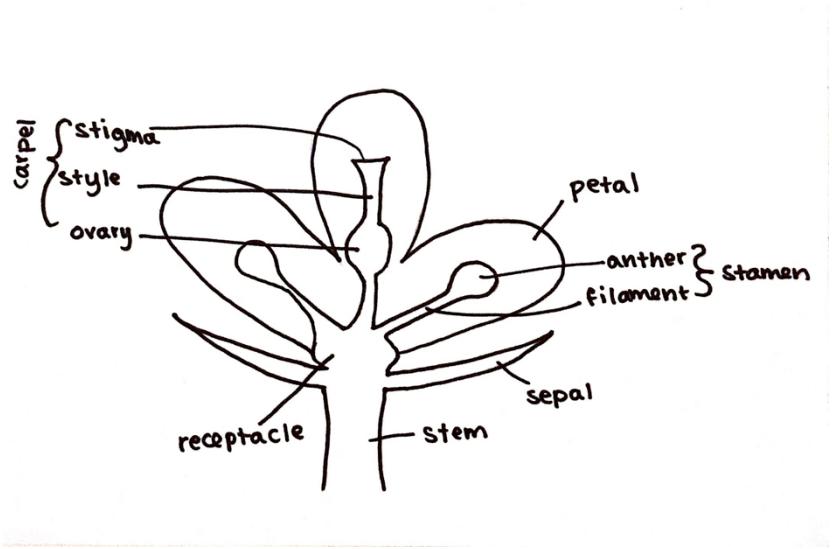
Sexual Reproduction in Flowering Plants

Sexual and asexual reproduction:

- *Asexual reproduction:* only one parent is involved
- *Sexual reproduction:* the fusion of 2 gametes. 2 parents are involved in this process.
- *Gametes:* haploid cells that are able to fuse together

Structure of the flower:



- *Receptacle:* supports the flower/ forms the base of the flower
- *Sepal:* protects the flower when is it a bud
- *Petal:* attracts animals to the flower
- *Stamen:* consists of the anther and filament. It is the male part of the flower.
- *Filament:* supports the anther
- *Anther:* produces pollen grains
- *Carpel:* contains the stigma, style and ovary. It is the female part of the flower.
- *Stigma:* pollen lands here
- *Style:* the pollen tube grows through the style
- *Ovary:* contains one or more ovules

Male gamete formation:

- The anther contains 4 pollen sacs
- Layers of the pollen sac from internal to external
  - Pollen sac
  - Tapetum – provides nutrients to pollen
  - Fibrous layer – for protection
  - Epidermis – for protection
- Microspore mother cells (2n – diploid), found in the pollen sacs, divide by meiosis to form a tetrad of haploid (n) cells.
- The tetrad separates, forming 4 haploid cells, called the pollen grains or the microspore.
- Each pollen grain divides by mitosis to form a tube nucleus and a generative nucleus, which are both haploid.

- The generative nucleus divides by mitosis to form two sperm nuclei (gametes)
- Once the generative nucleus has done this, it is termed a mature pollen grain – contains three nuclei (one tube nucleus and two sperm nuclei)

Female gamete formation:

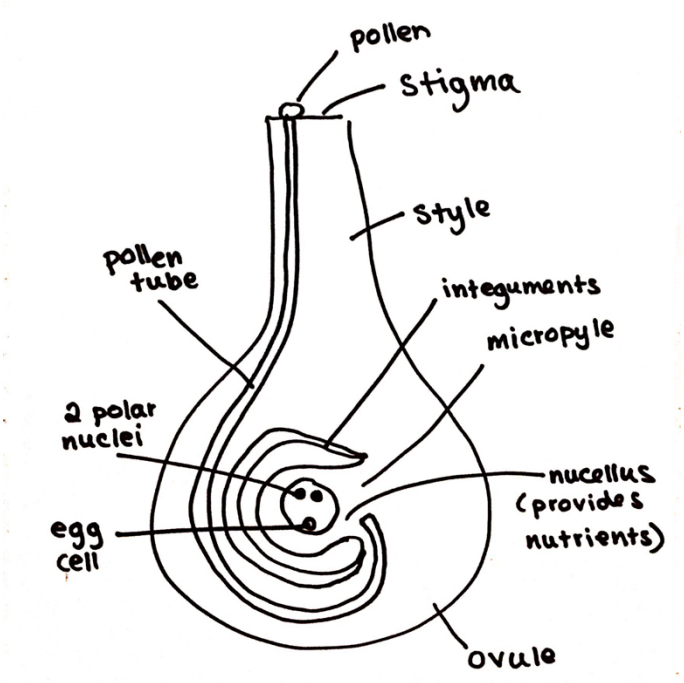
- The megaspore mother cell (2n), located in the ovule divides by meiosis to form 4 haploid cells.
- 3 of these degenerate. One becomes the embryo sac (n).
- The embryo sac divides by mitosis 3 times to form 8 haploid cells.
- 5 of these degenerate.
- One of these becomes the egg cell (gamete) and 2 of them become the polar nuclei.

Pollination:

- *Pollination:* Pollen is transferred from an anther to a stigma of a plant of the same species.
- *Self-pollination:* pollen is transferred from an anther to a stigma of the same plant.
- *Cross pollination:* pollen is transferred from an anther of one plant to a stigma of another plant of the same species.
- *Wind pollination vs animal pollination:*

Wind pollination	Animal pollination
Large amounts of small, light, dry pollen	Small amount of sticky, heavy, large pollen
Green petals	Large, bright, colourful petals
Anther and stigma are located outside of the petals	Have nectar

Fertilisation:



- ➢ *Fertilisation:* the fusion of a male (n) and female (n) gamete to form a diploid zygote (2n).
- ➢ *Process of fertilisation:*
  - A pollen grain lands on the stigma.
  - The pollen grain divides by mitosis to form a tube nucleus and a generative nucleus.
  - The tube nucleus grows towards the micropyle due to chemotropism, forming the pollen tube*
  - The generative nucleus divides by mitosis to form 2 sperm nuclei.
  - The sperm nuclei travel down the pollen tube to the ovule.
  - Plants undergo double fertilization:
  - One sperm nucleus joins with the egg cell to form a zygote (2n)
  - One sperm nucleus joins with the 2 polar nuclei to form a triploid endosperm nucleus (3n).
  - *Pollen tube allows the male gametes to move towards the egg without need for water/liquid

Seeds:

- ➢ The ovule becomes the seed
- ➢ The ovary becomes the fruit
- ➢ The integuments become the testa/seed coat. The testa is needed for seed protection.
- ➢ The radicle develops into a root.
- ➢ The plumule develops into a shoot.
- ➢ The endosperm forms from the nucellus
- ➢ The cotyledon is one of the food stores that a seed can have. It absorbs the endosperm
- ➢ *Non-endospermic seed:* has no endosperm when fully formed, e.g. broad bean [?] form dicots
- ➢ *Endospermic seed:* has endosperm when fully formed, e.g. maize [?] form monocots
- ➢ *Monocots:* have only one seed leaf (note: cannot say have only one cotyledon) eg. daffodils
- ➢ *Dicots:* have two seeds leaves eg. Peanuts
- ➢ Monocots store food in the endosperm
- ➢ Dicots store food in the cotyledons

Fruit:

- ➢ Fruit develops from the fertilized ovary
- ➢ Fruit formation is stimulated by auxins (growth regulators) which are produced by seeds
- ➢ Ovary wall becomes the pericarp, which is the wall of the fruit
- ➢ It is possible to form fruit without seeds eg. Seedless grapes. This is known as parthenocarpy and can occur in two ways
  - ○ May arise genetically, either naturally or by special breeding
  - ○ May arise from spraying plants with certain growth regulators

Dispersal:

- ➢ *Dispersal:* the transfer of a seed or fruit away from the parent plant

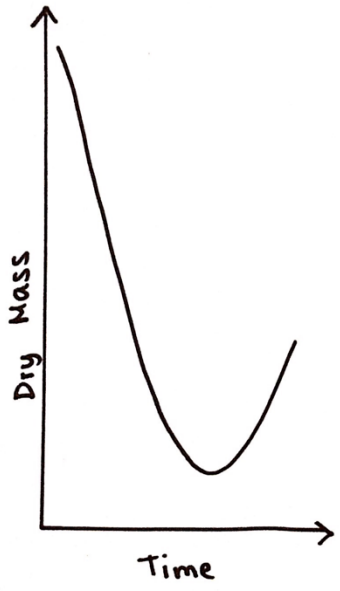
- Dispersal is necessary for colonisation (finding new areas to grow) and to prevent competition with other plants
- *Types of dispersal:*
  - Wind dispersal, e.g. sycamore
  - Water dispersal, e.g. coconuts
  - Animal dispersal, e.g. blackberries (seeds are undigestible)
  - Self dispersal, e.g. peas (the pod bursts open to release the seeds)

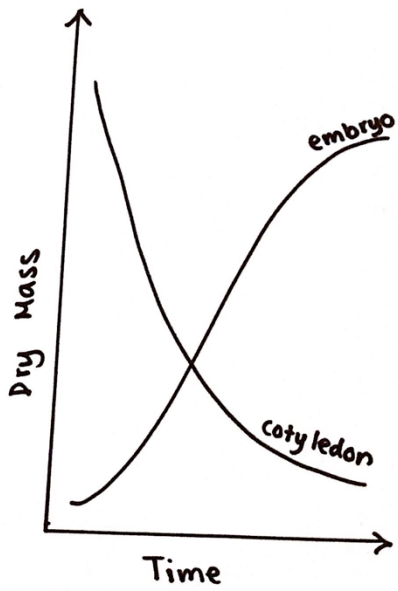
Dormancy:

- *Dormancy:* a period where no growth occurs and the metabolic activity of the plant is decreased
- *Methods of dormancy:*
  - Growth inhibitors
  - Testa that is too tough to let the embryo emerge
  - Testa that is impermeable to water
- *Advantages of dormancy:*
  - Allows time for dispersal
  - Allows time for the embryo to develop
  - The plant is protected from harsh winter conditions
- Horticulturists can break dormancy by placing seeds in the fridge or breaking the testa before germinating

Germination:

- *Germination:* a period of time following dormancy, where the embryo continues to grow if environmental conditions are suitable
- *Events in germination:*
  - The seed absorbs water through the micropyle or the testa
  - Digestion of food stores occurs: oils are digested to fatty acids and glycerol, proteins are digested to amino acids, starch is digested to glucose
  - The products of digestion are transported to the embryo
  - Glucose and amino acids are used to make cell walls and enzymes
  - Fats and glucose are used in respiration to make energy
  - The dry mass is reduced due to the foods being used up in respiration
  - The radicle bursts through the testa
  - The plumule grows above the ground and leaves grow
  - When the plant begins to photosynthesise, the dry mass increases again

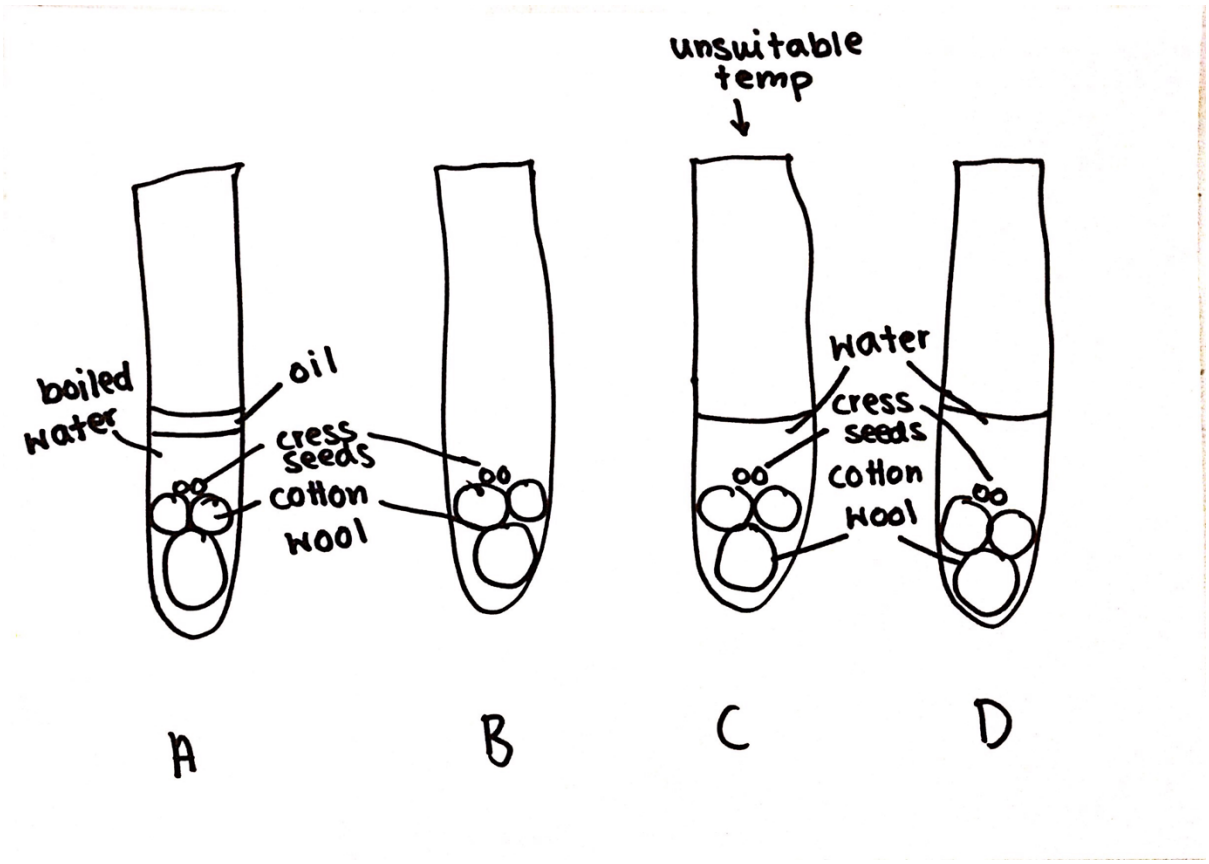




- ➢ *Conditions necessary for germination:*
  - Water – allows enzyme reactions to occur
  - Oxygen – required for aerobic respiration
  - Suitable temperature – allows enzyme reactions to occur without enzymes becoming denatured

Investigate the conditions necessary for germination:

- ➢ Place cotton wool in 4 test tubes
- ➢ Place cress seeds into the test tubes, onto the cotton wool
- ➢ Label the tubes A, B, C, D
- ➢ Add boiled water and a layer of oil to A (anaerobic conditions)
- ➢ Add tap water to C and D (no water in B).
- ➢ Place C in the fridge (incorrect temperature).
- ➢ Keep A, B and D at a suitable temperature – 25 degrees for 3 days
- ➢ Germination occurs in control test tube D that contains water, oxygen and a suitable temperature.
- ➢ Germination does not occur in A, B, C due to the absence of oxygen, water and a suitable temperature respectively.



To use starch agar to show digestive activity:

- ➢ Soak 4 broad beans in water for a day – this softens the testa and removes any inhibitors present
- ➢ Wash the bench with disinfectant – kills any micro-organisms present
- ➢ Kill 2 seeds by boiling them in water for 5 mins (control) – this denatures the enzymes

- Use a backed blade to cut the 4 seeds in half – this will increase the surface area between the enzymes in the seeds and the starch agar
- Sterilise by soaking the seeds in disinfectant for 10 mins
- Flame a forceps to sterilise
- Place 4 half seeds (unboiled) cut side down into the starch agar – label this dish A
- Place 4 half seeds (boiled) cut side down into the starch agar – label this dish B
- Place both dishes in a warm place for 2 days
- Add iodine to the dishes
- In dish A there are clear spots under the seeds, the rest of the agar is blue/black. Enzymes in the seeds (amylase) breaks down the starch
- In the control dish all of the agar turns blue/black. Amylase was denatured.

Vegetative propagation:

- *Vegetative propagation:* asexual reproduction in plants
- *Natural vegetative propagation:*
  - Stem, e.g. runners in strawberries
  - Root tuber, e.g. dahlia
  - Leaf, e.g. kalanchoe
  - Bulb, e.g. onion
- *Artificial vegetative propagation:*
  - Cutting: a portion of the plant is removed, placed in rooting powder and allowed to grow into a new plant, e.g. Busy Lizzie
  - Grafting: a part of a plant is cut and attached to a healthy rooted part of another plant, e.g. rose
  - Layering: the parent plant is bent and covered in soil. It forms new roots and shoots, e.g. blackberries
  - Micropropagation: small parts of a plant are grown on a nutrient medium

Sexual vs asexual reproduction:

Sexual	Asexual
More variation (2 parents)	No variation (1 parent)
Complex process	Simple process
Outside agents are needed for pollination and dispersal	No outside agents needed
Wasteful	No waste
	Offspring susceptible to the same diseases as parents
	Increased competition
	Desirable characteristics of parent plants can be maintained in the offspring

Sample Qs and answers:
2018 Q14 (a)

Q14. (a)(i) *Dispersal:* a seed is transferred away from the parent plant

Suggest: -For colonisation to occur
-To reduce competition
(ii) Horticulturists can break dormancy by placing seeds in the fridge or breaking the testa before planting the seed in order to break dormancy
(iii) -Oxygen
-Suitable temperature
(iv) *Digestion:* in order to make nutrients absorbable and transportable
Respiration: provides the seed with energy
(v) 1. Mass decreased due to food stores being used up in respiration
2. Mass increased as the peas grew leaves that began to photosynthesise, increasing the mass of the food stores
(vi) Glucose

2017 Q6.
Q6. (a) *In flowering plants:* meiosis, then mitosis
In humans: meiosis
(b) *In flowering plants:* embryo sac
In humans: Graafian follicle
(c) *In flowering plants:* embryo sac
In humans: fallopian tube
(d) *In flowering plants:* embryo
In humans: morula
(e) *Advantage:* allows for more variation
Disadvantage: two parents are needed

2017 Q9 (b)(i)

(b) (i) 1. Use boiled, cooled water and add a layer of oil on top
2. Shoots and roots grew from the seeds

2017 Q11 (c)

(c) (i) asexual reproduction in plants
(ii) -offspring is genetically identical to the parent
-There is only one parent plant
(iii) *leaf:* kalanchoe
bud: bulb, e.g. onion
(iv) cuttings/ grafting/ micropropagation
(v) characteristics that are useful/desirable (e.g. petal colour) can be maintained

Structure & Pollination:
HL Paper 2006 Q14 (A)

(a)

Answer the following in relation to sexual reproduction in flowering plants.

(i) State a role for each of the following: sepal, anther, stigma, ovary.

- The sepal protects the flower when it is a bud.
- The anther is part of the male part of the flower that produces pollen.

- The stigma is in the female part of the flower where the pollen lands in order for sexual reproduction to commence.
- The ovary contains the ovules which is the site of fertilisation.

(ii) Distinguish between pollination and fertilisation.

- Pollination is the transfer of pollen from an anther to a stigma of a flower from the same species.
- Fertilisation is the fusion of the male and female gametes to form a diploid zygote.

(iii) The two male gametes in the pollen tube are derived from the generative nucleus.

Do these gametes form as a result of mitosis or meiosis? Explain your answer.

- They divide via mitosis.
- This is because the generative nucleus is already haploid, so it cannot divide again y meiosis. Therefore it divides by mitosis so that there are two haploid sperm nuclei, that will continue onto fertilisation.

(iv) Describe the fate of each of the male gametes.

- One sperm nucleus will join with the egg nucleus to form a diploid zygote.
- The second sperm nucleus joins with the two polar nuclei to form a triploid endosperm nucleus, which acts as a food store.

Fertilisation:

HL Paper 2010 Q15 (B)

(i) Describe the development of pollen grains from microspore mother cells.

- From microspore mother cells, they divide by meiosis to produce a cluster of four haploid cells called a tetrad, which break up to for four separate haploid pollen grains.
- While still in the pollen sac, the pollen may divide by mitosis to produce two haploid nuclei – the tube and the generative nuclei.
- The tube nucleus will form the pollen tube and then degenerate. The generative nucleus will form the male gametes.
- When pollen grains have matured, the walls of the anther become dry and shrivelled. This results in the dehiscing of the anther walls. The pollen grains are then exposed to the outside of the anther.

(ii) What is meant by the term fertilisation?

- Fertilisation is the fusion of the male and female gametes to form a diploid zygote.

(iii) Give a brief account of the process of fertilisation in flowering plants.

- When a pollen grain lands on a stigma, the stigma produces sugars that stimulate growth. A pollen tube grows down through the style towards the ovule.
- The pollen tube grows towards chemicals released by the ovule (chemotropism) and is controlled by the nucleus, which degenerates upon reaching the micropyle.
- The haploid generative nucleus divides by mitosis as it moves down the pollen tube, and as a result, two haploid male gametes are formed.
- One sperm nucleus will join with the egg nucleus to form a diploid zygote.
- The second sperm nucleus joins with the two polar nuclei to form a triploid endosperm nucleus, which acts as a food store.

Fruit formation, seed dispersal & germination:

HL Paper 2010 Q15 (C)

(i) What is meant by the dormancy of seeds?

- Dormancy is a resting period, when seeds undergo no growth and have reduced all cell activity or metabolism.

*(ii) Give **one** way in which the dormancy of seeds is of benefit to plants.*

- It allows the plant to avoid harsh conditions of winter.

*(iii) Suggest **one** way in which a knowledge of dormancy is useful to farmers and gardeners.*

- They may need to know of a way in order to break dormancy before the seeds are planted, which may include soaking the seeds in water.

(iv) Water, oxygen and a suitable temperature are all required for the germination of seeds.
*In the case of **each** of these factors describe its effect on the process of germination.*

- Water is needed to allow enzyme reactions to occur. The seed absorbs water, causing it to swell, which allows enzymes to function.
- Oxygen is needed for aerobic respiration. It is absorbed from the soil.
- A suitable temperature is needed to allow enzyme reactions to take place. Each species has its own optimum temperature for optimum enzyme activity.

(v) Which part of the embryo in a germinating seed gives rise to each of the following parts of
the seedling?

1. The root

- Plumule.

2. *The shoot*.
   - Radicle.