



MORPHOLOGY, STRUCTURE, GROWTH AND DEVELOPMENT

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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

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

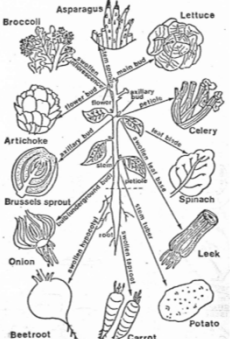
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Morphological Structure of Horticultural Commodities

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

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Derivation of Some Vegetables From Plant Tissue



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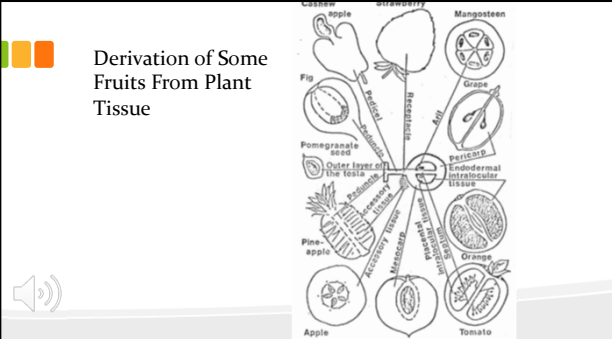

Morphological Structure of Horticultural Commodities

- 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



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Derivation of Some Fruits From Plant Tissue

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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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - Low perishability - Low respiration rate - Growth can accelerate deterioration
Mature seeds and nuts	<ul style="list-style-type: none"> - 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



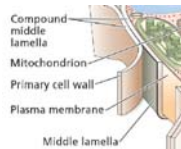
Taiz & Zeiger, 2002




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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

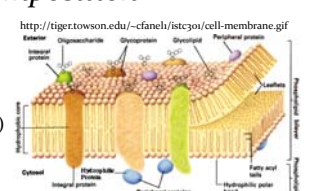


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Membrane Composition

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

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

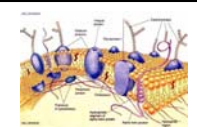


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Properties of Bilayer

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

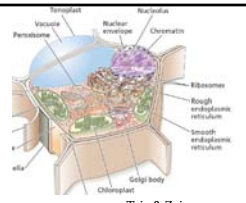
- Highly fluid
- Impermeable to polar molecules
 - Exception: H₂O
 - CO₂ & O₂ (non-polar) can pass readily
- Contains unsaturated fatty acids (= "kinks" in their "tails")



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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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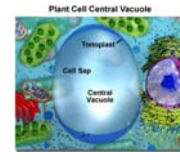
Nucleus - Information central

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

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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)

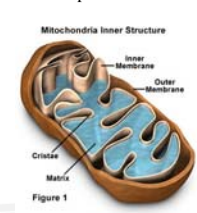


<http://micro.magnet.fsu.edu/cells/plants/images/plantvacuolesfigure1.jpg>

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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

Plant Cell Chloroplast
Outer Membrane
Inner Membrane
Stroma
Thylakoid
Grana (Stack of Thylakoids)
Intermembrane Space
Figure 1

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"

Primary walls
Middle lamella
Pectin-rich cell corner

Buchanan et al., 2000.

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Cell Walls

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

Buchanan et al., 2000.
Primary walls
Middle lamella
Pectin-rich cell corner

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Hemicelluloses
Cellulose microfibrils
Pectins
Rhamnogalacturonan I
Structural protein

Taiz & Zeiger, 2002

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Tissue systems and component cells

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

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Tissue systems and component cells

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

Upper epidermis
Cuticle
Palisade parenchyma
Spongy mesophyll
Stoma
Guard cell
Epidermal cell
Stoma
Palisade parenchyma
Spongy mesophyll
Cuticle

Taiz & Zeiger, 2002

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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.

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Asparagus epidermis and parenchyma tissue

(a) A simple epidermis - asparagus stem

- A stomate
- Cuticle
- Epidermis
- Parenchyma with chloroplasts
- Unspecialized parenchyma

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Cross Section of A Potato Tuber

Periderm of a Potato Tuber

(b) Periderm (cork) - potato tuber

- Cork cambium and corky tissue
- Parenchyma with starch grains

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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.

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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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A Lettuce Leaf

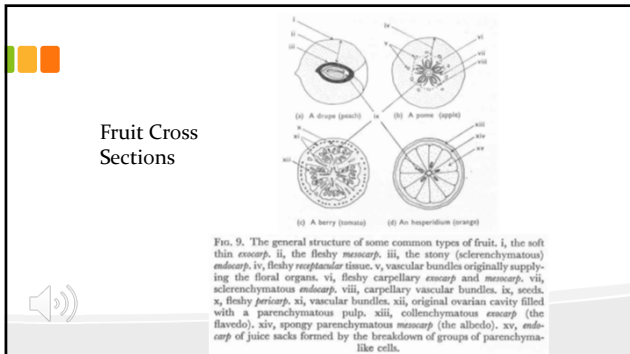
(f) Lettuce

A Celery Petiole

(e) Celery

- Vascular bundles
- Collenchyma
- Midrib of leaf
- Spongy chlorenchyma
- Blade of leaf

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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	268.1	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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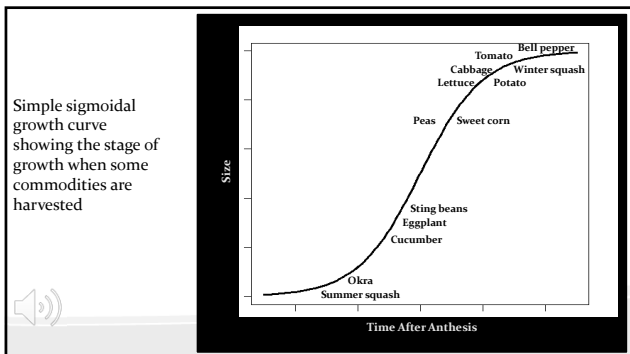
Simple sigmoidal growth curve – applicable to most cells, organs, individuals, or populations

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

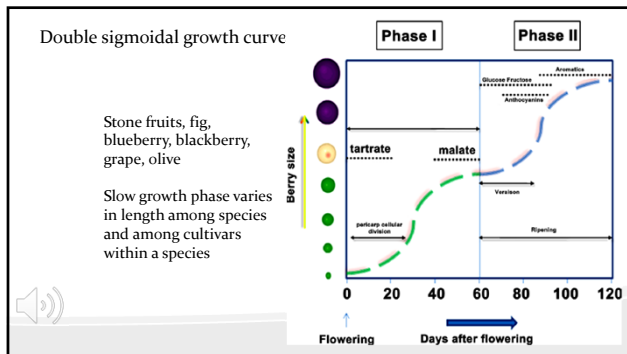
Duration between anthesis and ripeness varies from 3 weeks for strawberries to 60 weeks for Valencia oranges

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

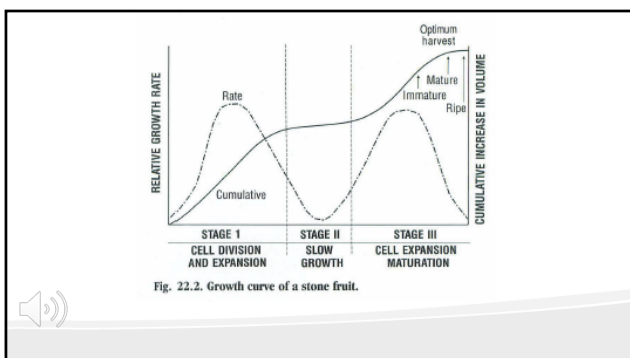
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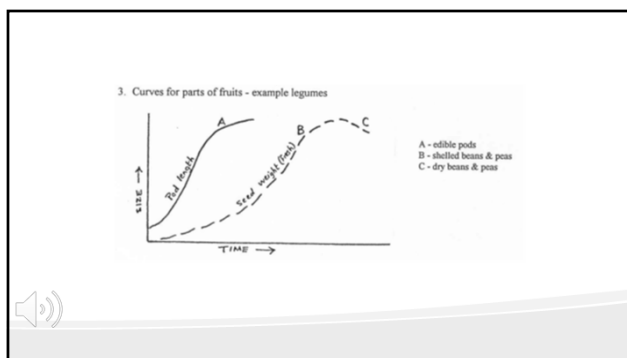
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Developmental Changes

- **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

- **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

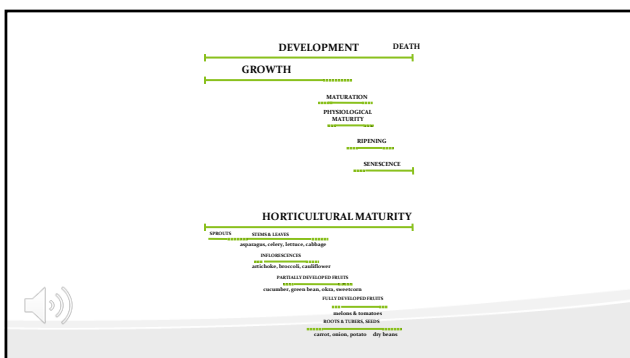
- Climacteric period:** The period in the development of some plant organs involving a series of biochemical changes associated with the natural respiratory rise and autocatalytic production of ethylene

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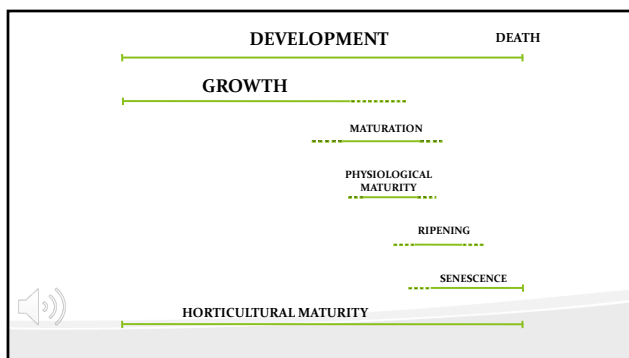
Developmental Changes

- 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

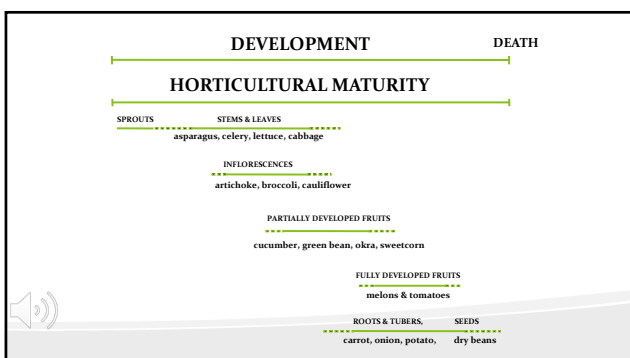
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Importance of Stage of Development

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

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