Meiosis Scope

TOPIC	SUBTOPIC	KEY INFORMATION
MEIOSIS	Why, where, when and how it occurs	• Identify the MAIN characteristics of each phase • Explain crossing over - homologous chromosomes form bivalent and NOT chromosomes only • The process using diagrams with labels
	Significance of meiosis	• Production of haploid gametes • The halving effect of meiosis overcomes the doubling effect of fertilisation, thus maintaining a constant chromosome number from one generation to the next • Mechanism to introduce genetic variation through crossing over and random arrangement of chromosomes on the equator
	Differences between meiosis I and meiosis II	• Especially in the different phases. E.g. In metaphase I chromosome pairs align and in metaphase II single chromosomes align
	Abnormal meiosis: Non-disjunction & Down syndrome	• Non-disjunction of chromosomes at position 21 during Anaphase in humans to form abnormal gametes with an extra copy of chromosome 21

You should be able to draw each phase. When given Metaphase I and told to draw the next phase, your drawing should resemble the given phase in terms of the number of chromosomes, shape and colour coordination.

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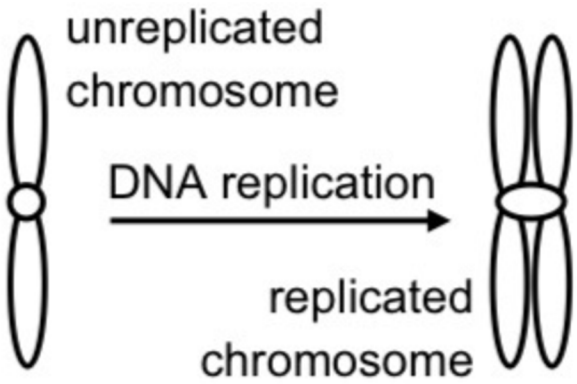
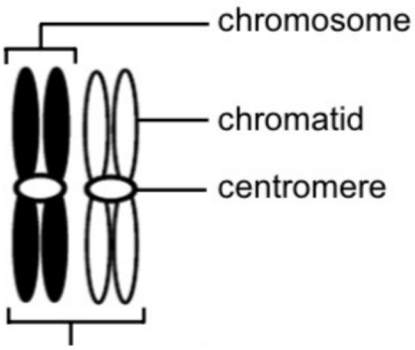
Adapted from DBE revision guidelines

Meiosis notes intro

Key concepts

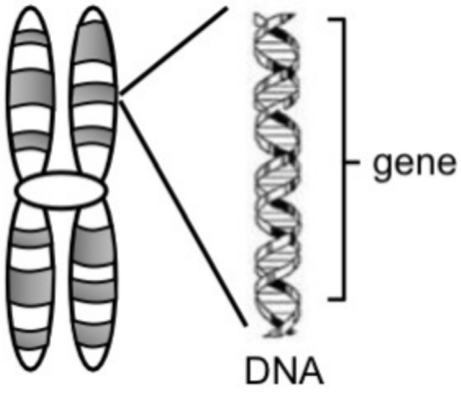


During interphase DNA replication occurs to form replicated chromosomes



homologous chromosome pair
One is paternal, the other is maternal

Each chromosome is made of two chromatids joined by a centromere



Each chromosome had segments called genes

Definition

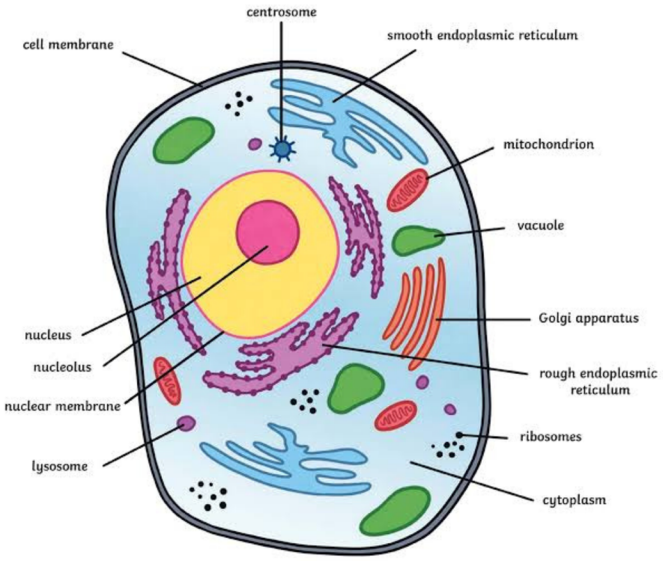
Meiosis is a special type of cell division that halves the number of chromosomes. Four genetically different haploid daughter cells are formed from one diploid cell.

Importance

- haploid gametes are produced
- the doubling effect of fertilization on chromosome number of future generations is overcome
- genetic variation occurs

Recap Gr10 : A cell

Focus on nucleus, cytoplasm and centrosome.



Somatic cells - body cells have 46 chromosomes (diploid-2n)
Gamete cells - sex cells have 23 chromosomes (haploid-n)

This is as a result of meiosis halving the chromosome number

A human cell has 23 homologous pairs of chromosomes pair 1-22 are called autosomes & pair 23 is called a gonosome

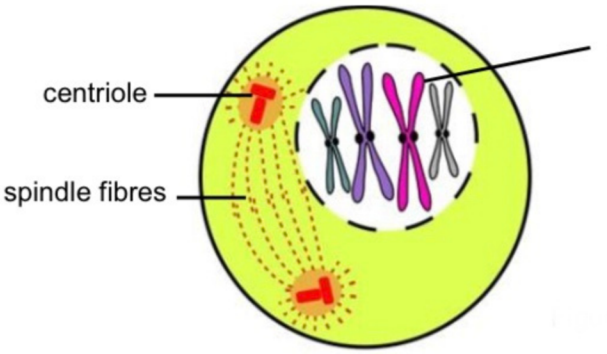
NB- during fertilisation haploid gametes fuse to form diploid zygote.

Meiosis Process

Meiosis occurs in two stages. Meiosis I and II

Meiosis I

Has 4 phases
- Prophase I
- Metaphase I
- Anaphase I
- Telophase I

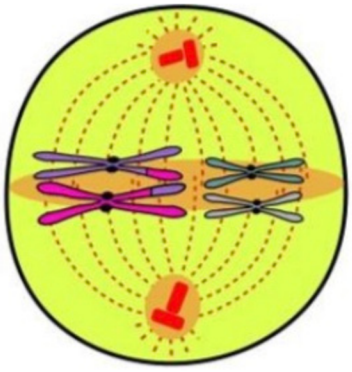


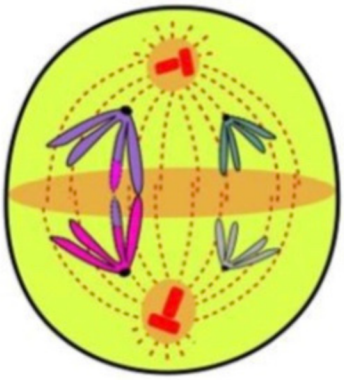
Prophase I

- Nuclear membrane and nucleolus start to disappear.
- Centrosome splits and the two centrioles move apart forming spindle fibres.
- Chromatin network condenses into individual chromosomes and pairs of homologous chromosomes lie next to each other forming a bivalent.
- Crossing over takes place.

Metaphase I

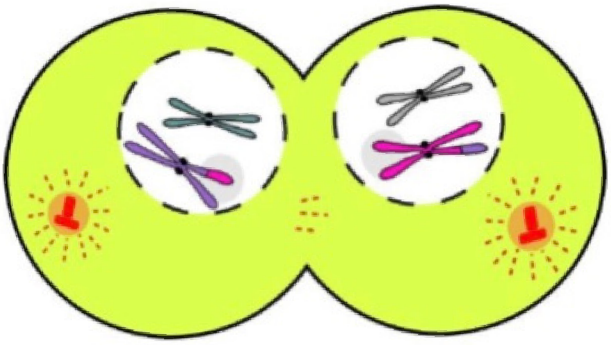
- Homologous chromosomes align at the equator in pairs
- Homologous chromosomes align at equator randomly.
- Each chromosome is attached to spindle fibre.





Anaphase I

- Spindle fibre contracts and pulls whole chromosome to opposite poles.
- Homologous chromosomes are separated.



Telophase I

- A new nuclear membrane forms around the group of chromosomes at each pole
- Nucleolus returns.
- Cytokinesis (division of cytoplasm) splits the mother cell into two daughter cells.

NB- karyokinesis is the division of the nucleus

Two haploid daughter cells form. Daughter cells are unidentifiable due to:
- crossing over at prophase I
- random assortment of chromosomes

Meiosis Process

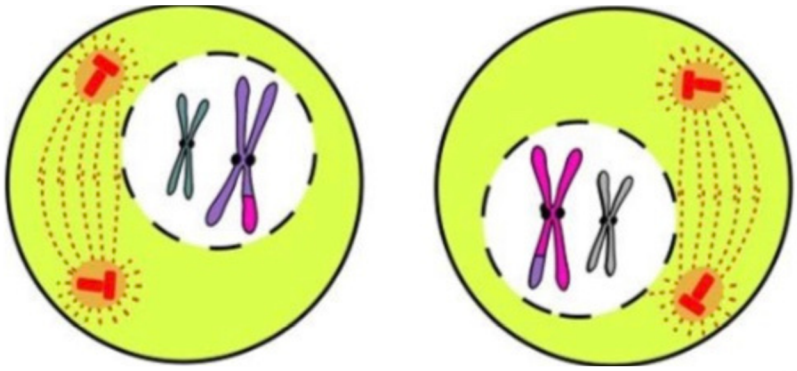
P-M-A-T (a way to remember the phases of meiosis in the correct order)

BOTH CELLS UNDERGO THE SECOND STAGE

Meiosis II

Has 4 phases

- Prophase II
- Metaphase II
- Anaphase II
- Telophase II

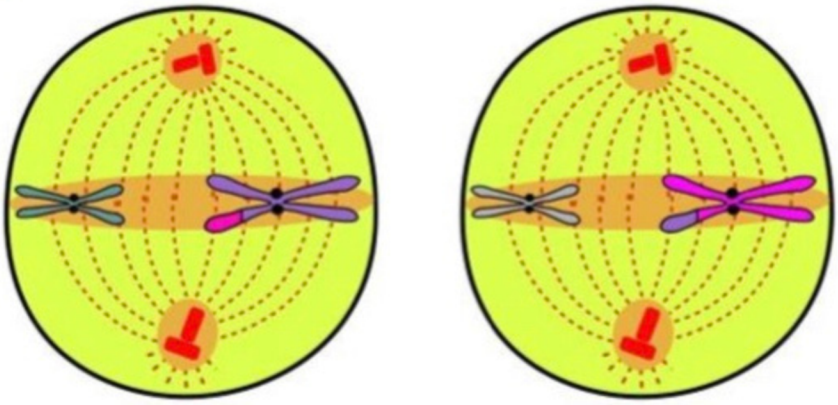


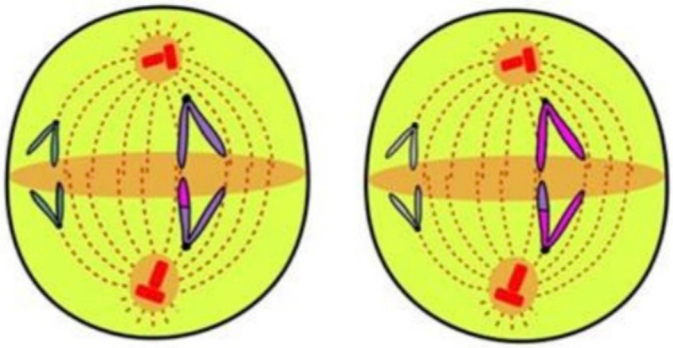
Prophase II

- Nuclear membrane and nucleolus start to disappear.
- Centrosome splits into two centrioles and a spindle forms.
- Chromosomes are NOT in pairs

Metaphase II

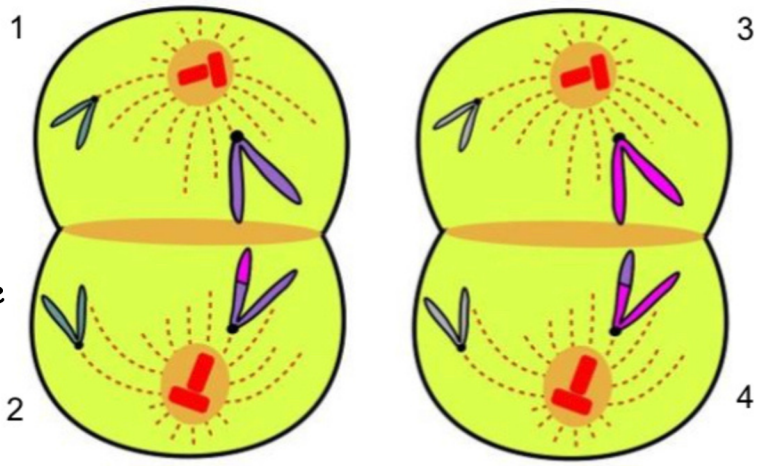
- Single chromosomes arrange themselves randomly along the equator. Which chromatid faces which pole is totally up to chance.
- Each chromosome becomes attached to a spindle fibre.





Anaphase II

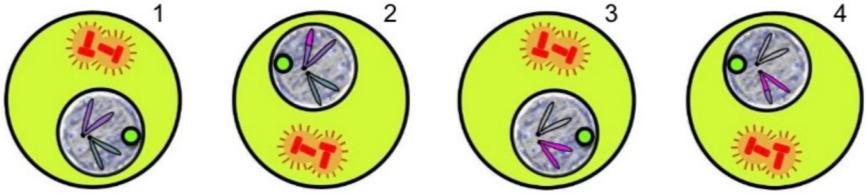
- Spindle fibre contracts, centromere splits and the two chromatids are pulled to opposite poles



Telophase II

- A new nuclear membrane forms around the unreplicated chromosomes at each pole.
- Cytokinesis splits the cell into two new cells

Four haploid daughter cells form at the end of meiosis II



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Meiosis Crossing over

Introduces genetic variation

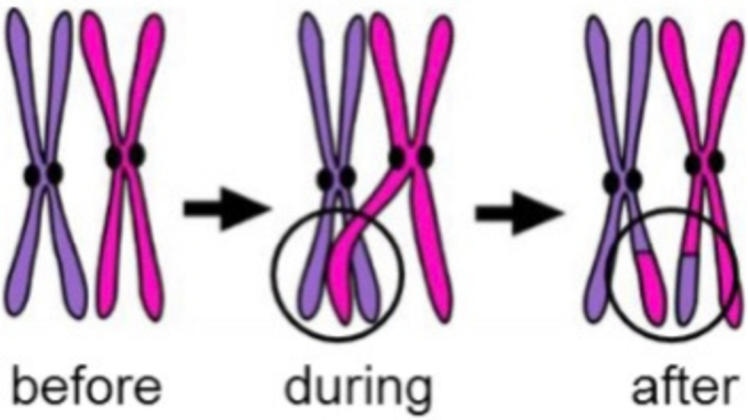
Description

• During prophase I, homologous chromosomes lie next to each other forming a bivalent.

• Inner chromatids from each homologous chromosomes overlap and touch each other at a point called the chiasma (plural: chiasmata) in a process called crossing over.

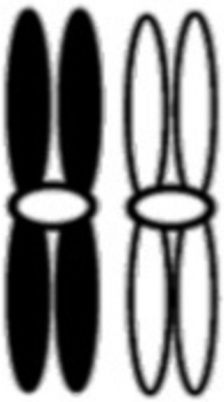
• Chromatid segments break off and are exchanged, resulting in the exchange of genetic material.

• This process is called crossing over and it brings about variation.



Paternal and maternal chromosome exchange genetic material to introduce genetic variation in species. This increases chances of survival among offspring.

The point in which crossing over takes place is called chiasma or chiasmata



A bivalent is a pair of homologous chromosomes which lie next to each other and are physically in contact with each other at a point where crossing over will occur

Meiosis Comparison

Introduces genetic variation

Comparison between meiosis I and II

Meiosis I	Meiosis II
Chromosomes arrange at the equator of the cell in homologous pairs	Chromosomes line up at the equator of the cell individually
Whole chromosomes move to opposite poles of the cell	Chromatids move to opposite poles of the cell
Two cells are formed at the end of this division	Four cells are formed at the end of this division
The chromosome number is halved during meiosis I (diploid → haploid)	The chromosome number remains the same (haploid) during meiosis II
Crossing over takes place	Crossing over does not take place

Comparison between meiosis I and mitosis

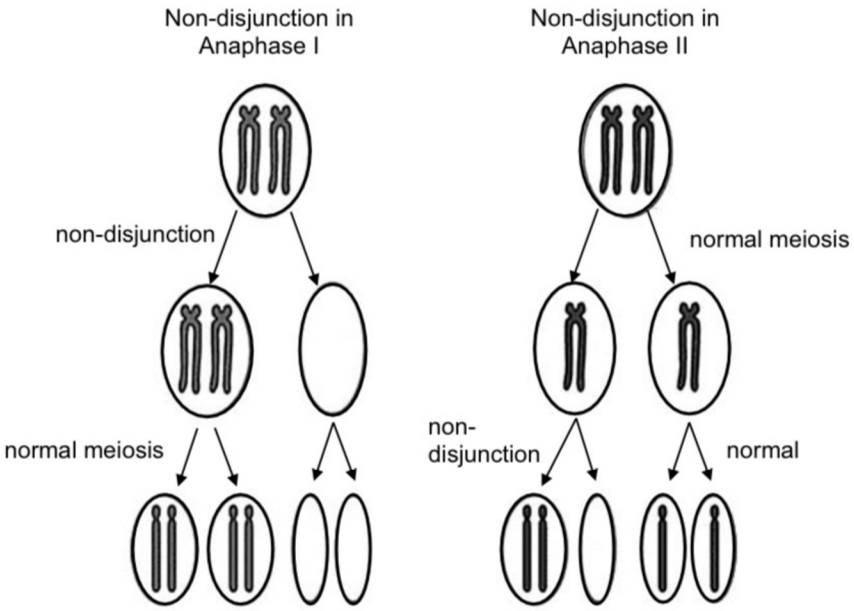
Mitosis	Meiosis
Mitosis occurs in body cells	Meiosis occurs in sex organs
Both karyokinesis and cytokinesis occurs once	Both karyokinesis and cytokinesis occurs twice
Two daughter cells are formed	Four daughter cells are formed
Daughter cells are genetically identical to one another and to the parent cell	Daughter cells are genetically different from each other and from the parent cell
Chromosome number remains constant	Chromosome number is halved
Crossing over does not occur	Crossing over occurs

Meiosis *Abnormal meiosis*

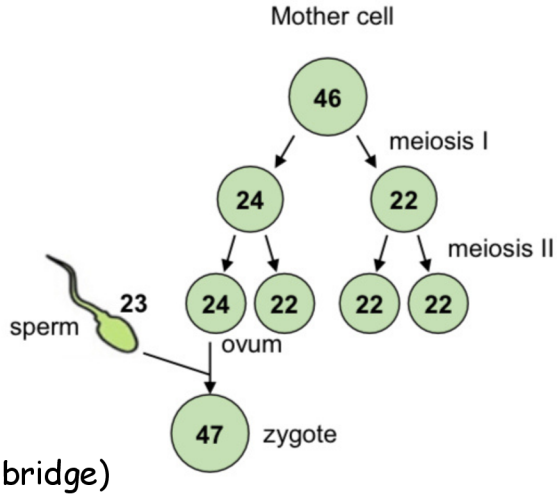
Errors during meiosis - chromosomal mutation

Non-disjunction

Failure of chromosomes to seperate during Anaphase I or II.



- If there is non-disjunction of chromosome pair 21 in humans, it leads to the formation of an abnormal gamete with an extra copy of chromosome 21.
- If there is fusion between a normal gamete (with 23 chromosomes) and an abnormal gamete (with an extra copy of chromosome 21) it leads to Down Syndrome (47 chromosomes in the zygote).



Down syndrome

<u>Symptoms</u>

- upwardly slanted eyes,
- small nose (with flat bridge) and mouth
- various degrees of mental retardation
- decreased muscle tone
- hearing loss
- heart defects.

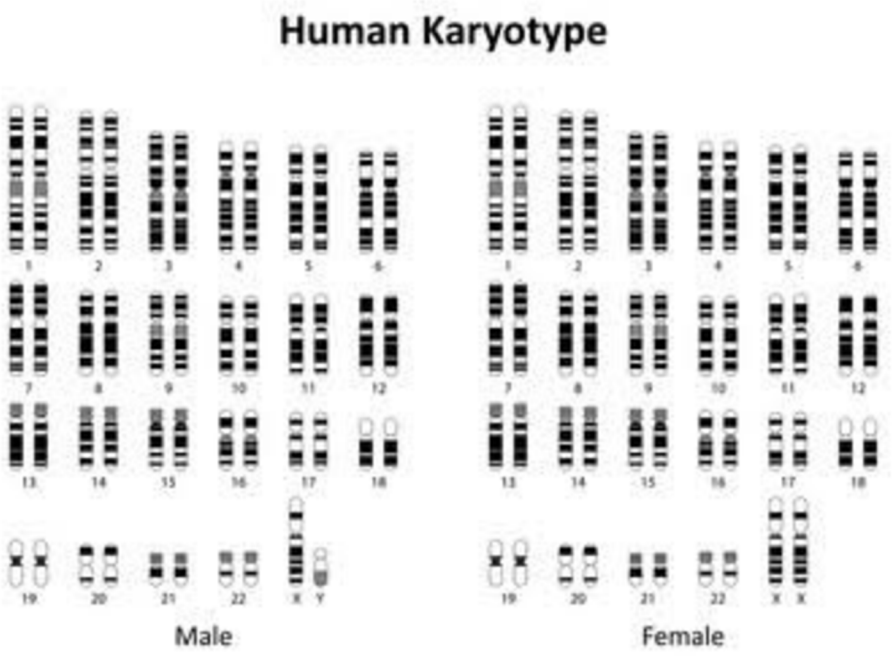
Down Syndrome is caused by the non-disjunction of chromosomes which results in the presence of an extra chromosome number 21 (referred to as trisomy).

An <u>amniocentesis</u> is the process by which amniotic fluid is removed, so that the karyotype of foetal cells in the amniotic fluid can be analysed to check for any defects.

Meiosis

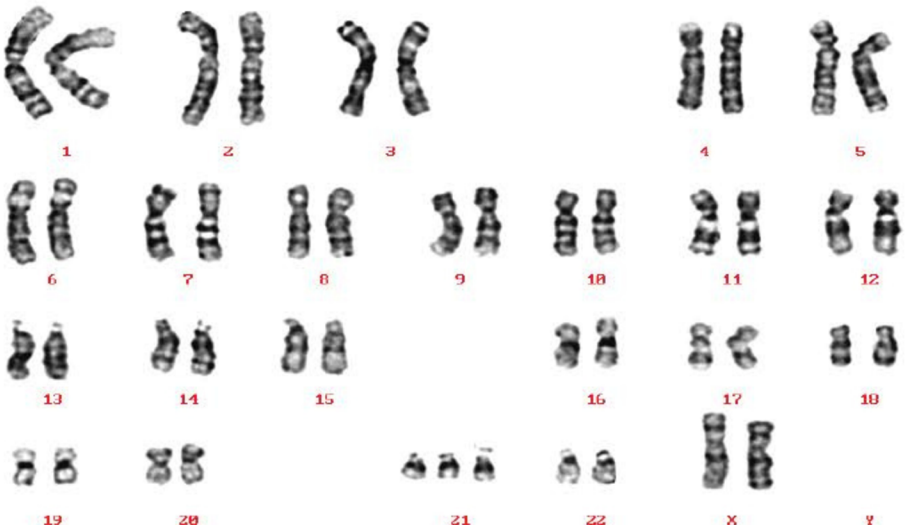
karyotype

a representation of the number, shape and arrangement of a full set of chromosomes in the nucleus of a somatic cell



A human karyotype has 46 chromosomes. 22 pairs of autosomes and 1 pair of gonosomes.

Karyotype of a human with Down syndrome



An extra chromosome at pair 21 leading to 47 chromosomes instead of 46

Meiosis Terminology

- Autosomes
- Centriole
- Centromere
- Chiasma
- Chromatid
- Chromosome
- Diploid number (2n)
- Daughter chromosome
- Gametes
- Gene
- Gonosomes
- Haploid number (n)
- Homologous chromosomes
- Bivalent
- Maternal
- Meiosis
- Mitosis
- Non-disjunction
- Paternal
- Replicated chromosome
- Somatic cells
- Spindle fibres
- Unreplicated chromosome
- Variation
- Zygote