How plants work:

plant science for the desert Master Gardener

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Note

- Throughout this presentation, I will attempt to avoid saying “always” and “never”.
- So often, there is an exception to many rules that seemed hard and fast.

Pre class assessment

1. A stomate is
    1. An opening permitting gas & water to enter or leave a leaf
    2. A type of root system
    3. A means for the plant to attract pollinators
2. (T/F) It is possible for plant respiration to be considered the opposite of photosynthesis
3. The green pigment in a plant is a compound called _____

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Pre-class assessment (cont.)

4. (T/F) A long day plant requires more than 12 hours of light
5. Cactus spines may have different roles:
    1. Water conservation
    2. Plant defense
    3. Reproduction
    4. All of the above
    5. 1 & 2 only

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General Class Outline

1. Life
2. Plant Processes
3. Environment
4. Monocots & Dicots
5. Life Span
6. Structures
7. Desert Adaptations

Organization of living things

Animal	*Plant*
Kingdom	Kingdom
Phylum	Division
Class	Class
	Legion
Order	Order
Family	Family
	Tribe
Genus	Genus
Species	Species

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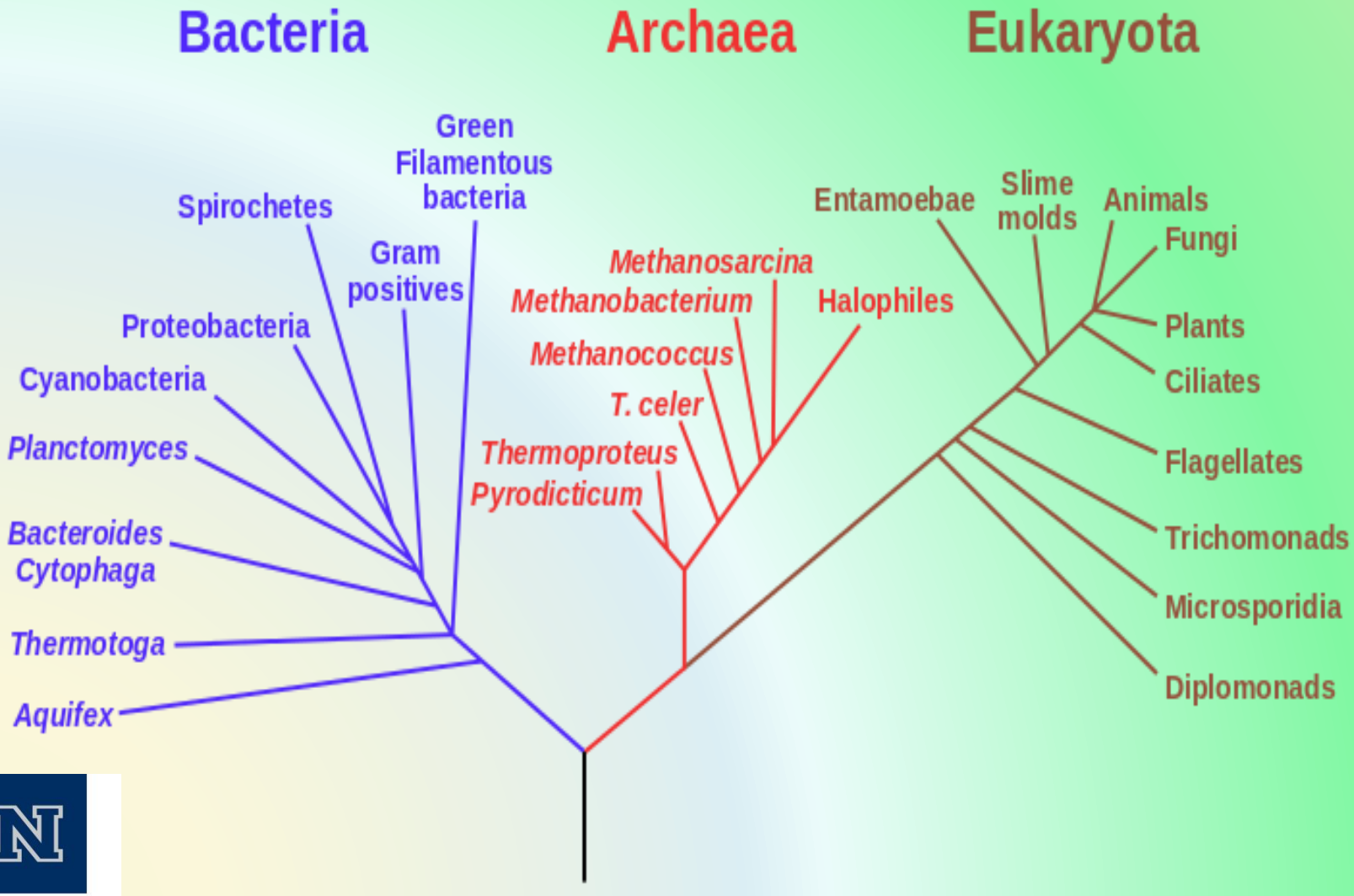
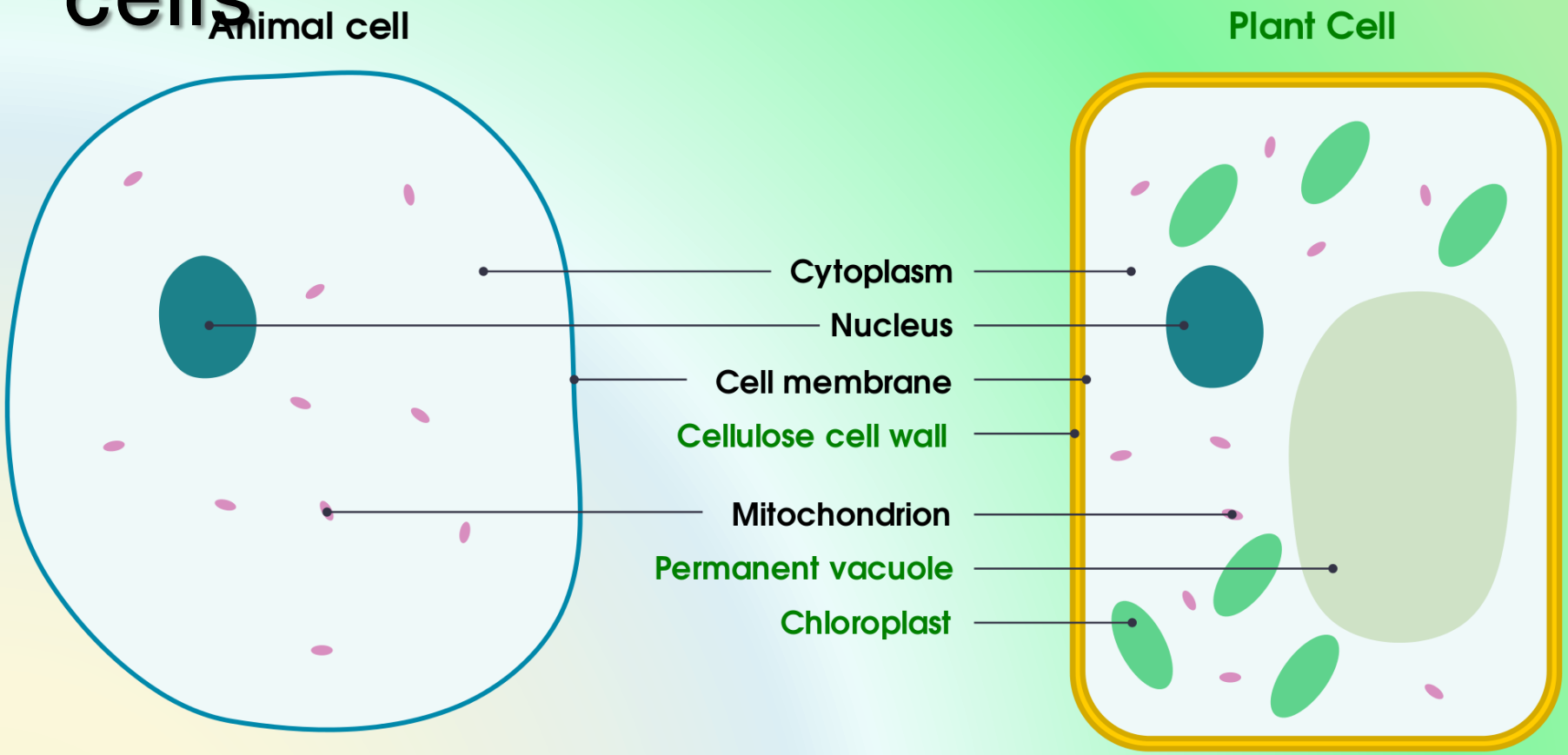
Phylogenetic Tree of Life

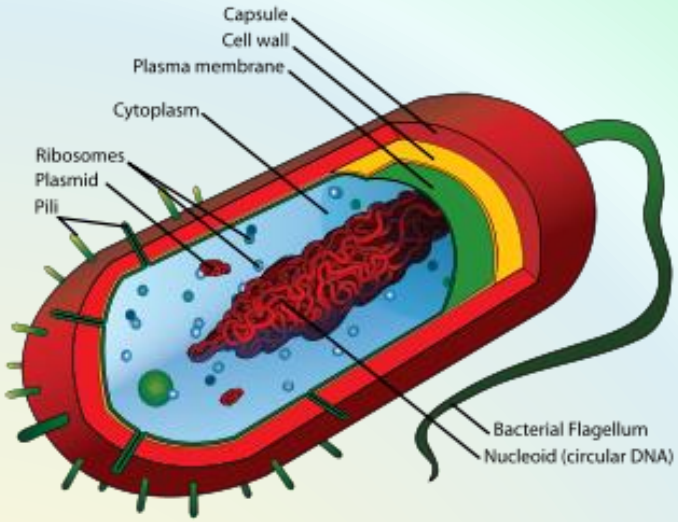


Living things are composed of cells



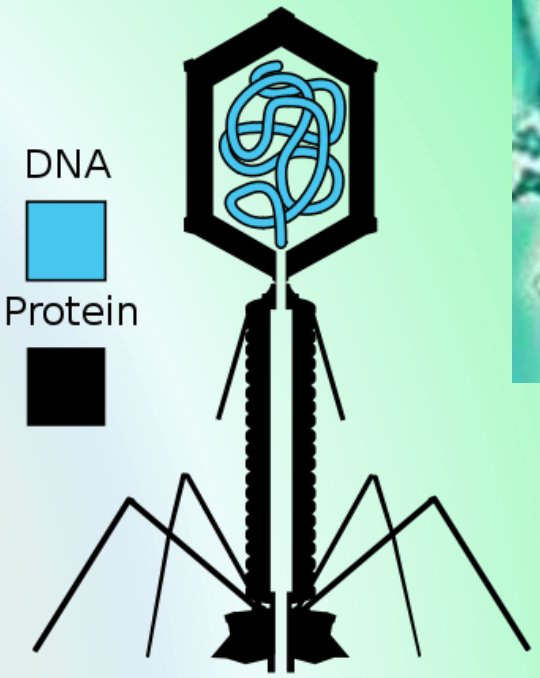
Simplified diagram comparing plant & animal cells (from wikimedia)

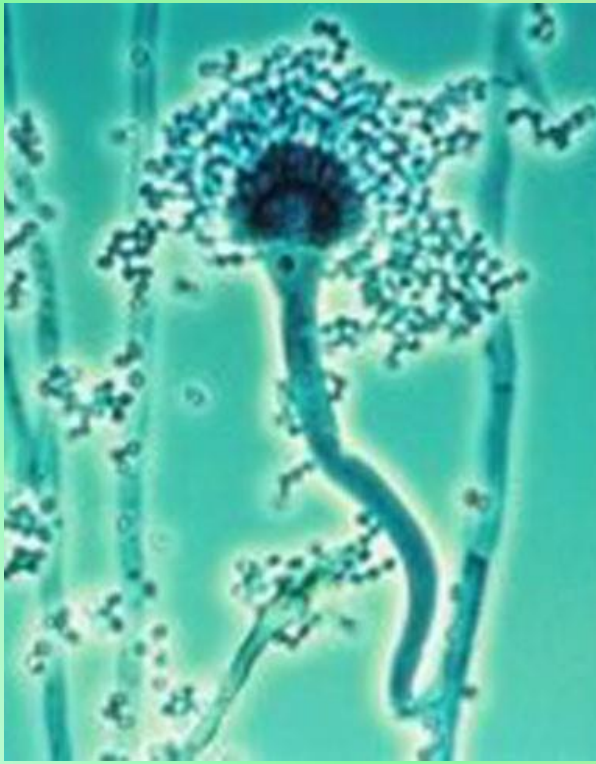
Even microorganisms



bacteria

viruses





fungi

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Plant Processes (Physiology)

- Photosynthesis
- Respiration
- Transpiration
- Reproduction
- Photoperiodicity

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Photosynthesis is the source of much life on earth

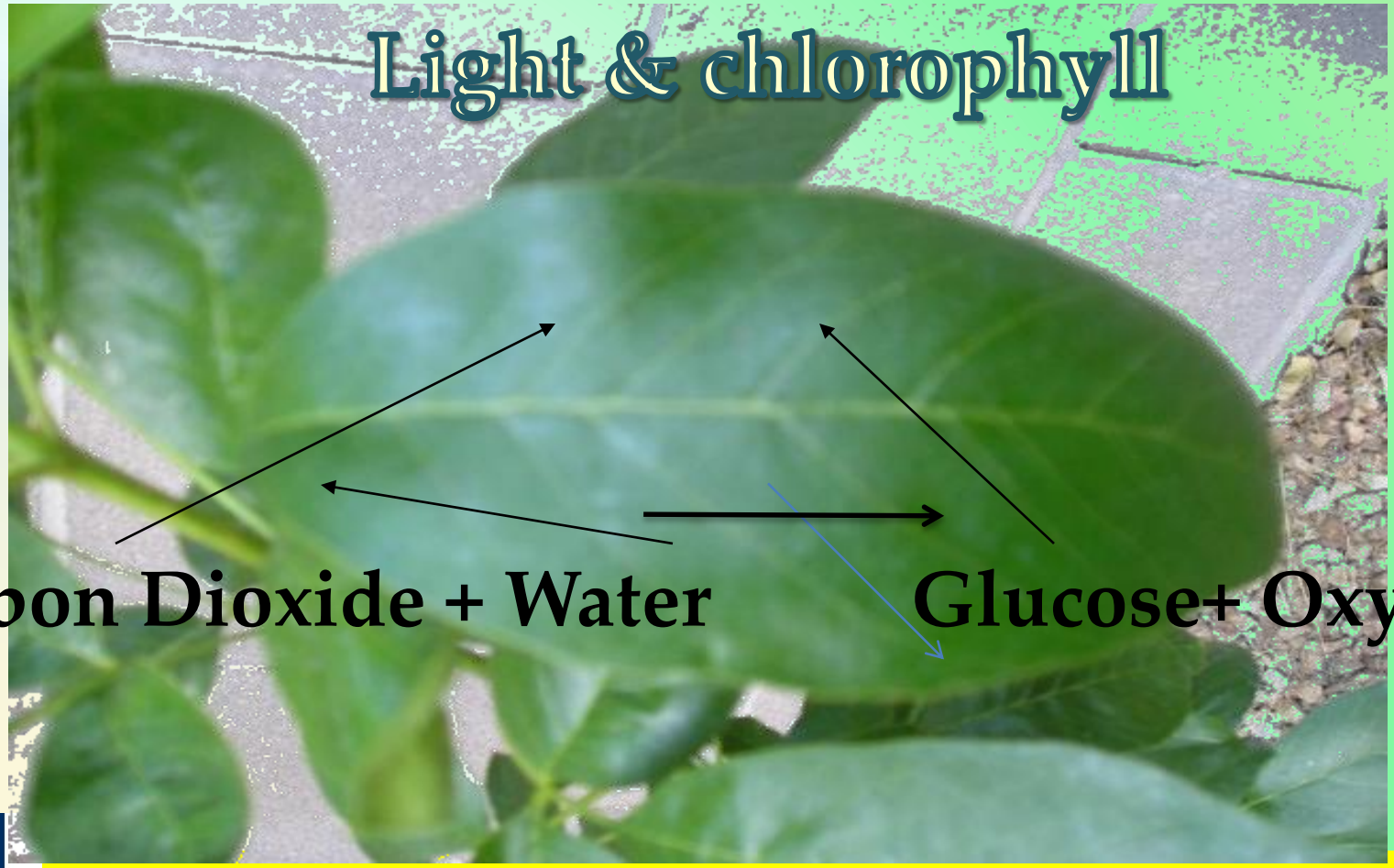

Photo = light Synthesis = making

Photosynthesis Summary

In the presence of light and chlorophyll:

$$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2$$

CO_2 = carbon dioxide

H_2O = water

$C_6H_{12}O_6$ = glucose (a sugar)

O_2 = oxygen

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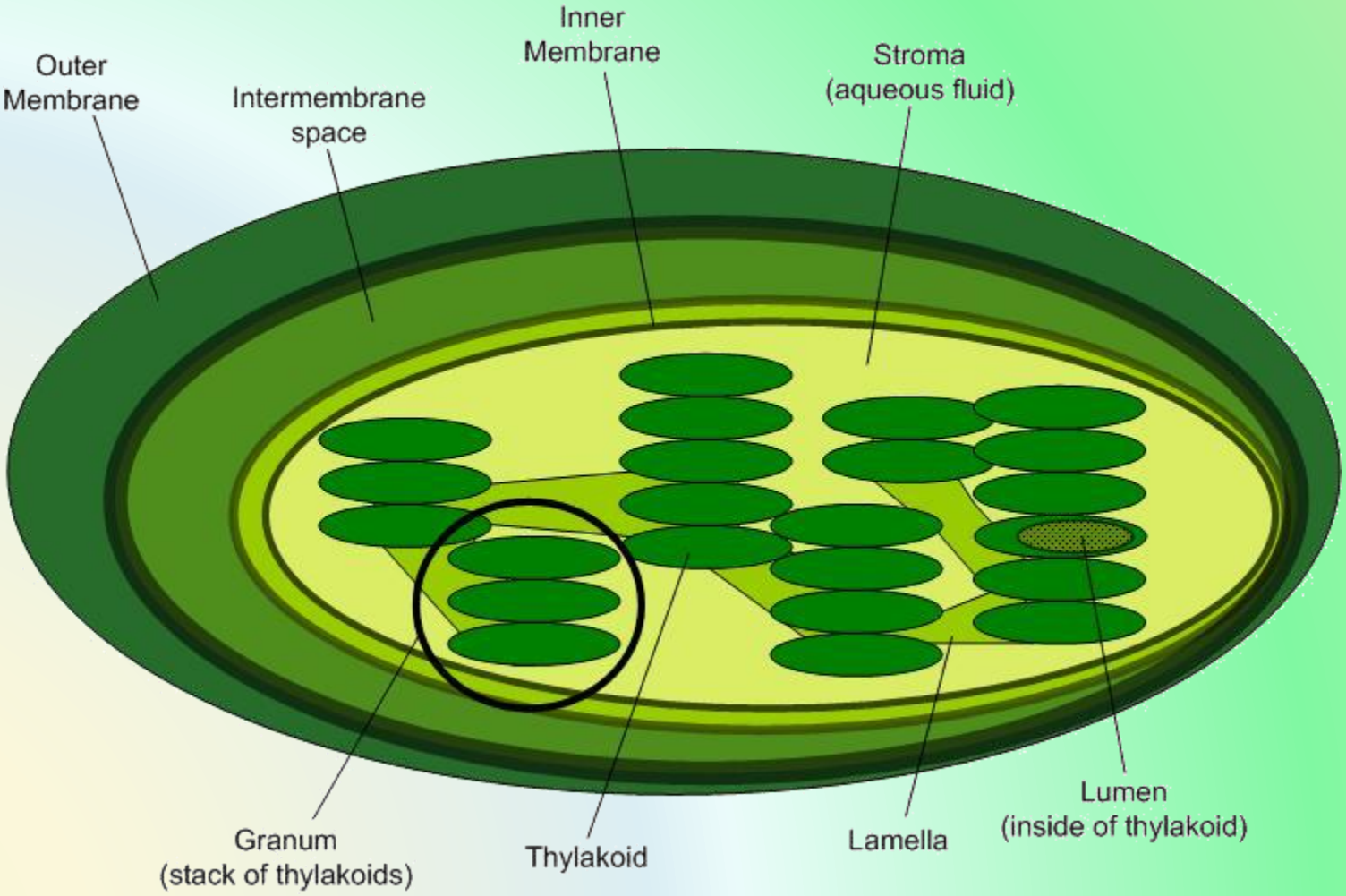
Inside a chloroplast



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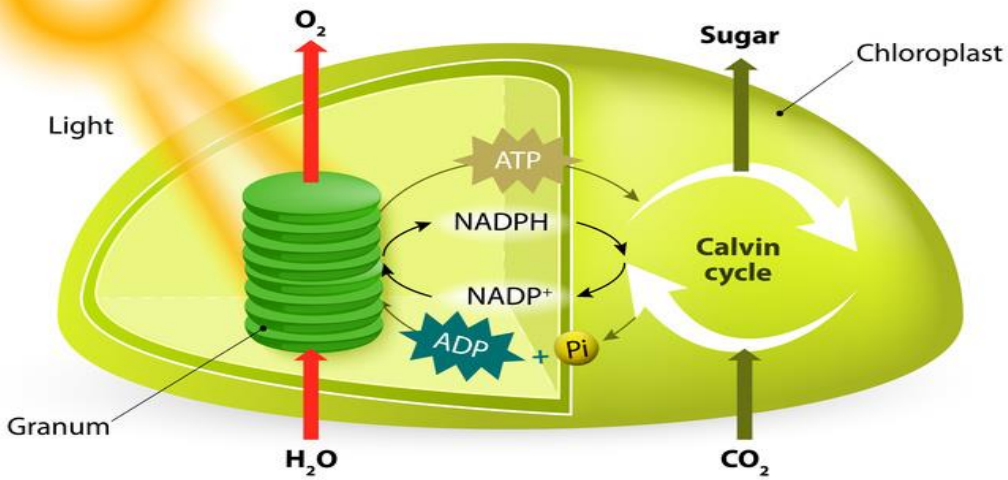
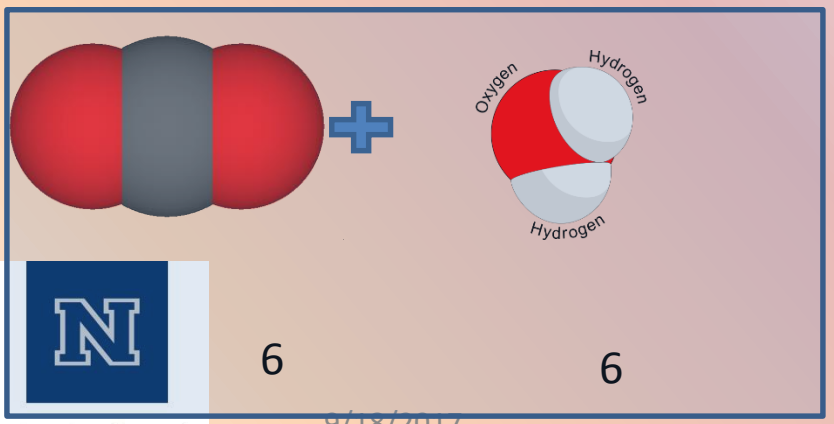
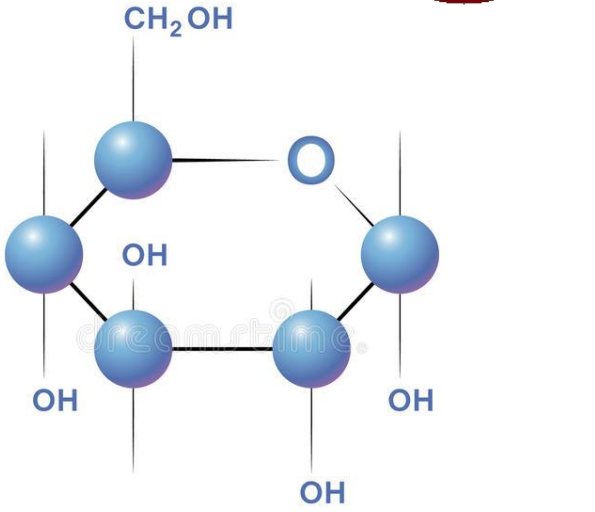
PROCESS OF PHOTOSYNTHESIS



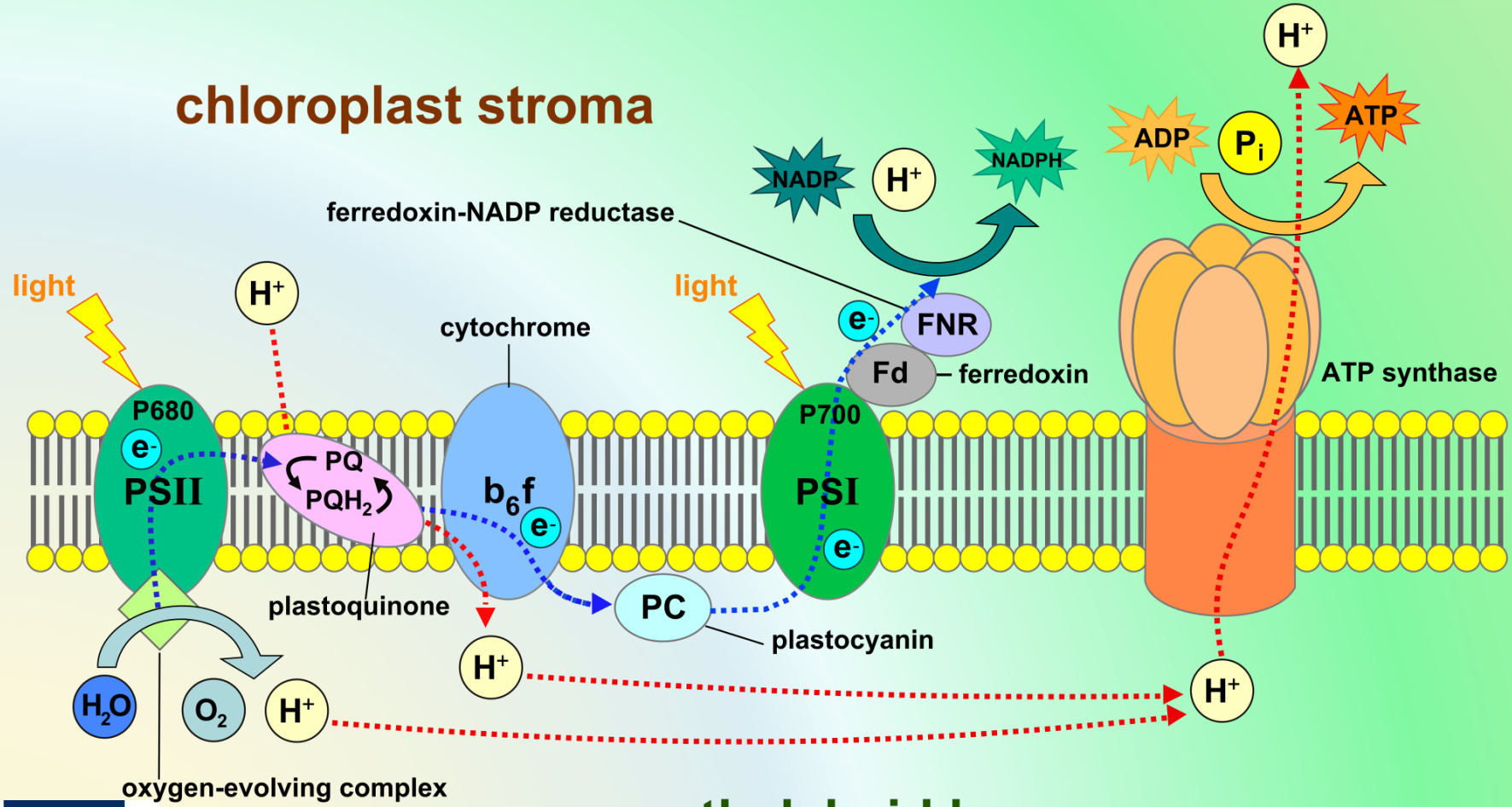


6



Glucose

Photosynthesis inside chloroplast



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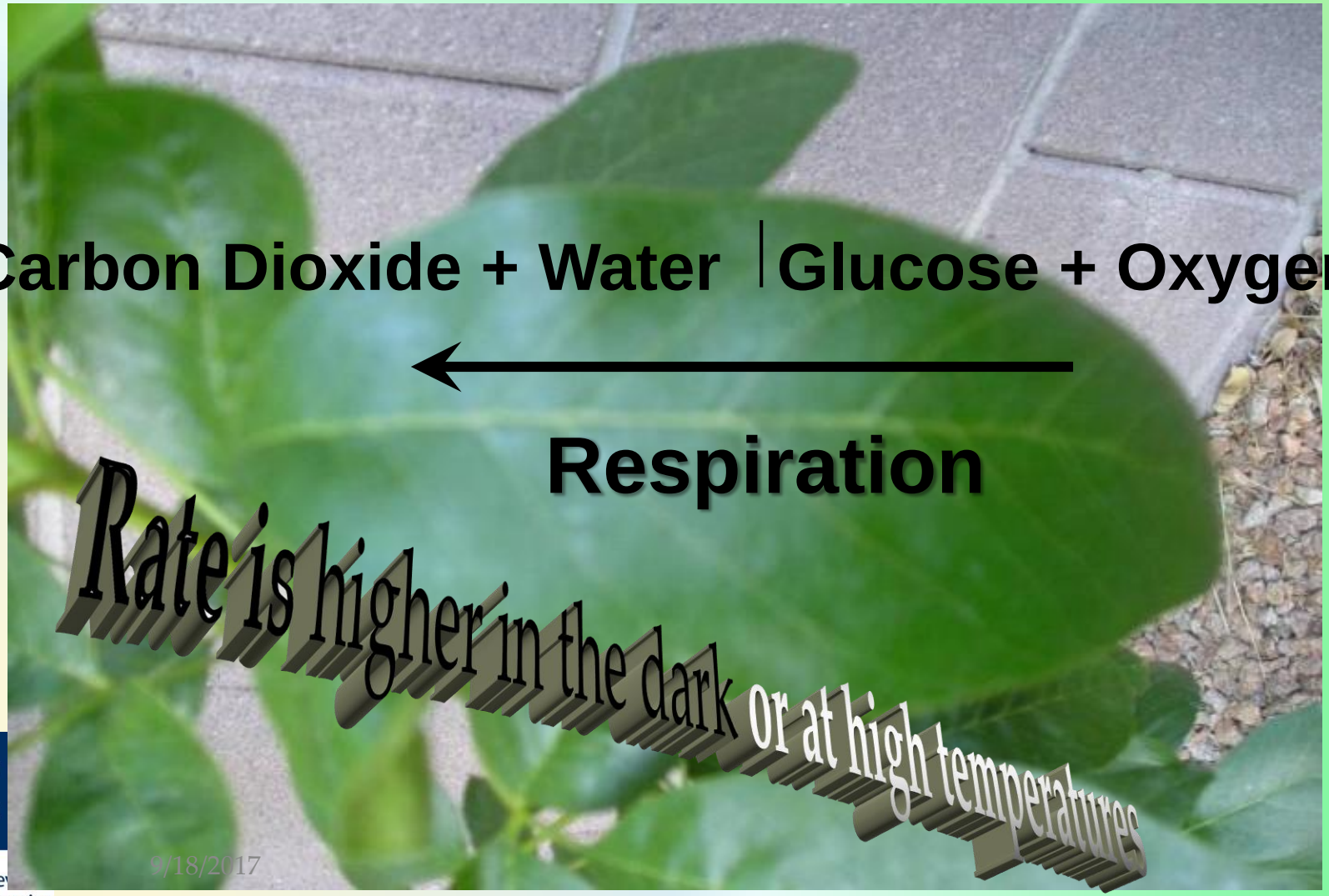
Respiration – breaks down sugar back into carbon dioxide & water



Summary –
sugar production & breakdown

Light is the energy source

Photosynthesis

Carbon Dioxide + Water → Glucose + Oxygen

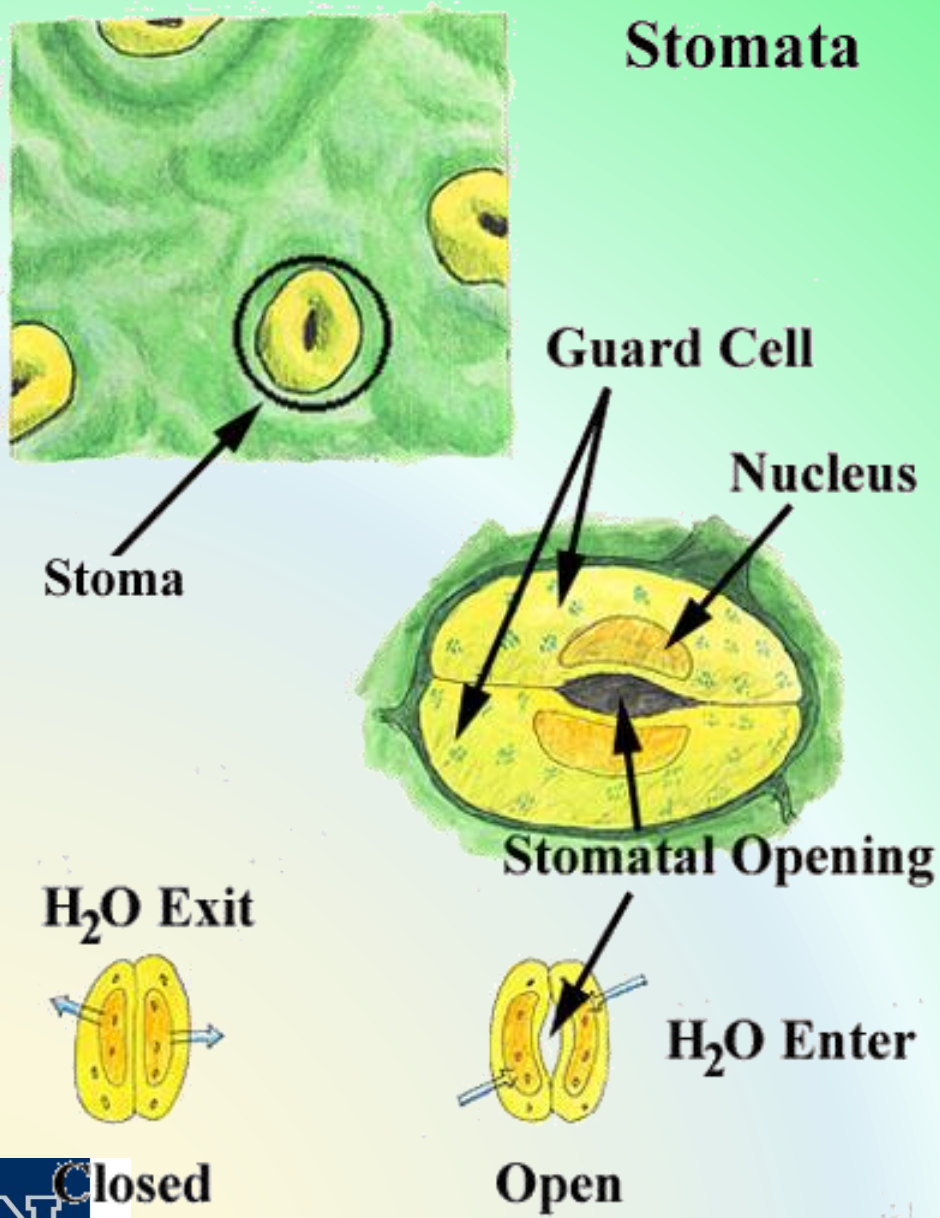
Respiration

uses glucose as the energy source

dark or heat

Stomates (or *stomata*)

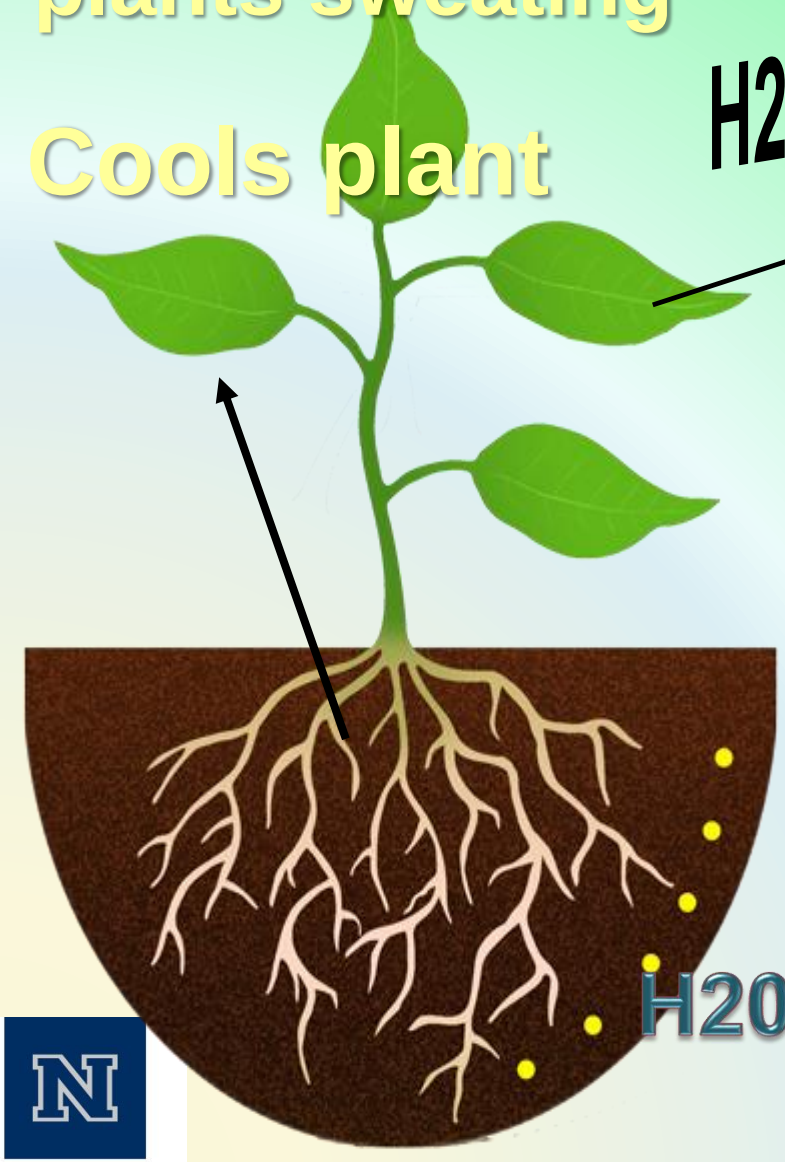
are the openings of the leaf to the air. Through the stomates, the plant releases water and oxygen, and obtains carbon dioxide.



Transpiration think of it as plants sweating

H2O vapor exits through stomates

Cools plant

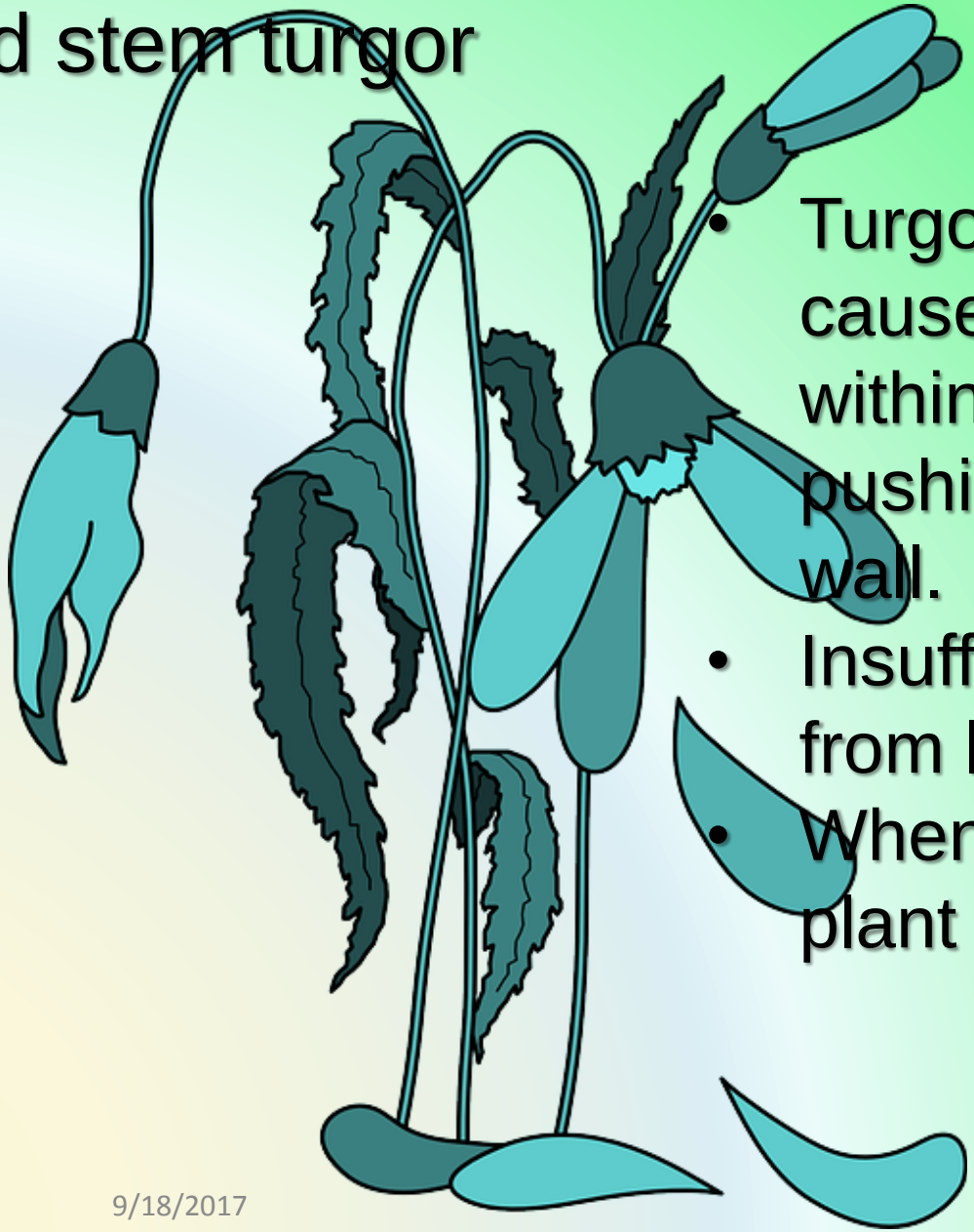


Nutrients remain, Create a pull for more water and nutrients from soil

H20 & nutrients enter leaves from soil through roots

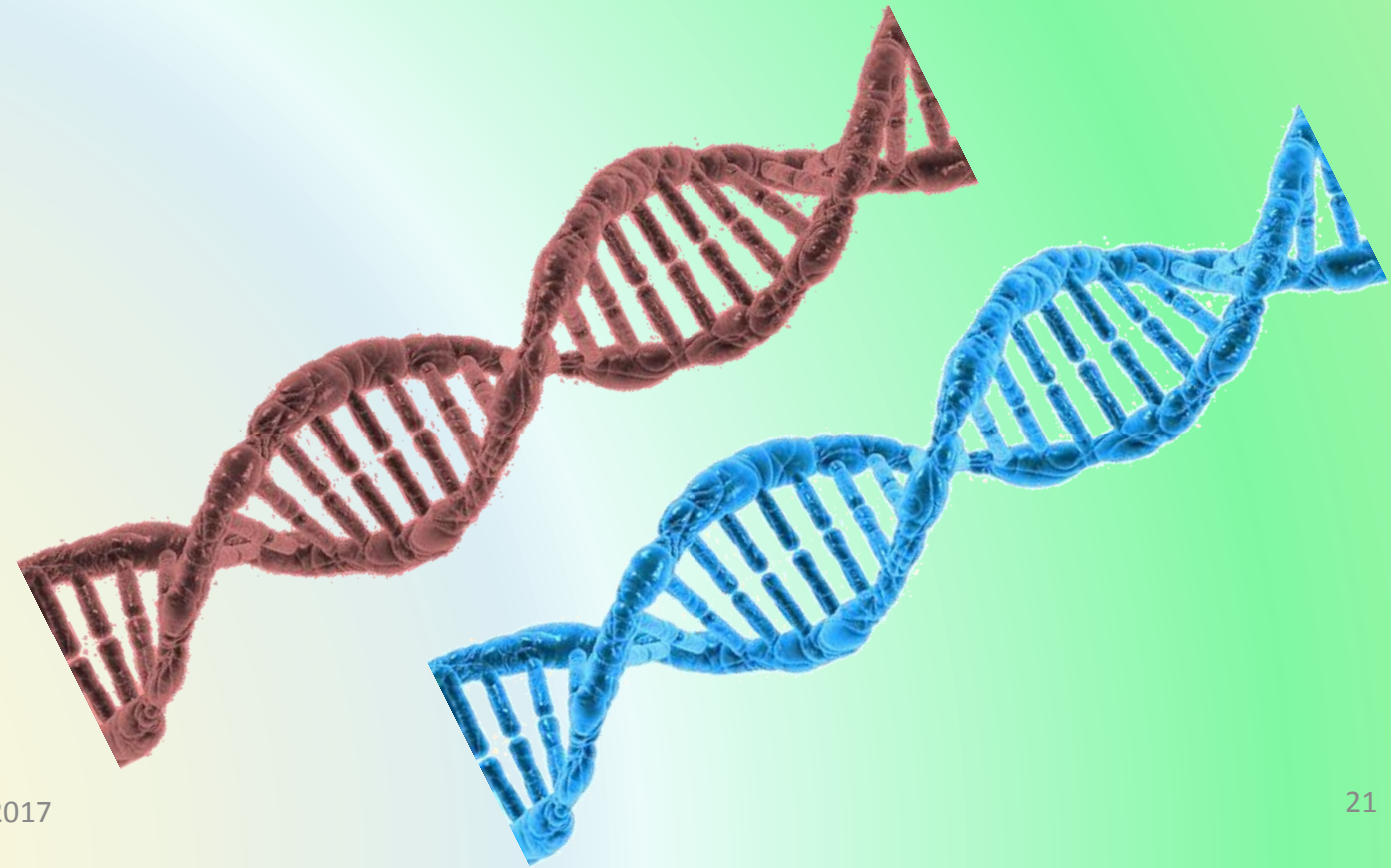
Transpiration

Maintains cell and stem turgor



- Turgor pressure (tp) is caused by the fluid within plant cells pushing against cell wall.
- Insufficient tp results from lack of water.
- When tp is insufficient, plant wilts

Various means of reproduction



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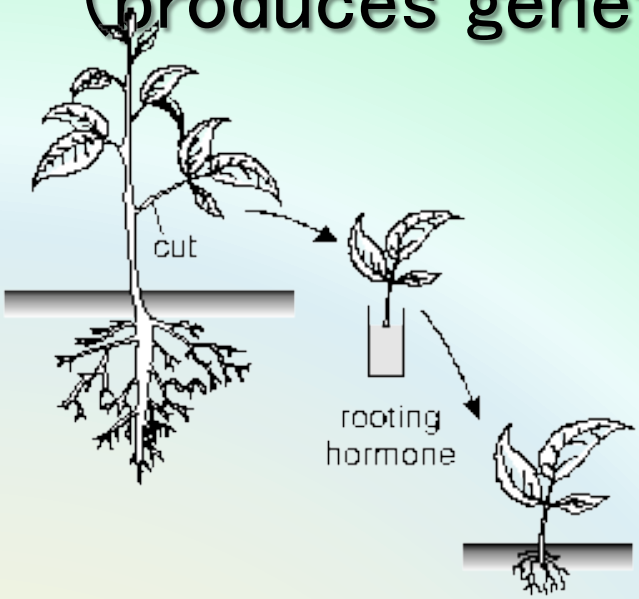
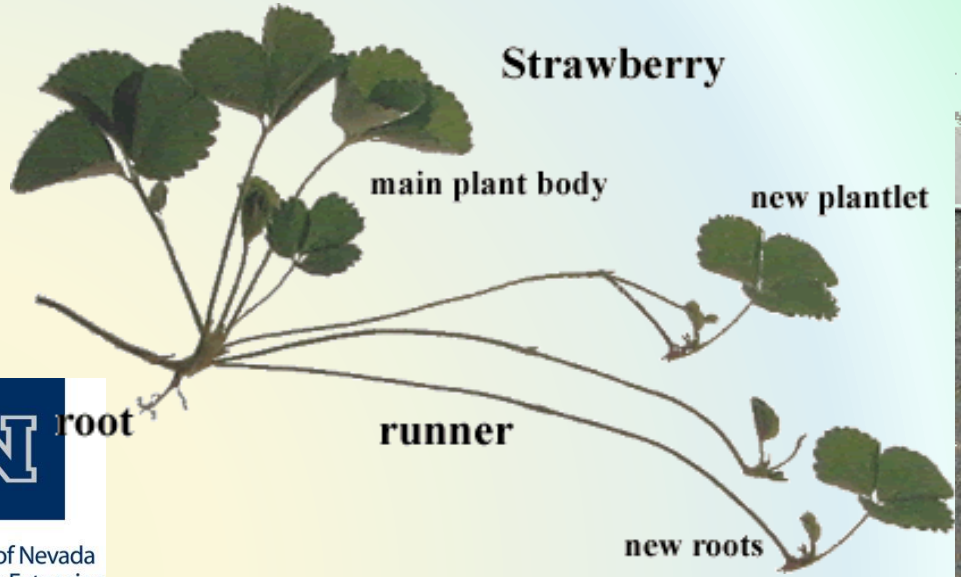
Clonal (asexual) propagation (produces genetic replica of parent)





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Spore producers reproduce in watery environments

Ferns
Horsetail
Mosses
Green algae

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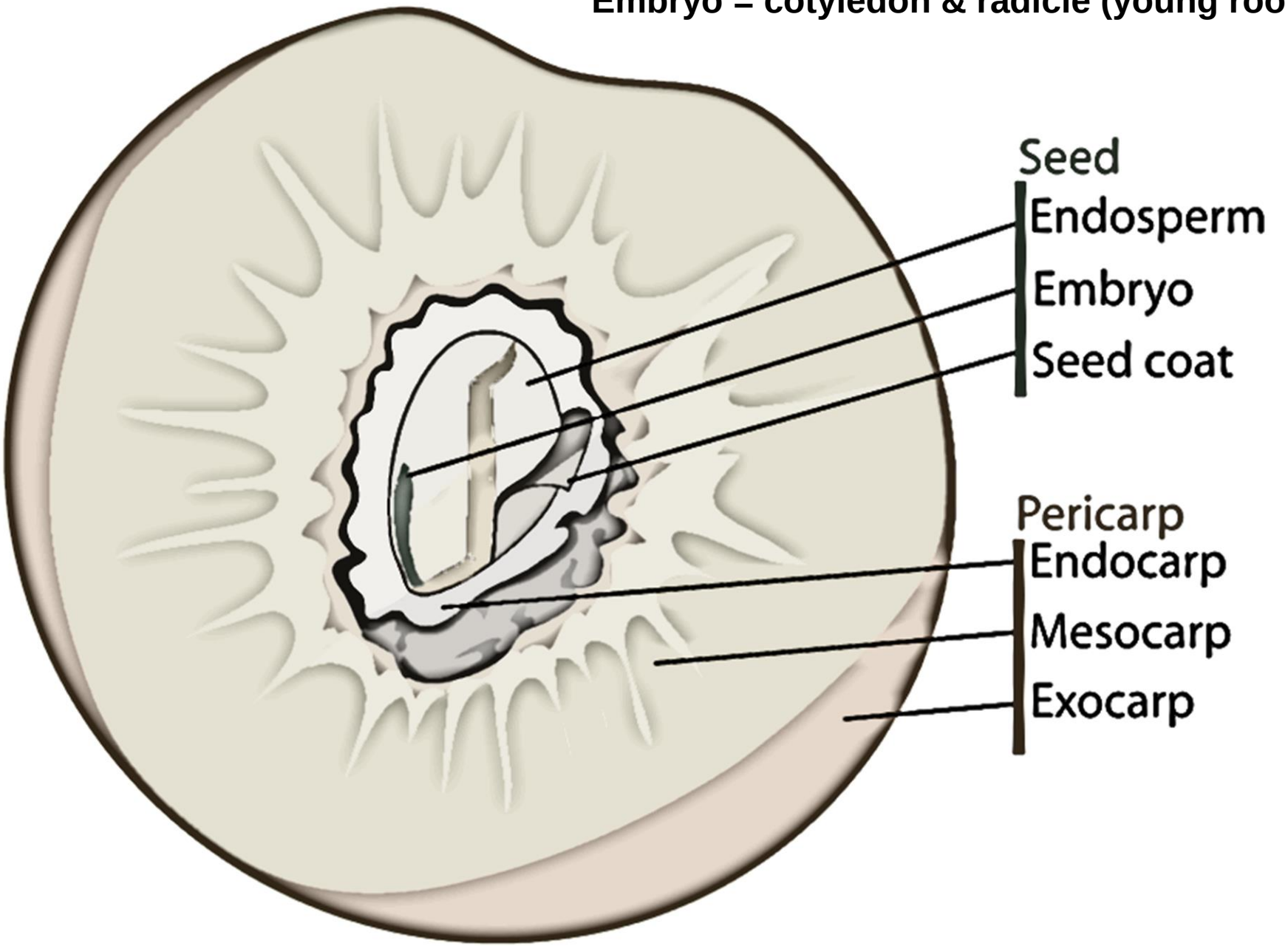
Seed producers

- Seeds contain plant's genetic material
- Contain seed leaves (not true leaves) – cotyledons
- Contain nutrients for plants to begin growth before photosynthesis occurs

Embryo = cotyledon & radicle (young root)



Gymnosperms do not produce fruit. Their seeds develop in cones (the term“conifer”).

Pine, juniper, cedar, fir, spruce, cycad, ephedra

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Crop plants
Most ornamentals
Recent evolutionary development

Angiosperms produce seeds in a fruit

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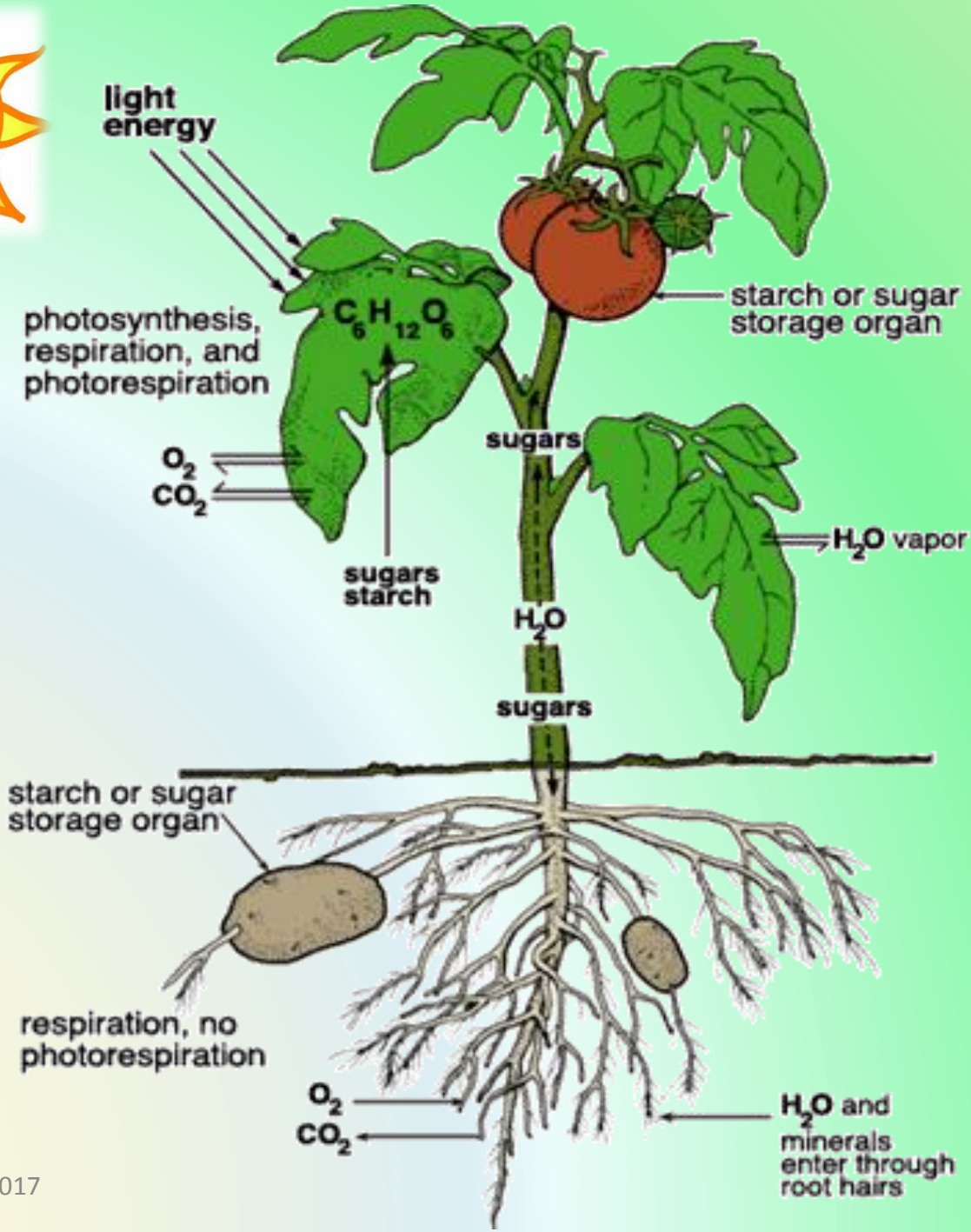
Inside the magic solanaceous plant!



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Chlorophyll (green pigment)

- In chloroplasts
- Destroyed by intense light
- Other pigments may appear when leaves are
  - Senescing
  - Exposed to high light intensity

We think of plants as **Green**

Red, orange and purple pigments protect chlorophyll from excess sunlight

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A healthy plant = "Right plant / Right spot"

- Sufficient, not excess
  - Light
  - Air circulation
  - Water
  - Nutrients
- Safe from
  -
  -
  -
  -
  -

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Not all plants thrive in the same settings

1

2

4

3

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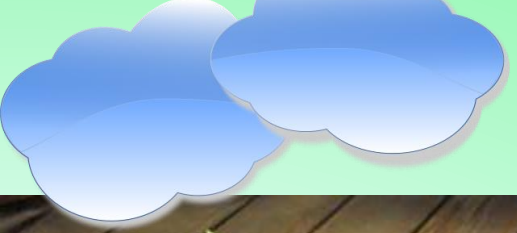
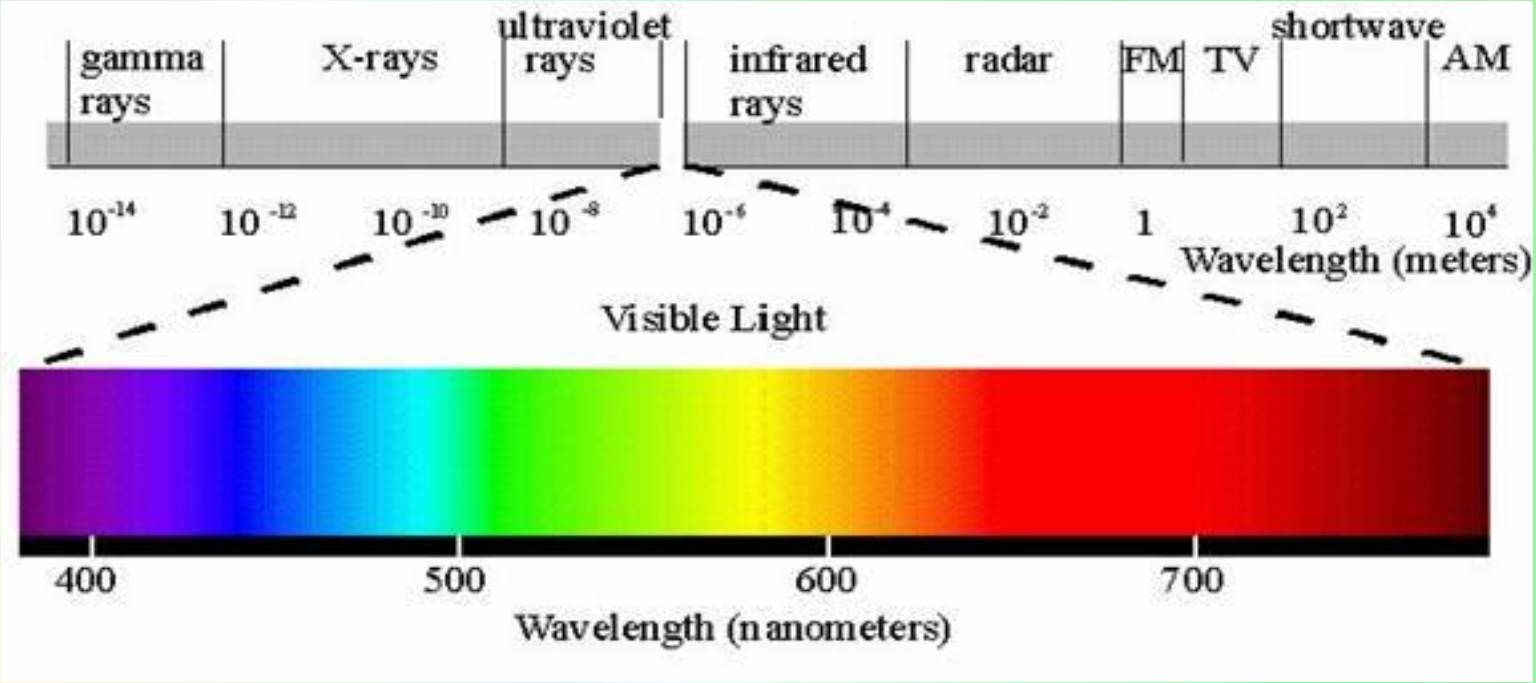
Competition can take several forms…



- **Plants rely on light for growth and color development.**
- **Too little light, and the**
-

Light

microwave



A nanometer is 1 billionth of a meter. Sheet of paper is about 100,000 nanometers.

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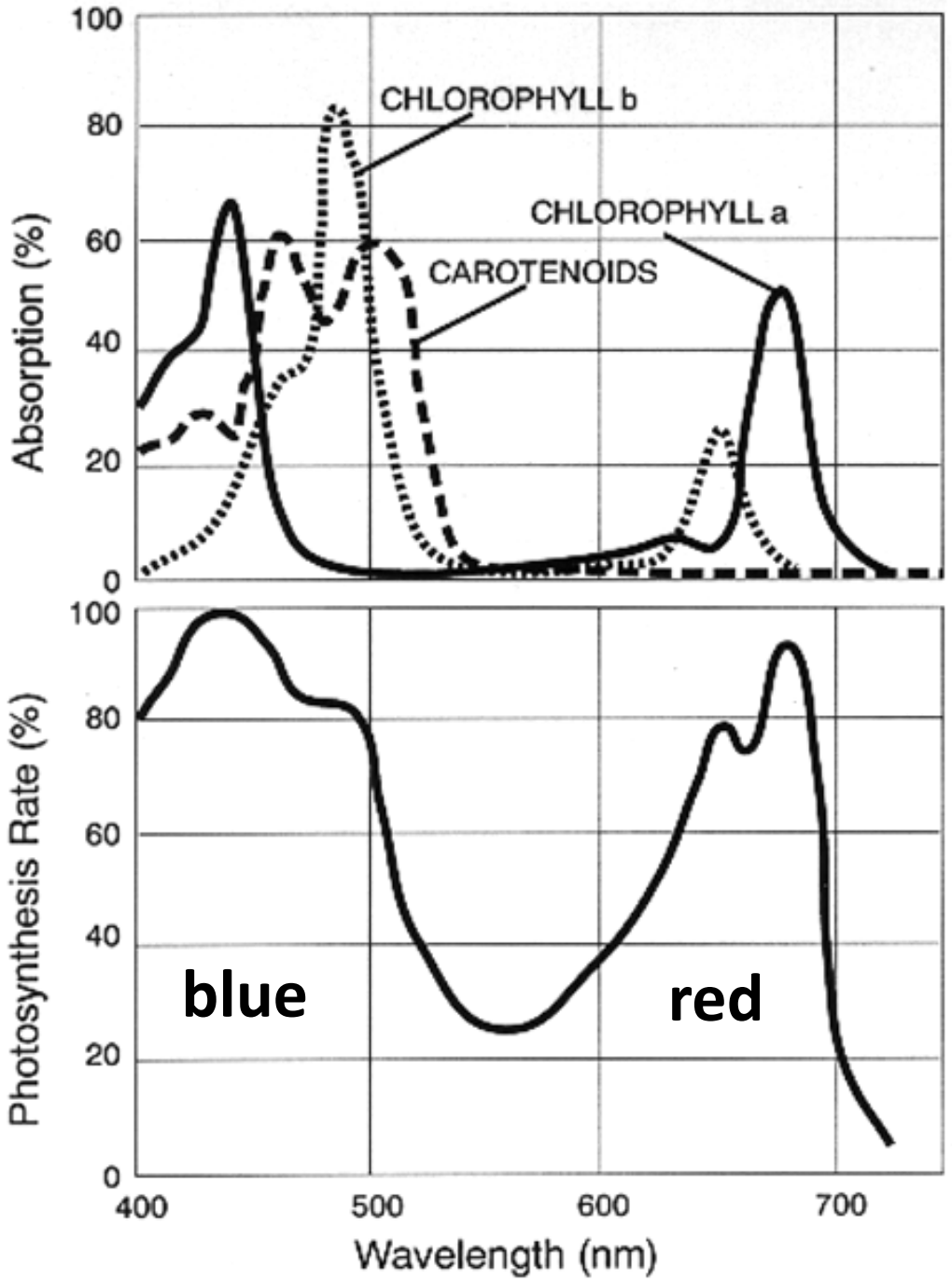
Different wavelengths have different effects

blue – foliage & stems

red –flowers



Light duration effect…

- **Short day plant** – process requires *minimum number of hours of darkness*
- **Long day plant** – process only occurs with *minimum number of hours of light*
- The plant determines the number of hours; it has nothing to do with a clock

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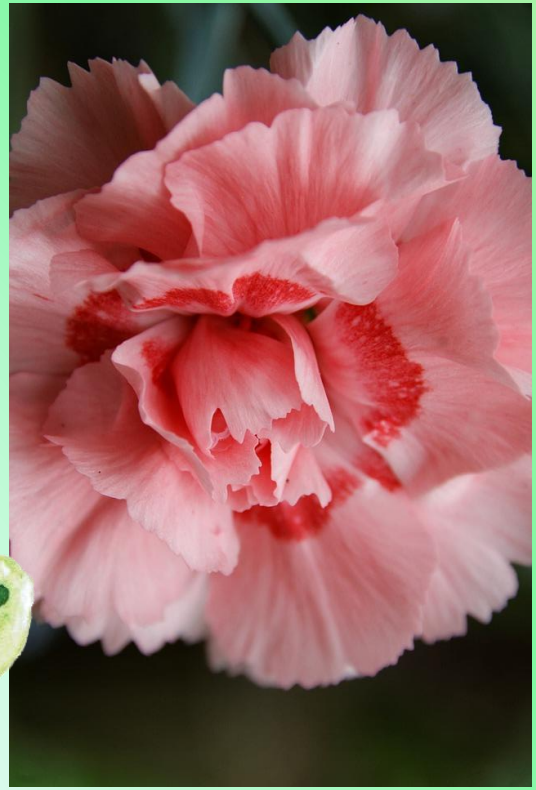
For some plants, specific day **length** necessary for different processes
(mums and poinsettias are short day)

flowering

Long day

- Spinach
- carnations



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Bulbing

Onions require long days

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STORAGE ORGAN PRODUCTION

Potatoes vary in their light requirements, depending on the cultivar

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Air -necessary for photosynthesis & respiration, also to prevent disease establishment on leaves.

But strong winds can cause plants extreme damage

Temperature

Minimum growing temperature ~ 45° but most plants stop growing when temperatures > 95°

Some bulbs and fruiting trees, require a certain number of hours of *chilling* (between ~ 35° - 45° F) for flowering, bulbing, or fruiting.

Water

- There is no life without it
- Too much though, we drown
- Plants can too
  - If plants have poor drainage, roots cannot pull up water and nutrients dissolved in it
  - Lower leaves turn yellow
  - Lower leaves yellow, but do not drop off

Nutrients

Plants require minerals and compounds to perform essential functions.

- Many of these are found in fertilizers, but also in:
  - Plants themselves
  - Compost
  - Fertile soil

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Angiosperms may be monocots (grassy) or dicots (broadleaves).

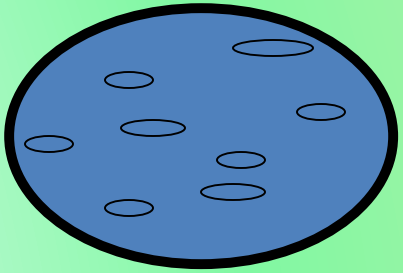
Monocots have one seed leaf (cotyledon)

Growing point is often below ground

Flower petals are usually in multiples of 3

Leaf Veins tend to be parallel

Vascular bundles are arranged randomly in stem



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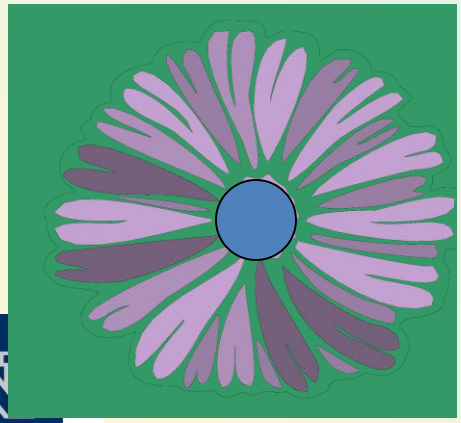
Dicots have 2 seed leaves (cotyledons)

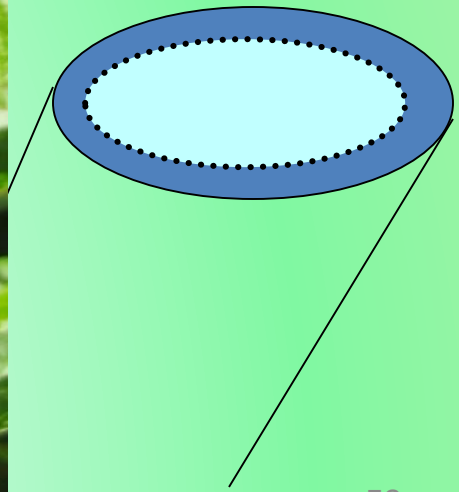
May have several growing points

Leaf veins usually intersect

Flower petals (and sexual organs) are in multiples of 4 or 5



Vascular bundles in the stem arranged in a ring



break

Questions?

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Regarding life span, plants generally fall into 1 of 3 categories:

- Annuals
- Biennials
- Perennials

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Annuals

- Seed gets planted
- Seed germinates:
  - Produces roots and foliage
  - Now the “parent plant”
- Plant produces flowers
- Flowers get pollinated
- Produce seeds
- Parent plant dies
- *Monocarpic*, in one season

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- *Summer Annuals*
  - Germinate in spring, produce foliage, flowers and seeds in the same season.

- *Winter Annuals*
  - Germinate and produce foliage in the fall, and produce new foliage, flowers and seeds, in the spring.

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Biennial

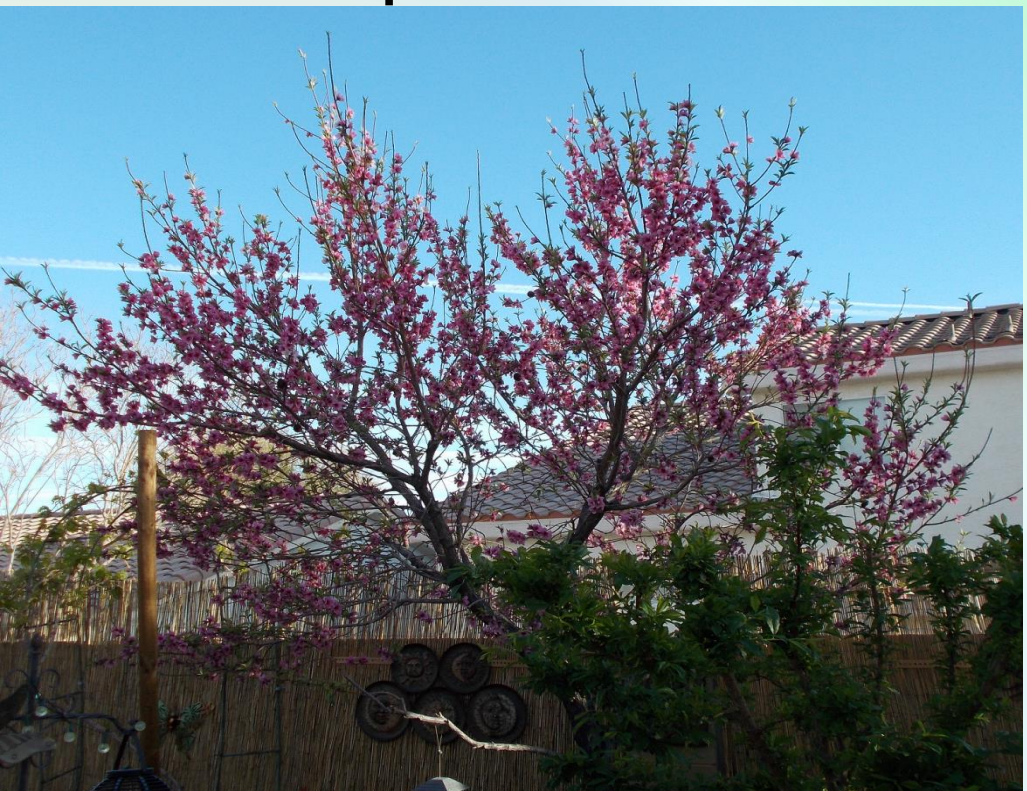
- Seed planted
- Germinates, produces roots and foliage
- Foliage dies back
- Chilling and short days; then
- Warming and longer days
- Produces new foliage and flowers
- Flowers pollinated
- Produce seeds
- Parent plant dies
- *Monocarpic*, in two seasons (years)

Winter annuals vs biennials

- Winter annuals are often the first green things in the spring, flowering early then dying
- Biennials often need a longer period of foliage production before flowering
- Winter annuals have been called “biennials on speed”

Perennials

- Seed is planted
- Germinates, produces root and leaf tissue
- Produces seeds
- Parent plant continues for subsequent seasons



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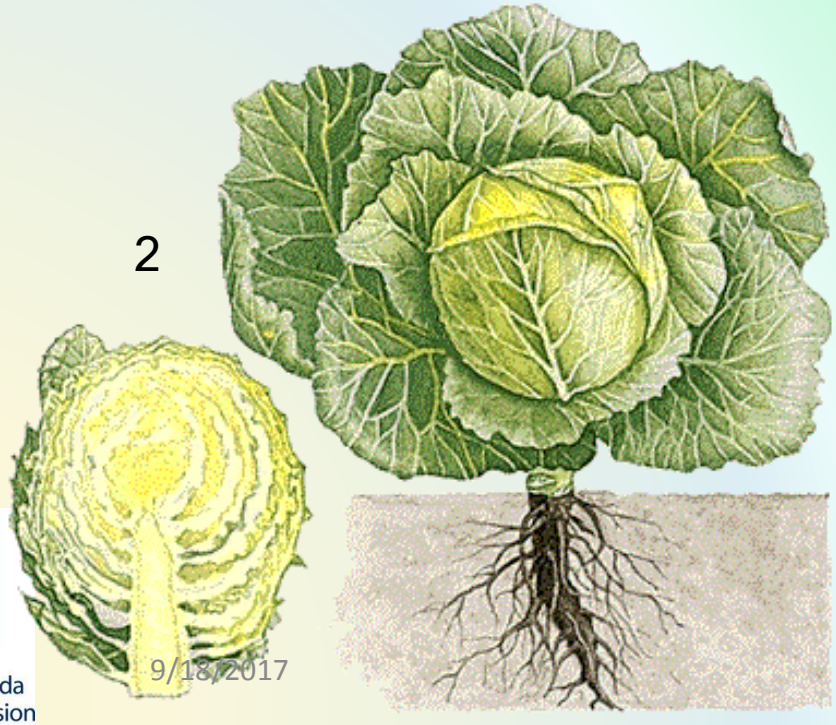

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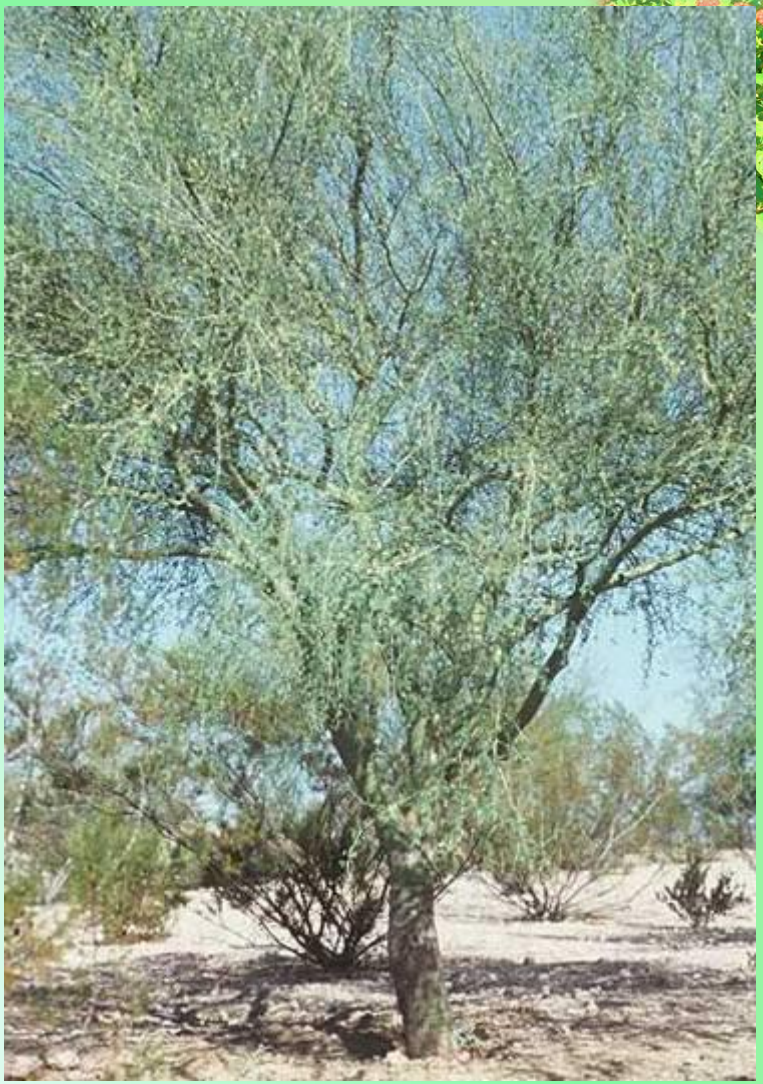
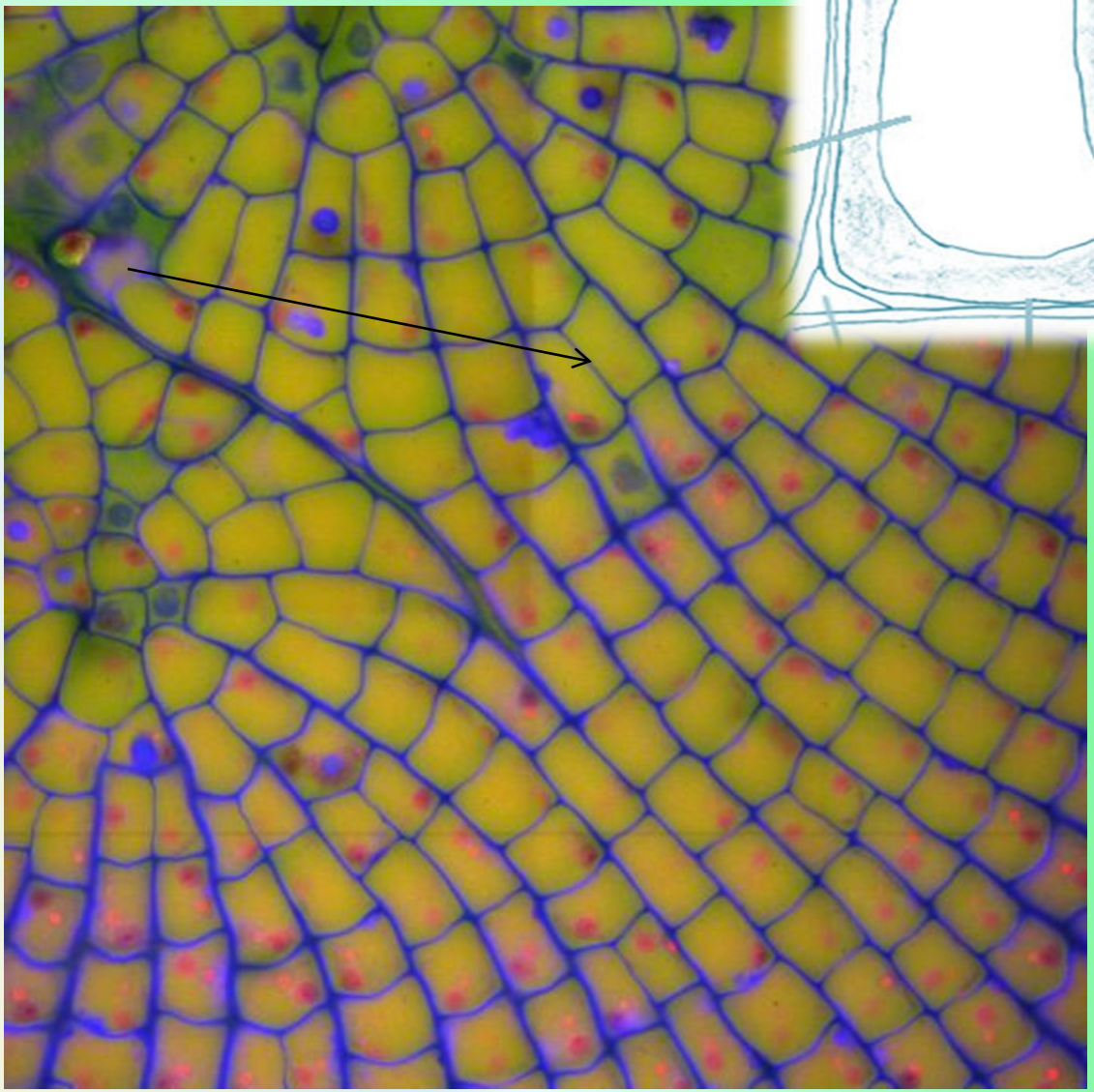
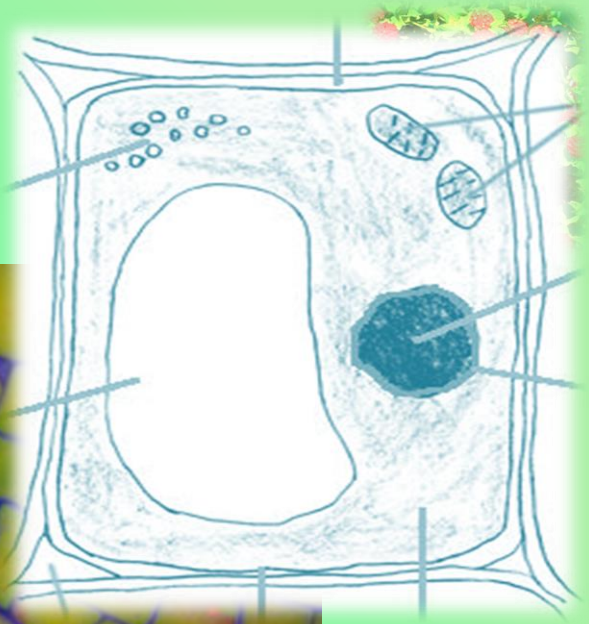


3

What is a plant made of?

Cells
Leaves
Stems
Roots
Flowers
Fruits
Seeds





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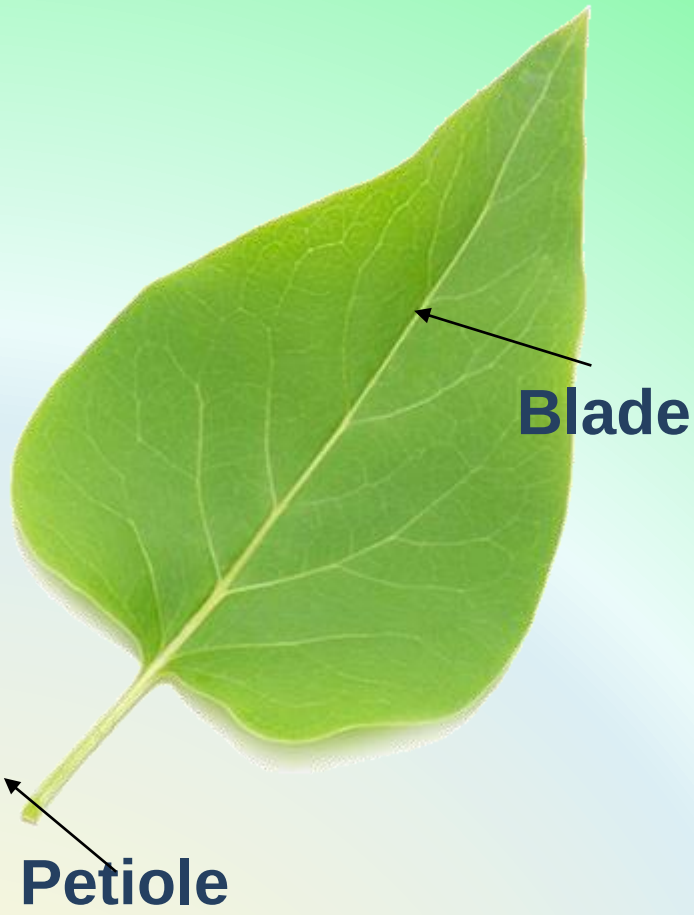
Leaf structure is highly varied, depending on:

whether plant is a monocot or a dicot,

its species,

and how much light and water it needs and normally obtains



- There are 2 parts to every dicot leaf
- The “blade” is the portion that we most think of as the leaf.
- The “petiole” is the ‘stem’ holding the leaf blade to the plant.

Monocots often do not have petioles

Leaves

Leaf arrangement: Alternate

Leaves appear one by one per node

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Leaf Arrangement Opposite

Leaves appear in pairs at each node

Leaf Arrangement: Whorled

Three or more true leaves appear per node

Rosette

Youngest leaves

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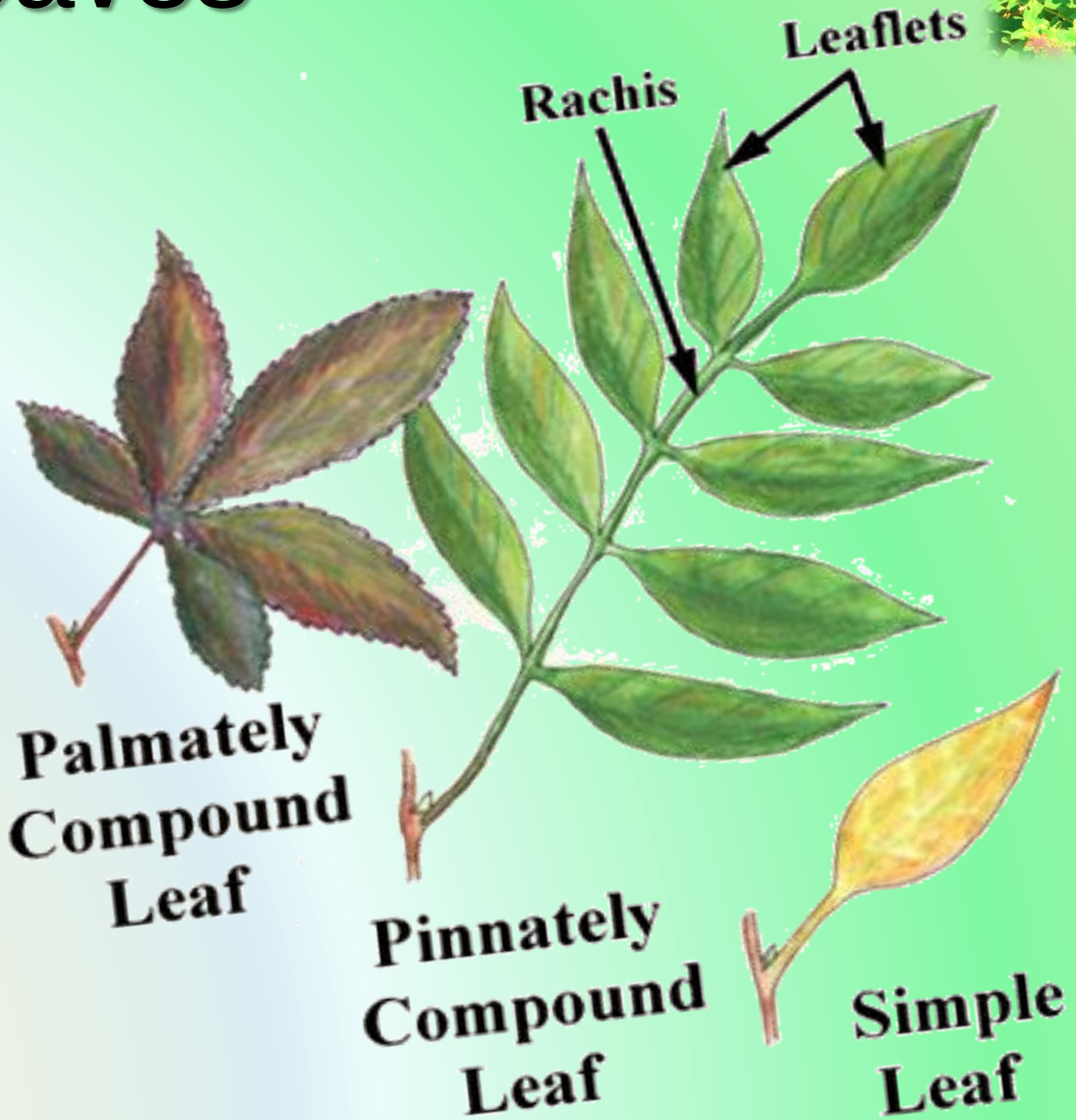
Types of leaves

These are all dicot leaves.



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Simple & Entire

- No leaflets
- Entire
- No indentations along leaf margin

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True leaves with bud at base

Compound

“Palmate”

All leaflets from a single point/area

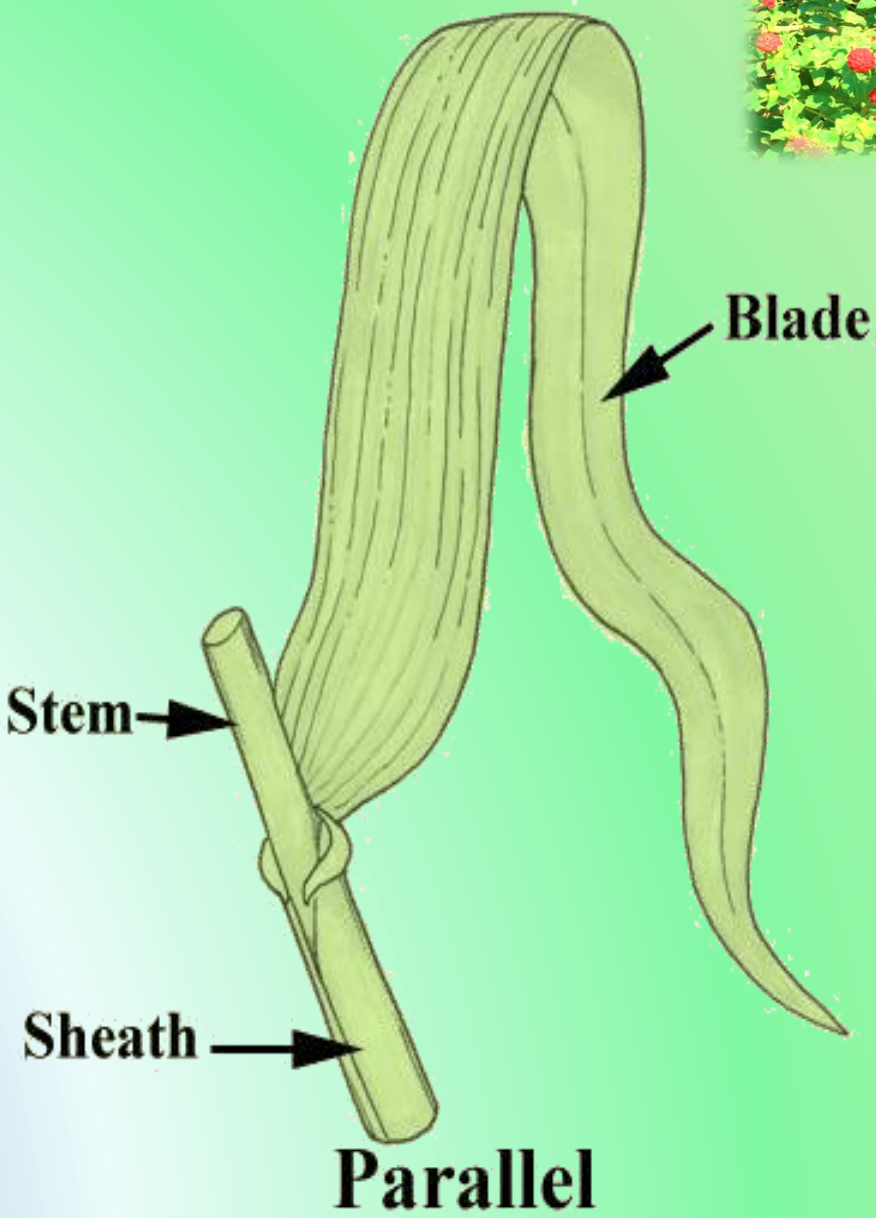
compound

- "Pinnate" (from Latin word *pinna* = feather)

Monocot Leaves

Can be different.

Note the parallel veins, and how the leaves attach to the stem. Often monocots do not have a petiole.



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Leaves & Water

Waxy layer (cuticle) protects the leaf from dehydration

Thickness depends on plant genetics & water availability.

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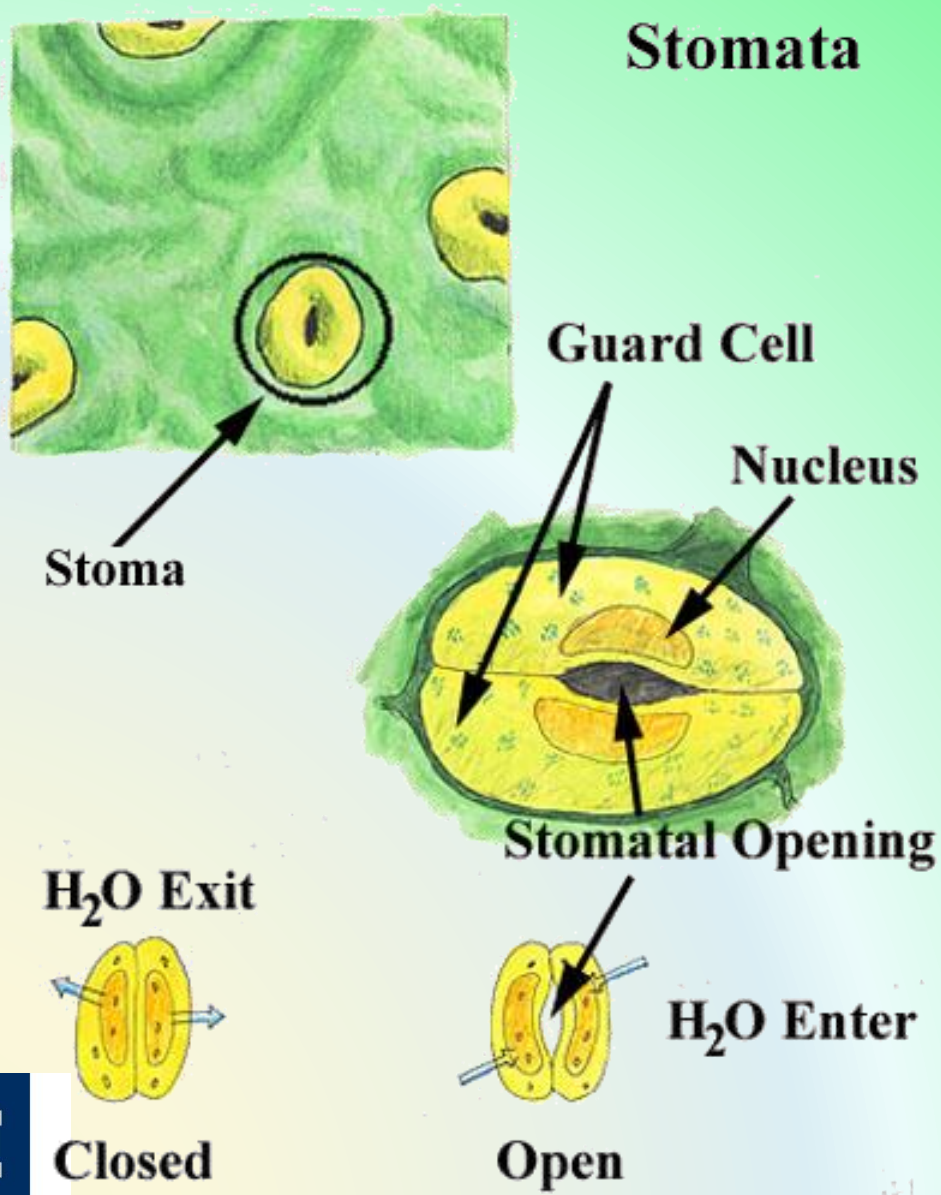
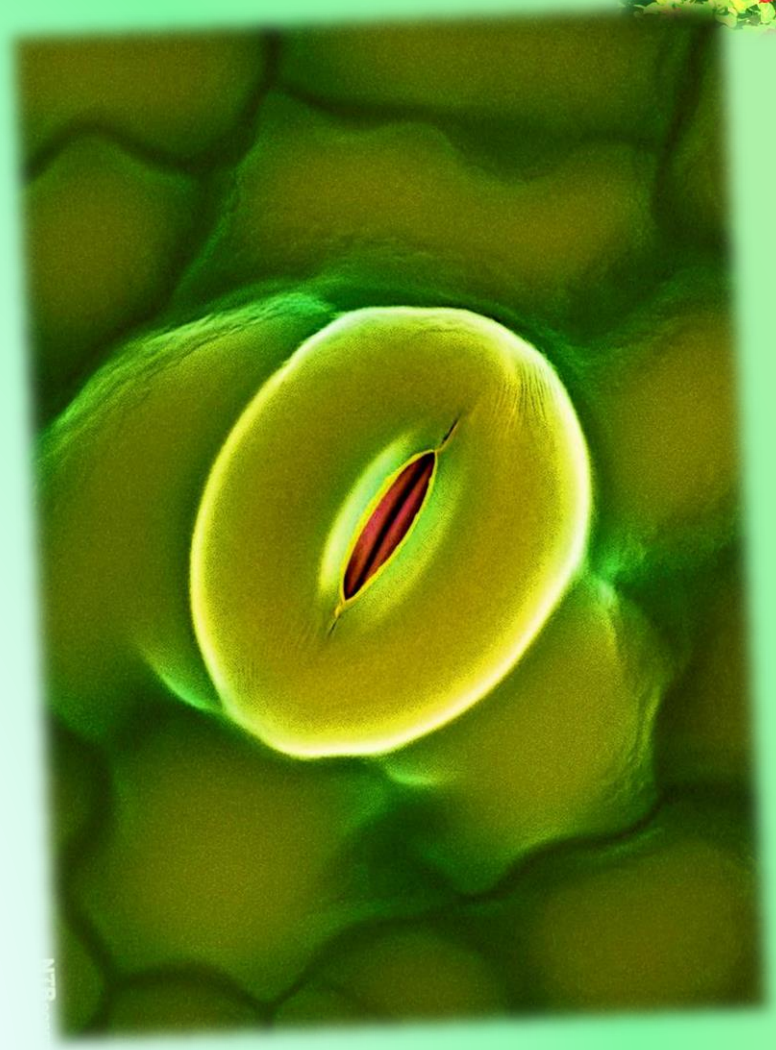
Stomates (or *stomata*)

are the openings of the leaf to the air. Through the stomates, the plant releases water and oxygen.



- Stomates are composed of a pore surrounded by two “guard cells”
- Most are on the underside
- Guard cells swell and close pore when plant needs to conserve water
- Guard cells contract and open pore when plant needs to release water



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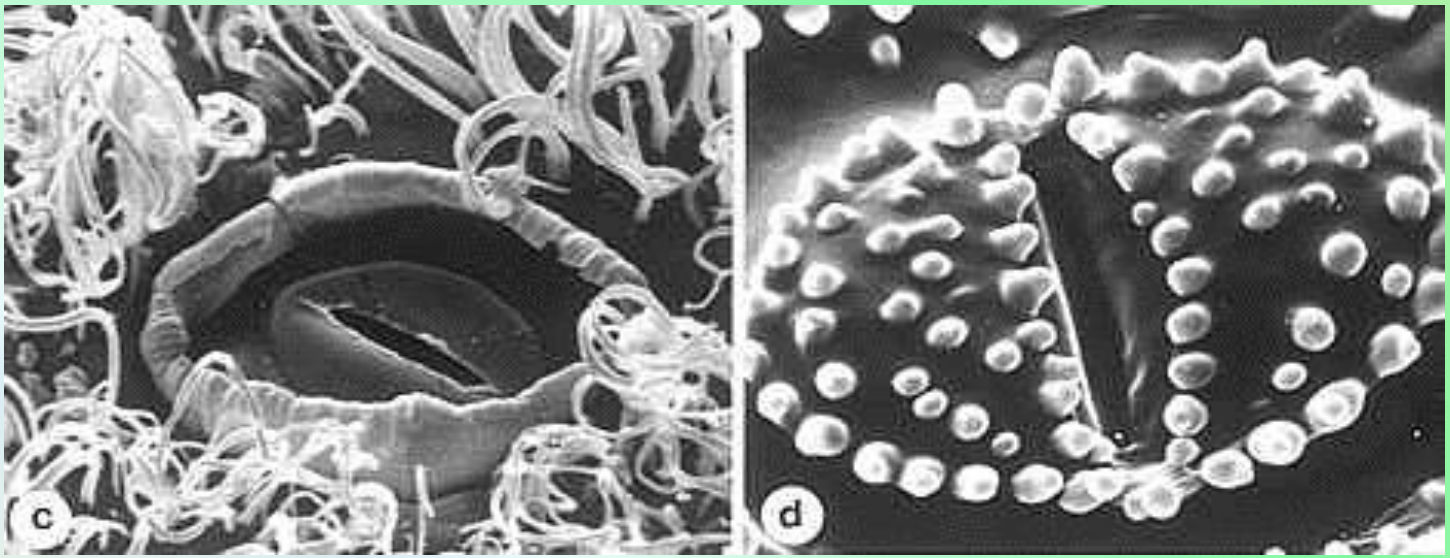
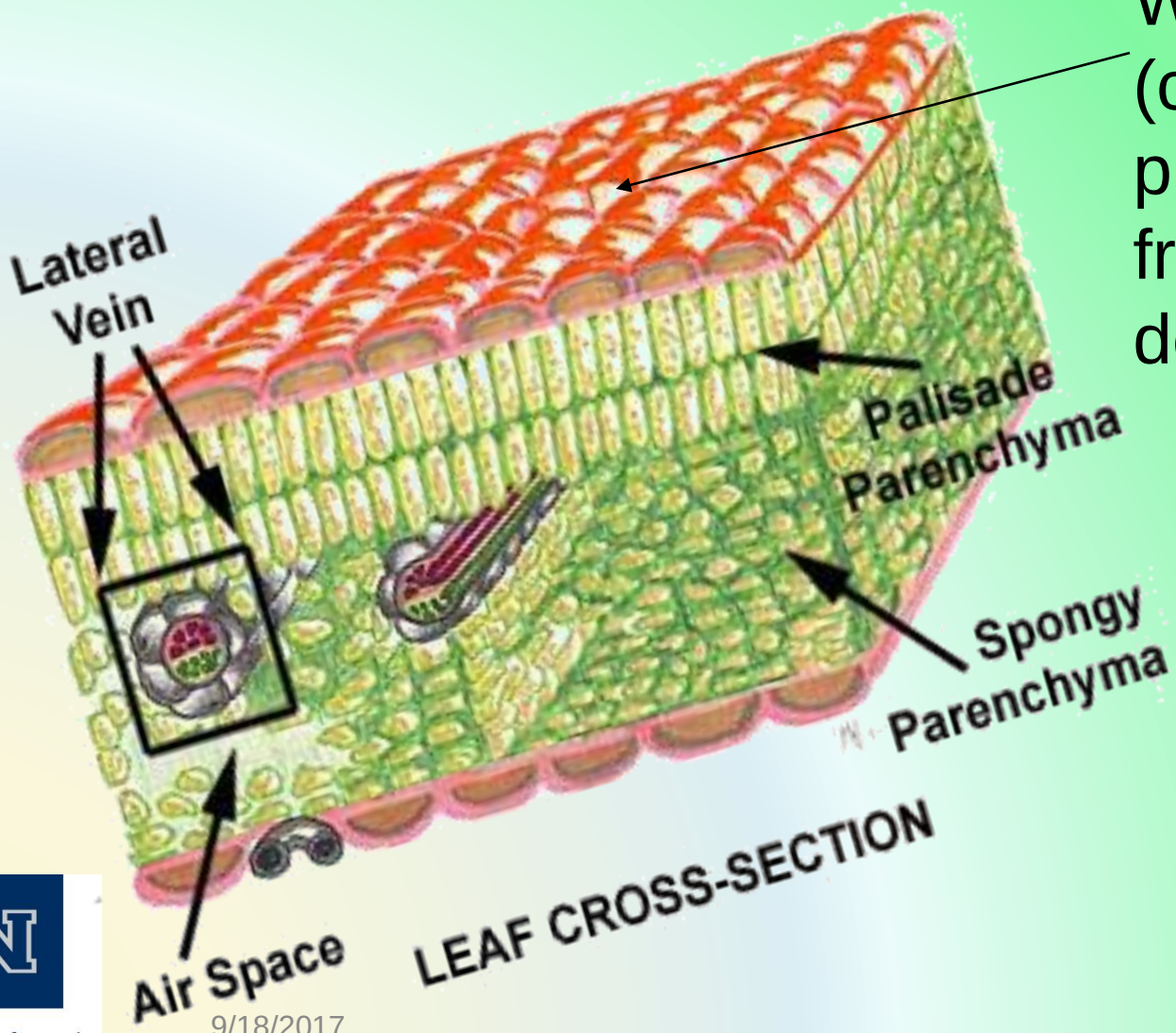


Dicot stomate

Monocot stomate

- Stomates perform the same functions, but may have different appearance
- Desert adapted plants often have stomates in “pits” to limit drying out.
- Desert adapted plants often have fewer stomates than plants that receive more water.

Leaf Cross-section



Waxy layer (cuticle) protects the leaf from dehydration

Modified Leaves

Vine tendril

Leaf architecture

- A broad thin leaf at a flat angle, will be able to “catch” sunlight and lose water quickly

- A narrow, thick leaf connected to the stem at an acute angle will not “catch” so much light and will tend to lose water slowly

Plant Vascular System

[slightly like our veins and arteries]

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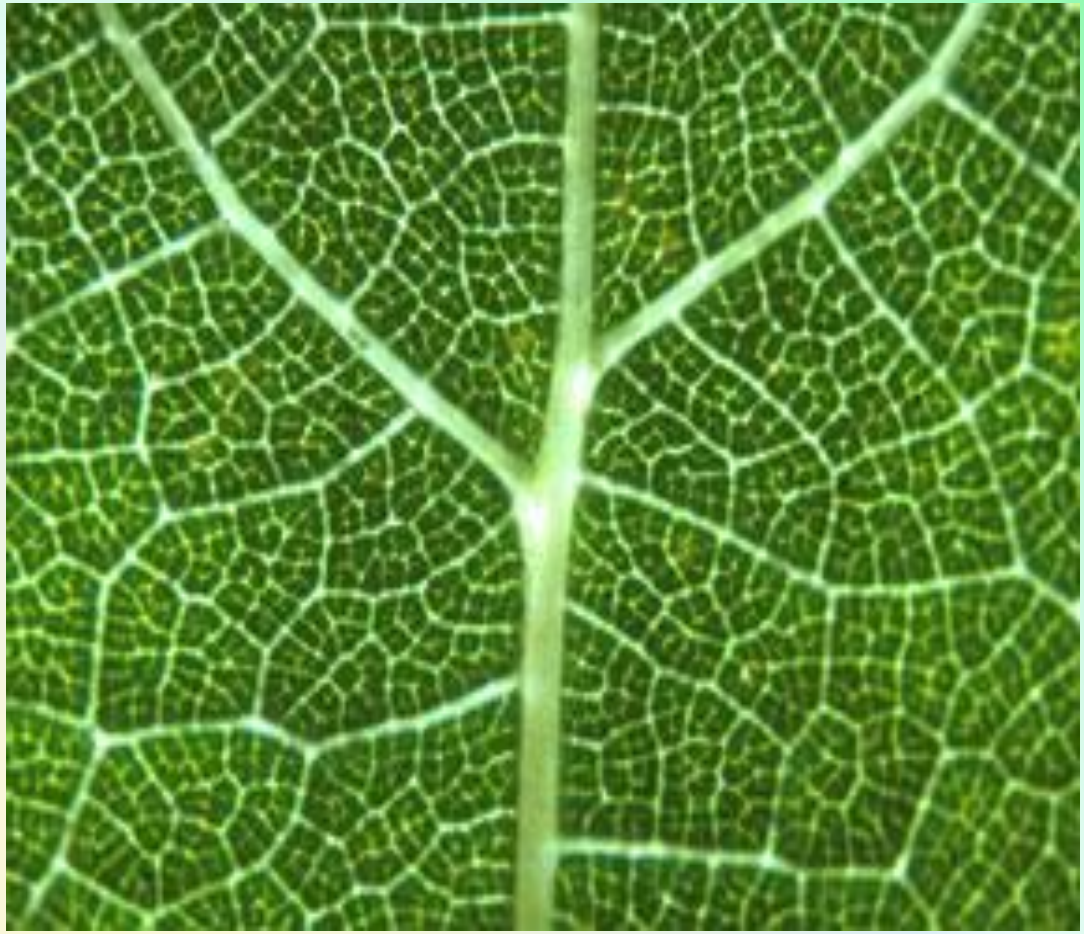
VEINS



The avenues where plant moves water and raw materials, and the finished products of the leaves

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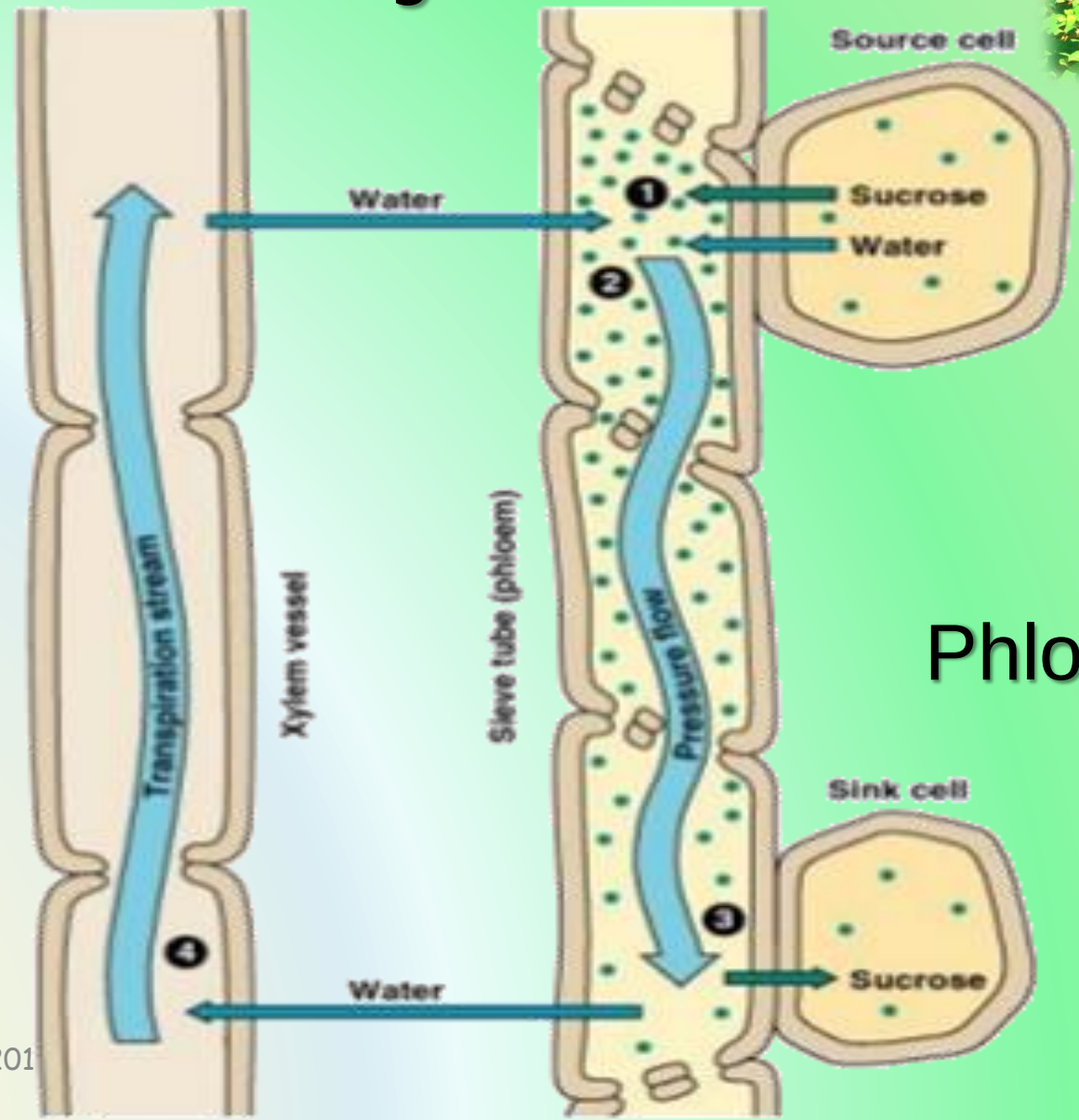
Veins have two major elements

Xylem



Phloem

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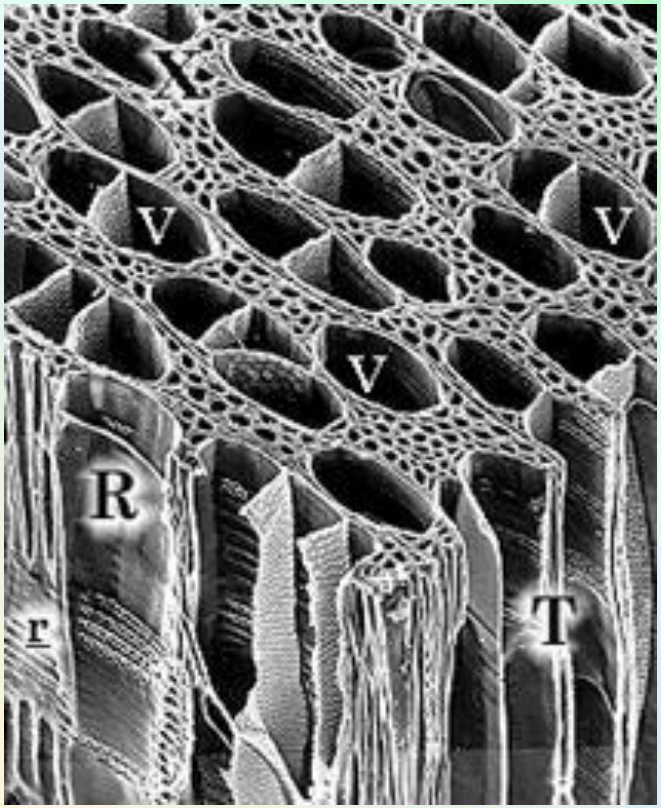
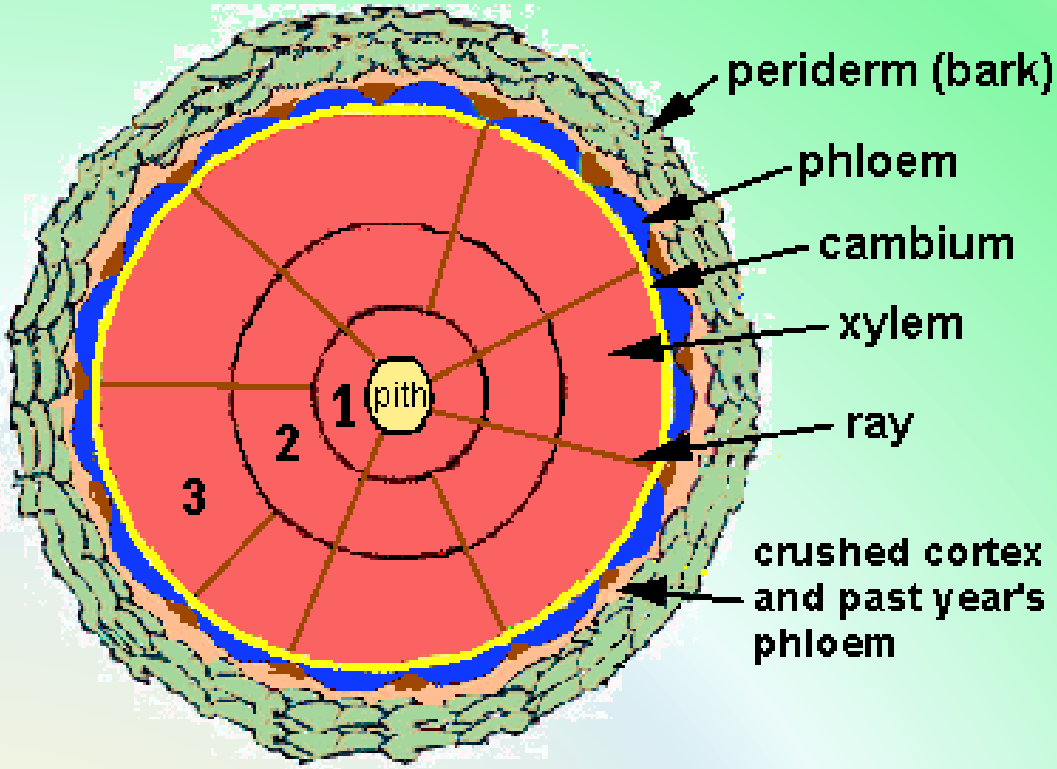
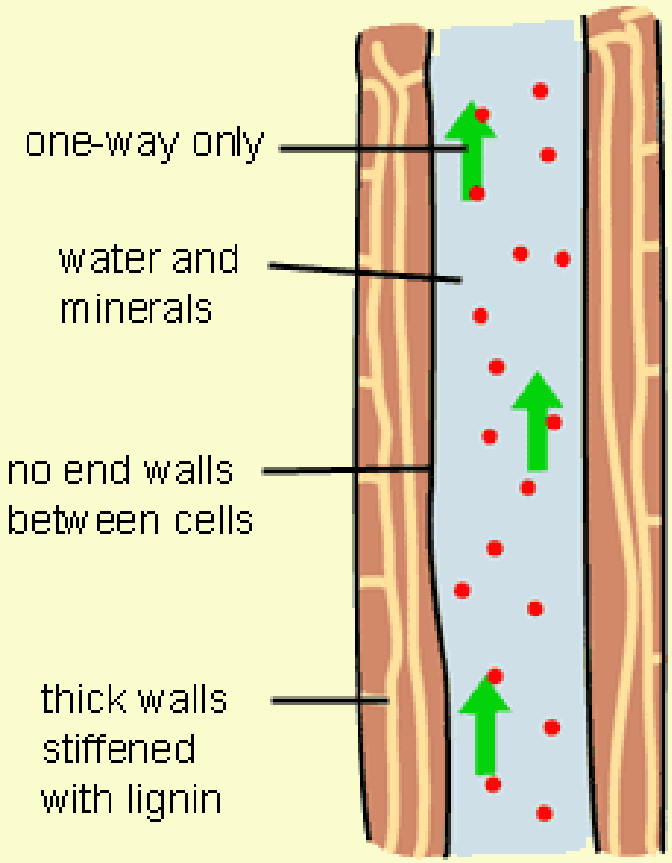


Xylem

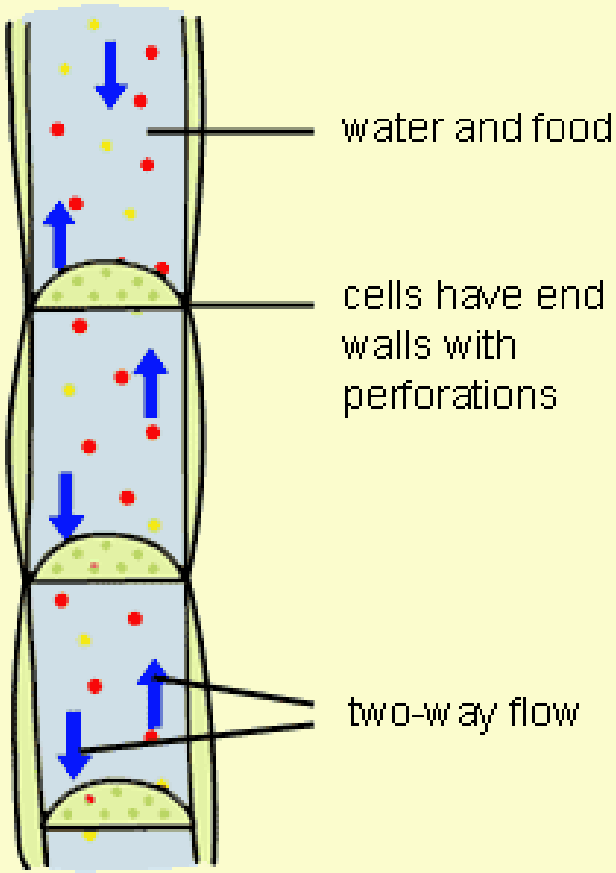
- The system of hollow vessels that carries water and raw materials from the soil, through the roots to the stem and leaves
- One-way only



- Phloem
  - carries carbohydrates produced by leaves to the rest of plant
  - 2 way flow

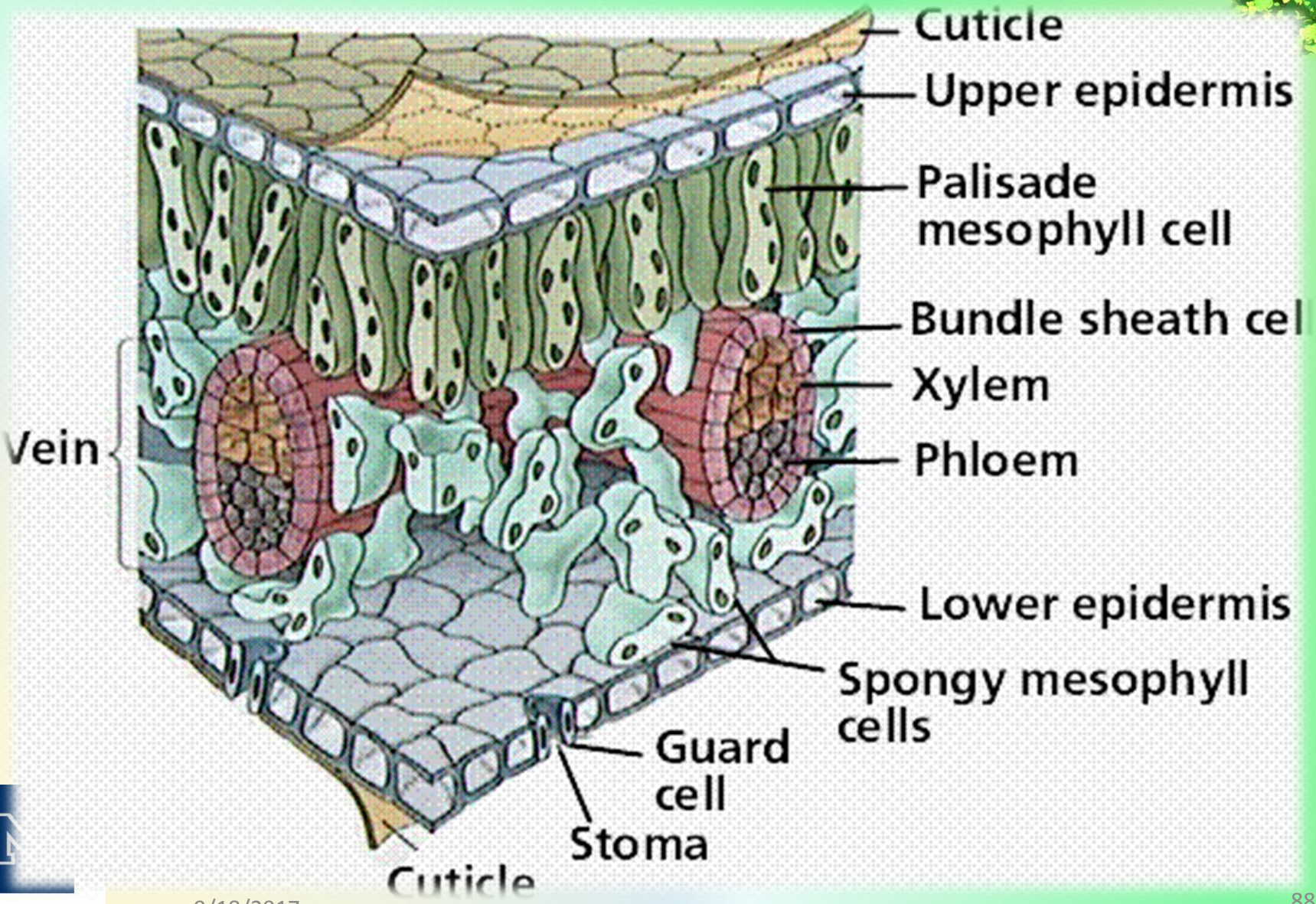


xylem vessel



phloem vessel

Leaf cross section



Stem structure

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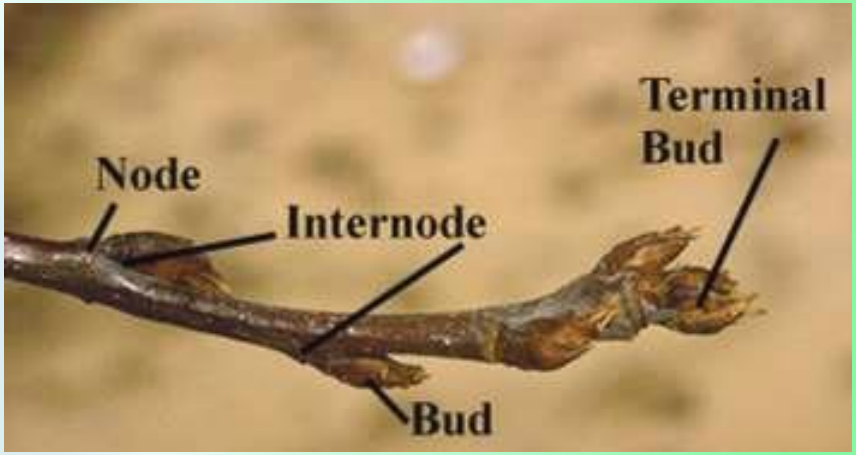
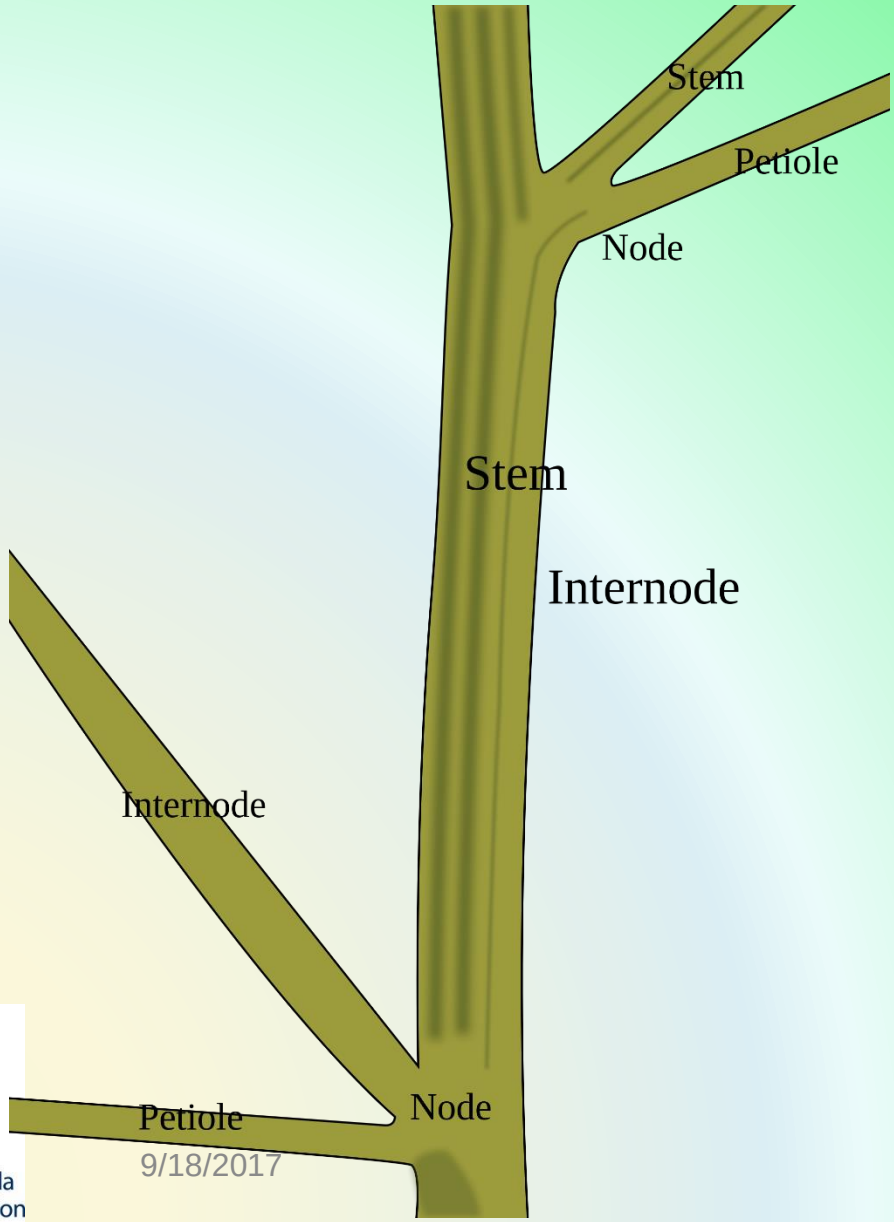
Plant stem

- The highway between roots and leaves
- Contains plant vascular system
- May be green (chlorophyll) or woody



Plant stem

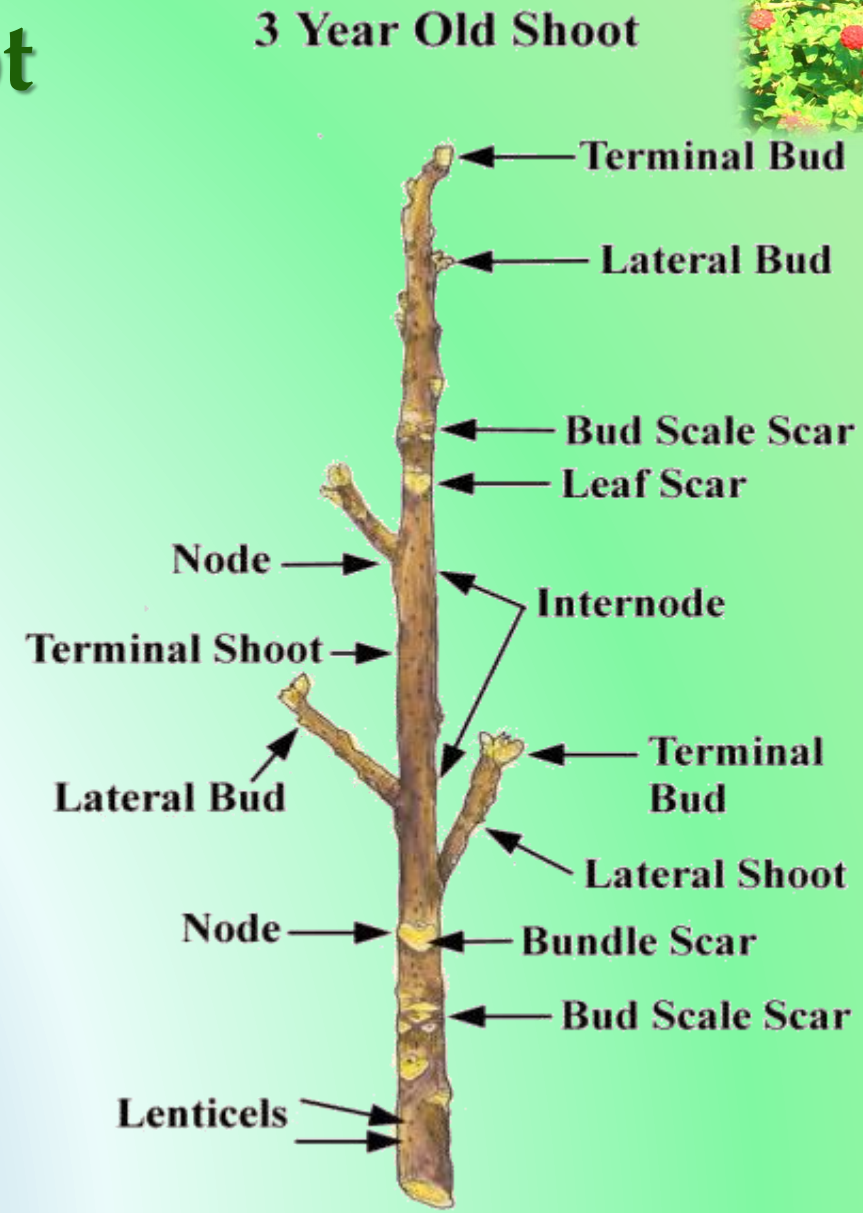


Modified stem

LENTICELS are like stomates, but located in the bark

Woody Plant shoot

Lateral buds: dormant buds at a node
Will grow into stems when they break dormancy.



Modified stem

Stolon – “a stem that grows horizontally along the ground surface and may form adventitious roots…” (e.g. strawberry, Bermuda grass)

Exception: potatoes are tubers, swollen stolons growing underground.

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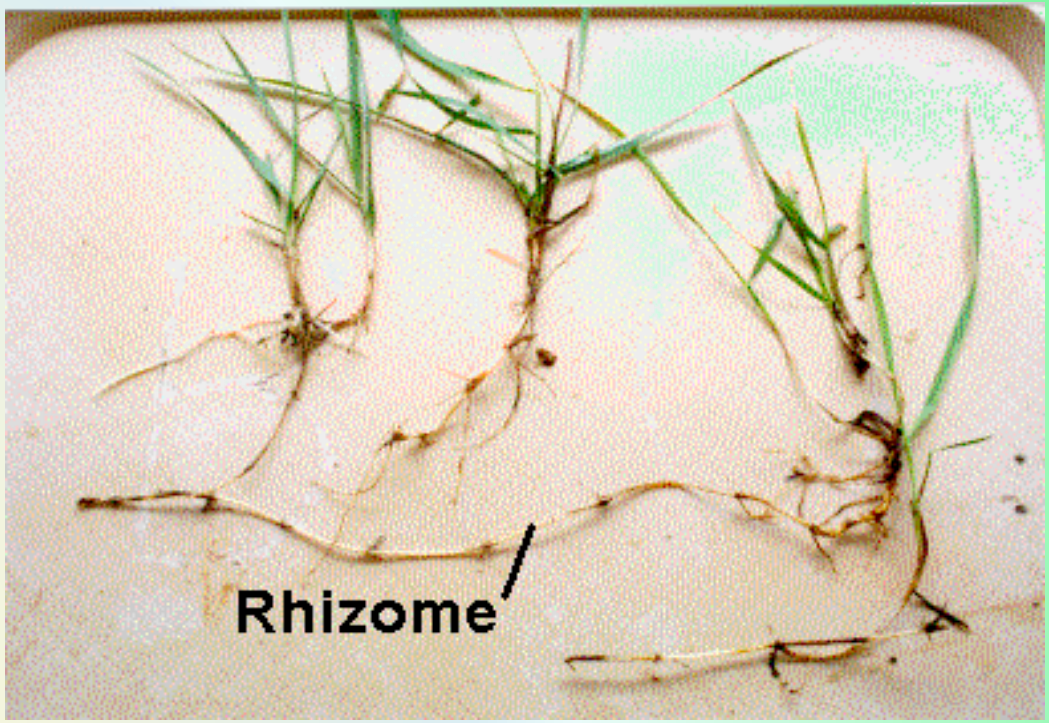
Modified stem

Rhizome: "a more or less horizontal underground stem."



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break

Questions?

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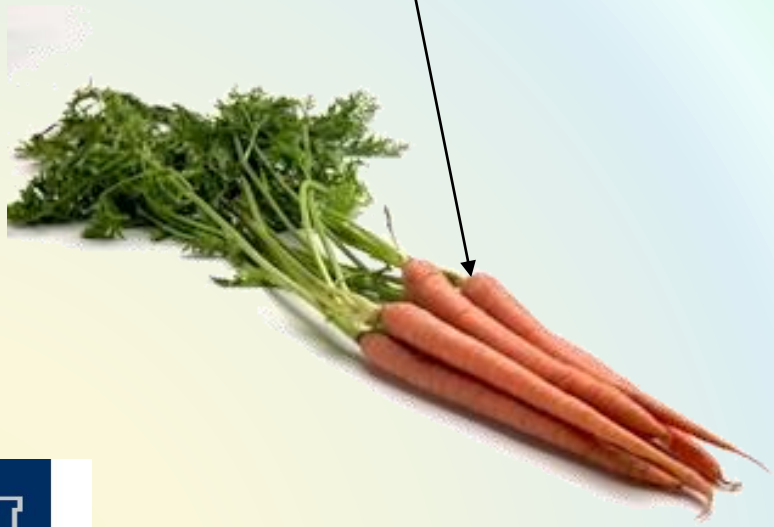
Roots

- Deliver water and nutrients from soil to leaves
- Anchor plant in soil
- Interact with <u>soil life</u>
- May be tap or fibrous roots



Roots

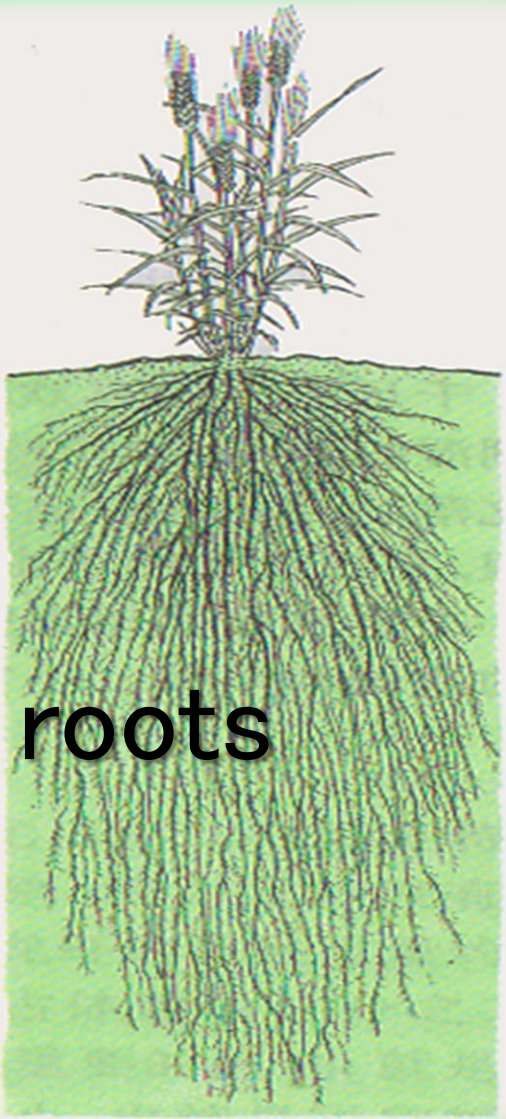
cottonwoods,

ash

maple

may not produce tap roots

Tap



Fibrous

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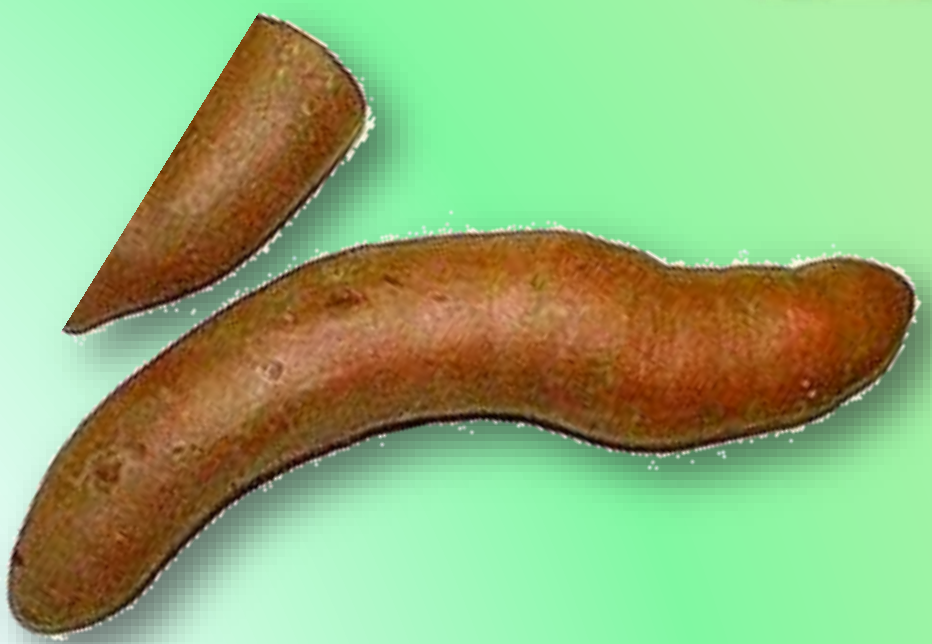
Storage Roots



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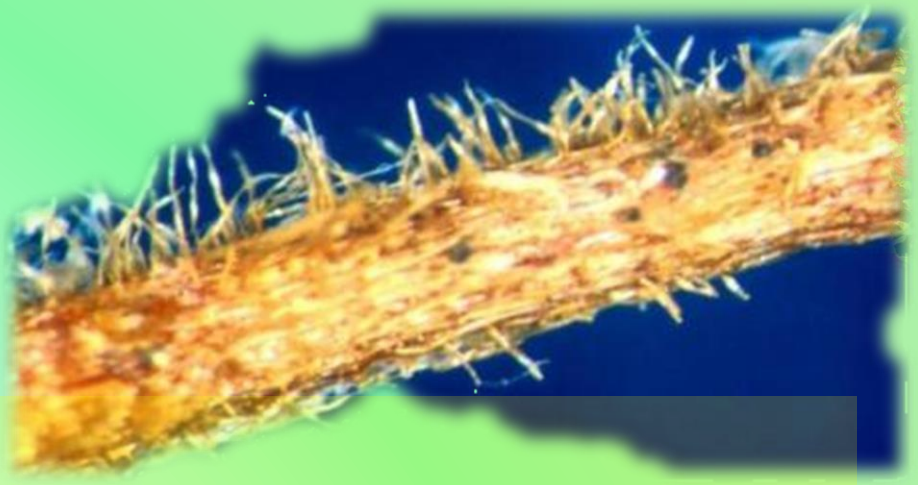
Root hairs



- Microscopic
- Fine extensions from single cells
- Increase root surface area
- Important in obtaining water and minerals from soil
- Not all plants have root hairs – e.g. *Vaccinium* spp., *Allium* spp.

- Flowering plants are ***angiosperms***.
- Flowers may be male, female, or perfect (contain male and female structures).

Flowers

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Flowers are for pollination

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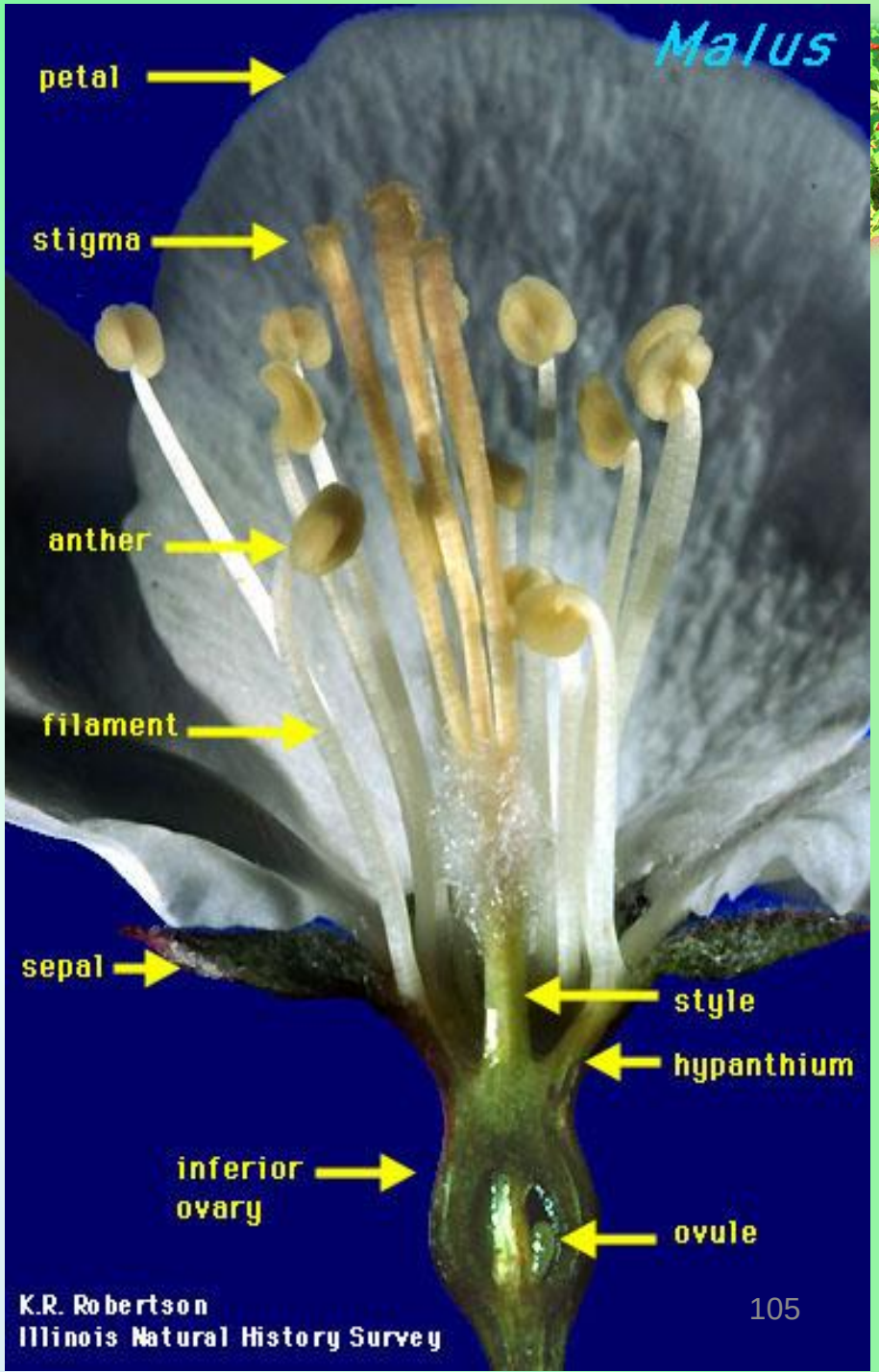
Flowers

Are plant reproductive organs



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Flower part roles

♂

Anther	produces pollen
Filament	holds anther to flower
Stigma	sticky, catches pollen
Style	connects stigma to ovary
Ovary	fruit, holds ovules
Ovules	eggs; become seeds when fertilized
Perianth	petals & sepals

♀

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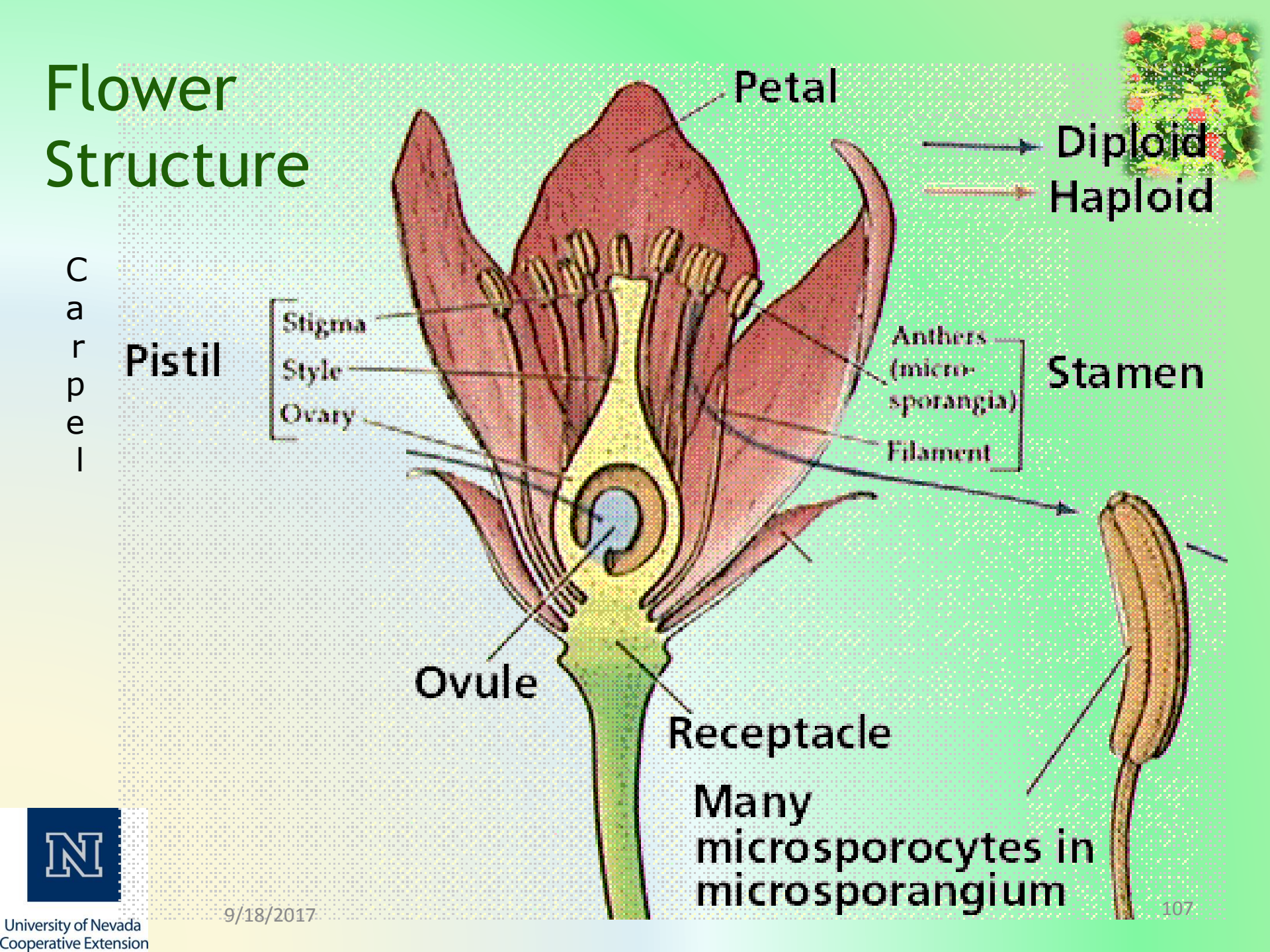
Flower Structure



Flowers can have many forms

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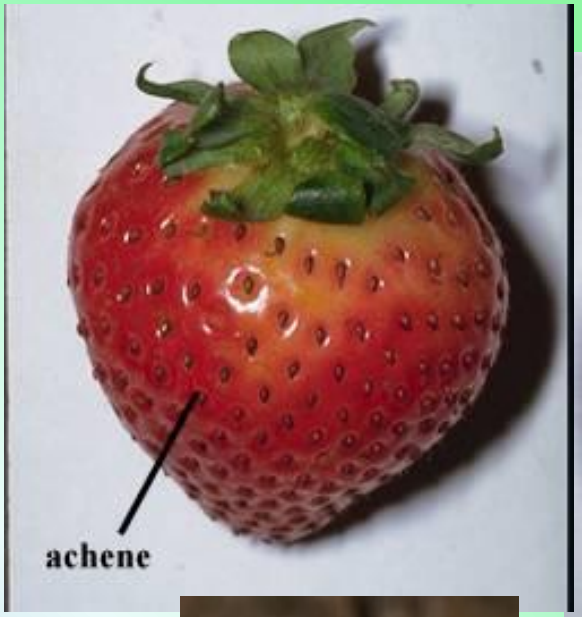
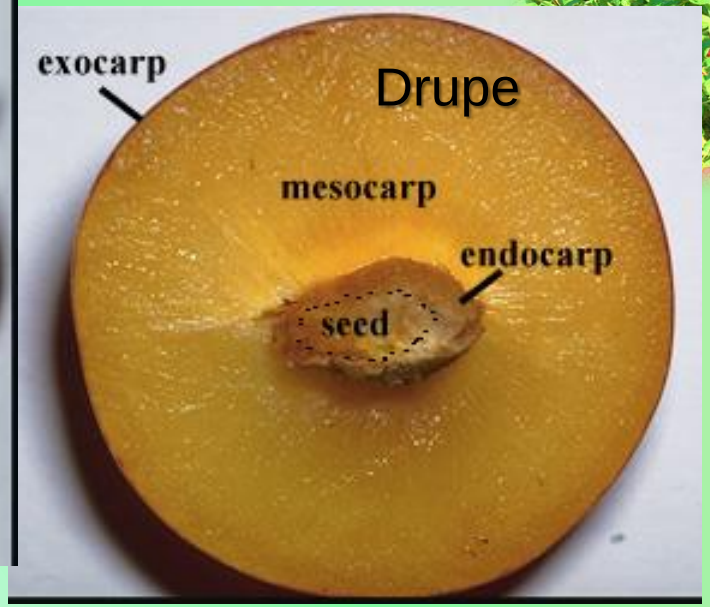
Fruits

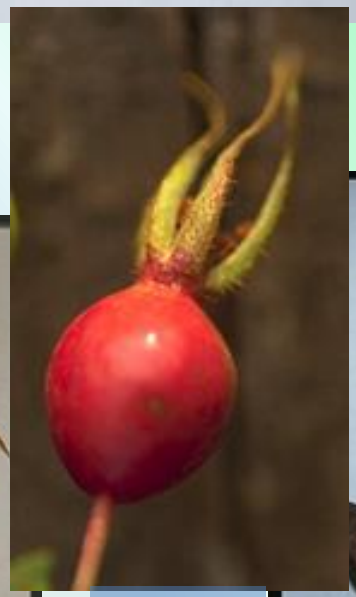
- Plant's seed-bearing structures
  - **Only** in angiosperms
- Do **not** care if we find them tasty

fruits

Berry







Hip

Multiple

Legume

Fruits protect and nurture seeds

Seeds

- the means by which most plants propagate

- the result of sexual reproduction

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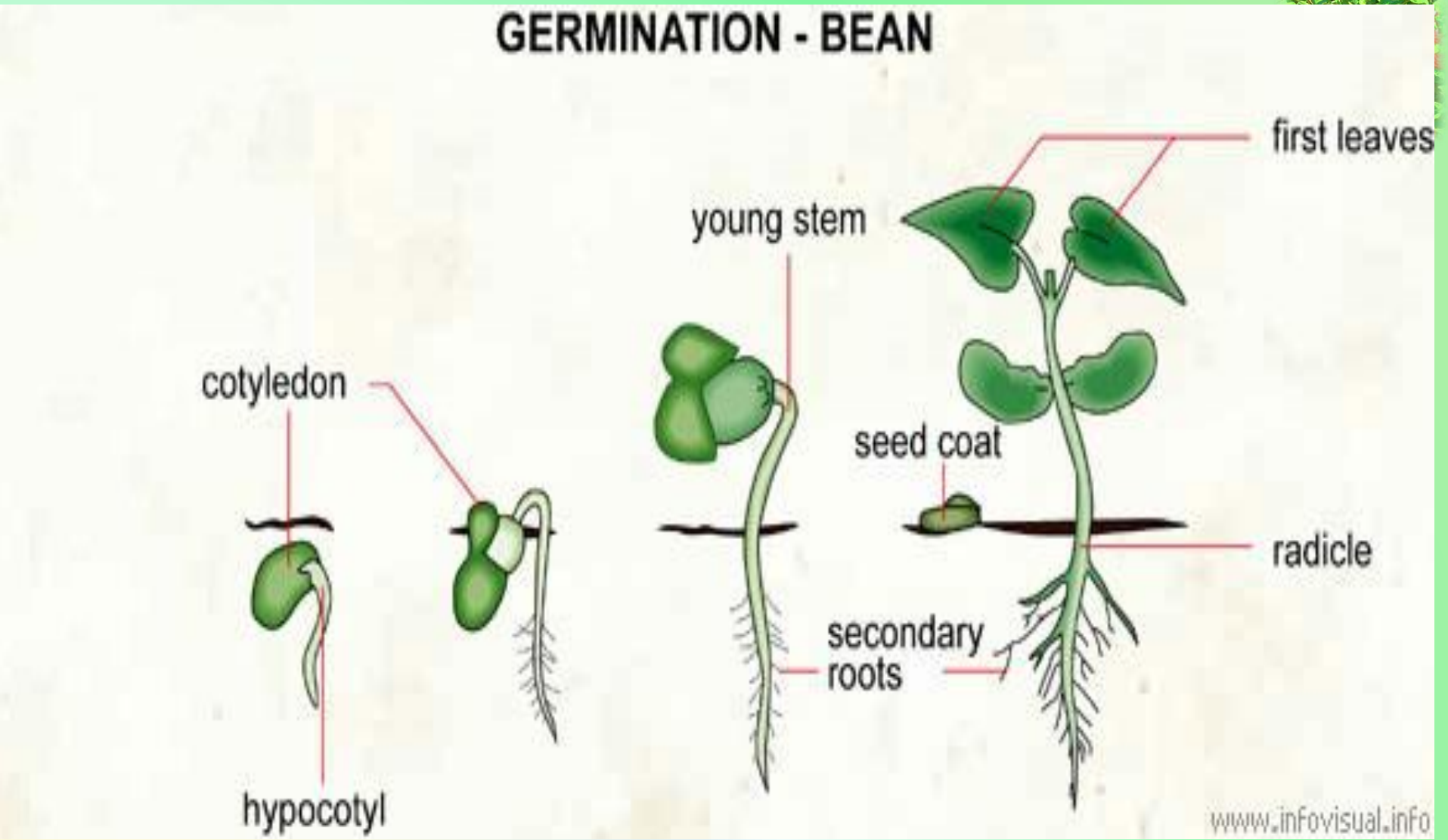
Seeds

- We seldom grow **ornamental** plants for seeds
- Certain **vegetables** are grown particularly for seeds
  - Beans
  - Peas
  - Sunflowers



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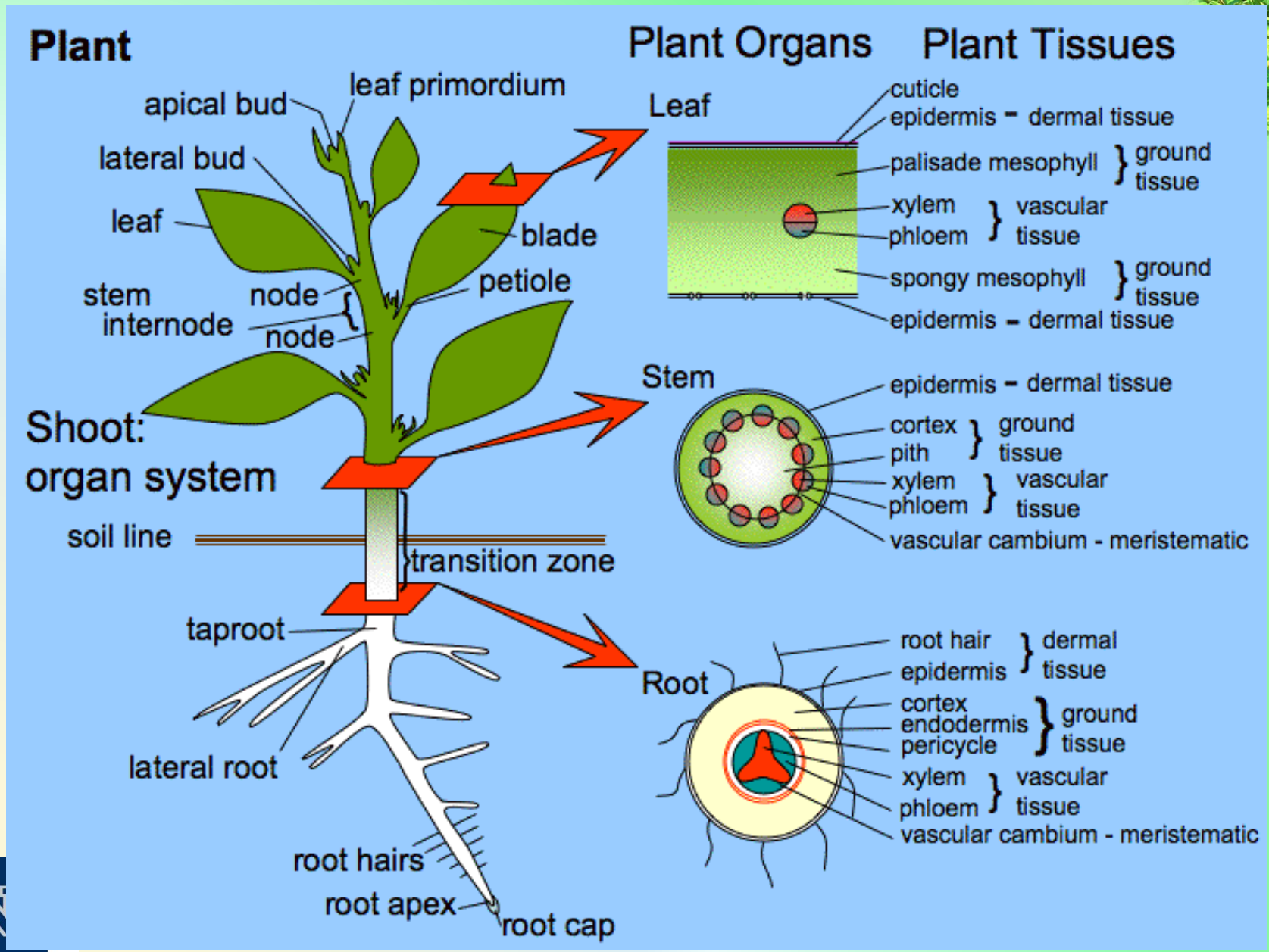
Avocado Pit Cross Section


Plant
Plant Organs
Plant Tissues
apical bud
leaf primordium
lateral bud
leaf
blade
petiole
stem
node
internode
node
Shoot:
organ system
soil line
transition zone
taproot
lateral root
root hairs
root apex
root cap
Leaf
cuticle
epidermis – dermal tissue
palisade mesophyll
ground tissue
xylem
phloem
vascular tissue
spongy mesophyll
ground tissue
epidermis – dermal tissue
Stem
epidermis – dermal tissue
cortex
pith
ground tissue
xylem
phloem
vascular tissue
vascular cambium - meristematic
Root
root hair
epidermis
dermal tissue
cortex
endodermis
pericycle
ground tissue
xylem
phloem
vascular tissue
vascular cambium - meristematic

Survival techniques

Plants have evolved many mechanisms to conserve water and deal with extreme environments.

Changing location of processes… (C4 plants)

- Many plants, e.g. corn, sorghum, and many **grassy weeds**, have a system to continue photosynthesis even when temperatures become high and water is in short supply.
- ½ of all grass species may be C4
- Few dicots: *Portulaca, pigweed*

Changing the timing ("cam" plants)

Many desert plants (most succulents and cacti) perform the functions that require the loss of water at night. Their stomates stay closed during the day to save much of their water.

Structural adaptations

- Thicker cuticle (waxy leaf coating)
- Leaves rolled
- Succulent leaves store water
- Deeply lobed leaves to escape sun
- Leaves with grey coat to escape sun
- Smaller leaves with fewer stomates


04.14.2008

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Water – *all* life needs it

- Even desert plants.
- Most nutrients are dissolved in it
- Most of a cell is filled with water-based solutions
- It maintains cell firmness
- It is the avenue by which plant nutrients are transported
- Loss of water through transpiration is the temperature control mechanism of a plant.
- Drought tolerant plants have devised ways to conserve water; they absolutely need it.


Death by Drowning
© 2010 Purdue Univ, RLNielsen

Post class assessment

1. A stomate is
    1. An opening permitting gas & water to enter or leave a leaf
    2. A type of root system
    3. A means for the plant to attract pollinators
2. (T/F) It is possible for plant respiration to be considered the opposite of photosynthesis
3. The green pigment in a plant is _____

Post-class assessment (cont.)

4. (T/F) A long day plant requires more than 12 hours of light
5. Cactus spines may have different roles:
    1. Water conservation
    2. Plant defense
    3. Reproduction
    4. All of the above
    5. 1 & 2 only

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QUESTIONS?

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