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*Fundamentals of*

# Histology

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**Part I**

# Histology

## Part I

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# **Contents**

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<b>1-THE CELL.....</b>	<b>1</b>
The structure of the cell	1
The cell membrane	1
The cytoplasm	2
The cell organelles	2
The cell inclusions	6
The nucleus	7
<b>THE EPITHELIAL TISSUE.....</b>	<b>9</b>
I- Epithelial membranes	9
Types	9
A) Simple epithelium	9
B) Stratified epithelium	10
II- Glands	12
Modifications in cell surface	14
Modifications in cell constituents	16
<b>THE CONNECTIVE TISSUE.....</b>	<b>18</b>
Structure	18
A) The cellular elements	18
<b>Types of connective tissue</b>	<b>21</b>
I- Connective tissue proper	21
1- Loose connective tissue.	21
2- Dense fibrous connective tissue	22
II- Cartilage	23
1- Hyaline cartilage	24
2- Elastic fibrocartilage	24
3- White fibrocartilage	25
III- Bone	25
A) Bone cells	25
Types of bones	26
B) Matrix	26
1. Cancellous bone (spongy bone)	26
2. Compact bone	26
Ossification (development of bone)	27
1- Intramembranous ossification.	27
2- Intracartilagenous ossification	27
<b>BLOOD.....</b>	<b>29</b>
I- Erythrocytes	29
II- Leukocytes (white blood cells)	29

Granular leukocytes	29	Neutrophil leukocytes	29
Eosinophil leukocytes.	30	Basophil leukocytes	30
Agranular leukocytes	30		
A) Lymphocytes.	30	B) Monocytes	30
III- Blood platelets	31		
<b>THE MUSCULAR TISSUE.....</b>	<b>32</b>		
1. The smooth muscle	32	3- The cardiac musc	34
2. The skeletal muscle	33		
<b>THE NERVOUS TISSUE.....</b>	<b>35</b>		
I- Nerve cells (Neurons)	35		
A) The cell body	35	B) The cell processes	35
Types of nerve cells	36		
II- Nerve fibers	36	Type of nerve fibers	36
Synapse (s)	37	Nerve trunk	37
Ganglia	38		
Sympathetic ganglion	38	Spinal gangli	38
III- Neuroglia	39		
A- Neuroglia proper	39		
1-Astrocytes	39	2- Oligodendrocytes	40
3-Microglia	40		
B- Other types of neuroglia	40		
<b>References.....</b>	<b>41</b>		

# THE CELL

The cell is the structural unit of the living organism. Organized animals possess millions of cells → tissues → organs → systems.

## The cells differ into:

### Shape:

Flat (Fig. 1a)- spindle (Fig. 1b)- cuboidal (Fig. 1c)- columnar (Fig. 1d)- triangular (Fig. 1e)- spherical (Fig. 1f)- irregular (star- shape, Fig. 1.g)- flagellated (Fig. 1h).

### Size:

Small - large.

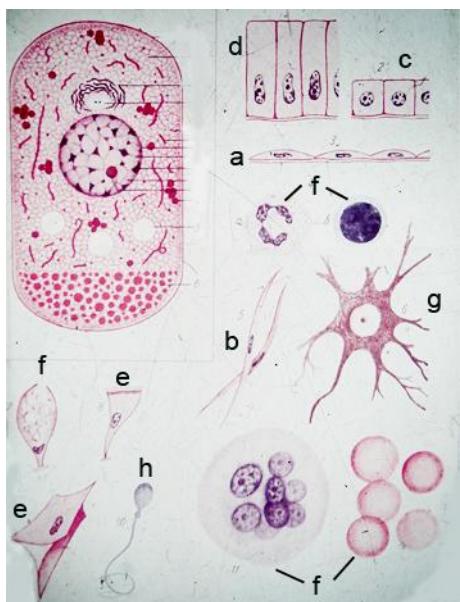


Fig.1: The morphology of a cell varies according to its function.

### The structure of the cell:

The cell (Fig. 2) consists of:

## I. Cell membrane.

## II. Cytoplasm.

## III. Nucleus.



Fig. 2 Structure of the cell. 1. The nucleus, 2. The nucleolus, 3. The nuclear membrane, showing nuclear pores, 4. Rough endoplasmic reticulum, 5. Smooth endoplasmic reticulum., 6. Golgi apparatus, 7. Centrioles, 8. Secretory granule, 9. Mitochondrion, 10. Phagocytosis, 11. Basal invagination, 12. Ribosome, 13. Cell membrane, 14. Endocytosis, 15. Microvilli, 16. Exocytosis, 17. Zonula occludens, 18. Zonula adherens, 19. Desmosome, 20. Hemidesmosome, 21. Basal lamina, 22. Residual body, 23. Glycogen, 24.Microtubule.

## I. The cell membrane

### (Plasmalemma):

\* L/M: Can not be seen.

\* E/M: Unit membrane.

75-100 Å in thickness.

Trilaminar membrane (Fig. 3& 4) consists of:

i) Osmiophilic layer: Electron dense.

ii) Osmiophobic layer: Less electron dense.

iii) Osmophilic layer: Electron dense.



Fig. 3: The plasmalemma of two neighbouring cells (arrows). Each is formed of trilaminar membrane consisting of two dark lines separated by an intermediate light zone.

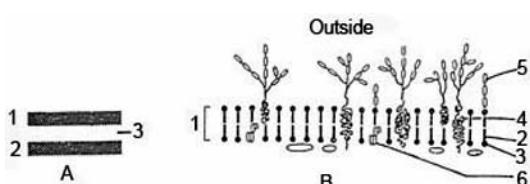


Fig. 4: A. The ultrastructure of the cell membrane: 1 + 2 - two electron dense osmophilic layers. 3 - A less electron dense osmiphobic layer. B. The molecular structure of the cell membrane: 1. Bimolecular lipid layer. 2. Hydrophobic (nonpolar) ends. 3. Hydrophilic (polar) ends. 4. Protein molecules. 5. Carbohydrate chains. 6. Cholesterol molecules.

## II- The cytoplasm:

Contains cell organelles and cell inclusions.

### A) The cell organelles:

Living materials.

Consist of:

i) Membranous cell organelles.

ii) Non-membranous cell organelles.

### i) The membranous cell organelles:

#### 1. Mitochondria:

\* They are also called:

- Power - house of the cell.
- Energy - producing center.
- Cell - respiration center.

\* L/M: Appear as black filaments and spheres when stained with iron-alum haematoxylin or acidophilic with trichrome (Fig. 5).

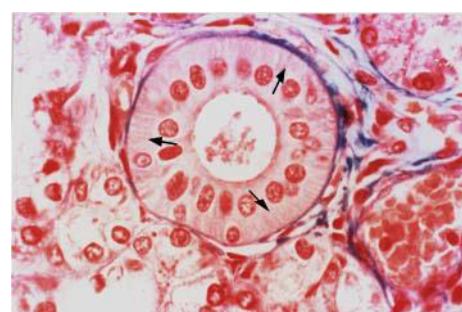


Fig. 5: The salivary duct, showing mitochondria (acidophilic basal striation, arrows), trichrome stain.

\* E/M: Tubules (Fig. 6), each consists of:

1. Outer membrane: smooth.
2. Inner membrane: folded (cristae).

3. Outer chamber.
4. Inner chamber = Matrix:  
Consists of:

Oxidative enzymes - DNA - RNA - Granules.

#### **Found into:**

- Muscle fibers.
- Heart.
- Liver.
- Kidney tubules.
- Sperms.

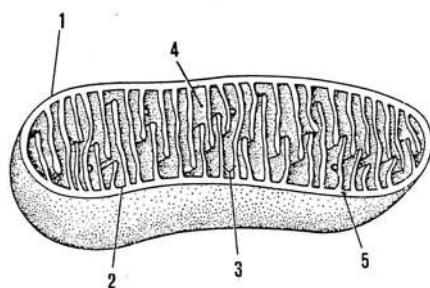


Fig. 6: The mitochondrion: 1. Outer membrane.  
2. Inner membrane. 3. Cristae. 4. Inner chamber. 5. Outer chamber.

## **2. Endoplasmic reticulum (ER):**

#### \* Types:

- a) Rough endoplasmic reticulum (rER):

\* L/M: Basophilia of the cytoplasm (Fig. 7).

\* E/M: Irregularly branched membranous tubules (CISTERNAE), covered with fixed ribosomes (Fig. 8).

#### **Found into:**

Pancreas - Nerve cells - Endocrines - Plasma cells.



Fig. 7: Serous acinus, showing basal basophilia (rER), H & E stain.

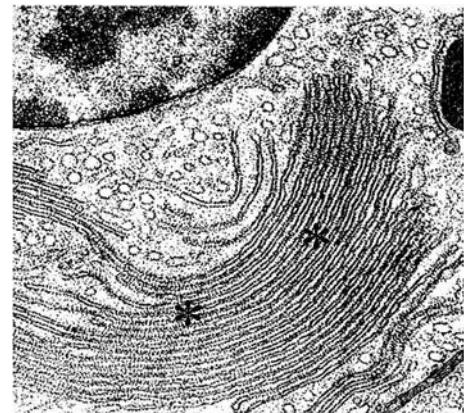


Fig. 8: Rough endoplasmic reticulum (asterisks) into a pancreatic acinar cell

- b) Smooth endoplasmic reticulum (sER)

\* L/M: Cannot be seen.

\* E/M: Irregular branched membranous tubules (CISTERNAE) with no ribosomes (Fig. 9).

#### **Found into:**

Testis - Skeletal muscles fibers - Heart.

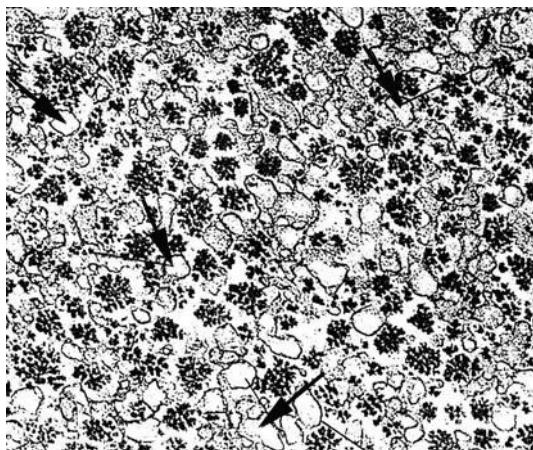


Fig. 9: Smooth endoplasmic reticulum into a liver cell (Arrows).



Fig. 10: A nerve cell, showing Golgi apparatus (arrowheads) surrounding the nucleus (arrow), silver impregnation.

### 3. Golgi apparatus:

\* L/M: Appears as clear unstained area near the nucleus (negative Golgi image) when stained with H&E. Appears as dark brown filaments and granules when stained with silver impregnation or Osmic acid (Fig. 10).

\* E/M:

A- Membranous saccules (STACKS),

Fig. 11, each has:

- i) Convex surface: immature (forming) face.
- ii) Concave surface: mature (secretory) face.

B- Transfer vesicles.

C- Secretory vesicles.

#### Found into:

Pancreas - Liver - Nerve cells.

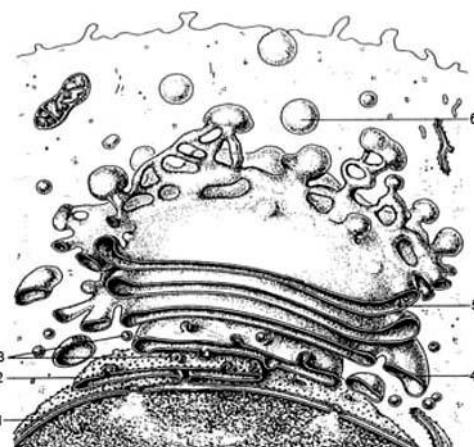


Fig. 11: The Golgi apparatus. 1. The nuclear membrane. 2. Rough endoplasmic reticulum. 3. Transfer vesicles. 4. Forming face of Golgi apparatus. 5. Secretory face of Golgi apparatus. 6. Secretory vesicle.

### 4. Lysosomes:

\* L/M: Histochemically (Acid phosphatase reaction).

\* E/M: Membranous vesicles containing lytic enzymes (Fig. 12).

#### Types:

a) Primary lysosomes:

Fresh vesicles.

b) Secondary lysosomes:

Primary vesicles fused to phagocytic vesicles.

#### **Found into:**

Macrophages - Neutrophil leukocytes  
- Monocytes.



Fig. 12: Lysosomes into the adrenal cortex (Arrows).

#### **5. Peroxisomes = Microbodies:**

\* L/M: Can not be seen.  
\* E/M: Membranous spheres (Fig. 13) containing enzymes e.g. catalase.

#### **Found into:**

Liver cells.

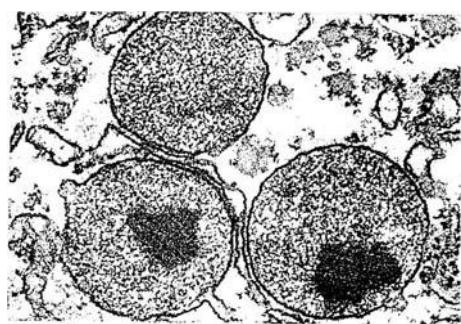


Fig. 13: Peroxisomes (Microbodies) into a liver cell.

#### **ii) The non-membranous cell organelles:**

##### **1. Ribosomes:**

- \* L/M: Cytoplasmic basophilia.
- \* E/M: Granules of RNA. (large subunit + small subunit).

##### **Types:**

- i) Monoribosomes: single.
- ii) Polyribosomes: groups.

Found into: Pancreas - Endocrines - Plasma cell.

##### **2. Centrioles:**

- \* L/M: Two spherical bodies.
- \* E/M: Two hollow cylinders perpendicular on each other.  
The wall of each cylinder consists of 9 triplets of microtubules (Fig. 14& 15).

#### **Found into:**

Ciliated cells, Sperms and Epidermis (skin).

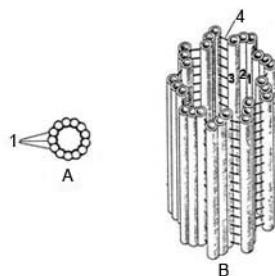


Fig. 14: The cytoplasmic microtubule and centriole. A- C.S. of microtubule: 1. Protofilaments ( $n=13$ ). B-L.S. of centriole: 1 + 2 + 3 = Microtubular triplets. 4- Protein links.

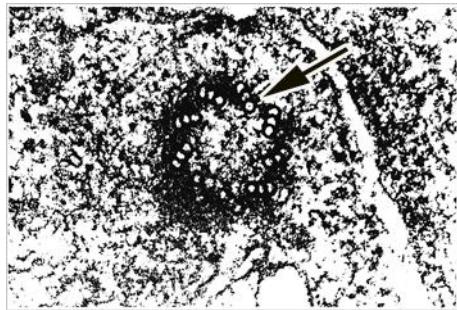


Fig. 15: Centriole into a pancreatic acinar cell.  
(Transverse section).

### 3. Cytoskeleton:

\* L/M: Could not be seen.

\* E/M: Consists of:

- i) Microfilaments (Fig. 16): Actin - myocin (sk. muscles).

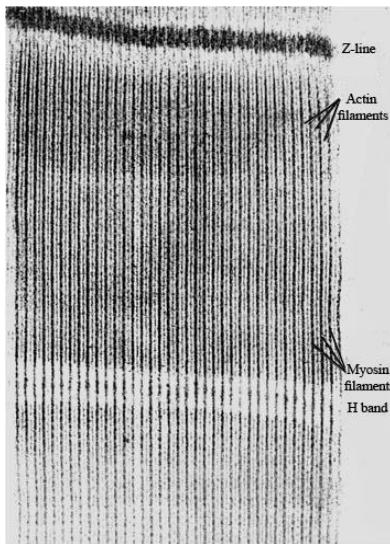


Fig. 16: Myofilaments (L.S.) into a skeletal muscle fiber

- ii) Microtubules: 13 protofilaments (Cilia).

- iii) Intermediate filaments: (Absorptive cells).

- iv) Microtrabeculae:

Connect microfilaments and microtubules with the cell organelles.

### B) The cell inclusions (Paraplasma):

Non-living materials.

#### 1. Stored food:

- a) Carbohydrates = glycogen (Best's carmine → Red). (PAS → purple, Fig. 17).

E/M: rosette- shape particles (Fig. 18).

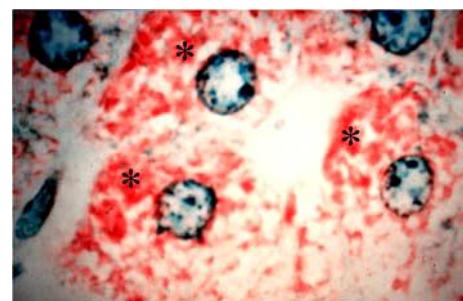


Fig. 17: Glycogen granules into the liver cells, PAS (asterisks).

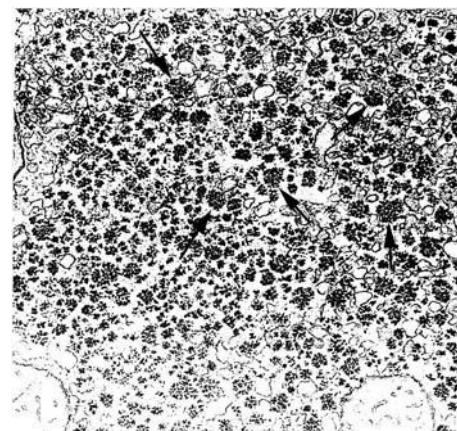


Fig. 18: Glycogen particles into a hepatic cell (E/M). Notice the rosette- shape particles of glycogen (alpha- particles, arrows).

b) Lipids = Fat (Sudan black → black), (Fig. 19).

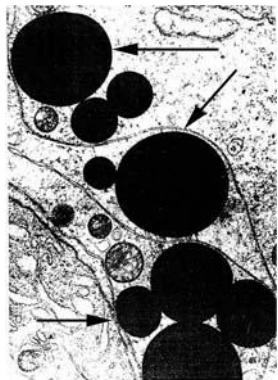


Fig. 19: Lipid droplets (arrows) into a Sertoli cell (E/M).

c) Proteins = (Bromophenol blue → blue)

## 2. Secretory granules:

Zymogen granules (H & E → Red, Figs. 7& 20).



Fig. 20: Secretory granules into the pancreatic acinar cells (asterisks), Azan stain.

## 3. Pigments:

- i) Exogenous = Carotin - dust - lipochrome.
- ii) Endogenous = Haemoglobin – melanin (Fig. 21).



Fig. 21: Melanin pigments (arrows) into a pigment cell from the iris (E/M).

## III- The nucleus:

Shape = spherical - oval - crescent - segmented (lobulated).

Size = small - large.

Structure:

### 1. Nuclear membrane:

- Double unit membrane (outer – inner (Fig. 22).
- Perinuclear space.
- Nuclear pores.

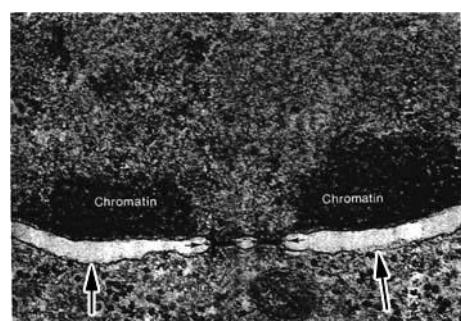


Fig. 22: A nuclear membrane (arrows) into an erythroblast

## **2. Chromatin:**

- i) Euchromatin: extended (active).
- ii) Heterochromatin: condensed (inactive, Fig. 23).  
Sex chromatin = condensed X-chromosomes (in females):
  - \* Drum-stick (in neutrophil leukocytes, Fig. 24).
  - \* Small dense granules adhering to the nuclear membrane (in oral epithelium).

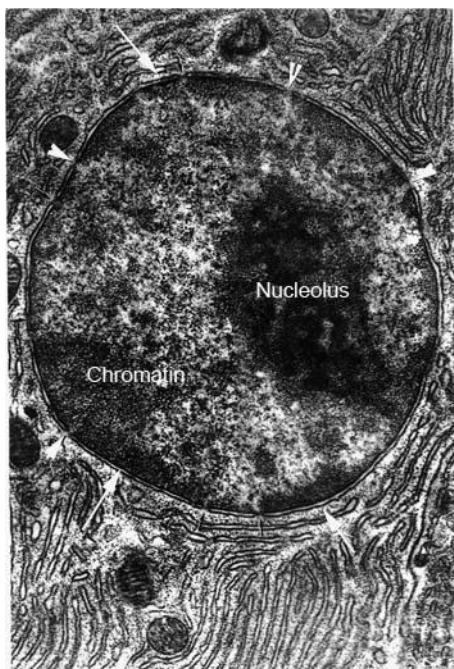


Fig. 23: Acinar cell from the pancreas. Notice the nuclear structure. Nucleolus. Nuclear membrane (arrows). Nuclear pores (arrowheads). Chromatin.

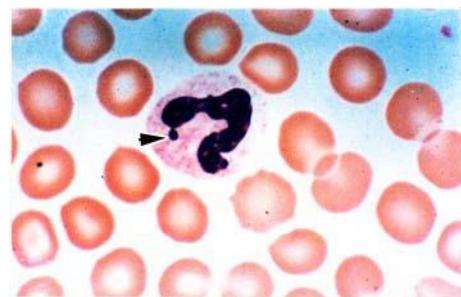


Fig. 24: The sex chromatin in a polymorphonuclear leukocyte (female). It has a drum-stick shape (arrowhead).

## **3. Nucleolus:**

(Fig. 23)

- i) Pars granulosa (RNA).
- ii) Pars fibrosa (DNA + RNA).
- iii) Perinucleolar chromatin.
- iv) Intranucleolar chromatin (DNA).
- v) Matrix (RNA).

## **4. Nuclear sap:**

Colloidal solution.

## THE EPITHELIAL TISSUE

The epithelial tissue is formed of closely aggregated cells with a very little intercellular substance.

It forms either membranes or glands.

### I- Epithelial membranes:

General features:

- Line body cavities.
- Cover body surfaces.
- Originate from the 3 germ layers.
- Lack blood vessels.
- Have terminal sensory nerves.
- Have a basement membrane.
- Divide mitotically.

Types:

#### A) Simple epithelium:

One layer.

i) Simple squamous epith.: Peritonium - pleura-blood vessels

(Figs. 25& 26).

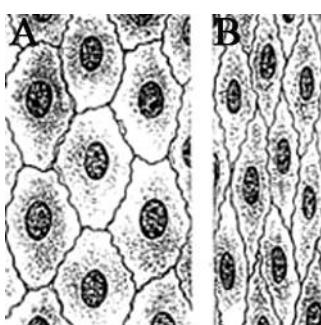


Fig. 25: Simple squamous epithelium (surface view). Endothelium of vein (A) and artery (B).

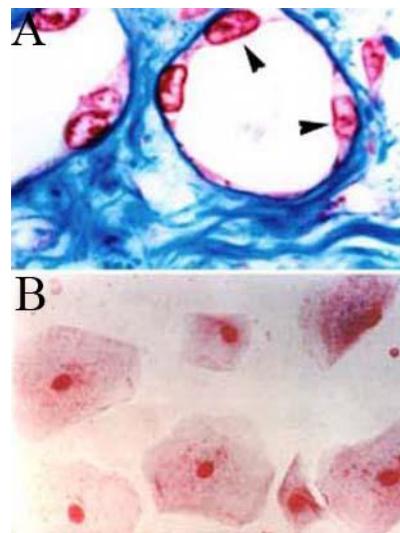


Fig. 26: Simple squamous epithelium, A: (Lateral view, arrowheads), Blood capillary (Azan stain). B: (Surface view), Buccal mucosa.

ii) Simple cuboidal epith.: Thyroid – ovary (Fig. 27).

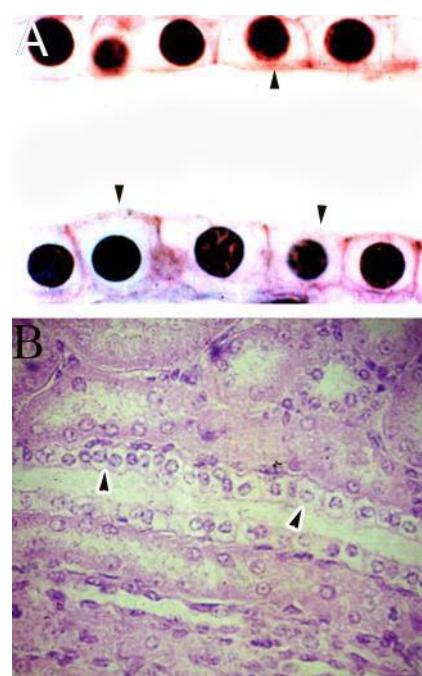


Fig. 27: Simple cuboidal epithelium into a collecting tubule (arrowheads, Kidney). A: (Azan stain), B: H & E.

### iii) Simple columnar epith.:

- Nonciliated: Stomach - intestine.
- Ciliated: Oviduct (Fig. 28).

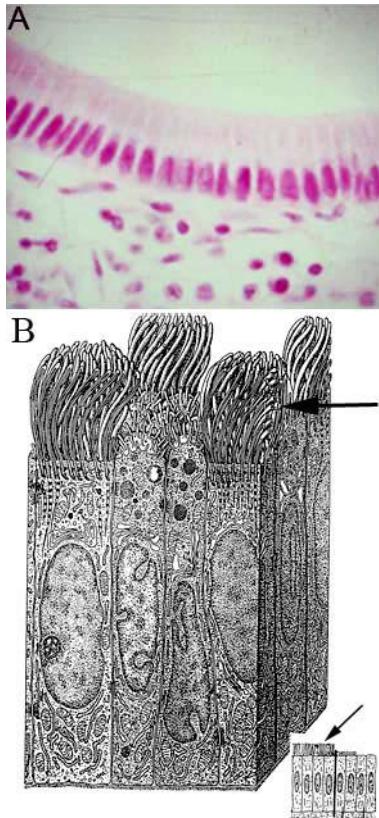


Fig. 28: Simple columnar epithelium. A: H & E. B: (Diagrammatic illustration) notice the kinocilia (arrows).

### iv) Pseudostratified columnar epith.:

Tall cells + short cells.

- Non ciliated: uterus.

- Ciliated:

a- Kinocilia: trachea (Fig. 29).

b- Stereocilia: epididymis.

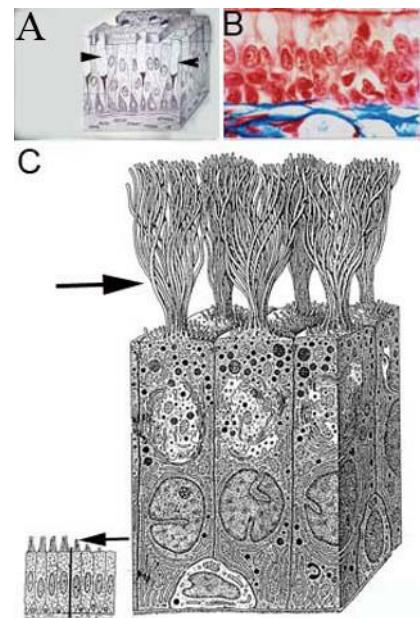


Fig. 29: Pseudostratified columnar ciliated epithelium with goblet cells (Trachea, arrowheads): A: Diagram, B: (Azan stain). C (Diagrammatic illustration) showing stereocilia (arrows).

## B) Stratified epithelium:

Several layers.

### i) Stratified squamous epithelium:

- Basal: Columnar cells.
- Middle: Polyhedral, cells.
- Superficial: Flat cells.

### Types:

- Non cornified: Oesophagus (Fig.30A).
- Cornified: Hard palate (Fig.30B&C).

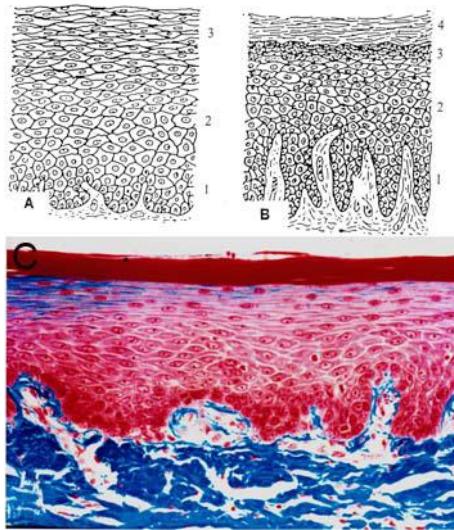


Fig. 30: A) Stratified squamous non-cornified epithelium. B) Stratified squamous cornified epithelium. C) Stratified squamous cornified epithelium (Azan stain). 1. Columnar or cuboidal cells. 2. Polyhedral cells. 3. Squamous cells. 4. Horny layer (keratin).

#### ii) Stratified columnar epithelium:

- Basal: Columnar cells.
- Middle: Polyhedral cells.
- Superficial: Columnar cells.
- Large ducts of salivary glands (Fig. 31).



Fig. 31: Stratified columnar epithelium (Azan stain).

iii) Stratified cuboidal epithelium:  
Two layers of cuboidal cells (Fig. 32).

- Ducts of the mammary glands.



Fig. 32: Stratified cuboidal epithelium (H & E).

#### iv) Transitional epithelium:

- Basal: Cuboidal cells (Fig. 33a).
- Middle: Pear -shaped cells (Fig. 33b).
- Superficial: dome-shaped cells (Fig. 33c).
- Ureter - Urinary bladder (empty)

In case of full bladder:

- Basal : Cuboidal.
- Superficial: flat.



Fig. 33: Transitional epithelium (Azan stain).

## **II- Glands:**

1. Endocrine glands: Ductless-secrete hormones.

2. Exocrine glands:

i) Unicellular glands: Goblet cells (intestine).

ii) Multicellular glands: Duct(s) + End-piece(s).

### **Classification:**

#### **According to:**

##### **1. The shape:**

i) Simple glands: Single duct.

- S. tubular (sweat glands, Fig. 34a).
- S. alveolar (sebaceous glands, Fig. 34b).
- S. tubulo-alveolar (small salivary glands, Fig. 34c).

ii) Branched glands: Branched end-pieces.

- B. tubular (gastric glands, Fig. 34d).
- B. alveolar (tarsal glands, Fig. 34e).
- B. tubulo-alveolar (prostate, Fig. 34f).

iii) Compound glands: Branched ducts.

- C. tubular (liver, kidney, Fig. 34g).
- C. alveolar (mammary gland, Fig. 34h).

- C. tubulo – alveolar (pancreas, Fig. 34i).

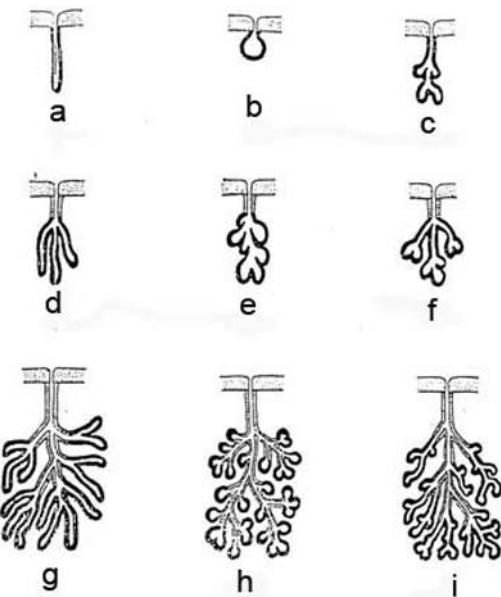


Fig. 34: Classification of the multicellular glands according to the shape: a- Simple tubular gland. b- Simple alveolar gland. c- Simple tubulo-alveolar gland. d- Branched tubular gland. e- Branched alveolar gland. f- Branched tubulo-alveolar gland. g- Compound tubular gland. h- Compound alveolar gland. i- Compound tubulo-alveolar gland.

##### **2. The nature of secretion:**

###### **i) Serous end-pieces:**

- Pyramidal cells.
- Rounded nucleus.
- Narrow lumen.
- Pancreas – parotid (Fig. 7& 35).

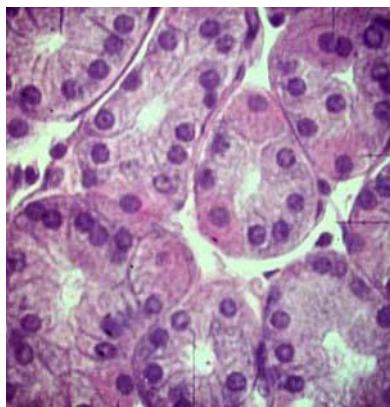


Fig. 35: Serous gland, H & E.

ii) Mucous end - pieces:

- Cuboidal cells.
- Flat nucleus.
- Wide lumen.
- Palatine salivary gland (Fig. 36).

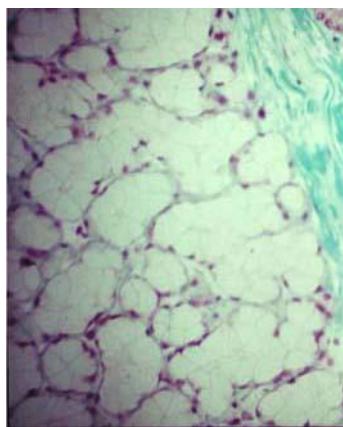


Fig. 36: Mucous gland (Trichrome stain).

iii) Mixed end-pieces:

- Crecents.
- Cell by cell.
- Acinus by acinus.
- Mandibular salivary glands (Fig. 37A& B).

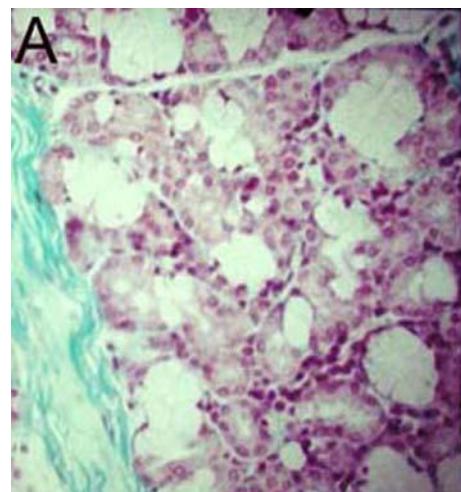


Fig. 37: A: Mixed gland (Trichrome stain). B: Mixed end-piece, H & E.

### 3. The mode of secretion:

i) Merocrine glands:

- No loss of cytoplasm.
- Pancreas.

ii) Apocrine glands:

- Loss of the cell apex.
- Mammary gland.

iii) Holocrine glands:

- Destruction of the whole cell.
- Sebaceous gland (Fig. 38).



Fig. 38: Sebaceous gland, H & E.

## **Modifications of the epithelial cells to correlate certain functions:**

### **I- Modifications in cell surfaces:**

#### **A) Basal border:**

a- Basal infoldings: Long invaginations of the basal plasma membrane.

Found into: ion-transport cells

e.g. the proximal convoluted tubules of the kidney (Fig. 39).

b- Hemidesmosomes: These structures take the form of half a desmosome on the epithelial cell plasmalemma. They probably serve to bind the epithelial cell to the subjacent basal lamina. Found into epidermis.

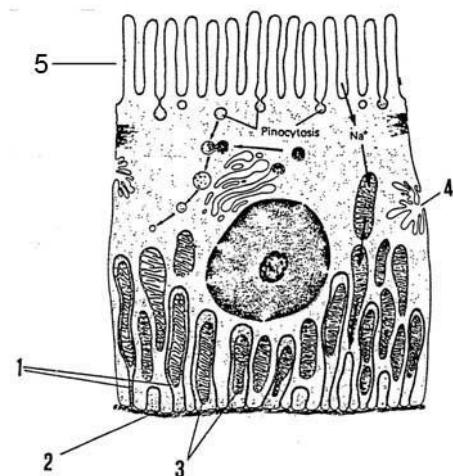


Fig. 39: Ion - transport cell: Showed 1 - Invaginations of the basal cell membrane. 2- Basement membrane. 3- Mitochondria. 4 - Invaginations of the lateral cell surface. 5- Apical microvilli.

The basal border rests on a basement membrane which consists of :

1. Basal lamina: granular (glycoprotein).
2. Middle layer: amorphus (protein + polysacch.).
3. Reticular layer: reticular fibers.

#### **B) Apical border:**

1. Striated border = Microvilli (Fig. 39).

#### **2. Cilia:**

a) Stereocilia (Fig. 29).

b) Kinocilia (Fig. 28& 40):

- Peripherally: 9 double microtubules.
- Centrally: 1 double microtubule.

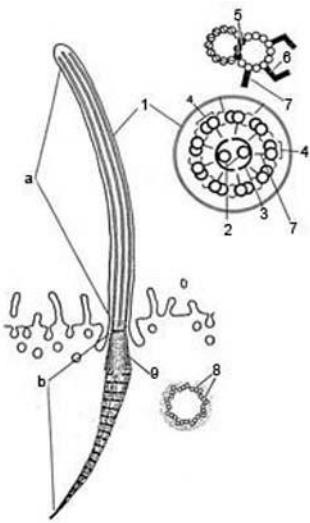


Fig. 40: The cilium (Kinocilium): a - The shaft; 1. Cell membrane. 2. Two central microtubules. 3. Central sheath. 4. Nine double peripheral microtubules. 5. 2-3 protofilaments. 6. Nexins. 7. Radial spokes. b- The base: 8. Nine triple peripheral microtubules. 9. Basal body.

### 3. Flagella:

They are similar in structure to cilia but are much longer and single. They are found into spermatozoa.

### C) Lateral border:

1. Zonula occludens (intestine), Fig. 41.
2. Zonula adherens (intestine), Fig. 41.
3. Desmosome (intestine + skin), Fig. 41& 42.

$1+2+3 =$  Junctional complex (intestine).

4. Gap junction (Heart - intestine), Fig. 41& 43.

### 5. Interdigitated membranes (Kidney).

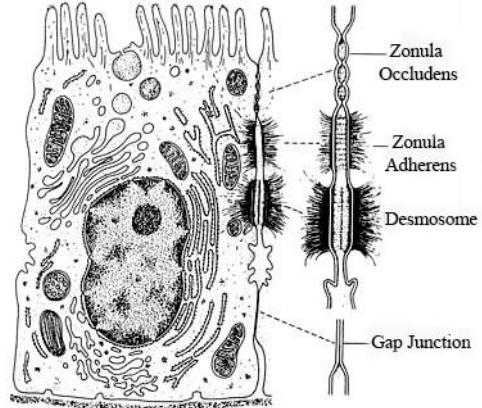


Fig. 41: Specialization of the lateral border

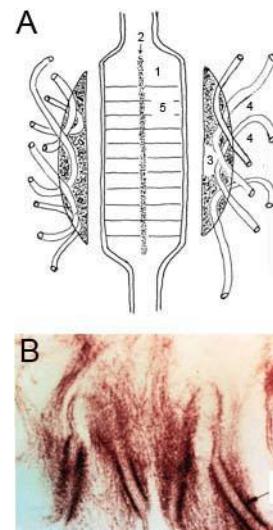


Fig. 42: Macula adherentes (Desmosome): A: 1- Intercellular space. 2 - Electrons opaque central line. 3- Dense attachment plate. 4- Microfilaments (tonofilaments). 5- Transemembrane linker. B: (arrow).

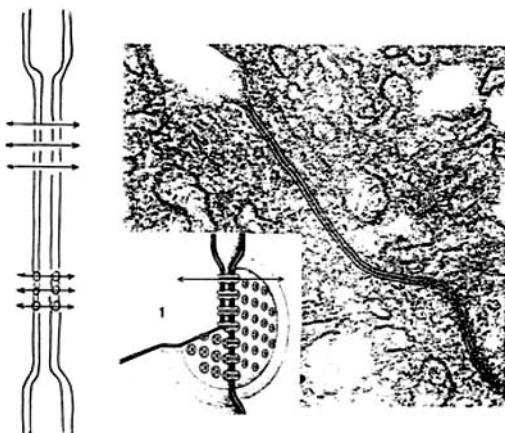


Fig. 43: Gap junction: 1 - Parallel hollow tube-like protein structure.

## II- Modifications in cell constituents:

1. Protein - secreting cell = Abundant rER.

**Found into:** Pancreas.

2. Glyco-protein-secreting cell: Abundant mucigen granules.

**Found into:** Goblet cell

3. Steroid-secreting cell = Abundant sER.

**Found into:** Testis.

4. Iron-transport cell = Abundant mitochondria (Fig. 39).

**Found into:** Kidney.

5. Neuro-epithelial cell = Abundant microvilli (Fig. 44).

**Found into:** Taste buds.

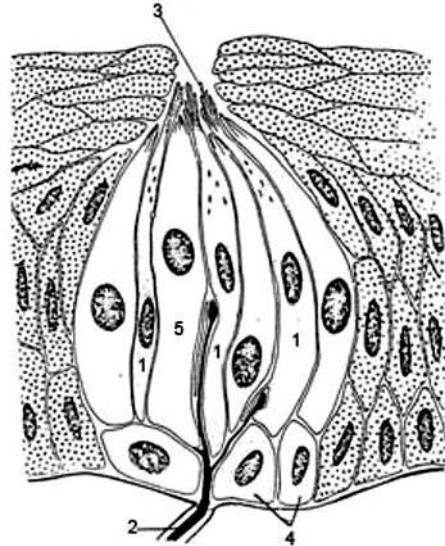


Fig. 44: Taste bud: 1 - Neuroepithelial cell. (Light cell). 2 - Nerve ending. 3 - Microvilli. 4 - Basal cells. 5 - Supporting cells. (Dark cell).

6. Epithelial reticular cell = Abundant cytofilaments (Fig. 45).

**Found into:** Thymus.

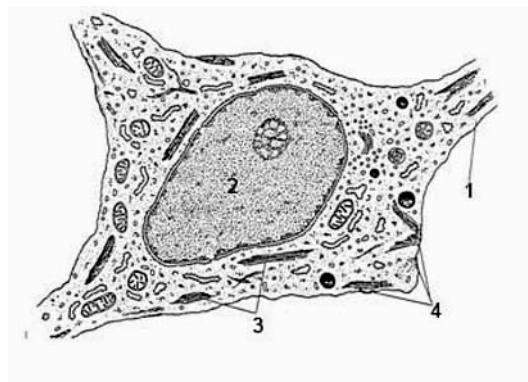


Fig. 45: Epithelial reticular cell: 1- Cytoplasmic process. 2- Nucleus. 3- Cytofilaments. 4- Desmosome.

6. Myoepithelial cell = Abundant myofilaments (Fig. 46).

**Found into:**

Salivary glands - mammary gland.

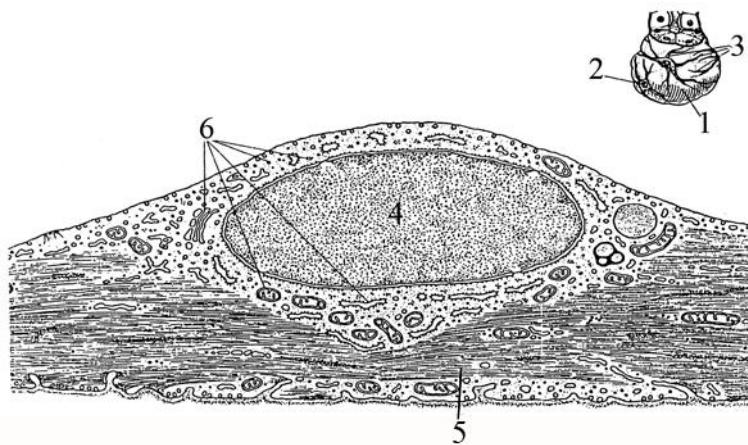


Fig. 46: Myoepithelial cell "Basket cell": 1 - Salivary adenomere. 2- Myoepithelial cell.

3- Cytoplasmic processes. 4- Nucleus. 5- Myofilaments. 6 - Cell organelles.

## THE CONNECTIVE TISSUE

The connective tissue is formed of widely scattered cells with plentiful intercellular substance.

### Structure:

The connective tissue consists of:

- A) The cellular elements.
- B) The connective tissue fibers.
- C) The matrix or ground intercellular substance.

#### A) The cellular elements:

##### 1.Undifferentiated mesenchymal cells (UMC):

- Small branching cells (Fig. 47).
- Large pale nucleus.
- Divide and differentiate into other cell types.

**Found into:** The embryo around the blood capillaries.

##### 2. Fibroblast cells:

Two types:

- a) Young active cells (Fibroblasts):
  - Large cells with cytoplasmic processes (Fig. 48A).
  - Large pale nucleus.
  - Basophilic cytoplasm (rich in rER).
- b) Mature inactive cells (Fibrocytes):
  - Smaller, spindle-shaped (Fig. 48B).
  - Small dark nucleus.

- Acidophilic cytoplasm.

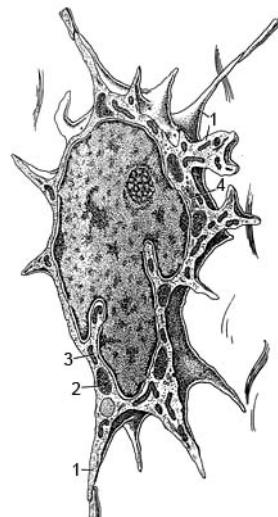


Fig. 47: Undifferentiated mesenchymal cell. 1. Cytoplasmic processes. 2. Mitochondria. 3. Rough endoplasmic reticulum. 4. Golgi apparatus.

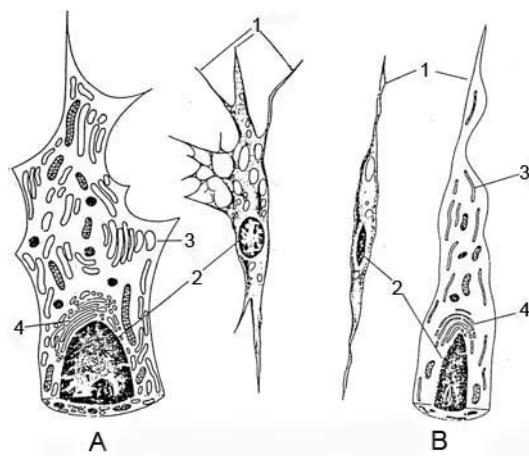


Fig. 48: A- Fibroblast; B - Fibrocyte: 1- Cytoplasmic processes. 2- Nucleus. 3- Rough endoplasmic reticulum. 4- Golgi apparatus.

##### 3. Macrophages:

- Oval, rounded, branched cells (Fig. 49).
- Small, kidney-shaped nucleus.

- Many lysosomes - Many mitochondria - Well developed Golgi apparatus.

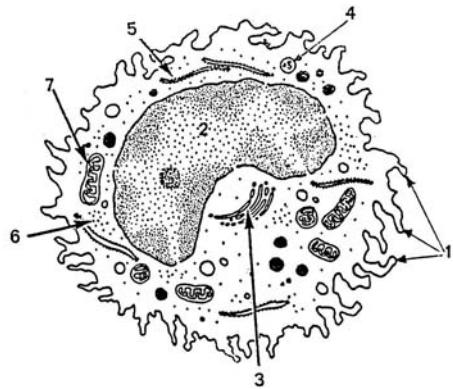


Fig. 49: Macrophage: 1. Cytoplasmic processes. 2. Nucleus. 3. Golgi apparatus. 4. Lysosome. 5. Rough endoplasmic reticulum. 6. Free ribosomes. 7. Mitochondria.

#### 4. Plasma cells:

- Large, round or oval cells (Fig. 50).
- Eccentric, rounded nucleus (cart - wheel or clock – face chromatin).
- Highly basophilic cytoplasm (rER).
- Well developed Golgi apparatus (Antibodies).

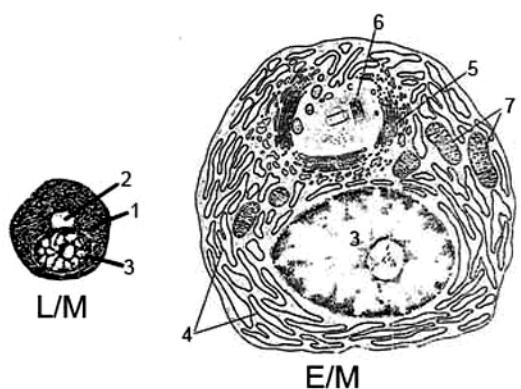


Fig. 50: Plasma cell: 1. Basophilic cytoplasm. 2. Juxtanuclear pale area. 3. Nucleus. 4. Rough endoplasmic reticulum. 5. Golgi apparatus. 6. Centrioles. 7. Mitochondria.

#### 5. Mast cells:

- Large, oval, rounded or irregular cells (Fig. 51).
- Central nucleus.
- Metachromatic cytoplasmic granules (Heparin - histamin - serotonin) - Toluidine blue → Red.

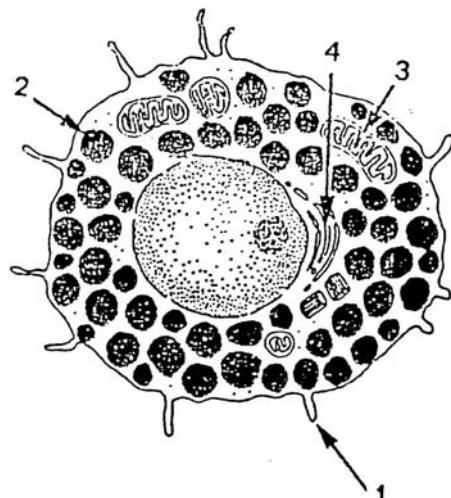


Fig. 51: Mast cell: 1. Cytoplasmic processes. 2. Coarse cytoplasmic granule. 3. Mitochondria. 4. Golgi apparatus.

#### 6. White fat cells: "Unilocular adipocytes".

- Large, oval or rounded cells (Fig. 52).
- Flat, peripheral nucleus.
- Cytoplasm is occupied by a large fat globule (Signet - ring).

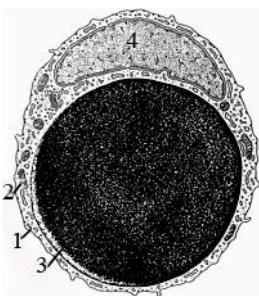


Fig. 52: White fat cell: (Unilocular adipocyte).

- 1. Cytoplasm (thin film).
- 2. Mitochondria.
- 3. Fat globule.
- 4. Nucleus.

- Cytoplasm contains melanin pigments.

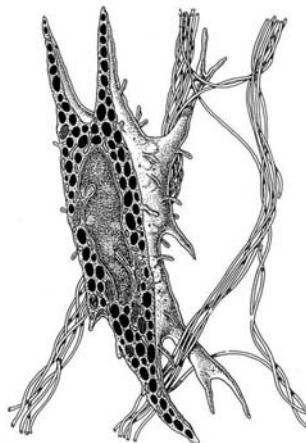


Fig. 54: Pigment cell.

## 7. Brown fat cells: "Multilocular adipocytes"

- Smaller, polygonal cells.
- Spherical eccentric nucleus.
- Cytoplasm contains multiple small fat droplets and many cytochrome-rich mitochondria (Fig. 53).

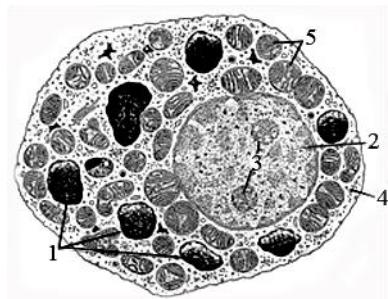


Fig. 53: Brown fat cell: (Multilocular adipocyte). 1. Small lipid droplets. 2. Nucleus. 3. Nucleoli. 4. Cytoplasm (abundant). 5. Mitochondria.

## 8. Pigment cells:

- Large, branched cells (Fig. 54).
- Small, rounded nucleus.

## 9. Eosinophil leukocytes:

- Rounded or oval cells (Fig. 55).
- Nucleus is bilobed.
- Cytoplasm contains coarse acidophilic granules.

### E/M:

The cytoplasmic granules consist of:

- Matrix.
- Equatorial band.

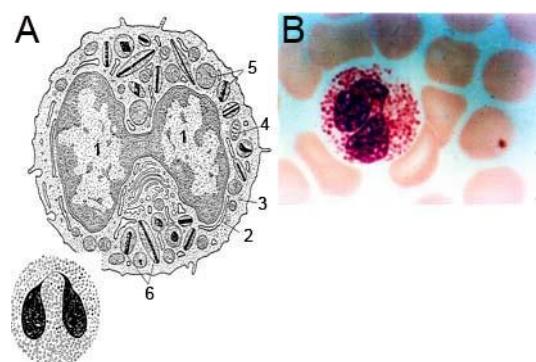


Fig. 55: Eosinophil leukocyte, A: 1 - Nucleus. 2 - rER (Few). 3 - Free ribosomes. 4 - Mitochondria (small). 5- Cytoplasmic granules. 6 - Equatorial band. B: Blood film.

## B) The connective tissue fibers:

### 1. White collagenous fibers:

- Run in wavy bundles.
- The bundles branch but the fibers do not branch.
- Stain blue with Mallory's stain.
- Found into tendons (Fig. 56).

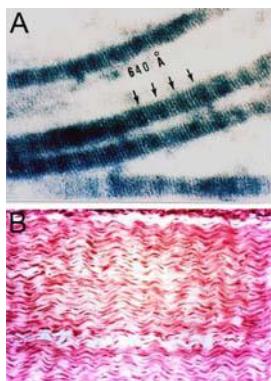


Fig. 56: A: The collagenous fibrils showing periodicity of light and dark bands. B: Tendon (L.S.) H&E.

### 2. Yellow elastic fibers:

- Thin-long (Fig. 57).
- Branch and form networks.
- Stain brown with orcein or deep blue with Resorcin-fuchsin.
- Found into lung - aorta.

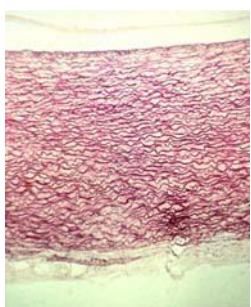


Fig. 57: Elastic fibers into the wall of aorta, orcein stain.

### 3. Reticular fibers: (Argyrophilic fibers).

- Very thin.
- Branch and form fine networks.
- Stain black with Ag N03 (Fig. 58).
- Found into spleen - liver.

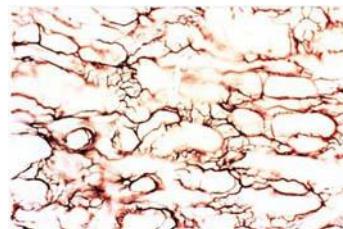


Fig. 58: Reticular fibers within the hepatic lobule (silver impregnation).

## C) The matrix:

### Consists of:

1. Amorphous viscid (jelly - like) substance (mucopolysacch.).
2. Tissue fluid.

### Types of connective tissue:

#### I- Connective tissue proper:

##### 1. Loose connective tissue:

- All c.t. cells (Fig. 59).
- All c.t. fibers.
- Matrix.

**Found into:** subcutaneous c.t.

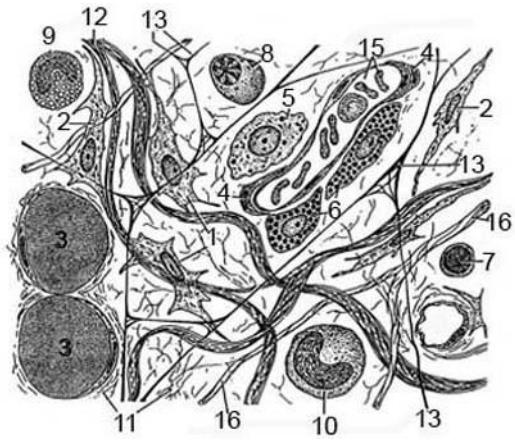


Fig. 59: Loose connective tissue. 1. Fibroblasts. 2. Fibrocytes. 3. Fat cells. 4. Pericytes. 5. Macrophages. 6. Mast cells. 7. Lymphocytes. 8. Plasma cells. 9. Eosinophilic leukocyte. 10. Monocyte. 11. Reticular fibers. 12. Collagenous fibers. 13. Elastic fibers. 14. Lymphatic vessels. 15. Blood vessels. 16. Nerve fibers.

## 2. Dense fibrous connective tissue:

### A) Dense white fibrous c.t.:

= Dense regular white fibrous c.t.:

- Collagenous fibers (Dense parallel bundles), Fig. 60.
- Fibroblasts (compressed).
- Matrix - poor in blood vessels.

**Found into:** Tendons.

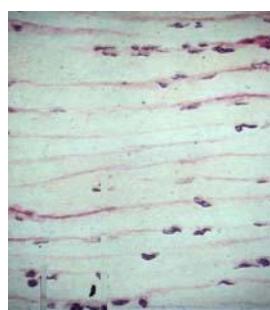


Fig. 60: Tendon (L. S.), Picrocarmine stain.

### B) Dense elastic connective tissue:

= Dense regular elastic c.t.:

- Elastic fibers (parallel), Fig. 57.
- Few collagenous fibers.
- Fibroblasts.

**Found into:** Ligamentum nuchae.

## 3. Adipose connective tissue:

### A) White adipose tissue:

- White fat cells - (lobules - lobes).
- Reticular fibers.
- Numerous blood vessels.

**Found into:** hump of camel -tail of sheep.

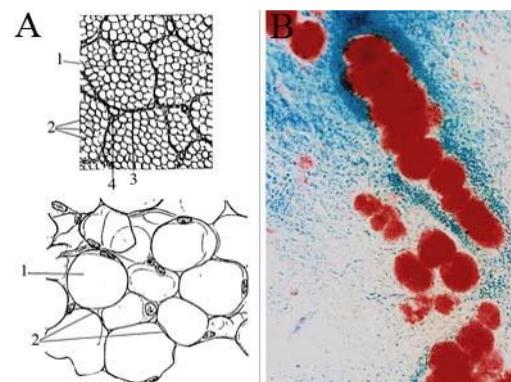


Fig. 61: White adipose c. t. A: 1. Fat cells (signet ring). 2. Reticular fibers. 3. C. t. septa. 4. Blood vessel. B: Oil red O.

### B) Brown adipose tissue:

- Brown fat cells, Fig. 62.
- Reticular fibers.
- Many blood vessels.

**Found into:** rodents.

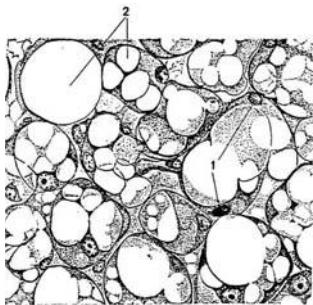


Fig. 62: Brown adipose tissue. 1. Nucleus. 2. Lipid droplets.

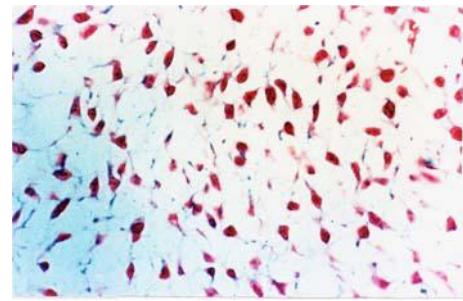


Fig. 64: Mesenchymal connective tissue, Azan stain.

#### 4. Reticular connective tissue:

- Reticular fibers, Fig. 63.
- Reticular cells (similar to UMC).

**Found into:** spleen - liver.

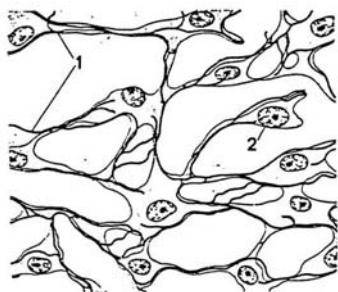


Fig. 63: Reticular connective tissue 1. Reticular fibers. 2. Reticular cells.

#### 5. Embryonic connective tissue:

##### A) Mesenchymal c.t.:

- UMC, Fig. 64.
- Amorphous ground substance.
- Few fibroblasts.

**Found into:** the embryo.

##### B) Mucous c.t.:

- Fibroblasts (Fig. 65, arrowheads).
- Amorphous ground substance.
- Fine collagenous fibers.

**Found into:** umbilical cord.

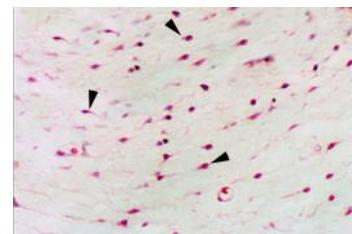


Fig. 65: Mucous c. t. fibroblasts (arrowheads), H & E.

## II- Cartilage:

**Formed of:**

### A) Cartilage cells:

#### 1. Chondroblasts:

- Flat.
- Basophilic cytoplasm.
- Oval nucleus.
- Present into the perichondrium.

#### 2. Chondrocytes:

- Oval - rounded - semicircular.

- Cytoplasm is granular with Golgi apparatus + rER + Glycogen.
- Nucleus is rounded - vesicular.
- Located in lacunae surrounded by capsules.
- May be found in groups (2 - 4 - 8 cells) = isogenous groups.
- Produce collagen and elastic fibers.

### B) Intercellular substance:

- a) Collagenous or elastic fibers.
- b) Matrix = glycoprotein.

### Perichondrium:

- a) Outer fibrous layer.
- b) Inner chondrogenic layer (chondroblasts).

### Types of cartilage:

#### 1. Hyaline cartilage:

- Matrix: basophilic (chondroitin sulphate), Fig. 66.
- Collagenous fibers (few).

**Found into:** larynx-trachea.

#### 2. Elastic fibrocartilage:

- Network of elastic fibers (Fig. 67).

**Found into:** Ear pinna - epiglottis.

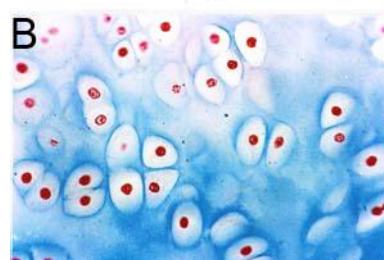
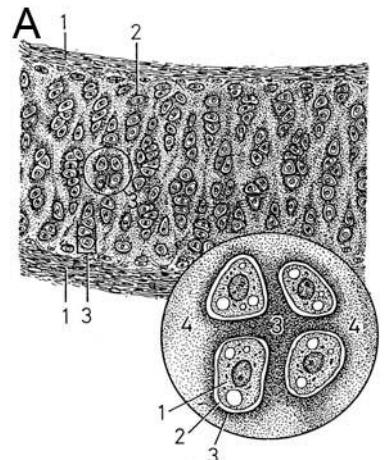


Fig. 66, A: Hyaline cartilage. 1. Perichondrium. 2. Chondrocyte (single). 3. Chondrocytes (group). Inset: 1. Chondrocyte. 2. Lacuna. 3. Capsule. 4. Matrix. B: Hyaline cartilage, Trichrome stain.

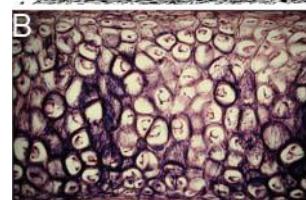
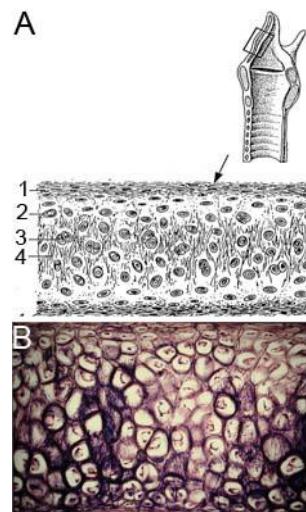


Fig. 67: Elastic cartilage. Epiglottis. 1. Perichondrium. 2. Chondrocyte single. 3. Chondrocytes (isogenous group). 4. Elastic fibers. B: Elastic cartilage, Resorcin-fuchsin stain.

### **3. White fibrocartilage:**

- Small groups of chondrocytes arranged into rows (Fig. 68).
- Bundles of Collagenous fibers.
- No perichondrium.

**Found into:** Intervertebral discs.

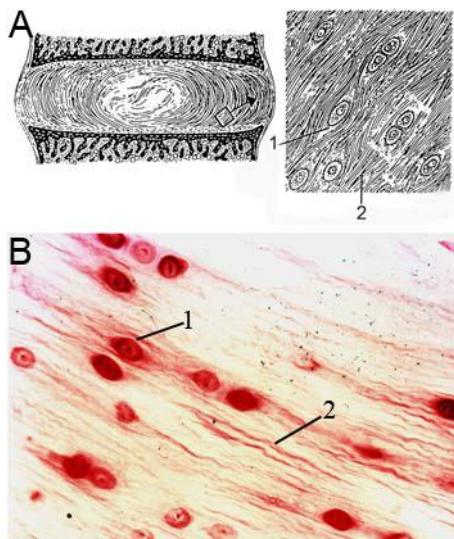


Fig: 68: White fibrocartilage. A: Intervertebral disc. B: Light microscopic magnification. 1- Chondrocytes. 2- Collagenous fibers. C: White fibrocartilage, H&E

## **III- Bone:**

### **Formed of**

#### **A) Bone cells:**

##### **1. Osteogenic cells:**

- Similar to UMC.

##### **2. Osteoblasts:**

- Small – branched cells.
- Nucleus is oval, pale, eccentric.
- Basophilic cytoplasm.

- Found into periosteum and endosteum (Fig.69).

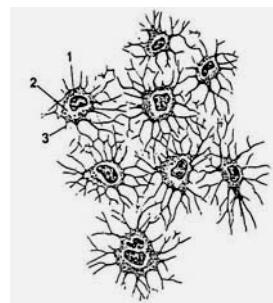


Fig. 69: Osteoblasts. 1. Nucleus. 2. Cytoplasm. 3. Cytoplasmic processes .

#### **3. Osteocytes:**

- Almond – shape cells (Fig. 70).
- Nucleus is elongated.
- Basophilic cytoplasm.
- Cytoplasmic processes.
- Located within lacunae - canaliculi.
- Produce bone matrix.



Fig. 70: Osteocytes. 1. Nucleus. 2. Cytoplasm. 3. Lacuna. 4. Canaliculus. 5. Cytoplasmic processes.

#### 4. Osteoclasts:

- Large - branched – motile cells.
- Multinucleated (5 - 50 nucleus), Fig.71.
- Cytoplasm is acidophilic (lysosomes).
- Found within grooves = Howship's lacunae.
- Brush border = comb - shaped.
- Produce proteolytic enzymes.

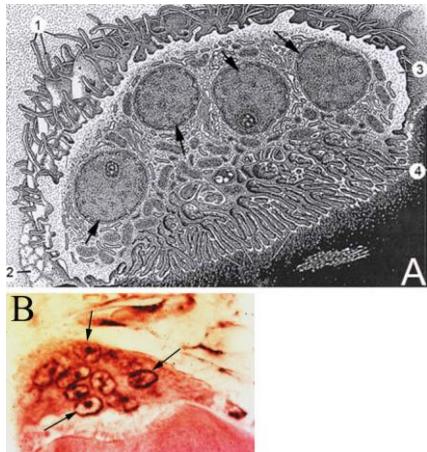


Fig. 71: A: Osteoclast. 1. Microvillous cytoplasmic processes. 2. Howship's lacunae. 3. Belt of cytoplasm free of organelles 4. Microvillous processes. Nuclei (arrows) B: Osteoclast, H&E.

#### B) Matrix:

= Bone lamellae

Consist of collagenous fibers and calcium salts.

#### Types of bones:

##### 1. Cancellous bone (spongy bone):

Branched bone trabeculae = formed of bony lamellae containing osteocytes and are covered by osteoblasts (Fig.72).

**Found into:** - Head of long bones.

- Ribs.
- Sternum.

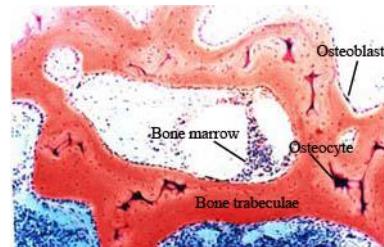


Fig. 72: Cancellous bone (Spongy bone).

##### 2. Compact bone:

**Consists of:**

- a) Haversian system(s) = Osteon(s):
  - Haversian canal (Bl. ves.).
  - Haversian lamellae (concentrically arranged).
  - Osteocytes (concentrically arranged).
- b) Interstitial lamellae (non-Haversian system).
- c) Outer circumferential lamellae.
- d) Inner circumferential lamellae.

**Found into:** Shaft of long bones,  
Fig.73.

**Volkmann's canals:**

Transverse canals between the Haversian canals.

**Periosteum and endosteum:**

**Consists of:**

- a) Outer fibrous layer.
- b) Inner vascular layer.  
(containing the osteoblast cells).

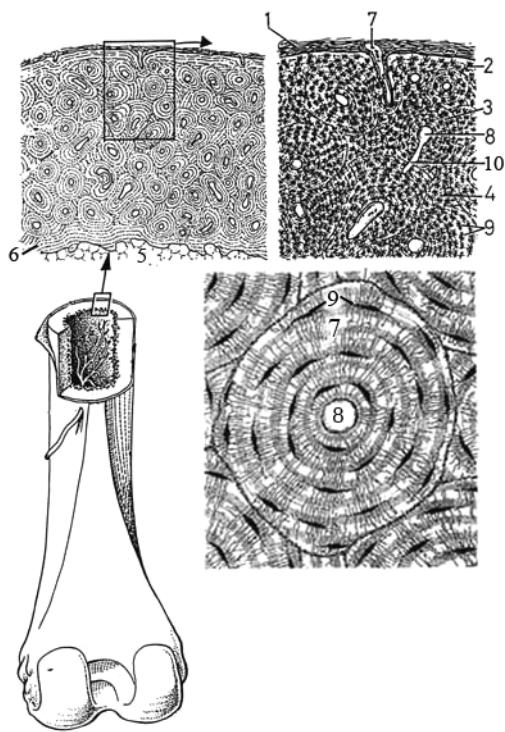


Fig. 73: Compact bone. 1. Periosteum. 2. Outer circumferential lamellae. 3. Haversian system (osteon). 4. Interstitial lamellae. 5. Medullary cavity (marrow cavity). 6. Inner circumferential lamellae. 7. Concentric bone lamellae. 8. Haversian canal. 9. Osteocytes. 10. Volkmann's canals

**Ossification (development of bone):**

**1- Intramembranous ossification:**

Occur within a membrane of mesenchymal c.t. which is converted into bone.

e.g. Flat bone of the skull.

**2- Intracartilagenous ossification:**

In this method cartilage is replaced by bone.

e.g. epiphyseal plate of cartilage.

Stages: Fig. 74

I- Resting cartilage: A piece of hyaline cartilage.

II- Zone of Proliferation: The chondrocytes are increase in number and arrange themselves into rows.

III- Zone of hypertrophy or maturation: The chondrocytes increase in size, accumulate glycogen and become rich in phosphatase.

The lacuna also widen and become separated by thin bars of matrix.

**IV- Stage of calcification:**

The chondrocytes deposit calcium salts around themselves, die and degenerate.

The lacunae open on each other forming longitudinal canals.

V- Stage of ossification (stage of invasion).

The osteoblasts deposit bone lamellae on the calcified matrix.

VI- Stage of spongy bone.

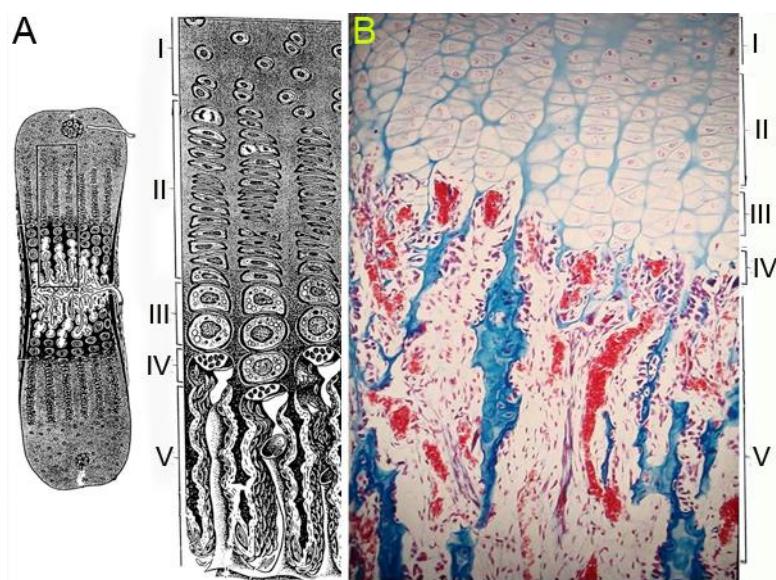


Fig. 74: A& B. Intracartilagenous ossification; I- Resting cartilage. II- Zone of proliferation. III- Zone of hypertrophy. IV- Stage of calcification. V- Stage of ossification. B: Azan stain.

## BLOOD

### Consists of:

65% blood plasma.  
35% formed elements.

### Formed elements:

#### I- Erythrocytes (Red blood corpuscles):

##### A) Mammalian erythrocytes:

- Non-nucleated, rounded, biconcave discs (Fig.75A.1 & B).
- Contain haemoglobin.
- Largest in dogs (7 mic.).
- Smallest in sheep (4 mic.).

##### In camel and llama (Tylopoda):

- Elliptical, non-nucleated (Fig.75A.2).

##### B) Avian erythrocytes:

- Oval, biconvex, nucleated (Fig.75A.3 & C).

##### C) Reptiles, Fish, Frog erythrocytes:

- Ovoid, biconvex, nucleated.

#### II- Leukocytes (white blood cells):

##### 1. Granular leukocytes: "Granulocytes"

###### a) Neutrophil leukocytes:

- = Polymorphonuclear leukocytes.
- Nucleus: 3-5 segments (Fig. 76).

- Neutrophilic cytoplasmic granules.

### E/M:

- Large granules = lysosomes.
- Small granules = bacterial substance.

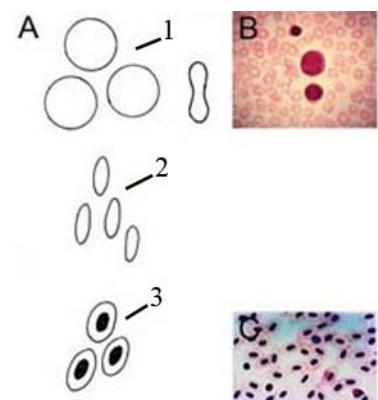


Fig. 75: Red blood corpuscles: A.1& B- Mammals. A.2- Tylopoda (camel and llama). A.3& C- Birds.

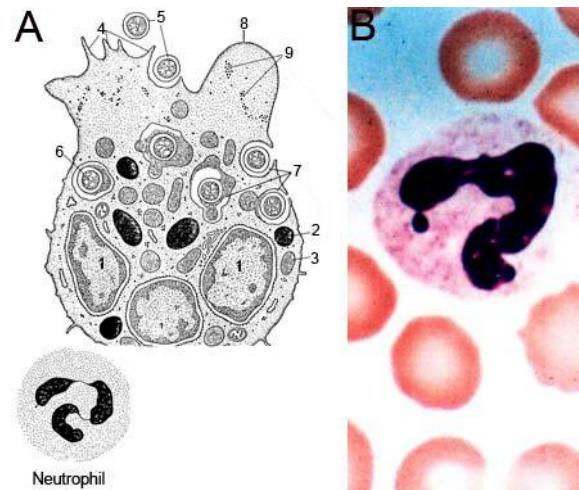


Fig. 76: Neutrophil or polymorphonuclear leukocyte. A: 1- Nucleus. 2- Large azurophilic granules. 3- Small specific granules. 4- Cytoplasmic arms. 5- Bacterium. 6- Phagocytic vacuole. 7- Specific granule joining a phagocytic vacuole. 8- Pseudopodia. B: Blood Film.

**b) Eosinophil leukocytes:**

See page 20.

**c) Basophil leukocytes:**

- Nucleus: bilobed (Fig. 77).
- Coarse basophilic cytoplasmic granules.

**E/M:**

The cytoplasmic granules are electron dense.

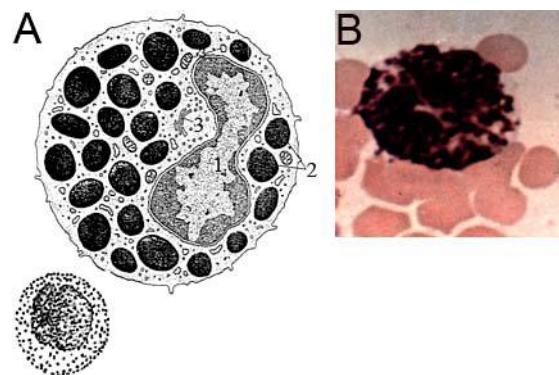


Fig. 77: Basophil leukocyte A: 1. Nucleus. 2. Electron dense granules. 3. Cytoplasmic organelles (Few). B: Blood film

**2. Agranular leukocytes:**

**"Agranulocytes"**

**A) Lymphocytes:**

**a) Large lymphocytes: "Active"**

- Large cells.
- Large indented nucleus.
- Abundant cytoplasm with numerous ribosomes.

**b) Small lymphocytes: "Inactive"**

- Small rounded cells.
- Large rounded deeply stained nucleus (Fig. 78).
- Few cytoplasm with few azurophilic granules (lysosomes).

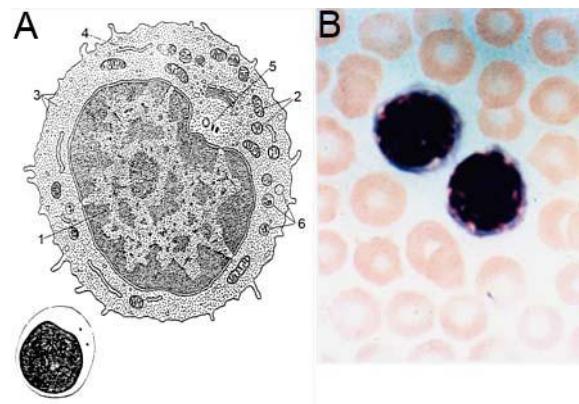


Fig. 78: Lymphocyte (Activated). A: 1- Nucleus. 2- Mitochondria (Few). 3- Free ribosomes. 4- rER (Few). 5- Centrioles. 6- Azurophilic granules (lysosomes). B: Blood film.

**B) Monocytes:**

- Nucleus: Kidney – shaped (Fig. 79).
- Cytoplasm: Abundant - greyish blue (numerous lysosomes).
- Highly phagocytic.

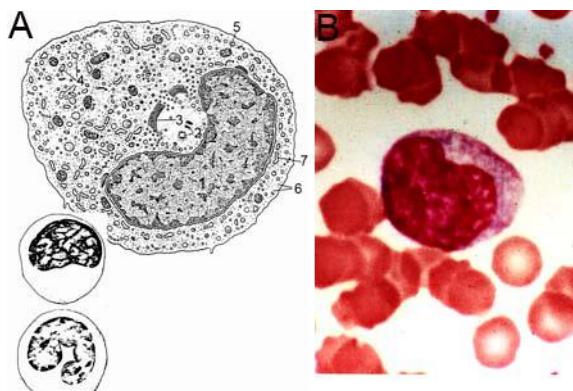


Fig. 79: Monocyte. A: 1- Nucleus. 2- Centrioles. 3- Golgi apparatus. 4- Lysosomes. 5- Mitochondria. 6- Ribosomes. 7- rER. B: Blood film.

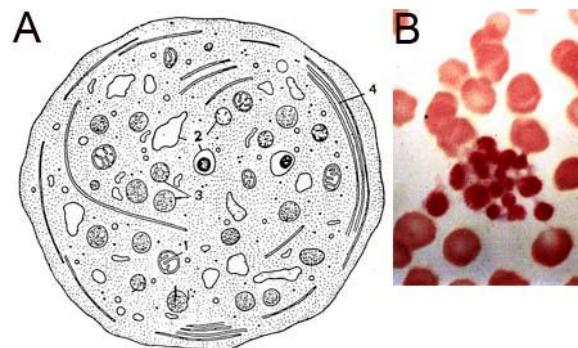


Fig. 80: Blood platelet. A: 1 - Mitochondria. 2- Vacuoles. 3- Azurophilic granules 4- Microtubules. B: Blood film.

### **III- Blood platelets: "Thrombocytes"**

#### **In mammals:**

- Non-nucleated cytoplasmic fragments (Fig. 80).

#### **E/M:**

Contain:

- Alpha granules = Azurophilic granules.
- Beta granules = Mitochondria.
- Delta granules = Vacuoles.
- Marginal zone = Microtubules.

#### **In birds:**

- They are nucleated.
  - Simulate R. B. Cs.
- Develop from Megakaryocytes  
(Large cell with lobulated nucleus).

## THE MUSCULAR TISSUE

The muscular tissue performs mechanical work by contraction.

### 1. The smooth muscle:

- Narrow, elongated and tapering cells (Fig. 81).
- 20 - 500  $\mu\text{m}$  X 5  $\mu\text{m}$ .
- Sarcolemma: is not clear.
- Nucleus: Single, oval, central, spiral chromatin.
- Sarcoplasm:
  - Myofibrils.
  - Glycogen.
  - Pigments (myoglobin).
- C.S.: Large nucleated and small non-nucleated cytoplasmic portions.

#### Found into:

- Small intestine.
- Uterus.
- Blood vessels.
- Ureter.
- U. bladder.

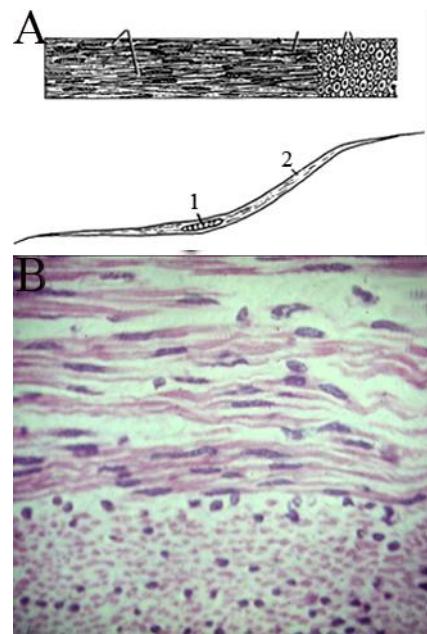


Fig. 81: Smooth muscle fibers. A, Upper: Longitudinal section. Middle: Longitudinal section (left). Cross section (right). Lower: L.S. in smooth muscle fiber: 1. Broad nucleus-containing portion. 2. Myofibrils. B, Smooth muscle fibers with H & E. Upper: L. S. Lower: C. S.

### 2. The skeletal muscle:

- Regular cylindrical cells (Fig. 82).
- 1 -300 mm X 10-100  $\mu\text{m}$ .
- Sarcolemma: is clear.
- Nucleus: multiple, flat, and peripheral.
- Sarcoplasm:
  - A) Cell organelles:
    - Myofibrils.
    - Sarcoplasmic reticulum = sER (SR)
    - Mitochondria (2%).
    - Golgi apparatus.
    - Ribosomes.

B) Cell inclusions:

- Glycogen.
- Pigments (Myoglobin).

The muscle fiber is transversely striated (clear).

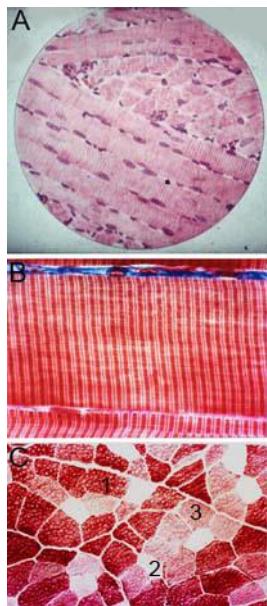


Fig. 82: Skeletal muscle fibers. A: H & E. Upper: L. S. Middle: C. S. Lower: L. S. B: Azan stain. C: Types of skeletal muscle fibers. (Stained for myosin ATPase) 1. Red muscle fibers. 2. White muscle fibers. 3. Intermediate muscle fibers.

### Myofibrils:

**L/M:** Are transversely striated (Fig. 83):

1. A- band: Dark band bisected by H - band.
2. I - band: Light band bisected by Z - line

**E/M:** Each myofibril is composed of:

- 1. Thick myofilaments (Myosin)**
  - 2. Thin myofilaments (Actin)**
- The segment between two successive Z lines = Sarcomere.
  - **Sarcomere** = A - band +  $\frac{1}{2}$  I- band on either side.

**C.S.:** The muscle fiber is polygonal in shape with peripheral, flat nuclei.

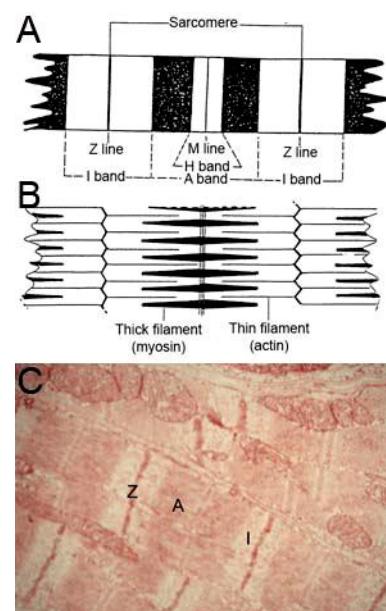


Fig. 83: A: Banding pattern of skeletal muscle. B: Relationship of cross banding to the arrangement of thin and thick myofilaments. C: Skeletal muscle fibers (L. S.), Notice: I- Band, Z- Line, A-Band.

### Types of skeletal muscle fibers:

1. Red muscle fibers: small - rich sarcoplasm - poor in glycogen (Fig. 82C.1).

2. White muscle fibers: large - poor sarcoplasm - rich in glycogen (Fig. 82C.2).

3. Intermediate muscle fibers (Fig. 83C.3).

### 3. The cardiac muscle:

- Elongated branching cells (Fig. 84a).
- Form networks (syncytium).
- $50-120 \times 20 \mu\text{m}$ .
- Sarcolemma is thin.
- Nucleus: single, oval, central.
- Sarcoplasm: abundant.
- Striation: less clear.
- Glycogen and lipofuscin: numerous.
- Sarcoplasmic reticulum: less developed than in skeletal muscle.
- Mitochondria: 40%.
- The muscle fibers are joined to each other by intercalated discs (step - wise pattern), Fig. 84B& C.

**C.S.:** The muscle fibers are polygonal in shape with or without central rounded nucleus (Fig. 84b).

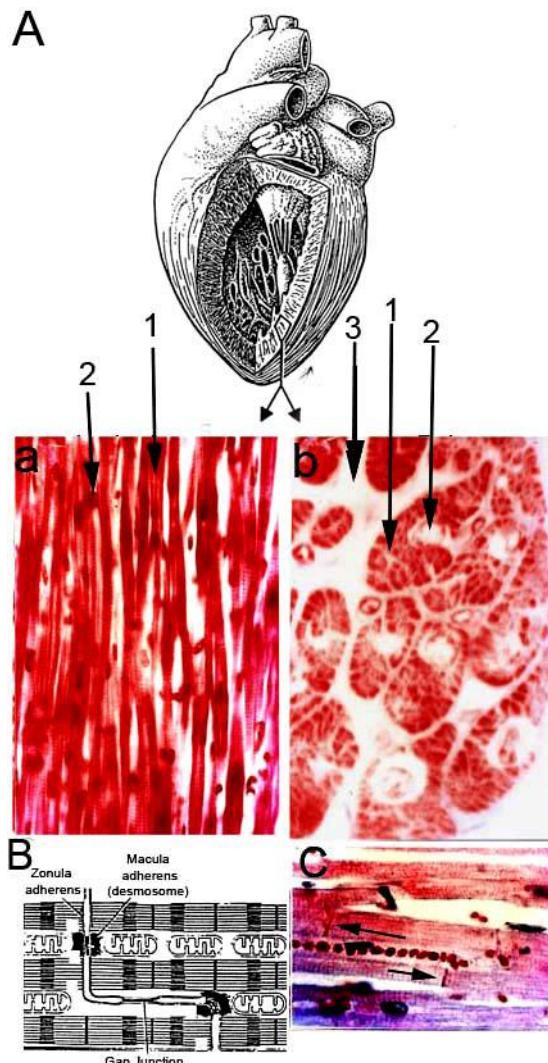


Fig. 84: Cardiac Muscle. A: a, L.S. b, C.S. of the cardiac muscle: 1-Cardiac muscle fiber. 2-Nucleus. 3- Endomysium. B: Intercalated disc. C: Cardiac muscle (L.S.). Notice the intercalated discs (Arrows).

## THE NERVOUS TISSUE

The nervous tissue is adapted to receive stimuli from the outside, to transform them to nervous impulses, and to convey these stimuli to other parts of the body.

The nervous tissue consists of:

Nerve cells - Nerve fibers - Neuroglia.

### I- Nerve cells (Neurons):

#### Structure:

##### A) The cell body:

Shape: Rounded - oval - pear shaped - pyramidal - irregular (Fig. 85).

Size: Large – Small.

a) **Nucleus:** Large - spherical - pale - central - 1 to 2 nucleoli.

##### b) Cyttoplasm:

###### Organelles:

- rER = Nissl's granules.
- Golgi apparatus: surrounds the nucleus.
- Mitochondria.
- Neurofibrils.

###### No centrioles (*do not divide*)

###### Inclusions:

- Pigments.
- Secretory granules.

### B) The cell processes:

Dendrites	Axon
One or more	One
Short	Long
Thick	Thin
Divide	Does not divide
rER	No rER

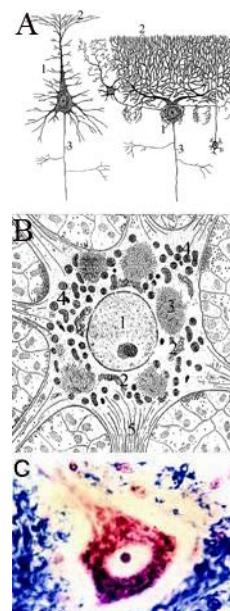


Fig. 85: The nerve cell. A: 1. Cell body. 2. Dendrites. 3. Axon. B: The nerve cell. 1. Nucleus. 2. Golgi apparatus. 3. Nissl's granules. 4. Mitochondria. 5. Neurofibrils. C: Multipolar neuron, Luxol Fast blue.

#### The nerve cells are found into:

- Gray matter of the brain and spinal cord.
- Retina.
- Ear.
- Olfactory region.

## Types of nerve cells:

1. Unipolar neurons : Embryo (Fig. 86A)
2. Pseudo - unipolar neurons: Spinal ganglia (Fig. 86B)
3. Bipolar neurons: Retina (Fig. 86C).
4. Multipolar neurons: Gray matter (Fig. 86D).

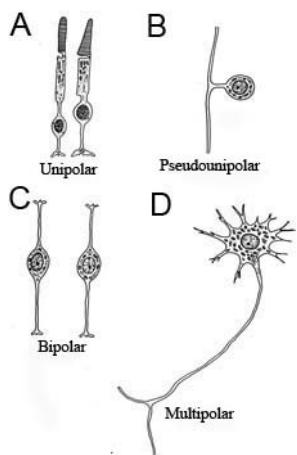


Fig. 86: Types of nerve cells.

## II- Nerve fibers:

A nerve fiber = Axon + its sheathes (Fig. 87)

### 1. Axon:

- Axolemma.
- Axoplasm: Mitochondria. Neurofilaments.

### 2. Sheathes:

#### A) Myelin sheath:

- Lipid.

- Segments.

- Nodes of Ranvier.

#### B) Neurolemma: Schwann's cells:

Flat - one for each segment.

## Type of nerve fibers:

1. Myelinated with neurolemma : Spinal nerve.
2. Myelinated without neurolemma: Optic nerve.
3. Unmyelinated with neurolemma: Sympathetic nerve.
4. Unmyelinated without neurolemma: Olfactory nerve.

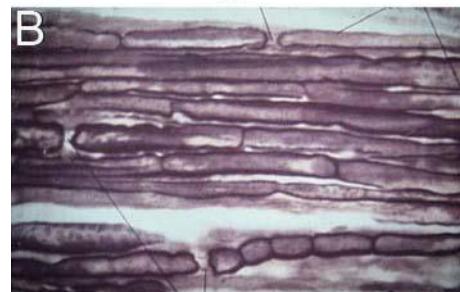
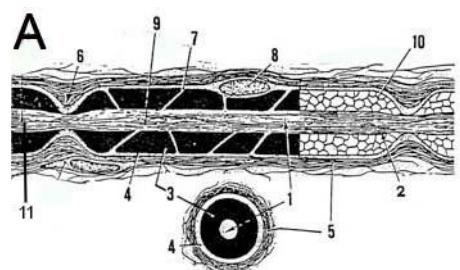


Fig. 87: A, Myelinated nerve fiber with neurolemma: 1- Axon. 2- Axolemma. 3- Myelin sheath. 4- neurolemma. 5- Endoneurim. 6- Node of Ranvier. 7 - Clefts of Schmidt - Lanterman. 8 - Nucleus of Schwann cell. 9 - Mitochondria. 10- Neurokeratin network. 11- Neurofilaments. B, Myelinated nerve fibers (L. S.), Silver impregnation.

## Synapse (s):

- The connection between:
  - neuron → neuron.
  - neuron → muscle.
  - neuron → gland.
- Conduction of nerve impulses occurs in one direction only.
- There is no actual continuity of substance between the cells.
- Synapses are electrochemical transmission sites.

## Structure:

- Cell processes (e.g. axon) provide synaptic end-bulb (boutons terminaux), Fig. 88.
- The synaptic end-bulb contains synaptic vesicles which contain the Neuro-transmitter substance which passes through
- The presynaptic membrane to
- The synaptic cleft to form
- The postsynaptic components which pass through
- The post synaptic membrane.

4- Axo – dendritic.

5- Dendro – somatic.

6- Axo – somatic.

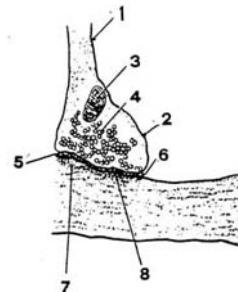


Fig. 88: A synapse: 1- Nerve cell process (presynaptic component). 2- Synaptic end - bulb. 3- Mitochondria. 4- Synaptic vesicles. 5- Presynaptic membrane. 6- Synaptic cleft. 7- Postsynaptic component of nerve cell process, 8- Postsynaptic membrane.

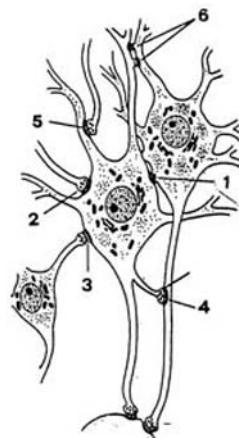


Fig. 89: Types of synaptic patterns: 1- Somato-somatic synapse. 2- Dendro- dendritic synapse. 3 - Axo- axonic synapse. 4- Axo- dendritic synapse. 5- Dendro- somatic synapse. 6- Axo- somatic synapse.

## Types: (Fig. 89).

- 1- Somato – somatic.
- 2- Dendro – dendritic.
- 3- Axo – axonic.

## Nerve trunk:

- Epineurium: surrounds the whole nerve (Fig. 90).

- Perineurium: surrounds the nerve bundle (Fig.91).
- Endoneurium: surrounds the nerve fiber.

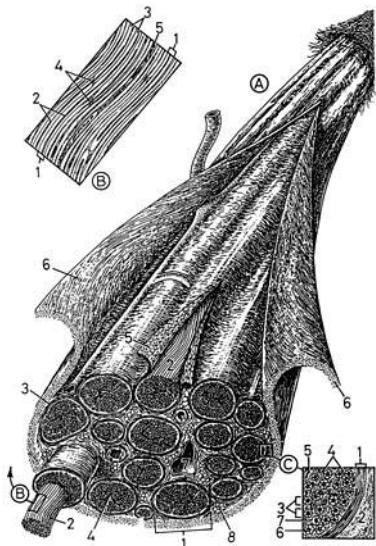


Fig. 90: Nerve trunk (Spinal nerve). A) Whole nerve trunk. 1. Nerve bundle. 2. Nerve fibers. 3. Perineurium. 4. Endoneurium. 5. Perineurium. 6. Epineurium. 7. Blood vessels. 8. Adipose tissue. B) L.S. 1. Nerve fiber. 2. Axon. 3. Myelin sheath. 4. Node of Ranvier. 5. Endoneurium. c) C.S. 1. Perineurium. 2. Epineurium. 3. Nerve fibers. 4. Endoneurium. 5. Blood capillaries. 6. Axon. 7. Myelin sheath.

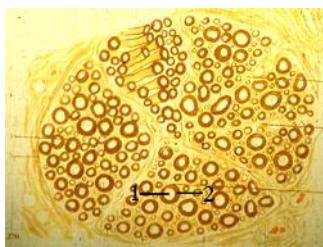


Fig. 91: Nerve bundle (C. S.), Silver impregnation. 1. Axon. 2. Myelin sheath.

## Ganglia:

A ganglion is a collection of nerve cells and nerve fibers.

	Sympathetic ganglion	Spinal ganglion
Cell	<ul style="list-style-type: none"> <li>* Small</li> <li>*Multipolar</li> <li>*Singly scattered</li> <li>*Surrounded by satellites in an irregular manner.</li> </ul>	<ul style="list-style-type: none"> <li>*Large</li> <li>*Pseudounipolar</li> <li>*In groups</li> <li>*Surrounded by satellites in a regular manner.</li> </ul>
Fibers	<ul style="list-style-type: none"> <li>*Unmyelinated with neurolemma</li> </ul>	<ul style="list-style-type: none"> <li>*Myelinated with neurolemma.</li> </ul>



Fig.92: Section from a sympathetic ganglion of the horse, showing the multipolar neurons (a) surrounded by a less apparent layer of satellites (b). Notice the sympathetic unmyelinated nerve fibers (c).

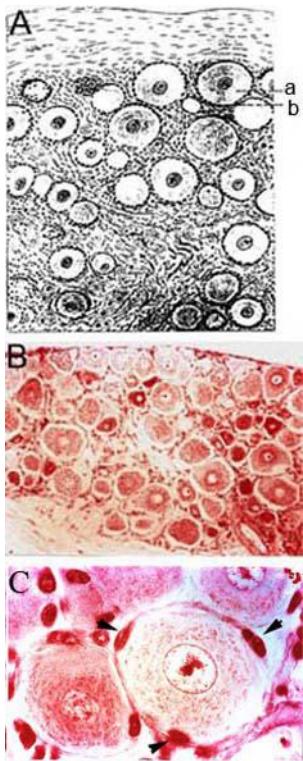


Fig. 93. A: Section from the spinal ganglion of a horse. a) Nerve cell (in groups). b) Single layer of satellite cells or capsule cells surrounding the nerve cells. B: Group of pseudounipolar neurons within a spinal ganglion. C: Pseudounipolar neurons surrounded by satellite cells (arrowheads) within a spinal ganglion.

### ***III- Neuroglia:***

Fig. 94

Connective tissue of CNS

#### **A- Neuroglia proper :**

##### **1-Astrocytes:**

a- Protoplasmic astrocytes (Fig.

94A & 95):

- Large cells.
- Numerous, thick, short and branching cytoplasmic processes.

These processes form perivascular feet.

- Numerous cytoplasmic granules (gliosomes).
- Central, large, rounded nucleus.
- Found into the gray matter.

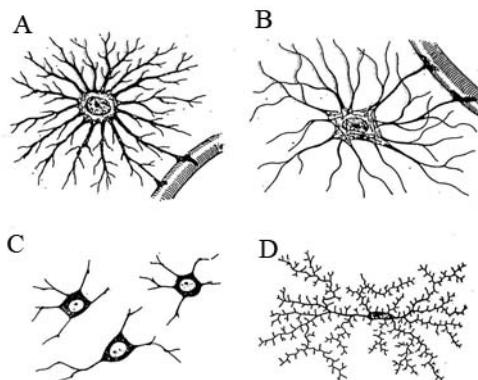


Fig. 94: Neuroglia. A- Protoplasmic astrocyte. B- Fibrous astrocyte. C- Oligodendrocyte. D- Microglia.

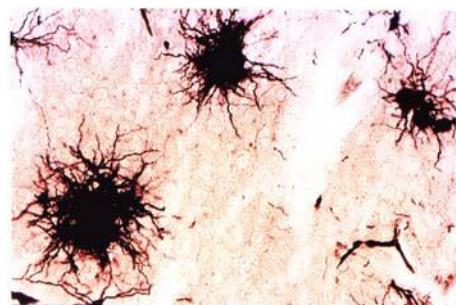


Fig. 95: Protoplasmic astrocytes, Silver impregnation.

b- Fibrous astrocytes: (Fig. 94B& 96)

- Large cells.
- The cytoplasmic processes are long, thin, straight and less branched.

These processes form perivascular feet.

- The cytoplasm is not granular.
- Central, large, rounded nucleus.
- Found into the white matter.

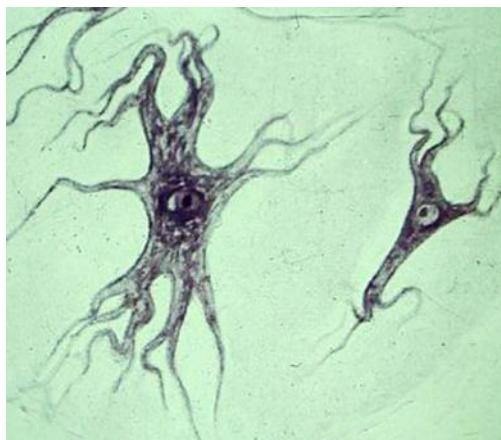


Fig.96: Fiberous astrocytes.

## 2- Oligodendrocytes:

- Small cells (Fig. 94C & 97).
- The cytoplasmic processes are few, short and less branched.
- Small, rounded dark nucleus.
- Found into both gray and white matters.

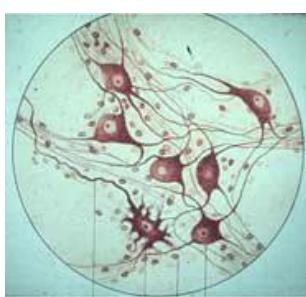


Fig. 97: Oligodendrocytes.

## 3-Microglia

### =Mesoglia=Microphage:

- Small cells.
- Spindle shaped.

- The cytoplasmic processes are thin, branched and arise from each of the two poles of the cell (Fig. 94D & 98).
- Little thorns cover the cell and its processes.
- Flat, oval, dark nucleus.
- Motile and phagocytic cells.

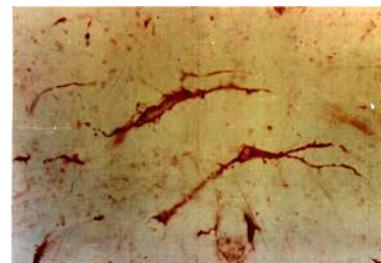


Fig. 98: Microglia cells, Hortega stain.

## B- Other types of neuroglia:

### a) Spongioblasts:

They are small cells with deeply stained nucleus. They are capable of differentiation into astrocytes and oligodendrocytes.

### b) Ependymal cells:

They are simple columnar ciliated cells, which line the central canal of the spinal cord.

### c) Capsule (or satellite) cells:

They surround the neurons of the ganglia (Fig. 93C).

### d) Cells of Schwann:

They surround the peripheral nerve fibers (axons), Fig. 87A.

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