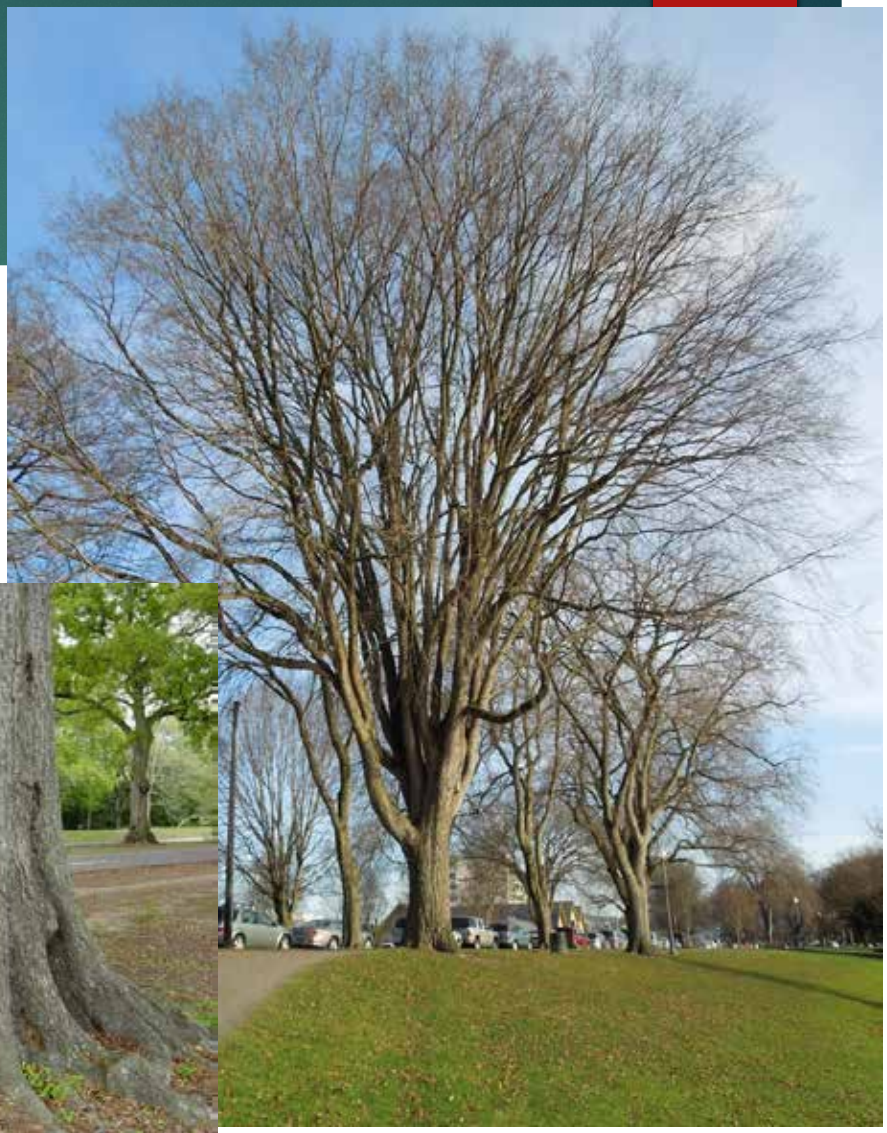
BASIC TREE BIOLOGY

Trees are:



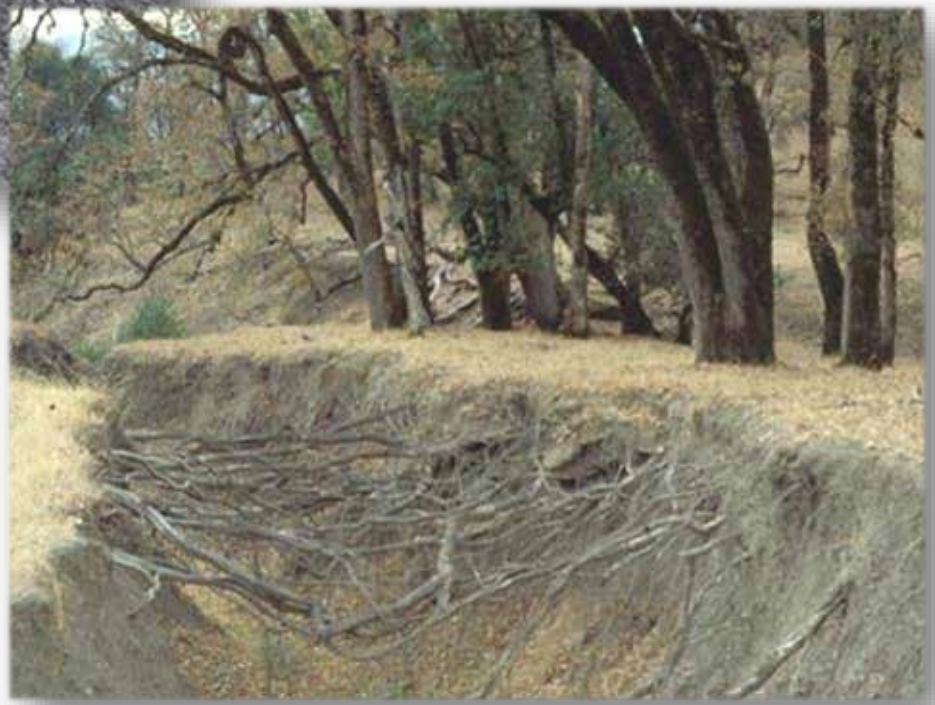
- woody
- complex, large, long-lived
- self-feeding
- shedding
- generating systems
- compartmented, self optimizing





Roots:

- absorb water and minerals
- store energy
- support and anchor
- produce hormones



Trees:

- respond to: injury, pathogens, & environmental change
- alter root-shoot ratios in response to change
- life-processes controlled by hormones
- can starve

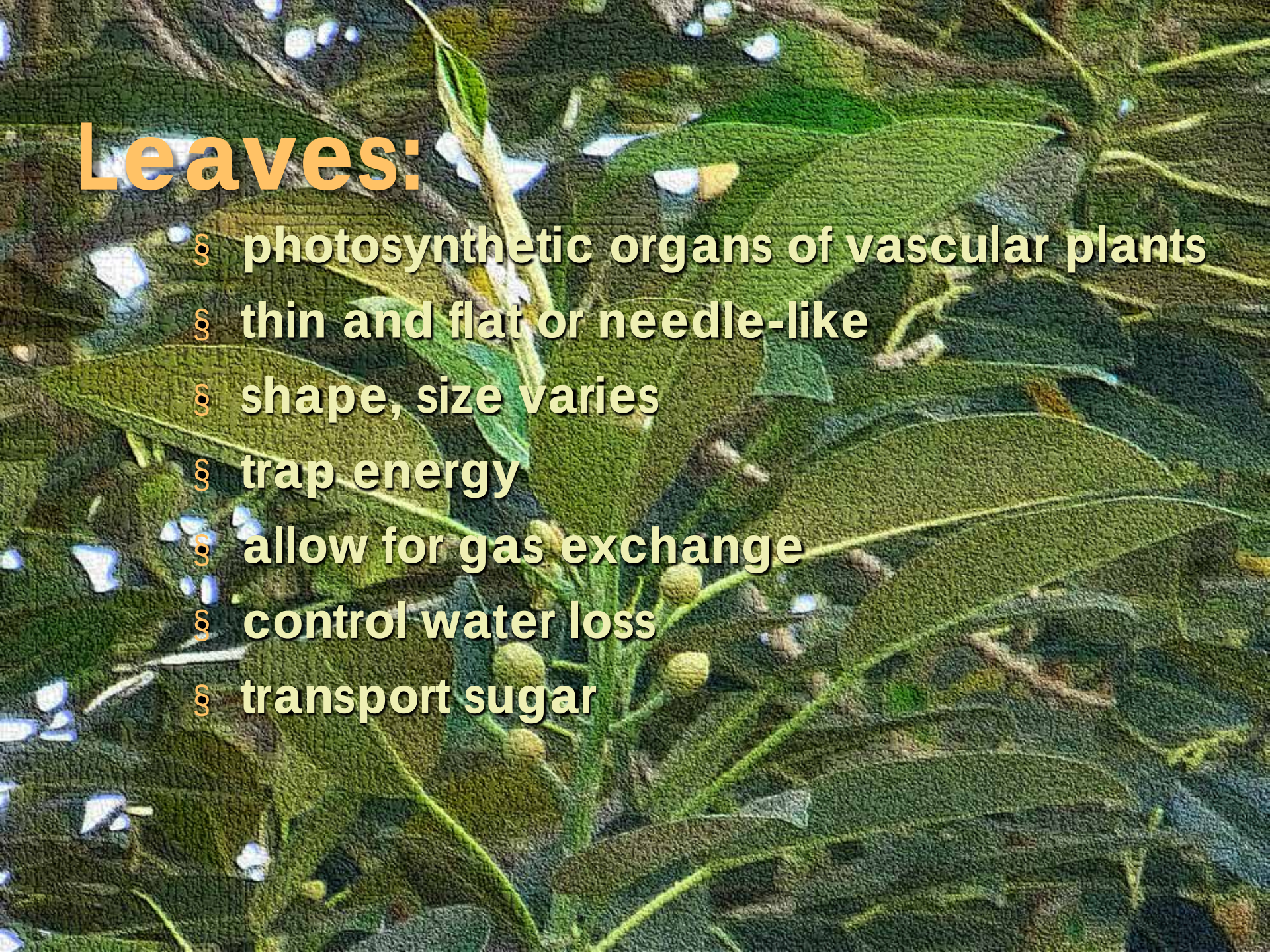
What trees need:

- sunlight
- water, minerals
- CO_2
- O_2
- space
- favorable temperature

Adaptability: not all created equal

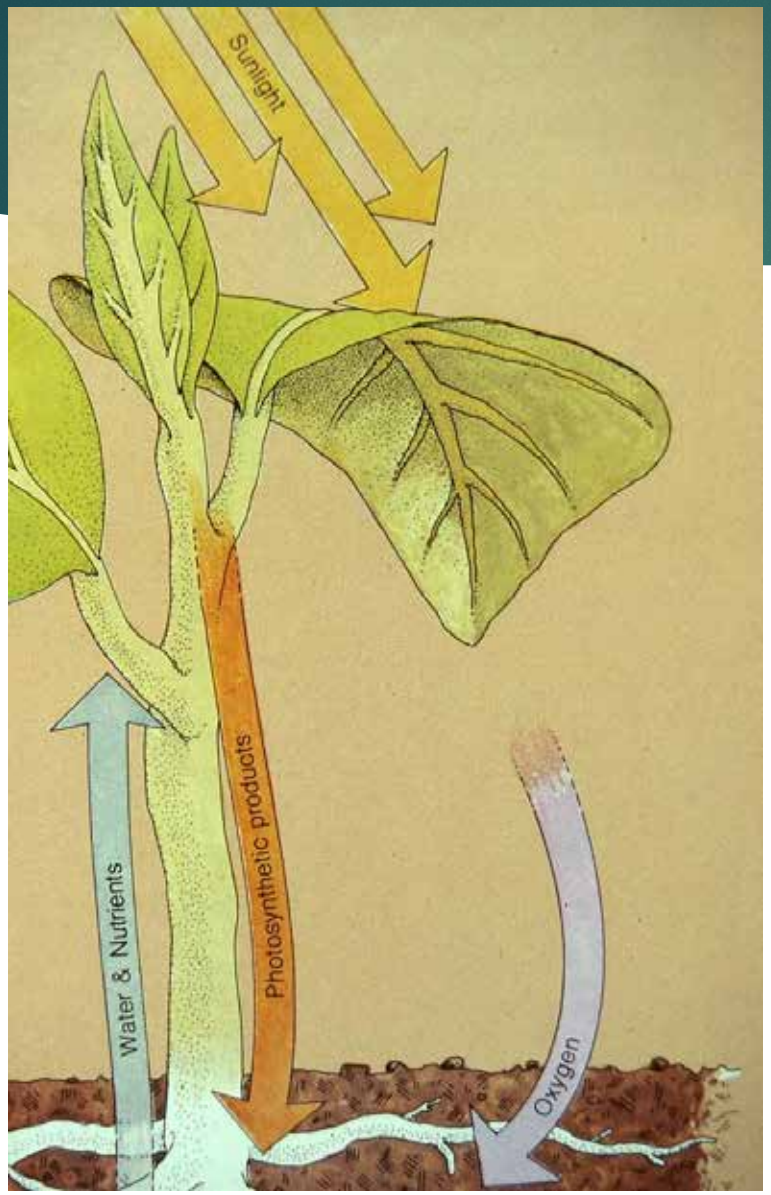
- arid conditions
- temperate
- tropical
- sub-tropical
- riparian
- swamps
- salinity
- pH
- shade
- fire, pests

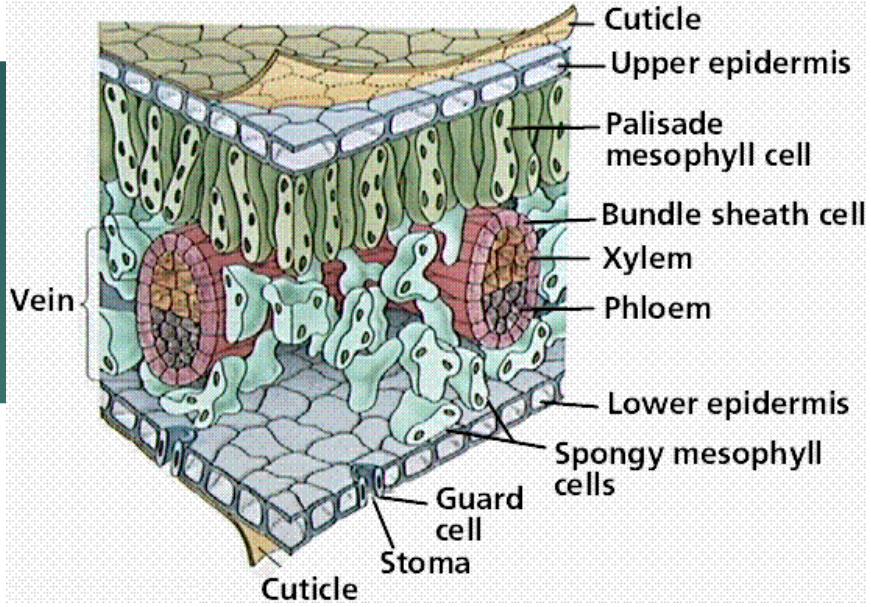
Huntington Library, Pasadena

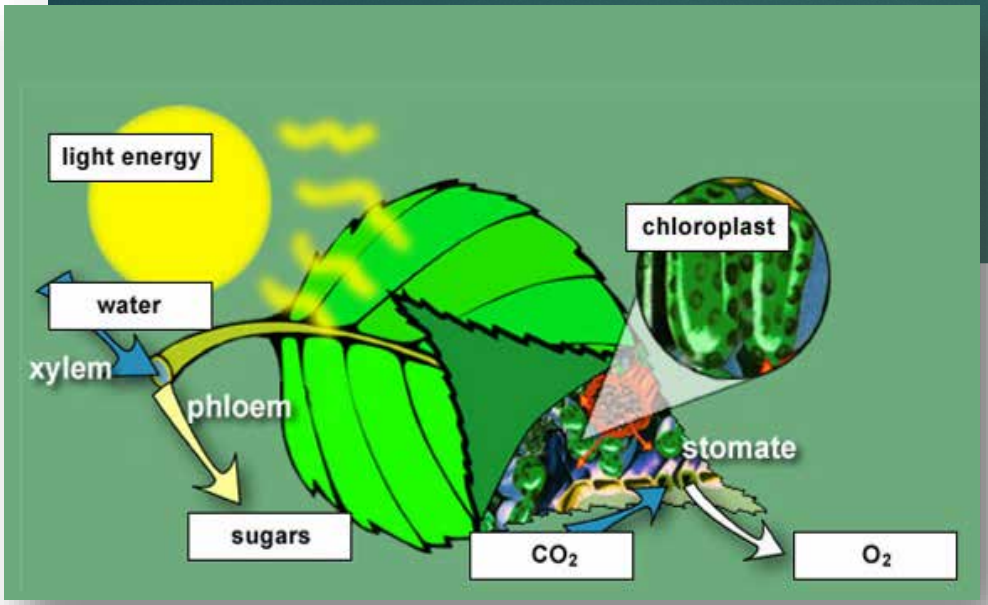


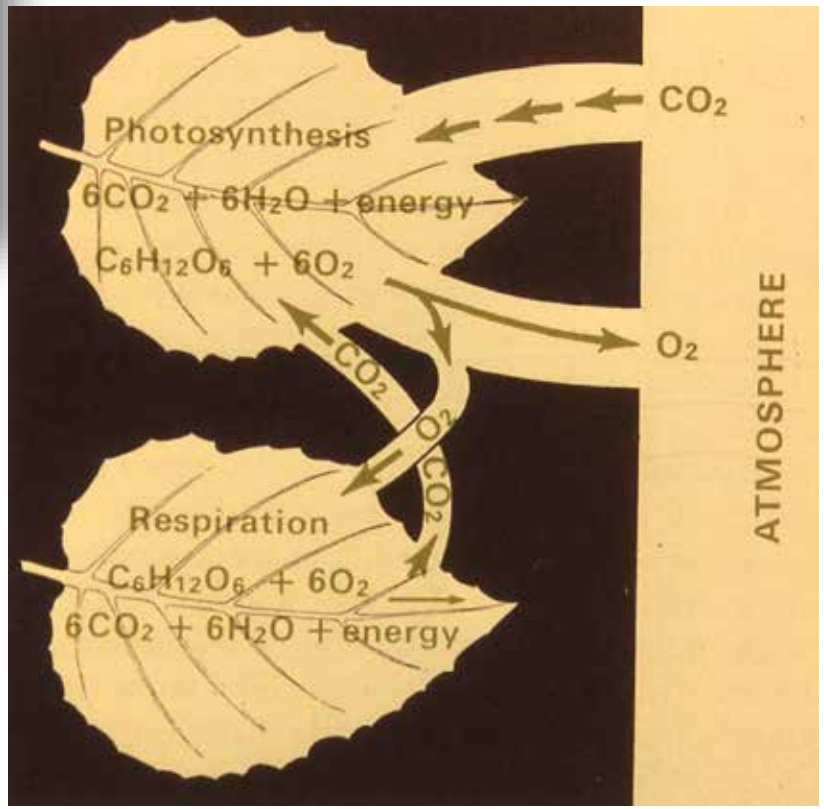
Leaves:

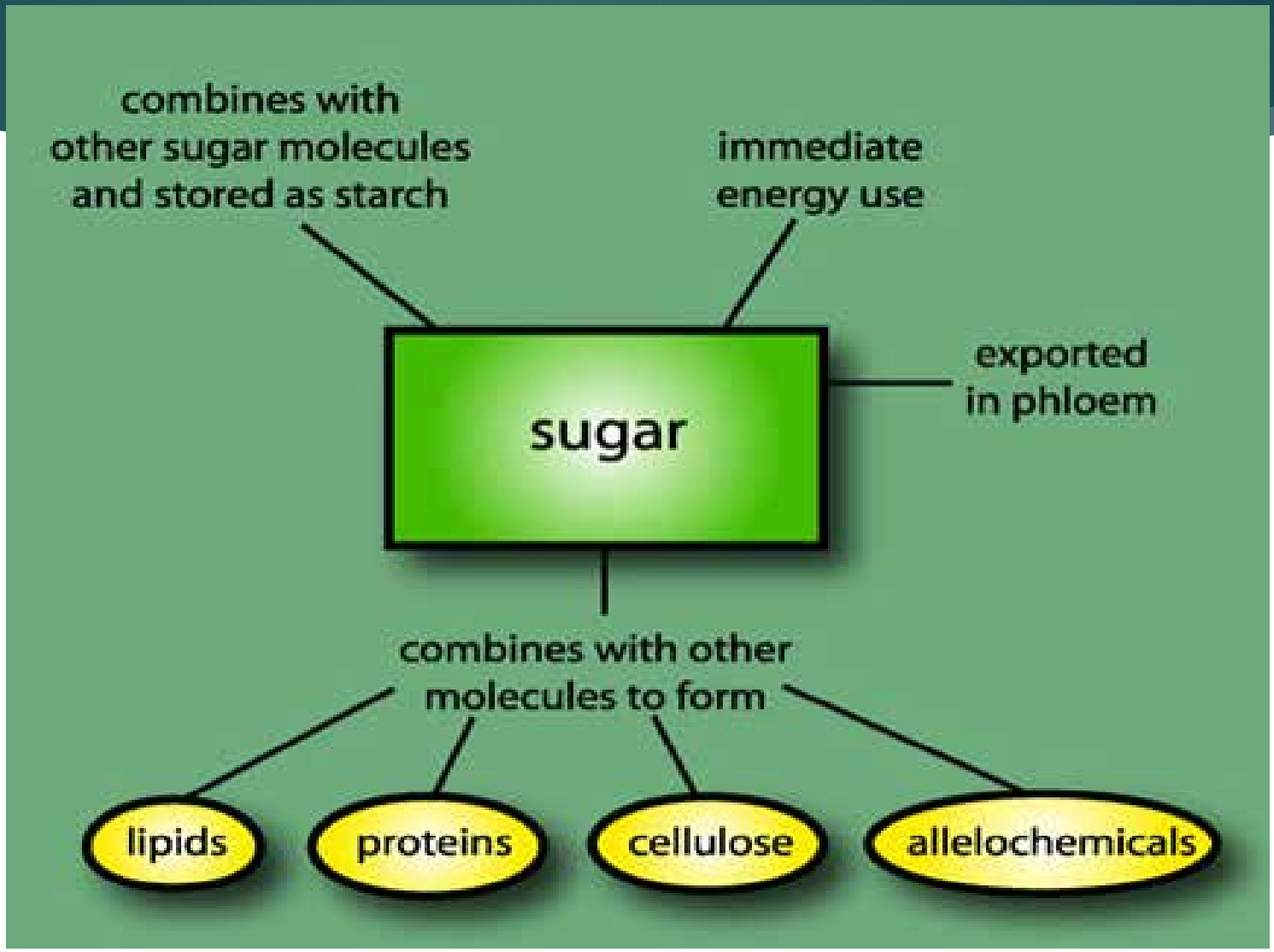
- photosynthetic organs of vascular plants
- thin and flat or needle-like
- shape, size varies
- trap energy
- allow for gas exchange
- control water loss
- transport sugar


Sunlight
Water & Nutrients
Photosynthetic products
Oxygen


Cuticle
Upper epidermis
Palisade mesophyll cell
Bundle sheath cell
Xylem
Phloem
Vein
Lower epidermis
Spongy mesophyll cells
Guard cell
Stoma
Cuticle


light energy
chloroplast
water
xylem
phloem
stomate
sugars
CO_2
O_2

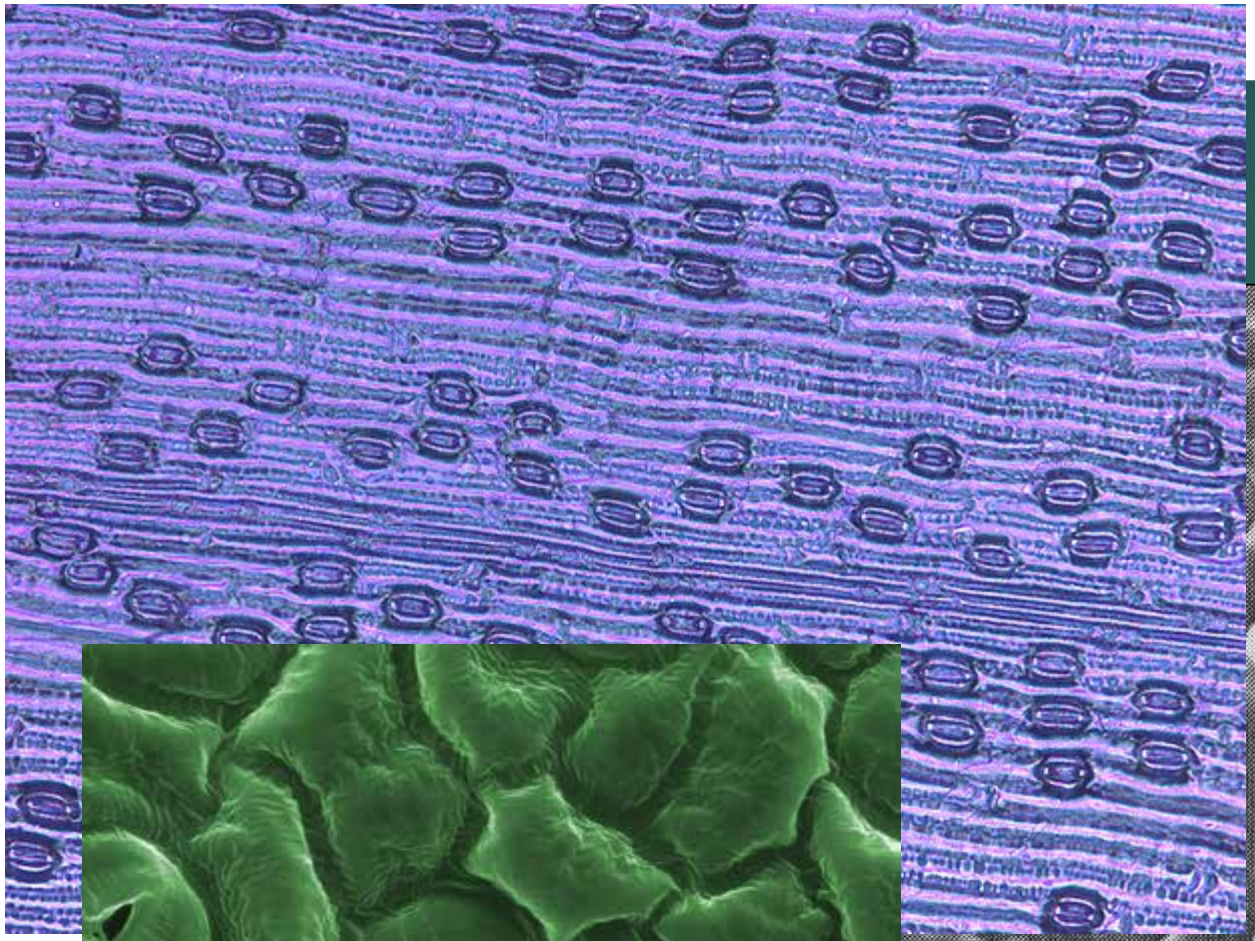

CO_2
Photosynthesis
$6CO_2 + 6H_2O$ + energy
$C_6H_{12}O_6 + 6O_2$
O_2
CO_2
O_2
CO_2
Respiration
$C_6H_{12}O_6 + 6O_2$
$6CO_2 + 6H_2O$ + energy
ATMOSPHERE

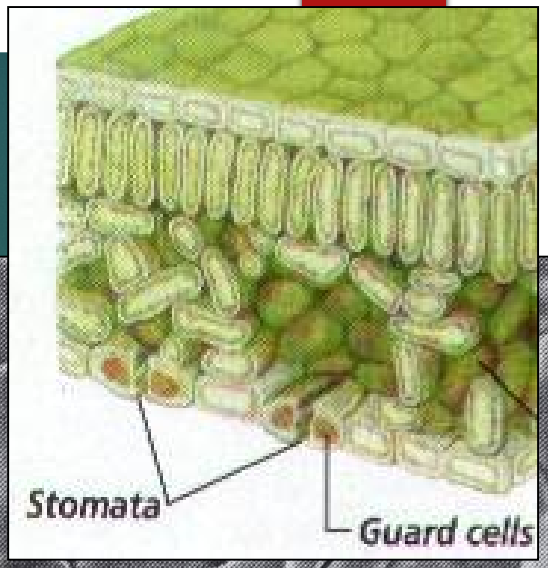

combines with other sugar molecules and stored as starch
immediate energy use
sugar
exported in phloem
combines with other molecules to form
lipids
proteins
cellulose
allelochemicals

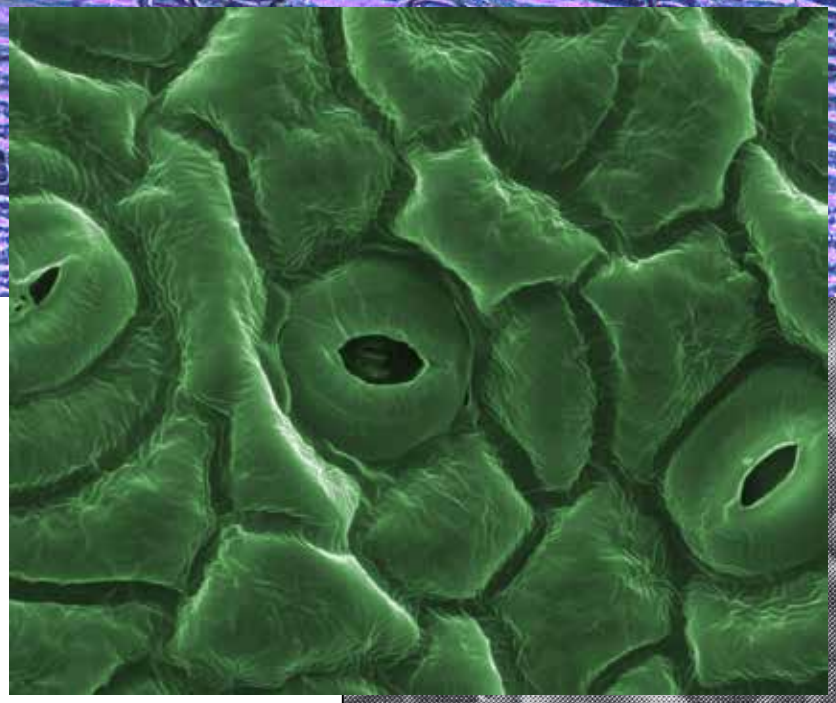
Energy allocation:

- maintenance (respiration)
- growth (primary and secondary)
- reproduction
- defense
- reserves

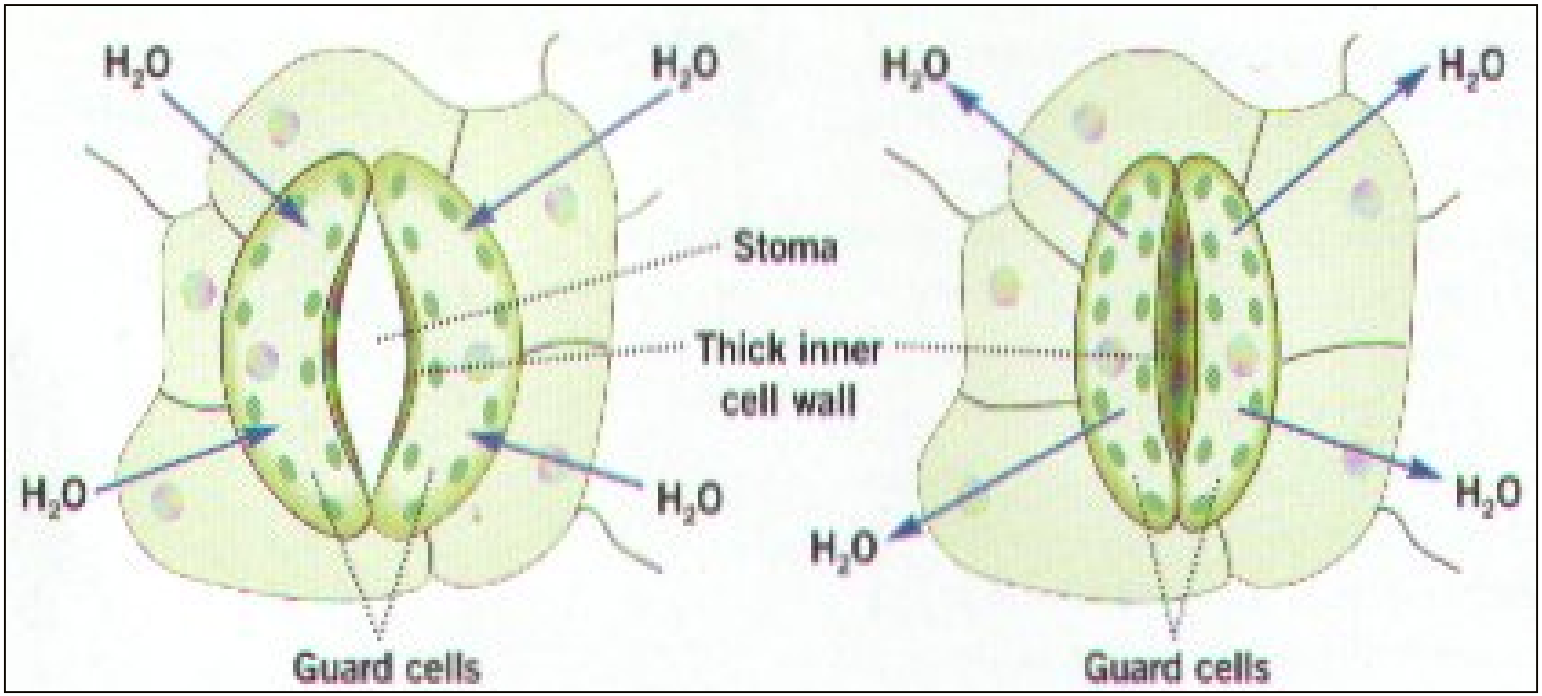
Foliage density

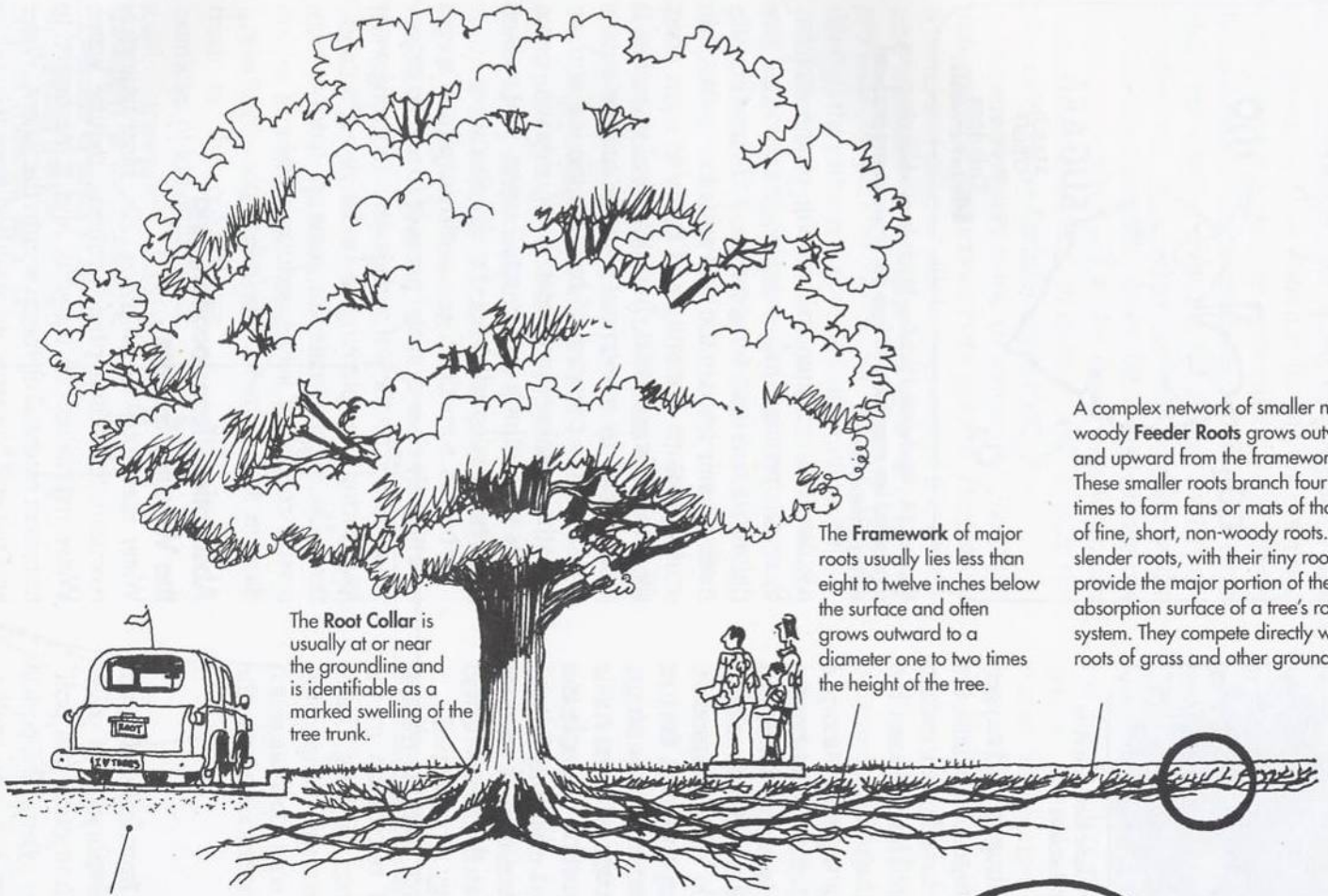



Stomata
Guard cells



Stomates


H_2O
H_2O
Stoma
Thick inner cell wall
H_2O
H_2O
Guard cells
H_2O
H_2O
H_2O
H_2O
Guard cells



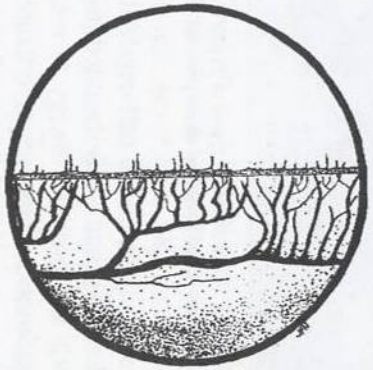
The **Root Collar** is usually at or near the groundline and is identifiable as a marked swelling of the tree trunk.

The **Framework** of major roots usually lies less than eight to twelve inches below the surface and often grows outward to a diameter one to two times the height of the tree.

A complex network of smaller non-woody **Feeder Roots** grows outward and upward from the framework roots. These smaller roots branch four or more times to form fans or mats of thousands of fine, short, non-woody roots. These slender roots, with their tiny root hairs, provide the major portion of the absorption surface of a tree's root system. They compete directly with the roots of grass and other groundcovers.

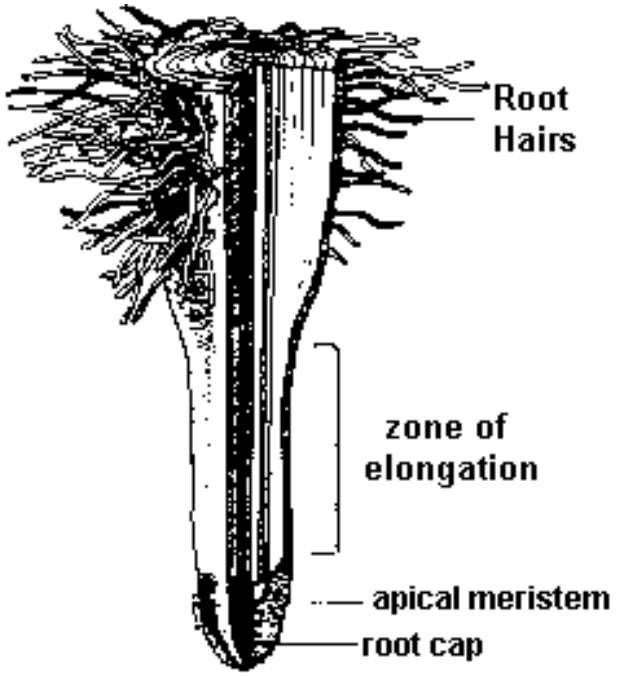
Because **Roots Need Oxygen** in order to grow, they don't normally grow in the compacted, oxygen-poor soils under paved streets.

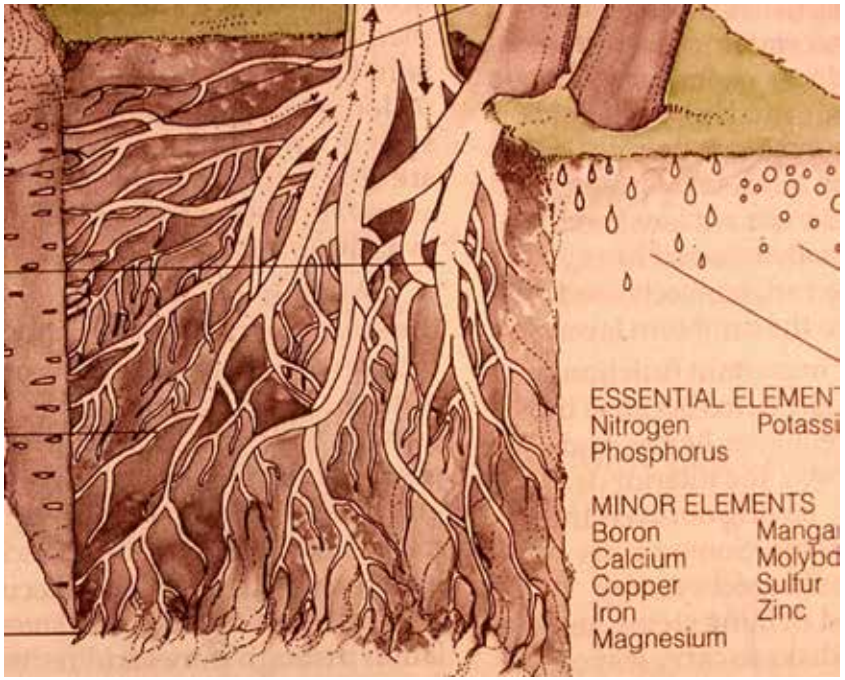
Note: A few species have a **Taproot** that grows straight down three to seven feet or more until it encounters impenetrable soil or rock layers, or reaches layers with insufficient supplies of oxygen.

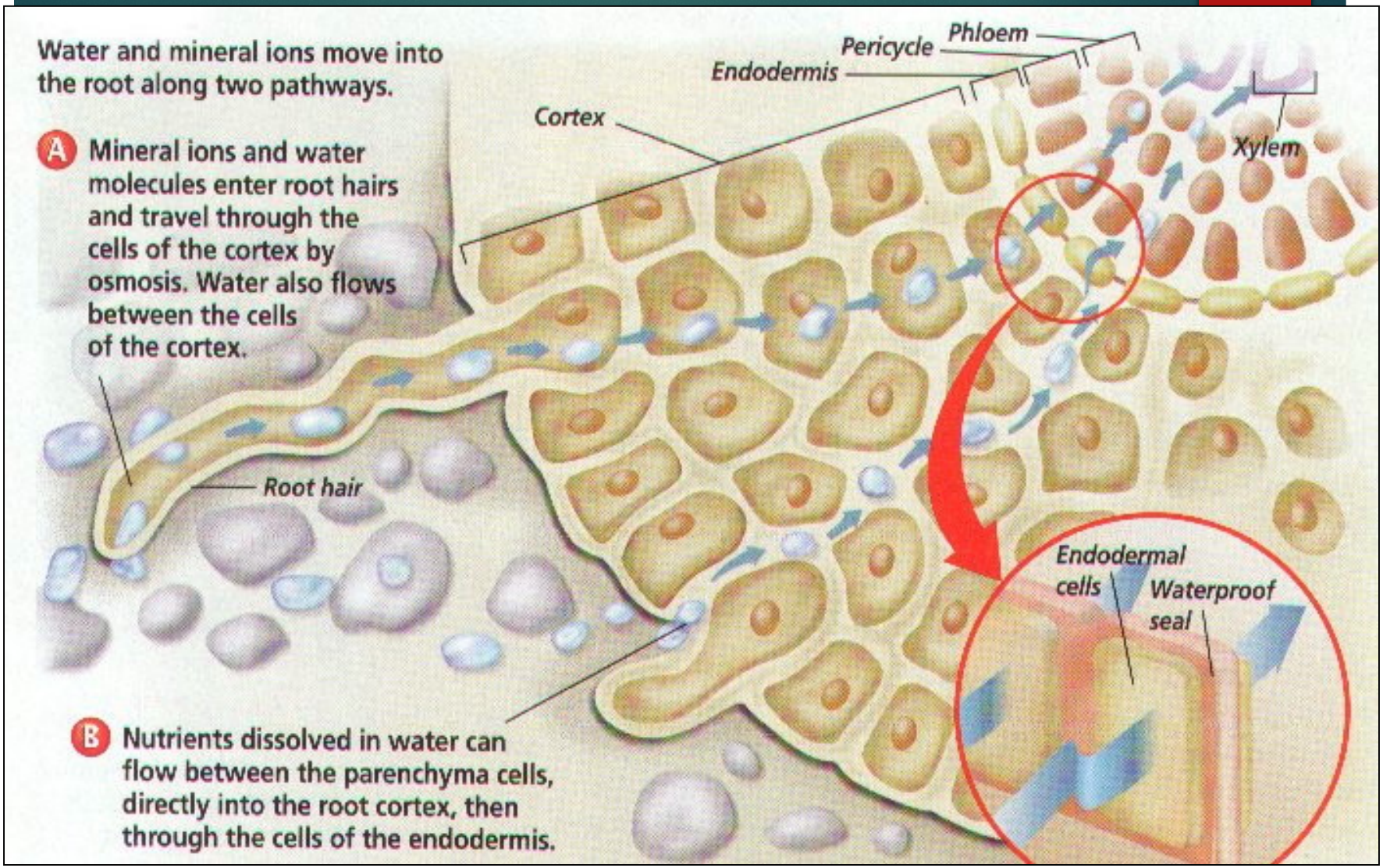


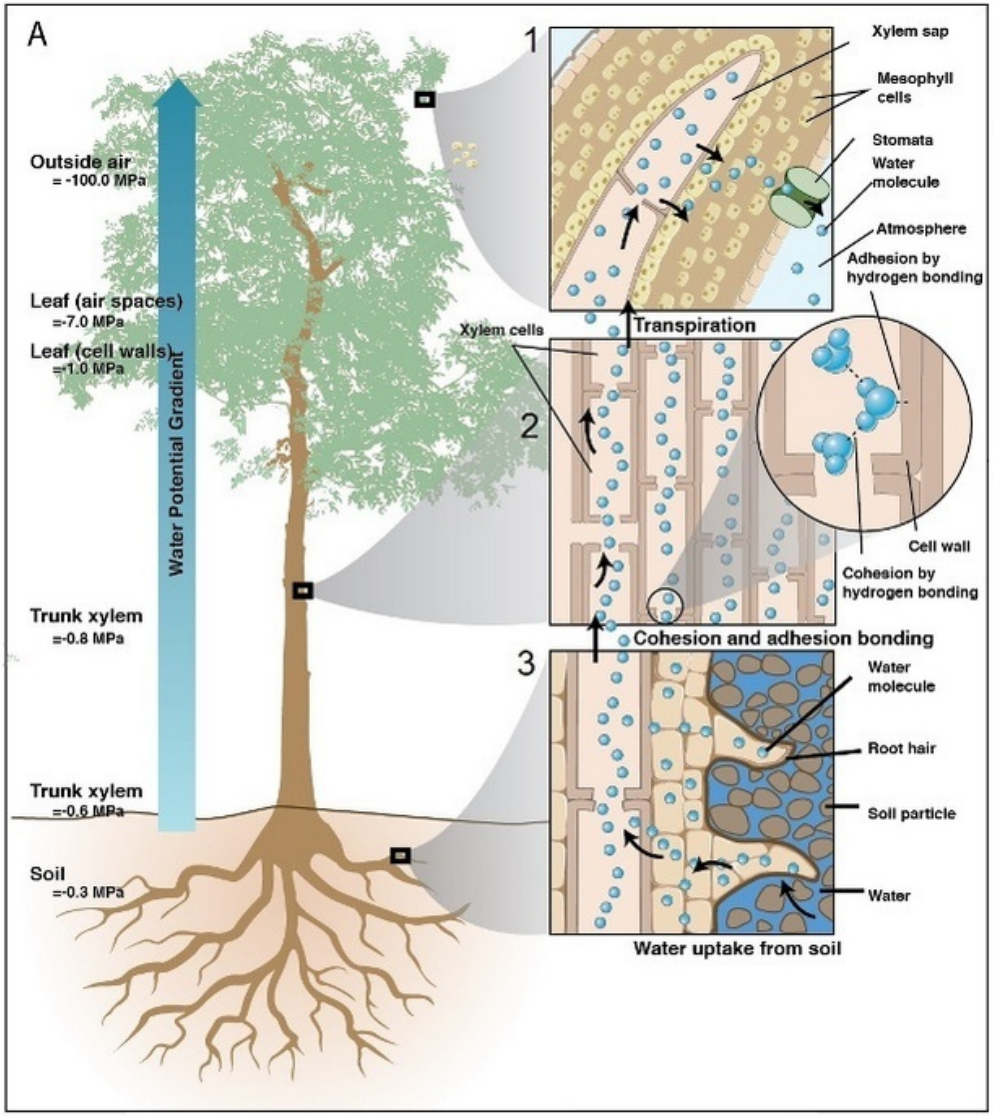
Roots need:

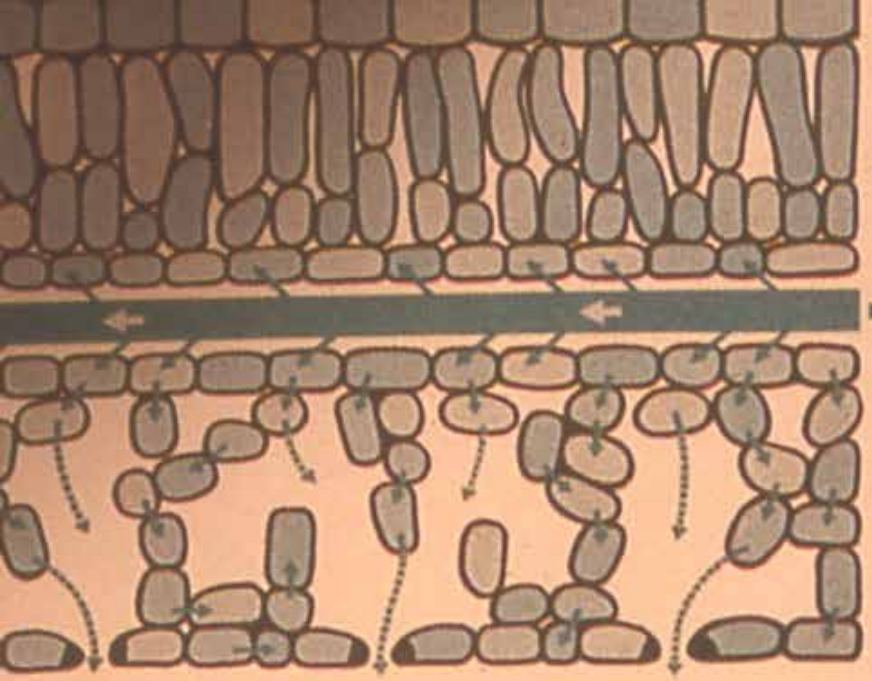
- water, minerals
- oxygen
- good soil structure
- physical space
- adequate soil volume

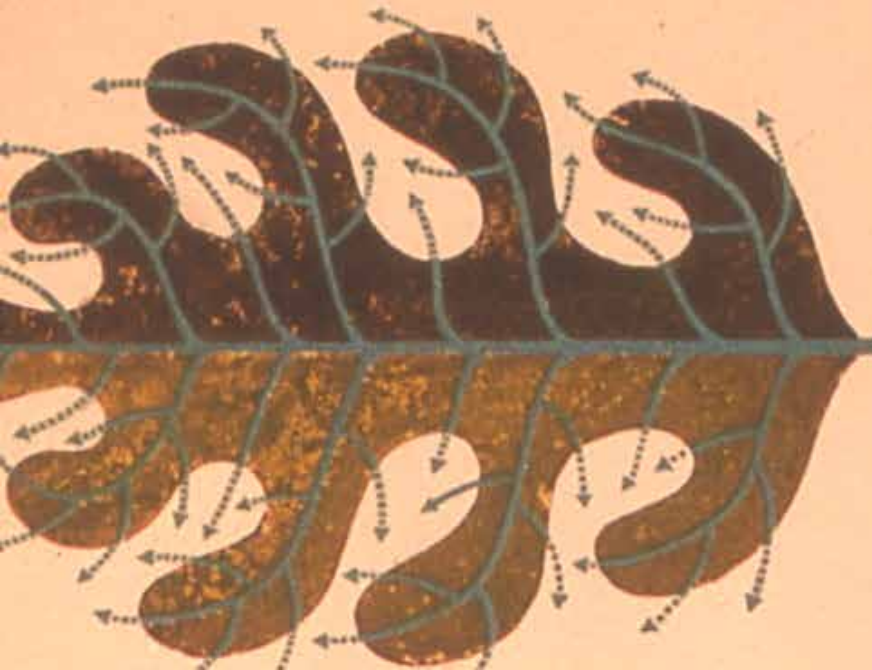

Root
Hairs
zone of
elongation
apical meristem
root cap


ESSENTIAL ELEMEN
Nitrogen
Potassi
Phosphorus
MINOR ELEMENTS
Boron
Manga
Calcium
Molybd
Copper
Sulfur
Iron
Zinc
Magnesium

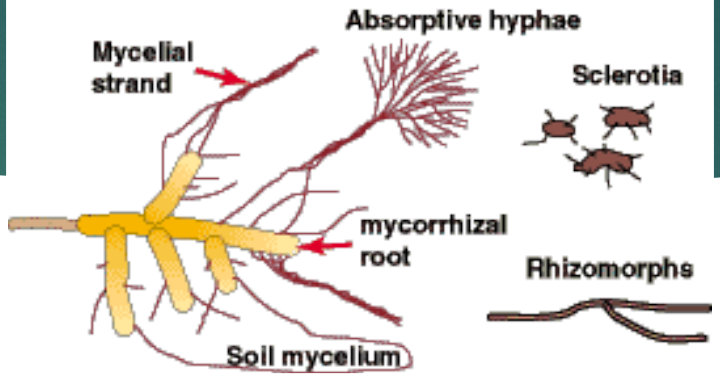

Water and mineral ions move into the root along two pathways.
A Mineral ions and water molecules enter root hairs and travel through the cells of the cortex by osmosis. Water also flows between the cells of the cortex.
Root hair
B Nutrients dissolved in water can flow between the parenchyma cells, directly into the root cortex, then through the cells of the endodermis.
Cortex
Endodermis
Pericycle
Phloem
Xylem
Endodermal cells
Waterproof seal

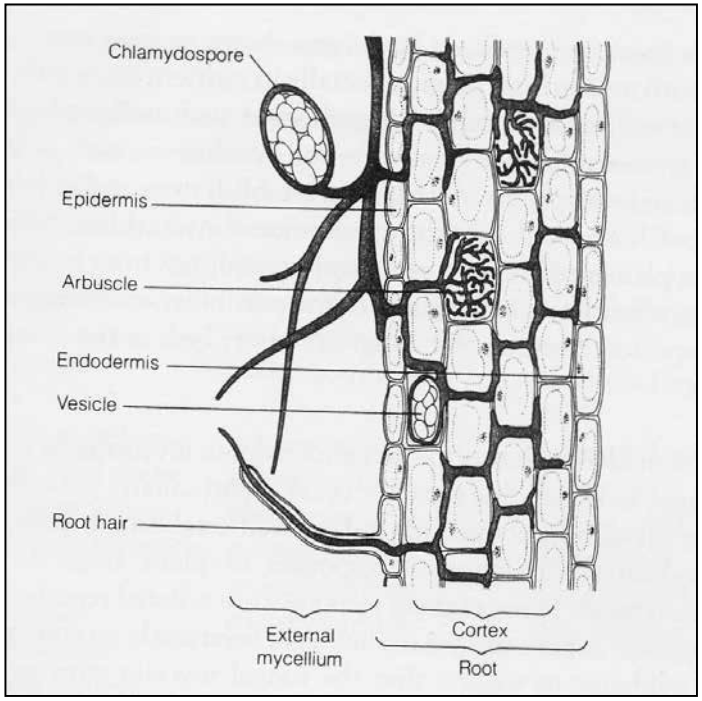

A
Outside air
= -100.0 MPa
Leaf (air spaces)
=-7.0 MPa
Leaf (cell walls)
=-1.0 MPa
Water Potential Gradient
Trunk xylem
=-0.8 MPa
Trunk xylem
=-0.6 MPa
Soil
=-0.3 MPa
1
Xylem sap
Mesophyll cells
Stomata
Water molecule
Atmosphere
Adhesion by hydrogen bonding
Transpiration
Xylem cells
2
Cell wall
Cohesion by hydrogen bonding
Cohesion and adhesion bonding
3
Water molecule
Root hair
Soil particle
Water
Water uptake from soil

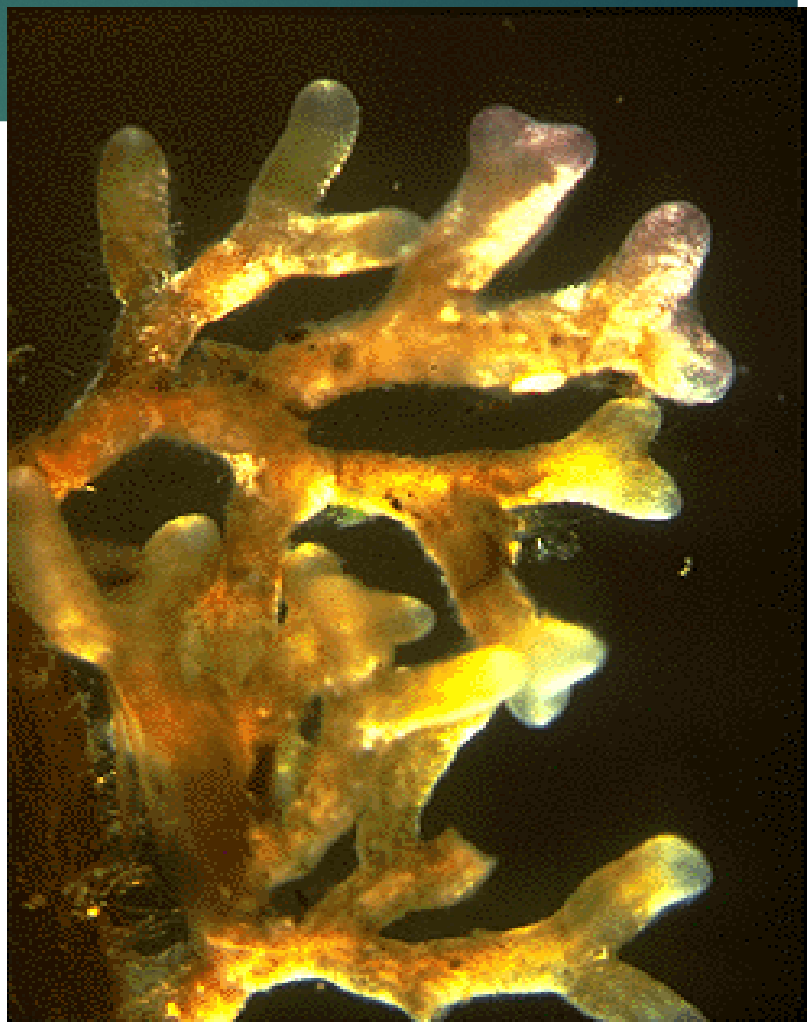




Fungal structures in soil




Chlamydospore
Epidermis
Arbuscle
Endodermis
Vesicle
Root hair
External mycellium
Cortex
Root



Organic matter:

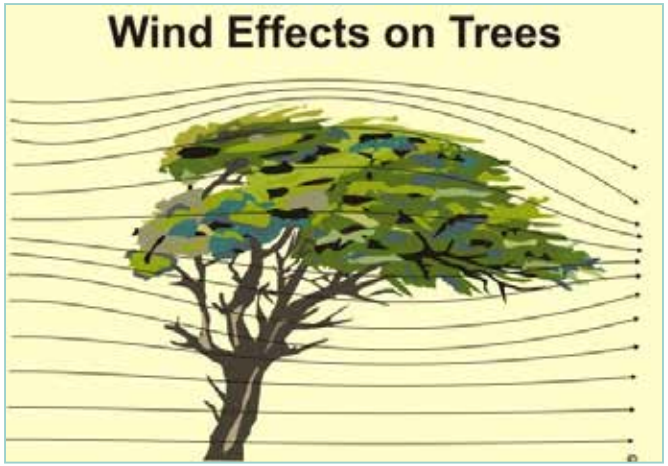
- improves soil structure
- source of nutrients
- improves water-holding capacity.
- improves nutrient-holding capacity.
- is a food source for soil-organisms

Health depends on:

- availability of water, minerals, O2,
- energy availability
- soil characteristics
- volume of soil
- cultural practices
- climate

Environmental factors:

- exposure to sunlight
- water & mineral availability
- temperature
- soil conditions
- wind, humidity
- topography
- competition
- horticultural care



When energy is low:

- growth slows
- resistance to serious pests decreases
- trees begin to decline and dieback
- death: starvation or secondary pests

Natural defenses:

- physical: e.g., hairs, spines, thick cuticle, indigestible substances: cellulose, lignin
- toxins (allelochemicals): tannins, phenols, terpenes, resins, essential oils, alkaloids, cyanogenic compounds
- low nitrogen content

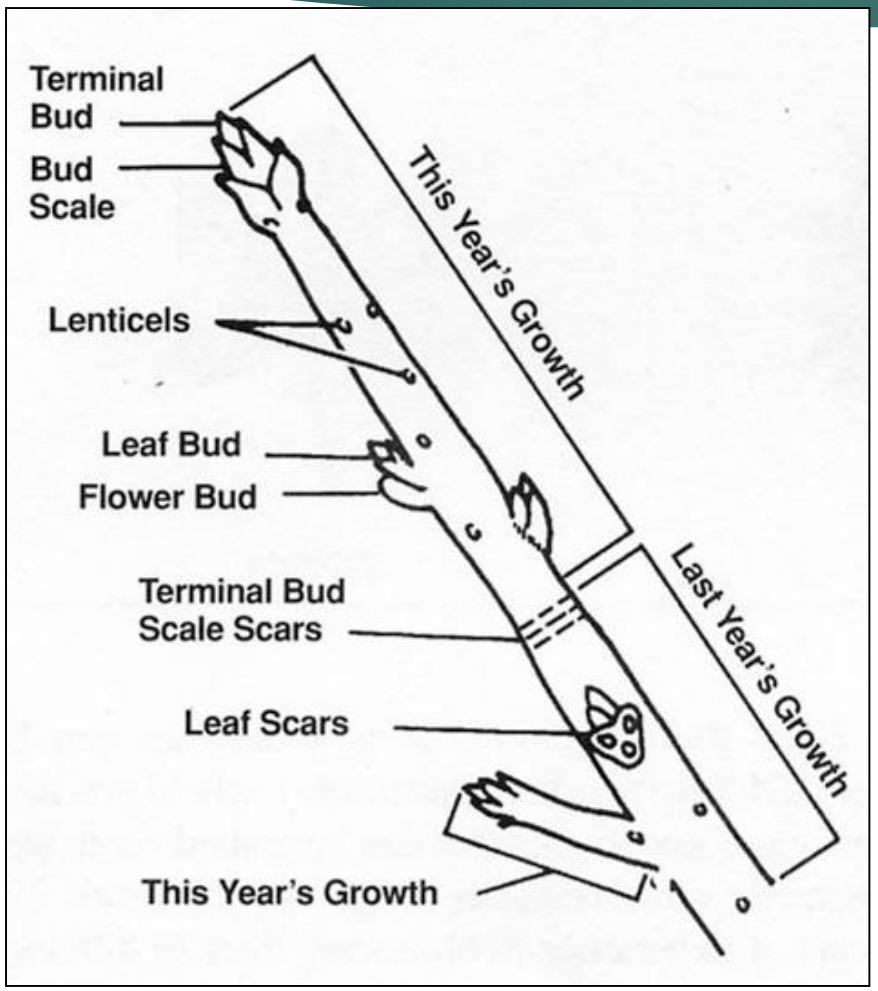
Growth:

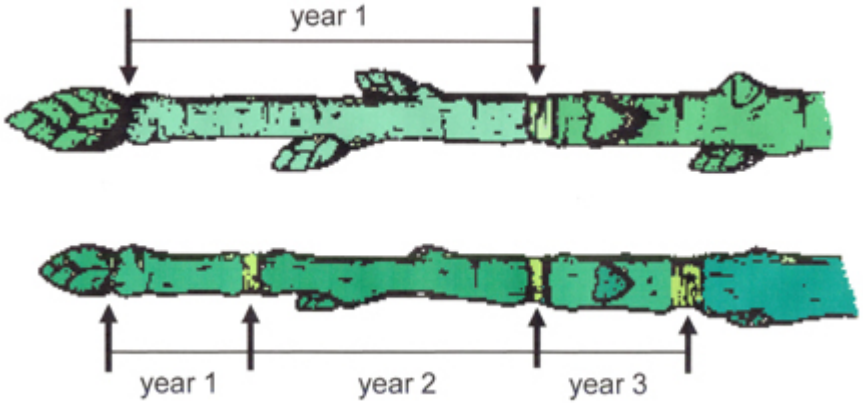
Primary: from apical or lateral buds, root tips (apical meristems).

Secondary: from cambial or lateral meristems

Growth:

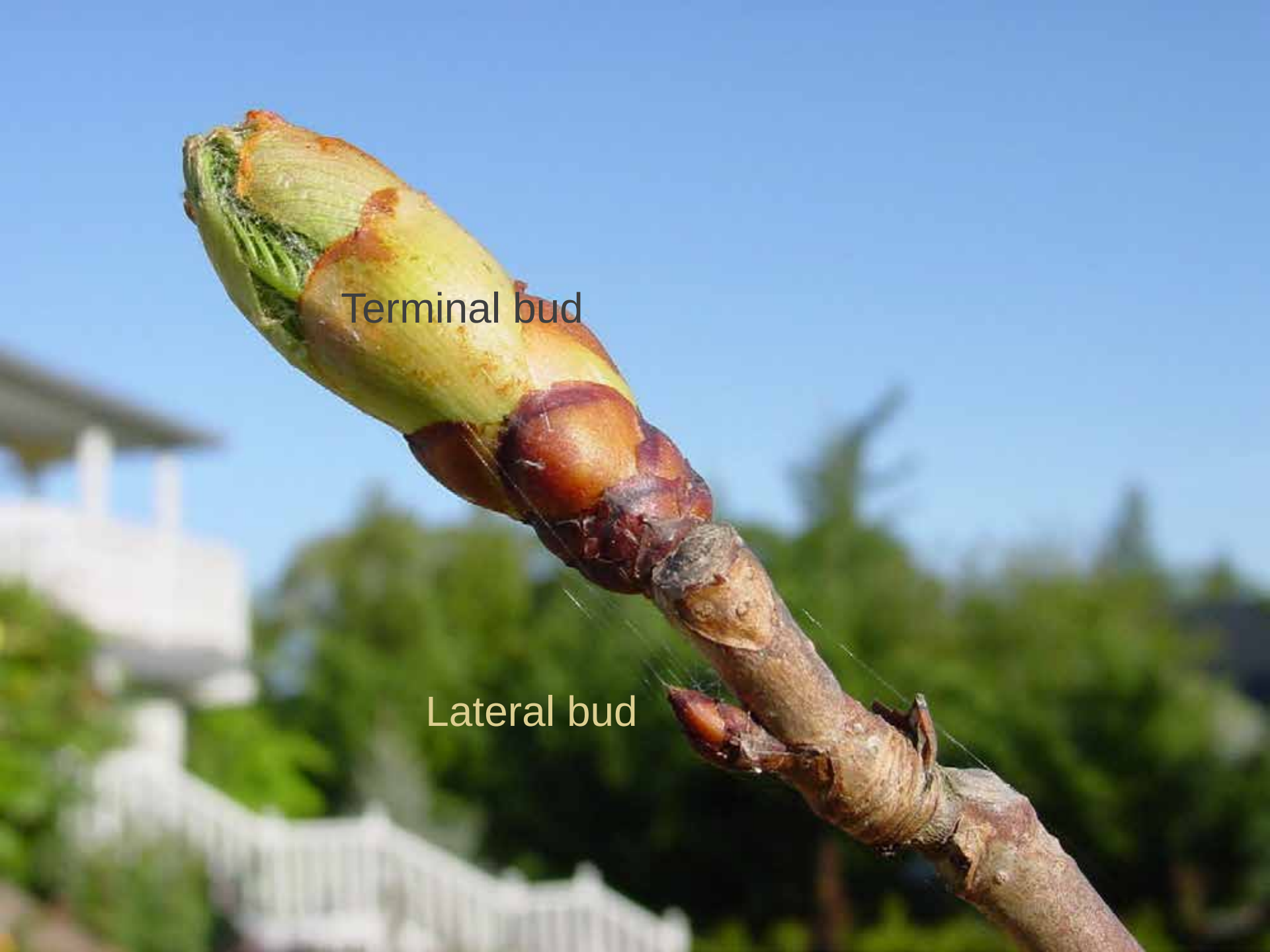
Shoot anatomy





Buds:

- unexpanded shoot with leaves and flowers or flowers alone.
- apical or lateral (dormant)
- epicormic (latent)
- adventitious (not pre-existing)

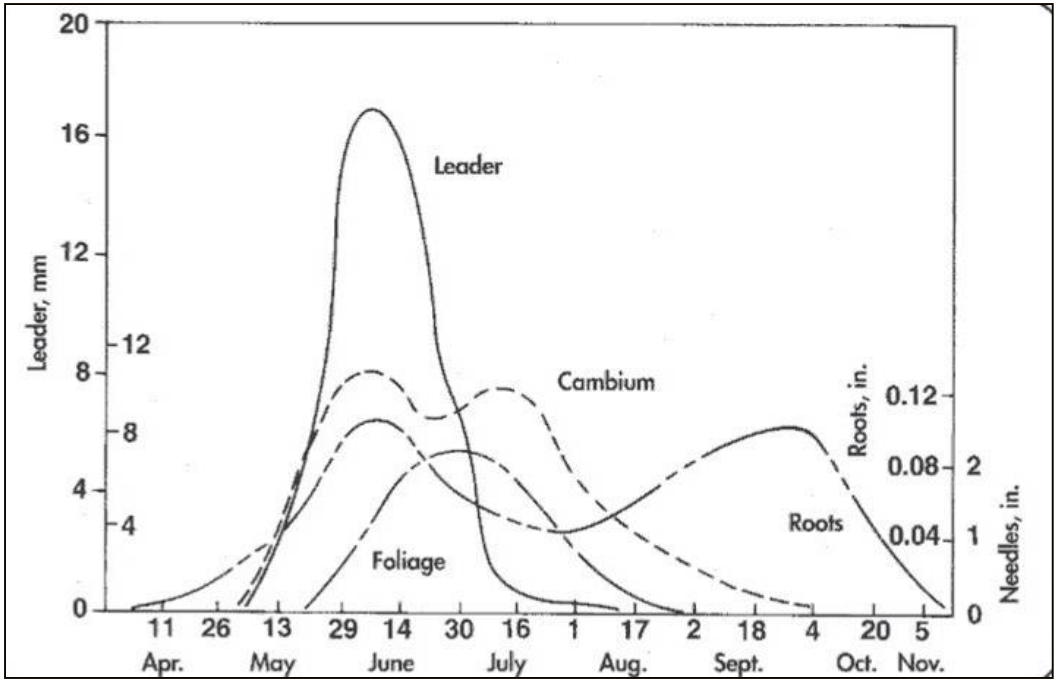

Terminal bud
Lateral bud

Latent buds

Adventitious bud

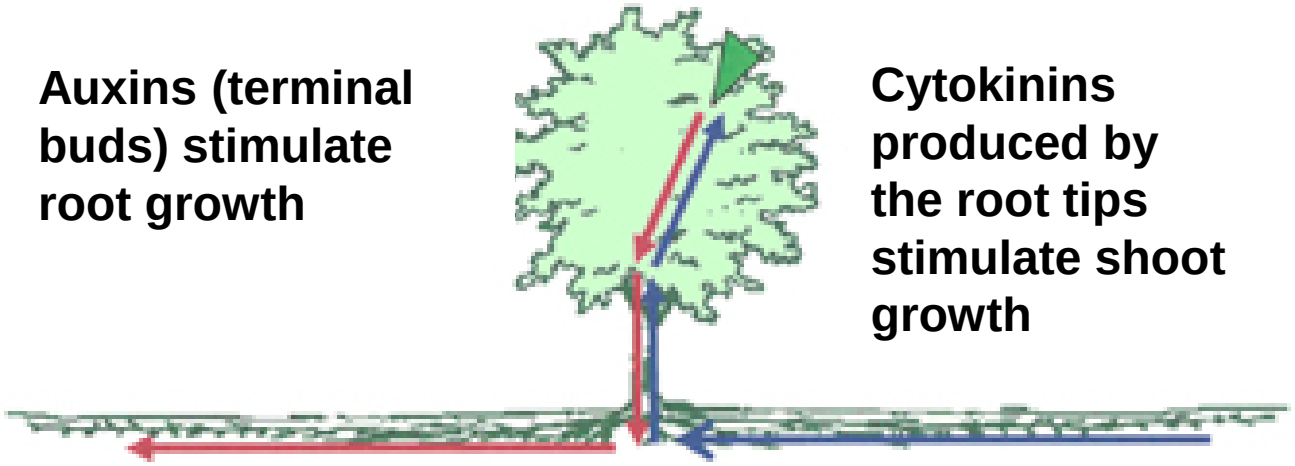
Growth regulators:

- bud break, flowering
- leaf flush/shoot elongation
- root growth
- radial growth
- fruit ripening
- energy storage
- leaf shedding
- dormancy
- combinations/ concentrations



Trees adopt the best strategy for given conditions: root/shoot balance

Auxins (terminal buds) stimulate root growth



Cytokinins produced by the root tips stimulate shoot growth

Auxins:

- suppress lateral (current year) & epicormic buds
- stimulate both root and shoot growth
- accumulate on the shaded side, causing elongation & bending toward the sun (phototropism)
- degraded by sunlight
- trunk sprouting when exposed to sun
- pruning -- disrupts production, slows root growth

Auxins:

- involved in reaction wood (compression or tension)
- tension wood:
  - prevents bending, cracking or corrects lean (negative geotrophism)
  - adaptive growth in response to flexing


Tension Wood
LEAN
ASH
Pith
TRUNK

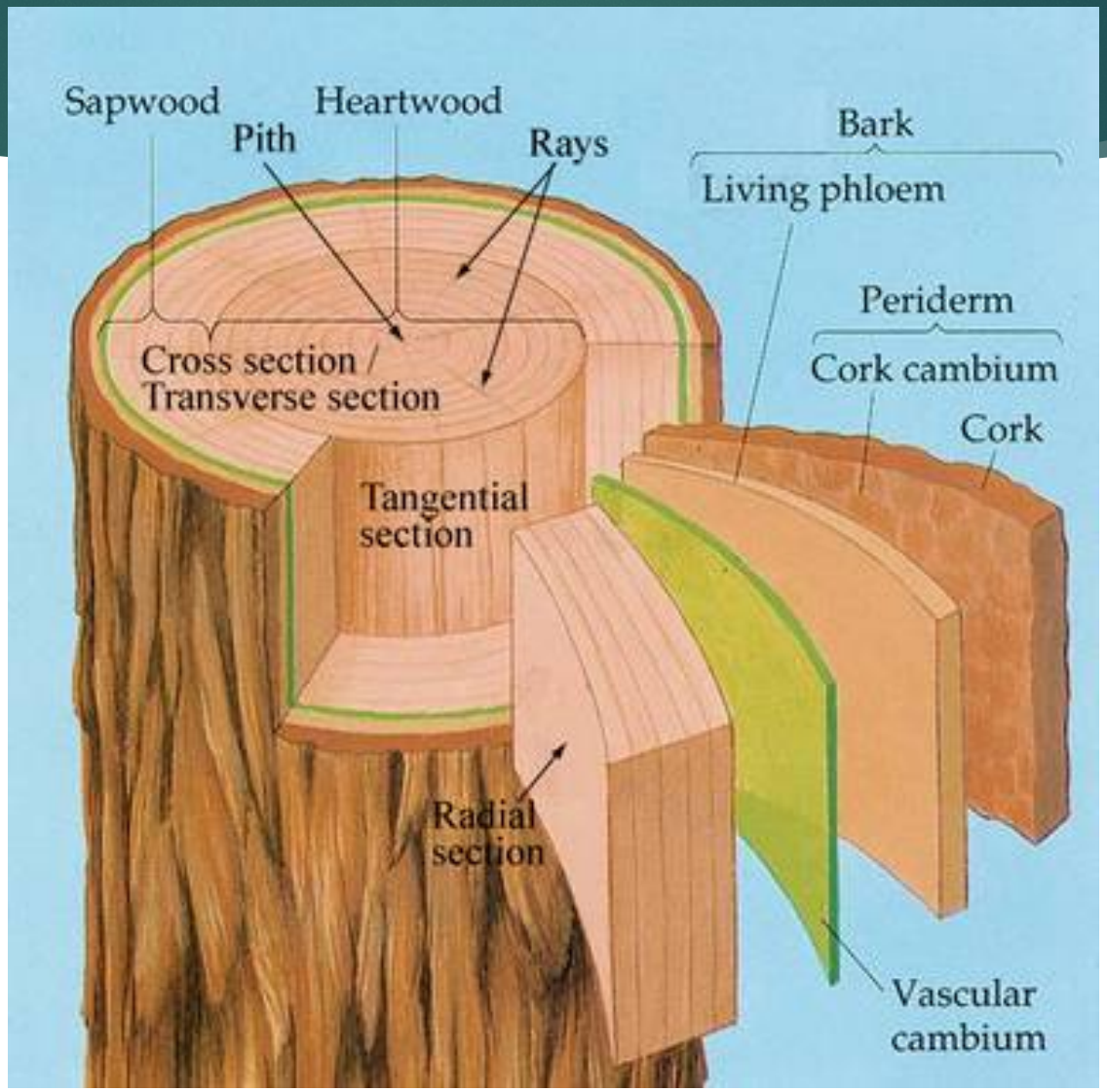
Cytokinins:

- root and shoot elongation
- promote growth of lateral buds - high concentration.
- when roots are cut, shoot growth <
- shoot growth > when carbohydrates low.

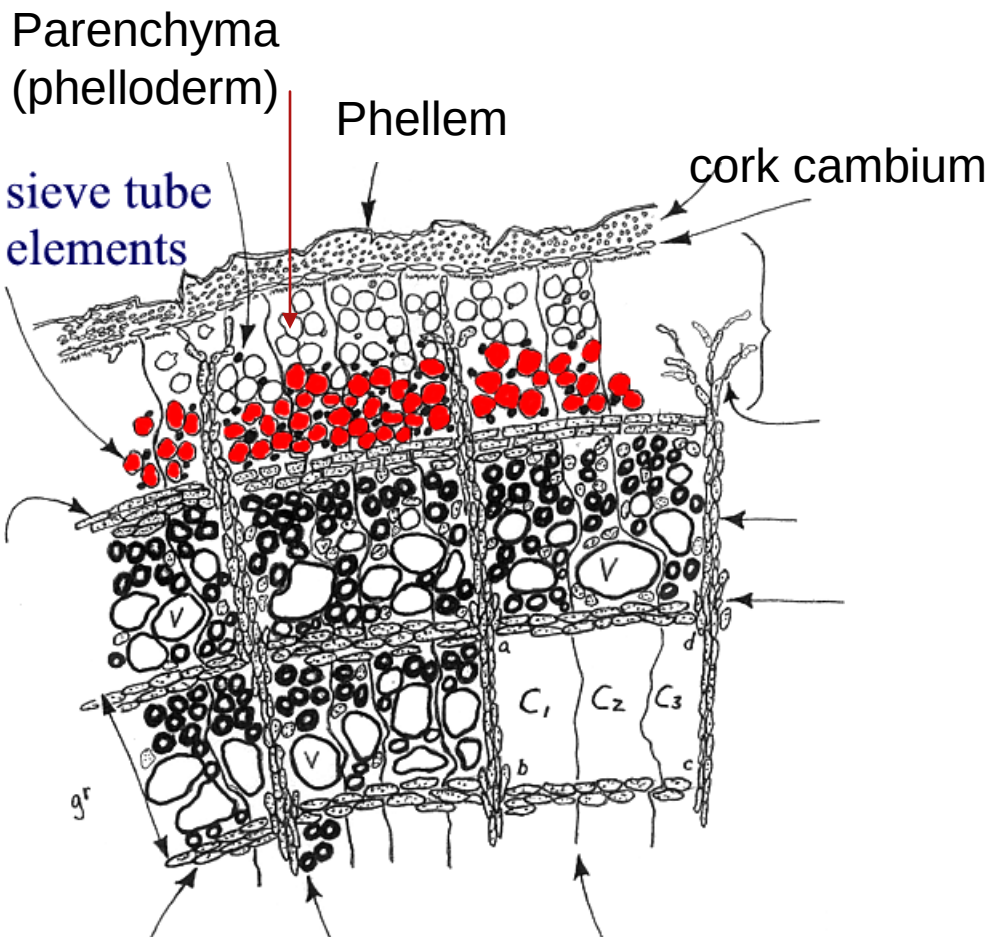
Others:

- **Gibberellins**: promote cell division, intermodal elongation of shoots, and induce flowering
- **Abscisic acid:** “stress” hormone. It inhibits the effects of other hormones to reduce growth during times of plant stress. It helps close stomata, and leads leaf abscission
- **Ethylene gas**: stem thickening near stress points

Secondary growth:



Phloem or inner bark



Water and mineral shortage:

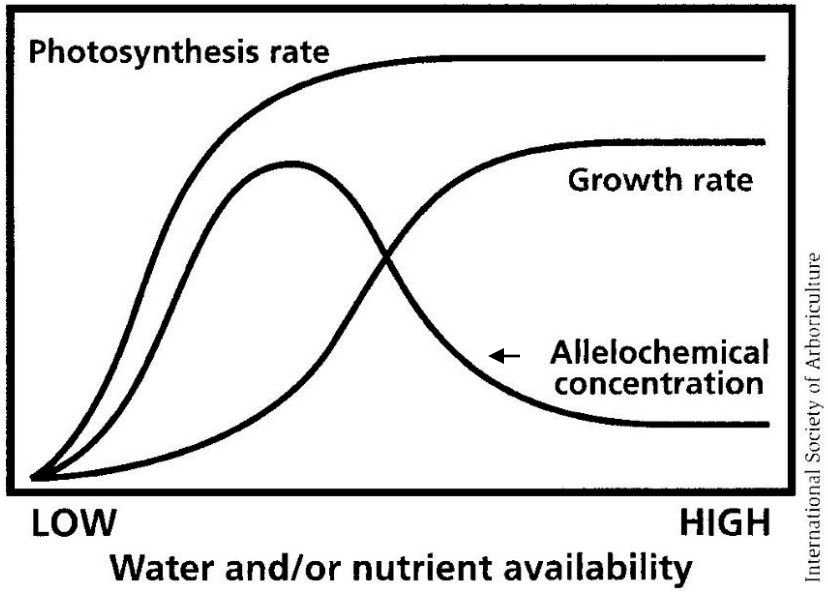
- adjust growth rate, and root/shoot ratio
- adopt the best strategy for the given conditions

Drought

Water deficit injury

Water & mineral shortages:

- growth: sensitive to shortages
- photosynthesis: less sensitive
- growth has priority when water/minerals are plentiful.



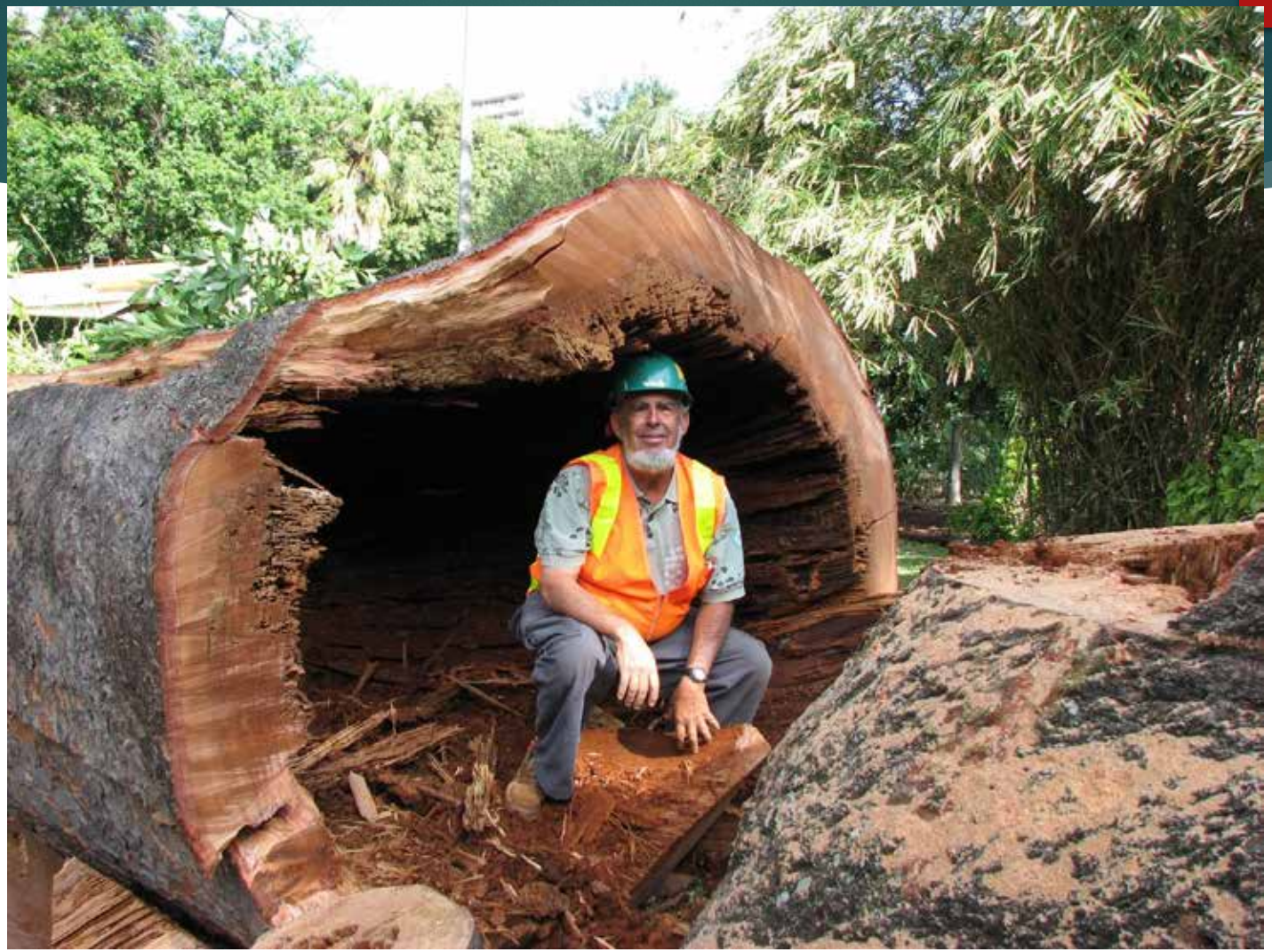
Severe stress:

- depletes energy reserves
- reduces growth
- slows wound closure
- secondary pests
- reduces resistance to decay
- causes dieback or mortality

Root : Shoot Ratio

Decline with age

- size and complexity >
- growth rate <
- leaf area static or <
- mass to energy ratio >
- respiratory demands >
- root tip to shoot tip >
- capacity to respond to change <
- pest resistance <



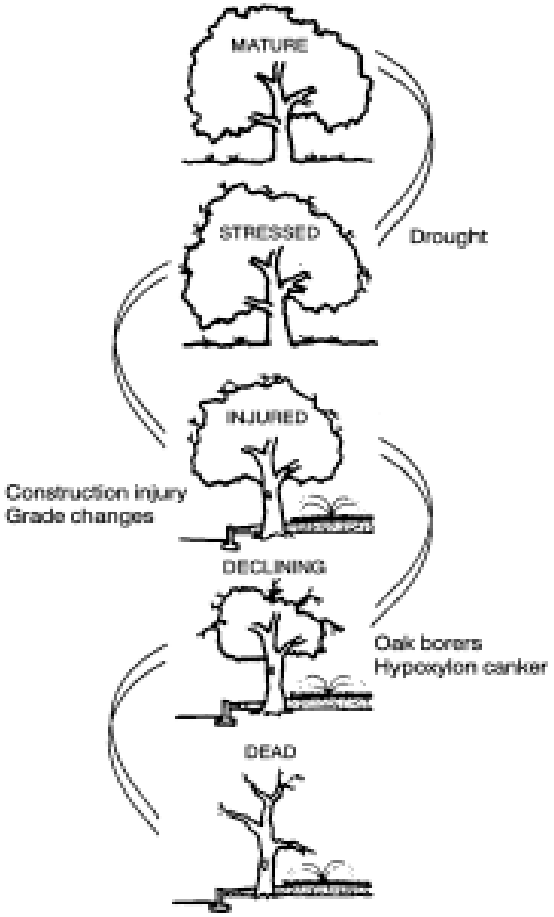
Steve Nims, New Zealand Kauri

Cultural practices should reflect age

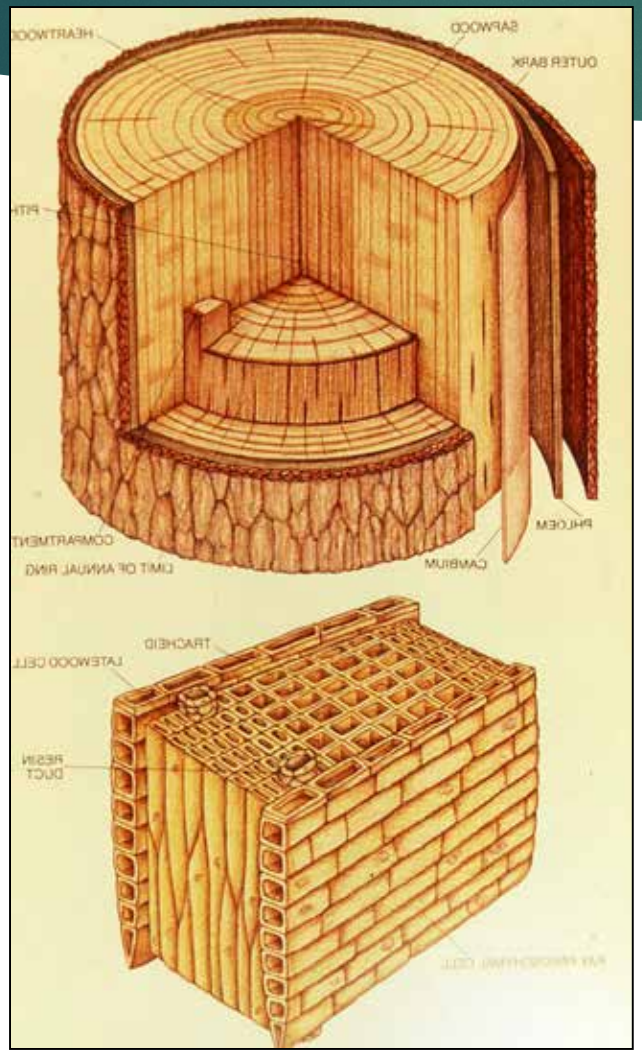
- maintain soil moisture/fertility according to species needs
- develop a stable structure
- avoid wounding
- avoid root zone disturbances
- maintain environmental stability
- mitigate stresses
- maximize leaf-surface area

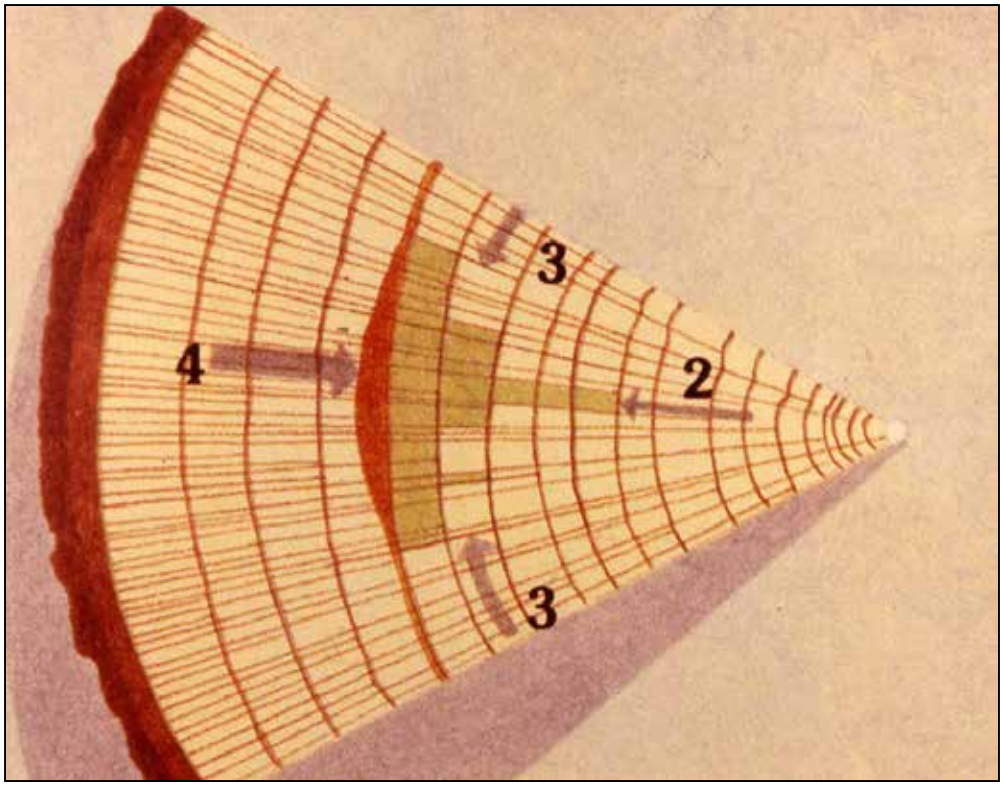
Why trees die:

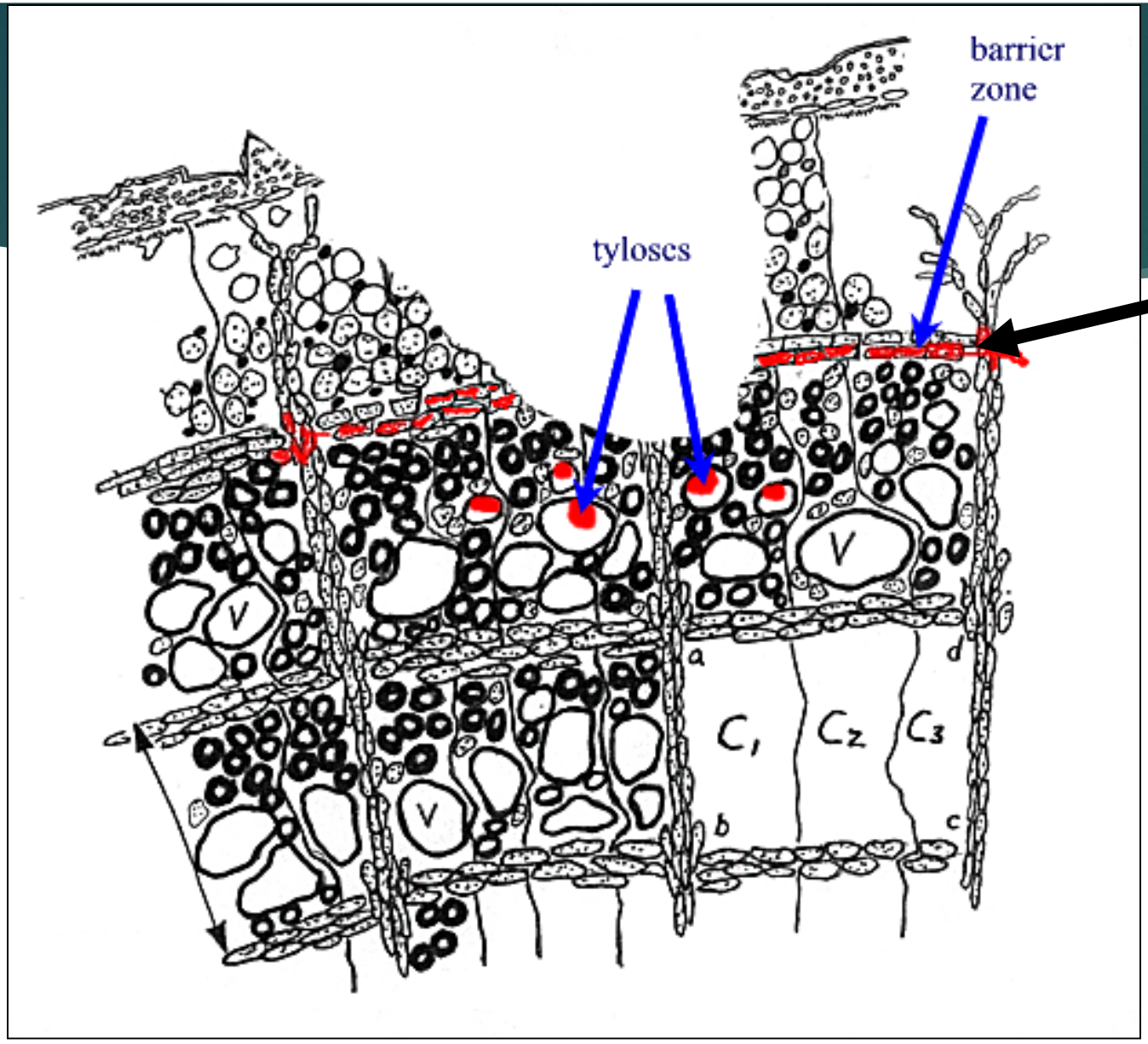
- usually multiple factors
- predisposing factors: climate, soil, shade
- inciting factors: drought, defoliation, soil compaction, etc.
- starvation
- secondary pest attack
- structural failure

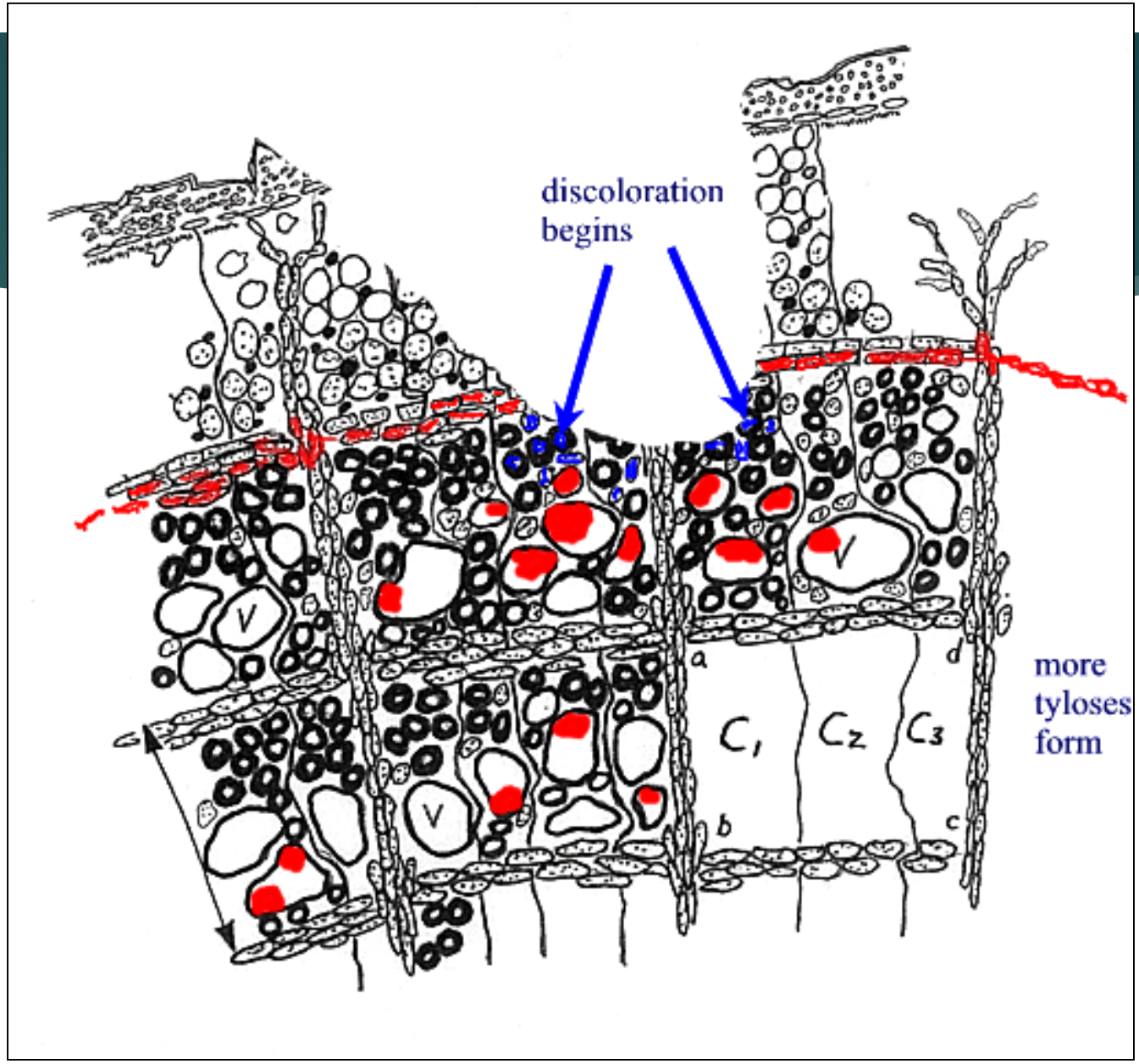


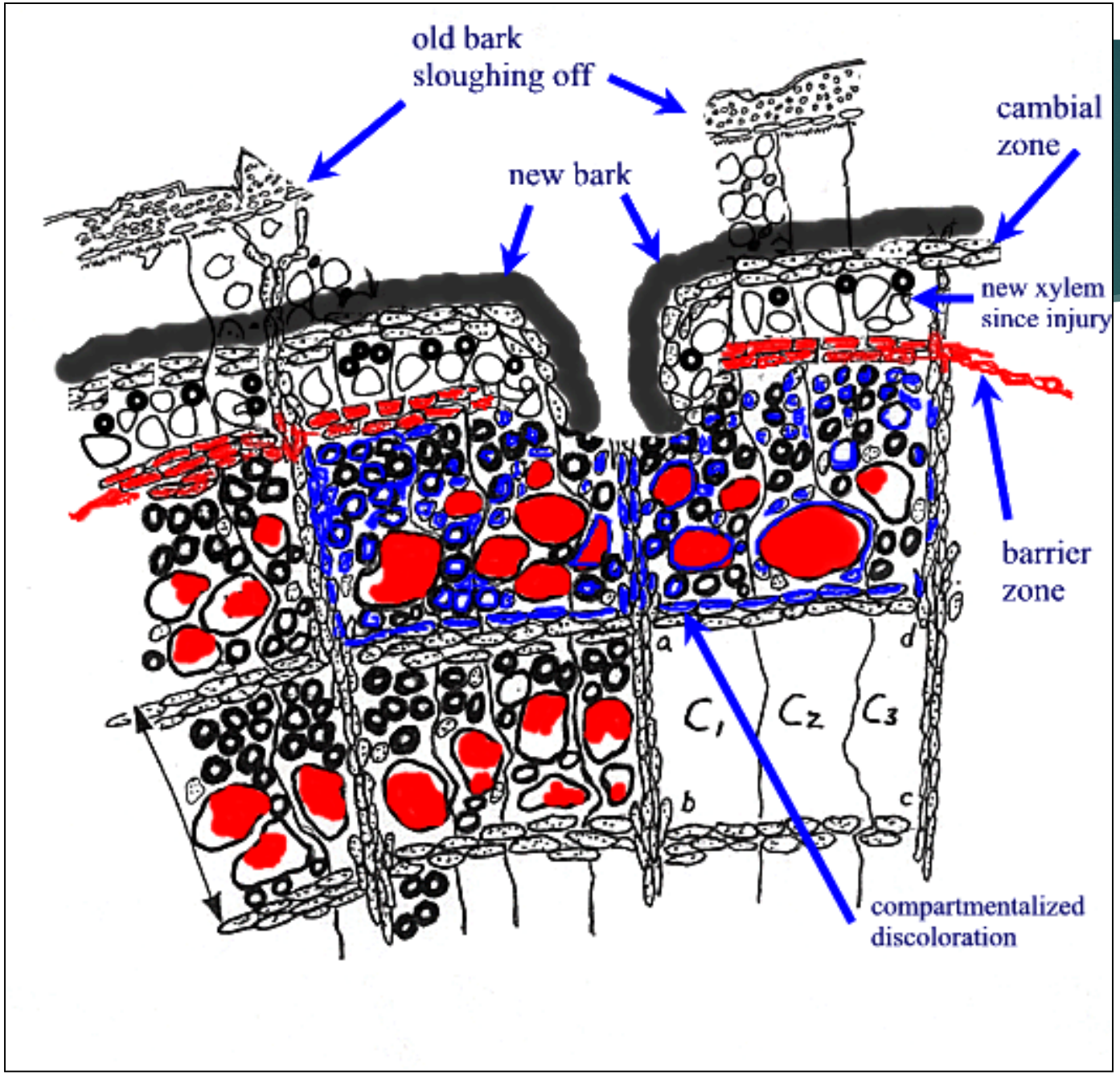
Wound response: Compartmentalization

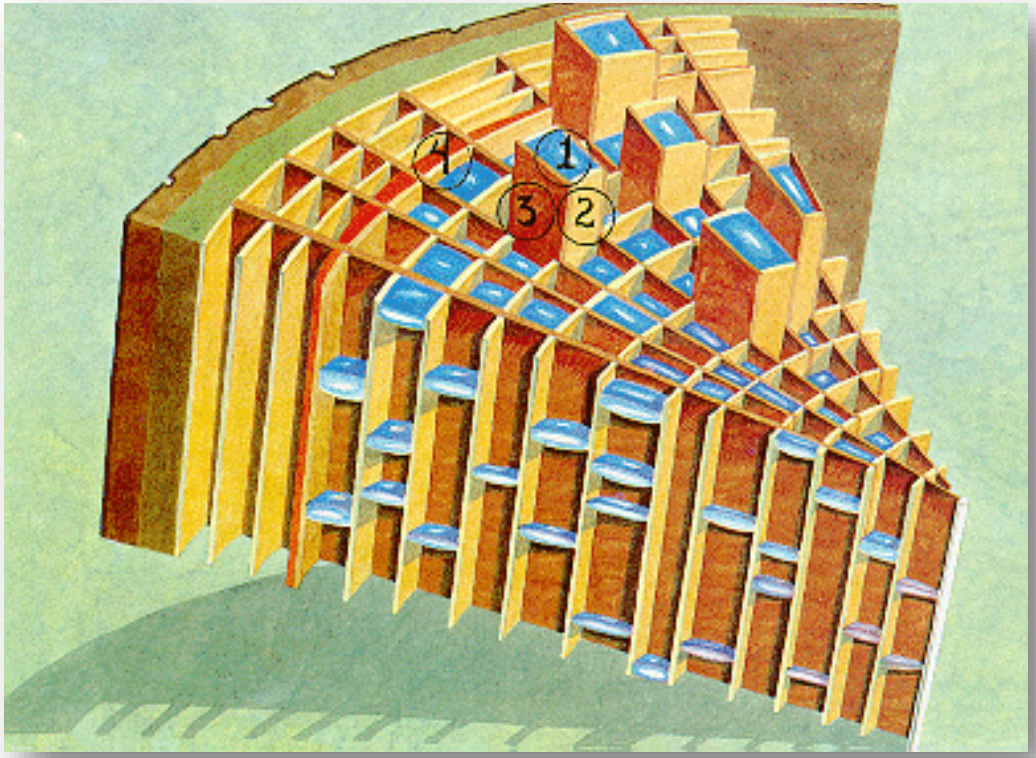


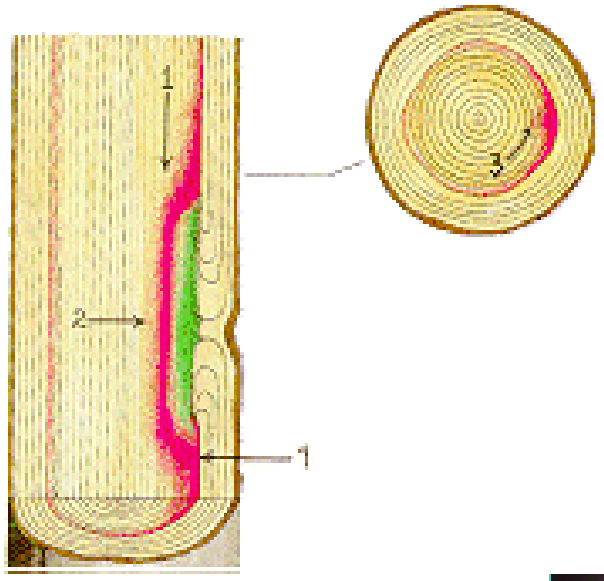


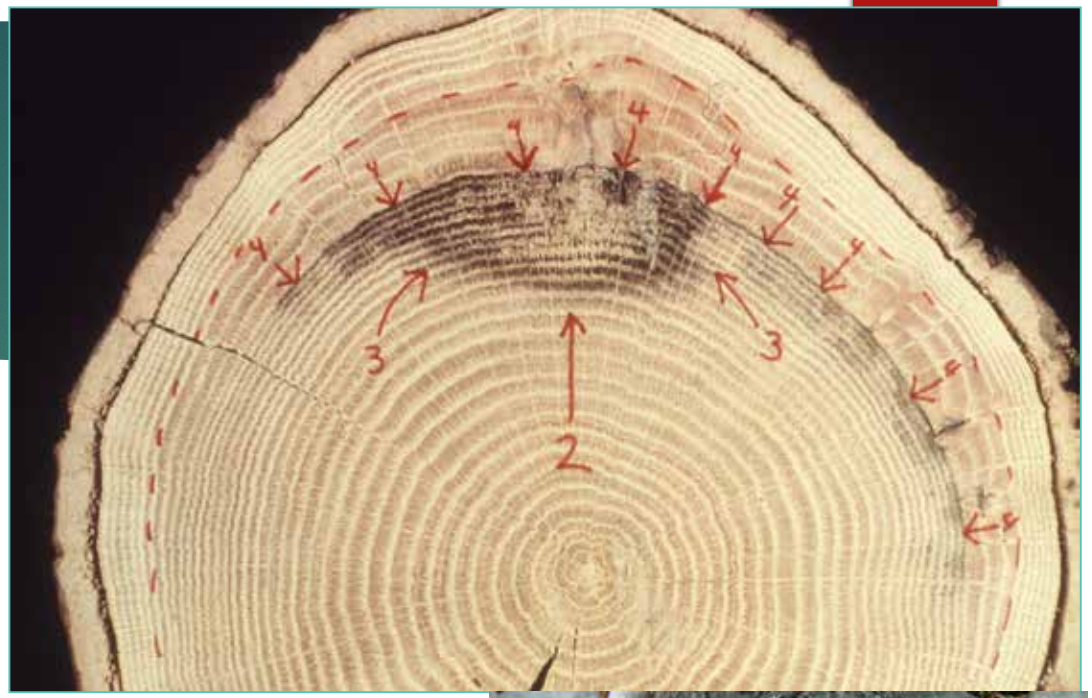

barrier
zone
tyloses
cambium
V
V
V
a
b
c
d
C1
C2
C3

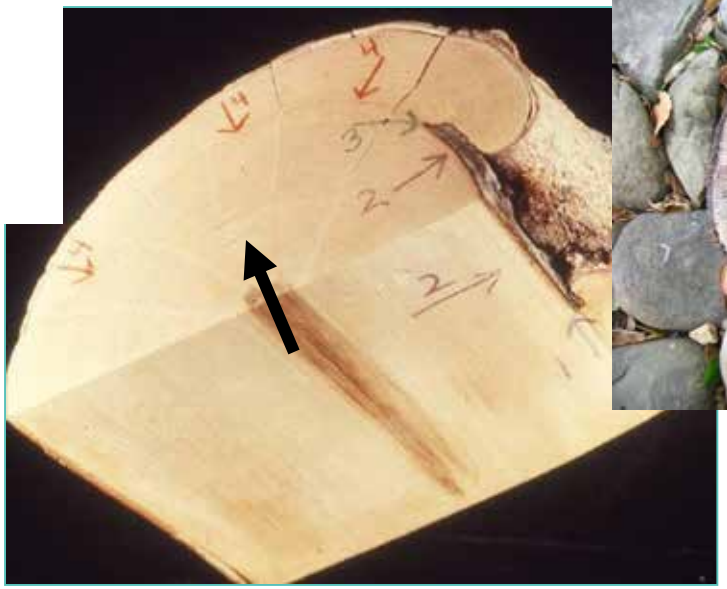

discoloration
begins
V
V
V
V
a
b
c
d
C1
C2
C3
more
tyloses
form


old bark
sloughing off
new bark
cambial
zone
new xylem
since injury
barrier
zone
a
d
C1
C2
C3
b
c
compartmentalized
discoloration

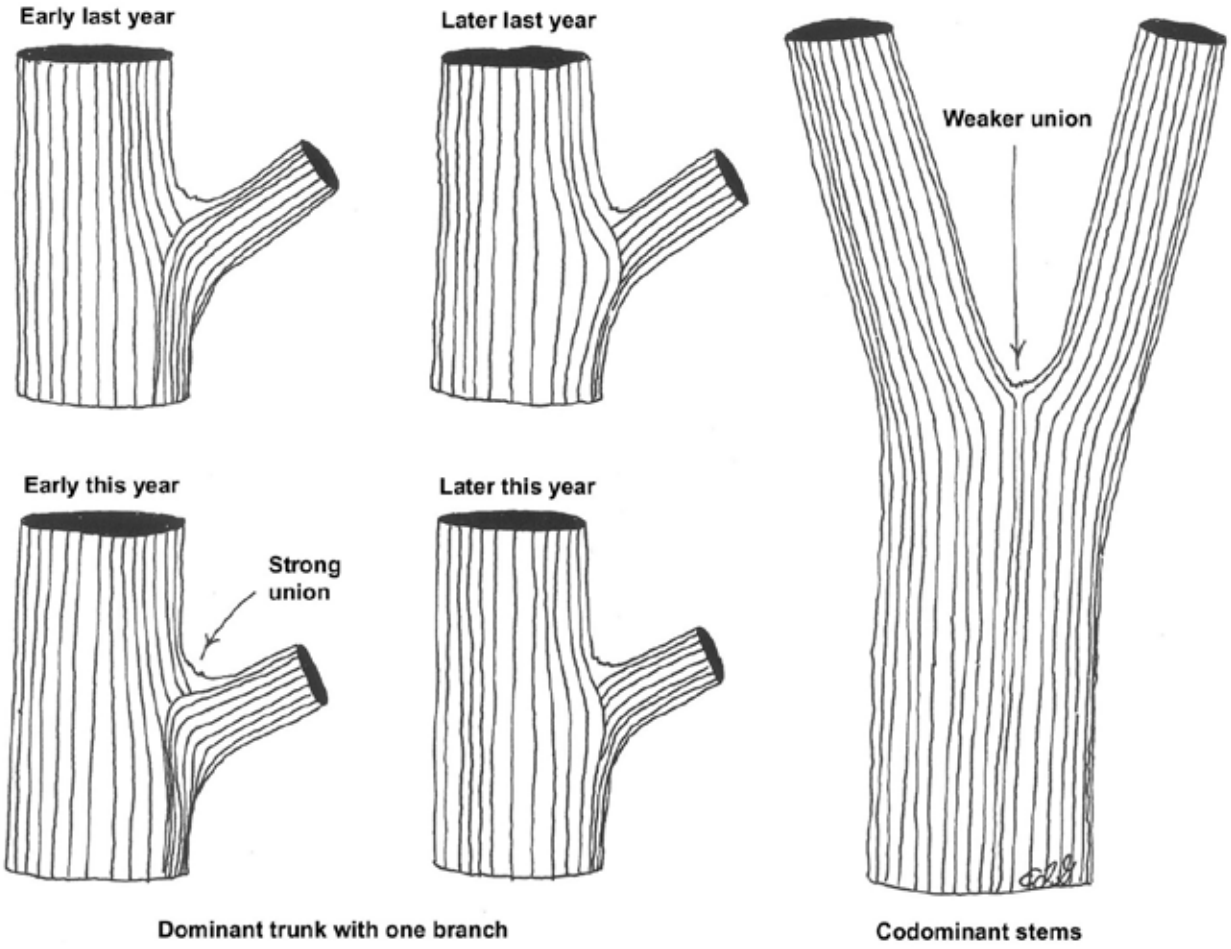

4
1
3
2

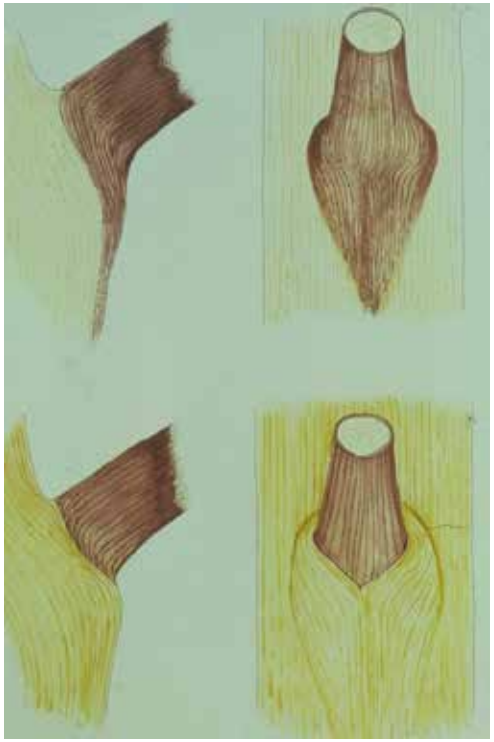

1
2
3
1

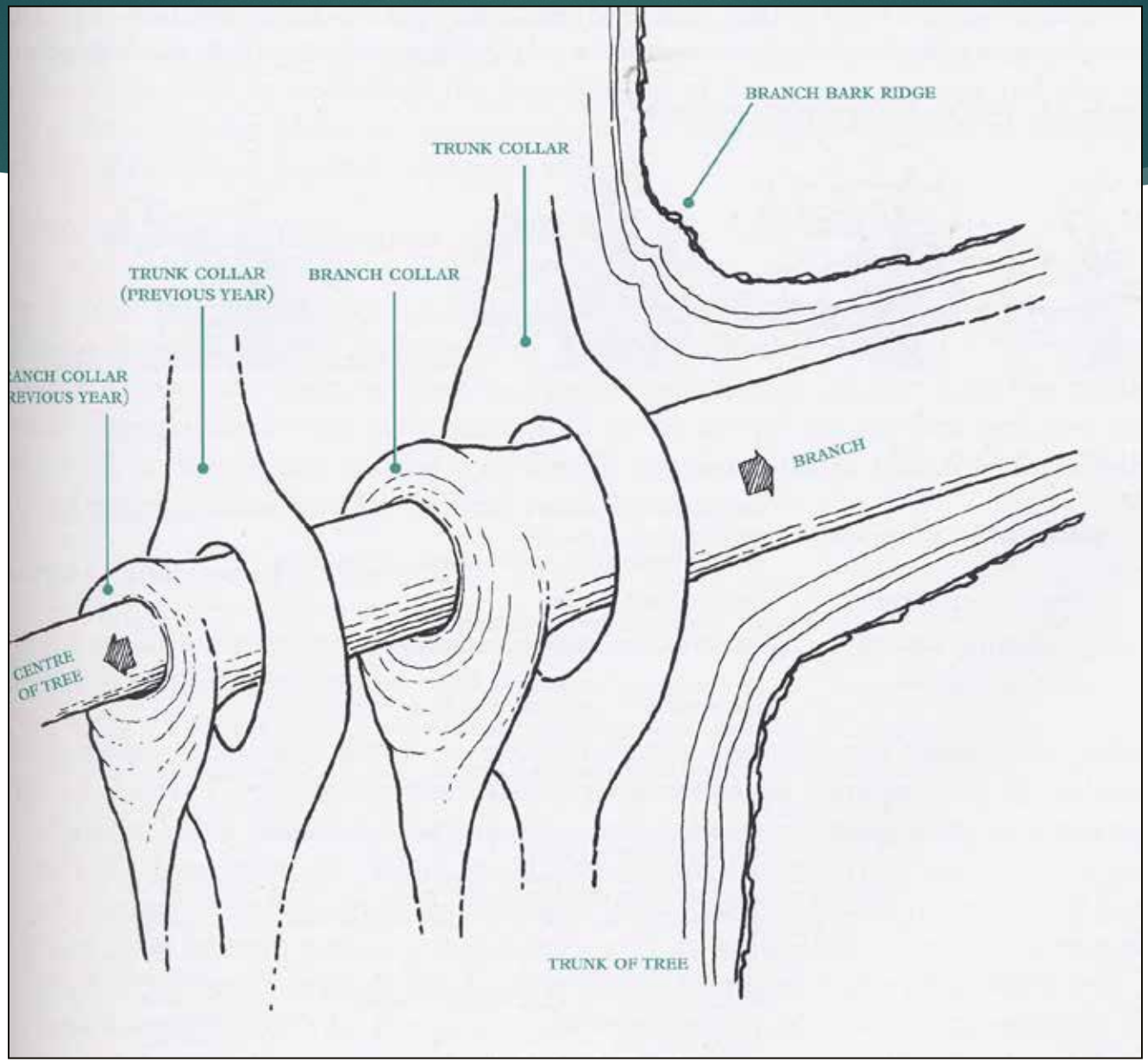

4
3
2
3


4
5
2
2

Branch attachment:


Early last year
Later last year
Weaker union
Early this year
Later this year
Strong union
Dominant trunk with one branch
Codominant stems




BRANCH BARK RIDGE
TRUNK COLLAR
TRUNK COLLAR
(PREVIOUS YEAR)
BRANCH COLLAR
ANCH COLLAR
REVIOUS YEAR)
BRANCH
CENTRE
OF TREE
TRUNK OF TREE

Branch collars