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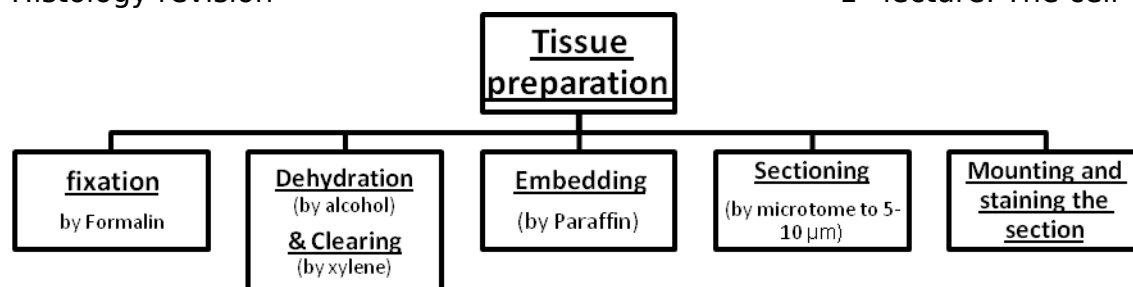
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Histology: Microscopic Anatomy, the study of tissues.

When studying any tissue, consider:

- 1- Appearance under light microscope (coloured). Resolution power (R.P.): 0.25 μ m
- 2- Appearance under electron microscope (black & white). It differentiates electron-dense structures from electron-lucent structures.
 - Transmission E/M: R.P. 0.2 nm.
 - Scanning E/M: R.P. 10 nm

Resolution Power (R.P): the least distance between 2 particles at which they will appear separated



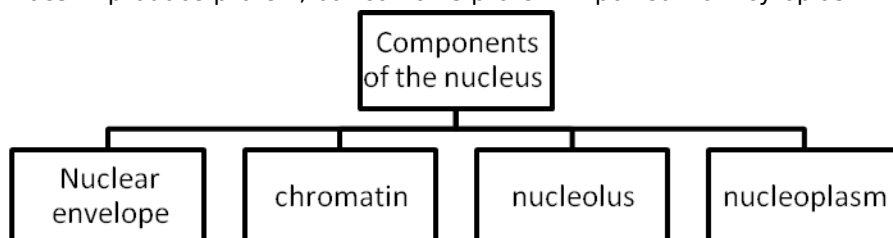
Types of Stains for Light Microscope

- **Staining:** tissues are stained by water-soluble stains to differentiate the various cellular components
- **Stains for Light microscope:** Hematoxyline and Eosin (H&E)
 - o Hematoxyline is a base, so it stains the acidic components of the cell *dark blue*. So they are called basophilic structures.. such as DNA & RNA
 - o Eosin is an acid, so it stains the basic components of the cell *pink*. So they are called acidophilic structures.. such as regions of the cytoplasm,

The Cell Components

The Nucleus (interphase)

- It is the largest organelle in the cell. Usually 1 in a cell, can be 2 or more.
- Position: central, eccentric, peripheral or basal.
- **Function:** - It is the control centre of the cell and contains DNA.
 - o Synthesis and processing of RNA
- It can be divided into several kinds according to shape, number, size, position, color.
- Blue-colored when stained with H&E and viewed under light microscope, as it is basophilic due to the acidic structures within it.
- Doesn't produce protein, but contains protein imported from cytoplasm



Nuclear envelope :

composed of two unit membranes that fuse together at certain regions to form nuclear pores.

1- inner nuclear membrane: Is 6 nm thick ,faces the nuclear contents.

- o It is in close contact with *nuclear lamina*. Which are intermediate filaments that organize and provide support to the lipid bilayer membrane

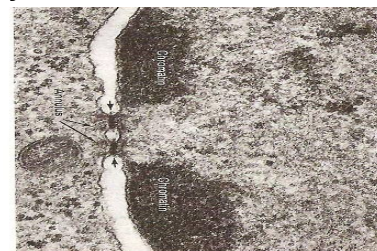
2- Perinuclear cisterna: space between inner and outer nuclear membrane.

3- outer nuclear membrane: faces the cytoplasm and is continuous with the RER¹.

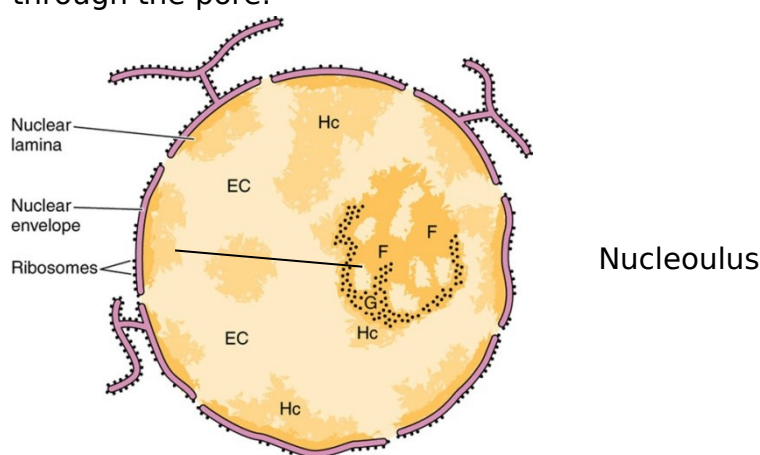
4- Surrounded by vimentin (intermediate filaments) and usually has ribosomes.

Vimentin: a thin, loose meshwork of intermediate filaments.

5- nuclear pores: Interruptions in the nuclear envelope where inner and outer membrane fuse with each other. Their number depends on the activity of the cell.



- surrounded by non membranous structure (glycoprotein)
 - Nuclear pore + glycoprotein = nuclear pore complex
 - Function of nuclear pore complex : selectively guards passage through the pore.

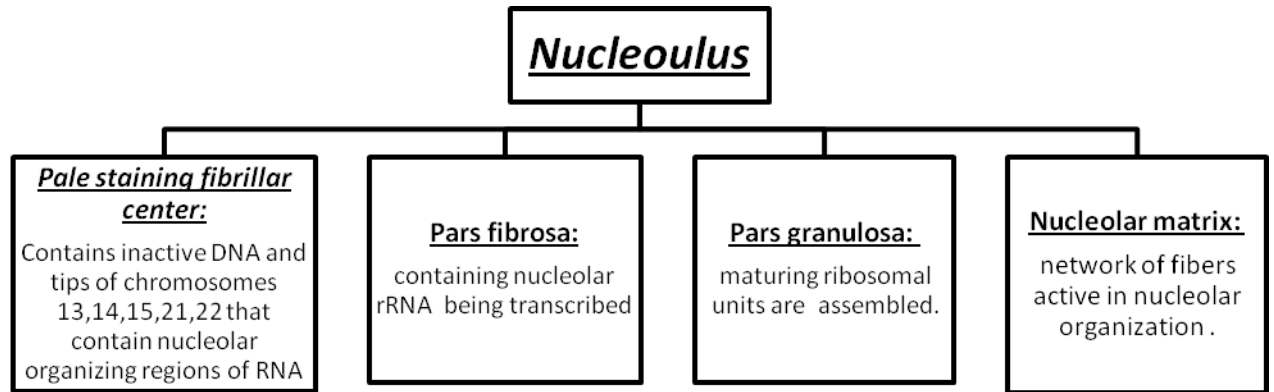


Chromatin: complex of protein and DNA that represents uncoiled chromosomes of the interphase nucleus.

- **Euchromatin:** Active form of chromatin, representing DNA that is being transcribed into RNA. It is scattered through the nucleus.
 - o Invisible under L/M. appears under E/M as unwound thread like material.
- **Heterochromatin:** condensed, inactive, peripheral.
 - o Stain deeply & visible under L/M. appears under E/M as coarse granules

Nucleolus: A dense non-membranous, basophilic structure within the nucleus in which rRNA is synthesized.

- o Contains protein, rRNA and small amount of inactive DNA.
- o Contains densely staining nucleolus-associated chromatin which is being transcribed into rRNA.
- o Number, size, and shape relate to activity of the cell.
- o Four distinctive areas (seen under E/M)



Nucleoplasm (Nuclear Matrix) Consists of:

- 1- **Interchromatin granules:** are located in clusters scattered among chromatin material and connected with each other by thin fibrils. They contain ribonucleoproteins and enzymes.
- 2- **Perichromatin granules:** are RNPs at the margins of heterochromatin.

Cell Cytoplasm

I. Organelles

Organelles:

A. Membranous:

1. Cell membrane
2. Mitochondria
3. ER (rough and smooth)
4. Golgi apparatus
5. Lysosomes
6. Peroxisomes
7. Proteasomes
8. Endosomes

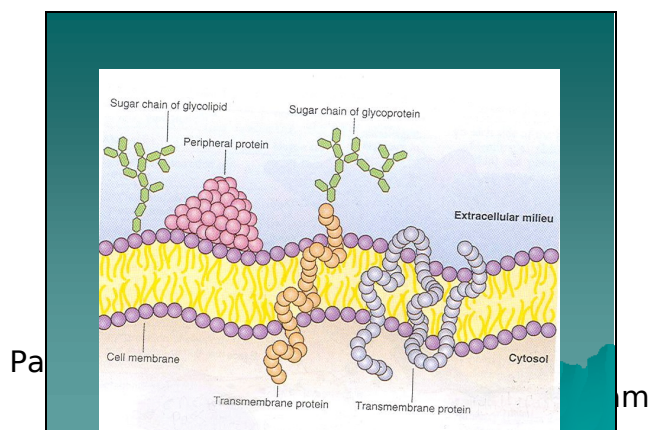
II. Inclusions

B. Non-Membranous

1. Ribosomes
2. Centrioles
3. Cytoskeleton
 - a. Microfilaments
 - b. Intermediate filaments
 - c. microtubules

Cell Membrane (plasma membrane):

- Invisible under L/M.
- Under E/M: trilaminar structure: two thin, dense lines with intervening light area.
- It is formed of two leaflets : inner & outer. Each leaflet is a single layer of phospholipids and associated proteins (1:1).
- **Types of proteins in cell membrane:**



- o integral proteins: span the entire lipid bilayer.
- o peripheral proteins : loosely attached to cytoplasmic aspect of cell membrane.
- **Glycocalyx (cell coat):** carbohydrate chains that are attached to protein (glycoprotein) or phospholipids molecules (glycolipid). Seen by E/M.
 - o **functions:** - protection of the cell -cell to cell recognition



Function of cell membrane

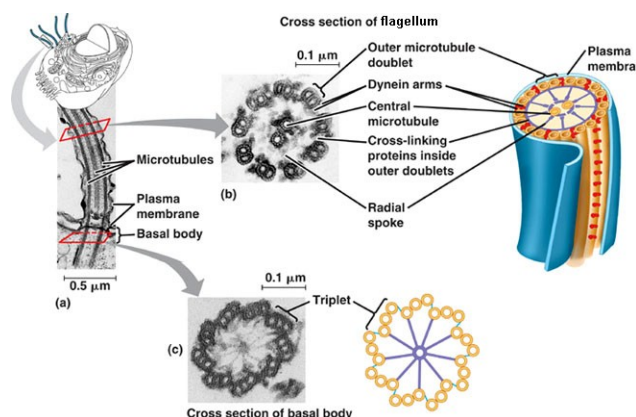
- **Endocytosis** (Phagocytosis, cell eating and pinocytosis, cell drinking)
- Control the transport of materials in and out of cell.
- Cell to cell recognition.
- Protection of the cell.
- Formation of cilia, flagella and microvilli.

microvilli:

- cylindrical, membrane-bound cytoplasmic projections of the striated border of the intestinal absorptive cells (invisible by L/M) and the brush border of the kidney proximal tubules (visible by L/M).
- Function: increase surface area for transport and absorption.
- Contains core of actin filaments (microfilaments).
- Stereosilia: long microvilli found in epididymis and hair cells of cochlea. They are not motile.

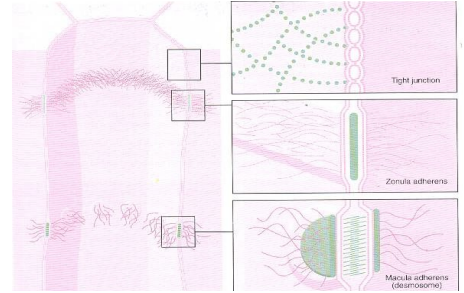
Cilia

- Motile hair-like projections (visible with L/M) surrounding cell membrane.
- Function: propelling mucus and other substances over the surface.
- Core of the cilia is consist of microtubules (axoneme)
- Composed of 9 doublets of microtubules (9+2) and two centrally placed microtubules (singlets).
- Cilia is attached to the basal body which is similar to centriole (9 triplets) and no singlets.
- Pairs are attached by dynein molecules.



Lateral membrane specialization (junctional complex):**1- Occluding or tight junctions (Zonulae Occludentes) (tight junction):**

- Forms impermeable barrier, apically located, form belt-like junction.
- formed by fusion of trans-membrane proteins of adjacent cell membranes.
- **Function:**
 - i. Prevents the movement of membrane proteins.
 - ii. Fuse membranes to prohibit water-soluble molecules from passing.

**2- zonulae Adherentes:**

- just basal to tight junction & encircle the cell.
- The intercellular space between joining cells is occupied by the extracellular cadherins (Ca dependent integral protein) that attached to intracellular actin filaments.

3- Desmosomes (Maculae Adherents):

- weld-like junctions appear randomly along the lateral cell membrane.
- They are formed of attachment plaques on the cytoplasmic aspect of adjoining cells.
- The intermediate filaments of both cells are inserted in these plaques forming hairpin turn to disperse the shearing forces on the cell.
- The intercellular space contains filamentous materials (a family of cadherins)

Gap (nexus or communicating) junctions:

- widespread in epithelial tissues, cardiac muscle, smooth muscle and neurons.
- They are narrow gaps (2nm) to communicate adjacent cells.
- They are built by transmembrane proteins that have aqueous pores (connetion).
- They are regulates (can open or close)
- **Function:** cellular sharing of molecules.

Endoplasmic Reticulum (ER)

- Largest membranous system of the cell.
- It is a system of interconnected tubules and vesicles whose lumen is called cistern.
- It has two components:

1- smooth endoplasmic reticulum (SER):

- Smooth surfaced tubules and occasional flattened membrane-bound vesicles.
- Abundant in cells active in synthesis of fats and cells that do detoxification.
- In skeletal muscle cells (SR) known as sarcoplasmic reticulum which regulates calcium in cytoplasm.

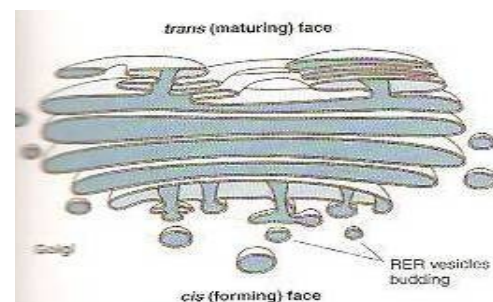
2-rough endoplasmic reticulum (RER):

- Rich in cells that synthesis proteins.

- Continuous to perinuclear cistern.
- Ribosomes bind to the surface of RER at integral proteins.
- Functions: performs post-translational modifications of these proteins.

Golgi Apparatus:

- Composed of one or more series of flattened, slightly curved membrane- bounded cisternae (golgi stack) and it has three levels of cisternae:
 1. cis face: closest to RER, convex in shape and is the entry face.
 2. medial face (intermediate face)
 3. trans-face : concave in shape, considered to be the exit face.
- Functions :
 1. synthesis of carbohydrates.
 2. modification and sorting of protein.
 3. formation of lysosomes.



Lysosomes:

- small membrane-bounded organisms that contain acid hydrolases as sulfatases, proteases, nucleases, lipases and glycosidases.
- Function: digest macromolecules, phagocytosed microorganism, cellular debris, excess of senescent organelles (mitochondria, RER).
- The small, soluble end products are either reused by the cell or exported into the extracellular space. (form lipofucin pigment in long-living cells)

Peroxisomes:

- Contains 40 oxidative enzymes such as urate oxidase, catalase.
- Function in catabolism of long fatty acids.

Proteasomes:

- small organelles composed of enzyme complex that are responsible for proteolysis (protein digestion)

Ribosomes:

- small non-membranous particles, composed of proteins and rRNA, which are responsible for protein synthesis.
- They are formed of 2 subunits (small and large), individually until synthesis begins.
- found freely in the cytoplasm (free ribosomes) or attached to RER (attached ribosomes)
- Few ribosomes can join together by mRNA forming polyribosomes.

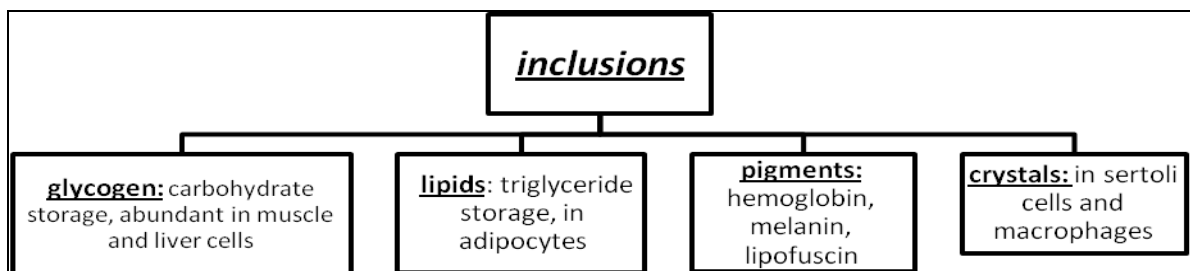
Centrioles

- Cylindrical, non-membranous structures located near the nucleus. (2 perpendicular in each cell). Formed of 9 triplets, each formed of 1 complete and 2 incomplete microtubules fused together.
- Important during cell division and for the formation of cilia and flagella.

Mitochondria:

- Flexible, rod-shaped organelles (L/M: visible with stain)
- Function: produce ATP through oxidative phosphorylation.
- Composed of two membranes: inner folded membrane and outer smooth membrane between them is intermembrane space.
- Inner membrane composed of folds (cristae) that increase the surface of the area, number of cristae related to energy requirement of the cell.
- Inner membrane encloses a space called matrix or intercrystal space.
- Matrix: space filled with a dense fluid composed of at least 50% protein.
- Components of matrix: circular DNA, tRNA, mRNA.
- They are self-replicating.

Inclusions: non-living components that do not possess metabolic activity and are not bounded by membranes.



- Lipofuscin: in neurons and cardiac muscle cells, membranous, formed from fusion of several residual bodies

Cytoskeleton:

- Three-dimensional meshwork of protein filaments.
- Functions: maintenance of cellular morphology and participate in cellular motion.
- Consist of :
 - 1-thin filaments (microfilaments):**
 - Contractile.
 - 6nm thick.
 - Myosin filaments are thicker 15nm and usually attached to actin especially in muscles.
 - 2-intermediate filaments:**
 - Between thin and thick filaments (8 to 10 nm).
 - Non-contractile.
 - Functions: provide structural support to for the cell, anchor the nucleus in place.
 - Examples: keratin, desmin, vimentin.
 - 3-microtubules:**
 - Long straight, rigid, hollow cylinder structural (25nm).
 - Dynamic structures.
 - Functions: provide rigidity, establish intercellular compartments, form the core of cilia and flagella.