الوراثة البشرية \ المرحلة الثالثة

العام الدراسي ٢٠٢٠-٢٠٢١

المحاضرة الثانية \ الانقسام الاختزالي و اهميته

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وزارة التعليم العالي و البحث العلمي

- **Meiosis** is a process that converts **diploid nuclei to haploid nuclei**.
  - **Diploid cells** have **2** sets of chromosomes.
  - **Haploid cells** have **1** set of chromosomes.
  - **Meiosis** occurs in the **sex organs**, producing **gametes**—**sperm** and **eggs.**
- **Fertilization** is the fusion of a sperm and egg cell.
- The **zygote** has a **diploid** chromosome number, **one set from each parent**.

Homologous Chromosomes

- Pair of chromosomes (maternal and paternal) that are similar in shape and size.
- Homologous pairs (tetrads) carry genes controlling the same inherited traits.
- Each locus (position of a gene) is in the same position on homologues.
- Humans have 23 pairs of homologous chromosomes.

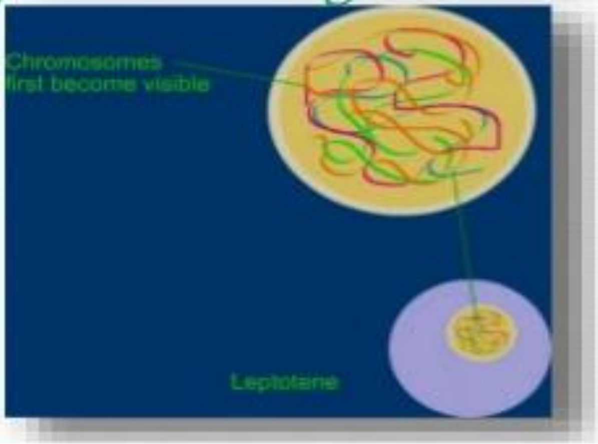
  a. 22 pairs of autosomes
  b. 01 pair of sex chromosomes

Prophase I

- **Longest and most complex phase (90%).**
- **Chromosomes** condense.
- **Synapsis** occurs: **homologous chromosomes** come together to form a **tetrad**.
- **Tetrad** is two **chromosomes** or four **chromatids** (sister and nonsister chromatids).

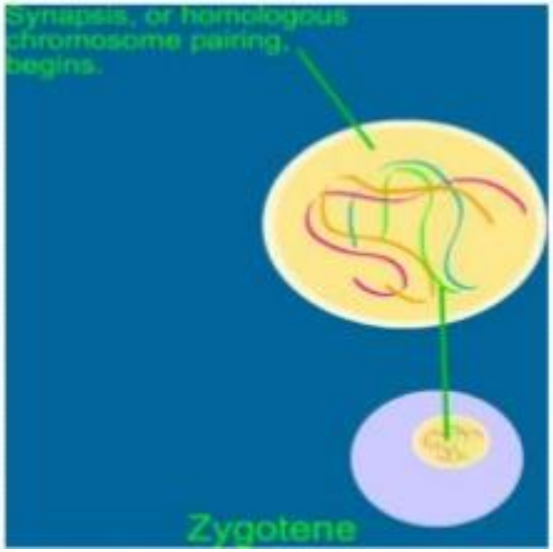
Leptotene

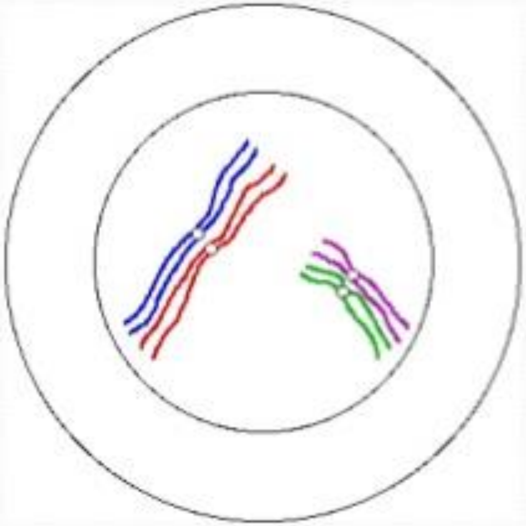
- The first stage of prophase I is the Leptotene stage
- Leptotene also known as Leptonema from Greek words meaning thin threads
- During this stage, individual chromosomes begin to condense into long strands within the nucleus
- However the two sister chromatids are still so tightly bound that they are indistinguishable from one another



Zygotene

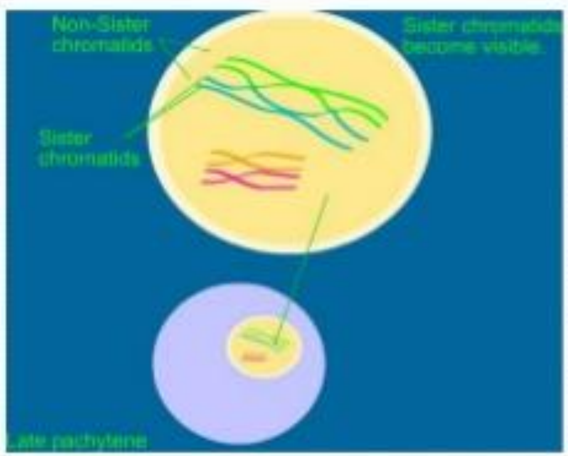
- The ***zygotene stage***, also known as zygonema, from Greek words meaning "paired threads"
- Zygotene, occurs as the chromosomes approximately line up with each other into homologous chromosomes.
- The combined homologous chromosomes are said to be bivalent

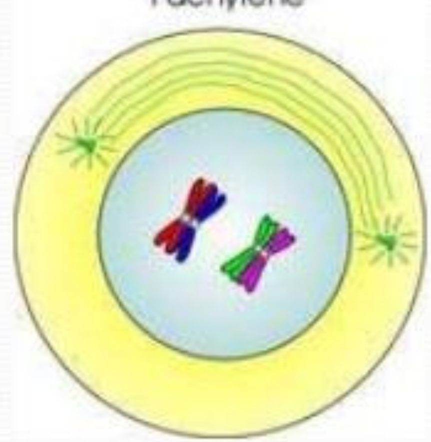




Pachytene

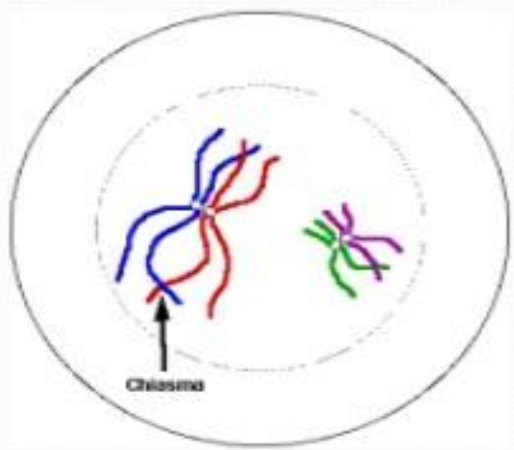
- In pachynema, the homologous chromosomes become much more closely associated. This process is known as synapses
- The synapsed homologous pair of chromosomes is called a tetrad, because it consists of four chromatids
- It can't be observed until the next stage, but the synapsed chromosomes may undergo crossing over in pachynema
- The chromosomes continue to condense

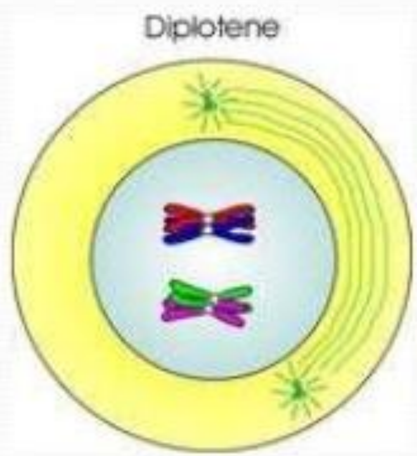




Diplotene

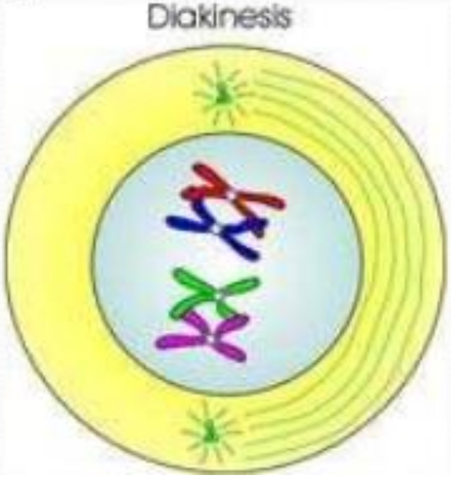
- During the diplotene stage, also known as diplonema, from Greek words meaning "two threads,"
- the homologous chromosomes separate from one another a little
- The chromosomes themselves uncoil a bit, allowing some transcription of DNA

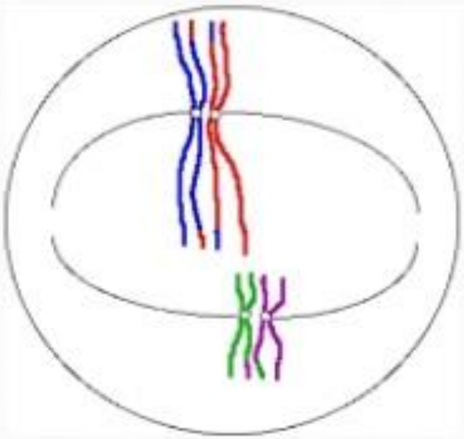




Diakinesis

- Chromosomes condense further during the diakinesis stage, from Greek words meaning "moving through."
- This is the first point in meiosis where the four parts of the tetrads are actually visible.
- In this stage, the homologous chromosomes separate further, and the chiasmata terminalize . Making chiasmata clearly visible.





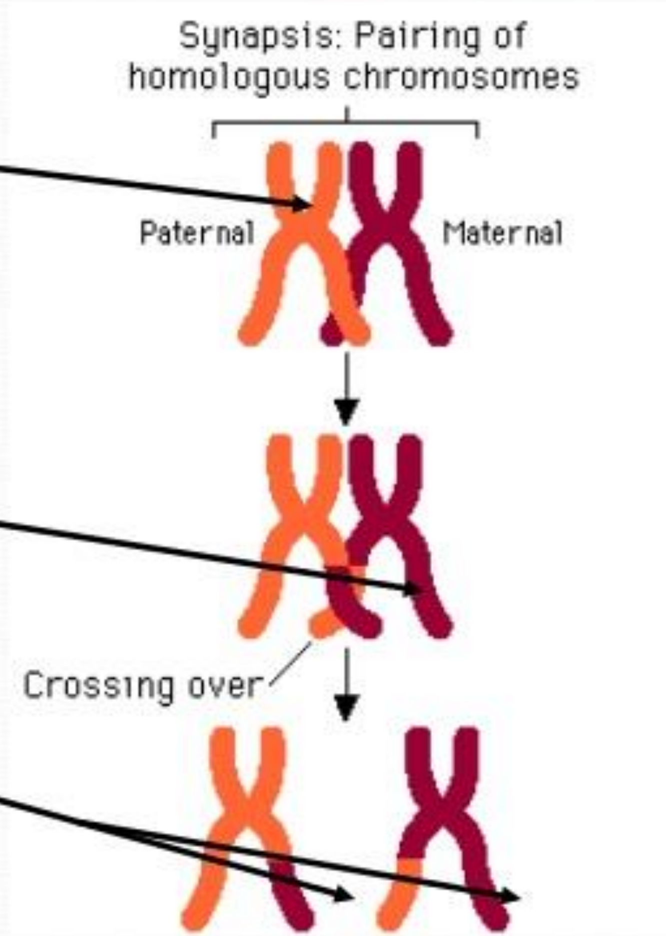
Crossing Over

- **Crossing over (variation)** may occur between nonsister **chromatids** at the **chiasmata**.
- **Crossing over**: segments of nonsister **chromatids** break and reattach to the other **chromatid**.
- **Chiasmata (chiasma)** are the sites of **crossing over**.

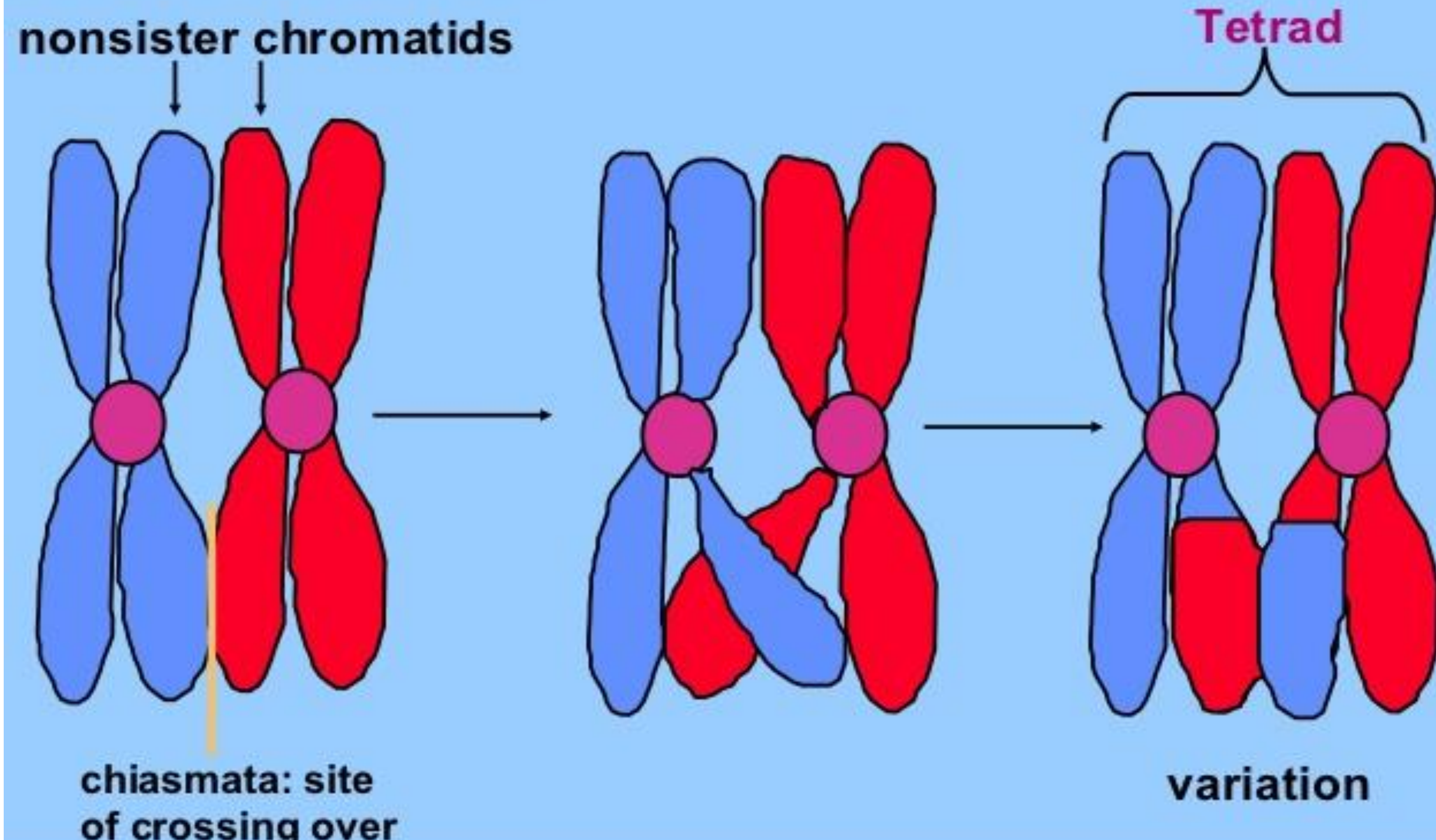
Homologous chromosomes in a tetrad cross over each other

Pieces of chromosomes or genes are exchanged

Produces Genetic recombination in the offspring

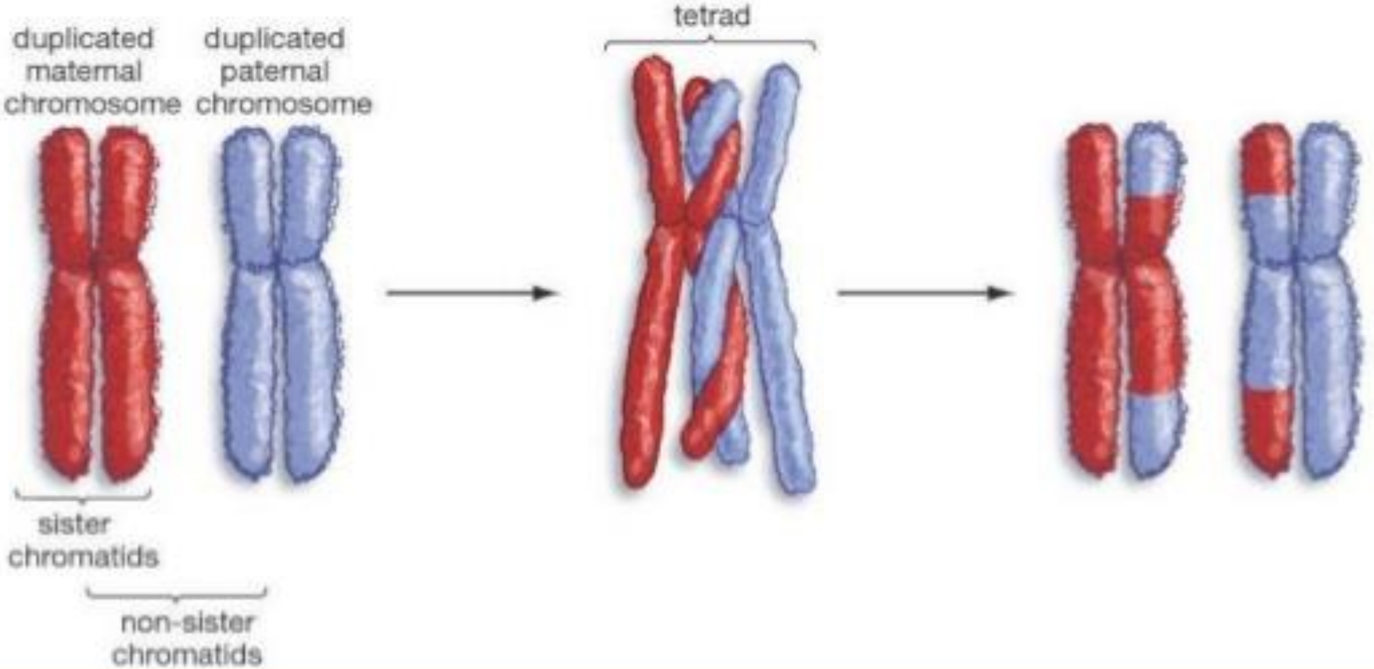


Crossing Over - variation



Another Way Meiosis Makes Lots of Different Sex Cells – Crossing-Over

Exchange of parts of non-sister chromatids.



Crossing-over multiplies the already huge number of different gamete types produced by independent assortment

Question:

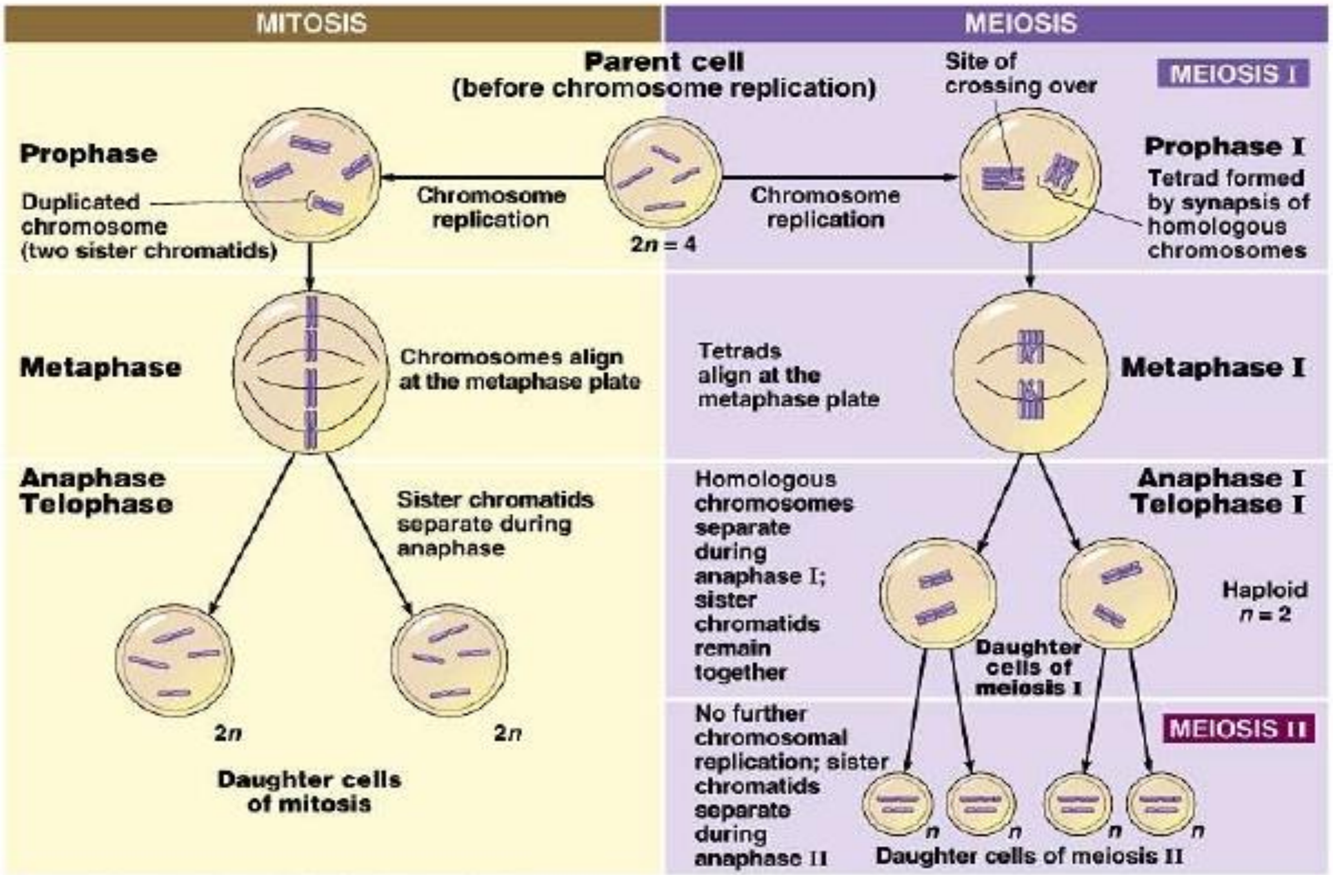
- In terms of Independent Assortment -how many different combinations of sperm could a human male produce?

Answer

- Formula: 2^n
- Human chromosomes: $2n = 46$

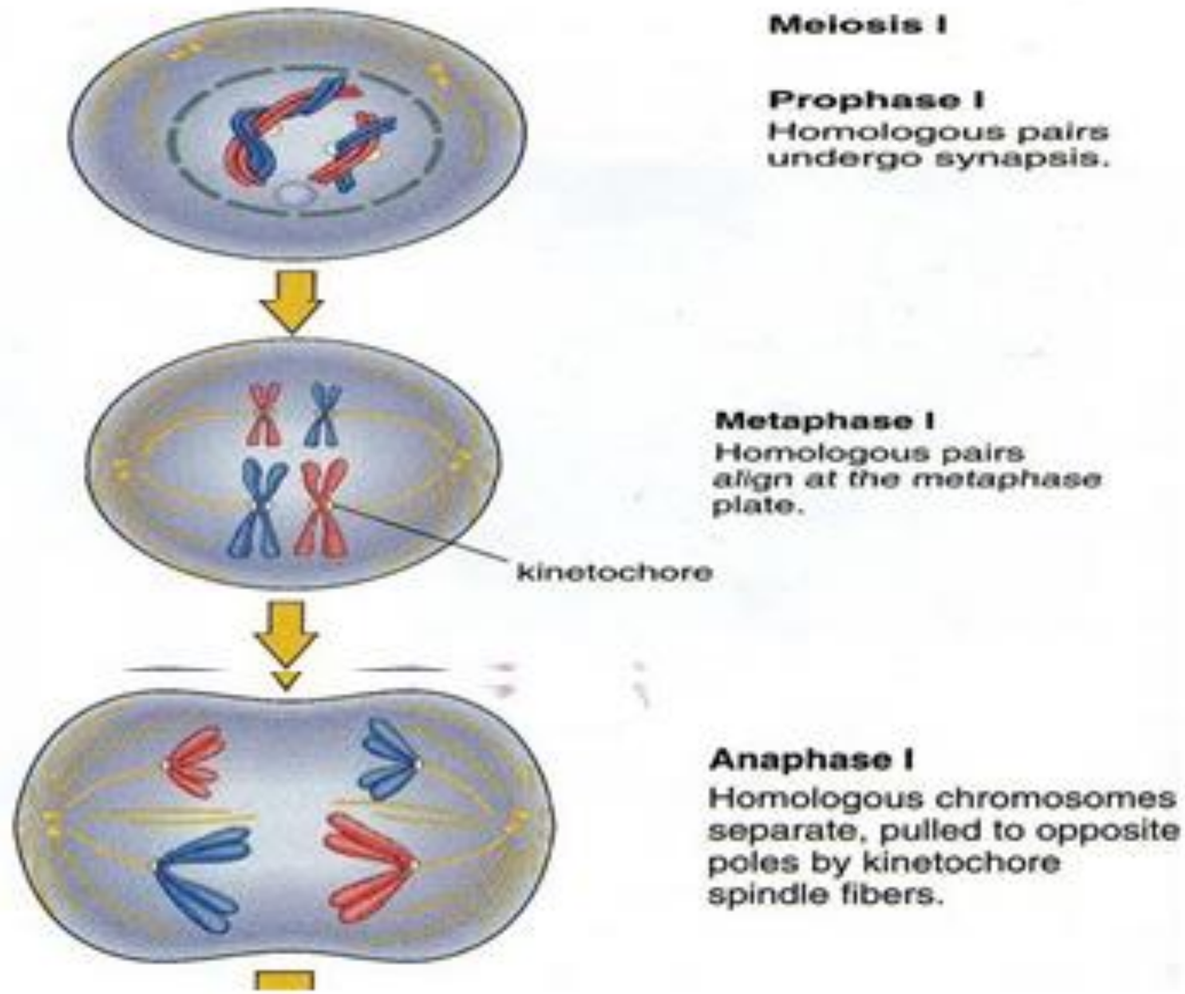
  $n = 23$

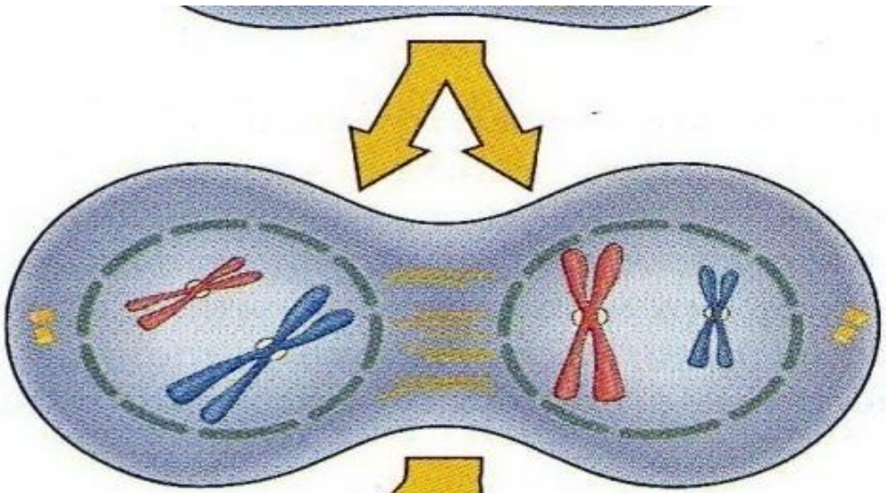
- 2^{23} = ~8 million combinations


MITOSIS
MEIOSIS
Parent cell
(before chromosome replication)
Site of crossing over
MEIOSIS I
Prophase
Duplicated chromosome (two sister chromatids)
Chromosome replication
2n = 4
Chromosome replication
Prophase I
Tetrad formed by synapsis of homologous chromosomes
Metaphase
Chromosomes align at the metaphase plate
Tetrads align at the metaphase plate
Metaphase I
Anaphase
Telophase
Sister chromatids separate during anaphase
Homologous chromosomes separate during anaphase I; sister chromatids remain together
Anaphase I
Telophase I
Haploid
n = 2
Daughter cells of meiosis I
2n
2n
Daughter cells of mitosis
No further chromosomal replication; sister chromatids separate during anaphase II
MEIOSIS II
n
n
n
n
Daughter cells of meiosis II

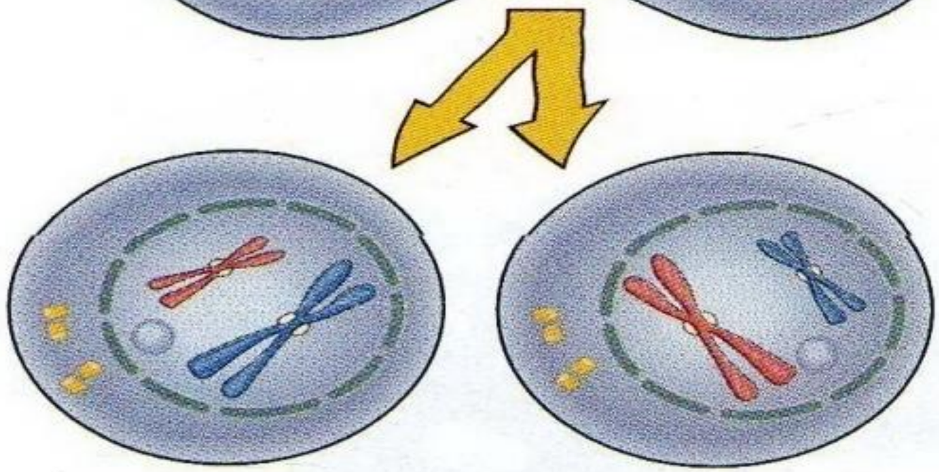
Differences between meiosis and mitosis

Mitosis	Meiosis
Occurs in body cells	Occurs in reproductive cells
Number of chromosomes remains the same in the daughter cells	Number of chromosomes is halved in the daughter cells
Daughter cells are identical to parent cells and each other	Daughter cells are genetically different to the parent cells and each other
Two daughter cells are formed	Four daughter cells are formed
Homologous chromosomes do not come together	Homologous chromosomes come together
There is no exchange of genetic material between Chromosomes	There is exchange of genetic material between chromosomes


Meiosis I
Prophase I
Homologous pairs undergo synapsis.
Metaphase I
Homologous pairs *align at the metaphase* plate.
kinetochore
Anaphase I
Homologous chromosomes separate, pulled to opposite poles by kinetochore spindle fibers.



Telophase I
Daughter cells have one chromosome from each homologous pair.

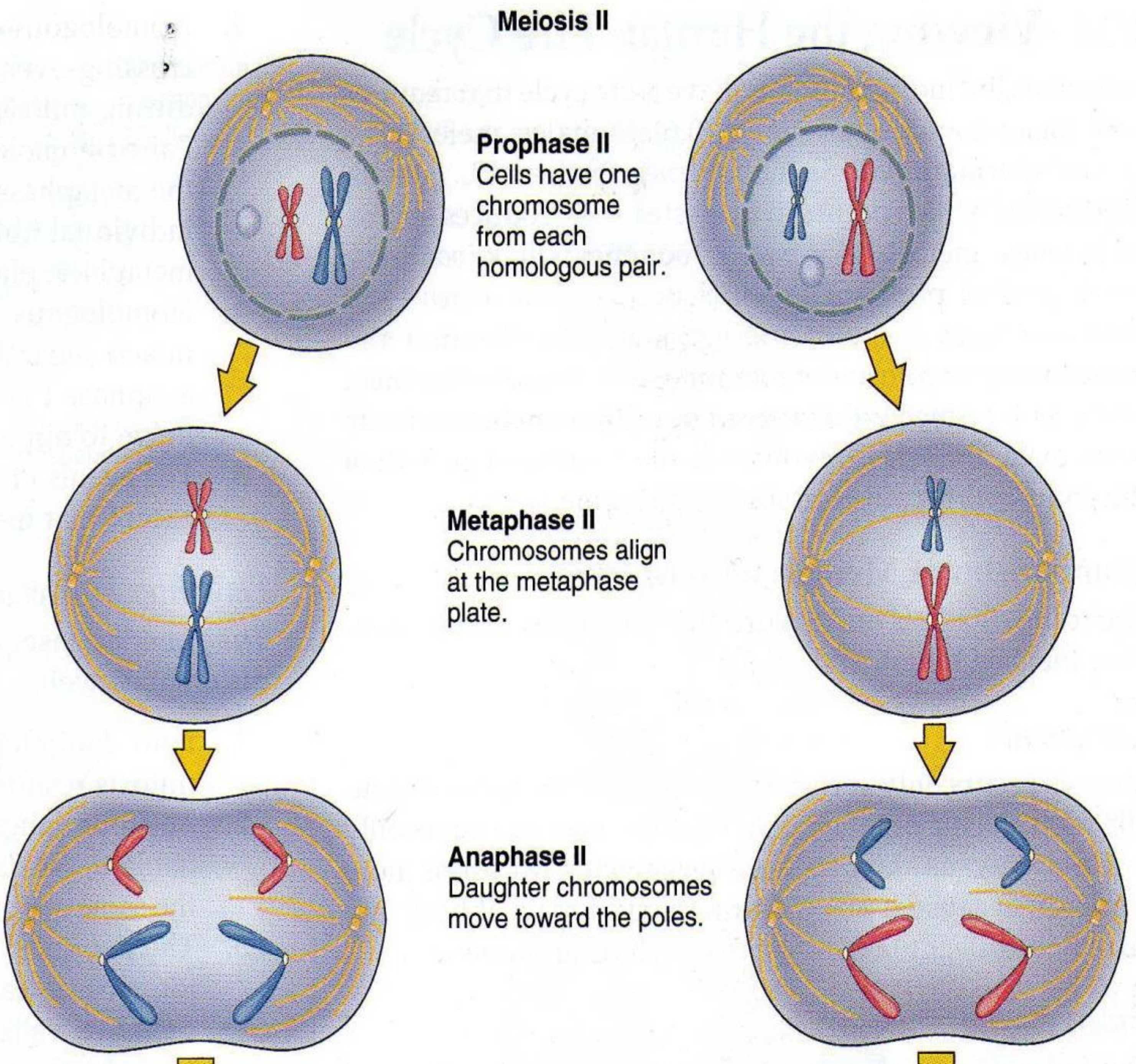


Interkinesis
Chromosomes still consist of two chromatids.

Figure 10.4 Meiosis I.
During meiosis I, homologous chromosomes undergo synapsis and then separate independently—a daughter cell receives one of each kind of chromosome in any of the possible combinations. Following meiosis I, there are two haploid daughter cells and the chromosomes are still duplicated. (The blue chromosomes were inherited from one parent, and the red chromosomes were inherited from the other parent.)

- Meiosis II

  The stage is similar to mitosis
- sister chromatids separate
- this division maintains haploid number of chromosomes
- this phase completes the goal of meiosis--producing four genetically unique cells from one original mother cell


Meiosis II
Prophase II
Cells have one chromosome from each homologous pair.
Metaphase II
Chromosomes align at the metaphase plate.
Anaphase II
Daughter chromosomes move toward the poles.

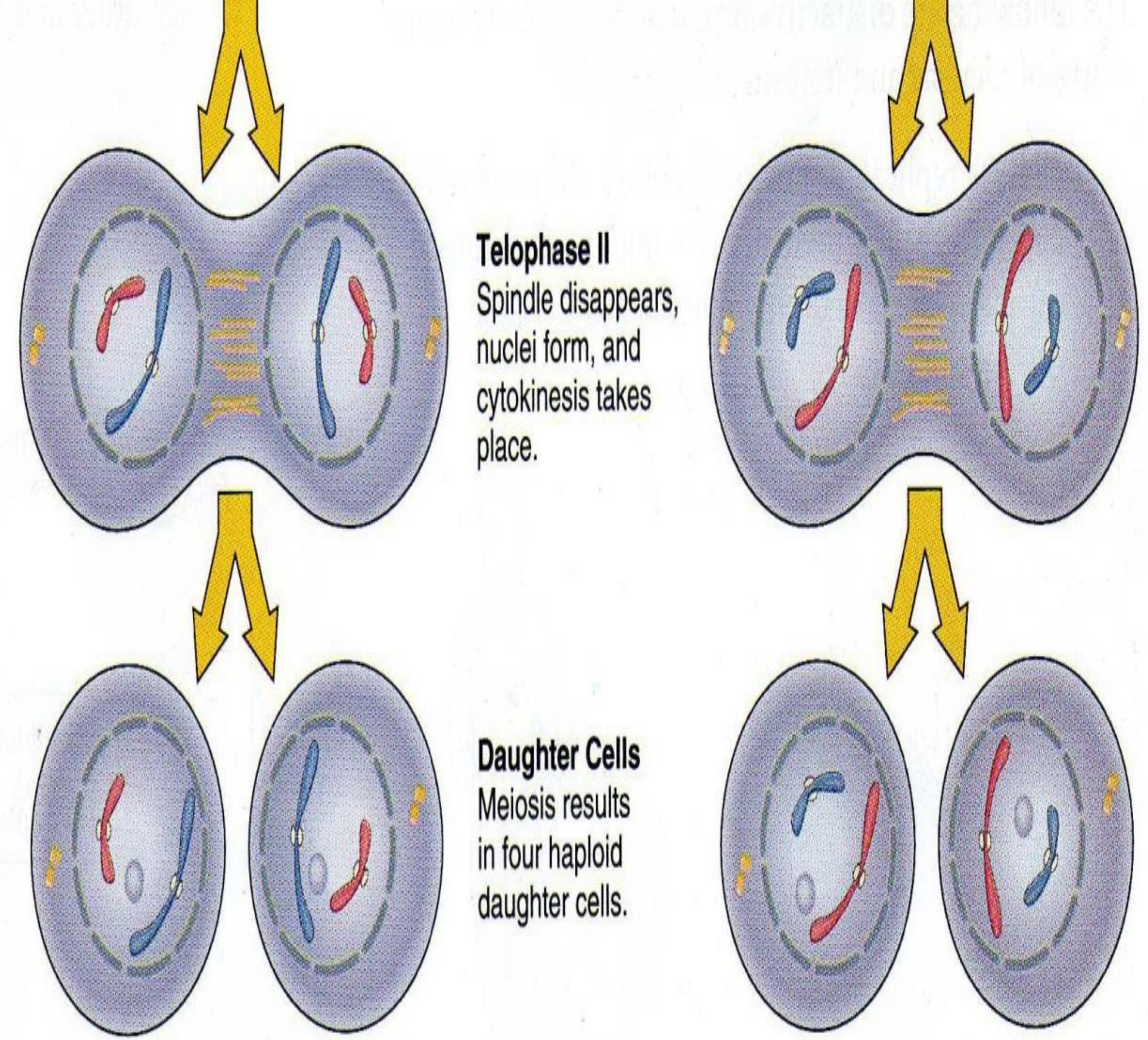


Figure 10.5 Meiosis II. During meiosis II, daughter chromosomes consisting of one chromatid each move to the poles. Following meiosis II, there are four haploid daughter cells.

Gametogenesis

The production of sperm (spermatogenesis) and eggs (oogenesis), takes place through the process of meiosis.

In oogenesis, diploid oogonium go through mitosis until one develops into

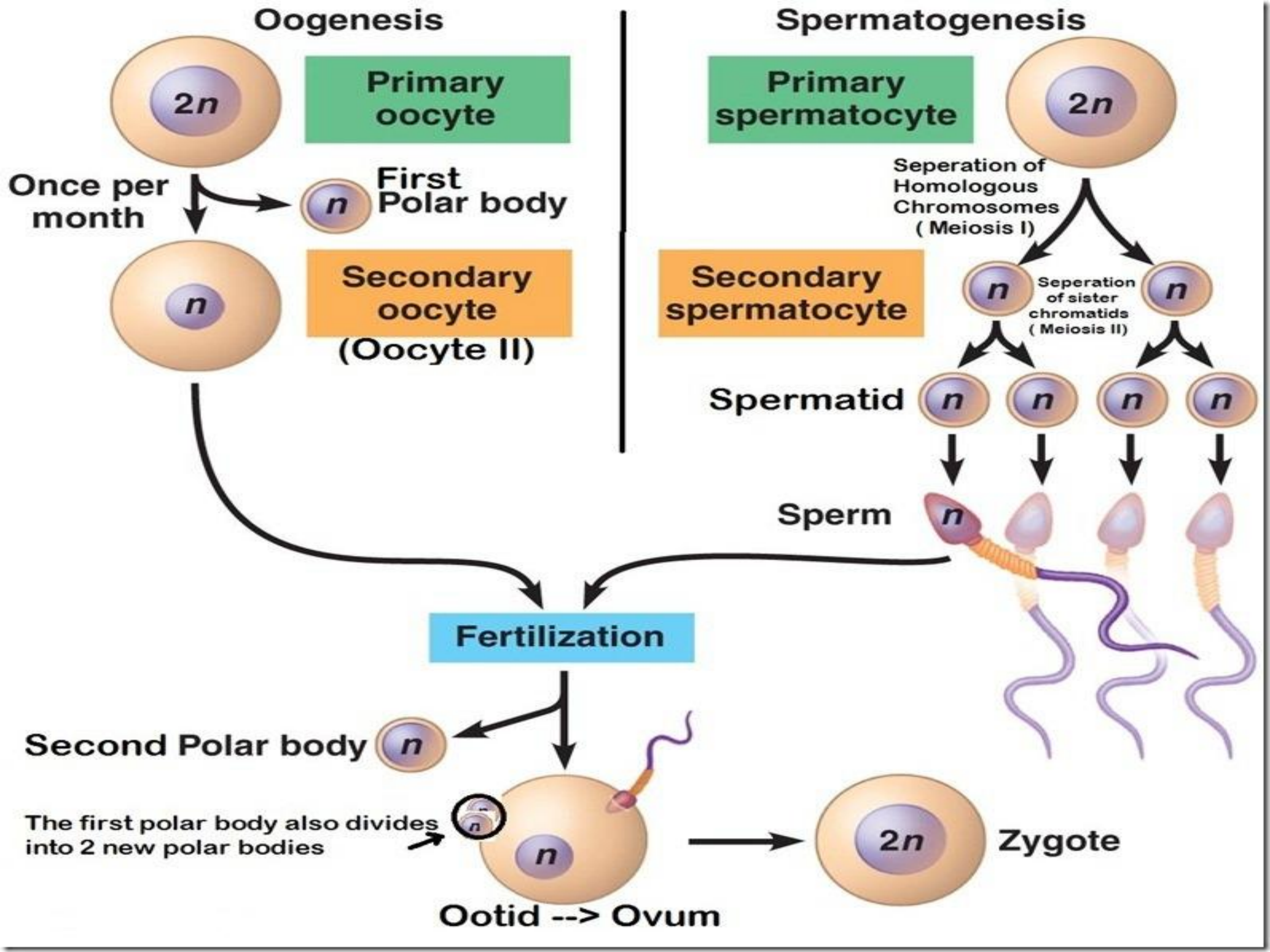
a primary oocyte, which will begin the first meiotic division, but then arrest; it will finish this division as it develops in the follicle, giving rise to a haploid secondary oocyte and a smaller polar body.

The secondary oocyte begins the second meiotic division and then arrests again; it will not finish this division unless it is fertilized by a sperm; if this occurs, a mature ovum and another polar body is produced.

- **In spermatogenesis, diploid spermatogonia go through mitosis until they begin to develop into gametes; eventually, one develops**

- **into a primary spermatocyte that will go through the first meiotic division to form two haploid secondary spermatocytes.**

- **The secondary spermatocytes will go through a second meiotic division to each produce two spermatids; these cells will eventually develop flagella and become mature sperm.**


Oogenesis
Spermatogenesis
2n
Primary oocyte
Primary spermatocyte
2n
Once per month
n
First Polar body
Seperation of Homologous Chromosomes (Meiosis I)
n
Secondary oocyte
(Oocyte II)
Secondary spermatocyte
n
Seperation of sister chromatids (Meiosis II)
n
Spermatid
n
n
n
n
Sperm
n
Fertilization
Second Polar body
n
The first polar body also divides into 2 new polar bodies
n
Ootid --> Ovum
2n
Zygote

- **Male abnormalities**
- **Oligospermia /Low sperm count: Less than 20 million sperm after 72 hour abstinence from sex.**
- **Azoospermia / Absent sperm as a result of blockage of duct network,**
- **Immotile Cilia Syndrome / Lack of sperm motility.**
- **Meiosis Abnormalities**
- **Meiotic Nondisjunction**
- **Chromosomal Translocation**

- **Female (Oogenesis)**
- **Involves the formation of haploid cells from the original diploid cells**
- **Female Abnormalities/ Meiotic non-disjunction resulting in aneuploidy, most embryonic lethal and not seen. The potential for genetic abnormalities increase with maternal age.**

- **Autosomal chromosome aneuploidy**
- **Sex chromosome aneuoloidy**

Thanks for your listening

Dr. Ayad