

Chromosomes, genes and proteins

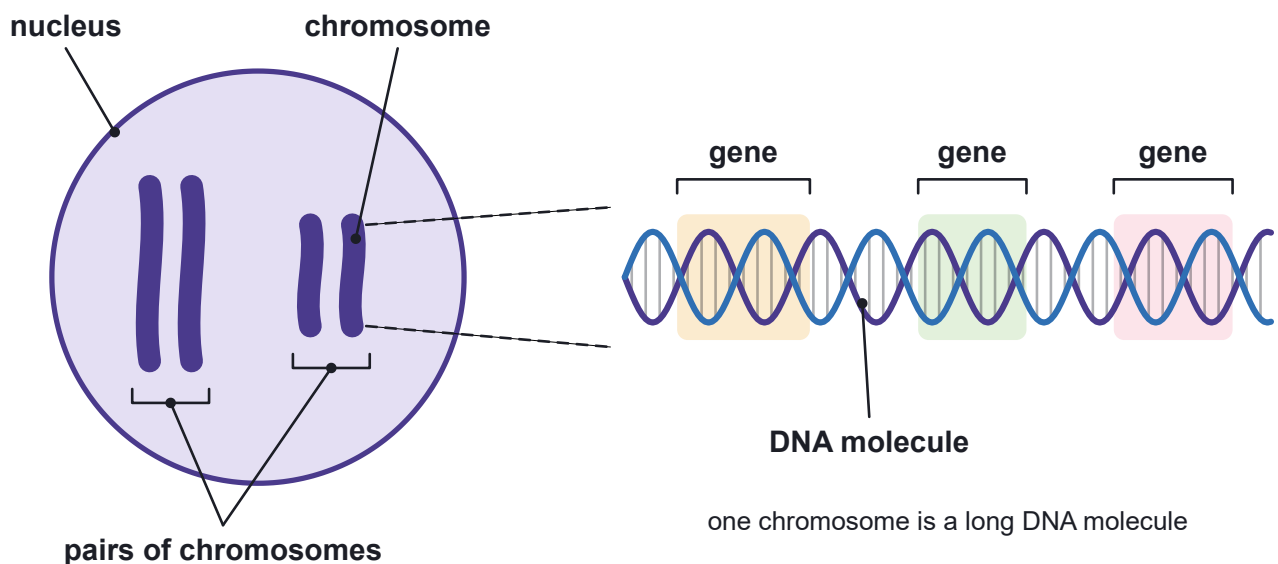
Revision notes • Chromosomes, genes and alleles, how sex is inherited, how genes control protein production, gene expression, and haploid and diploid nuclei.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

Chromosomes, genes and proteins Spec 17.1

Chromosomes, genes and alleles Spec 17.1.1, 17.1.2, 17.1.3

The nucleus of a cell contains **chromosomes**. Chromosomes are made of **DNA**, and the DNA contains genetic information in the form of **genes**.



A nucleus contains **chromosomes** in pairs. Each chromosome is a long DNA molecule carrying many **genes**.

Gene	A length of DNA that codes for a protein.
Allele	An alternative form of a gene.

Every gene has a fixed position on a chromosome. Many genes exist in more than one form. For example, the gene for flower colour may have an allele for red flowers and a different allele for white flowers. Different alleles of the same gene have slightly different DNA, so they can code for slightly different proteins.

Chromosome, DNA, gene and allele

Term	What it is
Chromosome	a structure in the nucleus made of DNA
DNA	the molecule that contains the genetic information
Gene	a length of DNA that codes for a protein
Allele	an alternative form of a gene

Common mistake: A gene is not the same as an allele. Write that an allele is an alternative form of a gene. Do not say a gene is a 'section of a chromosome' without saying it codes for a protein.

Inheritance of sex Spec 17.1.4

Human body cells contain one pair of **sex chromosomes**, which decide whether a person is male or female. There are two types, called X and Y.

- Females have two X chromosomes (XX).
- Males have one X chromosome and one Y chromosome (XY).

Gametes (sex cells) carry only one sex chromosome. All eggs carry an X chromosome. Half of the sperm carry an X chromosome and half carry a Y chromosome. The sex of a baby depends on which sperm fertilises the egg.

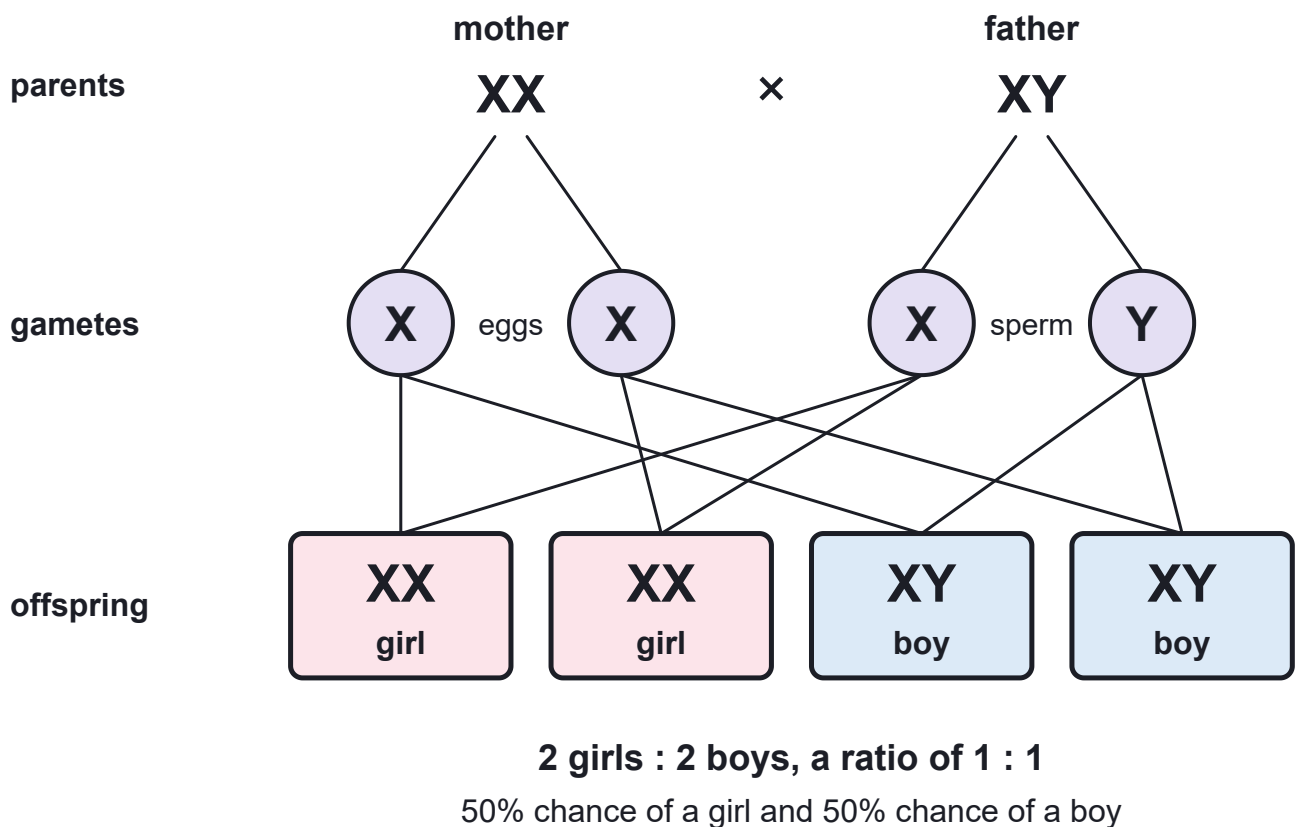
Genetic diagram: inheritance of sex

	Mother (female)	Father (male)
Parental genotypes	XX	XY
Gametes	X and X (every egg carries X)	X and Y (half the sperm carry X, half carry Y)

Punnett square: eggs across the top, sperm down the side

Sperm ↓ Eggs →	X	X
X	XX (girl)	XX (girl)
Y	XY (boy)	XY (boy)

Offspring: 2 XX (girls) : 2 XY (boys). The chance of a baby being a boy is the same as the chance of it being a girl: **1:1**, or 50% each.



Every egg carries X; half the sperm carry X and half carry Y, so the chance of a girl or a boy is **1:1**.

Exam tip: The father decides the sex of the baby, because only his gametes can carry either X or Y. State this in your answer and show the gametes in a genetic diagram.

How genes control proteins Spec 17.1.5, 17.1.6, 17.1.7, 17.1.8 Supplement

Supplement

A gene is a length of DNA. DNA contains a sequence of bases. The **sequence of bases** in a gene determines the **sequence of amino acids** used to make a specific protein.

Supplement

Amino acid sequence and protein shape

Supplement

A protein is a chain of amino acids. Different sequences of amino acids make chains that fold into different **shapes**. Each protein has a shape that suits its job. If the sequence changes, the shape may change, and the protein may no longer work.

Supplement

DNA controls cell function

Supplement

DNA controls cell function by controlling the production of proteins. Examples of proteins include:

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- enzymes, which control the chemical reactions in a cell
- membrane carriers, which move substances across the cell membrane
- receptors for neurotransmitters, which detect chemicals released at synapses

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How a protein is made

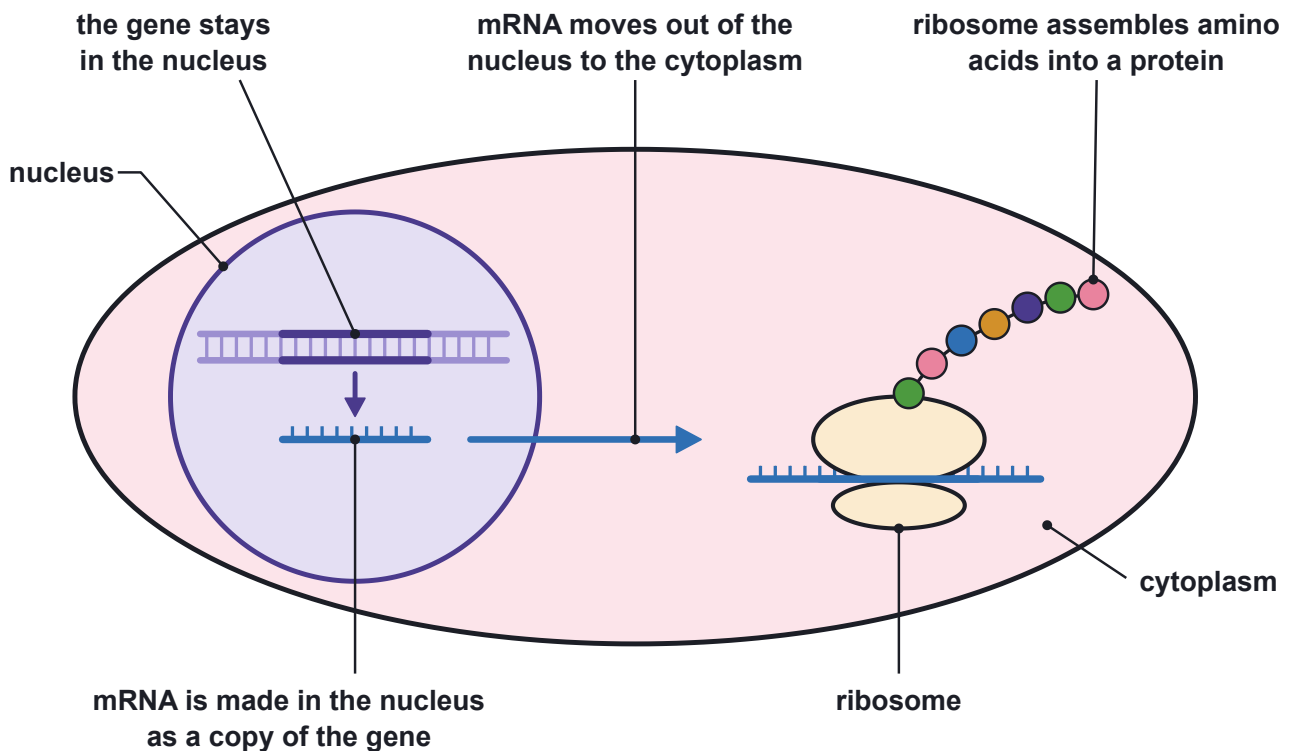
Supplement

The gene for a protein stays in the **nucleus**. A copy of the gene is made instead. This copy is called **messenger RNA** (mRNA).

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1. The gene coding for the protein remains in the nucleus.
2. mRNA is made in the nucleus as a copy of the gene.
3. The mRNA molecule moves out of the nucleus to the cytoplasm.
4. The mRNA passes through a ribosome.
5. The ribosome assembles amino acids into a protein molecule.
6. The specific sequence of amino acids is determined by the sequence of bases in the mRNA.

Supplement



The gene stays in the nucleus; an **mRNA** copy carries the code to a **ribosome** in the cytoplasm.

Supplement

Exam tip: Learn the order: gene in nucleus, mRNA copy made, mRNA to cytoplasm, ribosome assembles amino acids. You do not need the details of transcription or translation.

Supplement

Gene expression

Supplement

Most body cells in an organism contain the **same genes**. However, a cell only makes the specific proteins it needs. Many genes in a particular cell are therefore **not expressed**. For example, a cell in the pancreas makes the protein insulin, but a skin cell has the gene for insulin and does not make it.

Supplement

This is why cells can be different shapes and do different jobs, although they have the same genes.

Supplement

Haploid and diploid nuclei

Supplement

Haploid nucleus	A nucleus containing a single set of chromosomes.
Diploid nucleus	A nucleus containing two sets of chromosomes.

Supplement

In a diploid cell there is a **pair of each type of chromosome**. One chromosome in each pair came from the mother and one came from the father. In a human diploid cell there are **23 pairs** of chromosomes, which is 46 in total. Human gametes are haploid and have 23 chromosomes.

Supplement

Haploid and diploid human cells

	Haploid	Diploid
Sets of chromosomes	one	two
Number of chromosomes in a human cell	23	46 (23 pairs)
Example	sperm cell, egg cell	skin cell, muscle cell

Supplement

Common mistake: Say 23 pairs for a diploid cell and 23 chromosomes for a haploid cell. '23 chromosomes' on its own does not tell the examiner whether you mean pairs or a single set.

Quick check

1. Define a gene.
2. Define an allele.
3. Which sex chromosomes do males and females have?
4. **Supplement** What determines the sequence of amino acids in a protein?
5. **Supplement** How many pairs of chromosomes are in a human diploid cell?

Quick check answers

Chromosomes, genes and proteins

1. A length of DNA that codes for a protein.
2. An alternative form of a gene.
3. Males are XY; females are XX.
4. The sequence of bases in the gene.
5. 23 pairs.