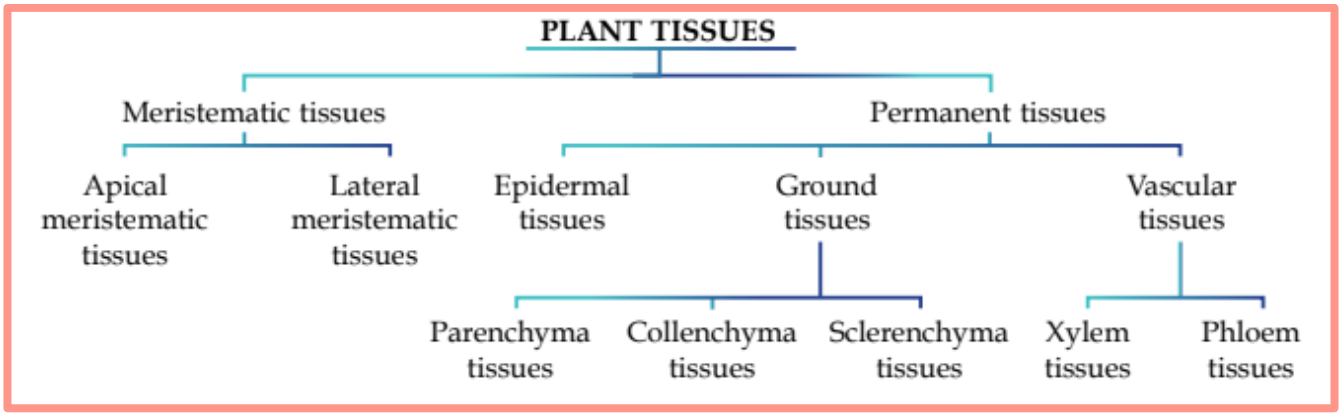
CHAPTER 1.1 – ORGANISATION OF PLANT TISSUES

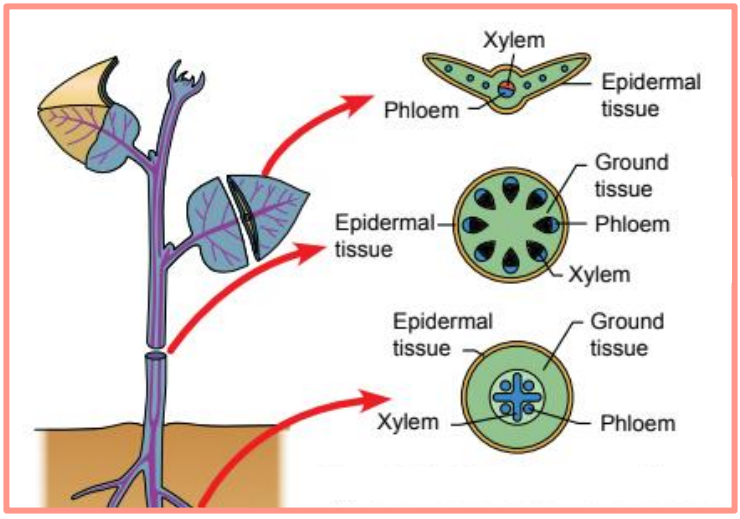
Organisation of plant tissues

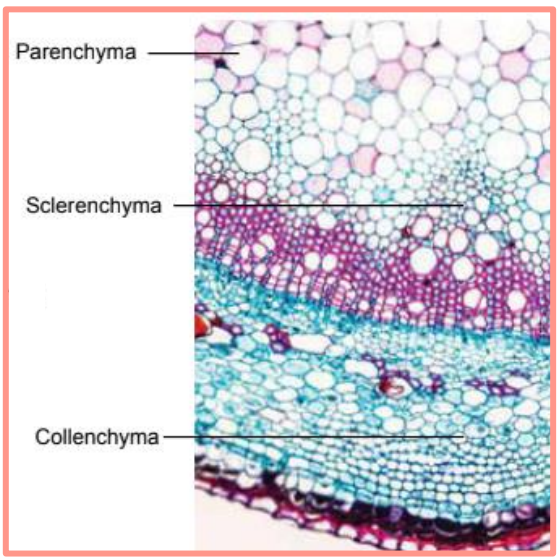
- A plant consists of two types of tissues, meristematic tissues and permanent tissues
- Meristematic tissues are actively dividing tissues through mitosis



PERMANENT TISSUES

- Permanent tissues are matured tissues which have experienced or are experiencing differentiation
- There are three types of permanent tissues
  1. Epidermal tissues
  2. Ground tissues
  3. Vascular tissues





Types of permanent tissues and their functions

Epidermal tissues

- Δ Epidermal tissues layer the outermost surface of stems, leaves and roots of young plants
- Δ Epidermal cell walls which are exposed to the air have a waxy and waterproof layer called cuticle
- Δ The cuticle reduces loss of water through evaporation (transpiration), protects the leaf from mechanical injuries and pathogens
- Δ There are modified epidermal cells according to their functions:
  - I. Guard cells – control the opening of the stoma
  - II. Root hair cells – increase the surface area of the root for water and mineral salts absorption

Ground tissues

PARENCHYMA TISSUES

- → Parenchyma tissues are simplest living cells and do not undergo differentiation
- → They have the thinnest cell walls
- → Parenchyma tissues are always in a turgid state providing support and maintaining the shape of herbaceous plants
- → Involved in photosynthesis, help in the storage od starch and sugar, and involved in gaseous exchange
- → Involved in the repair and regeneration of plant tissue as well as in the vascular system

COLLENCHYMA TISSUES

- ❑ Collenchyma tissues are made of living cells which mature into cells that are flexible
- ❑ Have cell walls made of pectin and hemicellulose
- ❑ Their cell walls are thicker than the parenchyma tissues
- ❑ Provide mechanical support and elasticity to plants

SCLERENCHYMA TISSUES

- » Sclerenchyma tissues consist of dead cells when they are matured
- » Their cell walls are the thickest among the three ground tissues
- » Provide support and mechanical strength to the parts of matured plants
- » These tissues also help in the transport of water and nutrients in plants

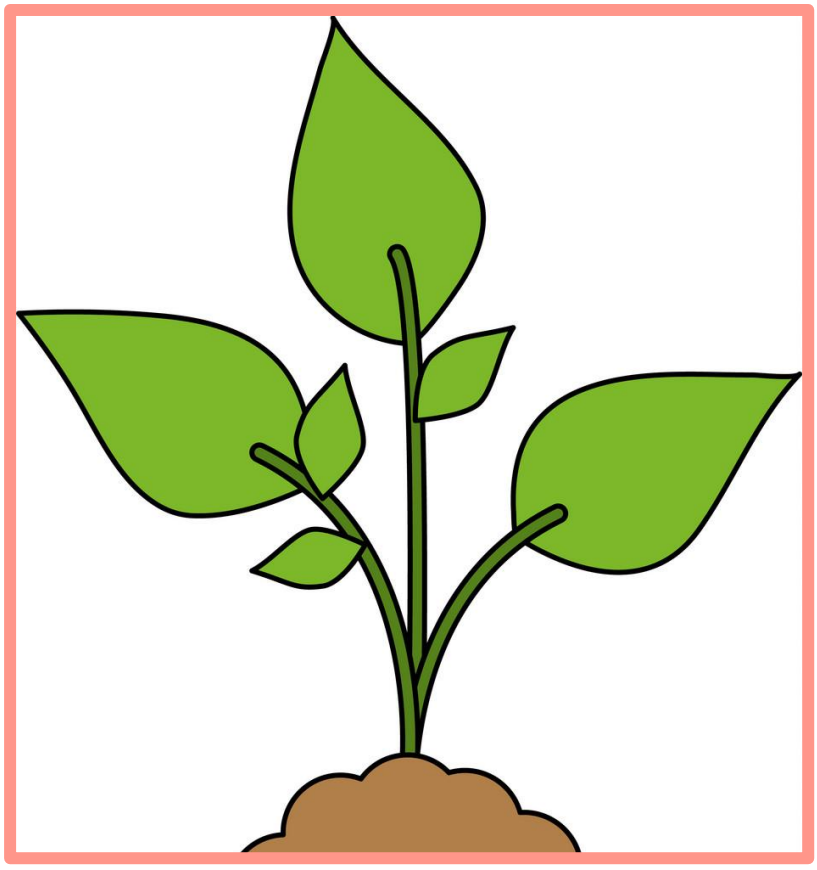
Vascular tissues

XYLEM

- ◊ Xylem is made up of dead cells without the cytoplasm
- ◊ The cell wall of xylem contains lignin
- ◊ Consists of xylem vessels that are elongated, hollow and connected to each other from its roots to the leaves
- ◊ This enables xylem to transport water and mineral salt to all parts of a plant

PHLOEM

- Phloems are made of companion cells and sieve tubes
- Made of living cells, which is the sieve tubes with the presence of cytoplasm
- The sieve tubes do not have any organelles such as nucleus and ribosome as they decompose at maturity stage
- Phloems consist of sieve tubes arranged from end to end forming elongated and continuous tube structures
- Phloems transport sugars produced from the photosynthesis from the leaves to storage organs such as roots, fruits and tubers



CHAPTER 1.2 – MERISTEMATIC TISSUES AND GROWTH

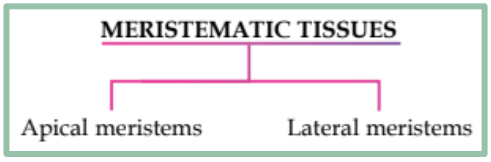
Meristematic tissues and growth

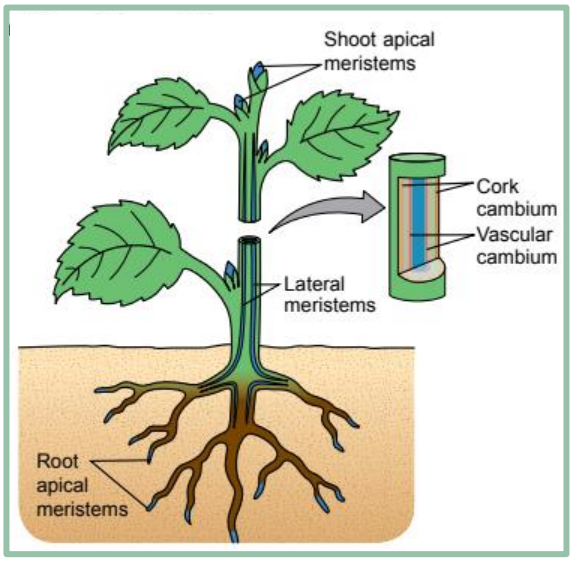
APICAL MERISTEM TISSUE

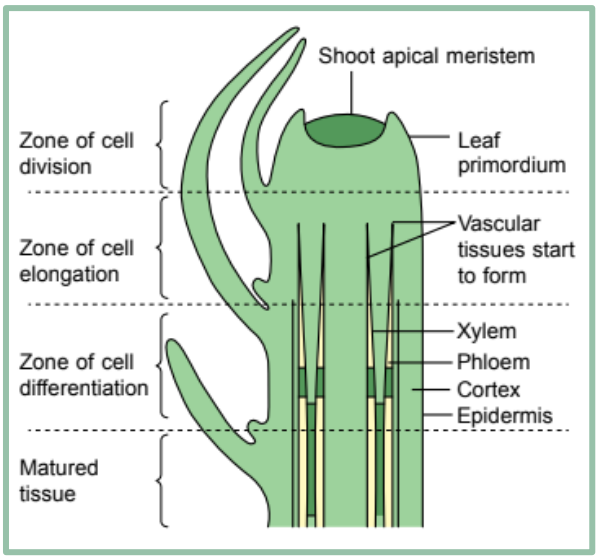
- Located at the tips of plant shoots and roots

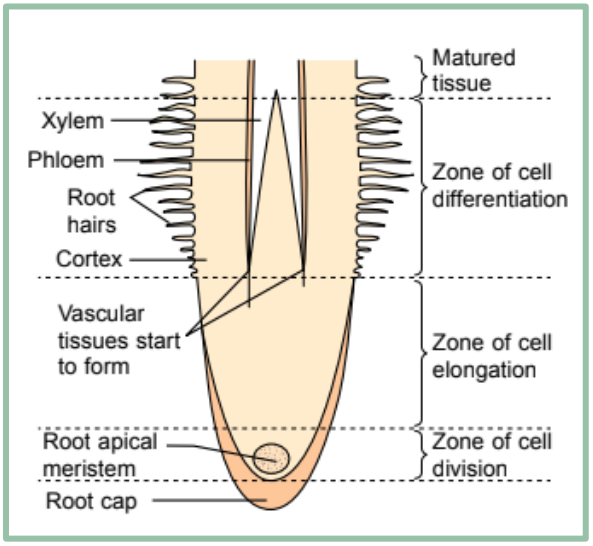
LATERAL MERISTEM TISSUE

- Consists of vascular cambium and cork cambium









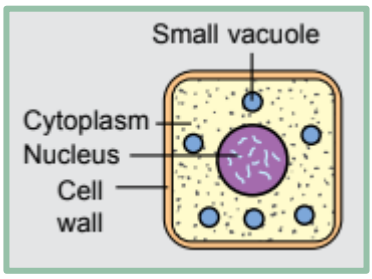
Zone of cell growth

There are three types of zones of cell growth

- Zone of cell division
- Zone of cell elongation
- Zone of cell differentiation

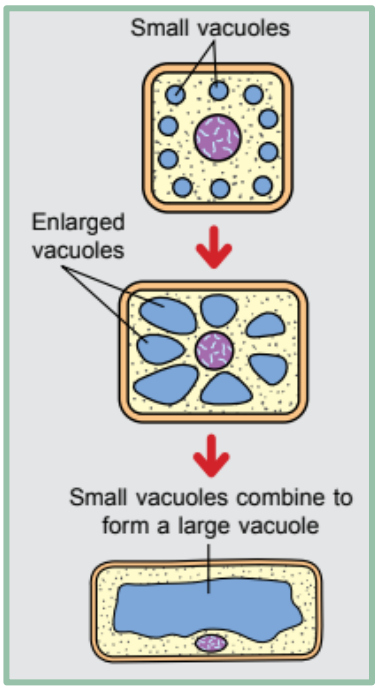
ZONE OF CELL DIVISION

- The zone of cell division takes place at the apical meristems which consists actively dividing meristem cells through mitosis
- The increase of the number of cells causes the elongation of the plant stem
- When new cells are forming, the cells formed previously are pushed to the zone of elongation



ZONE OF CELL ELONGATION

- The zone of cell elongation consists of cells that are increasing in size
- The increase in size happens through water diffusion by osmosis and the absorption of nutrients into the cells and stored in the vacuoles
- Small vacuoles fuse to form a large vacuole (vacuolation)
- The diffused water exerts pressure against the cell wall which pushes, elongates and widens the cells



ZONE OF CELL DIFFERENTIATION

- Cells differentiate to form permanent tissues such as epidermis, cortex, xylem and phloem
- The cells change their shapes and structures to become specialised cells with specific functions
- For example, epidermal cells in leaves differentiate and form guard cells that control the opening of stoma
- Other than that, epidermal cells in roots differentiate and form root hair cells

Types of growth

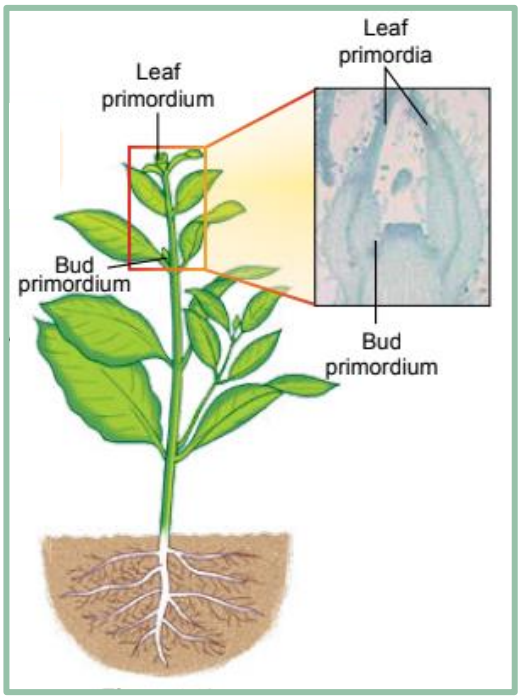
There are two types of growth

- Primary growth
- Secondary growth

Primary growth

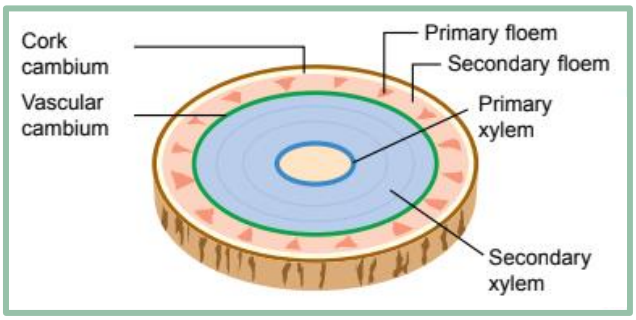
- Primary growth is the growth that occurs after germination and it takes place in all plants to elongate their stems and roots
- This growth takes place in the apical meristems at the shoot tips and root tips
- Primary growth starts when the meristem cells in the zone of cell division of apical meristems are actively dividing
- This is followed by elongation and differentiation of the cells
- At the shoot tips, leaf primordia and shoot primordia will grow to form new leaves and shoots
- This enables the plants to increase in height

- ❖ At the root tips, the root cap will become exhausted when they penetrate the soil
- ❖ This causes the cells of the root cap to be replaced by the meristem cells



Secondary growth

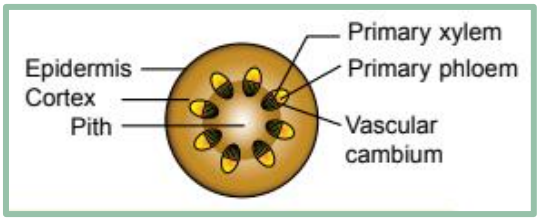
- ⌂ Secondary growth occurs mainly in eudicots and a small number of monocots (shrub) to increase the circumference or diameter of plant stem and root
- ⌂ For non-woody plants (herbaceous plant), secondary growth does not happen
- ⌂ Secondary growth results from the division of lateral meristem cells located in the stem and root
- ⌂ Lateral meristems consist of vascular cambium and cork cambium
- ⌂ Vascular cambium
  - i) Located between phloem and xylem tissues in vascular bundle
- ⌂ Cork cambium
  - 1) Located under the epidermal layer



SECONDARY GROWTH AT THE STEM

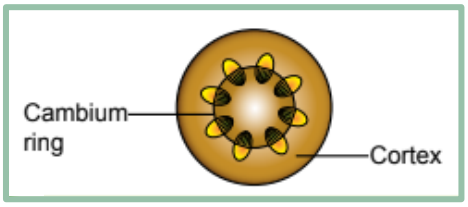
1

- ➢ Secondary growth starts when the vascular cambium divides actively through mitosis



2

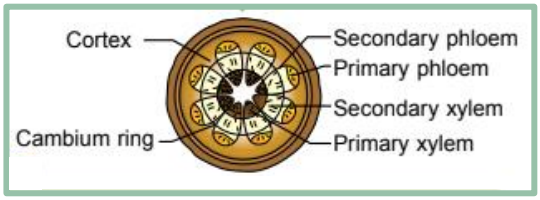
- → The cells in the cambium ring divide inwards to form new xylem and outwards to form new phloem
- → The new xylem tissue become secondary xylem and the new phloem tissue become secondary phloem



3

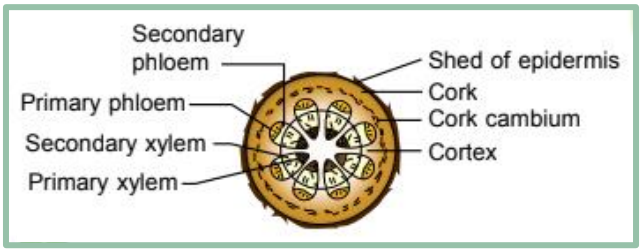
- Δ When undergoing secondary growth, primary xylem is pushed towards the pith whereas primary phloem is pushed towards the epidermis

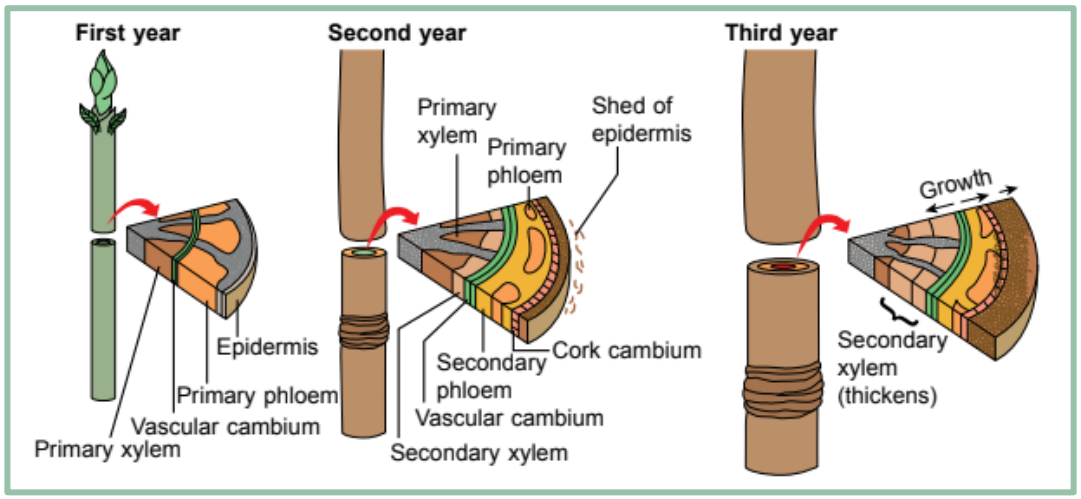
- Δ As a result, the primary xylem tissues are compressed to form a stronger wood layer
- Δ This is because the walls of xylem are thickened with lignin
- Δ The thickening of lignin provides mechanical support to plants



4

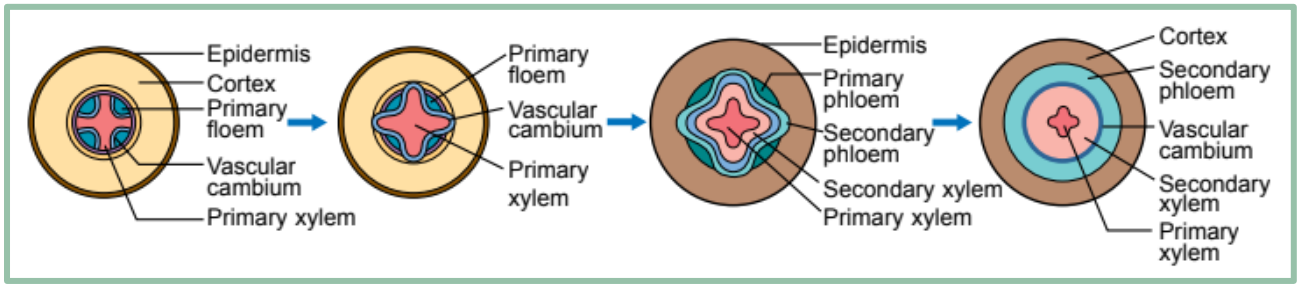
- ✓ When the secondary xylem layer is compressed, there is an addiction to the circumference of the stem which causes the epidermis of the stem to stretch and crack
- ✓ Cork cambium actively divides to form cork cells on the outer side and cortex on the inner side
- ✓ The cork layer protects the stem from insect and pathogen attack when the epidermis is cracked





SECONDARY GROWTH AT THE ROOT

- Vascular cambium cells divide actively and combine to form a complete ring
- The cells in the cambium ring divide inwards to form secondary xylem and outwards to form secondary phloem
- Due to the vascular cambium activity, the root becomes thicker
- The cork cambium located under the epidermis divides actively to form cork cells
- The cork cells provide protection to the root tissues



SECONDARY GROWTH OF MONOCOTS

- Even though most monocots do not undergo secondary growth, some do
- For example,
  a) *Draceana sp.*
  b) *Aloe sp.*
  c) *Agave sp.*

Draceana sp.

Aloe sp.

Agave sp.

The necessity of primary growth and secondary growth

THE NECESSITY OF PRIMARY GROWTH

- Allow maximum elongation of plants to absorb sunlight for photosynthesis
- Primary phloem can transport the products of photosynthesis from the leaves to other parts of the plants
- Primary xylem can transport water and mineral salts from the soil via the roots to the leaves
- Primary xylem provides support to herbaceous or young plants

THE NECCESITY OF SECONDARY GROWTH

- ♥ Provides stability to plants by increasing the stem and root diameters to suit the height of plants
- ♥ Provides mechanical support to plants
- ♥ Produces more xylem and phloem tissues
- ♥ Produces xylem and phloem tissues continuously to replace old and damaged xylem and phloem tissues
- ♥ Produces stronger and thicker bark to provide protection to the plants from excessive water loss, physical injuries and pathogen infections
- ♥ Able to live longer by increasing the chances of seed production and reproduction

Comparison between primary growth and secondary growth in eudicots

SIMILARITIES

SIMILARITIES
⊕ Both growths can increase the size of the plants permanently ⊕ Both growths occur in woody plants ⊕ Both growths involve cell division by mitosis

DIFFERENCES

PRIMARY GROWTH	ASPECT	SECONDARY GROWTH
Apical meristem	Meristem tissue involved	Lateral meristem (vascular cambium and cork cambium)
Occurs on stems and roots in younger regions of the plant	Parts of the plant that undergo growth	Occurs when primary growth has ceased on matured stems and roots
Growth occurs longitudinally	Direction of growth	Growth occurs radially
Increases the length of stems and roots of plant	Growth effects	Increases the thickness or circumference of stems and roots of plant
Epidermis, cortex and primary vascular tissue (primary xylem and primary phloem)	Tissues and structures formed	Bark, periderm (cork cambium and cork tissues), lenticels and secondary vascular tissue (secondary xylem and secondary phloem)
Do not have woody tissue	Presence of woody tissue	Have woody tissue
Thin	Thickness of bark	Thick
Absence of annual growth rings	Presence of annual growth rings	Presence of annual growth rings at the plant stem

The economic importance of plants that have undergone secondary growth

- Plants that undergo secondary growth have high economic values because they can produce timber
- For example,
  i. *Shorea sp.* (meranti)
  ii. *Balanocarpus sp.* (cengal)
- Plants that undergo secondary growth have strong and hard woods which are suitable to be used as structure as houseboats, furniture, fences, doors and others
- The presence of annual rings makes furniture look attractive and they can be made as decorative items
- The woods and barks of some plants can produce resin and oil
- For example, *Hopea* sp. (merawan) and meranti
- The substances can be commercialised as varnish, adhesive substance, perfume and medicine
- Flowering plants can be made as decorative plants
- Commercialised fruits are products of plants that have undergone secondary growth and they are able to generate income as well as boost economic growth

CHAPTER 1.3 – GROWTH CURVES

Types of plants based on life cycles

Plants can be classified based on their life cycle

- ♥ Annual
- ♥ Biennial
- ♥ Perennial

ANNUAL PLANTS

- » Annual plants are plants that have only one life cycle for a season or a year
- » These plants usually die after completing their biological cycle which starts from germination and ends with flowering or producing seeds
- » For examples
    1. Paddy
    2. Pumpkin
    3. Watermelon
    4. Corn
    5. Pea

BIENNIAL PLANTS

- ⊕ Biennial plants refer to plants which take two years with two seasons of growth to complete their life cycle
- ⊕ The first growth season is the vegetative growth which is the growth of roots, leaves and stem structures
- ⊕ The second growth season is reproduction
- ⊕ Most of the biennial plants grow in temperate regions
- ⊕ After going through vegetative growth, these plants briefly stop the growth process during winter
- ⊕ During spring and summer, the growth continues as preparation for reproduction by flowering
- ⊕ The plants produce fruits and seeds and eventually the plants will die
- ⊕ For examples
    a. Cabbage
    b. Carrot
    c. Silver cock's comb
    d. Celery
    e. Onions

PERENNIAL PLANTS

- ◊ Perennial plants refer to plants which live more than two years
- ◊ These plants have longer lifespan depending on the species and conditions
- ◊ Perennial plants can be classified into two categories
    i) Woody perennial plants
    ii) Herbaceous perennial plants
- ◊ Most of these plants are able to flower and bear fruits many times throughout their lives
- ◊ These plants have structures that are adaptable to their surroundings and temperature change
- ◊ Examples of woody perennial plants
    I. Mango
    II. Apple
    III. Maple
    IV. Pear
    V. Strawberry
- ◊ Examples of herbaceous plants
    i. Fennel
    ii. Mint

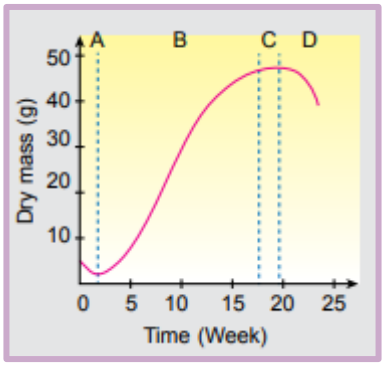
iii. Rosemary
iv. Sage
v. Thyme

Growth curve in plants

- The growth curve of most organisms are sigmoid curves

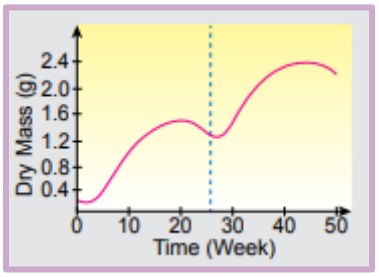
THE GROWTH CURVE OF ANNUAL PLANTS

- The growth curve is a sigmoid curve
- Stage A: Decreasing dry mass
  - Food stored in the cotyledon is used for germination before the leaves emerge to carry out photosynthesis
- Stage B: Increasing dry mass
  - The rate of photosynthesis increases rapidly
  - This is because the plant has carried out photosynthesis
- Stage C: Constant dry mass
  - The rate of growth is zero
  - Plant is matured
- Stage D: Decreasing dry mass
  Happens slowly because of
  - Aging
  - Lower rate of photosynthesis
  - Shedding of leaves and flowers
  - Seed dispersal



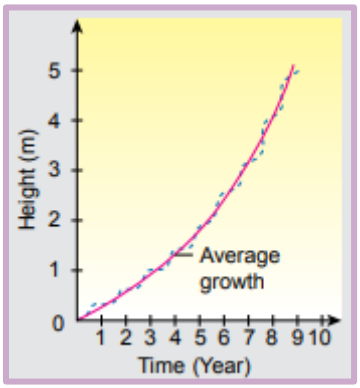
THE GROWTH CURVE OF BIENNIAL PLANTS

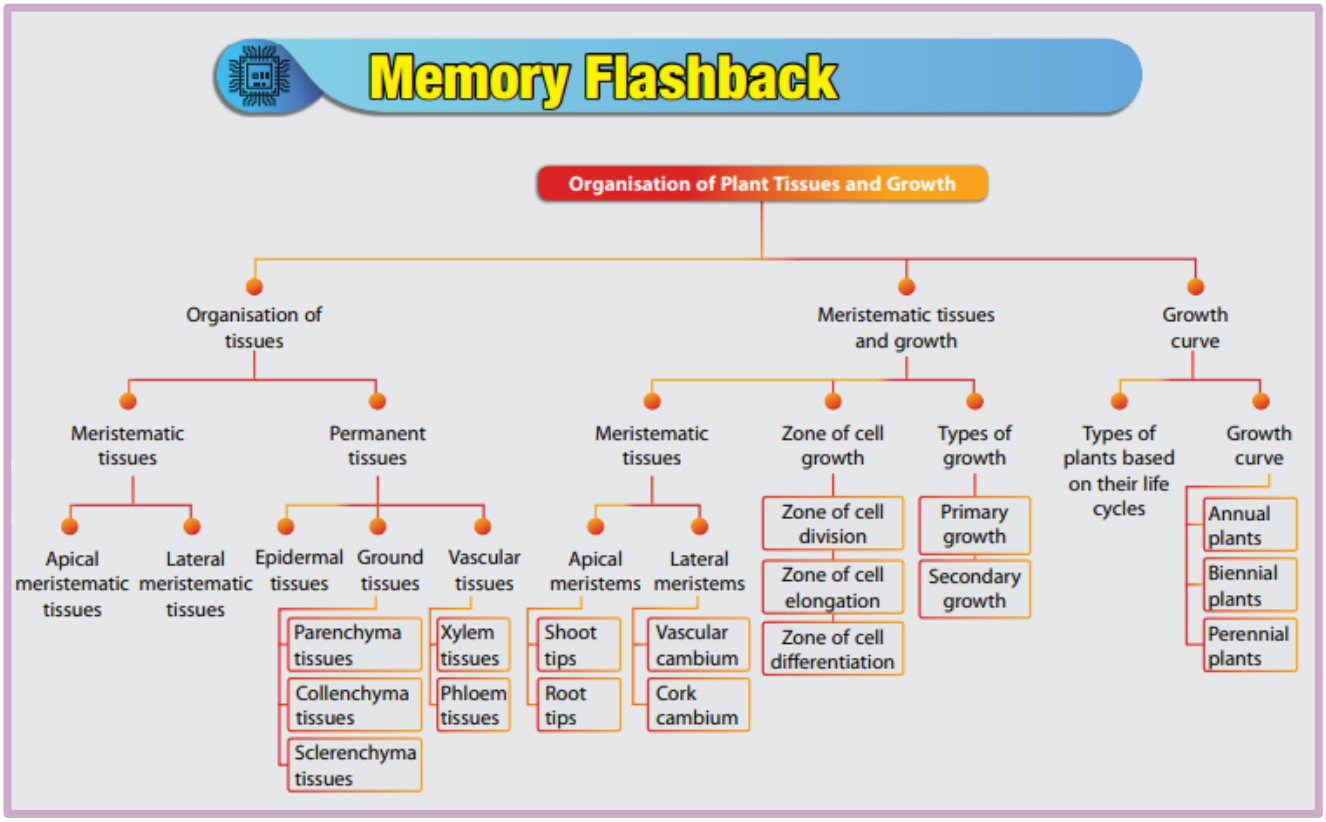
→ The growth curve has two sigmoid curves which are combined
→ First growth season:
  - Plants produce leaves, photosynthesis takes place
  - Food is stored in tubers
→ Second growth season:
  - The food stored is used to produce flowers and seeds



THE GROWTH CURVE OF PERENNIAL PLANTS

- The growth curve is a series of small sigmoid curves
- Every year, the growth curve is a sigmoid curve
- Growth occurs throughout the lifespan of the plant
- The rate of growth is high during spring and summer
- High light intensity increases the rate of photosynthesis
- The rate of growth decreases in winter




Memory Flashback
Organisation of Plant Tissues and Growth
Organisation of tissues
Meristematic tissues
Permanent tissues
Apical meristematic tissues
Lateral meristematic tissues
Epidermal tissues
Ground tissues
Vascular tissues
Parenchyma tissues
Collenchyma tissues
Sclerenchyma tissues
Xylem tissues
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Meristematic tissues
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