Sexual Reproduction of the Flowering Plant

https://www.youtube.com/watch?v=0UEpq1W9C_E

Prior learning

Working in Partnership draw a diagram of a flowering plant and write out the functions of the parts

Then bullet point a simple flowchart of sexual reproduction in the Flowering plant

Checklist

Learning objectives(1/4)

- State the structure & function of the floral parts including: Sepal, petal, stamen, carpel)
- State that the Pollen grain produces male gamete.
- State that the Embryo sac produces an egg cell & polar nuclei.
- Define the terms: pollination, self-pollination
- Outline methods of pollination including: cross-pollination & self pollination

Learning objectives(2/4)

- Define the term: fertilisation.
- Outline seed structure & function of following: testa, plumule, radicle, embryo, cotyledon
- Explain embryo & food supply (endosperm or seed leaves)
- Classify plants as monocotyledon or dicotyledon & distinguish between them.
- Make reference to non-endospermic seed.
- Outline fruit formation.
- Outline seedless fruit production

Learning objectives(3/4)

- Outline fruit & seed dispersal and give with examples of wind/water/animal/self dispersal
- Explain & emphasize the need for dispersal
- Define the term dormancy.
- State advantages of dormancy.
- Explain dormancy in agricultural & horticultural practice.
- Define the term: Germination.
- Explain the factors necessary for and role of digestion and respiration in germination.
- Outline the stages of seed development

Learning objectives(4/4)

- State that vegetative propagation is asexual reproduction
- Give 1 example of vegetative propagation from stem, root, leaf, bud
- Compare reproduction by seed and by vegetative reproduction
- Outline 4 methods of artificial propagation in flowering plants

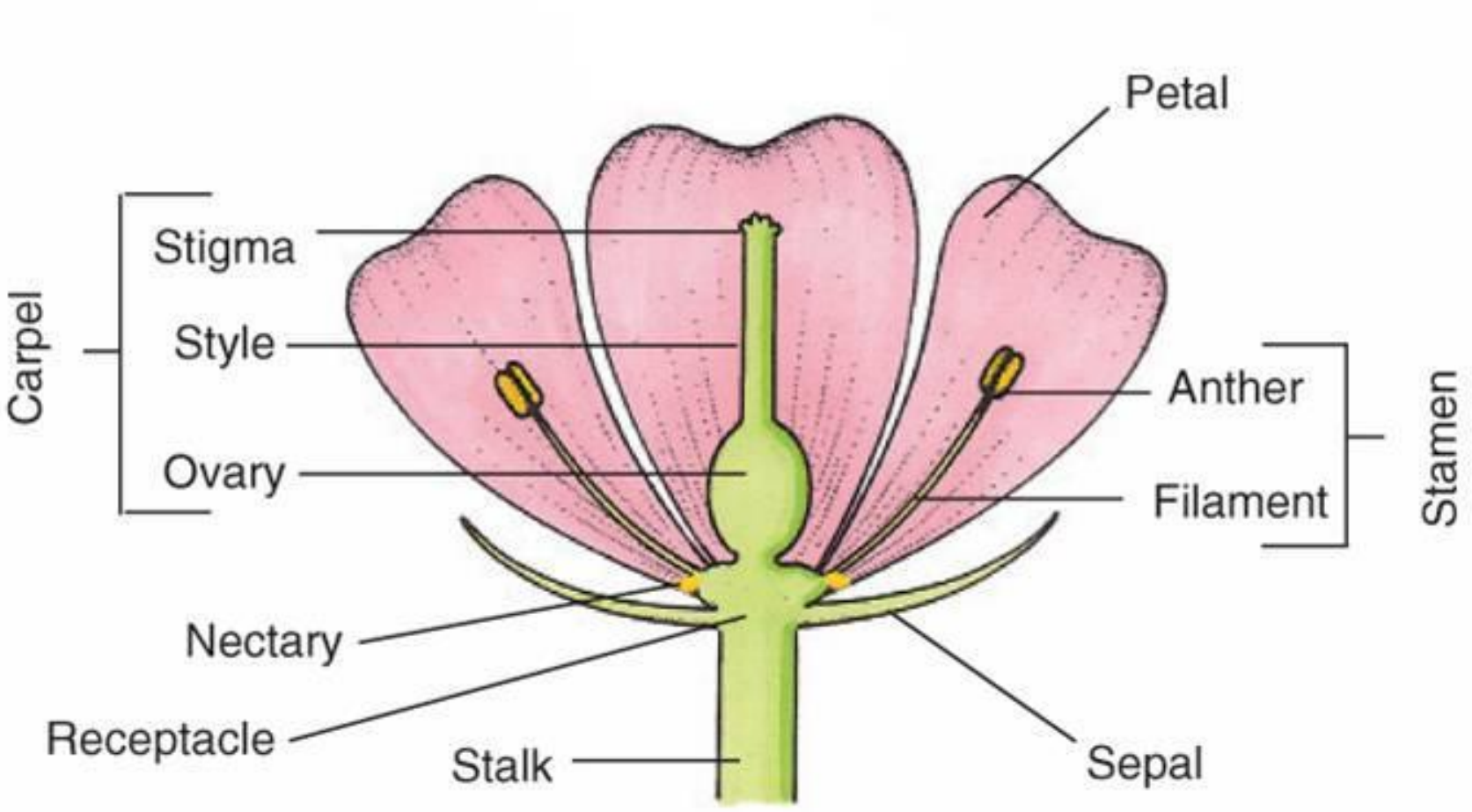
Sexual Reproduction of the Flowering Plant

Watch and Listen to the Video

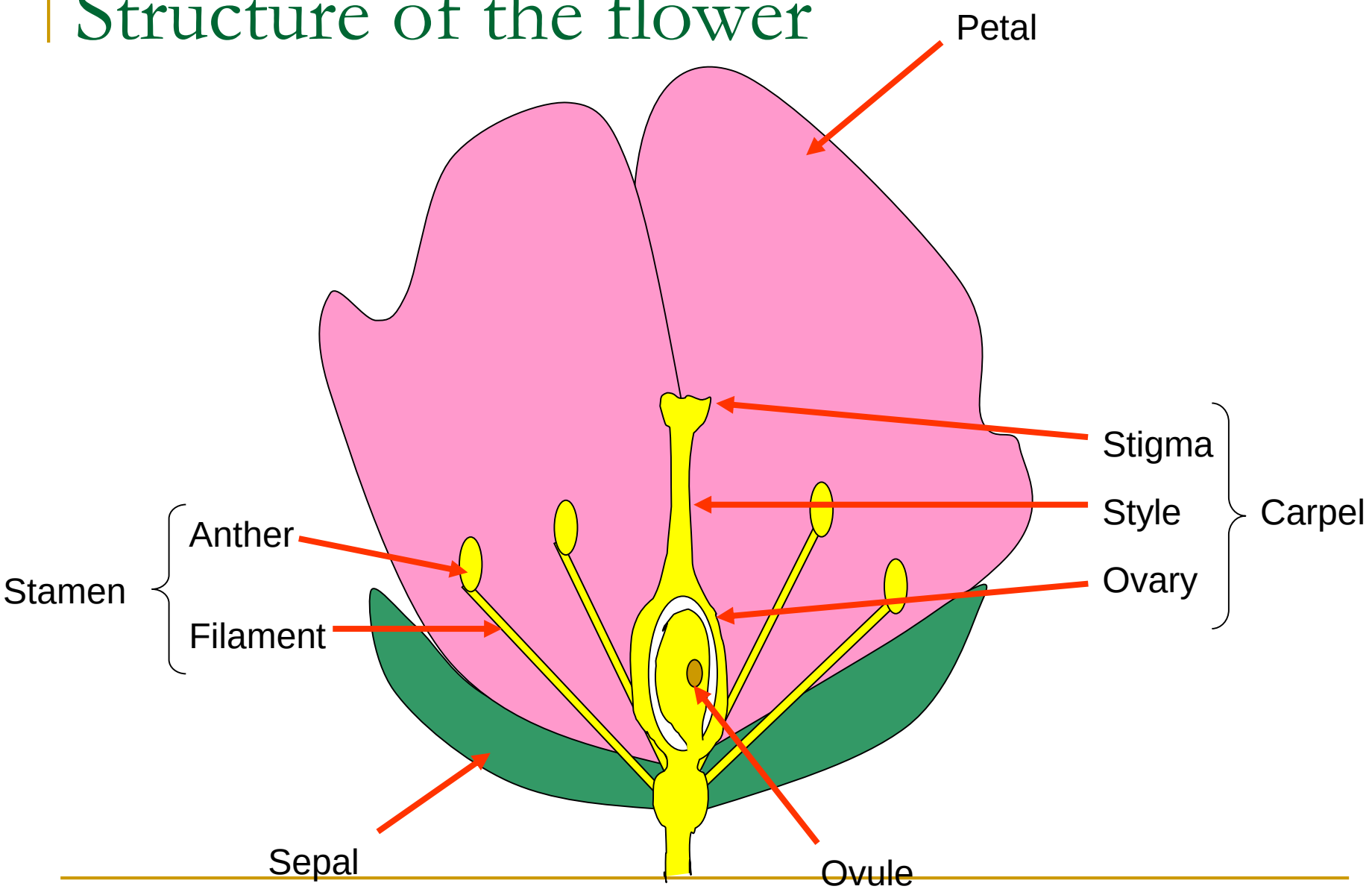
Take notes

Structure of the flower

Structure of the flower



Structure of the flower

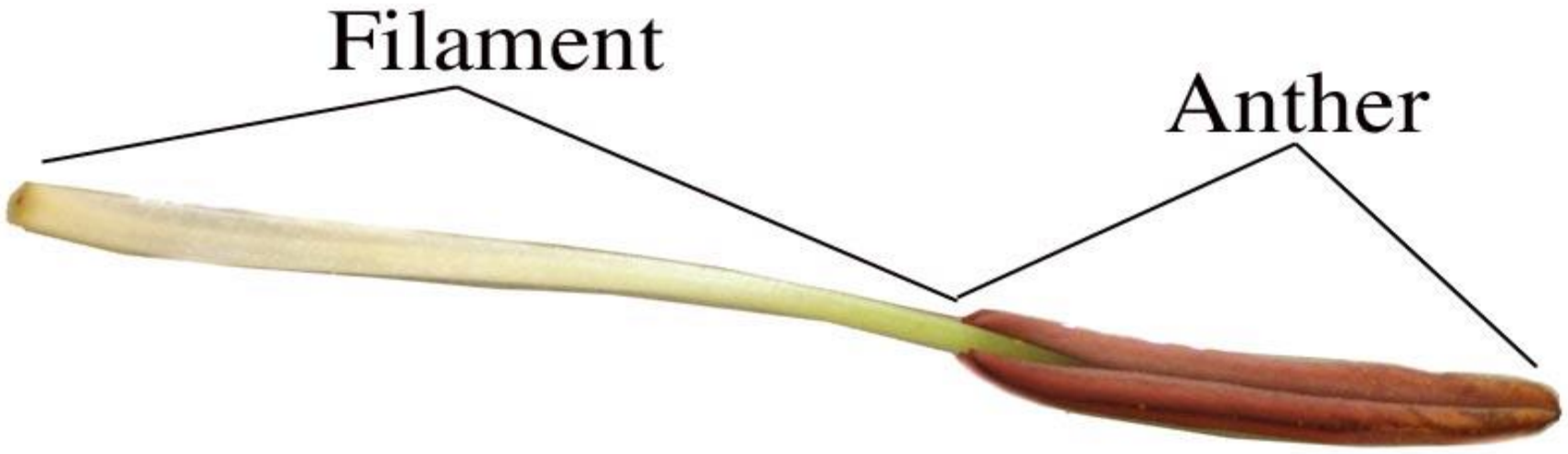


Function of floral parts

- **Sepal :** To protect the flower (and to prevent it from drying out
- **Petals :** To attract insects to the flower for pollination

Function of floral parts

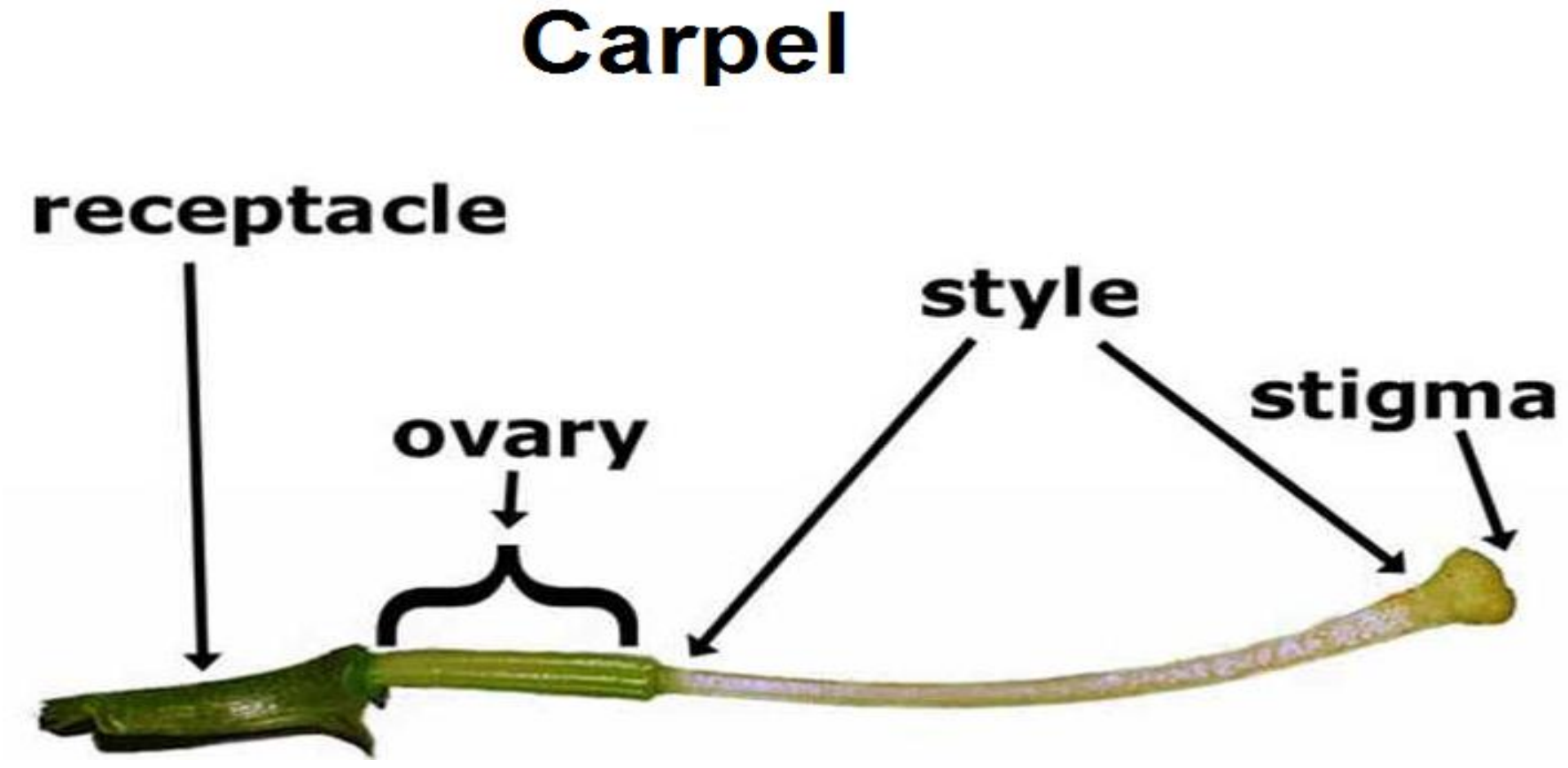
- **Stamen :** To produce the pollen grains in the anthers. (Each pollen grain produces two male gametes, one of which can fertilise an egg cell)



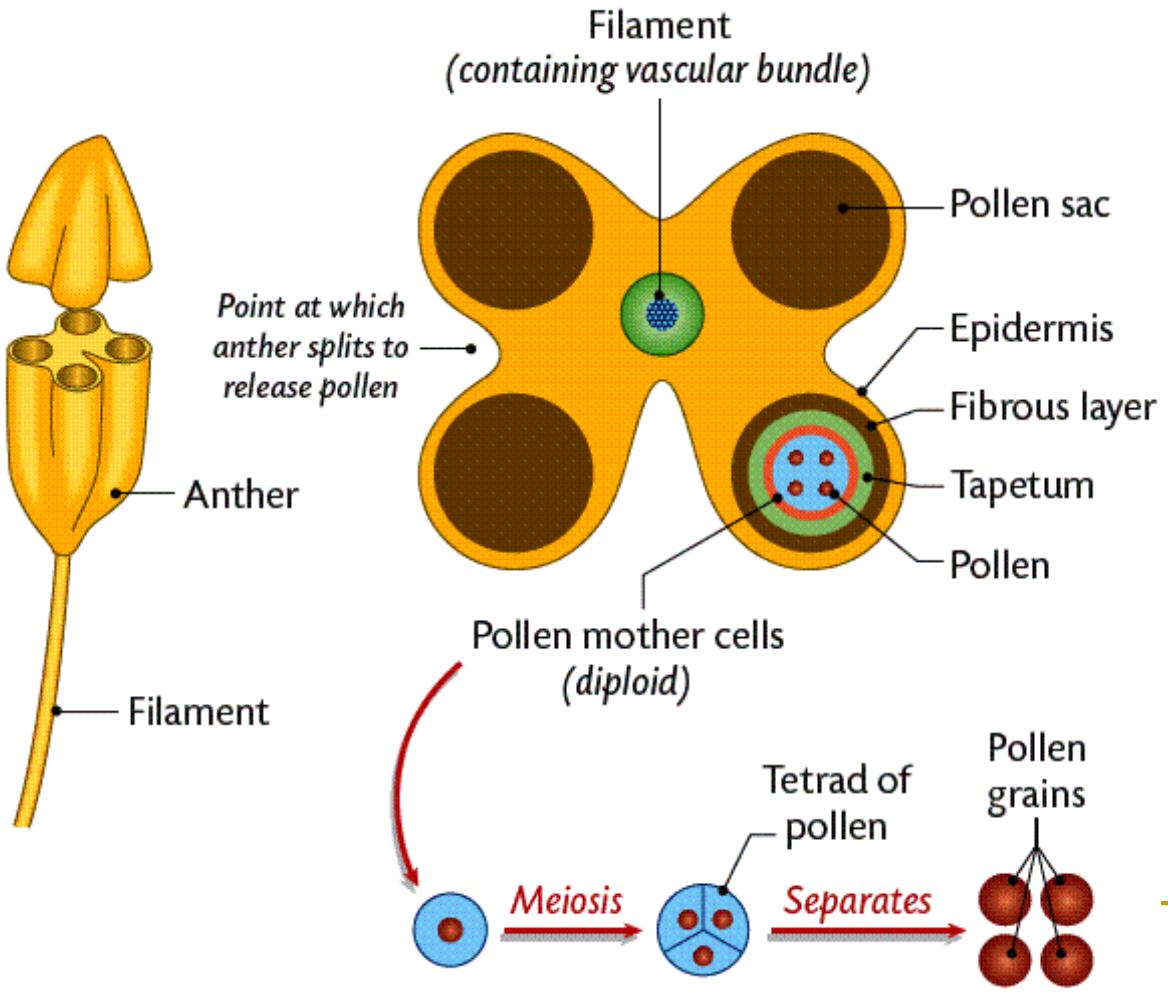
stamen

Function of floral parts

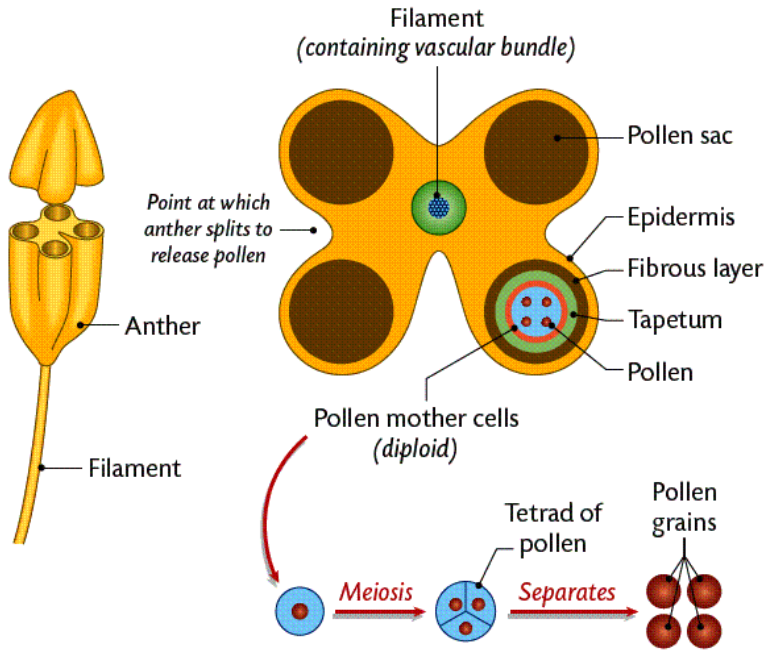
- **Carpel** : To produce the ovules (Each ovule contains an egg cell inside an embryo sac)



Pollen Grain Development and Formation of Sex Cells (gametes)

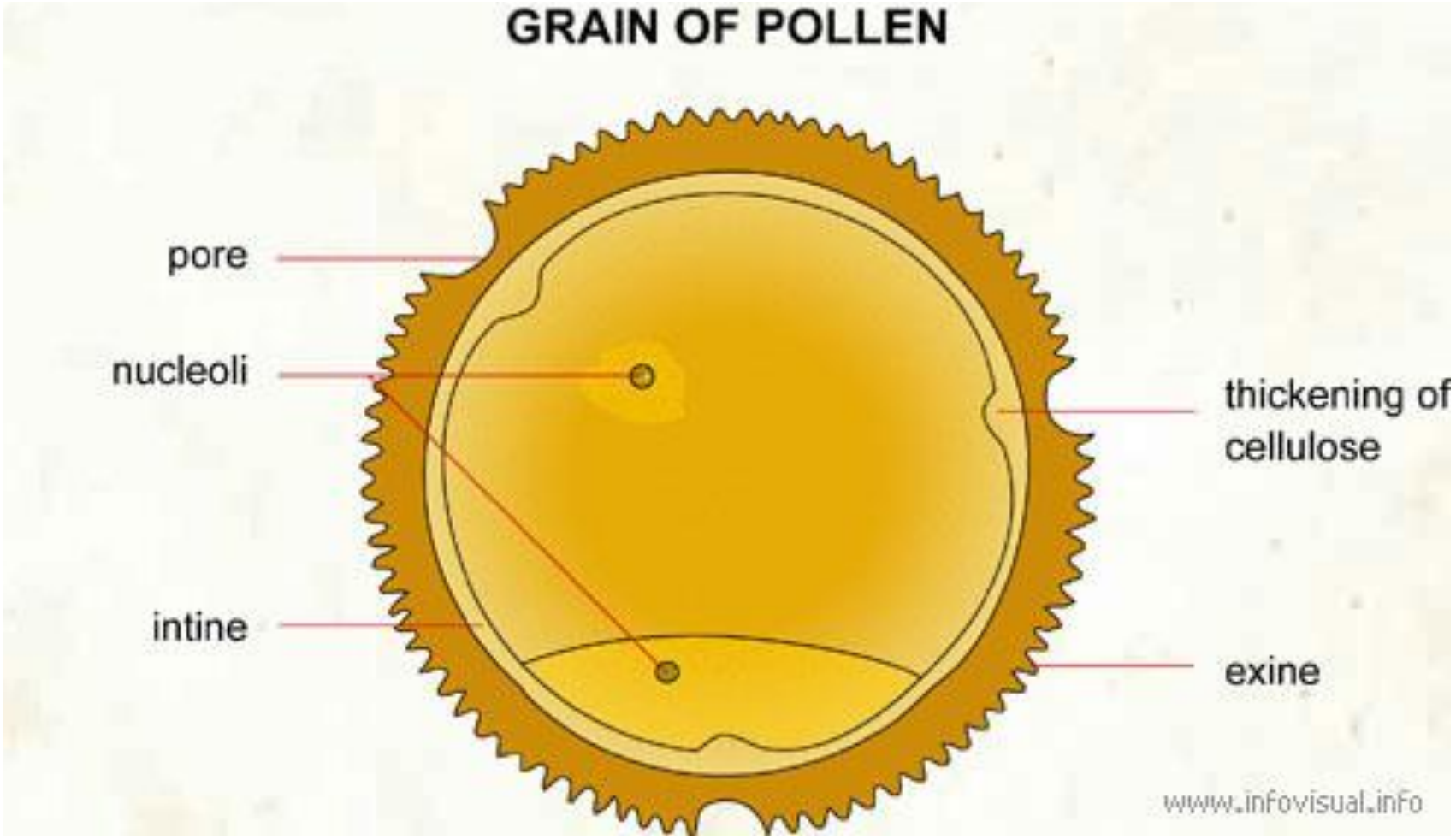


- Anthers contain four chambers called pollen sacs
- Each sac is enclosed by a protective epidermis and fibrous layer

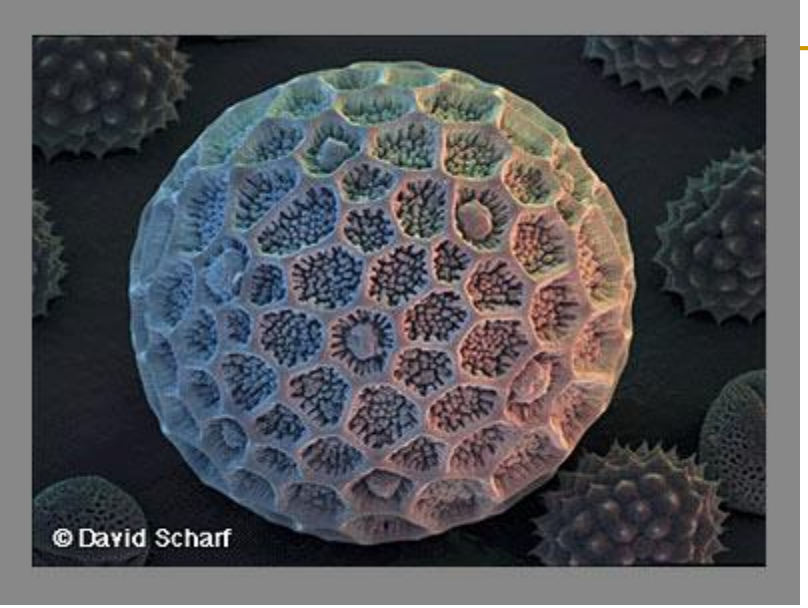


- Inside the Fibrous layer is the Tapetum (food store)
- Each pollen sac has a number of diploid microspore mother cells
- These cells divide by meiosis to produce four haploid cells called a tetrad
- The tetrad then breaks up to form four separate haploid **pollen** grains (microspores)

- Male Gamete Formation
  - The pollen grain then divides by mitosis to form two identical haploid nuclei
  - These are called the tube nucleus and the generative nucleus
  - Remember the anthers contain many thousands of pollen grains
  - When pollen is mature the anther becomes dried out and the anther splits (dihiscing) the grains become exposed on the outside of the anther

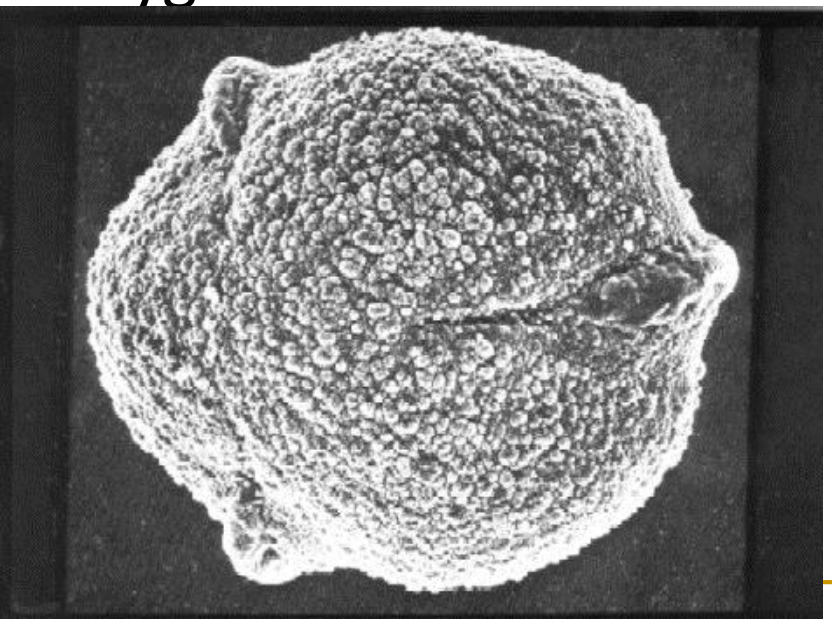


Each pollen grain has a thick outer wall called the exine, a thin inner layer called the intine,

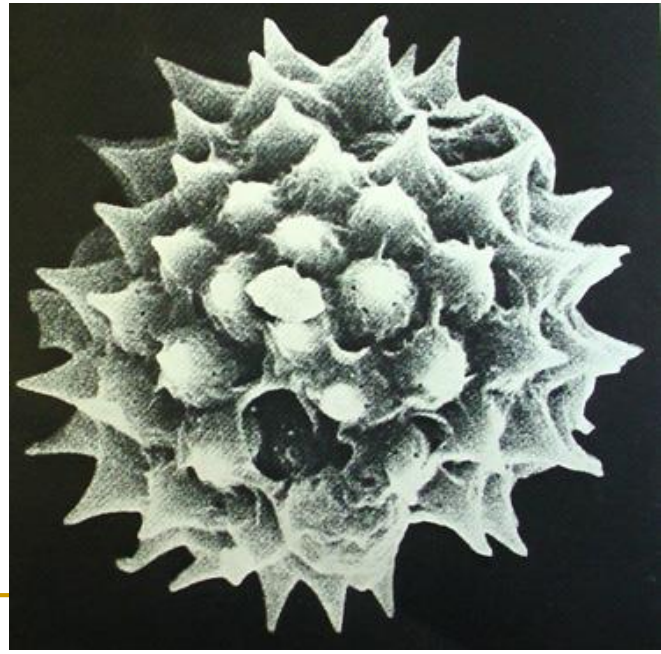


Plygonium Pollen Grain

Hibiscus Pollen Grain



Grass Pollen Grain

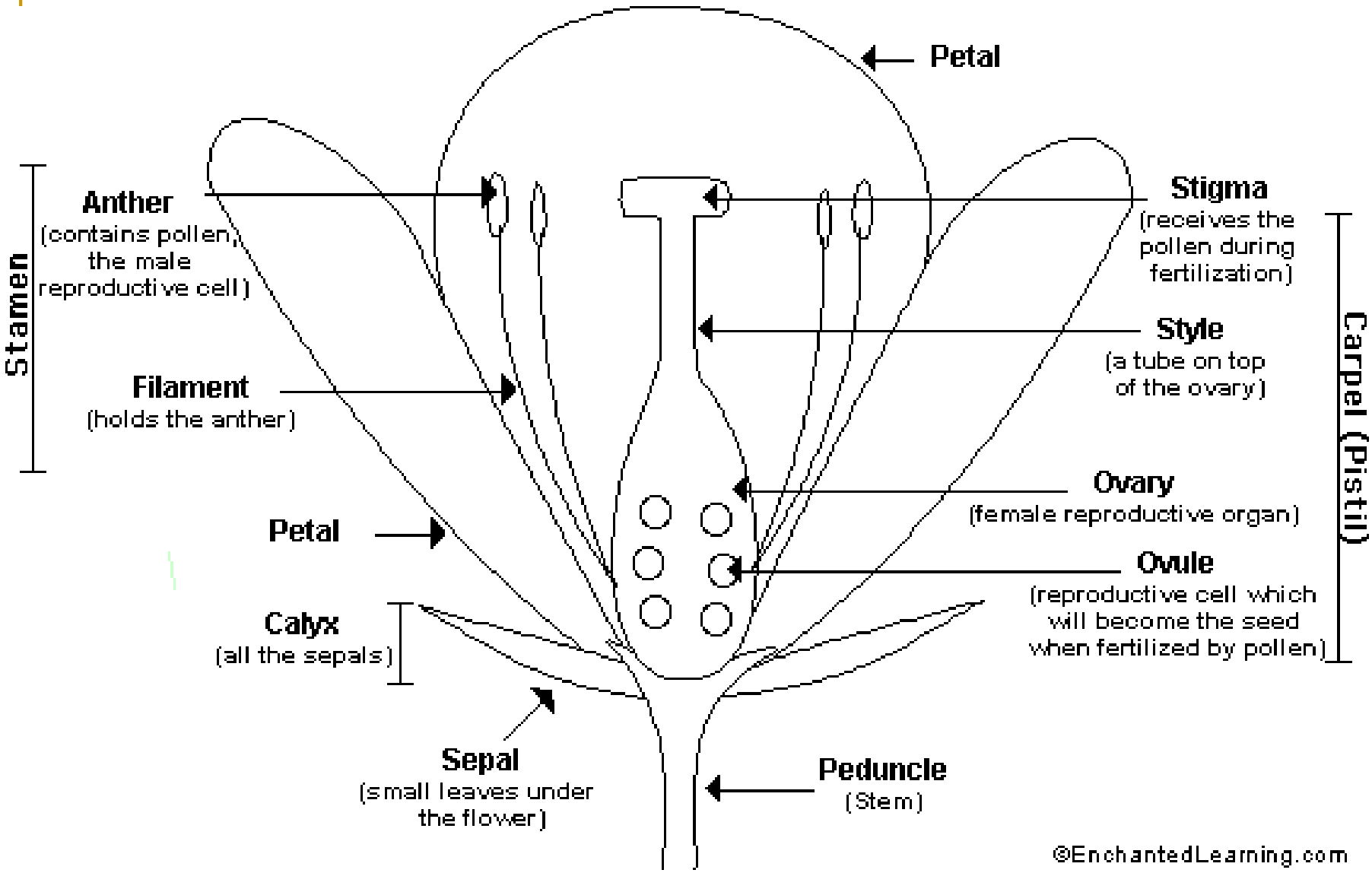


Scots Pine Pollen Grain

Male reproductive organs

Development of the Embryo Sac & Female Gamete formation

- The bulk of the ovule consists of diploid nuclellus cells acting as a food supply for the ovule
- The megaspore mother cell (found low down in the ovule) divides by meiosis to form 4 haploid cells
- 3 disintegrate and one goes on to help form the female gamete


Petal
Stamen
Anther
(contains pollen, the male reproductive cell)
Filament
(holds the anther)
Stigma
(receives the pollen during fertilization)
Style
(a tube on top of the ovary)
Carpel (Pistil)
Ovary
(female reproductive organ)
Petal
Ovule
(reproductive cell which will become the seed when fertilized by pollen)
Calyx
(all the sepals)
Sepal
(small leaves under the flower)
Peduncle
(Stem)
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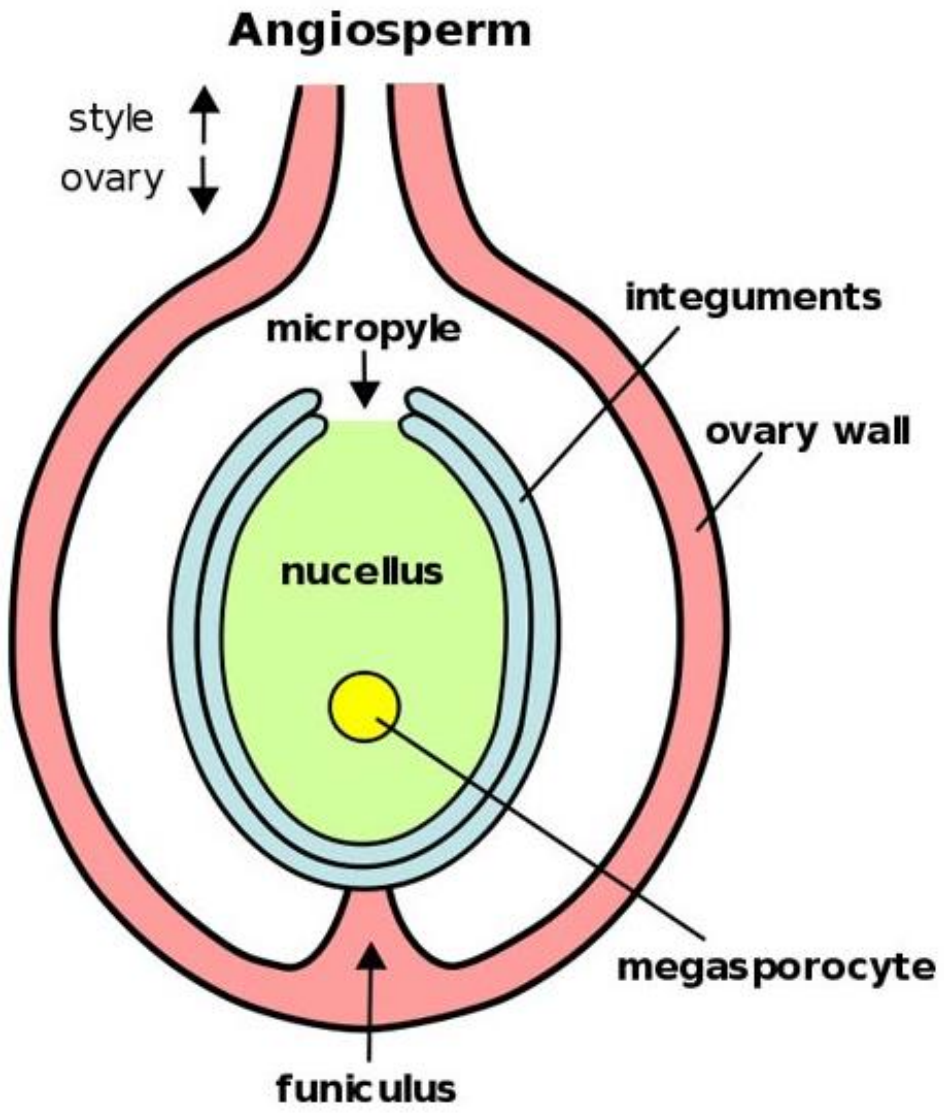
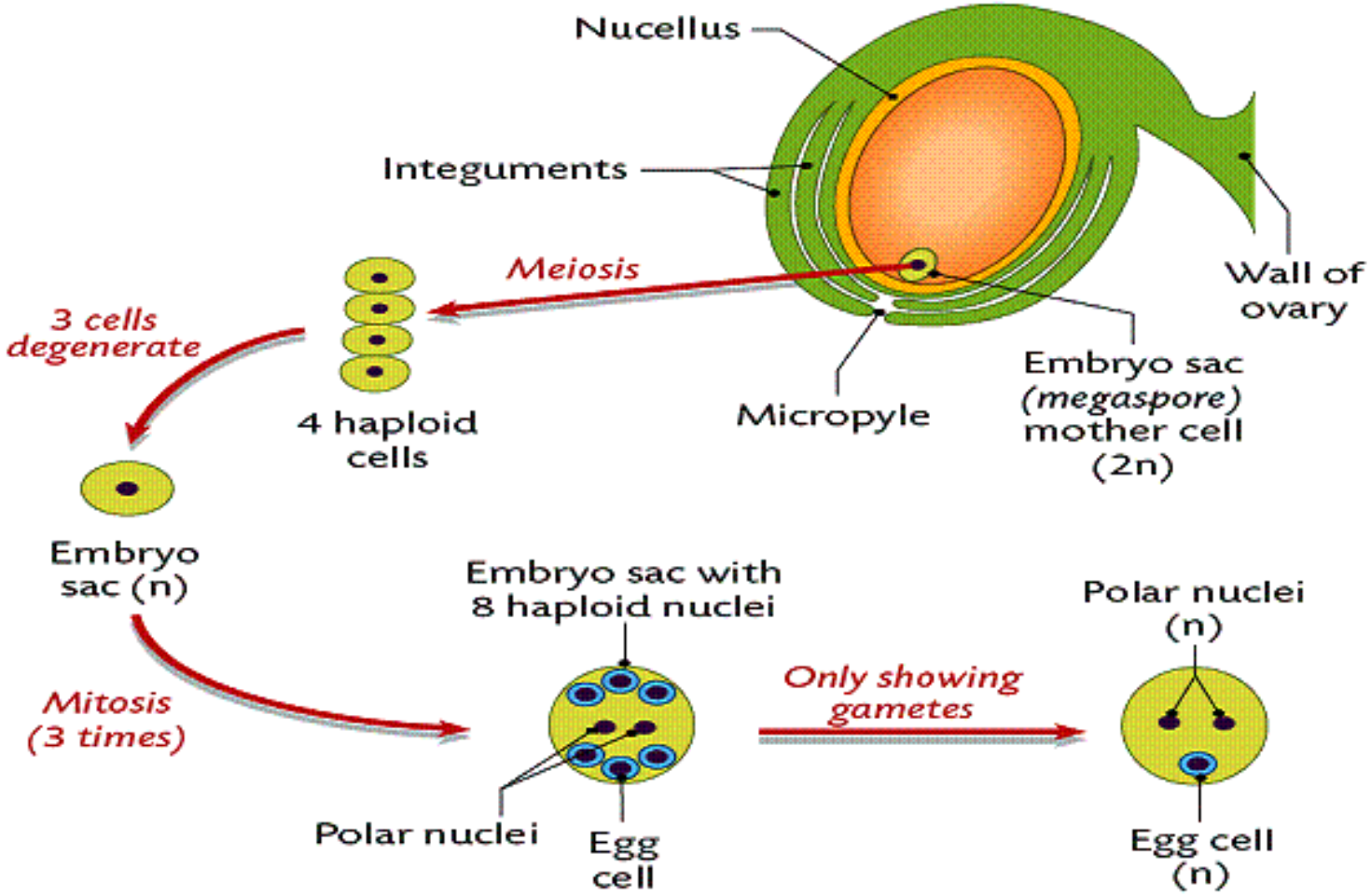

Angiosperm
style
ovary
integuments
micropyle
ovary wall
nucellus
megasporocyte
funiculus

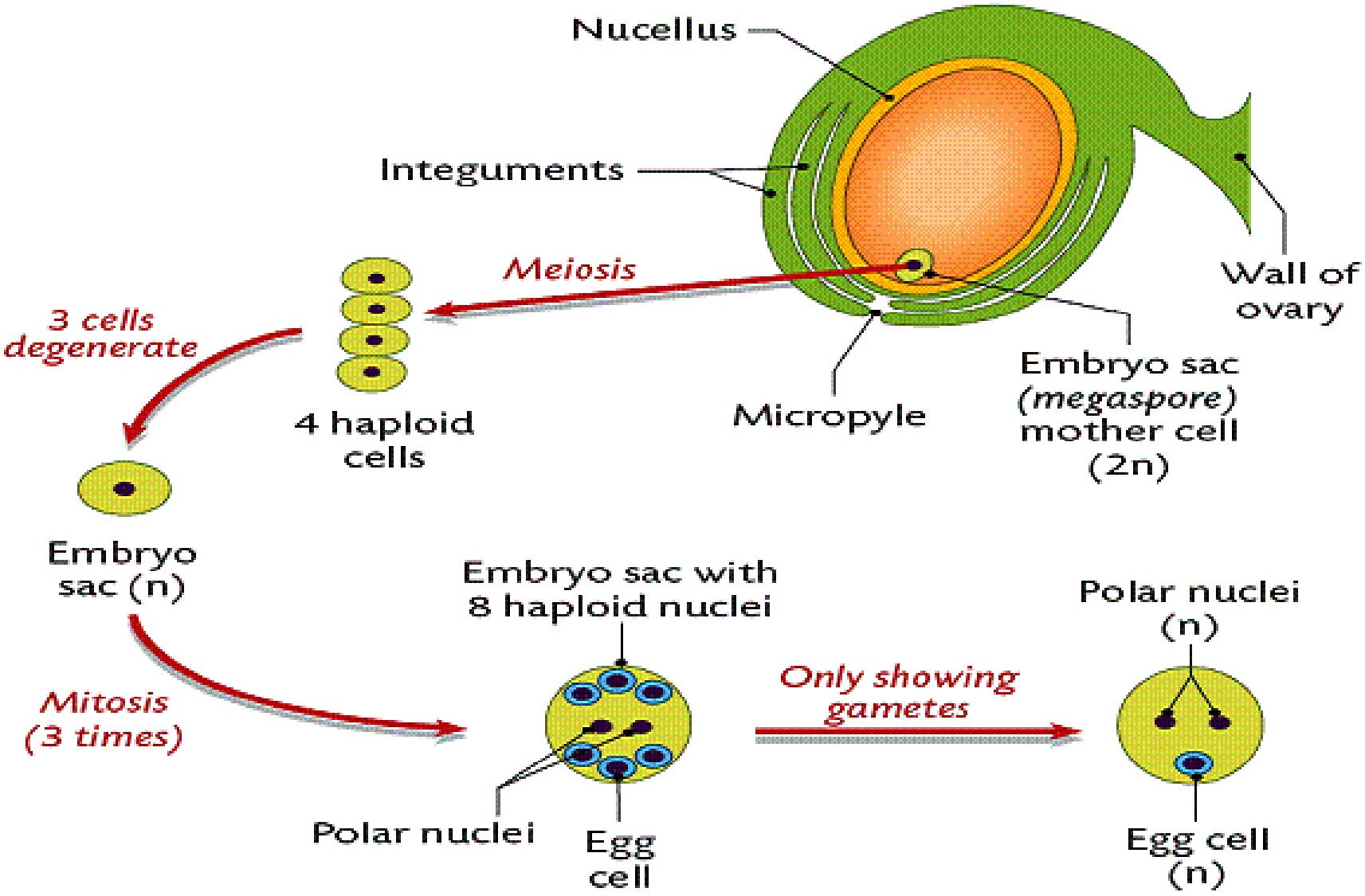
Structure of ovule and development of the embryo sac



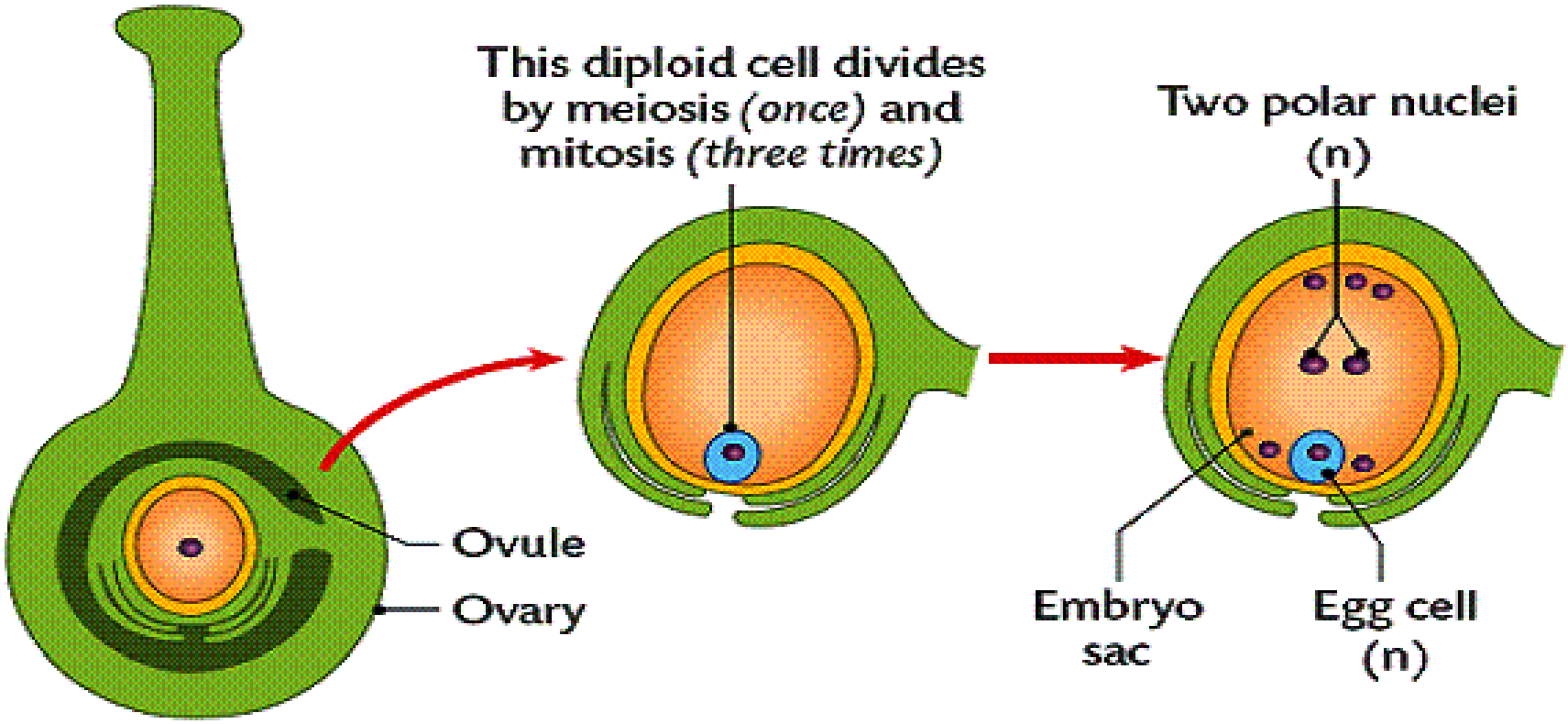
Development of the Embryo Sac & Female Gamete formation

- This haploid nucleus of the embryo sac divides 3 times by mitosis to form 8 haploid nuclei

- 5 die
- 3 form female gametes
  - 2 of the 3 form “the polar nuclei”
  - 1 forms a thin cell wall and becomes the egg cell

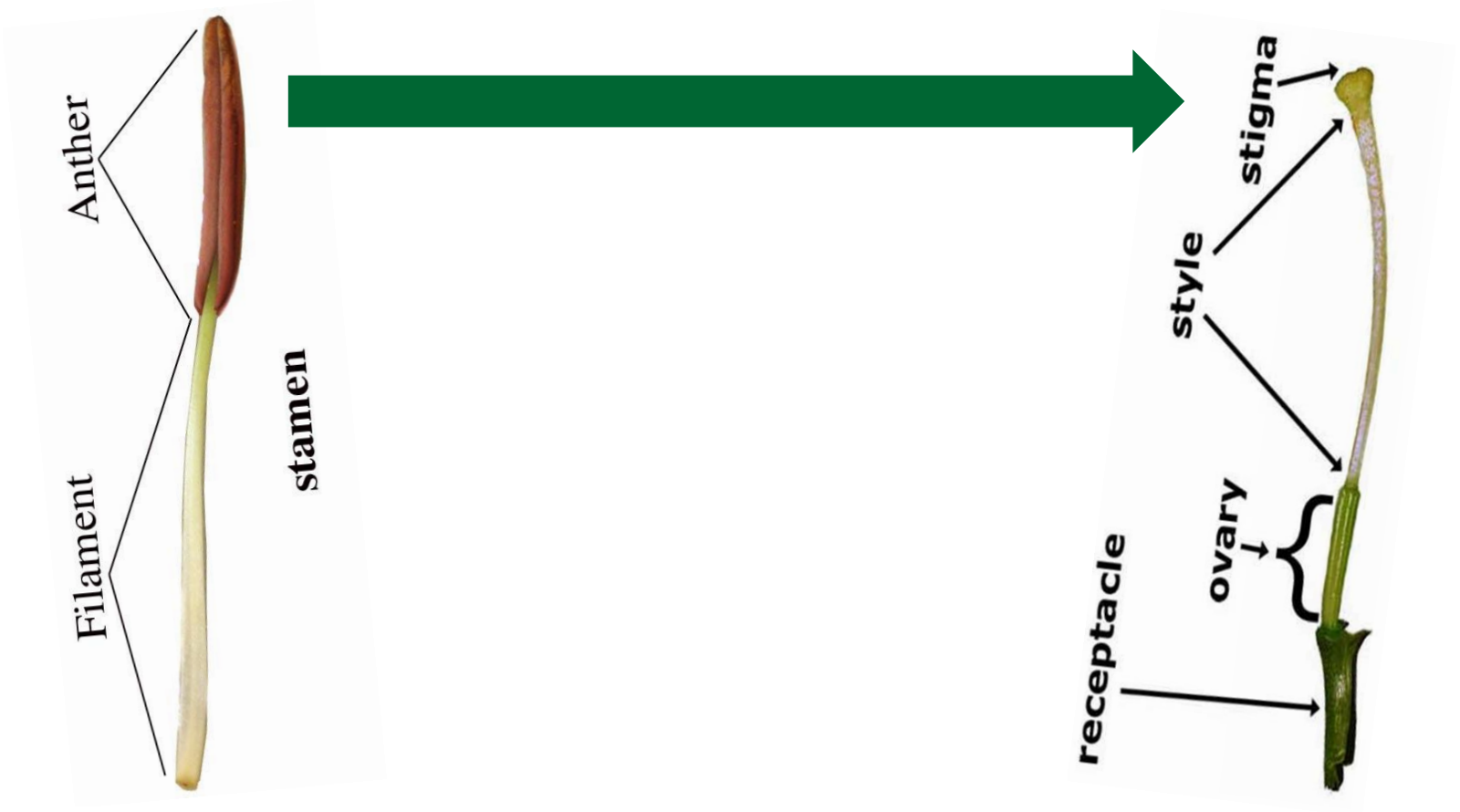

Nucellus
Integuments
Wall of ovary
Meiosis
3 cells degenerate
4 haploid cells
Micropyle
Embryo sac (megaspore) mother cell (2n)
Embryo sac (n)
Mitosis (3 times)
Embryo sac with 8 haploid nuclei
Polar nuclei
Egg cell
Only showing gametes
Polar nuclei (n)
Egg cell (n)

development of the embryo sac



Pollination

Pollination



Transfer of pollen from the anther to the stigma of a flower of the same species

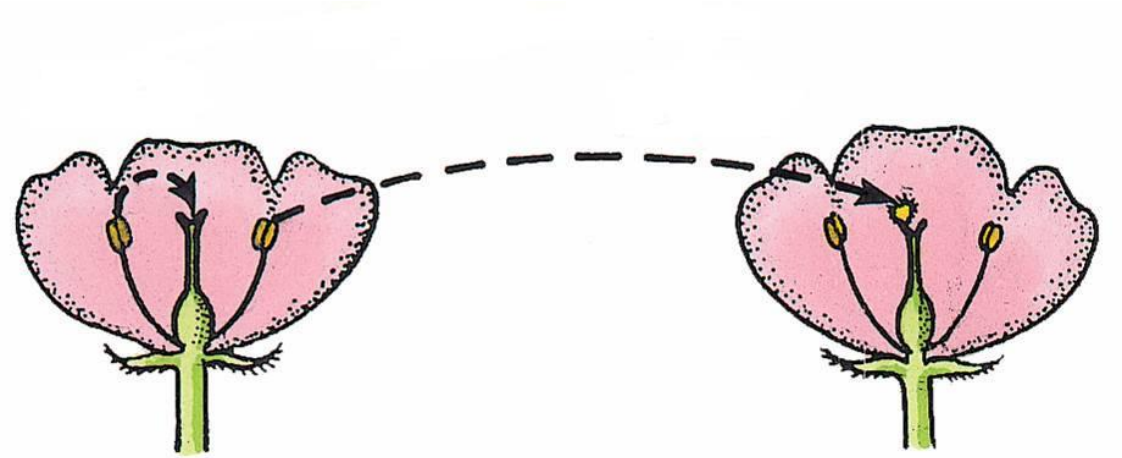
Pollination

Self pollination

- Transfer of pollen from an anther to a stigma of the same plant

Cross pollination

- Transfer of pollen from the anther to the stigma of a different plant of the same species



Methods of pollination

- Animal Pollination

- Wind Pollination

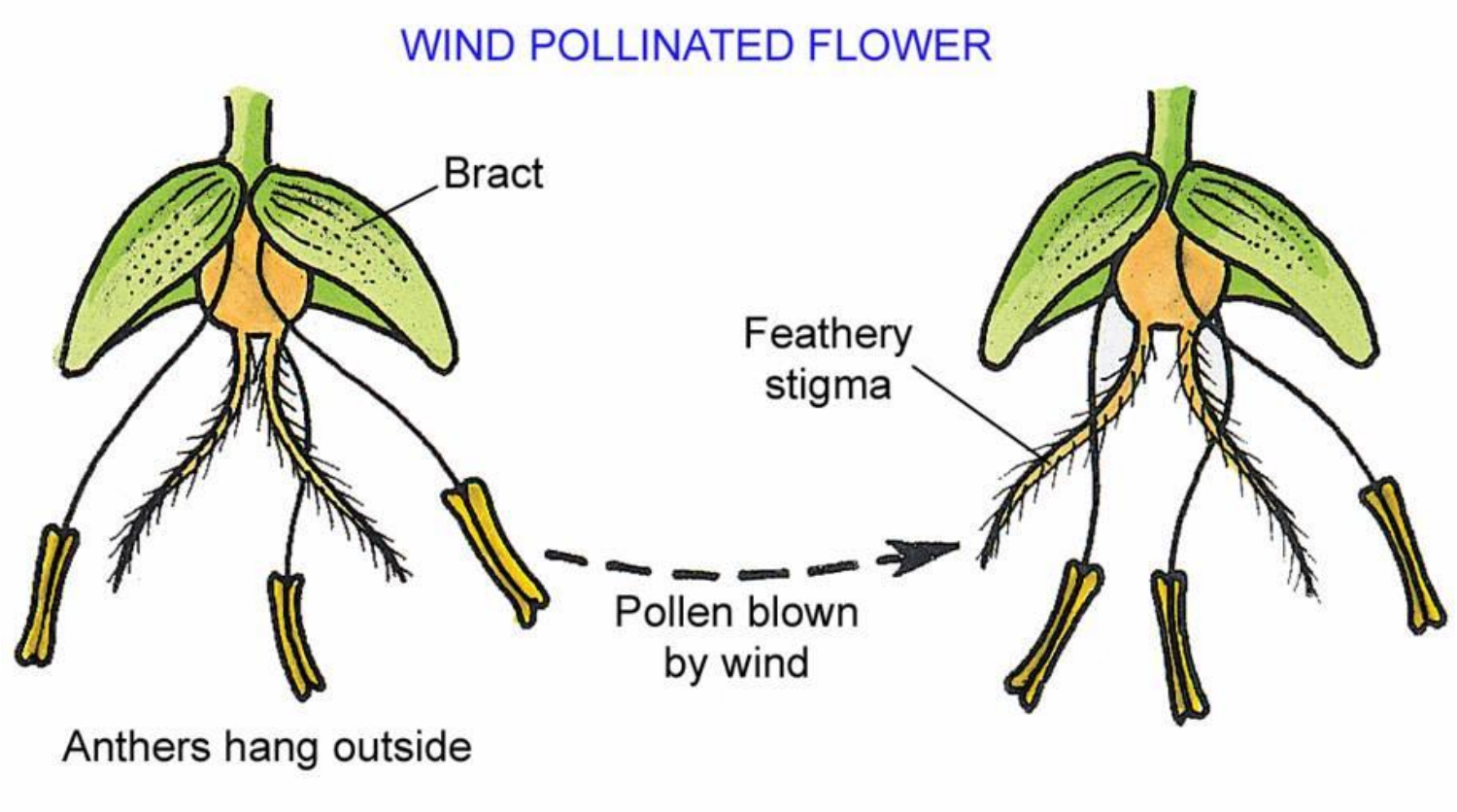
Adaptations for animal (insect) pollination

- Petals brightly coloured, scented with nectaries
- Small amounts of sticky pollen
- Anthers inside petals
- Stigmas sticky, inside petals

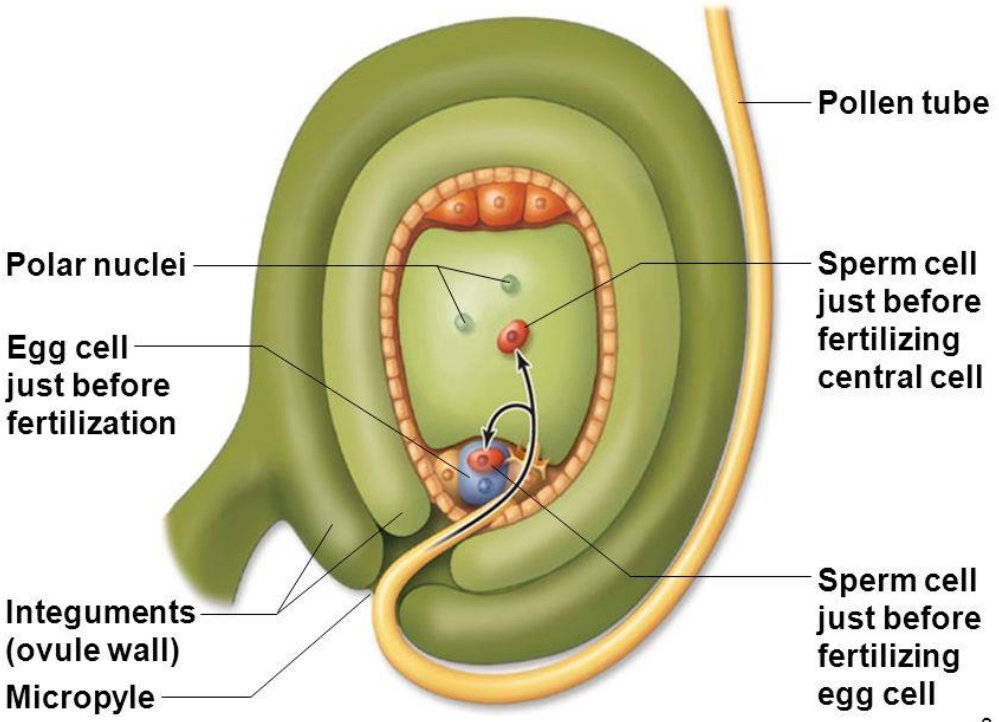
Adaptations for wind pollination

- Petals small, not coloured brightly
- Anthers outside petals
- Stigmas large, feathery and outside petals
- Pollen Large numbers, light, dry and small

Adaptations for wind pollination



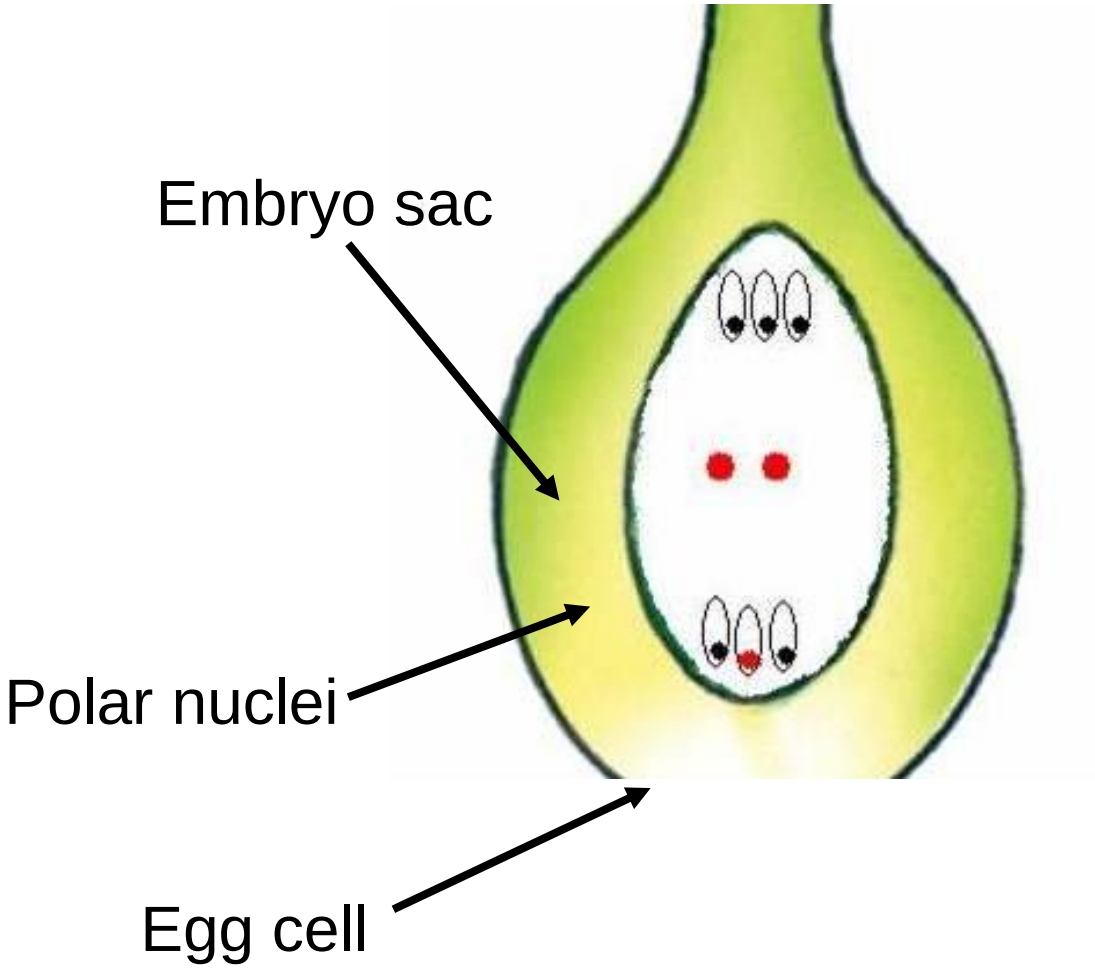
Fertilisation

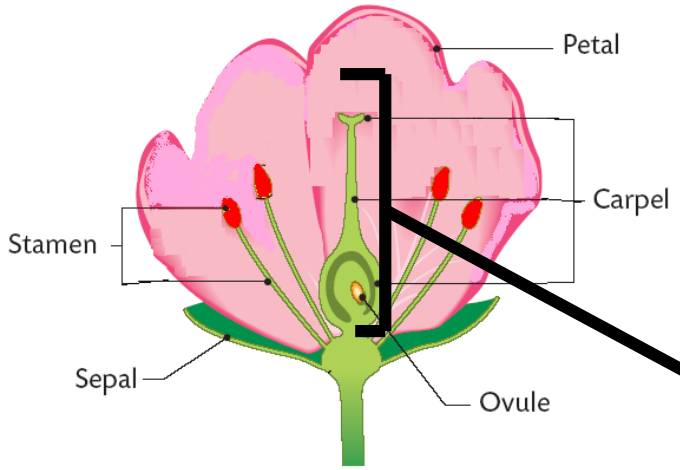


Fertilisation

- Fertilisation is the fusion of the male (n) and female (n) gametes to produce a zygote (2n)
- The pollen grain produces the male gametes
- Embryo sac produces an egg cell and polar nuclei

- The pollen grain produces the male gametes
- Embryo sac produces polar nuclei and an egg cell

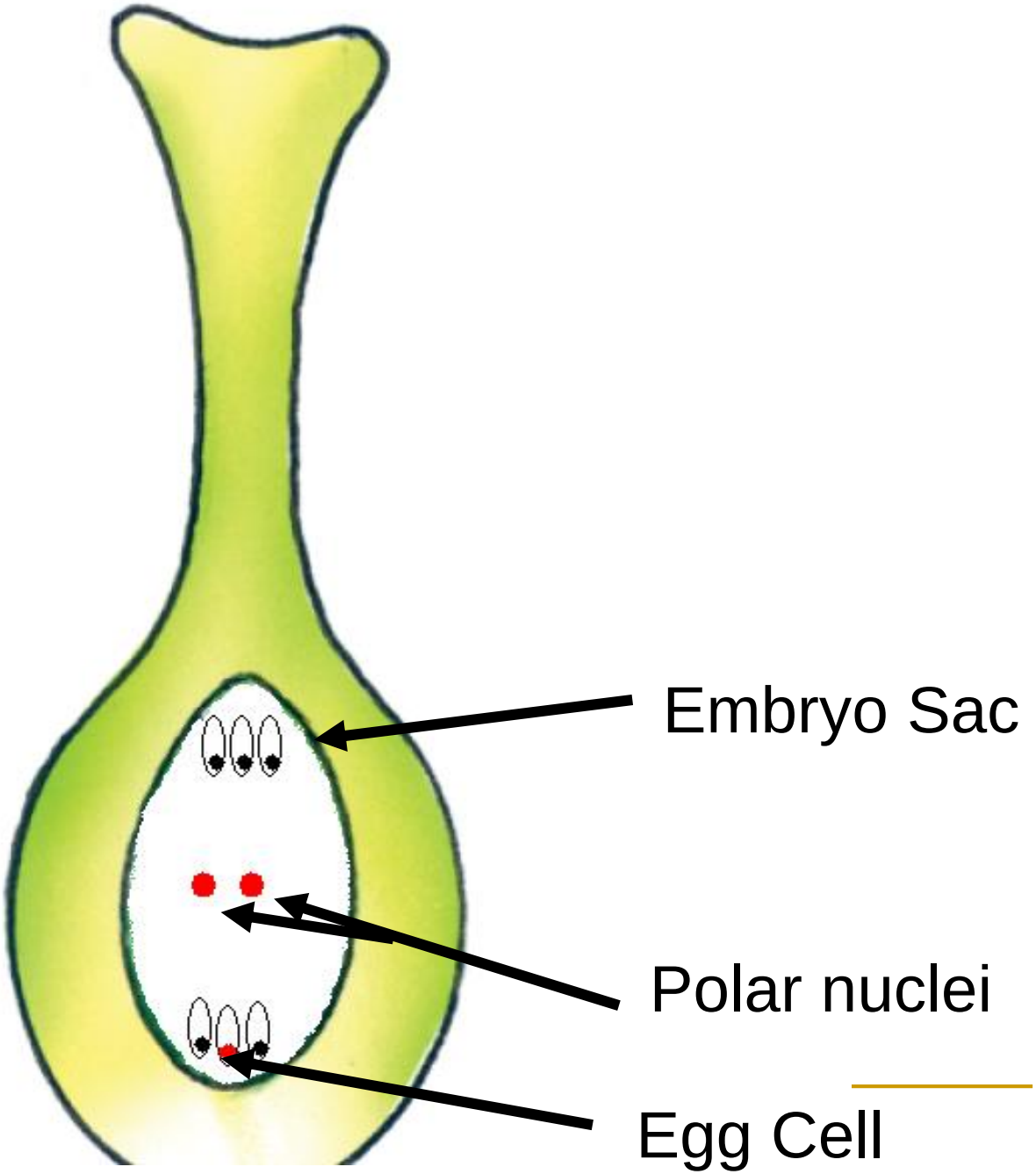


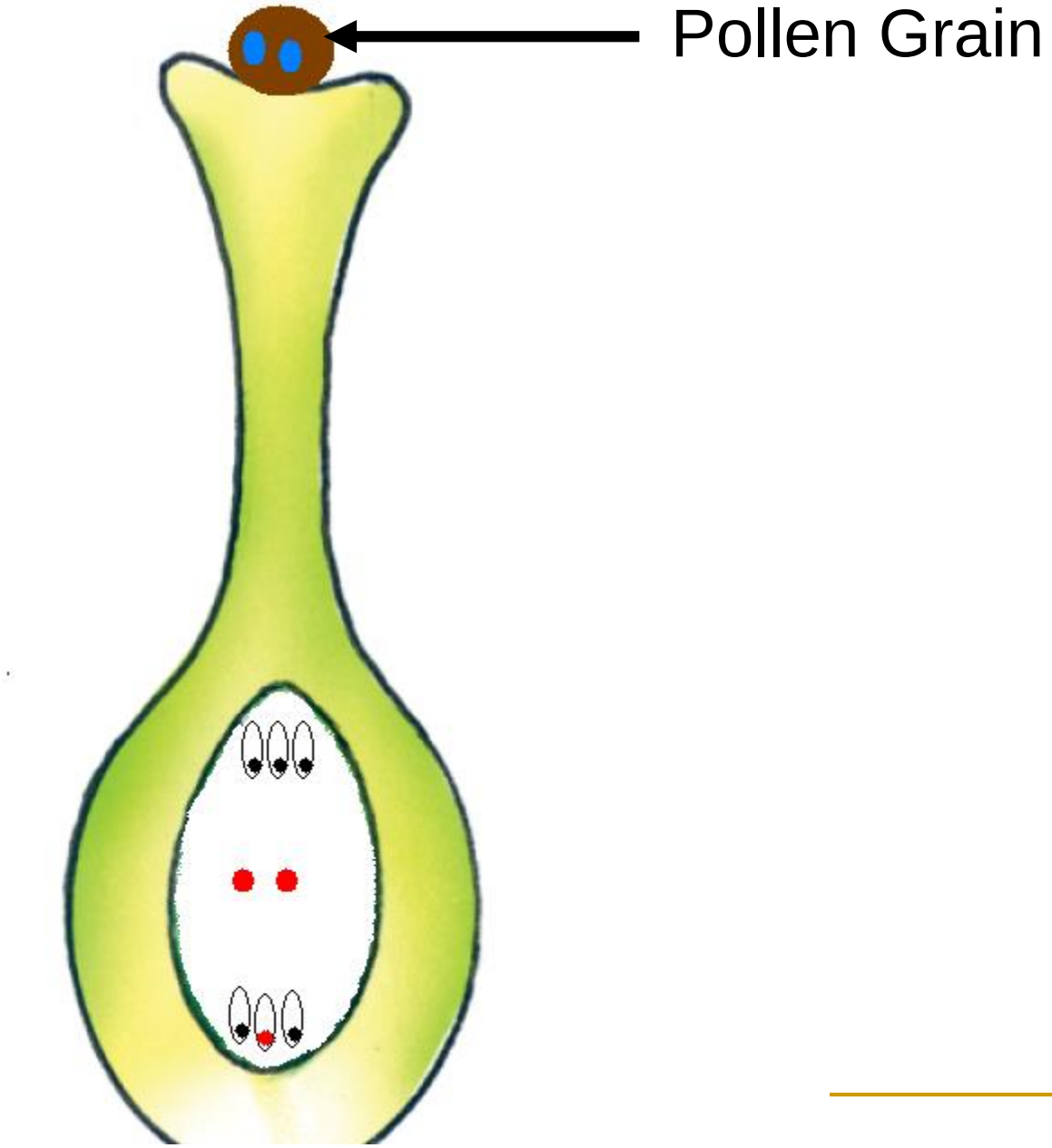


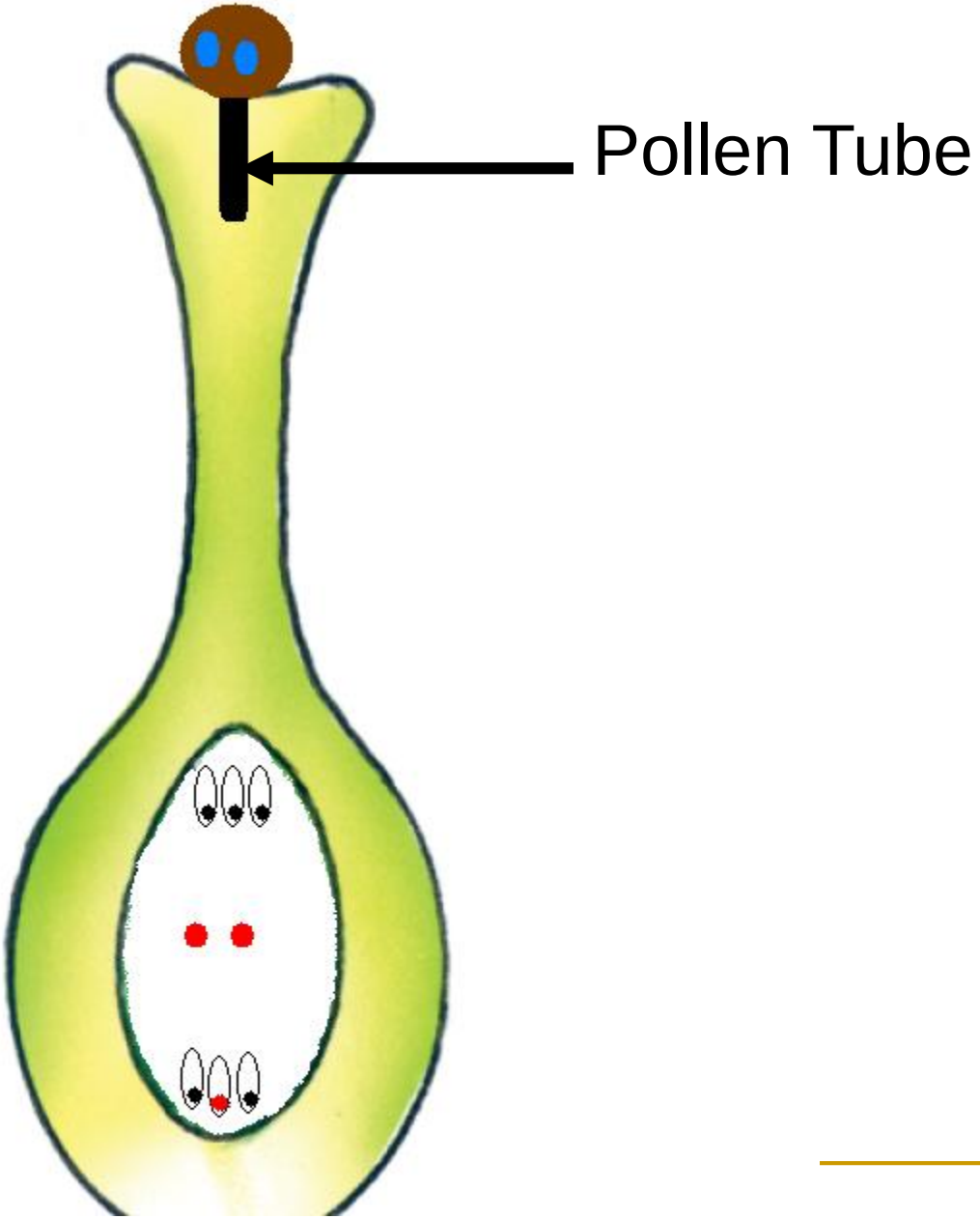
Stigma

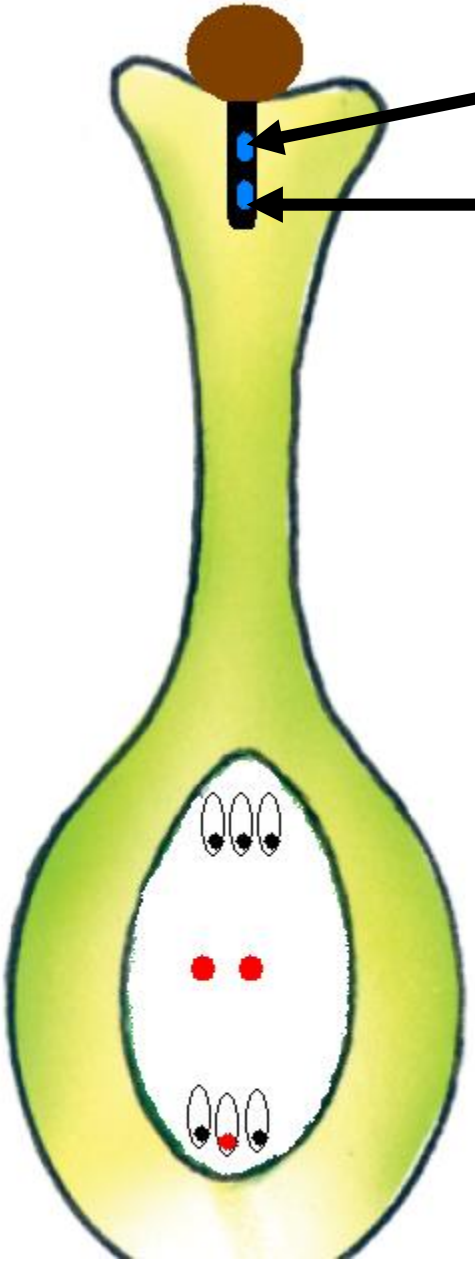
Style

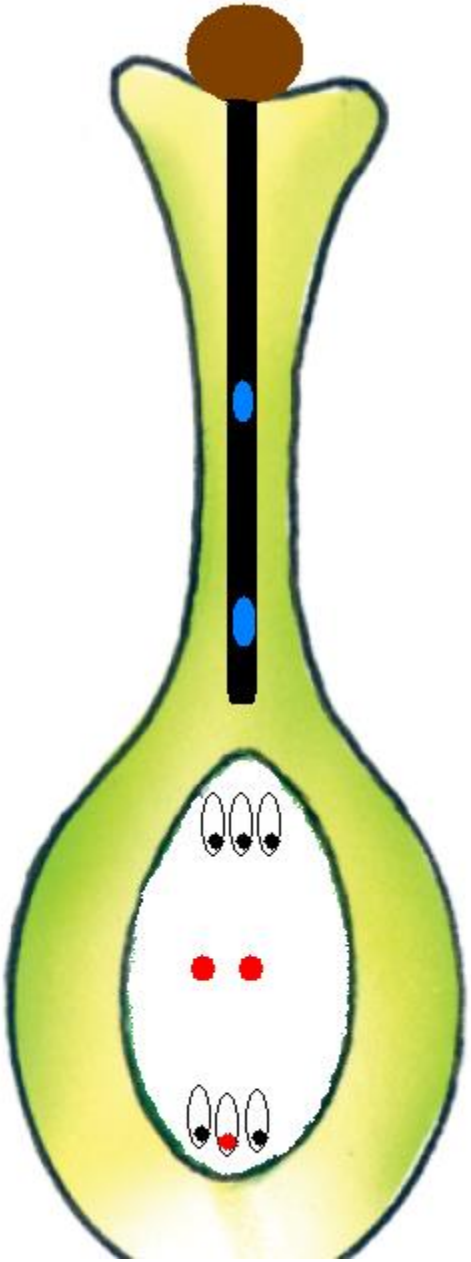
Ovary


Embryo Sac
Polar nuclei
Egg Cell

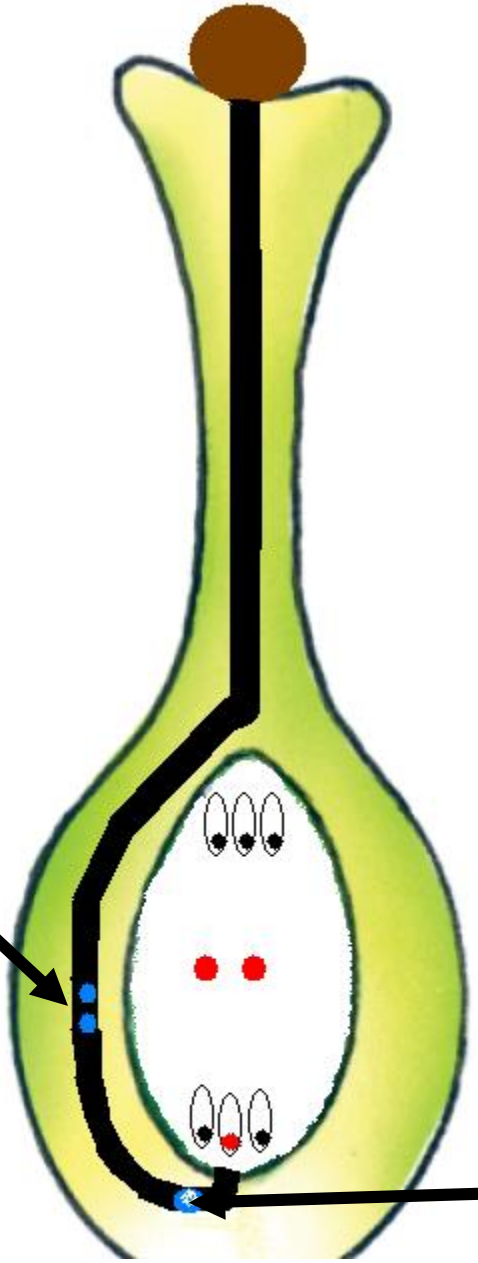

Pollen Grain


Pollen Tube

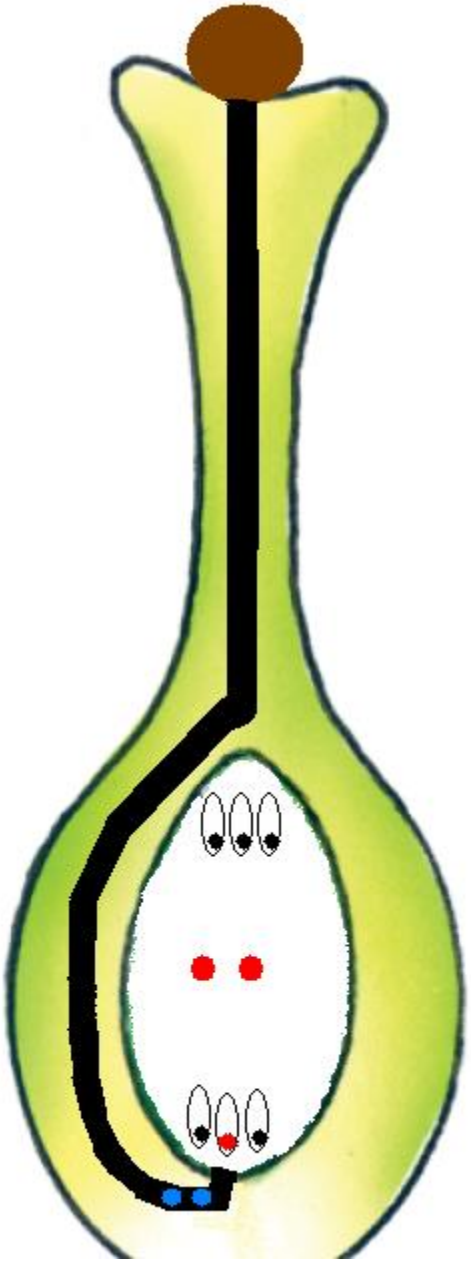

Generative Nucleus
Tube Nucleus



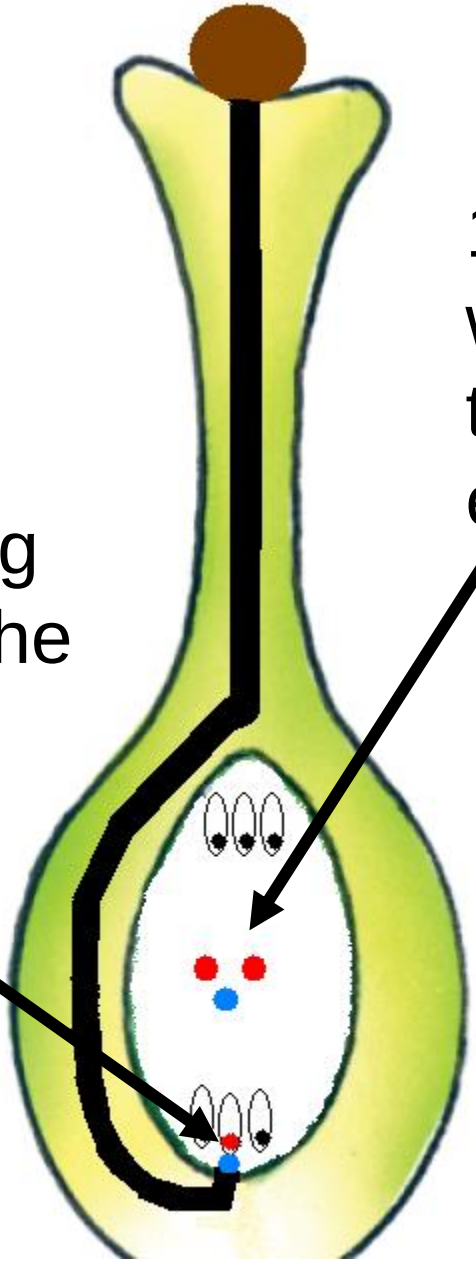
Mitotic division of generative nucleus to form 2 male gametes



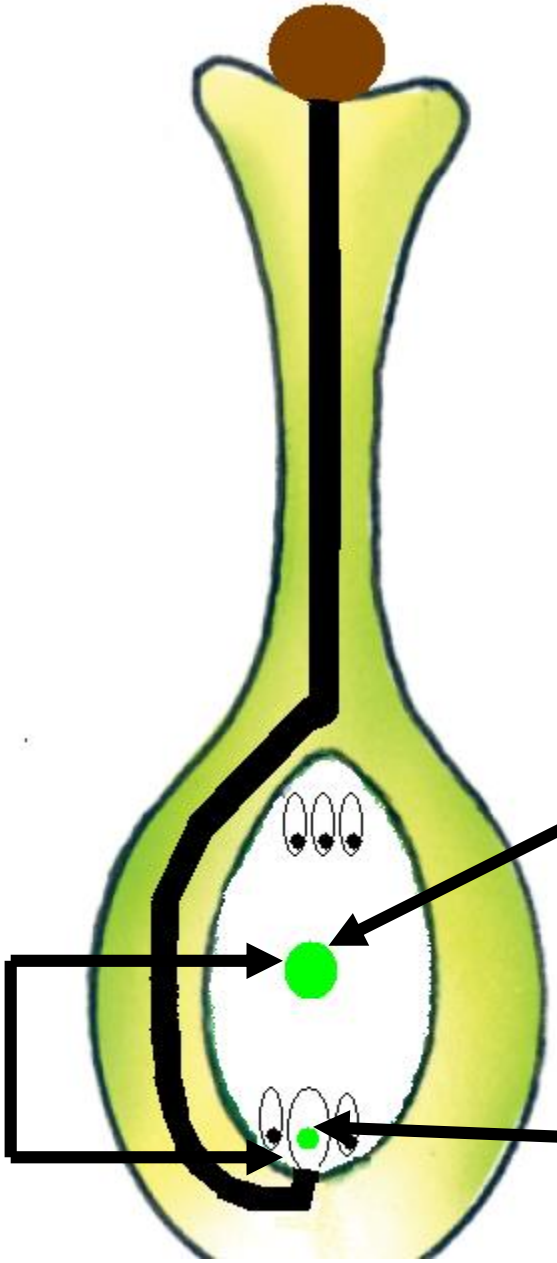
Tube nucleus disintegrates



1 male gamete fuses with the egg nucleus to form the diploid zygote



1 Male gamete fuses with the 2 polar nuclei to form the triploid endosperm nucleus



3N endosperm nucleus

Double fertilisation

2N Zygote

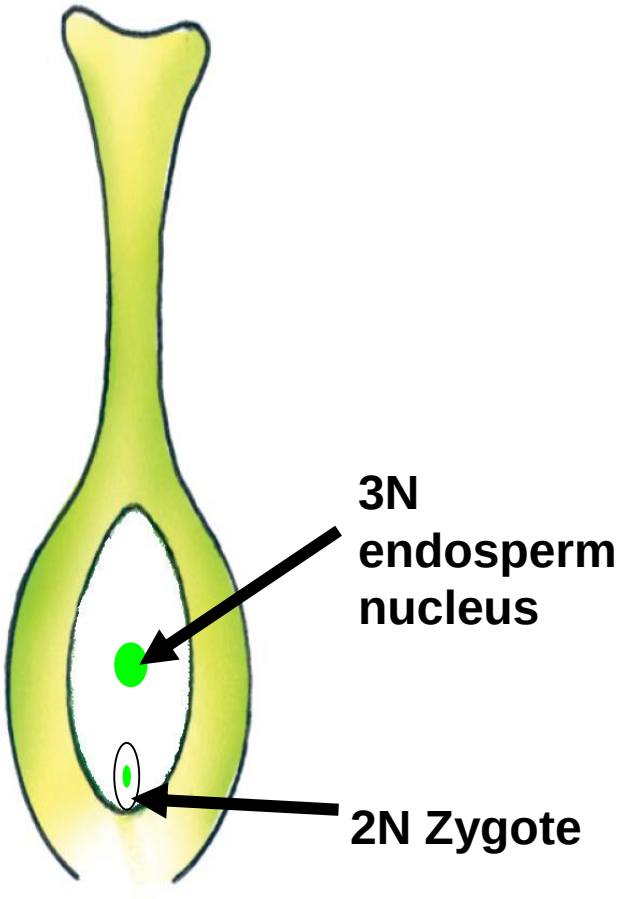
Seed formation

Endospermic & Non-Endospermic

Monocots & Dicots

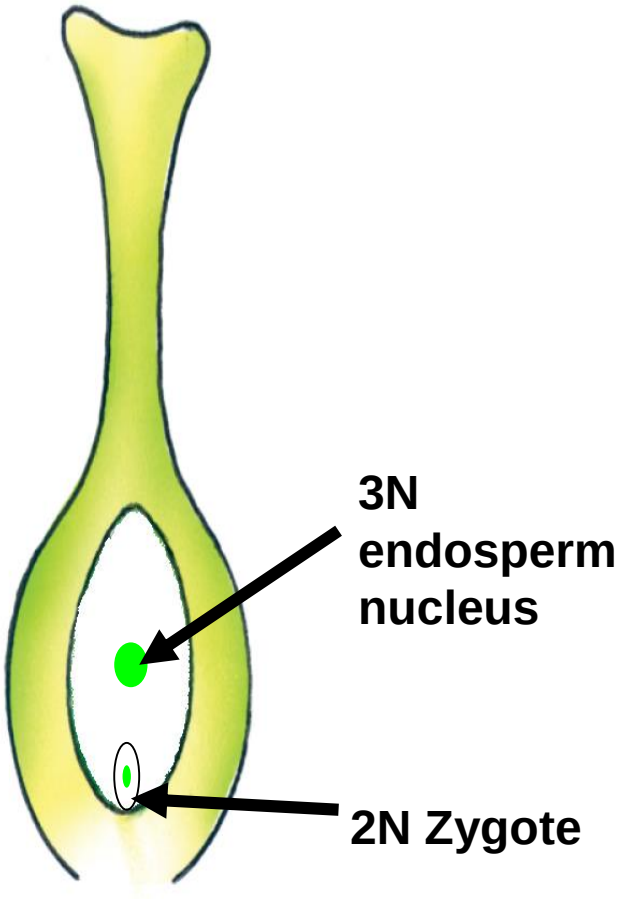
Seed Formation

- The zygote grows repeatedly by mitosis to form an embryo
- An embryo consists of a plumule (future shoot), a radical (future root) and cotyledons (food stores needed for germination)



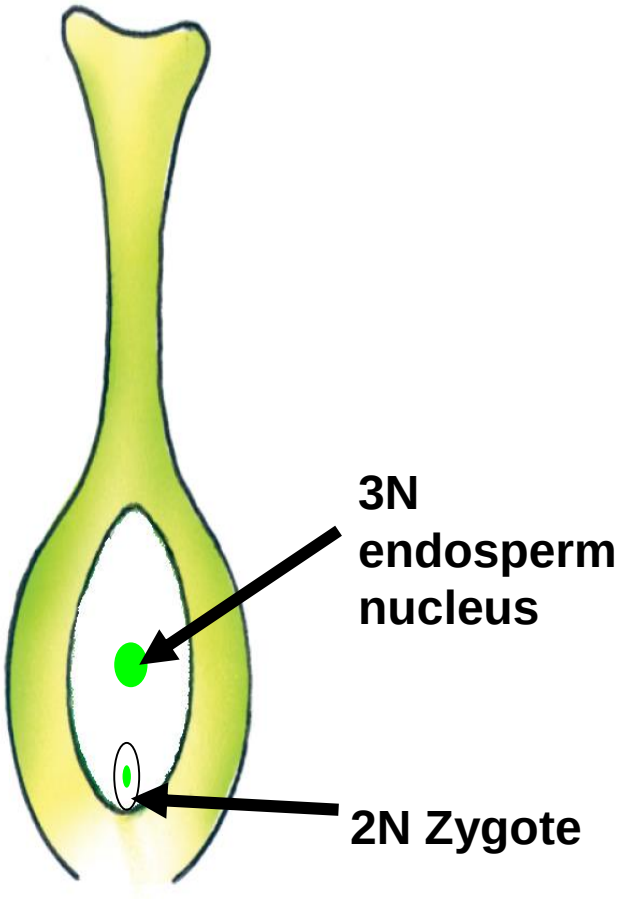
Seed Formation

- The endosperm nucleus (3N) divides repeatedly to form the endosperm in endospermic seeds. This endosperm acts as a food store for the developing seed
- e.g. maize

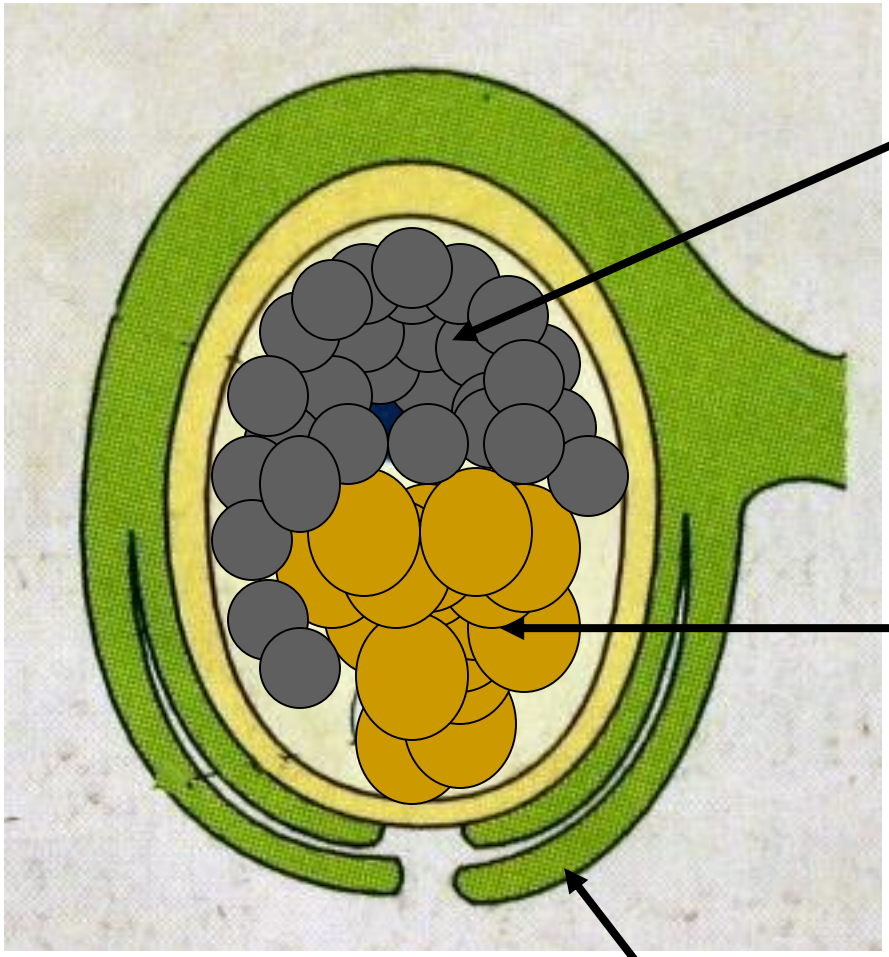


Seed Formation

- In non-endospermic seeds the endosperm is used up in the early stages of seed development so the food is stored in the cotyledons
- e.g. bean



Seed Formation

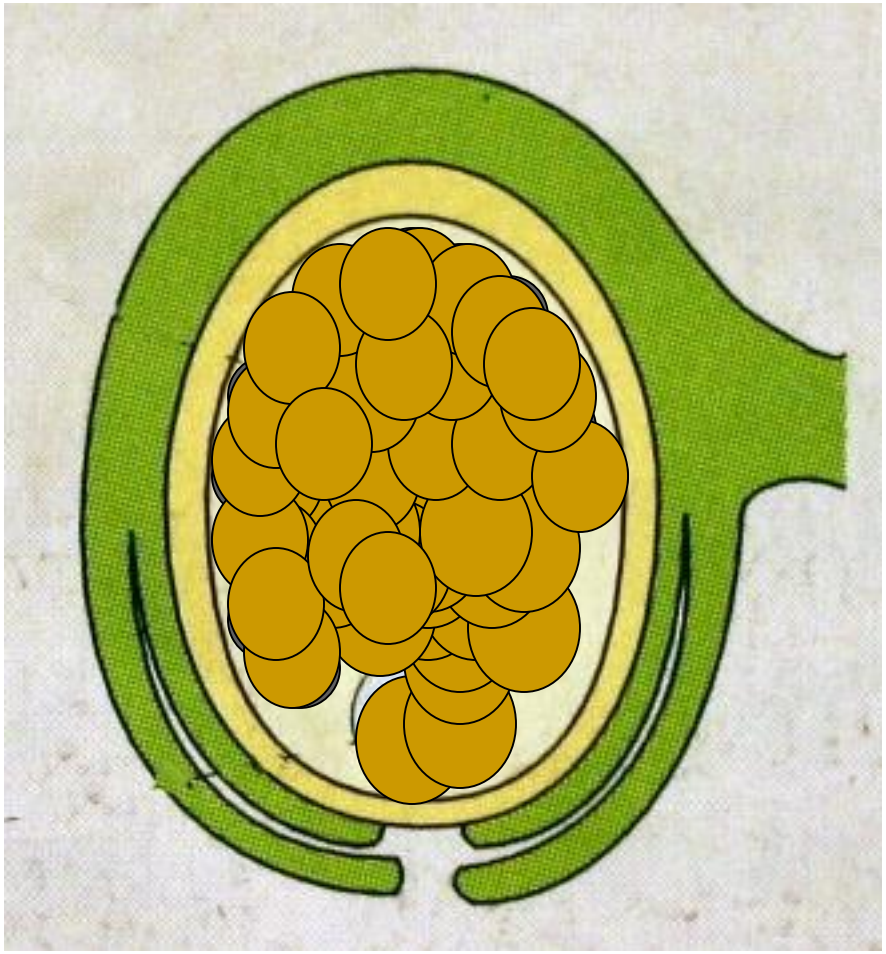


Endosperm
Food store for developing embryo

Embryo
Plumule, radicle, cotyledons

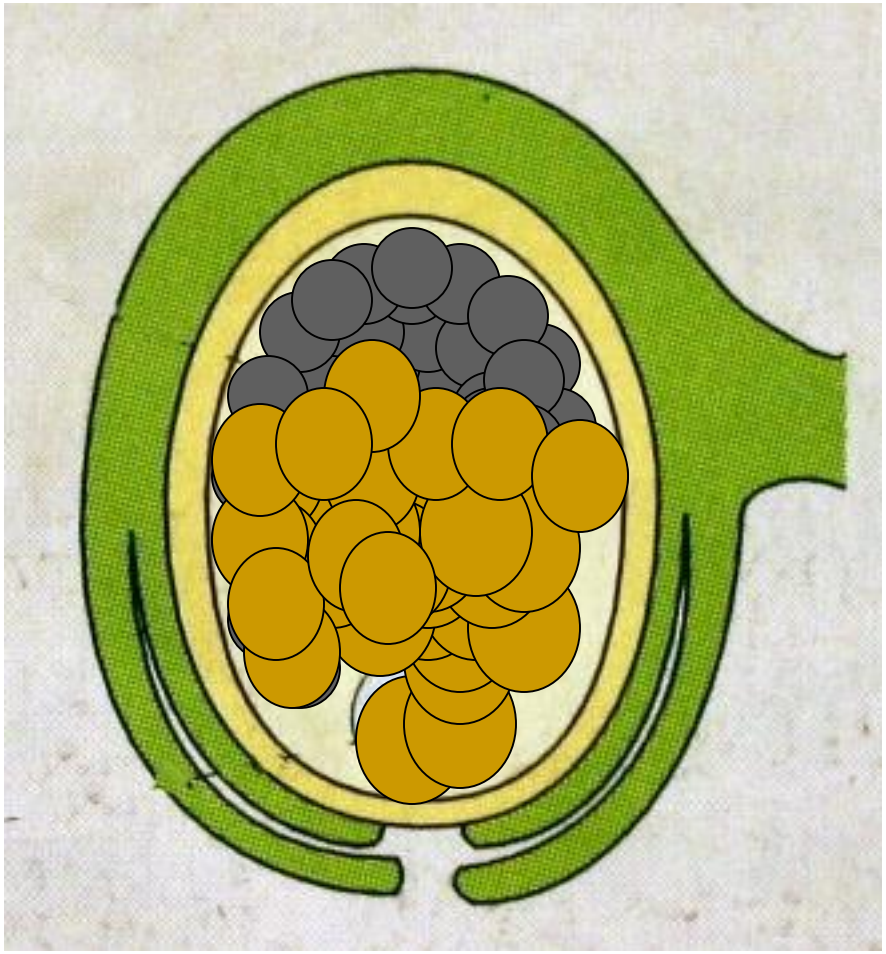
Integuments, becomes the seed coat

Seed Formation



If all the endosperm is absorbed by the developing embryo the seed is a non endospermic seed e.g. broad bean

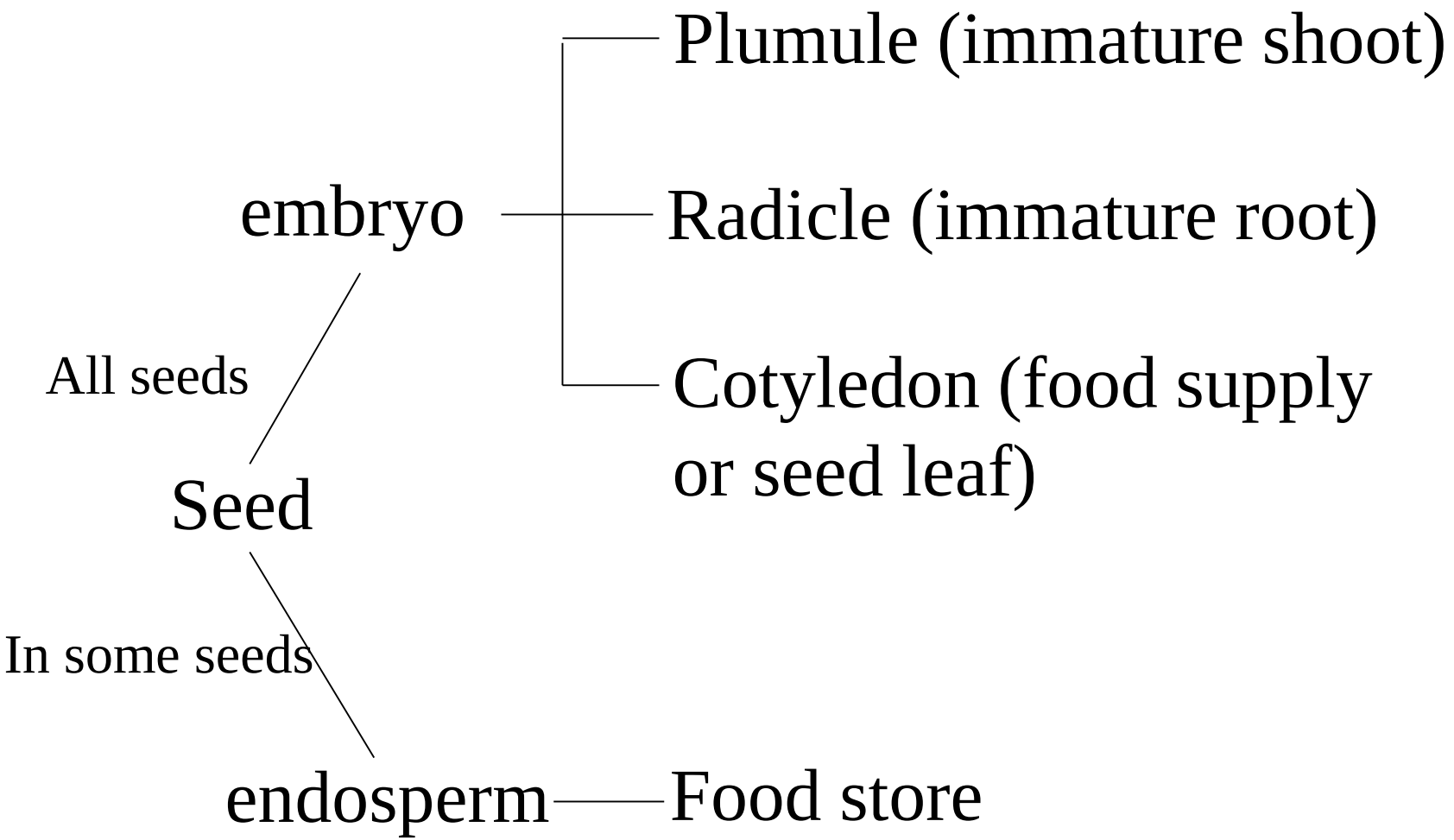
Seed Formation



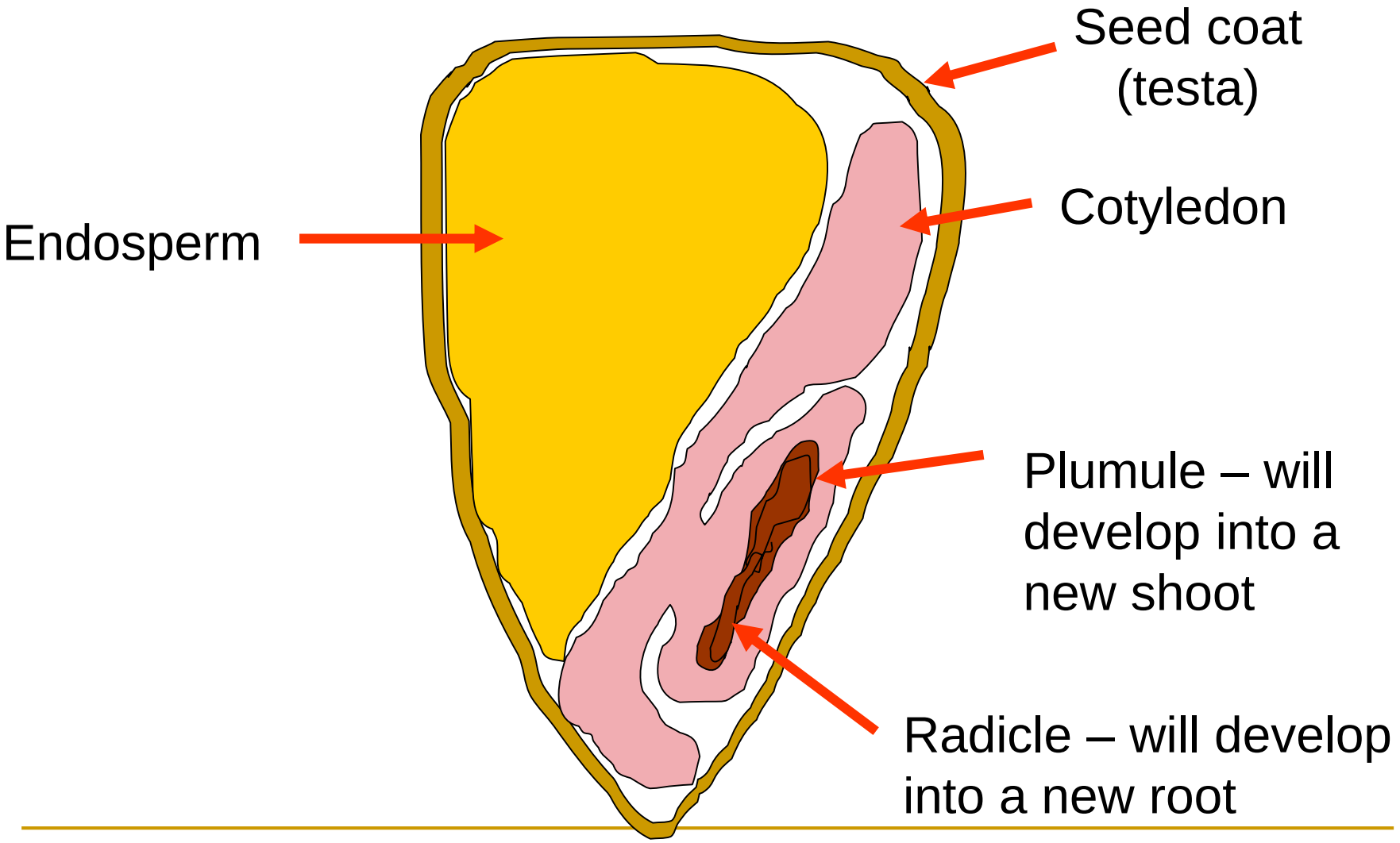
If all the endosperm is **not** absorbed by the developing embryo the seed is an endospermic seed e.g. Maize

QUICK REVISION VIDEO

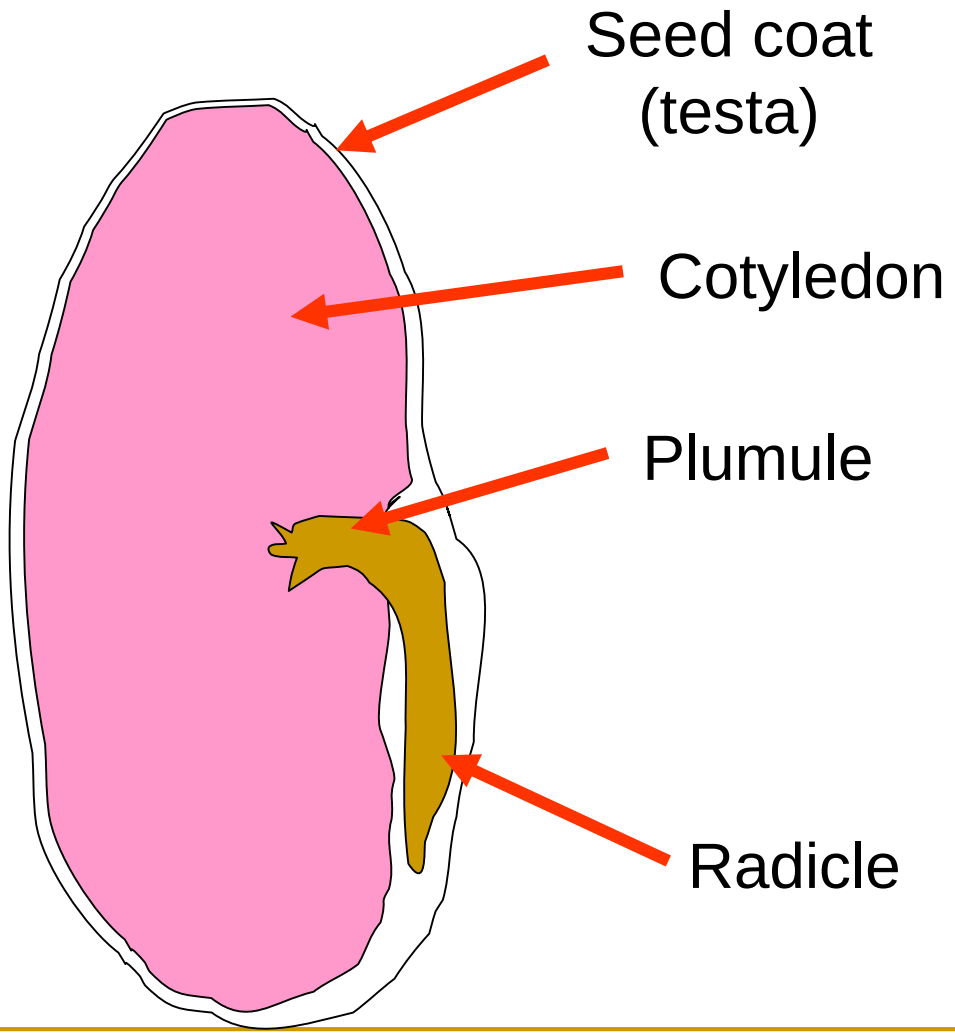
Seed types and structure



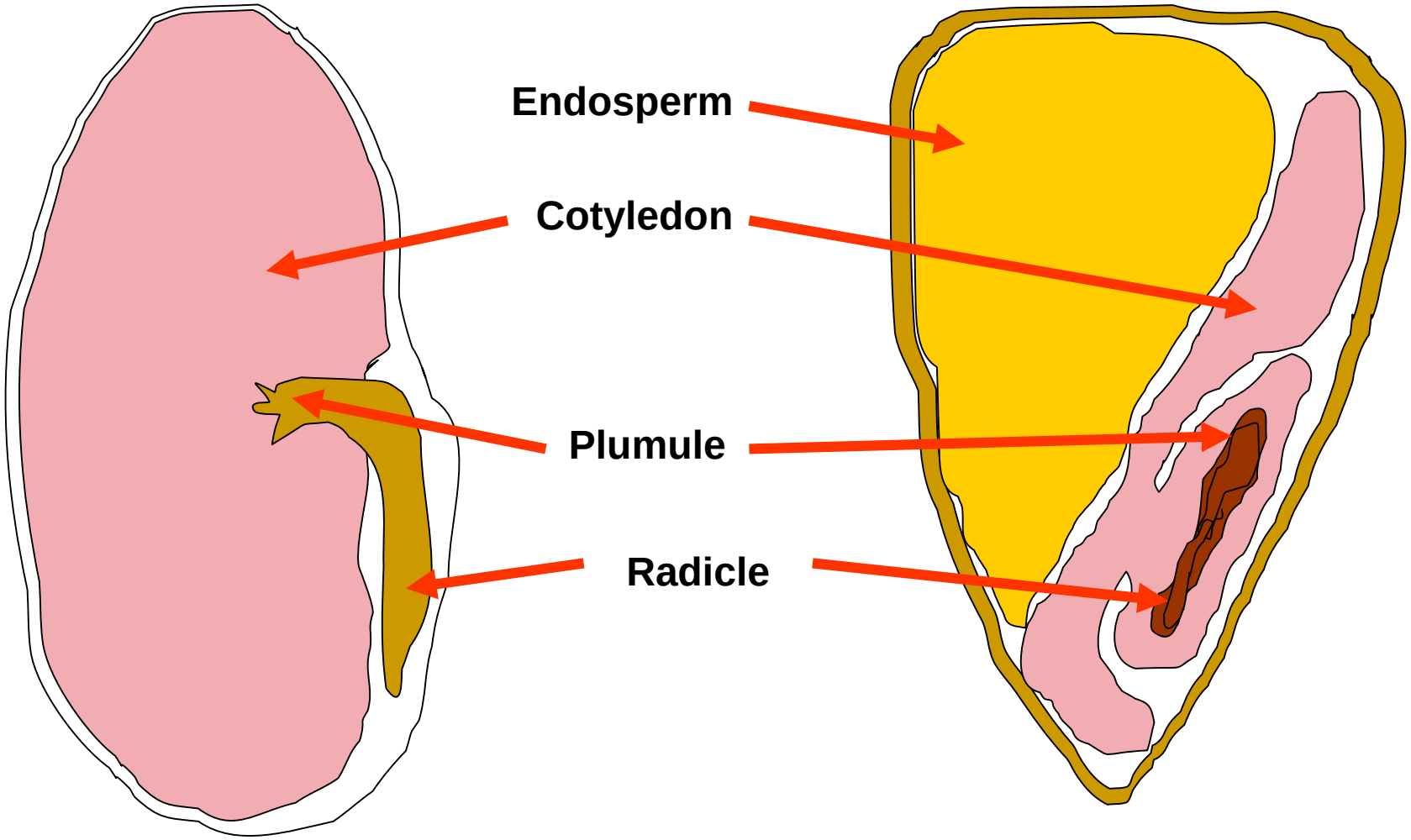
Endospermic Seed e.g. Maize



Non-Endospermic seed e.g. Broad Bean



Non–endospermic and Endospermic seed



e.g. Broad Bean

e.g. Maize

Classification of seeds

Classified according to two features:

1. Number of cotyledons (Seed leaves)
   - Monocotyledon – one cotyledon
     - E.g. Maize
   - Dicotyledon - Two cotyledons
     - E.g. Broad bean

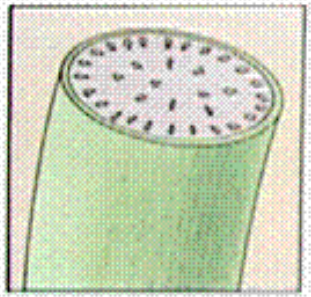
2. Presence of endosperm
   - Present – Endospermic e.g. maize
   - Absent – Non-endospermic e.g. broad bean

Broad Bean – Non-Endospermic Dicot

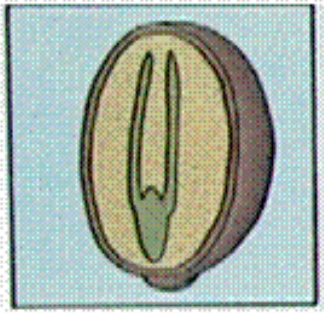
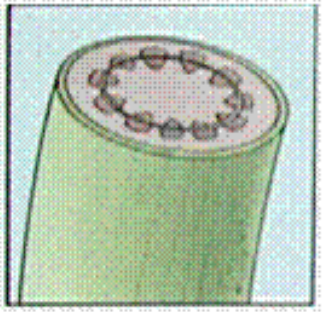
Differences between monocots and dicots

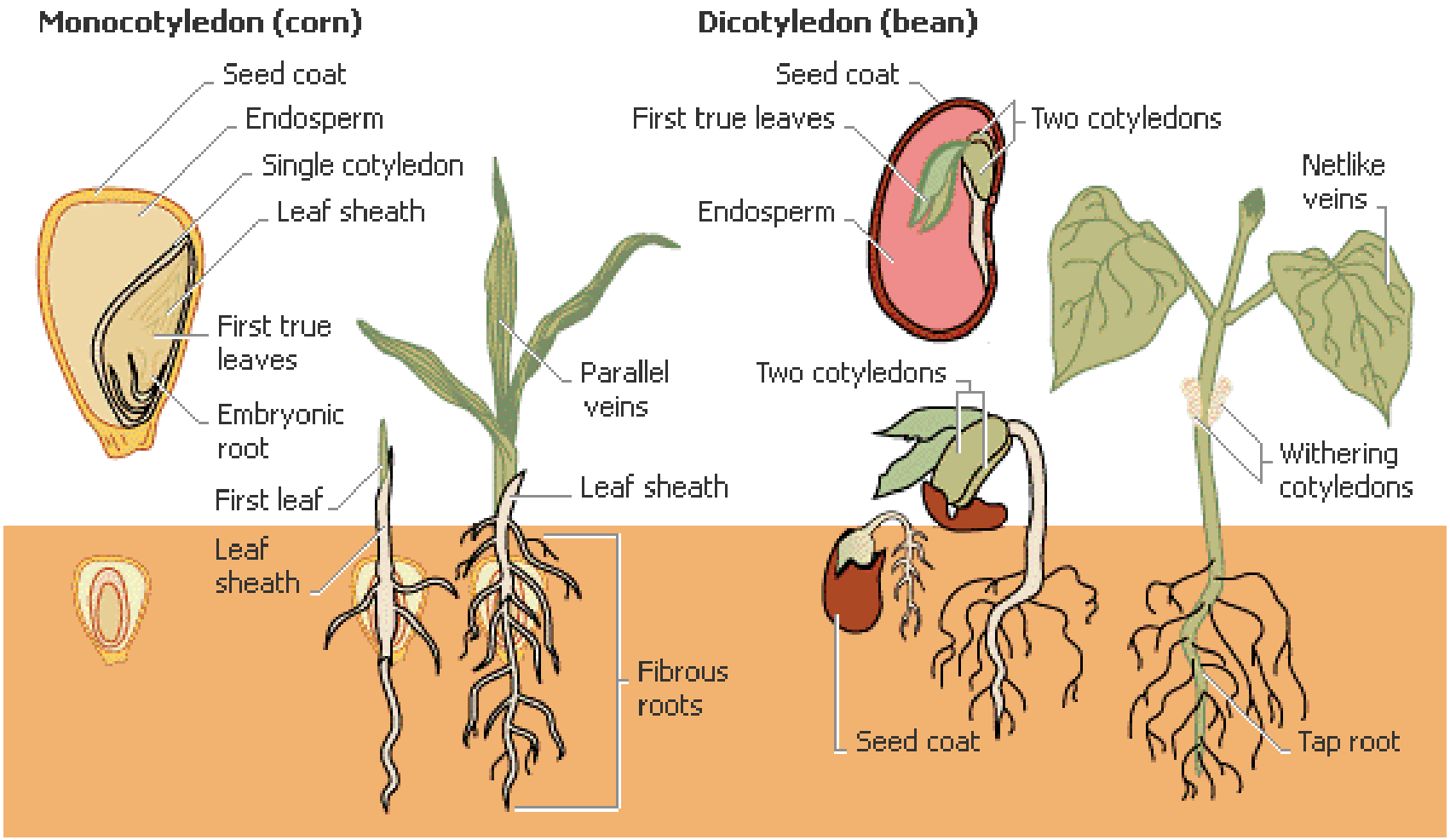
Feature	Monocot	Dicot
Number of cotyledons	1	2
Venation	Parallel	Reticulate (Net)
Vascular Bundle arrangement	Scattered	In a ring
Number of petals	Usually in multiples of 3	Usually in multiples of 4 or 5

MONOCOTS

Cotyledons	Veins in leaves	Flower parts	Arrangement of primary vascular bundles in stem
			
One cotyledon	Usually Parallel	Usually in multiples of three	Scattered

DICOTS

Two cotyledons	Usually netlike	Usually in fours or fives	In a ring
			


Monocotyledon (corn)
Seed coat
Endosperm
Single cotyledon
Leaf sheath
First true leaves
Embryonic root
First leaf
Leaf sheath
Parallel veins
Leaf sheath
Fibrous roots
Dicotyledon (bean)
Seed coat
First true leaves
Two cotyledons
Endosperm
Netlike veins
Two cotyledons
Withering cotyledons
Seed coat
Tap root

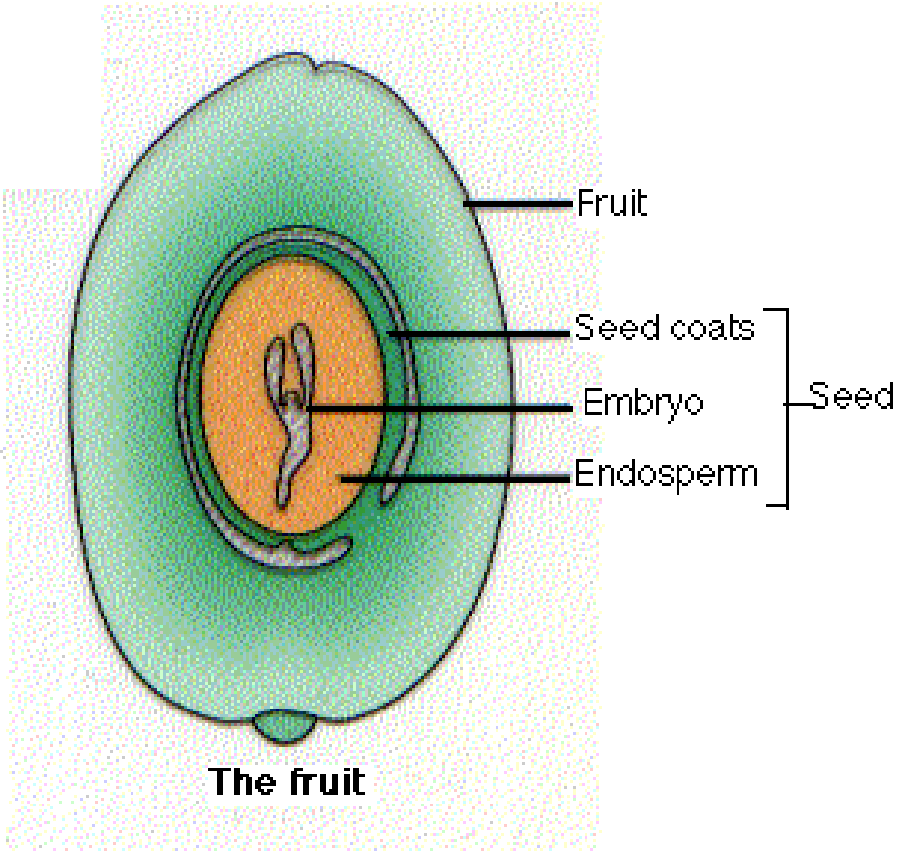
Fruit

We will look at

1. Fruit formation
2. Seedless fruits
3. Fruit and seed dispersal

Fruit Formation

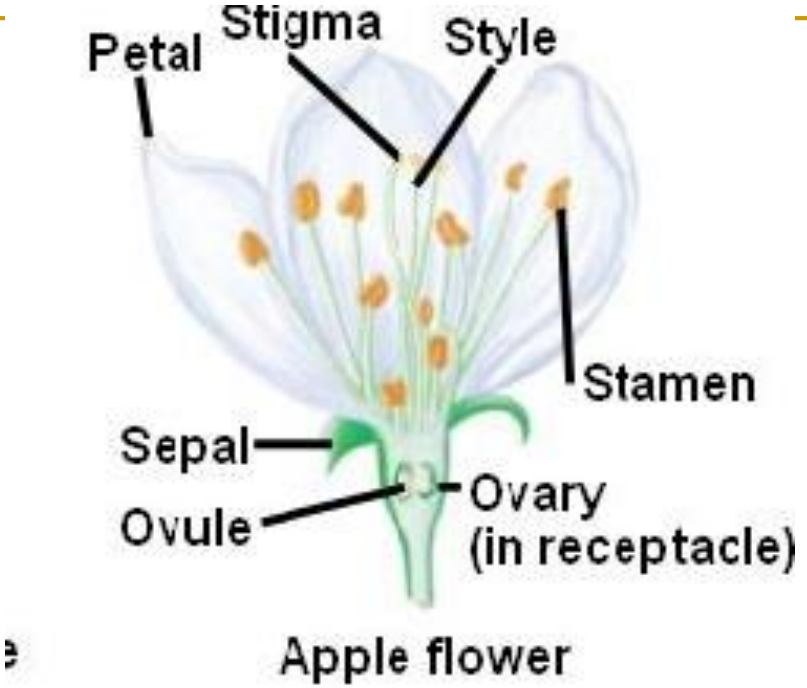
- The **ovule becomes the seed**
- The **ovary becomes the fruit**



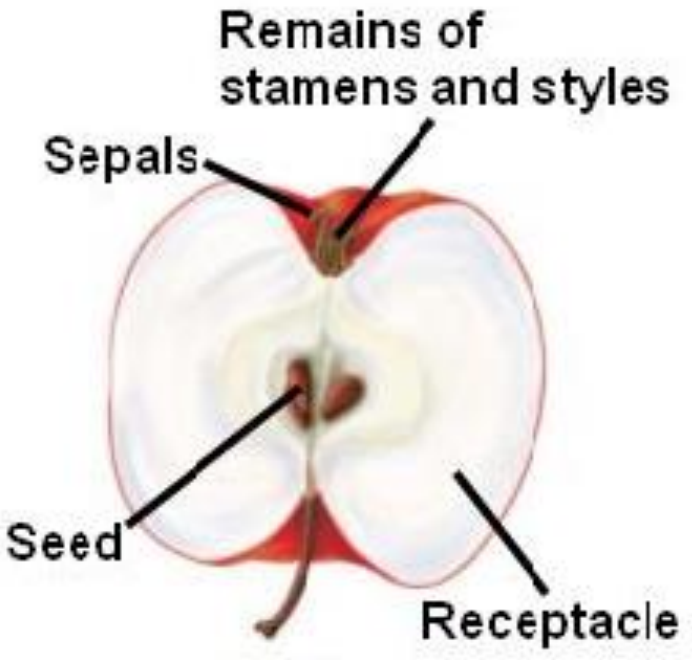
Fruit Formation

- A **fruit** is a mature ovary that may contain seeds
- The process of fruit formation is stimulated by growth regulators produced by the seeds

False Fruit



Apple flower



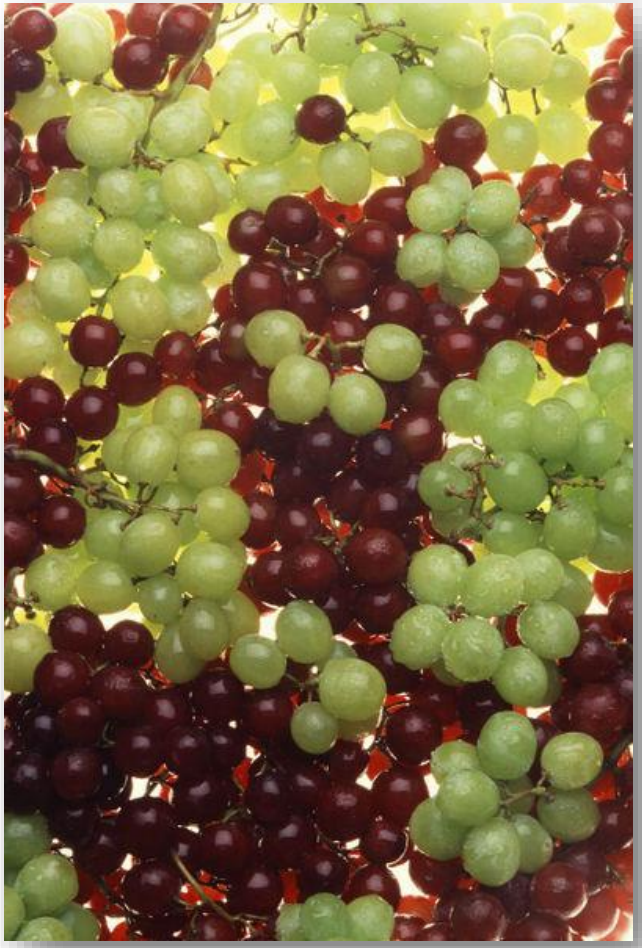
Seedless Fruits

Can be formed in two ways

1. **Genetically**
   - Either naturally or by special breeding programmes
   - e.g. seedless oranges

Seedless Fruits

2. **Growth regulators e.g. auxins**
   - If large amounts of growth regulators are sprayed on flowers fruits may form without fertilisation
   - e.g. **seedless grapes**



Fruit and seed dispersal

- **Need for dispersal**
  - Minimises competition for light, water etc.
  - Avoids overcrowding
  - Colonises new areas
  - Increases chances of survival

Types of dispersal

1. Wind
2. Water
3. Animal
4. Self

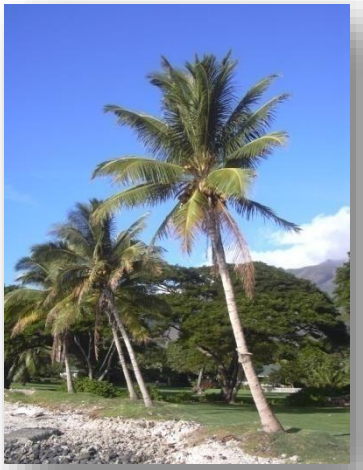
Methods of dispersal

1. **Wind**
   - **Sycamore** and ash produce fruit with wings
   - **Dandelions** and thistles produce fruit with parachute devices
   - Both help the disperse the seeds more widely using wind

Methods of dispersal

2. **Water**

- Light, air filled fruits that float away on water
- E.g. **coconuts**, water lilies



Methods of dispersal

3. **Animal**

Edible fruit

- Animals attracted to bright colours, smells and food
- Seed passes through digestive system unharmed
- E.g. **strawberries**, blackberries, nuts

Methods of dispersal

3. **Animal**

   Sticky fruit

   - Fruits with hooks that can cling to the hair of an animal and be carried away
   - E.g. **burdock**, goose grass

Methods of dispersal

4. **Self**
   - Some fruits explode open when they dry out and flick the seed away
   - E.g. **peas** and beans

Dormancy and Germination

Dormancy (definition)

- A resting period when seeds undergo no growth and have reduced cell activity or metabolism

Dormancy (advantages)

- Plant avoids harsh winter conditions
- Gives the embryo time to develop
- Provides time for dispersal

Application in agriculture and horticulture

- Some seeds need a period of cold before they germinate
- It may be necessary to break dormancy in some seeds before they are planted for agricultural or horticultural purposes
- This can be done by placing them in the fridge before they are planted

Germination

- The re-growth of the embryo after a period of dormancy, if the environmental conditions are suitable

Germination – Factors necessary

- Water
- Oxygen
- Suitable temperature

Dormancy must be complete

Germination – Factors necessary

- **Water**
  - Activates the enzymes
  - Medium for germination reactions e.g. digestion
  - Transport medium for digested products

Germination – Factors necessary

- **Oxygen**
  - Needed for aerobic respiration
- **Suitable temperature**
  - Allows maximum enzyme activity

Events in Germination

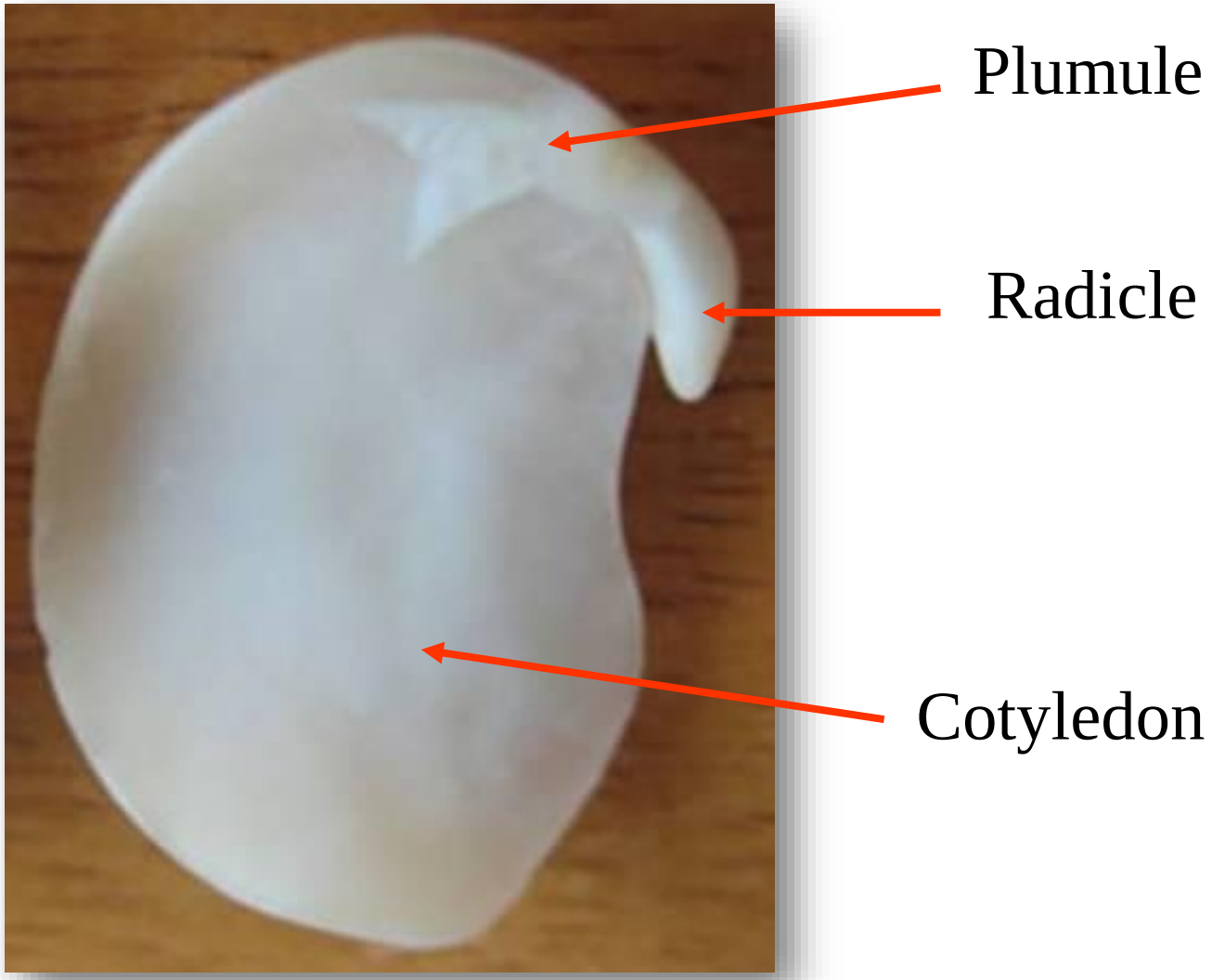
- Digestion
  - Of stored food in endosperm and cotyledon
- Respiration
  - To produce ATP to drive cell division

Events in germination cease when the plants leaves have developed and the plant has started to photosynthesise

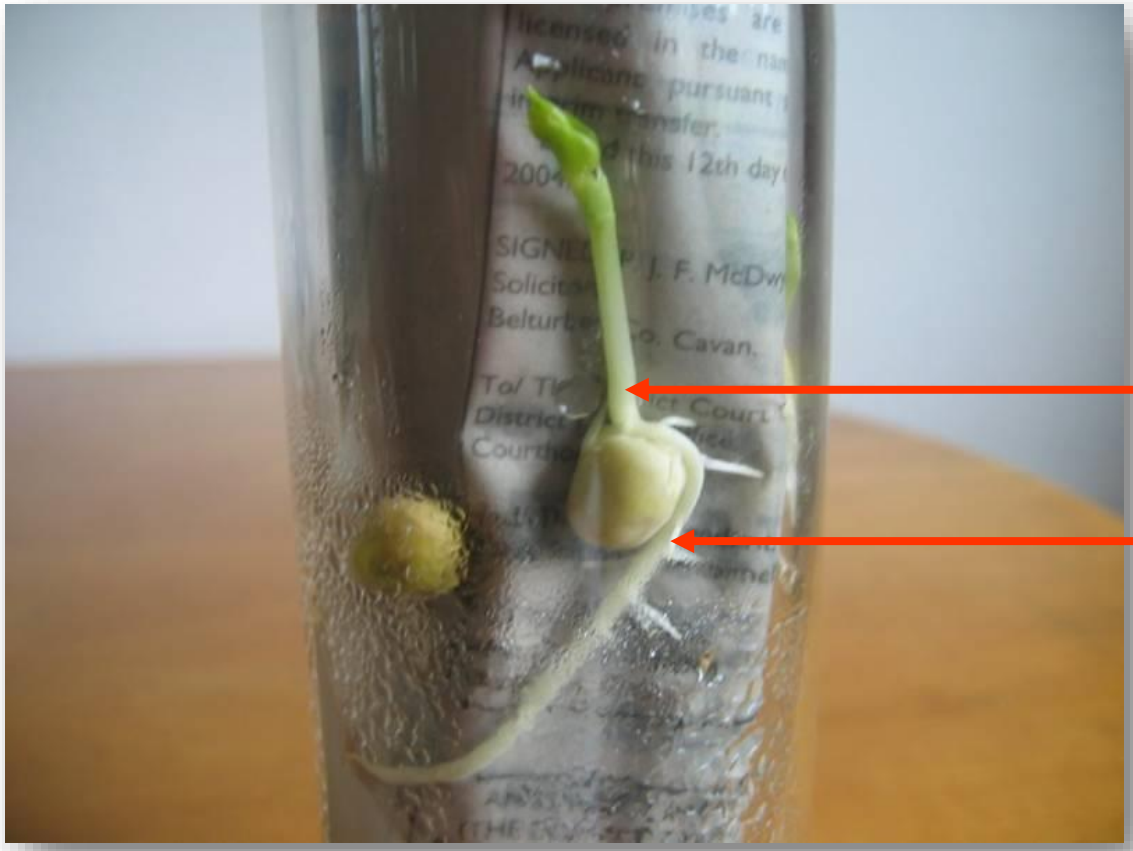
Events in Germination (detail)

1. Water is absorbed
2. Food reserves are digested
3. Digested food is moved to the embryo
4. New cells are produced using amino acids
5. Glucose is turned into ATP to drive cell division
6. Radicle breaks through the testa
7. Plumule emerges above ground
8. New leaves begin to photosynthesise

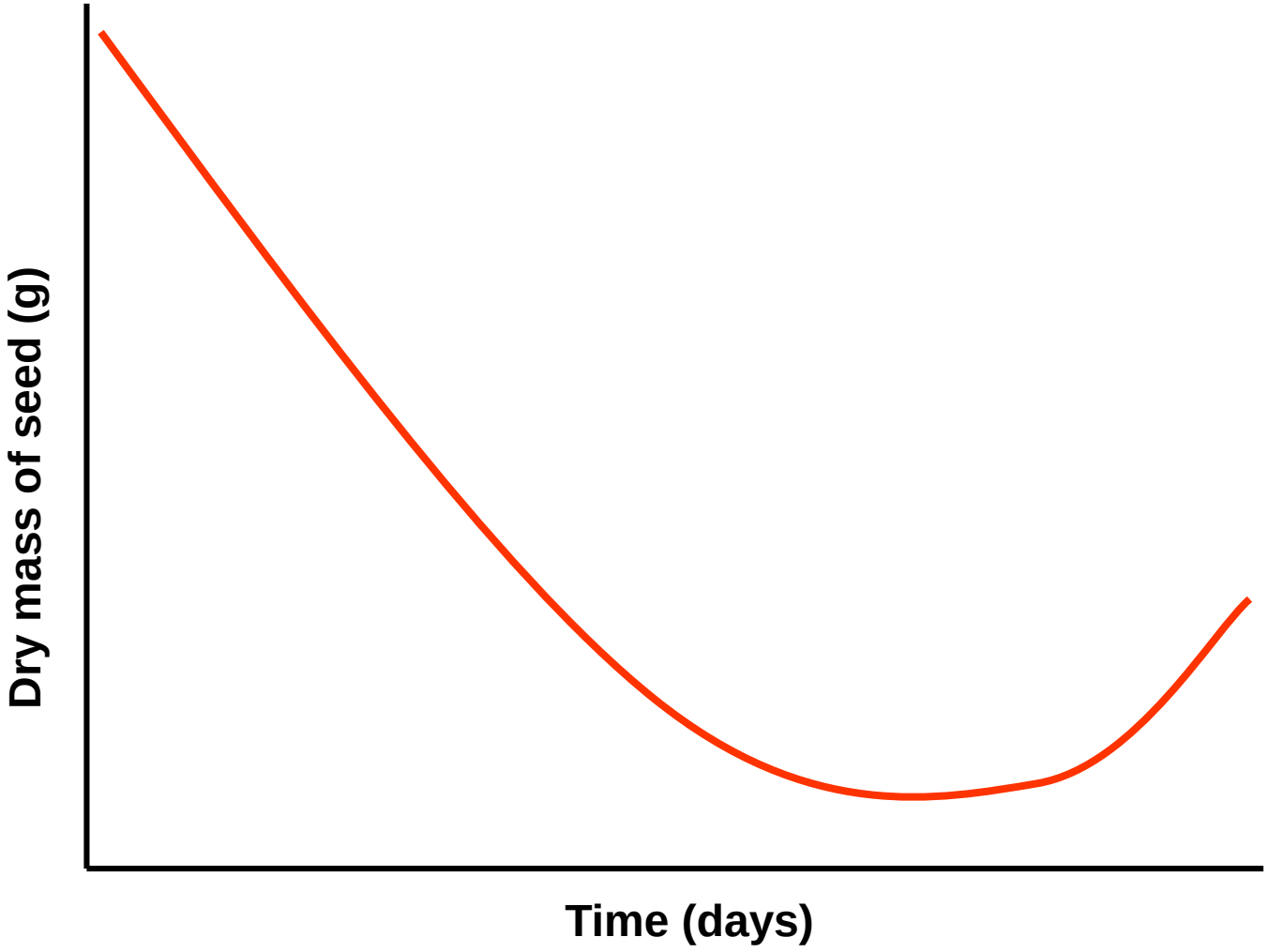
Events in Germination



Events in Germination

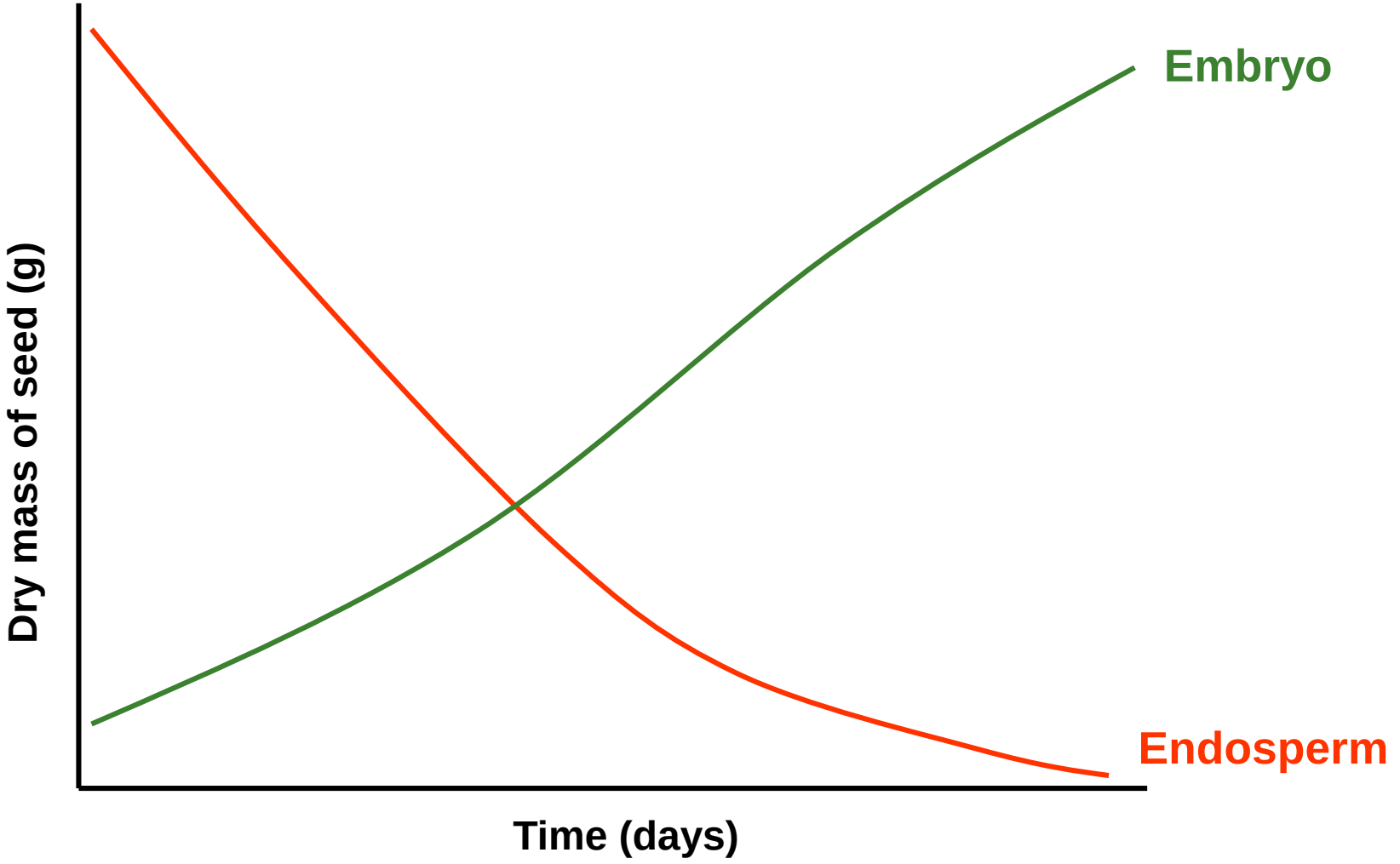


Changes in dry weight of seeds during germination



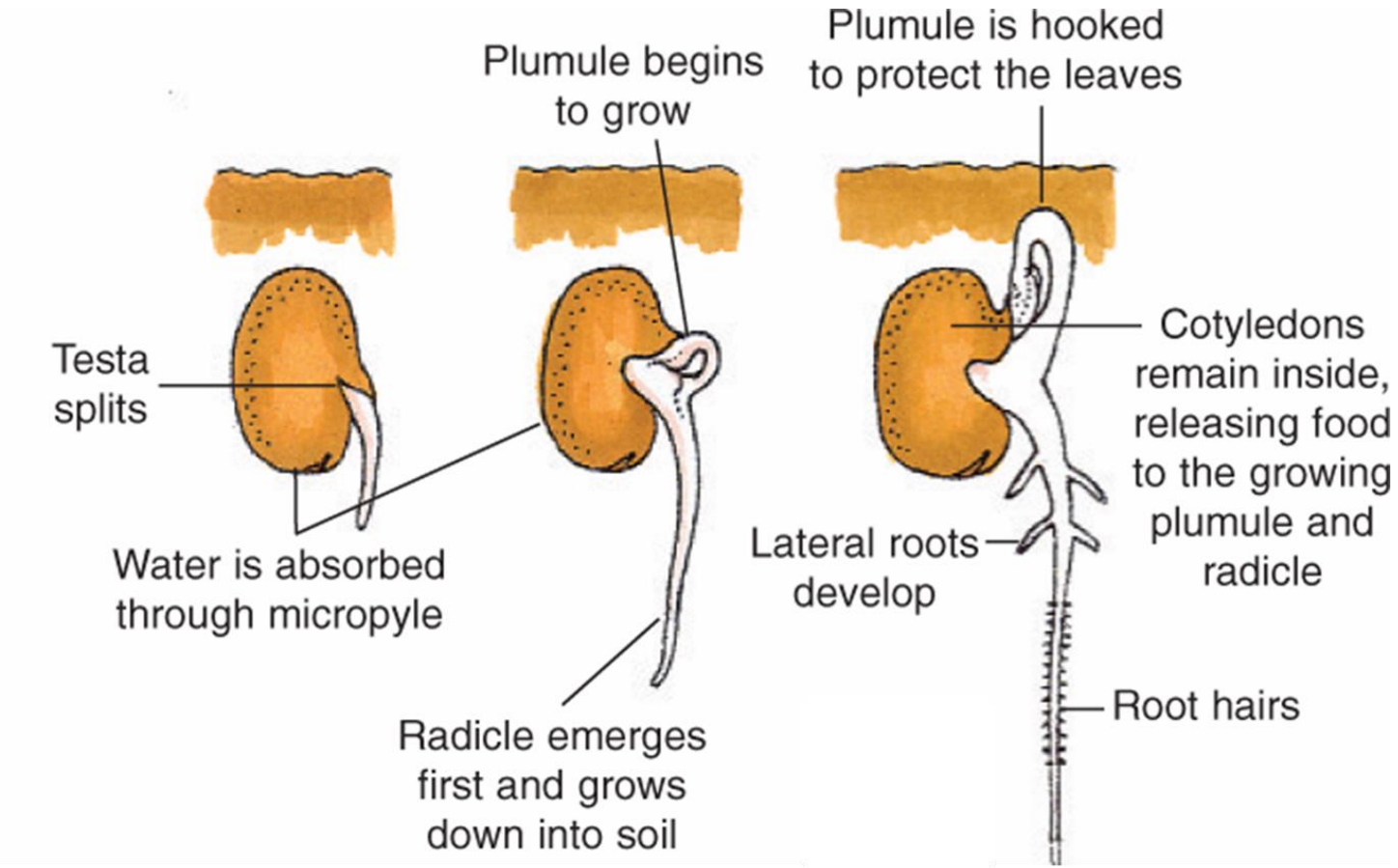
Mass drops initially due to respiration of stored food, but then begins to increase due to photosynthesis

Changes in dry weight of seeds during germination

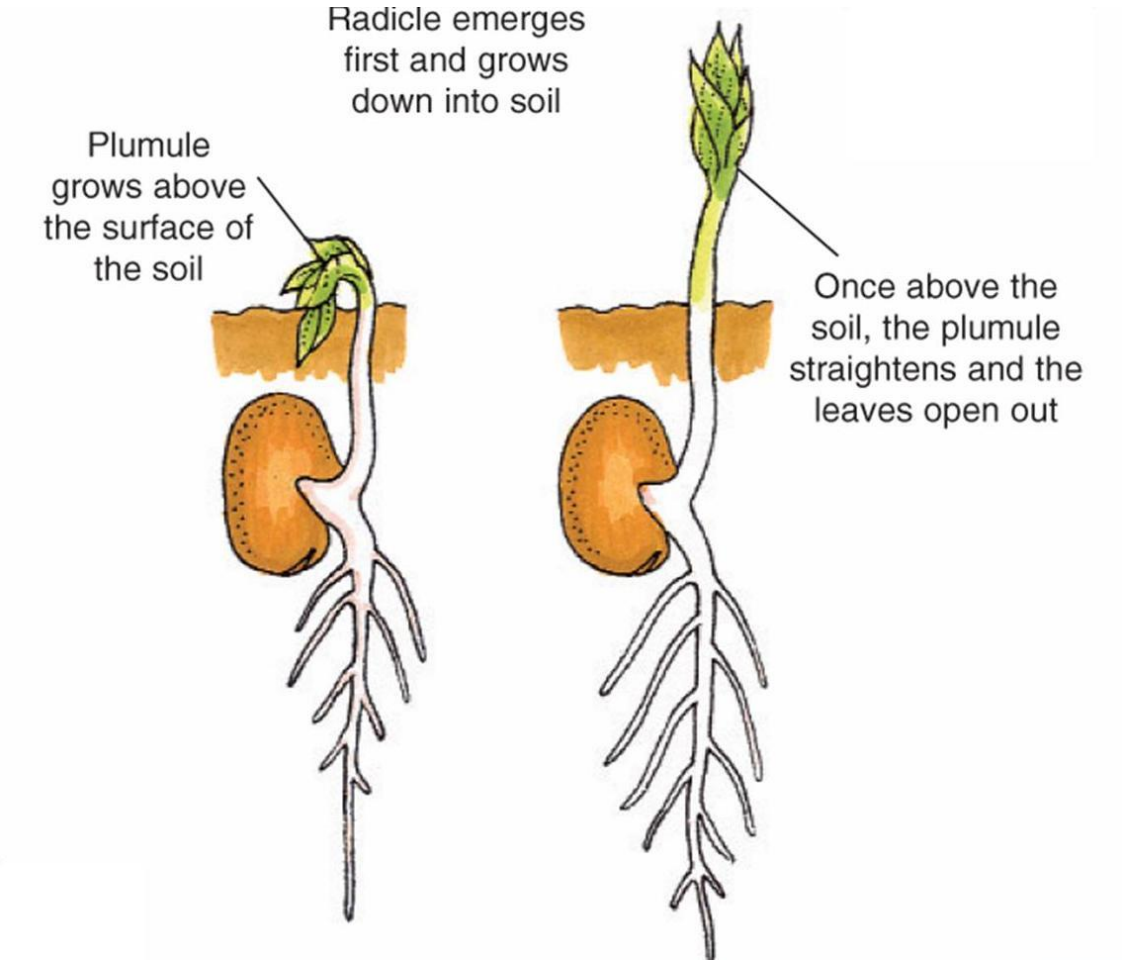


Food reserves in endosperm are transferred to the growing embryo

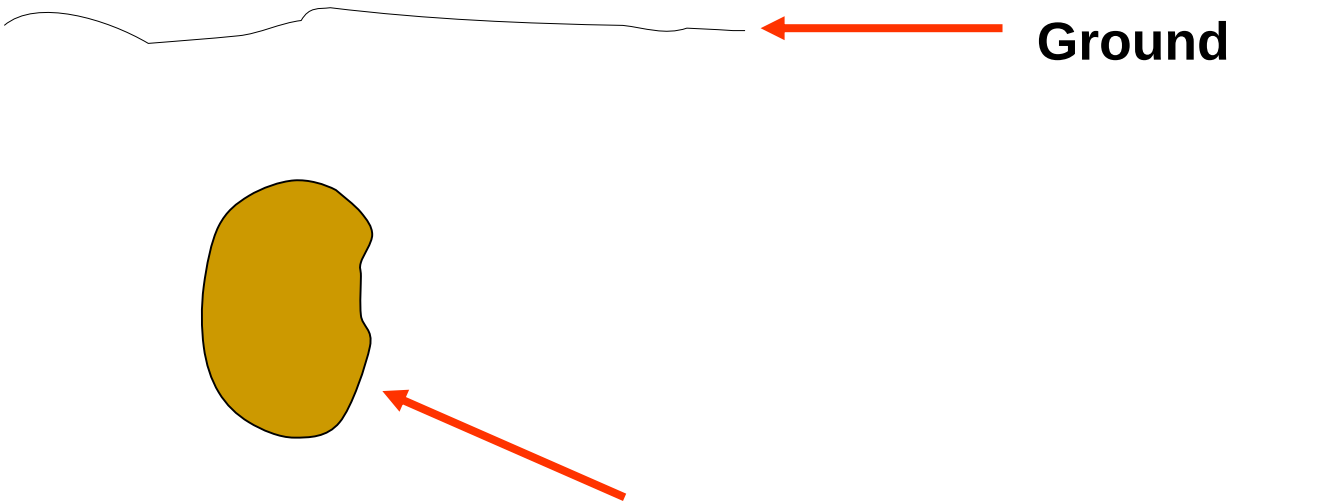
Germination of broad bean (hypogeal)



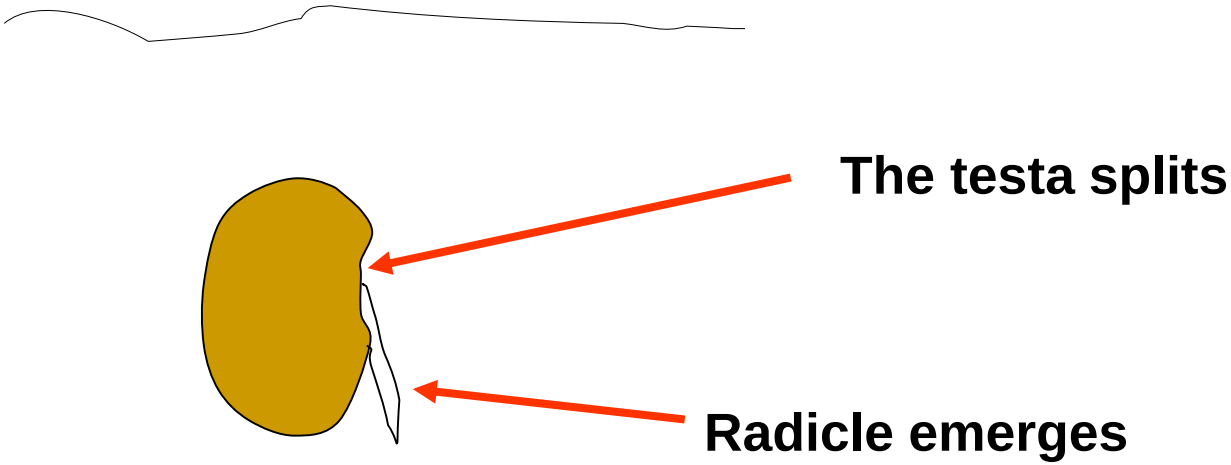
Germination of broad bean (hypogeal)



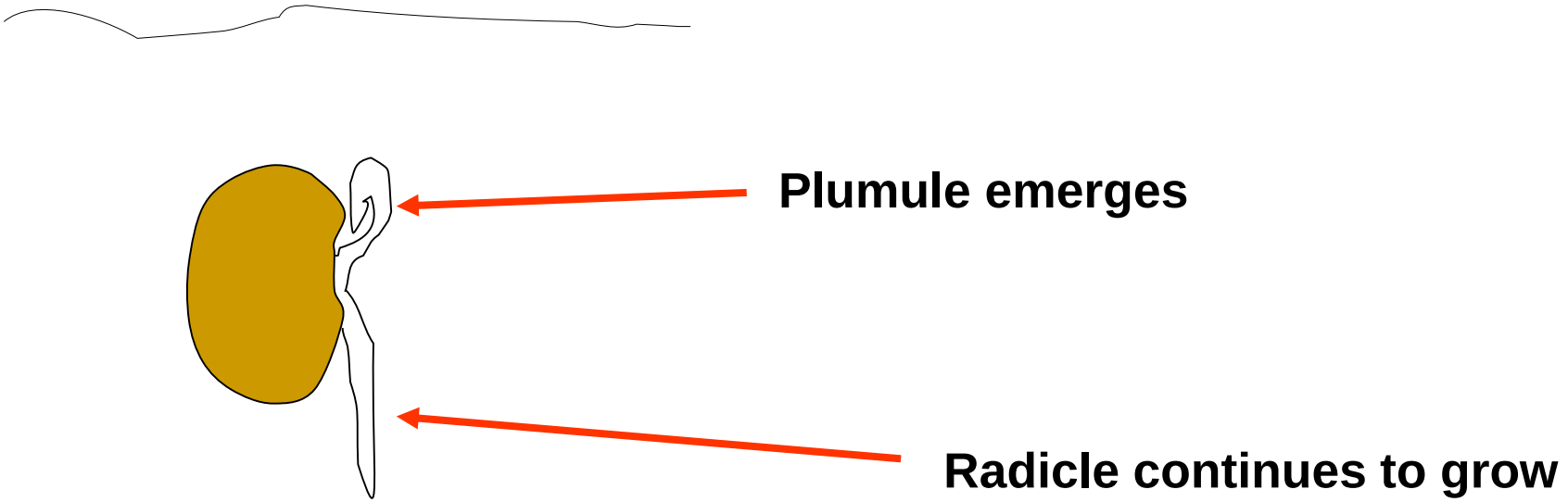
Germination of broad bean



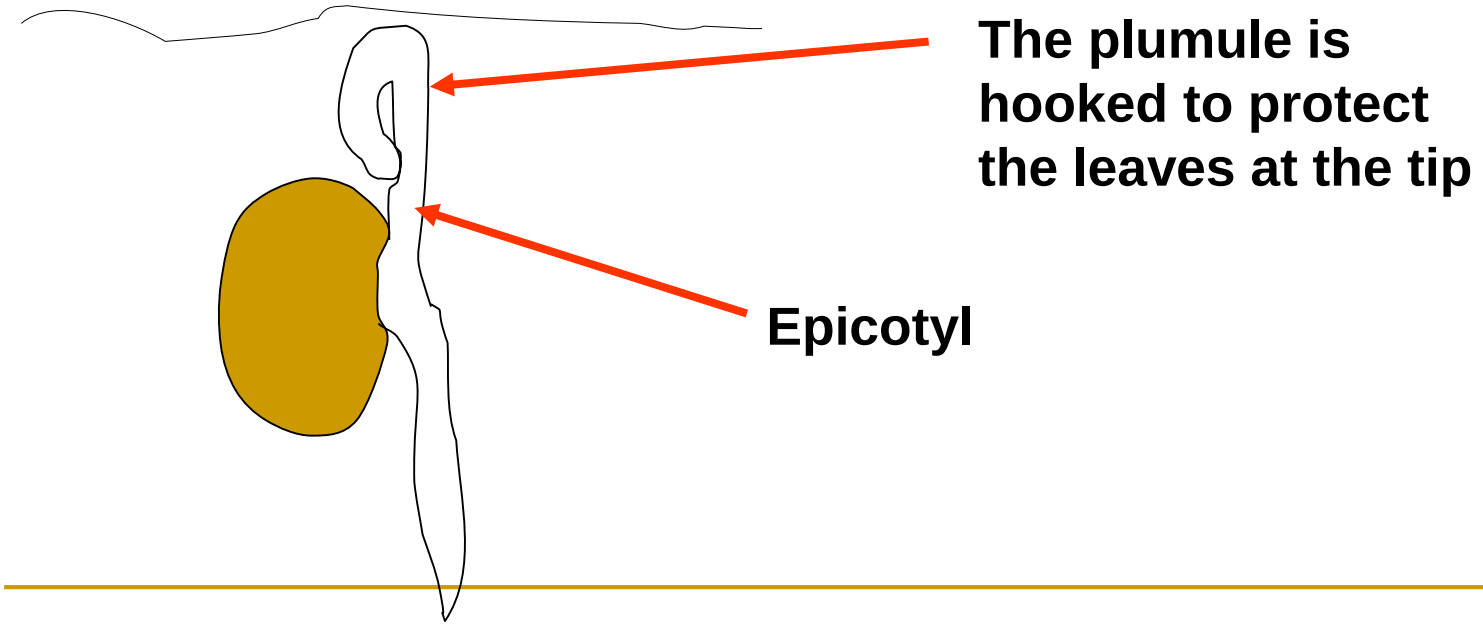
Germination of broad bean



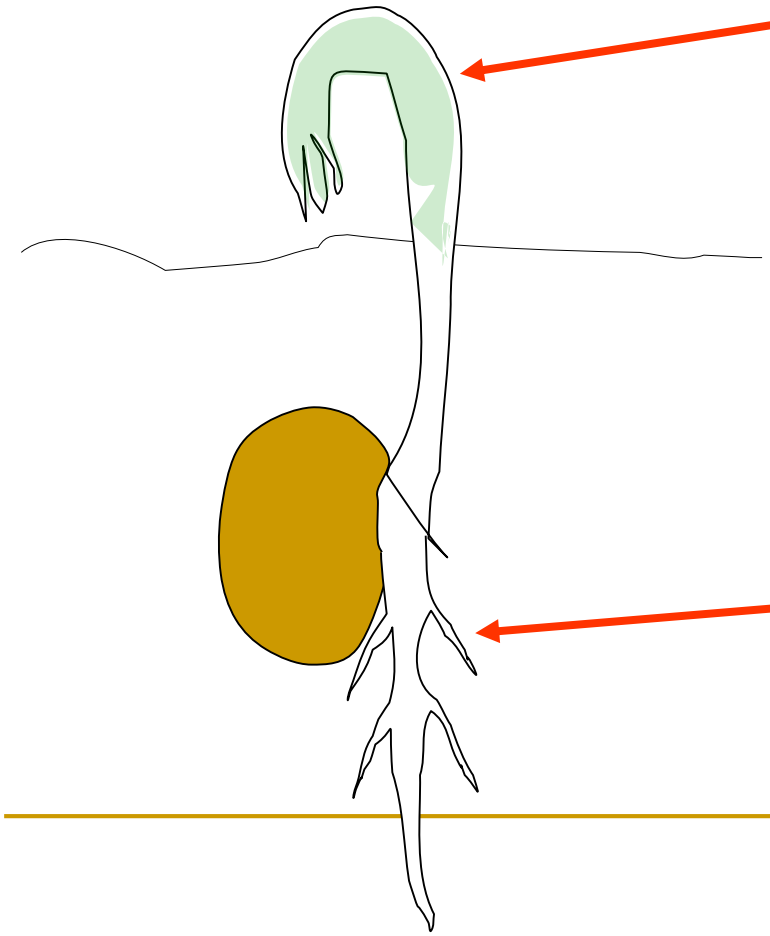
Germination of broad bean



Germination of broad bean



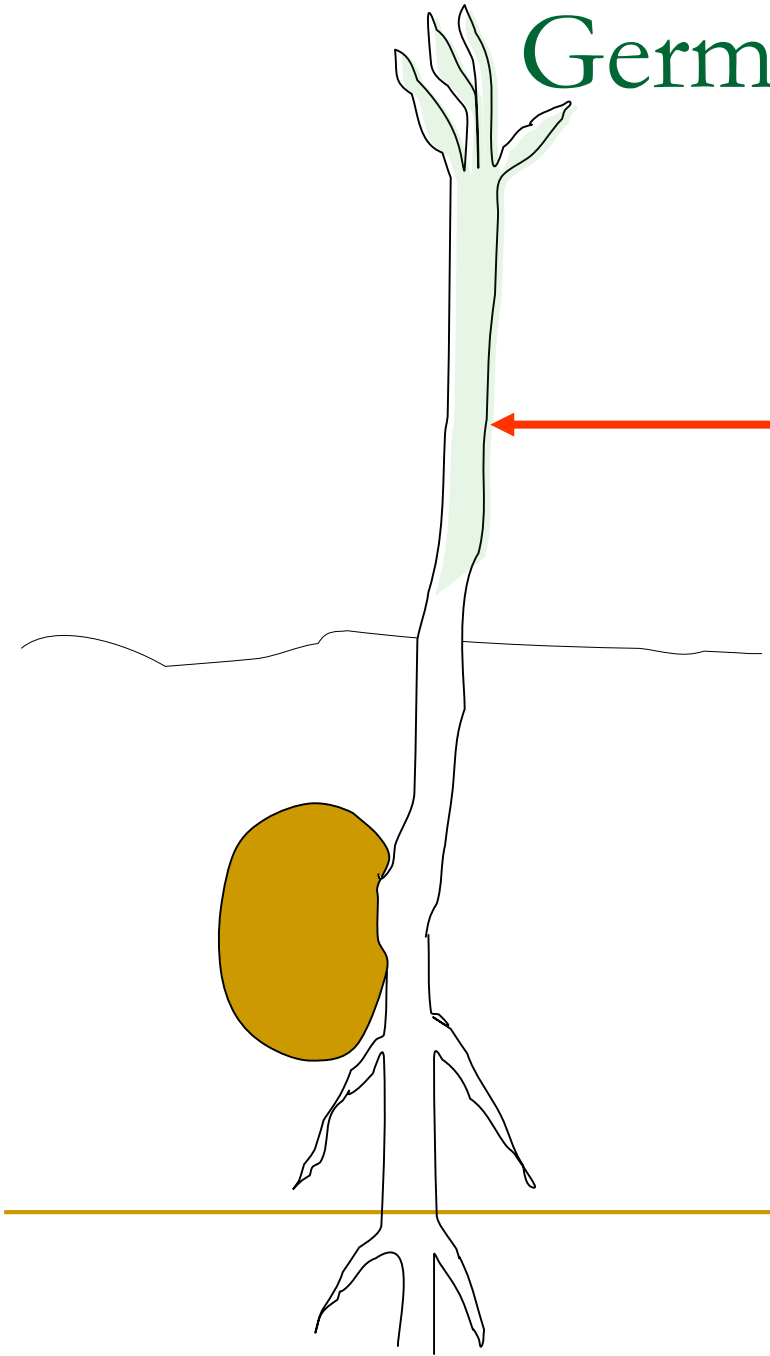
Germination of broad bean



The plumule grows above the surface of the soil

Lateral roots develop

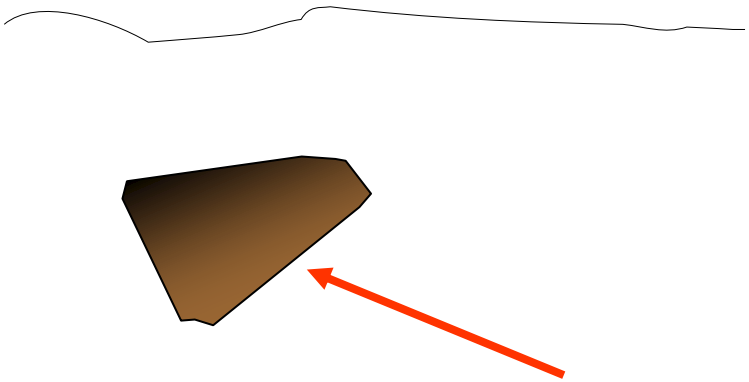
Germination of broad bean



Plumule straightens and the leaves open out

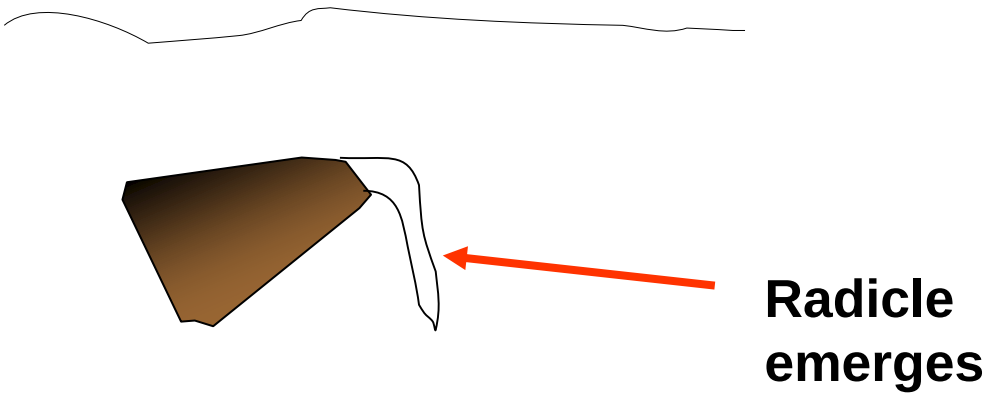
Throughout Hypogeal germination the cotyledons remain below the ground

Germination of sunflower (Epigael)

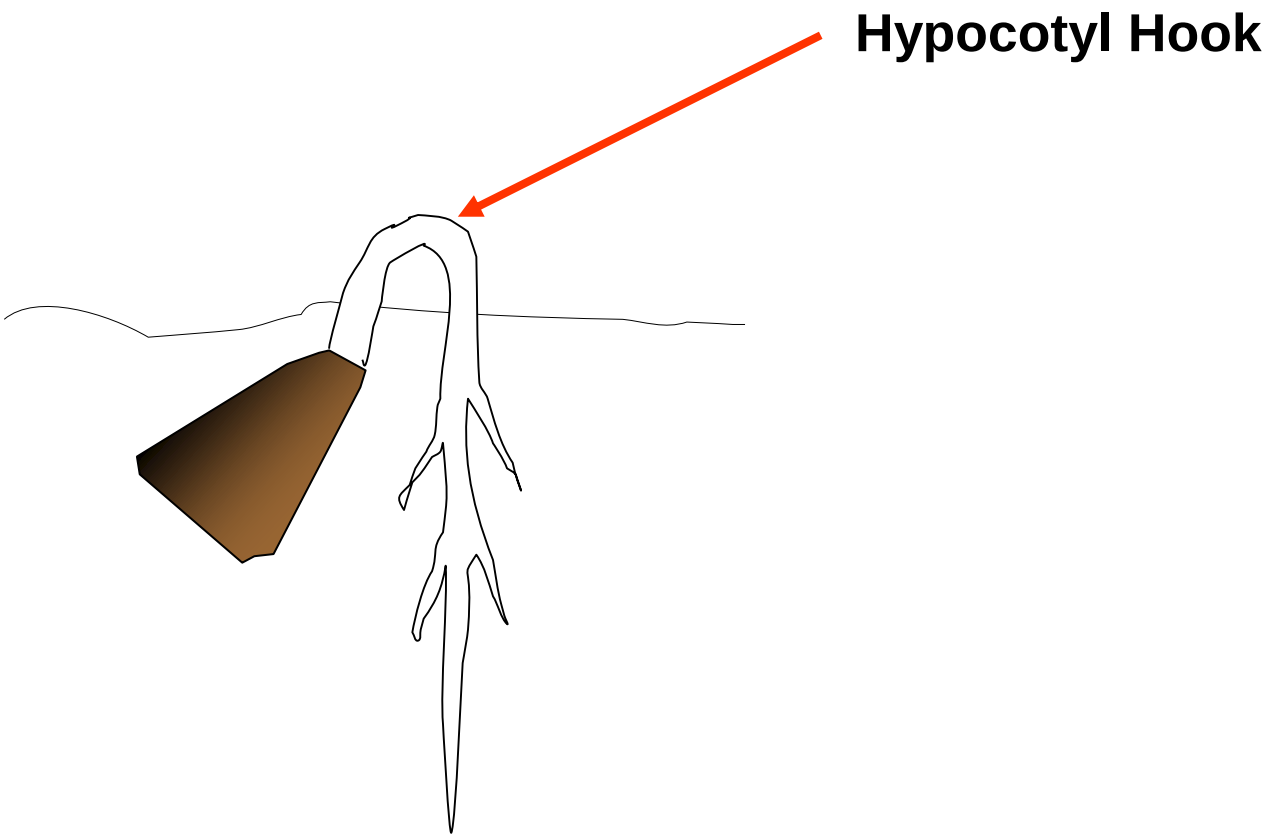


Seed – water is absorbed through the micropyle

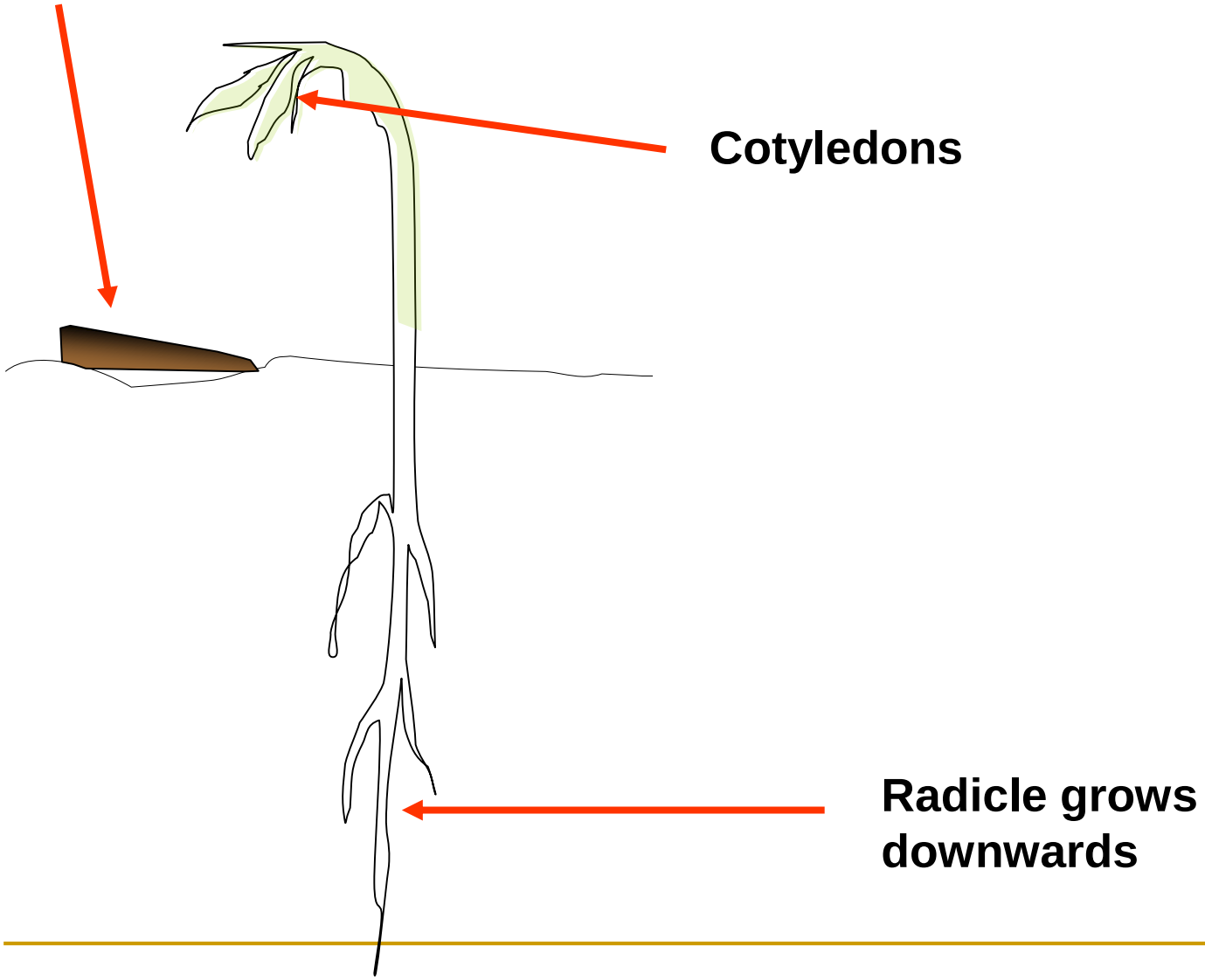
Germination of sunflower



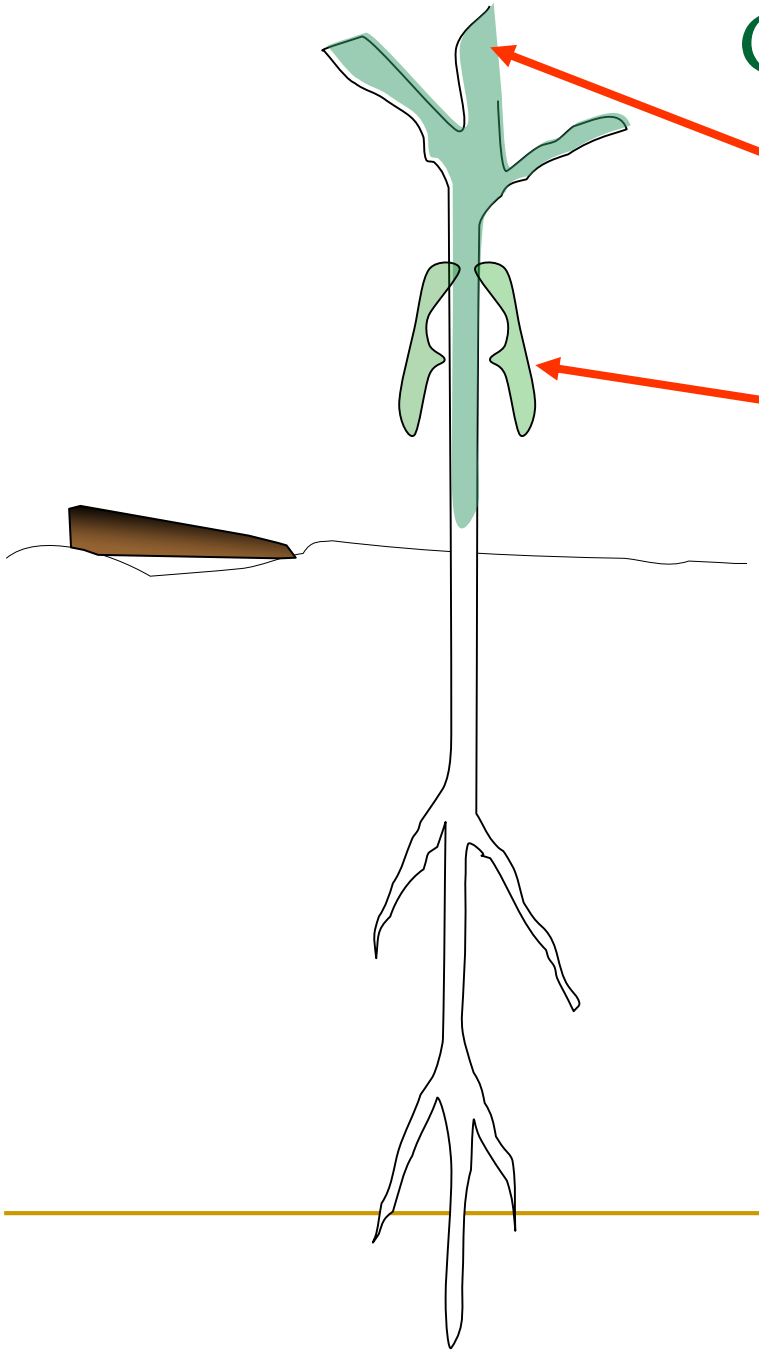
Germination of sunflower



Germination of sunflower



Germination of sunflower



Leaves emerge

Cotyledons wither

In Epigeal germination the cotyledons rise above the ground

Learning Check

Outline the main stages of sexual reproduction in plants

Review the plant life cycle

pollen is transferred

After fertilization flower withers

seeds develop in ovary

seeds disperse and germinate into new plant

Asexual Reproduction in Plants

Vegetative Propagation

Definition

Asexual reproduction

- does not involve the manufacture or union of sex cells or gametes e.g. binary fission, fragmentation, spore formation and budding

- It involves only one parent and offspring are genetically identical (have the same genetic content) to the parent

Vegetative Propagation

- A form of asexual reproduction in plants
- Does not involve gametes, flowers, seeds or fruits
- Offspring are produced by a single plant (genetically identical to parent)
- Can happen naturally or it can be done artificially

Vegetative Propagation

Natural

e.g. runners, tubers, plantlets, bulbs

What happens?

- Part of the plant becomes separated from the parent plant and divides by mitosis to grow into a new plant
- As a result the offspring are genetically identical to the parent

Parts of the parent plant may be specially modified for this purpose:

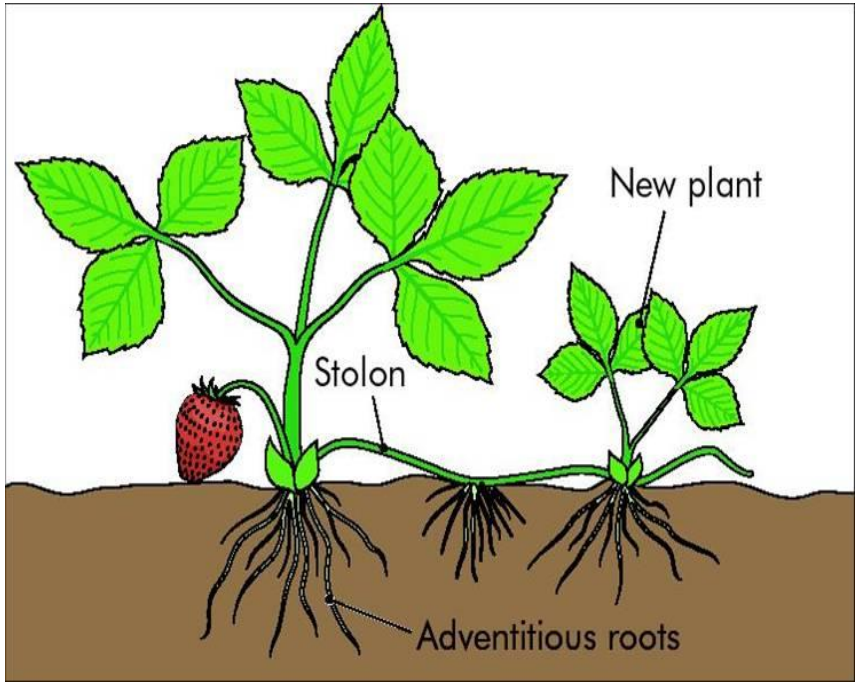
1. Stem
2. Root
3. Leaf
4. Bud

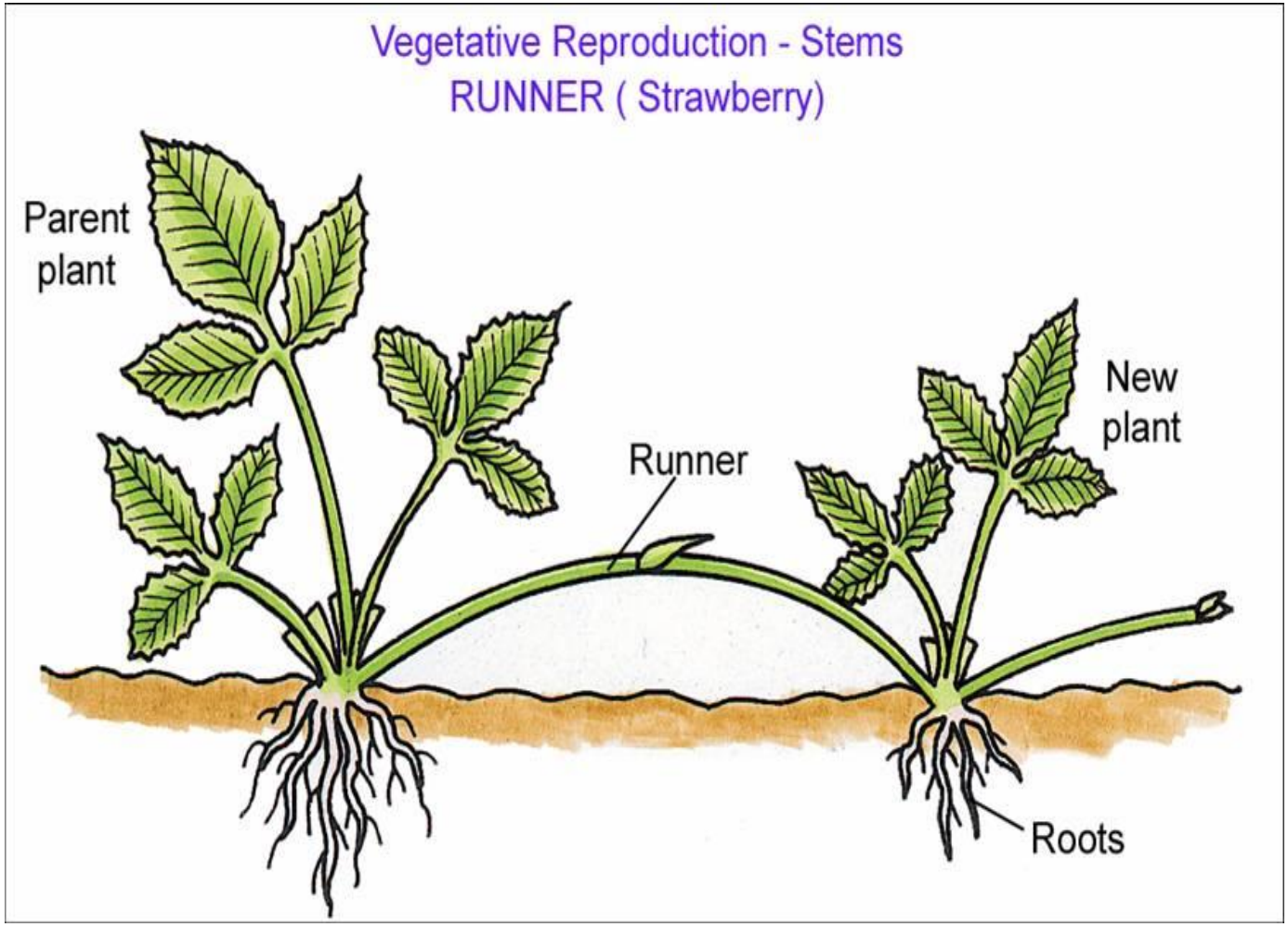
1. Modified Stems

Runners

- horizontal, running over the soil surface
- terminal bud of the runner sends up new shoots
- e.g. strawberry,

  creeping buttercup.



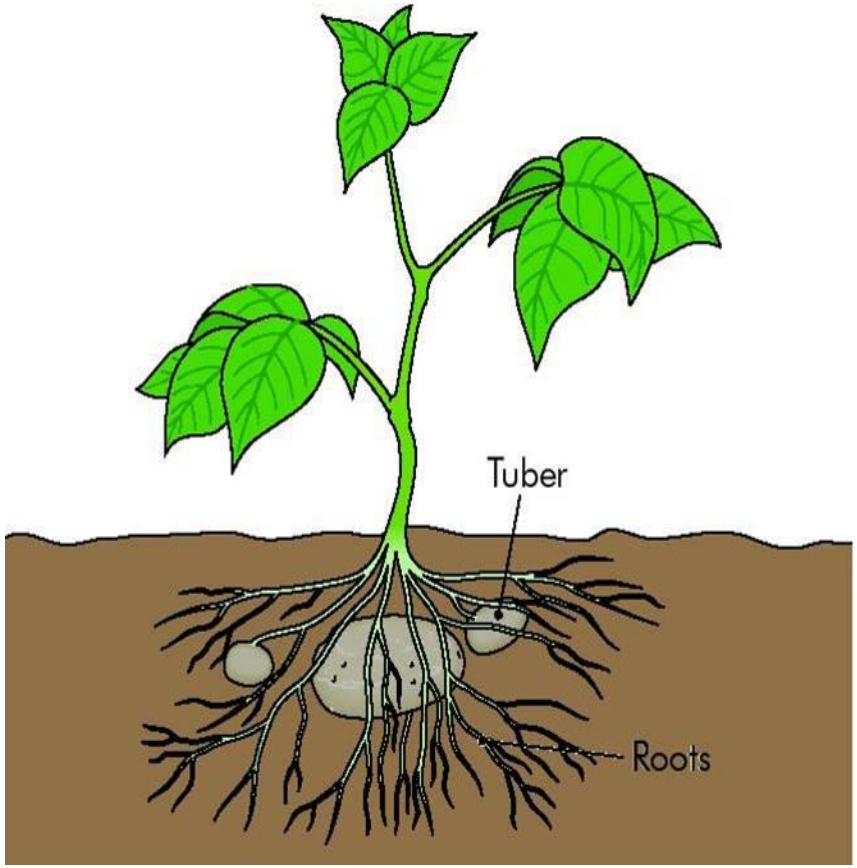

Vegetative Reproduction - Stems
RUNNER (Strawberry)
Parent plant
Runner
New plant
Roots

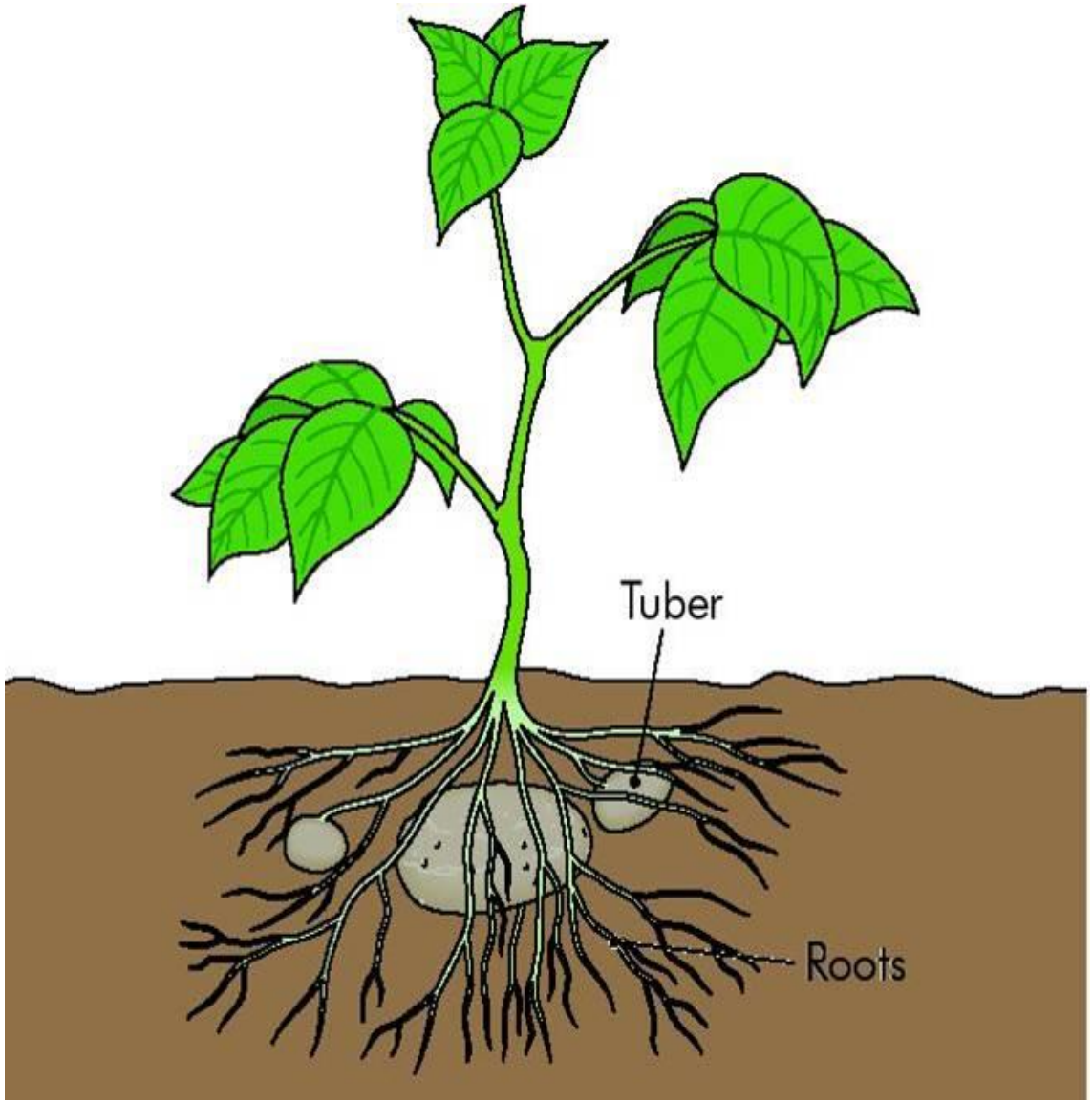
Creeping buttercup

Modified Stem (continued)

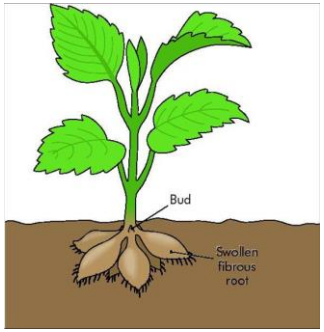
Stem Tubers

- swollen underground stem tips
- buds (eyes) produce new shoots
- e.g. potato




Tuber
Roots

2. Modified Roots



Root Tuber

- swollen fibrous roots
- the tuber stores food, but the new plant develops from a side bud at the base of the old stem

- e.g. dahlia, lesser celandine

Note:

Tap Roots e.g. carrot and turnip, are swollen roots for food storage in biennial plants… they are not reproductive organs

3. Modified Leaves

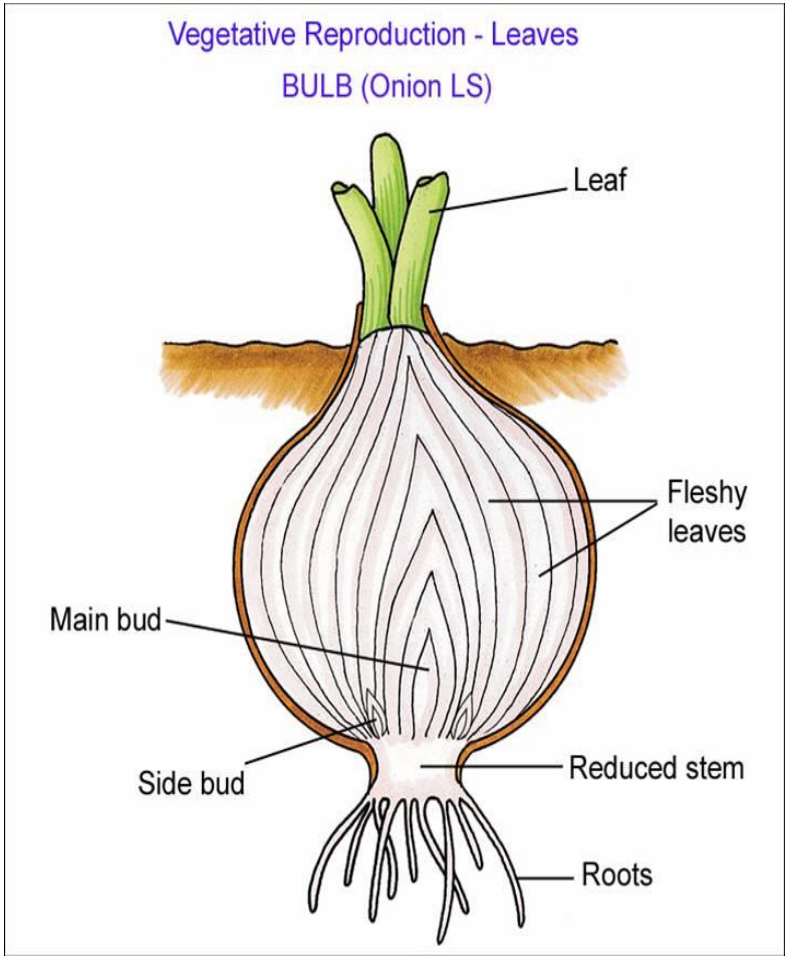
Plantlets

- Some plants produce plantlets along the edges of the leaves
- Plantlets reach a certain size, fall off and grow into new plants
- e.g. Lily, kalanchoe (mother of thousands)

4. Modified Buds

Bulbs

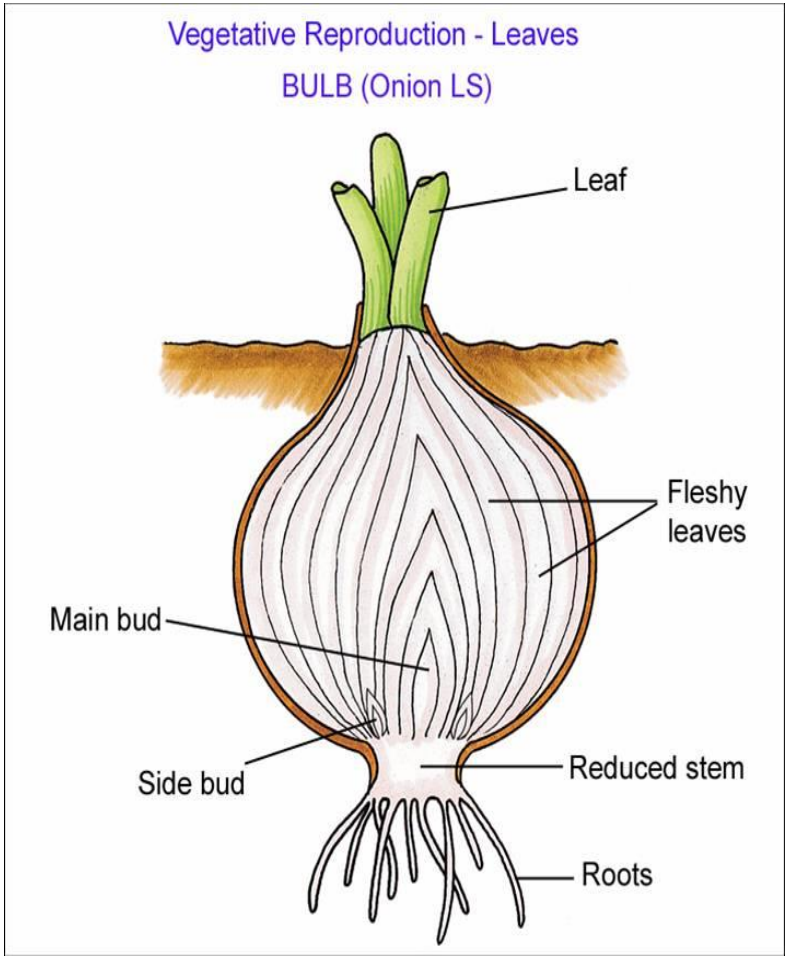
- A bulb contains an underground stem, reduced in size
- Leaves are swollen with stored food
- e.g. onion, daffodil, tulip

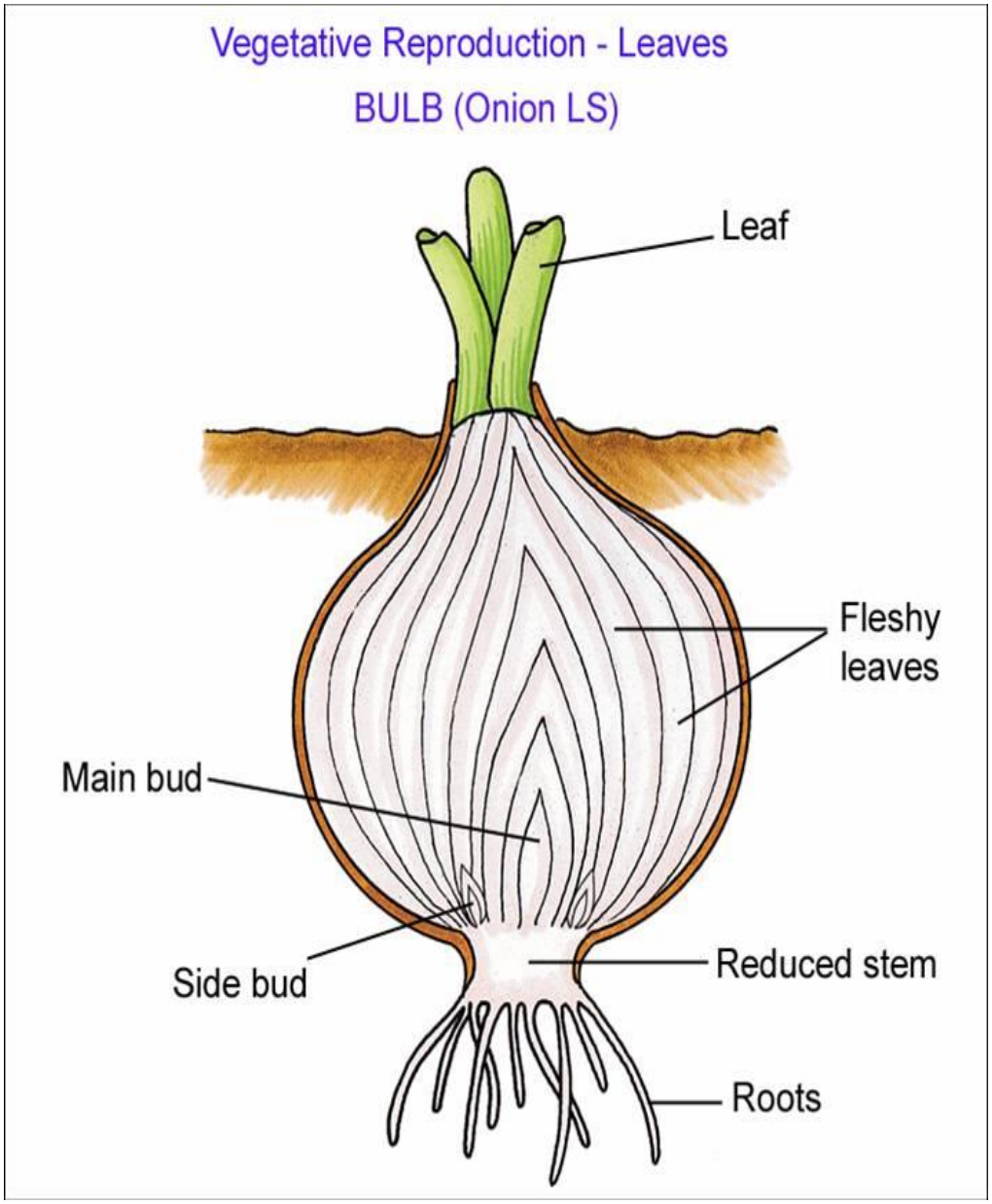


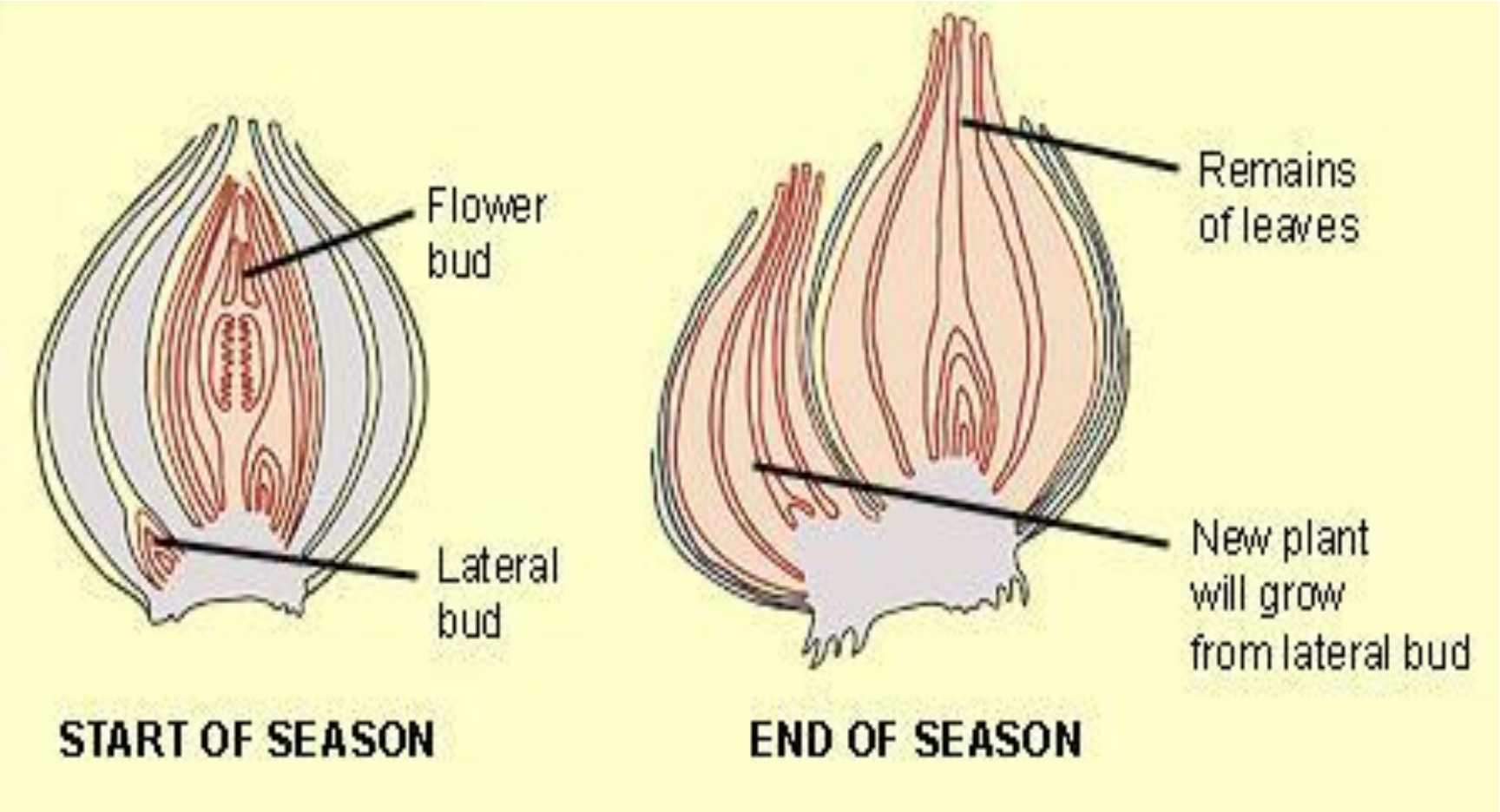
4. Modified Buds

Bulbs

- The main bud (apical bud) will grow into a new shoot)
- The side buds (lateral buds) will also grow into new shoots




Vegetative Reproduction - Leaves
BULB (Onion LS)
Leaf
Fleshy leaves
Main bud
Side bud
Reduced stem
Roots


Flower bud
Lateral bud
START OF SEASON
Remains of leaves
New plant will grow from lateral bud
END OF SEASON

Comparison of reproduction by seed (sexual) and by vegetative propagation (asexual)

Advantage to seed formation

Sexual (seed)	Asexual (vegetative)
Cross pollination ensures variation (allows evolution)	No variations – can be advantage in commercial horticulture
More resistant to disease	All plants are of same species susceptible to disease
Dispersal reduces competition	Overcrowding and competition
Seeds can remain dormant and survive unfavourable conditions	No seeds formed – no dormancy

Advantage to vegetative propagation

Sexual (seed)	Asexual (vegetative)
Complex process	Simple process
Depends on outside agents for seed dispersal	No outside agents needed
Slow growth of young plants to maturity	Rapid growth
Wasteful e.g. petals, pollen, fruit	No waste

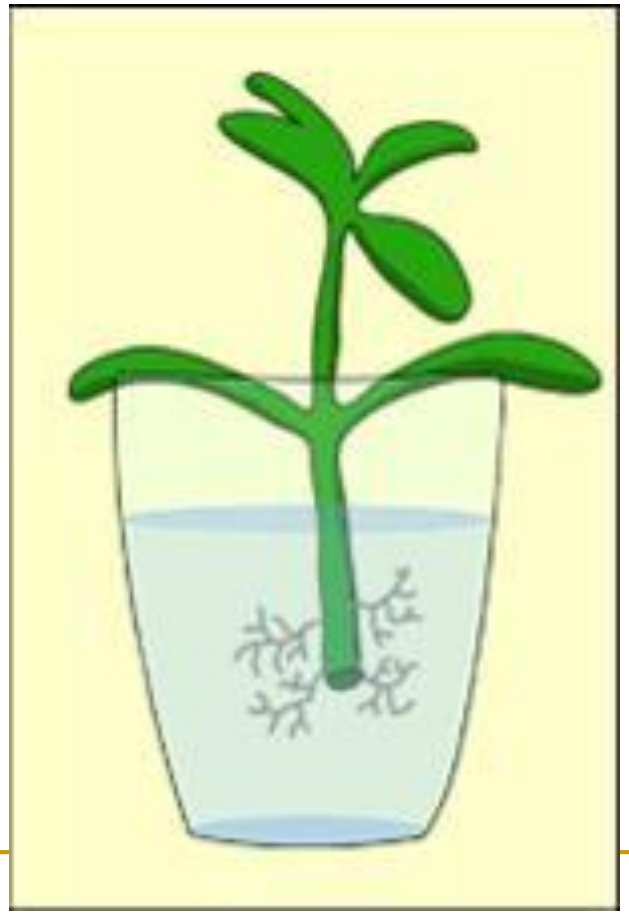
Vegetative propagation

Artificial

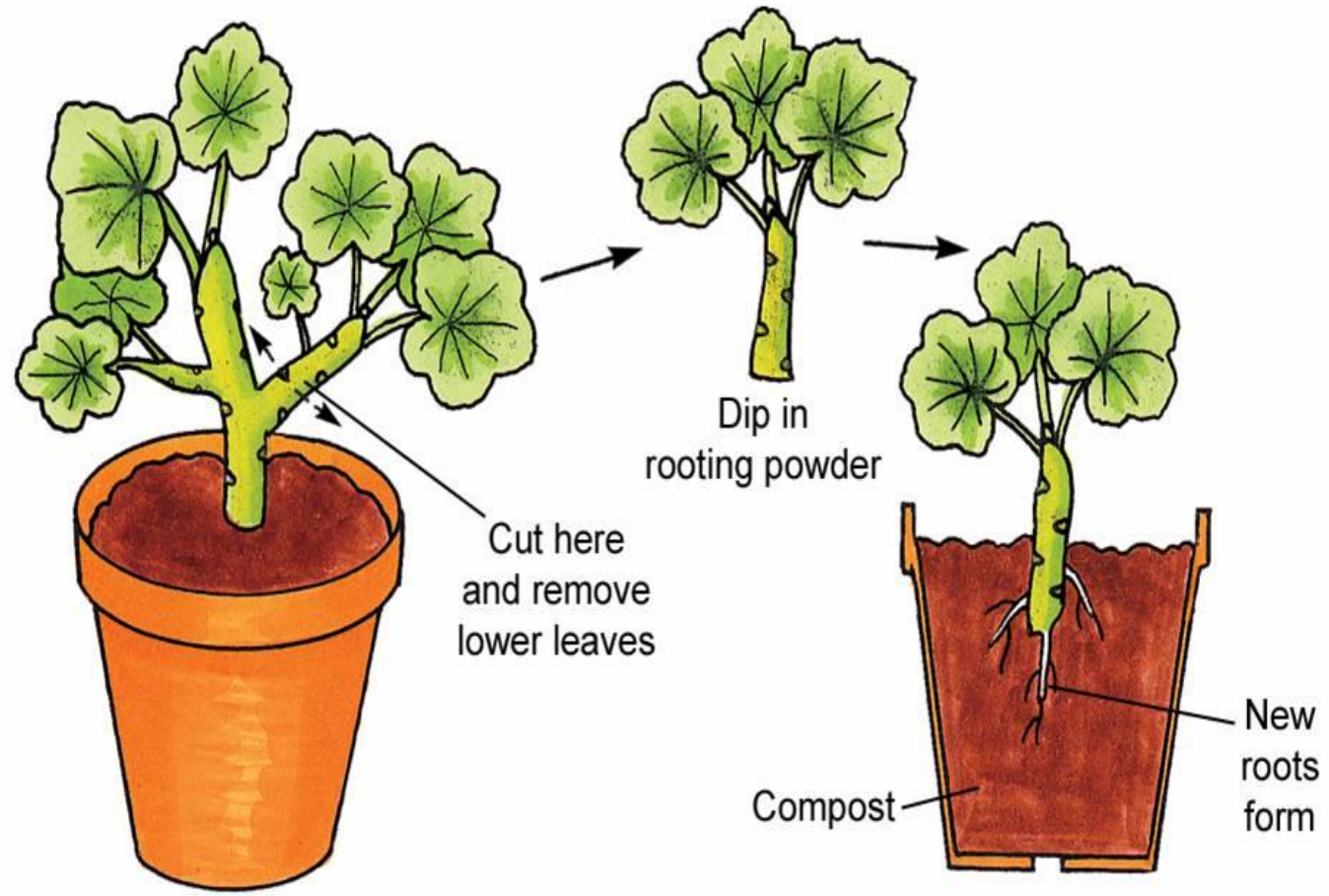
used by gardeners to propagate plants
e.g. cuttings, layering, grafting and budding

Cuttings

- Parts of a plant (usually shoots) removed from plant allowed to form new roots and leaves
- rooted in water, well-watered compost, or rooting powder
- e.g. busy lizzie, geranium

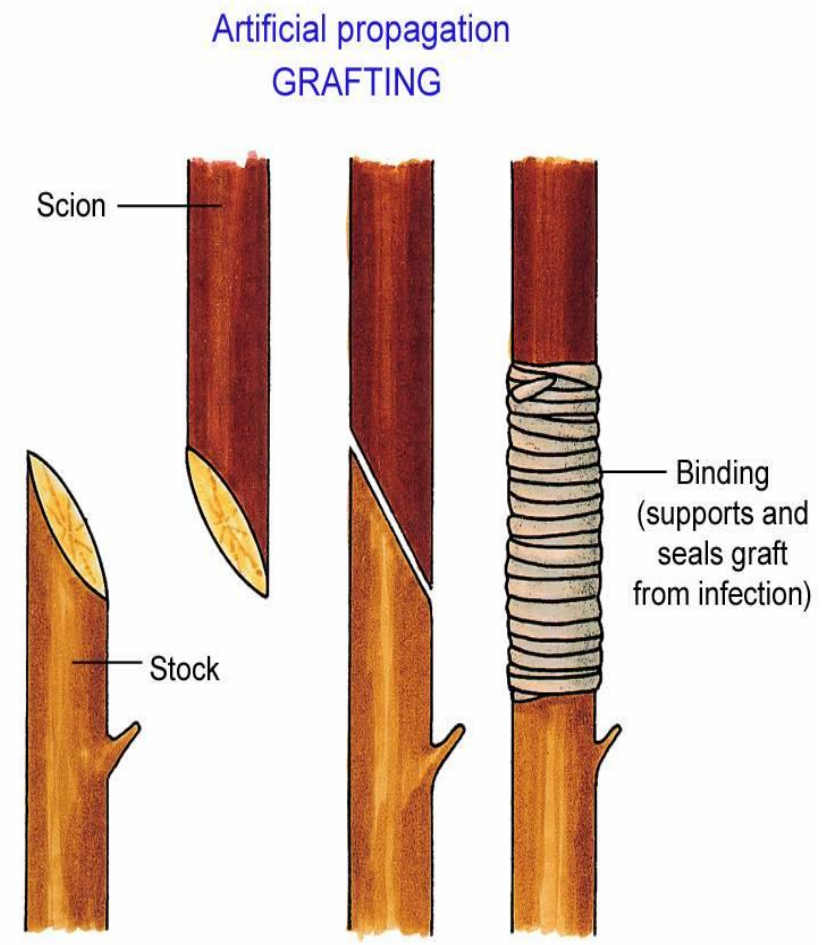


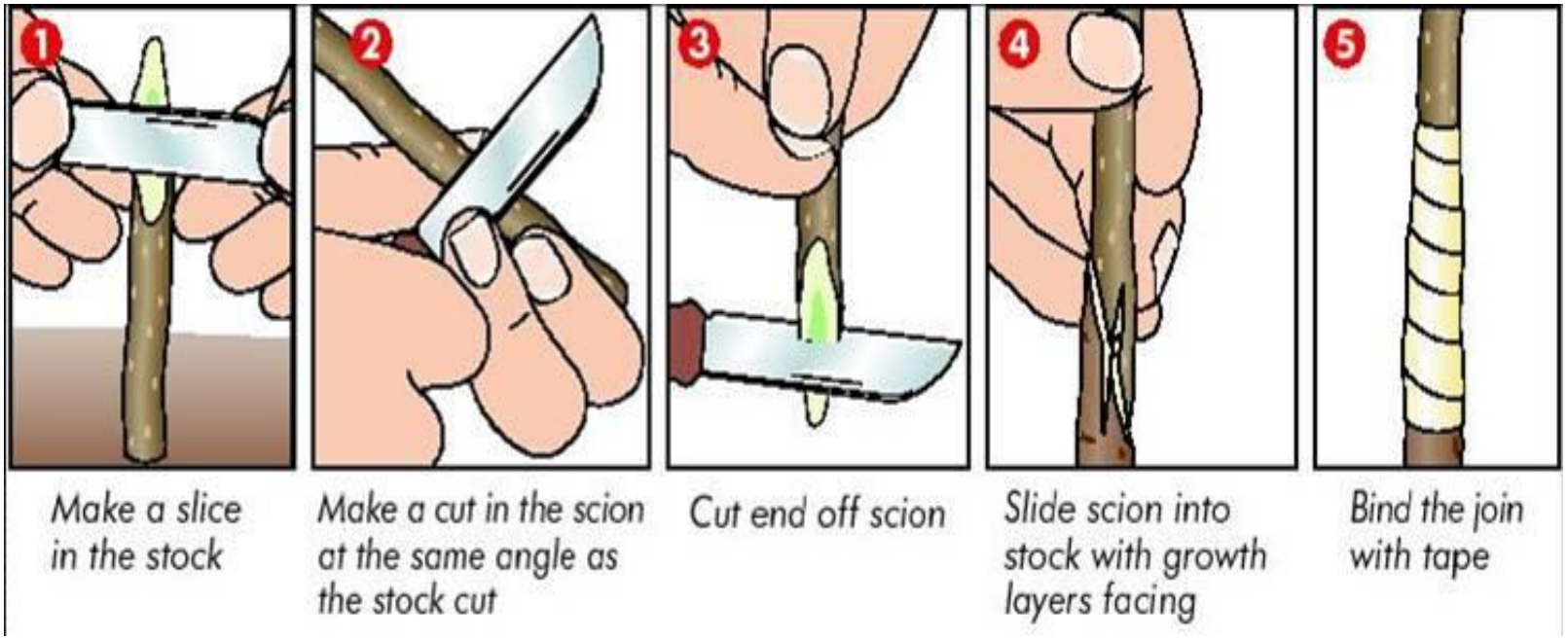
Artificial Propagation
CUTTINGS (Geranium)



Grafting

- Part of one plant (scion) is removed and attached to a healthy, rooted part of a second plant (stock)
- Useful qualities from both plants combined into one e.g. rose flower and thorn-less stem
- e.g. apple trees



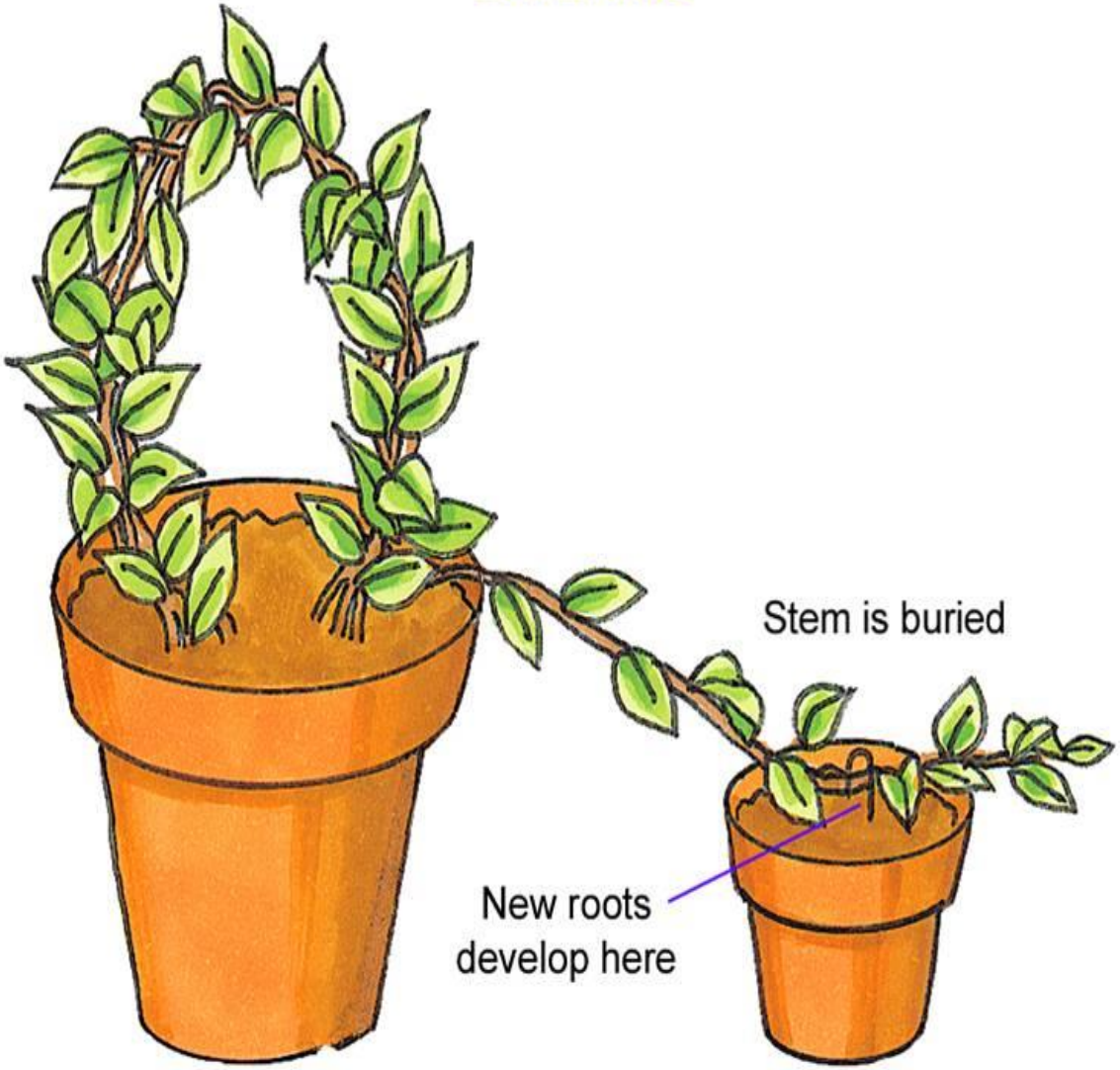

1
2
3
4
5
Make a slice in the stock
Make a cut in the scion at the same angle as the stock cut
Cut end off scion
Slide scion into stock with growth layers facing
Bind the join with tape

Layering

- A branch of a plant is bent over and pinned to the earth at a node
- When roots develop the branch is separated from the parent plant.
- Useful for the propagation of woody plants
- e.g. blackberry, gooseberry.

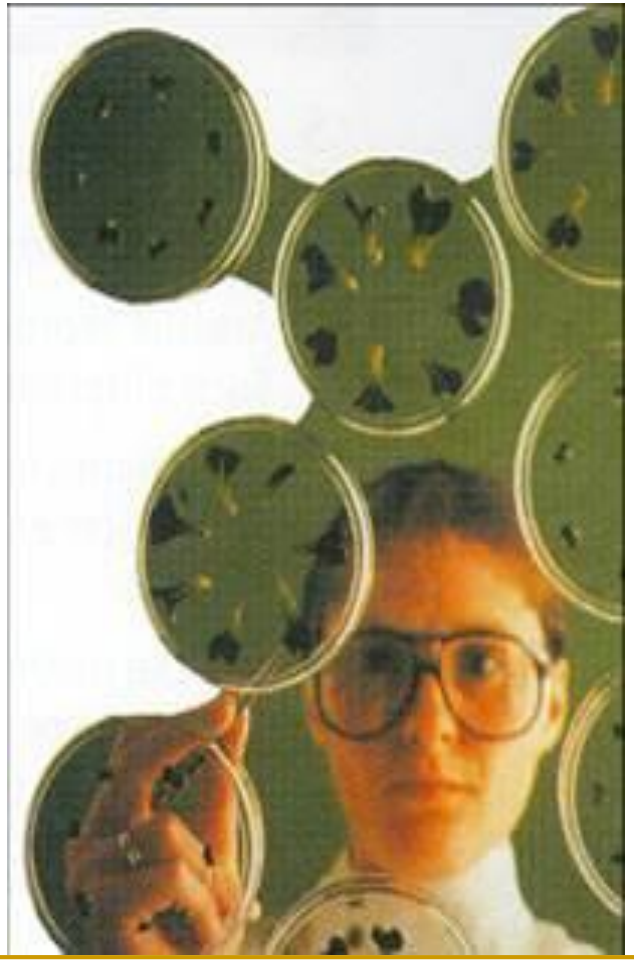
Artificial Propagation

LAYERING



Micropropagation (Tissue Culture) (1/3)

- Cells removed from plant and grown as a tissue culture in a special medium
- Growth regulators and nutrients added so that growing cells form a group of similar cells called a callus

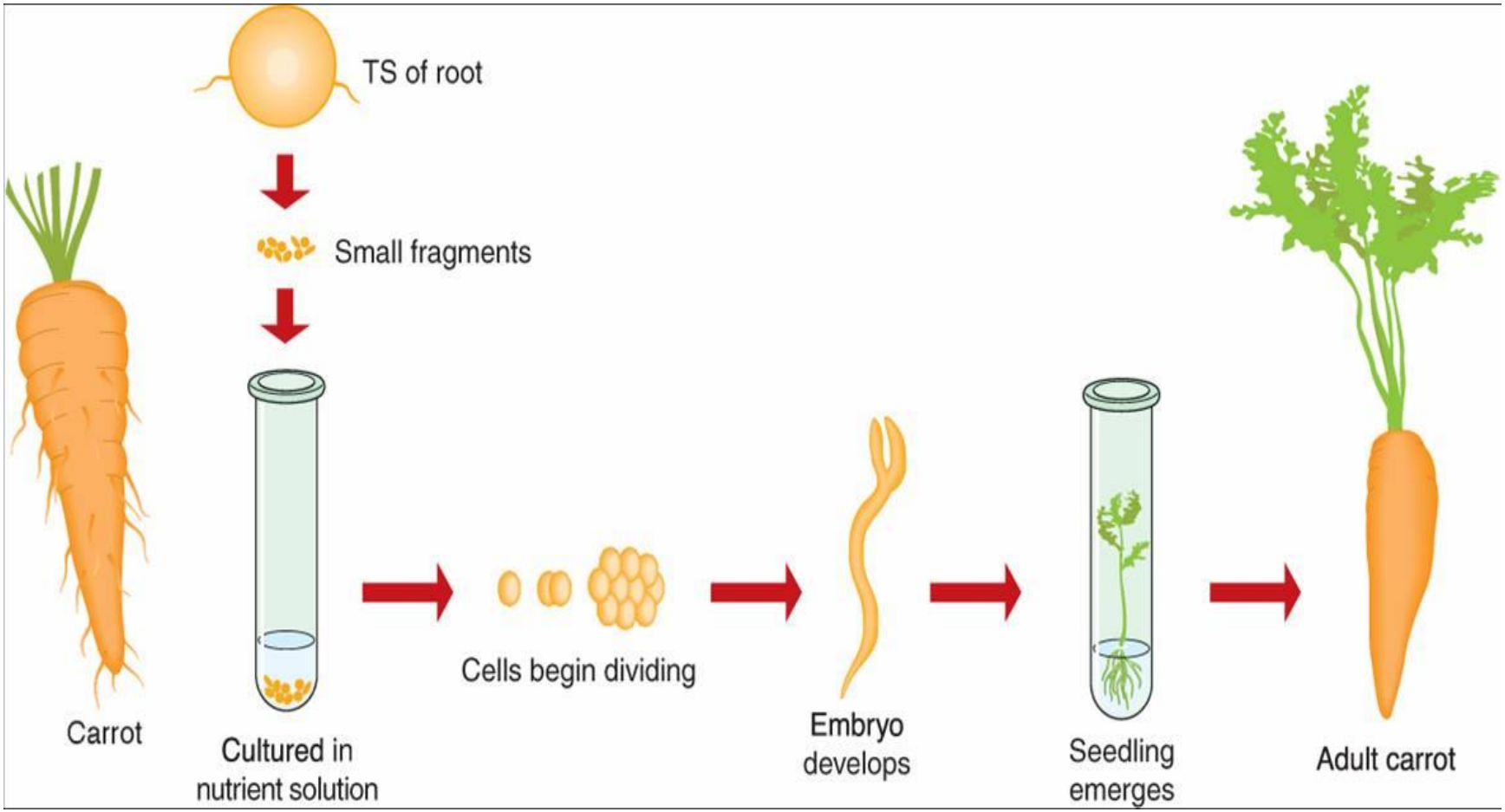


Micropropagation (Tissue Culture) (2/3)

- Different growth regulators are then added so that this tissue develops into a plantlet
- Plantlet can be divided up again to produce many identical plants
- Entire plant can be grown from a small piece of stem, leaf or root tissue
- Used in mass production of house plants and crops such as bananas and strawberries

Micropropagation (Tissue Culture) (3/3)

- Provides a larger number of plants more quickly than cuttings.
- Can be used to check cells for a particular feature e.g. resistance to chemicals or a particular disease


TS of root
Small fragments
Carrot
Cultured in nutrient solution
Cells begin dividing
Embryo develops
Seedling emerges
Adult carrot

Cloning

- All offspring genetically identical - produced asexually
- Clones are produced by mitosis
- All the offspring from the various methods of vegetative reproduction (both natural and artificial) mentioned are examples of clones

END