



# MORPHOLOGY, STRUCTURE, GROWTH AND DEVELOPMENT

Dr. Mark A. Ritenour

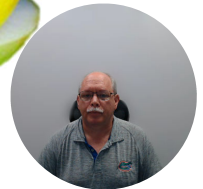
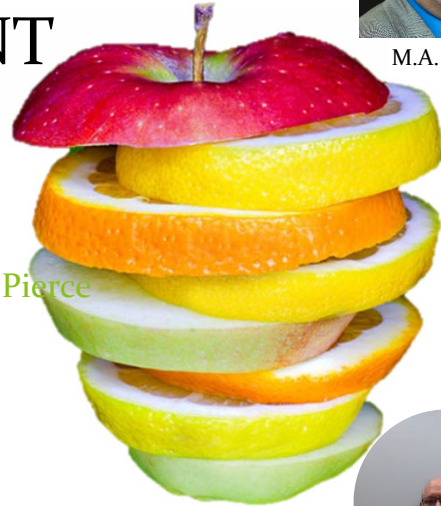
Indian River Research and Education Center, Fort Pierce

Dr. Jeffrey K. Brecht

Horticultural Sciences Department, Gainesville



M.A. Ritenour



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## **Classifications of Horticultural Crops and Their Usefulness in Relation to Postharvest Considerations**

- Botanical classification
- Classification by geographical origin
- General groups of horticultural commodities
- Subgroups within general groups
- Grouping by plant parts



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## Grouping by Plant Parts

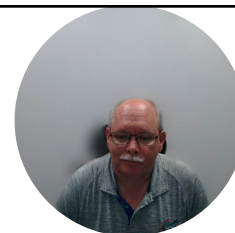
- This classification is the most useful in relation to postharvest considerations since, in most cases, commodities within a given group have similar postharvest requirements and recommendations.
- Couple with knowledge of geographical origin, which relates to chilling injury susceptibility



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## Grouping by Plant Parts

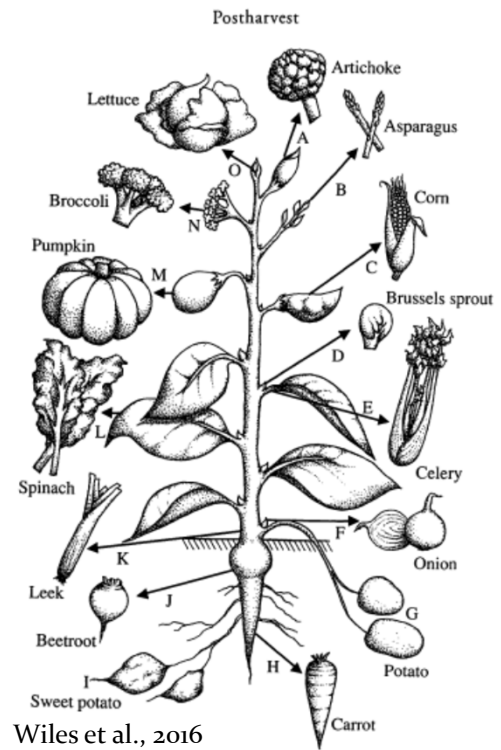
<b>Edible plant part</b>	<b>Examples</b>
Entire plant	-beet, radish, potted plants
Shoot	-green onion, cut flowers
Root	primary -carrot, turnip secondary -sweetpotato, cassava
Stem	-asparagus, kohlrabi
Tuber	-potato, yam, several ornamentals
Leaf	mainly leaf blade -leaf lettuce, spinach mainly petiole -celery, rhubarb buds -cabbage, head lettuce
Floral parts	-cut flowers, artichokes, cauliflower
Bulb	-onion, several ornamentals
Fruits	fleshy, mature -apples, pears, peaches, berries, grapes, citrus, melons, tomatoes, winter (hard-rind) squash fleshy, immature -cucumbers, summer (soft-rind) non fleshy, immature -peas, green beans, okra, sweetcorn non fleshy, mature -seeds and nuts



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# Morphological Structure of Horticultural Commodities

- A diversity of plant parts and their structures are represented by harvested fruits and vegetables



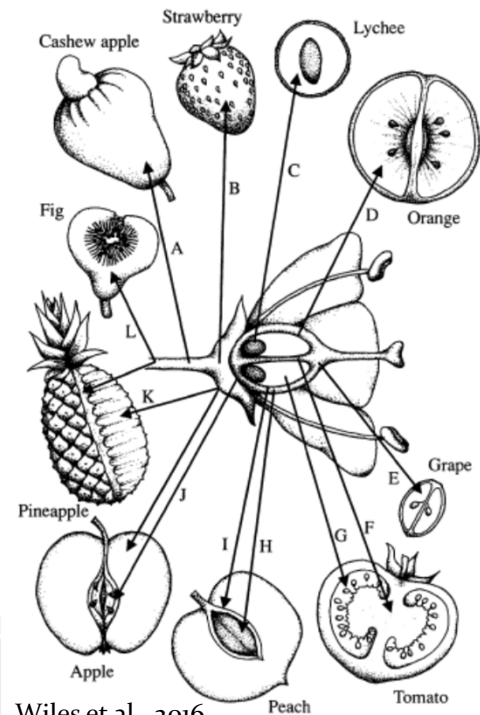
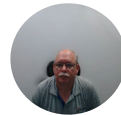
Wiles et al., 2016

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# Morphological Structure of Horticultural Commodities

- Note also the diversity of tissues that can develop into fruit flesh. All parts of the total inflorescence structure are, in one species or another, developed into fruit flesh

**Derivation of some fruits from plant tissue.** The letters indicate the tissues that comprise a significant portion of the fruit illustrated: (A) pedicel, (B) receptacle, (C) aril, (D) endodermal intra locular tissue, (E) pericarp, (F) septum, (G) placental intralocular tissue, (H) mesocarp, (I) endocarp, (J) carpels, (K) accessory tissue, (L) peduncle.



Wiles et al., 2016

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## Relationship between structure of horticultural commodities and their postharvest behavior

### Group

### General postharvest characteristics

Rapidly growing vegetative and immature fruit structures

- Highly perishable
- Usually high respiration rate
- Rapid chemical changes
- Weight loss is a major cause of deterioration
- Continued growth can be a problem

Mature fruits

- Vary in perishability from very high (strawberry) to low (apple)
- Undergo many physiological and compositional changes associated with ripening
- Decay can be an important deterioration factor
- Moisture content is important to storage-life
- Germination can be a factor



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## Relationship between structure of horticultural commodities and their postharvest behavior

(Cont.)

### Group

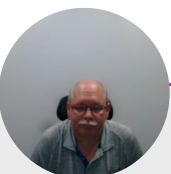
### General postharvest characteristics

Fleshy storage organs and propagules

- Low perishability
- Low respiration rate
- Growth can accelerate deterioration

Mature seeds and nuts

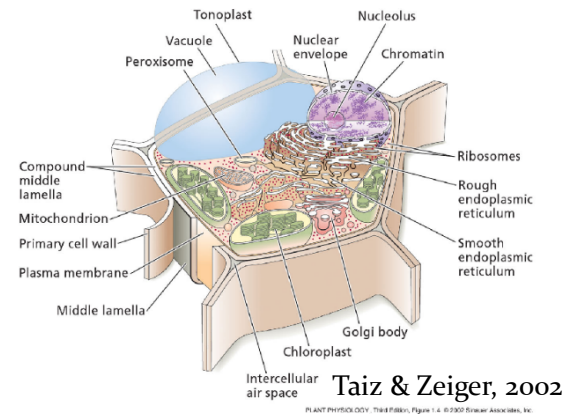
- Very low perishability
- Very low respiration rate
- Moisture content is important to storage life
- Germination can be a factor



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## The Plant Cell

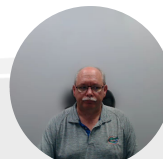
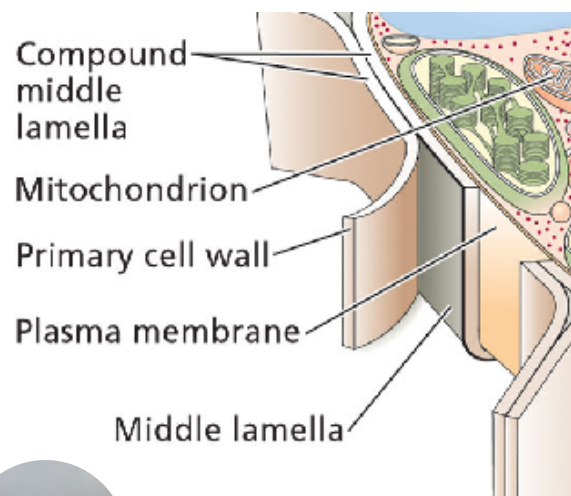
- A basic functional unit.
- Cell = cell wall + protoplasm
  - Protoplasm = cytoplasm + nucleus
    - Nucleus
      - Information center
    - Cytoplasm = everything within the cell except the nucleus or the cell wall
      - cytosol - watery matrix
      - organelles - membrane-bound, specialized function



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## Plasma Membrane

- Boundary between the living and non-living world
- *Selectively permeable*
  - Physically limits the cell
  - Controls exchange of "stuff"
  - Maintains differences between cell & environment
- Hormone perception
- Direct synthesis of cellulose

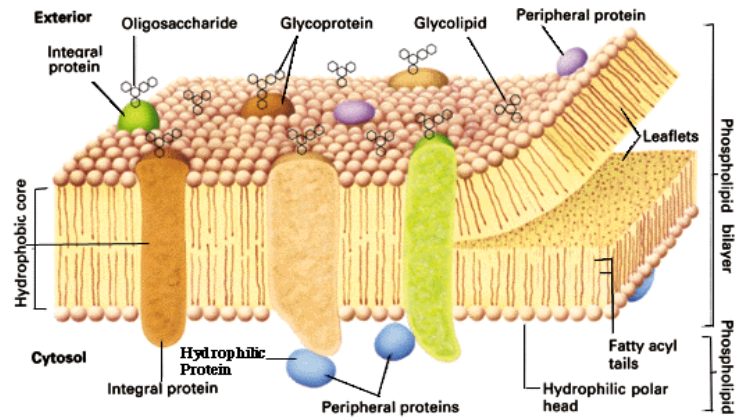


Taiz &amp; Zeiger, 2002

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## Membrane Composition

- Lipid bilayer.
  - Phospholipids & Sterols
- Proteins (~50%)
  - Functional component
- Carbohydrates
  - Glycoproteins & a few glycolipids
- Relative compositions of each vary

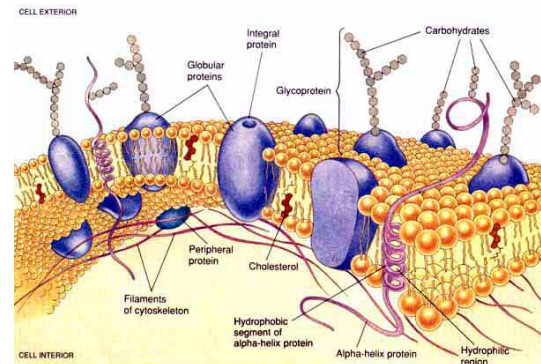


<http://tiger.towson.edu/~cfanel1/istc301/cell-membrane.gif>

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## Properties of Bilayer

- Highly fluid
- Impermeable to polar molecules
  - Exception: H<sub>2</sub>O
  - CO<sub>2</sub> & O<sub>2</sub> (non-polar) can pass readily
- Contains unsaturated fatty acids (= “kinks” in their “tails”)

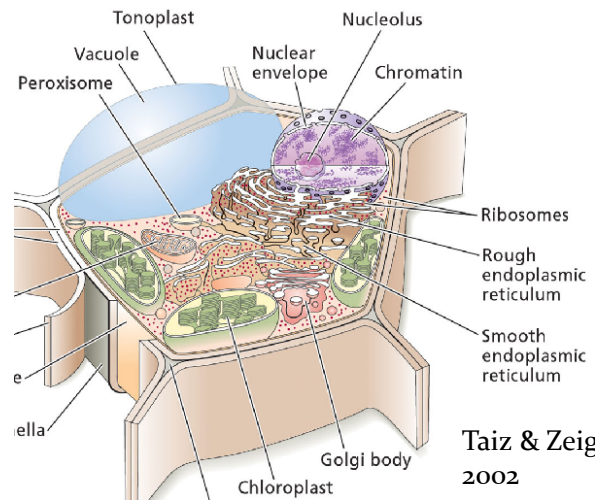


<http://bio.winona.edu/bergl/ILLUST/memb-mod.jpg>

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## Organelles

- Membrane limited compartments
- Each is involved with *specific chemical processes*
- Cytosol - liquid, jellylike component, full of “raw” chemicals which surround the organelles



Taiz & Zeiger, 2002



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## Nucleus - Information central

- Surrounded by a double membrane
- Contains DNA
  - encodes RNA (*Transcription*)
- Contains RNA
  - directs protein synthesis (*Translation*) in the cytosol

<https://micro.magnet.fsu.edu/cells/plants/nucleus.html>

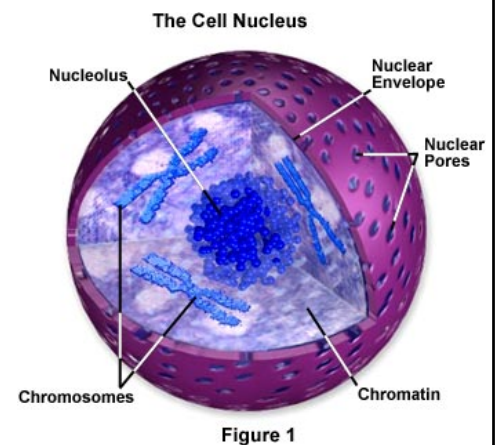
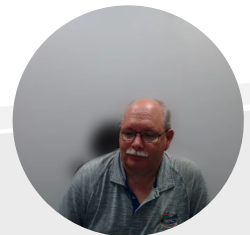


Figure 1

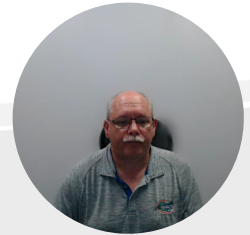
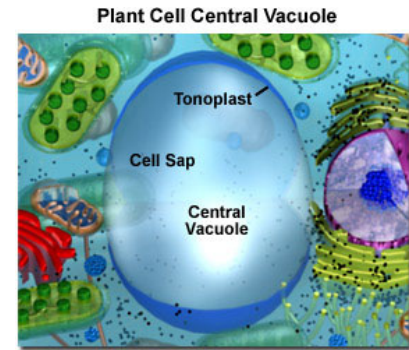


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<http://micro.magnet.fsu.edu/cells/plants/images/plantvacuolesfigure1.jpg>

## The Vacuole

- “Storage pool”
- Largest volume component of the cell
  - Often 80-90% of cell volume
- Vacuolar membrane = tonoplast.
- Allows uptake of water for cell enlargement (turgor pressure).
  - controls water potential of the cell
- Contains complex chemicals
  - Inorganic ions, organic acids, sugars, enzymes, pigments, secondary metabolites (e.g., phenolics)



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## Mitochondria

- Energy metabolism – site of cellular respiration
- Double membrane
- Sugar oxidation drives synthesis and transport of ATP
- Contain DNA
- Self replicating
- 100 to 1,000s per cell

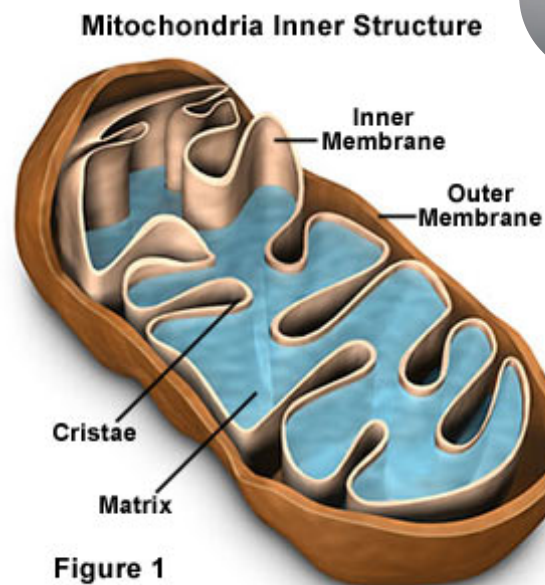


Figure 1

<http://www.biologyclass.net/mitochondria.jpe>

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## Plastids

- Energy harvesting
- Double membrane bound
- Contain DNA and ribosomes
- Self-reproducing

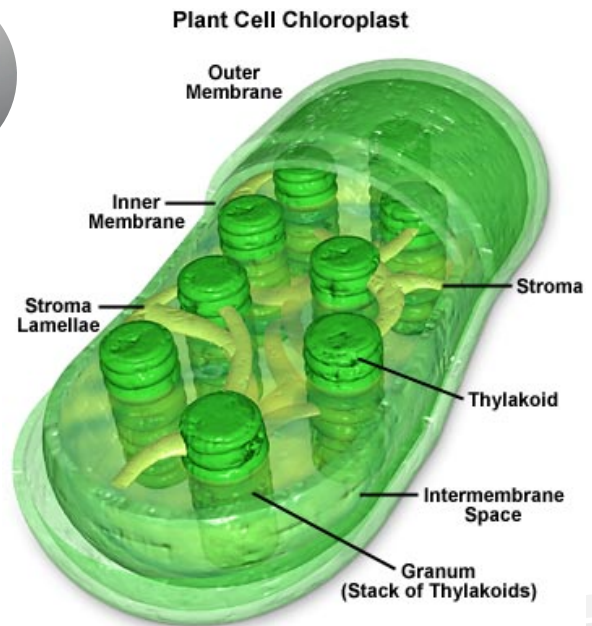


Figure 1

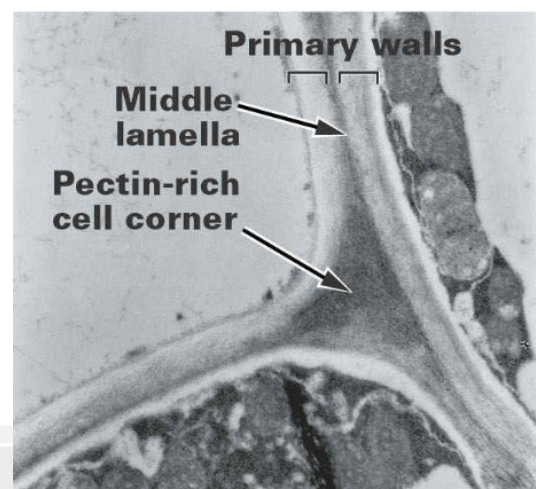
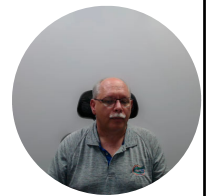
[http://homepage.smc.edu/hodson\\_kent/Cells/Energetics/chloroplastz.jpg](http://homepage.smc.edu/hodson_kent/Cells/Energetics/chloroplastz.jpg)

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## Extracellular Matrix

- A complex mixture [carbohydrates, phenolics & proteins (enzymes)]
- Cell Wall
  - Primary - comes first
  - Secondary - matures inside primary
  - Wall pits and plasmodesmata
- Middle Lamella - cellular “glue”

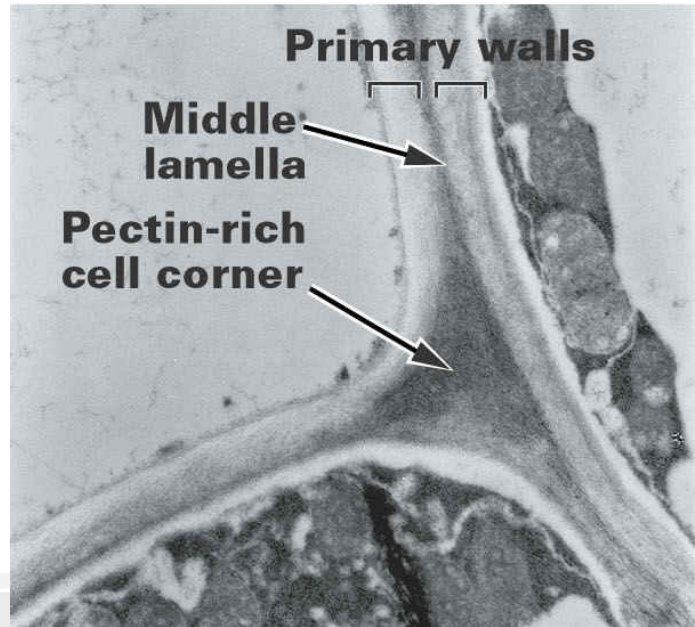
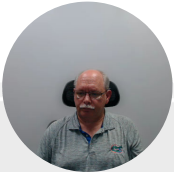


Buchanan et al., 2000

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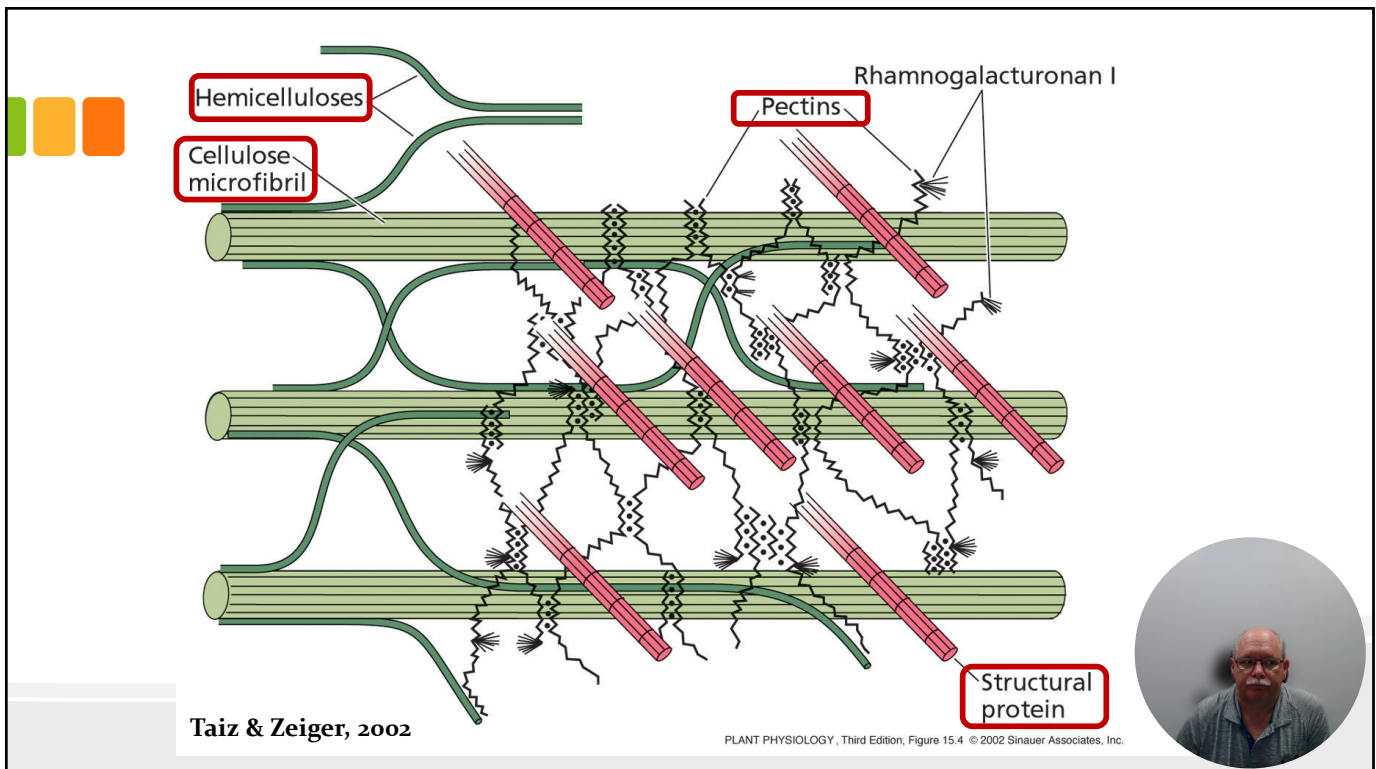
## Cell Walls

- Provide support (rigidity) to the cell and tissues
- Permeable
- Composed of:
  - Cellulose
  - Hemicellulose
  - Pectin
  - Protein
  - Lignin

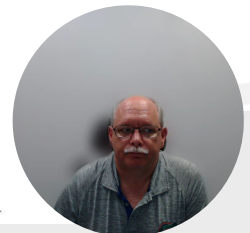


Buchanan et al., 2000.

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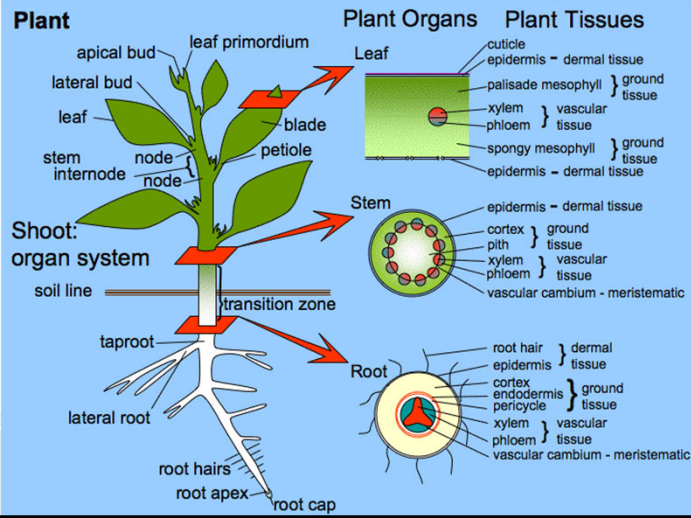
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# Tissue systems and component cells

- The dermal system (protective tissues)
- The ground system
  - Supporting tissues
- Vascular tissues

<https://organismalbio.biosci.gatech.edu/growth-and-reproduction/plant-development-i-tissue-differentiation-and-function/>

**Plant**

**Shoot: organ system**

**Plant Organs**

**Plant Tissues**

**Leaf**

- cuticle
- epidermis – dermal tissue
- palisade mesophyll } ground tissue
- xylem } vascular tissue
- phloem } vascular tissue
- spongy mesophyll } ground tissue
- epidermis – dermal tissue

**Stem**

- epidermis – dermal tissue
- cortex } ground tissue
- pith } ground tissue
- xylem } vascular tissue
- phloem } vascular tissue
- vascular cambium - meristematic

**Root**

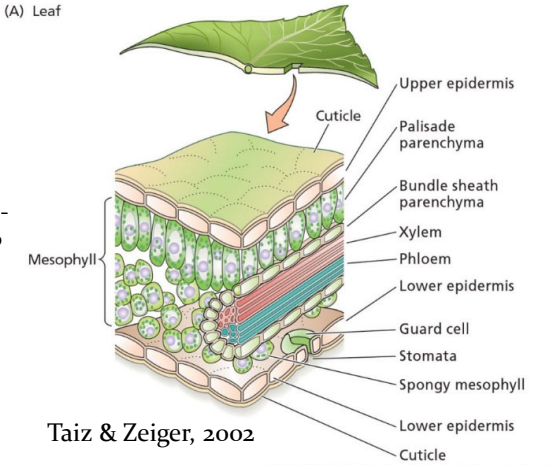
- root hair } dermal tissue
- epidermis } dermal tissue
- cortex } ground tissue
- endodermis } ground tissue
- pericycle } ground tissue
- xylem } vascular tissue
- phloem } vascular tissue
- vascular cambium - meristematic

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# Tissue systems and component cells

- The dermal system (protective tissues)
  - Epidermal cells
  - Cuticle (waxy coating)
  - Stomates
  - Lenticels
  - Trichomes
  - Periderm (cork)

<https://www.fast-growing-trees.com/products/fuzzy-kiwi-plants?variant=39398874841150>




**(A) Leaf**

- Upper epidermis
- Cuticle
- Palisade parenchyma
- Bundle sheath parenchyma
- Xylem
- Phloem
- Lower epidermis
- Guard cell
- Stomata
- Spongy mesophyll
- Lower epidermis
- Cuticle

Taiz & Zeiger, 2002

PLANT PHYSIOLOGY, Third Edition, Figure 1.11 (Part 2) © 2002 Sinauer Associates, Inc.



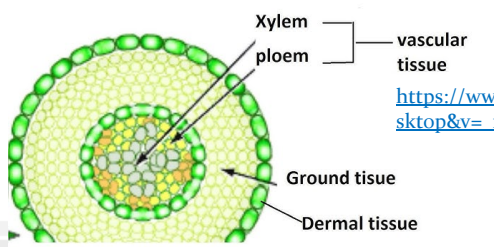
lenticels

<https://www.pinterest.com/pin/205124958009692756/>

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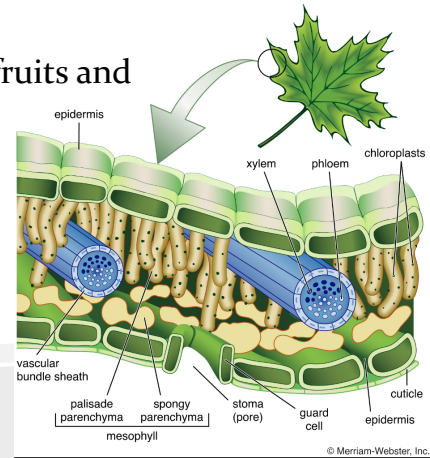
# Tissue systems and component cells

- The ground system
  - Parenchyma cells - constitute most of the edible portion of an apple or a potato, etc.
  - Intercellular spaces - constitute about 20% in fruits and roots, >20% in leaves.



<https://www.youtube.com/watch?app=desktop&v=rw4b08ogJE>

<https://www.britannica.com/science/parenchyma-plant-tissue>

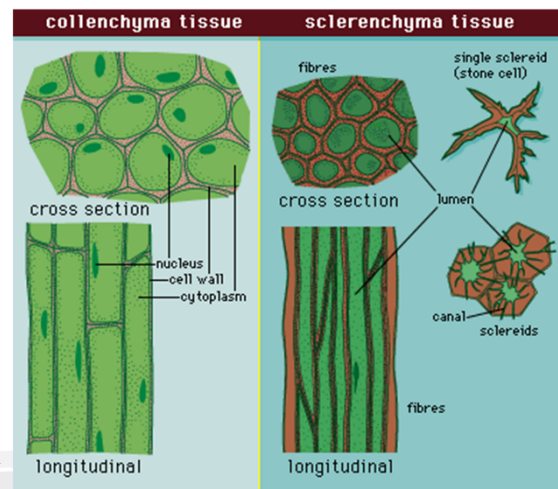


© Merriam-Webster, Inc.

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# Tissue systems and component cells

- Supporting tissues
  - Collenchyma cells - largely responsible for stringiness in celery stalks
  - Sclerenchyma cells
    - Sclerenchyma fibers are major constituents of the "string" in green beans.
    - Sclereids (stone cells) in the flesh of certain fruits (e.g., guava, pear, sapote) are responsible for their gritty or sandy texture.

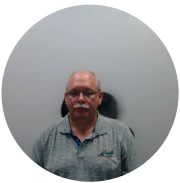


<https://www.britannica.com/science/parenchyma-plant-tissue>

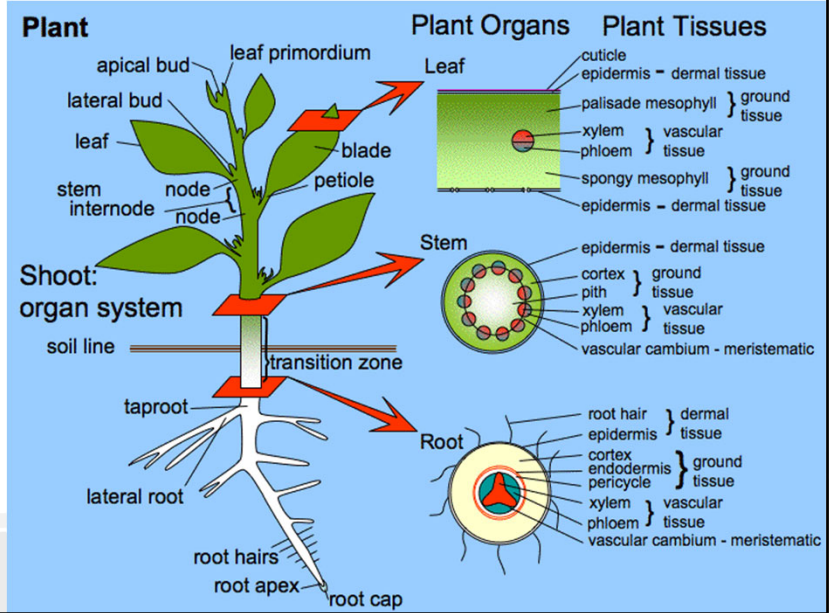
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# Tissue systems and component cells

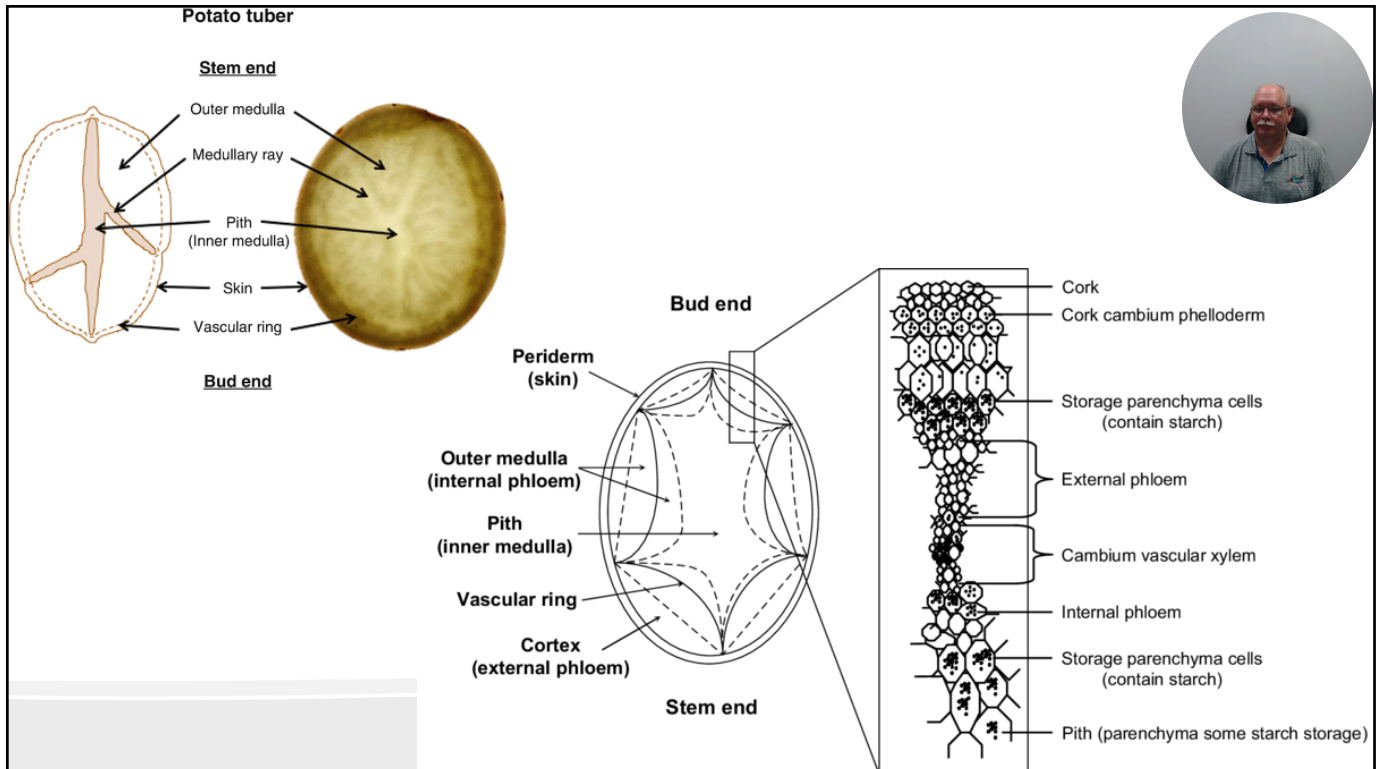
- Vascular tissues
  - Xylem
  - Phloem
  - Laticifers (latex-producing cells in papaya, banana, etc.)



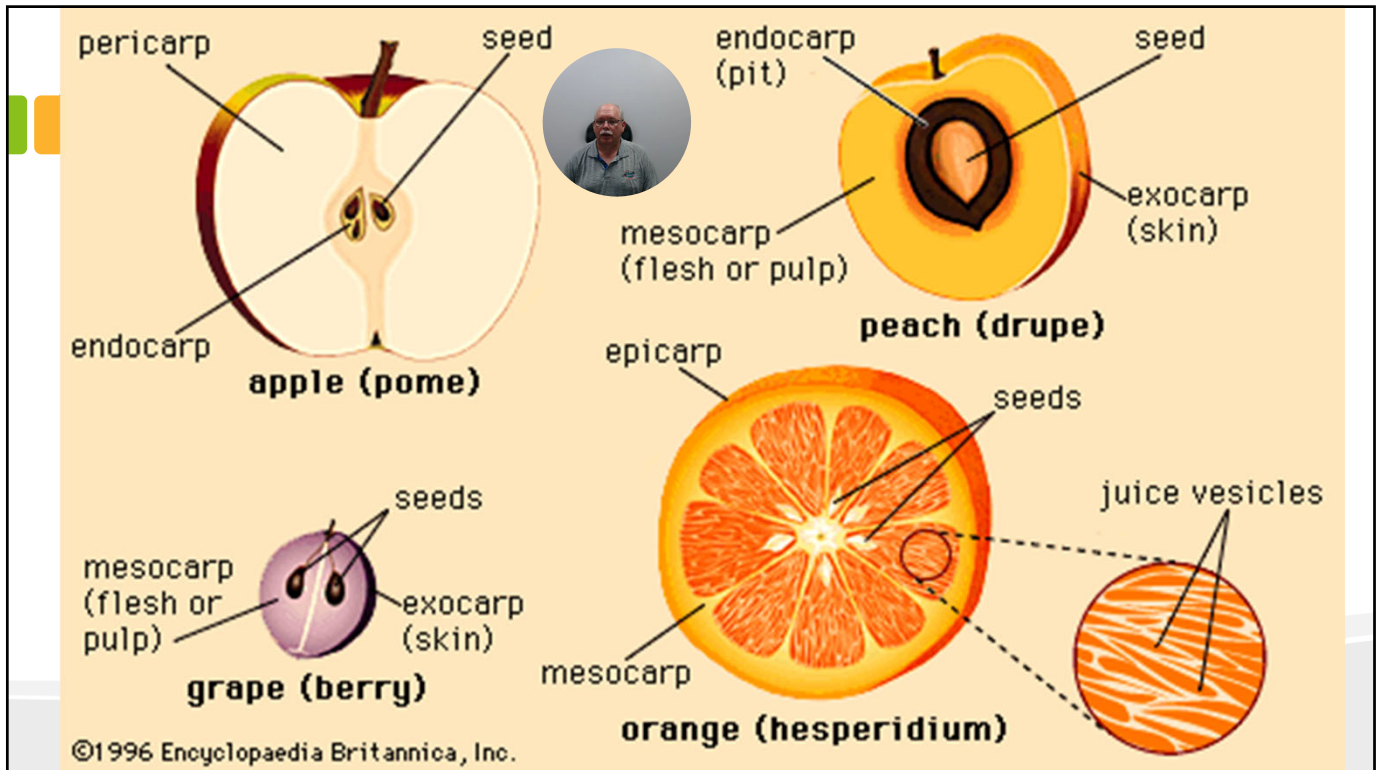
<https://organismalbio.biosci.gatech.edu/growth-and-reproduction/plant-development-i-tissue-differentiation-and-function/>



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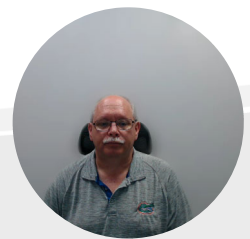
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## Surface to Volume Ratio

- Commodities with large surface to volume ratios (*i.e.*, leaf lettuce) experience much faster evaporative water loss.
- However, large, bulky commodities with low surface to volume ratios may not exchange gases (*i.e.*,  $O_2$ ) rapidly enough to satisfy aerobic respiratory demand.

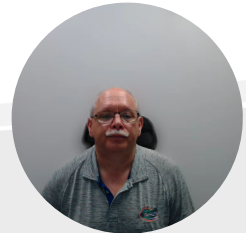


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## Surface to Volume Ratio

- In general, doubling dimensions of an object
  - = 4x increase in surface area
  - = 8x increase in volume
- Therefore, larger bulky crops have smaller surface to volume ratios.

Commodity	Length (in.)	Radius	Area	Volume	Area/Vol.
Tomato					
- small		2	50.3	33.5	1.50
- large		4	201.1 <sup>4x</sup>	268.1 <sup>8x</sup>	0.75
Cucumber					
- small	8	2	100.5	83.6	1.20
- large	16	4	402.0	670.2	0.60
Carrot					
- small	8	2	64.9	41.9	1.55
- large	16	4	259.5	335.1	0.77



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## Changes After Harvest

- Growth** - sprouting, rooting, elongation, seed germination
- Toughening** (due to increased lignification); fiber content
- Softening** (due to changes in cell wall)
- Wound periderm** (formed in response to wounding)
- Increased thickness of cuticle and wax deposits** with fruit ripening
  - Changes in water loss/gas diffusion



Image courtesy of Steve Sargent



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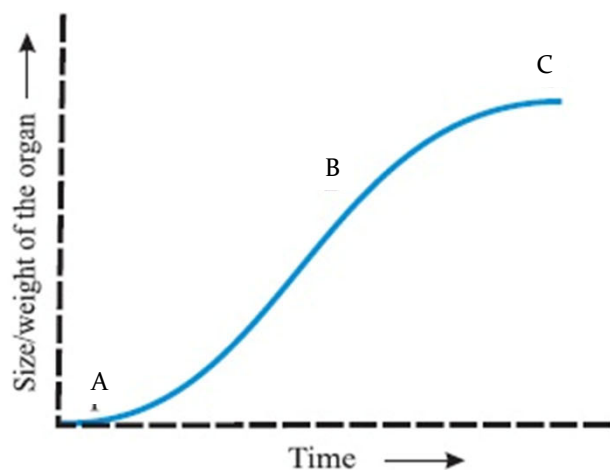
## Growth and Development of Plant Parts

- **Growth:** The irreversible increase in physical attributes of a developing plant or plant part
- **Development:** The series of processes from the initiation of growth to death of a plant or plant part



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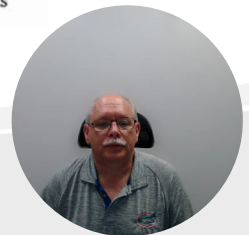
Simple sigmoidal growth curve – applicable to most cells, organs, individuals, or populations



apple, pineapple, strawberry, tomato, roots, bulbs and other vegetative organs

Duration between anthesis and ripenes varies from 3 weeks for strawberries to 60 weeks for Valencia oranges

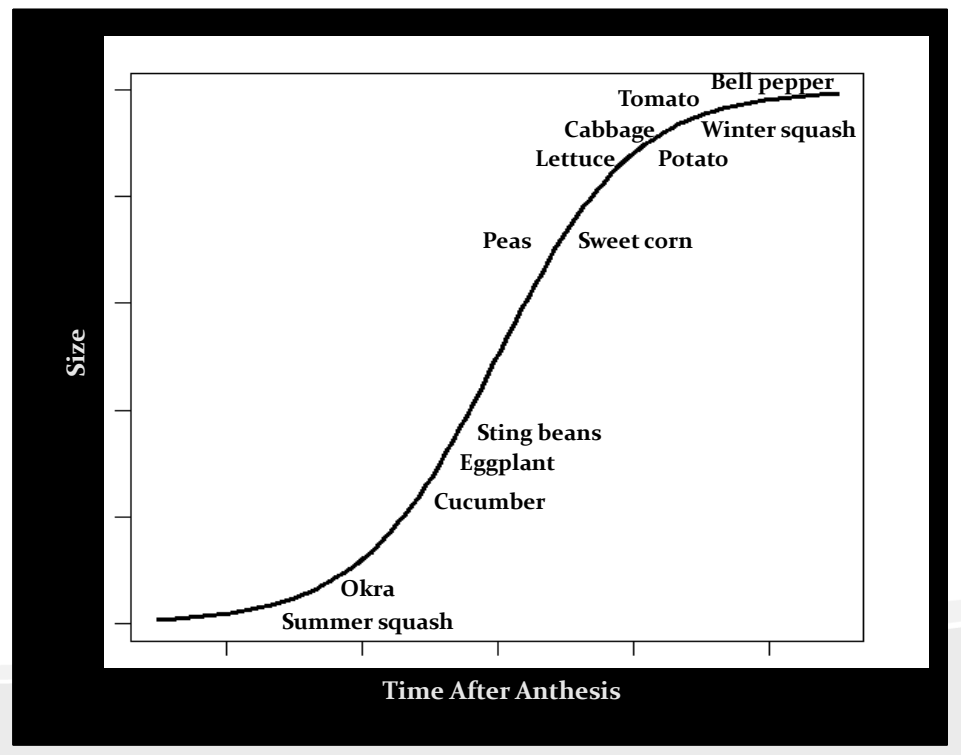
A - summer squash, okra  
 B - cucumbers, eggplant, beans  
 C - lettuce, potatoes, mature fruits



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Simple sigmoidal growth curve showing the stage of growth when some commodities are harvested



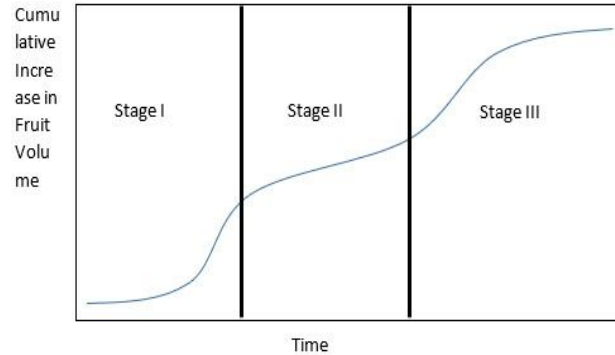
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### Double sigmoidal growth curve

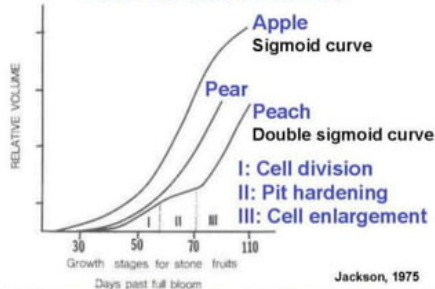
Stone fruits, fig, blueberry, blackberry, grape, olive

Slow growth phase varies in length among species and among cultivars within a species

<https://edis.ifas.ufl.edu/publication/HS1459>

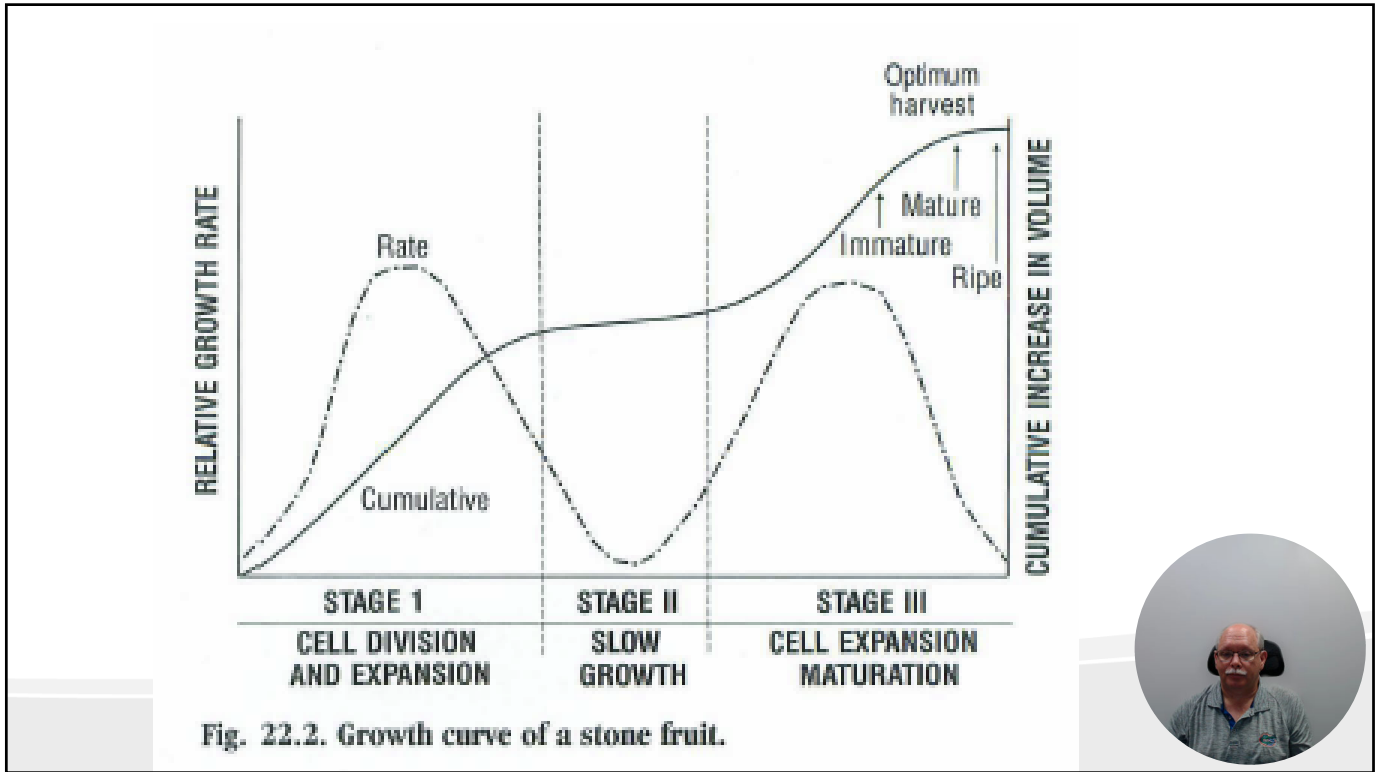


### Fruit Growth Curves

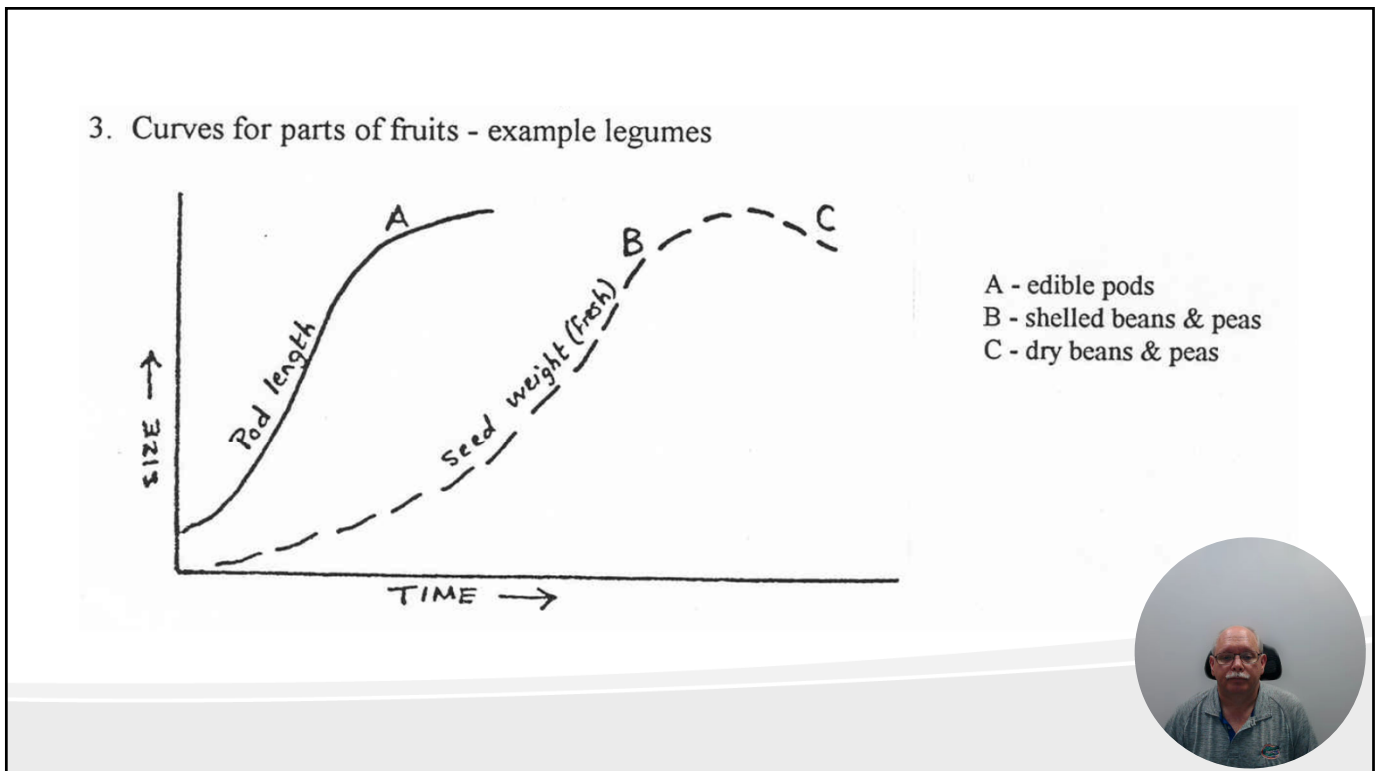


<https://www.slideshare.net/slideshow/8-plant-growth-and-development-and-dormancypptx/266284588#1>

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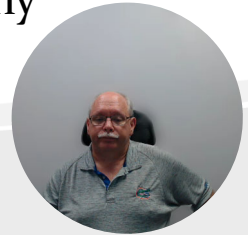
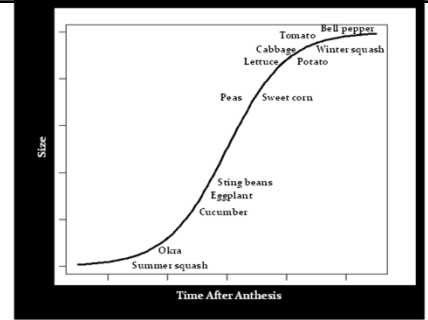
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## Developmental Changes

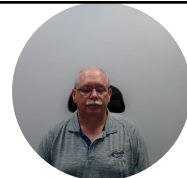
- **Horticultural maturity:** The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers for a particular purpose
- **Physiological maturity:** The stage of development when a plant or plant part will continue ontogeny even if detached



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## Developmental Changes

- **Maturation:** The stage of development leading to the attainment of physiological or horticultural maturity.
- **Ripening:** The composite of the processes that occur from the latter stages of growth and development through the early stages of senescence and that result in characteristic esthetic and/or food quality, as evidenced by changes in composition, color, texture, or other sensory attributes

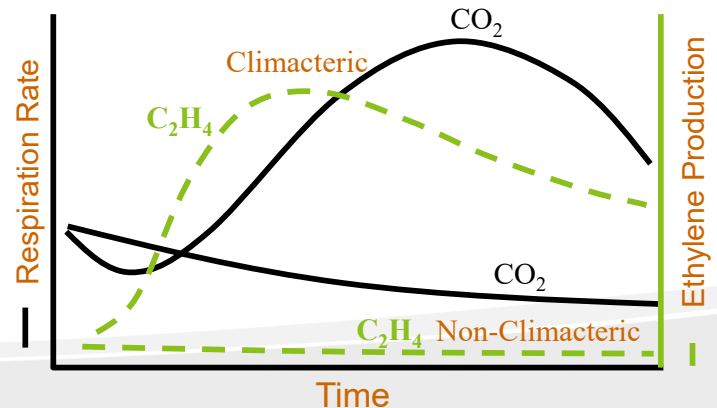


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## Developmental Changes

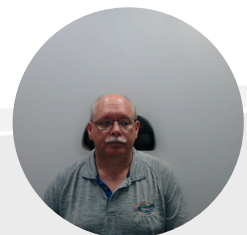
- **Climacteric period:** The period in the development of some plant organs involving a series of biochemical changes associated with the natural respiratory rise and autocatalytic production of ethylene



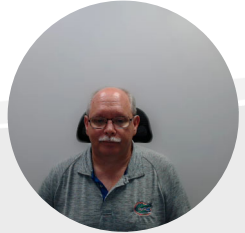
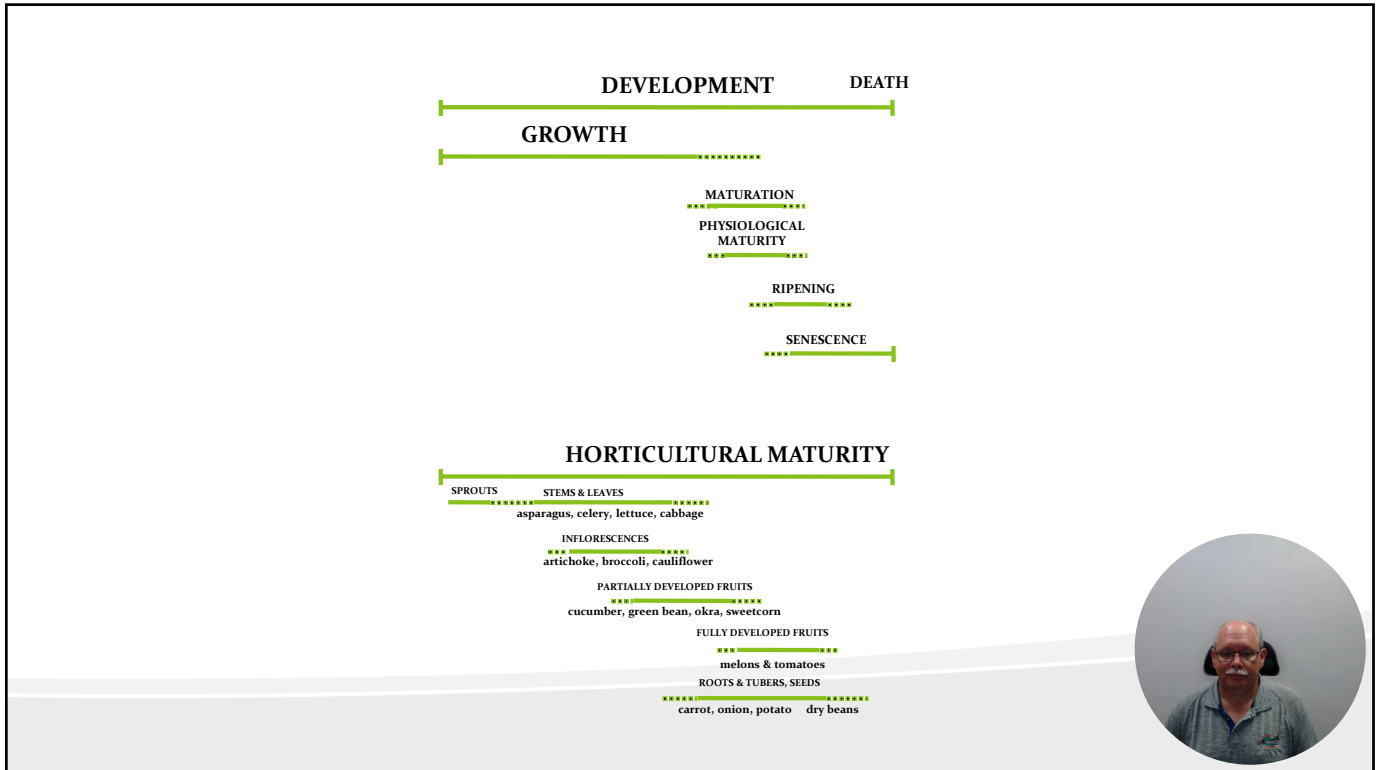
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## Developmental Changes

- **Senescence:** Those processes that follow physiological maturity or horticultural maturity and lead to death of tissue
- **Aging:** Any increment of time, which may or may not be accompanied by physiological change



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## Importance of Stage of Development

- **Time of harvest**
- **Quality when harvested**
- **Frequency of harvest (“harvest window”)**
- **Potential for mechanical harvest**
- **Intended use**
- **Behavior after harvest**



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