Name:

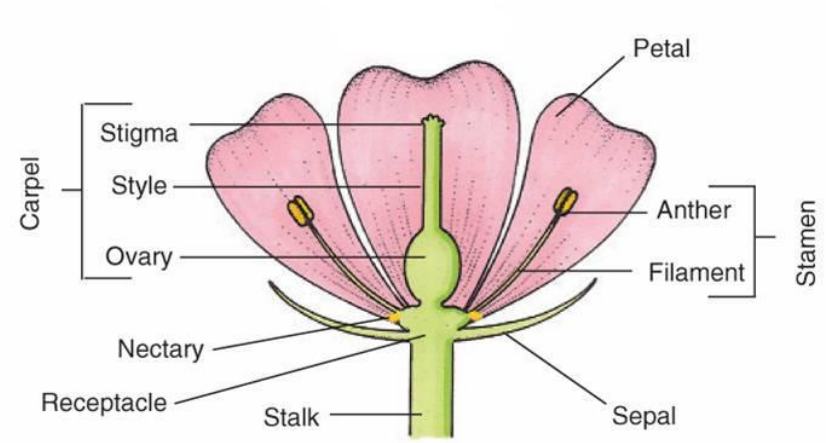
3.6 Reproduction and Growth – Plant	**Objectives** At the end of this sub section students should be able to:
3.6.1 Sexual Reproduction - Plants	1. State the structure & function of the floral parts including: Sepal, Petal, Stamen, Carpel 2. State that the Pollen grain produces male gamete. 3. State that the Embryo sac produces an egg cell & polar nuclei. 4. Define the terms: pollination, self-pollination 5. Outline methods of pollination including: cross-pollination & self pollination 6. Define the term: fertilisation. 7. Outline seed structure & function of following: testa, plumule , radicle, embryo, cotyledon 8. Explain embryo & food supply (endosperm or seed leaves) 9. Classify plants as monocotyledon or dicotyledon & distinguish between them. 10. Make reference to non-endospermic seed. 11. Outline fruit formation. 12. Outline seedless fruit production. 13. Outline fruit & seed dispersal and give with examples of wind/water/animal/self dispersal 14. Explain & emphasise the need for dispersal 15. Define the term dormancy. 16. State advantages of dormancy. 17. Explain dormancy in agricultural & horticultural practice. 18. Define the term: Germination. 19. Explain the factors necessary for and role of digestion and respiration in germination. 20. Outline the stages of seed development **Vegetative Propagation** 21. State that vegetative propagation is asexual reproduction. 22. Give one example of vegetative propagation from stem, root, leaf, bud. 23. Compare reproduction by seed and by vegetative reproduction. **24.** Outline four methods of artificial propagation in flowering plants
3.6.3.H Plants (extended)	25. Outline pollen grain development from microspore mother cells 26. Explain meiotic division of these cells 27. Explain mitotic division of these cells 28. Discuss generative and tube nuclei formation 29. Discuss formation of pollen grains 30. Outline embryonic sac development 31. Discuss meiotic division, cell disintegration **32.** Outline the formation of the egg cell by mitotic division

Practical Activity:

***ME** - To investigate the effects of water, oxygen and temperature on Germination*

***ME** - To investigate the use of Starch agar to show Digestive Activity during Germination*

The Flower



Flower parts:
Sepals - protect flower when it is a bud (usually green).

Petals - large, brightly coloured and scented to attract insects in animal-pollinated plants. Small, green or absent in wind-pollinated plants.

Stamen (male) composed of anther and filament. Anther produces pollen grains and filament supports anther and supplies it with food and water.

Carpel (female)- composed of stigma, style and ovary. Stigma is where pollen land. Style connects stigma to ovary. Ovary contains 1 or more ovule(s).

Receptacle - swelling on which flower is supported.

Nectary - produces sugary substance called nectar. Attracts insects for pollination.

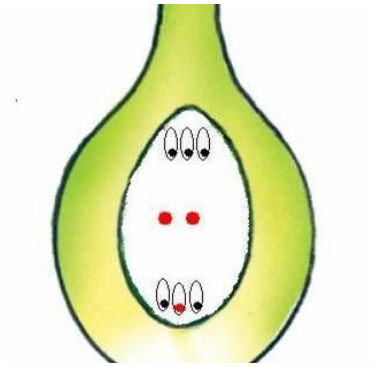
Sexual reproduction

1. Pollination: the transfer of pollen from anther to stigma.
2. Fertilisation: fusion of male and female gametes to form a zygote.
3. Dispersal: the spreading out of the seeds.
4. Germination: the growth of the plant embryo after the dormant period.

Development of pollen
Pollen grain produces male gametes.
T.S. of anther

1. Inside each pollen sac are a number of diploid pollen mother cells which divide by meiosis to form four haploid pollen grains which stick together (tetrad).
2. The pollen grains (microspores - called spores because unable to fertilise a female gamete) separate. Each pollen grain has a double wall (exine, intine).
3. The pollen grain nucleus divides by mitosis to form two haploid nuclei (tube nucleus and generative nucleus).
4. As the pollen grains mature, the tapetum (nourishment) is used up, the pollen sacs fuse and lines of dehiscence (splitting) appear, the sacs burst and the pollen grains are removed by insects or wind.

Development of embryo sac
Embryo sac produces an egg cell and polar nuclei.



Each ovule consists of a nutritious tissue called nucellus. Inside which lives the embryo sac mother cell.

1. The diploid embryo sac mother cell divides by meiosis to form four haploid cells, three of which die. The single haploid nucleus within the embryo sac (megaspore) undergoes mitosis 3 times (i.e. 8 haploid nuclei). One forms the egg cell and two form the polar nuclei (all three = female gametes)

Pollination is the transfer of pollen from an anther to a stigma of a flower of the same species.
Cross -pollination is the transfer of pollen from the anther of one plant to the stigma of another plant of the same species.
Self-pollination occurs when pollen is transferred from the anther to the stigma of the same flower or to another flower on the same plant e.g. cereals.
Cross pollination ensures seeds show more variation and vigour.
It may be brought about by wind or animals.

	Animal pollinated	**Wind pollinated**
Flower	Large, brightly coloured petals, scented and nectar to attract and reward insects.	Small and petals green if present, no scent/nectar.
Pollen	Small amount of large,	Large amounts, small,

	heavy, sticky, spiky pollen – to attach to insect's body.	light, dry, round, smooth pollen – easily carried by wind, large nos. allows for wastage.
Stigmas	Small, round, sticky, inside flower – forces insect to forage.	Large, feathery, outside flower easier to catch pollen.
Anthers	Small, inside flower - forces insect to forage e.g. wall flower, sweet pea, tulip, snowdrops.	Large, outside flower – for easy release of pollen e.g. grass, oak, hazel, alder, conifers.

Hay fever
Hay fever is an allergic reaction to the inhalation of certain harmless substances e.g. pollen grains, fungus spores, animal skin or scales, house dust & house dust mites.

- Symptoms = inflammation of mucous membranes in nose, sneezing, blocked and runny nose, watery & irritated eyes.
- Treatments – avoid the allergen, decongestant drugs to clear nose, antihistamines to reduce inflammation.

Plant breeding techniques
Plants such as wheat, which grows quickly, are resistant to disease and pests, and produce a large amount of good quality pollen. Cross-pollination can be brought about artificially. The anthers are removed from one plant – to prevent self-pollination. When the carpels are ripe, pollen from the second plant is dusted on using a brush and plant is covered.
Can also be achieved by tissue culturing. A piece of tissue is taken from plant, grown in nutrient medium until a mass of cells forms. One cell is taken and grown in another medium and a new plant is formed.

Fertilisation
This is the fusion of the male nuclei with the female nuclei to form a diploid zygote.
Events before fertilization:
Once the pollen grain lands on the stigma it produces a pollen tube, which grows down the style to the ovule. As the pollen tube grows down, the generative nucleus (n) divides by mitosis to form two sperm nuclei (male gametes) (n). The tube is guided by chemotropism and by the tube nucleus which dies when the tube enters the ovule by the micropyle.

Double fertilisation occurs:
One sperm nucleus fuses with the egg nucleus to produce a diploid zygote (2n).
The second sperm nucleus fuses with the two polar nuclei to form a triploid endosperm nucleus (3n)
The zygote develops into an embryo plant and the endosperm forms a food supply for embryo.

Seed/fruit formation

ovule	becomes	the seed.
integuments	become	the testa (seed coat)
ovary	becomes	the fruit (or a modified floral part e.g. apple & strawberry (from receptacle)
ovary wall	becomes	the pericarp (fruit wall)

Developing seeds produce growth regulators to stimulate growth of the fruit tissues.

Seed structure
Testa: tough hard seed coat. Protects seed before germination.
Hilum: Scar. Left by stalk which attached ovule to ovary wall.
Micropyle: pore
Embryo consist of the radicle, plumule and cotyledons:
Radicle: develops into the root.
Plumule: develops into the shoot.
Cotyledons: seed leaves – formed by some of the embryo cells. These contain food reserves which are used in the early stage of germination - before the young plant can make its own food. They secrete enzymes which digest endosperm food, absorb it and pass it on to the developing embryo.

Classification of seeds:

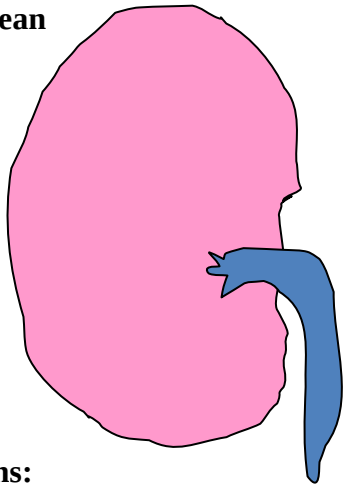
- **Number of cotyledons**

1 cotyledon (1 seed leaf) → monocotyledon e.g. grass, cereals, daffodils
2 cotyledons (2 seed leaves) → dicot e.g. broad bean, pea, sunflower, peanuts.

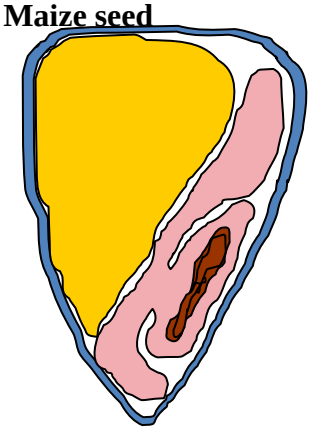
- **Endosperm**: may be present (maize) or absent (broad bean).

The endosperm of wheat seeds is full of starch and this is what is used to make flour.

Broad bean



Maize seed



Fruits
Functions:
To protect the seeds
To enable seeds to be dispersed.

Seedless fruit
Seedless fruit production (parthenocarpy) can be formed genetically, either naturally or by special breeding programmes e.g. bananas and cucumbers, seedless grapes/oranges.
Or by spraying flowers with growth regulators (auxin or gibberellin) - this causes fruit to form without fertilisation taking place e.g. seedless grapes, peppers, cherries, apricots, peaches & some tomatoes.
These growth regulators also cause fruit and vegetable to grow larger.
The plant growth regulator ethane is used to ripen or 'degreen' fruits e.g. melons, bananas, tomatoes. CO_2 inhibits production of ethene – hence apples can be stored over the winter.

DISPERSAL
This is the carrying of fruit or seed as far as possible from the parent plant to ensure survival and minimise the chance of overcrowding and competition.

(a) Wind dispersal:

- Small, light seeds e.g. orchids

- Winged fruits/seeds "helicopters" e.g. sycamore, ash
- Capsules e.g. poppy.
- Parachutes: Plumed fruits e.g. hairy tuft of dandelion, thistle or clematis acts as a parachute.

(b) Animal dispersal:

- Sticky, hooked fruit/seeds e.g. goosegrass, burdock, buttercup become attached to animal coat.
- Edible, fleshy or succulent fruits e.g. blackberry, acorns are eaten by animals, the seeds pass through digestive system and are deposited away from parent plant.

(c) Water dispersal

Floating fruits e.g. water-lily (spongy coat makes them buoyant), coconut (due to large air cavities), alder.

(d) Self-dispersal

Dehiscent fruits have an explosive mechanism e.g. peas, beans, gorse.

DORMANCY:

A resting phase of reduced metabolic activity.

Causes of dormancy:

- Chemical growth inhibitors (e.g. abscisic acid) in testa (may be broken down by water, cold, decay).
- Testa may be impermeable to water and oxygen (eventually decays and allows water and oxygen in)
- Testa too hard for embryo to emerge.
- Embryo is slow to develop due to lack of growth regulator. Regulator may be produced due to increased light or temperatures in spring.

Dormancy in agriculture and horticulture

- Some seeds need a long cold period to bring on germination e.g. apple seeds. The cold may cause the breakdown of the growth inhibitors or the production of the growth promoters such as auxins.
- Other conditions needed before seeds planted include soaking seeds in water, physical damage (e.g. scraping them with fine sandpaper), exposing them to light or dark, exposing them to cold temperatures).

Advantages of dormancy.

- Allows seed to withstand cold winter and adverse conditions e.g. drought.
- Allows germination in spring e.g. warm, good weather.
- By having some seeds dormant in the soil (seed bank) plants can recover from harsh conditions in any particular year or fire etc.
- Allows time for dispersal by wind, water etc. and colonise new areas.
- Allows time for immature embryo to develop.

GERMINATION:

Regrowth of embryo following dormancy.

Requirements:

- **Moisture**: for enzyme activity and for the formation of cell sap (it fills the vacuoles of the newly-formed cells to enlarge and give them turgor), to physically split the testa, to change insoluble food to soluble form (including hydrolysis of starch).
- **Oxygen**: for respiration of food in endosperm/cotyledon
- **Warmth:** effects enzyme action (5^oC - 40^oC).

(Light - most seeds are indifferent. Some need light e.g. lettuce, dandelion)

Digestion and use of food store in a seed

Enzyme	Food store digested	Product(s) formed	Use of products
	oils	**Fatty acids &glycerol**	**Respiration**
	starch	**glucose**	**Respiration & structures (e.g. cell walls)**
	proteins	**Amino acids**	**enzymes**

Expts.: To show the effect of oxygen/water/ temperature on germination.

Types of seedling growth:

(a) **cotyledon remains below ground** e.g. broad bean. Seed absorbs water and begins to grow. Radicle grows down. Plumule emerges and the region between the cotyledon and the plumule grows pushing plumule upwards. The plumule produces the first true leaves which start to photosynthesise.

(b) **cotyledons move above ground** e.g. sunflower. Seed absorbs water, radicle grows down. The region between the radicle and the cotyledons grows causing the cotyledons to be carried above the soil. The cotyledons become green and photosynthesise. The plumule emerges from between the cotyledons and forms the first foliage leaves.

Expt.:To investigate digestive activity in seeds during germination using starch agar plates.

Plant asexual reproduction

Asexual reproduction is the production of organisms from one parent only (no seeds involved).

- Binary fission e.g. bacteria, amoeba
- Spores e.g. fungi.
- Budding e.g. yeast.
- Vegetative reproduction is asexual reproduction in higher plants e.g. runners in strawberries.

A **clone** is a group of organisms which are formed by asexual reproduction (members have identical genotypes) e.g. potato, strawberry, amoeba, identical twins, 'Dolly' the sheep was cloned from the udder cells of another sheep.

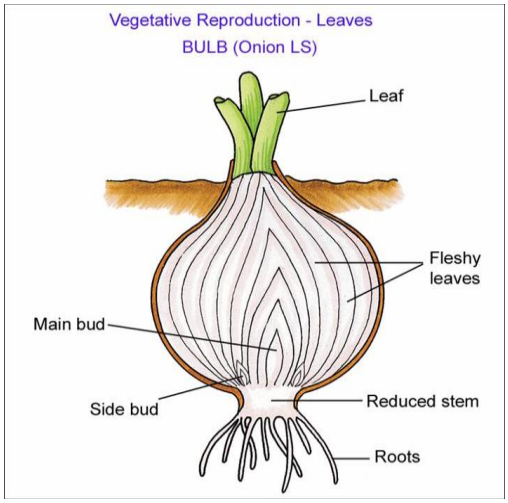
Perennation is the ability of a plant to survive winter as an underground food store.
Advantages:
It allows rapid growth in spring before larger plants/trees get their foliage leaves and block out the sunlight.
The plant can flower and seed quickly - thus reducing competition with other plants.
The plant can survive cutting e.g. daffodils.

Organs of vegetative propagation

(learn one example of each)

Modified Buds (bulbs):

- A bulb is an underground swollen bud (stem is much reduced) that can overwinter beneath soil until the following year e.g. daffodil, onion, tulip, garlic. There is a small stem bearing a terminal bud and axillary buds enclosed in the bases of leaves swollen with food reserves. The axillary buds can grow, using some of the stored food and form foliage leaves and adventitious roots to form independent plants that become detached from the parent.



- Buds sometimes grow into new plants e.g. cacti.

Modified Leaves

- Some plants e.g. Bryopyllum/kalanchoe (mother of thousands) have leaves which give rise to plantlets along their length. These plants fall off and grow into new plants.
- In Begonia leaves fall from the plant and develop into new offspring.

Modified Stems:

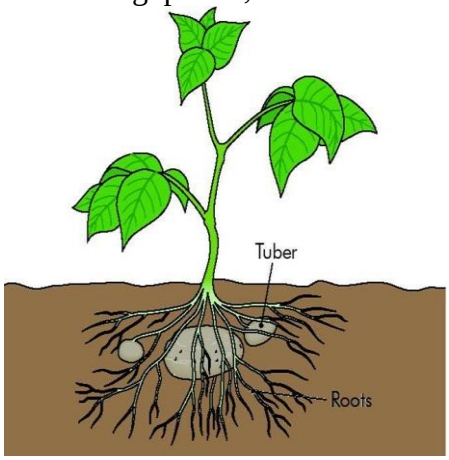
Identified as stems because they bear buds or leaves or leaf scars.

Modified underground stems:

- **Corms** are short vertical underground stems, swollen with food reserves e.g. crocus, cyclamen and gladiolus.
  Axillary buds develop between the stem and scale leaves surrounding the corm. Each may develop into a new plant. Each year the parent plant sends food down from the leaves to form a new corm on top of the old exhausted corm.

- **Rhizomes** are underground horizontal stems swollen with food reserves. It takes a few years to detach and form new plants e.g. primrose, mint, iris, couch grass. Axillary buds arise at scale leaves and grow side branches which grow adventitious roots and foliage leaves. They receive food from the parent and when the intervening rhizome dies, independent plants are established.

- **Tubers** e.g. potato, artichoke.



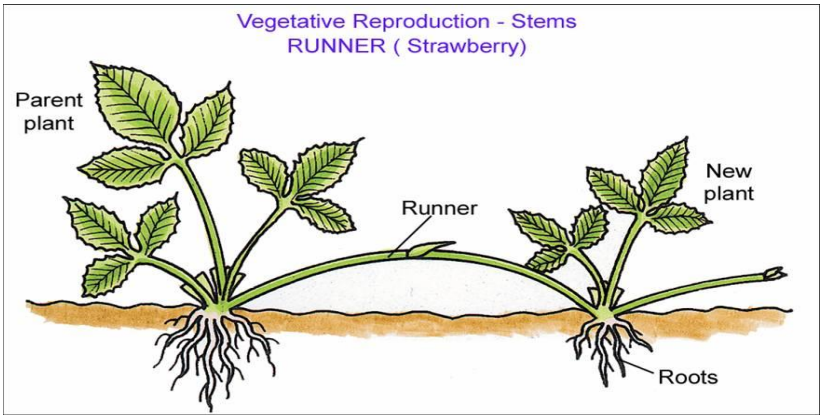
- Tubers are swollen tips of underground stems. It has axillary buds ('eyes') that produce new shoots and roots using the stored food in the tuber. The parent tuber eventually dies away.

- **Suckers**: These are underground stems which run from parent and form new plant e.g. raspberry.

Modified overground stems:

- **Runners** e.g. strawberry, creeping buttercup.

Runners develop from axillary buds at the base of the stem of the parent plant. The terminal bud of the runner sends up a daughter shoot and new roots form into the ground. They receive food from the parent. When the runner dies, independent plants are established.



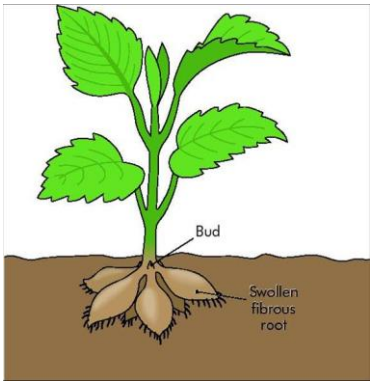
- **Stolons** e.g. blackberry, brambles.

These are aerial stems (branches) which bend over to touch the ground . They root and form new plants.

Modified Roots:

- **Tubers** e.g. dahlia, celandine.

Root tubers are swollen fibrous roots. An axillary bud lies at the top of each tuber just below the stem. Each bud can give rise to a new plant the following summer. Root tubers can be separated from parent plant.



- **Tap roots** e.g. carrot

Tap roots are swollen main roots. They survive the winter and carry on growth in the spring.

Artificial methods of vegetative propagation

Learn 4 methods

- **Cuttings**: part of shoot is removed (cut an internode) and placed in soil or water to form roots e.g. buzy-lizzie, geranium (rooting powder may be used to promote rapid root development).
- **Layering**: a cut shoot (rooting powder may be applied) is pegged into soil and develops there. After about one year adventitious roots grow and it is cut off from parent plant e.g. vines, carnation, blackberry.
- **Budding**: a bud (scion) is removed and taped into a cut on a root stock (e.g. wild rose) e.g. roses. Stock supplies food and support. Bud produces flowers and fruit. Often the stock has a good root system, but does not produce good flowers or fruit.
- **Grafting**: a shoot twig (scion) is removed and taped (and waxed to exclude microorganisms) into the root stock i.e. both cambium layers unite to form one plant e.g. apples, pears, roses.
- **Micropropagation (tissue culture)**
- Individual cells (small piece of stem, root or leaf) can be removed from a plant and then grown in tissue culture. Useful in the mass production of houseplants and commercial crops such as bananas, strawberries and oil palm trees.

Asexual v Sexual reproduction

Asexual reproduction	Sexual reproduction
Advantages: 1. Rapid growth due to maturity.	**Disadvantages:** 1. Plants may take years to develop.
2. Simple process (depends on mitosis) and reliable.	2. Complex.
3. Not dependent on external agents for pollination, fertilisation and seed dispersal.	3. Depends on external agents e.g. wind for pollination, seed dispersal etc. (Seeds are relatively large and makes dispersal difficult).
4. No waste.	4. Wastage of fruit/seed by being eaten by animals, disease, overcrowding, parasites etc.
Rhizomes, bulbs and tubers can be separated to increase stock.	
	Seedlings are delicate.
Offspring identical (helps growers of e.g. fruit.	
Disadvantages: 1. No variation.	**Advantages:** 1. Seeds show **variation** (helps evolution) e.g. getting disease resistant varieties.
2. Overcrowding and competition.	2. Wide **dispersal** due to seeds and fruits. Hence no overcrowding and competition.
3. One disease can wipe out all as plants are similar.	3. Some plants may be resistant to disease.
4. No seeds formed.	4. **Dormancy** - allows survival in adverse conditions.

Plants can be classified as follows:

Annual plants are short-lived, after the seed germinates the plant grows, flowers and produces seeds within one growing season and then dies e.g. sweet pea, cereals, nasturtiums and marigolds.

Biennials do not reach maturity until the second year after the seed is sown e.g. cabbage, celery, turnip, carrot. (We do not usually see them reach maturity, and produce seeds in the second year because they are harvested during the first growing season).

Perennials live for a number of years and may be <u>woody</u> e.g. trees and shrubs, with continuously growing stems (within this classification woody plants may be deciduous or evergreen) or they may be <u>herbaceous</u> stems which die down at the end of each season and are replaced by new ones when growth is renewed e.g. daffodils. They survive by producing perennating organs e.g. bulbs.

Ephemerals: plants which produce several vegetations in the one year e.g. groundsel, shepherd's purse, chickweed.