CELL DIVISIONS

- All multicellular organisms start with a single fertilized egg which proliferate by cell division. The new cells arise by the division of the pre existing cells. The cell division is fundamentally similar in all organisms. There are two types of cell divisions.
- **1.** Mitosis
- 2. Meiosis

Why mitosis?

- Mitosis is the cell division responsible for growth and repair.

- Meiosis, on the other hand, is involved in generating haploid sex cells called gametes that are used for sexual reproduction.

- Mitosis results in two identical diploid daughter cells, whereas meiosis results in four sex cells.

- We will highlight differences and similarities between the two types of cell division.

- All cells of an organism divides with mitosis.
- The process of cell division which results in the production of two daughter cells from a single parent cell.
- The daughter cells are identical to one another and to the original parent cell.

- When puberty is reached, meiosis begins providing the occurrence of mature gametes.

- Meiosis is the type of cell division by which germ cells (egg and sperm) are produced.
- One parent cell produces four daughter cells.
- Daughter cells have half the number of chromosomes found in the original parent cell.

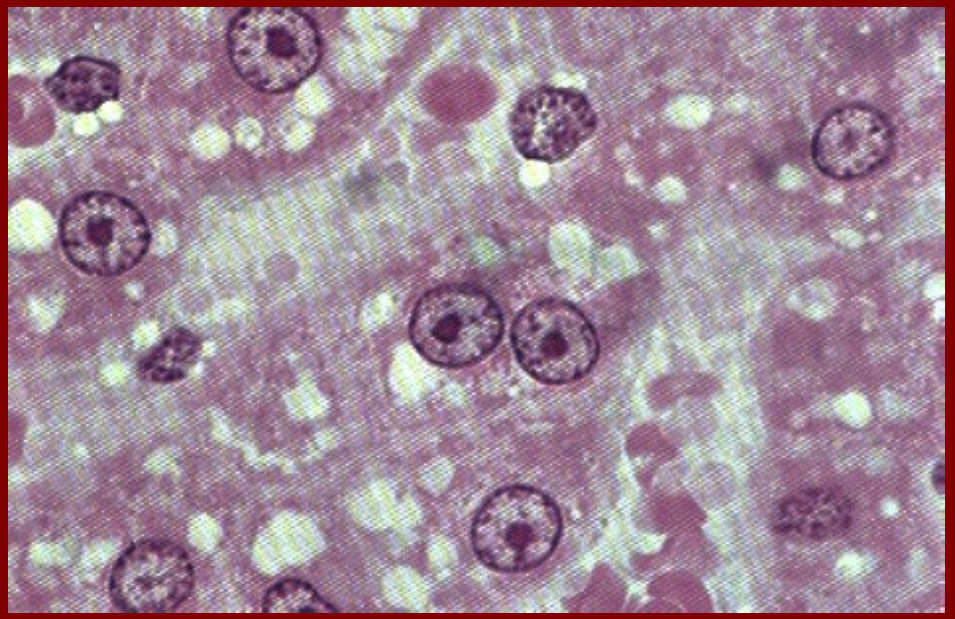
- Somatic cells is divided by amitosis, too. Amitosis is a nucleus division.

Amitosis

- Chromosome formation and melting of nuclear envelope is not seen.
- DNA replication happens before division is start.
- DNA molecules are clustered on both sides the nucleus. When divisions will start, microfilaments and microtubules begins articulation through the middle.

- Microfilaments and microtubules form a ring to gather at the equatorial region of the nucleus. These ring narrows and eventually break in.

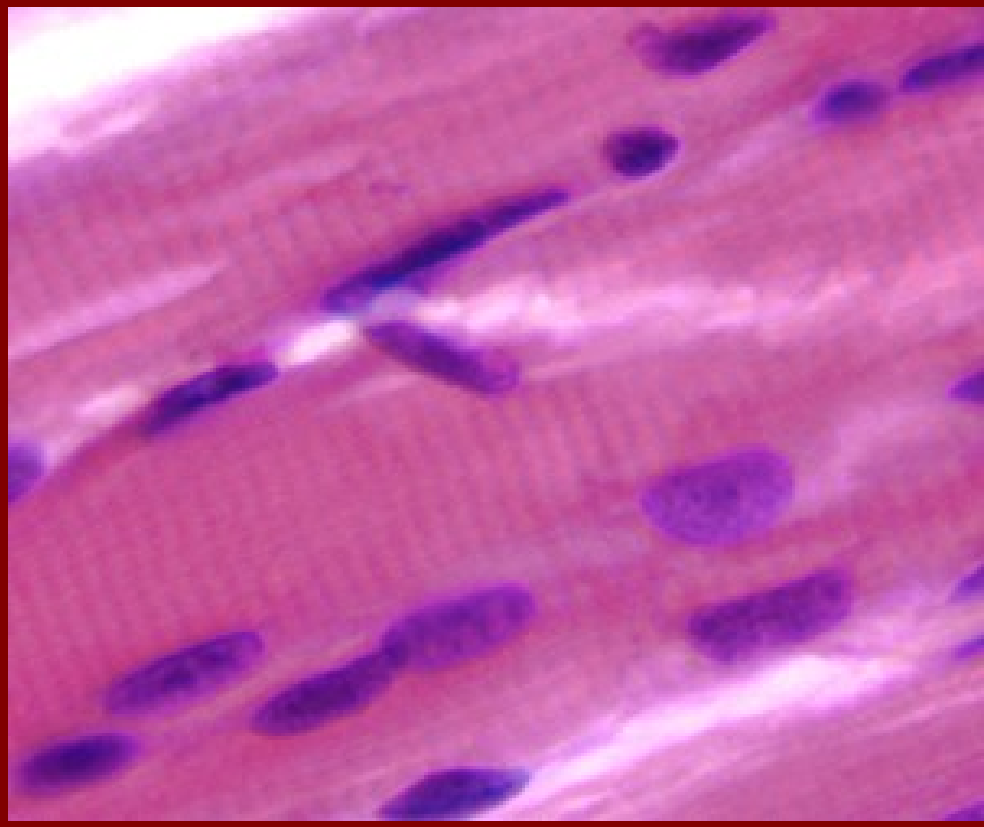
- Some cells which highly differentiated (liver, kidney and heart muscle fibers) thus have two nucleus.
- Thus, they have much more metabolic activity.



- The process of cell division usually includes division of both the nucleus (karyokinesis) and the cytoplasm (cytokinesis).

- What happens if a cell undergoes mitosis but not cytokinesis?

- If cytokinesis doesnt follow karyokinesis, a binucleate cell is formed.
- A primary example of a cell type that undergoes nuclear division but not cytoplasmic division is a skeletal muscle cell.



- Prior to mitotic cell division, a process called interphase occurs in the nucleus.

- Cells that are not in the process of dividing are called interphase cells.

- Cells replicate (or duplicate) their genetic material (DNA) during interphase.

- This phase of the cell cycle is called the S or synthesis phase. At the beginning of this phase, the chromosome number is 2n, and the DNA content is 2n; at the end, the chromosome number is 4n, and the DNA contents is 4n.

- The purpose of mitosis, hereditary factors (chromosomes) to distribute evenly to newly formed cells.

- Mitosis cell division happens in five steps:
- Interphase
- Prophase
- Metaphase
- Anaphase
- Telophase & Cytokinesis

Interphase

The cell prepares for division

- DNA is replicated
- Organelles are replicated
- Cell increases in size

1. PROPHASE: Prophase is the first and longest stage and may take about one to several hours.

- In this cells, permeability to water of the cell membrane increases. Cell gets tense and rounded form.
- Part of the water passes into the nucleus.

- All daughter cells contain the same genetic information with original parent cell from which it was copied.

- Every different type cell in your body contains the same genes, but only the cells specialise different tissues.

- During prophase, the chromosomes begins condense and become visible.

- Each of the chromosomes can be seen to consist of two chromatids.
- The chromatids are held together by the centromere.

- During the formation of chromosomes, nuclear membrane fragment into small vesicles. The nucleus and nucleolus disappear.
- Other changes at this time include replication of the centrioles. The centrioles move toward opposite sides of cells.

- Karyoplasm mixed with the cytoplasm by fragmenting nuclear membrane. (mixoplasma).
- Because of the ion balance is change, many functions of the cell stops.

- The spindle begins to form and attach to the chromosomes.

METAPHASE

- All chromosomes align in the middle of the spindle and they form a plaque on a plane (metaphase plaque).
- It now becomes apparent that there are two identical sister chromatids in each chromosome.

- Each chromatid has an area for the attachment to one of the spindle fibers, which extends to both spindle poles.

- This is the stage when karyotyping works best.

- Two chromatids of a chromosome is well defined in metaphase stage. They are interconnected only in the centromere region. Shortening and thickening of chromosomes continues at this phase.

- In this stage the chromosome number can be easily counted and it is possible to recognise the chromosomes from their sizes and shape.

ANAPHASE

- Anaphase is the stage of mitosis after the metaphase. It is the shortest phase.
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- During **anaphase,** replicated chromosomes are split and the daughter chromatids are moved to opposite poles of the cell.
- Chromosomes also reach their overall maximum condensation in late anaphase.

- Thus, genetic features are equally transfer to young cells.

- In this case, the number of chromosomes in the cell will have doubled.

- Sister chromosomes are separated from the spindle fibers when they reach the poles.

TELOPHASE

- Telophase is the final stage of mitosis. When the chromosomes reaches the poles, they become thicker and shorter.

- Such a time remaining chromosomes, then they begin to lose their matrix. Decondensation takes place. The chromatids combine and form a coil.

- **Telophase** is characterized by the reappearance of nucleus in the daughter cells.

  Reformation on the nuclear membrane by certain unknown process takes place.

- While these nuclear alterations are taking place, a constriction develops at the equatorial plane of the parent cell and the cytoplasm divides by contracting the cytokinetic actin ring (division ring). This is called cytokinesis.

- Thus, a double spirem is occurred in poles of the cell.

- After the membrane is formed, nucleolus occurs in the nucleus.

- Karyokinesis is division of the nucleus during the cell cycle.
- **Cytokinesis** is that part of the cell division process during which the cytoplasm of a single eukaryotic cell divides into two daughter cells.

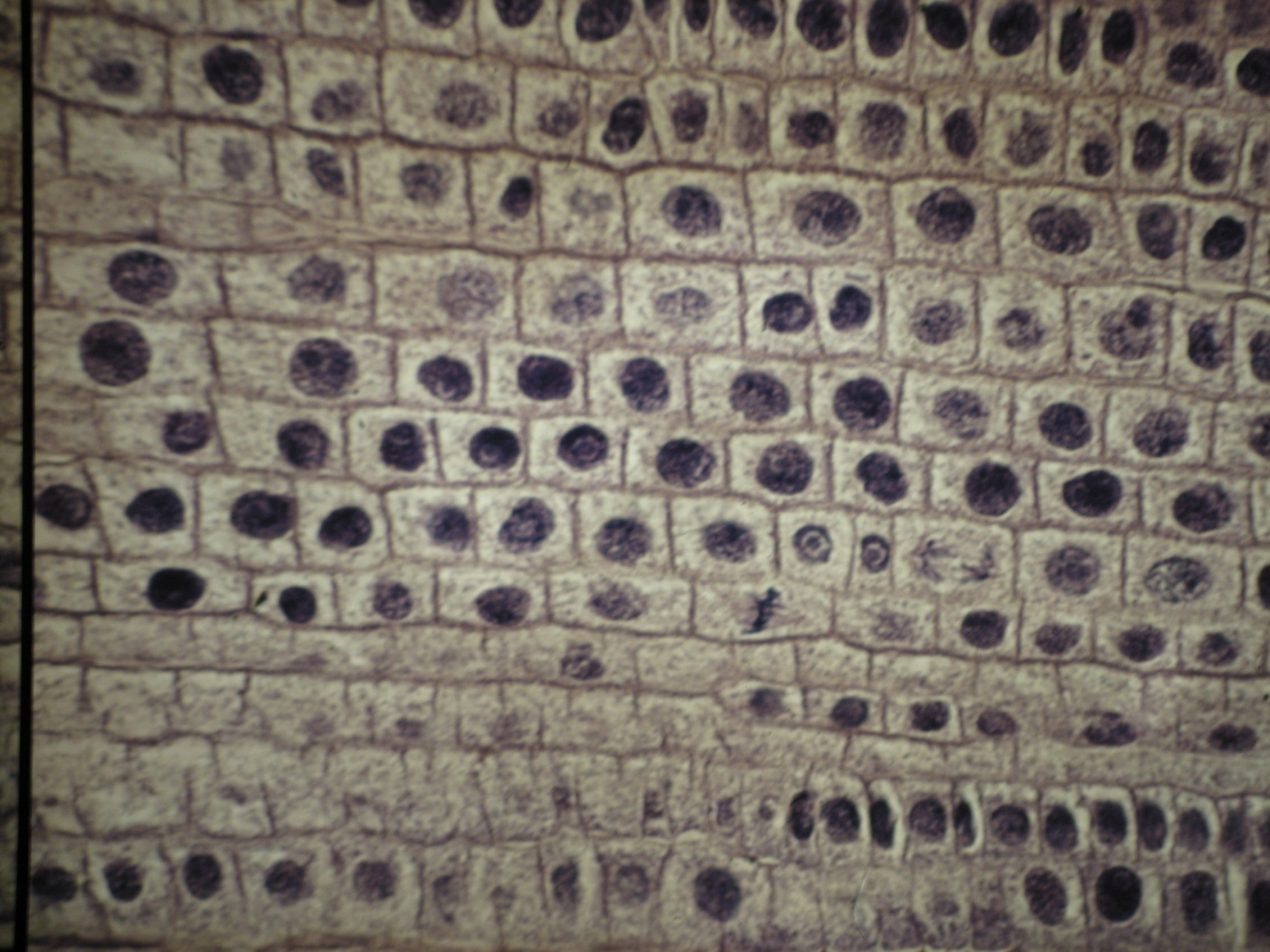
- Cytoplasm splitting occurs in two ways.

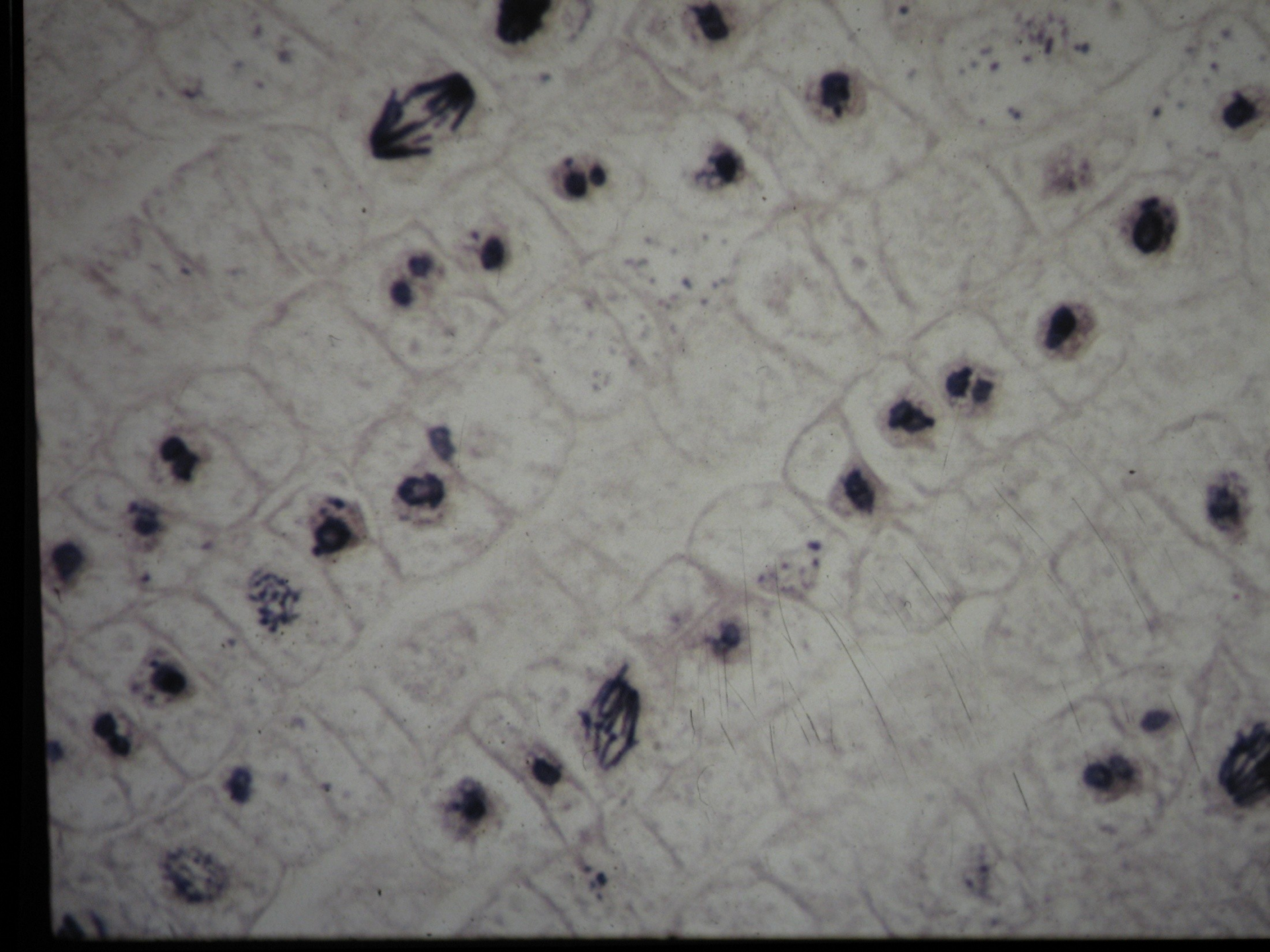
- Microfilaments are actively involved in animal cell cytokinesis. It starts a constriction in the cell membrane. Then the cell is split.

- Plant cell have a rigid cell wall unlike animal cell. It cannot constrict like a plasma membrane.
- Vesicles which form originated endoplasmic reticulum and Golgi develop in the equatorial plane.

- These vesicles fuse together until a plate is formed. These membranes expands until the cell membrane and combined with the cell membrane. Thus, it is divided into two cells.

- Daughter cells remain connected to each other for a while. There is an intense region in the middle of the bridge.The separation of the cells occur here.





ENDOMITOSIS

- This is a type of mitosis. Chromosomes occurs in the nucleus. Chromatids are separated from each other and chromosomes doubled (tetraploidi). Such cells compared with diploid cells exhibit higher metabolic activity.
- To be more than of the number of the diploid of number of chromosomes was called polyploidy. Polyploidy is a phenomenon that occurs with more pathological factors (such as X-rays).

Meiosis

- MEIOSIS is a specialized cell division found in all organisms with a sexual life cycle. Sexual reproduction occurs only in eukaryotes.
- **Haploid** cells are a result of the process of meiosis, a type of reductional cell division in which diploid cells divide to give rise to haploid germ cells
- As a result of such a division of sex cells be mature (maturation division).

- During meiosis, DNA replicates ***once***, but the nucleus divides *twice*.

Meiosis I

- First division of meiosis

- **Prophase 1:** Each chromosome duplicates and remains closely associated. These are called sister chromatids. The prophase of meiosis I is an extended phase that is subdivided into five stages.

- **Leptotene**: The chromosomes become visible as thin strands.

Zygotene: Homologous chromosomes of maternal and paternal origin pair. This pairing involves the formation of synaptonemal complex.
Synaptonemal complex is a three partite structure that brings the chromosomes into physical association so that crossing over may occur.

Pachytene: As the chromosomes condense, the individual chromatids become visible. Crossing over occurs early in this phase.

- **Diplotene**. The chromosomes condense further, and chiasmata or contacts between the chromatids appear. The chiasmata indicate crossing over may have occurred.

- **Diakinesis**: The chromosomes reach their maximum thickness, the nucleolus disappears, and the nuclear envelope disintegrates.

- Metaphase I is similar to the metaphase of mitosis except that the paired chromosomes line up at the equatorial plate. (still in homologous pairs).

- Anaphase I is similar to the same phases in mitosis except that the centromers do not split and the paired chromatids held by the centromere remain together.
- The homologous chromosome moves toward the opposite poles.

- Segregation occurs because the maternal and paternal chromosomes of each pair are randomly aligned on one side or the other of the metaphase plate, thus contibuting to genetic diversity.

Telophase I:This is the end of the first meiotic cell division.

- The cytoplasm divides and is formed two new daughter cells.
- Each of the newly formed cells has half the number of the parent cell's chromosomes, but each chromosome is already replicated for the second meiotic cell division.

- At the completion of meiosis I, the cytoplasm divides. Each resulting daughter cell (a secondary spermatocyte or oocyte) is haploid in chromosome number, containing one member of each chromosome pair, but is still diploid in DNA content (2n).

Second Division of Meiosis

- Meiosis II: After meiosis I, without passing through an S phase, the cells quickly enter meiosis II. During meiosis II, the cells pass through prophase II, metaphase II, anaphase II, and telophase II.

These stages are essentially the same as those in mitosis. However, they involve a haploid set of chromosomes and produce daughter cells that have only the haploid DNA content (1n).

- Unlike the cells produced by mitosis, which are genetically identical to the parent cell, the cells produced by meiosis are genetically unique.

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Metaphase 2:
Chromosomes line up at the center of the cell **in a mitosis-like fashion**

http://everyschool.org/u/logan/cellreproductionx/rogersa/research/meiosis.html

- **Anaphase II: The** centromeres divide and sister chromatids separate and move to opposite poles of the cell.

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- Telophase 2: Cell division is complete. Nuclei is formed at opposite poles of the cell and cytokinesis occurs.
- After completion of cytokinesis, four haploid daughter cells are formed (n).

- One purpose of meiosis is to keep the number of chromosome constant from generation to generation.

- We assume that a male germ cell with 6 chromosome divides in this shape:
- The cell has four chromosomes other than X and Y chromosomes. Two of them are similar in terms of shape and size of the chromosomes (homologous chromosome). One homologous chromosome is inherited from the organism's mother; the other is inherited from the organism's father.

- The cell in our example is a primary spermatocyte:
- Primary spermatocytes derive from immature germ cells called spermatogonia.

- All chromosomes in primary spermatocytes are long and thin in the beginning of the prophase and are located far from each other.
- Each chromosome made up of two chromatids (leptotene).

- Homologous chromosomes begin to approach each other and the chromosomes
- appear as single chromosome (zygotene).

- This homologous chromosomes pair are called bivalent chromosomes. Homologous pairs of chromosomes match up with one another.
- Thus, chromosomes is paired (Synapsis).

What is the difference between chromatin vs. chromosome?

- Chromatin and chromosomes are both structures of DNA, but chromosomes are condensed chromatin.

- The chromosome pairing provides by synaptonemal complex. The **synaptonemal complex** is a protein structure that forms between homologous chromosomes (two pairs of sister chromatids) during meiosis and is thought to mediate chromosome pairing and recombination.

- The synaptonemal complex is a tripartite structure consisting of two parallel lateral elements and a central element.
- Formation of the SC usually reflects the pairing or "synapsis" of homologous chromosomes.
- The sex chromosomes in male mammals show only "partial synapsis" as they usually form only a short SC in the XY pair.

- In cell development the synaptonemal complex disappear during the late prophase of meiosis I.

The length of the pairing chromosomes is shortened, it's thickness increases (Pachytene).

Not pairing chromatin of each chromosome starts to move away other than. So, the bivalent chromosome becomes 4 chromatids (tetrads). So the tetrad has four chromatids all together.

During
he *diplotene* stage, the synaptonemal
complex degrades and homologous
chromosomes separate from one another a
ittle. However, the homologous
chromosomes of each bivalent remain tightly
bound at chiasmata, the regions where
crossing-over occurred.

- The chiasmata remain on the chromosomes until they are at the transition to anaphase I.

- Diplotene period is followed by diakinese period. The number of chiasmata in this period reduces; even homologous chromosomes are held together by a single chiasmata.

- Homologous chromosomes were moved away completely from each other.
- Diakinesis lasts for many years especially in females.

- All events which occur from leptotene to the end of diakinesis is equivalent to prophase.

- The tetrads arranged on the metaphase plate and are attached to the fully formed meiotic **spindle (metaphase).**

- Genetic recombination involves the pairing of homologous chromosomes. This may be followed by information exchange between the chromosomes. The information exchange may occur by the breaking and rejoining of DNA strands, which forms new molecules of DNA.

- At the end of metaphase chromosomes, chiasma is dissolved and chromosomes become independent.

- Homologous chromosomes separate from each other and are migrate toward the opposite poles of the cell by spindle fibers.

- When chromosomes are gathered together at the poles, the cell divided into two. Nuclear membrane is formed and 2 secondary spermatocytes occur. Although primary spermatocytes are diploid, secondary spermatocytes are haploid. However, each chromosome has yet the two chromatide.
- X and Y chromosome passes to different cells.

- Secondary spermatocytes enter 2.meiosis after a short resting phase. The purpose of this division is transferred one of two chromatids of a chromosome in a separate cell (spermatid). In order to achieve this, the cells undergo prophase, metaphase, anaphase and telophase stages.

- Chromatids become an independent chromosome with division of centromeres at the end of metaphase.

- Both secondary spermatocytes divide after the anaphase and telophase stages and then a couple of young cells (spermatids) occurs.

- Spermatids are haploid, truly. Each chromosome is have one chromatid.

- Spermatids are transformed into spermatozoa changing their shape and internal structure.

- Division stages in the egg cell are the same. Only one mature cell occurs.

- Meiosis results in genetically different cells
- Meiosis and fertilisation are the basis of **sexual reproduction**

MITOSIS----------MEIOSIS

1. **One division occur after DNA replication and then become two diploid cell.**
2. **The chromosomes behave independently.**
3. **It is complete up to 5 hours (1-2 hours).**
4. **The genetic material does not change.** Genetic information is identical
5. Asexual

1. **Two division occur after DNA replication and then become 4 haploid cell.**
2. **The pairing of homologous chromosomes occurs.**
3. **It will take long.**
4. **The genetic material changes.** Genetic information is different
5. Sexual

Similarities

Mitosis

- Diploid parent cell
  Consists of interphase, prophase, metaphase, anaphase and telophase
  In metaphase individual chromosomes (pairs of chromatids) line up along the equator.
  During anaphase the sister chromatids are separated to opposite poles.
  Ends with cytokinesis.

Meiosis

- Diploid parent cell
  Consists of interphase, prophase, metaphase, anaphase and telophase (but twice!)
  In metaphase II individual chromosomes (pairs of chromatids) line up along the equator.
  During anaphase II the sister chromatids are separated to opposite poles.
  Ends with cytokinesis.

CELL CYCLE

- The life of cell species determine other cell types in the same environment.
- Survival of cells continue dividing power is divided into two main phases.

1. Division phase
2. Interphase

   Interphase stage is longer than the division stage. This phase is divided into three sub-stage.

G1 phase: This is the longest stage of the interphase. Transcription and translation is very active.

S phase: DNA replication occurs.

Thus, DNA quantities are doubled in somatic cells.

G2 phase: Transcription and translation is accelerated again. Most of the synthesized proteins are used in cell division.

Phases of the Cell Cycle

- The cell cycle consists of
  - Interphase – normal cell activity
  - The mitotic phase – cell division

Cell Differentiation

- The zygote divide and prolifere. Thus, they constitute different cells. These cells differentiate to perform various functions. Cell differentiation does not cause a change in the size, shape and number of chromosome.
- How is this same genetic material in cells in different structures and functions can be caused to occur?

- There is different chemicals which control different genes in the cytoplasm of the egg cell. These substances are settled in a manner that unequal in the cytoplasm. This material passes in various types and quantities to daughter cells occurred by the division of the zygote.
- This leads to show activity of different genes in the daughter cells. This is a differentiation at the molecular level. This differentiation reaches the morphological level with the formation of the endoderm.

- Morphologically differentiated cells secrete some substance which affect DNA molecules of undifferentiated cells, that occur new cell types.This influence mechanism is called INDUCTION EVENT.

TISSUES

- Cells those similar in terms of shape and function come together and form a union.
- This union is called **tissue**.
- Cells need to be held together with a binding substance so that they can make a unit. This material is made by cells and given to the spaces between the cells. If the amount of this material is less, they called intercellular substance. If the amount of this material is more, in this case the cells are in the minority and this material called basic substance.

- As a result of cell differentiation, four basic tissue occurs in organism.
- 1. Epithelial tissue
- 2. Supporting tissues (connective tissue, cartilage, bone, blood tissue): Intercellular substance abound in these tissues..
- 3. Muscle tissue
- 4. Nerve tissue