

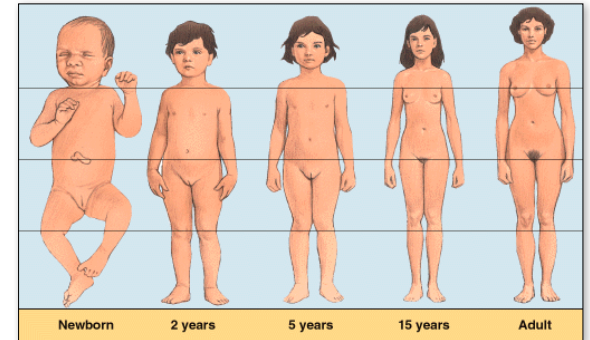
## Plant Growth



2006-2007

## Growth in Animals

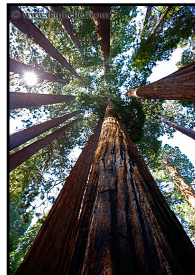
- Most animals grow throughout the whole organism
  - many regions & tissues grow at different rates
- Determinate Growth**
  - Go through distinct embryonic and juvenile periods before reaching adulthood



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## Growth in Plants

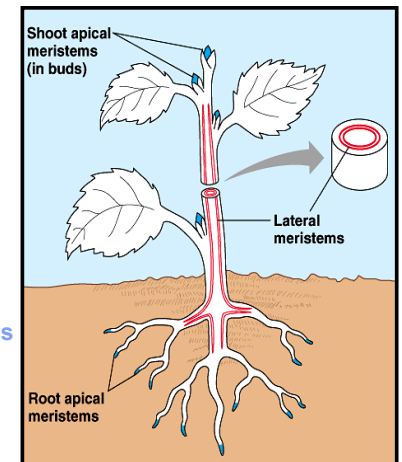
- Growth occurs throughout a plants life
- Indeterminate Growth**
  - At any moment, a plant consists of embryonic, developing, and mature organs
    - Only some plant organs experience **determinate growth** and stop growing when reaching a certain size:
      - Ex: Leaves, thorns, flowers
- Annuals**
  - Complete life cycle (seed to death) in 1 year or less
    - EX: Rice
- Biennials**
  - Life cycle takes two growing seasons (flower and fruit only in second year)
    - EX: Carrots
- Perennials**
  - Live many years
    - EX: Trees, shrubs, some grasses



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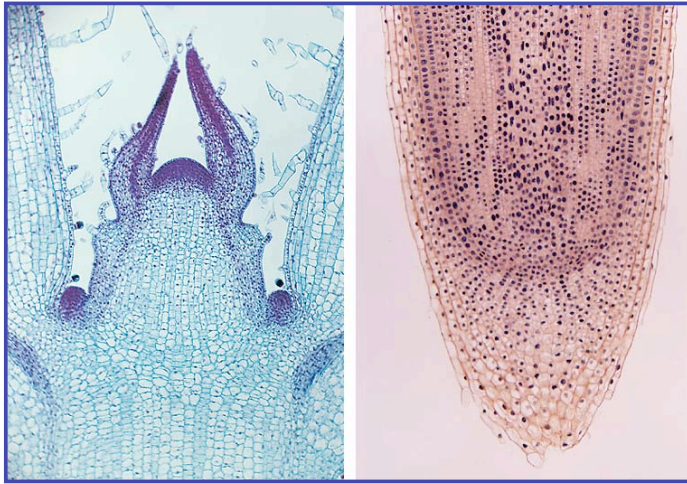
## Growth in Plants

- Specific regions of growth: **meristems**
  - Contain stem cells:**
    - perpetually embryonic tissue that regenerates new cells
  - Primary growth**
    - = allows plant to grow in length
      - apical shoot meristem**
        - Tips of shoots and axillary buds of shoots
      - apical root meristem**
        - Tips of roots
  - Secondary growth**
    - = allows plant to grow in thickness
      - Wood Plants
        - lateral meristem**
          - includes **vascular cambium** and **cork cambium**



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## Apical meristems



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shoot

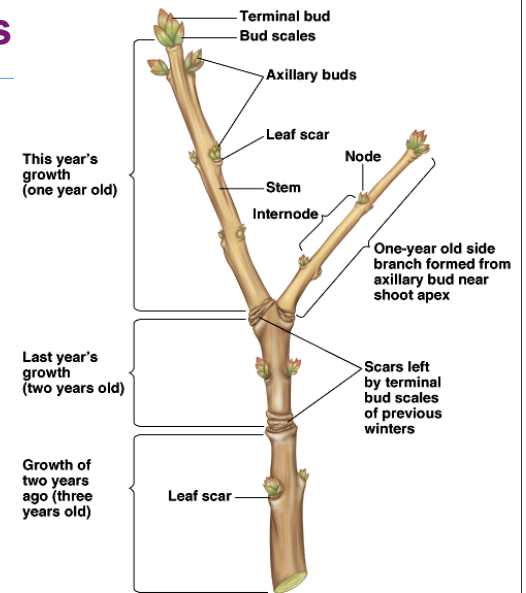
root

## Growth marks

### ■ Scales of bud protect apical meristem

- ◆ In spring, scales are shed and new growth commences at the terminal bud
  - Scar is left behind
- ◆ Leaf scars remain where leaves fell off
  - Axillary buds may grow into branches or lateral shoots above leaf scars

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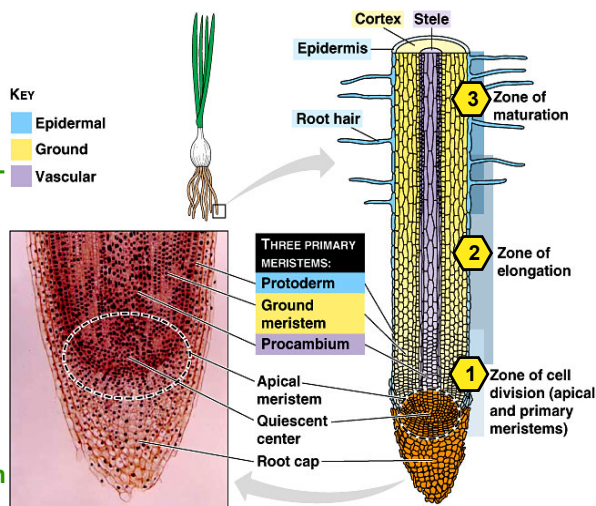


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## Primary meristems & grows of roots

In woody plants, primary growth happens in the youngest parts of the plant that are not yet woody

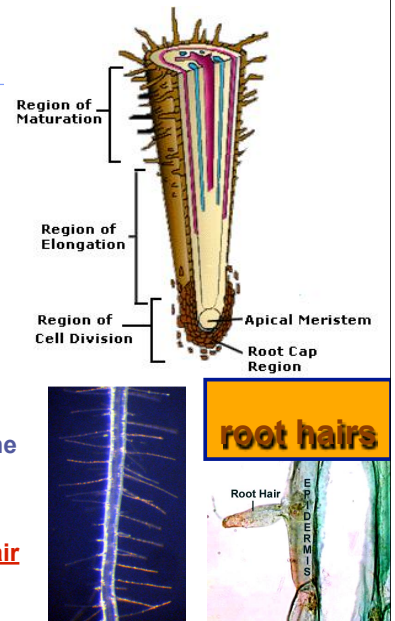
- ◆ Tip of root is covered by thimble-like root cap
  - Protects the delicate apical meristem as the root pushes through abrasive soil
  - Secretes polysaccharide slime to lubricate the root tip
- ◆ Primary Growth occurs behind tip in three zones



## Growth in Plants

- Mitosis concentrated in zone of cell division
- Lengthening of root occurs in zone of elongation
- Cells become functionally mature in the zone of differentiation
- Primary growth of root produces epidermis, ground tissue, and vascular tissue.
- Water and minerals enter through the root's epidermis.
  - ◆ Roots have epidermal cell extensions that help increase absorptive surface area = Root Hair

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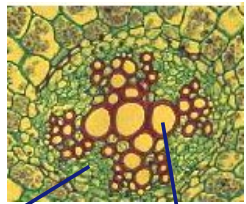




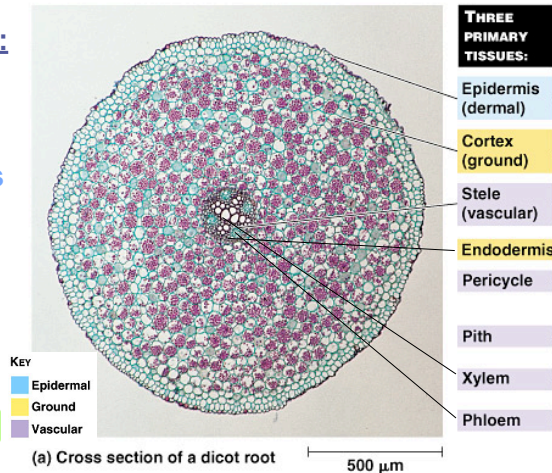
## Vascular tissue in roots: eudicots and gymnosperms

- **Root stele** consists of xylem and phloem in the center

- **Vascular Stele:**  
Lobed core of xylem with phloem in between lobes

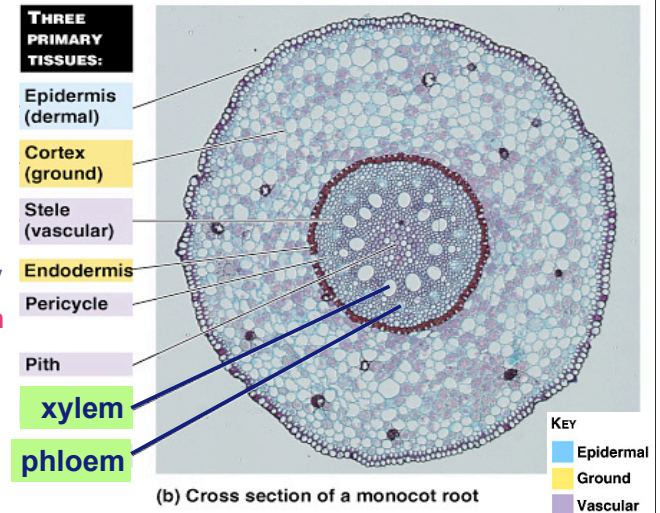


phloem xylem  
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## Vascular tissue in roots: monocots

- **Root stele**  
with parenchyma cell in the center (*pith*) surrounded by a ring of xylem and a ring of phloem

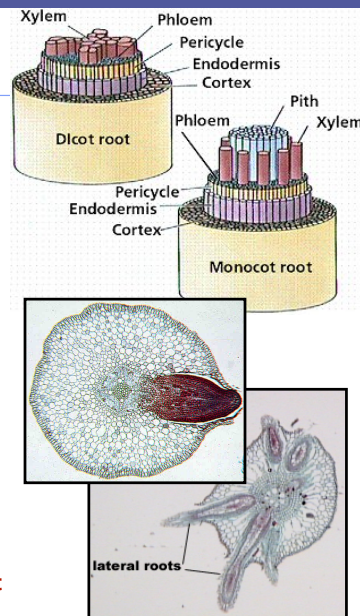


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## Uptake Selectivity and Lateral Roots

- **Endodermis**
  - Cylinder of one cell thick that forms the boundary with the vascular cylinder (containing xylem and phloem)
  - Functions as a **selective barrier**
    - Regulates passage of substances from the soil into the vascular cylinder
- **Pericycle**
  - The outermost cell layer in the vascular cylinder (just inside endodermis)
  - Place where lateral roots originate from
    - Allows vascular system to be continuous with new lateral root

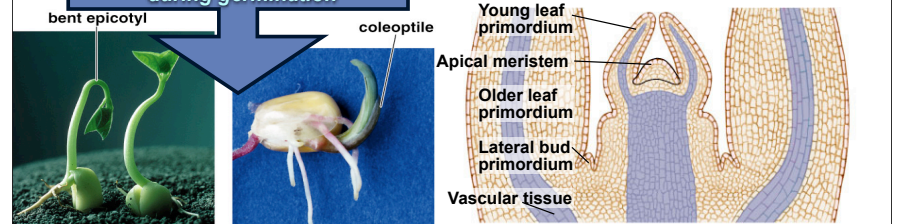
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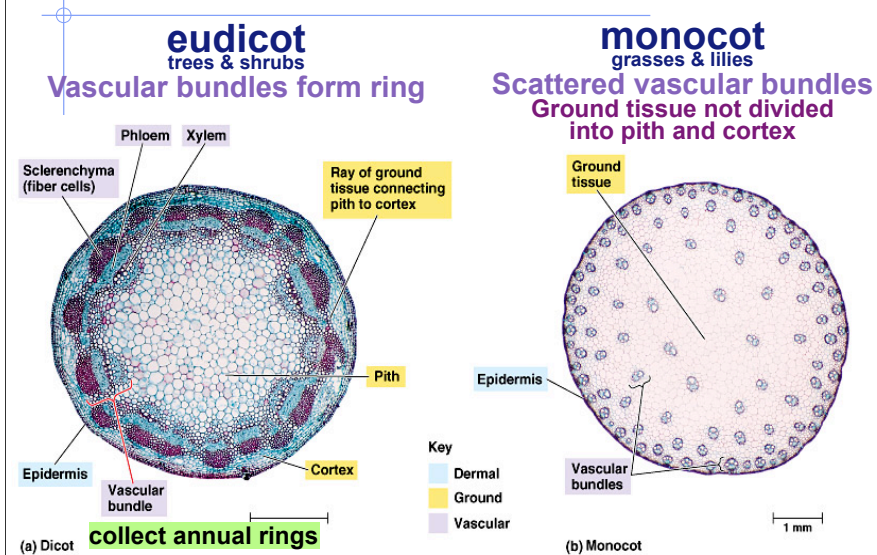
## Shoot growth

- **Apical bud** causes the primary growth of shoot - shoot lengthening
  - ♦ region of stem cells that lead to stem growth
- **Axillary buds**
  - ♦ dormant stem cell tissue - "waiting in the wings"
- First leaves develop from **leaf primordia**

*Epicotyles & Coleoptiles protect the meristems when seedlings push through the soil during germination*

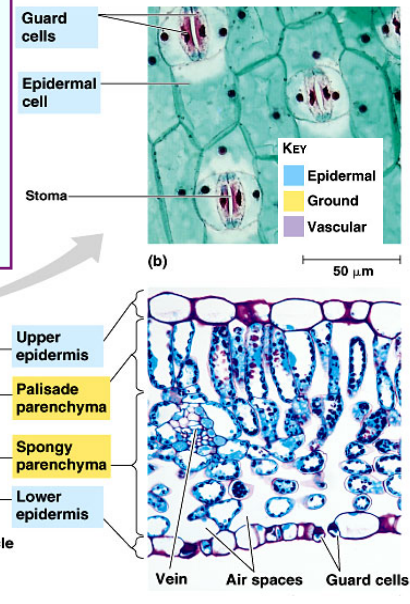


## Vascular tissue in stems



## LEAF TISSUE ORGANIZATION

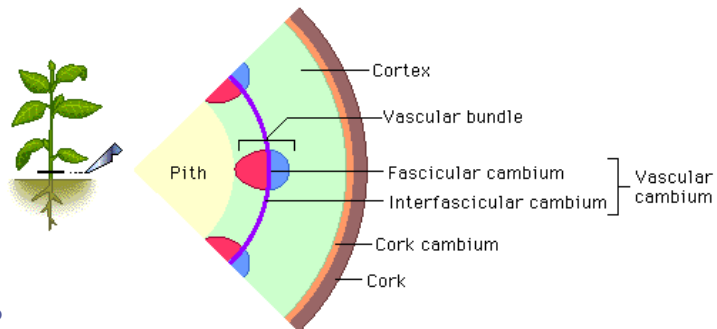
- **Epidermis** covers leaf as part of **dermal tissue**
- **Ground tissue** of a leaf is called **mesophyll** ("meso" for "middle" & "phyll" for "leaf")
- Mesophyll consists of mainly **parenchyma cells** specialized for photosynthesis.
- **Form fits Function:** Spongy mesophyll cells are loosely arranged to allow air spaces where  $\text{CO}_2$  and  $\text{O}_2$  can circulate.



## Secondary Growth

### Growth in thickness by lateral meristems

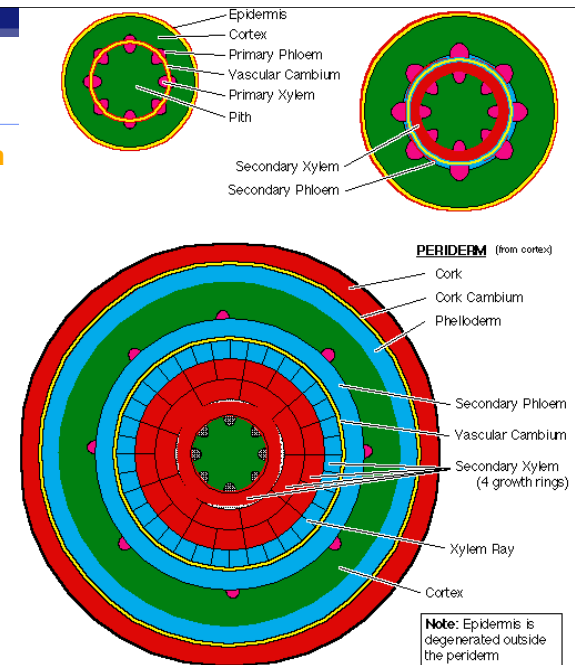
- ♦ In stems and roots of woody plants but rarely in leaves or monocots
  - The **secondary plant body** is composed of tissue produced by vascular cambium and cork cambium
- ♦ Lateral meristems include **cork cambium** and **vascular cambium**



## Secondary Growth

### Vascular Cambium = one cell thick cylinder of meristematic cells

- ♦ Adds **secondary xylem (wood)** to its interior and **secondary phloem** to its exterior
- Increases **vascular flow** and support for the shoot system
- Secondary xylem is heavily **lignified** for strength



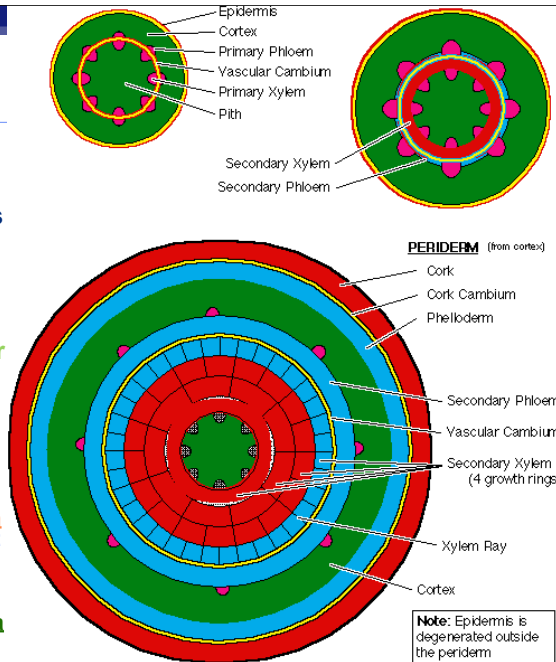


## Secondary Growth

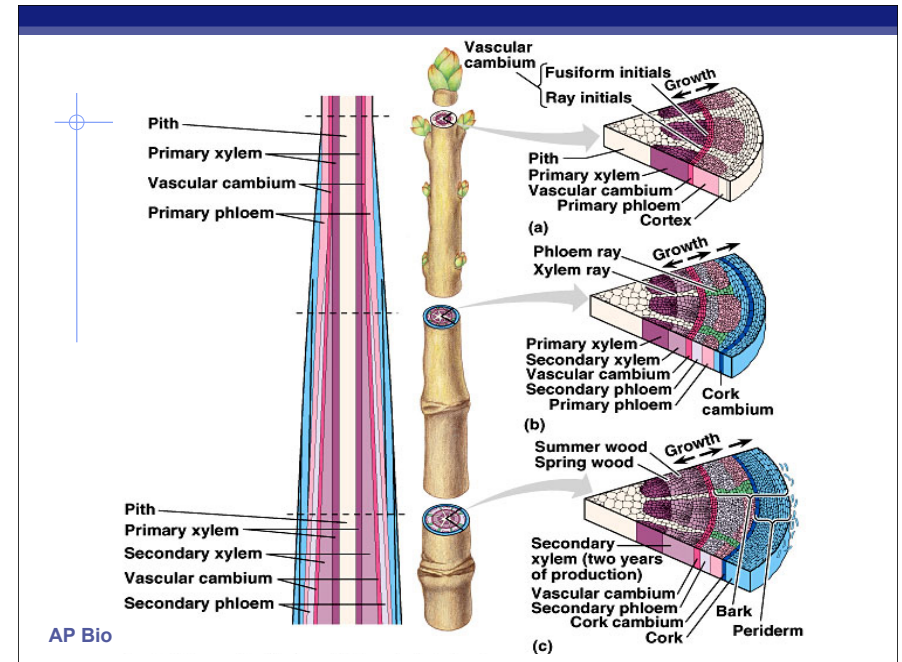
- **Cork Cambium** = cylinder of dividing cells that arises in the outer cortex of stems and outer pericycle in roots

- ◆ Replaces the epidermis with the thicker, tougher **periderm**

- Produces **cork cells** to the exterior of the cork cambium
- Deposits waxy material **suberin** in cell walls that **protect stems from water loss & invasion by insects, bacteria and fungi**



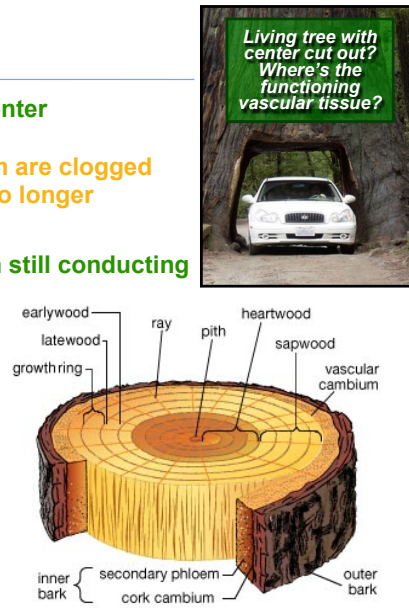
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## Types of Wood

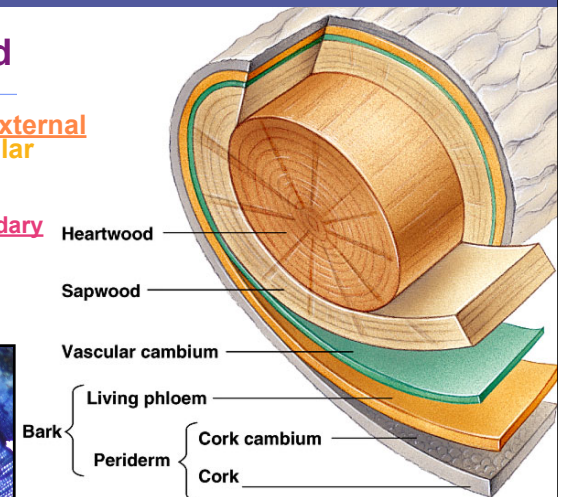
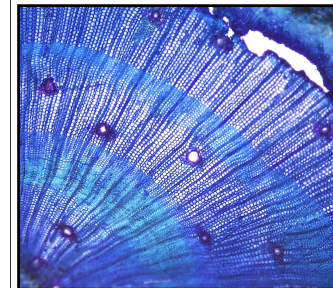
- **heartwood**: dead inner xylem center of the woody stem
  - conducting elements of xylem are clogged with **tannins and resin**, and no longer function to conduct fluids.
- **sapwood**: external ring of xylem still conducting fluid **xylem sap**
- **Vascular Cambium goes dormant in winter**
  - **springwood**
    - large-lumen (interior) xylem cells formed in spring
  - **summerwood**
    - small-lumen xylem cells formed in summer/late autumn, just prior to dormancy



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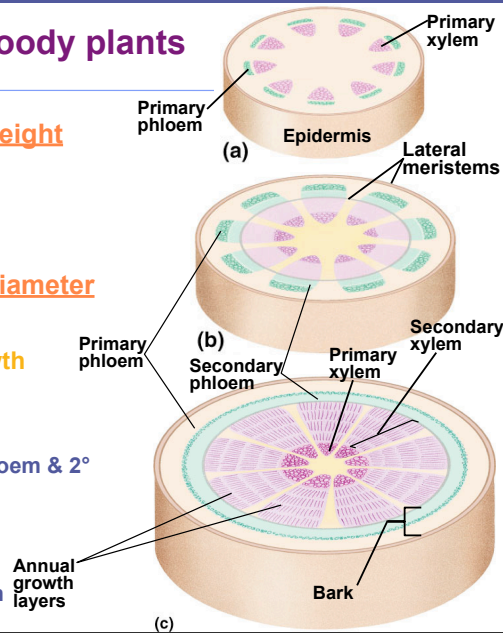
## Types of Wood

- **Bark** = All tissues external to the vascular cambium
- Each new **growth ring** consists of the **secondary xylem** deposited that growing season
  - Rings consist of **Early & Late Wood**



## Review: Growth in woody plants

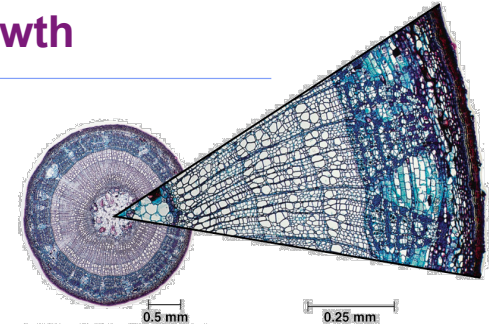
- Woody plants grow in **height** from tip
  - Called **primary growth**
    - apical meristem**
- Woody plants grow in **diameter** from sides
  - Called **secondary growth**
    - lateral meristems**
      - vascular cambium**
        - makes 2° phloem & 2° xylem
      - cork cambium**
        - makes cork & phelloderm



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## Secondary growth

- Secondary growth
  - growth in diameter
    - thickens & strengthens older part of tree
  - cork cambium** makes the **periderm**
    - growing ring around tree
  - vascular cambium** makes **secondary xylem & phloem**
    - growing ring around tree



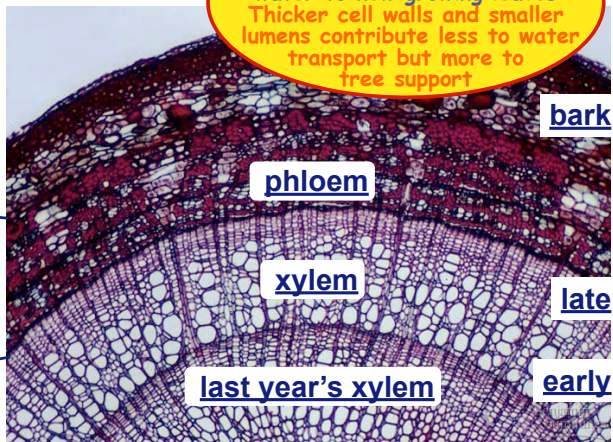
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## Vascular cambium

- Phloem** produced to the **outside**
- Xylem** produced to the **inside**

Why are early & late growth different?

Large lumen and thin walls of spring time cells transports more water to new growing leaves  
Thicker cell walls and smaller lumens contribute less to water transport but more to tree support



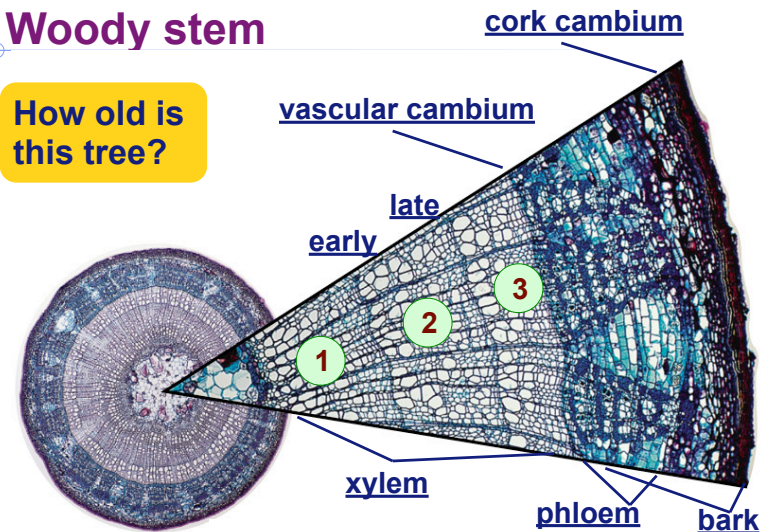
cork cambium

vascular cambium

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## Woody stem

How old is this tree?



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# Tree trunk anatomy

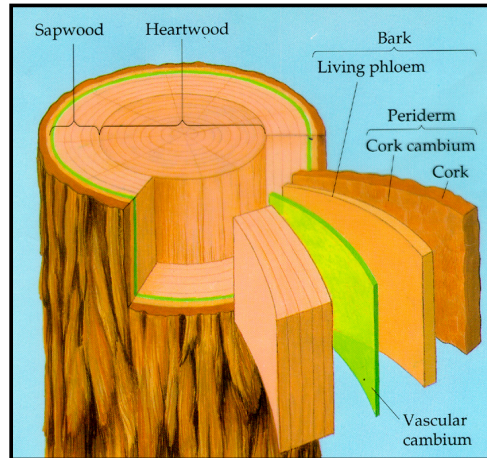
Aaaargh!  
Murderer!  
Arborcide!



## Tree girdling or ring barking:

- Completely removing a strip of bark around a tree's outer circumference
  - Removes Secondary Phloem tissue, cork cambium, and cork

What does girdling do to a tree?



Nothing but  
love, respect &  
appreciation!!!

