How Plants Grow

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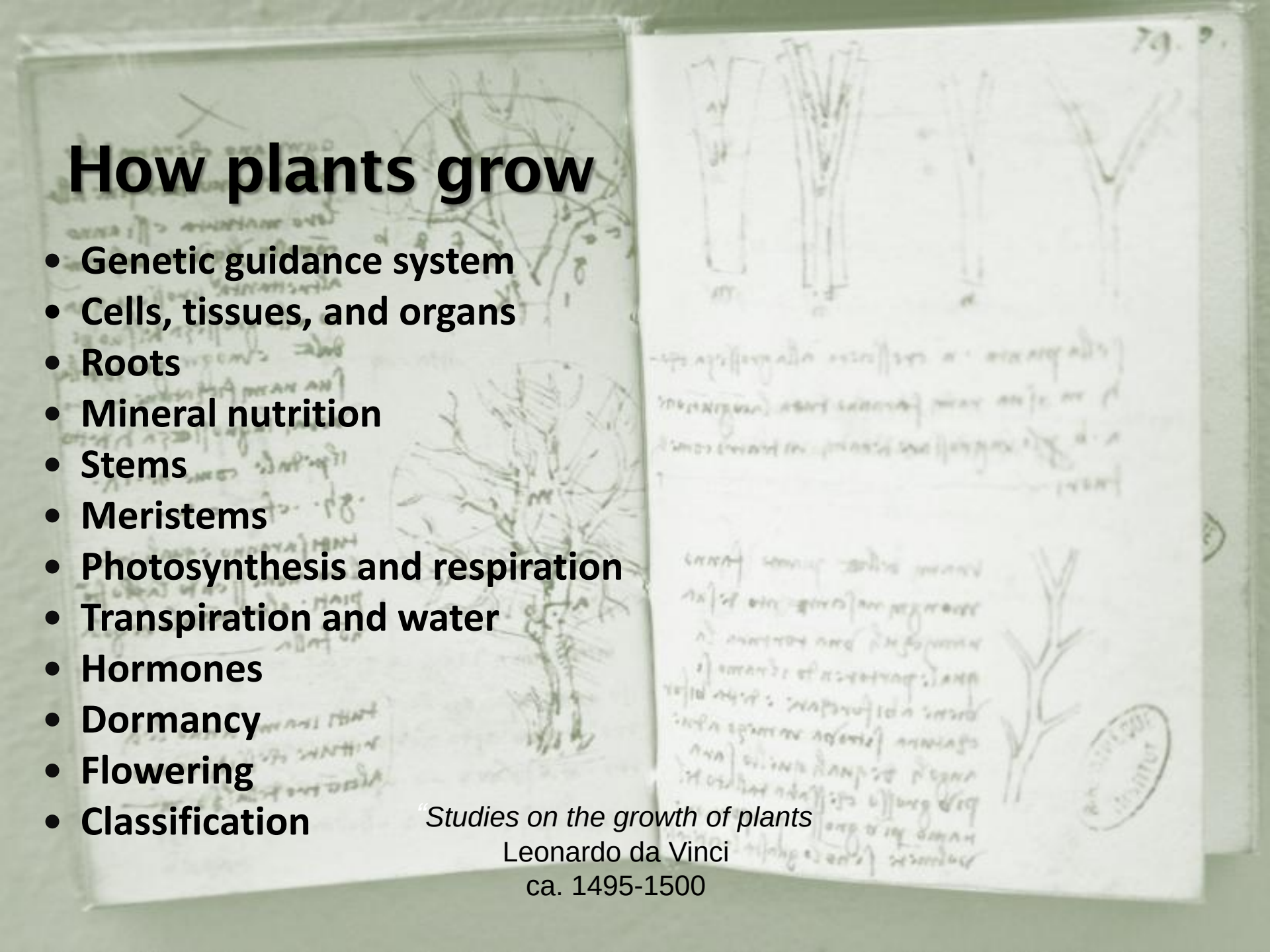
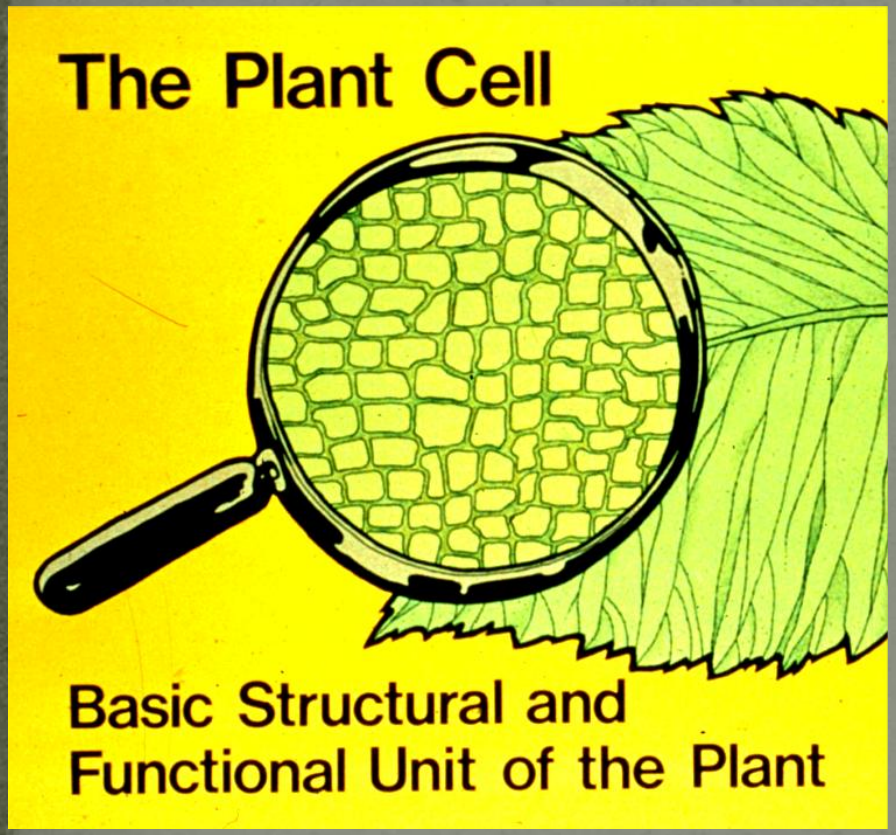
How plants grow

- Genetic guidance system
- Cells, tissues, and organs
- Roots
- Mineral nutrition
- Stems
- Meristems
- Photosynthesis and respiration
- Transpiration and water
- Hormones
- Dormancy
- Flowering
- Classification

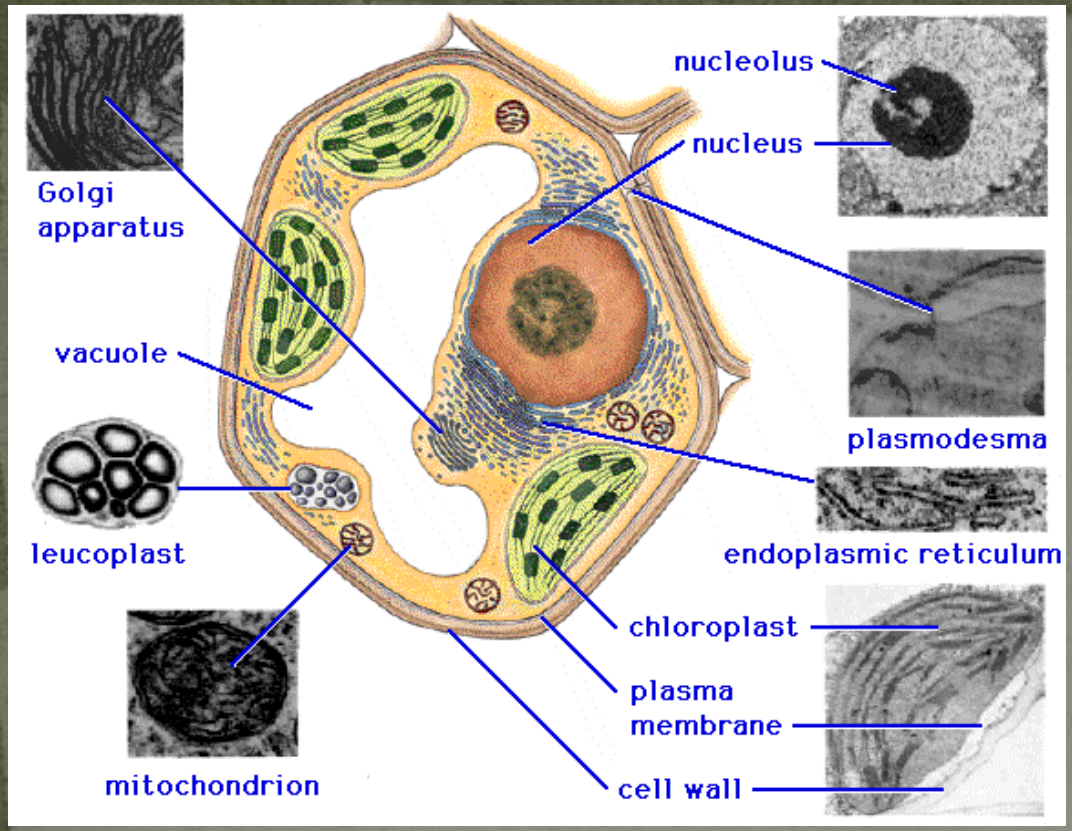


Studies on the growth of plants
Leonardo da Vinci
ca. 1495-1500

Cell Functions

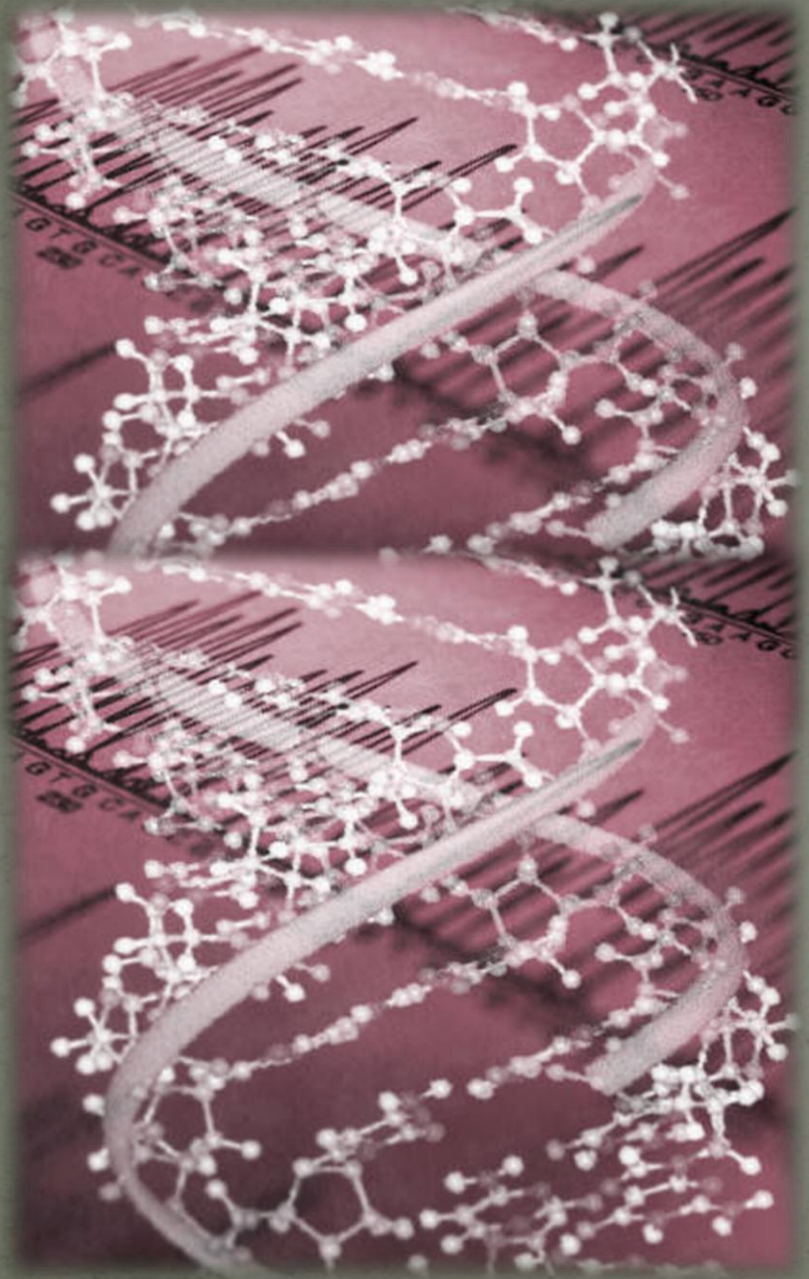


- Absorbs and secretes metabolites
- Light energy to chemical energy
- Respires and releases energy
- Processes and transforms foods
- Synthesizes complex chemicals and amino acids



Cell Contents

Cell wall: gives some support to the cell.
Water: 70-95% of plant by weight
Plasma membrane: the skin of the cell, water, substances transported
Vacuoles: store substances: salts, wastes, and sugars
Chloroplasts: capturing and storing light energy
Mitochondrion: energy production
Endoplasmic reticulum: protein production
Golgi apparatus: processes proteins
Nucleus: contains DNA



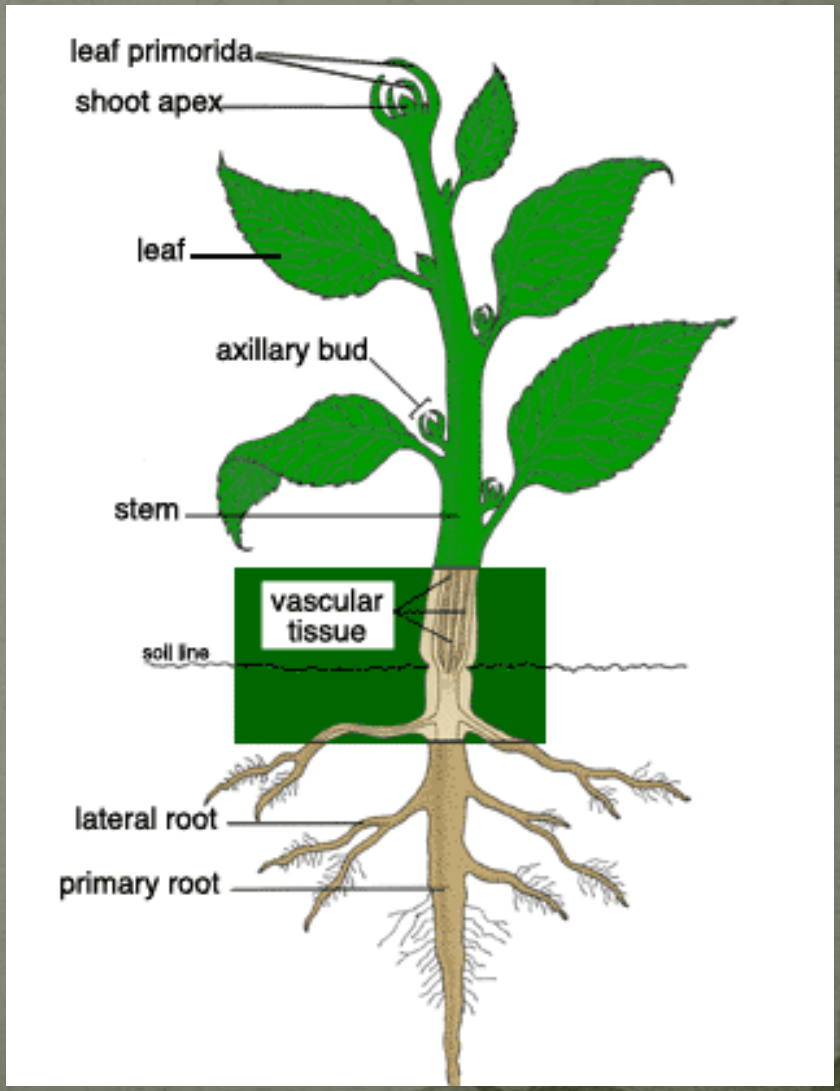
DNA

- Deoxyribonucleic acid
- Genetic code information that controls the physiological functions of cells and ultimately the makeup of the entire plant.

Plant tissues:

Plant tissues are organized cells that have similar function

Vascular tissue composed of xylem and phloem tissue. This tissue functions to conduct water and sugars throughout plant.



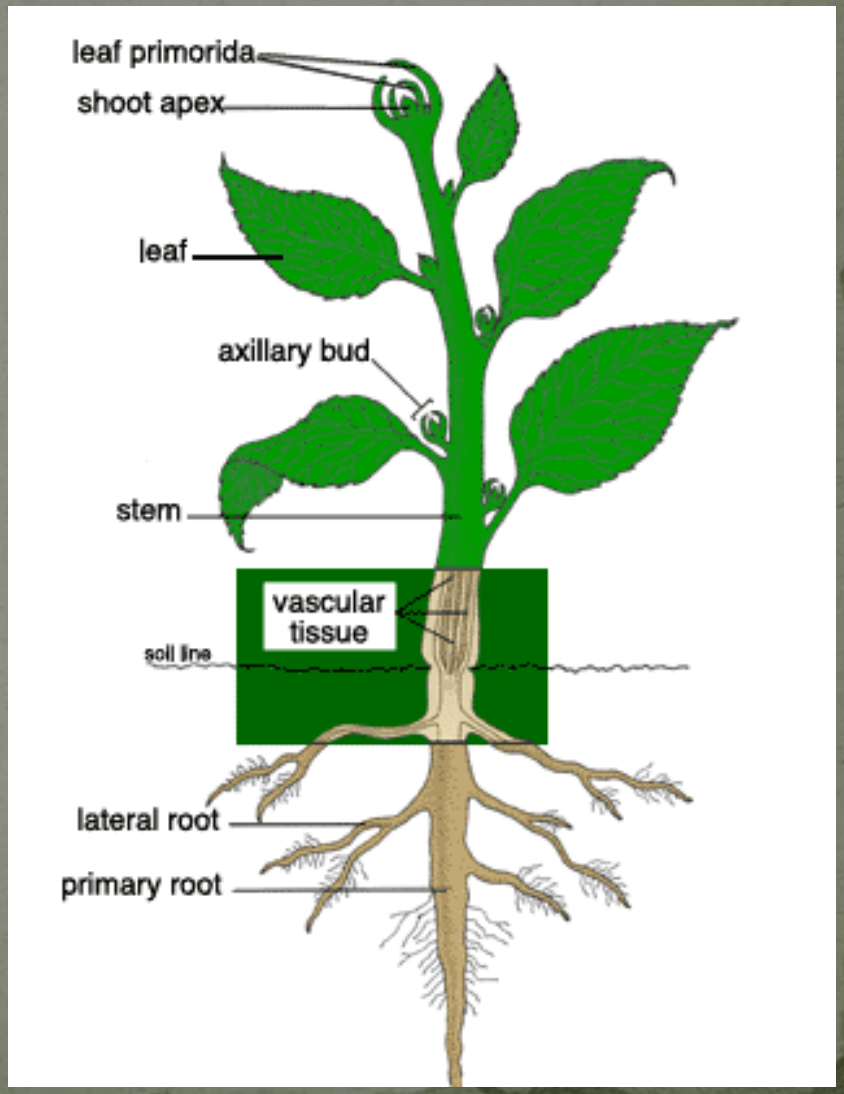
Plant organs: roots, stems, buds, leaves, flowers, fruits and seeds

An organ is an organized group of cells tissues that work together to perform a specific function.

Sexual reproductive parts produce seed; they include flower buds, flowers, fruit, and seeds.|

Vegetative parts include roots, stems, shoot buds, and leaves.

- Not directly involved in sexual reproduction.
- Vegetative parts often are used in asexual forms of reproduction such as cuttings, budding, or grafting.



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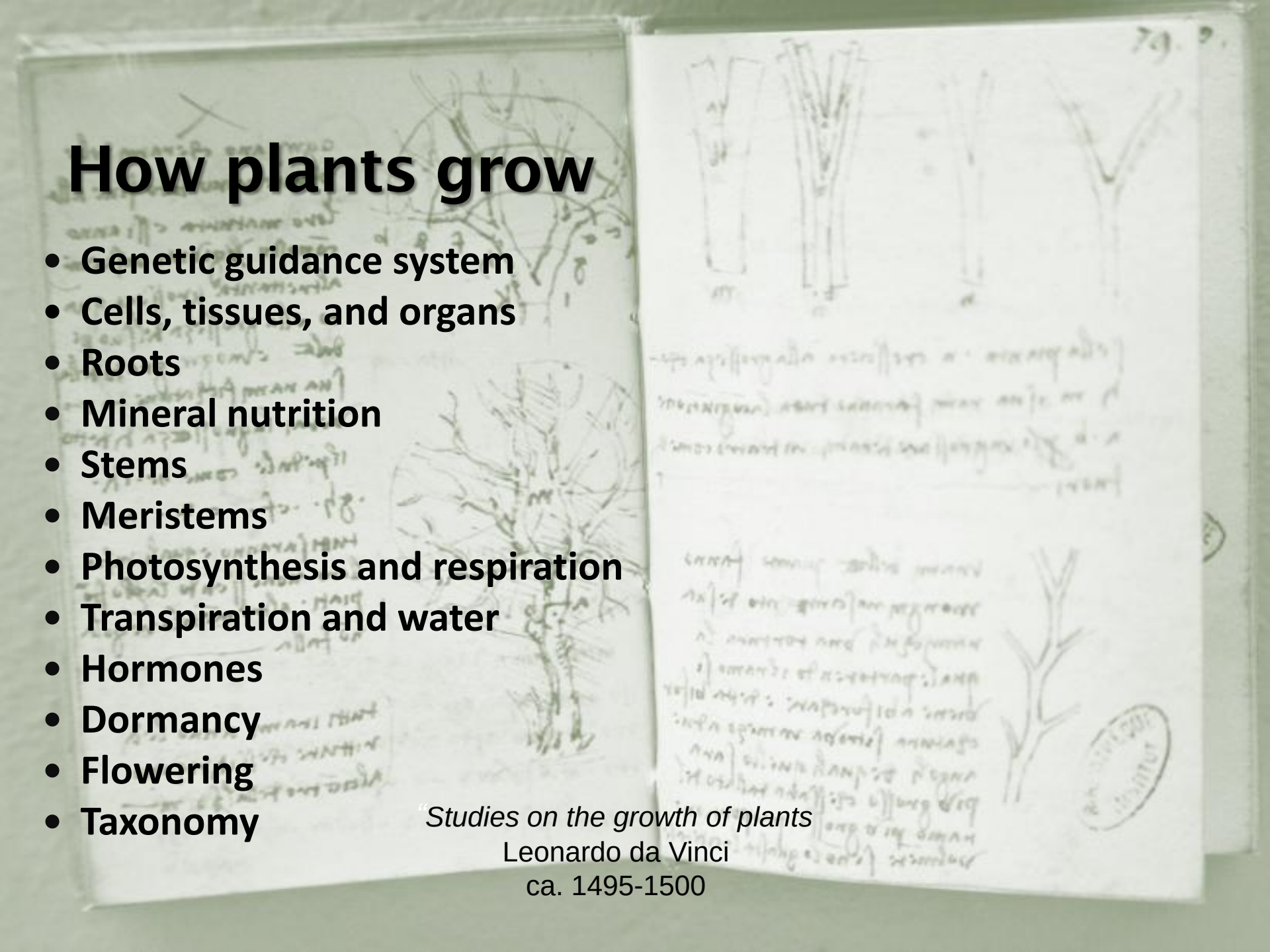
- Taxonomy



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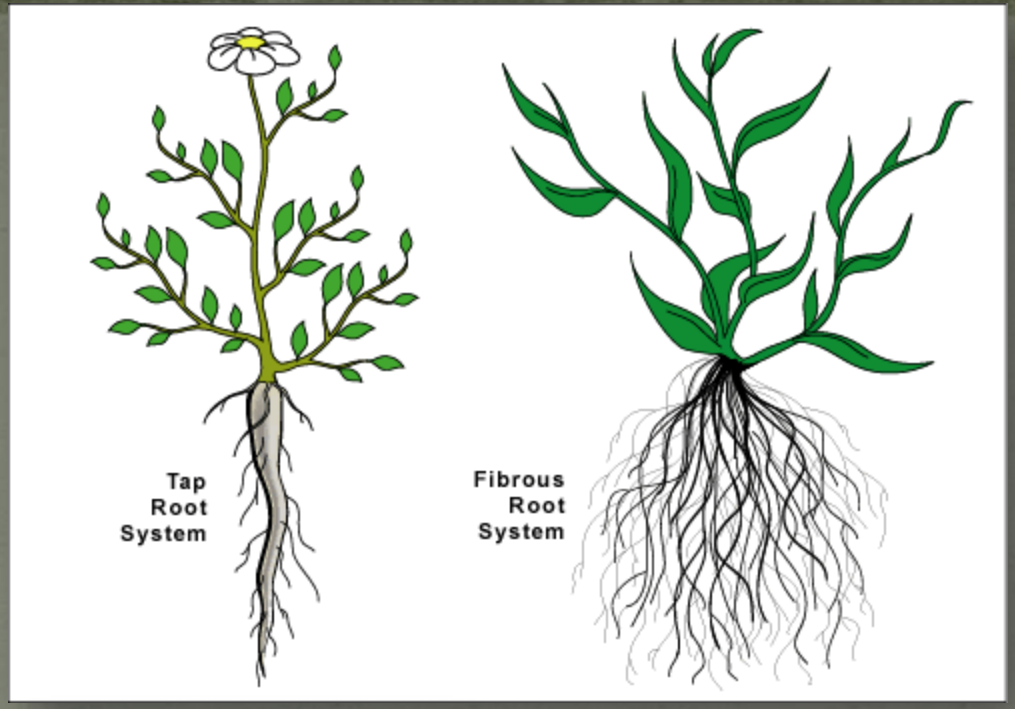
Root System Structure



Root growth is a function of genetic makeup and adaptations to particular environmental factors

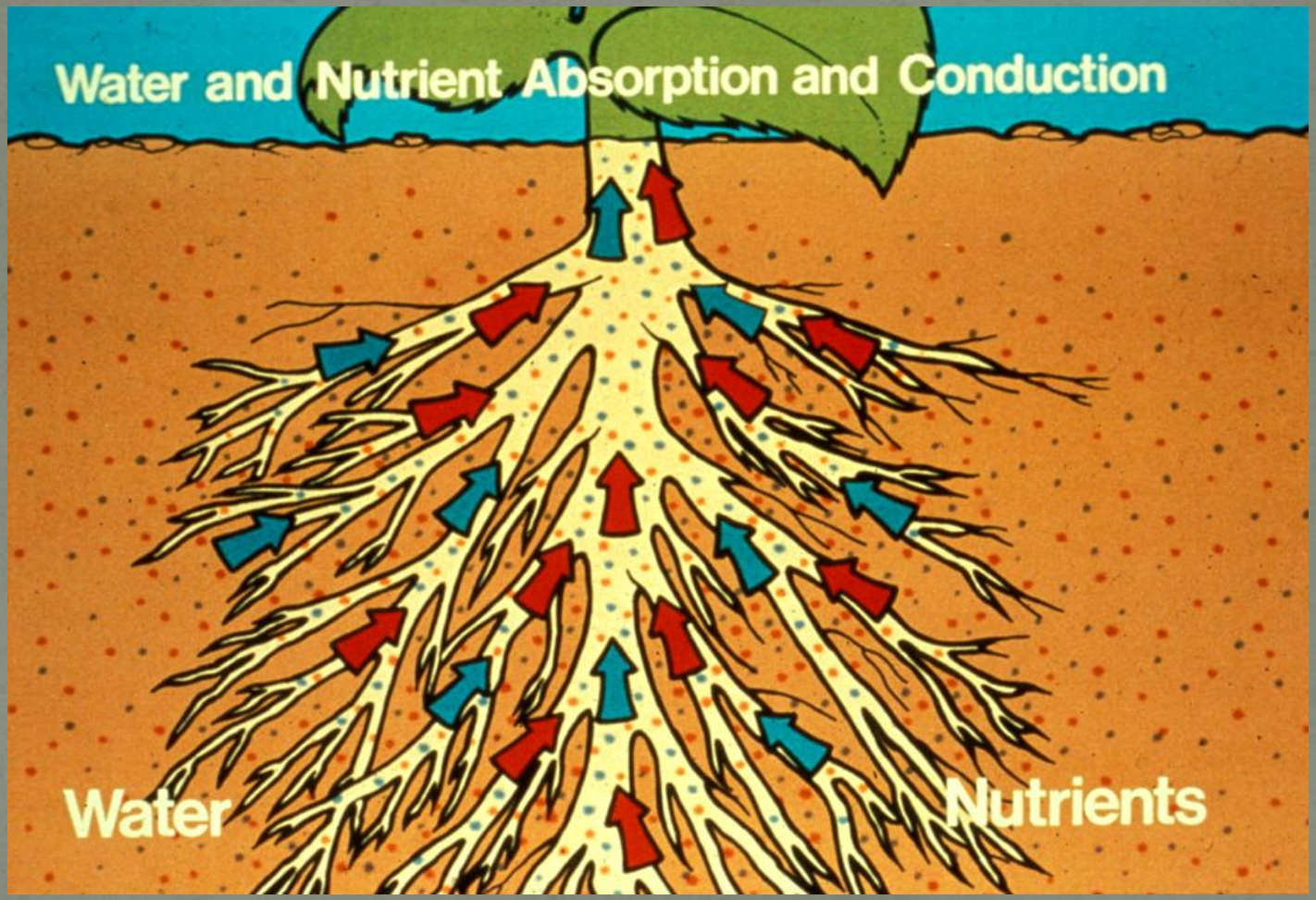
Factors Influencing Root Growth

- Light
- Gravity
- Temperature
- Mineral nutrition, salinity
- Oxygen
- Moisture
- Oxygen and Moisture influenced by soil physical properties and irrigation practices

Root Functions

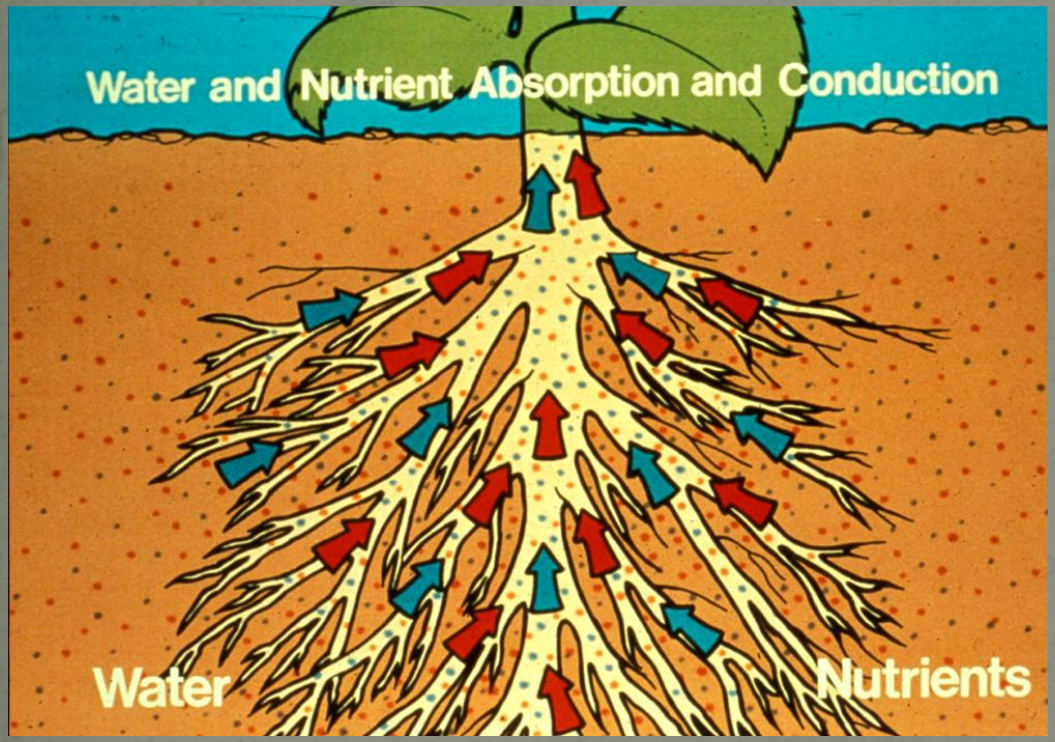
- Anchorage
- Storage of food
  - Carrot
- Regeneration of new plants
  - Dahlia, Tuberous begonias, Sweet potato
- Absorption of water and nutrients

Water and Nutrient Absorption and Movement



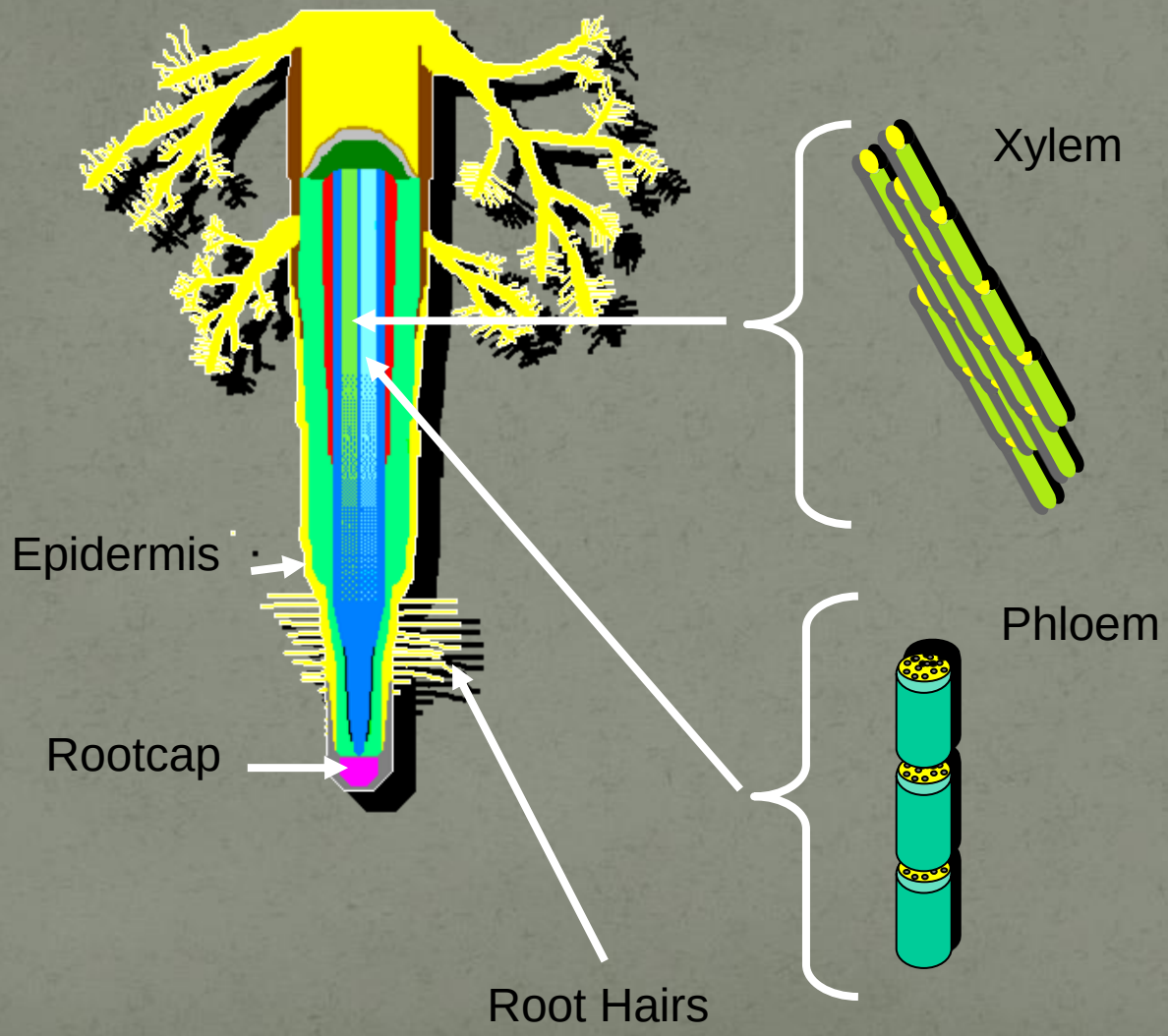
If you slice a root down its length……

Mineral Nutrient Uptake



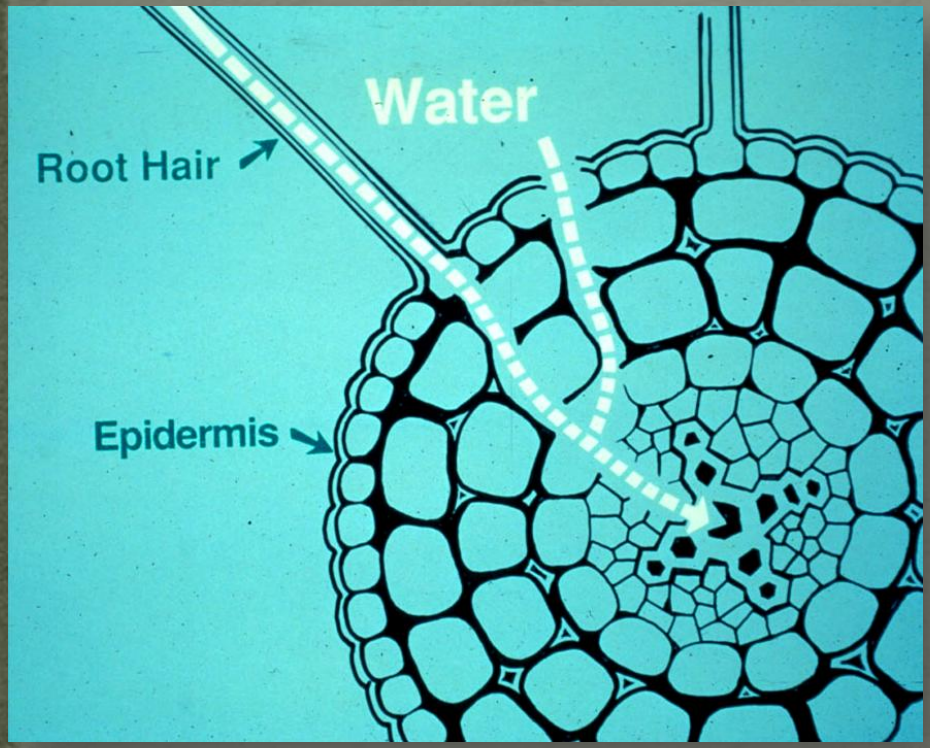
- Passive: flow along with the conduction of water
- Selective: roots can actively distinguish one nutrient from another nutrient
- Selective uptake: requires energy and therefore sugars and starches and oxygen

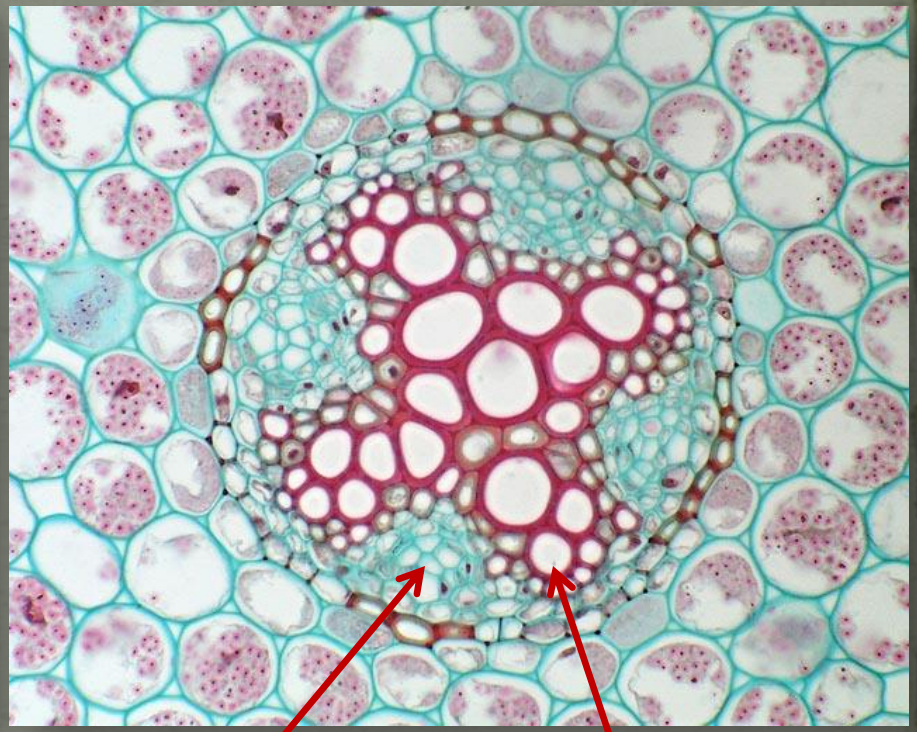
Root: longitudinal view



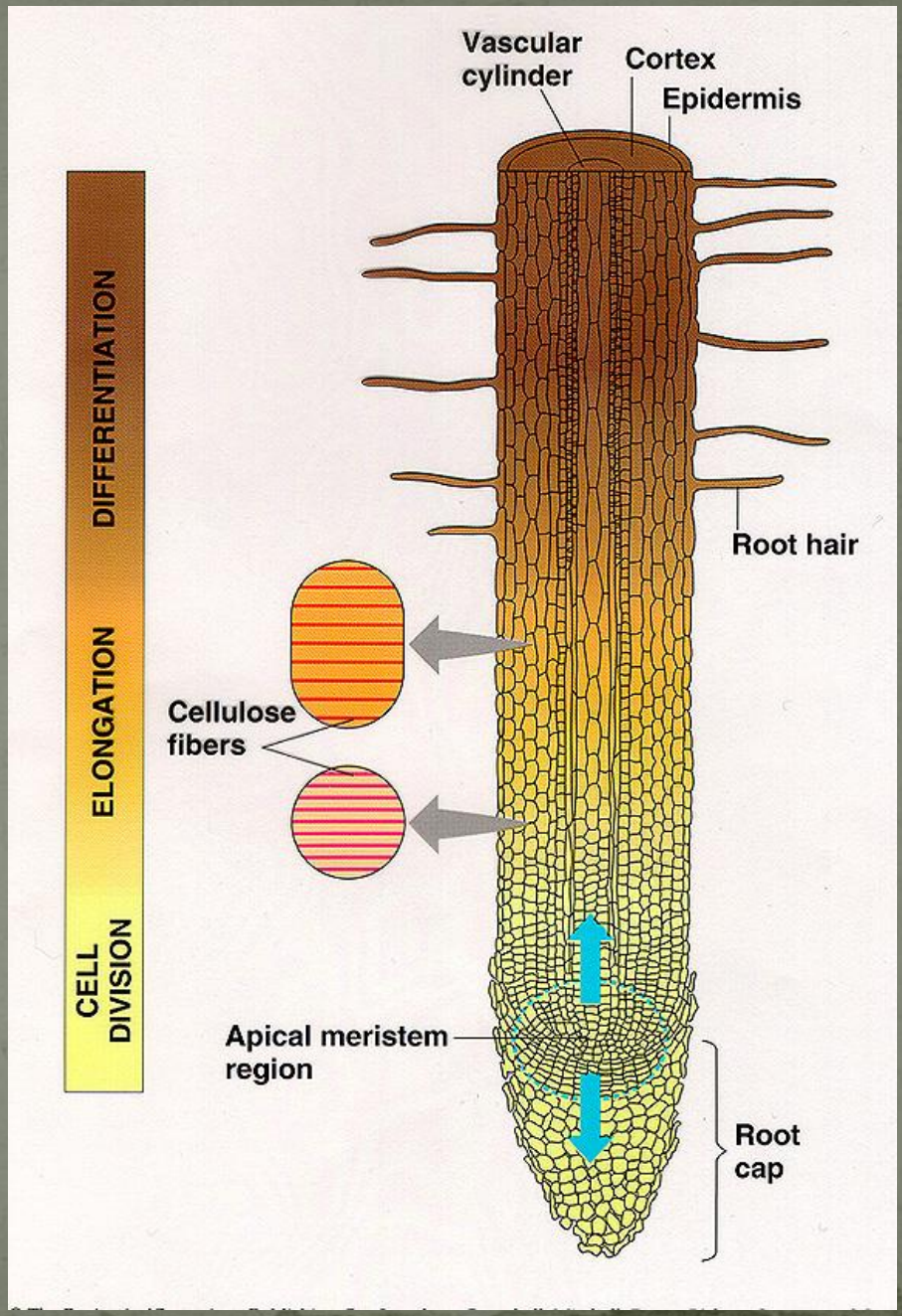
If you slice a root across ……

Root: cross-sectional view





Cell division, elongation, differentiation



Root hairs

Are the root tips and hairs healthy ?

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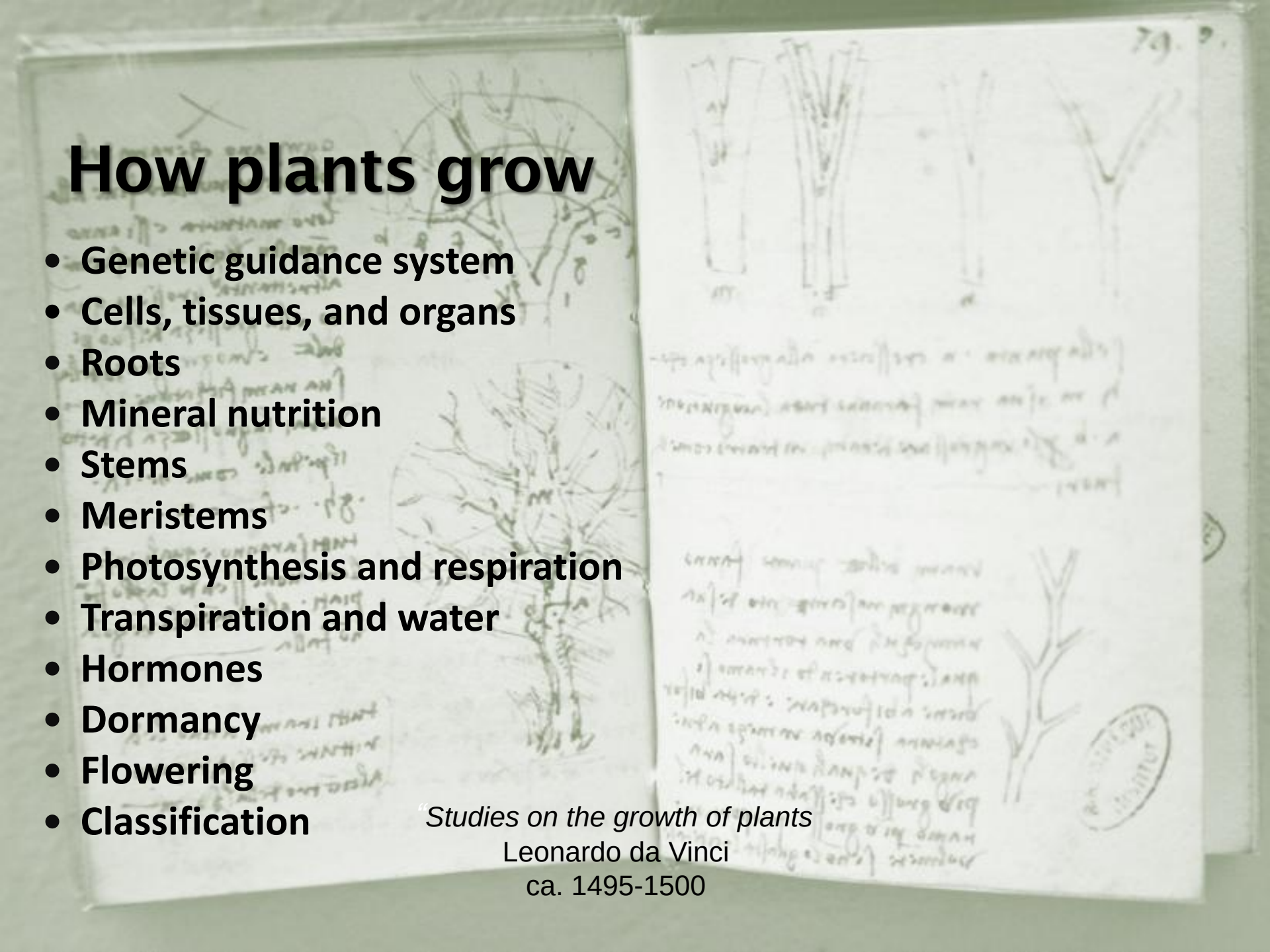

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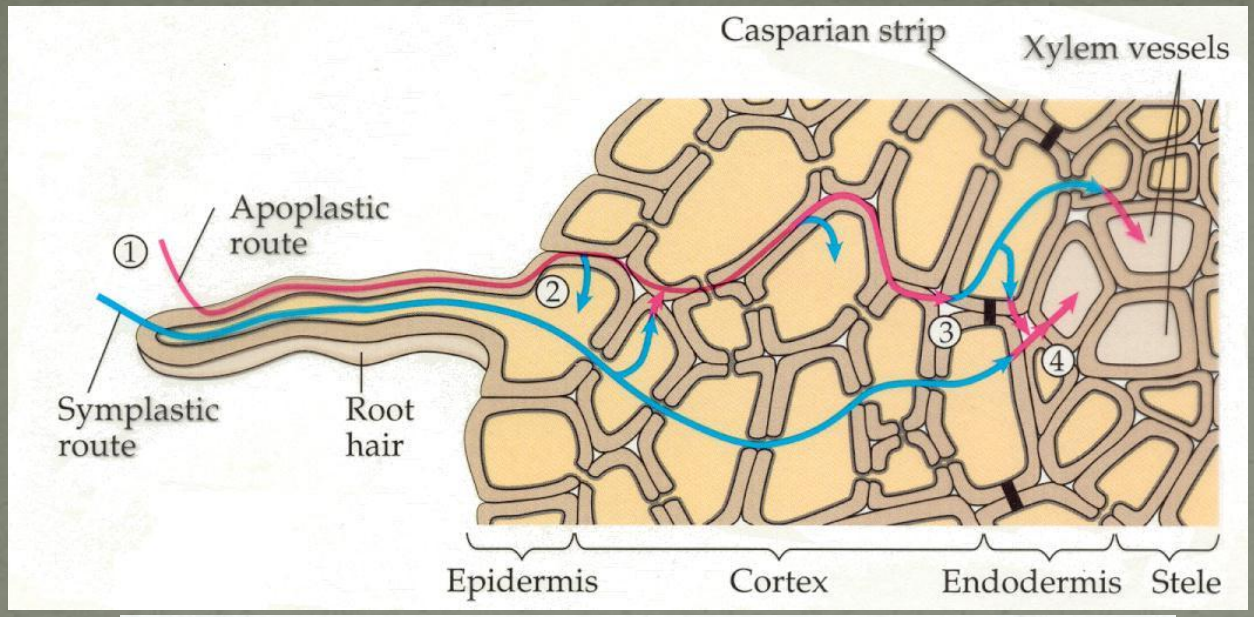
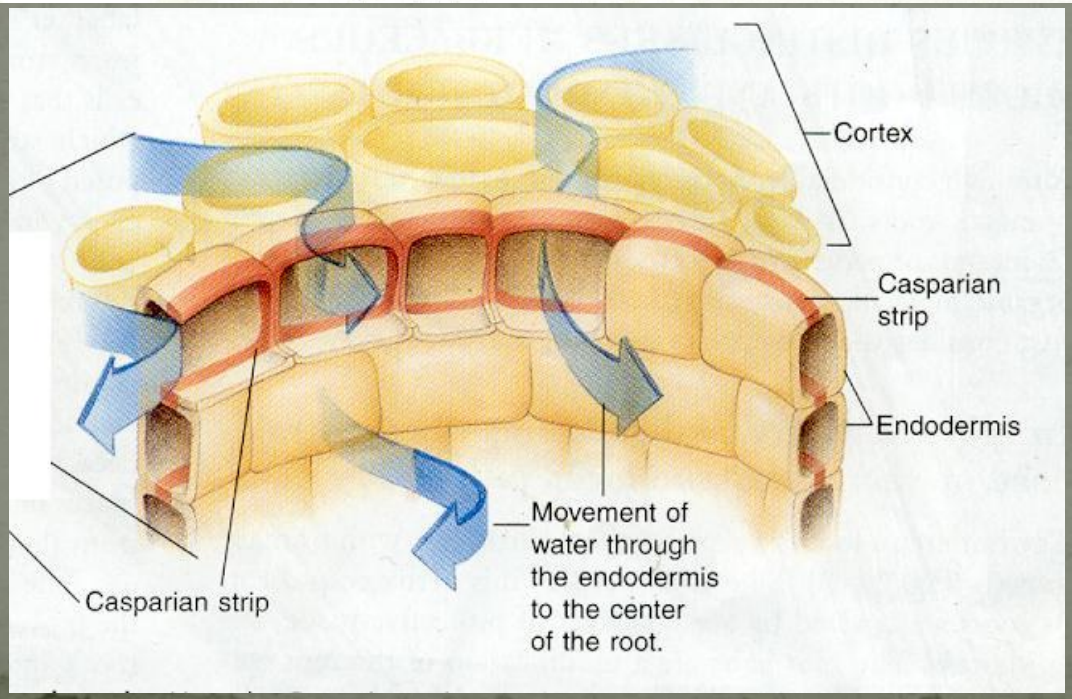
Nutrient Uptake

- Passive: flows along with conduction of water
- Selective: roots can actively distinguish one nutrient from another nutrient
- Selective uptake: requires energy and therefore sugars and starches and oxygen





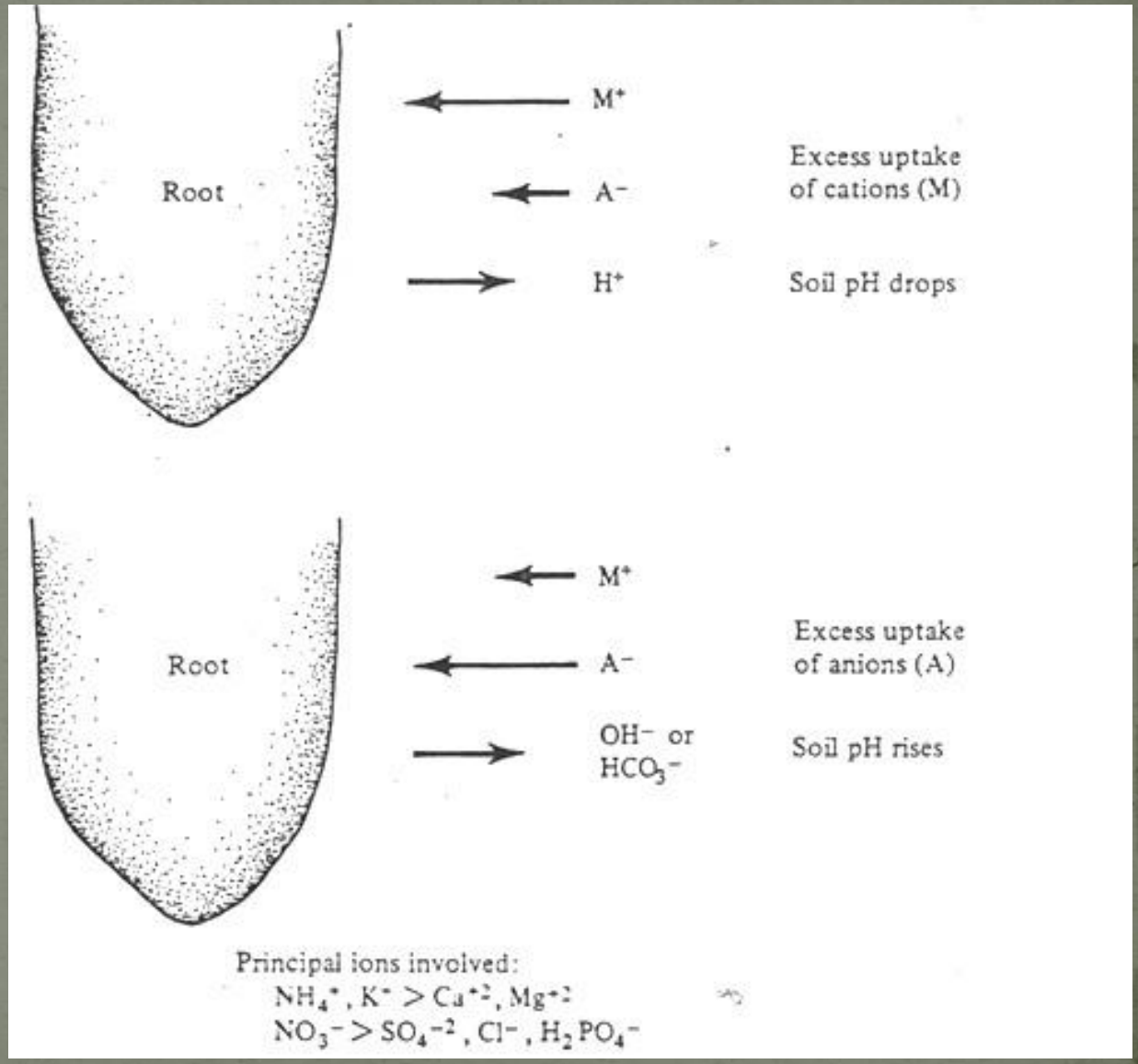
Passive and Selective Mineral nutrient Uptake

Physiological Acid Nitrogen Fertilizers

Cation is +

Anion is -

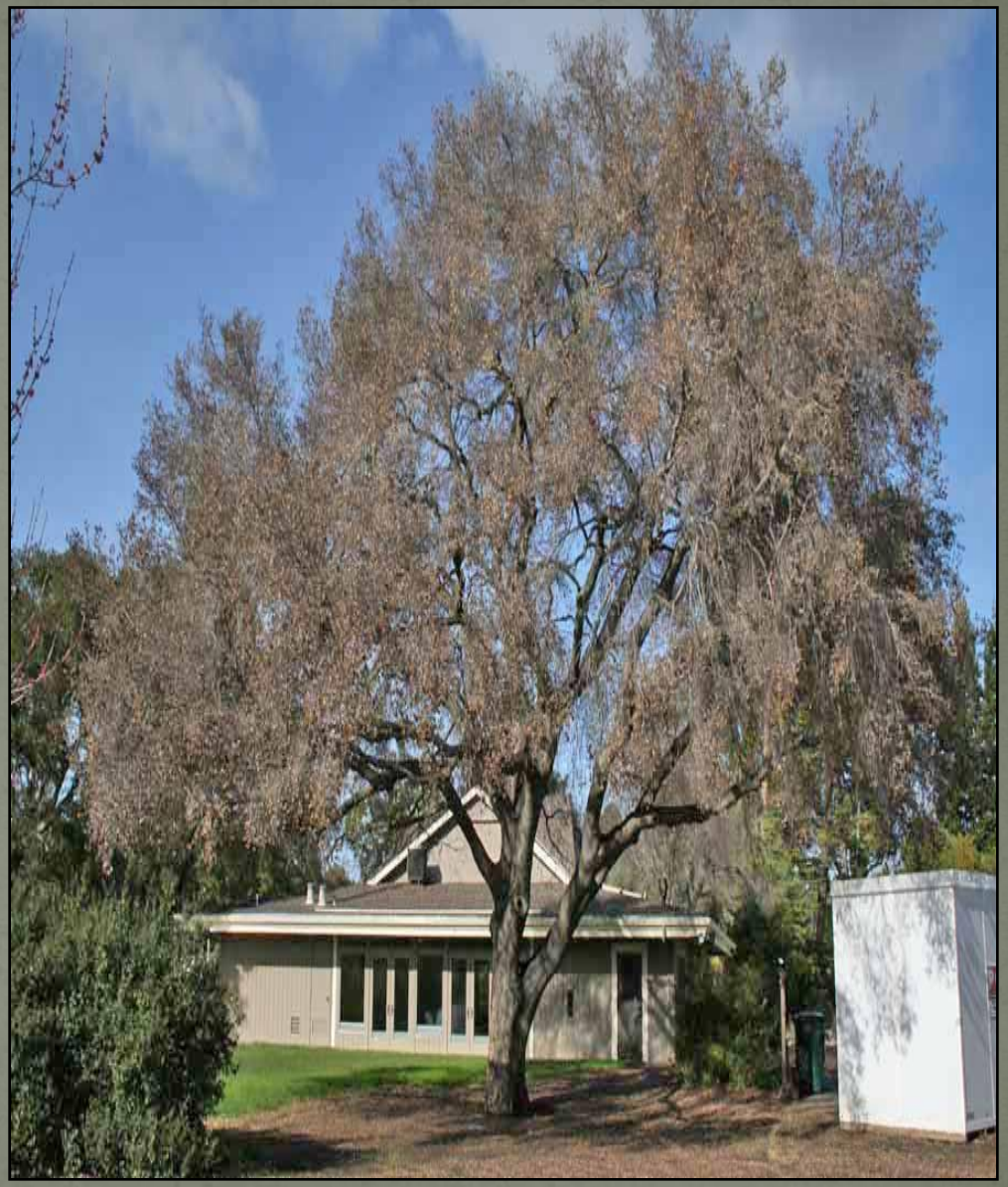
Mostly H+ is acid



Aeration Deficits

Excess water in the root zone can lead to oxygen deficits.

Trees are not good swimmers!



Aeration deficits can lead to plant diseases

Increasing salt concentration →

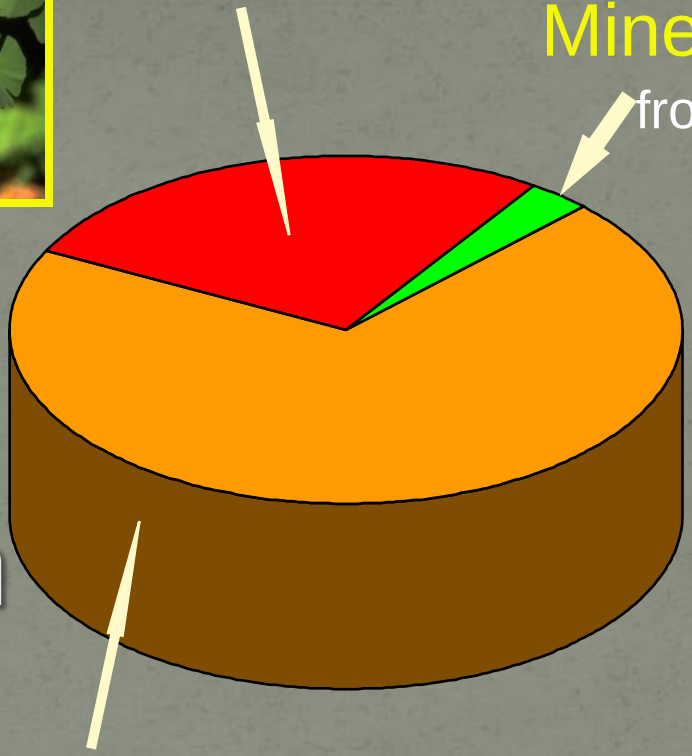
Growth reduction and necrosis in Hebe

Needle necrosis in pine

Plant Composition

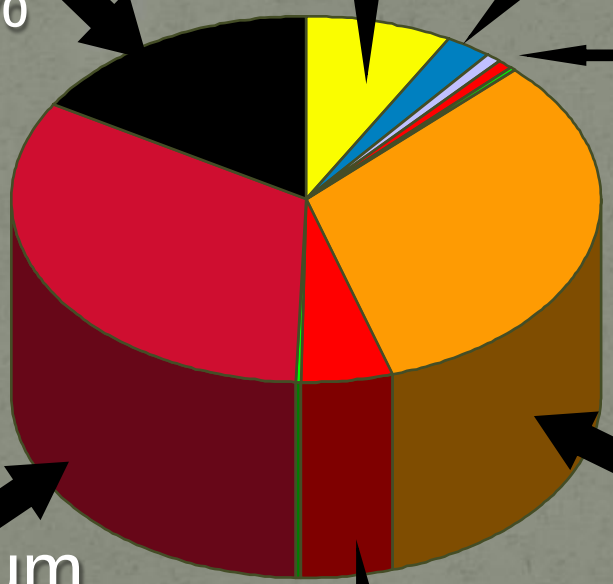
Organic matter - 27%
(carbon, sugars)

Minerals - 3%
from soil by roots



Water - 70%
from soil by roots

Mineral Composition



Magnesium
0.1-1.5%

Iron
.003-.08%

Calcium
0.2-4.2%

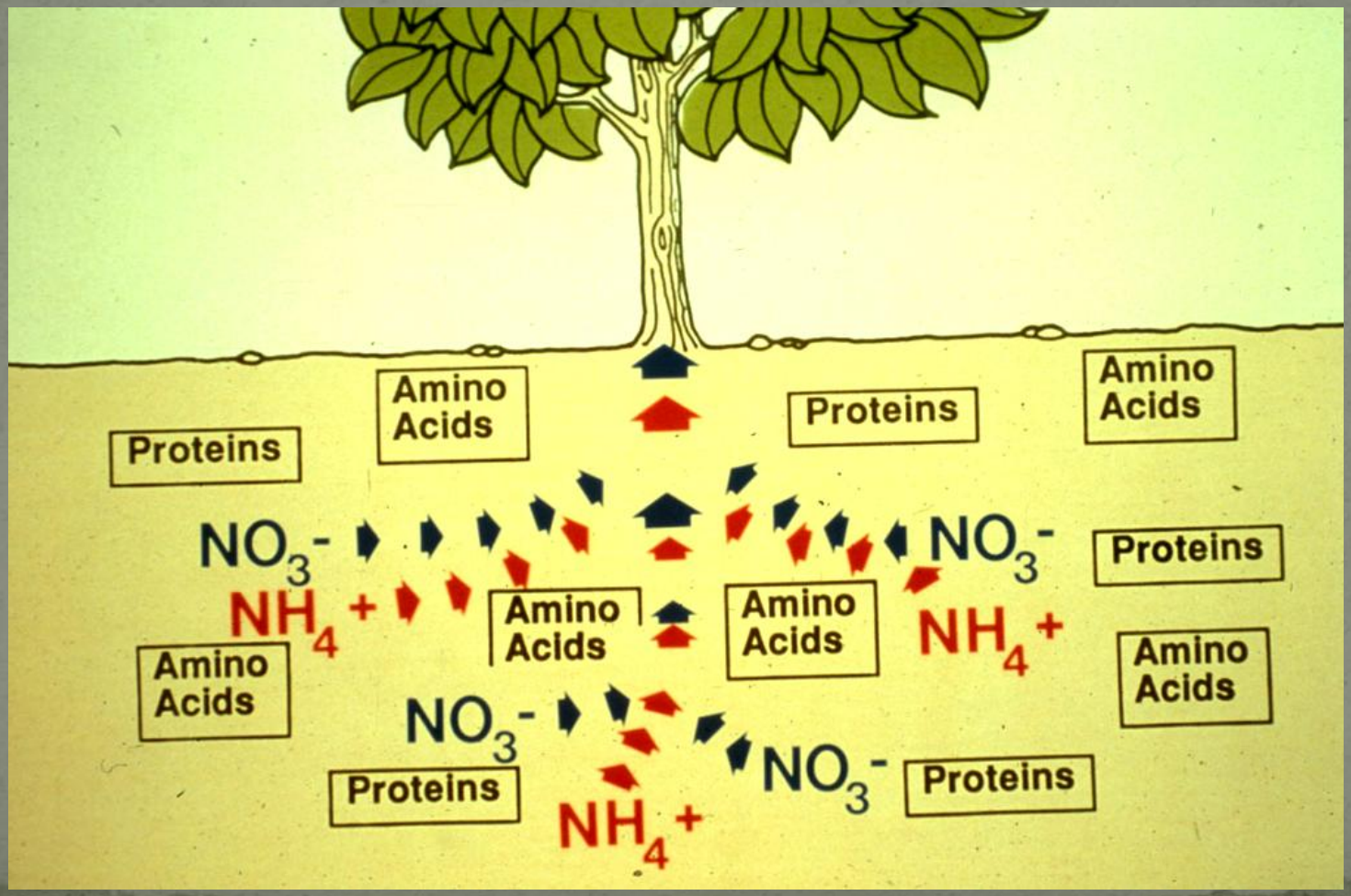
Minor
elements
1%

Nitrogen
2-6%

Potassium
0.2-6.3%

Phosphorus
0.2-2.5%

Nitrogen Sources



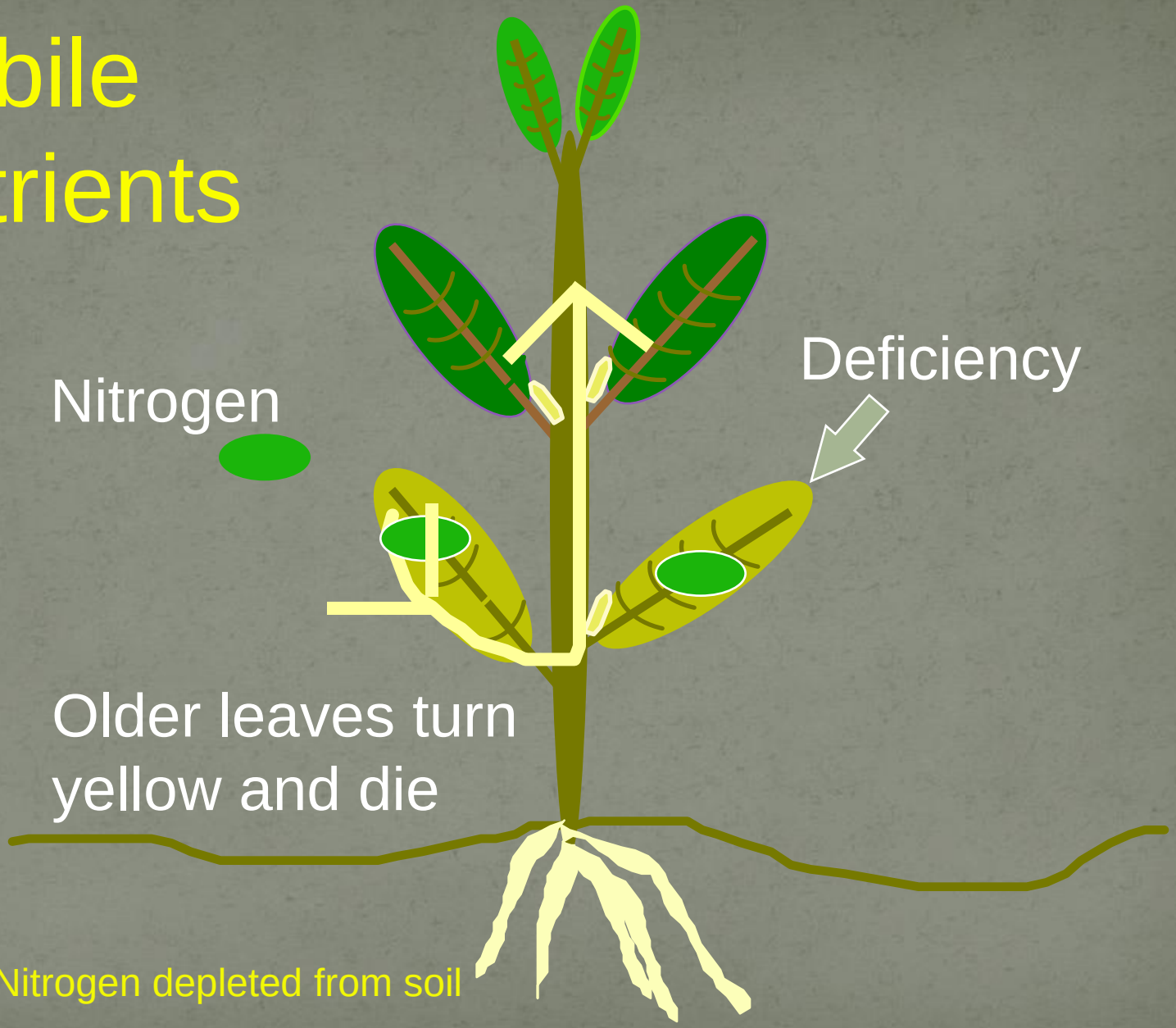
Homework

- Select a bag of fertilizer
- What are the mineral nutrients and their relative proportions?
- Do the proportions fit what you would suspect?

Nutrient Mobility In Plant

Mobile	Immobile
Nitrogen	Calcium
Magnesium	Iron
Phosphorus	Manganese
Potassium	Boron
	Copper
	Zinc
	Molybdenum

Mobile Nutrients



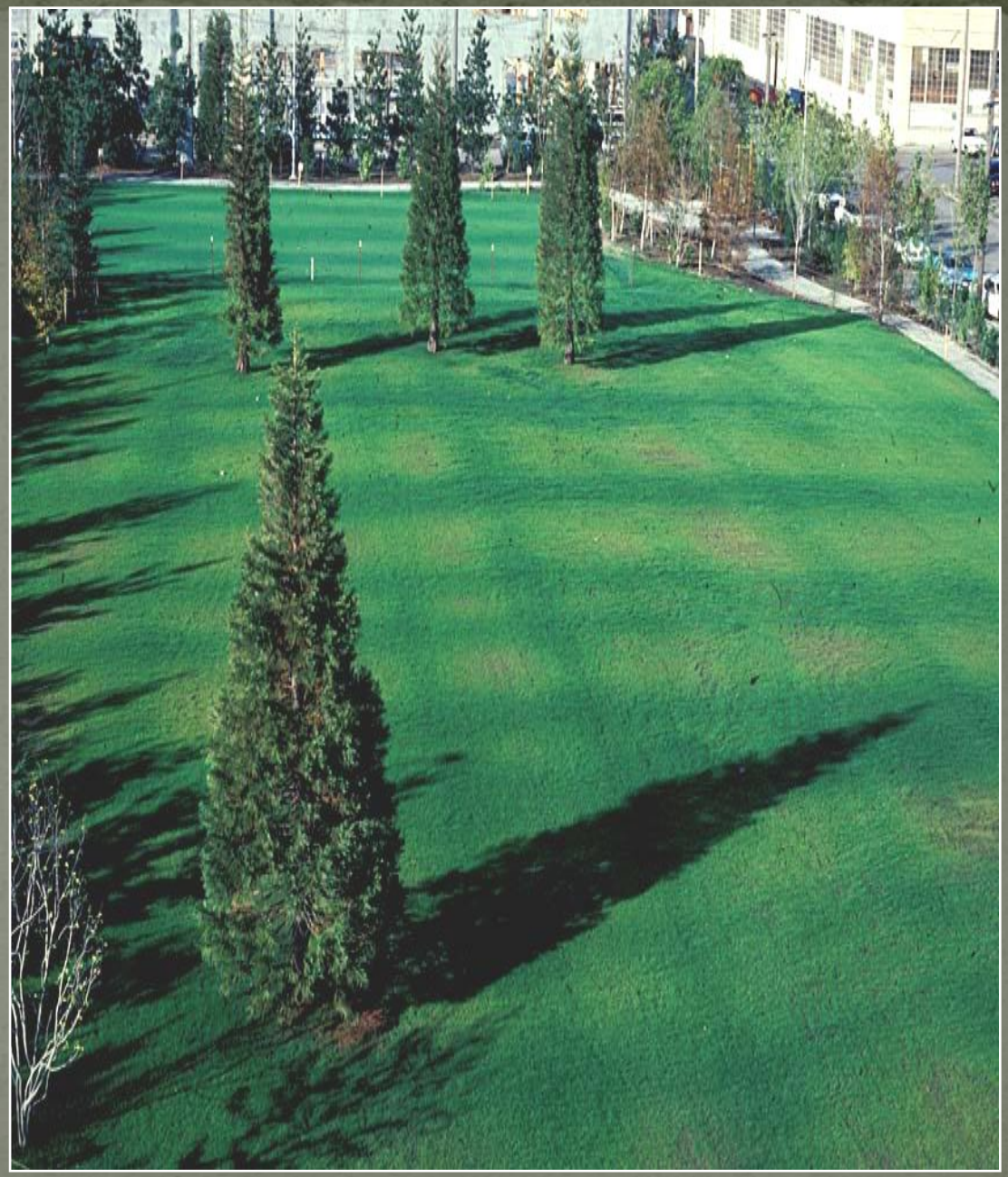
Scenario: Nitrogen depleted from soil

Nitrogen Deficiency

Symptoms of a mobile nutrient

Roses “forced “ in greenhouse

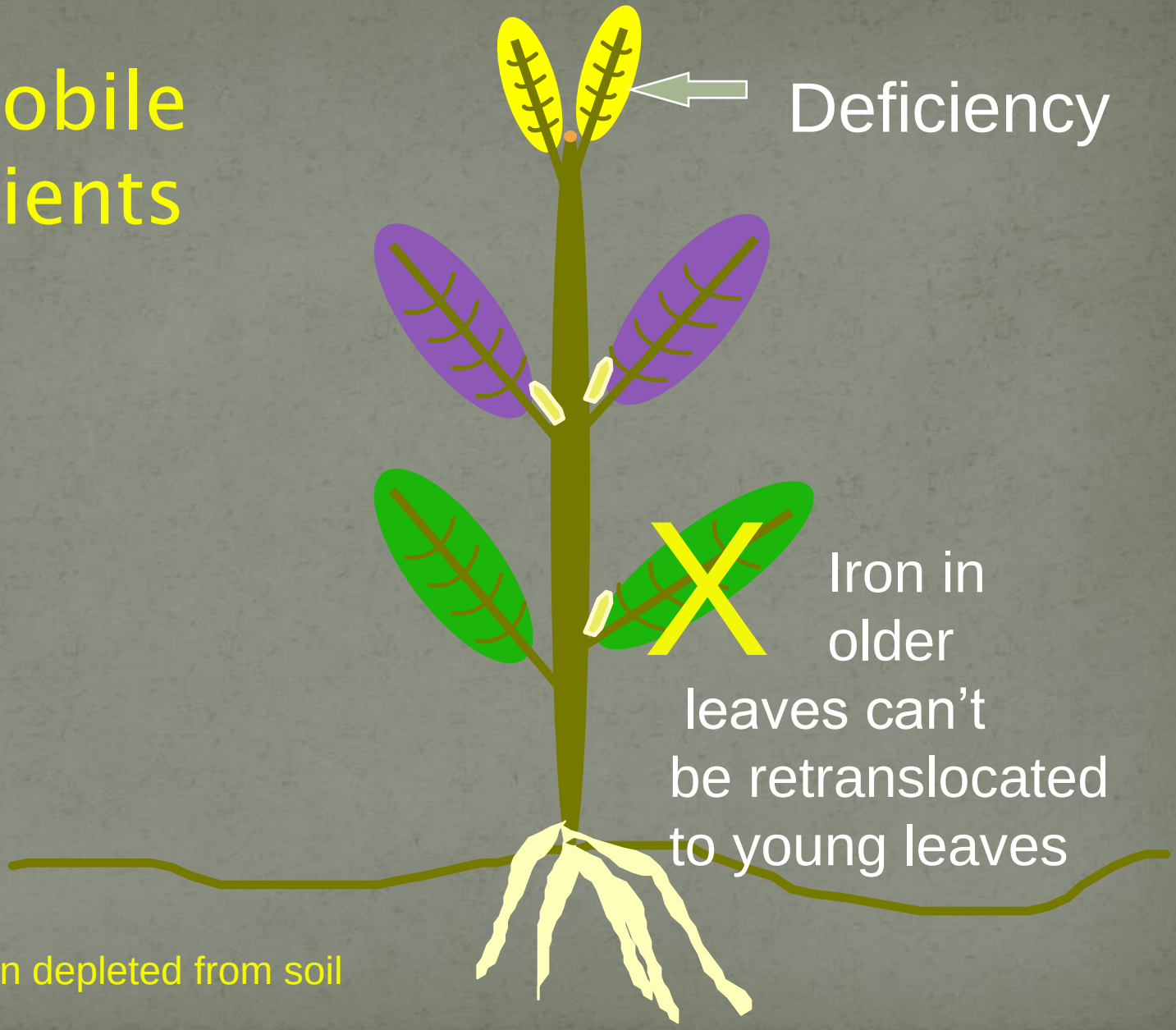
Nitrogen deficiency is common in turf, but not common in woody plants that are well established in the landscape.



Nitrogen deficiency in potted citrus

1 month after N application

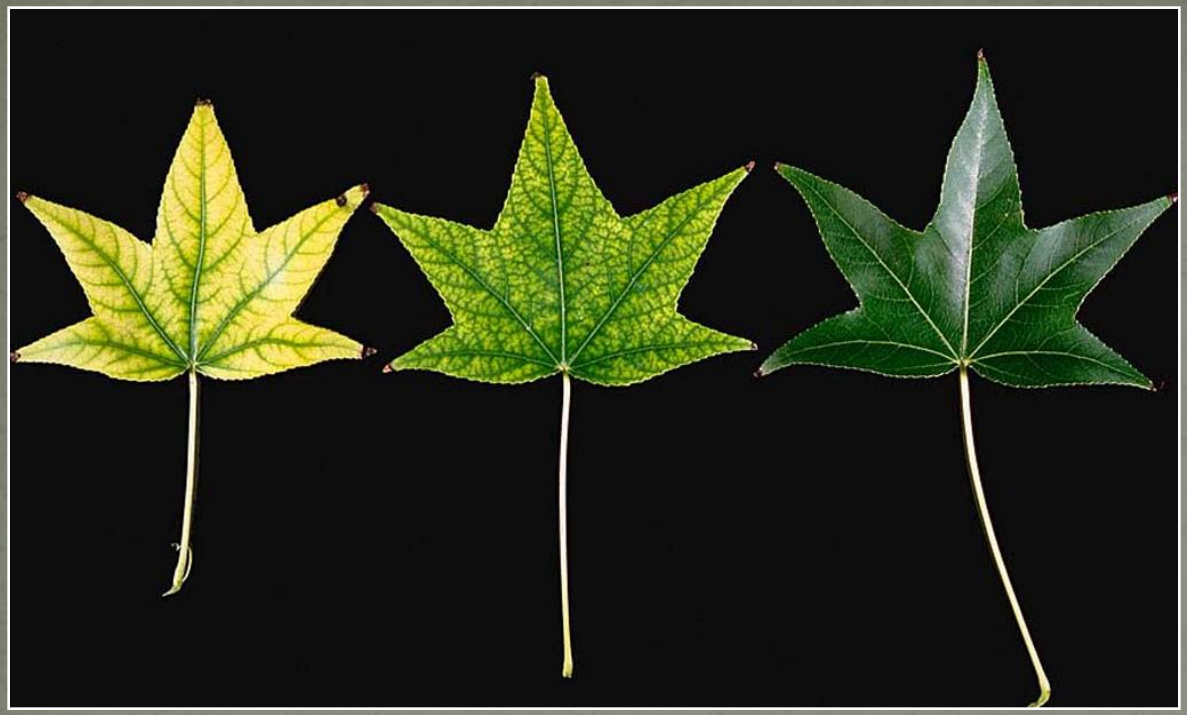
Immobile Nutrients



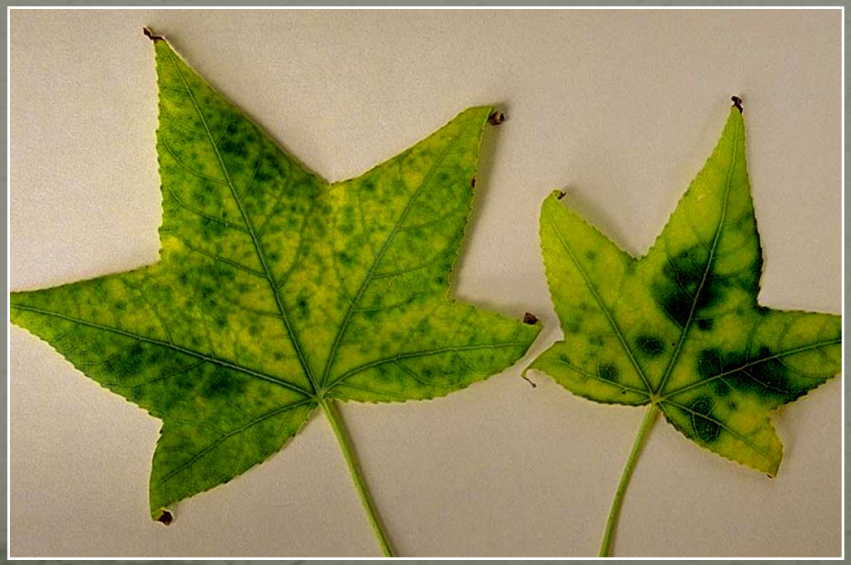
Scenario: Iron depleted from soil

Iron Deficiency

Iron Deficiency in Sweetgum



Stages of iron deficiency in sweetgum leaves



Treated with iron chelate

Specific Ion Toxicity

Boron toxicity on elm

Chloride toxicity on hackberry

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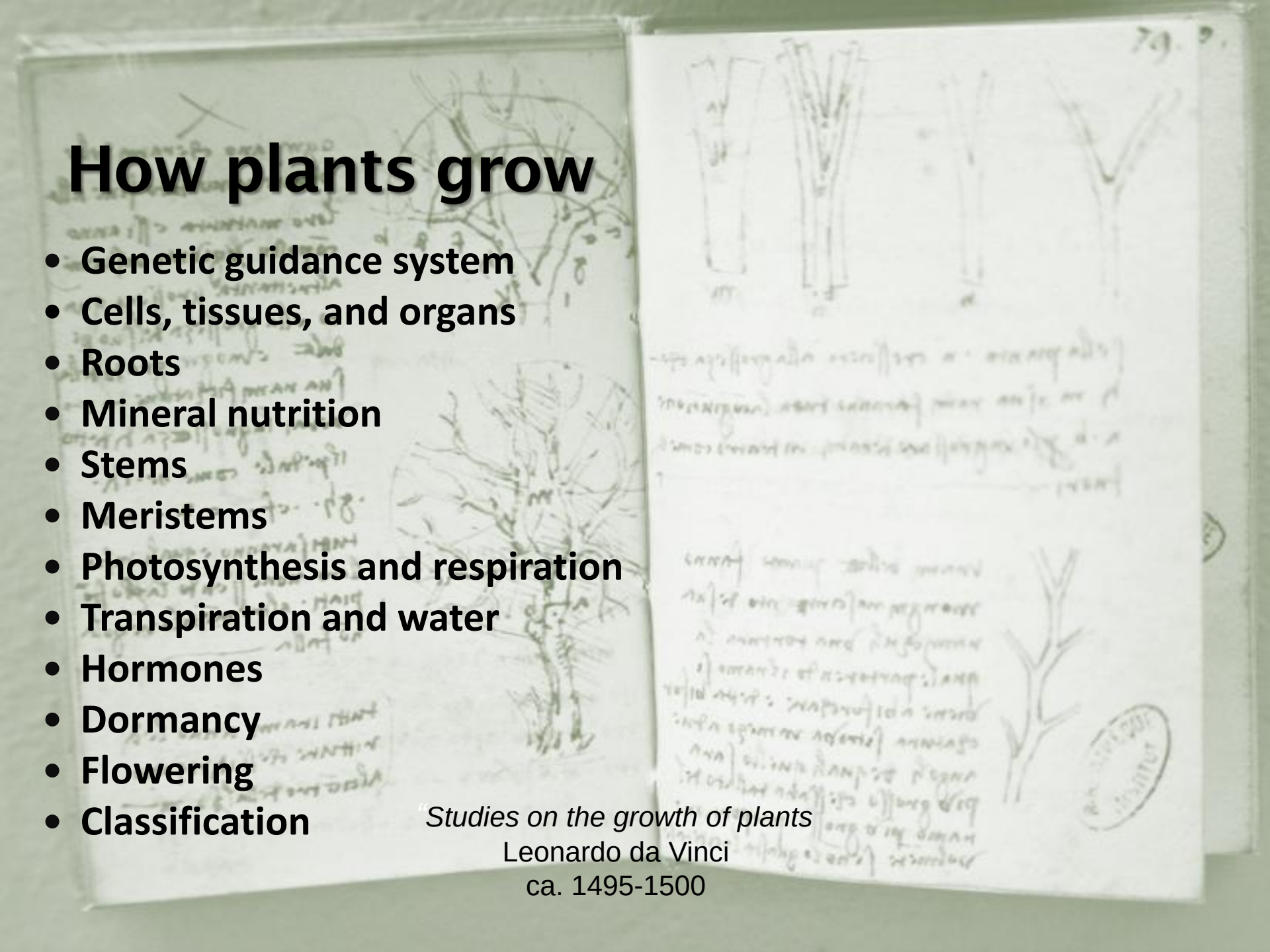

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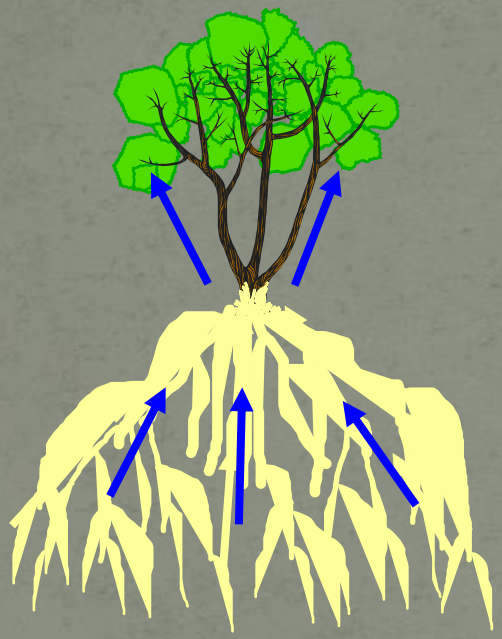
Stem Functions

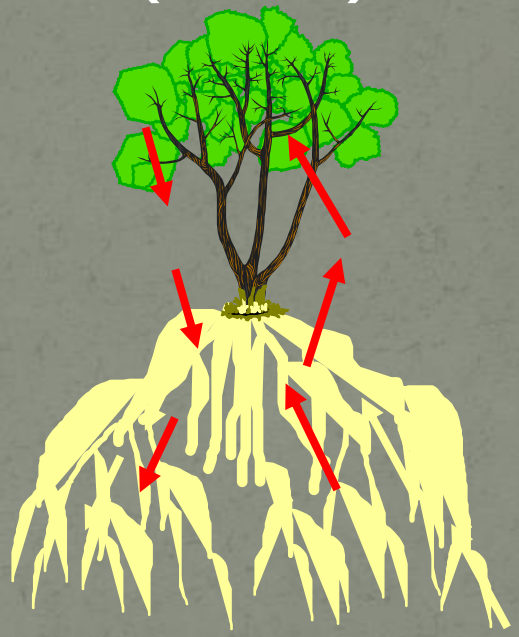
- Supports leaf canopy and flowers
- Produces and stores sugars
- Shoot regeneration
  - Bermuda grass, strawberry runners
- Pathway for water and nutrient transport
- Pathway for food transport

Vascular System

water

sugars
(food)

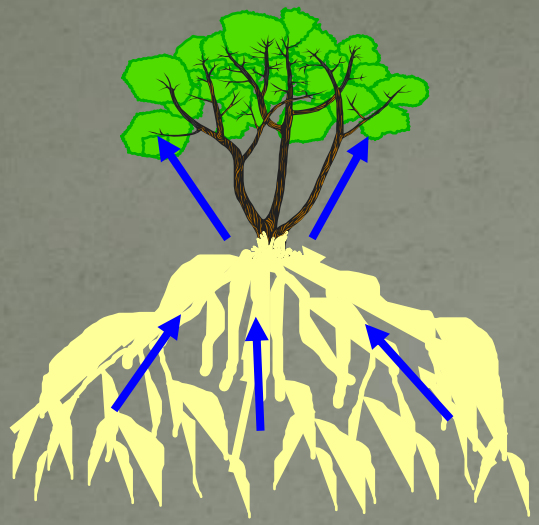


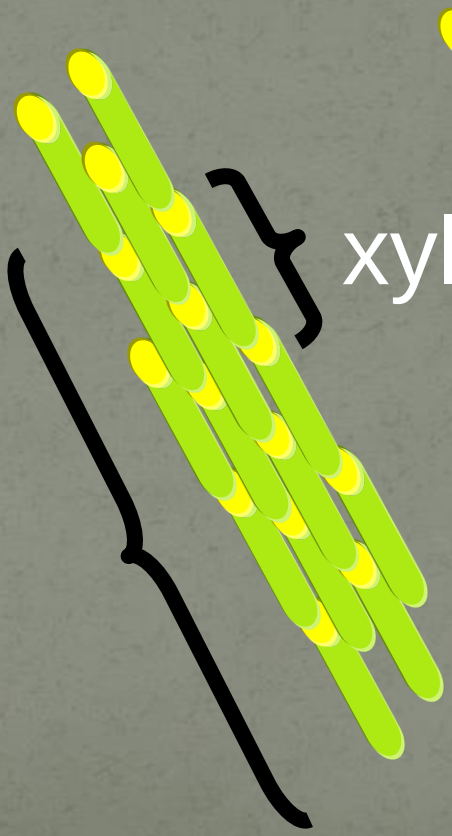


Xylem tissue

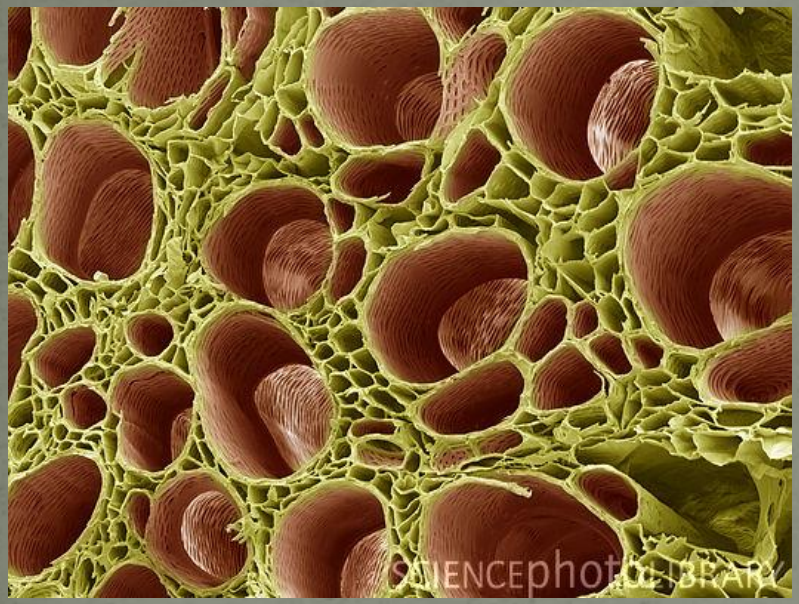
Phloem tissue

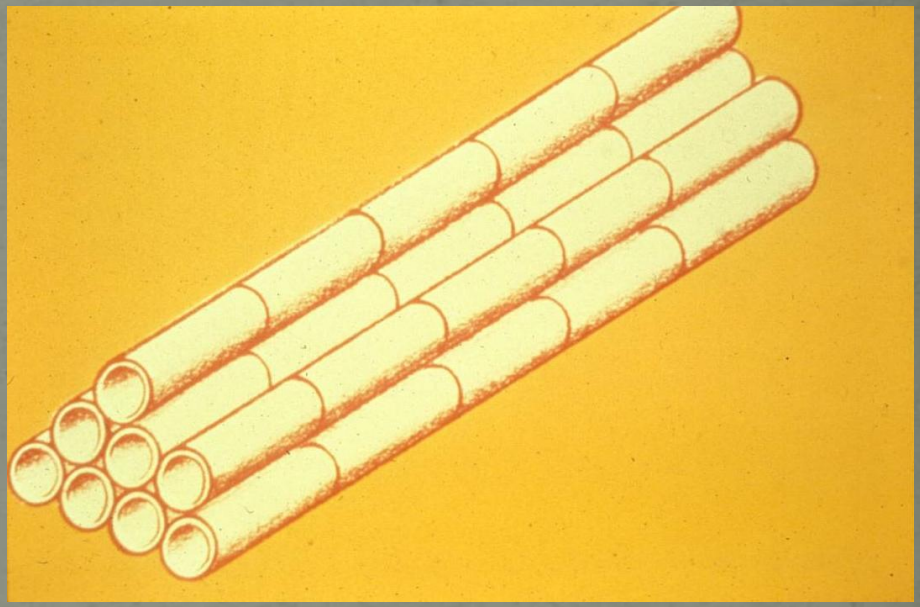
Xylem



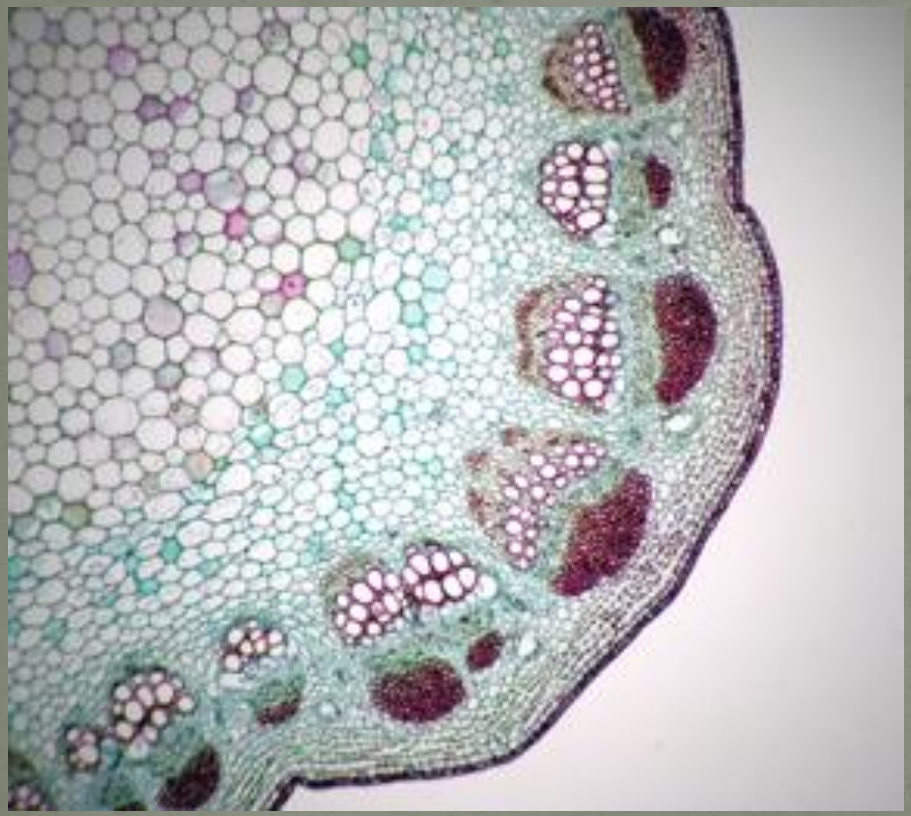


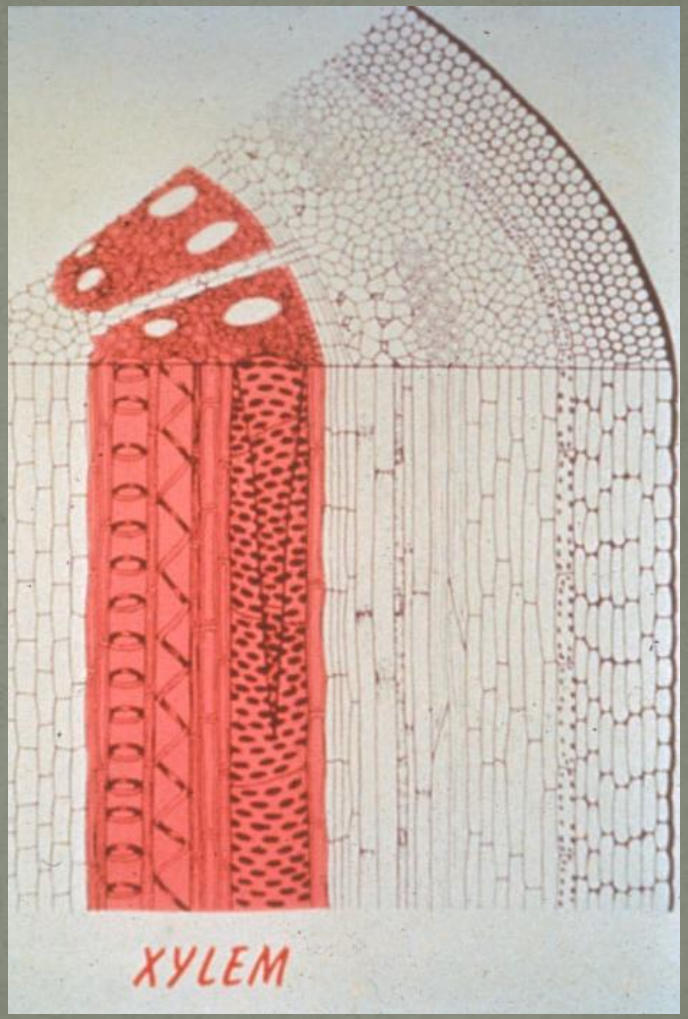
Xylem



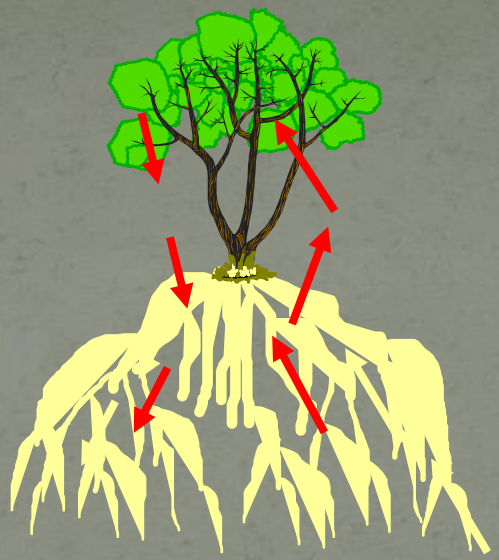


Xylem



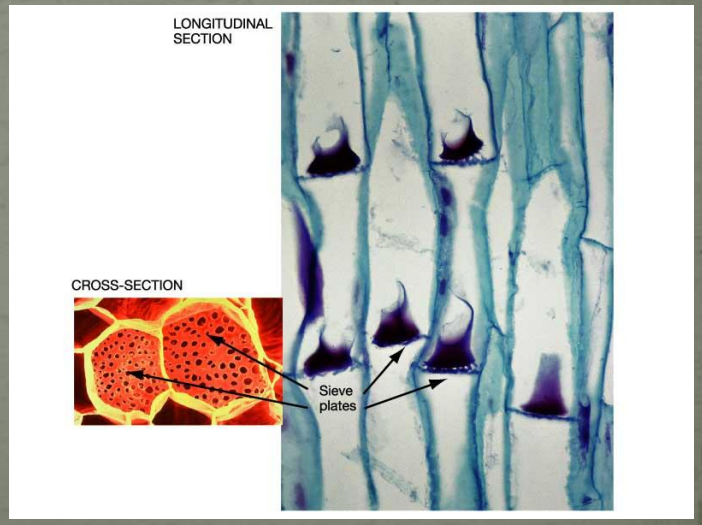


Phloem



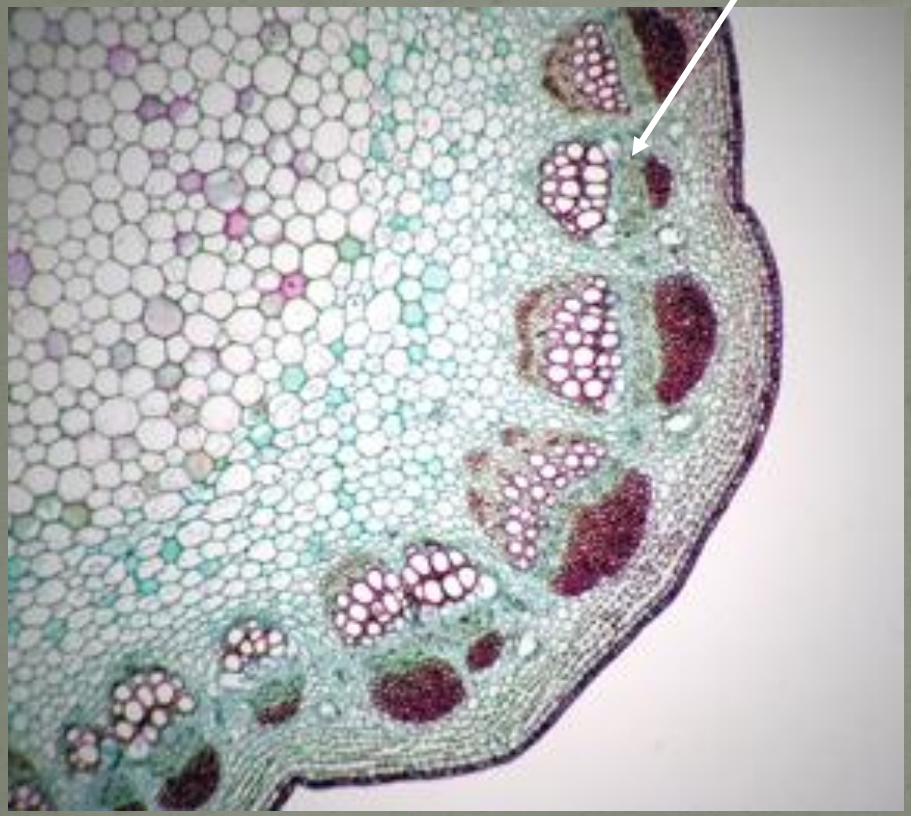
Sieve plate

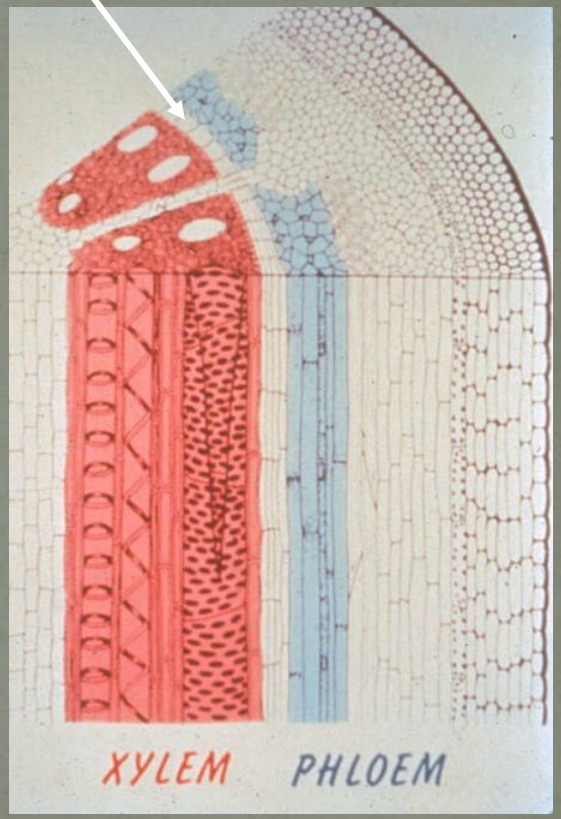
phloem cell



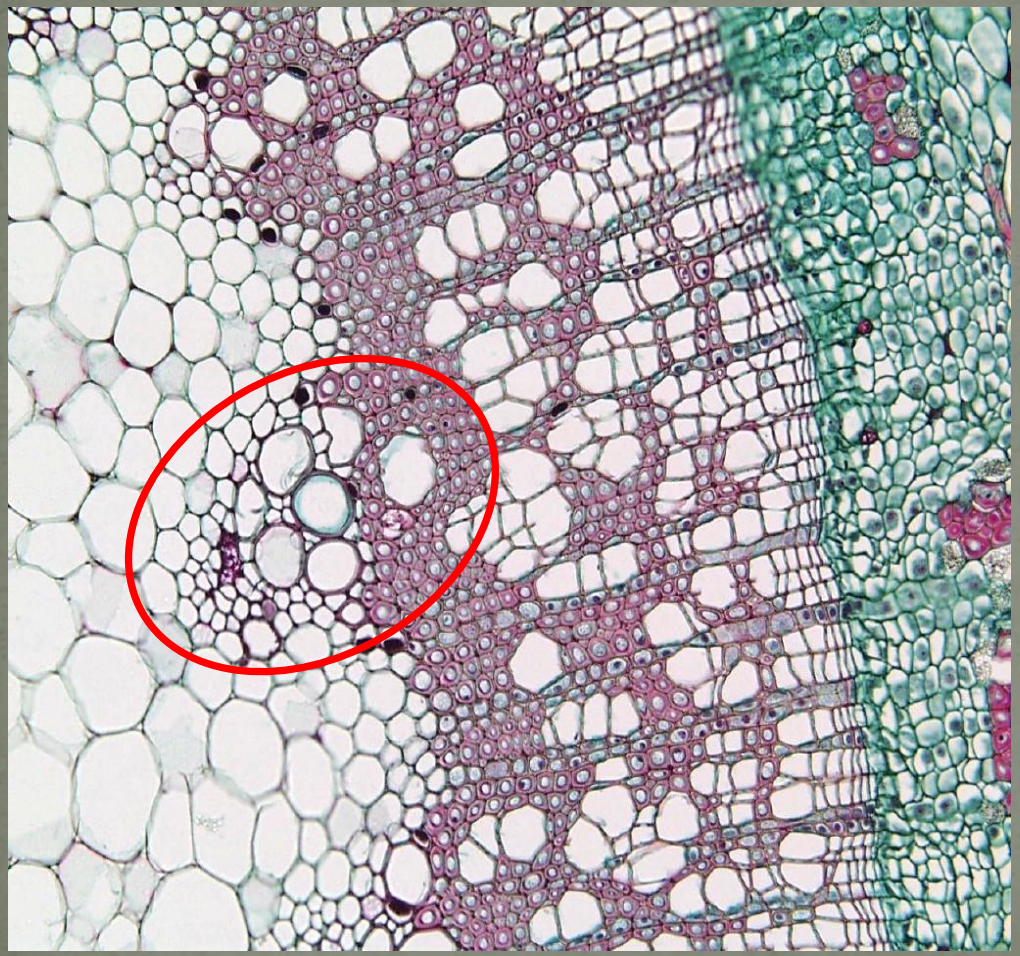
Primary growth: xylem and phloem in bundles

Vascular Cambium
A meristematic region



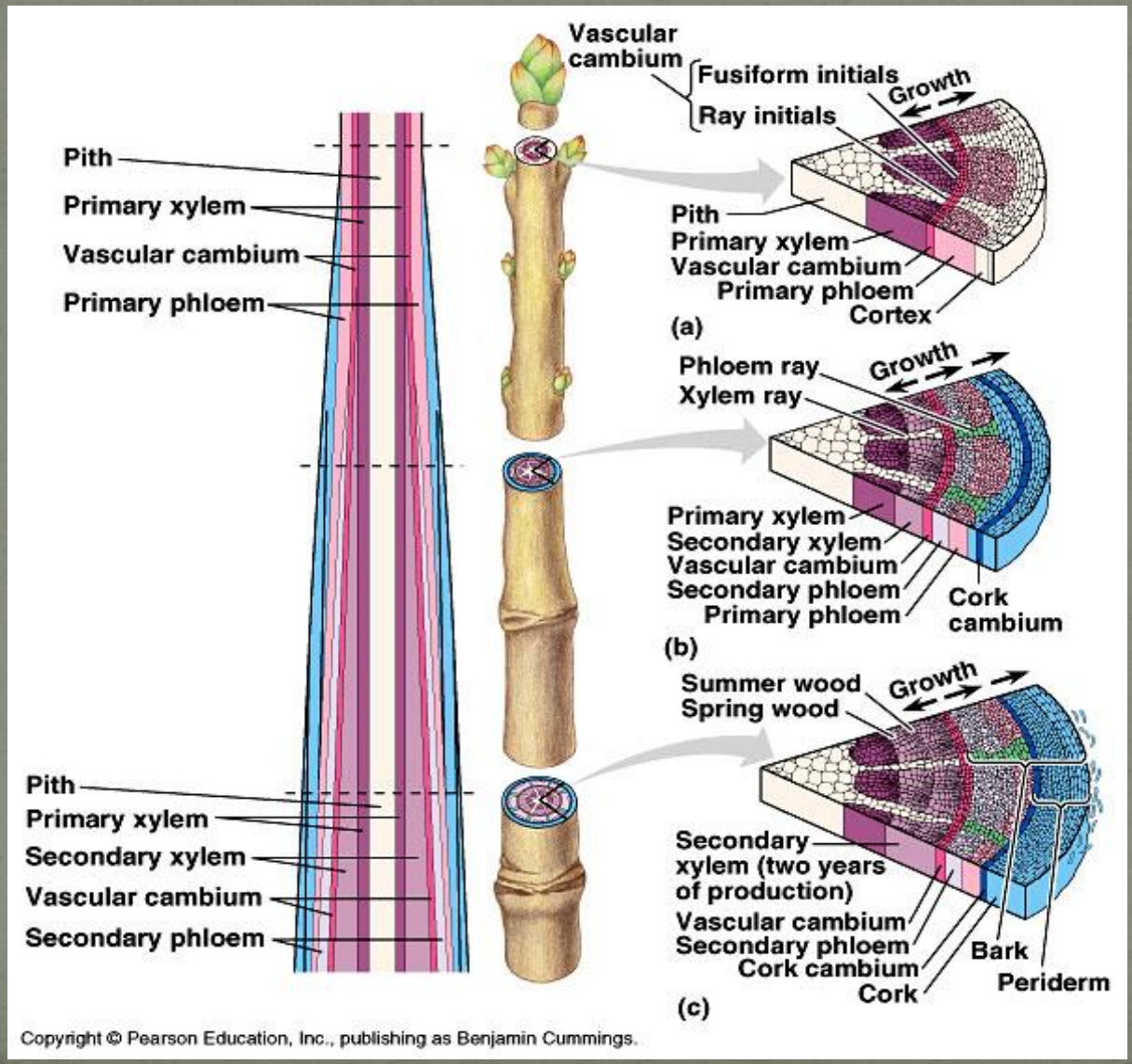


Primary to secondary growth



- Primary growth limits the plants life and ability to grow in girth, typical of herbaceous annual plants

Primary to secondary growth



Remember the Meristems

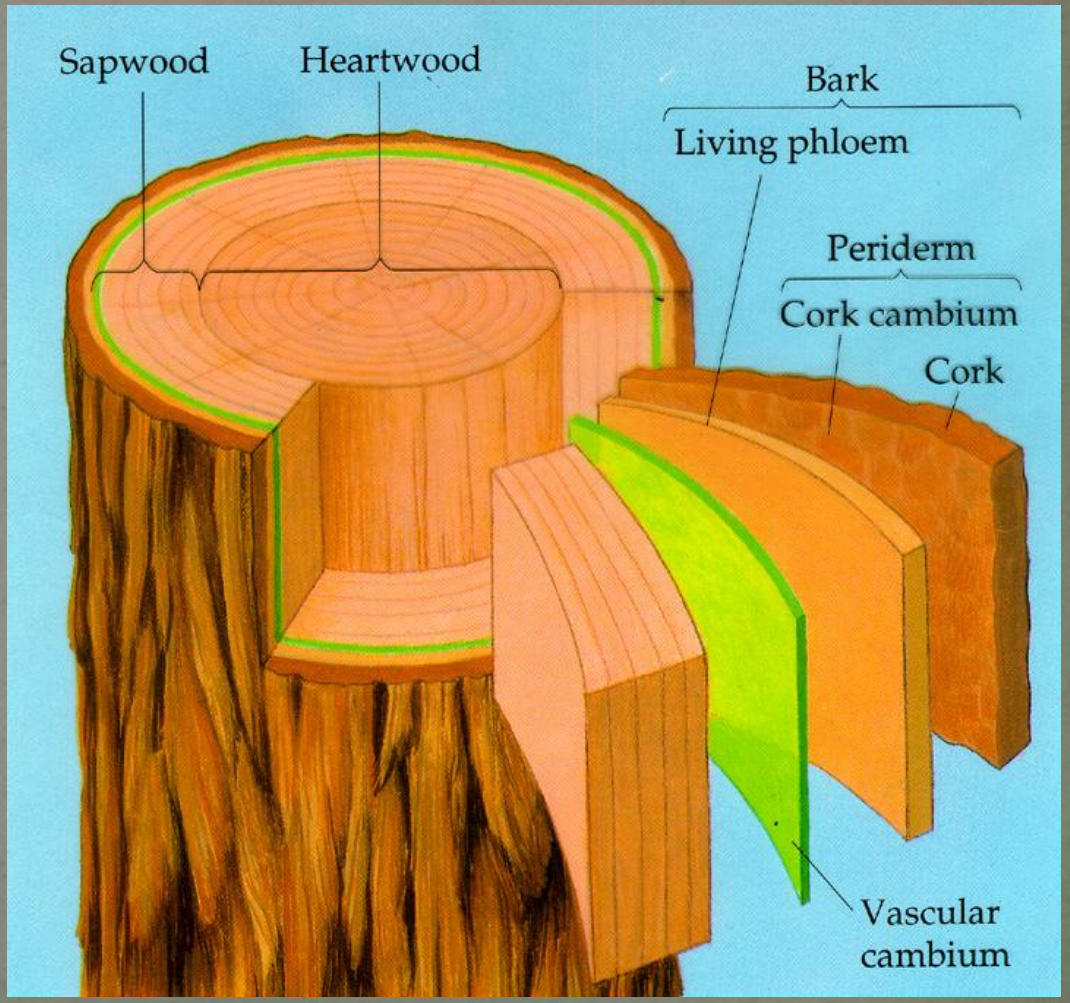
Merizein (μερίζειν), meaning to divide.
A **meristem** is the tissue in most plants consisting of undifferentiated cells capable of dividing and producing all the specific cells, tissues, and organs

Shoots

Roots

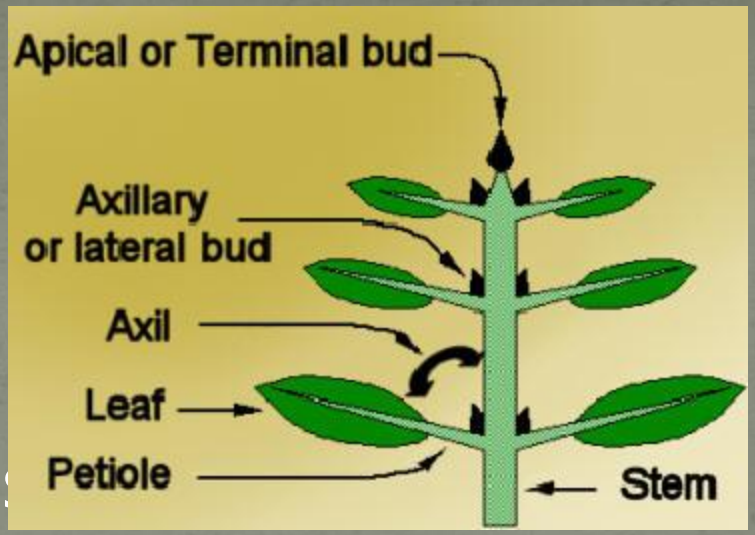
Woody plant meristems

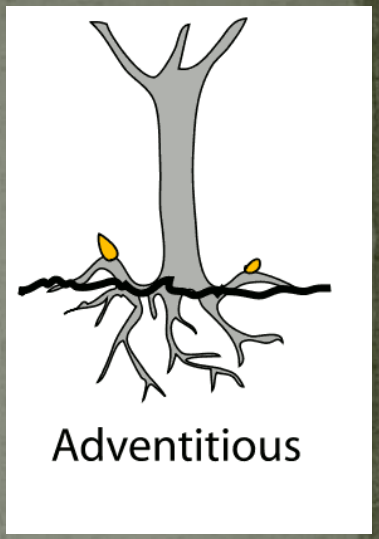
- Vascular cambium
- Cork cambium



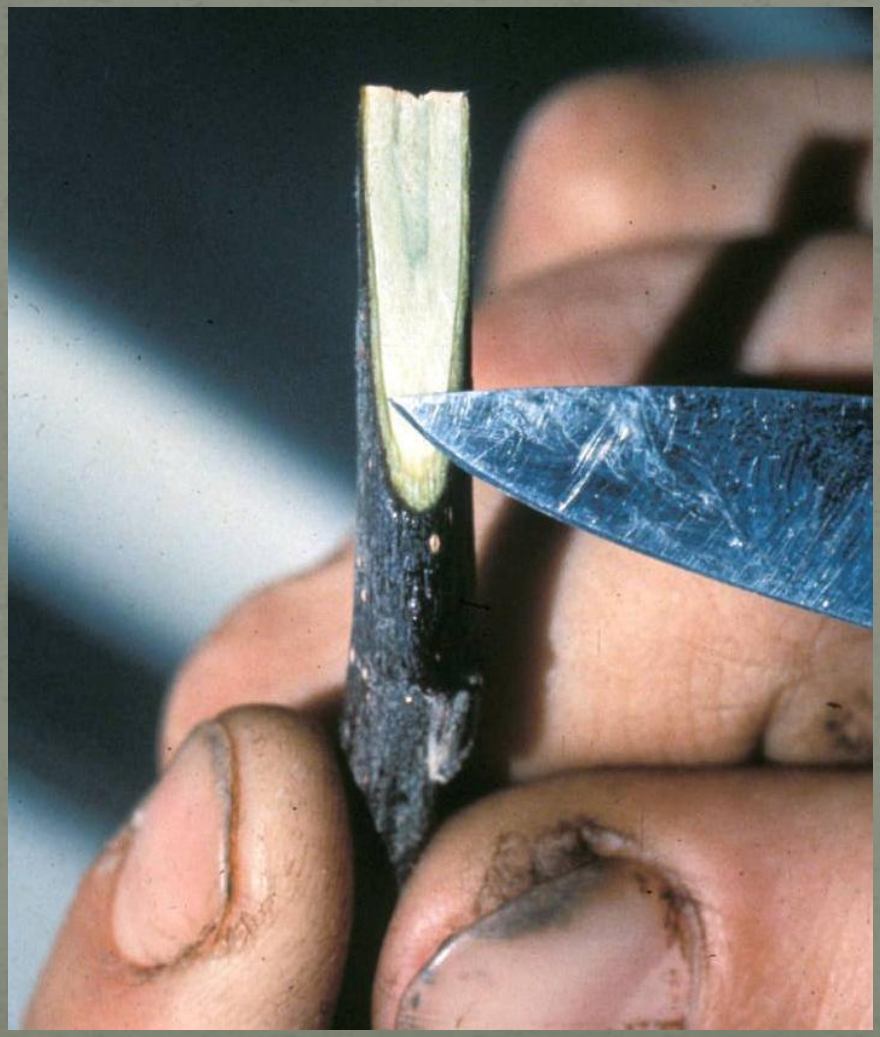
Meristems

- Apical
- Lateral buds
- Adventitious buds
- Vegetative or flowering buds



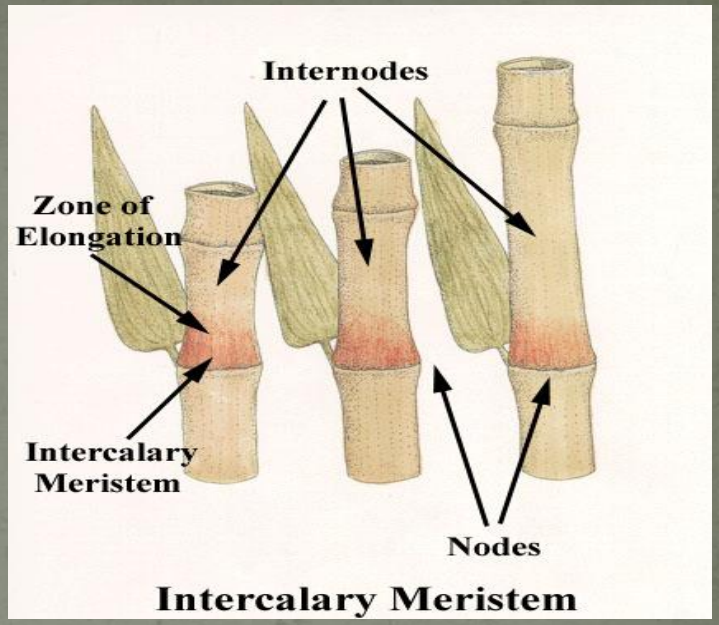


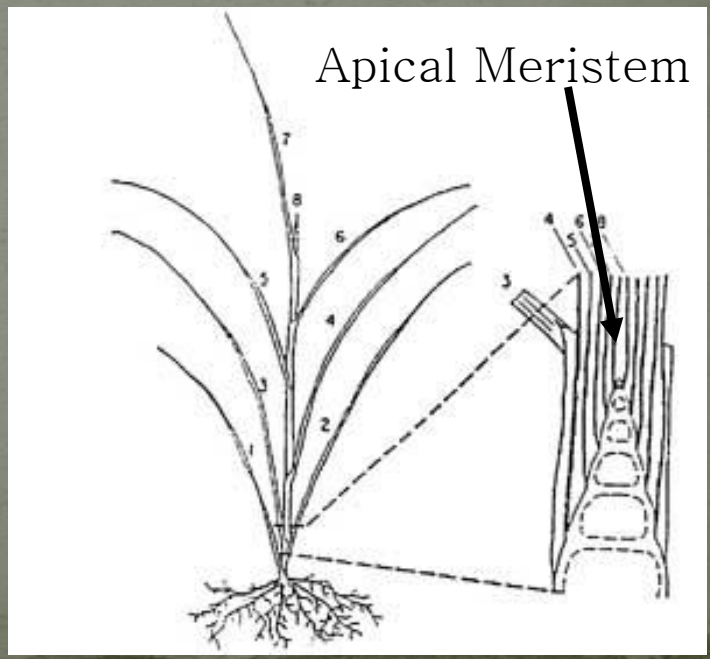
Vascular Cambium



Grass meristems

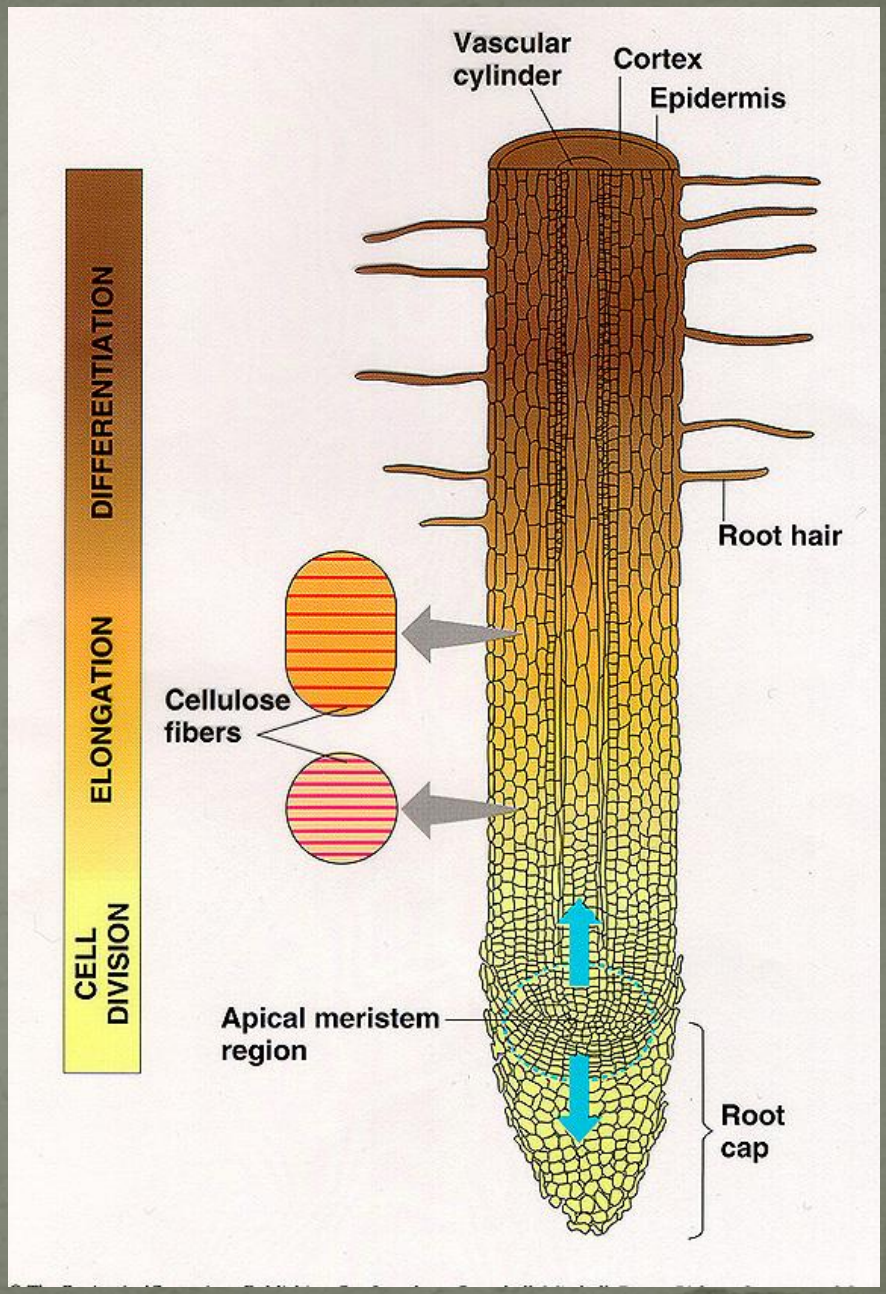
- Apical meristems
- Intercalary meristems





Root meristems

- apical meristems
  = root tips

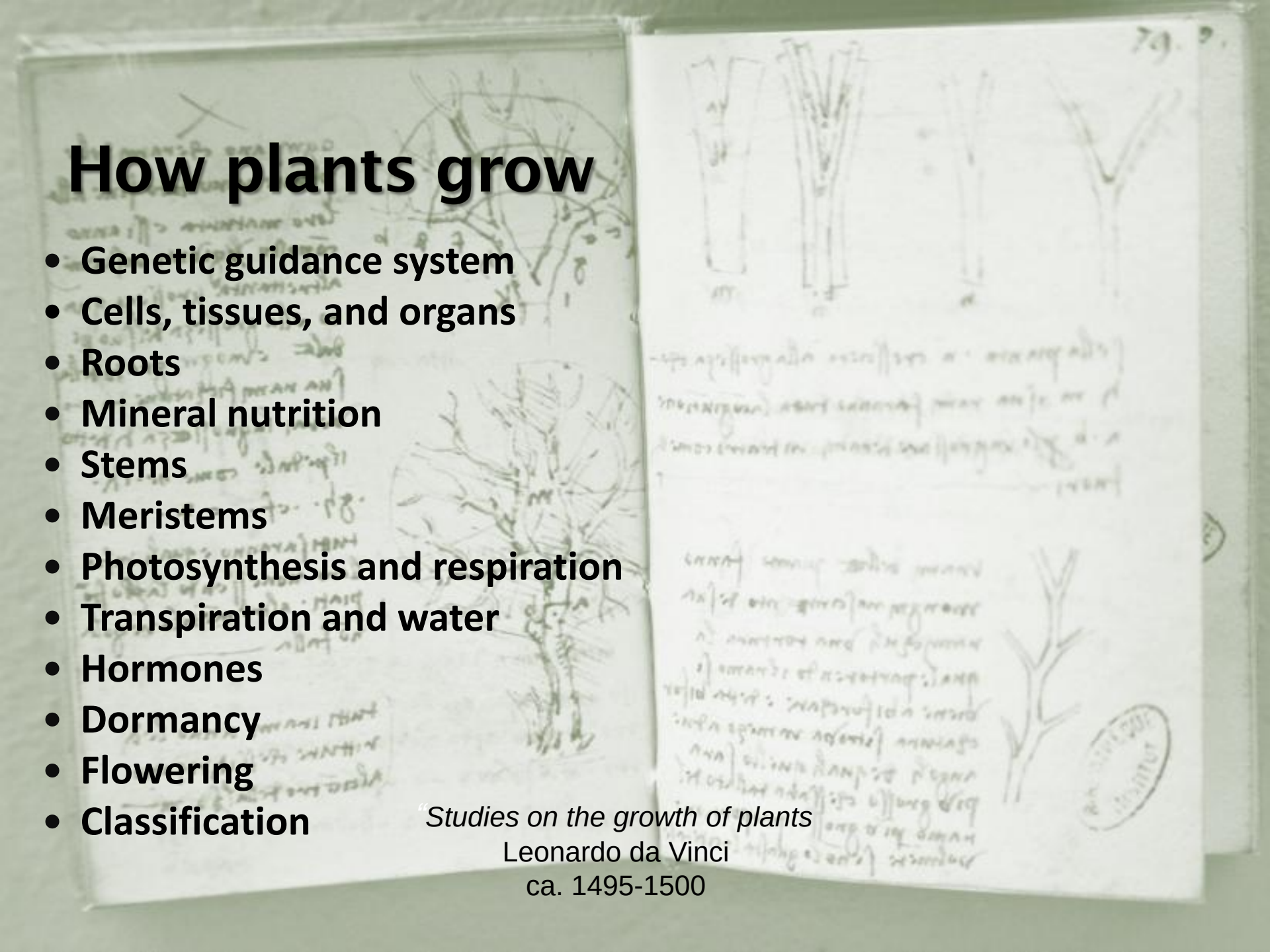


Homework

- Take a walk around your home landscape or garden and look at herbaceous and woody plants.
- Consider the plant's structure: What makes the plants and their parts so different ?
- Consider differences in the type of meristems and their location.

How plants grow

- Genetic guidance system
- Cells, tissues, and organs
- Roots
- Mineral nutrition
- Stems
- Meristems
- Photosynthesis and respiration
- Transpiration and water
- Hormones
- Dormancy
- Flowering
- Classification



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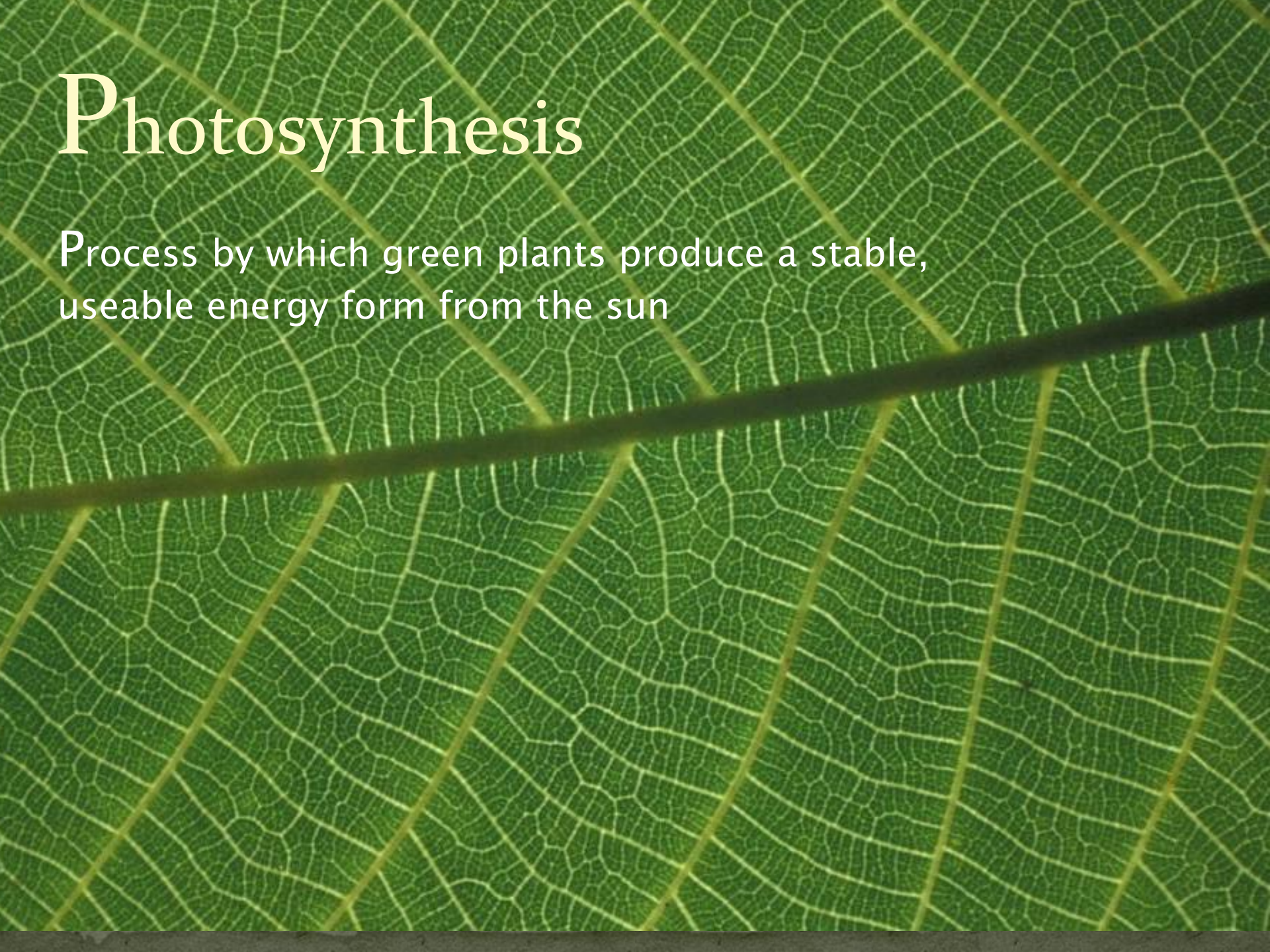
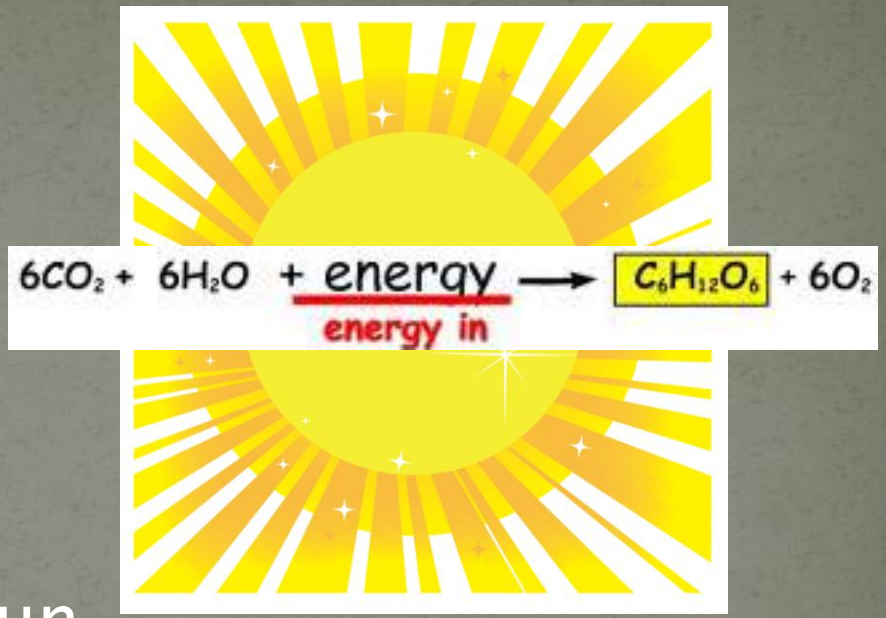
Leonardo da Vinci
ca. 1495-1500

Photosynthesis

Process by which green plants produce a stable, useable energy form from the sun

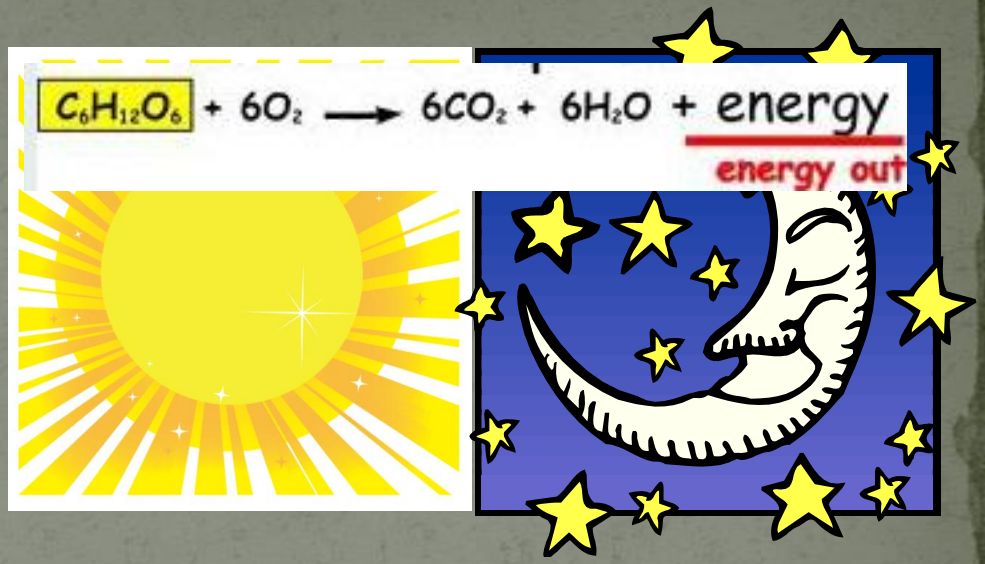


Photosynthesis



- Light energy from the sun
- Carbon dioxide from the air
- Water and minerals from roots and soil
- Sugars and carbohydrates produced
- Oxygen produced

Respiration



- Oxygen from the air
- Stored sugar and carbohydrate
- Energy produced
- Carbon dioxide produced

Photosynthesis versus Respiration

Photosynthesis

- only in light
- only in green tissue such as leaves and some stems

Respiration

- occurs in the dark and light
- occurs in all living tissue
- enzyme regulated and rate is dependent on temperature

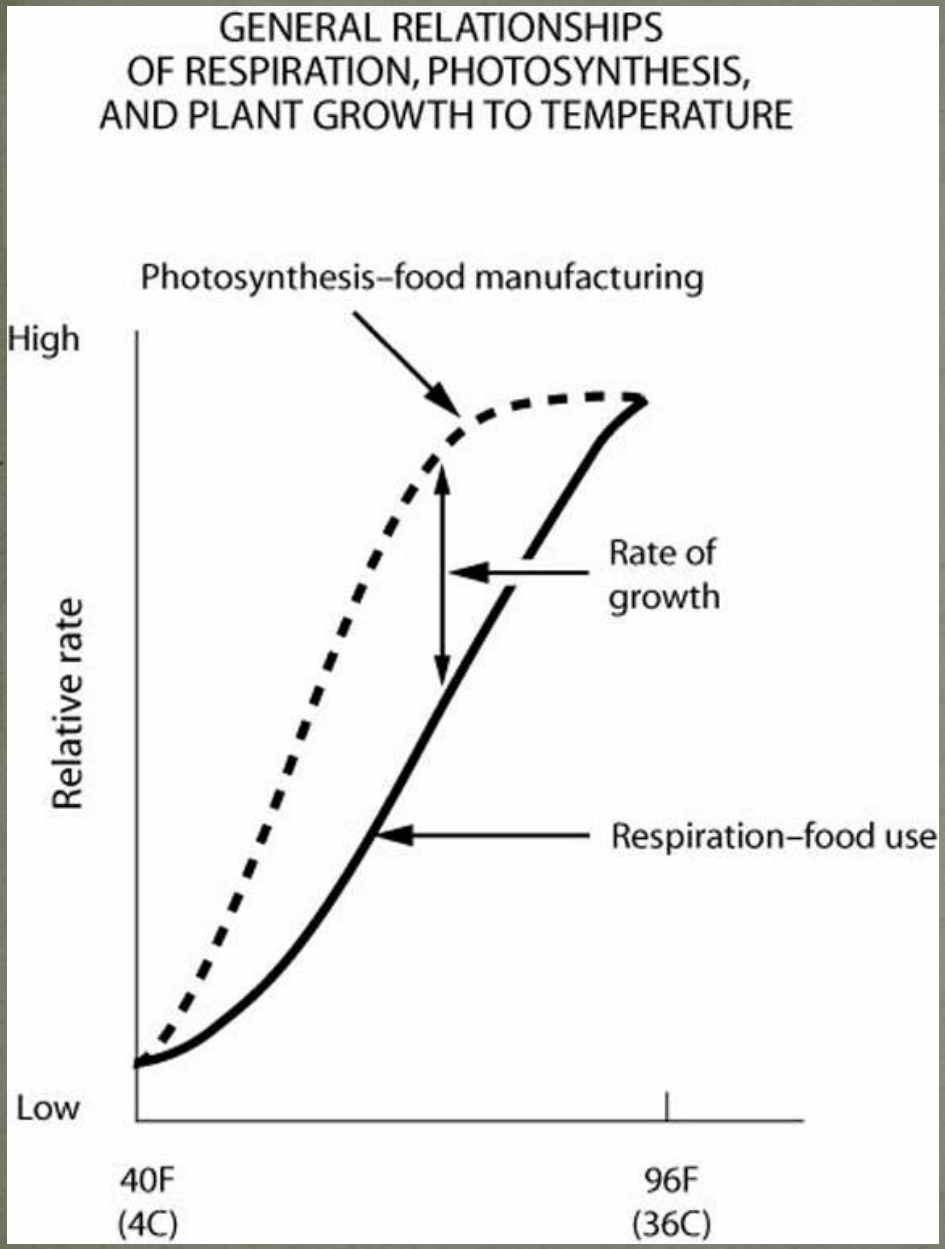


Photo. >Resp. = Plant Growth

Photo. < Resp. = Plant Death

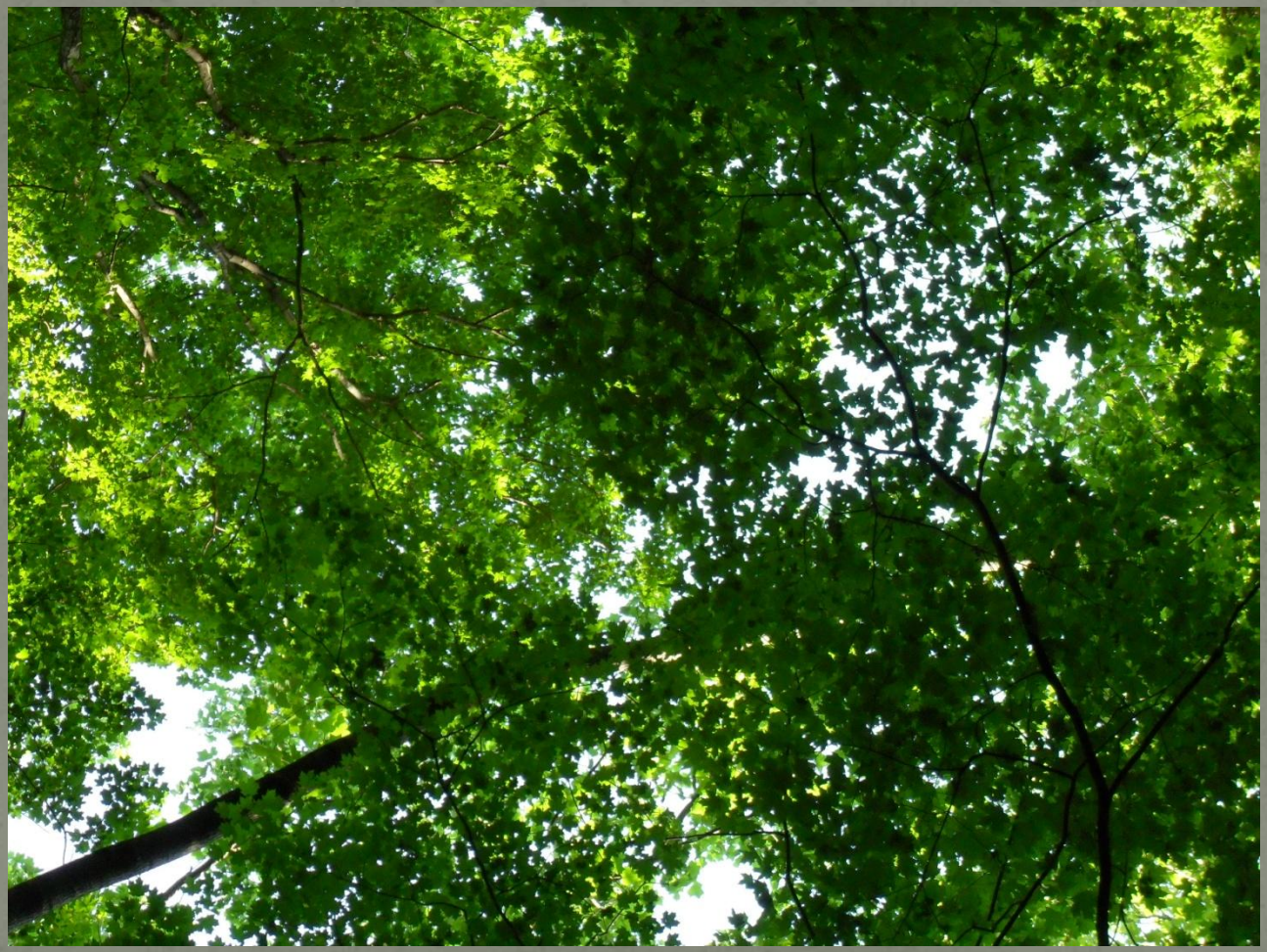
Respiration nearly doubles for every 18°F rise in temperature between 40°F and 96°F

Photosynthesis versus Respiration

What happens when you put a plant in the dark?

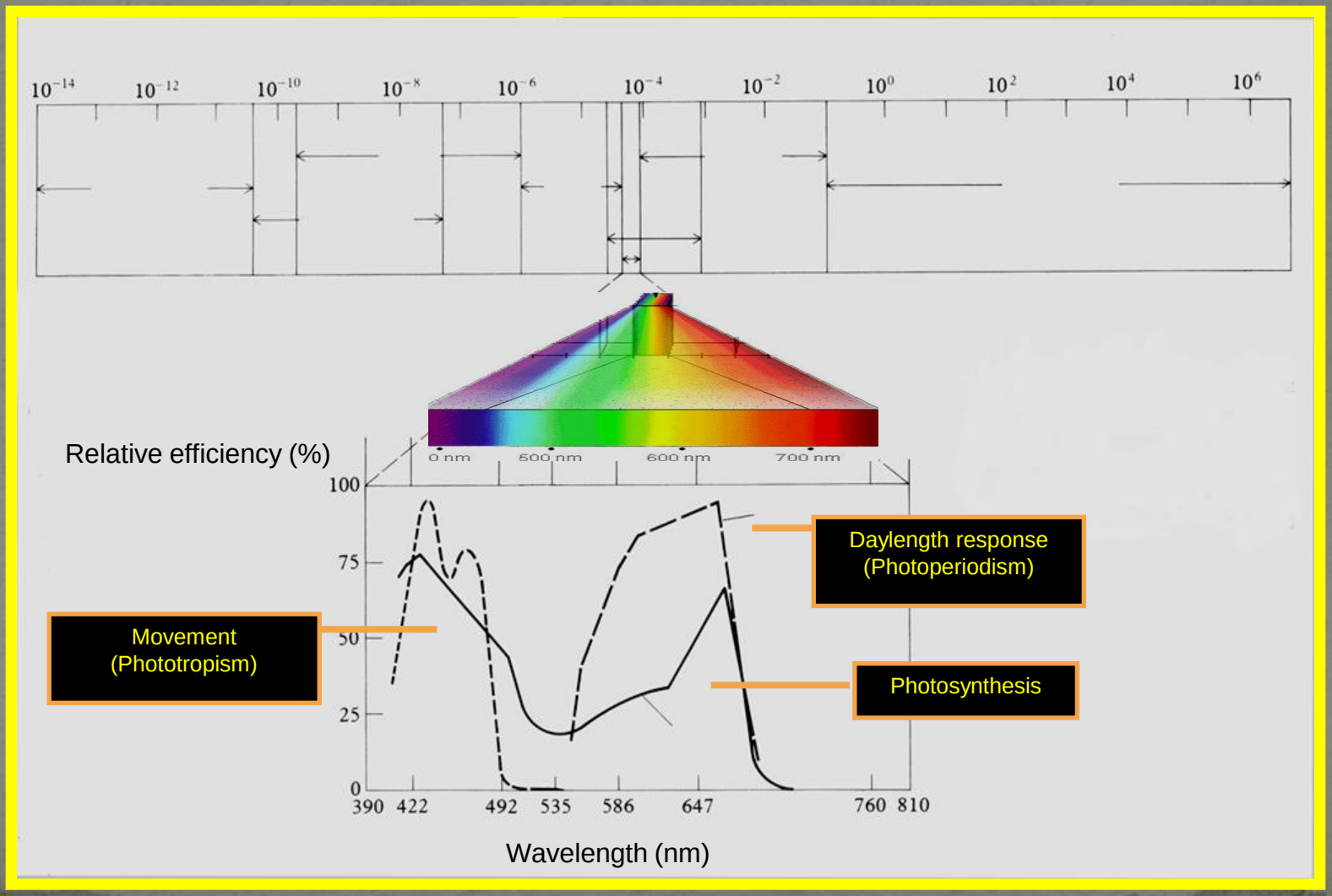
What happens when you pick and store fruit or vegetables?

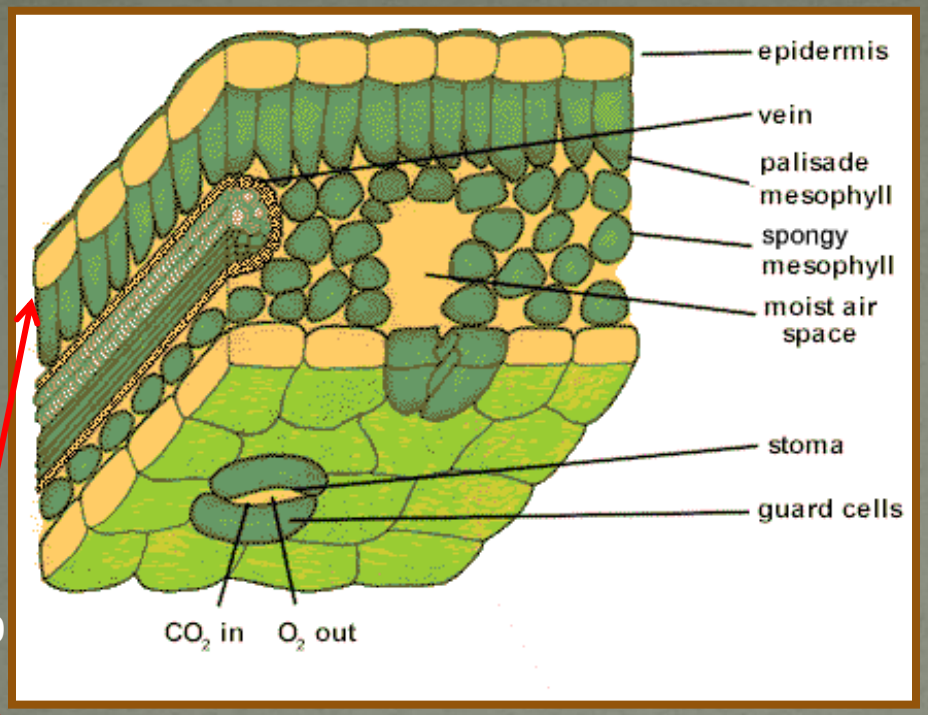
Plants intercept light



People try to intercept light

Plants use different parts of sunlight





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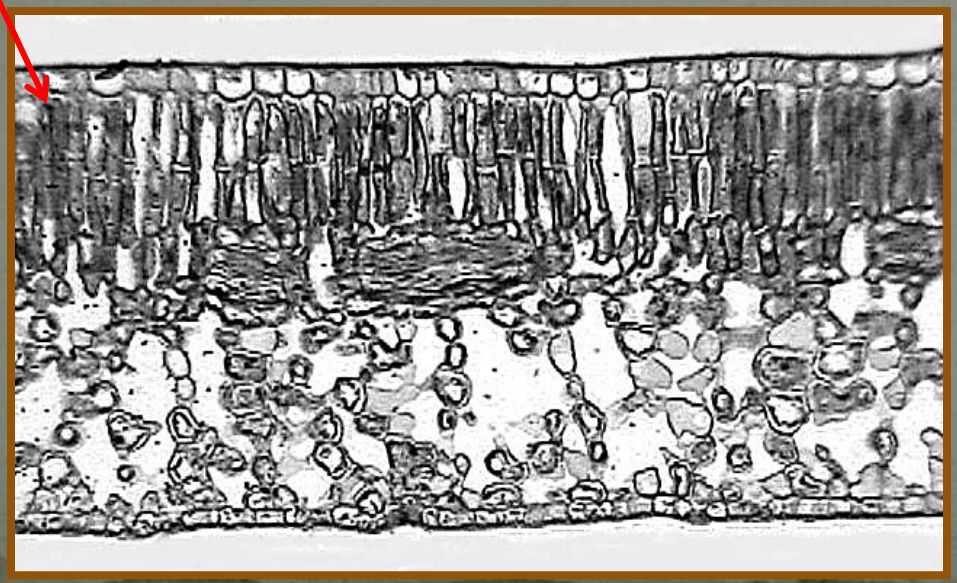
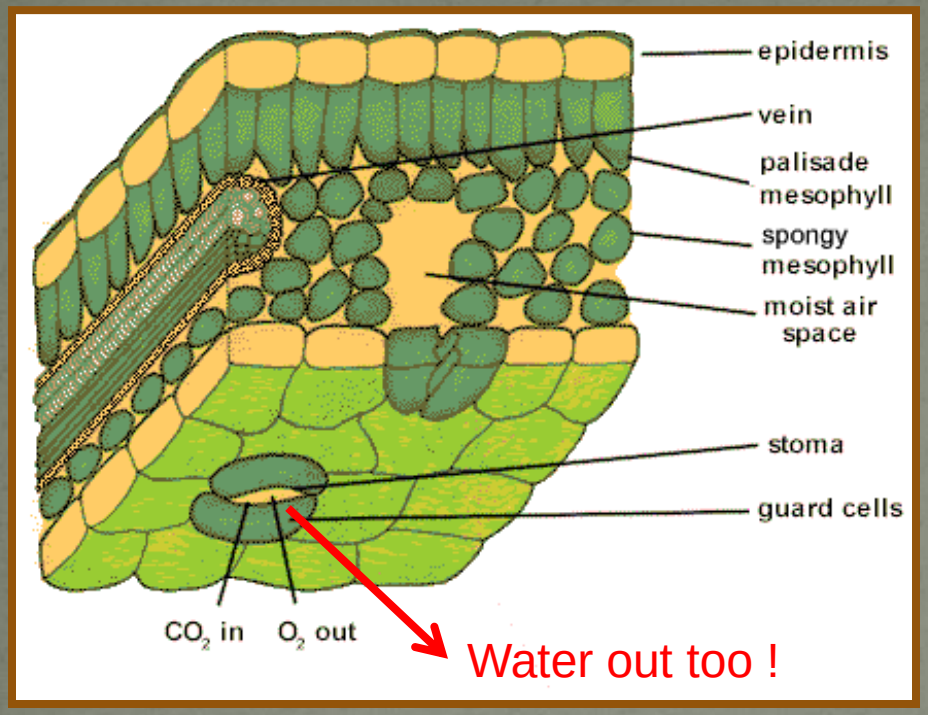
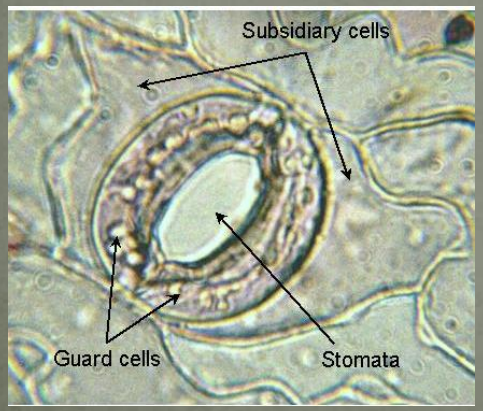
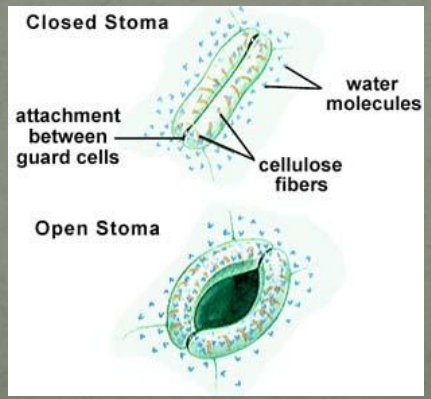


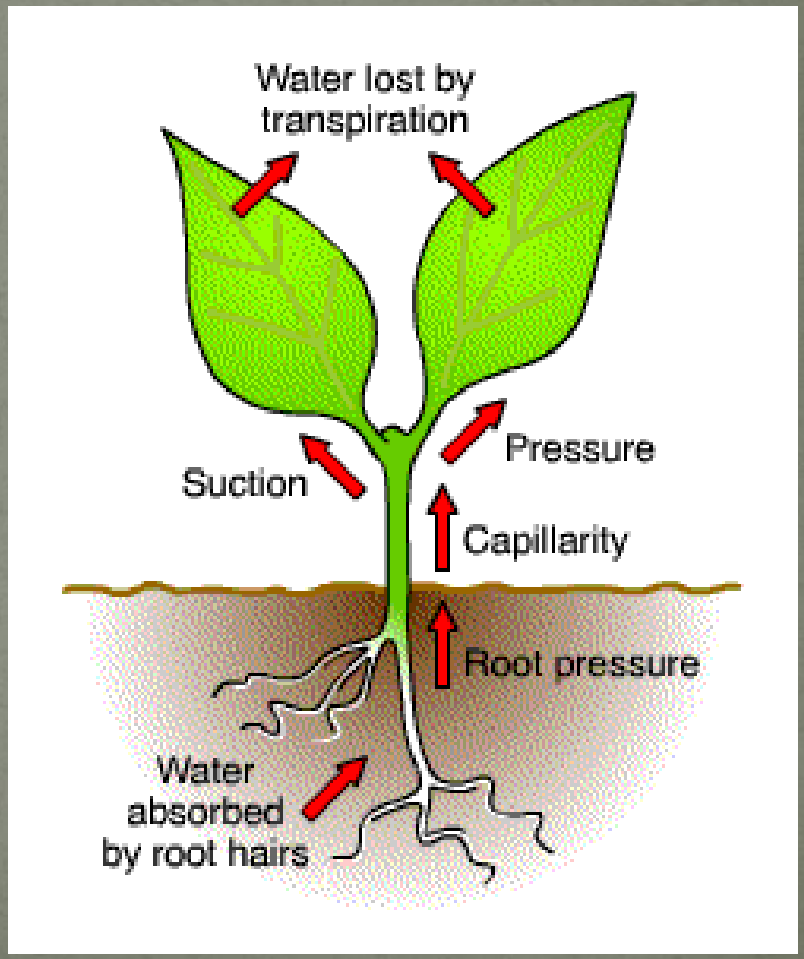
Plants need to absorb carbon dioxide

Transpiration

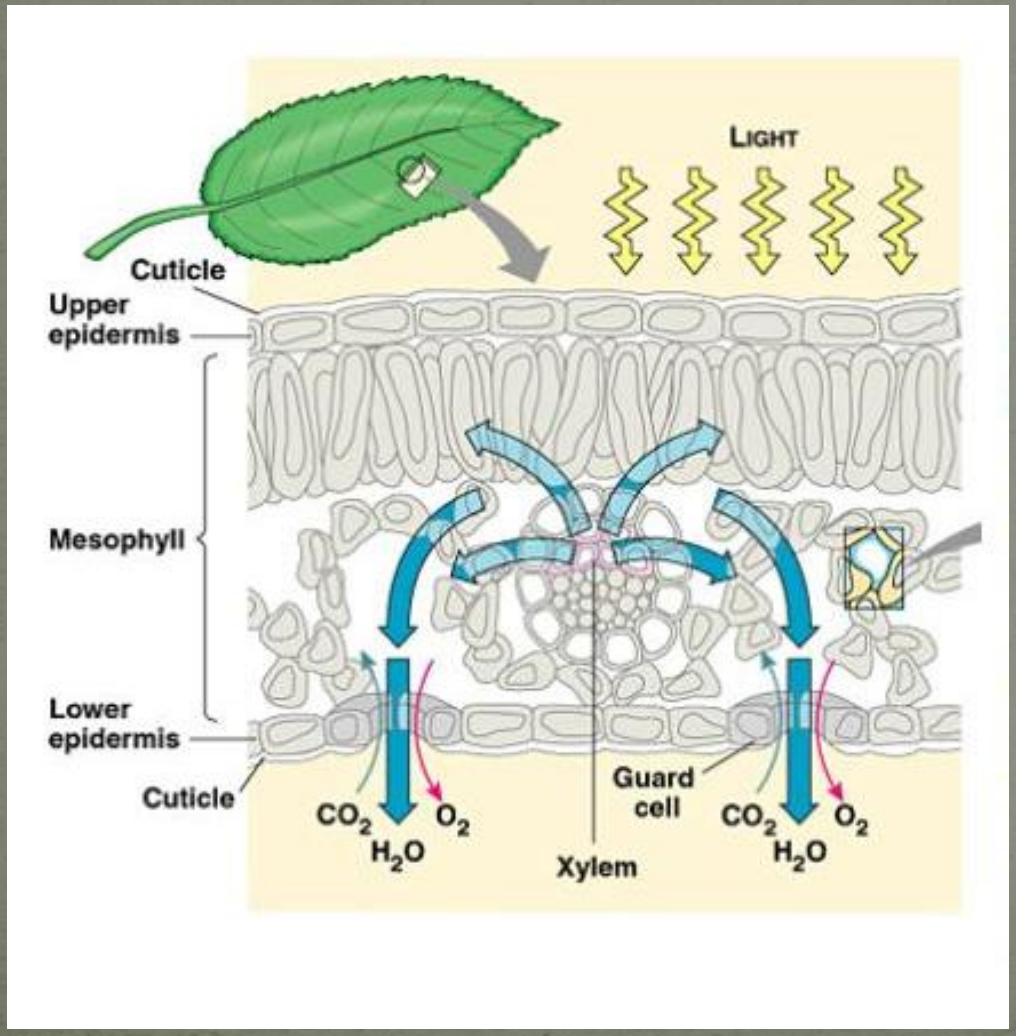








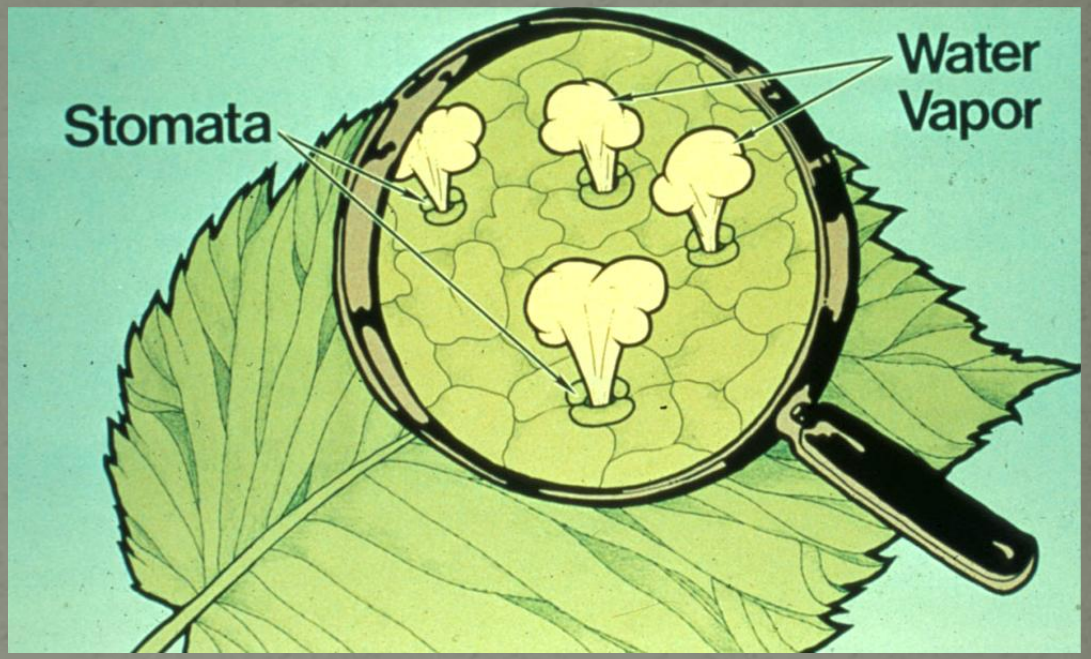
Transpiration



- Evaporation of water cools leaf
- Evaporation of water “pulls” water up through the plant

Factors Affecting Transpiration

- Light
- Temperature
- Humidity
- Wind Velocity
- Soil Moisture



Photosynthesis versus Respiration

What happens when you limit soil water ?

How might these affect plant growth?


Powdery mildew


Rust


Magnesium deficiency


Mosaic virus

Homework

- Consider this and explain in the context of photosynthesis and respiration balance…..
- There is tenacious dandelion that keeps popping up in a container of bedding plants. You keep picking the shoots off, and again it comes up, you pick off the shoots, and again…..
- If you are tenacious in your picking, why do you eventually win?

How plants grow

- Genetic guidance system
- Cells, tissues, and organs
- Roots
- Mineral nutrition
- Stems
- Meristems
- Photosynthesis and respiration
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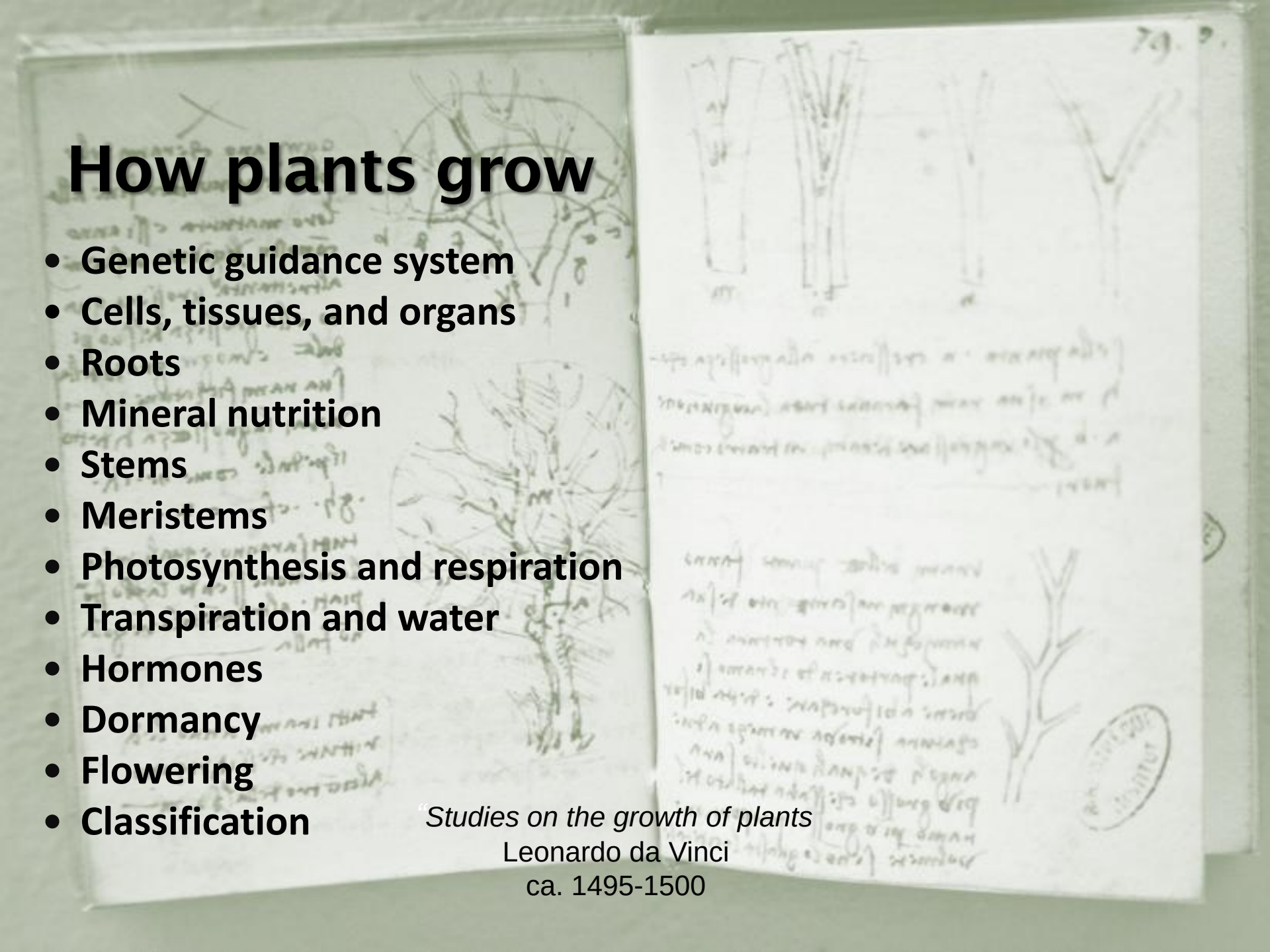
- Flowering
- Classification



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Leonardo da Vinci
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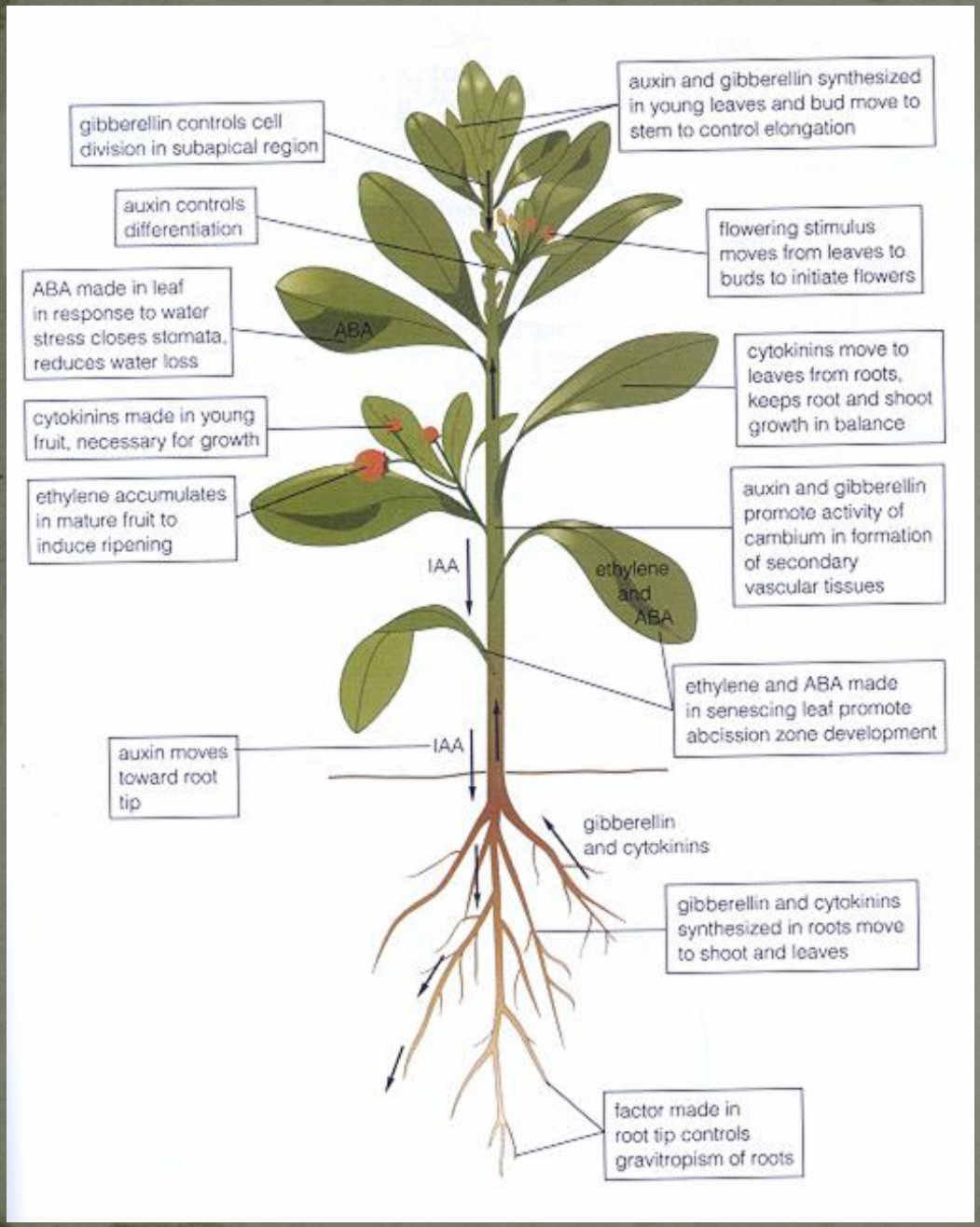
Plants respond to the environment

- Daylength
- Light intensity
- Light quality
- Temperature
  - Interactions of photoperiod and temperature
- Soil moisture conditions
- Carbon dioxide and oxygen concentration



Hormones

- Auxins
- Cytokinins
- Gibberillins
- Ethylene
- Abscisic acid (ABA)

Dormancy

Mechanism to survive adverse conditions

- Must have stored food reserves to support respiration
- Physical dormancy
  - Closed cone
  - Hard seed coat
- Physiological dormancy
  - Day length
  - Chill hours (fruit trees, bulbs)

Chilling Requirements to Break Winter Rest

Flower induction

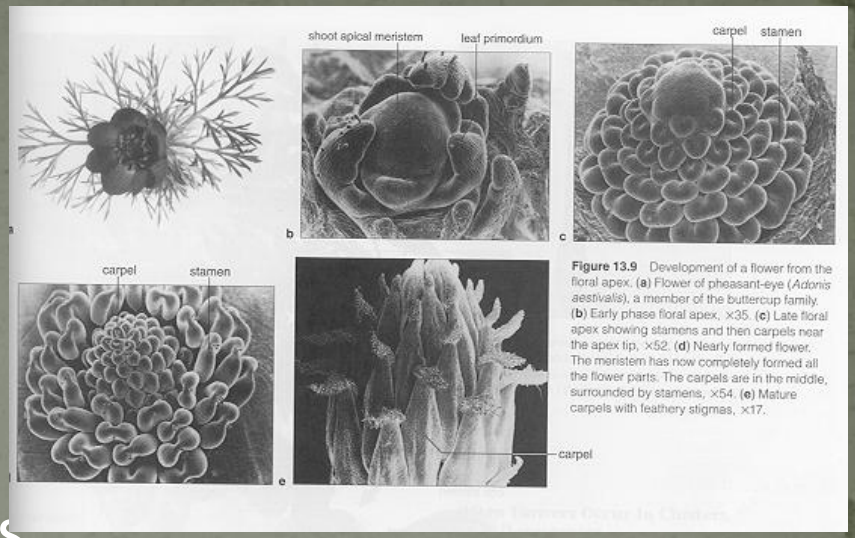


Figure 13.9 Development of a flower from the floral apex. (**a**) Flower of pheasant-eye (*Adonis aestivalis*), a member of the buttercup family. (**b**) Early phase floral apex, ×35. (**c**) Late floral apex showing stamens and then carpels near the apex tip, ×52. (**d**) Nearly formed flower. The meristem has now completely formed all the flower parts. The carpels are in the middle, surrounded by stamens, ×54. (**e**) Mature carpels with feathery stigmas, ×17.

- Meristems receives "signal" to change from a vegetative flowering state
- Timing differs among species
  - Annuals may flower within weeks of germination
  - Biennials and Perennials
  - Many woody perennials initiate flowers in previous year

- Can be controlled by day length, light intensity, air temperature, soil moisture, carbohydrate, mineral nutrition

Flower induction by day length

- Short-day plants - light period usually less than 12 hours long (chrysanthemum, poinsettia, strawberry)
- Long-day plants - light period usually more than 14 hours long (fuchsia, spinach, perennial ryegrass)
- Day neutral - processes not affected by day length (fruits and nuts, grapes, corn)

Flower pollination and fertilization

- Controlled by environmental cues: **day length,** light intensity, temperature, soil moisture content, nutritional status of plant
- Pollination - self-, cross- (wind, insect)
- Fertilization
  - Only fraction of flowers normally mature
  - “drop” at petal fall
  - “June drop” 4 to 6 weeks after petal fall

Reproductive Development

Fruit Quality and Ripening

Sugars and aromatic compounds begin to accumulate

- Some fruits picked when physiologically mature but not fully ripe
  - Tomato, banana, avocado, apples
- Other fruits must be allowed to mature on plant
  - Grapes, citrus, strawberries

How plants grow

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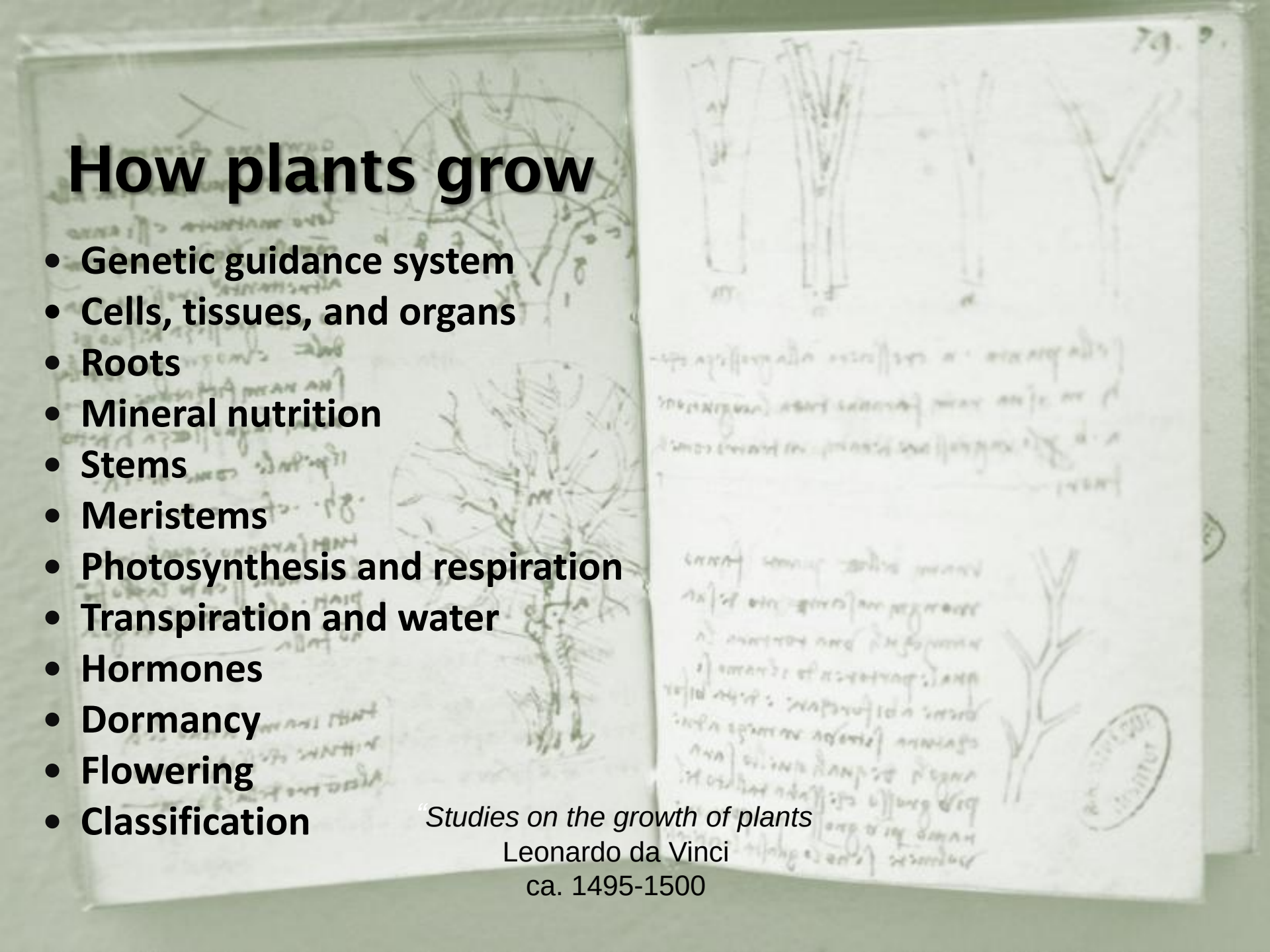

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Plant Classification

Plant Classification

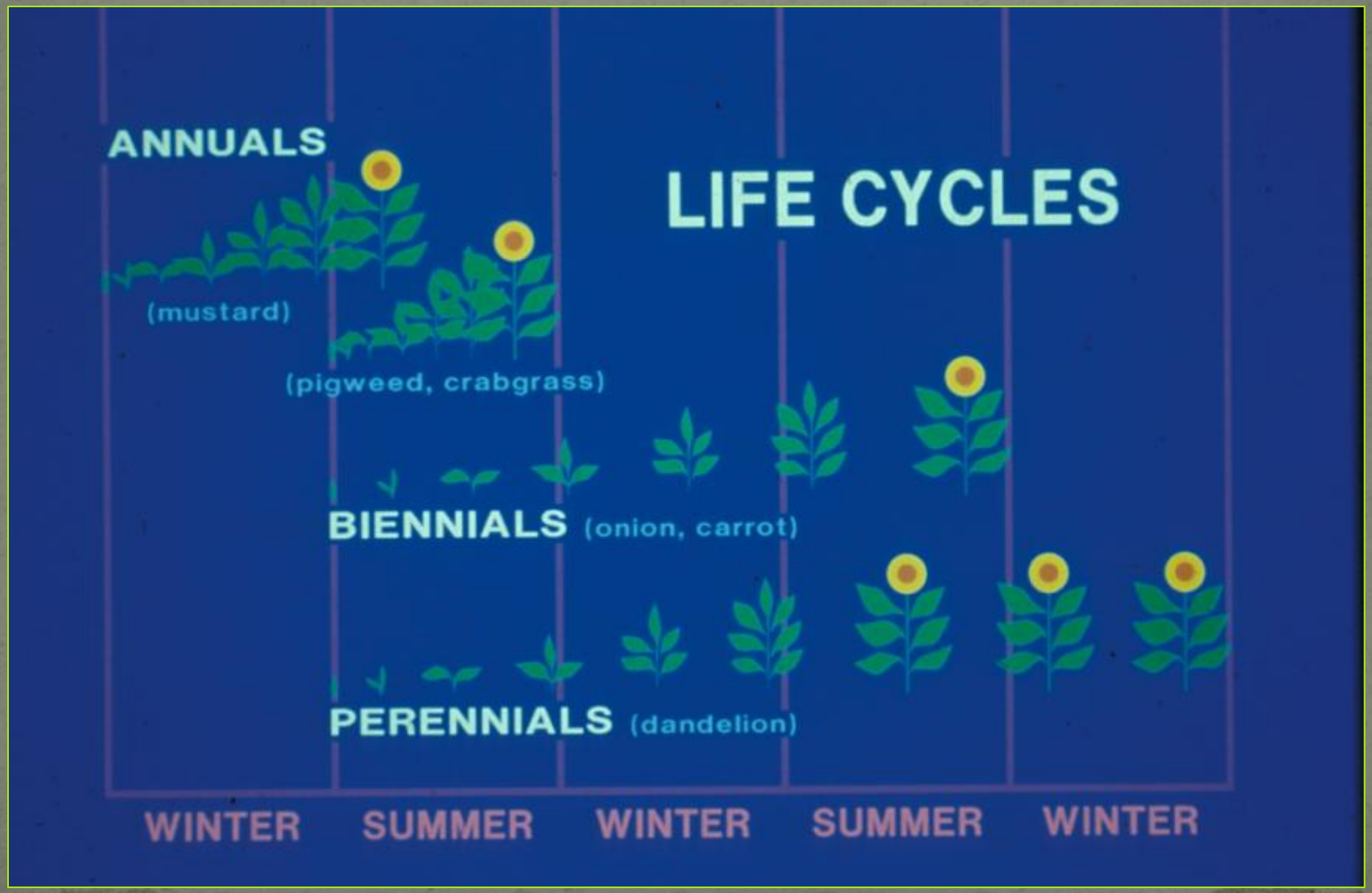
- Growth Habit
- Structure or Form
- Leaf retention
- Climatic Adaptation
- Use
- Botanical or Scientific Classification
  - Flower or fruit characteristics
- Genetic relationships

Plant Classification

Growth Habit

- Annuals
  - complete a life cycle (seed to flowering to re-seeding) in one growing season and then die
- Perennials
  - may go through repeated flowering and seeding cycles before dying
  - may grow for several years before flowering and dying
- Biennials

Plant Classification



Plant Classification

Structure or Form

- Herbaceous -- tender stemmed species
- Woody -- hard fibrous stems
  - Form
    - Vine
    - Shrub
    - Tree (includes tree shape also…weeping, vase, etc.)

Plant Classification

Leaf retention

- Deciduous
- Evergreen
  - broad-leaved -- azaleas, some magnolias
  - needle-leaved -- pine, redwood

Plant Classification

Climatic Adaptation

- Perennial plants are classified according to minimum temperatures they will tolerate
  - tropical, subtropical, temperate
- Cool- and warm-season plants
  - cool season grow best with average daytime temperatures of 55º to 75º F (carrot, asparagus, spinach, broccoli)
  - warm season grow best with average daytime temperatures of 65º to 95º F (tomato, sweet corn)

Plant Classification

Use

- Fruits
- Herbs
- Vegetables

Plant Classification

Botanical or Scientific Classification
Similar morphology, flowers, fruit, and vegetative characteristics

- Genus + specific epithet
  - Together called the species
- Red Raspberry (common name)
  - *Rubus idaeus*, or Rubus ideaus
- Botanical Variety (natural heritable)
  - *Pisum sativum var. sativum* (common pea)
  - *Pisum sativum var. saccharatum* (sugar pea)
- Cultivated Variety (cultivar)
  - *Liquidamber styraciflua* 'Palo Alto'
  - *Liquidamber styraciflua* cv. Palo Alto

Plant Classification

Most horticulturally important plants belong to

- Coniferphyta - cone-bearing plants
  - Gymnosperms - seeds exposed at base of scales
- Anthrophyta - true flowering plants
  - Angiosperms - seeds buried in fruit developed from ovary
    - Monocots - “one seed leaf” - *Gramineae* grasses
    - Dicots - “two seed leaves” - *Rosaceae*

Plant Classification

- Monocots - “one seed leaf” - *Gramineae* grass
- Dicots - “two seed leaves” - *Rosaceae*

Monocots	Dicots
Vascular tissues scattered in stem	Vascular tissues in circular pattern
Flower parts in three	Flower parts in 4-5 or multiples
Leaf veins parallel	Leaf veins branched

How plants grow

- Genetic guidance system
- Cells, tissues, and organs
- Roots
- Mineral nutrition
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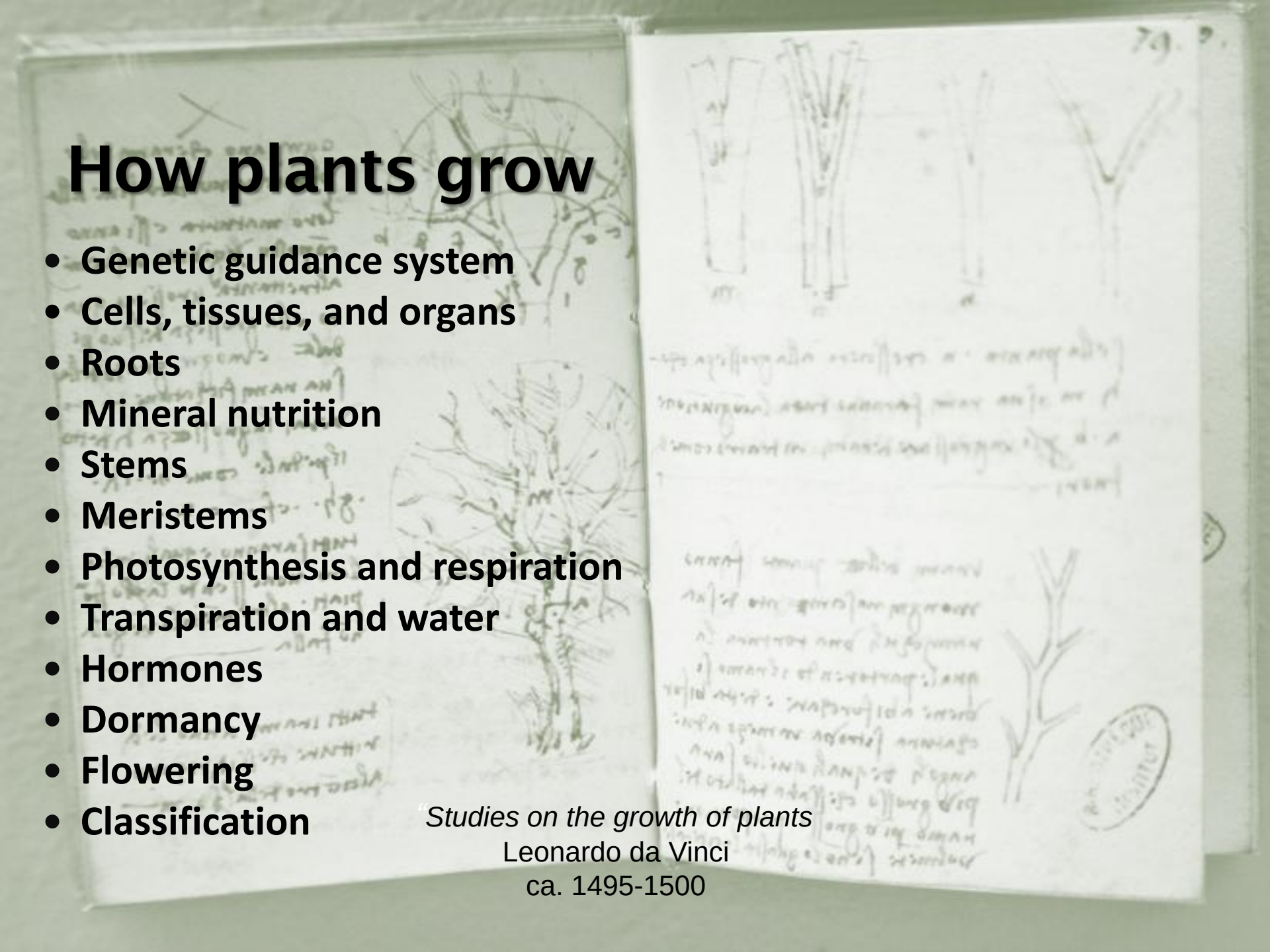

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Tired ?

Homework

Time to go home……