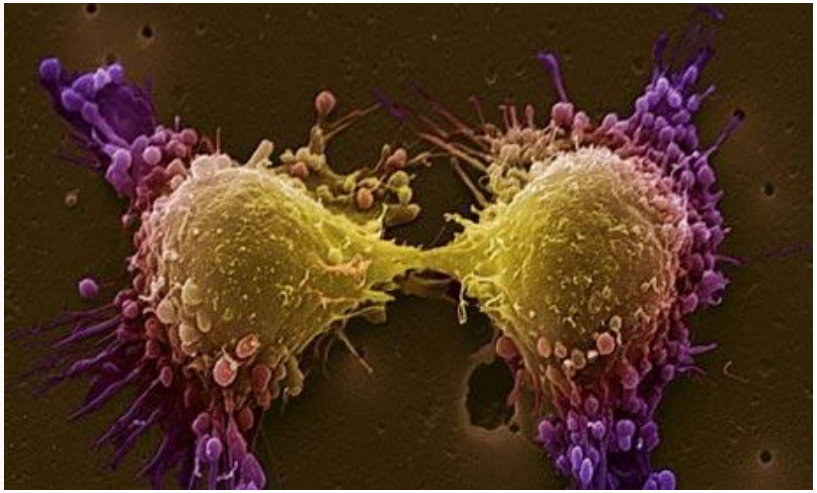
Cell division and function



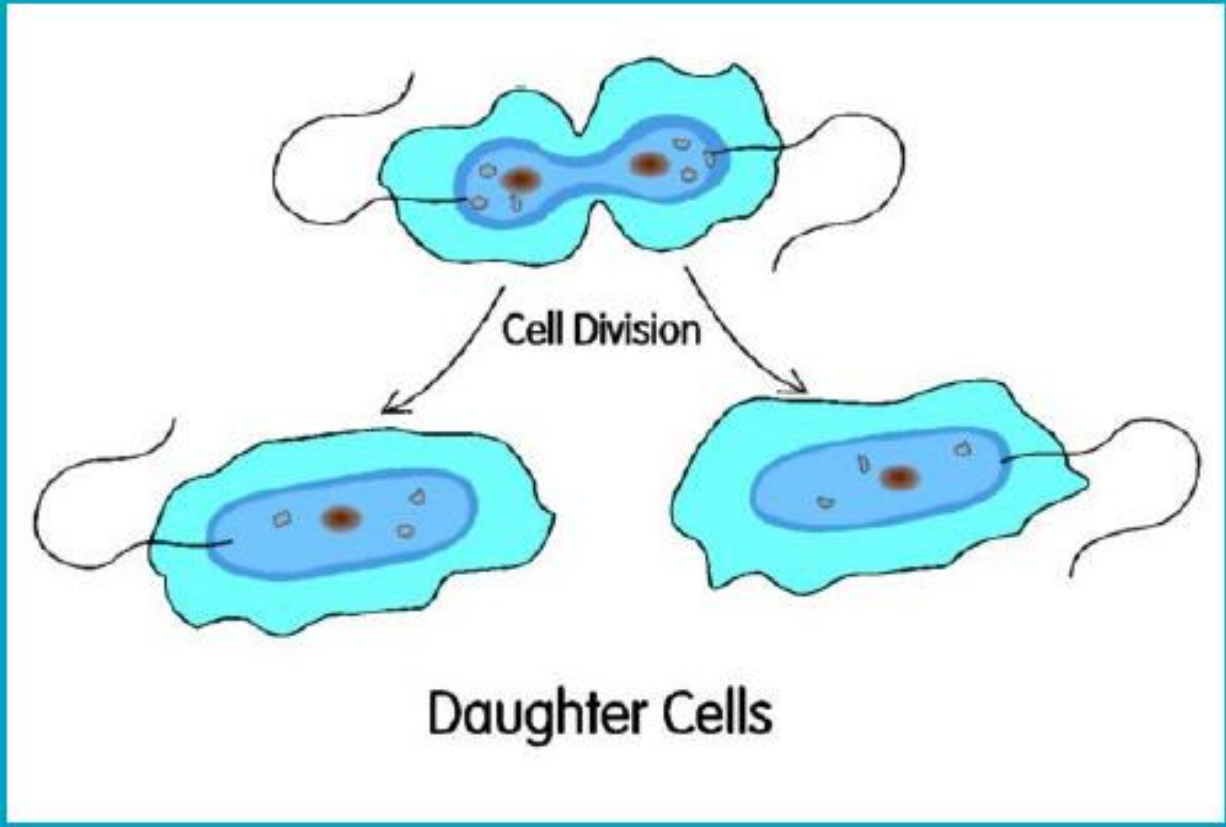
Part 1

Cell Division

What is it?

Why do Cells do it?

Why is it important to me?



Why do cells undergo divisions or Why cell divides?

1). To prevent DNA overload: If cell grows without limit, "information crisis" would develop. DNA cannot meet the demand of increasing cell size. Therefore, cell divides to increase the number rather than increasing the size.

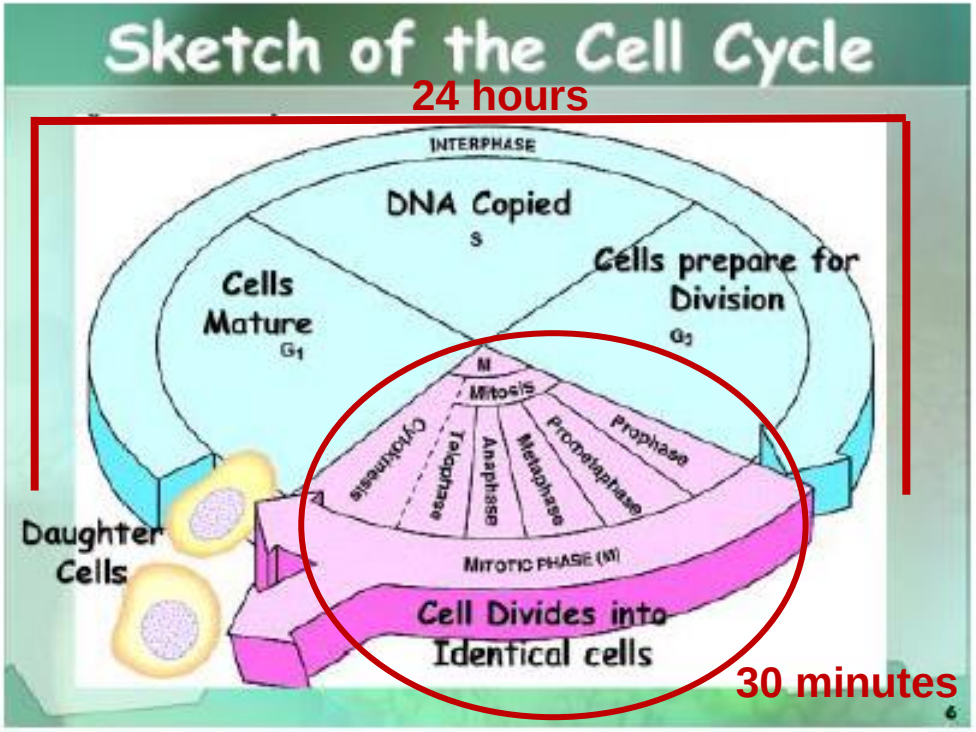
2). For efficient exchange of materials: If cell is too large, exchange of materials through cell membrane such as food and oxygen, and removal of waste products, will occur slowly and cell will die either due to starvation or toxic wastes accumulation.

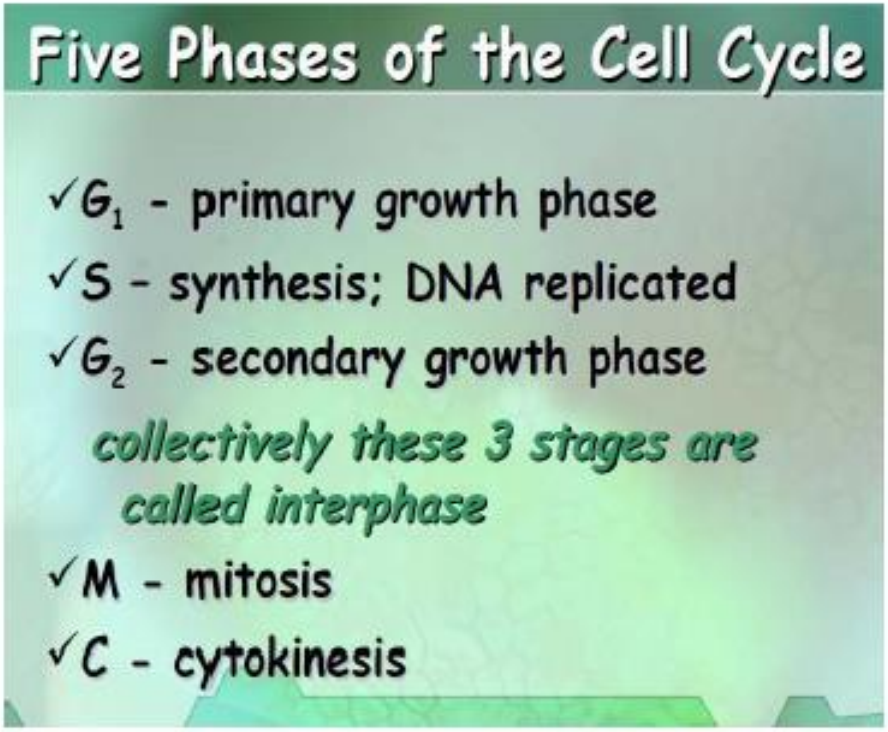
3) Growth and reproduction: Organisms need to grow which is fulfilled by increasing cell numbers rather than increasing cell size. For example, a single celled zygote (sperm and ova fertilization) develops by **number of cell divisions to form different parts of body and ultimately a full organism.**

4) Tissue repair and regeneration: Dead and injured cells can be replaced by cell divisions.

What is cell cycle

The **cell cycle**, or **cell-division cycle**, is the series of events that take place in a cell **that cause it to divide into daughter cells**. These events include the duplication of its DNA (DNA replication) and some of its organelles, and subsequently the partitioning of its cytoplasm and other components into daughter cells in a process called cell division



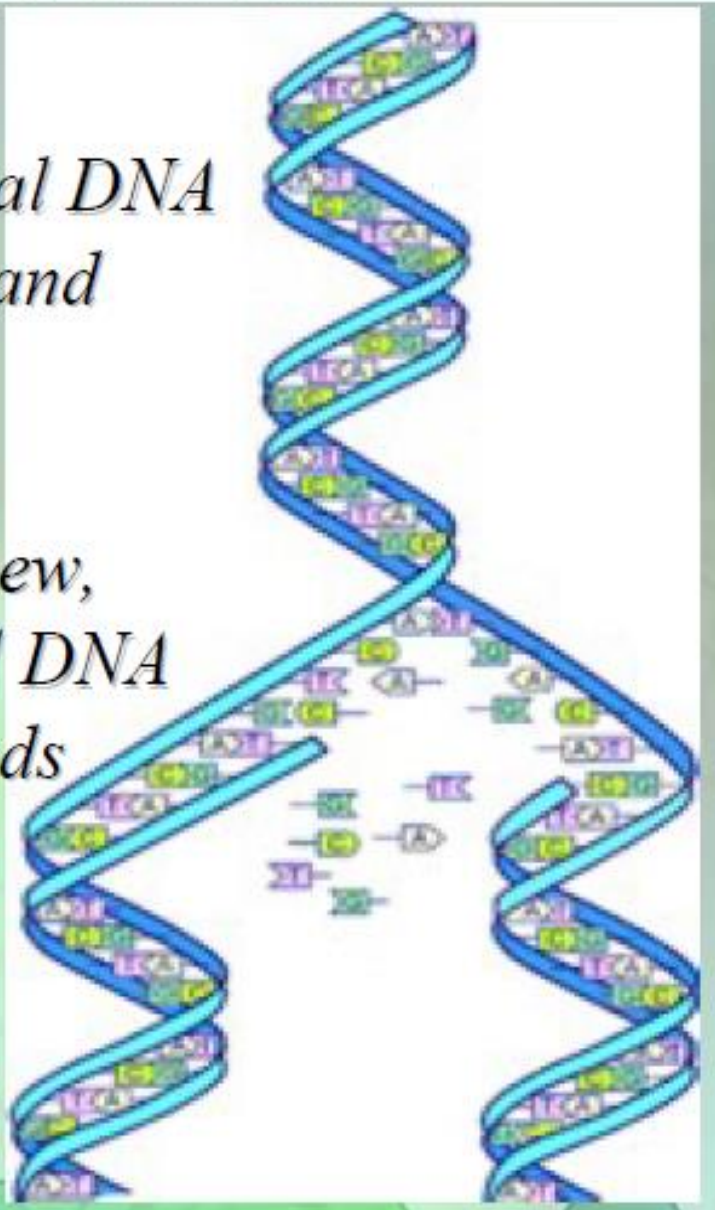


Stages of Interphase

Interphase stage of cell cycle	Important events in a particular phase
G1 (Gap 1)- primary growth phase	Increase in cell size, synthesis of proteins, carbohydrates and lipids, Synthesis of RNA, synthesis of enzymes and energy molecules. **(Time duration: generally 5-6 hours, sometimes 9 hours depending upon the cell type and organism)**
S (Synthesis)	Replication of DNA, synthesis of histones and formation of new nucleosomes. **(Time duration: 10-12 hours)**
G2 (Gap 2) - secondary growth phase	Synthesis of spindle proteins, duplication of mitochondria, , synthesis and storage of ATP molecules for M-phase, Damaged DNA is repaired. **(Time duration: 4-6 hours)**

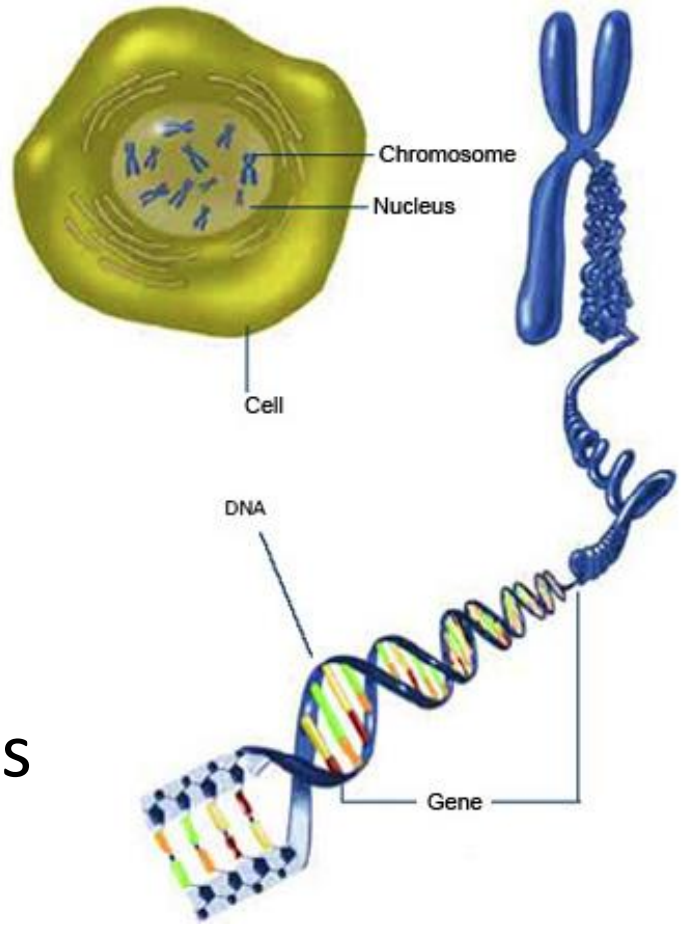
DNA Replication

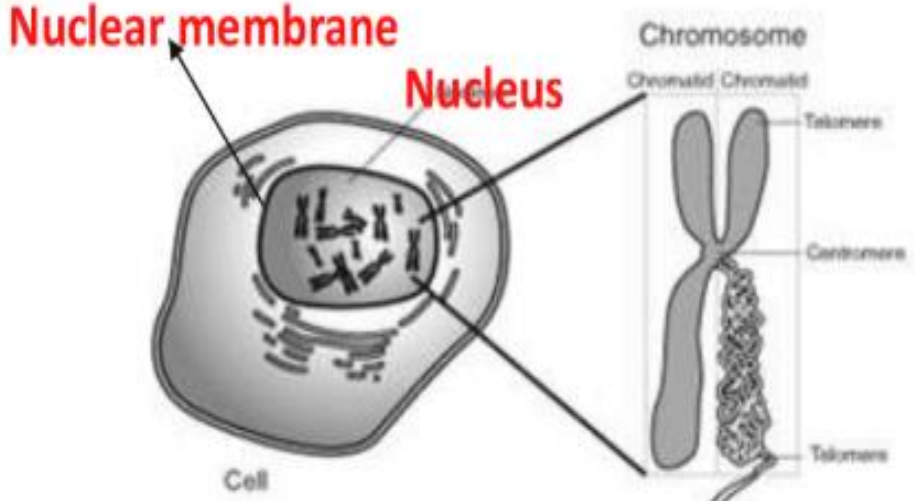
- DNA must be copied or **replicated** before cell division
- Each new cell will then have an **identical copy** of the DNA

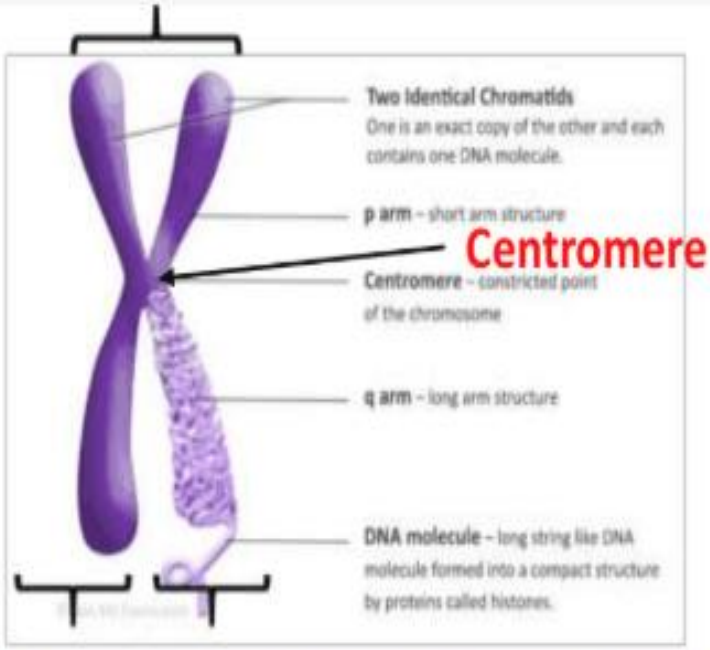


Where Do I Find DNA?

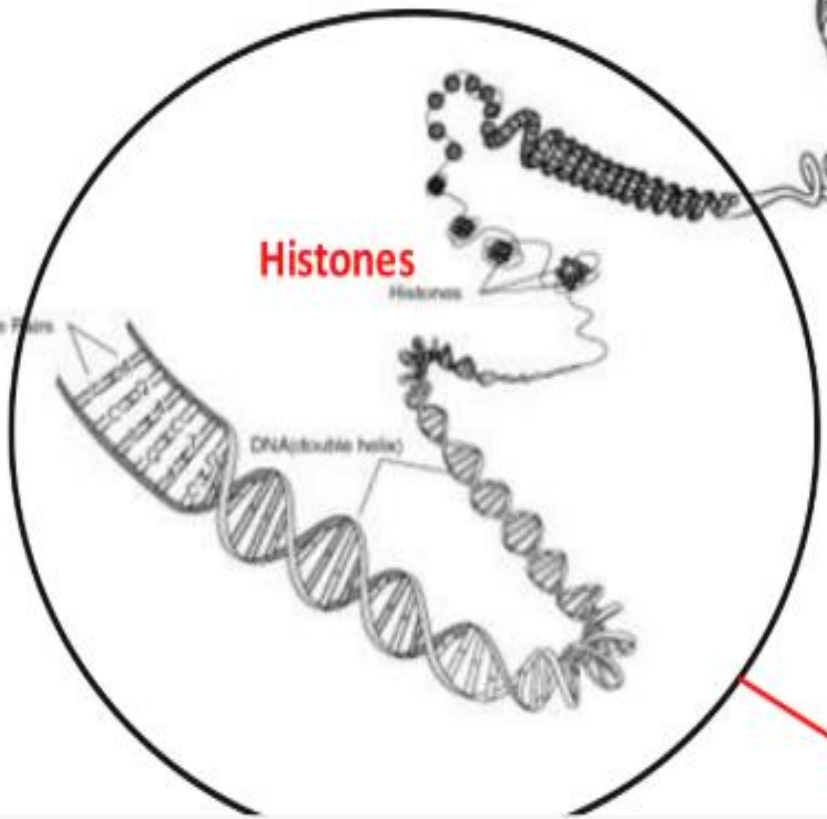
- Chromosomes are in the nucleus of every cell.
- Chromosomes are made up of DNA.
- Genes are pieces of DNA that contain the instructions for building a protein.

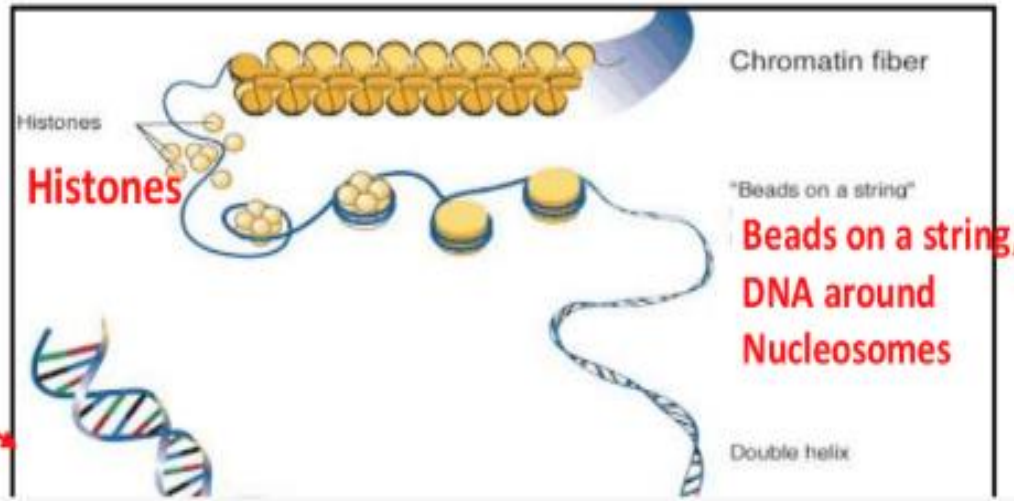






Chromatids: two identical chromatids and called sister chromatids,each containing DNA molecule. DNA molecule is replicated.





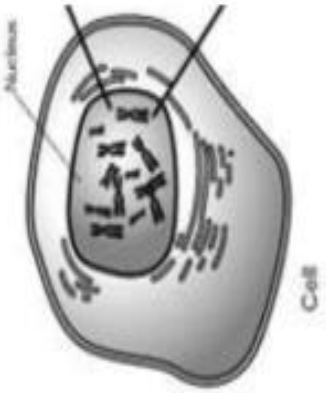
Beads on a string, DNA around Nucleosomes

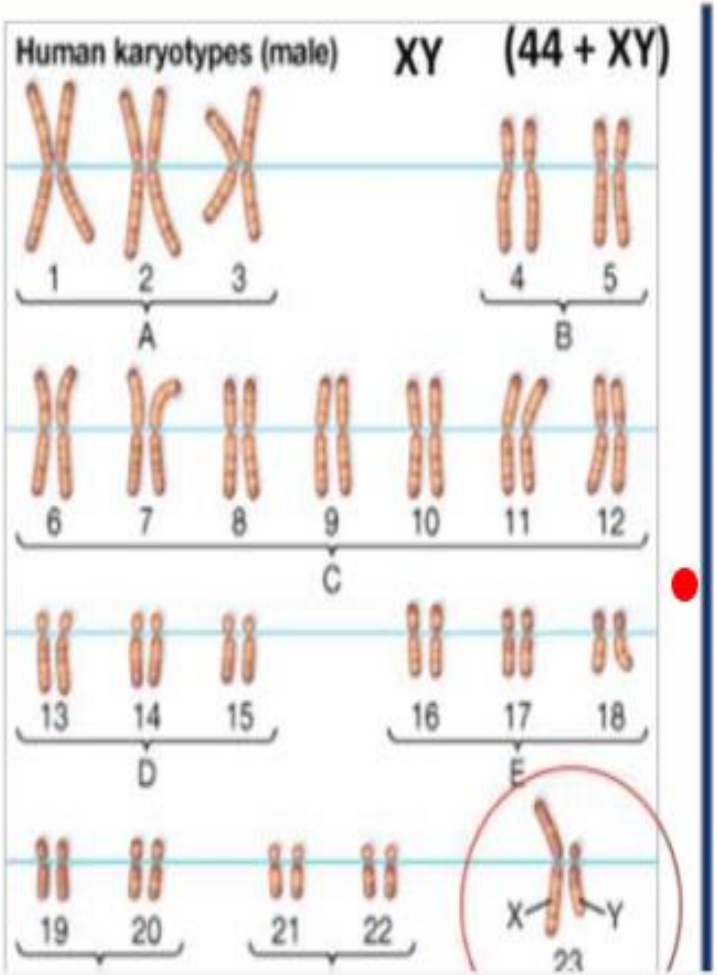
Human Karyotype of male and female (orderly arrangement of chromosomes)

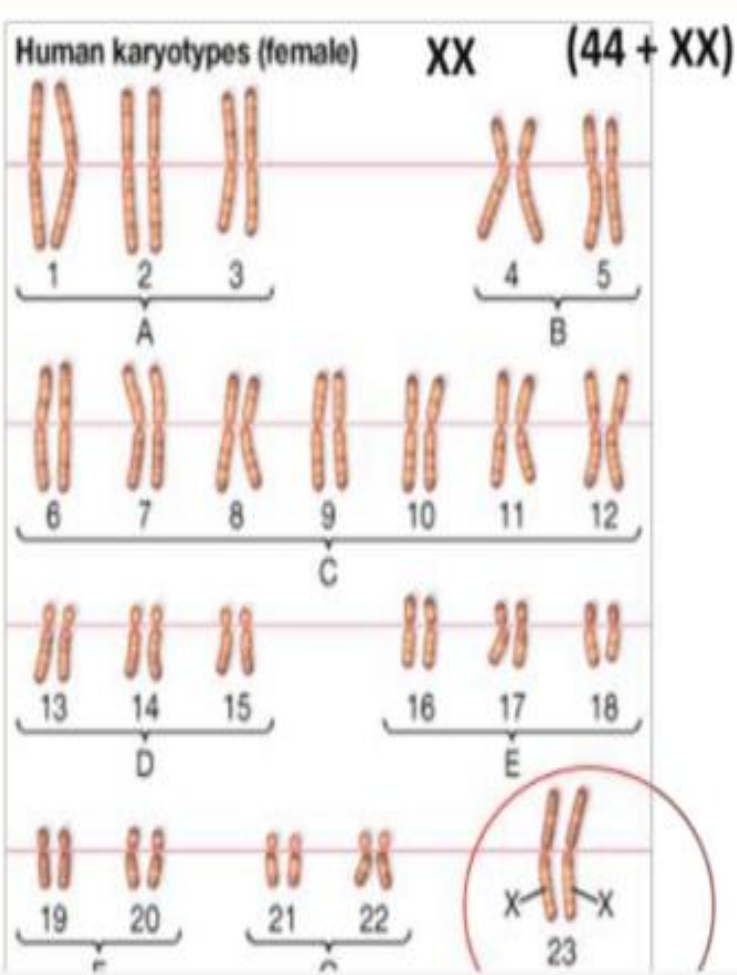
A Karyotype is the map of individual's chromosomes, Homologous pairs of chromosomes of an individual cell. Since every cell in the human body has the same DNA an therefore the same chromosomes, the analysis of one cell is enough.

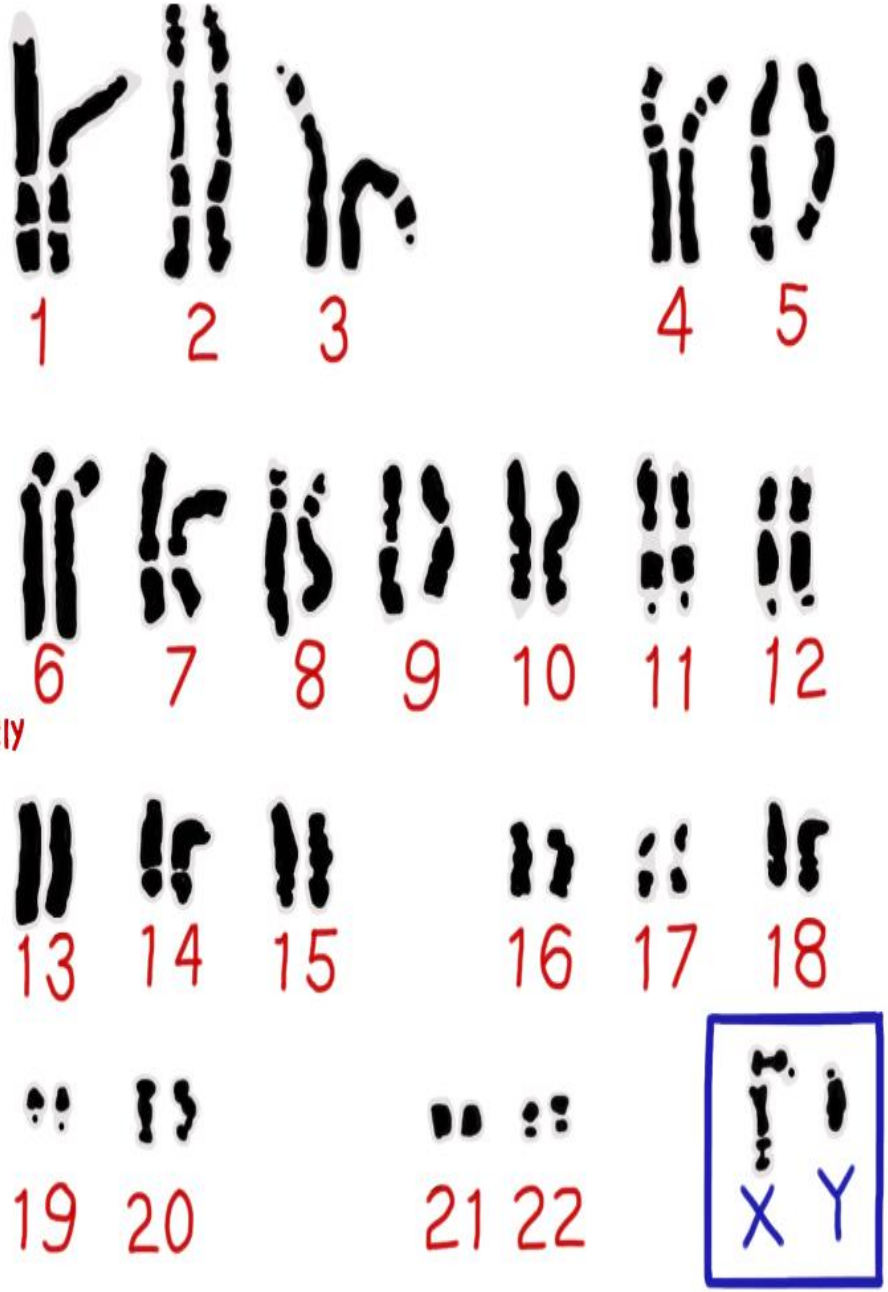
Human has 46 chromosomes, or 23 pairs of chromosomes. Also called , 2n or dipoid

Chromosomes in duplicated forms inside the nucleus







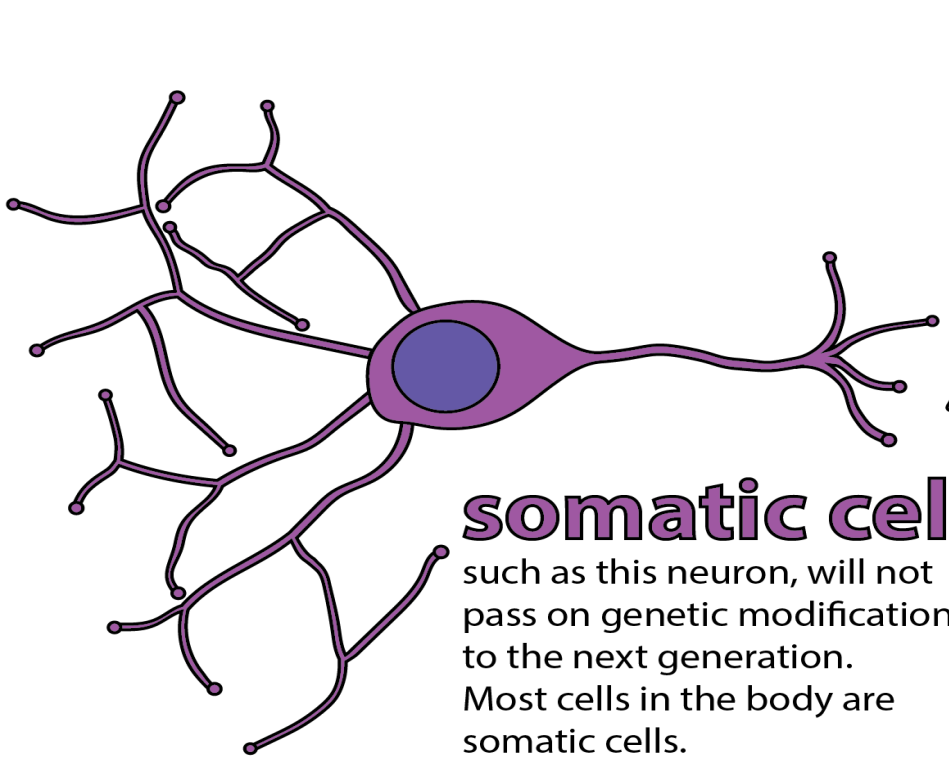


autosome

A chromosome that is not directly involved in determining the sex of an organism.

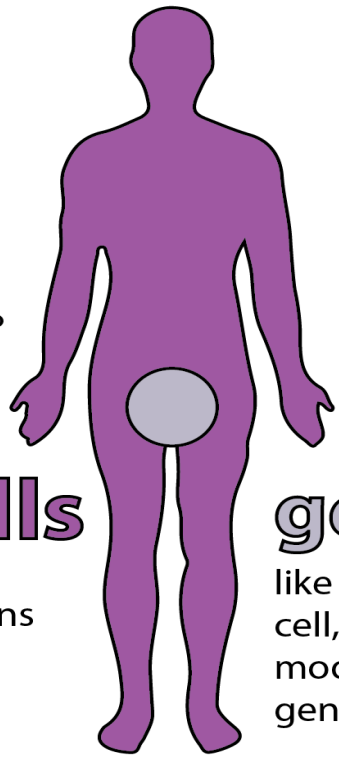
sex chromosome

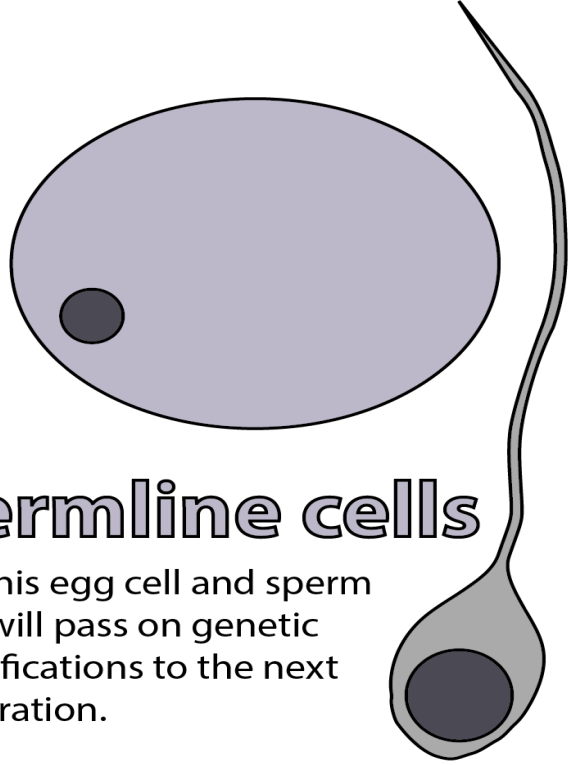
A chromosome that determines whether an organism is male or female.



somatic cells

such as this neuron, will not pass on genetic modifications to the next generation. Most cells in the body are somatic cells.





germline cells

like this egg cell and sperm cell, will pass on genetic modifications to the next generation.

Somatic Cells vs Gametic Cells

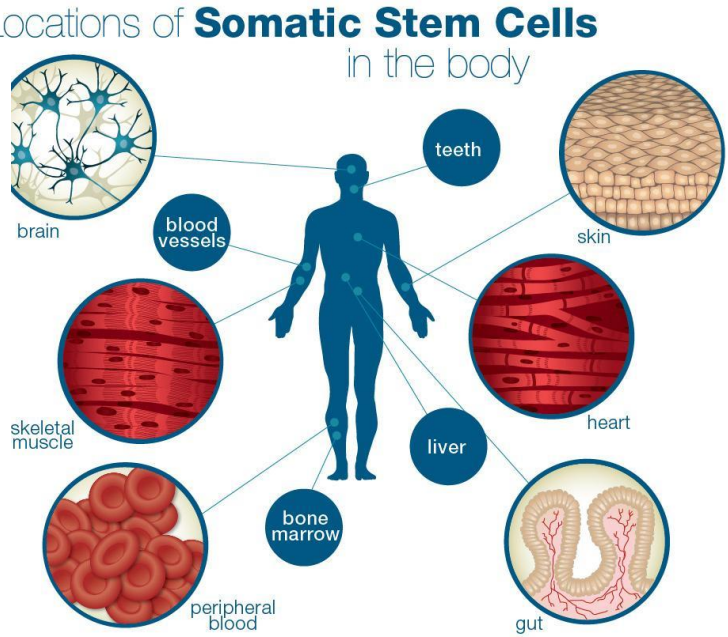
Somatic cells are cells of the body

In humans somatic cells are diploid which means they contain two copies of each chromosome

Human somatic cells have 23 pairs of chromosomes for a total of 46 chromosomes

Gametes are reproductive cells such as sperm and oocytes

Gametes are haploid which means that there is one copy of each chromosome in each gamete

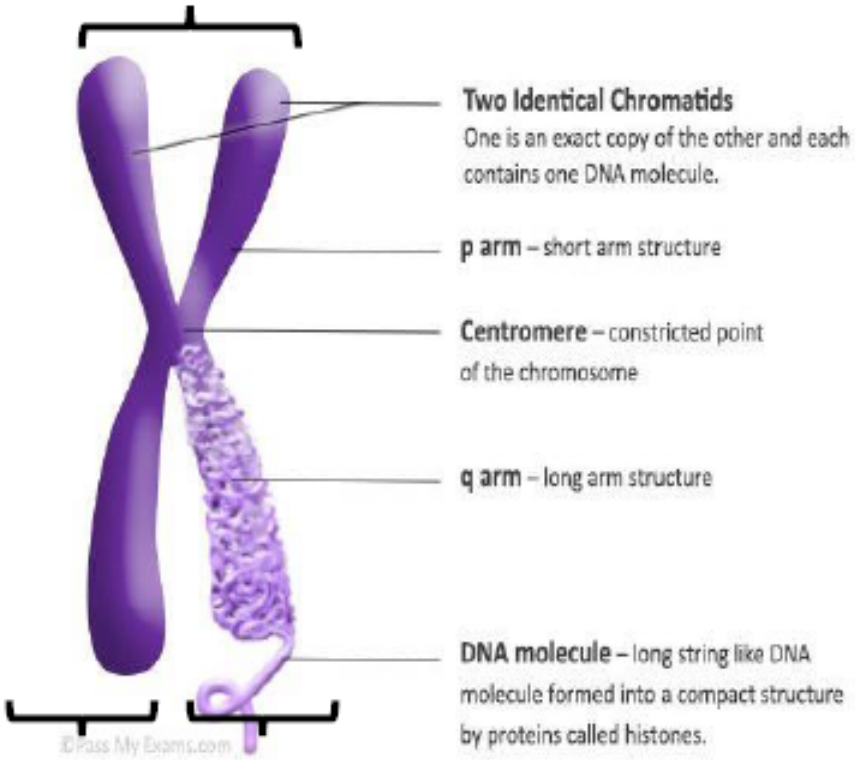


Key words to understand the process of cell divisions

1) Chromosome: A **chromosome** is an organized package of DNA found in the nucleus of the cell. DNA is tightly coiled and package into DNA in chromosome. Different organisms have different numbers of **chromosomes**. Humans have 23 pairs of **chromosomes (so total 46 chromosomes)**--22 pairs of numbered **chromosomes**, called autosomes, and one pair of sex **chromosomes**, X and Y..

2) Chromatid: A chromatid is one copy of a newly copied chromosome which is still joined to the original chromosome by a single centromere. Chromatids are formed after DNA replication. **In other words, chromosome duplicates to form sister chromatids.**

Chromosome

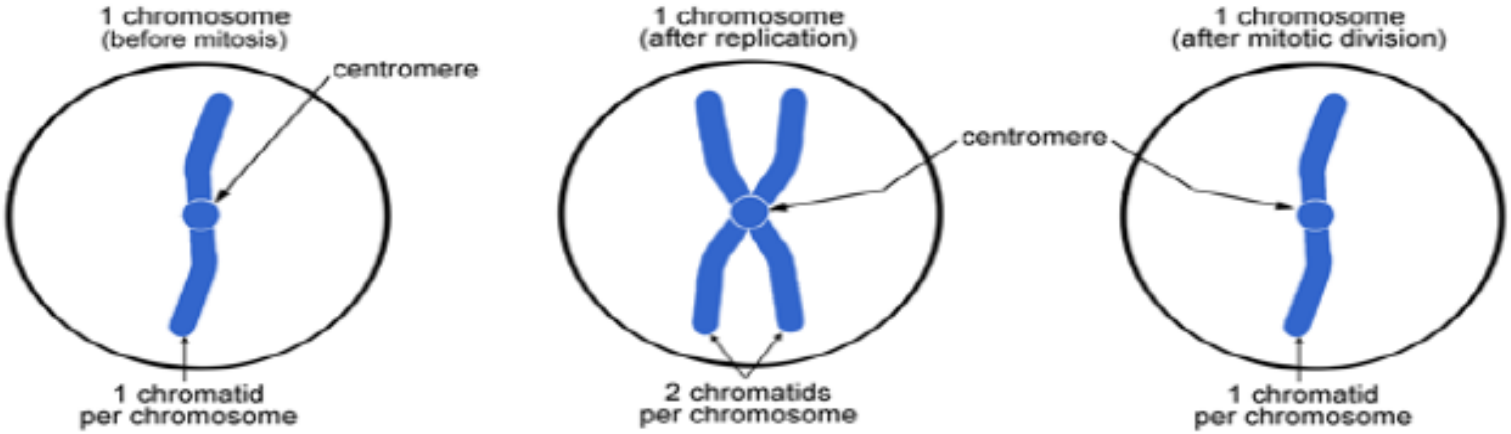


Chromatids: two identical chromatids called sister chromatids,each containing DNA molecule. DNA molecule is replicated.

The concept46 chromosomes----------46 x 2=92 chromatids

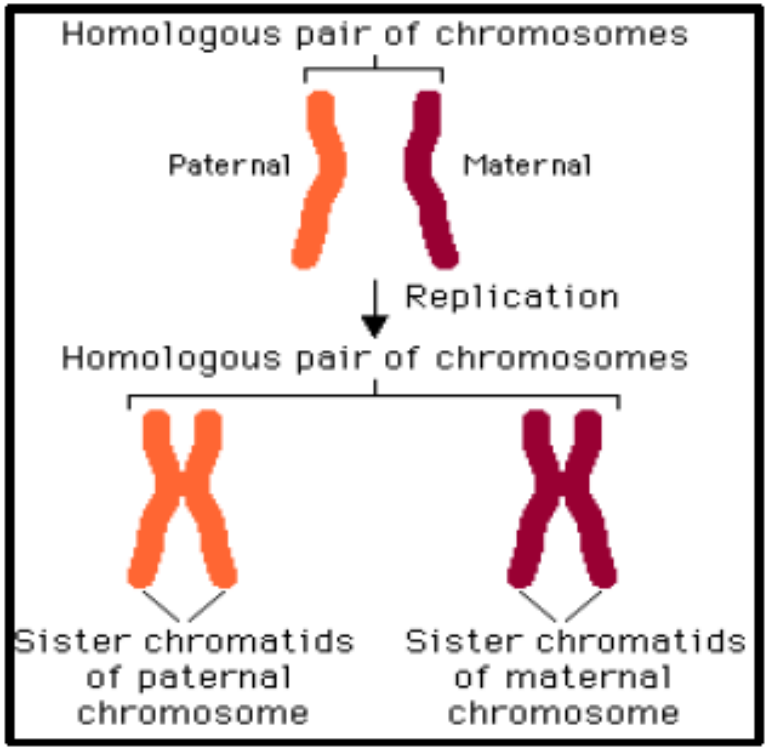
*****The concept from previous slide:

46 chromosomes---------- after DNA replication chromosomes duplicates to form sister chromatids……**46 x 2 = 92 chromatids but 46 chromosomes.**

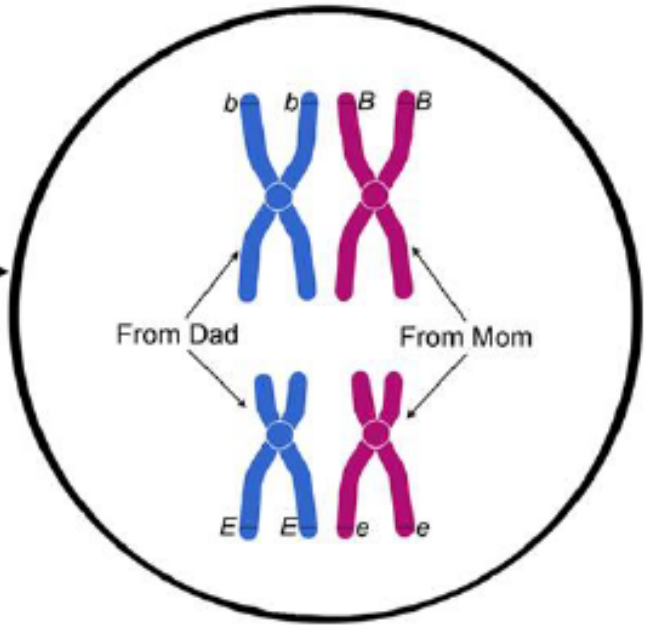


Solve this question?

3) Homologous chromosomes/ homologs/ homologous chromosomes. One pair of chromosomes with the same gene sequence, loci, chromosomal length, and centromere location. In a homologous pair, one chromosome is inherited **from father (paternal)** and other is **inherited from mother (maternal).** The DNA sequences of homologous chromosomes are usually not exactly identical. **Humans have 23 pairs of homologous chromosomes**.



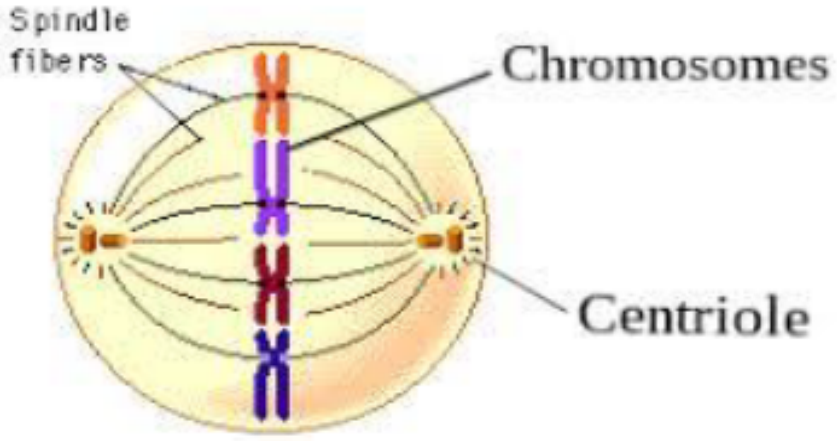
Here, two pairs of homologous chromosomes. One pair blue and pink inherited from dad and mom respectively. **B, b, E and e are gene segments that are aligned together in homologs.**



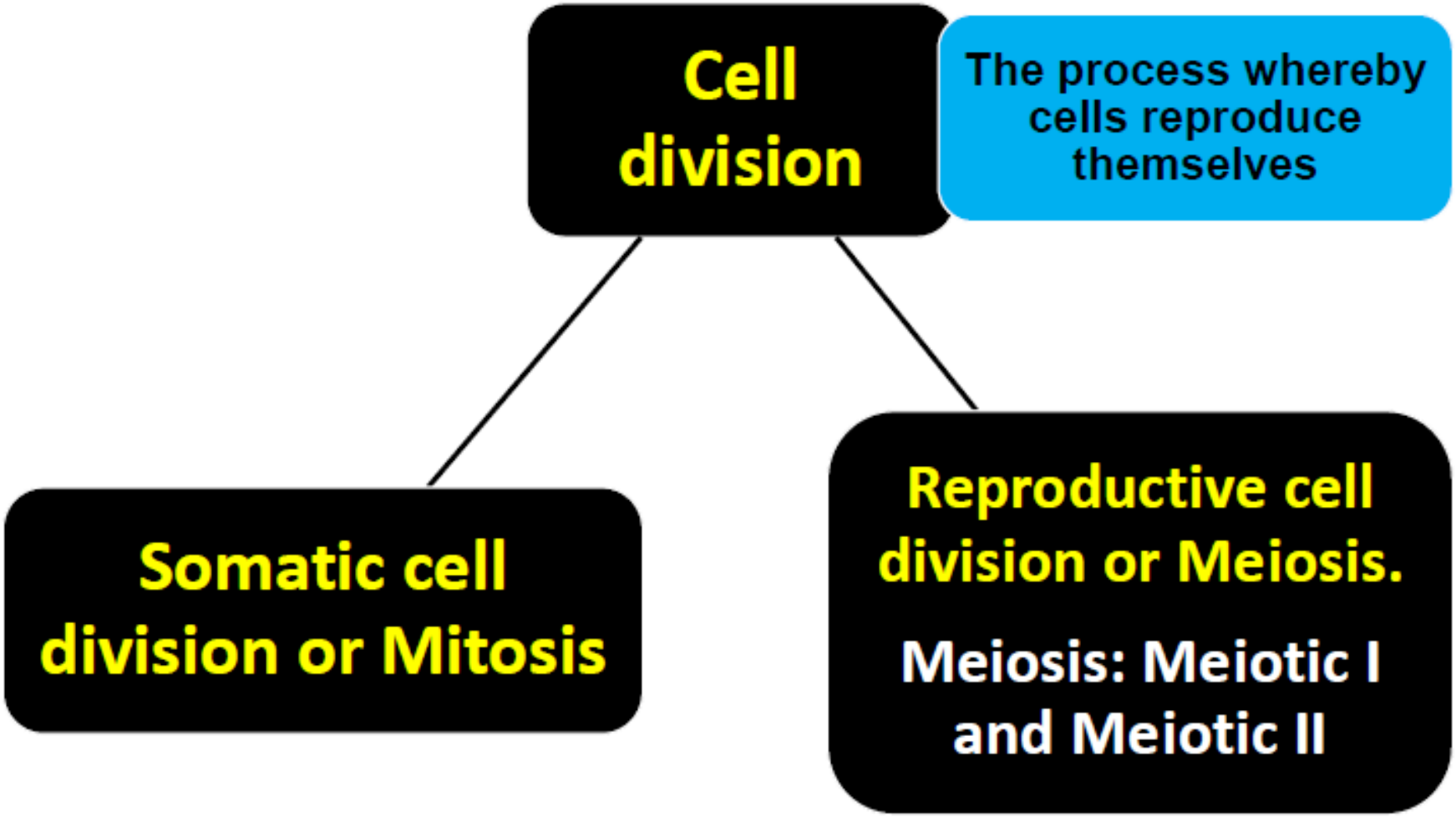
4) Diploid: Diploid is a cell or organism that has paired chromosomes, one from each parent. In humans, all somatic cells other than gametes are **diploid** and have 23 pairs of chromosomes.

5) Haploid: Only single set of chromosomes present in cells. No homologous pairs. For example, Human gametes (egg and sperm cells) contain a single set of chromosomes and are known as haploid.

6) Spindle fibers: They are filaments made up of microtubules that form the mitotic **spindle** in cell division, i.e. mitosis and meiosis. They are chiefly involved in moving and separating the chromosomes into daughter cells during cell division.



After interphase stage of cell cycle, cell divides by two processes either mitosis and meiosis, depending on the cells that is undergoing division.

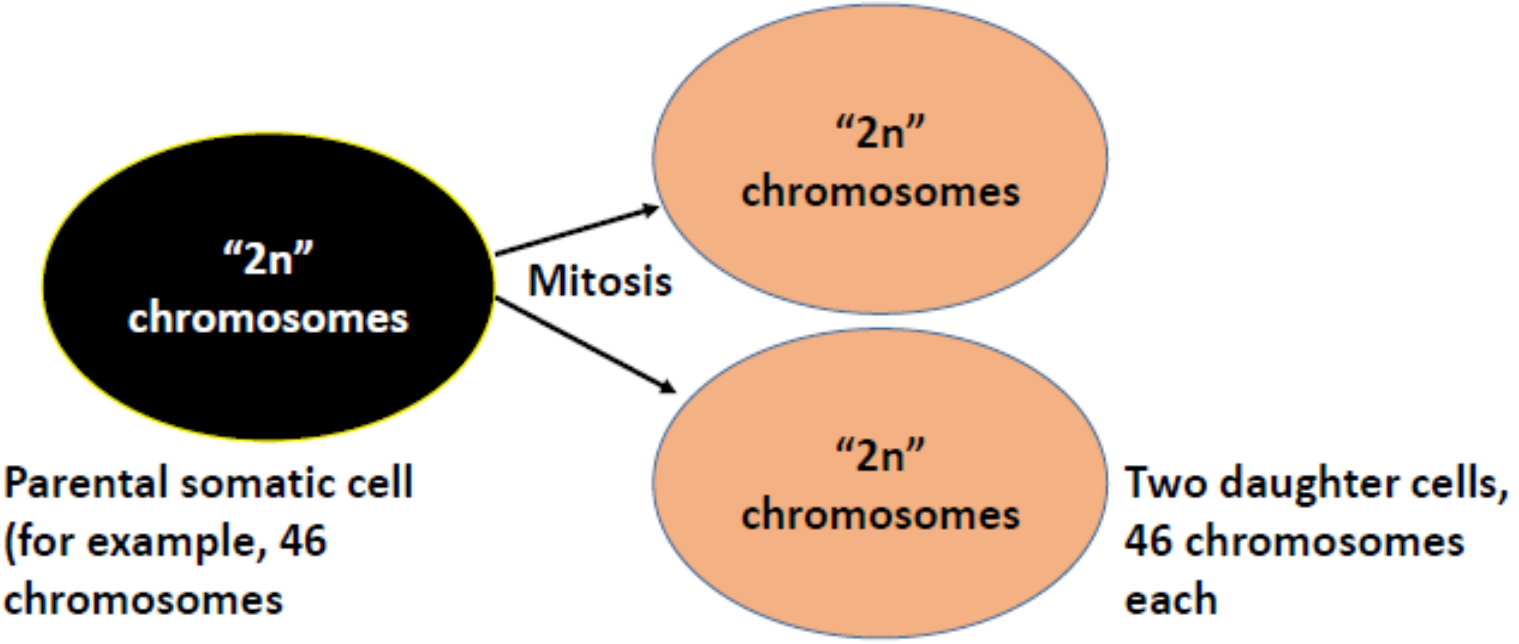


Somatic cell division or Mitosis

1) A cell divides into two identical cells. **(Equational division)**

2) The same genetic material is passed on to the newly formed cells. So after mitosis, each newly formed cell has the same number of chromosomes as the original cell. For example, if the cell has 46 chromosomes, each daughter cell will have 46 chromosomes, **or parental cell diploid state (2n) is maintained in daughter cells**.

3) Significance of mitosis: mitotic cell division maintains replaces dead or injured cells and adds newe ones for tissue growth. For example, skin cells are continually replaced by somatic cell division.



Reproductive cell division or Meiosis

1) **Meiotic cell division occurs** in reproductive cells called **germ cells to produce gametes- sperm and ova. Germ cells are testes in males, and ovaries in females.**

2) Meiotic division **separates** **first pair of homologous chromosomes** (meiotic I: reducing 2n number of chromosomes to "n" chromosomes, and so two daughter cells will half the number of chromosome as its parental cell; meiotic II: mitotic division of the meiotic I daughter cells. So , in meiosis 4 daughter cells are produced with "n" of chromosomes.

After meiosis, **each newly formed cell has the half number of chromosomes as the original cell**. For example, if the cell has 46 chromosomes, each daughter cell will have 23 chromosomes, **or parental cell diploid state (2n) is changed to "n" in daughter cells**.

3) **Significance of meiosis**: the next generation is formed in sexually reproducing organisms. New offsprings are produced.

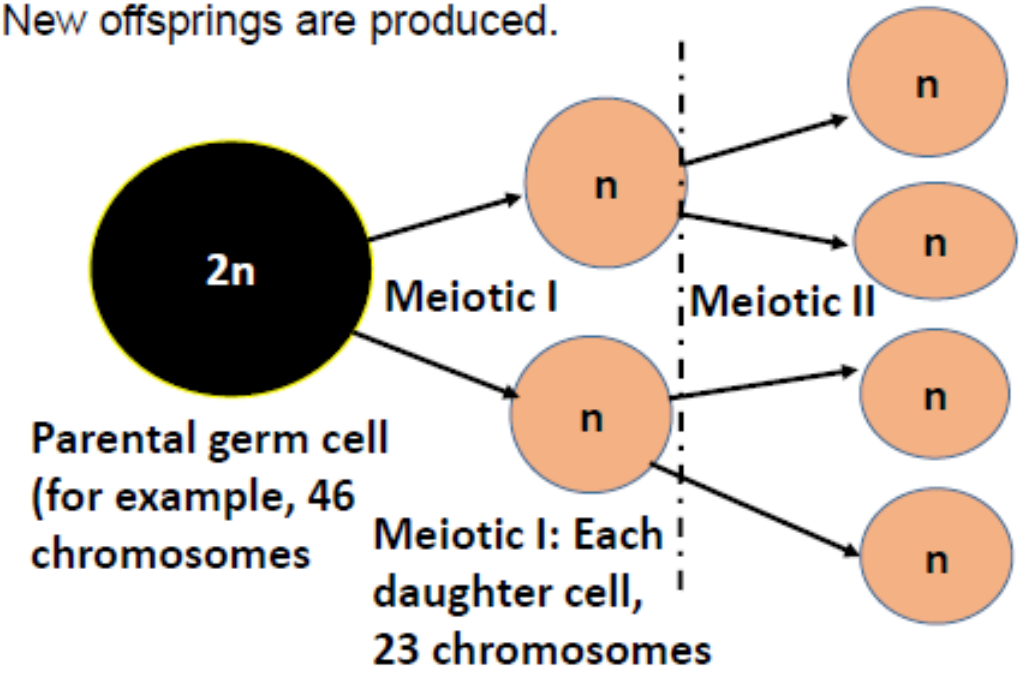


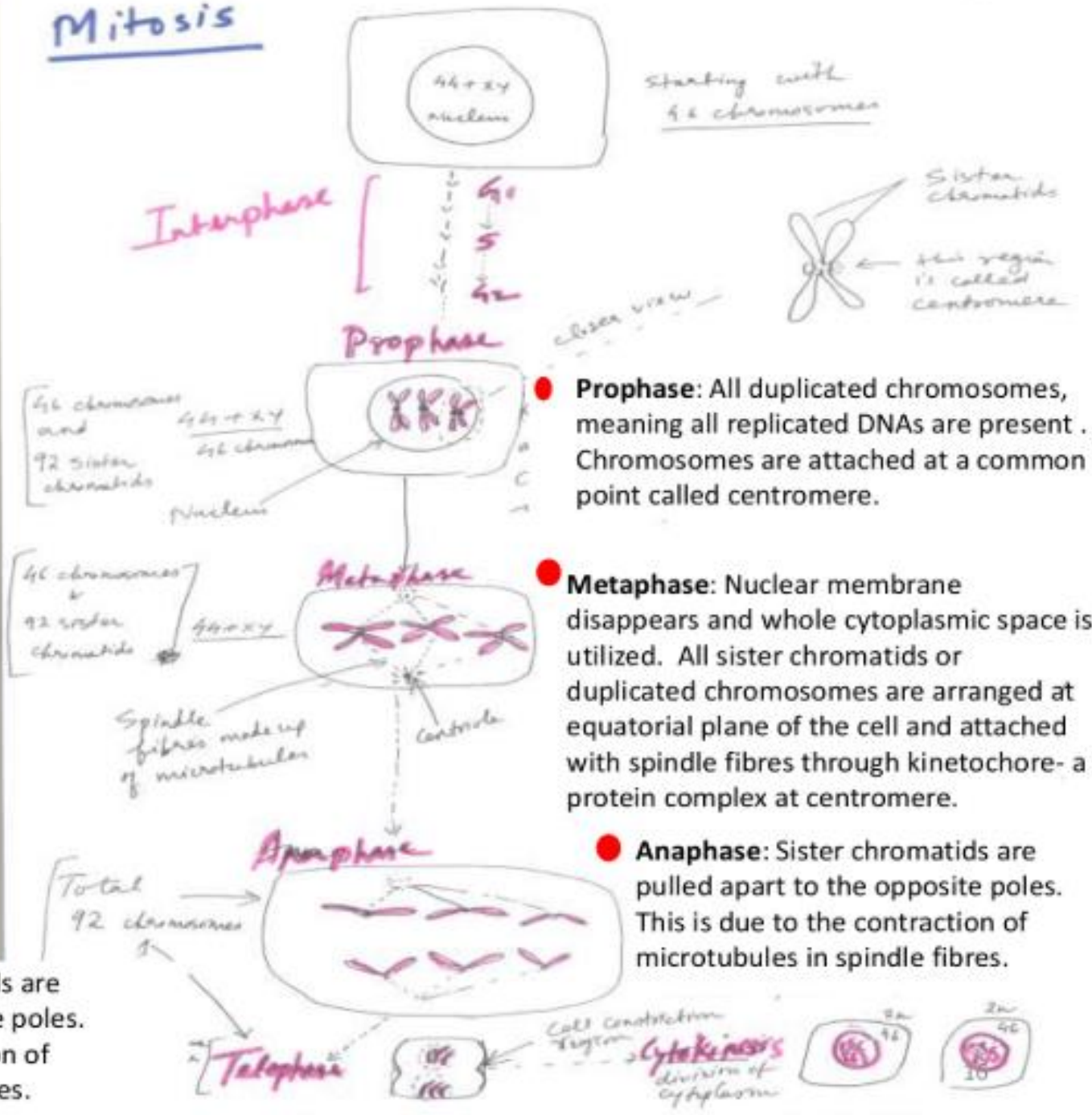
***Figure is explanation of point no. 2

(Reductional division)

Mitosis cell division: different stages

Stages in mitosis: (PMAT)

1. **Interphase**
2. **Prophase-intact nuclear membrane**
3. **Metaphase-no nuclear membrane**
4. **Anaphase-no nuclear membrane**
5. **Telophase-nuclear membrane reappears**
6. **Cytokinesis: division of cytoplasm that leads to two daughter cells with nucleus in each cell**



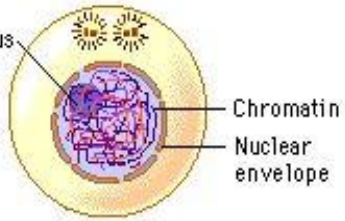
Prophase: All duplicated chromosomes, meaning all replicated DNAs are present . Chromosomes are attached at a common point called centromere.

Metaphase: Nuclear membrane disappears and whole cytoplasmic space is utilized. All sister chromatids or duplicated chromosomes are arranged at equatorial plane of the cell and attached with spindle fibres through kinetochore- a protein complex at centromere.

Anaphase: Sister chromatids are pulled apart to the opposite poles. This is due to the contraction of microtubules in spindle fibres.

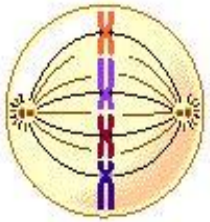
Telophase: Sister chromatids are pulled apart to the opposite poles. This is due to the contraction of microtubules in spindle fibres.

Interphase
The nucleolus and the nuclear envelope are distinct and the chromosomes are in the form of threadlike chromatin.

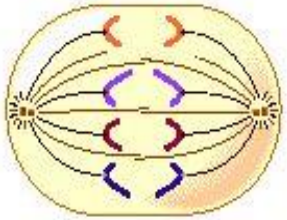


Prophase
The chromosomes appear condensed, and the nuclear envelope is not apparent.

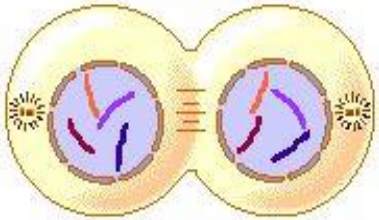
Metaphase
Thick, coiled chromosomes, each with two chromatids, are lined up on the metaphase plate.



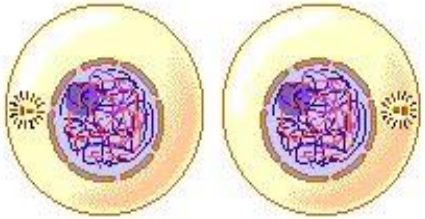
Anaphase
The chromatids of each chromosome have separated and are moving toward the poles.

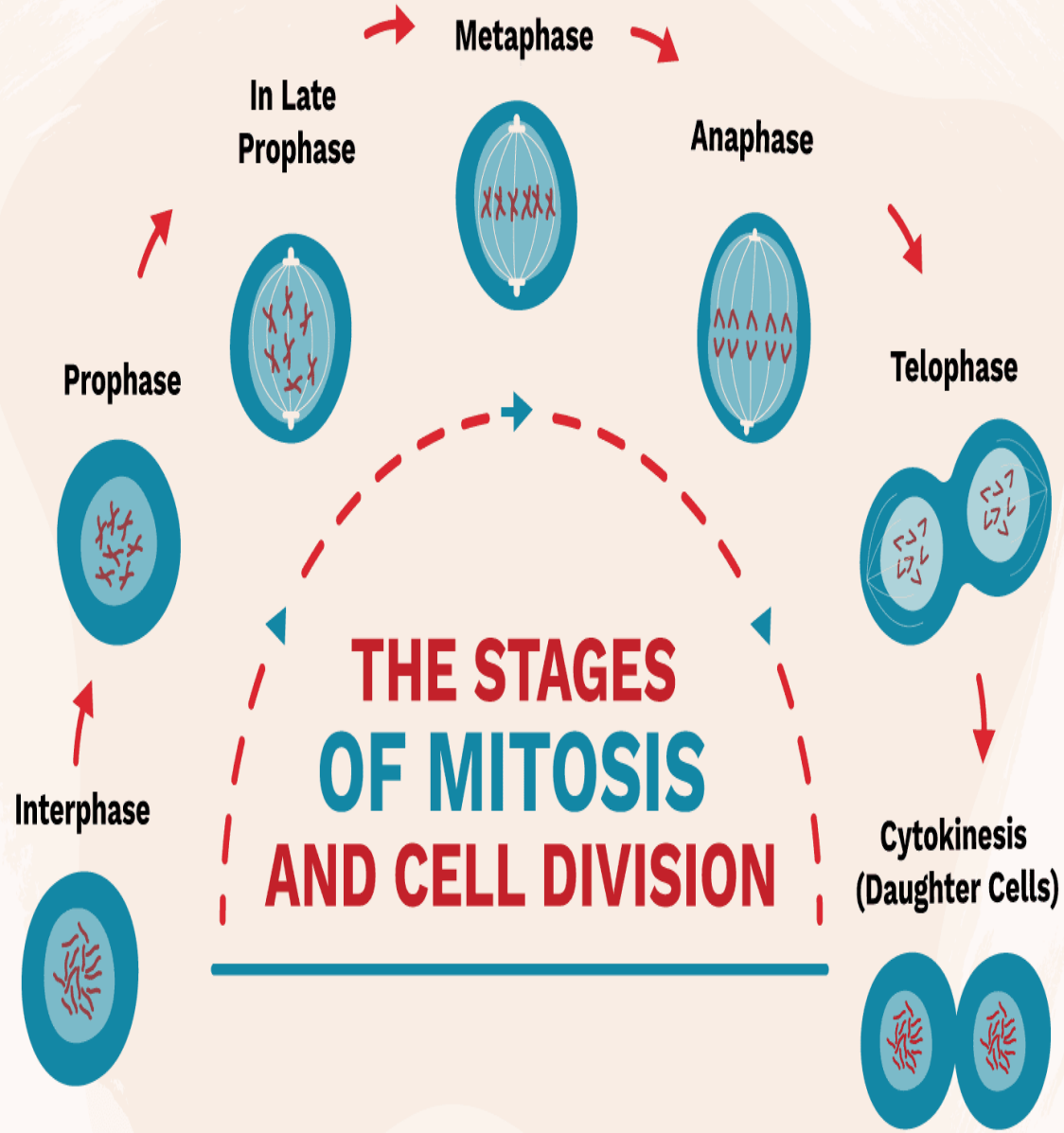


Telophase
The chromosomes are at the poles, and are becoming more diffuse. The nuclear envelope is reforming. The cytoplasm may be dividing.



Cytokinesis
Division into two daughter cells is completed.

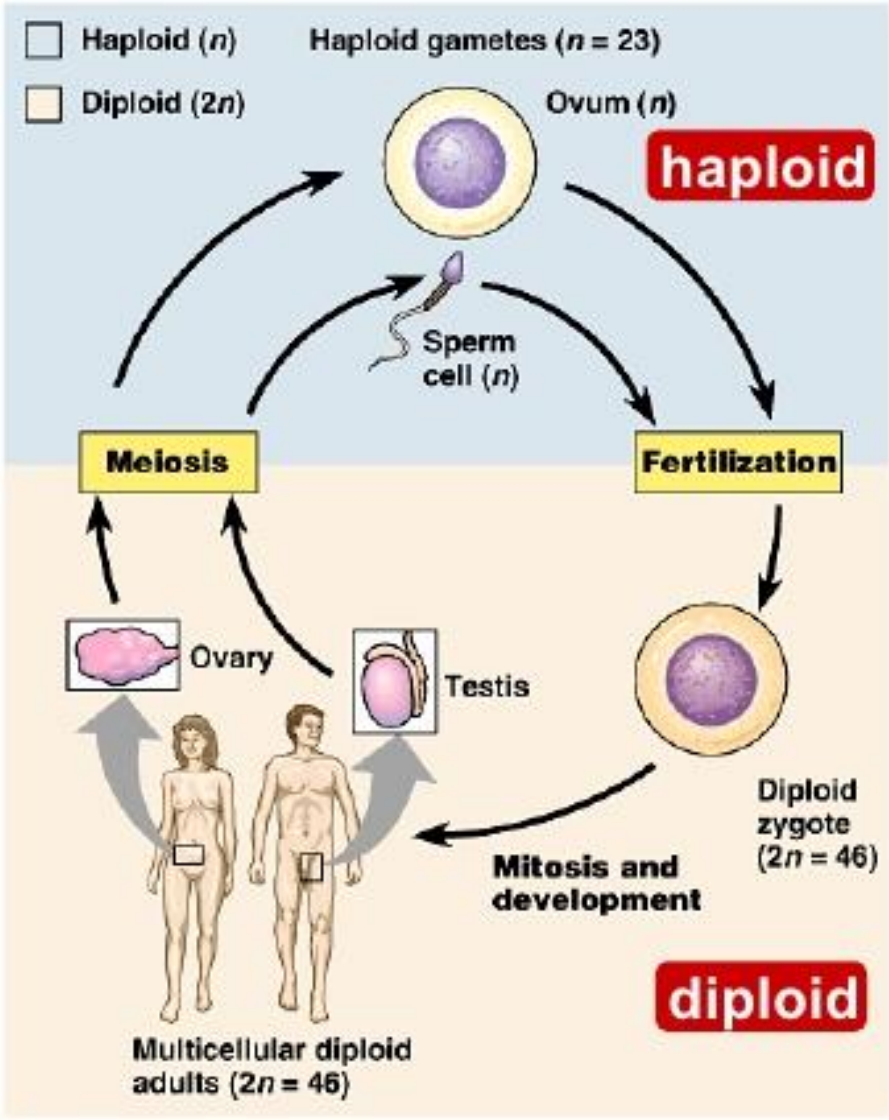




ThoughtCo.

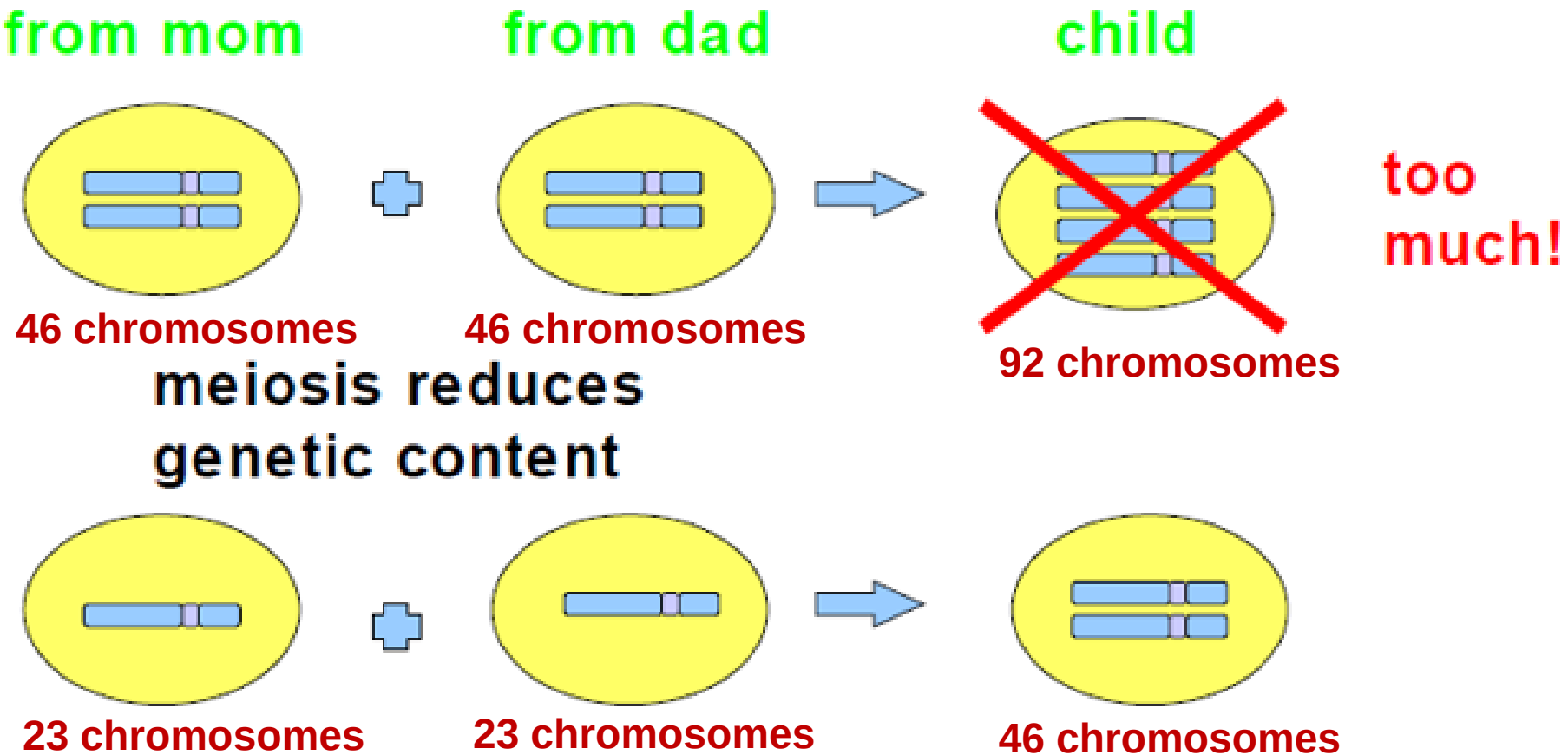
Meiosis: production of gametes

- **Alternating stages**
  - chromosome number must be reduced
    - diploid → haploid
    - 2n → n
      - humans: 46 → 23
    - meiosis reduces chromosome number
    - makes gametes
  - fertilization restores chromosome number
    - haploid → diploid
    - n → 2n



Why form gametes?

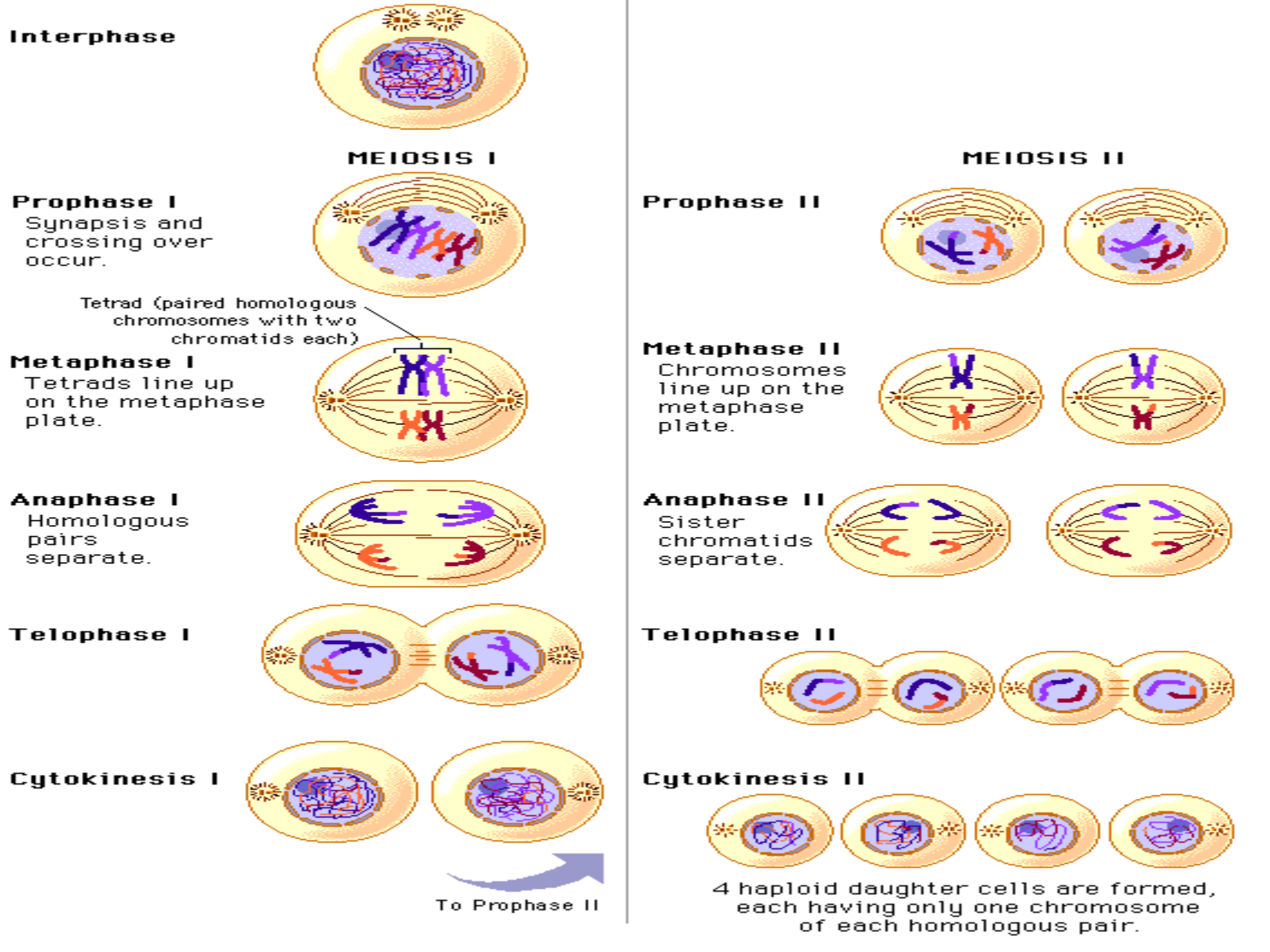
- **Sperm and eggs(ova) are gametes**
- Goal: Reduce genetic material by half



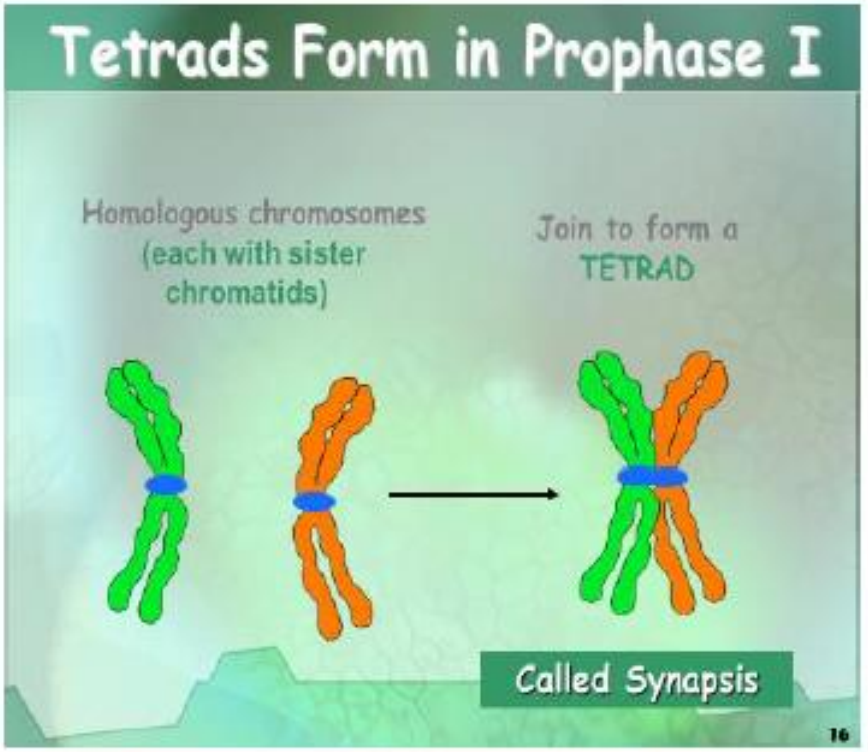
Meiosis is a **process** where a single cell divides twice to produce four cells containing half the original amount of genetic information.

Interphase

Meiosis I	Meiosis II
Prophase I	Prophase II
Metaphase I	Metaphase II
Anaphase I	Anaphase II
Telophase I	Telophase II
Cytokinesis	Cytokinesis


Interphase
MEIOSIS I
Prophase I
Synapsis and crossing over occur.
Tetrad (paired homologous chromosomes with two chromatids each)
Metaphase I
Tetrads line up on the metaphase plate.
Anaphase I
Homologous pairs separate.
Telophase I
Cytokinesis I
To Prophase II
MEIOSIS II
Prophase II
Metaphase II
Chromosomes line up on the metaphase plate.
Anaphase II
Sister chromatids separate.
Telophase II
Cytokinesis II
4 haploid daughter cells are formed, each having only one chromosome of each homologous pair.

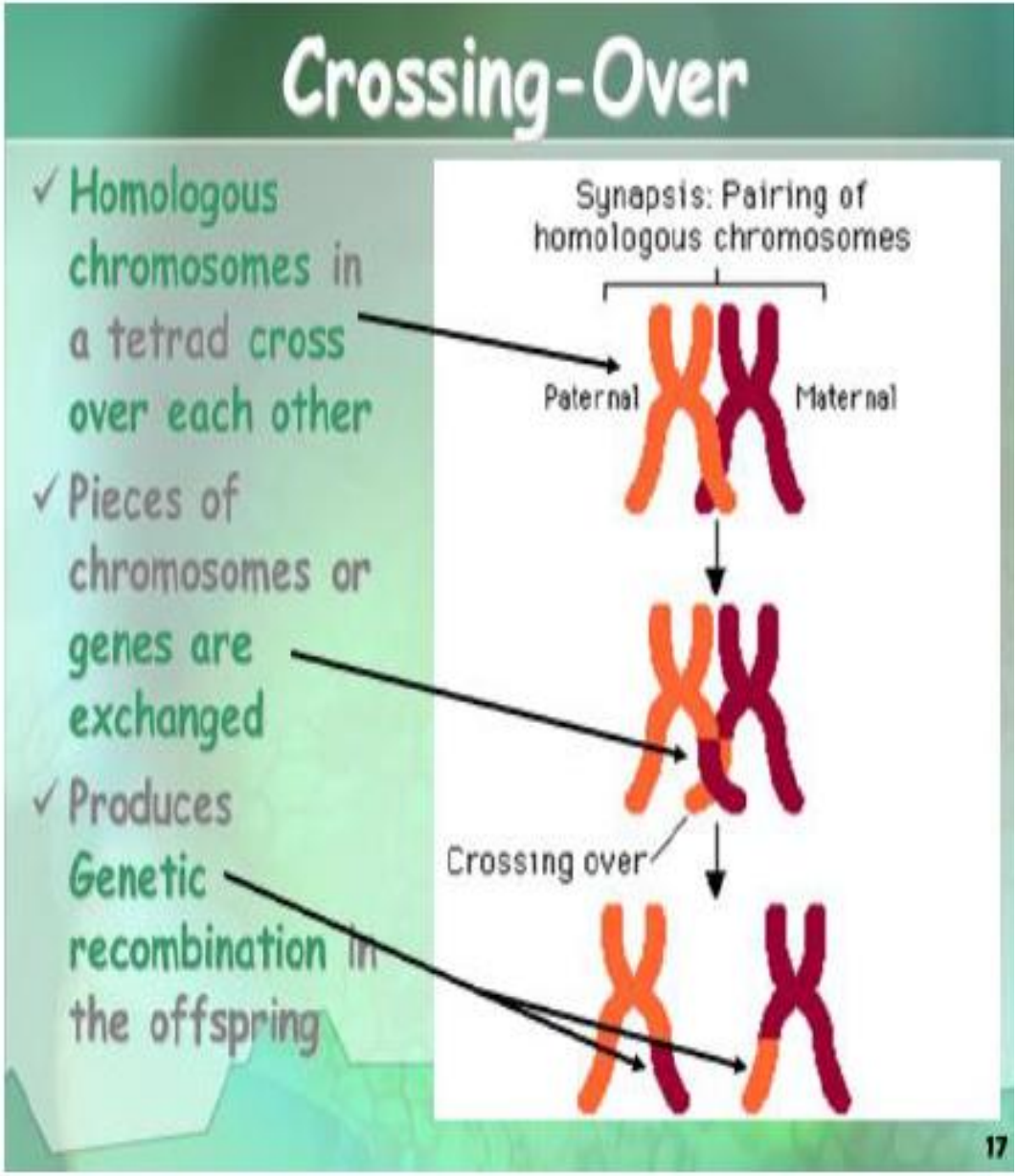
Prophase I of meiosis I– important stage for crossing over and exchange of genetic material



Tetrads formation and crossing over are important processes of meiosis which result in genetic variation among organism. In simple words, there is exchange of genetic material between "mom and dad" that results in offspring "with mom and dad characters".

1) Prophase I is the longest phase of meiosis and divided into 5 stages- leptotene, zygotene, pachytene, diplotene, diakinesis. Zygotene stage is characterized by tetrad formation (Synapsis). Pachytene is characterized by crossing over (exchange of genes) between non sister chromatids.

2) The point at which crossing over takes place is called chiasmata. Exchange of genetic segments produces genetic recombination in the offspring, and brings variation in traits.

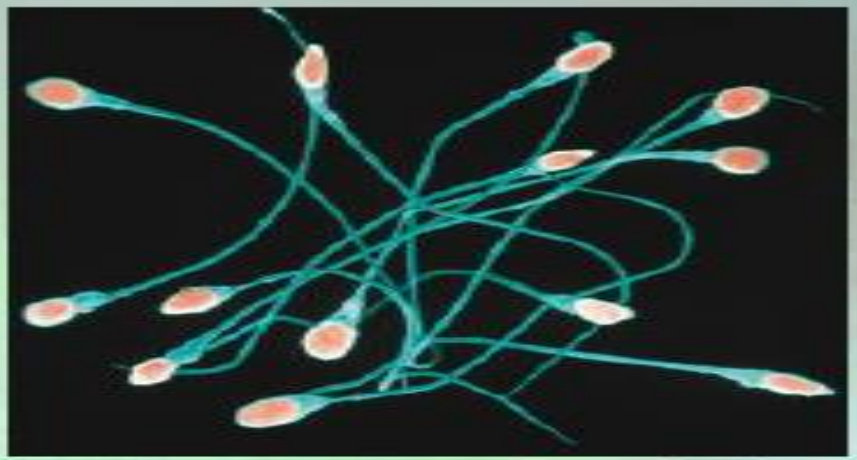


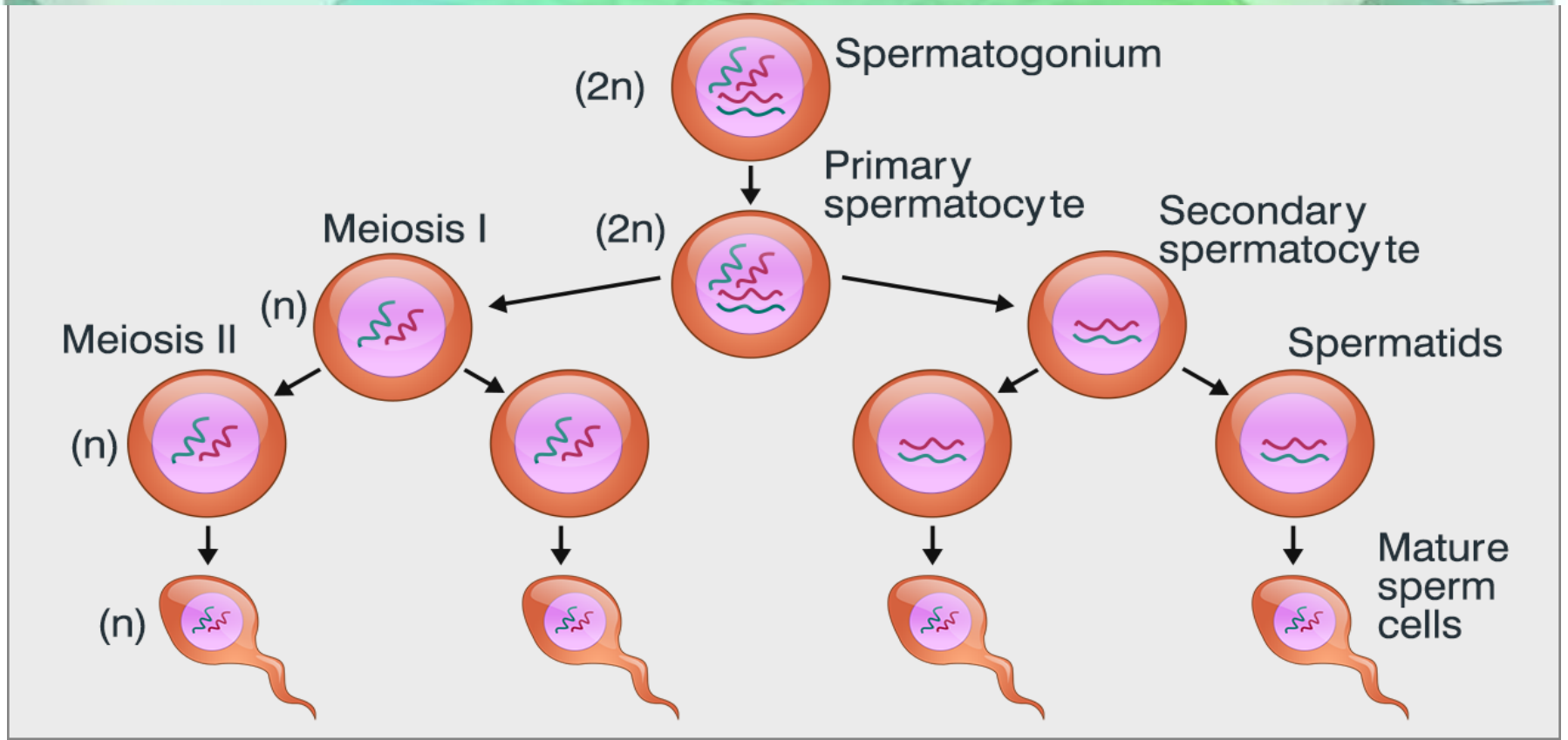
Chromosomes and chromatids numbers in cell divisions

Phase (Mitosis)	# Chromosomes	# Chromatids
Prophase	46	92
Metaphase	46	92
Anaphase	92	92
Telophase	92	92
End of Mitosis (separated cells)	46	46
Phase (Meiosis I)	# Chromosomes	# Chromatids
Prophase I	46	92
Metaphase I	46	92
Anaphase I	46	92
Telophase I	46	92
End of Meiosis I (separated cells)	23	46
Phase (Meiosis II)	# Chromosomes	# Chromatids
Prophase II	23	46
Metaphase II	23	46
Anaphase II	46	46
Telophase II	46	46
End of Meiosis II (separated cells)	23	23

Spermatogenesis

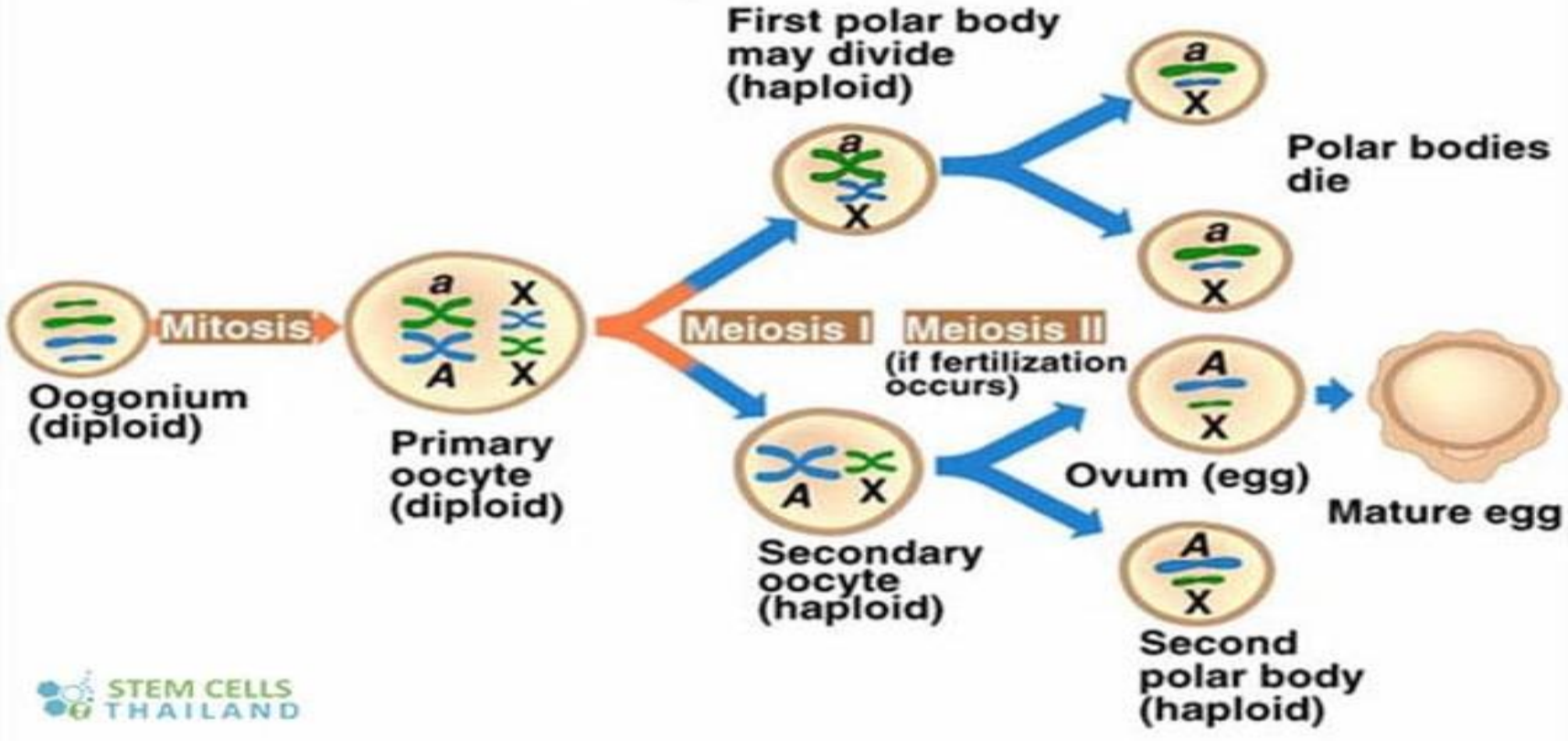
- ✓ Occurs in the testes
- ✓ Two divisions produce 4 spermatids
- ✓ Spermatids mature into sperm
- ✓ Men produce about 250,000,000 sperm per day

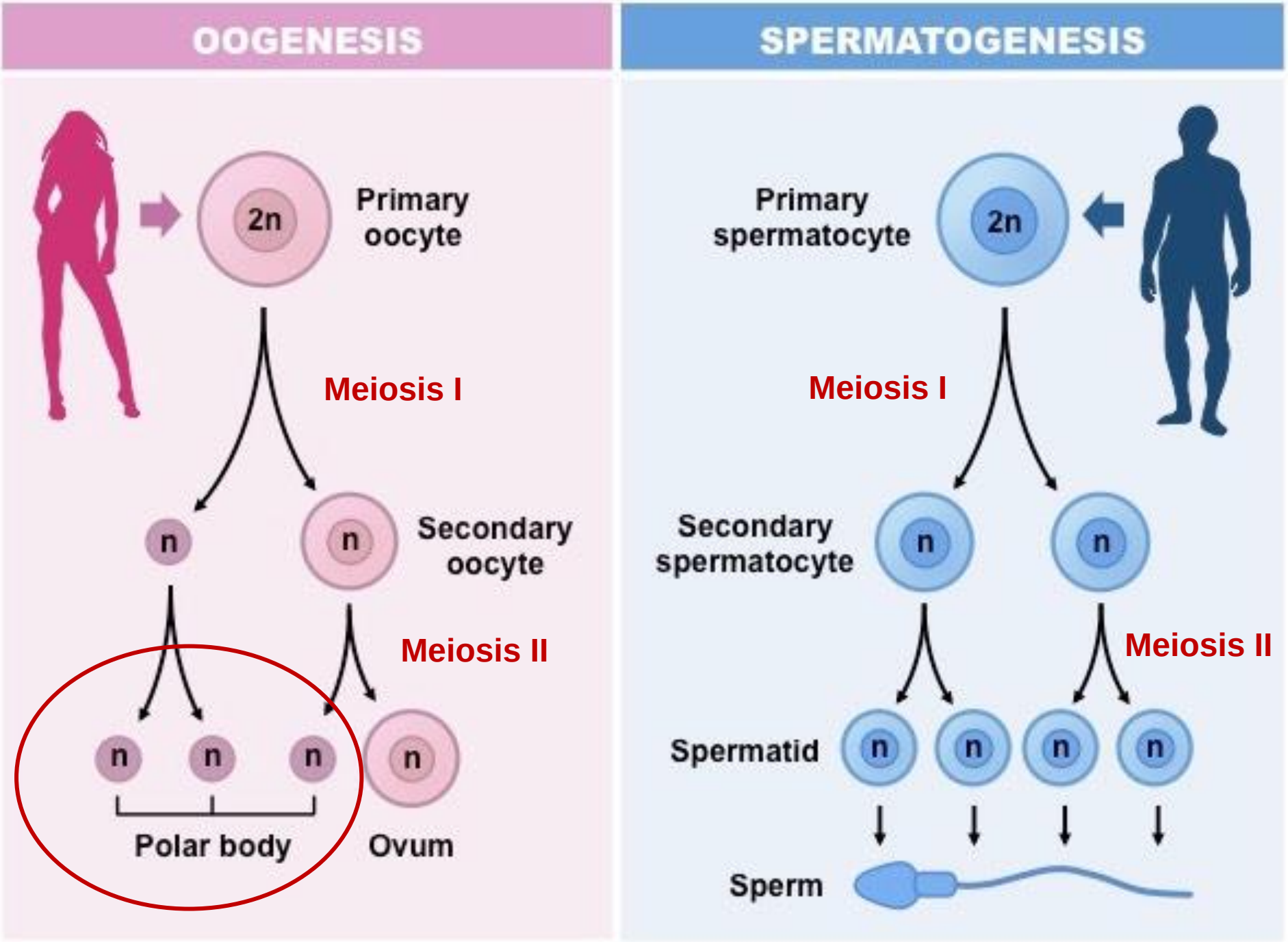




Oogenesis

- Occurs in the ovaries
- Two divisions produce 3 polar bodies that die and 1 egg
- Polar bodies die because of unequal division of cytoplasm
- Immature egg called oocyte
- Starting at puberty, one oocyte matures into an ovum (egg) every 28 days




OOGENESIS
SPERMATOGENESIS
2n
Primary oocyte
Meiosis I
n
n
Secondary oocyte
Meiosis II
n
n
n
n
Polar body
Ovum
Primary spermatocyte
2n
Meiosis I
Secondary spermatocyte
n
n
Meiosis II
Spermatid
n
n
n
n
Sperm

mitosis

1. All organism
2. Asexual
3. Genetically - identical cells
4. No crossing over occurs
5. No pairing of homologous chromosome
6. One cell division occurs
7. 2 diploid cells are produced

meiosis

1. Reproductive cells of humans, plants, animals & fungi
2. Sexual
3. Genetically - Different cells
4. Crossing over occurs
5. Pairing of homologous chromosome
6. Two cell division occurs
7. Four haploid cells are produced