Vivekanand College, Kolhapur (Empowered Autonomous)

DEPARTMENT OF BOTANY

B.Sc. I : Open elective

Topic: Modification of Stem

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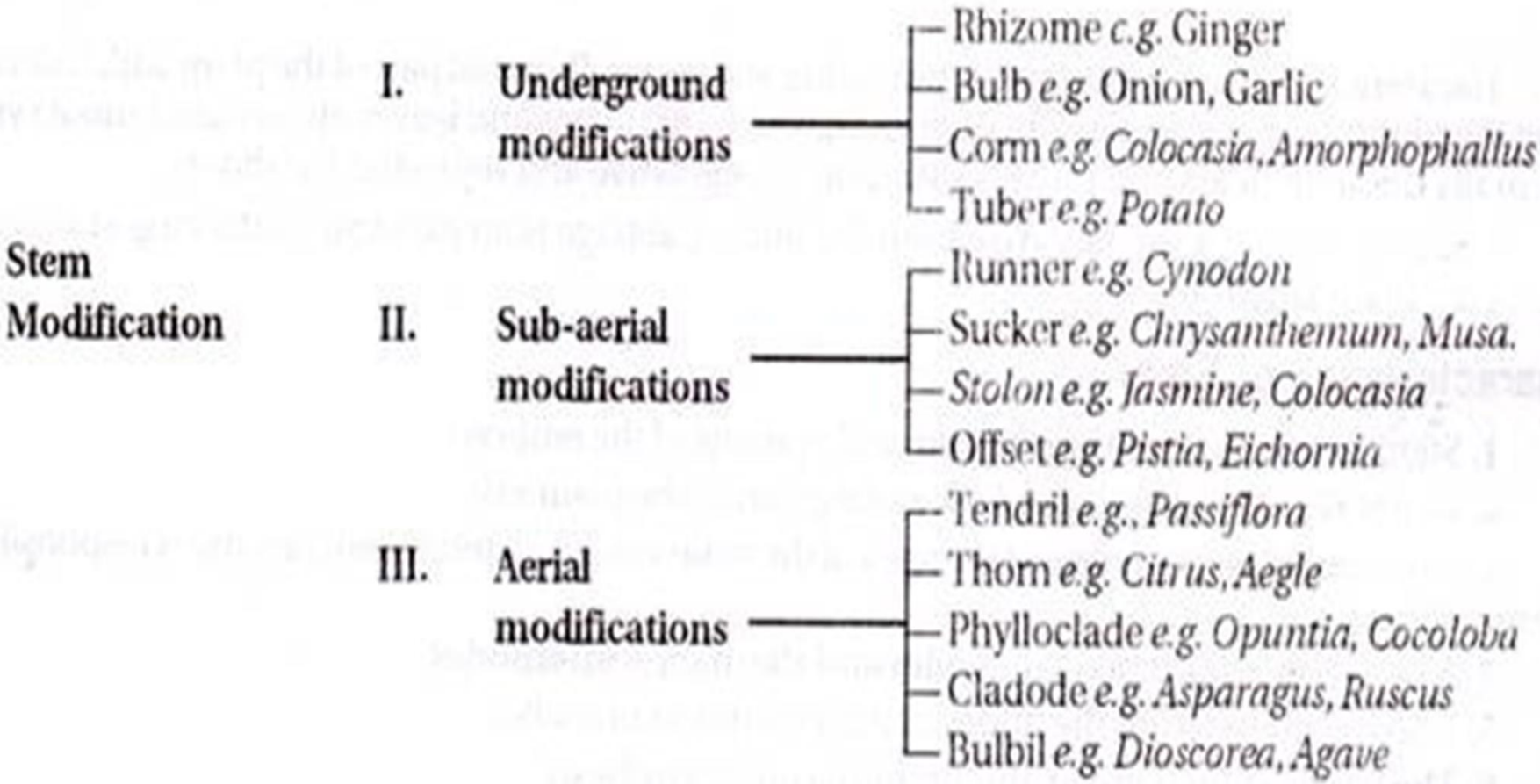
M.Sc., Ph.D.

- Stems are modified variously for some specialized additional purposes, such as mechanical strength and support, perennation (tiding over unfavourable conditions), vegetative propagation, food storage, and so on.
- Such modifications are classified into three groups, namely ***underground***, ***sub-aerial*** and ***aerial modifications***.


Stem Modification
I. Underground modifications
Rhizome e.g. Ginger
Bulb e.g. Onion, Garlic
Corm e.g. Colocasia, Amorphophallus
Tuber e.g. Potato
II. Sub-aerial modifications
Runner e.g. Cynodon
Sucker e.g. Chrysanthemum, Musa.
Stolon e.g. Jasmine, Colocasia
Offset e.g. Pistia, Eichornia
III. Aerial modifications
Tendril e.g., Passiflora
Thorn e.g. Citrus, Aegle
Phylloclade e.g. Opuntia, Cocoloba
Cladode e.g. Asparagus, Ruscus
Bulbil e.g. Dioscorea, Agave

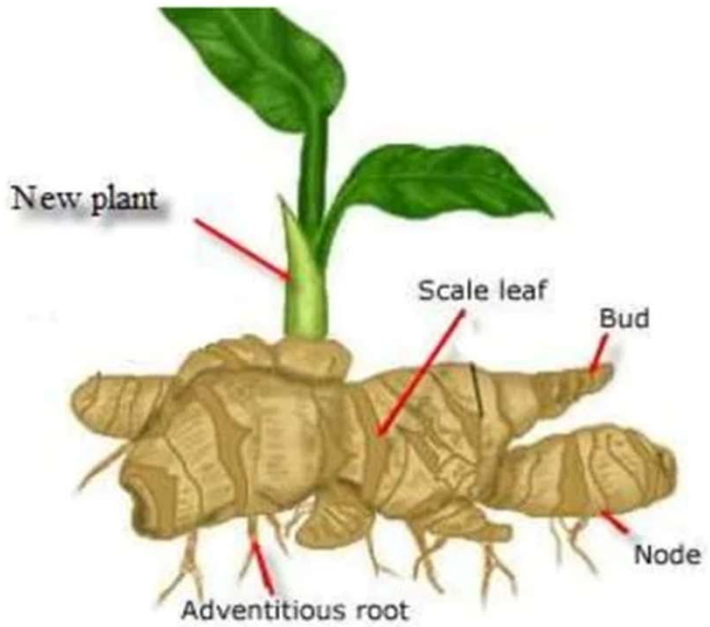
(a) Underground (subterraneous) stem modifications

- These are modifications for perennation, storage of food materials and vegetative propagation.
- They are non-green and superficially very much resemble roots.
- Still, they can be easily distinguished from roots by the presence of nodes, internodes, scale leaves and axillary and terminal buds.
- Underground stems can survive even when the aerial parts die during unfavourable season.
- On the return of favourable conditions, they may produce new shoots.
- The common underground stem modifications include ***rhizomes***, ***stem tubers***, ***corms***, and ***bulbs***.

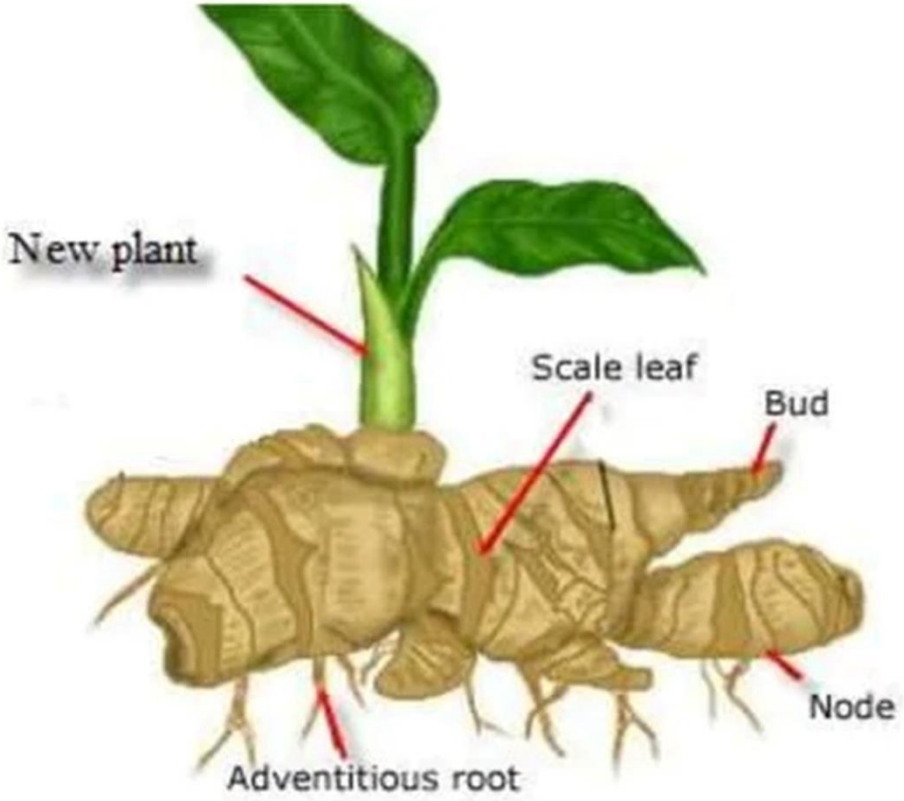
(i) Rhizome

- Rhizome is a horizontal, short, thick, fleshy and irregularly branched underground stem, with nodes, highly condensed internodes, terminal buds, and rumerous leaf scars (e.g., ginger, turmeric, canna).
- Nodes bear adventitious roots, and small, thin and white scale leaves. In the axils of the scale leaves, there are axillary buds.
- The terminal buds of the rhizome grow out of the soil and give rise to green shoots and flowers during the growing season.
- At the end of the season, the green aerial portion dies out further growth of the rhizome is taken up by the axillary bud nearest to the terminal bud.
- Rhizome serves as a perennating organ, as an agent of vegetative propagation and also as a depot of reserve food.
- It may be thick and fleshy due to the storage food materials.

(i) Rhizome- Ginger



(i) Rhizome- Ginger

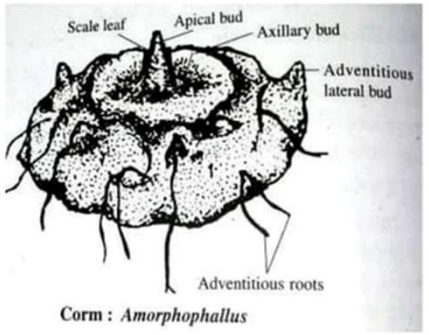


(ii) Corm

- Corm is a short, thick, massive and nearly spherical base of an underground Stem axis, with nodes, internodes, scale leaves, apical and axillary buds, and adventitia roots.
- Adventitious roots hold the corm in erect posture and hence they are als termed contractile roots, or pull roots.
- Corn serves as a perennating and vegetatively reproducing organ and also as store house of reserve food.
- In corm, stem is not - elongated as in rhizome, but it lateral bud is quite massive, swollen and slightly spherical.
- On this massive stem, there is a very prominent terminal bud, surrounded by numerous scale leaves.
- Each scale leaf will have a small bud in its axil.

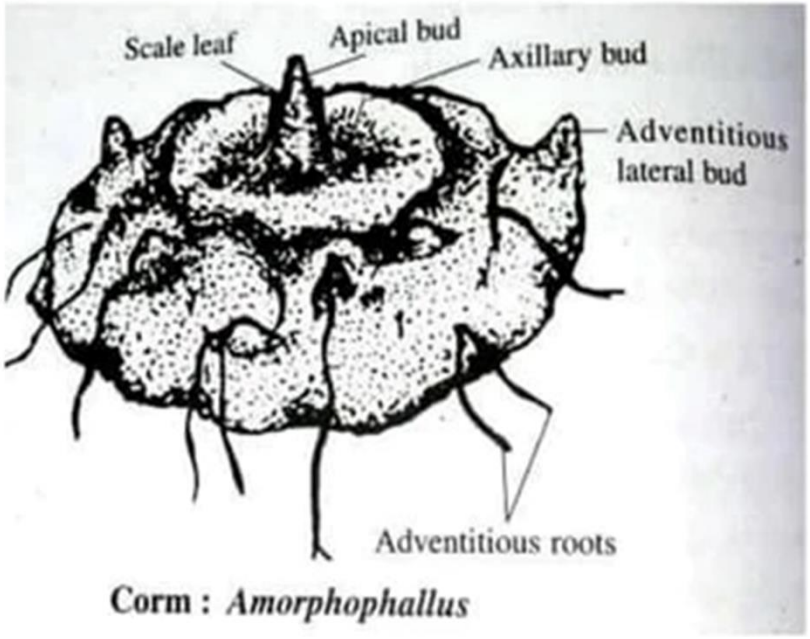
- The terminal bud can develop to a s vegetative aerial shoot.
- Many adventitious lateral buds may also be present.
- They are produced from nodes and are protected by scale leaves.
- They can grow to ***daughter corms***, or ***cormlets***.
- Corm is fixed to the soil by numerous adventitious roots.
- Under favourable conditions, the terminal bud develops to a green aerial shoot, at the expense of the food material stored inside the corm.
- Corms are seen in ***Amorphophallus***, ***Colocasia***, ***Gladiolus***, ***Dioscorea***, etc.
- Corm differs from bulb in having greater amount of stem tissue and distinct nodes and internodes.

(ii) Corm- Amorphophallus



Corm : *Amorphophallus*

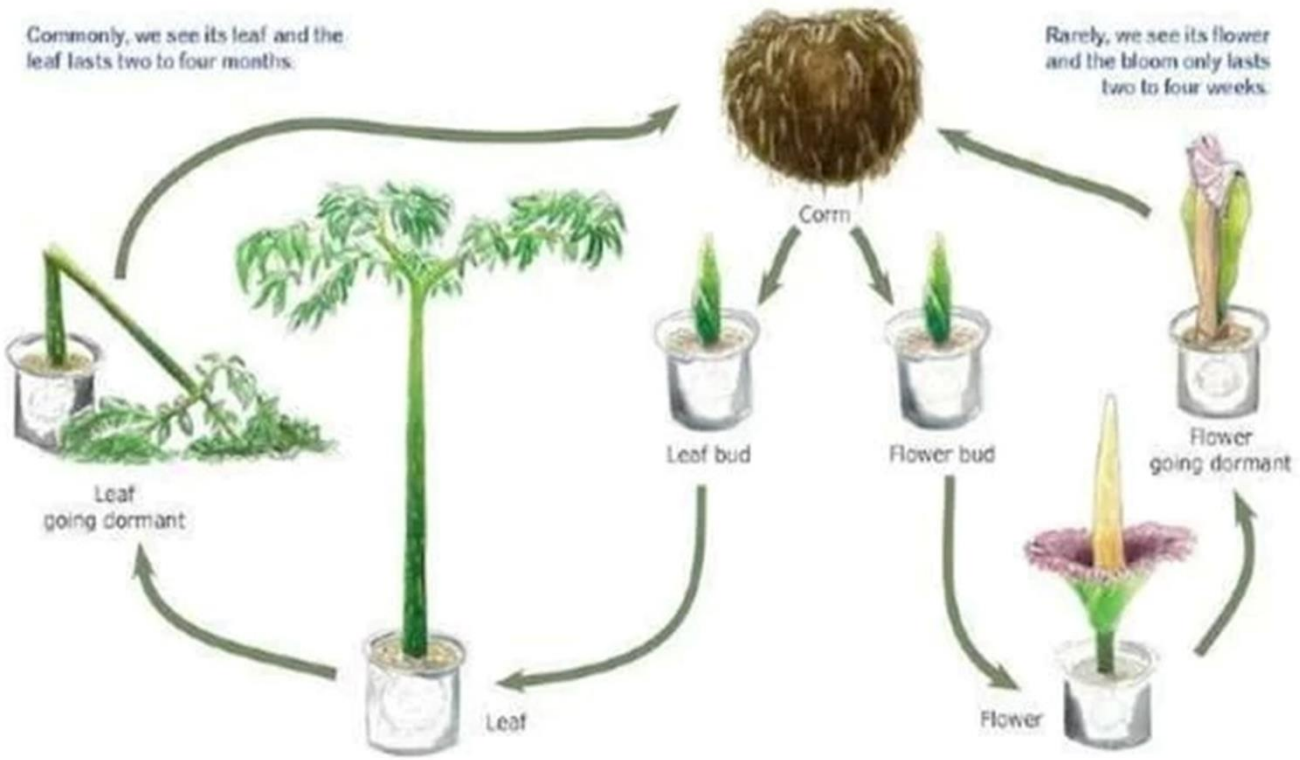
(ii) Corm- Amorphophallus

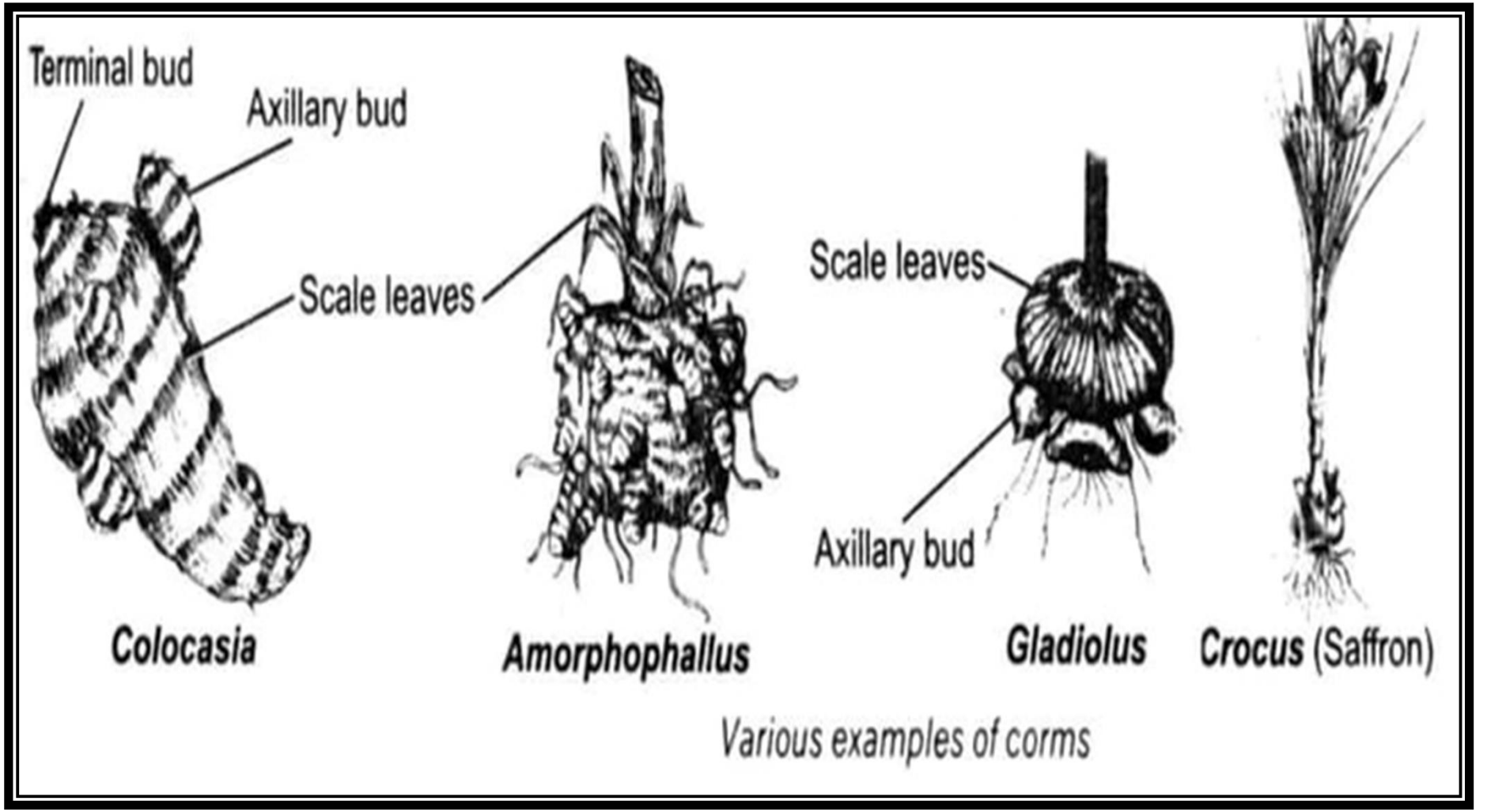


Corm : *Amorphophallus*

Amorphophallus titanum Lifecycle

An underground stem (or corm) with two options: flower or leaf

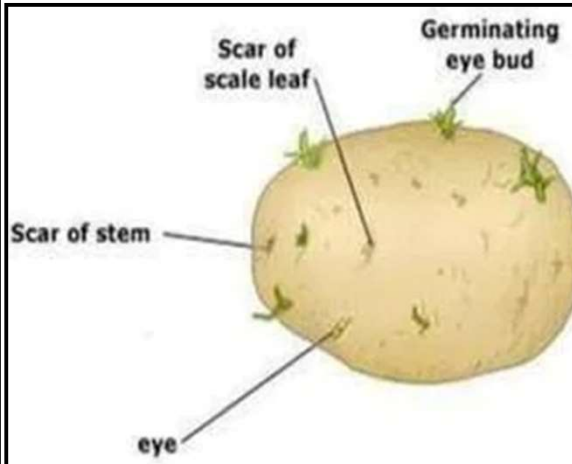




Various examples of corms

(iii) Stem tuber

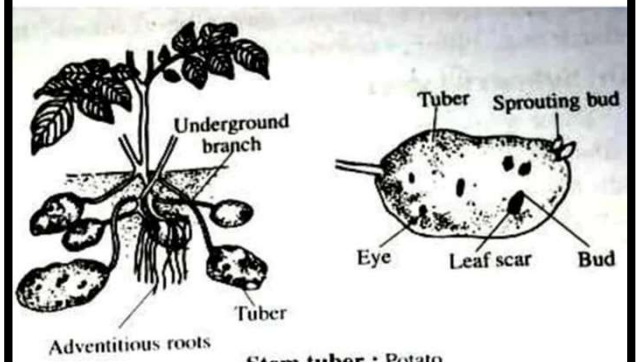
- Stem tubers are the swollen tips of underground stem branches (stolons), containing rich storage of reserve food.
- They lack adventitious roots.
- Potato is an example of tem tuber.
- In potato, stem tuber is terminal, swollen, fleshy and nearly spherical, with distinct nodes and internodes.
- On the surface of the nodal region, there is a escentic scar enclosing small depression.
- Each scar represents the leaf scar and it bears an axillary bud.



Tuber : Potato

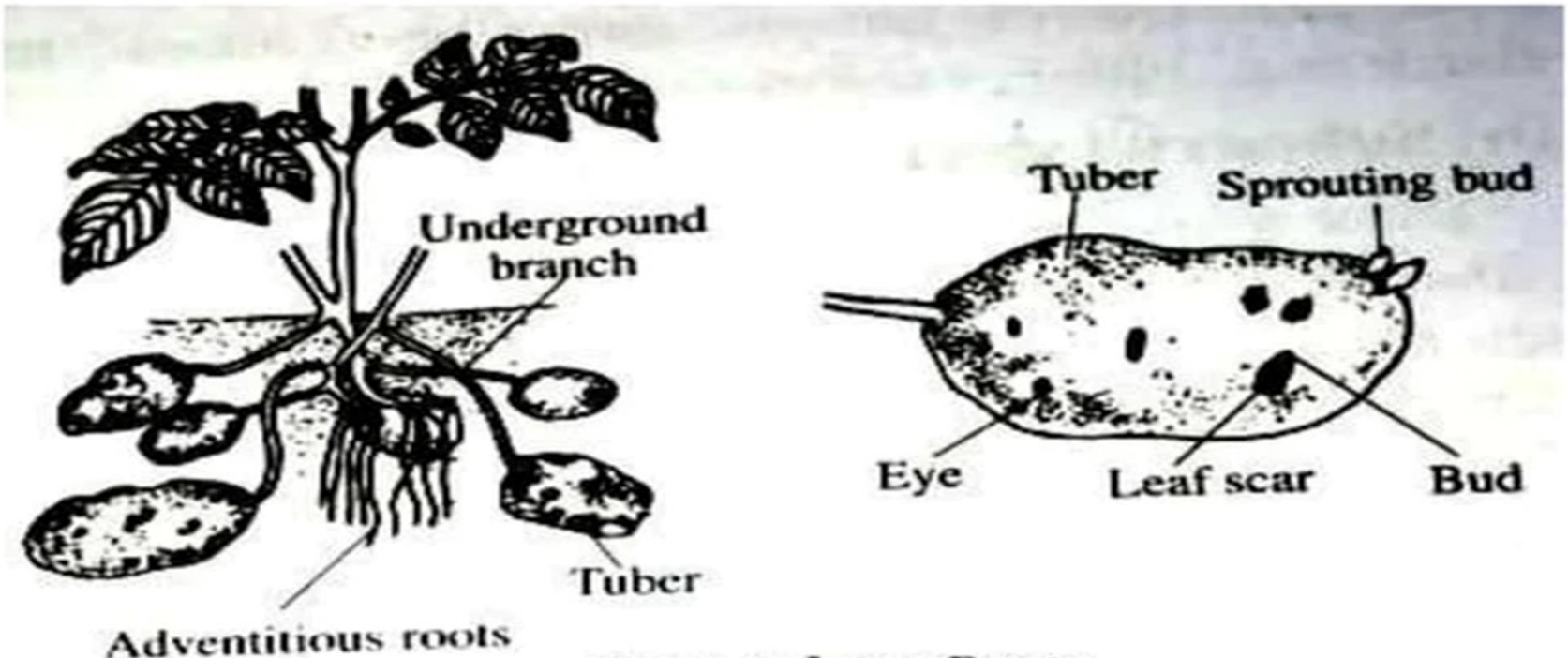
- A leaf scar, together with its axillary bud, is known as an eye of the potato.
- The possession of leaf scars and axillary buds indicates the stem nature of the potato.
- Axillary bud can develop to a new plant.
- Stem tubers are produced in a peculiar manner.
- Some of the branches of the main stem, which are near the soil, instead of growing normally, bend down and grow into the soil.
- The ends of these branches swell out due to the accumulation of food and become tubers.
- A the end of a growing season, the mother plant dies.
- Then, new plants develop from tubers. Stem tubers are found in Helianthus, Cyperus, etc. also.

(iii) Stem tuber-Potato

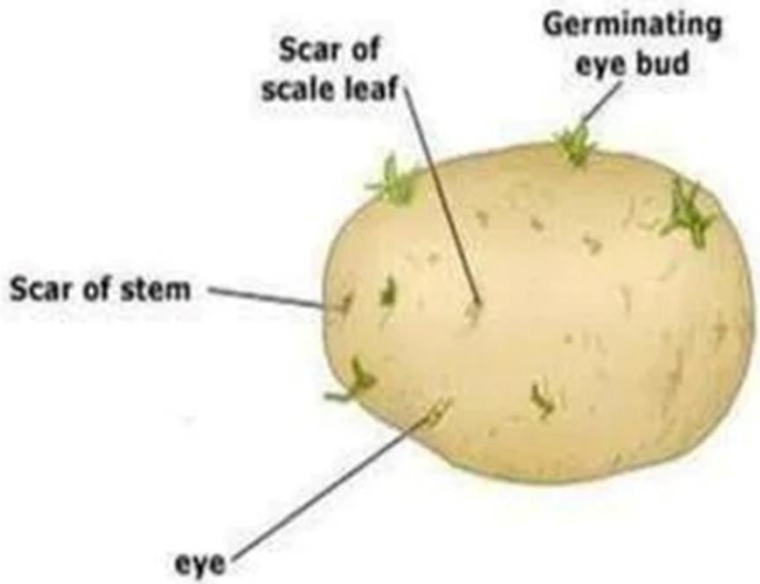


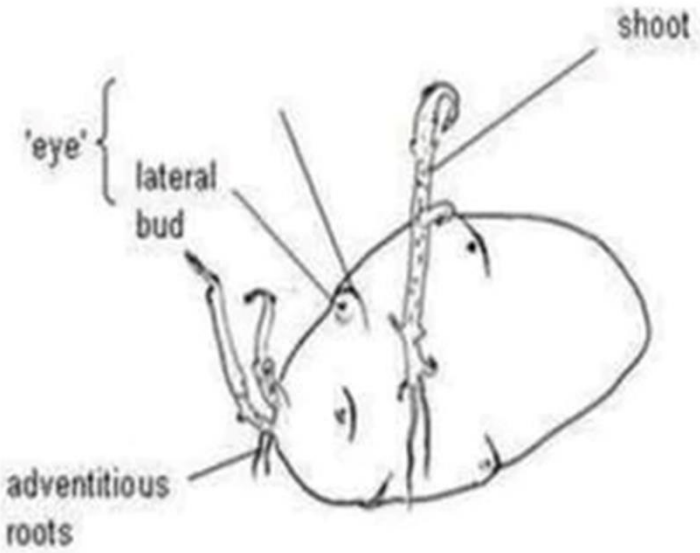
Stem tuber : Potato

(iii) Stem tuber-Potato



Stem tuber : Potato





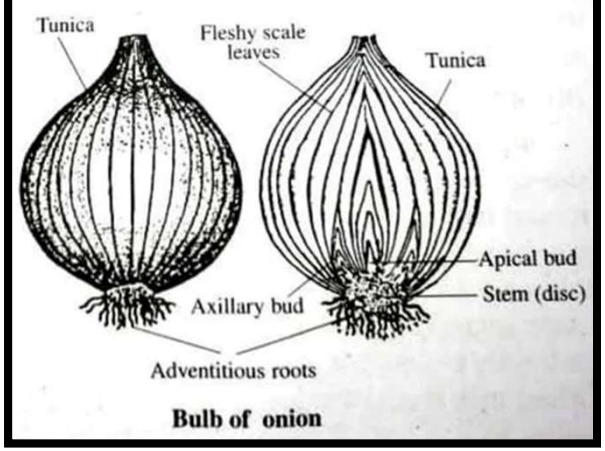
Potato tuber sprouting

Tuber : Potato

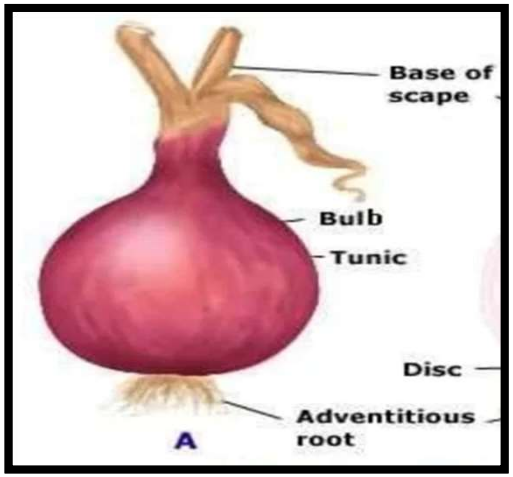
(iv) Bulb

- Bulb is a fleshy, much reduced, highly condensed, disc-like and conical underground stem, with compressed and indistinct nodes and internodes.
- It is usually found in monocots as a specialisation for food storage and reproduction.
- Concentrically arranged, water-storing and food-storing ***scale leaves*** arise from its nodes.
- The inner scales are fleshy, and the outer ones dry. The dry outer leaves form a protective covering, called ***tunica.***
- In the centre, there is a ***terminal bud***, surrounded by several ***axillary buds***.
- Terminal bud gives rise to the flowering shoot in the growing season.
- Axillary buds may grow to ***bulblets*** which, in turn, grow to new plants.
- A tuft of small ***adventitious roots*** arise from the base of the disc (stem).
- e.g. onion (***Allium cepa***), garlic (***Allium sativum***), garden lily (***Lilium***).
- The reserve food starch (e.g., tulip) or sugars (e.g., onion)

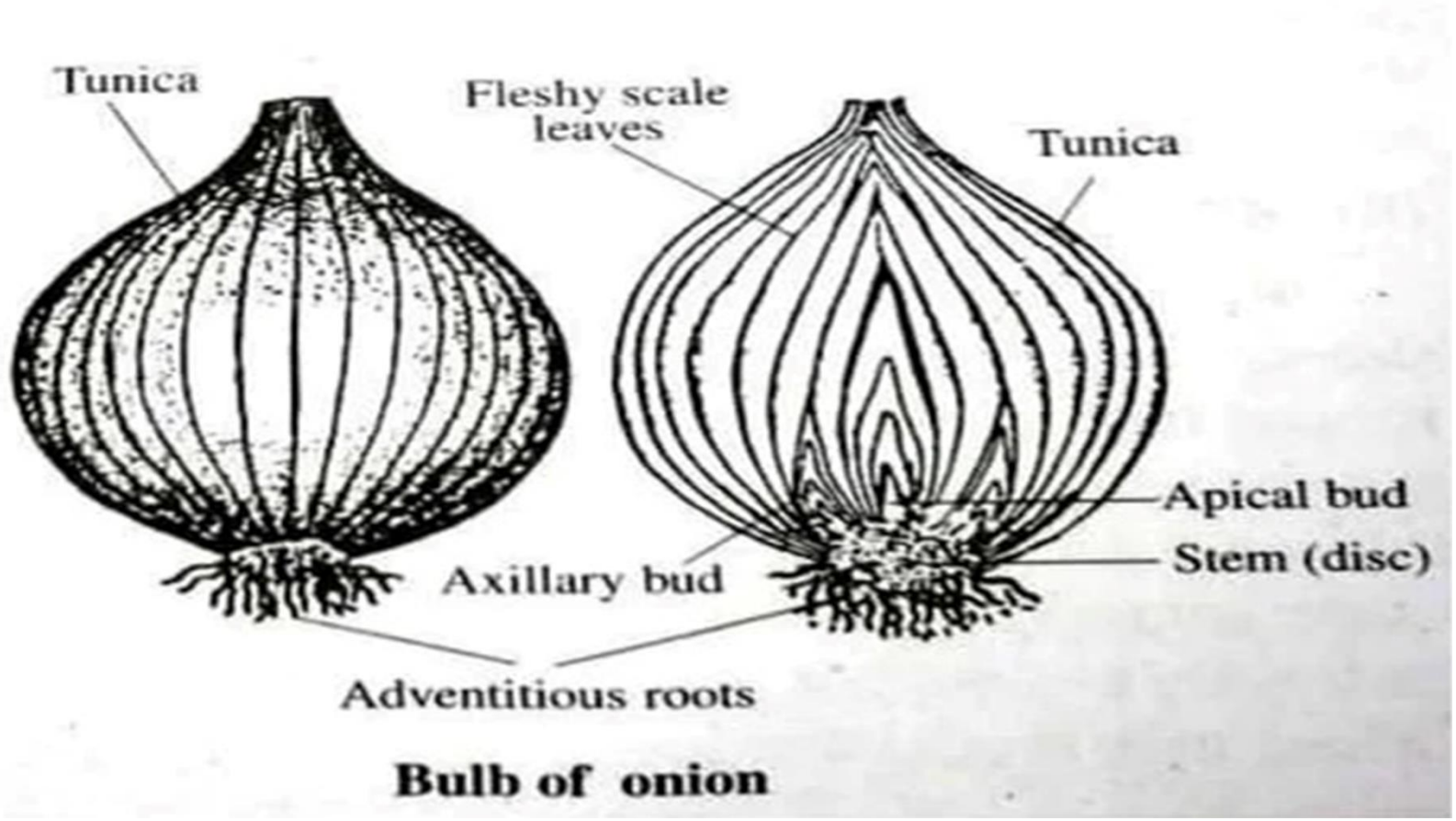
(iv) Bulb-Onion



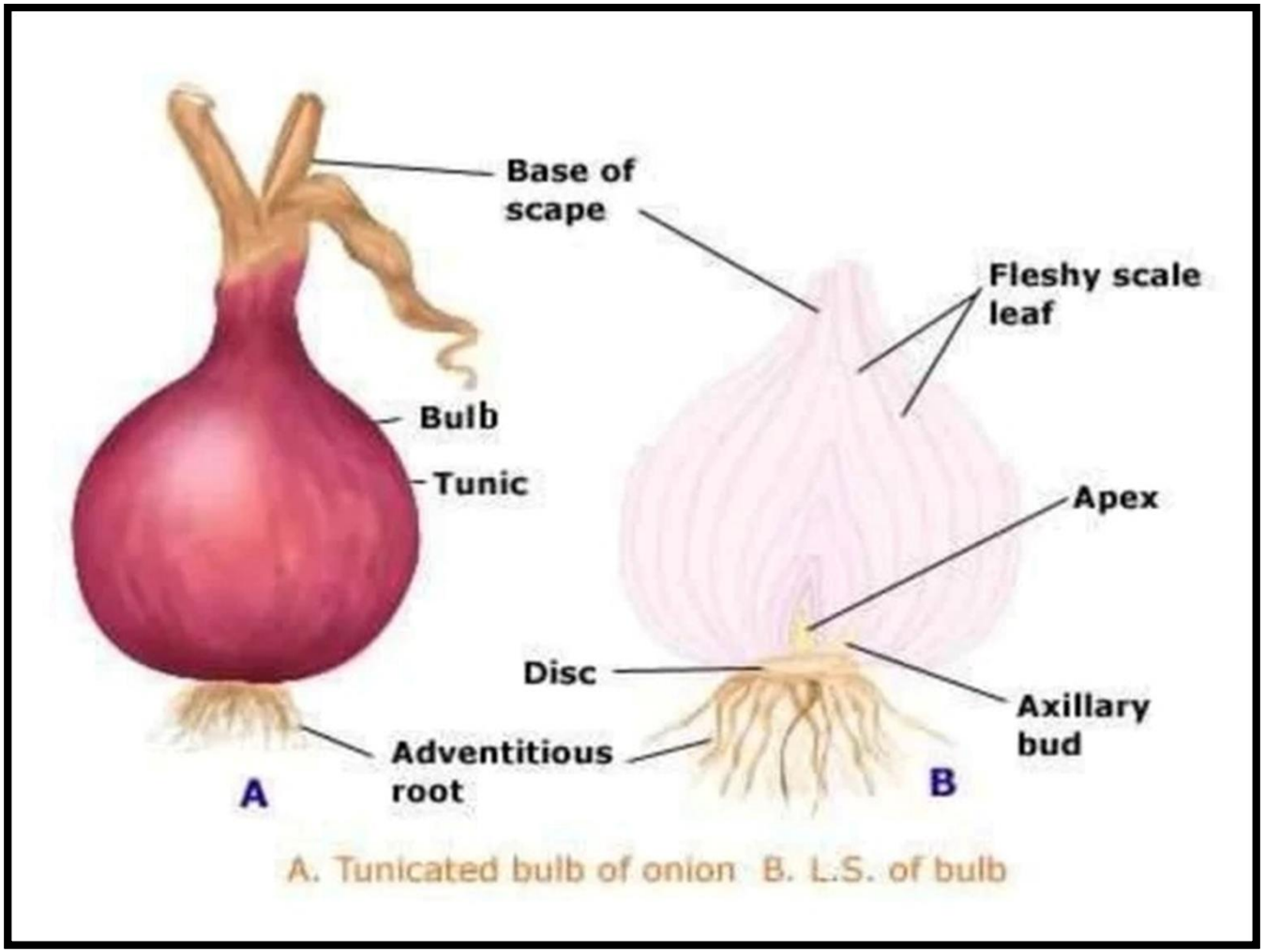
Bulb of onion



(iv) Bulb-Onion



Bulb of onion



A. Tunicated bulb of onion B. L.S. of bulb

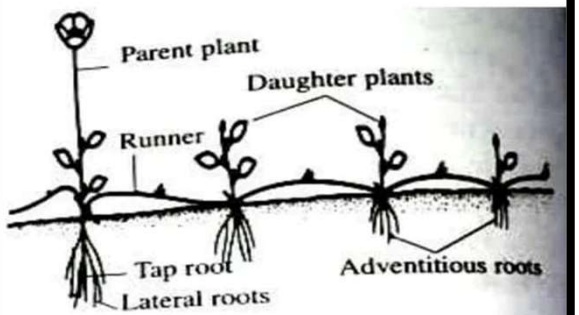
(b) Sub-aerial stem modifications

- Some weak-stemmed herbaceous plants produce modified branches which crop either on the ground surface or below the surface soil.
- The prostrate plants whose sub-aerial branches bear adventitious roots at nodes for fixation and absorption are called ***creepers*** and those which grow along the soil surface without giving out adventitious roots from nodes are called ***trailers***.
- The major types of creepers or sub aerial stem modifications include ***runners***, ***offsets***, ***suckers*** and ***stolons***.

(i) Runners

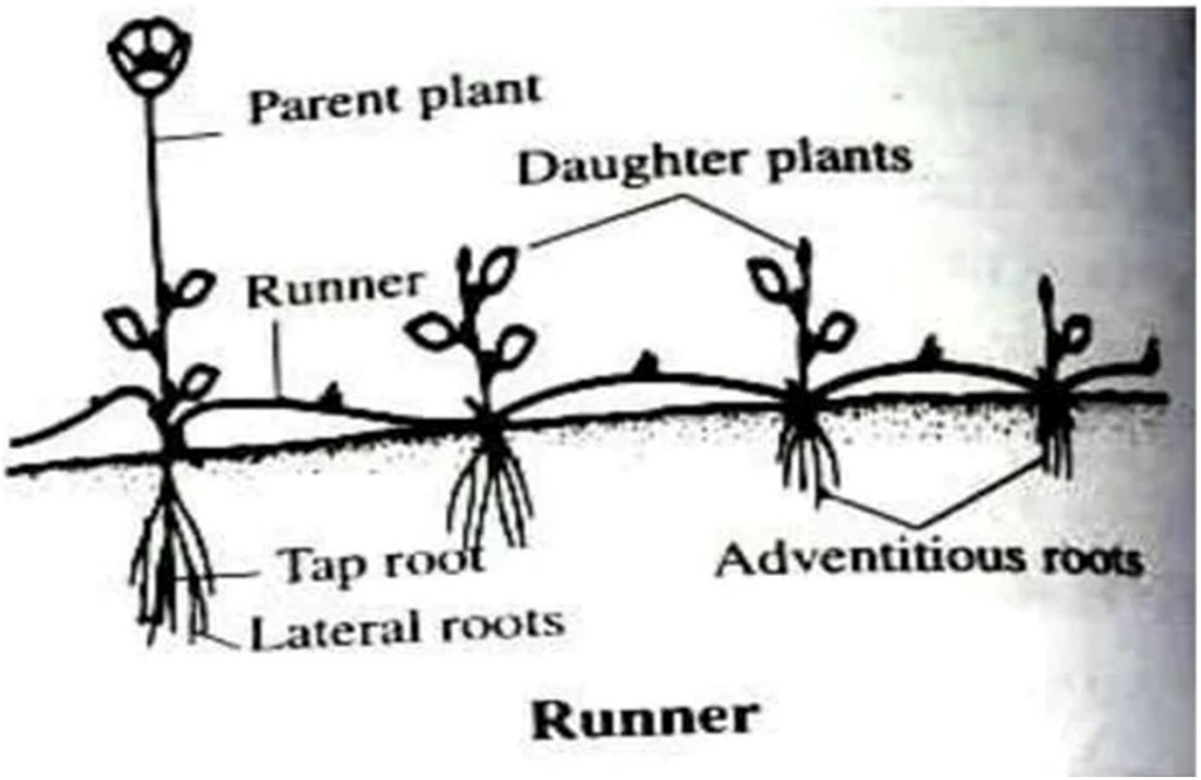
- Runners are horizontal creeping stems, with long and lean internodes on the soil surface.
- They grow horizontally on the soil surface in all directions.
- New aerial shoots may be produced from axillary buds.
- From each node upward leaves and downward adventitious roots are given out for producing daughter plants.
- The daughter plants get separated from the parent plant on the death of runners.
- Runners are found in ***Oxalis***, ***Centella***, ***Hydrocotyle***, ***Cynodon***, ***Fragaria***, etc.
- Underground runners are sometimes called ***soboles.***

Runner

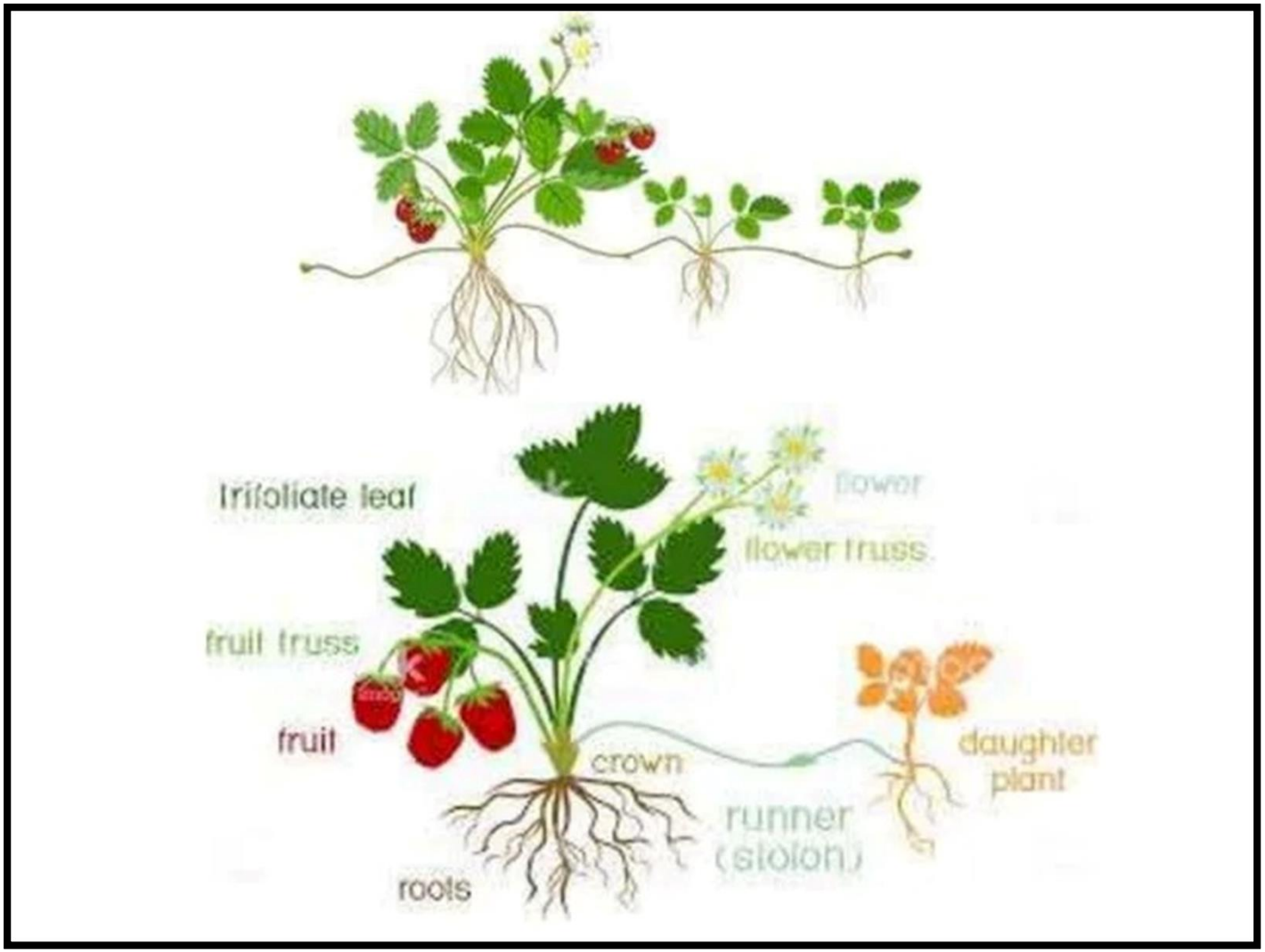


Runner

Runner



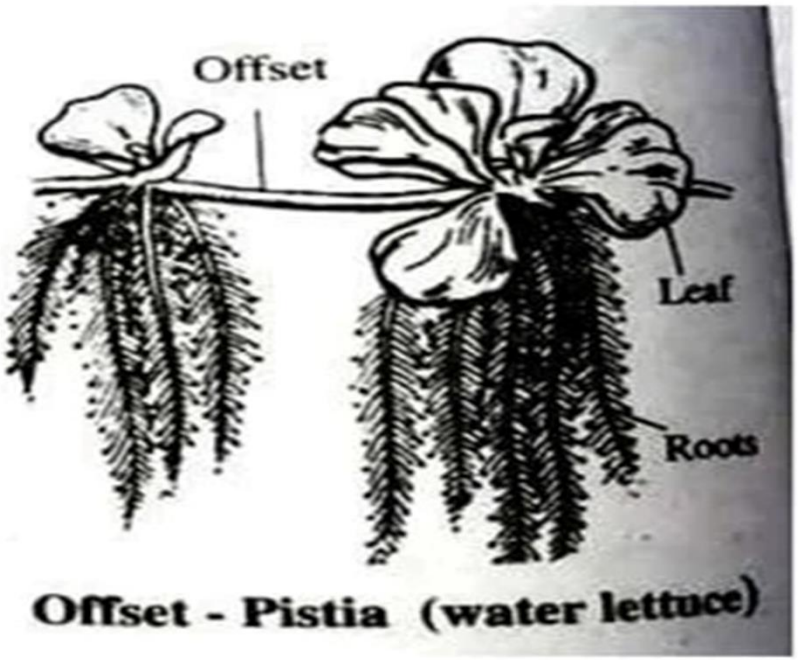
Runner


trifoliate leaf
flower
flower truss
fruit truss
fruit
crown
daughter plant
runner (stolon)
roots

(ii) Offsets

- Leaf Offsets are short, runner-like horizontal creeping shoots, with short and thick internodes.
- They are formed from axillary buds near the base of the main stem and produce daughter plants at their apices.
- Offsets are found in some hydrophytes, such as ***Pistia*** (water lettuce), ***Eichhornia*** (water hyacinth), etc.
- From each node a cluster of leaves and a bunch of adventitious roots may be given Offsets may break away and grow to new plants.

Offsets- Pistia



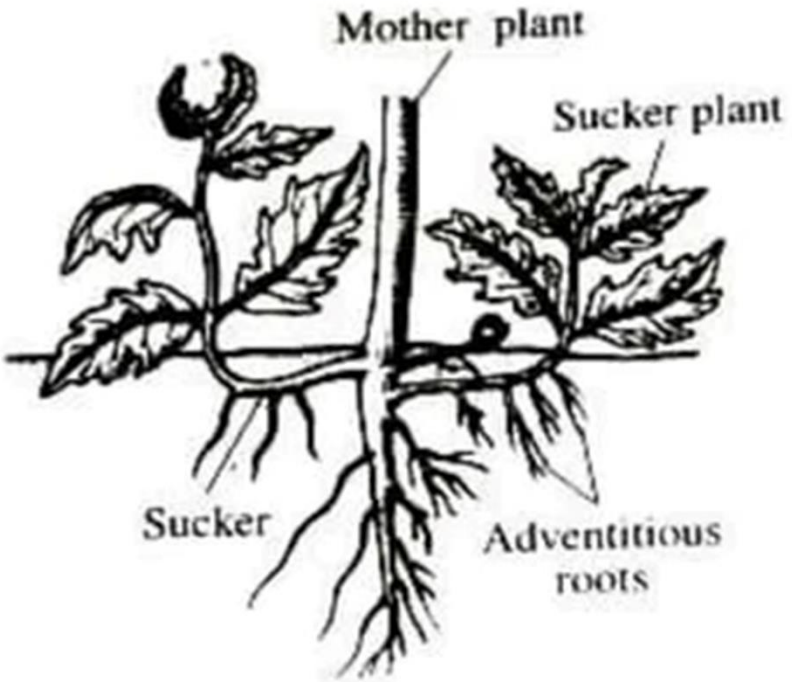
Offset - Pistia (water lettuce)

Offsets- Eichhornia

(iii) Suckers

- Underground adventitious branches.
- They develop from the axillary bud of the sub-terraneous part of the main stem.
- Sucker is she is shorter and stouter than a runner.
- It grows horizontally for a short distance below the soil, then comes up obliquely and gives rise to a leafy shoot.
- ***Chrysanthemum***
- ***Ananas (pine apple)***
- ***Musa (banana)***
- Suckers can be separated from the parent plant after root formation and planted elsewhere to produce new plants.

Suckers-Chrysanthemum



Sucker - *Chrysanthemum*

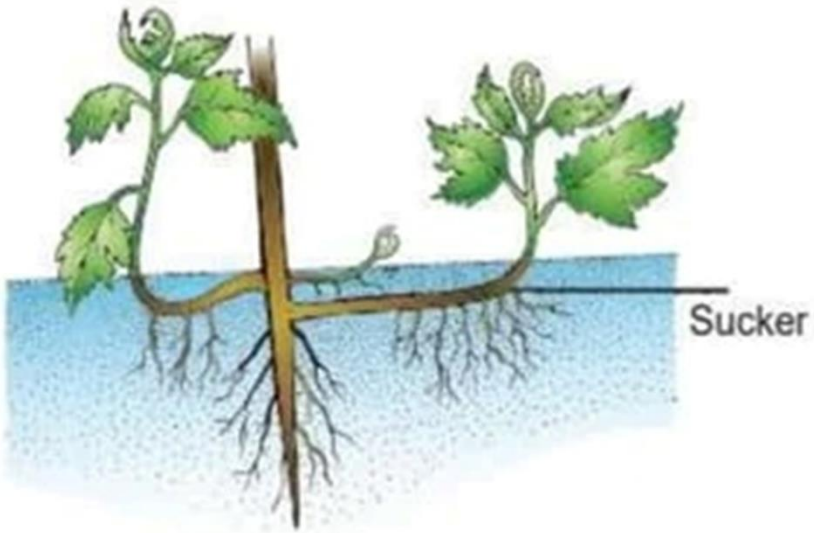
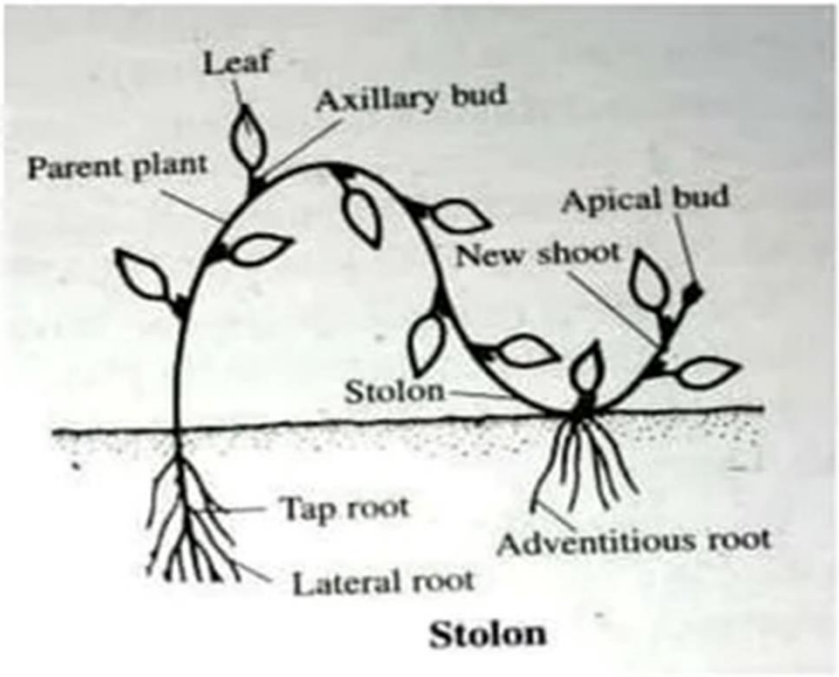


Figure 4b: Sucker - *Chrysanthemum*

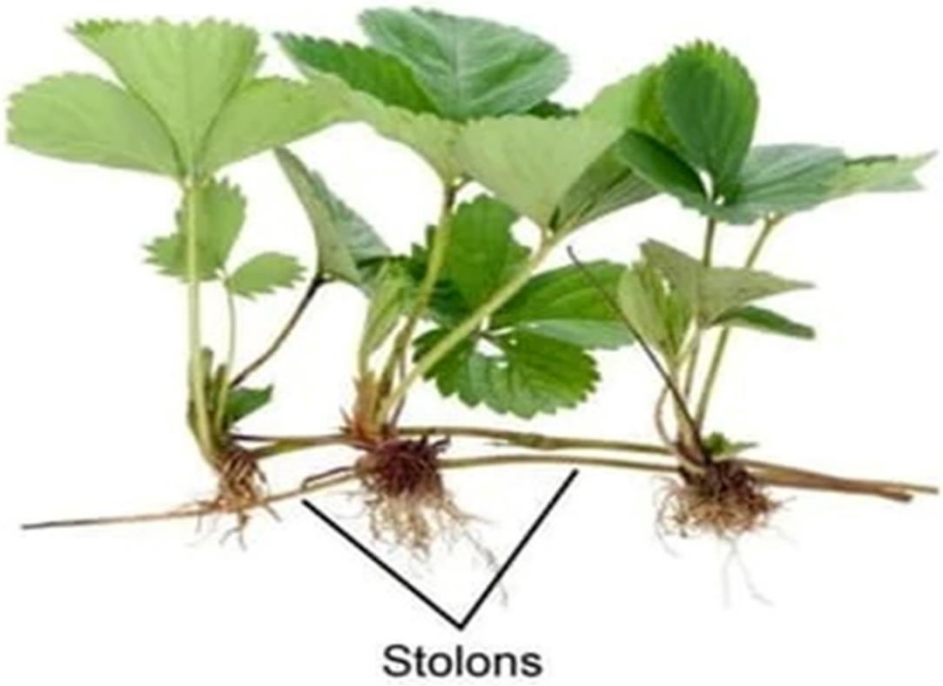
(iv) Stolons

- Stolon is a slender lateral branch that arises from the base of the main stem of some creepers.
- It grows aerially at first, then arches down to touch the ground, and finally gives out new shoots and roots from its axillary buds at places where nodes touch the soil
- ***(e.g. Jasminum,***
- ***Colocasia,***
- ***Mentha - mint).***

Stolon



Stolon



(c) Aerial stem modifications

- Modification of aerial stem is to serve some special functions, such as climbing, mechanical support, protection, water storage, vegetative propagation and photosynthesis.
- ***Tendrils,***
- ***Thorns,***
- ***Phylloclades (cladophylls),***
- ***Cladodes,***
- ***Bulbils and***
- ***Pseudobulbs***

- are the common modifications of the aerial stem.

(i) Tendrils

- Tendrils are long, slender, spirally coiled and spring-like parts of a climbing plant, specialized for climbing on a support.
- They are specialised to coil around a support to elevate the climber.
- Tendrils are formed from leaf, stem or inflorescence.
- Accordingly, there are three kinds of tendrils, namely

1. **leaf tendrils** (e.g., Gloriosa, Lathyrus, sweet pea),
2. **stem tendrils or branch tendrils** (e.g.. Bryonia)
3. **inflorescence tendrils** (e.g., Parthenocissum).

Terminal bud modified into tendril - *Vitis*

Axillary bud modified into tendril - *Passiflora*

Stem tendrils for mechanical support

LEAF MODIFICATIONS AS TENDRILS

ENTIRE LEAF EXCEPT STIPULES AS TENDRIL
(Ex: *Lathyrus*)

TERMINAL LEAFLETS AS TENDRILS
(Ex: *Pisum*)

LEAF APEX AS TENDRILS
(Ex: *Gloriossa*)

PETIOLE AS TENDRIL
(Ex: *Clemantis*)

STIPULES AS TENDRIL
(Ex: *Smilax*)

stem tendrils or branch tendrils
(e.g.. Bryonia)

Inflorescence tendrils (e.g.,Parthenocissum).

- Stem tendrils are modifications of
- ***terminal buds*** (***e.g. Vitis - grape vine***),
- ***axillary buds*** (***e.g. Passiflora - passion flower***), or
- ***stipules or bractioles*** (***e.g. snake gourd, bitter gourd, cucumber, pumpkin, water melon***).
- When terminal buds transform tendrils, further growth is effected by axillary buds. This is called ***sympodial growth.***
- The tendrils of some species end in discoidal suckers for attachment, while those of some others become negatively phototrophic, grow into the dark cracks and crevices in the support and thus behave like climbing roots.

(ii) Thorns

- Thorns are hard and sharply pointed woody structures, developed from terminal buds (***e.g. Carissa***), or axillary buds (***e.g. Canthium, Citrus, Duranta, Bougainvillaea***) for protection or support.
- They are ***endogenous*** in origin having vascular connections (Spines and prickles are exogenous structures, without vascular connections. Spines are modified parts of leaves, and prickles are hard epidermal outgrowths)
- In most cases thorns serve as defensive structures for protection from herbivorous animals.
- But, in ***Bougainvillaea*** they are slightly curved and help the plant to climb on a support.

Citrus *Duranta*

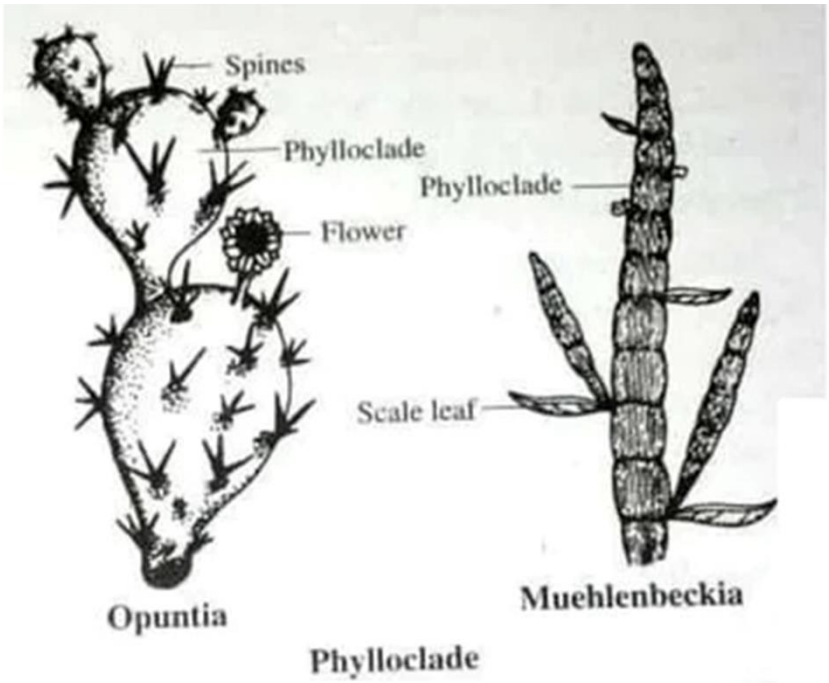
Axillary buds modified into thorns

Stem modifications

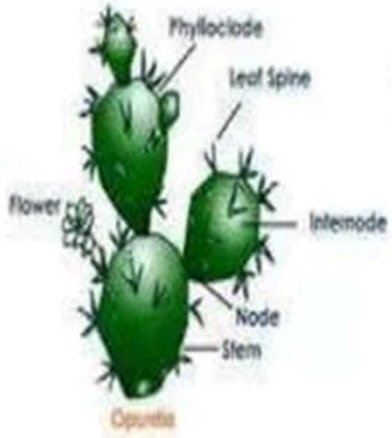
Underground modifications	Sub-aerial modifications	Aerial modifications
(i) Rhizomes -e.g. Ginger	(i) Runners - e.g. Oxalis	(i) Tendrils - e.g. Cucumber
(ii) Tubers - e.g. Potato	(ii) Offsets - e.g. Pistia	(ii) Thorns - e.g. Canthium
(iii) Corms - e.g. Amorphophallus	(iii) Suckers - e.g. Musa	(iii) Phylloclades - e.g. Opuntia
(iv) Bulbs - e.g. Onion	(iv) Stolons- e.g. Jasminum	(iv) Cladodes -e.g. Asparagus.

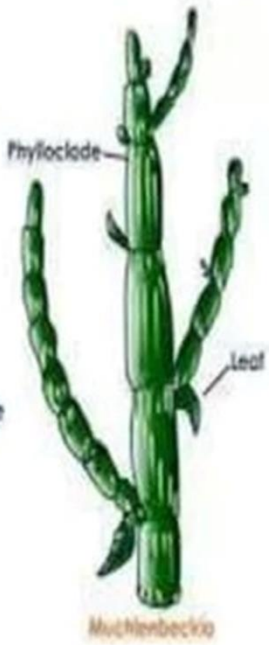
(iii) Phylloclades (cladophylls)

- These are green, flat or globose ***photosynthetic stems***, with nodes and internodes.
- They are xerophytic adaptations to reduce transpirational water loss.
- So, they are common in plants living in dry and arid soil.
- They become almost leaf-like in appearance and take up a photosynthetic function.
- In some xerophytes, leaves are absent, very small, or modified into protuberances, scale leaves, or spines to reduce transpiration.
- Under such circumstances stem becomes a green, flat and photosynthetic phylloclade.
- A phylloclade consists of nodes and internodes.
- Nodes bear scaly or spiny leaves, and sometimes flowers also.
- Often, they give out branches also (***e.g. Casuarina, Muehlenbeckia, Opuntia, Euphorbea***).
- In ***Opuntia*** and many other cacti, the stem is swollen and fleshy due to the storage of water.



Phylloclade

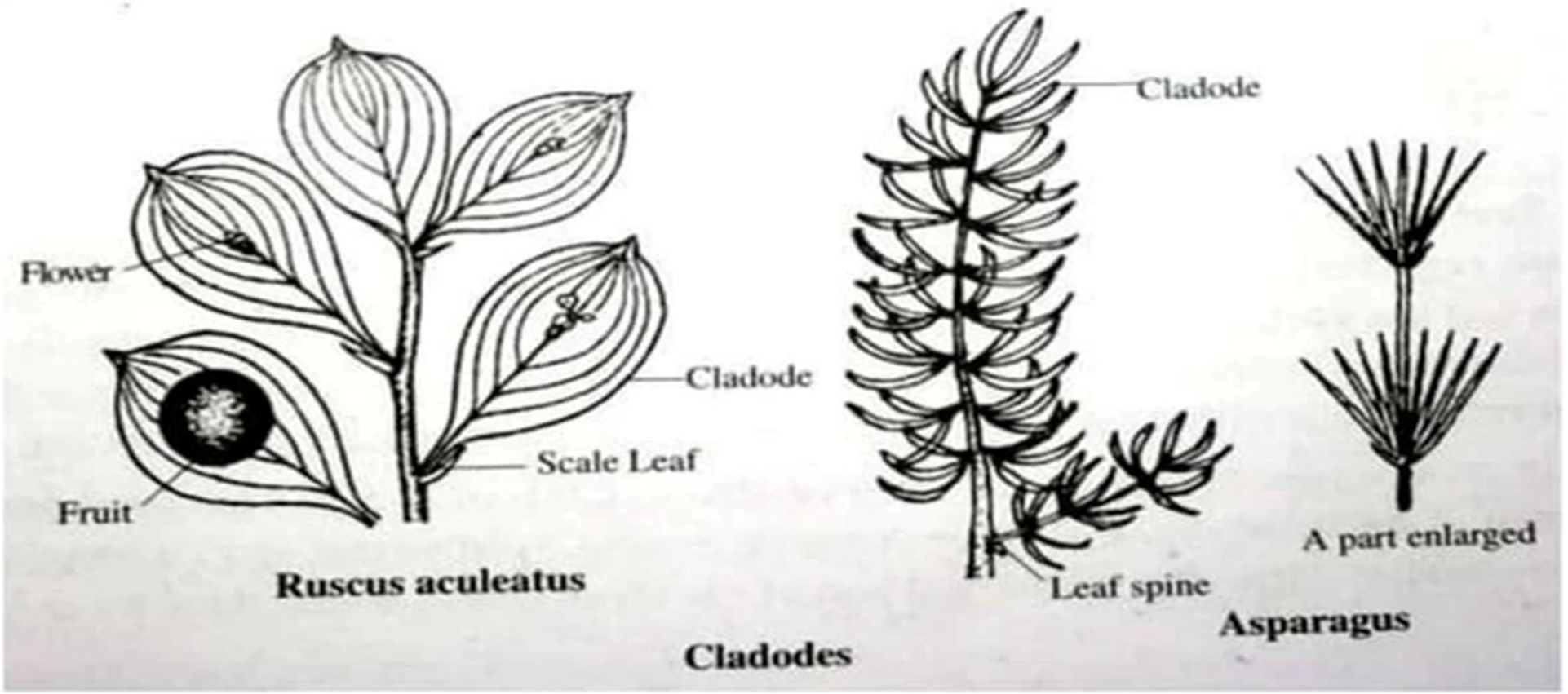




(iv) Cladodes

- Cladode is a green, short and flat photosynthetic internode, which functions as a leaf.
- In it, leaves are extremely reduced and functionless.
- It is a xerophytic adaptation to reduce water loss. ***e. g. Asparagus, Ruscus.***
- In ***Asparagus,*** cladodes are fied axillary buds.
- They are green, slightly flattened and sickle-shaped, and very much leaf-like with only a single internode.
- So, they are often mistaken for Leaves are reduced to scales and spines.
- The cladodes of ***Ruscus (butcher's broom)*** are modified axillary branches are that, thick and leaf-like, with veins.
- Yet, they may bear terminal buds and flowers.
- Actual leaves are reduced to scale leaves.

Cladodes


Flower
Cladode
Scale Leaf
Fruit
Ruscus aculeatus
Cladode
Leaf spine
A part enlarged
Asparagus
Cladodes

Thorns, spines, prickles

- Though the terms thorns, spines and prickles are usually used indiscriminately these structures are distinctly different.
- Thorns are woody structures and they represent modified stems.
- Spines are leaves or leaf parts.
- Prickles are superficial structures (e.g., rose) and hence are called ***emergences***.
- Thorns, spines and prickles are primarily meant for protection against browsing animals

Functions of stem

- Stem has both primary (principal) and secondary (accessory) functions.
- **Its primary functions are the following:**

(i) Provides support to leaves, flowers and fruits

(ii) Transports water and mineral nutrients to leaves, and prepared organic nutrients from leaves to other parts.

- **The secondary functions of the stem are the following:**

(i) Storage of food and water in bulbils, pseudobulbs and corms.

(ii) Underground stem modifications help in vegetative propagation and perennation.

(iii) Aerial modifications of stem serve for defence, protection, support, propagation, photosynthesis, water storage and control of transpiration and water loss.