MORPHOLOGY, STRUCTURE, GROWTH AND DEVELOPMENT


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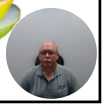
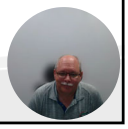


1

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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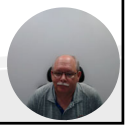
Grouping by Plant Parts

- 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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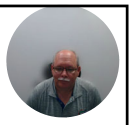
Grouping by Plant Parts



Edible plant part		Examples
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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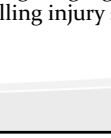
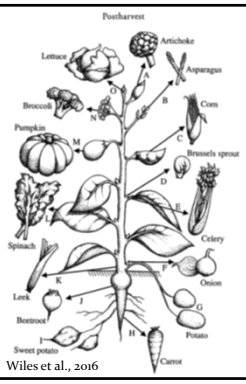
Morphological Structure of Horticultural Commodities

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





Wiles et al., 2016

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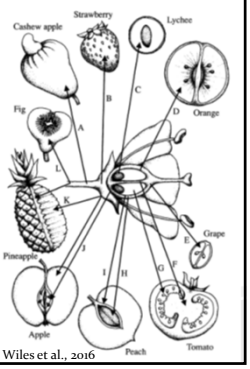
Morphological Structure of Horticultural Commodities

- 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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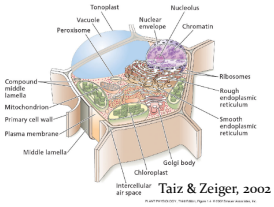
The Plant Cell

- 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



Taiz & Zeiger, 2002

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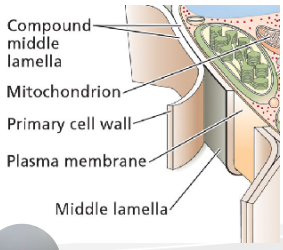
Plasma Membrane

- 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 & Zeiger, 2002

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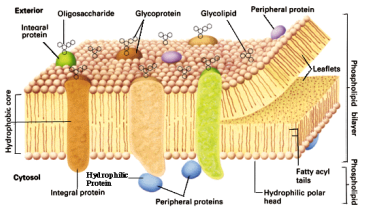
Membrane Composition

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



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

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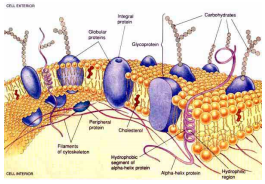
Properties of Bilayer

- Highly fluid
- Impermeable to polar molecules
  - Exception: H_2O
  - CO_2 & O_2 (non-polar) can pass readily
- Contains unsaturated fatty acids (= "kinks" in their "tails")


http://bio.winona.edu/berg/ILLUST/memb-mod.jpg

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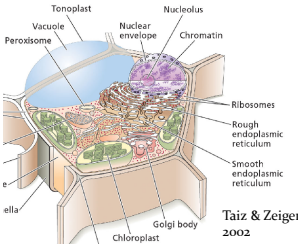
Organelles

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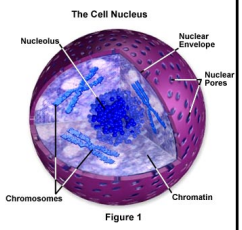
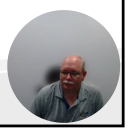
https://micro.magnet.fsu.edu/cells/plants/nucleus.html

Nucleus - Information central

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





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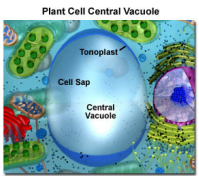
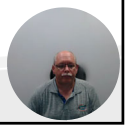
http://micro.magnet.fsu.edu/cells/plants/images/plantvacuolesfigure1.jpg

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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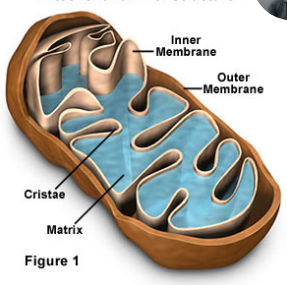
Mitochondria

- 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



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

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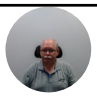
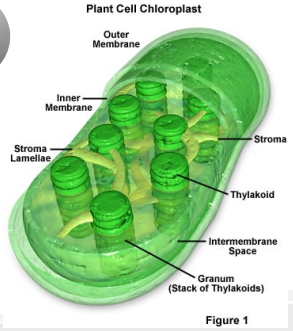
Plastids

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





http://homepage.smc.edu/hodson_kent/Cells/Energetics/chloroplast2.jpg

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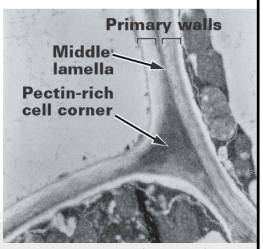
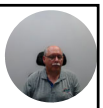
Extracellular Matrix

- 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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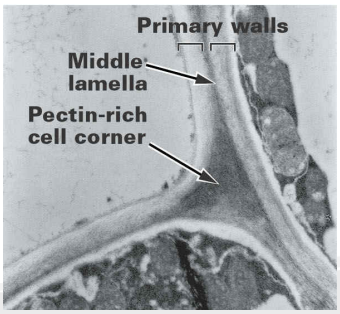
Cell Walls

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



Buchanan et al., 2000.

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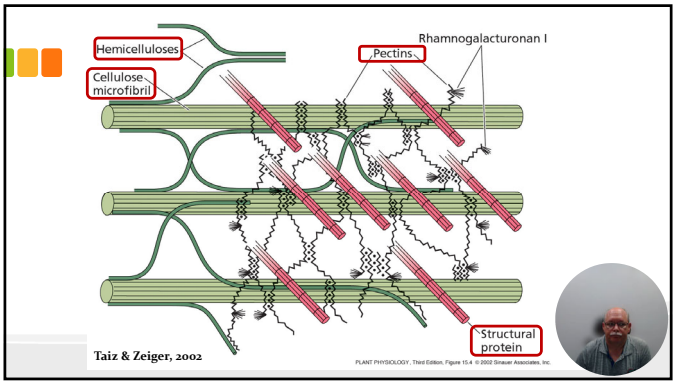

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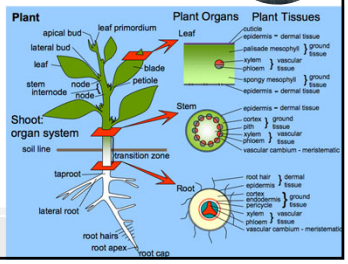
Tissue systems and component cells

- 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/

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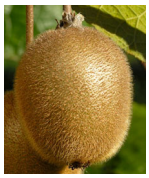
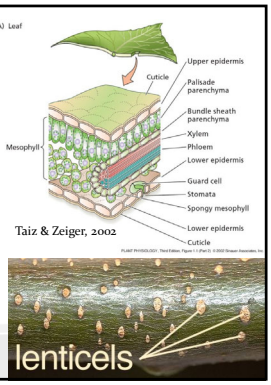
Tissue systems and component cells

- 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





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

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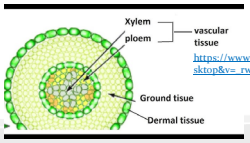
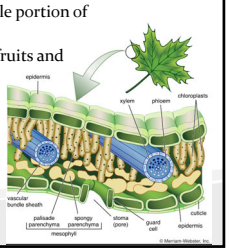
Tissue systems and component cells

- 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=_rw4bo80qIE



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

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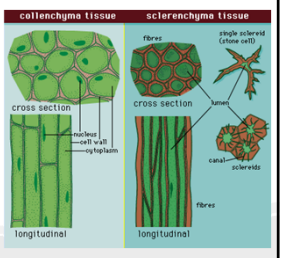
Tissue systems and component cells

- Supporting tissues
  - Collenchyma cells - largely responsible for stringiness in celery stalks
  - Sclerenchyma cells
    - Schlerenchyma 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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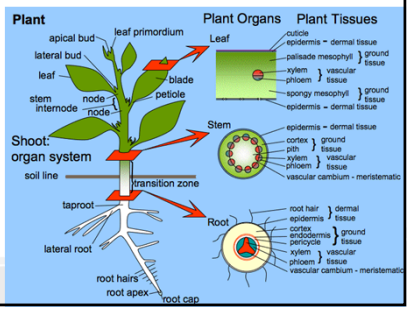
Tissue systems and component cells

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



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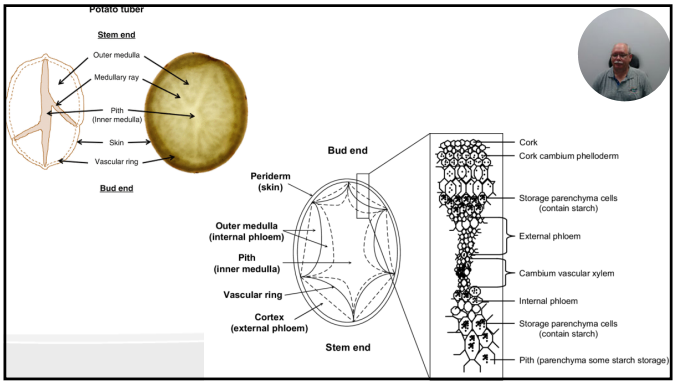

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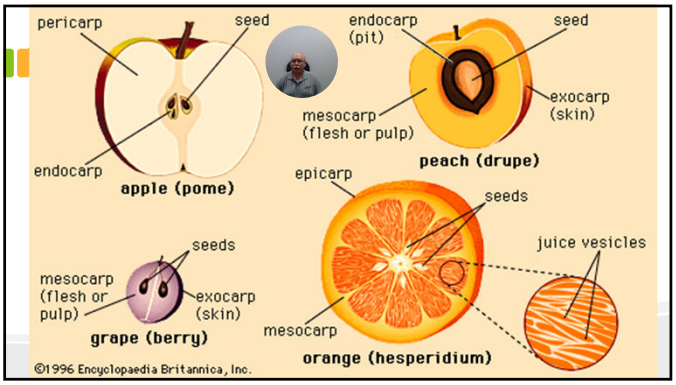

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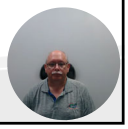
Surface to Volume Ratio

- 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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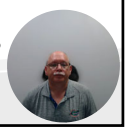
Surface to Volume Ratio

- 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 (4x)	268.1 (8x)	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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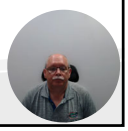
Changes After Harvest

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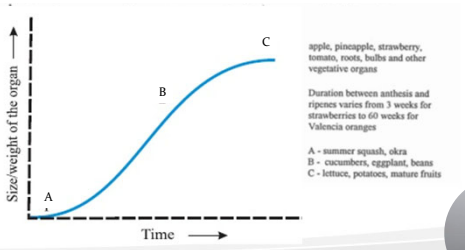
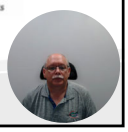
Simple sigmoidal growth curve – applicable to most cells, organs, individuals, or populations





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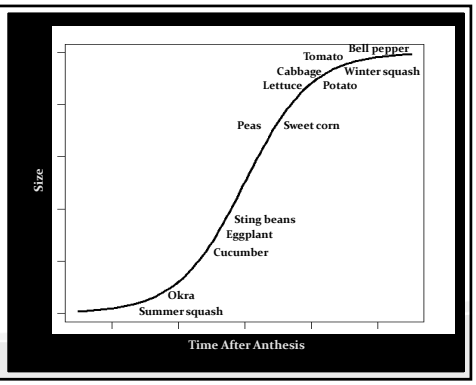
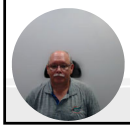
Simple sigmoidal growth curve showing the stage of growth when some commodities are harvested





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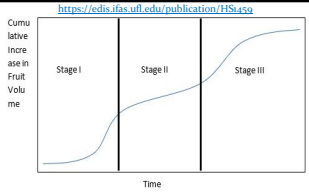
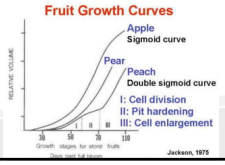
Double sigmoidal growth curve

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

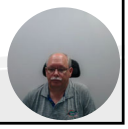
Slow growth phase varies in length among species and among cultivars within a species

https://edis.ifas.ufl.edu/publication/HS1450





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



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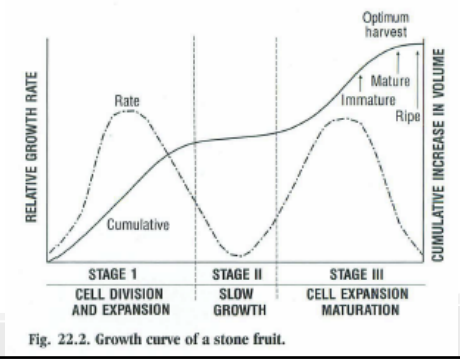
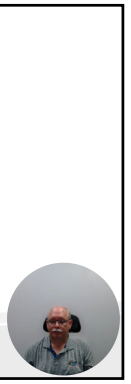


Fig. 22.2. Growth curve of a stone fruit.



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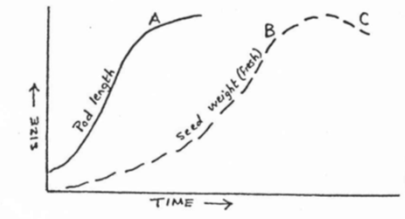
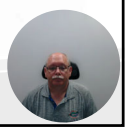
3. Curves for parts of fruits - example legumes





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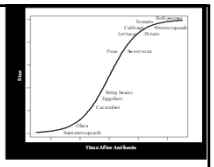
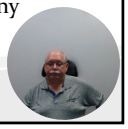
Developmental Changes



- **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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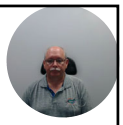
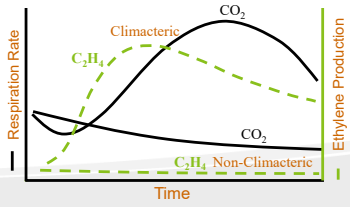
Developmental Changes



- **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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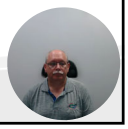
Developmental Changes

- **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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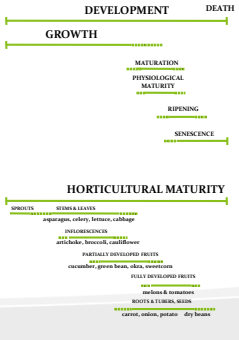

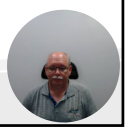

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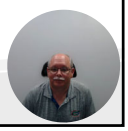
Importance of Stage of Development

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



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