

CIE Biology GCSE

16: Reproduction Notes

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

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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.
- 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 process of the gametes fusing 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.
- **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:

- **Sepals** - protects unopened flowers.
- **Petals** - flowering plants have petals which are brightly coloured to attract pollinating insects to the plant. Insects are also attracted by scents and nectar in the plant.
- **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.
- **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. Fertilisation occurs when the nucleus of this fuses with a pollen cell nucleus.

Sexual reproduction in plants takes place in the **flowers using pollen**. **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. 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 expend 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**.

Methods of pollination:

There are two methods of pollination in plants: **insect pollination** and **wind pollination**. In insect pollination, insects are attracted to the plant, where pollen sticks to them. They then move to another plant and drop the pollen, causing the second plant to be pollinated. In wind pollination, the wind blows pollen off the first plant and carries it to the second plant. Pollen that is carried by insects is adapted to be **sticky** and have **hooks** which **attach to the insect**. Pollen carried by the wind does not need to stick to anything, thus is **smooth**. It is also very **light**.

Fertilisation:

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 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 so that it can fuse 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.**

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 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.

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.

Diet is also important during pregnancy. A **greater amount of protein and carbohydrates** should be consumed to provide nutrients for the foetus to grow. **Nutrients** such as **iron**, which is needed to make haemoglobin in blood, and **calcium**, which is used in bone growth, are also essential to the foetus. Drugs, alcohol and cigarettes should be avoided as they can harm the foetus. Babies whose mothers **smoked or consumed alcohol** during pregnancy are more likely to have issues in **cognitive development, behaviour and growth**. There is also a **larger risk of fetal mortality**.

Birth of the child:

1. The **amniotic sac breaks**, releasing the **amniotic fluid**.
2. **Muscles in the uterus wall contract** to push the baby out while the **cervix dilates**.
3. The baby exits the mother through the vagina.
4. The **umbilical cord**, which is still attached to the baby, is **cut and tied**.



Breastfeeding vs bottle-feeding:

- Breastfeeding allows **antibodies** to be passed from the mother to the child, providing **immunity**.
- Breastfeeding **contains all the essential nutrients** for the baby. Some nutrients in **bottled milk** may be **harder for the baby to digest**. There is also no risk of an **allergic reaction** to breastmilk.
- Breastfeeding may be **painful** for the mother.
- Breastfeeding can only occur when the mother is present.

Sex 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.

Birth control in humans

Birth control is used in family planning to control when, and how many, children are produced. There are many methods to prevent pregnancy if children are not wanted, including:

- **Natural birth control methods** - these methods use the knowledge of the menstrual cycle to avoid pregnancy. This is done by **monitoring body temperature and cervical mucus** to predict when **ovulation** is occurring and avoiding sexual intercourse in this period. As cycles can be irregular and difficult to accurately predict, this method is **not always reliable**. Another natural method is to abstain from sexual intercourse.
- **Chemical methods** - chemical methods include the contraceptive pill, implant and injection, as well as IUD and IUS. These contain hormones which stop pregnancy. **The contraceptive pill contains the hormones progesterone and oestrogen, which prevents ovulation. The contraceptive implant, injection and IUS both release progesterone and cause the uterus lining to thin, preventing the fertilised egg from implanting in the uterus wall. IUD also prevents implantation of the egg by thinning the uterus lining, and also acts as a physical barrier to stop sperm reaching the egg.**
- **Barrier methods** - this includes the condom, femidom and diaphragm. These are used to act as a **physical barrier** and prevent the sperm from reaching the egg. Condoms also have the advantage of preventing the spread of STIs.
- **Surgical methods** - these procedures **prevent the release of sperm and egg cells**. A vasectomy involves the **sperm ducts being tied or cut**, preventing sperm from exiting the testes. In women, the **oviducts can be tied or cut** to prevent the release of egg cells from the ovaries.



Fertility treatments:

On the other hand, there are also people who would like to have children who have difficulty becoming pregnant. **In vitro fertilisation (IVF)** and **artificial insemination (AI)** are two fertility treatments which can solve this:

- **IVF** - If fertilisation cannot occur due to the sperm count or quality being too low, the egg cell can be fertilised outside of the body and then be implanted back into the uterus.
- **AI** - sperm is directly inserted into the uterus. This sperm can be from the partner, or from a sperm bank if their sperm is not of a high enough quality.

Social implications of contraception and fertility treatments:

Some people believe that fertility treatments, such as IVF, and genetic screening of embryos may lead to '**designer babies**', where parents will discard eggs which do not have **desired characteristics**, for example a certain hair colour or gender. In addition, they may avoid having a child with an inherited disease.

Some **religious groups** do not agree with artificial methods of contraception. This is because they believe that they are **preventing a life** that otherwise would have been created, which goes against their beliefs. Fertility treatments are also contentious as during IVF, **multiple eggs** are taken and fertilised at once, leading to **spare embryos** which are afterwards frozen and stored or destroyed.

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 an 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.

