Reproduction

PLAN

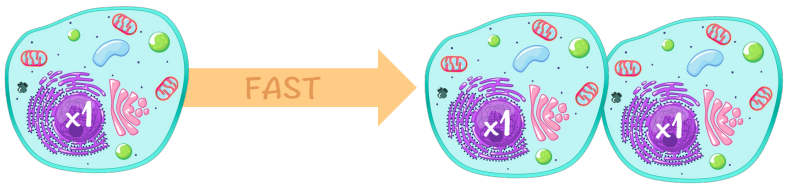
REPRODUCTION – refers to the biological process by which organisms produce new individuals of the same species. It ensures the continuation of a species and the transfer of genetic information from one generation to the next.

Section 1
HUMAN AND ANIMAL REPRODUCTION

A multitude of methods may be employed by organisms to pass on their genetic material to their offspring, and we can categorize them into two main ways: **ASEXUAL REPRODUCTION** and **SEXUAL REPRODUCTION** which differ in their mechanisms.

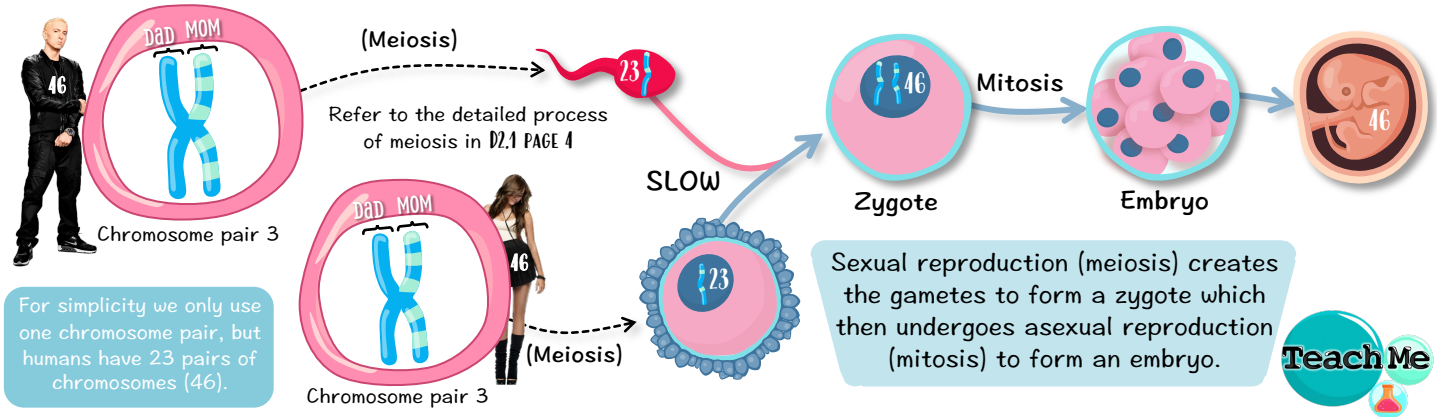
	Asexual reproduction	Sexual reproduction
What	A process that aims to pass **GENETIC INFORMATION** onto the offspring **WITHOUT** gametes (sex cells) and **FERTILIZATION** (see page 9).	A process that aims to pass **GENETIC INFORMATION** onto the offspring **WITH** gametes (sex cells) and **FERTILIZATION** (see page 9).
Parents	Only **ONE PARENT** required.	**TWO PARENTS** required (sperm and egg).
Offspring	Genetically **IDENTICAL** to parent.	Genetically **UNIQUE** compared to both parents.
Variation	Relatively **LITTLE** genetic variation.	Promotes genetic **VARIATION**.
Adaptation	Allows **LITTLE** adaptation (good in non-changing area).	**ALLOWS** adaptations for a changing environment.
Examples	*Binary fission, mitosis, budding, fragmentation, vegetative propagation, parthenogenesis.*	*Human with human. Mantis with Mantis.*

Asexual reproduction diagram:



NOTICE!
Asexual reproduction is **NOT** any less important (or inferior) of a form of reproduction.

Sexual reproduction diagram:



Reproduction

A Asexual Reproduction

Various ways may be undertaken for a cell to undergo asexual reproduction, the method by which it does so depends mainly on the cell type.

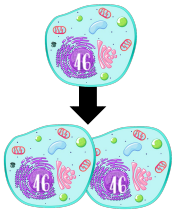
1. Mitosis

What – Production of two genetically identical cells. Applies to eukaryotic cells (plants or animals.)

Why – Repair and growth

How – Replication of organelles and genetic material followed by spitting of the cell.

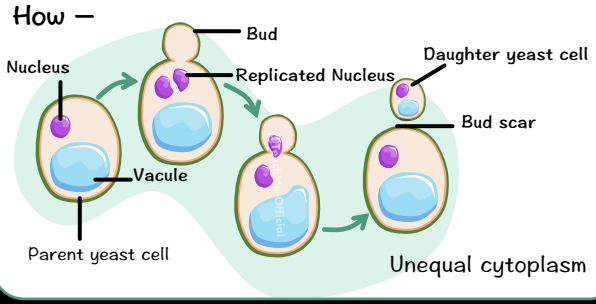
(details in D2.1)



2. Budding

What – Cell division in fungi (yeast) and in some animals (hydra).

How –

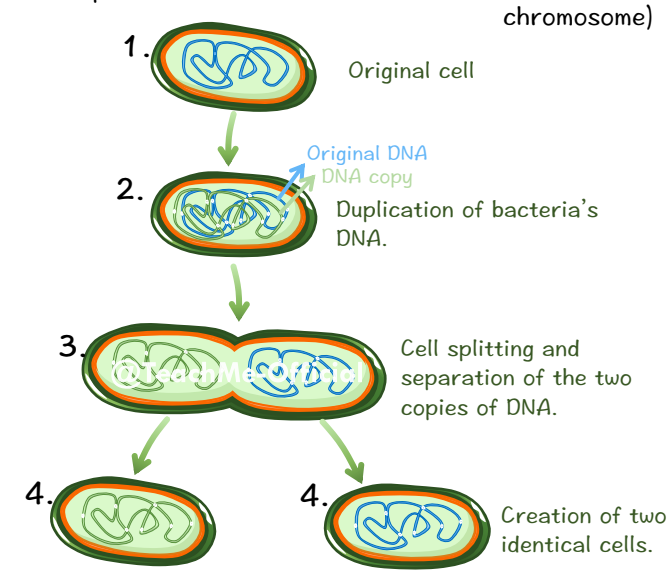


3. Binary Fission

What – Cell division in prokaryotic cells (like bacteria). Very FAST process.

How – process learned in A2.2

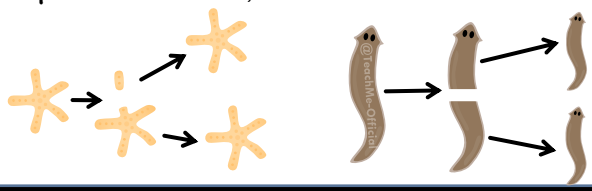
(Only a single chromosome)



4. Fragmentation

What – A piece (fragment) of the body of an existing organism breaks off; each develops into an individual offspring.

Examples – Sea stars, annelid worms



5. Parthenogenesis

What – Growth and development of an egg cell without the involvement of a male gamete (only female). No fertilization.

Examples – Bees, ants, wasps, some reptiles and fish

6. Vegetative Propagation

What – A new plant grows from a fragment of the parent plant or grows from a specialized reproductive structure (roots, bulbs, tubers or shoots). Runners grow into clones of the parent plant.

Runner – a slender stem that grows horizontally along the ground, giving rise to roots and aerial (vertical) branches at specialized points called nodes

Examples – Strawberries (runners), potatoes (tubers).

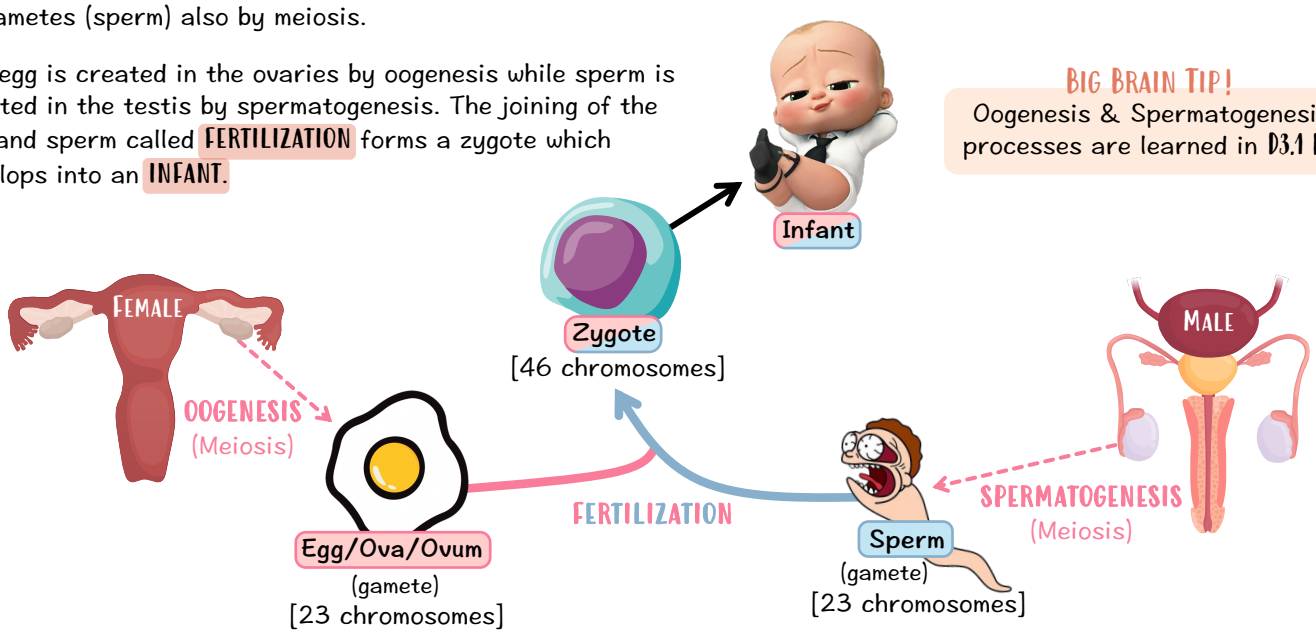
Reproduction

B Sexual Reproduction

The process of sexual reproduction includes two main stages: **Meiosis** and **Fertilization**. In females, **oogenesis** is the process by which gametes (the egg) are produced by the process of meiosis. In males, **spermatogenesis** is the production of gametes (sperm) also by meiosis.

The egg is created in the ovaries by oogenesis while sperm is created in the testis by spermatogenesis. The joining of the egg and sperm called **fertilization** forms a zygote which develops into an **infant**.

Big Brain Tip!
Oogenesis & Spermatogenesis processes are learned in D3.1 HL



Meiosis allows the formation of a haploid cell (cell which only contains half of the genetic material) from a diploid cell. Each gamete containing only **half of the genetic material** allows for the zygote to contain half of the father's and half of the mother's DNA. Meiosis is known as a type of reductive division.

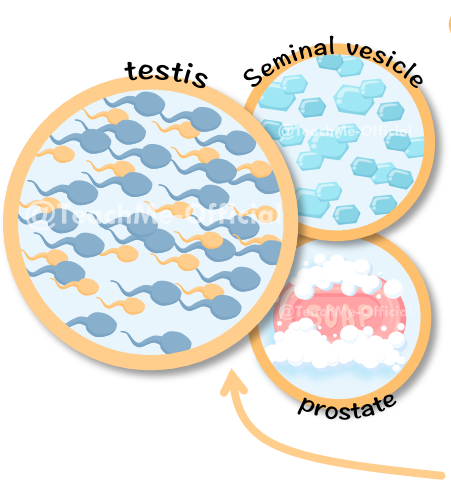
Diploid (2n) → Haploid (n)
Reduction Division

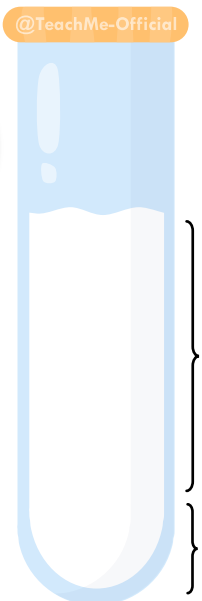
A Male Reproductive System

In males, the reproductive tract and urinary system are intricately connected (see page 4).

Spermatozoa (sperm) forms in the **testis**, and in the **epididymis** they develop the ability to swim. The **seminal vesicles** produce a sugar-rich fluid and the **prostate** produces a fluid with high pH. The combination of these form **semen**: sugar-rich to fuel the spermatozoa's potentially long journey and high pH to overcome they highly acidic vaginal fluids.

Composition of semen





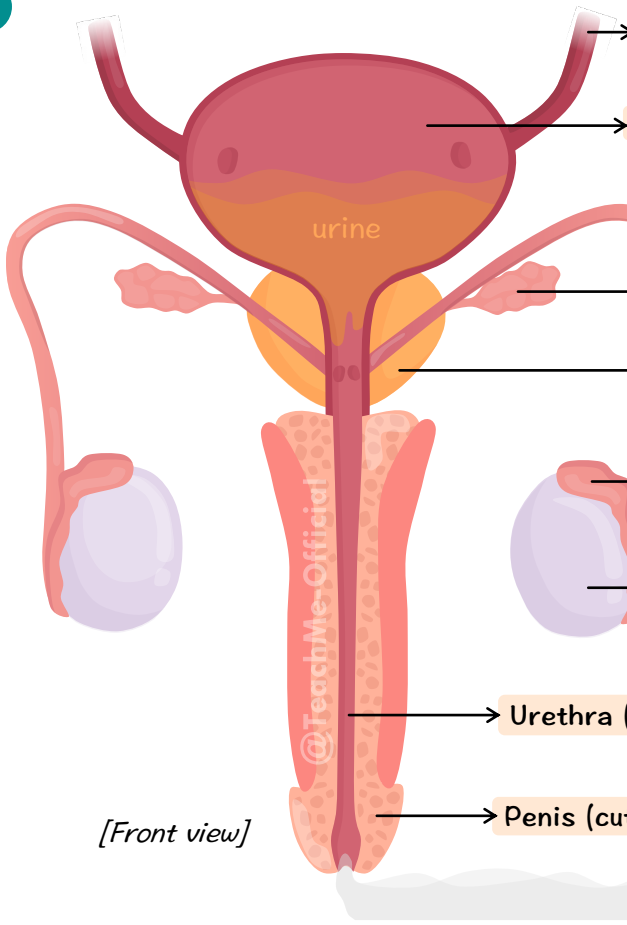
70% of semen is from the seminal vesicle: semen can also be called seminal fluid.

Remainder made up of prostatic fluid and sperm

Big Brain Tip!
Seminal vesicle - Sugars
Prostate - PH

Reproduction

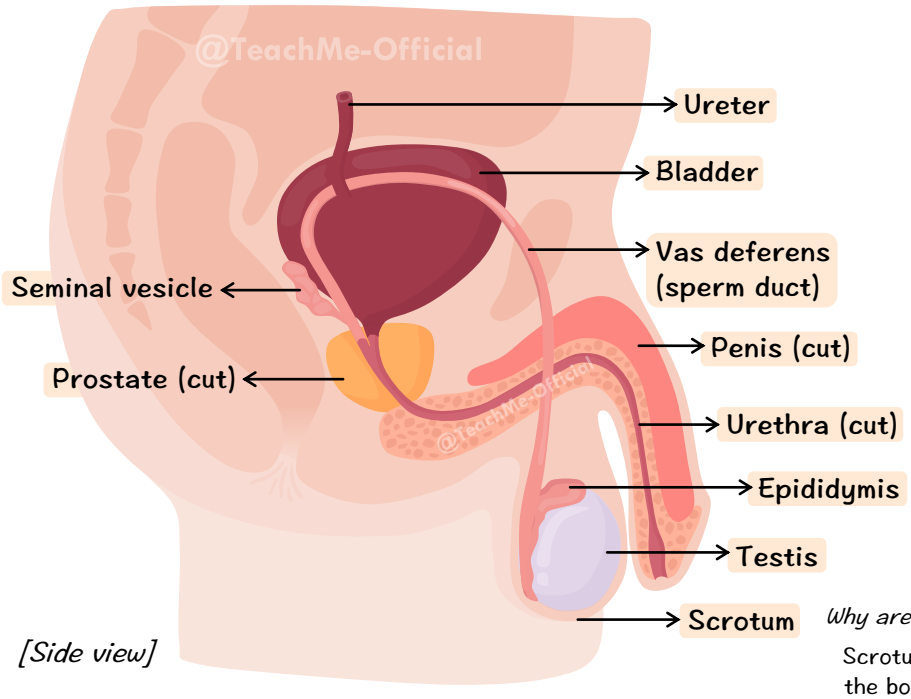
The structure of the male reproductive tract is best understood when combining a front and a side view to accurately depict the relationship and position of each organ and structure:



[Front view]

- **Ureter** — A muscular tube that transports urine from kidneys to the bladder.
- **Bladder (cut)** — A bag-like structure that stores urine.
- **Vas deferens** — Pipe that carries mature sperm from the epididymis to the urethra during an ejaculation.
- **Seminal vesicle** — Gland that makes fructose (energy), and mucous that will join the sperm.
- **Prostate (cut)** — Gland that makes alkaline solution to aid sperm in defense against the acidic environment of the vagina.
- **Epididymis** — Where sperm is received, then become mature and become capable of swimming.
- **Testis** — Male gonads. Where sperm is made (more specifically within the seminiferous tubules).
- **Urethra (cut)** — Where the urine, sperm and all other contents (from glands) exit the male reproductive system.
- **Penis (cut)** — A pipe-like organ that becomes erect because of blood engorgement to facilitate ejaculation.

Semen



[Side view]

2 systems share 1 opening!

Pathway of Sperm

SPERMATOZOA move from the TESTIS into the EPIDIDYMIS, and into the VAS DEFERENS. Here the fluids from the seminal vesicle and the prostate join in to form semen. Finally, semen is ejaculated by the PENIS through the URETHRA.

Pathway of Urine

Urine, created in the KIDNEYS (chapter D3.3 HL), travels into the URETERS and is stored into the BLADDER. During urination, urine makes its way out via the PENIS through the URETHRA.

*Why are testis held **outside** the body in the scrotum?*

Scrotum is a sac in which the testis are held outside the body. Sperm production and maturation requires temperature cooler than internal body temperature.

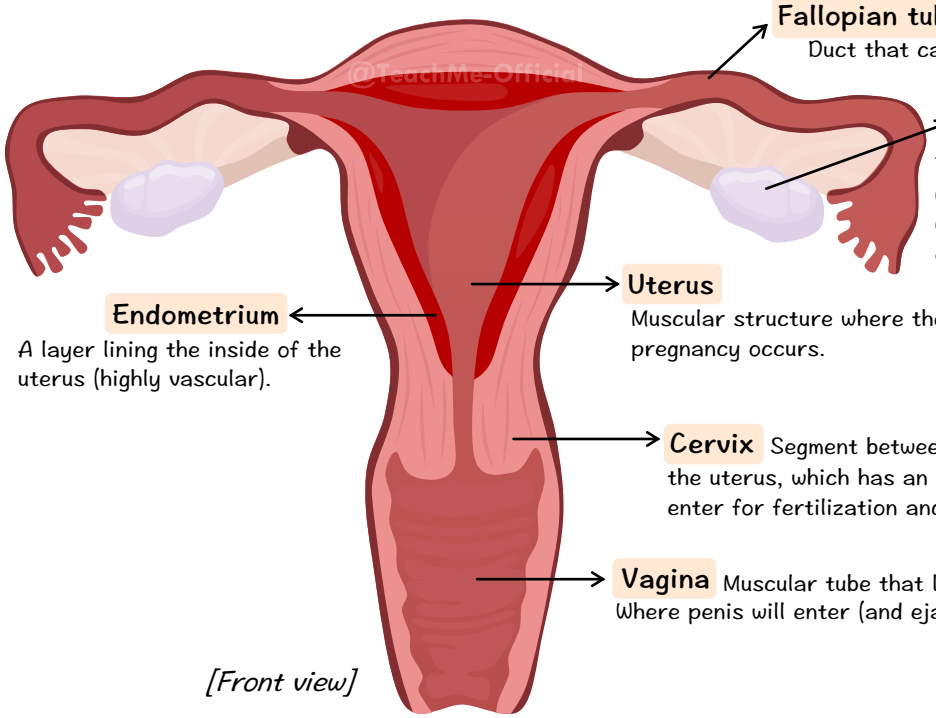
Sound-a-like words

Ureter (two: one right, one left) – urine from kidney to bladder
Urethra (one only) – semen and urine

Reproduction

2 Female Reproductive System

Oocytes (egg) form in the **ovaries**, during **ovulation** (page 8) an egg is released and travels through the **Fallopian tube**. If the egg gets fertilized by sperm, this embryo will implant in the **uterus** to grow into a fetus. If fertilization does not occur, the unfertilized egg will continue its journey through the uterus and will be excreted during menstruation through the **cervix** and out the **vagina**.



Fallopian tube (oviduct)
Duct that carry the egg (or early embryo to the uterus).

Ovary
The female gonads. (1) Where the female egg will be created. (2) Ovulation occurs here. (3) Corpus luteum formation occurs here. (4) estrogen & progesterone production.

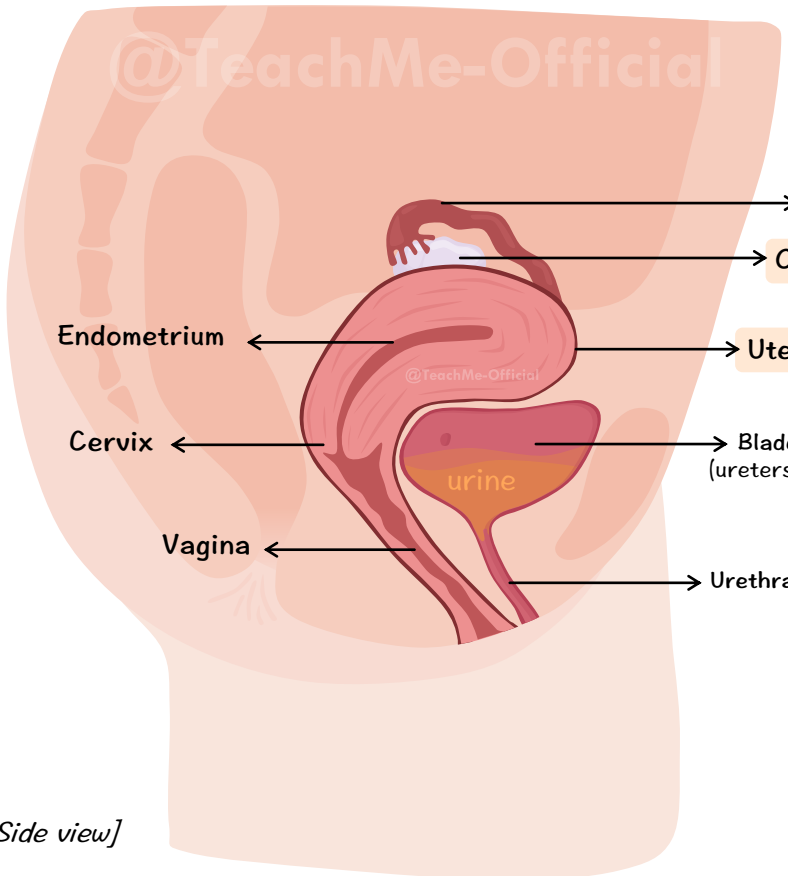
Endometrium
A layer lining the inside of the uterus (highly vascular).

Uterus
Muscular structure where the embryo implants and develops if a pregnancy occurs.

Cervix Segment between the vagina and the uterus. Lower portion of the uterus, which has an opening to the vagina that allows the sperm to enter for fertilization and provides a pathway for childbirth

Vagina Muscular tube that leads from the external genitals to the cervix. Where penis will enter (and ejaculate).

[Front view]



[Side view]

Big Brain Tip!
Notice the female reproductive system is separate from the urinary system - unlike in males.

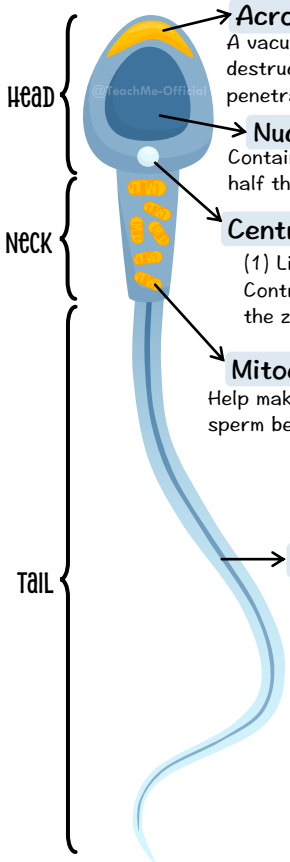
Reproduction

3 Sperm vs. Egg Structure

Some animals produce large numbers of eggs, especially if the fertilization process is external – such as frogs. However human females typically release ONE EGG during the menstrual cycle (although two or more is possible). This egg provides all the nutrients needed to sustain the growth of the embryo. Eventually, when the embryo implants into the uterus, the uterus and placenta will continue providing nutrients.

Sperm structure	Egg structure
Sperm is very small	Egg is very large
Motile	Sessile (non-motile)
Millions of sperm each day	One egg each month
Contributes nothing towards the food serves, merely to deliver DNA to the egg	Contains all the nutrients needed for early embryonic growth

The structure of sperm and egg was also learned in chapter B2.3 (HL)



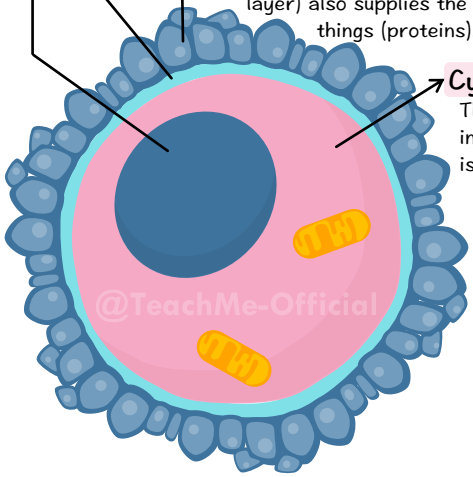
Acrosome
A vacuole (or sac like thing) that contains enzymes useful in destruction of the egg membrane to allow the sperm to penetrate the egg.

Nucleus
Contains the DNA. Gametes (like sperm & egg), only contains half the number of DNA.

Centriole
(1) Links the head and the tail. (2) Cell division role. (3) Controls beating (swimming). (4) Plays a role in forming the zygote cell structure (cytoskeleton).

Mitochondria
Help make ATP (cell energy). There are a lot of them in the sperm because "swimming" takes lots of energy.

Filament (flagellum)
This structure is responsible for allowing swimming to happen. It is like the fins of a fish.



Nucleus
Organelle that contains the genetic material (DNA). Egg cells (sex cells) only carry half the DNA.

Zona pellucida
A layer inner to the corona radiata to prevent polyspermy and only allows species-specific fertilization.

Corona radiata
A layer of cells surrounding the egg (protective layer) also supplies the egg cell with vital things (proteins).

Cytoplasm
The jelly-like liquid in which everything is floating.

Did you know?

In humans, SPERM is the smallest cell and the EGG is the largest!

Have you Noticed...?

The mitochondria found in the sperm are only used to provide energy for sperm to move towards the egg. The zygote will use the egg's mitochondria (FERTILIZATION – PAGE 9).

Reproduction

4 The Menstrual Cycle

What is the menstrual cycle?

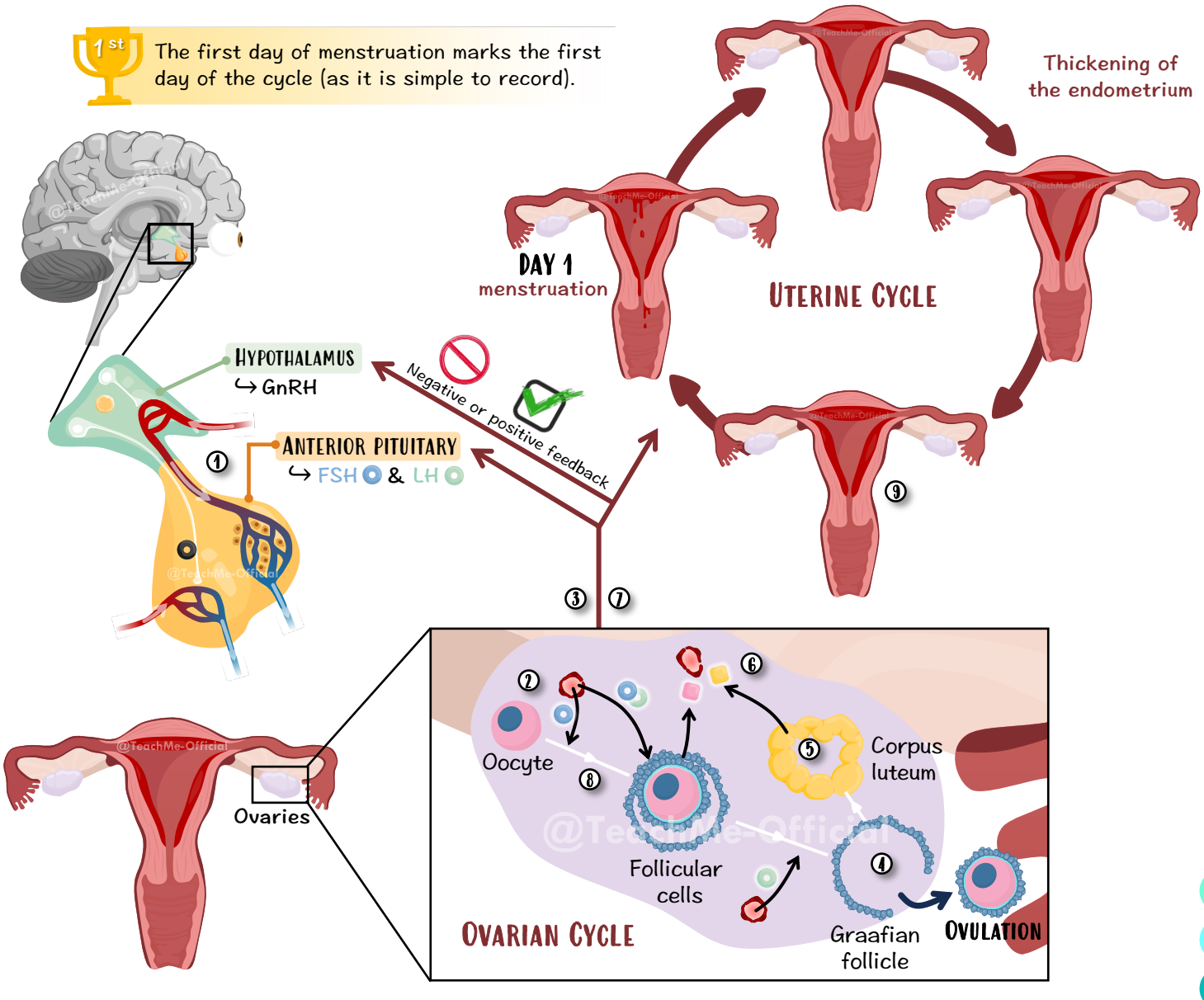
MENSTRUAL = MONTHLY

The menstrual cycle is a **HORMONAL CYCLE** which lasts approximately **28 DAYS**. This cycle times the release of an egg for possible **FERTILIZATION** (see more details on page 8) and implantation into the endometrium. This cycle begins at **PUBERTY**. It is characterized by **MENSTRUATION** (menstrual bleeding) which is the shedding of the endometrium in the absence of fertilization.

Menstrual cycle = Ovarian cycle + Uterine cycle

The menstrual cycle comprises the **OVARIAN CYCLE**: the monthly preparation and the release of an egg cell from the ovary. As well as the **UTERINE CYCLE**: the build-up of the uterine lining (the endometrium).

On **PAGE 8**, find the detailed steps of the menstrual cycle, follow along with the numbers on this diagram:



BIG BRAIN TIP!
LH – Let Her go (egg)

GnRH (Gonadotropin-releasing hormone)
LH (luteinizing hormone)
FSH (Follicle stimulating hormone)
Progesterone
Estrogen

Reproduction

Ovarian & Uterine Cycle

1. **GnRH** (from hypothalamus) stimulates production of **FSH** & **LH** (by pituitary).
2. **LH & FSH** → Stimulates ovary to produce **Graafian follicles** (mature eggs). Increase the production & secretion of **Oestradiol** by **follicle cells**.
3. **Oestradiol** → At low concentrations, negative feedback (reduce **GnRH**, **LH** & **FSH**). Increase blood **vessel density** in the **endometrium** (highly vascular).
4. At high concentrations, positive feedback (increases GnRH, FSH & **LH**).
4. Positive feedback of Oestradiol leads to **LH** surge (spike), which leads to **ovulation**.
5. **Graafian follicle's** outer ring of follicle cells remains within the ovary to becomes **corpus luteum**.

Corpus luteum — Body: Yellow

6. These follicle cells produce and secrete **progesterone**. Active for 10-12 days after ovulation.
7. **Progesterone** → Maintains the thickened **highly vascular endometrium**. High levels provide a negative feedback signal to hypothalamus and prevent production of **GnRH**.
8. **FSH** and **LH** will be low, another **Graafian follicle** will NOT be made.

9 Pregnancy:

After fertilization, a special hormones is made.

This hormone keeps the corpus luteum **alive**.

Endometrium can be **maintained**.

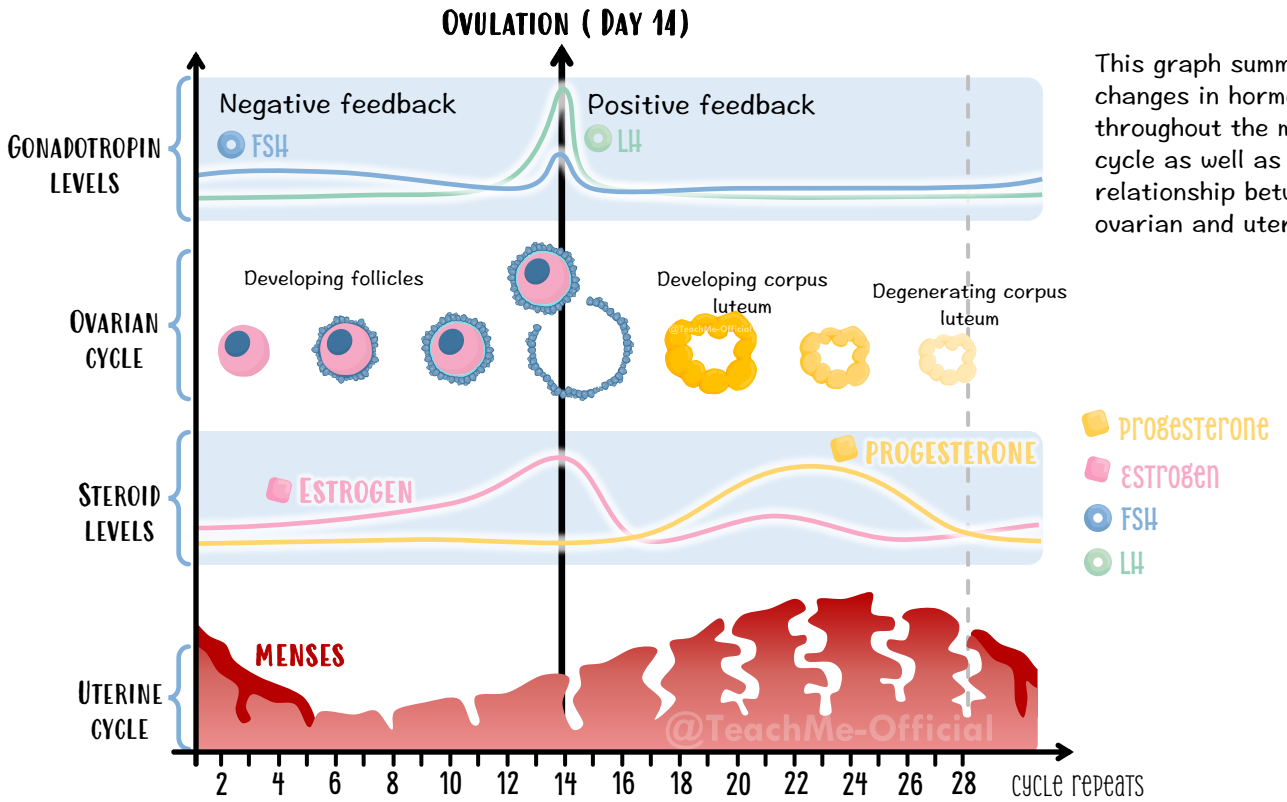
9 No Pregnancy:

Without fertilization, the special hormone isn't made to maintain the corpus luteum.

Corpus luteum will **break down**, leads to decline in **progesterone**.

Vascular endometrium **no longer maintained**. Blood vessels of the endometrium rupture and **menstruation** begins.

The drop in **progesterone** also signals the hypothalamus to begin secreting **GnRH**, and thus another menstrual cycle begins.



This graph summerizes the changes in hormone levels throughout the mentrual cycle as well as the relationship between the ovarian and uterine cycle.

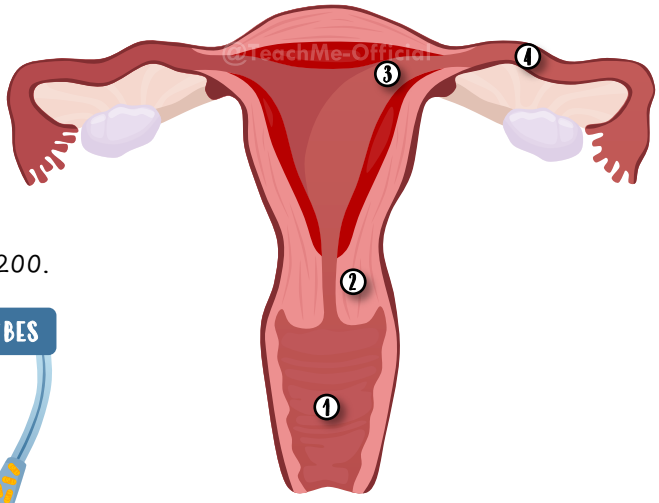
Reproduction

5 Fertilization

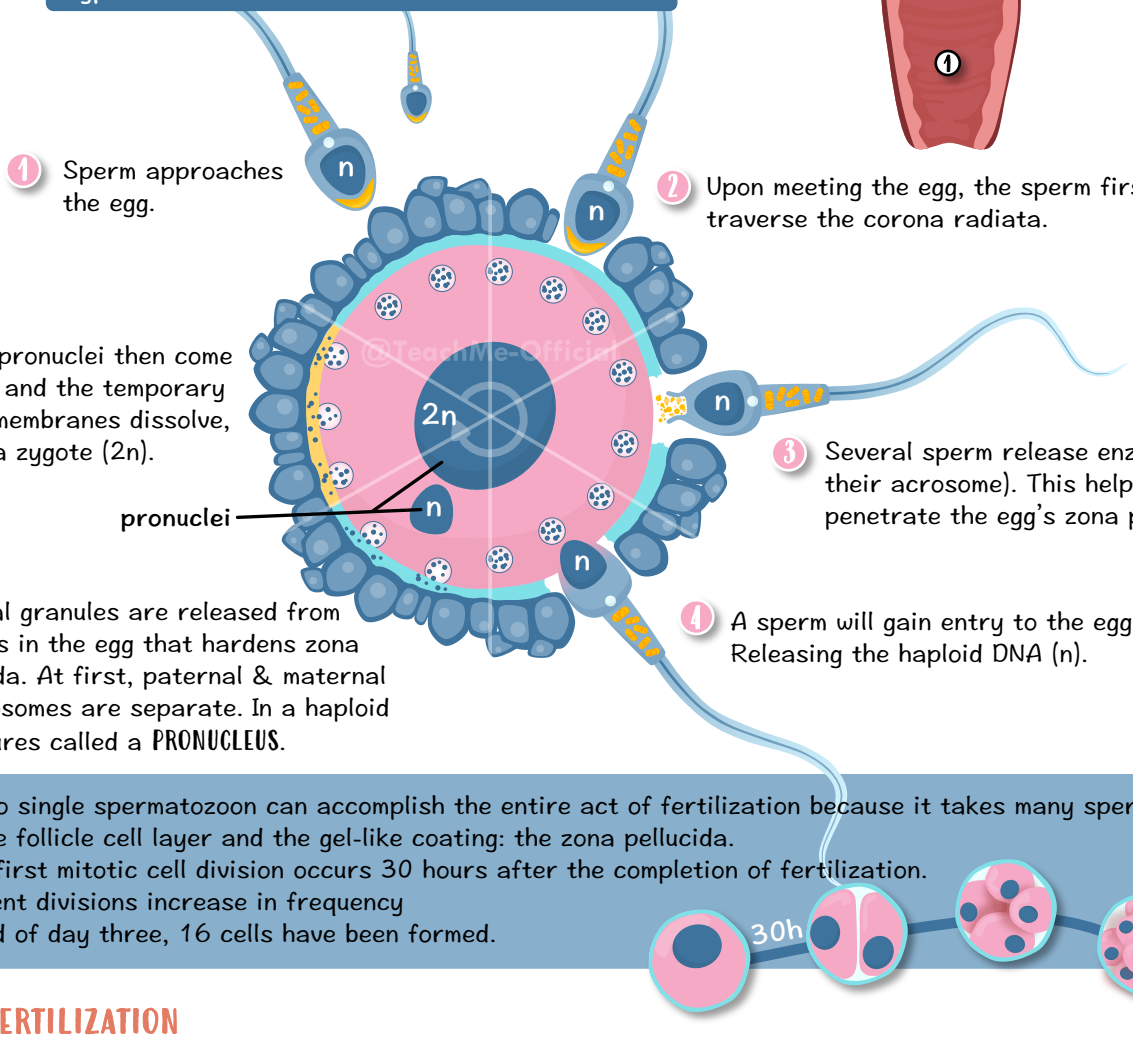
The process of fertilization occurs when the gametes (sperm and egg) fuse into a single cell. The purpose of it is to restore the diploid (2n) number of chromosomes. This process may occur internally (e.g. humans) or externally (e.g. frog).

Internal Fertilization

1. Firstly, millions of sperm are ejaculated into the female's vagina.
2. Some sperm pass through the cervical opening and enters the uterus.
3. Some sperm swim up the endometrial lining and enter the fallopian tubes.
4. Some sperm may (or NOT) encounter an egg. Usually around 200.



Typical location for fertilization: FALLOPIAN TUBES



1. Sperm approaches the egg.
2. Upon meeting the egg, the sperm first must traverse the corona radiata.
3. Several sperm release enzymes (from their acrosome). This helps them penetrate the egg's zona pellucida.
4. A sperm will gain entry to the egg. Releasing the haploid DNA (n).
5. Cortical granules are released from vesicles in the egg that hardens zona pellucida. At first, paternal & maternal chromosomes are separate. In a haploid structures called a **PRONUCLEUS**.
6. The two pronuclei then come together and the temporary nuclear membranes dissolve, forming a zygote (2n).

Notice how no single spermatozoon can accomplish the entire act of fertilization because it takes many sperm to penetrate the follicle cell layer and the gel-like coating: the zona pellucida.
The zygotes first mitotic cell division occurs 30 hours after the completion of fertilization.
The subsequent divisions increase in frequency
– by the end of day three, 16 cells have been formed.

External Fertilization

Animals including reptiles, birds and mammals use internal fertilisation but aquatic species including invertebrates and fish, and also frogs and toads (which return to the water to breed) employ external fertilization. Whereby **SPAWNING** (egg and sperm get released) occurs and fertilization happens in the water.

Advantage
- Higher probability of egg & sperm meeting.

Disadvantage
- Once zygote formed it is nor safe nor protected.

Reproduction

In Vitro Fertilization (IVF)

In vitro fertilization (IVF) is a technique which involves an egg being removed from the woman's ovaries and fertilized with sperm in a laboratory (artificial, not natural). The embryo is then returned to the woman's uterus to grow and develop. The main purpose of IVF is to help people who experience infertility (inability of conceiving).

Infertility may be due to either the male or the female, for either case, IVF is a viable treatment.

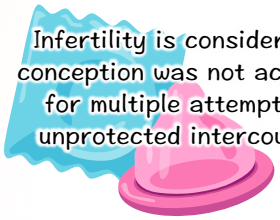
Inability to ovulate normally

Blocked fallopian tubes in females

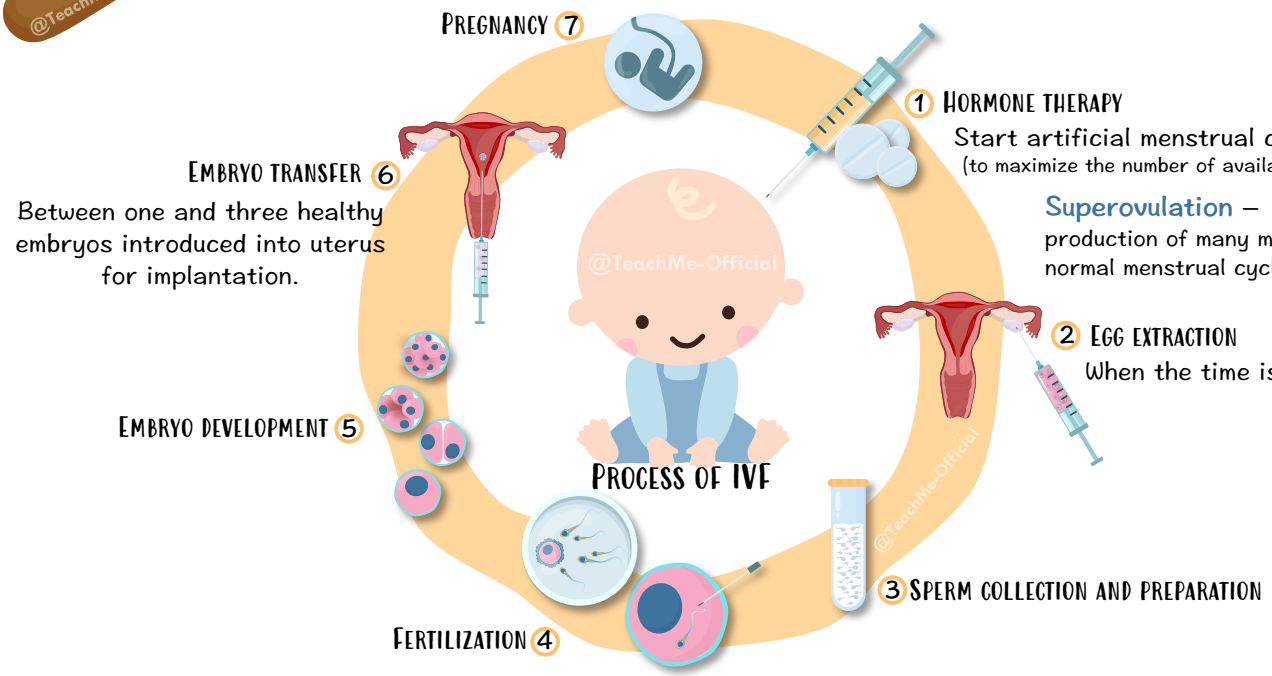
Low sperm count in males

Structurally abnormal sperm

Impotence (failure to achieve an erection)



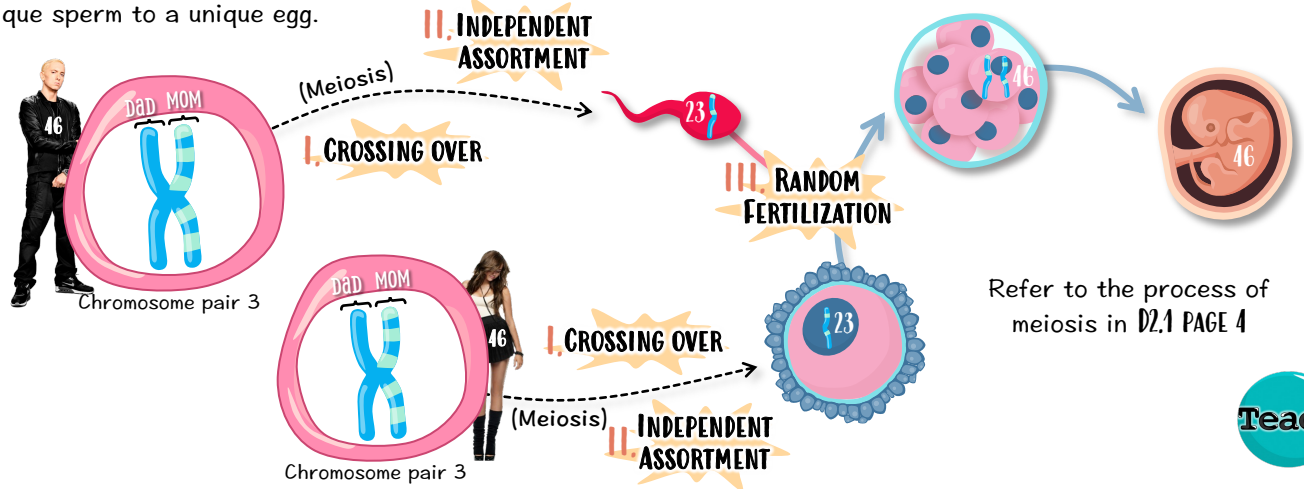
Infertility is considered if conception was not acheived for multiple attempts of unprotected intercourse!



6 Meiosis and Variation

Have you ever noticed that even though siblings share the same parents, they are not identical to each other (except for identical twins). This difference is due to variation provided by MEIOSIS and FERTILIZATION.

Meiosis allows for variation in the gametes produced by the mom and dad while fertilization randomizes the joining of a unique sperm to a unique egg.



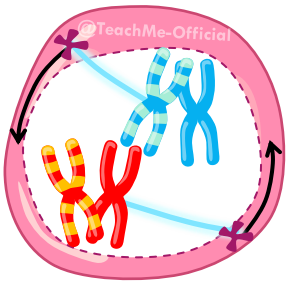
Refer to the process of meiosis in D2.1 PAGE 4

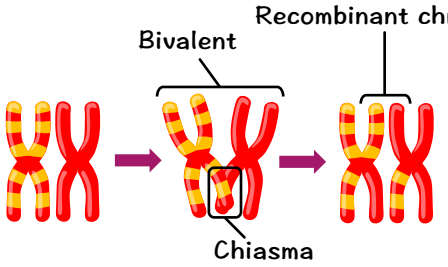
Reproduction

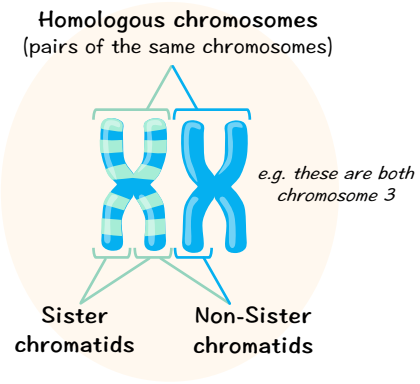
I. Crossing Over *During Prophase I*

*Allele – Version of a gene

A process where two non sister chromatids (from a bivalent) exchange (swap) DNA, allowing mixing of **alleles***.





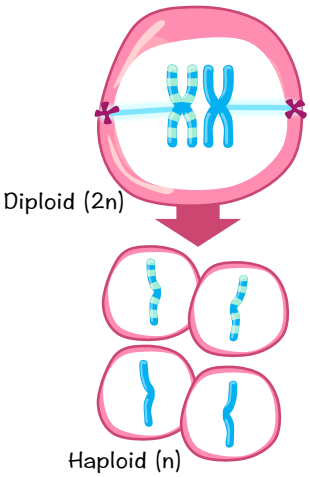


II. Independent Assortment *During Metaphase I*

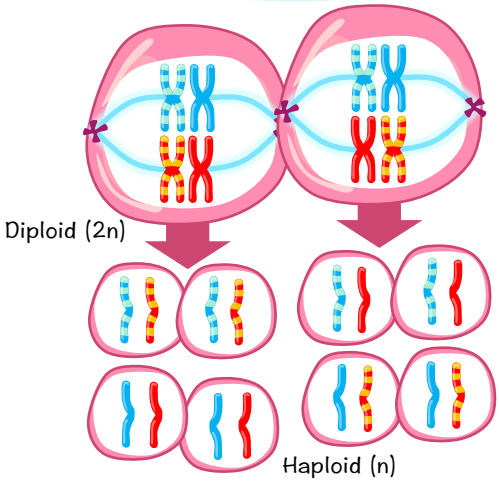
At the metaphase plate in metaphase I, the homologous chromosomes line up in a random fashion (in a random orientation) which allows them to be sorted into separate cells randomly, allowing for a multitude of possible combinations.

Example (if crossing over does not occur)

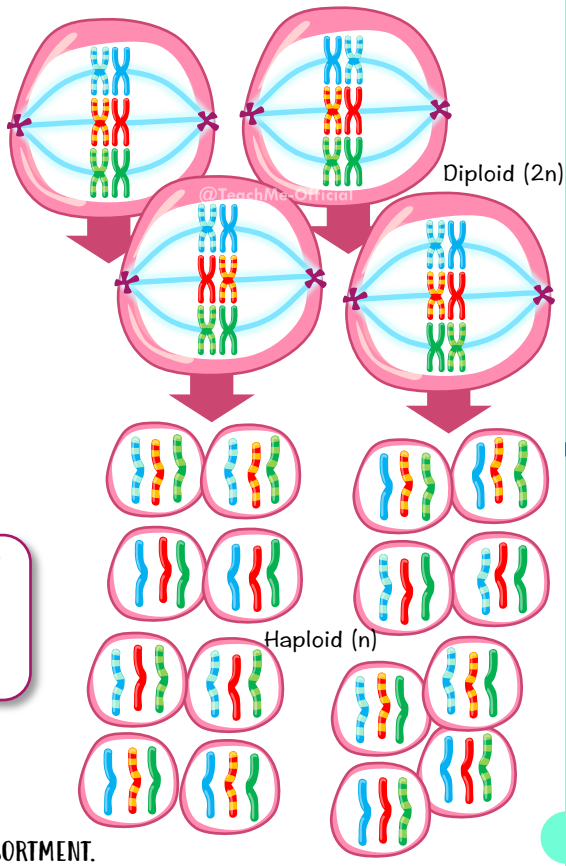
1 homologous chromosomes can yield 2 genetically unique gametes



2 homologous chromosomes can yield 4 genetically unique gametes



4 homologous chromosomes can yield 8 genetically unique gametes



Promotes genetic variation

2^N = unique gametes (*N = Number of chromosomes*)

Humans have 23 chromosomes

2^{23} = 8,388,608 unique gametes

III. Random Fertilization

Each EGG and SPERM is highly variable due to CROSSING OVER and INDEPENDENT ASSORTMENT.
Fertilization of such unique gametes creates a highly variable outcome for a zygote. The combination of a unique egg with a unique sperm leads to millions of zygote possibilities between two parents only.

Imagine combining crossing over, independent assortment and fertilization how many different combinations of genetic material we can get?

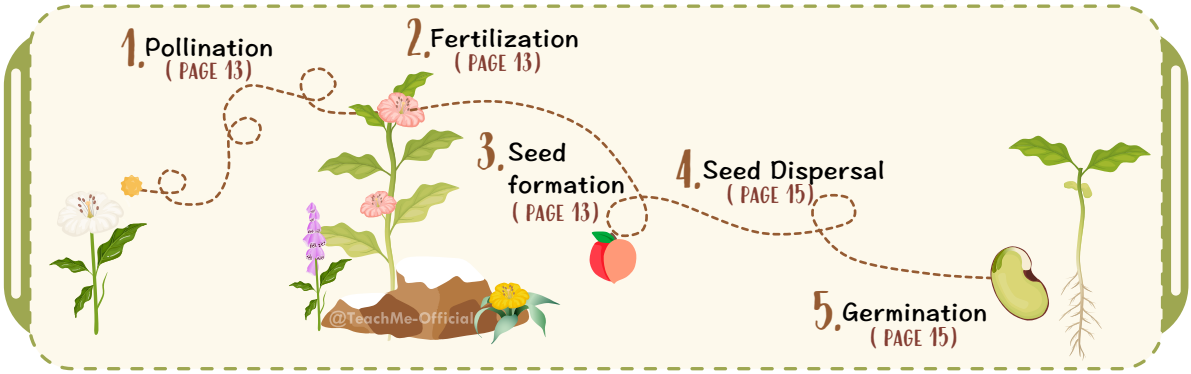
Reproduction

Section 2
Plant Reproduction

SOME plants have only male OR female flowers. SOME plants have both male flowers AND female flowers. MOST plants have flowers that are HERMAPHRODITIC.

→ Containing both female & male parts (within a single flower).

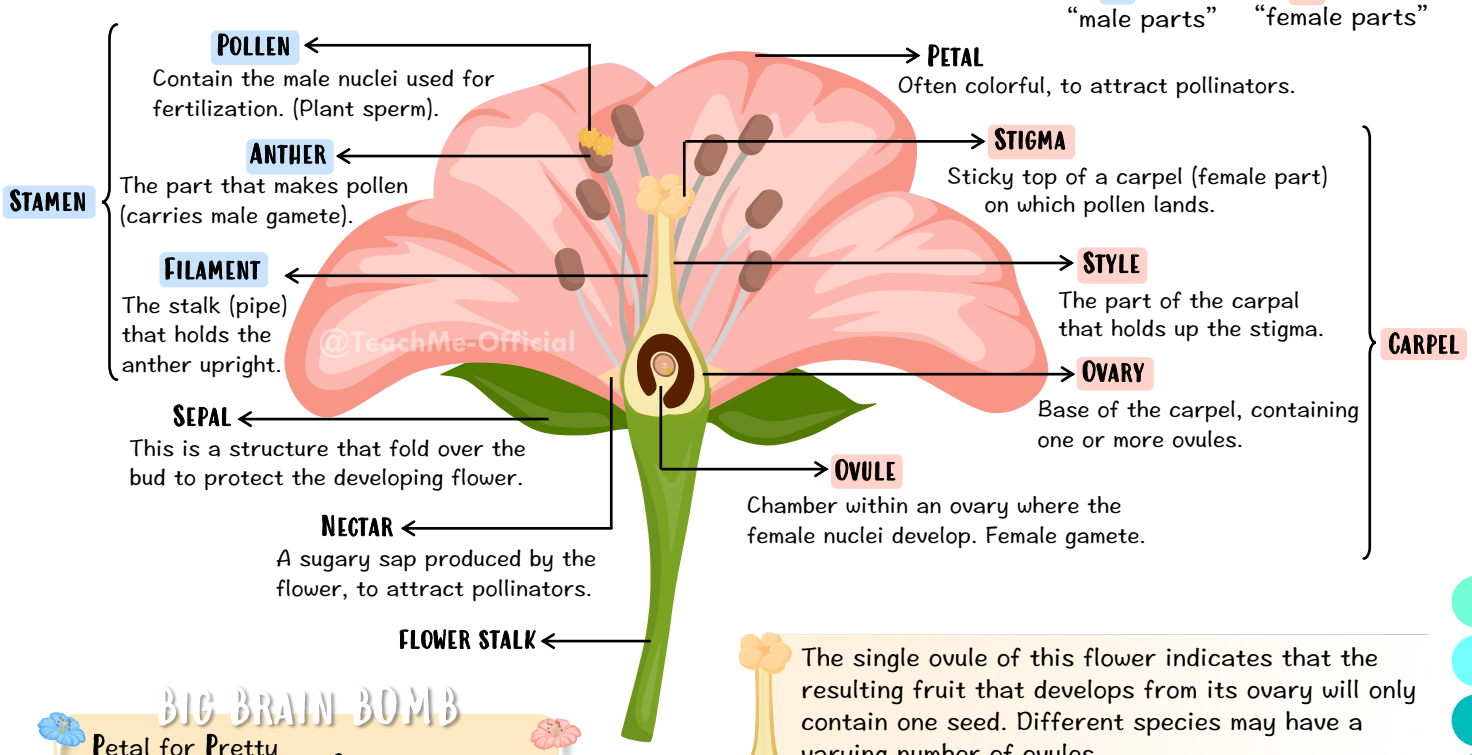
Plant reproduction includes multiple steps that we cover in this section:



1 Flower Structure

To understand how plants reproduce, we must first analyze the anatomy of a FLOWER – the reproductive structures of a flowering plant. In this instance, we look at a hermaphroditic flower with its male parts in blue and female parts in pink.

STAMEN "male parts" CARPEL "female parts"



The single ovule of this flower indicates that the resulting fruit that develops from its ovary will only contain one seed. Different species may have a varying number of ovules.

BIG BRAIN BOMB

Petal for Pretty
ANTHERS: Ain't hers
staMEN is male

STIGMA is Sticky
Women have STYLE

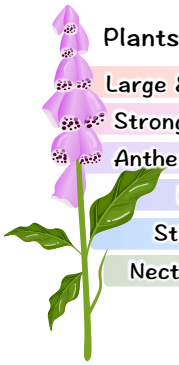
Reproduction

2 Pollination

Pollination – The transfer of POLLEN produced in one plant's anther to another (or same) plant's STIGMA. This process is carried out by POLLINATORS.

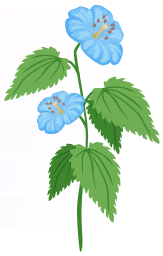
Pollinators are organisms that carry out the transferring process. Different pollinators for different flower species, including insects, birds, bats, and even some mammals.

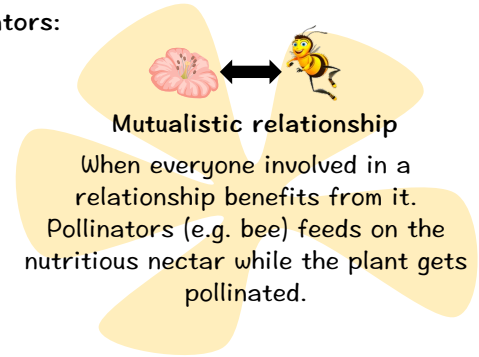
Stamens are often found deep inside, so that insects (while drinking the nectar) will brush up against the pollen grains, letting the pollen be placed on the plant's stigma.



Plants therefore have developed some **ADAPTATIONS** to attract pollinators:

- **Large & brightly colored petals** – Attract pollinators.
- **Strong scent** – Attract pollinators.
- **Anther positioning** – Easy to contact pollinators.
- **Pollen is sticky** – Easy to adhere to insect.
- **Stigma is sticky** – Easy to adhere to pollen.
- **Nectar** – A reward to the pollinator flower base).





Mutualistic relationship

When everyone involved in a relationship benefits from it. Pollinators (e.g. bee) feeds on the nutritious nectar while the plant gets pollinated.

There are two ways pollination may occur:

Self Pollination

Pollen travels from the anther of one plant to the stigma of the same plant.

Advantage – Preserve good genes (good for stable environment).
Disadvantage – Reduction in genetic variation (bad for changing environment)

Cross Pollination

Pollen travels from the anther of one plant to the stigma of another plant.

Advantage – Genetic variation. Good in changing environment.
Disadvantage – Element of chance.

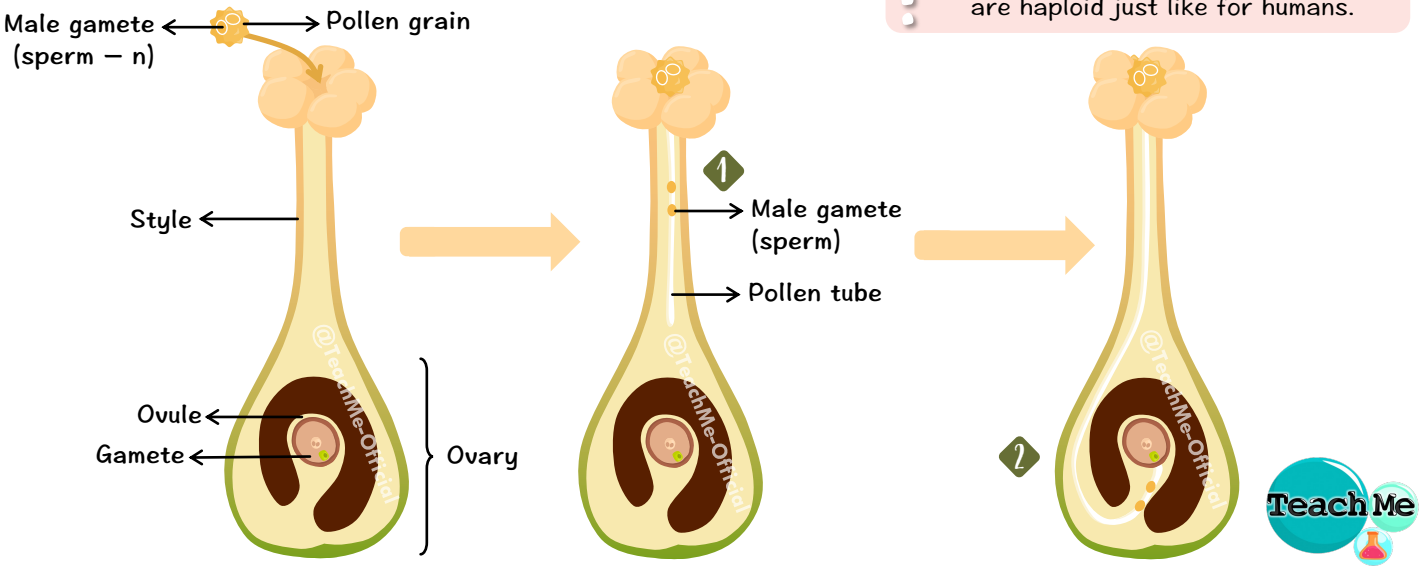
3 Fertilization and Seed Formation

Fertilization is the process of when the male and female gametes come together to form a zygote.

1. Pollen that adheres to a stigma will begin to grow into POLLEN TUBE.
2. The pollen tube will continue to grow all the way to an OVULE.

Big Brain Tip!

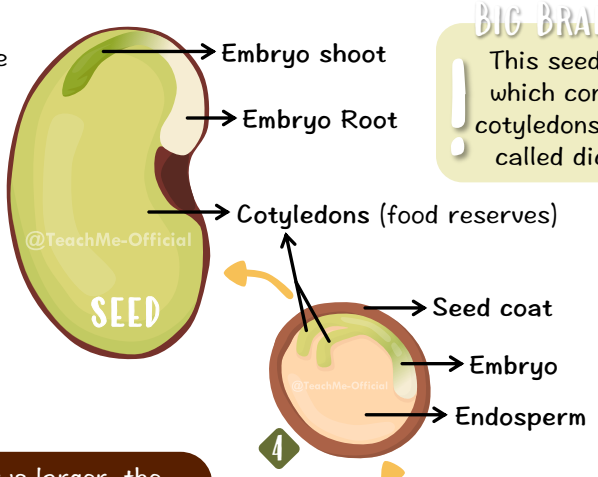
The male and female gametes in plants are haploid just like for humans.



Reproduction

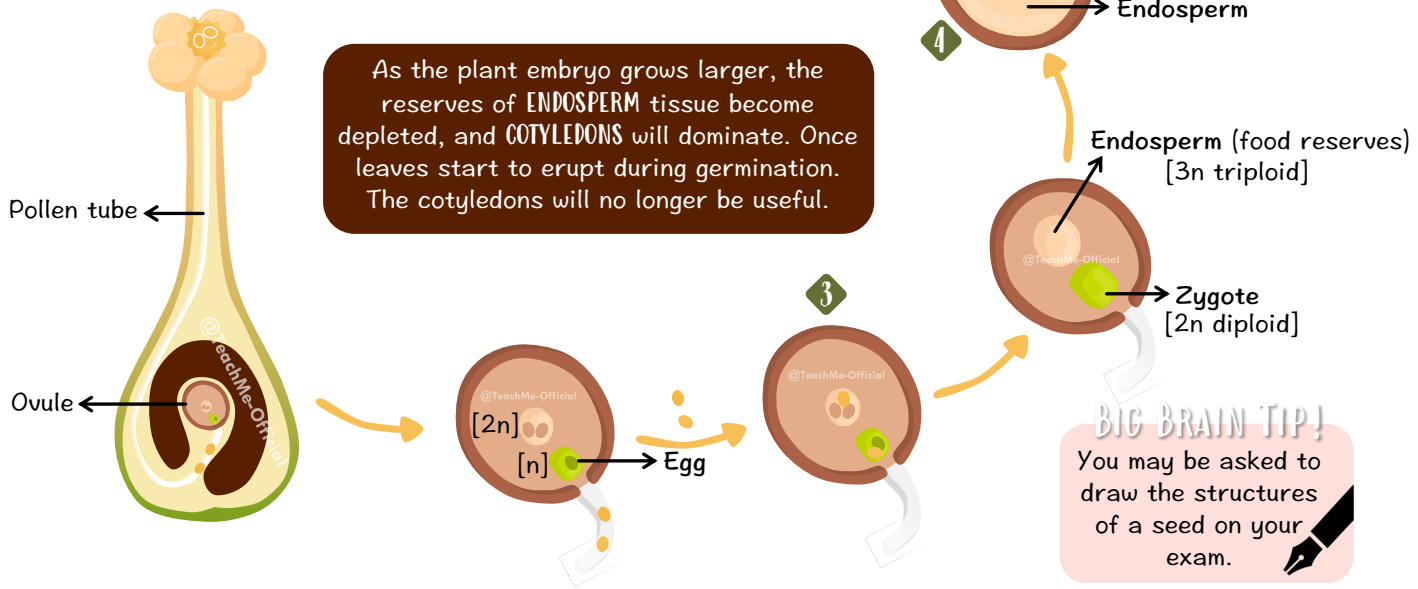
3. Within the ovule there are three haploid nuclei (n). One pollen nucleus fertilizes one ovule nucleus to create a ZYGOTE. The other pollen nucleus fertilizes the other two nuclei within the ovule to create ENDOSPERM. This is DOUBLE FERTILIZATION.

4. The zygote will grow into the plant. Endosperm will grow to produce nutrition within the seed to nourish the early plant embryo.



BIG BRAIN TIP!
This seed is a type which contains two cotyledons (therefore called dicot seed).

As the plant embryo grows larger, the reserves of ENDOSPERM tissue become depleted, and COTYLEDONS will dominate. Once leaves start to erupt during germination. The cotyledons will no longer be useful.



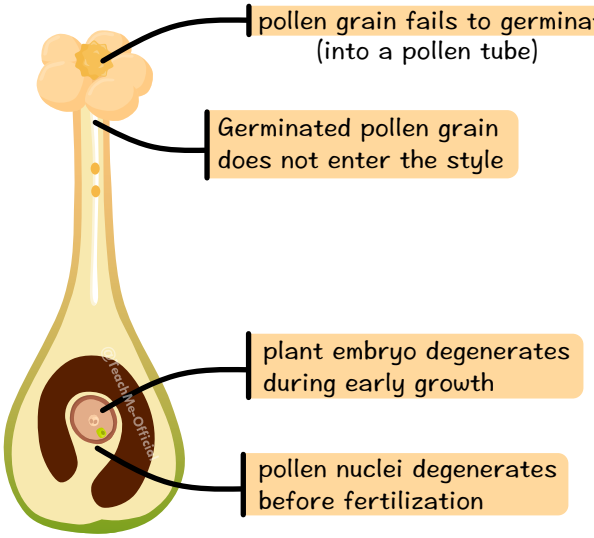
BIG BRAIN TIP!
You may be asked to draw the structures of a seed on your exam.

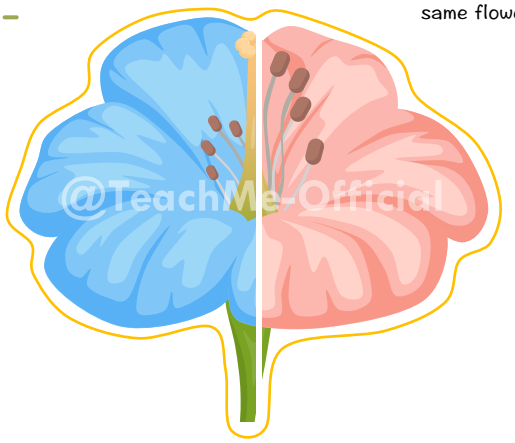
Plants benefit from genetic variation within populations just as much as animals do. Even in plant species where flowers are hermaphroditic, a variety of mechanisms have evolved to promote cross-pollination such mechanisms include the following:

- Wind pollination
- Pure flowers (only male/female)
- Pure plants (only male/female)
- Stigma & anther at different heights
- Maturation times (Different maturation times for the pollen and ovules of the same flower)

CHEMICAL SELF-INCOMPATIBILITY

A mechanism which promotes cross-pollination – When the pollen of a plant lands on the stigma of a flower of the same plant, protein interactions occur that reduce or stop growth of the pollen tube.





The most successful pollination occurs when the pollen is from one plant and the stigma is in the flower of a completely different plant of the same species.

This promotes genetic variation in and healthy growth of the new plant (called vigour). Self-pollination leads to inbreeding and a decrease in genetic diversity and vigour.

Reproduction

4 Seed Dispersal

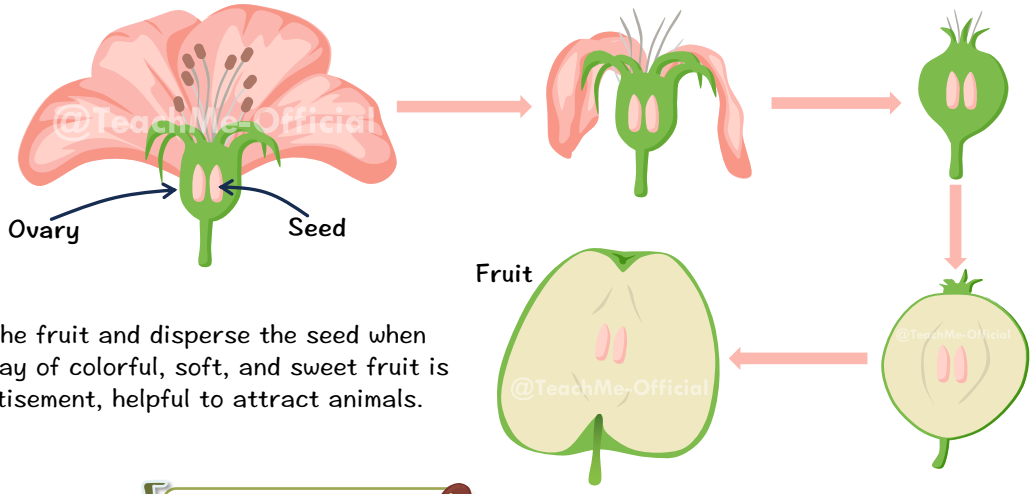
- Successful seeds dispersal depends on various factors.
- Seeds can be dispersed by way of fruit (see next). Consumed and ingested by animals. Seeds may still be protected (within seed coats). Deposited in animal feces away from the parent plant.
- Some seeds: Use water to float to a new location (coconut).
- Some seeds: Have structures that allow them to be easily carried by the wind for dispersal (dandelion).
- Some seeds: Develop pods that dry out (during ripening). When the pod is dry enough, it pops open explosively, releasing the seed away from the parent plant.

Where do fruit come from?

Most fruits are green when they start their development and then become a **(1) bright** (less camouflaged) color as they ripen. Most fruits also become **(2) sweeter**, and **(3) softer** as they ripen.

Did you know?

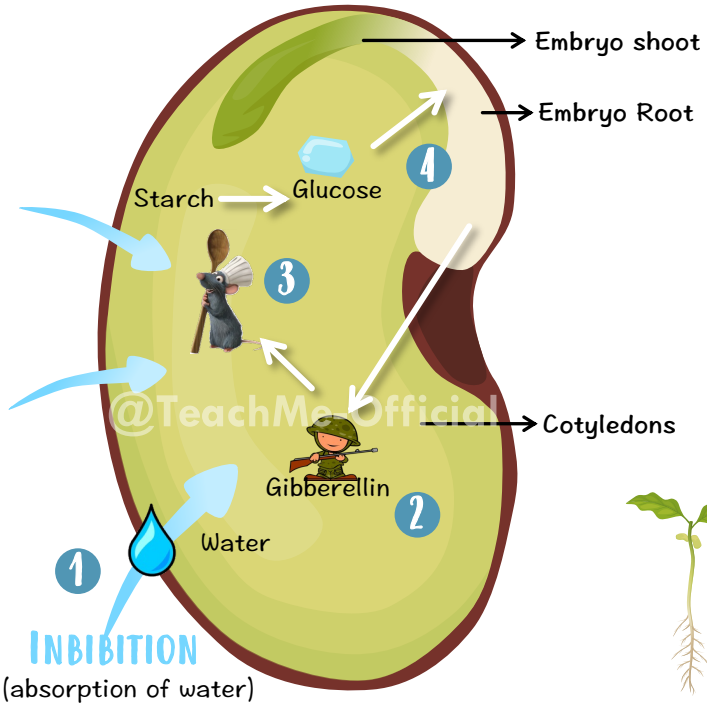
The ovary itself grows (ripens) and becomes a fruit. the number of seeds inside a fruit is an indication of how many ovules the ovary contained.



Purpose of this mechanism?

To attract herbivores that eat the fruit and disperse the seed when they deposit their feces. A display of colorful, soft, and sweet fruit is intended to be a beautiful advertisement, helpful to attract animals.

5 Seed Germination



Seed germination is the early growth of a seed as it develops into a plant.

Summary of Steps:

1. Absorb water in a process called imbibition.
2. Embryo produces gibberellin, which goes to food stores to activate enzymes.
3. Enzymes: amylase (starch into glucose) & proteases (protein into amino acids).
4. These nutrients are moved to the embryo to help with growth.
5. Once leaves have formed these food stores will no longer be required. Photosynthesis.

Reproduction

Which are required for seed germination?

Factors which do not affect germination

- Soil
- Carbon dioxide
- Sunlight

OXYGEN – Oxygen is needed, to allow aerobic respiration to produce adenosine triphosphate (ATP).

TEMPERATURE – An appropriate temperature for the seed is necessary. For its enzymes to start working (amylase).

WATER – Water is needed, to rehydrate the dried seed tissues. Imbibition.

Dormancy (variable period)

Is an adaptation feature to overcome harsh, but potentially temporary, environmental conditions. It allows the seed to wait until conditions are suitable for growth by maintaining a very low metabolism without any growth or development.

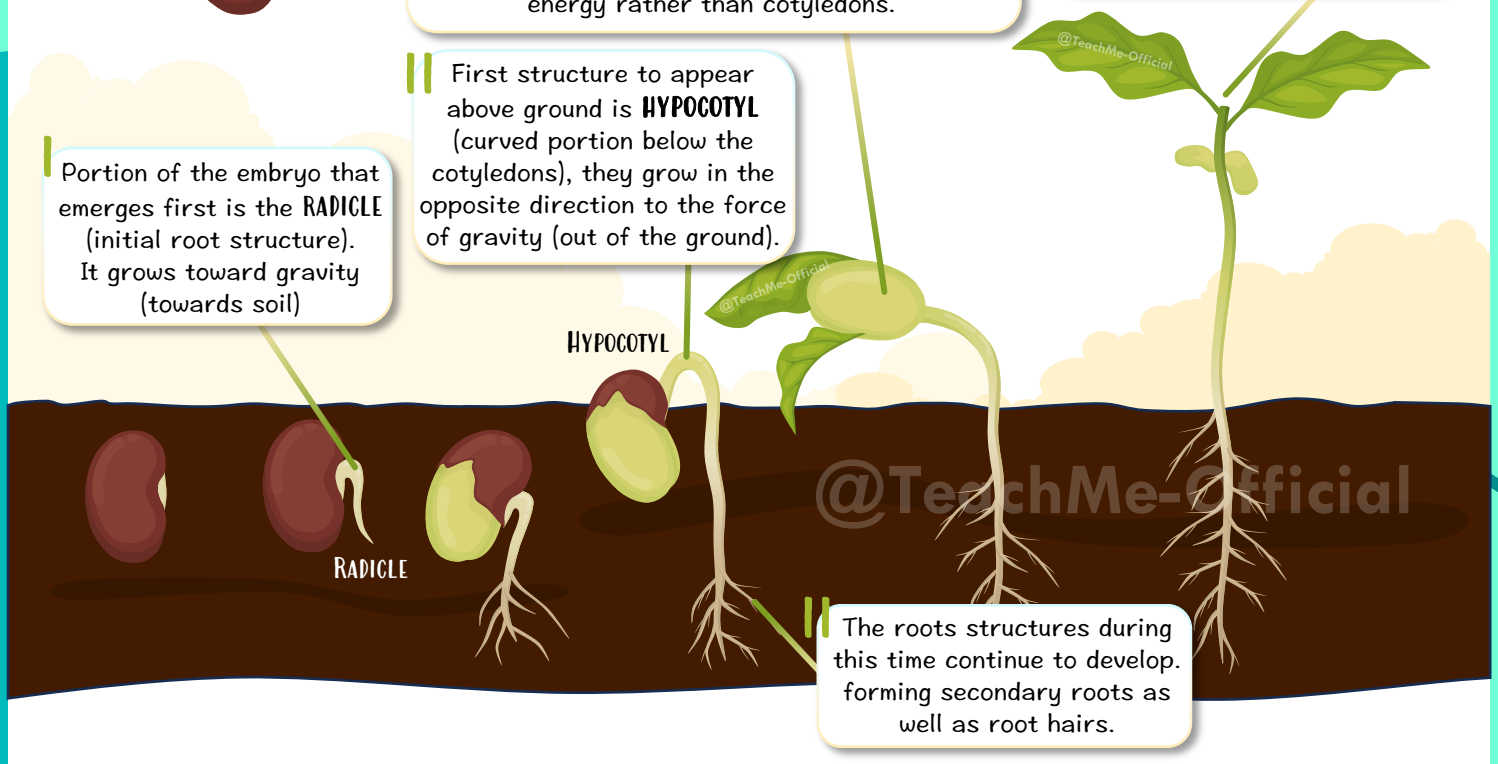
I Portion of the embryo that emerges first is the **RADICLE** (initial root structure). It grows toward gravity (towards soil)

II First structure to appear above ground is **HYPOCOTYL** (curved portion below the cotyledons), they grow in the opposite direction to the force of gravity (out of the ground).

III Once above ground, the early shoot will straighten orientating the growing young plant perpendicular to the ground. the first real leaves then develop and begin photosynthesis as a new source of energy rather than cotyledons.

IV All plant growth from this point on will occur at areas called **MERISTEM** tissue located at the tips of shoot and roots.

II The roots structures during this time continue to develop. forming secondary roots as well as root hairs.



notes