NUCLEUS, CELL DIVISION, AND CELL CYCLE

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OUTLINE

LEGENDS			
Must know	**Lecturer**	**Book**	**Presentation**
❗	👩‍🏫	📖	🖥️

LEARNING OBJECTIVES

At the end of the lecture, the student should be able to:

- ✔ Identify the ovary and uterine tube on histologic sections and distinguish them from other reproductive organs.
- ✔ Describe the structural organization of the ovary and uterine tube, including key layers and regions.
- ✔ Differentiate stages of follicular development and recognize major ovarian structures.
- ✔ Recognize epithelial cell types and histologic features responsible for ovum transport and fertilization.
- ✔ Correlate histologic structure with reproductive function and hormonal regulation.

NUCLEUS

PROKARYOTE AND EUKARYOTE

Figure 1. Prokaryote

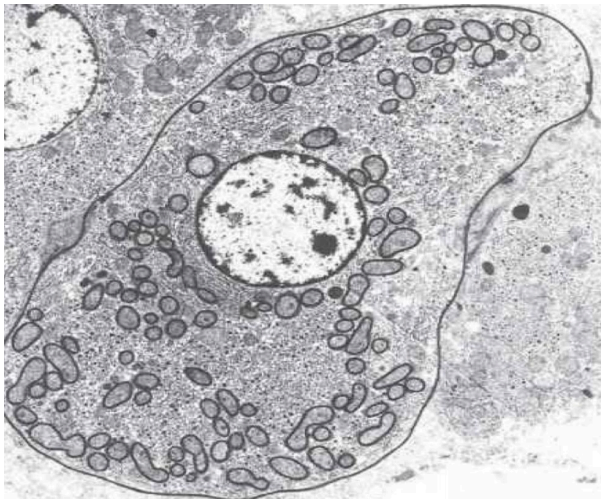
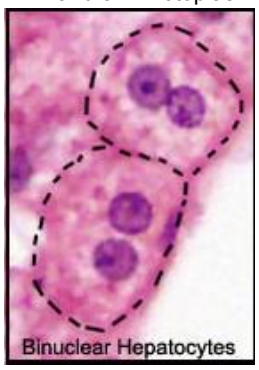
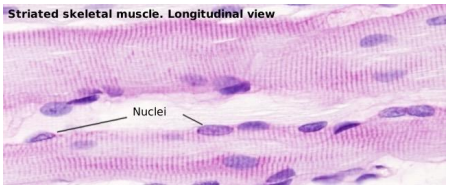


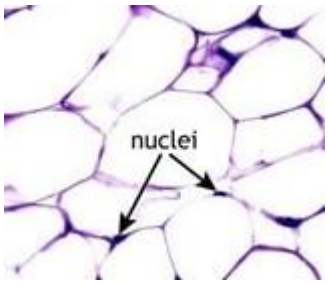
Figure 2. Eukaryote

BASIC PARTS OF THE CELL

- Plasma membrane
- Cytoplasm
- Nucleus
- 2 and 3 = Protoplasm (living component)







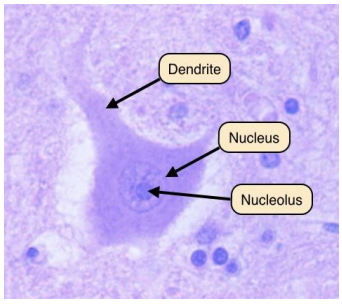


Figure 1. Different type of cells

- Liver cells / Hepatocyte - binucleated, nucleus is on the center
- Neuron - mononucleated, center, oval/round nucleus
- **Adipose cell/Adipocyte- mononucleated**, nucleus is close to the cell membrane; white is the f**at vacuole** (grew bigger because accumulate fats)
  - **Signet ring appearance**
- **Skeletal Myocyte-** peripheral cells, longer shape nucleus, **multinucleated**

COMPARTMENTALIZED CELL

- Eukaryotic cells have a compartmentalized cell structure
- These are organelles that form different compartments in the cell

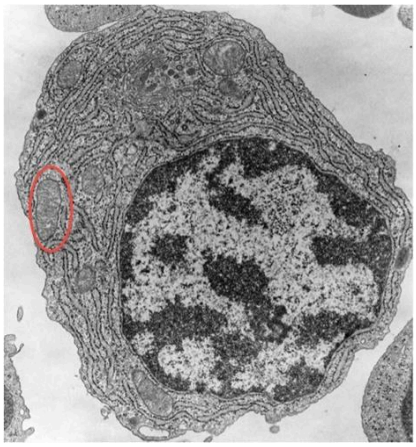


Figure 2. Compartmentalized Cell

NUCLEUS

- selectively permeable
- Cell's production (DNA)
- **Perinuclear space** - separate the inner and outer membrane
- **Inner membrane proteins**: Nuclear lamina (IF:**Lamins**)- made up of chemical **proteins**; intermediate filaments; **stabilizing the opening** or kept intact; strengthen the nuclear pore
- Double membrane

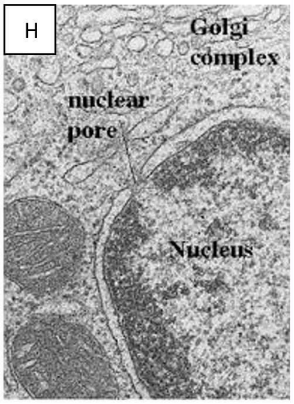


Figure 3. Nucleus

NUCLEAR PORE COMPLEX

- aperture, the inner and outer membrane becomes continuos
- **Nucleoporins-** proteins, become associated with nuclear pore
  - Made up of proteins surrounding the lumen
  - Make substances move easier
  - Maintain the circumference or lumen of the pore

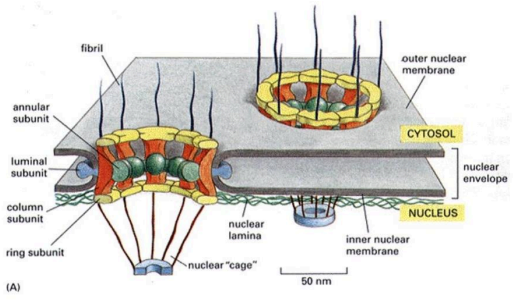


Figure 4. Nuclear pore

NUCLEOLUS

- Similar composition of RNA
- Not always on the center

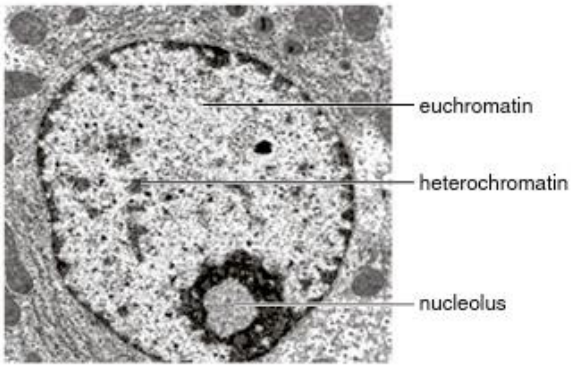


Figure 5. Nucleolus

EUCHROMATIN

- **Lighter, loose**
- Gene expression- information from a gene is used to **produce a functional product**. E.g. Hair color, eye color, etc.
- **Metabolically active cells** (duplication of DNA) - E.g. neuron
- Chromosomes- thread-like structure, condensed structure, made up of DNA
- Gene- segment of DNA
- DNA- carries genetic information

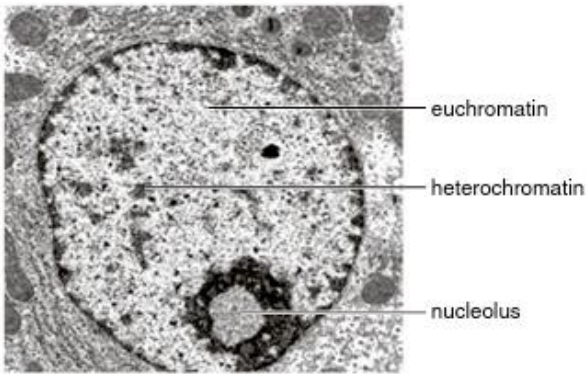


Figure 6. Euchromatin

HETEROCHROMATIN

- **Darkly stain**; dispersed
- **Not metabolically active** (not transcribed)
  - E.g. Lymphocyte
- **Silent genes** - gene that is present in the genome but is not actively expressed into RNA or protein due to regulatory mechanisms or genetic changes; do not participate in genetic changes
- **Constitutive heterochromatin**- no activity
- **Facultative heterochromatin**- present but not that active, on and off

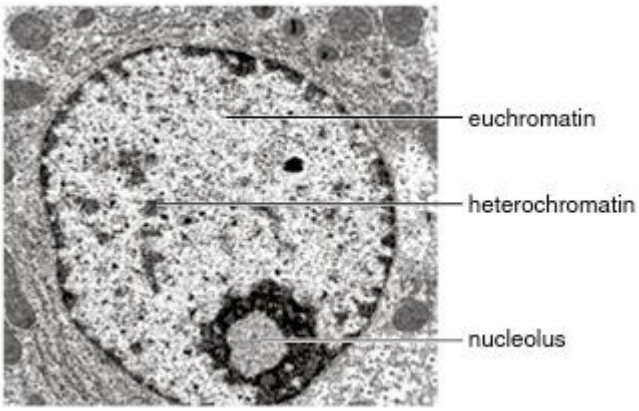


Figure 7. Heterochromatin

CHROMOSOMES

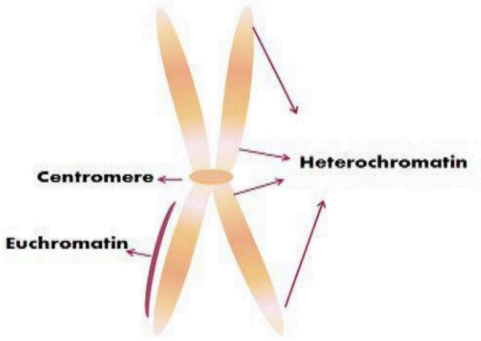


Figure 8. Euchromatin; Heterochromatin; Centromere

- Female
  - **XX**
- Male
  - **XY**
- *Picture*
- 2 meters
- 320 billion base pairs
- Diploid and Haploid count

NUCLEOSOMES

- *Diagram of a nucleosome
- 8 histones wrapped by 150 base pairs
  - causing the appearance of “beads on a string

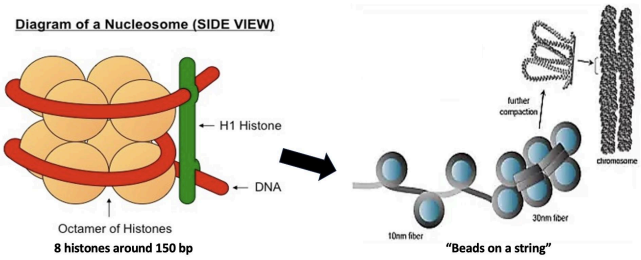


Figure 9. Nucleosome Side View

CELL CYCLE

INTERPHASE

- About 95%
- Metabolically active
- 👩‍⚕️ also known as a resting place but not inactive
- 👩‍⚕️ preparation phase divided by G1, S, and G2 phase
  - G1 phase - 8-10 hours
    - cell growth
    - RNA synthesis
    - Organelle duplication
    - Centrosome replication starts
  - S phase - 6-8 hours
    - DNA replication
    - Chromosomes are formed into sister chromatids
  - G2 phase - 2-5 hours
    - Enzyme synthesis
    - Centrosome replication completed
    - Duplication of mitochondria

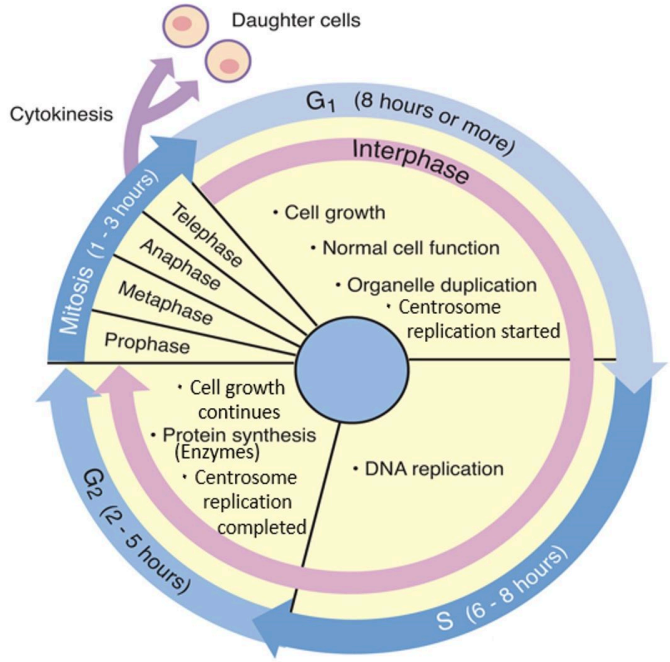


Figure 10. Cell Cycle

CHECKPOINTS

- 👩‍⚕️ Acts as a failsafe
- 👩‍⚕️ Occurs:
  - Before G1 finishes for damaged DNA
  - In the middle of S phase for checking unreplicated or damaged DNA
  - Before G2 finishes for checking of damaged or unreplicated DNA
  - Right before mitosis finishes for chromosome misalignment

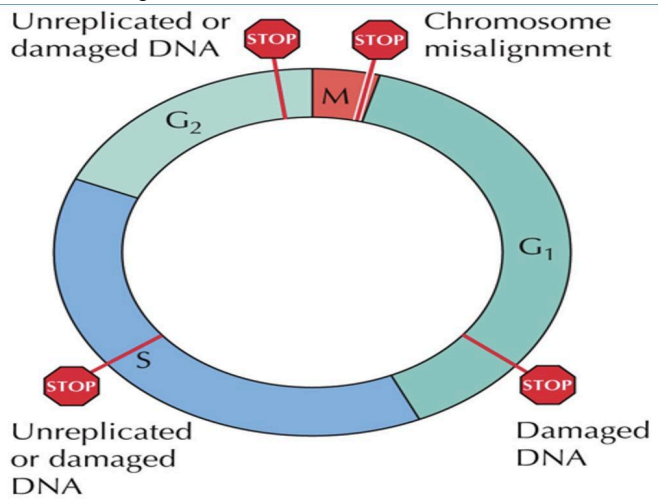


Figure 11. Checkpoints

MITOSIS

- Karyokinesis
  - Nuclear division
  - Phases:
    - Prophase
    - Metaphase
    - Anaphase
    - Telophase
- Cytokinesis
  - Cytoplasmic division

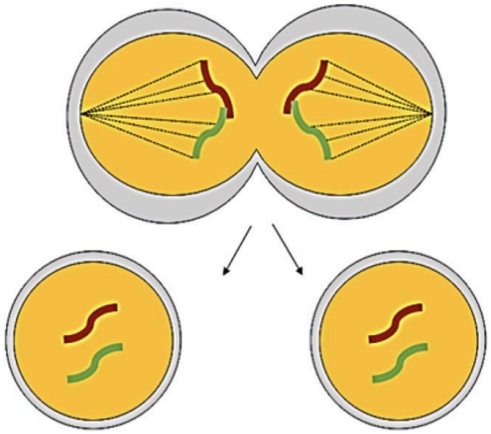


Figure 11. Mitosis

GOALS OF MITOSIS

- Produce 2 daughter cells
- Identical to the parent cell
- Same number of chromosomes
- Tissue formation
- Growth and reproduction (asexually)
- Repair and regenerate body parts

PROPHASE

- Loose chromatin **condenses** and forms into a visible, **X-shape** called **sister chromatids** (identical DNA) joined at the centromere
- Centrosomes (centrioles) move to opposite poles and form mitotic spindle fibers

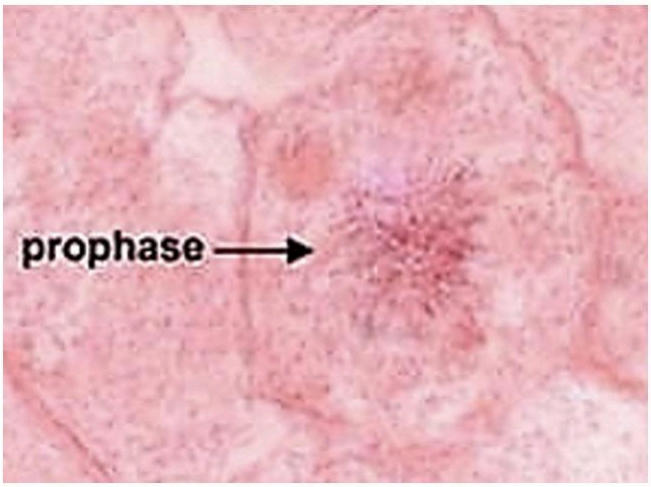


Figure 12. Prophase.

Late Prophase

- 🖥️Also called Prometaphase
  - Nuclear membrane breaks into membrane vesicles
  - Kinetochore microtubules attach to sister chromatids

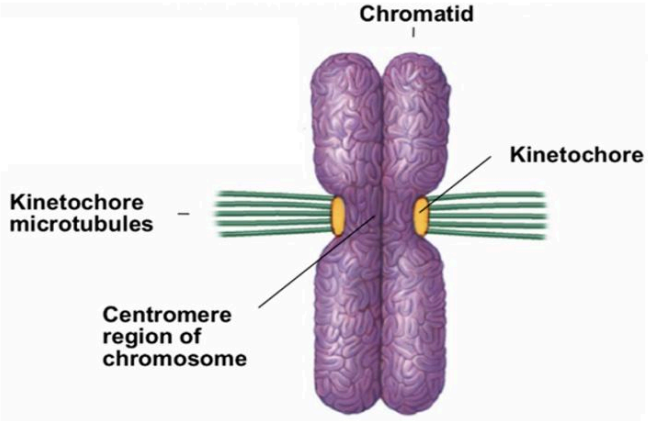


Figure 13. Kinetochores attached to sister chromatids.

METAPHASE

- Force generated by kinetochore on microtubules pulls the sister chromatids on opposite sides.
- The back-forth pulling of the sister chromatids lands them into the middle of the cell, the so-called metaphase plate or equatorial plane.

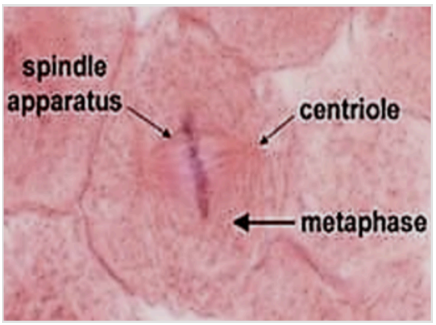


Figure 14. Metaphase

- Cell above is (+) in metaphase checkpoint
- Kinetochores are properly attached to mitotic spindles (from centrosomes).

ANAPHASE

- Centromere splits due to enzymatic breakdown of cohesin.
- Spindle fibers pull these independent sister chromosomes to opposite ends of the cell.
- Spindles fibers not connected to chromosomes lengthen and cell elongates.
- Each pole now receives identical copies of the parent cell's DNA.

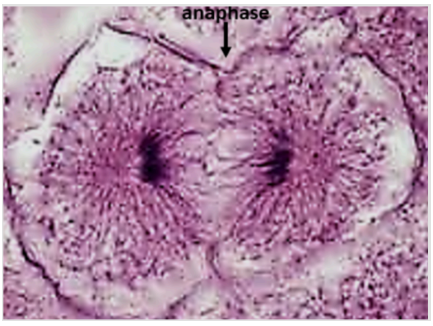


Figure 15. Anaphase.

TELOPHASE

- Reformation of nuclear envelope from the membrane vesicles around the 2 daughter chromosomes and create 2 separate nuclei.
- The chromosomes unwind into chromatin.

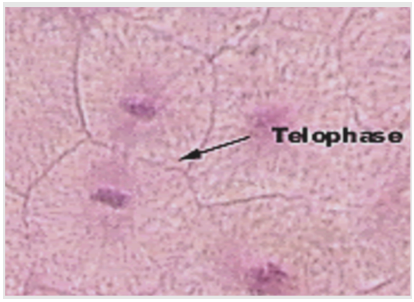


Figure 16. Telophase.

CYTOKINESIS

- Actual division of the cell membrane into 2 cells.
- Contractile ring made of protein filaments develops here the metaphase plate used to be.
- Shrinking of the contractile ring pulls the plasma membrane inwardly and then divides the old cell into 2.
- Begins in late anaphase.

G0 PHASE

- When cells exit the cell cycle and stop dividing
  - 👩‍⚕️ After mitosis, cell would proceed to interphase or G1. However, some cells exit to G0.
  - Neurons, Muscle cells
- Semi-permanent
- For conserving energy and resources
- Specializing cells for specific functions
  - 👩‍⚕️ Instead of wasting their energy on dividing

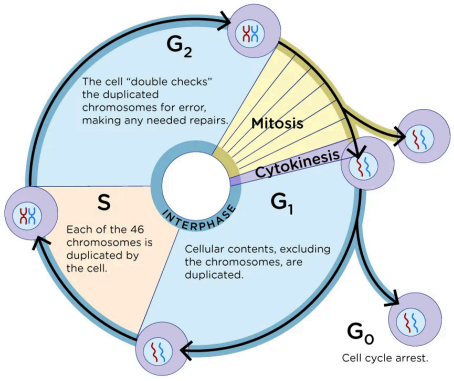


Figure 17. Phases of cell cycle

TYPES OF CELLS BASED ON MITOTIC ACTIVITY

Permanent Cells

- Non-dividing cells or proliferation
- Remain in G0 phase permanently
- No regenerative capacity
- Irreversible damage
  - 👩‍⚕️ *Ang delikado, pag nainjured sila, mamamatay sila.*

→ E.g. Cardiac and Skeletal muscle cells, CNS Neurons

Labile Cells

- Constantly dividing or moving through cell cycle
- Higher regenerative capacity
- Never enter G0 phase
  - 👩‍⚕️ After cytokinesis, these cells go straight to G1

→ E.g. Epithelial lining of Skin, GIT, Reproductive, Urinary tract and Exocrine duct, Hemopoietic stem cells (of bone marrow)

Stable Cells

- Can divide but not constantly
- Usually in G0 phase but can re-enter cell cycle and divide when injured
- Moderate regenerative capacity
- Can proliferate when stimulated

→ E.g. Cells of the liver, kidney, lung, pancreas, smooth muscles cells, fibroblasts, endothelial cells (BV)

APOPTOSIS

- 🖥️ Is a programmed cell death that helps shrinks and eliminates defective and unneeded cells.
- It is the reason why the web between fingers disappears during development.
  → 👩‍⚕️ *syndactyl*
- It is a common mode of death for abnormal cells (infected by virus or with genetic mutation) and for maintenance of health by removing old and worn-out cells.
- Two pathways:
  → Intrinsic Pathway
  → Extrinsic Pathway

Intrinsic Pathway

Effects:

1. **Pyknosis**
   → condensation of chromatin
2. **Karyorrhexis**
   → nuclear fragmentation

3. **Karyolysis**
   → nuclear dissolution

- 👩 *Pag may mga ganitong condition, stress 'yan sa mitochondria.*

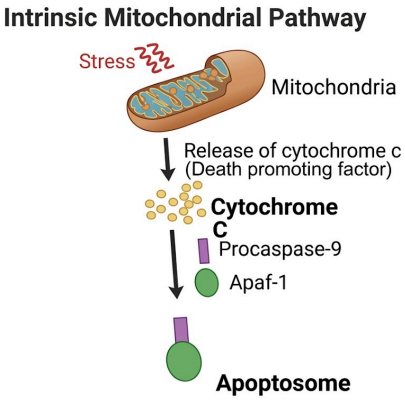


Figure 18. Intrinsic Pathway

- 👩Mitochondria induce ATP process by oxidative phosphorylation.
- 👩 Mitochondria will release Cytochrome C (a chemical that is death promoting factor) which will combine with chemicals (specifically with caspase chemicals) in a cascade system.
  - 👩 Procaspase 9 - final product of cascade system.
- 👩 These combination will lead to the formation of **Apoptosome.**
- 👩 The presence of apoptosome will undergo cascade effect to other procaspase, ultimately will be **procaspase 3** inducing an enzyme destruction of the cell.

Extrinsic Pathway

- 👩 There are factors that will enter the cell which comes from the tissue (extracellularly). Neighboring cells sense these, resulting in the secretion of substances. (or) The complementing substances in the blood can get into the tissue. This will then go to the extracellular space to get access inside the cell through the cell membrane receptors.

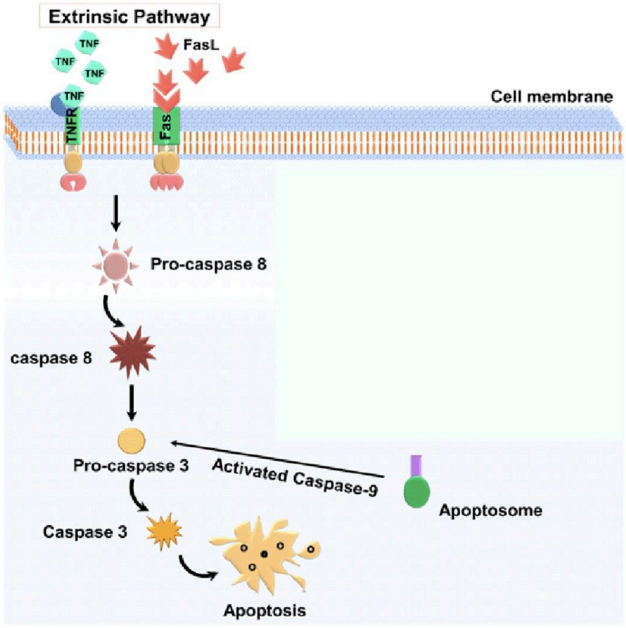


Figure 19. Extrinsic Pathway

MEIOSIS I

- Resulted into 2 daughter cells
- Reduces the original diploid number of chromosomes into haploid (Reduction division)
- Prophase I is the first and longest
- Prophase I is divided into 5 substages:
  - Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis

Figure 20. 2 Daughter cells at end of Meiosis I

PROPHASE I

LEPTOTENE STAGE

- Long thin strands of chromosomes
- Condensation and coiling of chromosomes
- Nucleolus disappear

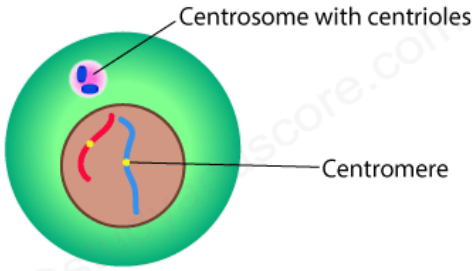


Figure 21. Leptotene

ZYGOTENE

- "Paired threads" or "Bouquet stage"
- Homologous chromosome pairing producing Bivalent chromosomes
- Synaptonemal complex (zipper-like) causes the pairing
- Centrosome (centriole divides into 2)

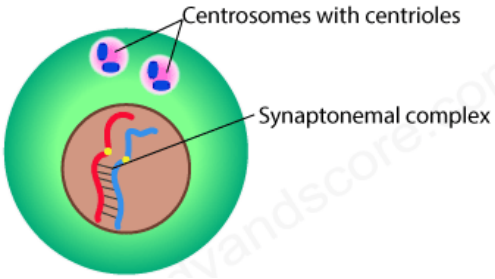


Figure 22. Zygotene

PACHYTENE

- Shorter but thicker chromosomes
- Formation of Tetrad (4 chromatids)
- Crossing over formation between non-sister chromatids causing Recombination of traits

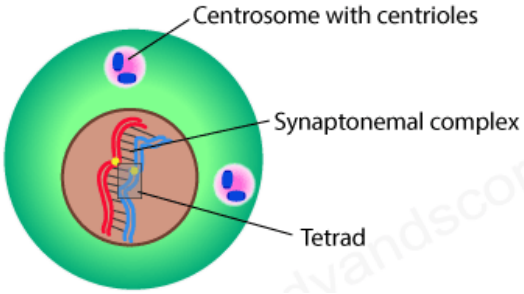


Figure 23. Pachytene

DIAKINESIS

- Separation of chromosomes by terminalization
- Nuclear membrane disappear
- Spindle fibers formed from centrioles

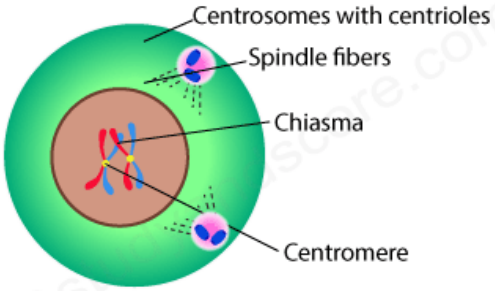


Figure 24. Diakenesis

METAPHASE I

- Pairs of homologous chromosomes move to the equator of the cell

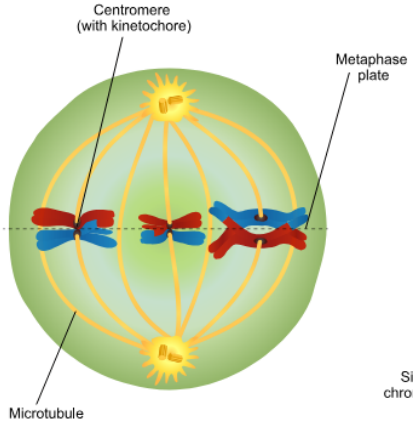


Figure 25. Metaphase I

ANAPHASE I

- Homologous chromosomes move to the opposite poles of the cell

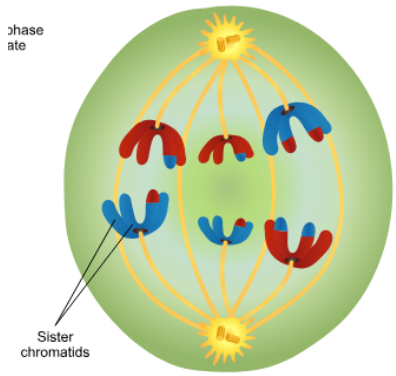


Figure 26. Anaphase I

TELOPAHASE I

- Chromosomes gather at the poles of the cells
- Cytoplasm divides (Cytokinesis)
- Forming to 2 daughter cells

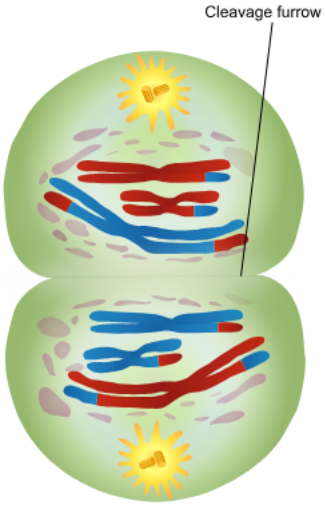


Figure 27. Telophase I

REFERENCES

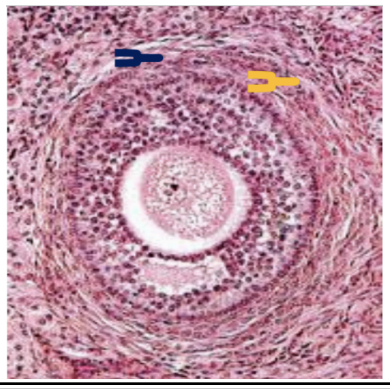
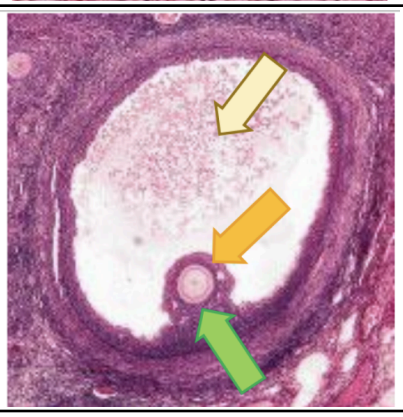
1. Powerpoint (2026) Dr. Cervales - Female I- Ovaries and Oviduct
2. Pamana Trans 2029

APPENDIX

Table 1. General Features of the Ovarian Follicles[PPT]

Feature	Description	Function	Location
Follicular Cells or Granulosa Cells	Flat follicular cells or Cuboidal granulosa cells	Protect and support the growing oocyte	Outside the zona pellucida
Zona Pellucida	Thick acellular layer surrounding the oocyte	Form a protective shell around the oocyte	Immediately outside of the oocyte
Theca Interna	Rounded stromal driven cell layer	Secrete estrogen precursors	Outside the granulosa cell layer, separated by a thin basement membrane
Theca Externa	Spindle-shaped stromal cells and Smooth muscle cells forming a capsule-like layer	Form a capsule-like structure Contract during ovulation	Outside of the theca interna Boundary is indistinct
Antrum	Fluid-filled space within granulosa cell layer	Filled with fluid, liquor folliculi, build pressure within the follicle, deliver nutrients	Within secondary follicles and Graafian follicles
Corona Radiata	Collection of granulosa cells that surround oocytes in Graafian follicles	Surround the oocyte	Outside of zona pellucida in Graafian follicles
Cumulus Oophorus	Collection of granulosa cells that forms a hillock	Connect the oocyte and corona radiata to the rest of the granulosa cells	Between the corona radiata and the rest of the granulosa cells

Table 2. General Features of the Ovarian Follicles[PPT]

Feature	Description	Function
Follicular Cells or Granulosa Cells	Flat follicular cells or Cuboidal granulosa cells	
Zona Pellucida	Thick acellular layer surrounding the oocyte	
Theca Interna	Rounded stromal driven cell layer	
Theca Externa	Spindle-shaped stromal cells and Smooth muscle cells forming a capsule-like layer	
Antrum	Fluid-filled space within granulosa cell layer	
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