

CIE Biology GCSE

17: Inheritance Notes

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

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Key words:

- **Inheritance** - the transmission of genetic information from parents to offspring.
- **Chromosome** - a thread-like structure of DNA that carries genetic information in the form of genes.
- **Gene** - a length of DNA that codes for a particular protein.
- **Allele** - one of a number of different versions of a gene.
- **Genotype** - the genetic makeup of an organism, consisting of all the alleles present.
- **Phenotype** - the observable features of an organism as a result of the expression of particular alleles of the gene.
- **Homozygous** - an organism containing two identical alleles of a particular gene.
- **Heterozygous** - an organism containing two different alleles of a particular gene.
- **Diploid nucleus** - nuclei which contain a full set of chromosomes (23 pairs).
- **Haploid nucleus** - nuclei which only contain half the number of chromosomes. These cells are egg and sperm cells, which fuse during fertilization to produce a diploid cell.

There are **23 pairs** of chromosomes in the nucleus of all **diploid** human cells. One of these pairs **determine gender**. These chromosomes are therefore called the **sex chromosomes**. For females these chromosomes are **XX** and for males the chromosomes are **XY**. All female **egg cells contain only an X** chromosome, whereas male **sperm cells may contain an X or a Y**, thus the gender of the baby depends on which sperm cell fertilizes the egg cell.

Protein synthesis:

DNA controls the function of the cell by regulating protein synthesis, antibodies and receptors for neurotransmitters. Protein synthesis is important to maintain cell **structure**, as well as for **producing enzymes** to catalyze metabolic reactions:

1. The gene which codes for the protein is used to make an **mRNA copy** in the **nucleus**. mRNA is similar to a single strand of DNA, although contains the base U rather than T.
2. The **mRNA copy leaves the nucleus** and travels through the **cytoplasm** to a **ribosome**.
3. The ribosome uses the mRNA strand to produce a chain of **amino acids** which make up the protein. The order of the amino acid chain is determined by the order of bases on the mRNA. This order is **specific** to each protein made.

As each type of cell has a **different function**, not every type of protein is synthesized in every cell. The **genes** to code for each protein are present in every cell, however. These genes are therefore **switched 'on' or 'off'**. When the gene is switched **on**, it is **expressed**, and the protein associated with the gene is synthesized. When the protein is not required, the gene is switched **off**.



Mitosis:

Mitosis is a form of cell division. During mitosis, **nuclear division** of a parent cell occurs, producing **two genetically identical daughter cells**. Mitosis is used to create new cells in the body to **repair and replace old and damaged tissues**, as well as allowing **growth** of the organism and playing a role in **asexual reproduction**. Mitosis involves the **splitting of chromosomes** into their two halves, each of which are known as a **chromatid**:

1. Before replication can occur, the chromatids in the parent cell must **replicate** to produce **identical copies** of themselves which **pair as chromosomes**.
2. The **chromosomes line-up** along the nucleus.
3. The chromosomes **separate** so that each identical chromatid is pulled to opposite **poles** of the cell.
4. The **cell membrane constricts** in the middle and the **nucleus is separated** as the cell splits into two new daughter cells. Each of these cells will contain a set of chromatids, which then **replicate** themselves again to **produce new chromosomes**.

Stem cells:

Stem cells are found in **embryos** or in the **bone marrow**. These cells are **unspecialized** and divide by mitosis to produce daughter cells which then specialize to have a variety of functions. Cells, once specialized, **cannot produce unspecialized cells**. For example, a cell which makes up the heart tissue cannot divide to make a cell which can act as skin tissue as the cell produced will already be specialized as a heart cell.

Meiosis:

Meiosis is used to make **four genetically unique** daughter cells and is used in the production of **gametes**. During meiosis, the **chromosome number is halved**, and a **diploid cell divides** to produce four **haploid** cells. As each gamete produced is genetically unique, each of the offspring will also be unique. This is beneficial for a species as it produces **genetic variation**.

Monohybrid inheritance:

Offspring **inherit characteristics** from both their mother and father and **two sets of genes are inherited**, one from each. If the mother and father pass down the **same allele** for a particular trait, e.g. they both pass down the allele for blue eyes, the offspring will have two identical alleles for this trait, which is referred to as **homozygous**. If two **separate alleles** are passed down, e.g. the mother has blue eyes and the father has brown eyes, the offspring will have two different alleles for the gene, which is called **heterozygous**.

If two **identical homozygous** individuals are bred together, it is referred to as **pure-breeding**, and the offspring will have the **same characteristics as the parents**. Breeding heterozygous



parents is not pure-breeding, as there are a number of different alleles that the offspring could display in their phenotype.

Alleles can be **dominant** and **recessive**. A **dominant allele is always expressed if present**, whereas the **recessive allele** is only expressed in the **absence of the dominant allele**. For example, the allele for brown eyes is dominant and the allele for blue eyes is recessive. This means that if two parents with blue and brown eyes were bred, the offspring would have brown eyes as this allele is dominant.

Monohybrid crosses:

Monohybrid crosses are used to predict the ratios of inherited characteristics in a population. There are always **four outcomes**. The dominant allele is written as a capital letter and the recessive as the lowercase of that letter.

E.g. 1) Crossing two **heterozygous** green and yellow pea plants (both parents contain the alleles for both traits):

G= green (dominant allele)
 g= yellow (recessive allele)

Parent one → Parent two ↓	G	g
G	GG	Gg
g	Gg	gg

The outcomes are GG, Gg, Gg and gg. As G is dominant, there is a 75% chance that the offspring will display this allele in the phenotype and be green. There is a 25% chance that the offspring will be yellow therefore the ratio is **3:1**.

E.g. 2) Crossing a **homozygous recessive** (yellow) pea plant with a **heterozygous** pea plant:

G= green (dominant allele)
 g= yellow (recessive allele)

Parent one (homozygous) → Parent two (heterozygous) ↓	g	g
G	Gg	Gg
g	gg	gg



The outcomes are Gg, Gg, gg and gg. There is a 50% chance of the offspring being green or yellow, therefore the ratio is **1:1**.

Co-dominance:

Some alleles are **co-dominant**, meaning that **neither is recessive**, and they are **both displayed in the phenotype**. An example of this is blood groups. The three possible alleles for blood groups are A, B and O. The **A and B alleles are co-dominant**, which leads to the AB blood group. O is recessive, and thus is only displayed in the phenotype if both parents have O blood groups.

When writing codominant alleles, a capital letter is used to show the gene, and a superscript letter is used to denote the allele, e.g. C^w

Sex-linked characteristics:

Some genes are located on the **sex chromosomes**. A characteristic which comes from one of these genes is referred to as a **sex-linked characteristic**. A result of this is that some traits are **more common to one gender**, for example any gene located on the Y chromosome can only be present in males as females do not have this chromosome. An example of a sex-linked characteristic is **colour blindness**, which is a **recessive** characteristic found on the **X chromosome**.

