CAIE Biology IGCSE

16: Reproduction

Notes

(Content in **bold** is for Extended students only)

Asexual Reproduction

Asexual reproduction is a process which results in the production of **genetically identical offspring**, known as **clones**. This only requires **one parent**, unlike sexual reproduction. Asexual reproduction occurs predominantly in plants, although some animals such as starfish also reproduce in this way.

Advantages of asexual reproduction:

- **Only one parent is required - this is helpful for organisms which live in desolate environments where finding a mate is difficult.**
- **Can reproduce quickly - large quantities of offspring can be produced quickly to rapidly populate an area. This helps to dominate a habitat and prevent competition from other species. This is also helpful in crop production.**
- **It takes less energy to reproduce asexually.**

Disadvantages of asexual reproduction:

- **Lack of diversity - all offspring are genetically identical.**
- **Prone to extinction - as each organism produced is genetically identical, a disease which harms one will be dangerous to all of them, thus it is easy for the whole population to be destroyed by one pathogen.**
- **Cannot adapt - organisms are adapted to one environment and cannot adapt to changes. If the environment changes, e.g. the temperature rises, they are likely to be killed.**
- **Overpopulation - too many offspring may be produced, which causes overcrowding in a habitat.**

Sexual Reproduction

Sexual reproduction requires **two parents.** The nuclei of two **gametes**, one from each parent, fuse together to form a **zygote**. Each offspring is **genetically different**. The fusion of the nuclei of gametes is called **fertilisation**.

Most cells in the body are diploid cells, meaning that they have a full set of chromosomes, whereas haploid cells (egg and sperm cells) only have half as many chromosomes. This means that when two haploid gametes fuse during fertilisation, a complete set of chromosomes is produced - half from the mother and half from the father. The nucleus of a zygote is therefore diploid as it has a complete set of chromosomes.

Advantages of sexual reproduction:

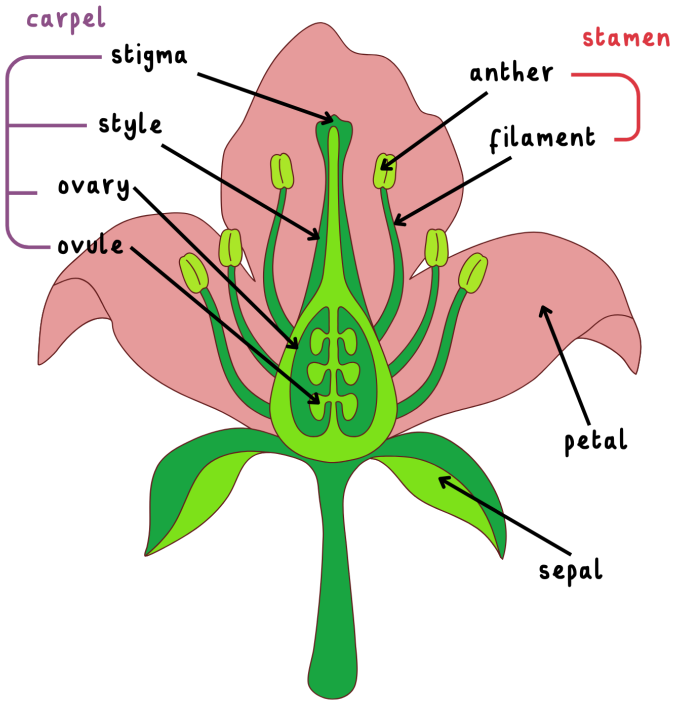
- **Wide diversity - each offspring is genetically unique.**
- **Promotes survival - each organism is unique so disease cannot spread as easily. This is a good advantage in crop production to ensure crops do not die from diseases easily.**
- **Organisms can adapt - as each offspring is born with different genes, those with a genetic advantage are more likely to survive and pass their positive traits on to their offspring, whilst those with a genetic disadvantage are more likely to die without producing offspring. This allows the species to evolve through natural selection.**

Disadvantages of sexual reproduction:

- **Two parents are required - it may be difficult for some species to find mates, especially when there is an imbalance of males and females in an area or if the species is endangered.**
- **Fewer offspring produced - it takes longer and requires more energy to produce offspring, therefore it is less efficient than asexual reproduction.**

Sexual reproduction in plants

Plant reproductive system in an insect-pollinated flower:

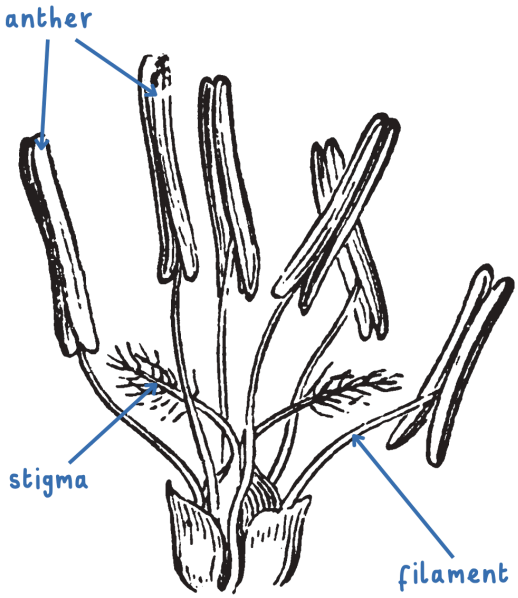


Structure	Description
Sepals	Protects unopened flowers
Petals	Brightly coloured to attract pollinating insects to the plant. Insects are also attracted by scents and nectar in the plant.
Stamen	Male reproductive part of the flower that consists of **anthers** and **filaments**.
Anthers	Produces male sex cells in the form of **pollen**. This pollen is then either picked up by insects or blown off the plant and carried in the wind.
Filaments	Stalk that attaches to the base of **anthers** and supports **anthers** by holding them up.
Carpel	Female reproductive organ of a flower which contains an **ovary**, a **stigma**, and **style**.
Style	Assist with fertilisation by being the location where **pollen tubes** travel to deliver **sperm cells** to the egg.
Stigmas	The female part of the plant which collects pollen from insects or from the air. In wind-pollinated plants, the stigmas and anthers hang out of the plant where they are more exposed to the wind.
Ovaries	Produces the female sex cells which are contained in the **ovules**.
Ovules	The part of the **ovary** which contains the female sex cells. Fertilisation occurs when the nucleus of the ovules fuses with a pollen cell nucleus.

Wind-pollination:

Stigmas and **anthers** are arranged differently in wind-pollinated flowers.

The stigma extends **outside** the plant and is **feathery**. This means it can catch pollen more easily. The anthers hang **outside** the flower so the wind can carry the pollen more easily.



Pollen grains:

Pollen grains of wind-pollinated flowers	**Pollen grains of insect-pollinated flowers**
Smaller in diameter	**Larger** in diameter
Lighter in weight (can be carried through the air more easily)	**Heavier** in weight
Greater number of grains produced (increases the chance of pollination)	**Fewer** number of grains
No **spikes** or **hooks** on the outside of grains	Contain **spikes** or **hooks** on the outside (increases the chance of grains sticking to insects and attaching to the stigma)

Sexual reproduction in plants takes place in the **flowers using pollen**. **Pollination** is the transfer of pollen grains from an anther to a stigma. **Cross-pollination occurs when grains of pollen are transferred from the anthers of one plant to the stigma of another plant of the same species. Some flowers can produce male and female gametes, and thus can self-pollinate by transferring pollen from their anther to their stigma. Self-pollination can also occur if a pollen grain from the anther of a flower is transferred to the stigma of a different flower on the same plant. This is considered as sexual reproduction as there is still a male and female gamete.**

Cross-pollination vs self-pollination:

- **Cross-pollination results in more genetic diversity in a species, thus the species can adapt and is more resilient to diseases.**
- **Self-pollination uses less energy as the plant does not need to spend energy in attracting pollinating insects.**
- **Self-pollinating plants can spread to areas where the species does not currently exist as other pollinators are not required. Cross-pollinating plants, however, are reliant on pollinators.**
- **Cross-pollination can only occur when the flowers are open.**

Structural adaptations:

Insect-pollinated flowers	**Wind-pollinated flowers**
Large, **bright** and **scented** petals so they can attract insects	**Small**, **dull** (green/brown) and **non- scented** petals as there is no need to attract insects
Sticky stigmas to catch pollen when insects brush against the stigma	Stigma is **outside** the flower and **feathery** to catch pollen grains
Nectar is produced to attract insects	**Nectar** is not produced
Anthers are **inside** the flower and **firmly attached** to brush against insects	**Anther** is **outside** the flower and **hangs loosely** to release pollen grains easily

Fertilisation process in plants:

1. Pollen grains land on a plant **stigma.**
2. **If the pollen is of the same species, a pollen tube begins to grow.**
3. **The pollen moves down the pollen tube to the ovule.**
4. Fertilisation occurs when the nucleus from the **pollen cell** fuses with a nucleus in an **ovule**. This produces a **zygote**.
5. The zygote develops into an **embryo plant**.

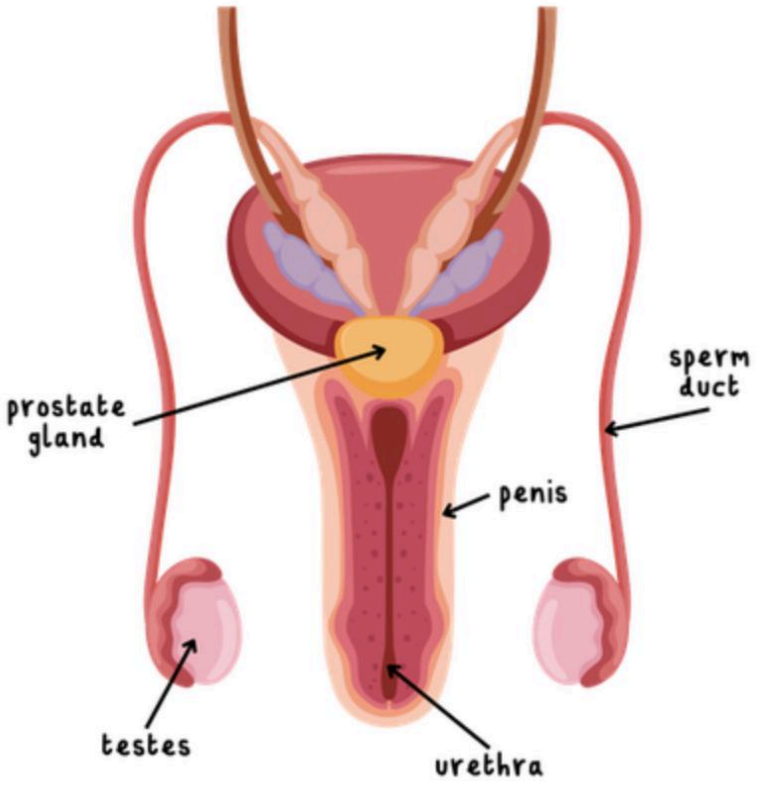
Factors affecting seed germination:

- **Water** - water moves into the seed, causing it to swell. This allows the embryo to begin growing.
- **Oxygen** - used in respiration to produce energy for growth.
- **Temperature** - the seed contains enzymes, e.g. for respiration, which will work faster at the plant's optimum temperature. This is why seeds are dormant in the winter and grow again in the spring.

Sexual reproduction in humans

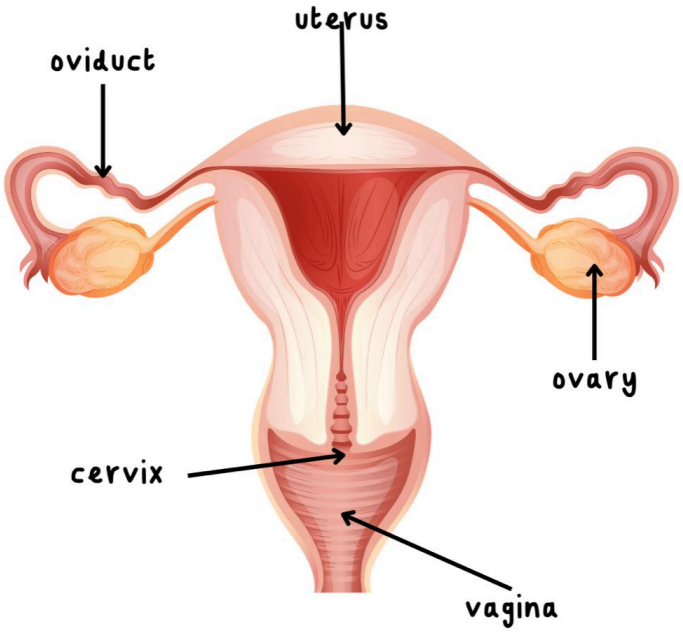
Male reproductive system:

- **Testes** - there are two testicles. This is where sperm cells are produced, as well as testosterone.
- **Scrotum** - Contains the testicles.
- **Sperm ducts** - Tubes that carry sperm from the testes to the urethra.
- **Prostate gland** - Secretes nutritive fluid which combines with sperm to form semen.
- **Urethra** - Tube which allows excretion of urine and semen from the body.
- **Penis** - Allows semen to pass into the vagina during sexual intercourse. Also allows urine to pass out of the body.



Female reproductive system:

- **Ovaries** - there are two ovaries. Their function is to develop egg cells. Women have undeveloped egg cells from birth, whereas men produce new sperm throughout their lives.
- **Oviducts** - connect to each ovary and contain cilia to transport the egg cells through the tube. This is where fertilisation occurs.
- **Uterus** - this is where the foetus develops.
- **Cervix** - separates the vagina from the uterus, and also holds the baby in place during pregnancy. The cervix is made of muscular tissue.
- **Vagina** - Tube that leads from the cervix to outside of the body. Receives the penis during intercourse.



Fertilisation:

Fertilisation occurs when a **sperm** cell and an **egg** cell **fuse their nuclei** together. Sperm cells are male **gametes** produced in **large numbers** in the testes. They are adapted by having a tail-like **flagellum** which allows movement to the egg cell. Sperm cells also contain many **mitochondria** to produce energy for this movement. Eggs, in contrast, are much larger than sperm and are unable to move themselves. They are instead transported by **cilia** on the walls of the oviducts. When the sperm cell reaches the egg cell, it must **digest the wall of the cell s**o that it can fuse with their nuclei. This is done using **enzymes** located in the **acrosome.** The egg contains a **jelly coat** which changes after fertilisation and ensures that only one sperm cell can enter.

Comparing male and female gametes:

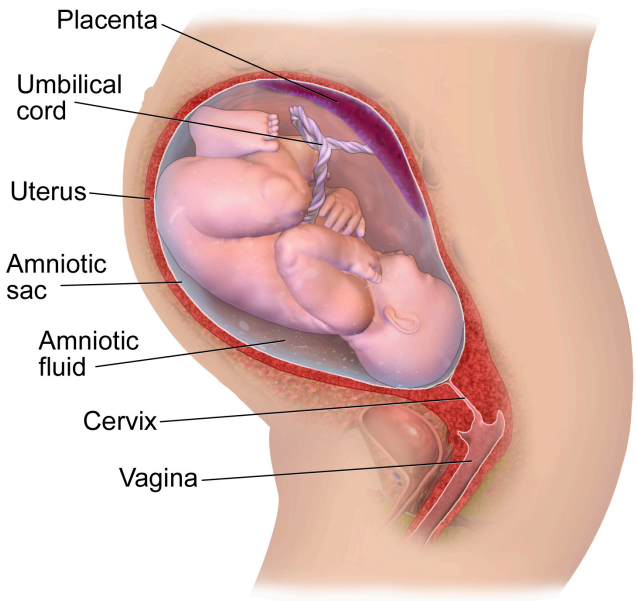
	Sperm	**Egg**
Size	Very **small**	**Large** - just visible to the naked eye
Structure	Consists of a **nucleus**, **mitochondria**, very little cytoplasm and **flagellum**	Round cell covered with a **jelly coat**
Motility	The **flagellum** undergoes a whipping motion to propel them towards the egg	Immobile
Number	Millions of sperm are released every day	Only one egg is released every month from puberty to menopause

Once fertilisation has occurred, the **zygote** undergoes mitosis (cell-division) to produce many cells which make up an **embryo**. The egg cell contains **energy stores** to allow this to happen**.** The embryo, which is just a ball of cells, is implanted into the wall of the **uterus,** where it grows.

Development of the foetus:

Key structures:

- **Umbilical cord** - allows the exchange of substances between the foetus and the mother through the cord.
- **Placenta** - Connects to the foetus end of the umbilical cord and allows exchange of substances. It also produces hormones such as oestrogen and progesterone.
- **Amniotic sac** - Surrounds the foetus and produces amniotic fluid.
- **Amniotic fluid** - protects the foetus.



Pregnancy

The mother passes essential nutrients to the foetus through the umbilical cord, such as amino acids, oxygen and glucose. These help build cells, and hence structures, in the foetus. In addition, waste products diffuse out of the foetus to be excreted from the mother's body. This prevents a build-up of toxins which could harm the foetus. In addition, antibodies are passed to the foetus, allowing it to develop a resistance to pathogens.

Throughout this exchange of substances, the blood of the foetus and mother do not mix; instead, substances diffuse between them. This is to prevent diseases passing to the foetus through the blood, although some toxins, such as nicotine from cigarettes, and pathogens such as the rubella virus, can still pass from the mother to the foetus.

Sexual hormones in humans

Two hormones are key to the **development of secondary sexual characteristics** during **puberty** and the subsequent **regulation** of these characteristics:

- **Testosterone** - **Testosterone is produced in the testes of males, and in small amounts in the ovaries of females.** It is responsible for muscle development and the deepening of the voice, amongst other things.

- **Oestrogen** - **made in the ovaries of females**. It leads to the development of widened hips, breasts, and plays a part in the menstrual cycle.

Menstrual cycle:

The menstrual cycle happens approximately every **28 days**. During each cycle, an **egg cell is released** from the ovaries. The **uterus wall thickens** by filling with blood capillaries in preparation for a pregnancy, which would occur if the egg is fertilised. If this egg is not fertilised, the egg dies and **menstruation** occurs, where the dead egg cell and old uterus lining is expelled from the body in a **period**.

The menstrual cycle is regulated by four hormones:

- **FSH - Follicle stimulating hormone triggers the development of an egg cell in the ovary, and also stimulates oestrogen production in the ovaries. This is produced in the pituitary gland.**
- **LH - Luteinising hormone triggers an egg to be released, as well as stimulating progesterone production in the ovaries.**
- **Progesterone - Progesterone is responsible for maintaining the thick uterus lining in the cycle and during pregnancy. It also decreases FSH production.**
- **Oestrogen - Stimulates LH production, whilst decreasing FSH production.**

At the beginning of the cycle, levels of FSH and LH are high to stimulate egg production and cause the production of oestrogen which thickens the uterus lining. When the egg is released, the levels of LH, FSH and oestrogen decrease, whilst progesterone is released to maintain the uterus lining. If the egg is not fertilised, progesterone levels decrease and the uterus lining breaks down, causing menstruation.

Sexually transmitted infections

Sexually transmitted infections, known as **STIs**, are **infections** that are transmitted via **bodily fluids** during sexual intercourse or contact. The spread of STIs can be controlled by **abstaining** from sexual contact, **avoiding risky sexual practices** and **always using protection** such as condoms.

HIV

Human immunodeficiency virus (HIV) is an example of a pathogen that causes STI. HIV is present in the bodily fluids of infected people, such as blood and semen, and can be transmitted during sexual intercourse. In the blood, HIV attaches to **lymphocytes** (white blood cells) and enters the cell. Here, it uses the cell to replicate itself and thus the cell cannot carry out its normal functions. Consequently, HIV **reduces the number of functioning lymphocytes**, as well as **reducing the body's ability to produce antibodies** to fight off infection. HIV leads to **AIDS**, which makes the person extremely susceptible to other pathogens as the white blood cells can no longer fight off disease, which can be fatal.