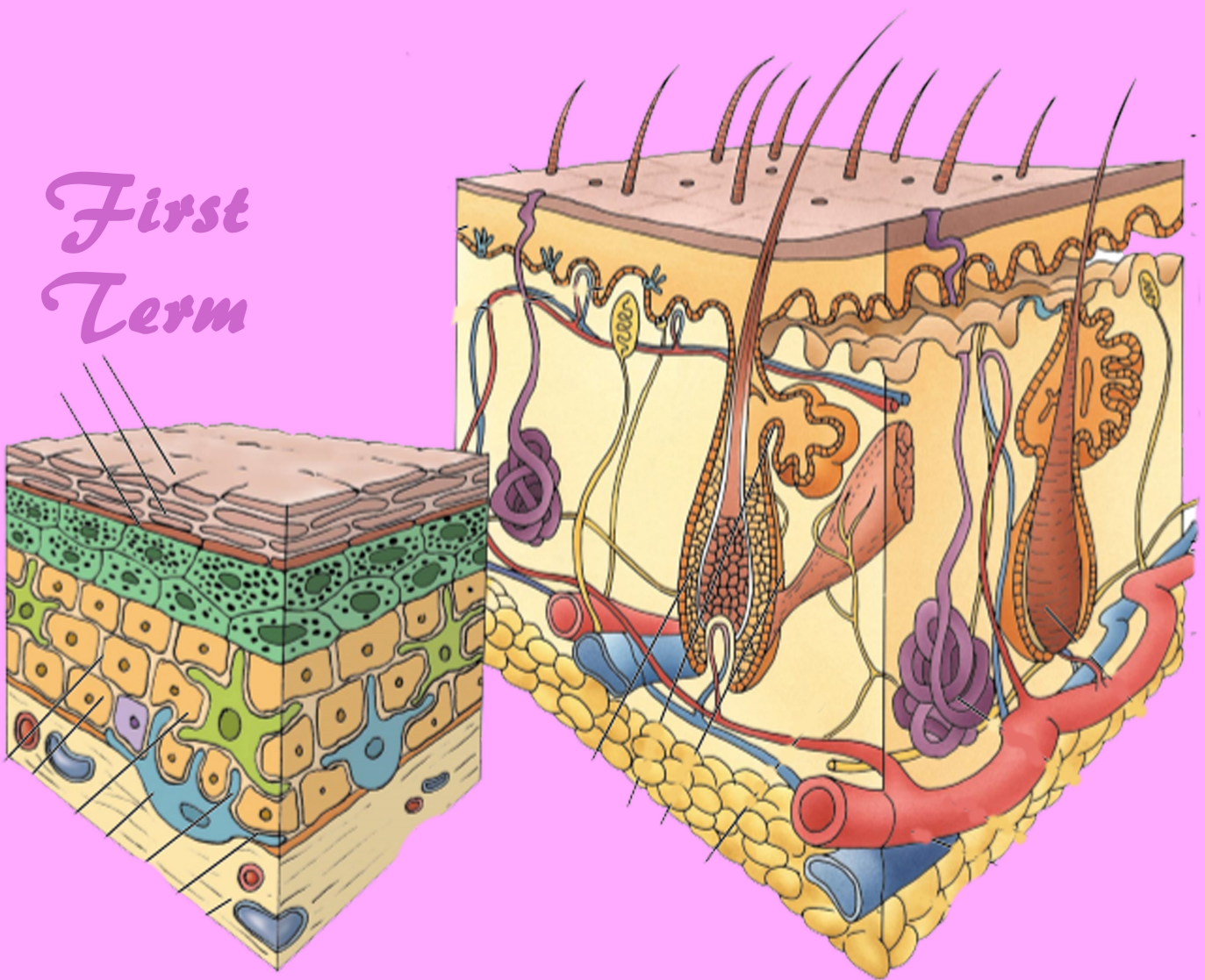


Histology

Dr. Gihan

*First
Term*



by **forsan alazhar**

Chapter 1

Introduction

Cell = the structural & functional unit of ^{all} living tissues.
or the smallest unit of living tissues that can exist independently & perform a vital function

The 4 Basic Tissues :

1. Epithelial tissue
2. Connective tissue
3. Muscular tissue
4. Nervous tissue.

Microscopes

Magnification power = power of enlargement

Resolution power = the least distance between 2 points that can be seen as 2 points & not one.

Resolution power of naked eye = 0.2 mm.

" " " L.M = 0.2 μ m

" " " E.M = 0.2 nm.

(N.B) 1 mm = 1000 μ m

1 μ m = 1000 nm

1 nm = 10 angstrom (\AA)

4 Steps to: prepare tissues for Microscopy:

1. Fixation: preserve the tissue:.....
2. Embedding: convert the tissue into solid form to be sliced.
3. Sectioning: into thin section to be examined.
4. Staining: help to identify tissue components & provide visual contrast

Methods for light microscopy:

- Paraffin technique: most common
- Celloidin technique: most perfect
- Freezing technique: most rapid

1. Obtain Samples: small pieces [1 cm] are cut [after death, biopsy or experimental animals].

2. Fixation: samples are immediately immersed in fixative:

Fixatives used: formol saline, Bouin, Suzo & Zinker.

Functions of fixatives:

- (1) preserve molecular & morphological structure.
- (2) harden tissues: coagulate their proteins.
- (3) prevent putrefaction: stop autolysis & Kill bact.
- (4) Facilitate cutting & enhance staining

3. Wash in tap H_2O .

4. Dehydration: H_2O is removed to be replaced by paraffin [notmissible e' H_2O] by ascending grades of alc. (to prevent shrinkage of tissues).

5. Clearing in Xylol: [paraffin solvent] to replace alc. (the tissue appears clear).

6. Impregnation: in molten soft paraffin wax (melting point = $50^\circ C$) It infiltrates the tissues & replaces Xylol.

7. Embedding: in molten hard paraffin wax (melting point = $55^\circ C$) It hardens as it cools, surrounds the tissue \rightarrow paraffin block hard enough to be cut into thin sections ($4-8 \mu m$).

8. Sectioning: by microtome \rightarrow ribbon of thin sections.

9. Mounting on glass slide smeared e' egg albumin & stained.

Technique	Advantages	disadvantages
<u>Paraffin</u> [most common]	<ol style="list-style-type: none"> 1. short time of preparation 2. serial sections for research. 3. Very thin sections. 4. easy staining 	<ul style="list-style-type: none"> - solvents e.g. Xylol dissolve fat - heat damage enzymes \rightarrow not suitable to show chemical composition of cells.
<u>Celloidin</u> [most perfect]	<ol style="list-style-type: none"> 1. perfect section for fine details. 2. No heat so preserve structure 3. suitable for large organs e.g. eye ball soft tissues e.g. brain. 	<ol style="list-style-type: none"> 1. long period. 2. No serial sections. 3. Thick sections. 4. not easily stained.
<u>Freezing</u> [most rapid]	<ol style="list-style-type: none"> 1. most rapid for diagnosis of tumours during surgery 2. preserved chemistry, fat & enzymes [histochemistry] 	<ul style="list-style-type: none"> - Difficult cutting \rightarrow - no serial sections - thick sections - difficult staining.

Scanning E.M.: gives 3 dimensional image

The image will show only the surface of the examined objects.

The most commonly used stain in slides is

Hematoxylin & eosin (H & E)

- Basic stain	acidic stain .
- blue	- red
- binds to acidic e.g. nucleus (DNA & RNA)	- binds to basic structures

* cytoplasm of ptr. forming
cells (ribosomes)

Special stains for light microscope.

1. Silver: stains G.A., nerve cells & fibres e' brown colour
" reticular fibres (brown to black)

2. Neutral stain = Leishman (acidic + basic) for blood cells
(eosin) methylene
+ fixative blue
" methyl alcohol.

3. Vital stain:
staining living cell inside living animal e.g. stain phagocytic
cells w' eat the stain e' trypan blue or indian ink.

4. Supravital stain:
Staining living cell outside living body e.g. staining
reticulocytes e' Brilliant cresyl blue.

5. metachromatic stain:

the stain will give a new colour diff. from that of the stain
e.g. When we stain basophils of blood or mast cells of
c.t. with toluidine blue the content of the granules
(mucopolysaccharides) react e' the stain giving a violet or
red colour. This is called Metachromasia.

Histochemical stains:

stains which show chemical content or enz in the cell

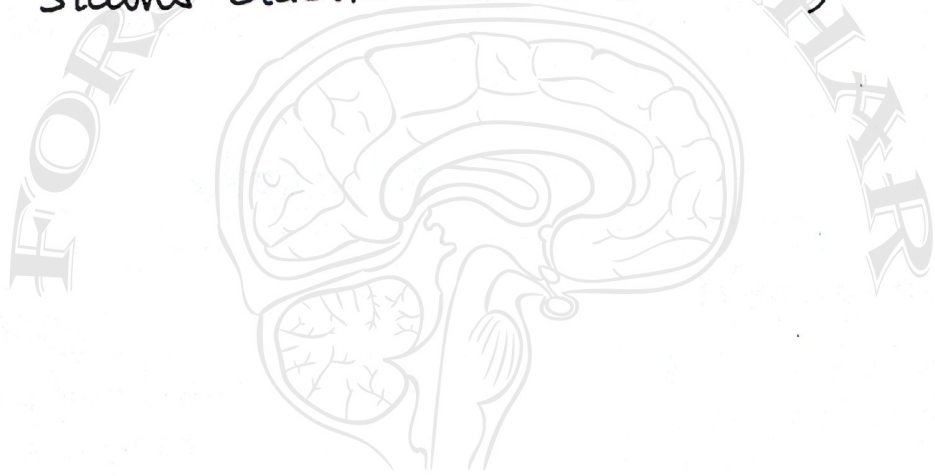
e.g * Fat stains e' Sudan III → orange
(frozen section)

* PAS stains glycogen → magenta red

* Enzs e.g. acid phosphatase in lysosomes
[alk. "]

7. Trichrome stain → 3 stains combined → 3 colors
for diff. components. Used to demonstrate collagen &c.

8. Orcein: stains elastic fibres (brown)



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The Cell

Structure

2

It has 2 major components: 1. Cytoplasm 2. Nucleus

Cytoplasm

Organelles

- living structures
- permanent
- Essential
- in all cells
- metabolically active
- have vital function

Inclusions

- Non-living
- Temporary
- not essential
- in some cells
- inert
- result from cell activity.

Cytosol

- Fluid formed of
- lipids
 - proteins
 - carbohydrates
 - minerals & enzymes
 - Ions & salts
 - O_2 & CO_2
 - waste products

Organelles

Membranous

- covered by membrane
- contain enzymes.
- cell memb
- mitochondria
- Endoplasmic Reticulum
- Golgi Apparatus.
- lysosomes.
- peroxisomes.

Non-membranous

- Not covered by memb.
- have no enzymes.

• Ribosomes

• Cytoskeleton:

a: Microtubules:

- centrioles
- cilia & flagella.

b. Filaments:

- thin filaments.

• Proteasomes.

Cell Membrane

• def.: a living membrane that forms the outer cover of cytoplasm.

• L.M.: cannot be seen as it is very thin (7.5-10 nm)

- can be stained e.g. Hg or PAS.

• E.M.: 2 dark layers separated by a light one [Trilamellar memb. = Unit memb.]
The fuzzy layer covering the outer surface = cell coat or Glycocalyx.

Molecular Structure:

I. Lipid Component:

(a) phospholipids:

molecules arranged in 2 layers [lipid bilayer]. Each molecule has:

1. Hydrophilic polar end = [Head]: (phospholipid)

has affinity to aqueous solutions, so directed outwards (on both sides)
+ charged.

2. Hydrophobic non-polar end = [Tail]: (Fatty acid)

has no affinity to aqueous solutions, so directed inwards (in the centre)
+ non-charged.

(b) Cholesterol:

small molecules in the hydrophobic zone limiting the movement of molecules
+ keeping its fluidity.

(N.B) The ratio bet phospholipid : cholesterol = 1:1.

II. Protein Component: 50% w/w

(a) Integral protein:

- embedded in the lipid bilayer
- some extend across the memb. from side to side → [pass/multipass transmembrane proteins].

(b) Peripheral protein:

small molecules w form a non-continuous layer loosely attached to both sides of the lipid bilayer.

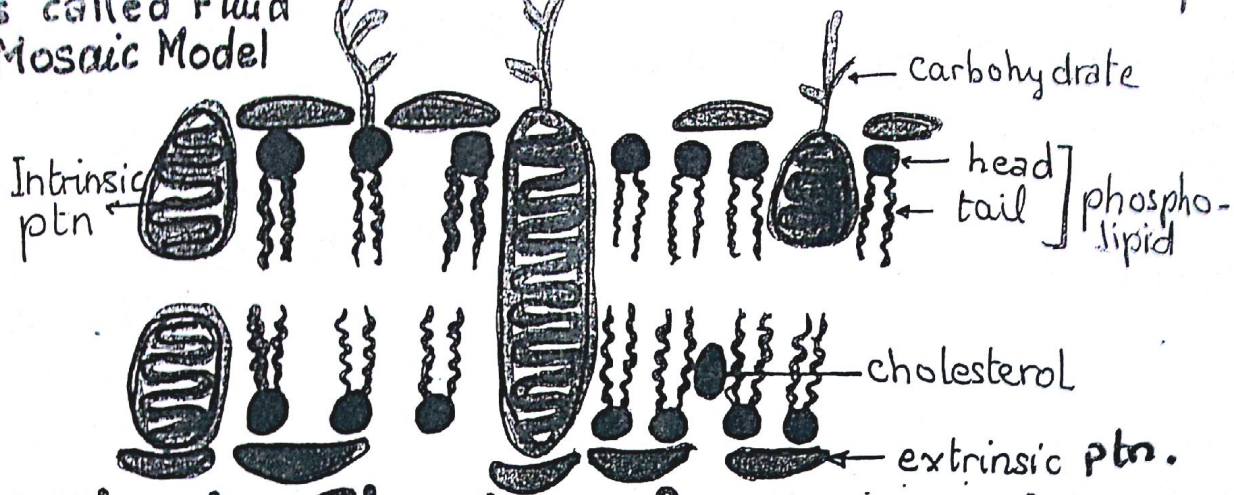
III. Carbohydrate component

Oligosaccharides linked to ptn. → glycoprotein
" " lipid → glycolipid } both form cell coat.

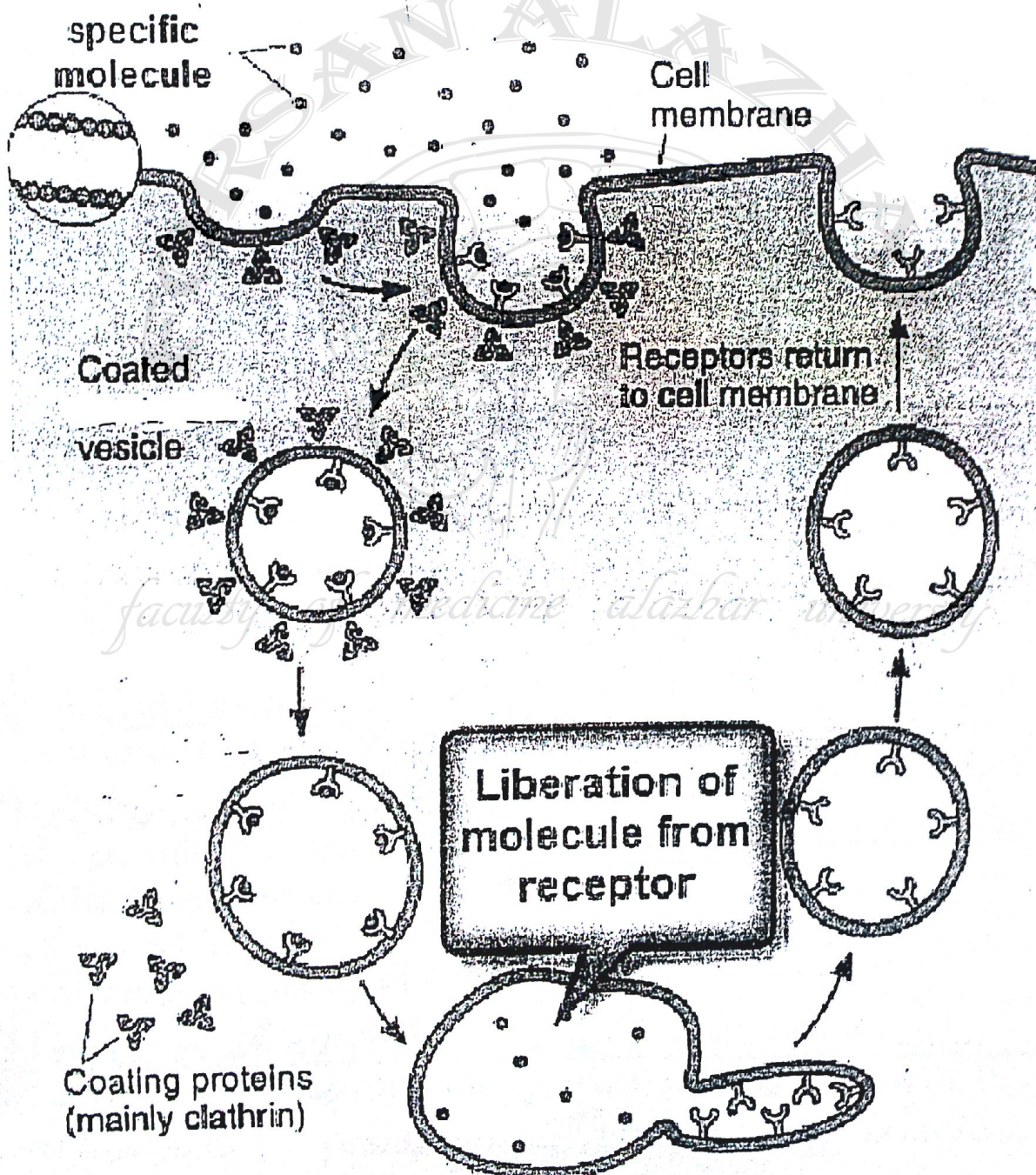
Cell Coat = Glycocalyx:

glycoprotein & glycolipid molecules present on the external surface of the cell memb. & rich in receptors that control entrance of bacteria, viruses, drugs & hormones into the cell.

The mosaic appearance of ptns. & Fluid nature of the lipid bilayer is called Fluid Mosaic Model



Molecular Structure of cell Membrane



Functions:

A) Exchange of materials:

- ① Passive diffusion: e.g. H_2O , ions & gases, controlled by concentration gradient
- ② Facilitated ...: e.g. glucose & a.a.s (do not dissolve in fat) & need transmembrane channels, controlled by concⁿ gradient.
- ③ Active transport: Against concⁿ gradient. needs Energy e.g. Na^+/K^+ pump
- ④ Bulk transport: the cell can take up or release large substances:

a. Endocytosis:

- Phagocytosis: [Cell eating]:
the cell memb. can engulf bact & damaged cells. When bacteria bind to the surface of macrophage or neutrophil, the cell memb. extends processes that fuse forming a phagosome.
- Pinocytosis: [Cell drinking]:
the cell memb. can engulf extracellular fluid. membrane invaginations enclose the fluid forming pinocytic vesicles

receptor mediated endocytosis:

= integral ptns.

receptors for specific protein hormones & growth factors
Binding of the hormone to the receptors causes the widely dispersed receptors to accumulate in coated pits. their cytoplasmic side are coated w/ Clathrin ptn. The coated pits invaginate & pinch off as coated vesicles carrying the hr. & its receptors.

b. Exocytosis:

when a membranous vesicle fuses w/ the cell memb. It releases its contents & the wall of the vesicle is added to the cell memb.
Memb. Trafficking := memb. recycling in Endocytosis & exocytosis

B) Cell Coat Functions:

- cell protection • Cell adhesion • Cell recognition (identity) • Cell immunity.

C) Cell Memb. Modifications:

- Microvilli (↑ surface area for absorption e.g. absorbing cells of intestine).
- Cilia (move particles in one direction).
- Flagella (form the tail of sperms)
- Stereocilia (non-motile) = long microvilli.

D) Conduction of excitation waves: in nerve cells & muscles.

(N.B) Defective receptors for parathormone & growth hr. in the target organ Causes pseudohypoparathyroidism & dwarfism

Mitochondria

6

def.: membranous ^{thread} ^{granules} organelles responsible for ^{aerobic} respiration & energy production.
They are the power house of the cell.

No.: Variable according to cell activity. More numerous in highly active cell
e.g. few in small lymphocytes & about 1000 in liver cells.

- Can divide by simple division (have their own genetic apparatus DNA).

Site: at site of most activity.

L.M.: appear as rods or granules after staining.

Iron Hx → dark blue or Janus green → green.

E.M.: rounded or oval vesicles 0.5 → 1 μm in diameter & 10 μm in length.

- surrounded by 2 unit membranes separated by intermembranous space

• Outer smooth membrane: contain ptns. called porins, so permeable.

• Inner membrane: less permeable (selective), form shelf like folds (Cristae) projecting into the cavity. to \uparrow the surface area.

Elementary Particles = globular structures connected to the inner memb. by cylindrical stalks. Globular structures = ptn. e^- ATP synthetase activity i.e. form ATP in (oxidative phosphorylation)

• Mitochondrial matrix: formed of:

- Oxidative enzs. of Citric A.A. (Kreb's) Cycle.

- DNA - the 3 types of RNA.

- electron dense granules rich in Ca^{++} w act as catalyst for the activity of mitochondrial enzs.

Functions:

Cell respiration:

- ① Obtain energy from metabolites in cytoplasm by Kreb's cycle
- ② ~~most~~ of Energy is stored as ATP [by oxidative phosphorylation] & some is dissipated as heat [to maintain body temp].

Medical application

Mutation in mit. DNA → muscle dysfunction.

Endoplasmic Reticulum

def.: Communicating membranous channels to form reticulum inside the cytoplasm & enclose a space called Cisterna

2 Types: Rough (granular) ER

Smooth (non-granular)

Sites: excessive in ptn. secreting cells
e.g. plasma cells & fibroblasts.

Sites in fat & steroid hr. forming cells.
e.g. liver & endocrine cells.

L.M. basophilia of cytoplasm < diffuse or localized

E.M. Parallel cisternae or flattened membranous tubules w̄ extend from nuclear memb. to cell memb. Studded w̄ ribosomes (electron dense) w̄ are bounded to specific receptors [= ribophorins] by their large subunits. Pores under the receptor allow new ptn. to enter & to be stored.

L.M. cannot be seen but when abundant → acidophilia of cytopl.

E.M. branching & anastomosing tubules w̄ smooth surface (no ribosomes).

Functions:

1. Synthesis of ptn. by the attached polyribosomes.
2. Segregation of the formed ptn.
3. Initial glycozylation of ptn: by addition of monosaccharides.
4. Packing of formed ptn. in transfer vesicles that bud off to be delivered to G.A.
5. Protection of cytoplasm from hydrolytic enzs.
6. Act as intracellular pathway for formed substances.

Functions:

1. Synthesis of phospholipids of the cell memb.
2. Synthesis of steroid hrs. hormones e.g. cortisol & testosterone
3. Storage & breakdown of Glycogen in liver & muscles
4. Detoxification of drugs & hrs. & alcohol in liver cells.
5. Muscle Contraction by pumping of Ca^{++}
6. Act as intracellular pathway

Golgi Apparatus

=18-

def.: membranous organelles responsible for secretion, so well developed in site: secretory cells.

L.M. by (H & E): doesn't appear, but if cytoplasm is deeply basophilic appear as unstained area near the nucleus = -ve Golgi image e.g. plasma cell

by (Ag): appears as brown granules & fibrils.

Sites: • Apical: bet. the nucleus & apex of secretory cells.

• Perinuclear: around the nucleus e.g. nerve cells.

E.M.: flattened curved membranous sacculi w' narrow lumen but expanded ends. 3-10 parallel sacculi are arranged one above the other like saucers forming stacks. Each stack has 2 faces:

• Entry (Cis) face:

receives transfer vesicles budding from rER & carry ptn. to GA.

• Exit (Trans) face:

from w' diff. vesicles arise. The vesicles may be:

→ secretory vesicles: migrate to cell memb. & discharge their contents by exocytosis.
→ Lysosomes w' remain in the cytoplasm & contain hydrolytic enzymes.

Functions:

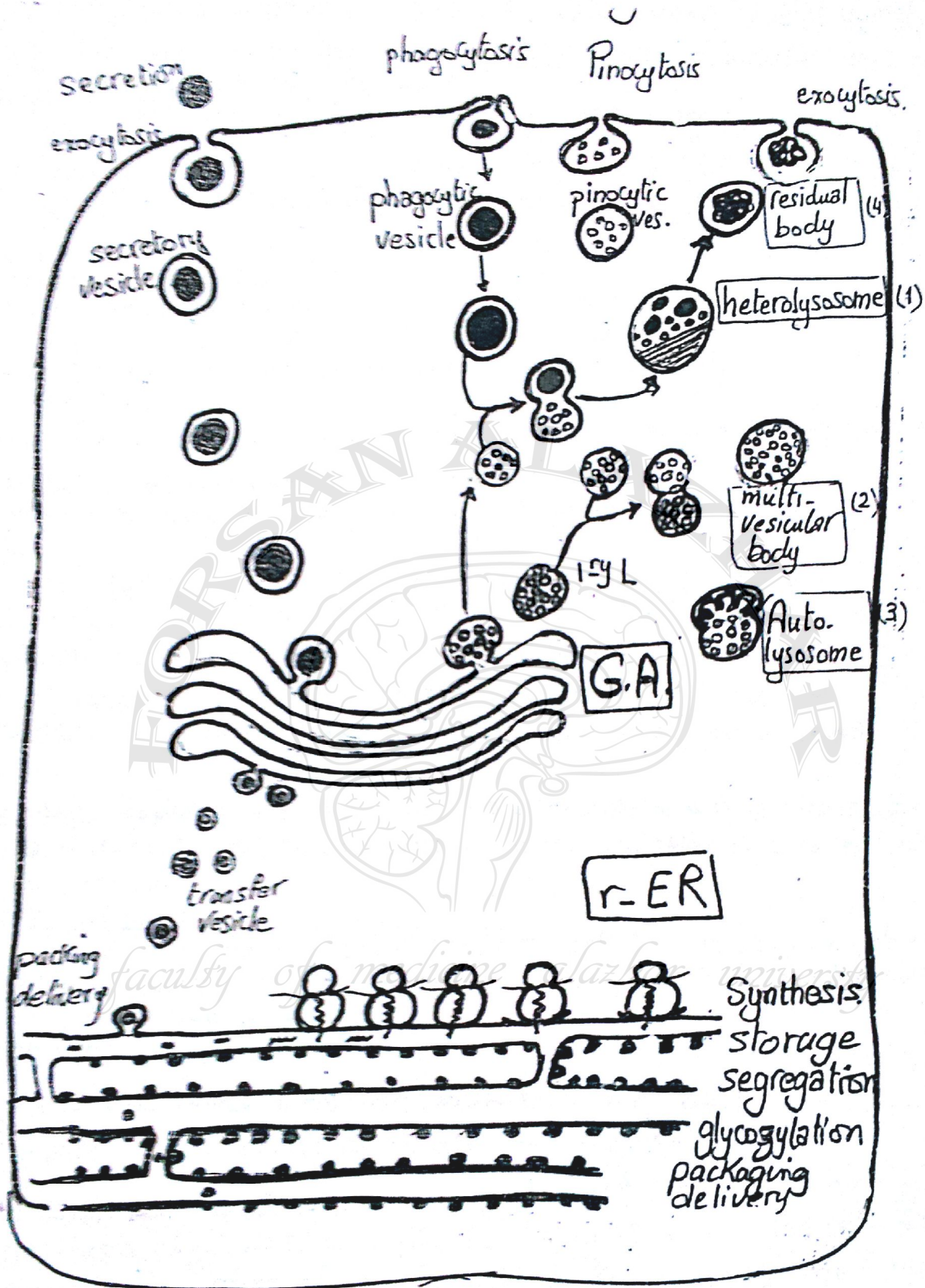
1. Concentration & storage of ptn. formed in rER

2. Modification of ptn. by addition of → carbohydrate
→ sulfates

3. Discharge contents of secretory vesicles { enzymes
hormones } by exocytosis

4. Renewal & Maintenance of cell membrane (integral ptn. is provided from the membranes of secretory vesicles).

5. Formation of lysosomes, & coated vesicles.



lysosome

def.: membranous organelles concerned e' intracytoplasmic digestion.

Content: hydrolytic enzymes e.g. lipase, protease, nuclease & acid phosphatase.

Origin: their enzs are ptn. so formed in r.ER, pass as transfer vesicles to G.A. to come out as lysosomes.

Nº abundant in phagocytic cells e.g. macrophages & neutrophil.

L.M. Histochemical tests detect enzs. inside e.g. acid phosphatase.

In macrophages & neutrophils, they are large so can be seen by L.M.

E.M. 1ry lysosomes

- newly released from G.A. & have not entered digestion.
- membranous vesicle surrounded e' single membrane.
- have homogenous moderately electron dense contents.

2ry lysosomes

- When 1ry lysosome fuses e' intracytoplasmic content → 2ry lysosome
- appear heterogenous due to the digested material.
- Many types according to type of vesicles 1ry lysosome fuses e' :

Types:

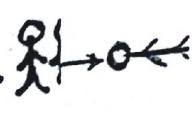
1. Heterolysosome: when 1ry lysosome fuses e' phagocytic vesicle the hydrolytic enzs. digest its contents (food or bact.).
2. Multivesicular body: when 1ry lysosome fuses e' pinocytic vesicle.
3. Autolysosome: when 1ry lysosome fuses e' autophagic vesicle.
(Vesicle containing old organelles e.g. old mit. i.e. endogenous content).

4. Residual bodies: After digestion of the contents of 2ry lysosomes, the useful material diffuse back to cytoplasm while the undigested retained contents are called residual bodies.

Fate of residual body:

either discharge their contents outside the cell by exocytosis → cytostools.
Or accumulate as lipofuscin pigment (age pigment) in long lived cells e.g. nerve cell & cardiac muscle.

Functions:

1. Digest nutrients & foreign invaders e.g. bact.
2. Maintain cell health: eliminate old organelles.
3. Post-mortum autolysis: digestion of the whole cell after death: lysosomes rupture & the enzs digest the cell. 
4. During Fertilization: help the sperm to penetrate the ovum.
5. In thyroid Gland: Activate the hormone

lack of lysosomal sulfatase → intracellular accumulation of sulfated compounds interfering e' the function of nerve cells

Peroxisomes [Microbodies]

def: membranous organelles similar to lysosomes but contain oxidoreductase enzs. as a.a. oxidase, catalase & peroxidase.

L.M.: cannot be seen.

E.M.: small rounded or oval membranous organelles [0.5 μ m in diameter]

Origin:

- the outer vesicle bud off the rER.
- the ptn. of their enzs is formed in free polysomes.
- the enzs. are recognized & internalized by receptors on their memb.

Functions:

- Oxidation of long chain Fatty acids forming \rightarrow Acetyl Coenz A [CoA]
 \rightarrow H_2O_2
- Acetyl CoA is used by the cell
- H_2O_2 Kills microorganisms & detoxifies agents as ethanol.
- Excess H_2O_2 (toxic) is reduced by catalase to $H_2O + O_2$

N.B.

Energy produced is not stored as ATP but comes out as heat.

Medical application

Fatal medical Syndrome:

deficiency of peroxisomal enzs. \rightarrow muscular dystrophy.
 E.M. shows empty peroxisomes \rightarrow liver & kidney lesions.

Non-Membranous Organelles

-11-

1- Ribosomes

def.: Non-membranous electron dense bodies, (20x30 nm)

Formed in: nucleolus & pass to cytoplasm through nuclear pores.

Origin: Formed of: r-RNA (formed in nucleolus) + ptn. (formed in cytoplasm)

No.: Abundant in ptn. forming cells.

L.M. too small, so cannot be seen but when abundant \rightarrow basophilia of cytoplasm
 \bar{w} may be * Diffuse: e.g. in embryonic cells.

* Localized: e.g. at the base of the cell as in pancreas.

* Spotty: e.g. Nissl granules in nerve cells.

E.M. Small dense granules. Formed of 2 subunits (small & large) \bar{w} attach by m-RNA. The large subunit contains a groove in its centre \bar{w} contains the polypeptide chain. There are 2 forms:

1- Free ribosomes:

scattered singly or as Polysomes [Polyribosomes]:

linked by m-RNA \rightarrow rosette-shaped or spiral aggregations.

2- Attached: to rER by its large subunit at glycoprotein receptors = ribophorins. They are attached to m-RNA that carry the information of sequence of a.a.s.
t-RNA picks up a.a.s & transports them to the ribosomes
 \bar{w} reads & translates the code & form the polypeptide chain
 \bar{w} is injected into the lumen of rER cisternae.

Function: ptn. synthesis.

1- Free ribosomes:

Form ptn. used inside the cell e.g. glycolytic enzs.
(build)

2- Attached ribosomes:

Form ptn. secreted by the cell e.g. enz. or hormones.

Microtubules + filaments + some ptns. bind them to each other & to cell memb. → Microtubular lattice.

A) Microtubules

def.: Fine tubes of constant diameter (24 nm) but unfixed length.

L.M.: cannot be seen except by using immunofluorescent technique.

E.M.: Fine tubules formed of α & β ptn. called tubulin that arrange in 13 protofilament. Their length change by polymerization of tubulin. This is directed by Microtubular Organizing Centre to contain gamma tubulin.

2) Forms:

• Dynamic form:
e' continuous assembly & disassembly → cell reshaping

• Stable form: in wall of centrioles, cilia & flagella

Functions:

1. Cytoskeleton → preserve cell shape
2. Form mitotic spindle during cell division.
3. Intracellular transport of molecules
4. Form centrioles, cilia & flagella.

Chemotherapy arrest cell proliferation in Cancer (tumours) by interfering e' M.T. assembly.

[2] Cytoskeleton

B) Filaments

def. minute ptn. threads. 2 forms:

1) Thin = Actin = microfilaments: 6 nm
- Fine strands of 2 chains of globular G actin coiled to form filamentous F actin

Sites & Functions:

1) In most cells:

a. Form a network under the cell memb. → cell shape changes e.g. amoeba or eukaryotes & amoeboid movements.

b. movement of organelles or vesicles. (cytoplasmic streaming)

2) In dividing cells: → cleavage of mitotic cells.

3) In skeletal ms: together e' thick myosin → "Muscle contract"

4) In Microvilli: form their core, give their shape, their shortening & elongation helps absorption.

2) Intermediate filaments: 10 nm

A family of filaments formed by polymerization of tetrameric subunits in different chemically 6 types:

1. Keratin: in epithelium, hairs & nails.
2. Vimentin: in muscle & c.t.
3. Desmin: in muscles to join myofibrils.
4. Neurofilaments: in neurones
5. Glial Fibrillary acidic ptn: in glial cells.
6. Lamins: in nuclear envelope.

Immunocytochemical methods are important for Diagnosis & treatment of tumours by diagnosis the cell of origin by the type of filaments in that tumor.

Structures formed by Stable Microtubules

1. Centrioles

def: non-membranous organelle in an area of cytoplasm near the nucleus = Centrosome

L.M.: appear as 2 small dark bodies in the centrosome after staining e' iron Hx

E.M.: 2 hollow cylinders perpendicular to each other.

- In cross section, its wall is formed of 9 bundles of microtubules, each bundle is formed of 3 microtubules (triplets) i.e. $9 \times 3 = 27$ microtubules.

- The inner microtubule (A) is complete while B & C microtubules share the wall of the adjacent one.



A = 13 protofilament
B & C = 10 " "

Functions: [interphase]

1. **Cell division** | the 2 centrioles duplicate \rightarrow 2 pairs, each pair migrates to one side of the cell & become surrounded by area of cytoplasm rich in tubulin called **MTOC**. From w microtubules arise \Rightarrow **mitotic spindle**.

2. **Form Cilia & Flagella.**

2. Cilia

def: motile hair like processes formed of a core of microtubules covered by cell memb.

Origin: during development, centrioles duplicate many times & give basal bodies w migrate to the apex to give cilia.

L.M.: acidophilic striations (hair like)

E.M.: Each cilium is formed of 3 parts:

1. **Basal body:**

= a centriole i.e. 27 microtubules in 9 triplets embedded in the cytoplasm.

2. **Shaft = axoneme.**

- Finger like projection covered e' cell memb.

- From each triplet, the inner 2 MTs. A & B linked by nexin \rightarrow doublets.

i.e. the shaft = 9 bundles of doublets + 2 single microtubules in the centre (singlets). So the shaft is formed of $[(9 \times 2) + 2] = 20$ microtubules.

3. **Rootlets:**

- Formed by growth of the 3rd (outer) microtubule (c) in each triplet into the cytoplasm i.e. 9 microtubules. It fixes the basal body & shaft to cytoplasm.

Functions:

1. Their rhythmic beating move fluids or particles in one direction by axonemal dynein

e.g. respiratory system & ♀ genital system.

2. Modified cilia act as receptors e.g. rods & cones of retina.

3. Flagella

Single extra long shaft of cilium = $[9 \times 2 + 2] = 9$ peripheral doublets + 2 central singlets e.g. form the tail of sperm. Its whip like movement helps to move the sperm.

Immotile Cilia Syndrome:

Immotile sperms \rightarrow σ infertility + chronic respiratory infections

3. Proteasomes

def. : Non-membranous organelle that degrades ptn. molecules attached to ubiquitin ptn. through ATP-dependent pathway.

E.M.:

A barrel-shaped core particle = 4 rings stacked over each other. At both ends of the " " is regulatory particle that contain ATPase & recognize ptns attached to ubiquitin molecules.

Functions:

1. remove excess enzs & unnecessary ptns.
2. " ptns. that are incorrectly folded.
3. destroy " infected by viruses.

Defective proteasomes lead to accumulation of unwanted ptns related to Alzheimer's disease.

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Cell Inclusions

def.: Non-living, temporary structures, not present in all cells inert, result from cell activity. Include:

A. stored food B. pigments C. crystals.

A. Stored Food

[1] Carbohydrates:

stored as glycogen in $\left\{ \begin{array}{l} \text{liver \& muscle cells} \end{array} \right.$

- L.M.: By H & E appear as vacuoles.

e' Best's carmine \rightarrow red e' PAS \rightarrow magenta red

- E.M.

2 types: a. granules: single granules

B. granules: rosette-shaped aggregates

- Site: at areas rich in s.e.r.

[2] Fats:

stored as fat droplets e.g. in liver cells or
" globules " " fat cells.

- L.M. By H & E appear as vacuoles

By Sudan III \rightarrow orange.

B. Pigments

def.: materials that possess color of their own

types: 1. Exogenous:

taken from outside

e.g. a. Carbon & dust as in dust cell of lung

b. Carotene: taken e' food
e.g. carrots.

c. Tattoo marks: injected
under the skin & taken
by phagocytic cells.

2. Endogenous:

formed by the cell

a. Hb in RBCs to carry $\left\{ \begin{array}{l} O_2 \& CO_2 \end{array} \right.$

b. melanin in skin & eye:
give its color & protect from
ultra violet rays (UVR.)

c. lipofuscin: in long lived cells
e.g. nerve cell & cardiac muscle
they are waste products of age.

Nucleus

- def. The largest component of the cell. present in all cells except: RBCs & platelets (not true cells)
- No. : usually one, some cells are binucleated (2 nuclei) e.g. liver cells & some are multinucleated (many nuclei) e.g. osteoclasts & skeletal muscles
- Position : usually central, may be eccentric, basal or peripheral.
- Shape : rounded, oval, flat, kidney-shaped, bilobed (horse-shoe), segmented or lobulated.
- L.M. : basophilic due to RNA & DNA. (Hx or methylene blue)
- Appearance : either:
 - * Lightly stained (Vesicular) : pale (open face) e' extended chromatin & prominent nucleolus e.g. nerve cells.
 - * Deeply stained (Condensed) : dark (closed face) e' condensed chromatin e.g. small lymphocyte

Structure of Nucleus

I] Nuclear membrane [envelope]

- L.M. basophilic line (due to ribosomes outside & chromatin inside)
- E.M. 2 membranes separated by perinuclear space & interrupted by nuclear pores (30-50 nm)
- 1. Out. rough membrane: due to attached ribosomes & continuous e' r.E.R.
- 2. Inner fibrillar " : e' "associated" chromatin threads on its inner surface

Nuclear Pore Complex:

Formed of transmembrane ptns. w form an octagonal annulus (ring)
Nucleoporin filaments extend into the cytoplasm & nucleus

Function:

- a. transport of proteins to the nucleus
 - b. export of RNA & ribosomes to the cytoplasm
- through receptor proteins

II] Chromatin Material:

def. basophilic particles or threads that change into chromosomes during division
chemically: DNA + ptn (histone)

Types a) Euchromatin [extended or active]:

(L.M.) extended parts of chromatin so pale by L.M. (vesicular)
carry active genes w direct ptn. synthesis in ptn. forming cells:

b) Heterochromatin [condensed or inactive]:

- coiled parts of chromatin so dark by L.M. (condensed)
- carry inactive genes.

E.M.: 1. Euchromatin = fine granules.

2. Hetero " " = Condensed masses at 3 sites :

a. peripheral chromatin : attached to inner nuclear memb.

b. chromatin islands : clumps scattered in the sap.

c. nucleolus associated chromatin : around nucleolus.

Functions of chromatin:

1. Carry genetic information.

2. Direct ptn. synthesis.

3. Form 3 types of RNA $\left\{ \begin{array}{l} \text{r.RNA} \\ \text{m.RNA} \\ \text{t.RNA} \end{array} \right.$

V.B. Chromosomal alterations $\xrightarrow{\text{t.RNA}}$ Tumours or genetic diseases.

III Nucleolus:

L.M. one or 2 basophilic rounded masses rich in nucleic acids.

E.M. Spongy appearance = dark & light areas : not limited by membrane.

dark areas = pars amorpha = central filaments of DNA [nucleolar organizer]

pars fibrosa = strands of newly formed r.RNA

pars granulosa = granules of mature r.RNA (ribosomes)

both pars fibrosa & granulosa are called nucleolonema.

Light areas = nucleolar sap.

Functions : Formation of r.RNA & ribosomes w pass through nuclear pores to cytoplasm to form protein. So, ptn-forming cells have prominent nucleoli (1 or 2)

IV Nuclear Sap :

def: solution that fills the spaces bet. chromatin & nucleolus. Formed of: nucleoptns, sugars, enzymes, Ca, K & phosphorus ions.

Functⁿ act as medium for transport of RNA to nuclear pores \rightarrow cytoplasm.

Rapidly growing malignant cells have large nucleoli.

Functions of the Nucleus

1. Controls all functions & ptn. synthesis.

2. Form all types of RNA.

3. directs cell division.

4. Carry genetic information & heredity factors.

Cell Cycle

-1-

A series of changes to prepare the cell for division. 2 phases:

1. Mitosis: [1 hr.] Changes are visible e' L.M.

2. Interphase [20 hrs] " " " not seen " = period bet. 2 successive divisions.
the cell grows, does specific function & replicates its genetic material.

Ⓐ Gap 1 (G₁) phase: [8 hrs]

- the nucleus contains 46 chromatids (Single S-chromosomes)
- the daughter cells grow in size, acquire energy & start ptn. synthesis for duplication of DNA. The cell become specialized.
- the more specialized the more prolonged G₁ & less rate of division.

Ⓑ Synthesis (S) phase: [8 hrs].

- duplication of DNA → double (d-chromosomes)
- " " " centrioles.

Ⓒ Gap 2 (G₂) phase: [4 hrs].

- any error in DNA replication is corrected.
- second growth (synthesis of RNA) & storage of energy for next mitosis.
- synthesis of tubulin to build microtubules needed for mitosis.

• G₀ (Outside or Stable) phase := cells that have left the cycle (resting stage)

• Cell Cycle Check points:

G₁, G₂ & M check points to ensure that the processes at each phase of the cycle have been completed before progressing to the next phase.

Cell Renewal

Most of specialized cells are in prolonged G₁ of interphase.

There are 3 types of specialized cells according to their ability to reproduce.

1] Non-Renewing Cells:

Highly specialized cells leave the cycle in G₁ to G₀ = (permanent exit)

Never divides again & cannot be replaced by new ones. e.g. Cardiac cell + nerve cell

2] Potentially Renewable Cells:

Specialized cells w leave the cycle in G₁ to G₀ but returns back on need for renewal (transient exit) e.g. liver cells when destroyed or partially removed can restore their normal size.

3] Continuously renewing Cells:

Specialized cells w cannot divide, but replaced from stem cells e.g. blood cells & Sperms.

Stem Cells

2 types:

• Pluripotent [multipotent] Stem cells:

Have the potential to give > one type of specialized cells e.g. blood cells & cells lining gastro-intestinal tract [GIT].

• Unipotential stem Cells: able to produce only one type of specialized cells e.g. σ germ cells

Cell Death

Necrosis

pathological condition results from

- ↳ anoxia
- ↳ toxins
- ↳ mechanical injury

The cell & its organelles, swell then burst & release their contents in the extra cellular space & finally phagocytosed by macrophages.

Apoptosis

- programmed cell death.
- occurs normally at end of life span.
- cells do not swell but ↓ in size
- Nuclei show:

* Pyknosis: become small, dark & condensed chromatin

* Karyorrhexis: " fragmented into pieces by endonuclease enz

* Karyolysis: dissolution then disappear, cytoplasm breaks → vesicles phagocytosed by macrophages.

Mitosis

Def.: the process by which the cell divides into 2 equal cells genetically identical to the parent cell. 4 Stages:

1. Prophase:

- The 46 chromosomes become, shorter, thicker, darker & appear as threads
- The nuclear membrane & nucleolus disappear.
- Each pair of centrioles move towards one pole of the cell by growth of microtubules from the microtubular organizing centre (MTOC) around the centrioles. Microtubules form the mitotic spindle.

2. Metaphase:

- Chromosomes migrate to the equatorial plane [Metaphase plane].
- At the centromere, each chromosome develops a disc like Kinetochore to which chromosomal microtubules attach
- ∴ the mitotic spindle is formed of:
 - Cytoplasmic microtubules: arise from MTOC around centrioles to elongate the cell. (continuous)
 - Chromosomal " ": arise from MTOC attached to Kinetochores [non-continuous]
 - ↳ arrange chromosomes in equatorial plane
 - ↳ pull sister chromatids apart.
 - Astral microtubules: arise from MTOC around centrioles in a star like fashion to establish the axis of the spindle.

3. Anaphase:

- Chromosomes split longitudinally at the centromere into 2 chromatids which migrate towards the opposite poles by interaction between chromosomal & cytoplasmic microtubules.

4. Telophase:

- A constriction develops at the equatorial plane [cleavage furrow] by contraction of actin microfilament. It deepens until the cell divides into 2.
- The 46 chromatids (s-chromosomes), start to uncoil, lengthen & become invisible
- The nuclear memb. & nucleoli reappear.

Meiosis

It is a type of division in which the diploid mother cells in the testis & ovary undergo 2 successive divisions without S-phase to produce haploid germ cells (sperms or ova).

First Meiotic division [Reduction division]

1. Prophase (I):

22 days in ♂ & 12-45 years in ♀. 5 stages:

a. Leptotene: [thin ribbon]

The 46-d. chromosomes appear as long thin separate threads.

b. Zygotene:

The chromosomes are arranged in 23 pairs = **bivalents**. Each pair is formed of 2 homologous chromosomes: [1 maternal & 1 paternal] alongside each other.

c. Pachytene: (thick)

- Chromosomes become shorter & thicker & appear as tetrads of 4 chromatids.
- segments of the chromatids may break by recombinase enzyme.
- The segments rejoin & exchange of segments bet. the non-sister chromatids of homologous chromosomes. [**Crossing Over**]
- The region of crossing over is called **Chiasmata**.

d. Diplotene: (double)

- Chromosomes continue to condense & separate revealing chiasmata.

e. ^{across move} Diakinesis:

- Chromosomes condense maximally.
- nucleolus & nuclear membrane disappear, freeing chromosomes in the cytoplasm.

2. Metaphase (I)

Mitotic spindle is well developed & the 23 bivalent chromosomes are arranged in the equatorial plane & attached to the microtubules of the spindle.

3. Anaphase (I):

- Each chromosome of a bivalent moves to one pole of the cell.

4. Telophase (I):

The 2 daughter cells are formed each with 23 d. chromosomes.

Second Meiotic Division [equatorial division]

Mitosis like e' very short interphase (e' out s. stage). Each daughter cell has 23 d. chromosomes.

1. Prophase (II):

- Chromosomes become shorter & thicker.
- Mitotic spindle starts to appear.

2. Metaphase (II):

- the 23 d. chromosomes are aligned at the equatorial plane.

3. Anaphase (II):

- Each d. chromosome splits at the centromere \Rightarrow 2 chromatids each moves to one pole of the cell. (s. chromosomes)

4. Telophase (II):

- The 2 daughter cells separate, each e' 23 s. chromosome.

Mitosis	Meiosis
<ul style="list-style-type: none"> - In somatic cells. - Single division \rightarrow 2 daughter cells e' diploid No. of chromosomes. - daughter cells are genetically identical. - No pairing \rightarrow No crossing over - no exchange of genes. - Each chromosome divides longitudinally at the centromere into 2 chromatids. 	<ul style="list-style-type: none"> - In germ cells of < testis & ovary. - 2 successive divisions \rightarrow (e' out s-phase) 4 daughter cells e' haploid No. of chromosomes (show genetic variation) - pairing allows crossing over - exchange of genes. - Each chromosome of a bivalent migrates to one pole of the cell (in 1st division).

Human Chromosomes

-6-

= Chromatin fibres \bar{w} become so coiled & condensed so, become visible e' L.M
At G_1 of interphase: the chromosome is a single thread = s. chromosome
At S. stage: " " " is double threads = d. " "

At Metaphase & late prophase:

- * each chromosome is formed of 2 chromatids joined at the centromere \bar{w} divides the chromosome into 2 arms: short arm (p) & long arm (q).
- Kinetochore = 2 discs of ptn. at both sides of the centromere to \bar{w} spindle fibres are attached.
- Each chromatid = DNA molecule coiled around histone & non-histone ptns
- genes = segments of DNA that code for specific ptn. Each gene has a specific position (locus)
- Telomere: the terminal end of the chromosome. Has a repeated sequence of bases to protect the end of the chromosome & prevent end to end fusion of chromosomes.

* Classification of Chromosomes:

A) According to length:

- 22 homologous pairs are numbered serially from 1-22, then grouped into 7 groups in a descending order of length: (A, B, C, D, E, F & G)
- the sex chromosomes are either arranged alone or X in group C & Y in group G.

B) According to position of centromere:

1. Metacentric: centromere at the centre i.e. the 2 arms are equal $p=q$.
2. Submetacentric: " " midway bet. the centre & the upper end i.e. $p < q$.
3. Acrocentric: " " close to one end (p is very short). Some of them have small mass of chromatin = Satellite attached to p arm by 25y constriction containing genes for r-RNA. (except in Y. chromosomes).
4. Telocentric: centromere is terminal i.e. no short arm. Not in humans.

C) According to genes:

1. Autosomes: 22 homologous pairs = control somatic characters
2. Sex chromosomes: 1 pair = control sex
 - homologous (identical) XX in ♀
 - heterologous (unidentical) XY in ♂

Karyotyping

def. : the study of the No & types of chromosomes according to their length & position of the centromere.

Technique : WBCs are the best cells to study chromosomes.

1. A heparinized blood sample is obtained (prevent clotting)
2. the sample is centrifuged to separate WBCs.
3. WBCs are incubated in a culture medium to w a mitogenic factor is added. at 37°C for 3 days. (phytohemagglutinin)
4. Colchicine is added to stop cell division at metaphase.
5. Hypotonic solution is added so cells swell & chromosomes disperse
6. Cells are spread on a slide, fixed, stained e' Giemsa & photographed.
7. Chromosomes in the photo are cut, matched into pairs & arranged according to their length & position of centromere.

Banding Technique:

It can differentiate chromosomes by staining different segments [genes] by different colours.

Clinical Importance of chromosomal Examination

1. Identification of sex $\begin{cases} \rightarrow \text{in Foetus (in cells in amniotic fluid)} \\ \rightarrow \text{" doubtful cases of hermaphroditism.} \end{cases}$
2. Diagnosis of abnormalities in sex chromosomes e.g. Turner's syndrome (XO) & Klinefelter's syndrome (XXY).
3. Diagnosis of numerical abnormalities in chromosomes e.g. Mongolism.
4. Diagnosis of structural " " " " " " e.g. deletion in mental retardation & translocation in chronic myeloid leukemia.
5. Medico legal importance in Forensic Medicine.

Sex Chromatin [Barr body]

- Dark mass of chromatin, present in:
 - 60% of ♀ epithelial cells lining the buccal cavity: appear a dark body inner to the nuclear membrane.
 - 3-5% of ♀ neutrophils: appear as drum stick-like mass attached to the nucleus.
 - It represents inactive coiled X-chromosome. The other X is active, extended & not apparent.
 - It appears in ♀ cells & in ♀ e' Klinefelter syndrome [XXY]
 - Absent in ♂ cells & in ♀ e' Turner syndrome [XO].
- (N.B) Somatic cells have at least 1 X-chromosome w must be active, extended & not visible). It carries other genes (not sex determining).

Chromosomal Aberrations

def.: deviation from the normal N^o or structure of chromosomes.

- Most of abnormalities cause
 - mental retardation
 - developmental " "

Causes of chromosomal aberrations :

1. Viral Infection: e.g. german measles → Fragmentation of chromosomes
2. Radiation: → chromosomal damage & non-disjunction.
3. Drugs e.g. cytotoxic drugs e.g. colchicine → inhibit mitotic spindle
4. Pregnancy in old women → ↑ risk of non-disjunction (long prophase)
5. Auto. immune disease: associated e' non-disjunction.

I-Numerical Aberrations

a) Euploidy: - multiple of haploid N^o & exceeds the diploid N^o .

1. Triploidy = $3n = 69$ chromosome.

2. Tetraploidy = $4n = 92$ "

due to failure of 1st cleavage of the fertilized ovum.

3. Polyploidy $\geq 5n$: one or both gametes are not haploid.

b) Aneuploidy:

abnormal N^o is not the exact multiple of the haploid N^o .
e' addition or loss of a chromosome. Types:

1. **Trisomy:** $2n+1$ e' addition of an extra-chromosome [47]
e.g. trisomy 21 or Mongolism or Down syndrome
i.e. 3 copies of a chromosome instead of 2 in a pair.

2. **Monosomy:** $2n-1$ e' missing of one chromosome [45]
e.g. Turner syndrome (1 copy instead of 2 in a pair).

Causes of an euploidy:

1. **Simple loss** [Anaphase lag]

failure of a chromosome to align during metaphase or lag to move in anaphase

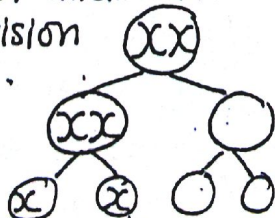
2. **Failure of duplication:** of a chromatid in S-stage.

3. **Non-disjunction:** types

(a) **Primary**

= failure of separation of chromosomes
- during 1st meiotic division

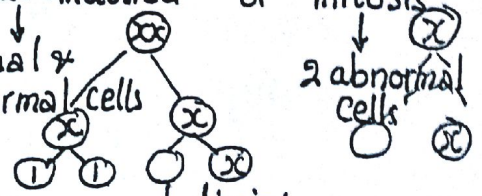
→ 4 abnormal cells



(b) **Secondary**

= failure of separation of chromatids
- during 2nd meiotic or mitosis

2 normal &
2 abnormal cells



(c) **Mosaic** if non disjunction occurs after many normal divisions →
Cells e' more than Karyotype: some e' 46, others e' 45 or 47.

Numerical Aberrations in Autosomes

Down Syndrome = Mongolism = Trisomy 21

- A child e' 47 chromosomes, the extra-chromosome is similar to pair N^o 21 i.e. each cell has 3 chromosomes e' the criteria of chromosome 21.
- Due to → Non-disjunction of chromosome 21
- Have mongol Features: mental retardation, hypotonia, cardiac abnormality, small genital organs, lateral upward sloping eyes, small ears, short broad nose, neck & hands.
- N.B. the older the woman at conception, the greater the risk of a child e' Down Syndrome

Numerical Aberrations in Sex Chromosomes

Cause: Non-disjunction in 1st meiotic division of 1st Oocyte. the produced ovum contains XX or no X (O).

1. Klinefelter's Syndrome (47XXY) = [Trisomy of sex chr.]

- ♂ e' additional X-chromosome → So, have +ve Barr body
- due to non-disjunction of the X-chromosome in the 1st meiotic division in the Oocyte & the ovum e' 2X - " is fertilized e' Y-sperm.
- Features: mentally retarded ♂: tall child e' small testes, large breasts & widely separated nipples.

2. Multiple X chromosome [47XXX] = trisomy of X-chromosome

- similar cause as Klinefelter but the ovum is fertilized e' sperm e' X-chr
- ♀ e' additional X chromosome so - Have 2 barr bodies.
- Features: ♀ e' delayed language development, motor coordination problems, auditory disorders, accelerated growth until puberty.

3. Turner's Syndrome [45XO] = monosomy of X-chromosome.

- due to non-disjunction of the X-chromosomes during 1st meiotic division of oocyte the ovum e' no X chrom. is fertilized e' X sperm → 45 XO(-) →
- ♀ e' missing X " → -ve Barr body
- Clinically: short ♀ e' mental retardation, undeveloped ovaries & ext. genitalia, 1st amenorrhea + edema of limbs.

Structural Aberrations (Mutation)

-11-

They are mostly due to: viruses, exposure to radiation, drugs & insecticides
If the chromosome has its normal genetic information → balanced aberration.
If there is additional or missing " " → unbalanced " (e' affected phenotype)

Types:

1. Breaks: rapidly heal by reunion of the sticky ends of the chromosomes.

2. Deletion: = loss of fragmented part of a chromosome. 3 types:

a. Terminal: loss of a segment from one end by a single break.

b. Interstitial: loss of a segment bet. 2 breaks e.g.

e.g. Wolf Syndrome: deletion of short arm of chromosome No 4.

Cri du chat " : " " " " " " " 5.
(cry like cat)

c. Ring chromosome: 2 breaks, loss of fragments & reunion in a ring form.

3. Duplication = Addition:

the addition of extra piece to a homologous chromosome mostly due to unequal crossing over of homologous chromosomes → double the dose of genes on a chromosome i.e. 2 copies of the same gene on the same chromosome.

4. Inversion:

2 breaks in a chromosome & the broken segment rejoin its place but in an inverted form. 2 types:

a. Pericentric: the break is on either side of the centromere.

b. Paracentric: the break is on one side " " " "

5. Translocation:

= transfer of a chromosomal segment to a non-homologous chromosome.

2 types:

a. Robertsonian translocation [centric fusion]:

in acrocentric chromosomes 21 & 14: by fusion of the long arms of chromosomes 21 & 14 → E-chromosome. The short arms of both

" are lost (insignificant). It occurs in 3.4% of cases of Down Syndrome.

N.B. If a parent is a carrier of chromosome 21 translocation, the risk of having a child e' Down Syndrome is as high as 100%

Reciprocal translocation:

Reciprocal Translocation:
Exchange of segment bet. non homologous chromosomes - 12 -
It is balanced, since no genes are lost or added.

Philadelphia Chromosome:

Philadelphia Chromosome :
= reciprocal translocation bet chromosome 22 & chromosome 9
It is diagnostic for chronic myeloid leukemia.

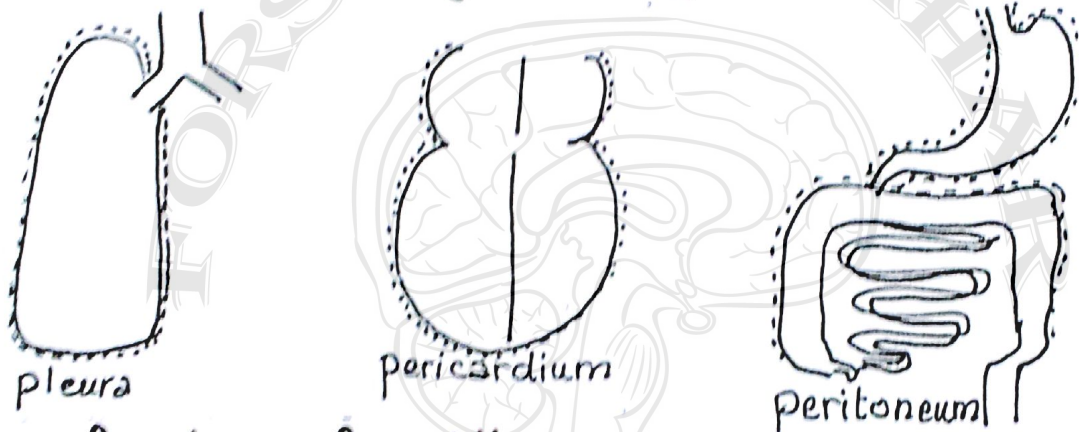
6 - Isochromosomes:

- 6) - Isochromosomes:**
- transverse instead of longitudinal division of the centromere
 - during anaphase of mitosis
 - results in 2 non-similar chromatids.
-
- It occurs in submetacentric chromosomes.

Epithelial Tissue

General Characteristics:

1. Origin: either ectodermal [e.g. skin], mesodermal [serous membrane] or endodermal [GIT].
2. Formed of crowded cells with minimal intercellular space.
3. Cells rest on a basement memb. which may be clear or non-clear
4. Avascular: blood vessels & lymph vessels can not penetrate it but nerves can. [receives nutrition by diffusion from underlying c.t.]
5. It either covers surfaces or line cavities.
6. It may modify to: form secretion Glandular epith.
7. " " " " act as receptor neuro-epith. or
8. " " " " contract myo-epith.
9. have high power of regeneration.



Classification of epith:

1. Surface epith.: cover surface or line cavity.
2. Glandular epith. → secretion.
3. Neuro-epith → sensation.
4. Myo-epith. → contraction.

1. Surface Epith

1. Simple epith
(1 layer)

2. Stratified epith.
(> 1 layer)

N.B.: Epith - metaplasia = transformation of epith from one type to another under abnormal condition.
Eg:- epith of Bronchi (ps shed cell) $\xrightarrow{\text{by smoking}}$ St. Sq.

Simple Epithelium

Formed of 1 layer of cells & subdivided according to shape of cells into:

1) Simple Squamous Epith:

1 layer of flat cells & flat nuclei

• Sites & functions:

1. Heart & blood vessels → smooth surface.

It is called endothelium.

2. Lung alveoli → thin surface for easy exchange of gases. It is called pneumocytes.

3. Serous membranes: Pleura, Pericardium, Peritoneum
→ smooth surface for easy movement
It is called mesothelium.

4. Bowman's Capsule of kidney → easy filtration.

2) Simple Cubical Epith:

1 layer of cubical cells with central rounded nuclei.

Function: Secretion & reabsorption.

• Sites:

1. lining acini & small ducts of all exocrine glands. e.g. (salivary)

2. Thyroid Follicles.

3. Kidney tubules (have microvilli) for reabsorption.

3) Simple Columnar Epith:

1 layer of tall columnar cells & basal oval nuclei.

Function: Secretion & absorption:

• Sites: GIT.

1. Stomach → secretion.

2. Intestine → absorption

3. Main pancreatic duct, common bile duct & gall bladder
(N.B) Goblet cells: modified col. cells = cub-shaped secrete mucous present in small & large intestine & resp. tract.

4) Simple Columnar Ciliated Epith:

1 layer of columnar cells. The free surface have cilia.

• Functions: cilia push fluids or particles in one direction.

• Sites:

♀ Genital tract: uterus & fallopian tube (move the ova).
lung bronchioles: (push mucus)

5) Pseudo-stratified Columnar Epith:

1 layer of columnar cell crowded over each other.

- All cells rest on the basement membrane but some cells fail to reach the surface. Nuclei are present at different levels giving the appearance of many layers (stratified). 2 types:

a) Pseudo-stratified columnar ciliated Epith:

i) motile cilia & goblet cells:

lining upper respiratory tract e.g. nose, trachea & bronchi

It is called respiratory epithelium.

ii) non-motile cilia (stereocilia) = not = not true cilia = long microvilli

e.g. in epididymis.

b) Pseudo-stratified Columnar Non-ciliated Epith.

In ♂ genital tract.

e.g. Vas deferens
membranous part of ♂ urethra.

Stratified Epithelium

Formed of 1 layer of cells: Its main function is protection. Classified according to the shape of superficial cells into

1. Stratified Squamous epith.

- Formed of 5-30 layers (thickest type)
- Cells rest on a clear & wavy basement memb.

The basal layer:

- Columnar cells & basal oval nucleus.
- From this layer, the other cells originate

The intermediate layers:

- polygonal cells & central rounded nuclei & minimal intercellular spaces & joined by desmosomes.
- Cells become smaller towards the surface (less nourished)
- The superficial layer:
 - Flat squamous cells & flat nuclei.

2 types:

(a) Non-Keratinized: (wet)

the superficial cells are living & no keratin.

(b) Keratinized: (dry)

the superficial cells die, lose their nuclei & form keratin scales

Sites:

1. Oral cavity: lip, & tongue (mouth)
2. Oesophagus.
3. Cornea.
4. Anal canal
5. Tip of urethra
6. Vagina.

Sites: (dry & exposed surfaces)

1. Epidermis of skin: ext. ear
2. Openings upon skin: ext. nose, anus.

2. Transitional Epith. (str. cuboidal)

- Formed of 6-8 layers: (in empty bladder)
- Cells rest on non-clear wavy basement memb.

The basal layer: high cuboidal cells & central rounded nucleus

The intermediate layers = polygonal cells & central rounded nuclei & wide intercellular spaces w contain mucous like substance to allow gliding of cells over each other.

The superficial layer: large cuboidal cells & upper convex surface [dome cells] & may be binucleated. It is covered & mucous to protect against action of urine.

(N.B)

Absence of desmosomes & presence of wide intercellular spaces filled & mucous like substance help gliding of cells over each other during distention of the bladder & epith becomes thinner (2-3 layers. During full distention, cells may become flattened i.e. changeable.

Sites: Urinary tract: [uroepith.]

e.g. renal pelvis, ureter & urinary bladder.

4. Stratified Columnar epith.

- Similar to stratified, squamous but: Fewer No. of layers & superficial cells are columnar

2 types:

Non-ciliated in

- recto-anal junction
- penile part of urethra
- large ducts of glands

Ciliated.

rare in

foetal Oesophagus

II Glandular Epithelium

-4-

f.: epithelial cells specialized to produce secretion.

According to presence or absence of ducts, glands are classified into 3 types:

A. Exocrine glands:	B. endocrine glands	C. Mixed glands.
Have secretory unit & ducts to carry the secretion to the surface. e.g. Salivary glands.	groups of cells but no ducts. & cells pour the hormone directly into blood e.g. thyroid gland.	have both exocrine & endocrine parts e.g. pancreas.

• Classification of Exocrine Glands:

1. According to No. of cells:

- a. Unicellular glands: e.g. goblet cells.
- b. Multicellular " : all other glands e.g. salivary glands.

2. According to Mode of secretion: [Mechanism].

i.e according to the changes in the secretory cells.

- a. Merocrine: no change, secretion passes by exocytosis e.g. salivary glands.
- b. Apocrine: the apex of the cell detach & come out e' the secretion.
e.g. mammary gland & axillary sweat glands.
- c. Holocrine: the whole cell is destroyed & lost e' the secretion.
e.g. sebaceous gland.

3. According to the Nature [Kind] of Secretion:

- a. Watery secretion: e.g. sweat glands.
- b. Serous glands: Watery secretion containing enzymes e.g. Parotid & Pancreas
- c. Mucous glands: e.g. goblet cells.
- d. Muco-serous gls: e.g. submandibular & sublingual glands.
- e. Fatty secretion: e.g. sebaceous glands.
- f. Waxy glands: e.g. glands of external ear.
- e. Cellular " : → cells e.g. Testis (sperms) & Ovary (ova).

4. According to function:

- a. Secretory: secrete useful substance e.g. salivary glands
- b. Excretory: excrete waste products e.g. kidney & sweat glands.

According to the shape of the secretory unit:

tubular, alveolar or tubulo-alveolar.

6. According to branching of the ducts:

a. Simple: have single non-branching duct

b. Simple branched: the duct is not branched but acini are branched

c. Compound: the ducts are branched like a tree.

Examples of exocrine glands according to shape of acini & branching of the ducts.

a) Tubular:



• Simple tubular

e.g. intestinal gl. (crypts)



• Simple branched tubular:

e.g. Fundic gland of Stomach



• Simple Coiled tubular

e.g. Sweat gl.



• Compound tubular:

e.g. Liver
Kidney
testis.

b) Alveolar:



• Simple Alveolar

e.g. Sebaceous gland.



• Simple branched alveolar

e.g. Sebaceous gls.



• Compound alveolar

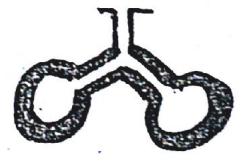
e.g. Mammary gland

c) Tubulo-alveolar:



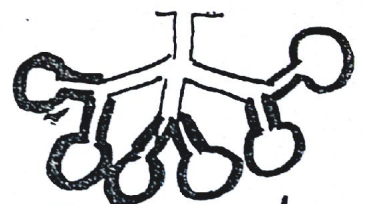
• Simple tubuloalveolar

not in Man.



• Simple branched tubulo. alveolar

e.g. minor salivary glands of mouth cavity.



• Compound tubulo. alveolar

e.g. Main salivary gls. (parotid) + pancreas + prostate.

III - Myoepithelium

- epithelial cells modified to contract.
- branched cells & many processes that contain contractile filament.
- they surround the acini of the glands, between the base of cells & the basement memb. When they contract they squeeze the acini so, discharge the secretion into the ducts. e.g. sweat glands, salivary gls. & mammary gland.

IV Neuro-epithelium

- epithelial cells modified to act as receptors.
- formed of: sensory cells & supporting cells.

Sites :

1. Taste buds : in tongue : for taste.
2. Organ of Corti : in inner ear : for hearing .

<u>Crista ampularis</u>	} " " " : for equilibrium.
<u>Macula utriculi</u>	
" <u>sacculi</u>	
3. Rods & Cones : in retina : for vision.

faculty of medicine alazhar university

Polarity & Memb. Specializations

I. Lateral [Intercellular] Specializations

Epith. cells are linked by diff. types of junctions.

1] Tight [Occluding] Junctions

A. Zonula Occludens =

- The 2 adjacent cell membranes fuse completely at certain points where the intercellular space is (0).
- It completely encircles the apex of the cell like a belt.
- function: prevent passage of substances bet. the cells.

B. Fascia Occludens:

- Similar to Z.O. but not like a belt. It is a patchy fusion of the two cell membranes e.g. bet. endothelial cells.

2] Adherens Junctions [Zonula Adherens]:

- the 2 adjacent cell membs. are separated by a wide space (20 nm) filled w' adhesive (cell coat) material.
- At the cytoplasmic side, there is condensation of actin microfilaments.
- It encircles the cell like a belt.
- Function: fix adjacent cells to prevent their separation.

3] Macula Adherens = Desmosomes:

- the 2 adj. cell membs. are separated by a very wide space (30 nm) filled w' adhesive material. It does not encircle the cell but scattered as circular spots.
- the cytoplasmic side is thickened → attachment plates in w^h tonofilam (intermediate) filaments are inserted & return back to cytopl. → hair pin like loops
- It shows electron-dense line in the middle of the intercellular space. formed of transverse filaments = trans-membrane linkers.
- Present bet. epithelial cells esp. in strat. squamous epith.
- functions: strongest type that holds cells together & give support to surfaces subjected to mechanical stress & friction.

(N.B.) Junctional Complex:

If more than 1 junction are present bet. adjacent cells e.g. Col. cells lining the small Intestine show Z. occludens at the apex followed by Z. adh. & desmosomes.

Gap Junction: [Nexus] = Communicating Junction

-0-

the 2 adjacent cell membs. are separated by a very narrow gap (2 nm) but connected by narrow channels = 6 integral transmembr. ptns (hexameric) forming tubules called connexons.
The joined connexons → nexus.

Functions:

1. permit passage of ions & small molecules from one cell to the other.
2. passage of impulses bet. muscle cells e.g. cardiac & smooth muscles.

II Basal Specializations

1. Hemidesmosomes:

- take the shape of $\frac{1}{2}$ a desmosome.
- at basal part of basal cells.

Function: fix epith. to underlying b.m. & c.t.

2. Basement membrane:

- memb. beneath all epithelia, bet. epith. & c.t.
- L.M.: red line by (PAS) or brown by (Ag).

Maybe → Clear (thick) e.g. skin.

→ non-clear (thin) e.g. transitional epith & capillaries.

- E.M.: 2 components:

A. Basal Lamina = Cell Coat = [epith. component]

→ lamina lucida = electron-lucent (clear) layer → glycoptn. of cell coat + laminin

→ lamina densa = electron-dense & more condensed " " " " " " collagen granules (type IV)

B. Reticular lamina = collagen of c.t. [c.t. component].

= fine collagen fibrils (type III) = reticular fibres + glycoptns.

Both layers are fixed to c.t. by collagen fibres type VII = anchoring fibres

Functions:

1. Support epith & help to form sheets.

2. fix epith. to c.t.

3. help repair of epith.

4. act as a sieve to control passage of nutrients & ions e.g. Kidney caps, lung alveoli

3. Basal Infoldings:

In ion transporting cells e.g. Kidney tubules. the basal cell memb. shows invaginations + vertical mitochondria to give Energy for active transport of Na^+

III Apical Specializations

1. Microvilli:

- finger like projections from the cell memb., shorter than cilia.
- L.M. = apical striated (brush) border.
- E.M. have a core of actin filaments inserted into a terminal web.
the actin core maintain its shape & help shortening & elongation of microvilli.
- Functions: ↑↑ surface area for absorption up to 30 times e.g. small intestine
kidney tubules

2. Stereocilia = [non-motile cilia]

- Not true cilia but long microvilli.
- L.M. hair like processes from free surface of some cells.
- E.M. no microtubules (not cilia), their core have actin filaments.
- Function: help absorption in ♂ genital system e.g. epididymis.

3. Cilia:

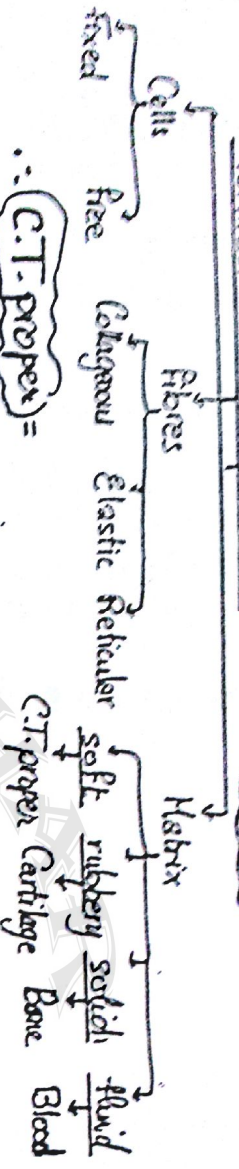
- L.M. hair like processes w arise from the free border of some cells.
- E.M. formed of a core of 20 microtubules arranged as 9 peripheral doublets & 2 central singlets called axoneme covered e' cell memb. & continuous e' the basal body.
- Functions:
 - their rhythmic beating push particles or fluids in one direction.
 - In cells lining upper respiratory tract e.g. trachea & bronchi, mucous traps dust & bacteria move it towards the throat to be coughed.
 - In cells lining Fallopian tube: transport the ovum towards the uterus.

4. Flagella:

- Single extra long cilium that form the tail of sperm.
- Its whip like movement help to move sperms.

Formed of 3 components:

C.T.



Cells + Fibres + soft matrix

C.T. Cells

Fixed Cells: stable population, produced & remain in c.t. & long lived:

(1) **UMC** = undifferentiated mesenchymal cell

Site: in c.t. of embryo. (mesenchymal c.t.) in adults → around bl. capillaries (pericyte)

L.M.: small branched stellate shaped cells. → in bone marrow → give bl. cells.

N. large, pale, oval e' clear nucleolus.

C. pale basophilic

F.M. Few organelles but many free ribosomes

Functions: 1. Other c.t. cells 2. bl. cells 3. smooth muscles 4. endothelial cells

Reticular cells.

(2) **Pericyte** = UMC of adults

- around bl. capillaries. along their long axis.

- branched cell

N. large, pale & oval

C. pale, basophilic

- few organelles, many free ribosomes + actin & myosin.

F: 1. Their contract? vasoconstriction 2. can form fibroblasts & smooth ms & endothelial cells after injury.

Characters of c.t.

1. mesodermal in origin
2. Cells are widely separated & large amount of matrix
3. bl. vs, lymph us where can penetrate it.
4. Connect, support & protect tissues & organs.

mesoderm → mesenchymal c.t. = UMCs + ground subst

(3) **Fibroblasts & Fibrocytes** (build c.t.)

Origin: UMC & Pericytes.

Site: in all types of c.t. [most common type].

L.M.: Flat (stellate) branched cell & long process

N. large, pale, oval e' prominent nucleolus.

C. deeply basophilic.

- E.M. picture of ptn. forming cells:

N. Euchromatic nucleus e' prominent nucleolus

C. many mit., rER, ribosomes, well developed G.A.

Functions: 1. Form c.t. matrix.

2. " " Fibres.

3. Healing of wounds.

4. secrete growth factors for growth

Fibrocyte = Old Fibroblast (inactive)

- Spindle shaped e' few processes

- small dark Nucleus & pale basophilic cytopl.

E.M. Fewer rER, N. e' condensed chromatin

F: maintenance of c.t. Active during healing of wounds.

(6) Fat Cells [Adipocyte]

Origin: UMC \rightarrow lipoblast \rightarrow lipocyte

A. Unilocular Fat Cell

Site: - white adipose c.t.

L.M.: Large oval cell (50-150 μ m)
e' large globule of fat surrounded e'
small rim of cytoplasm.
N. Flat & peripheral.

by H & E: fat dissolves \rightarrow empty space \rightarrow
signet ring appearance
by Sudan III \rightarrow Orange.

E.M.: few ^{filamentous} mit., many free ribosomes + S-ER
dense inclusion filling the cell.

Functions: 1. storage of fat.
2. Heat insulator
3. support organs e.g. kidney

N.B. Fat cells do not divide but long lived.

B. Multilocular fat cell

- Brown adipose c.t.

- Small rounded cell e' small
fat droplets & central rounded N.

- No signet ring appearance.

E.M.: many ^{spherical} mitochondria ^{contain}
brown cytochrome pigment +
few free ribosomes

Function: **Heat generator.**

(7) Fixed Macrophages [Histocytes]:-

Origin: monocyte.

Site: Scattered in c.t. attached to collagen fibres.

L.M. large branched cell e' pseudopodia, so have variable shapes
N: small, dark & kidney shaped.
C: Non-clear, pale basophilic

Special stain: vital stain as trypan blue or Indian ink.
where the stain is phagocytosed by the cell.

E.M. Irregular surface due to pseudopodia.

- Few rER, well developed G.A. many lysosomes ^{1.34} & ^{2.74} phagocytosed particles
+ residual bodies.

Functions:

1. Phagocytose & digest microorganisms.
2. Fuse \rightarrow multinucleated foreign body giant cells to phagocytose large foreign bodies.
3. Clean wounds from dead cells [debris].
4. destruction of old RBCs in liver & spleen.
5. Antigen presenting cells i.e. trap & partially digest the antigen to present it to lymphocytes.
6. secrete enzs e.g. collagenase & cytokines [important in defence & repair].

Free C.T. cells: motile, migrate from blood, belong to immune system, short lived & continuously reg

(1) Plasma Cell	(2) Mast Cell	(3)	Free Macrophages	[4] Bl. leucocytes
<p><u>Origin</u>: β-lymphocytes \rightarrow plasma blasts \rightarrow plasma cells.</p> <p><u>Site</u>: - lymphatic tissue.</p> <p><u>L.M.</u>: large Oval cell (20 μm)</p> <p><u>N.</u>: eccentric rounded e' Cart. wheel or clock face appearance</p> <p><u>C.</u>: deeply basophilic e' unstained area near the nucleus = -ve Golgi image.</p> <p>- may contain acidophilic granules = Russell bodies = accumulations of defective products of antibody synthesis.</p> <p><u>E.M.</u>: of pln. secreting cells i.e. mit, many cisternae of rER, well developed G.A.</p> <p><u>N.</u>: radiating chromatin masses under the nuclear memb.</p> <p><u>Function</u>: form & secrete antibodies</p>	<p>- UMC</p> <p>\rightarrow around bl. capillaries under epith. of respiratory & digestive tracts.</p> <p>- Oval Cell e'</p> <p>- N: central & rounded.</p> <p>C. have basophilic granules w are metachromatically stained e' toluidine blue \rightarrow purple or red color</p> <p><u>E.M.</u>: mit, rER, G.A. + memb. bound dense granules.</p> <p><u>Functions</u>:</p> <ol style="list-style-type: none"> 1- Secrete Heparin (anticoagulant) 2- Secrete Histamine \rightarrow Vasodilation that initiates allergy. 3- Secrete Eosinophil chemotactic factor w attracts eosinophils to site of allergy 4- Secrete leukotrienes: \rightarrow contraction of smooth muscles of the bronchial tree \rightarrow bronchial asthma. 		<p>blood monocytes w migrate to c.t. & Same as Fixed macrophages</p>	<p>migrated from blood through capillaries & small venules</p>

Lipocytes: secrete leptin hormone to regulate appetite & the amount of fat in the body.

In multilocular fat cells: the mitochondria contain a protein called thermogenin (a unique marker for these cells) that \uparrow heat production.

C.T. cells are classified according to **function** into:

1. Undifferentiated cells = UMCs + pericytes
2. C.T. forming cells = fibroblasts, fibrocytes + reticular cells
3. Fat storing cells = unilocular & multilocular fat cells.
4. Cells responsible for immunity & defense = plasma cells, mast cells, leucocytes + macrophages [fixed & free].

Extracellular Matrix = Ground Substance + tissue fluid

def. Jelly like, transparent substance formed by fibroblasts.

formed of:

① **Glycosaminoglycans = GAGs**

= polysaccharides = repeated disaccharides e.g. $\left[\begin{array}{l} \text{chondroitin sulphate} \\ \text{heparan} \\ \text{Hyaluronic A} \end{array} \right] +$

② **Proteoglycans:**

90-95% CHO linked to ptn. molecules (10%)

③ **Glycoproteins:**

large ptn. molecules (90%) linked to $\left[\begin{array}{l} \text{repeated} \\ \text{monosaccharides} \end{array} \right] \rightarrow \text{polysaccharides}$

Tissue fluid:

similar to plasma (- plasma ptns) derived from capillaries (through pores)

Stain: Ag \rightarrow brown. Toluidine blue \rightarrow purple [metachromatic stain].

Functions:

1. Allow passage of nutrients, & waste products bet. cells & blood.
2. physical barrier against spread of microorganisms.

Edema = accumulation of excess fluid in the extracellular space

Causes: 1. \uparrow capillary permeability.

2. \downarrow venous flow.

3. lymphatic obstruction.

C.T. Fibres

White Collagenous fs	Yellow Elastic fs.	Reticular fibres
<p><u>L.M.</u> - Wavy branching bundles formed of parallel non-branching fibres.</p> <p>- Colourless, appear white when condensed.</p> <p>Stains : H+E : acidophilic → pink (e' eosin)</p> <p>Mallory → blue</p> <p>Van Geison → red</p> <p>Structure : preprocollagen → procollagen → tropocollagen = 3 polypeptide chains intertwined in triple helix</p> <p>tropocollagen polymerize → fibrils → fibres → bundles</p> <p><u>E.M.</u> collagen fibrils have t.v. striations with dark bands that react more intensely w/ the lead stain used in EM than do the light bands.</p>	<p>- thin, single fibres</p> <p>- branching.</p> <p>- appear yellow in fresh section</p> <p>- H+E → pink.</p> <p>- Orcein → brown.</p> <p>- Von Geison → yellow</p> <p>2 types of ptn → elastin glycoprotein.</p> <p>core of elastin surrounded by microfibrillar ptn.</p> <p>No fibrils, No periodicity</p>	<p>- Very thin fibres w/ branch & anastomose to form reticulum.</p> <p>- Ag → black [argyrophilic]</p> <p>- PAS → purple (high CHO content)</p> <p>- Collagen type III</p> <p>thin fibres of tropocollagen bound by glycopn. molecules (contain 6-12% hexose) compared to 1% in collagen type I</p>
<p>Character : strong, resist stretch, flexible.</p> <p>- by boiling → gelatin.</p> <p>- destroyed by acids & alkalies</p> <p>- digested by pepsin & trypsin.</p> <p>- tanning → leather.</p>	<p>- stretch & recoil.</p> <p>- resist boiling.</p> <p>- resist chemicals.</p> <p>- digested by pancreatic elastase</p>	
<p>Function : give tissues strength & resist stretching</p>	<p>- give tissues elasticity.</p>	<p>Supportive stroma. allows motility of cells in b.m, lymph Node & spleen.</p>
<p>Formed by : Fibroblasts, chondroblasts (in cartilage), Osteoblasts & odontoblasts. (in teeth) (in bone)</p>	<p>Fibroblasts, chondroblasts in elastic cart. smooth muscles in elastic arteries</p>	<p>Fibroblasts, reticular cells smooth muscles.</p>

Collagen is the most abundant ptn. in the body

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Types of collagen: >20 type

Type	Main Sites	Cell of Origin
Type I	C.T. proper, bones, tendons + capsules of organs	- Fibroblast + Osteoblasts
Type II	Cartilage + vitreous body of eye	- Chondroblasts + Chondrocytes.
Type III reticular fibres	loose c.t. Stroma of organs wall of bl. vessels.	- Fibroblasts, reticular cells + smooth ms. cells.
Type IV	- basal lamina of epith. & endoth.	- Epithelial cells.
Type V	Ext. lamina of smooth & skeletal ms.	- Fibroblasts. - muscle cells.
Type VI	- Associated w' type I & III	- Fibroblasts.
Type VII anchoring fibres	In skin in dermo-epidermal junctions.	- Fibroblasts

Scurvy: vit.C. deficiency → defective collagen synthesis
characterized by: bleeding gums & loss of teeth & unhealed wounds

Types of c.t. Proper

Loose

1. loose areolar c.t.
2. Adipose c.t.
3. Reticular c.t.
4. Mucoid c.t.

Dense

1. White fibrous c.t.
2. Yellow elastic c.t.

A. loose C.T.

(1) Loose [Areolar] C.T.

- The most common type :
- Structure → all cells mainly: Fibroblasts, fat cells, mast cells + macrophages
 → all fibres " collagenous + abundant matrix.
- Characters : - contain cavities (areolae) w^h can accomodate fluids & gases.
 - well vascularised delicate & flexible.
- Functions : 1. binds organs & tissues.
 2. exchange of nutrients e^l bl. vs.
 3. limits spread of infection.

Sites : all over the body except the brain.

1. Subcutaneous (dermis of skin).
2. Submucosa.
3. Serous membranes.
4. around blood vessels & nerves.

2. Adipose c.t.

- Similar to areolar c.t. but fat cells predominate.
- Cells: large No of fat cells e^l few fibroblasts & mast cells in between.
- Fibres: collagenous & elastic fibres form septa bet. lobules of fat cells.

Types : A. White Adipose c.t.	B. Brown adipose c.t.
<u>Characters</u> : have Unilocular fat cells Non pigmented poor in blood supply affected by diet & hormones	→ multilocular fat cells. → brown due to cytochrome in mit. → rich in bl. supply. → not affected by starvation.
<u>Functions</u> : 1. Storage of fat. 2. support organs e.g. kidney 3. heat insulation 4. give skin its normal contour.	<u>Functions</u> : - heat generator for newborns.
<u>Sites</u> : 1. <u>Under skin</u> esp. ♀ e.g : mammary gland & gluteal region 2. Abdominal wall & mesentery. 3. Around kidney & bl. vs.	<u>Sites</u> : • <u>In Embryo & newborns</u> : bet. scapulae, axilla, mediastinum & gradually replaced by white fat.

3] Mucoid C.T.

Embryonic type in w matrix predominate

Formed of:

1. Cells: UMC or young Fibroblasts e' multiple connected processes
2. Fibres: fine collagenous & reticular fs.
3. Matrix: soft, jelly-like rich in mucus & hyaluronic acid.

Sites:

1. Umbilical Cord [Wharton's Jelly]
2. Vitreous humor of eye.
3. Pulp of teeth.

4] Reticular C.T.

Formed of:

1. Cells: reticular cells joined by their long processes
2. Fibres: fine reticular fibres together e' the cells form reticulum.

Sites:

Stroma of all organs
↳ all glands.

Stain: Ag → brown to black

B. Dense types of C.T.

5] White Fibrous C.T.

Very dense e' predominant collagenous fibres e' few cells.

Formed of: white collagenous bundles separated by fibroblasts (tendon cells) & small amount of matrix

Characters: white in fresh section.

types: according to arrangement of collagenous bundles: 2 types:

Regular	Irregular
<ul style="list-style-type: none"> - the bundles are regular & parallel - Fibroblasts are arranged in rows (tendon cells) in bet. collagen bundles - very little amount of matrix - <u>Function</u>: withstand stretch in 1 direction - <u>Sites</u>: <ol style="list-style-type: none"> 1. Cornea of eye 2. Tendons of skeletal muscles 	<ul style="list-style-type: none"> - Collagen bundles are irregular - withstand stretch in diff. directions - <u>Sites</u>: <ol style="list-style-type: none"> 1. Sclera of eye 2. ligaments 3. capsule of organs 4. perichondrium & periosteum. 5. Dermis of skin

6. Yellow Elastic C.T.

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dense type e' predominant elastic fibres

formed of: fibres: regular parallel elastic fs.

Cells: few fibroblasts & fibrocytes.

Characters: yellow in fresh section.

Stain e' Orcein → brown.

function :- form elastic membranes

- have great elastic power (rubber like)

Sites:

1. **Aorta** & large arteries.
2. **Bronchi**, bronchioles & around alveoli
3. **Ligaments**: ligamentum nuchae
ligamentum Plavum
suspensory lig. of penis
4. **Vocal Cords**.

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Cartilage

def: It is a type of c.t. in which the matrix is rubbery to bear mechanical stress.

Characters:

1. arise from UMCs.
2. the matrix is rubbery but flexible.
3. Cells are widely separated by large amount of intercellular matrix.
4. It is avascular & no lymph vessels & no nerves.
5. Nourished by diffusion of O₂ & nutrients from c.t. (perichondrium) or synovial fluid in joints.

Structure:

- Cells = Chondroblasts & chondrocytes.
- Fibres = Collagenous & elastic fibres (in diff. proportions)
- matrix = abundant & firm (rubbery)

3 Types:

1. Hyaline Cartilage

the most common type. It is translucent (glassy) in fresh section.

Structure:

A. Perichondrium:

- dense fibrous c.t. that covers the cartilage except at articular surface of joints
- formed of 2 layers:
 1. Outer Fibrous Layer = Collagenous bundles (type I) + fibroblasts + bl. vessels + nerves.
 2. Inner Chondrogenic L. (Cellular L.) = Chondrogenic cells that change into chondroblasts & secrete the matrix & collagen (type II).

Functions:

- ① Nutrition of the non-vascular cartilage (by diffusion)
- ② Give muscle attachment.
- ③ Formation of new cartilage during growth.

B. Cartilage Cells:

1. Chondroblasts: [young or immature chondrocytes]

Origin: UMC withdraw their processes, proliferate & give chondrogenic cells → Chondroblasts start to secrete matrix.

Site: inner layer of perichondrium

L.M.: small oval cell & pale oval nucleus & clear nucleolus & deeply basophilic cytoplasm (it can divide)

E.M.: ptn. forming cell i.e. Euchromatic nucleus, many mit., well developed G.A. + r.E.R.

Functions: ① Form collagen [type II]. ② Form cartilage matrix. ③ change into chondrocytes. ④ growth of cartilage [appositional].

2. Chondrocytes:

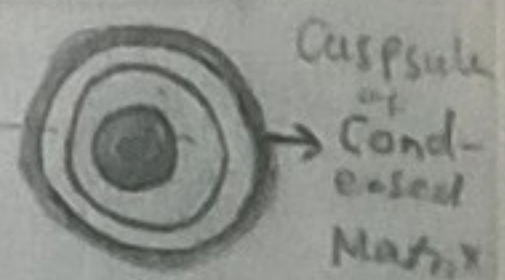
Origin: Chondroblasts when surrounded by the matrix (imprisoned)

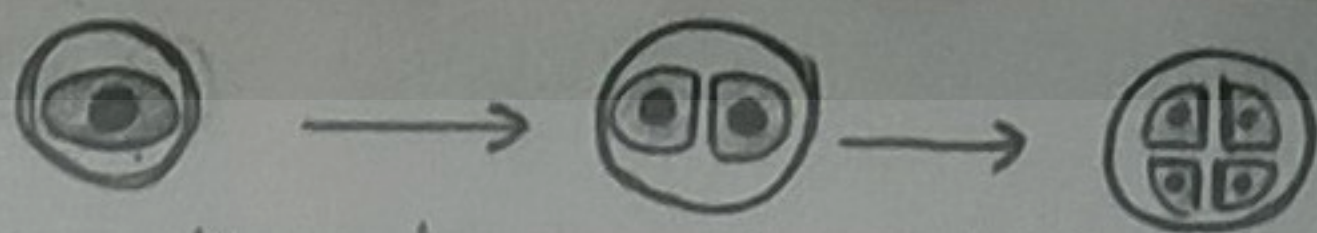
Site: present inside lacunae & surrounded by capsule of condensed matrix.

L.M.: Cells have pale basophilic cytoplasm (rich in glycogen & fat which dissolve during preparation) & central rounded nucleus.

(N.B.) during preparation, cells shrink leaving space called lacuna (not present during life)

→ Cell shrinks inside - Matrix shrinks outside → Lacuna





Parallel - 2-

- the superficial cells are small, oval, present singly inside their lacunae & // to surface
- the deep cells (older): are large, rounded or triangular either single or divide to give groups of 2, 4 or 8 cells (isogenous groups) in lacunae → cell nest.

E.M. mit., G.A., rER + fat droplets + glycogen granules.

Function: maintain matrix by secretion of its components.

C. Fibres:

Collagen fibres (type II) embedded in the matrix w appears homogenous & transparent. They cannot be seen by L.M. because ① they are very thin ② they have the same refractive index as the matrix.

(N.B.) can only be seen after digestion of the matrix by enzymes

D. Matrix (ground Subs.):

- 'rubbery', homogenous (transparent) & deeply basophilic
- produced by chondroblasts & chondrocytes.
- consists of proteoglycans + glycoproteins + H₂O
- stains metachromatically e' basic stains.

Sites:

- ① Costal Cartilage.
- ② Upper respiratory passages e.g. nose, larynx, trachea & bronchi.
- ③ Articular surface of joints.
- ④ Foetal skeleton.
- ⑤ Epiphyseal plate. (in long bone)

2. Yellow Elastic Cartilage

Structure: Similar to hyaline cartilage but the matrix is rich in branching yellow elastic fibres e' few collagenous fibres (type II). It is yellow in fresh section & more flexible. It is covered e' perichondrium. Chondrocytes are single or form small cell nests (2 cell isogenous groups).

Function: very flexible, recovers its shape after being deformed.

Sites: (where support & flexibility are needed)

LE:

- ① Ear pinna
- ② Ext. auditory canal. → قناة السمع الخارجية
- ③ Eustachian tube. → قناة تصل الأذن الوسطى بالأنف
- ④ Epiglottis & some laryngeal cartilages.

3. White Fibro-Cartilage

Structure:

- It has no perichondrium.
- Formed of parallel collagenous bundles (type I) separated by chondrocytes in rows embedded in little amount of matrix
- has intermediate characters bet. hyaline cartilage & dense regular white fibrous CT

Functions:

1. strong tough type w resist stretch.
2. Imp. in bone to bone attachment e' limited movement.

Sites:

- ① Intervertebral disc. ترابط عظمتي الجوف في منطقة العانة
- ② Symphysis pubis. عظمة الحوض
- ③ lip of acetabulum (hip) & glenoid cavity (shoulder) joints.
- ④ Sternoclavicular & mandibular joints.
- ⑤ Semilunar cartilage of knee joints.

Intervertebral disc:

- bet. adjacent vertebrae
- Formed of
 - Out. fibrous ring annulus fibrosus = White fibro-cartilage.
 - Inn. soft mass nucleus pulposus = collagen (type II).
- Clinical Note: Herniation of nucleus pulposus from annulus fibrosus → compress nerve roots → severe pain. انزلاق غضروف

Growth of Cartilage1. Appositional Growth: (exogenous)

Addition of new layers of cartilage to the surface by chondroblasts in the inner chondrogenic layer of perichondrium

2. Interstitial Growth:

growth from inside by proliferation of young chondrocytes w divide & form matrix around them.

Functions of Cartilage

- 1 Keep patent ^{مفتوح} airways.
- 2 Support soft tissues & give some flexibility & weight bearing.
- 3 Shock absorbing.
- 4 Smooth & easy (sliding) movement of joints.
- 5 development & growth of bone (before & after birth)

