TOPIC: MEIOSIS

Key Knowledge:

- The production of haploid gametes from diploid cells by meiosis, including the significance of crossing over of chromatids and independent assortment for genetic diversity

MEIOSIS VS MITOSIS

Meiosis is the process by which haploid sex cells (gametes) are made in the reproductive organs. It follows a similar process to mitosis: it is preceded by interphase, separates the chromosomes in sequential stages (prophase, metaphase, anaphase and telophase) and divides cells via cytokinesis. However, there are also several key differences between the two processes.

	MEIOSIS	MITOSIS
Type of Cell Produced	Sex cells / gametes	Body cells
Number of Divisions	Two divisions (MI and MII)	One division
Number of Cells Formed	Four haploid cells	Two diploid cells
Outcome of Process	Cells are different (genetic variation)	Cells are identical (cloning)
Purpose of Process	Sexual reproduction (more biodiversity)	Growth and repair of tissues

HOMOLOGOUS CHROMOSOMES

Sexually reproducing organisms receive genetic information from both parents and so have two copies of every chromosome – a maternal copy and a paternal copy. The chromosome pairs are called homologous chromosomes and the cell is described as **diploid** (two chromosome sets). Meiosis functions to separate the homologous pairs to form sex cells that are **haploid** (one chromosome set). Via sexual reproduction, the male and female gametes can then be fused (fertilisation) to form a new, distinct diploid cell (zygote). Homologous chromosomes will have the same genes, but may have different versions of the gene (alleles).

MEIOTIC DIVISIONS

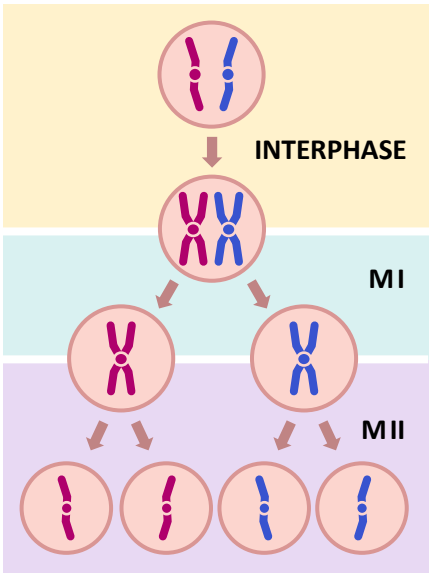
Meiosis consists of two cellular divisions which function to separate a germline cell (diploid) into four genetically distinct sex cells (haploid).

Because meiosis is preceded by interphase, all of the chromosomes will consist of two sister chromatids (formed via replication of DNA).

In the first meiotic division, homologous chromosomes will pair up via connection points called **chiasmata** to become single units (**bivalents**).

These bivalents are then separated in a **reduction division** that halves the chromosome number in the daughter cells (i.e. diploid → haploid).

The second meiotic division separates the two sister chromatids that were formed via replication of DNA during the S phase (interphase).

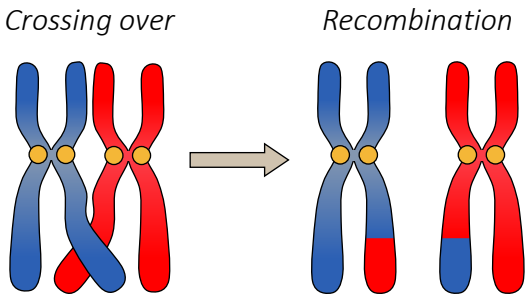


GENETIC VARIATION

Sexual reproduction promotes variation in populations by creating new gene combinations in offspring. Progeny inherit genetic characteristics from both parents and the 'shuffling' of these characteristics via sexual reproduction may result in new phenotypic variants. This recombination of traits occurs via meiosis and involves two distinct processes: crossing over (in prophase I) and random assortment (in metaphase I). Also, fusion of male and female gametes is random, meaning the same parents have distinctive offspring.

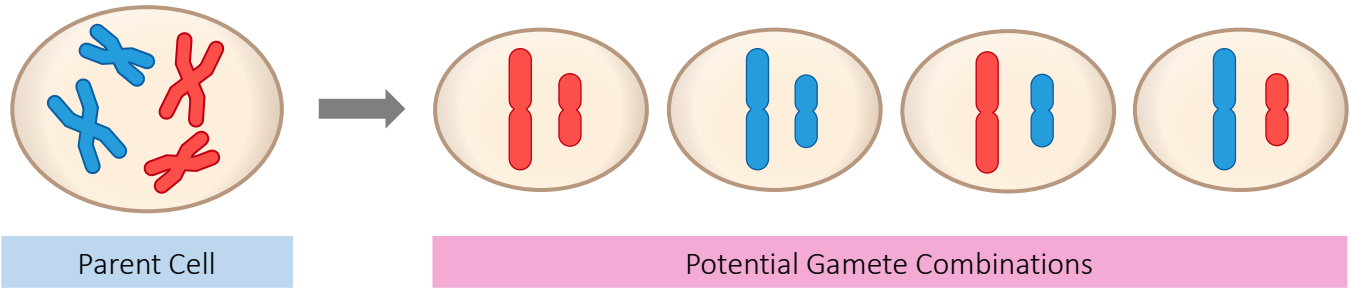
1. CROSSING OVER

Crossing over involves the exchange of segments of DNA between homologous chromosomes during prophase I of meiosis. This exchange of genetic material occurs at points called **chiasmata**. As a consequence of this recombination, all four chromatids of the homologous chromosomes will be genetically distinct, leading to new phenotypic variants.



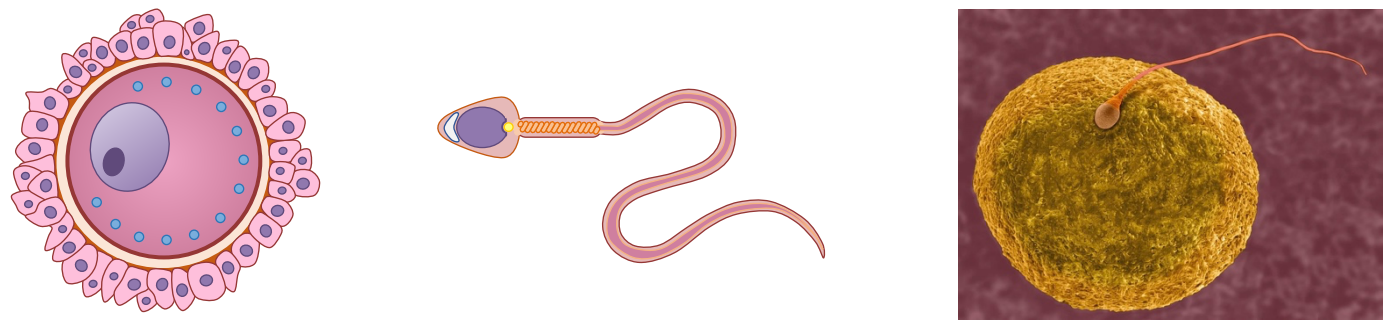
2. RANDOM ASSORTMENT

During metaphase I, the homologous chromosomes line up at the equator in a random orientation. The orientation of each homologous pair occurs independently of all other chromosome pairs, meaning that different combinations of maternal and paternal chromosomes will be formed within gametes. As humans have 23 pairs of chromosomes, each person can produce 2^{23} (over 8 million) distinct gamete combinations.



3. RANDOM FERTILISATION

Following meiosis, the haploid daughter cells undergo a process called gametogenesis to differentiate into functional sex cells. Males form **spermatozoa** (via spermatogenesis), whereas females will form egg cells or **ova** (via oogenesis). Fertilisation is a random process (specific egg and sperm fusion is different each time), which means that all siblings should be genetically distinct from each other. Identical twins will only result if the diploid zygote is split into two separate cell masses *after* fertilisation has occurred.



OVERVIEW OF MEIOSIS

Meiosis consists of two divisions, each involving four phases (prophase, metaphase, anaphase, telophase).

Stage	Diagram	Diagram	Stage
Before (1 × 2n)	Interphase (**S**)		**After** (4 × n)
Prophase I (2n)			**Cytokinesis** (2n → n) × 4 **Telophase II** (2n) × 2
Metaphase I (2n)			**Anaphase II** (n → 2n) × 2
Anaphase I (2n)			**Metaphase II** (n) × 2
Telophase I (2n) **Cytokinesis** (2n → n) × 2			**Prophase II** (n) × 2

MEIOSIS I SUMMARY	MEIOSIS II SUMMARY
• Is a reduction division (diploid → haploid) • Separates the homologous chromosomes • Crossing over may occur during Prophase I to create genetically distinct sister chromatids	• Akin to a mitotic division (but of haploid cells) • Separates the sister chromatids • Occurs because DNA is replicated in interphase to create chromosomes with sister chromatids