2022-2023

General Zoology

Cytology & Histology

Practical course

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Lab Safety Rules and Guidelines

For practical study in lab, it is important you follow these safety rules:

1- Come to class well prepared for the lab. Read the required lab to understand the background material and procedures.

2- At all times, follow the directions of your instructor. These directions may differ from the procedures listed in the lab manual or packet.

3- Keep your counter clean and uncluttered. Unnecessary items should be placed as directed by your lab instructor. Cubbies have been provided in most labs for storage of your personal items such as bags and coats.

4- Lab coats are required for most lab works.

5- Wear safety glasses when working with chemicals, liquid cultures of organisms, or when instructed.

6- Always use mechanical pipetting devices when pipetting fluids.

7- Keep water away from electrical cords and electronic equipment. Electricity and water do not mix.

8- Food and drink are forbidden in the lab. This includes gum, candy, throat drops, and all beverages. If you wish to eat or drink, you may step outside the doorway of the lab to do so. Drink bottles are never to be placed on the lab bench. Bacteria and other organisms are grown in the lab. This is another Federal lab requirement.

9- No cell phones are to be used in the lab. Keep it in your bag, not on you, when in the lab, unless instructed otherwise.

10- Inform your instructor immediately of any breakage, spill, or injuries, even minor ones so proper protocols can be followed.

11- Be sure you know how to use a piece of equipment before using it. When in doubt ask your instructor.

12- At the end of the period, wash your glassware and other materials and then return them to their original location. All equipment should be cleaned and returned to its original location.

CONTENTS

CYTOLOGY PART

HISTOLOGY PART

EPITHELIAL TISSUE

(A)Simple epithelial tissue:

1- Simple squamous epithelium
2- Simple cuboidal epithelium
3- Simple columnar epithelium
4- Simple columnar ciliated epithelium
5- Simple columnar ciliated epithelium
6- Pseudostratified columnar ciliated epithelium

(B) Stratified (Compound) epithelial tissue:

1- Stratified squamous epithelium
2- Stratified cuboidal epithelium
3- Stratified columnar epithelium
4- Stratified columnar ciliated epithelium
5- . Transitional epithelium

(C)Glandular epithelium

CONNECTIVE TISSUE

(A) Connective tissue proper

1- Areolar connective tissue
2- Adipose connective tissue
3- Reticular connective tissue
4- Fibrous connective tissue
5- Elastic connective tissue proper
6- Mucous connective tissue proper

(B) Skeletal connective tissue

I- Cartilages
  1- Hyaline Cartilage
  2- Elastic cartilage
  3- Fibro cartilage
II- Bones

1- Spongy bone

2- Compact bone

(C) Vascular connective tissue

Blood and Lymph

MUSKULAR TISSUES

(A) Unstrained or Smooth muscles

(B) Straited or Skeletal muscles

(C) Cardiac muscles

NERVOUS TISSUE

Nerve cell (Neurons) and glia

1- Unipolar neurons

2- Bipolar neurons

3- Multipolar neurons

DIFFERENT ORGANS TISSUE STRUCTURES

1- Digestive system

T.S. of Esophagus-Stomach- Ileum -Liver of toad.

2- Respiratory system

T.S. of Lung of toad

3- Urinary system

T.S. of Kidney of toad

4- Nervous system

T.S. of Spinal cord of rabbit.

5- Skin

V.S. of skin of toad

6- Blood vessels

S. of an artery and a vein.

7- Genital systems

T.S. of testis - ovary

REFRENCES

CYTOLOGY PART

MICROSKOPY

(A) Principles of microscopy:

Microscopes make small objects appear bigger. A light microscope will magnify an image up to 1500 times its original size. Electron microscopes can achieve magnifications up to 1 million times. However, bigger is only better when more details are revealed. The fineness of detail that a microscope can reveal is its resolving power. This is defined as the smallest distance that two objects can approach one another yet still be recognized as being separate. The resolution that a microscope achieves is mainly a function of the wavelength of the illumination source it employs. The smaller the wavelength, the smaller the object that will cause diffraction, and the better the resolving power. The light microscope, because it uses visible light of wavelength around 500 nanometers (nm, where 1000 nm = 1 μm), can distinguish objects as small as about half this: 250 nm.

It can therefore be used to visualize the smallest cells and the major intracellular structures or organelles. The microscopic study of cell structure organization is known as **cytology.** An electron microscope is required to reveal the **ultrastructure** (the fine detail) of the organelles and other cytoplasmic structures. The wavelength of an electron beam is about 100,000 times less than that of white light. In theory, this should lead to a corresponding increase in resolution. In practice, the electron microscope can distinguish structures about 1000 times smaller than is possible in the light microscope, that is, down to about 0.2 nm in size.

(B)Types of microscopes:

1- The Light Microscope:

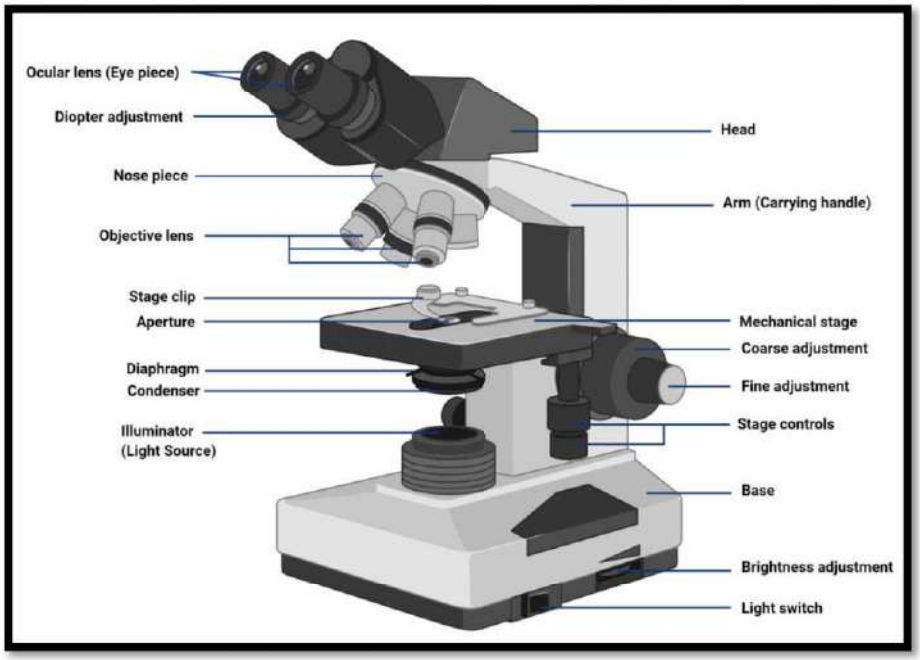
A light microscope consists of a light source, which may be the sun or an artificial light, plus three glass lenses: a **condenser lens** to focus light on the specimen, an **objective lens** to form the magnified image, and a **projector lens,** usually called the eyepiece, to convey the magnified image to the eye. Depending on the focal length of the various lenses and their arrangement, a given magnification is achieved.

In **bright-field microscopy,** the image that reaches the eye consists of the colors of white light less that absorbed by the cell. Most living cells have little color (plant cells are an obvious exception) and are therefore largely transparent to transmitted light.

This problem can be overcome by **cytochemistry,** the use of colored stains to selectively highlight particular structures and organelles. However, many of these compounds are highly toxic and to be effective they often require that the cell or tissue is first subjected to a series of harsh chemical treatments.

A different approach, and one that can be applied to living cells, is the use of **phase contrast microscopy.** This relies on the fact that light travels at different speeds through regions of the cell that differ in composition. The phase-contrast microscope converts these differences in refractive index into differences in contrast, and considerably more detail is revealed. Light microscopes come in a number of physical

orientations (upright, inverted, etc.) but whatever the orientation of the microscope the optical principles are the same.



The light microscope.

2- The Electron Microscope:

a. Transmission electron microscope:

The most used type of electron microscope in biology is called the transmission electron microscope because electrons are transmitted through the specimen to the observer. The transmission electron microscope has essentially the same design as a light microscope, but the lenses, rather than being glass, are electromagnets that bend beams of electrons. An electron gun generates a beam of electrons by heating a thin, V-shaped piece of tungsten wire to 3000◦C. A large voltage accelerates the beam down the microscope column, which is under

vacuum because the electrons would be slowed and scattered if they collided with air molecules. The magnified image can be viewed on a fluorescent screen that emits light when struck by electrons. While the electron microscope offers great improvements in resolution, electron beams are potentially highly destructive, and biological material must be subjected to a complex processing schedule before it can be examined.

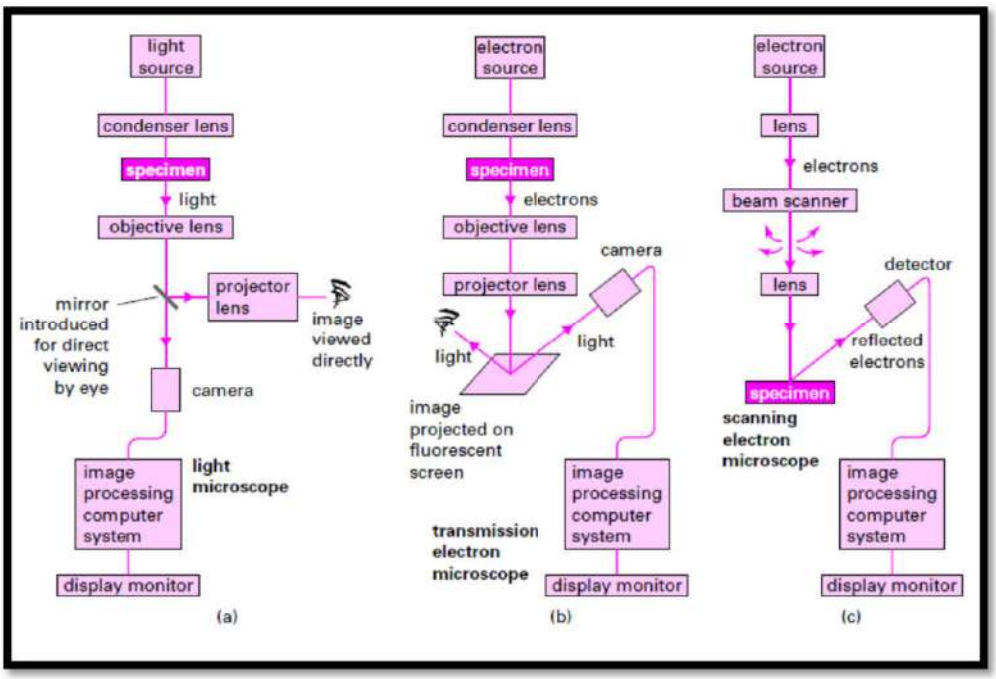
The transmission electron microscope produces a detailed image but one that is static, two-dimensional, and highly processed. Often, only a small region of what was once a dynamic, living, three-dimensional cell is revealed. Moreover, the picture revealed is essentially a snapshot taken at the particular instant that the cell was killed. Clearly, such images must be interpreted with great care. Electron microscopes are large and require a skilled operator. Nevertheless, they are the main source of information on the structure of the cell at the nanometer scale, called the **ultrastructure.**

b. The Scanning Electron Microscope:

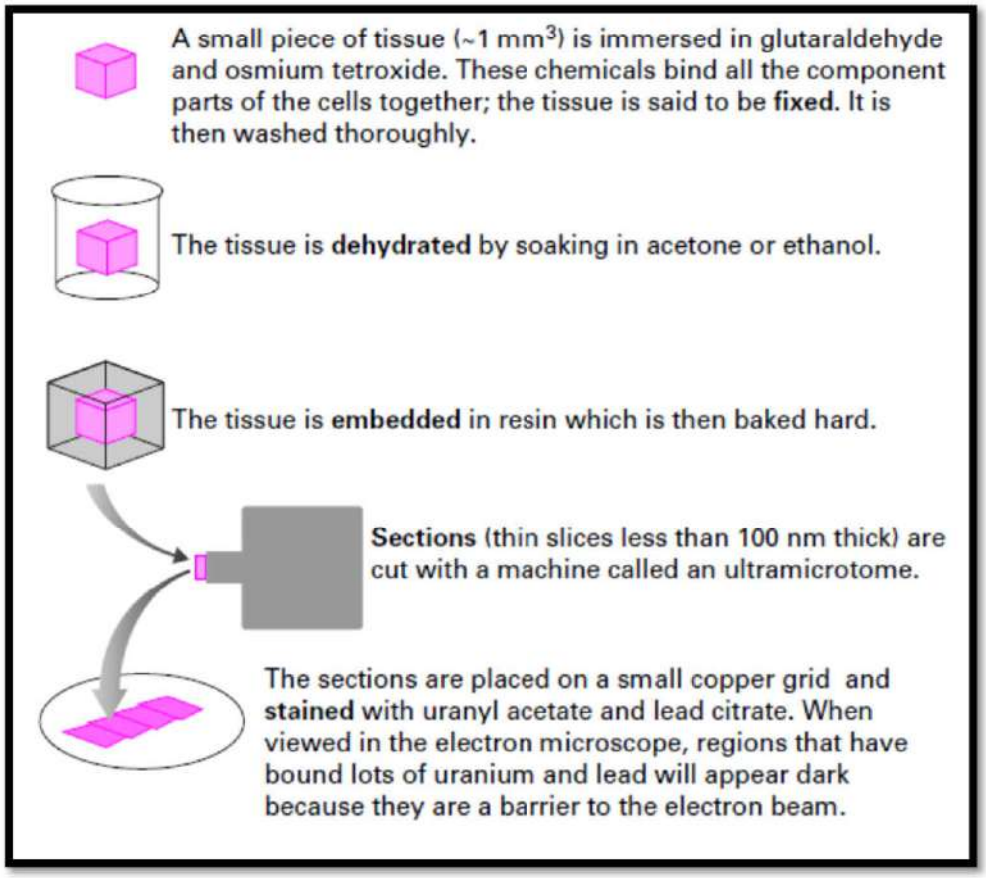
Whereas the image in a transmission electron microscope is formed by electrons transmitted through the specimen, in the scanning electron microscope it is formed from electrons that are reflected back from the surface of a specimen as the electron beam scans rapidly back and forth over it. These reflected electrons are processed to generate a picture on a display monitor. The scanning electron microscope operates over a wide magnification

range, from 10× to 100,000×. Its greatest advantage, however, is a large depth of focus that gives a three-dimensional image. The scanning electron microscope is particularly useful for providing topographical information on the surfaces of cells or tissues. Modern instruments have a resolution of about 1 nm.

Modern electron microscope (EM). The electron beams travel from the beam generator (electron gun, 1) and pass through a condenser lens system (vertical tube 5) from top to bottom, the specimen sitting in the strong vacuum of the tube (preparation hatch 2 with lateral Dewar flask 4 for liquid nitrogen to cool the specimen hatch; 3 motorized tip-tilt bench for the specimen), then the fields of the electromagnetic objective and projective imaging lenses (in 5) and finally hit a fluorescent light screen. This final picture can be observed through a viewing window (6) or on monitors and can be photographed or stored digitally (digital camera 7). The residual gas pressure in the tube is maintained by high-vacuum pumps to values of under one millionth of atmospheric pressure. 9 Computer tower for image acquisition and manipulation.

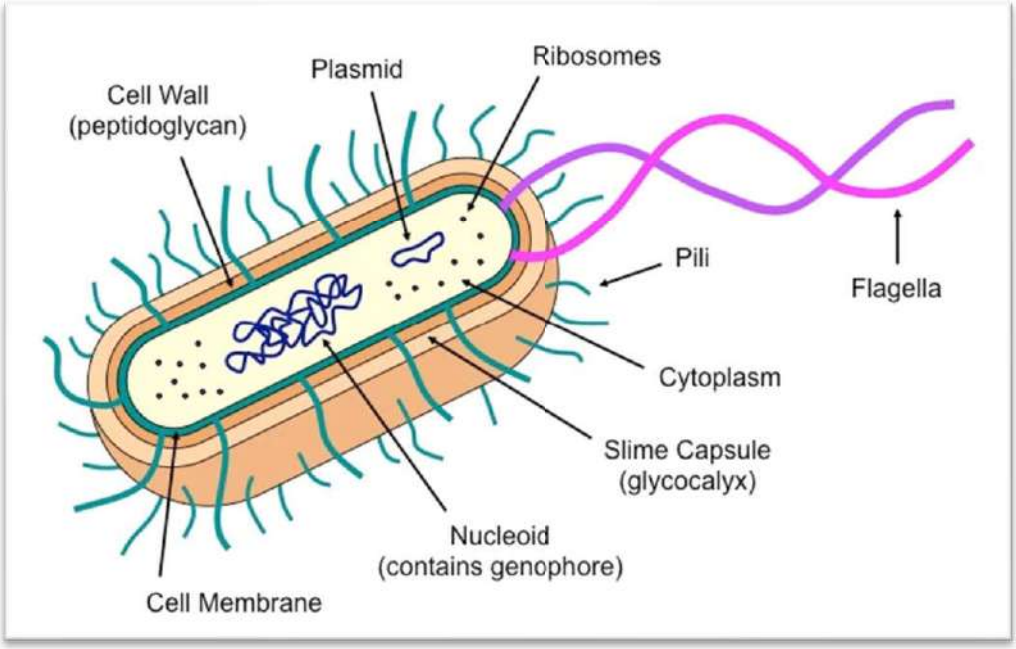


Basic work. idea of different types of microscopes.

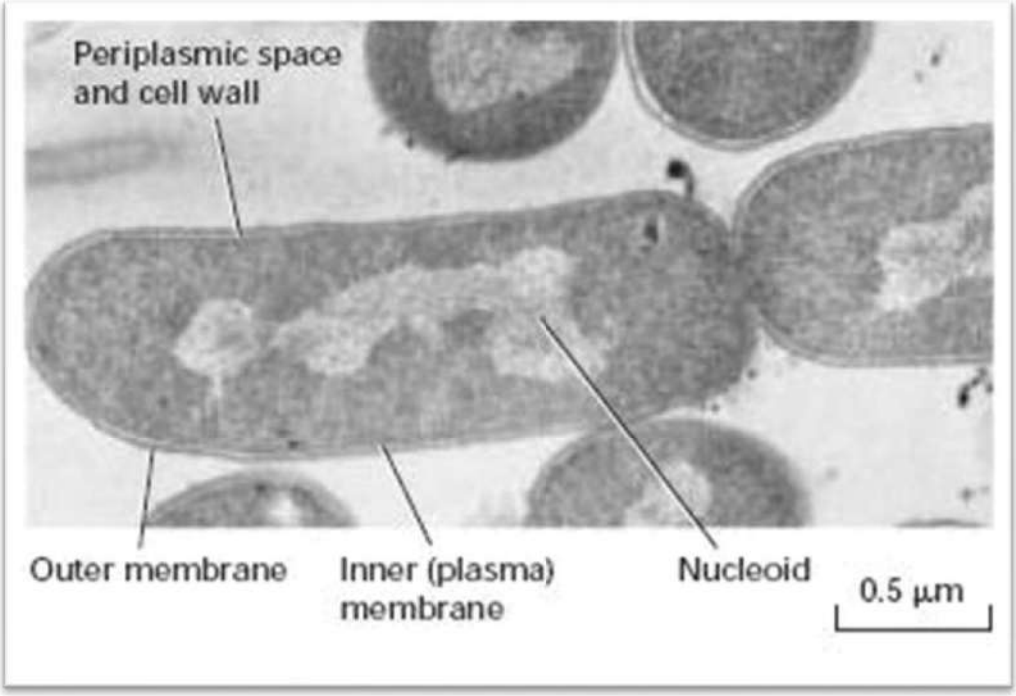


The preparation steps of samples for electron microscope.

PROKARYOTIC CELL

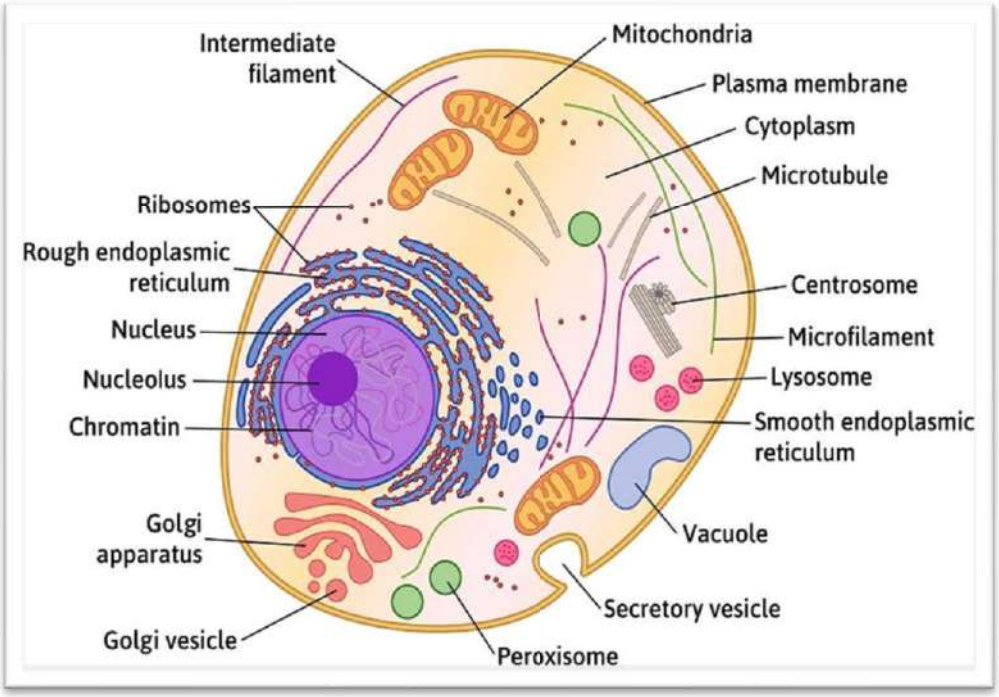


Prokaryote cell components

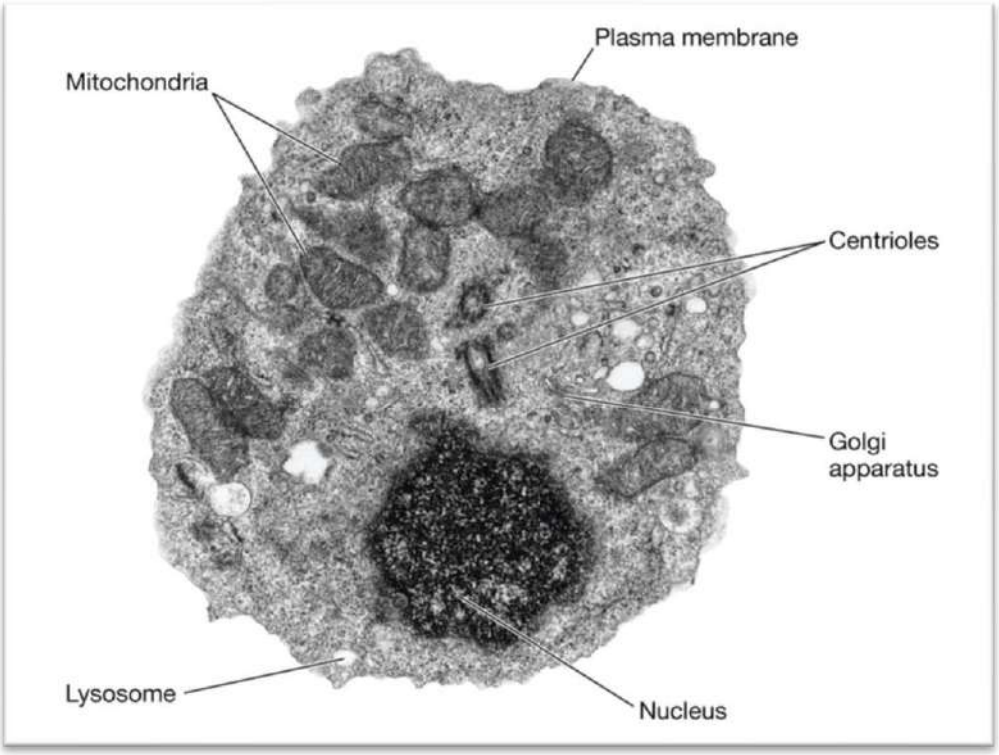


Prokaryote cell ultrastructure

EUKARYOTIC CELL

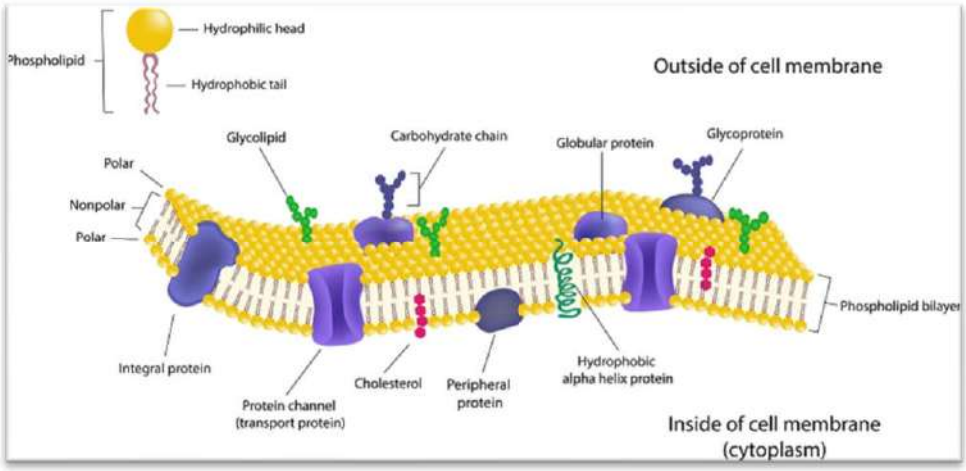


Animal cell components diagram

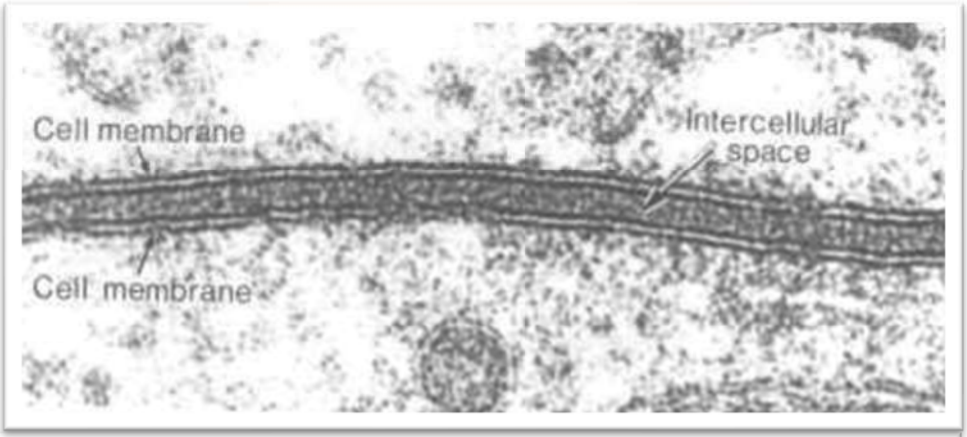


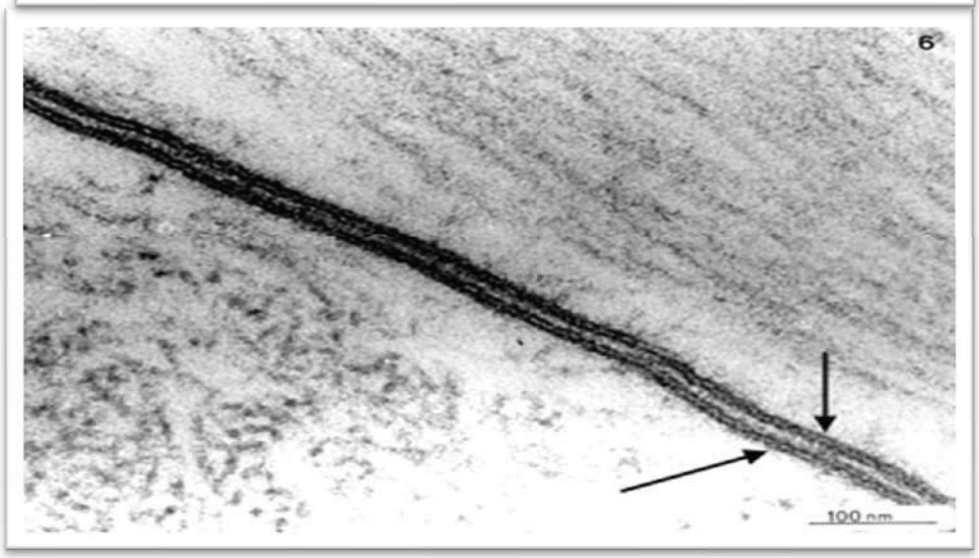
Animal cell components ultrastructure

CELL MEMBRANE



Plasma membrane structure diagram





Plasma membrane ultrastructure

Transport of substances through membrane:

1- Passive Transport

- Passive transport involves the movement of material along a concentration gradient (high concentration ⇒ low concentration) with no energy required.
- There are three main types of passive transport:
  - **b. Simple diffusion**: movement of small or lipophilic molecules (e.g.: O_2, CO_2, etc.).
  - **c. Facilitated diffusion**: movement of large or charged molecules via membrane proteins (e.g.: ions, sucrose, etc.).
  - **d. Osmosis**: movement of water molecules (dependent on solute concentrations).

2- Active Transport

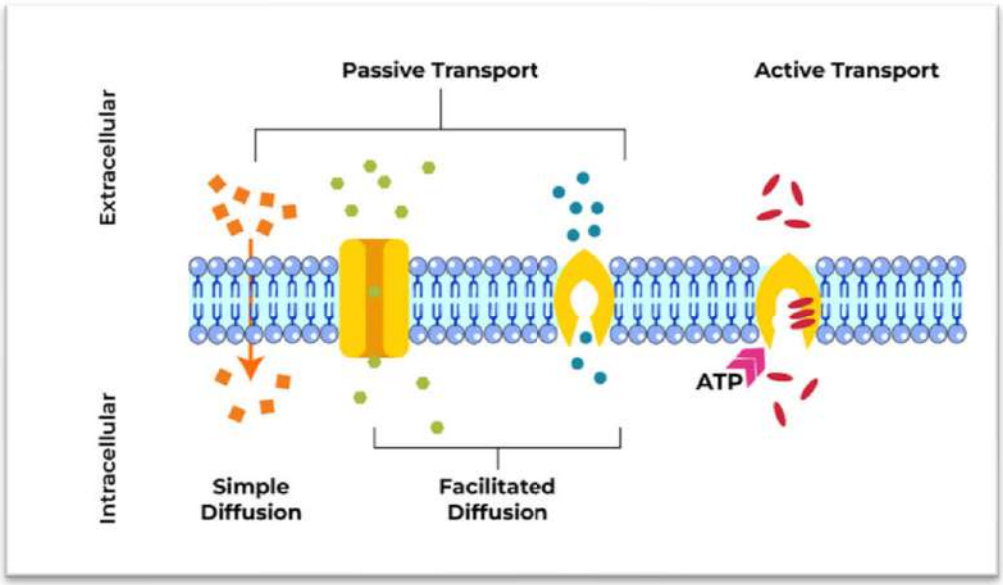
- Active transport involves the movement of materials against a concentration gradient (low concentration ⇒ high concentration)
- Because materials are moving against the gradient, it requires the expenditure of energy (e.g.: ATP hydrolysis).

3- Endocytosis

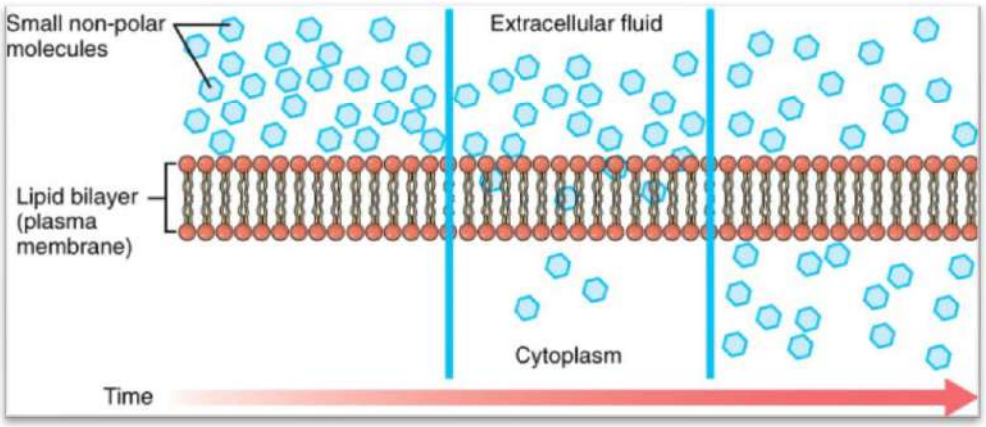
- The process by which large substances (or bulk amounts of smaller substances) enter the cell without crossing the membrane.
- There are two main types of endocytosis:
  - **Phagocytosis**: The process by which solid substances are ingested (usually to be transported to the lysosome).
  - **Pinocytosis**: The process by which liquids / dissolved substances are ingested (allows faster entry than via protein channels).

4- Exocytosis

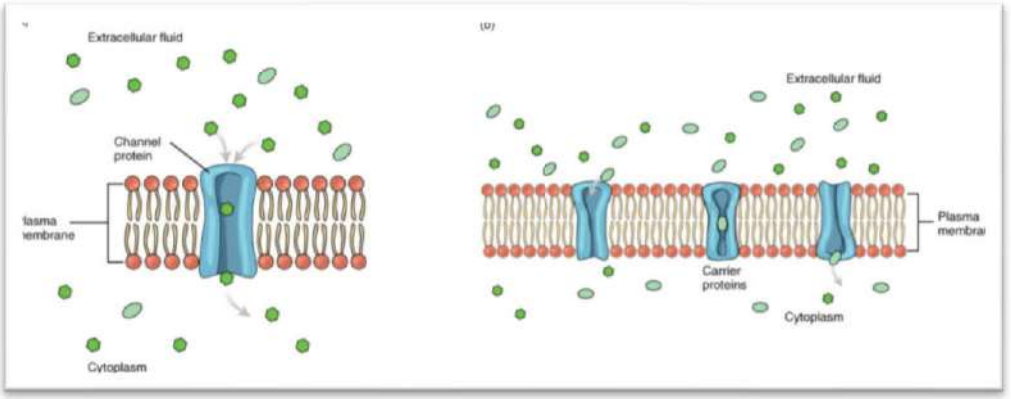
- The process by which large substances (or bulk amounts of small substances) exit the cell without crossing the membrane
- Vesicles (typically derived from the Golgi) fuse with the plasma membrane, expelling their contents into the extracellular environment
- The process of exocytosis adds vesicular phospholipids to the cell membrane, replacing those lost when vesicles are formed via endocytosis.



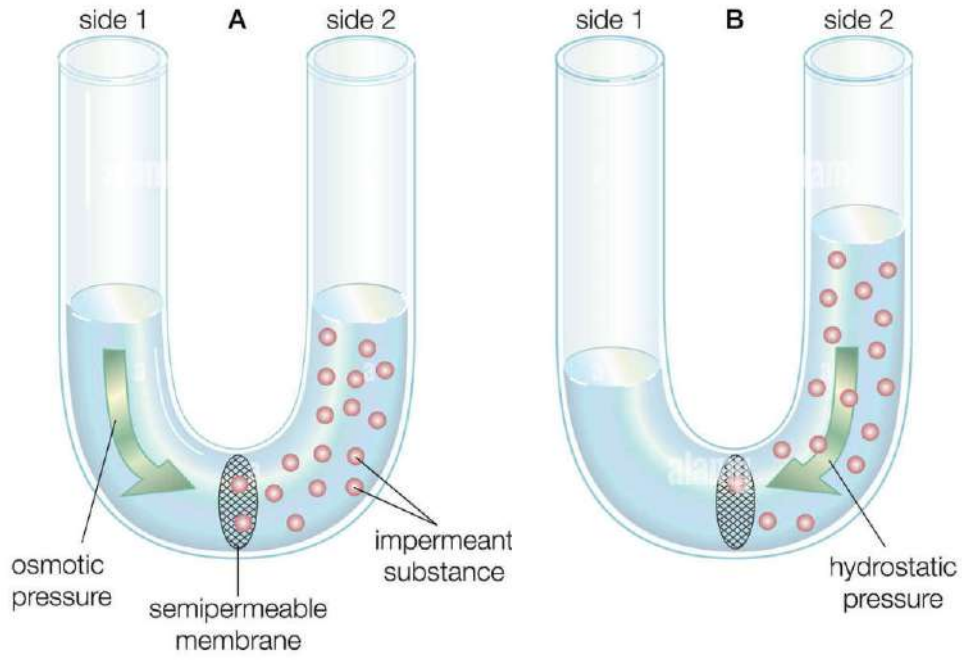
Transport across cell membrane diagram



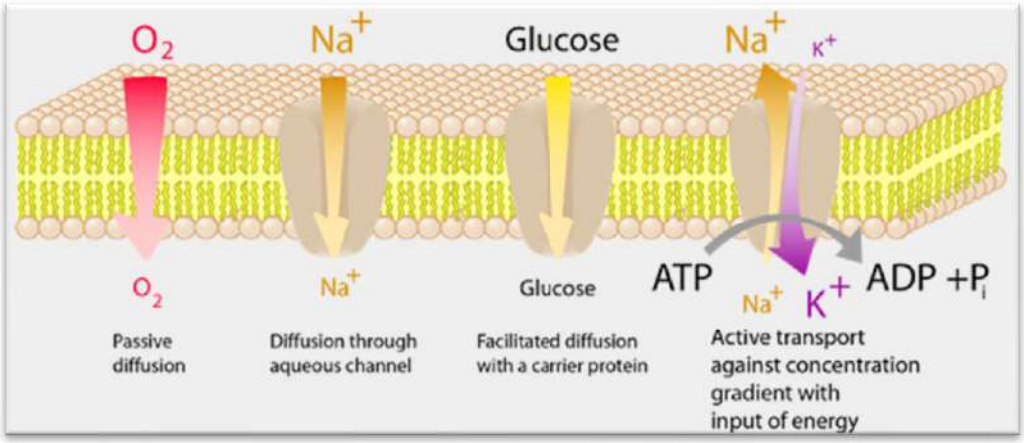
Simple diffusion transport diagram



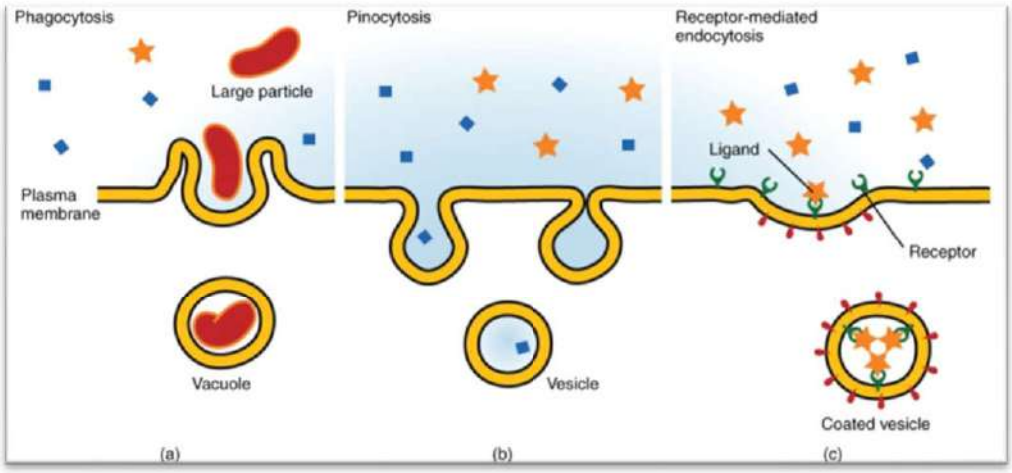
Facilitated diffusion transport diagram



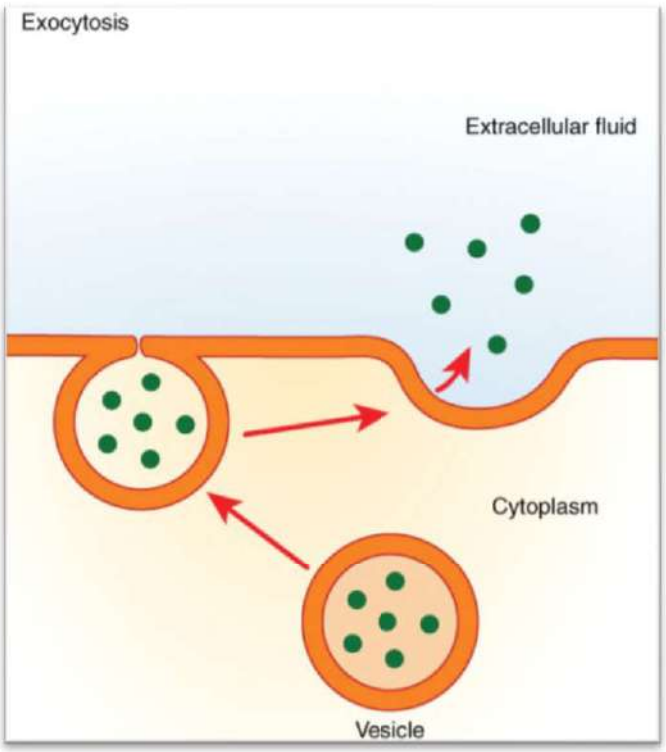
Osmosis transport diagram



Active transport diagram

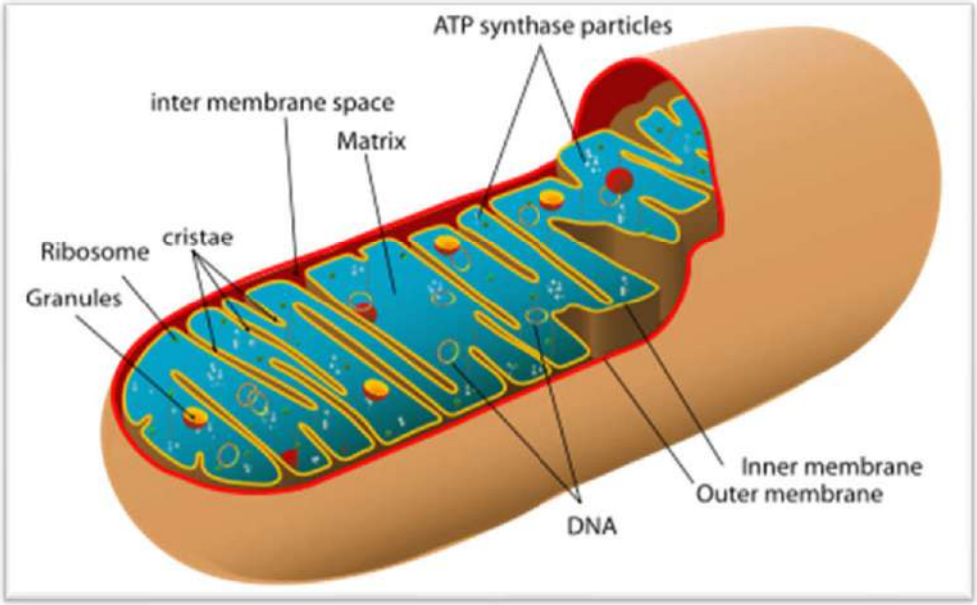


Endocytosis transport diagram

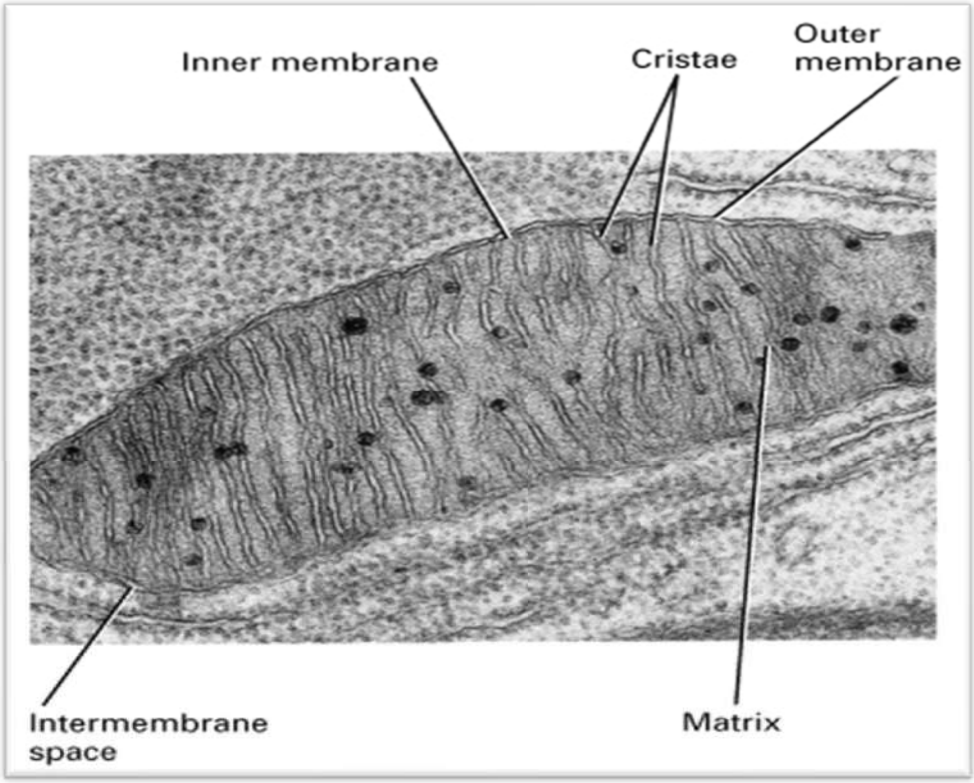


Exocytosis transport diagram

MITOCHONDRIA

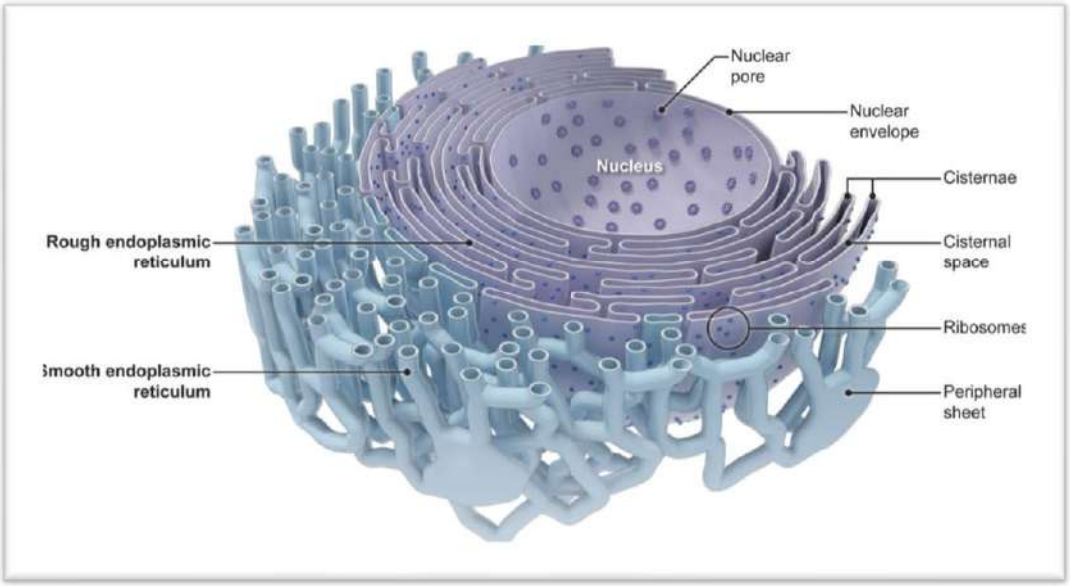


Mitochondria structure diagram

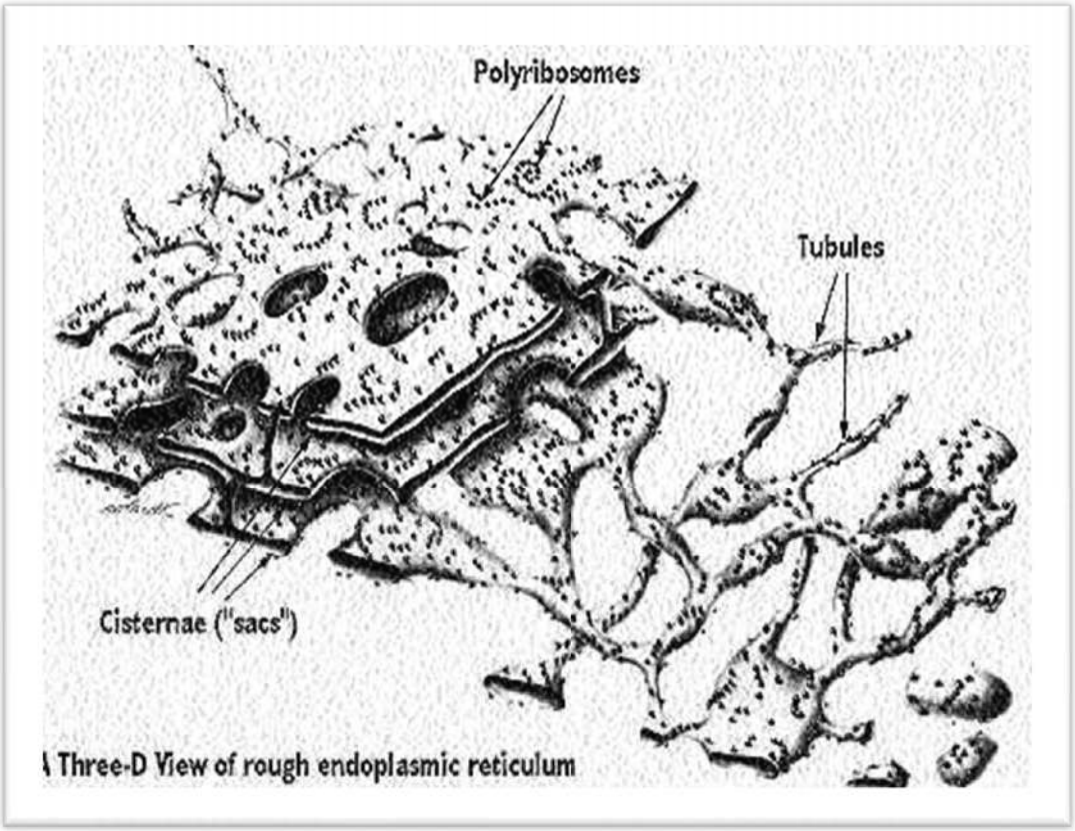


Mitochondria structure ultrastructure

ENDOPLASMIC RETICULUM

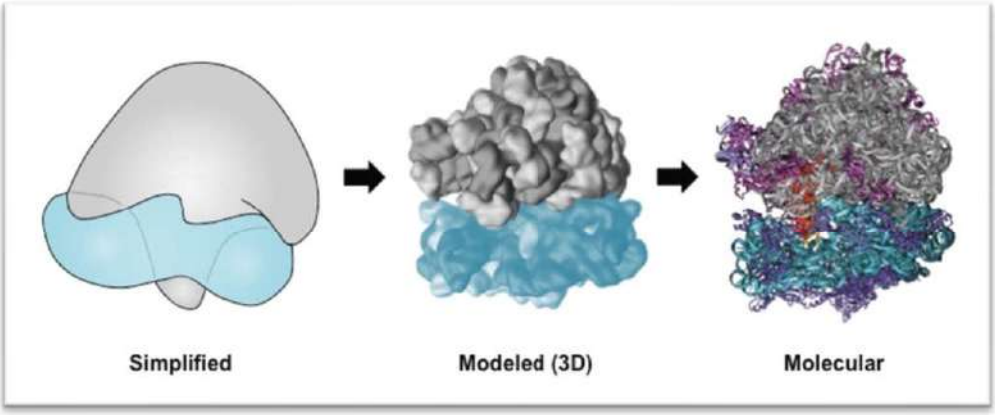


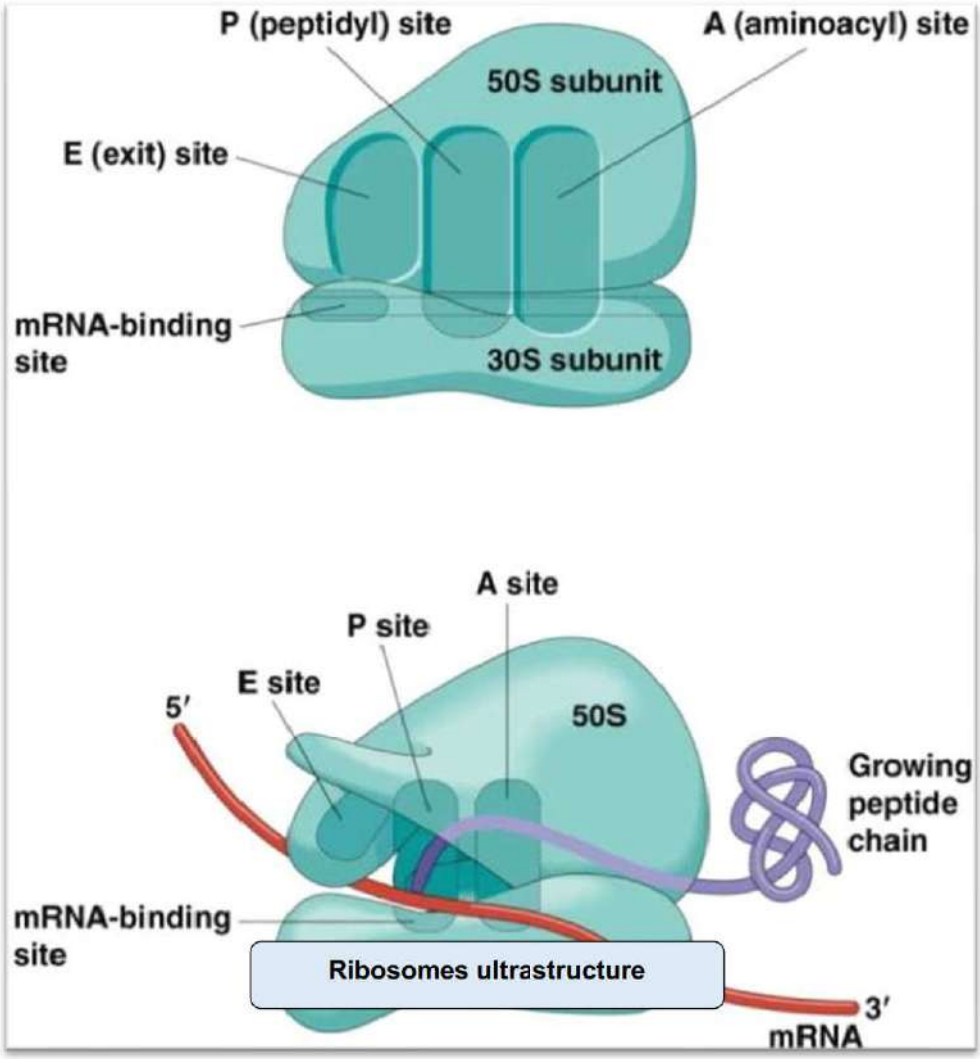
Endoplasmic reticulum structure diagram



Rough Endoplasmic reticulum 3D structure diagram

RIBOSOMES

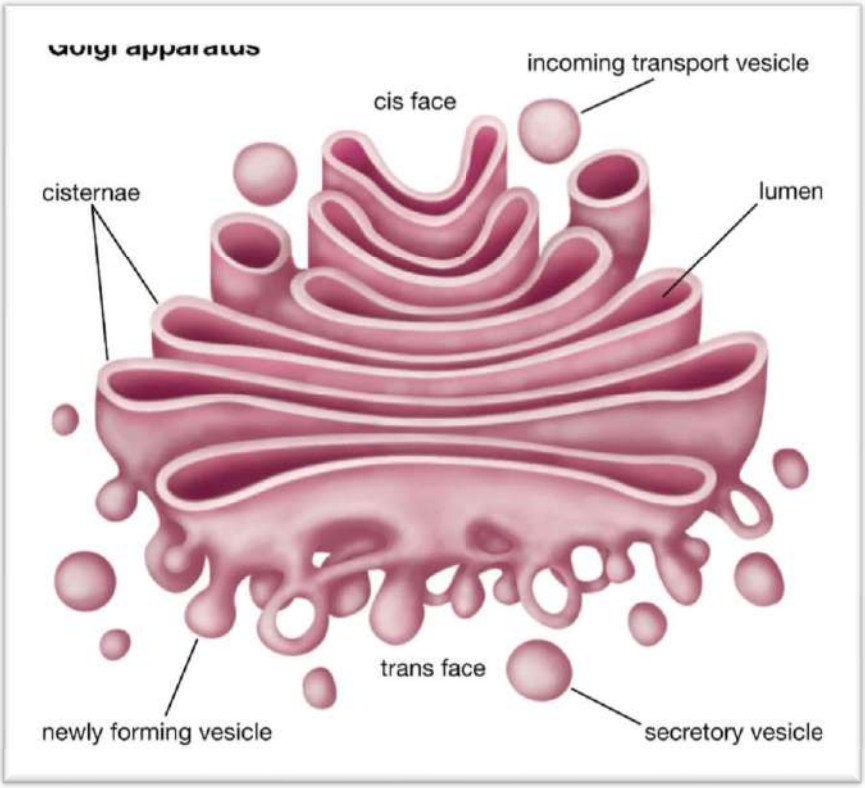


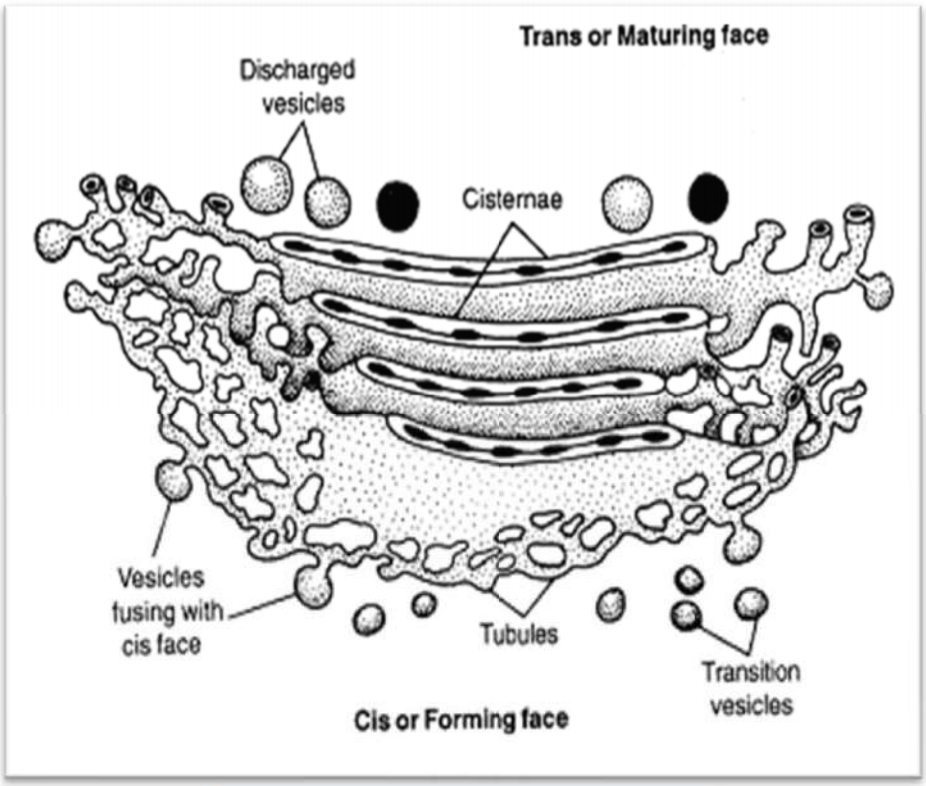


Ribosomes ultrastructure

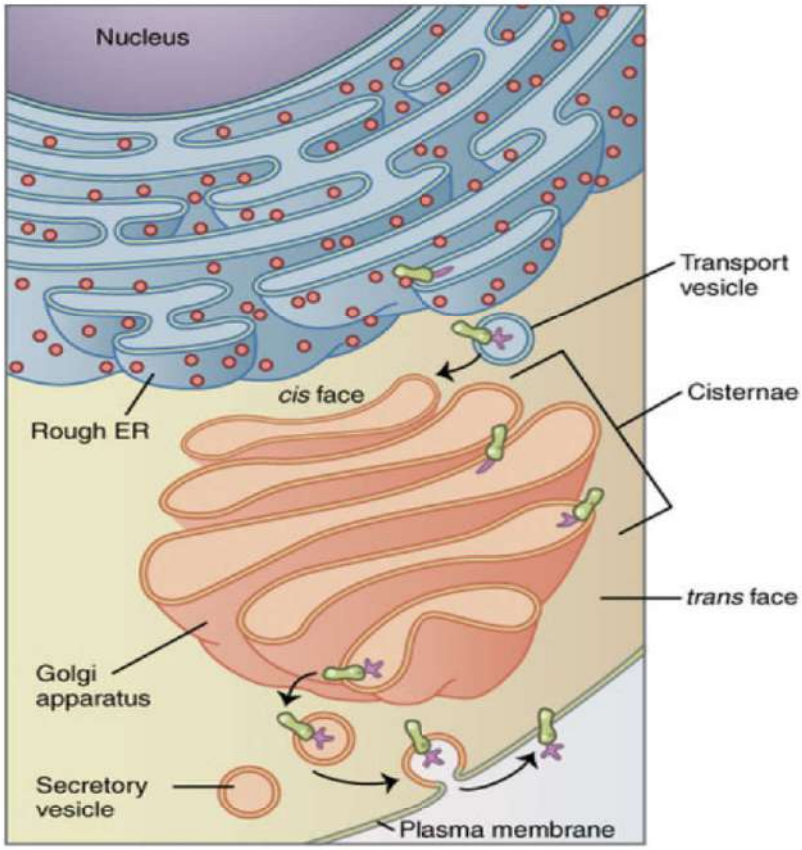
Ribosome & ribosomal unit sites structure diagram

GOLOGI APPARATUS

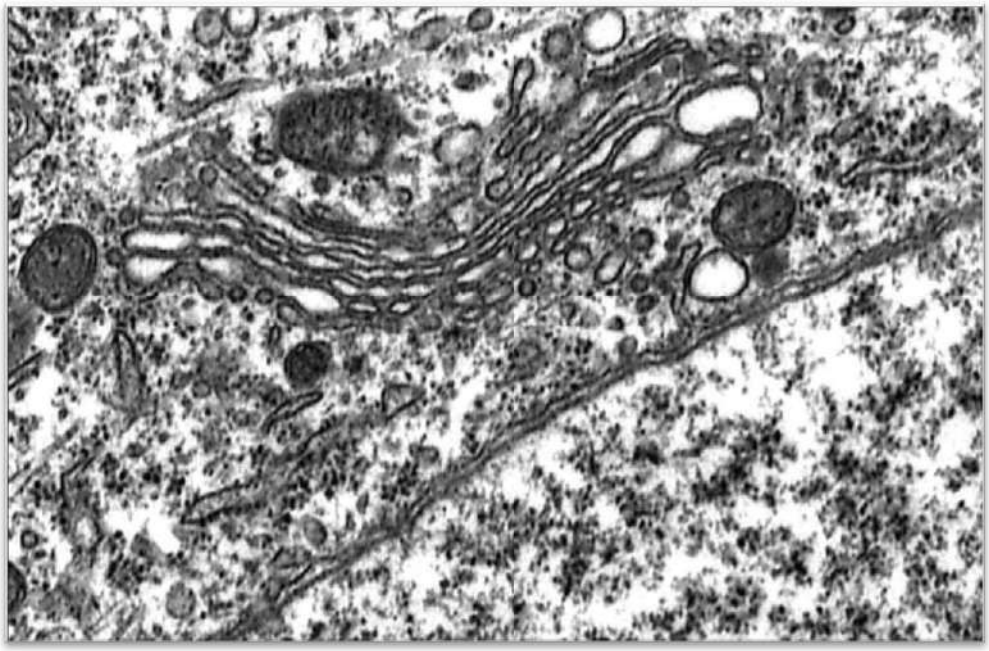




Golgi apparatus structure diagram

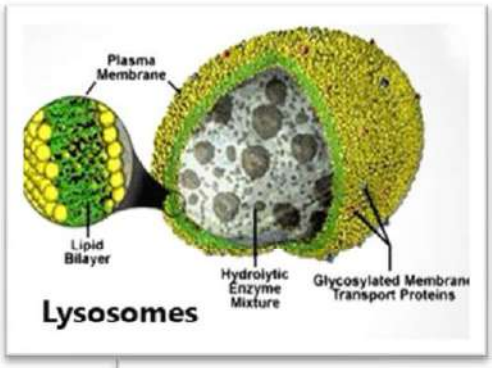


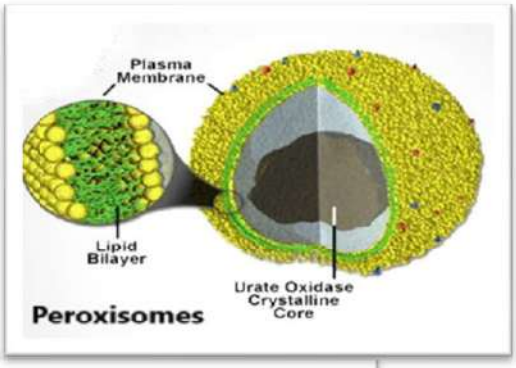
Golgi apparatus transport diagram

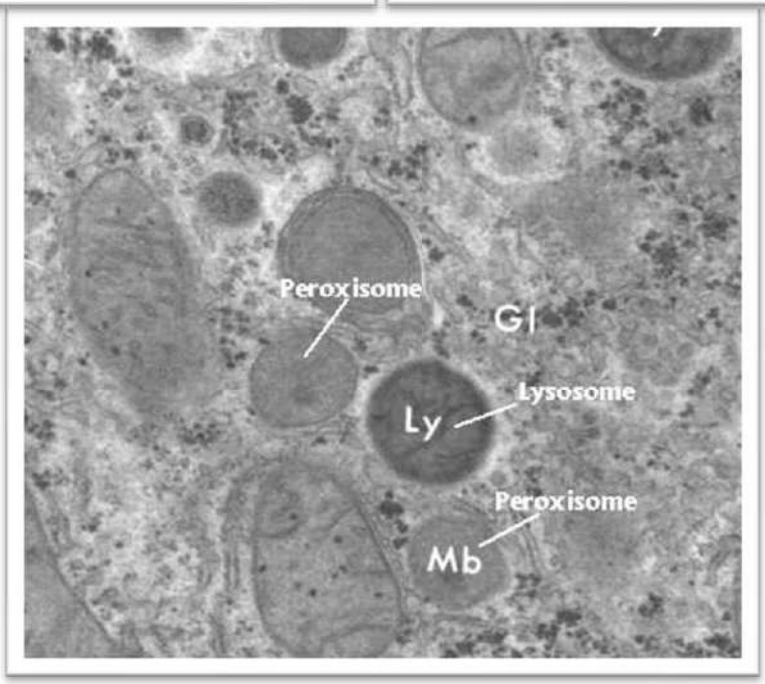


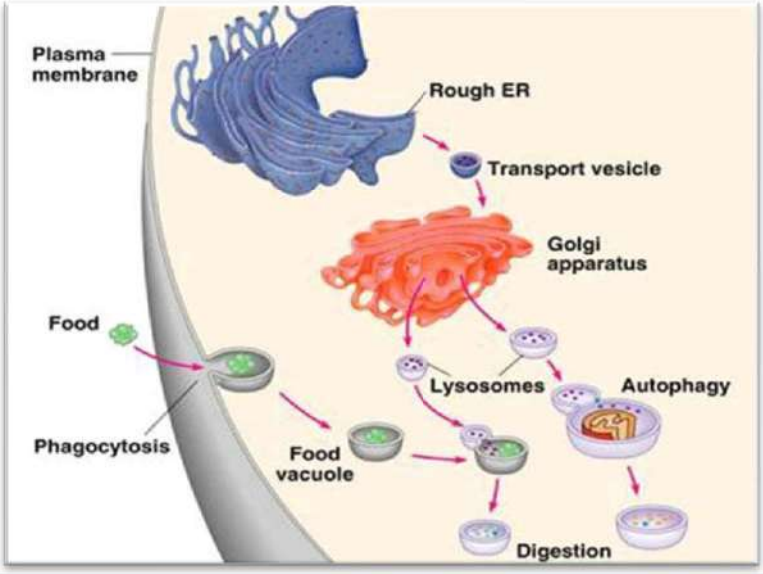
Golgi apparatus ultrastructure

LYSOSOMES & PEROXISOMES



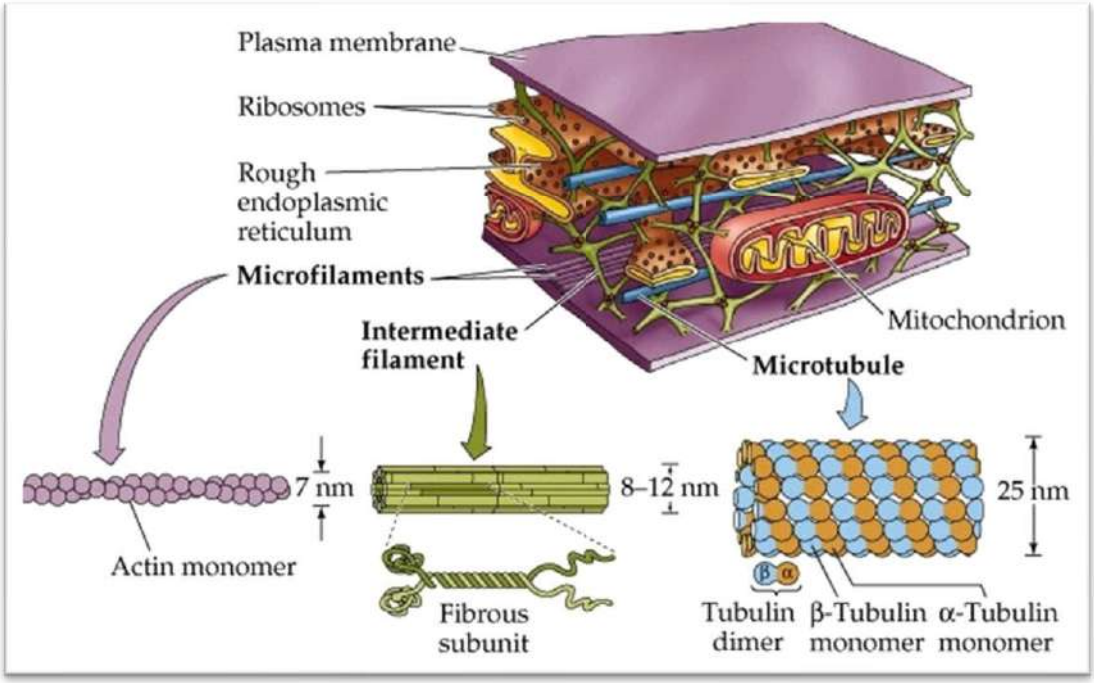




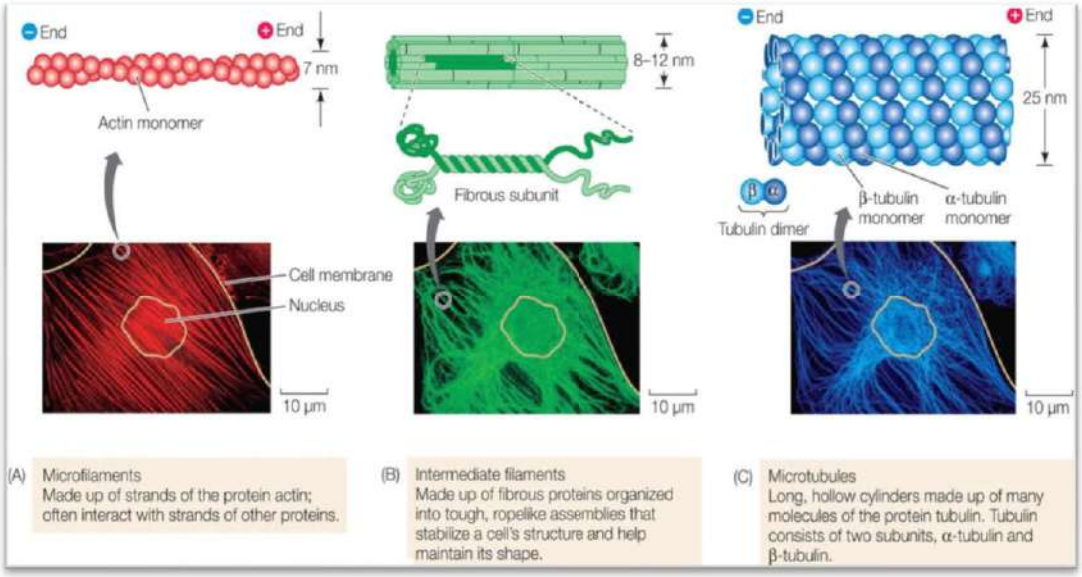


Lysosomes and peroxisome's structure diagram and ultrastructure

CYTOSKELETON

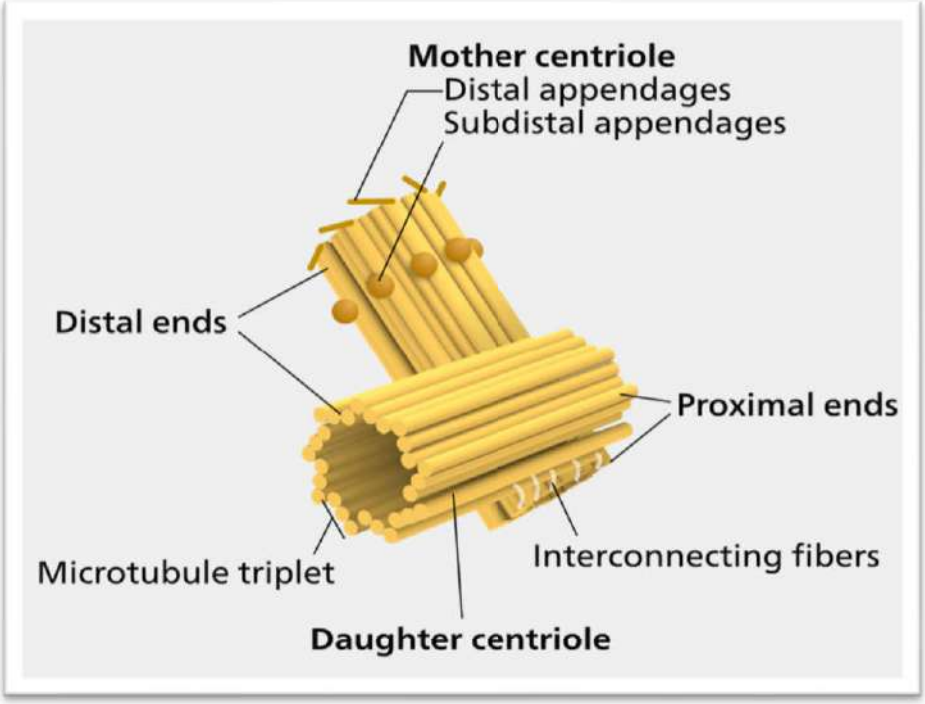


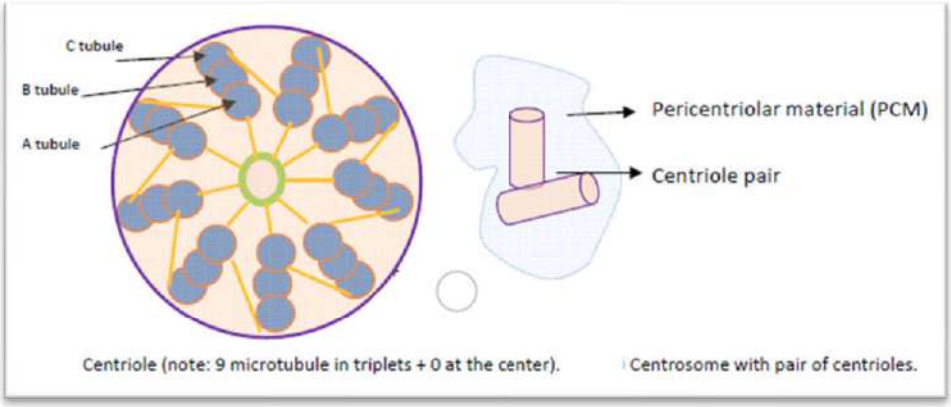
Cytoskeleton structure diagram



Cytoskeleton component's structure diagram

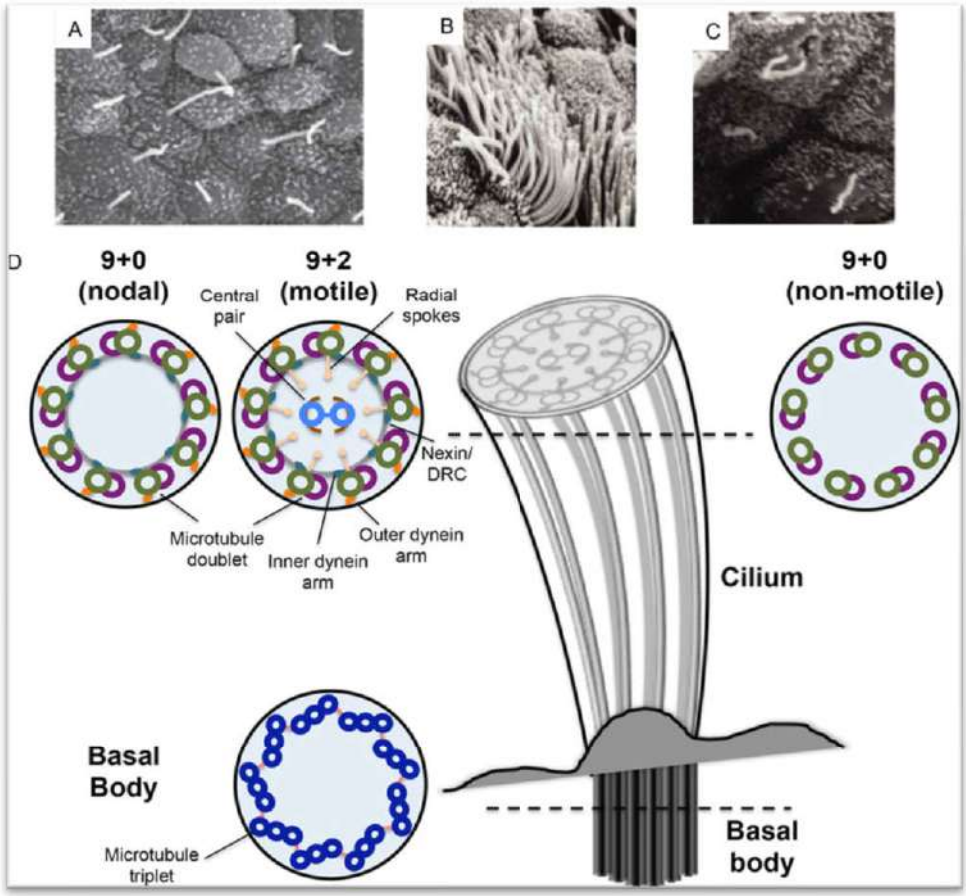
CENTROSOME (CENTRIOLES)

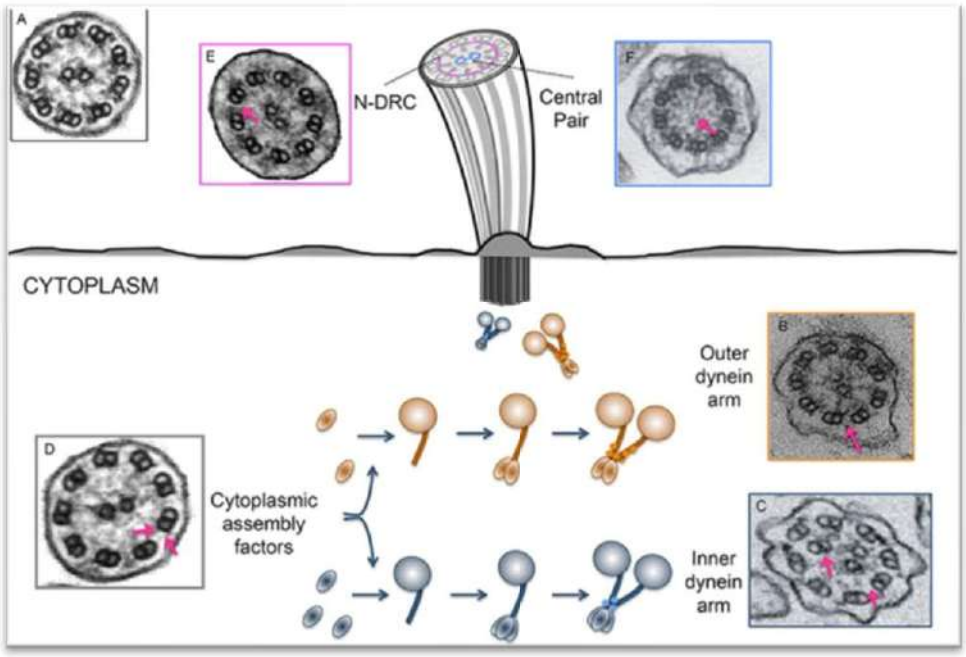




Centrosome structure diagram

CILIA & FLAGELLUM



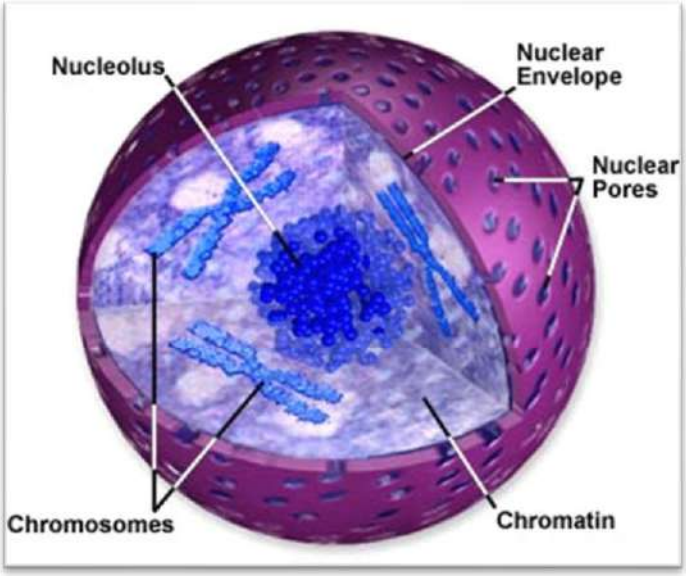


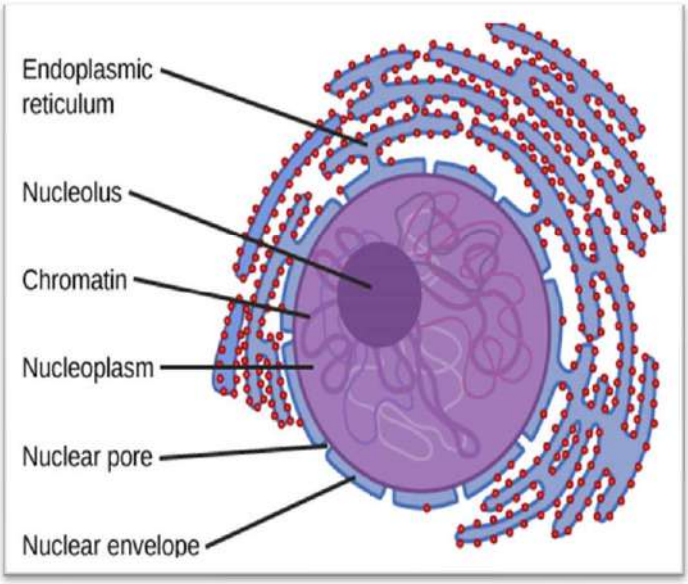
Cilia and flagellum structure diagram & ultrastructure

NUCLEUS

Nuclear structure:

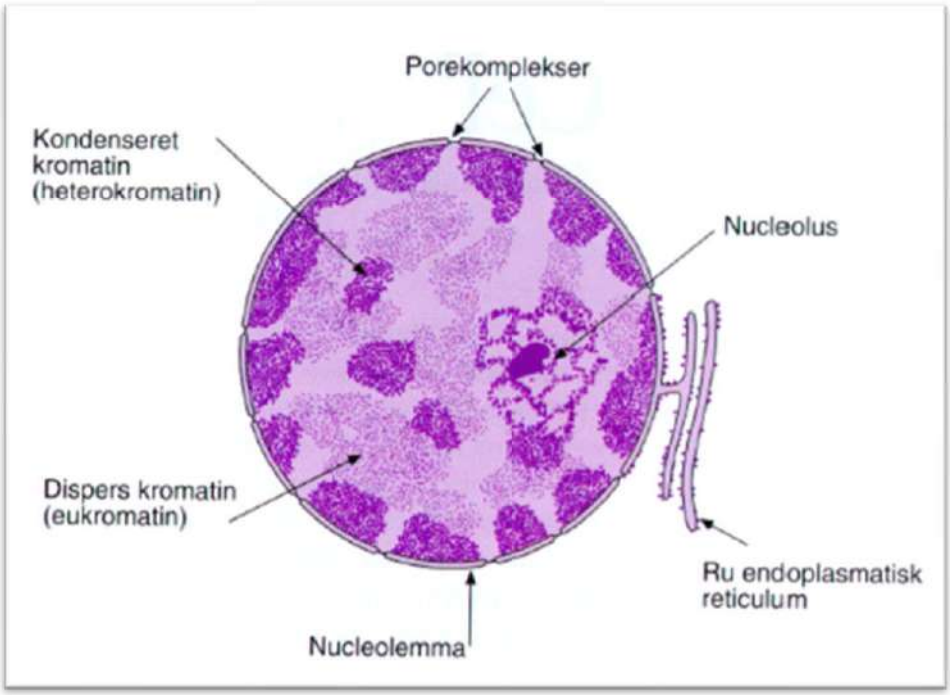
- **Nuclear envelope**
- **Nuclear pores**
- **Lamina**
- **Nucleolus**
- **Chromatin**

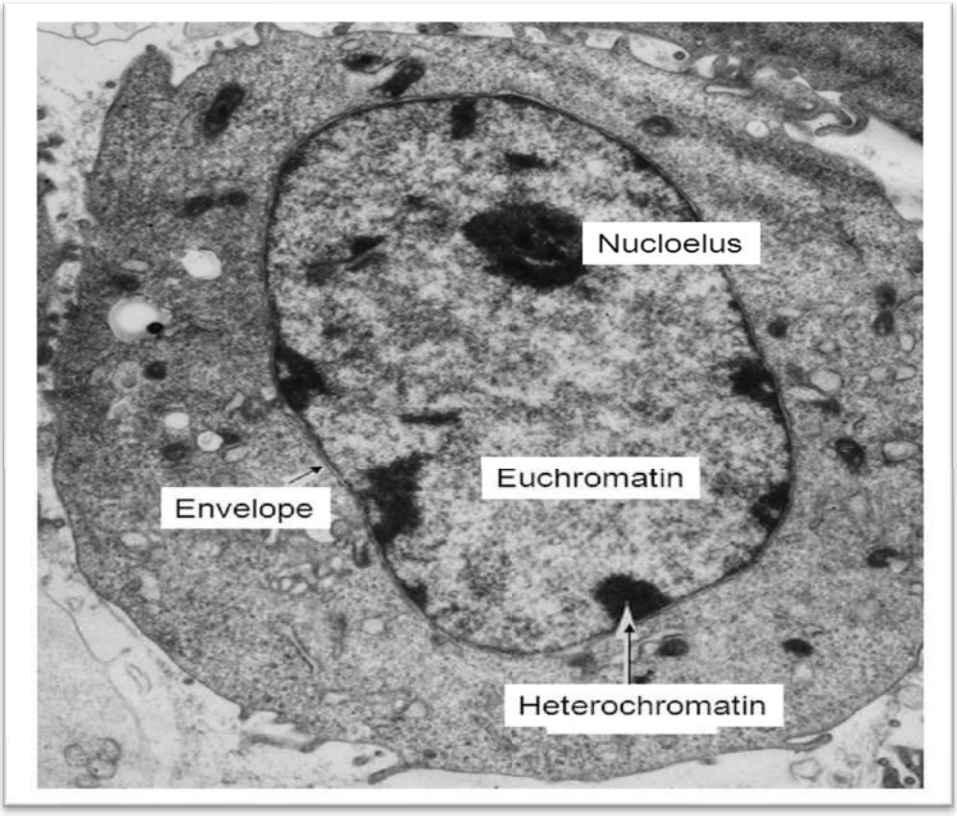




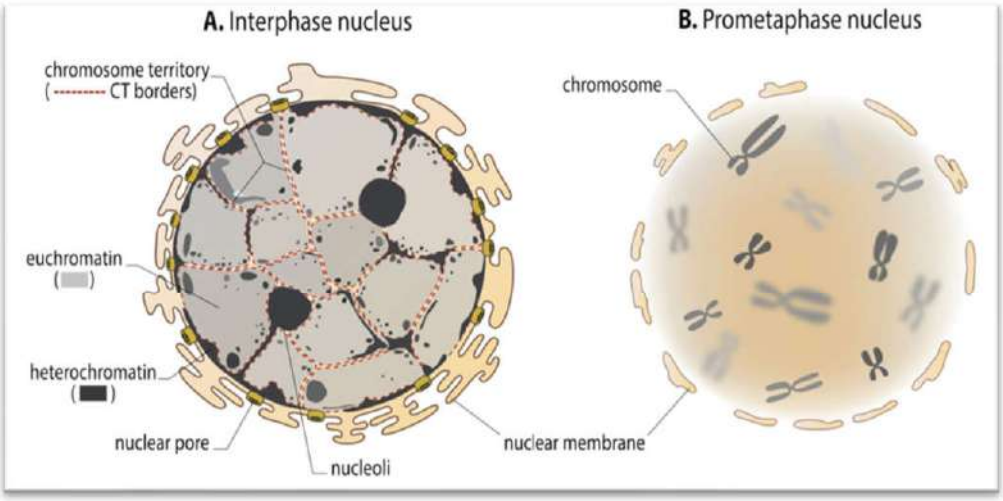
Nucleus structure diagram

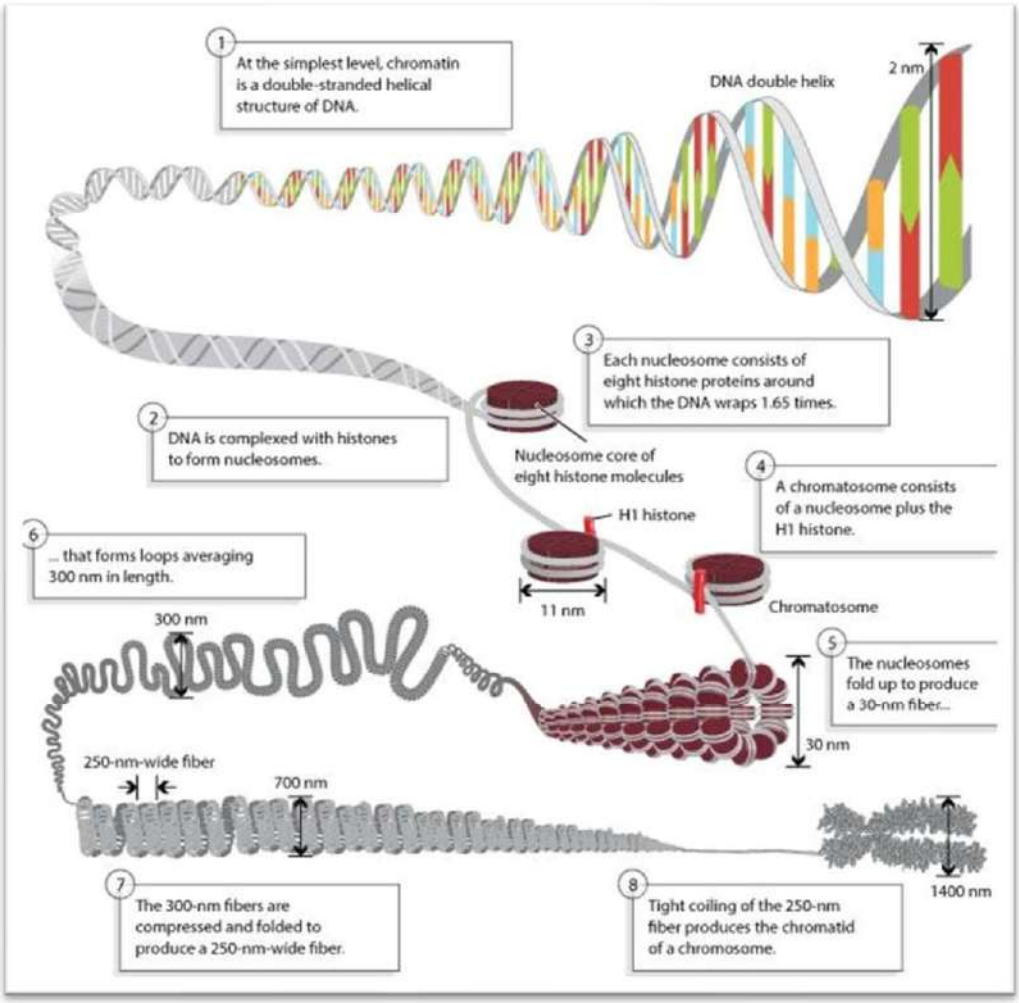
THE CHROMOSOMES



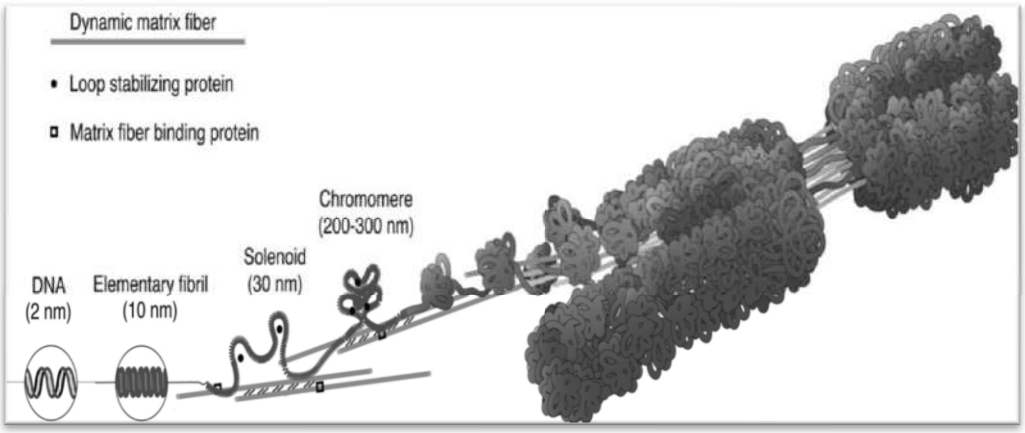


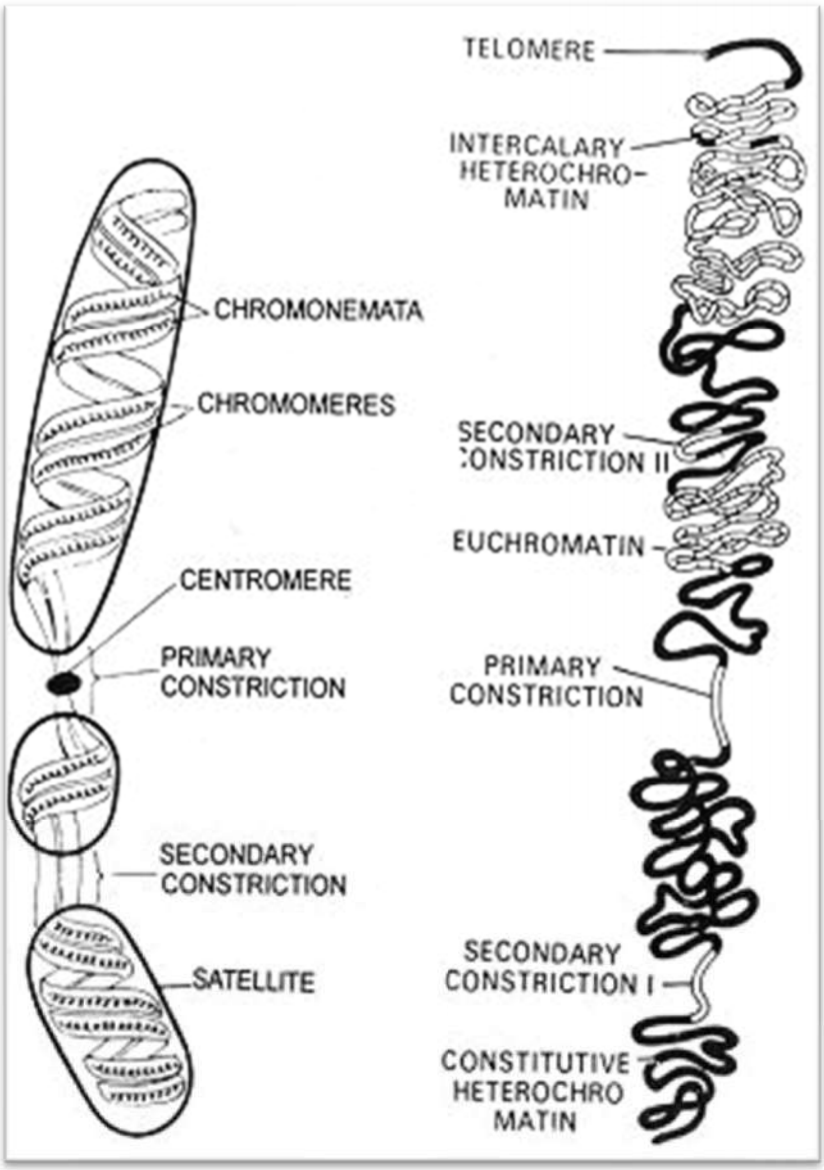
Chromatin structure diagram & ultrastructure



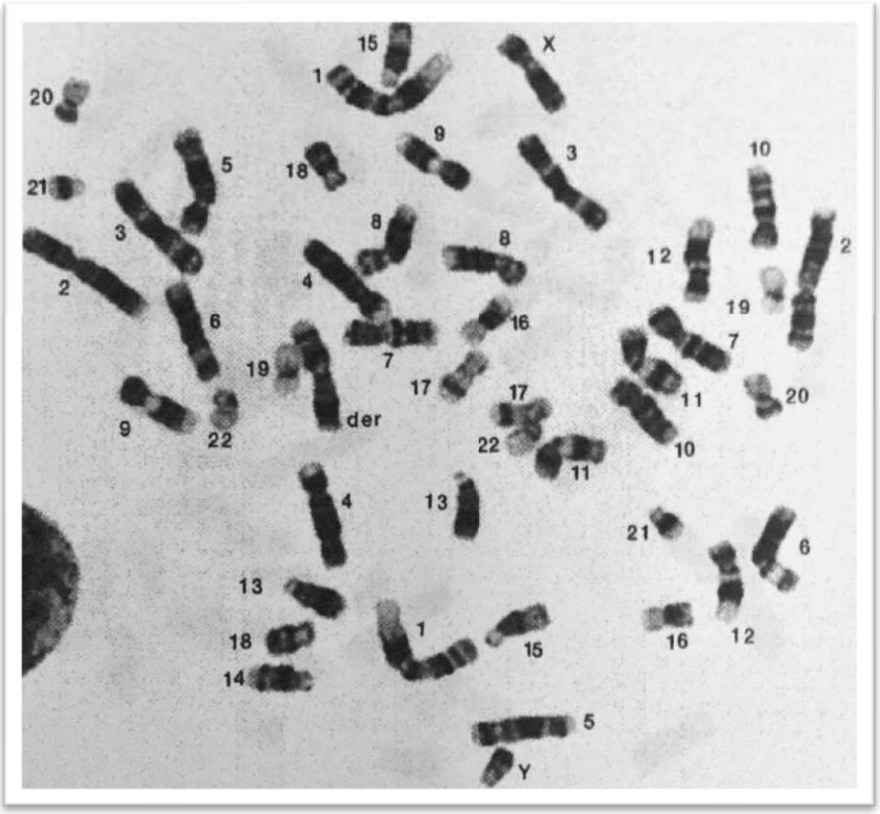


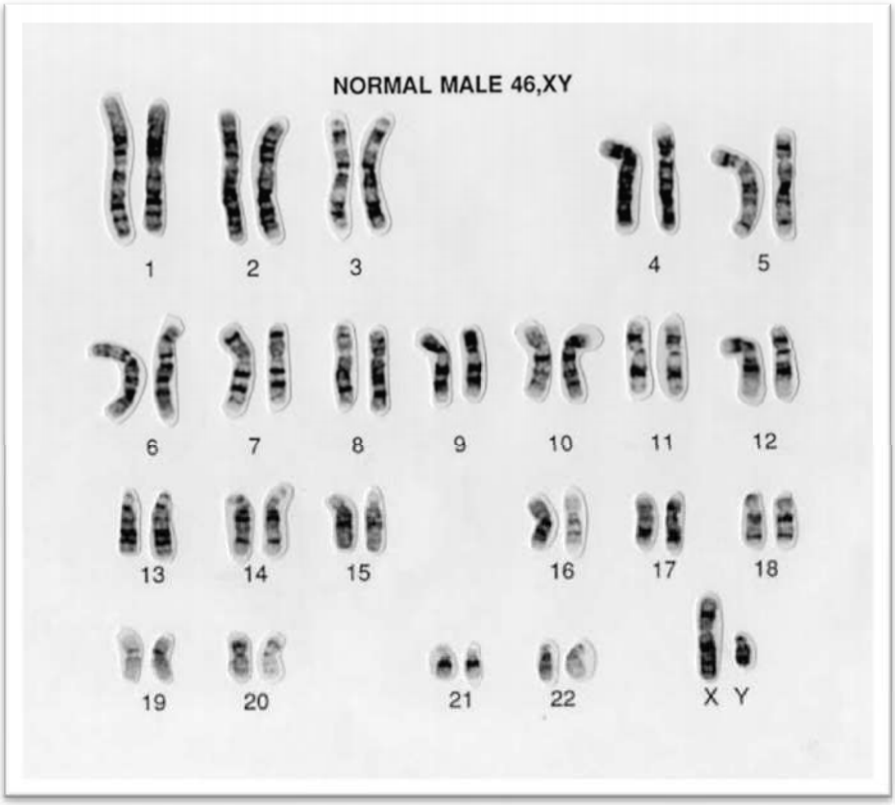
Chromosome's structure diagram





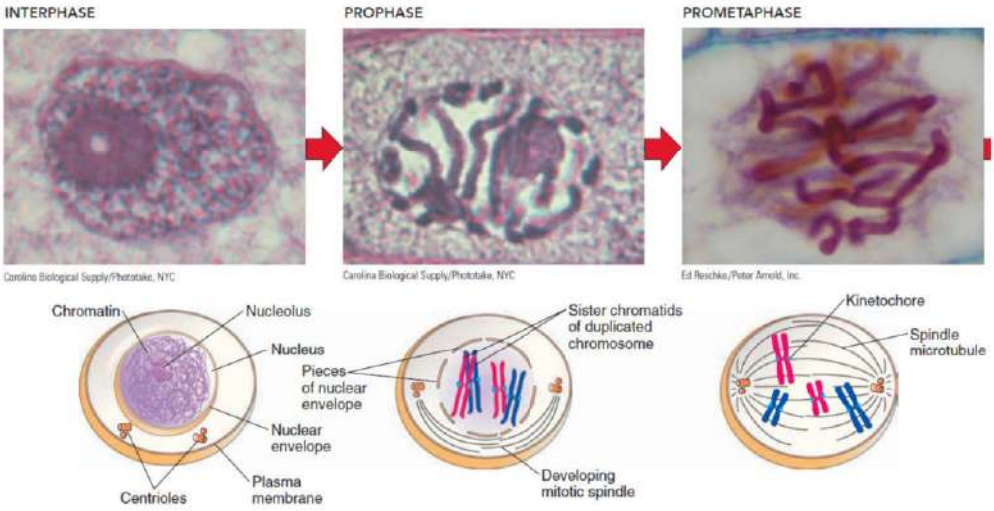
Chromosome's structure diagram





Normal human karyotype

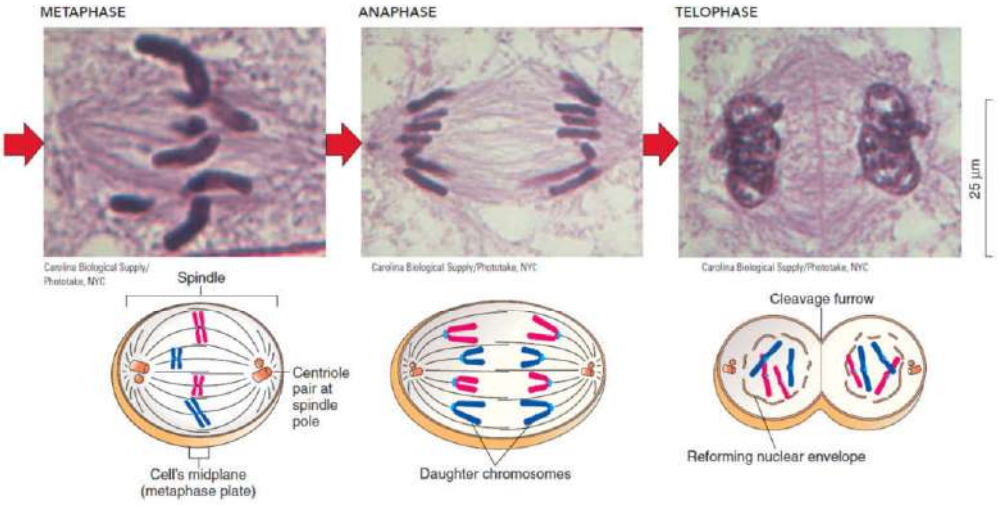
MITOSIS DIVISION



Cell carries out normal life activities. Chromosomes become duplicated.

Long fibers of chromatin condense as compact mitotic chromosomes, each consisting of two chromatids attached at their centromeres. Cytoskeleton is disassembled, and mitotic spindle forms between centrioles, which have moved to poles of cell. Nuclear envelope begins to disappear.

Spindle microtubules attach to kinetochores of chromosomes. Chromosomes begin to move toward cell's midplane.

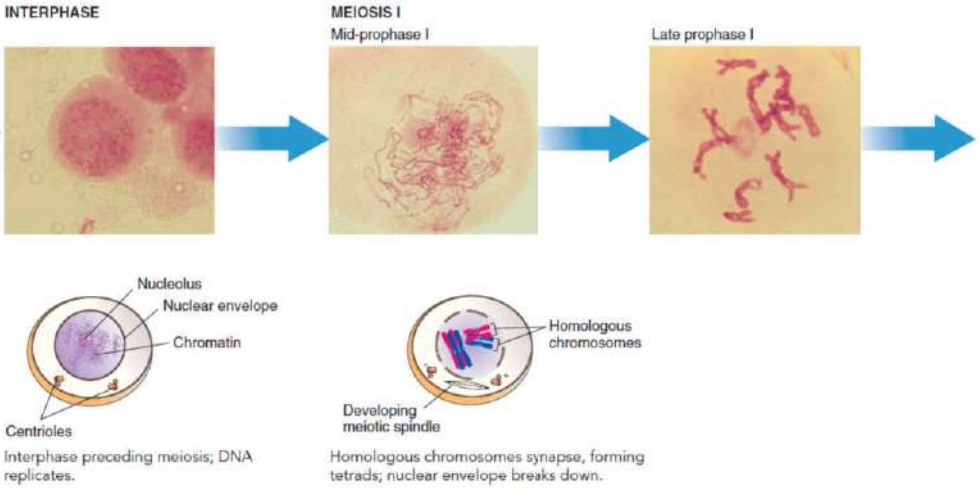


Chromosomes line up along cell's midplane. Spindle microtubules attach each chromosome to both poles.

Sister chromatids separate at their centromeres. One group of chromosomes moves toward each pole of cell. Spindle poles move farther apart.

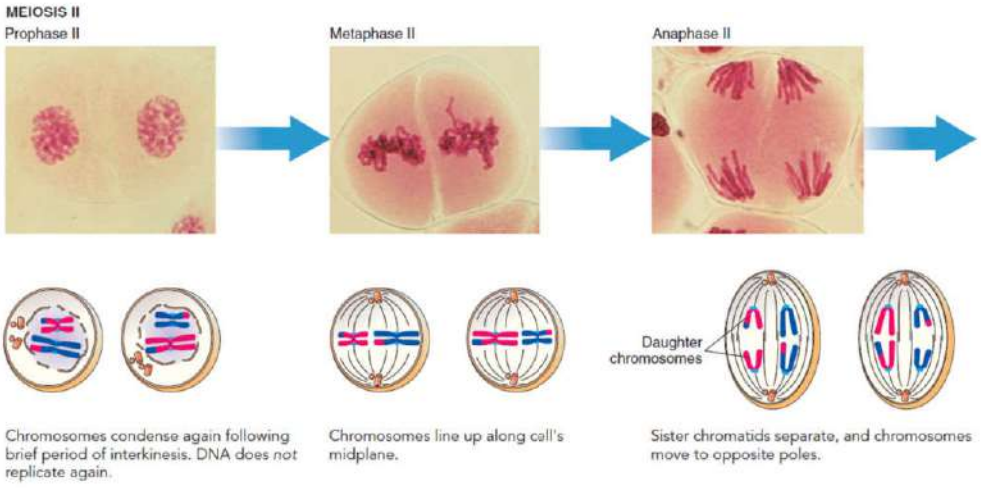
Chromosomes are grouped at poles. Chromosomes decondense, and nuclear envelopes begin to form. Cytokinesis produces two daughter cells.

MEIOSIS DIVISION



Interphase preceding meiosis; DNA replicates.

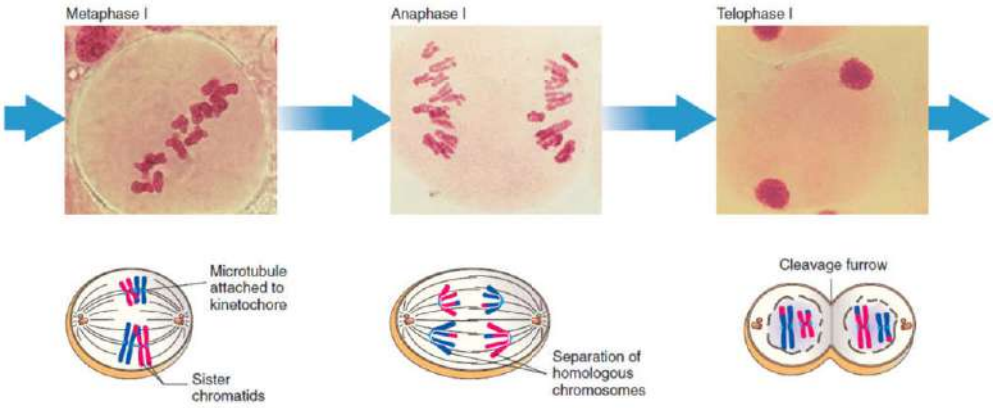
Homologous chromosomes synapse, forming tetrads; nuclear envelope breaks down.



Chromosomes condense again following brief period of interkinesis. DNA does not replicate again.

Chromosomes line up along cell's midplane.

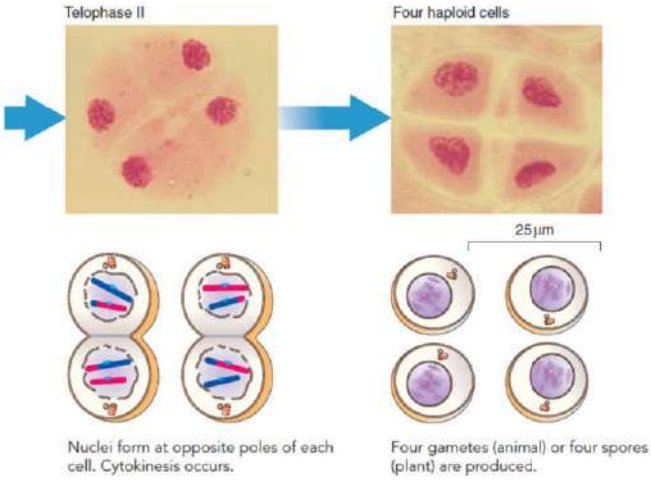
Sister chromatids separate, and chromosomes move to opposite poles.



Tetrads line up on cell's midplane. Tetrads held together at chiasmata (sites of prior crossing-over).

Homologous chromosomes separate and move to opposite poles. Note that sister chromatids remain attached at their centromeres.

One of each pair of homologous chromosomes is at each pole. Cytokinesis occurs.



Nuclei form at opposite poles of each cell. Cytokinesis occurs.

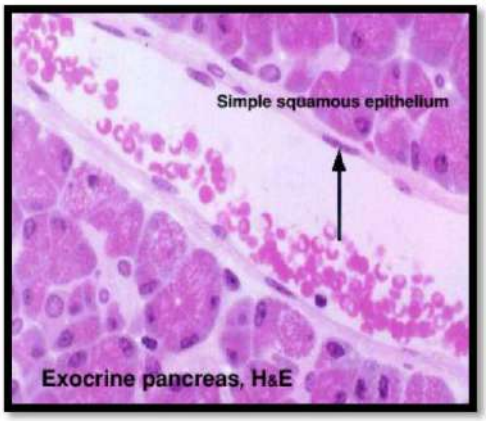
Four gametes (animal) or four spores (plant) are produced.

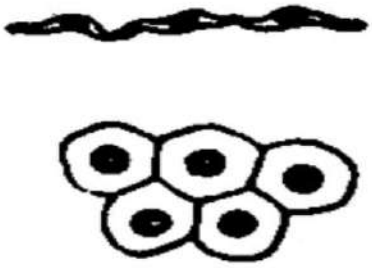
HISTOLOGY PART

EPITHELIAL TISSUES

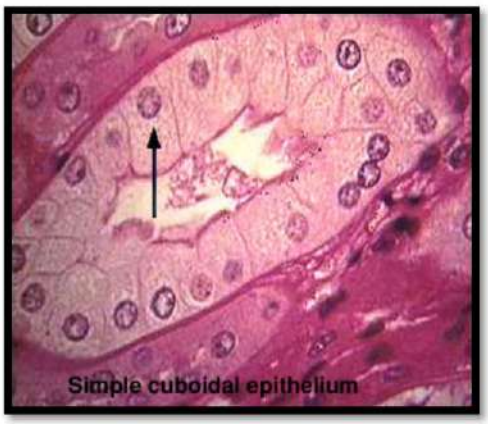
(A)Simple epithelial tissue:

1- Simple squamous epithelium

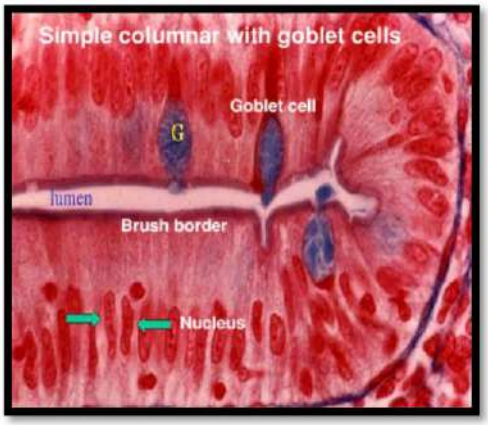




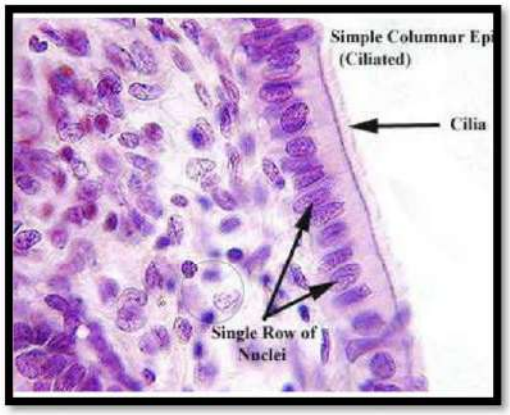
2- Simple cuboidal epithelium



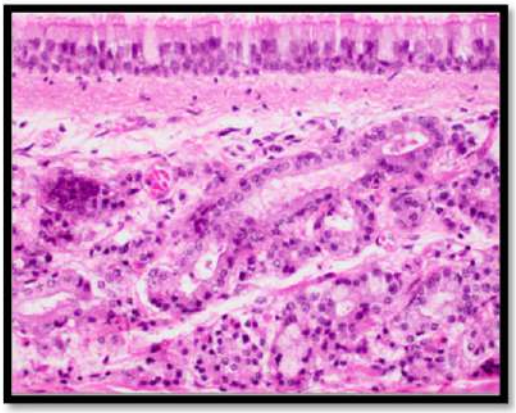
3- Simple columnar epithelium



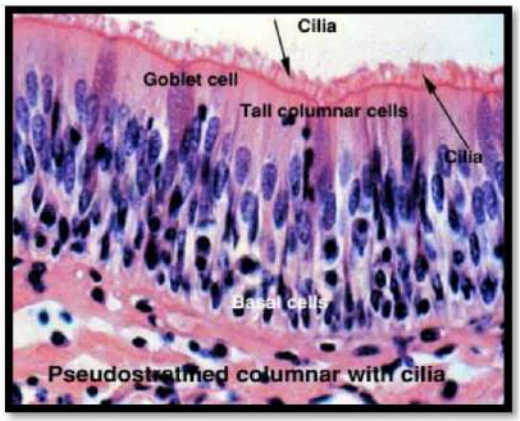
4- Simple columnar ciliated epithelium



5- Simple columnar ciliated epithelium

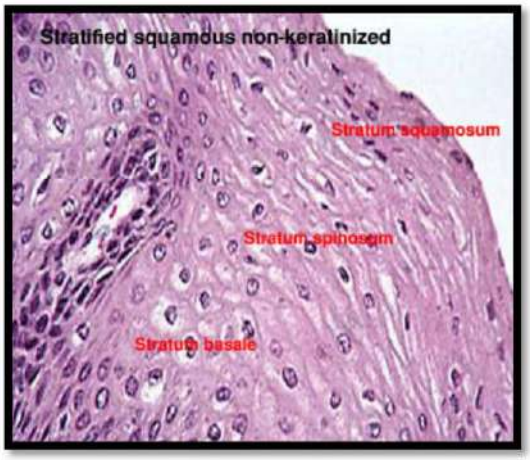


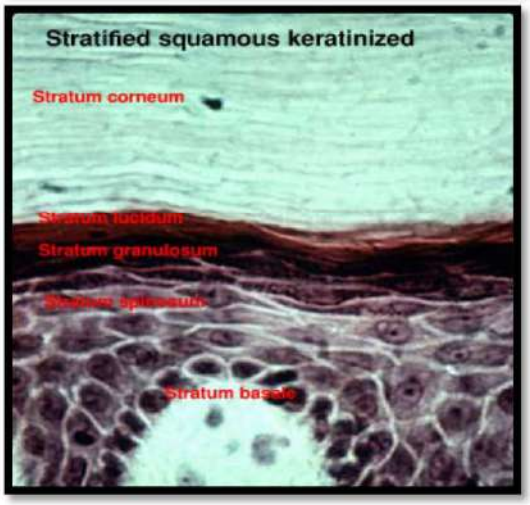
6- Pseudostratified columnar ciliated epithelium

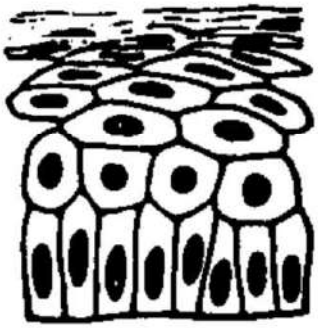


(B) Stratified (Compound) epithelial tissue:

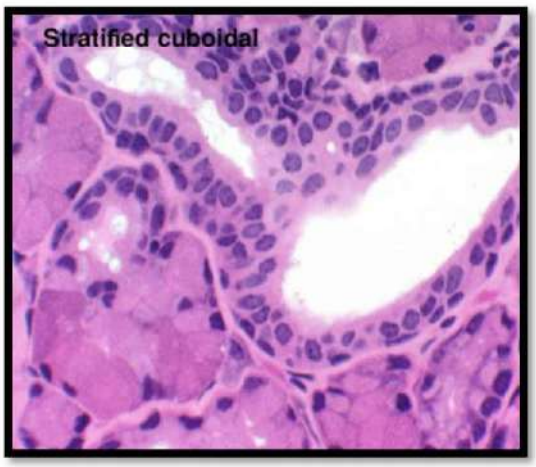
1- Stratified squamous epithelium



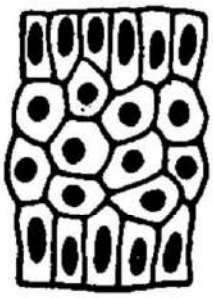




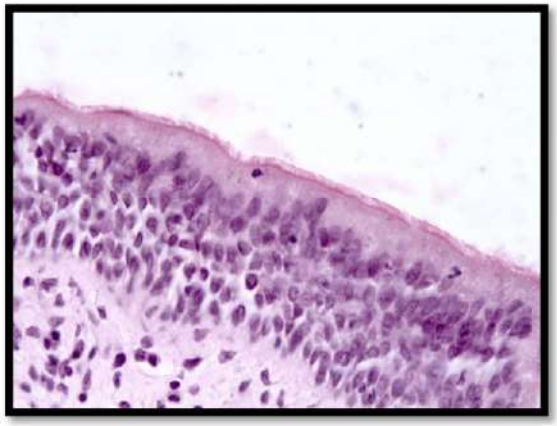
2- Stratified cuboidal epithelium



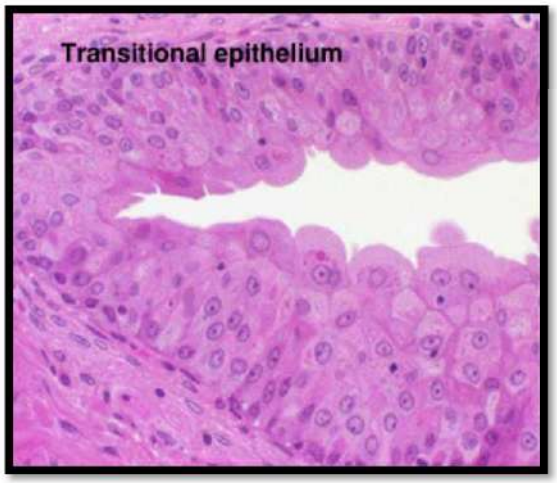
3- Stratified columnar epithelium



4- Stratified columnar ciliated epithelium

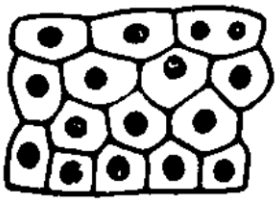


5- Transitional epithelium



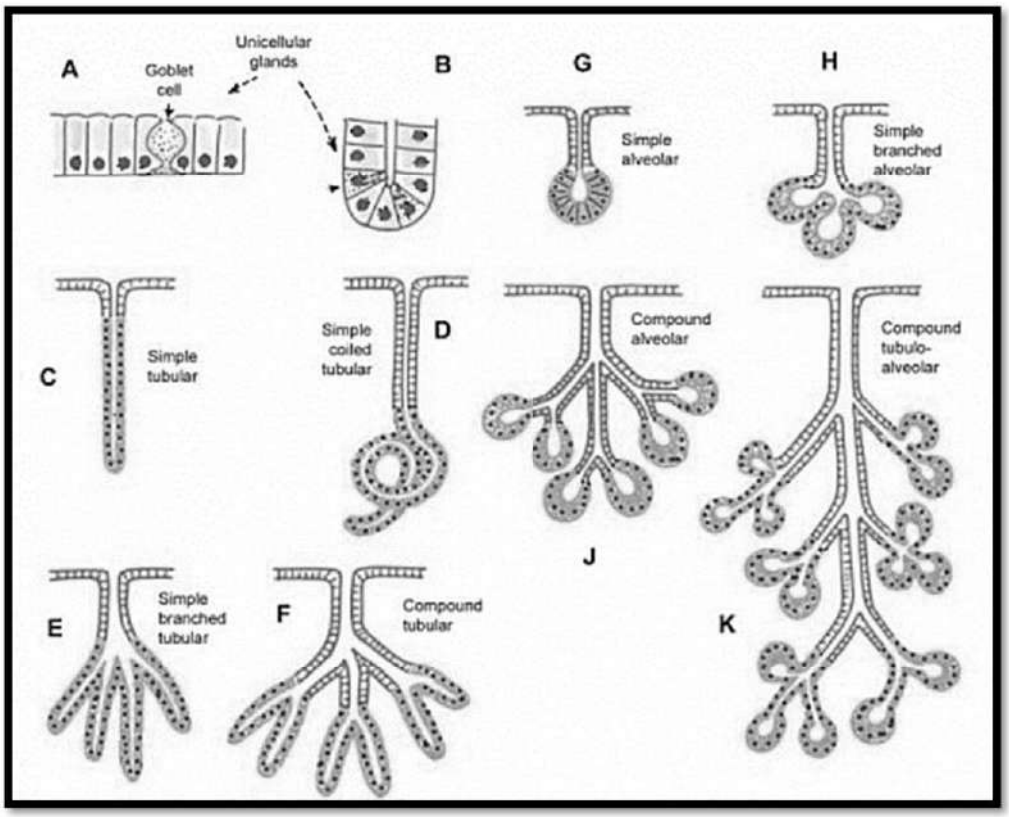
Stretched

Collapsed

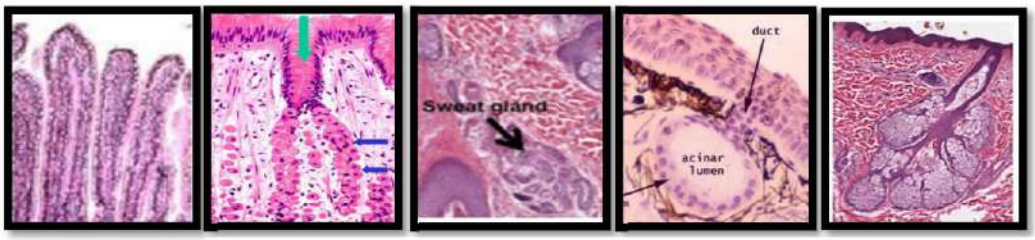


Modification of epithelial tissue

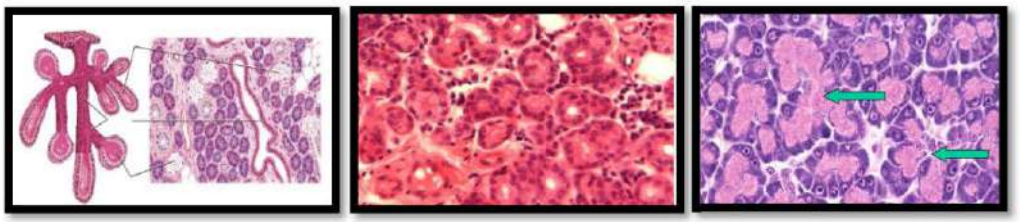
Glandular epithelium



Examine different slide sections of animal's organs and identify the different types of glands.



Simple. tubular | Branched tubular | Coiled tubular | Simple alveolar | Branched alveolar

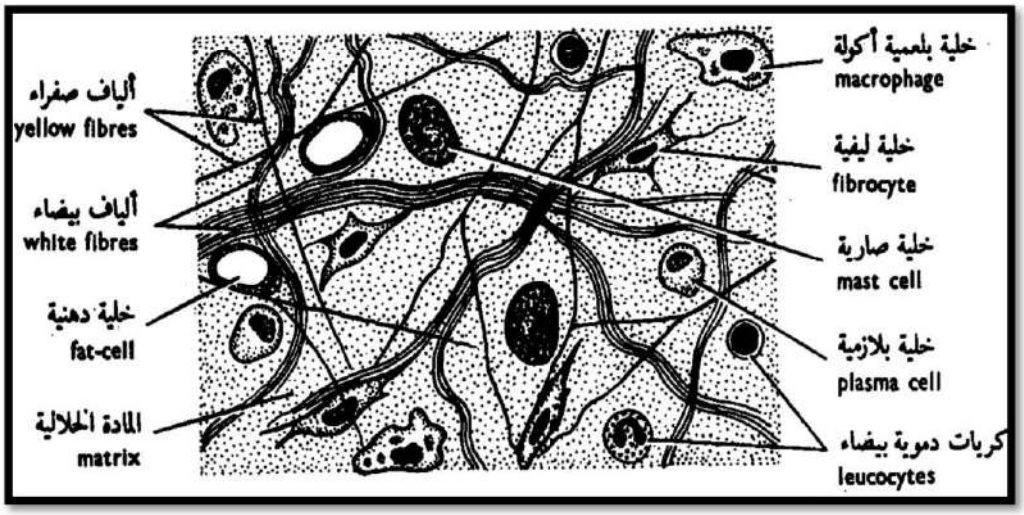


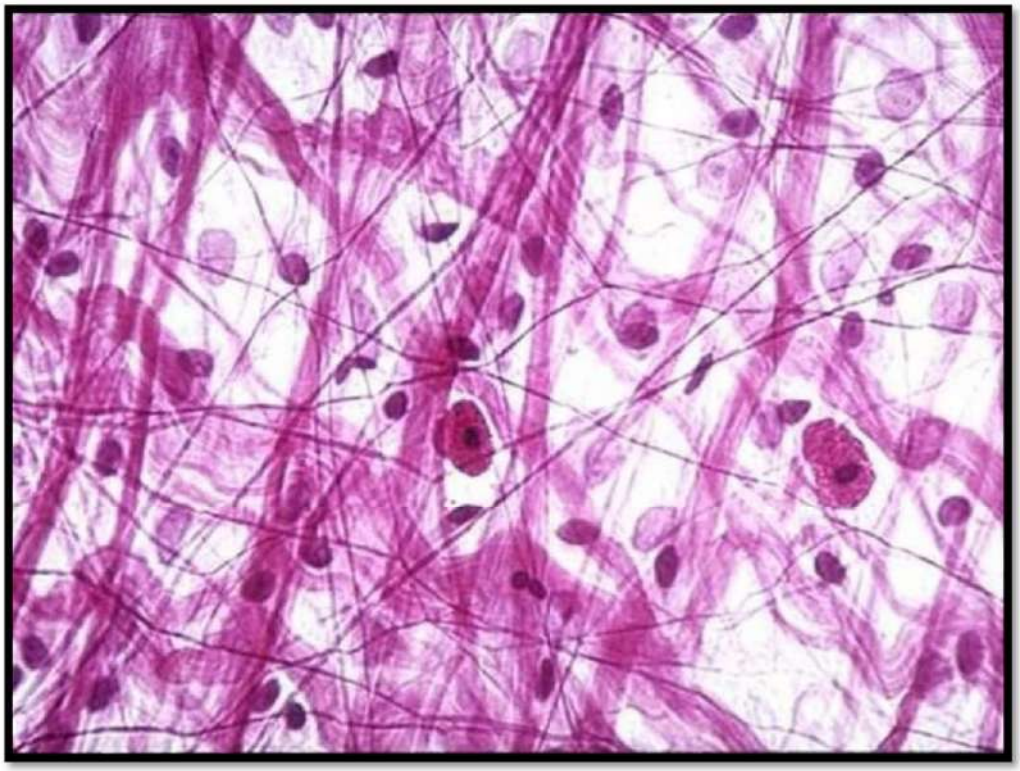
Compound alveolar | Compound tubular | Compound tubu-alveolar

CONNECTIVE TISSUES

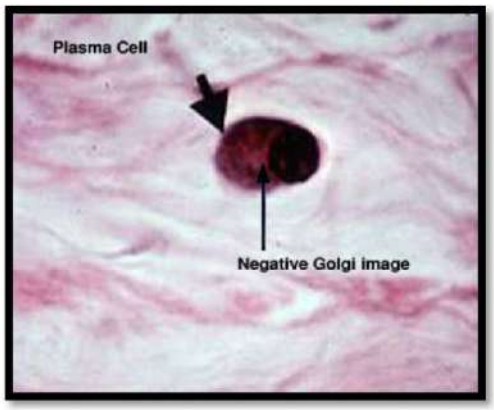
(B) Connective tissue proper

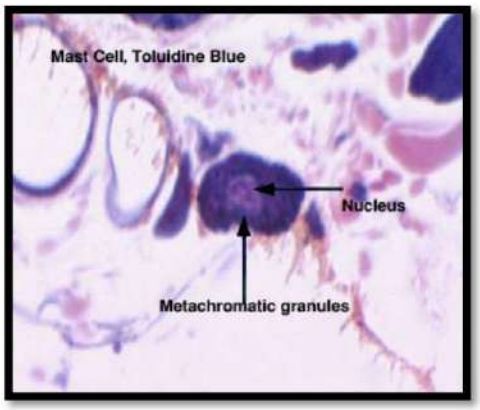
1- Areolar connective tissue proper

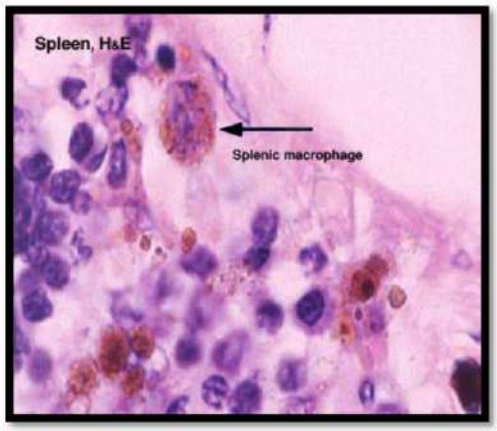


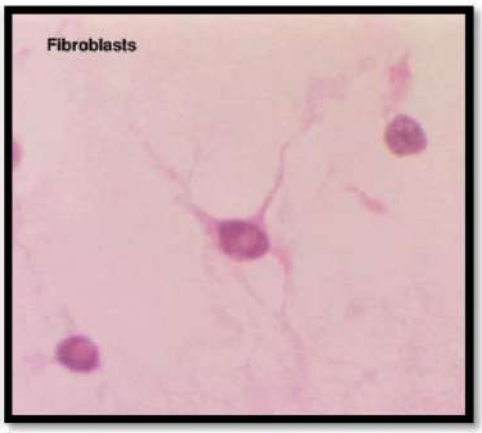


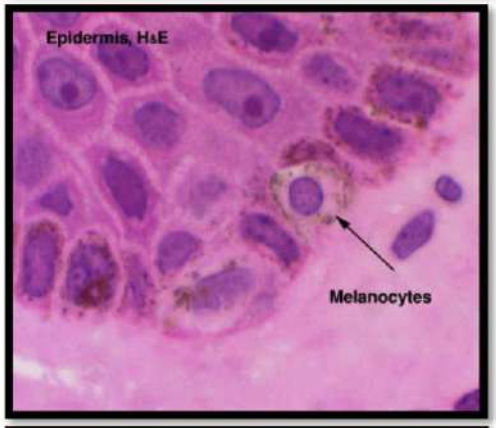
Types of cells

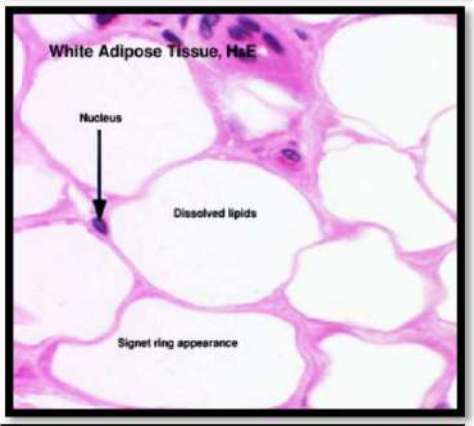


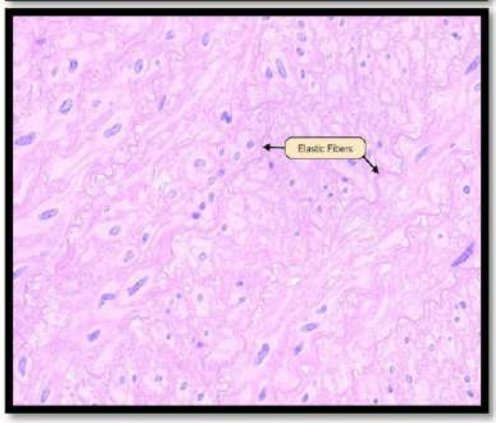


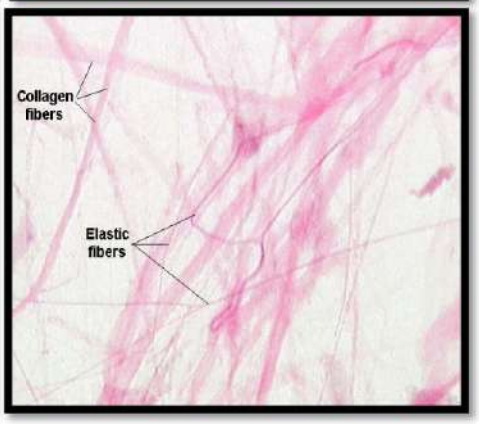




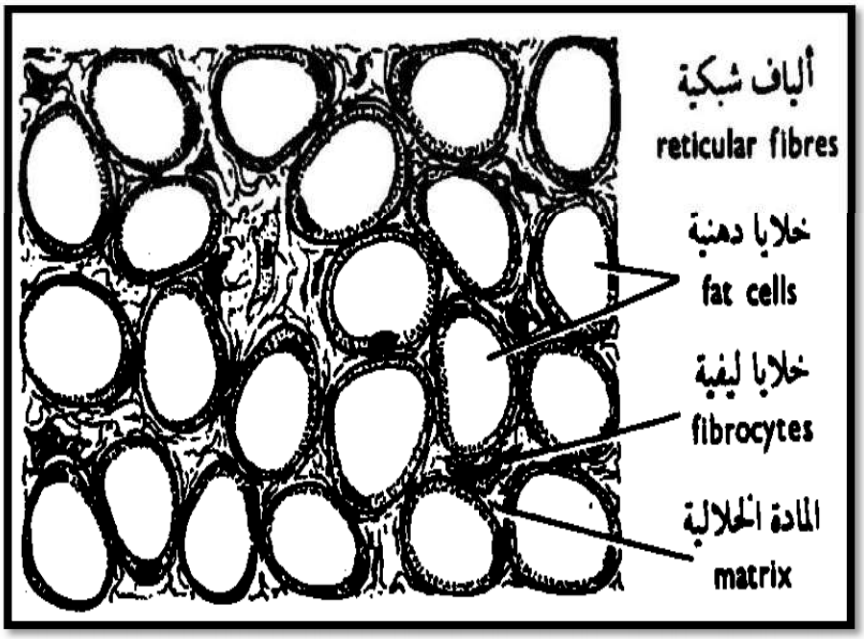


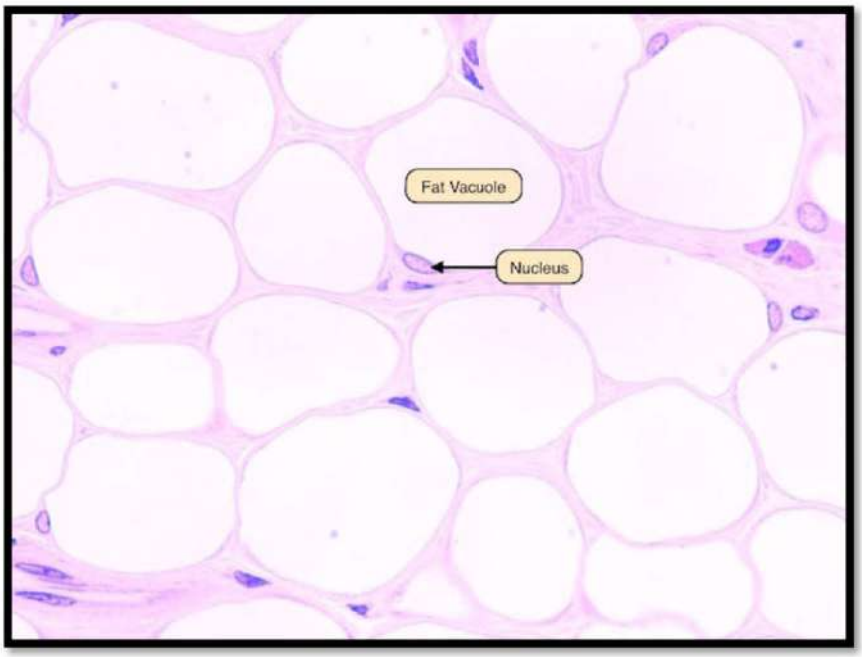




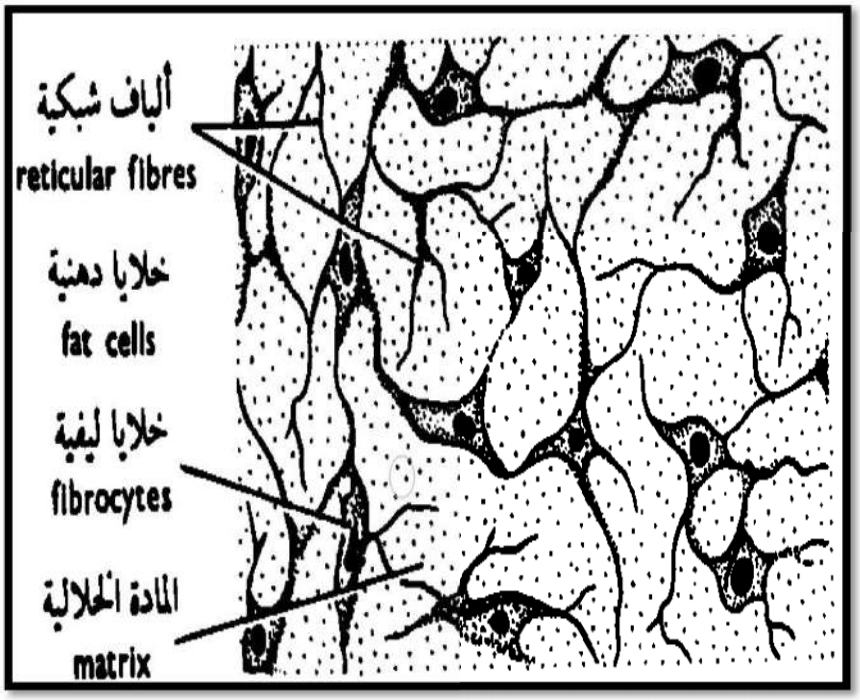


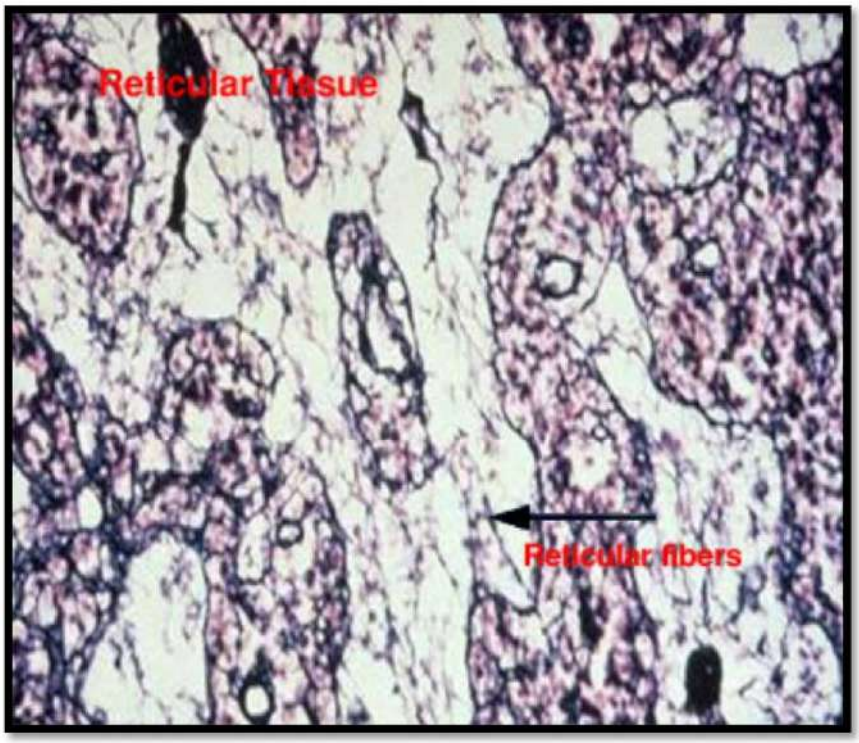
2- Adipose connective tissue



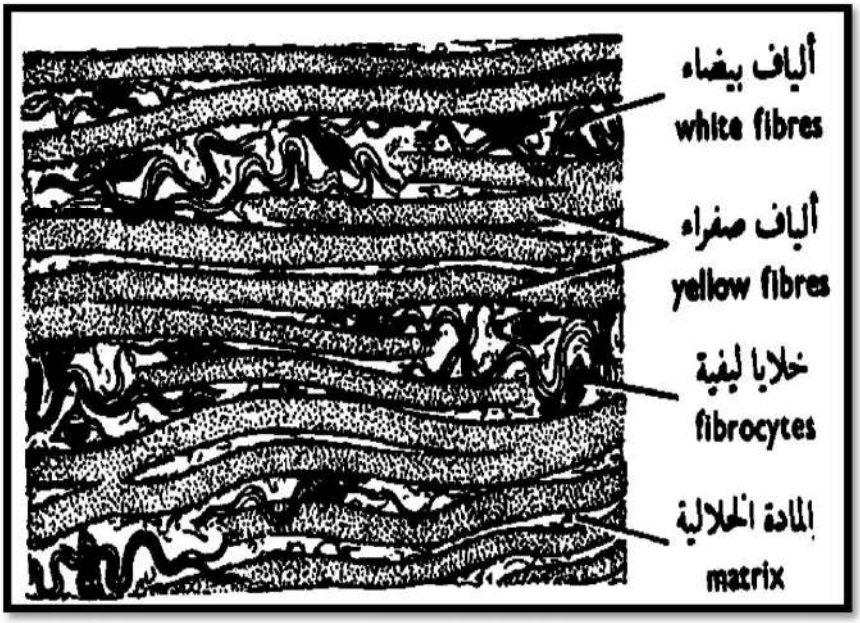


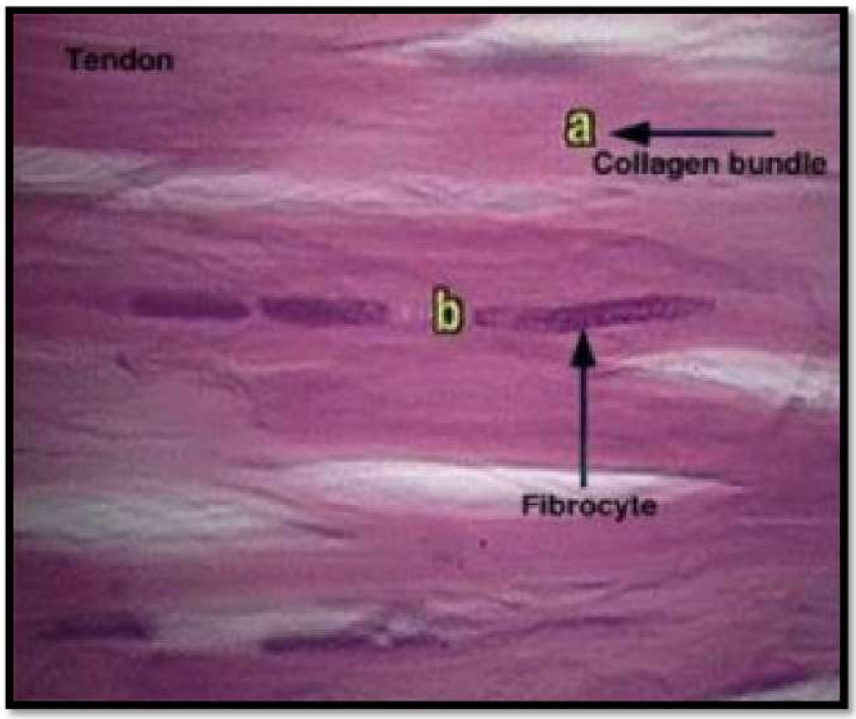
3- Reticular connective tissue



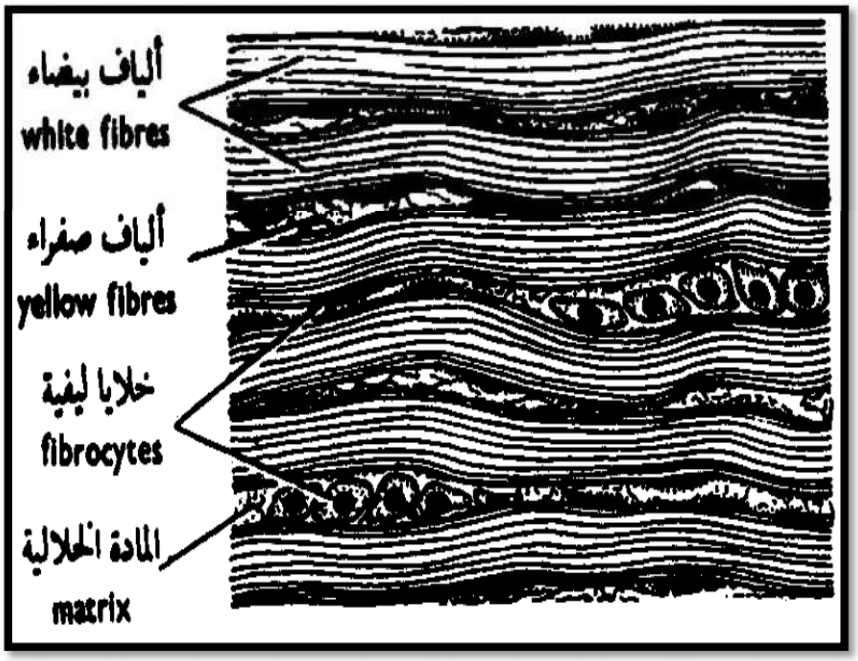


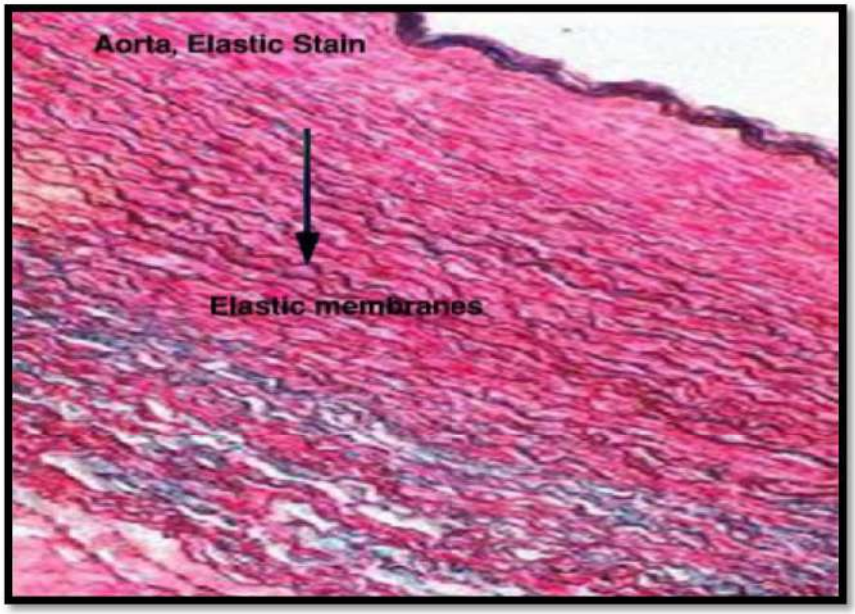
4- Fibrous connective tissue



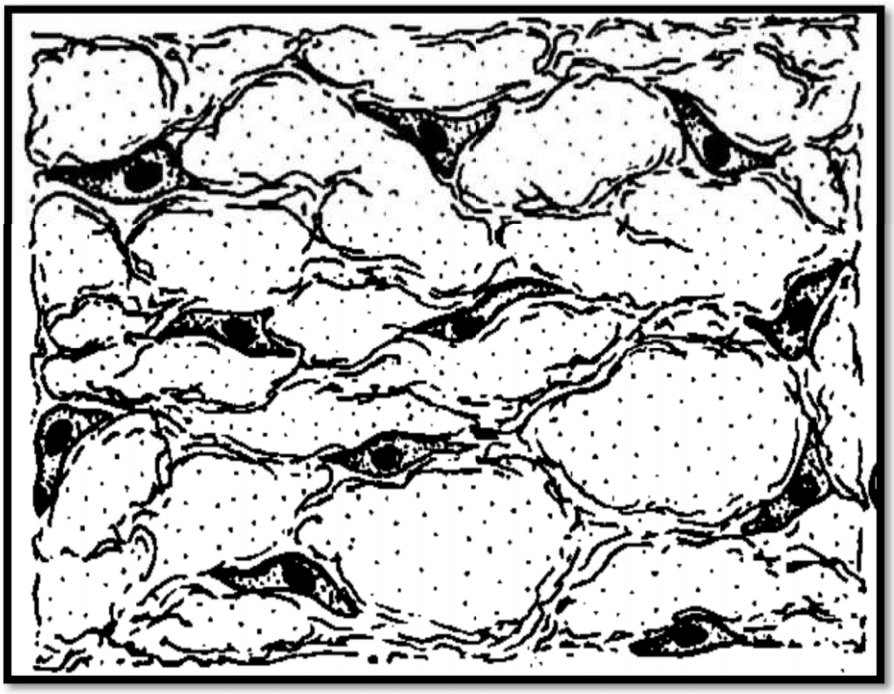


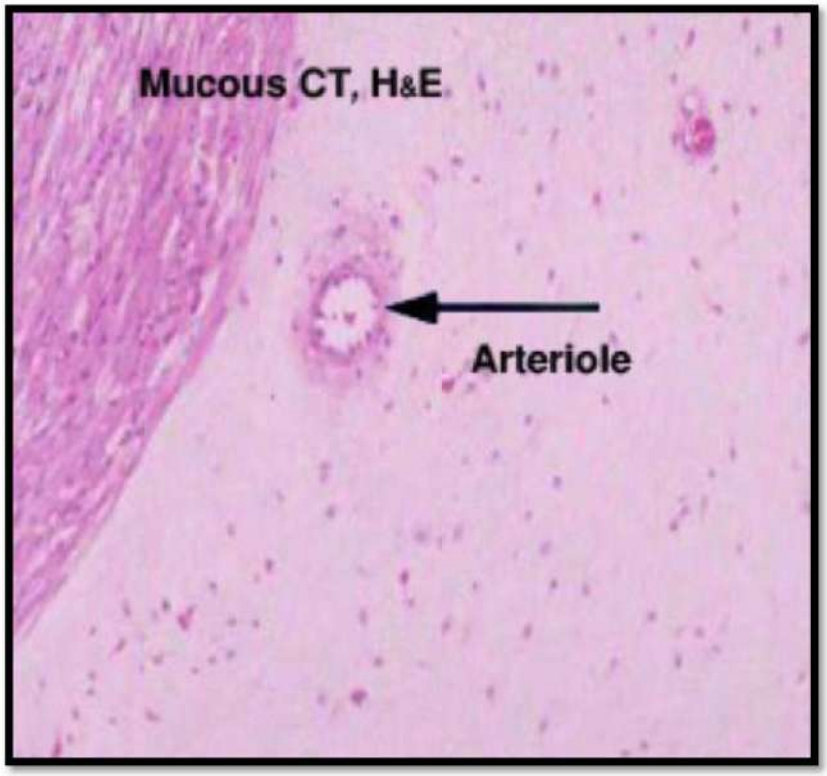
5- Elastic connective tissue proper





6- Mucous connective tissue proper

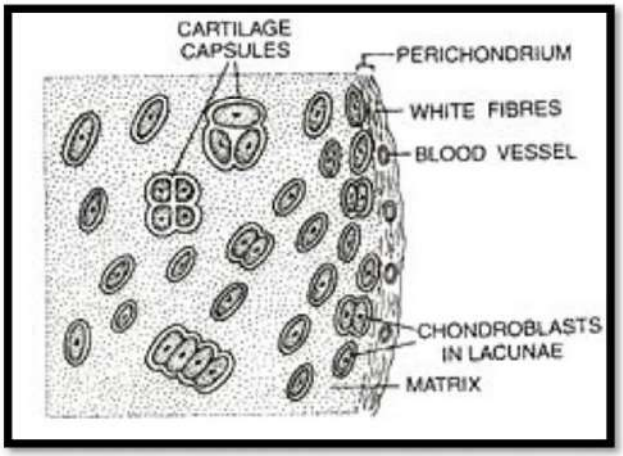


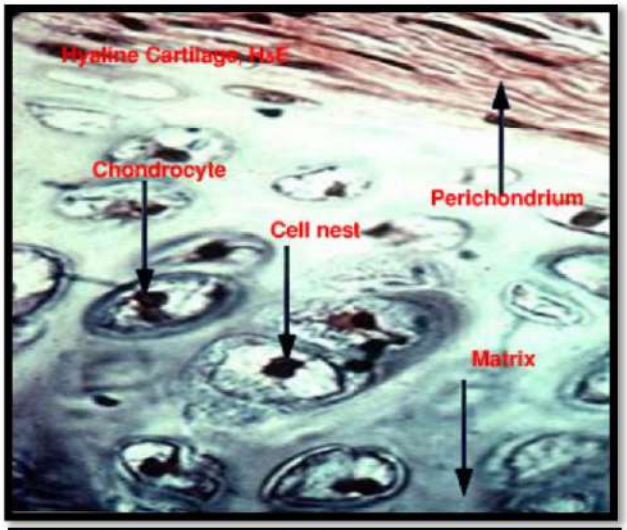


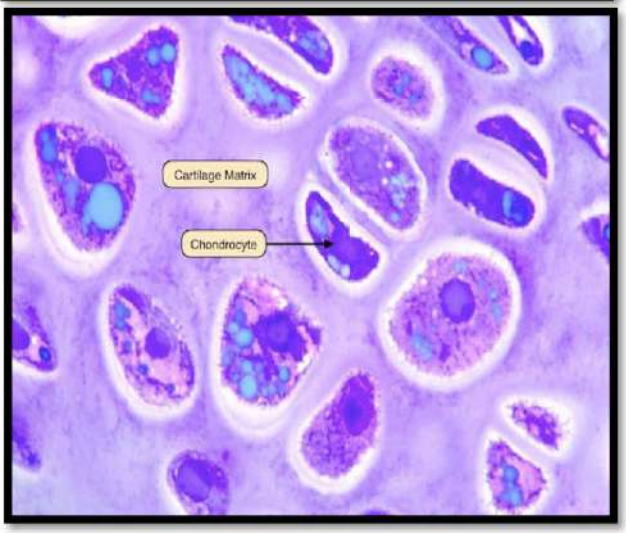
(D) Skeletal connective tissue

III- Cartilages

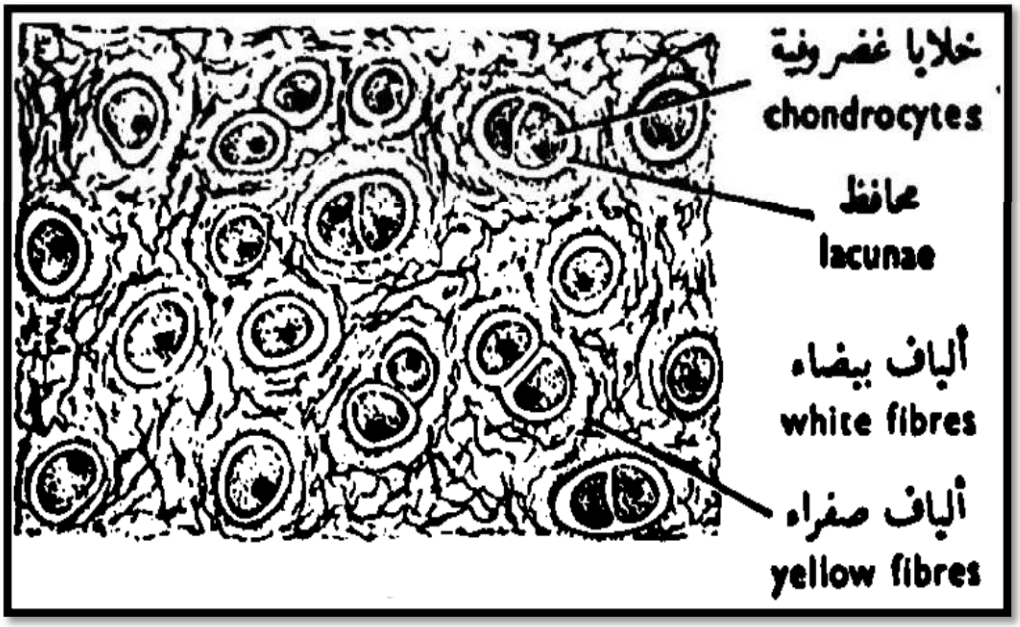
1- Hyaline Cartilage

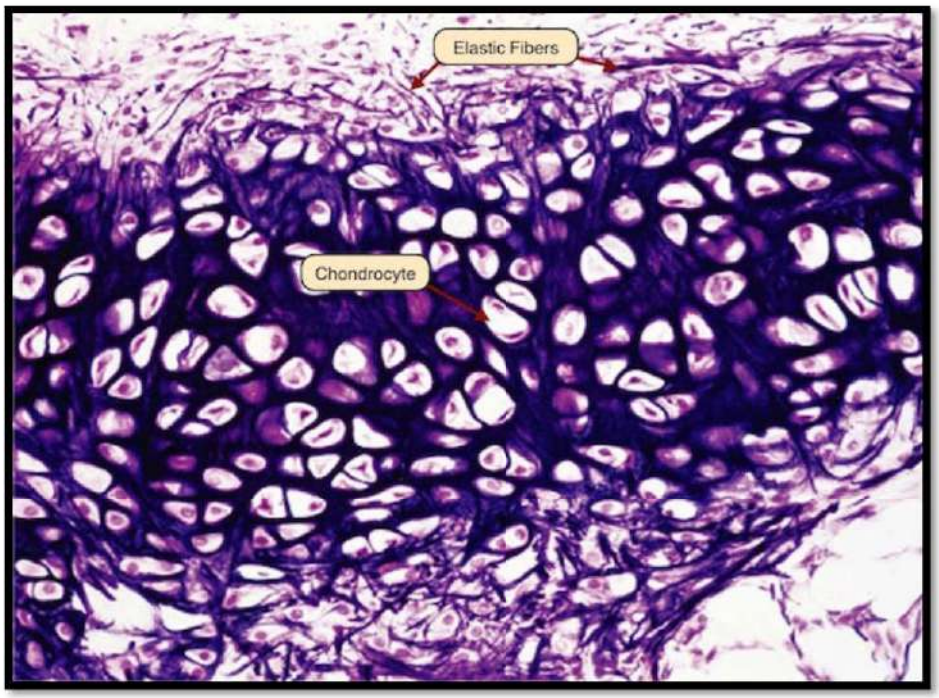




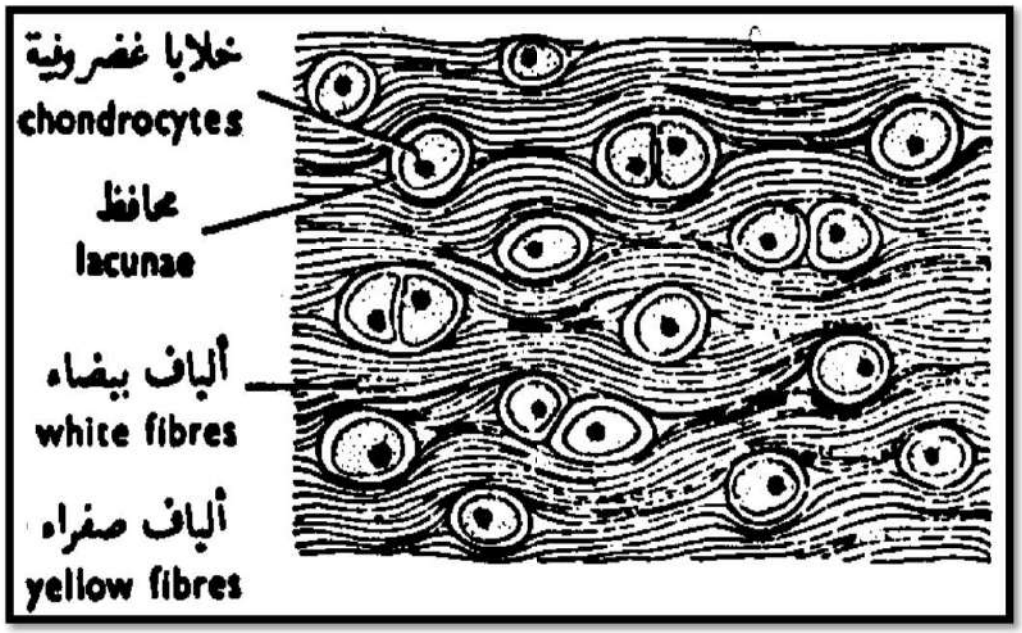


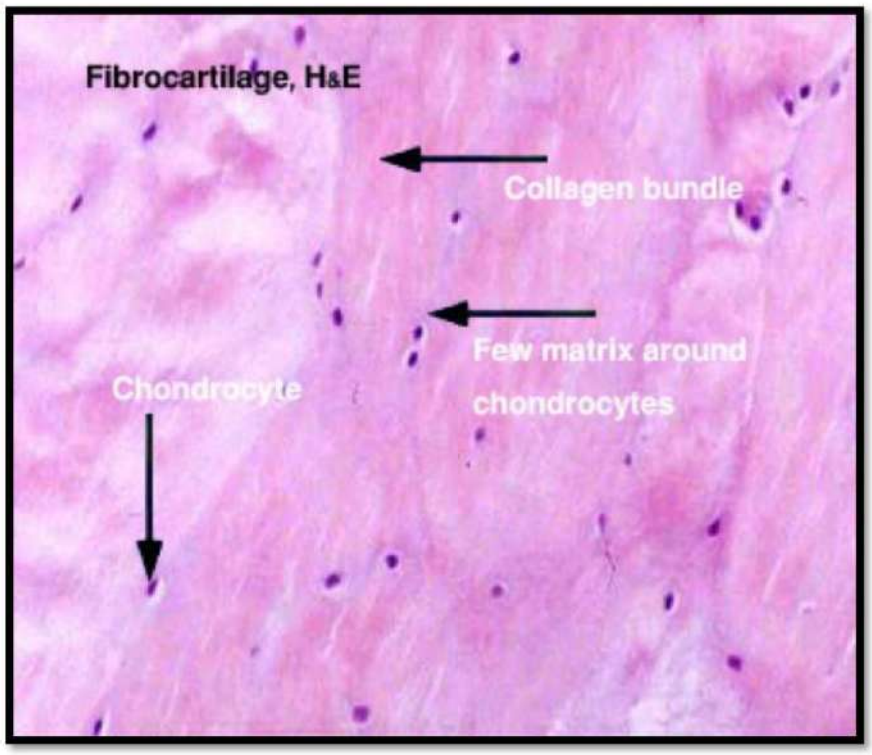
2- Elastic cartilage





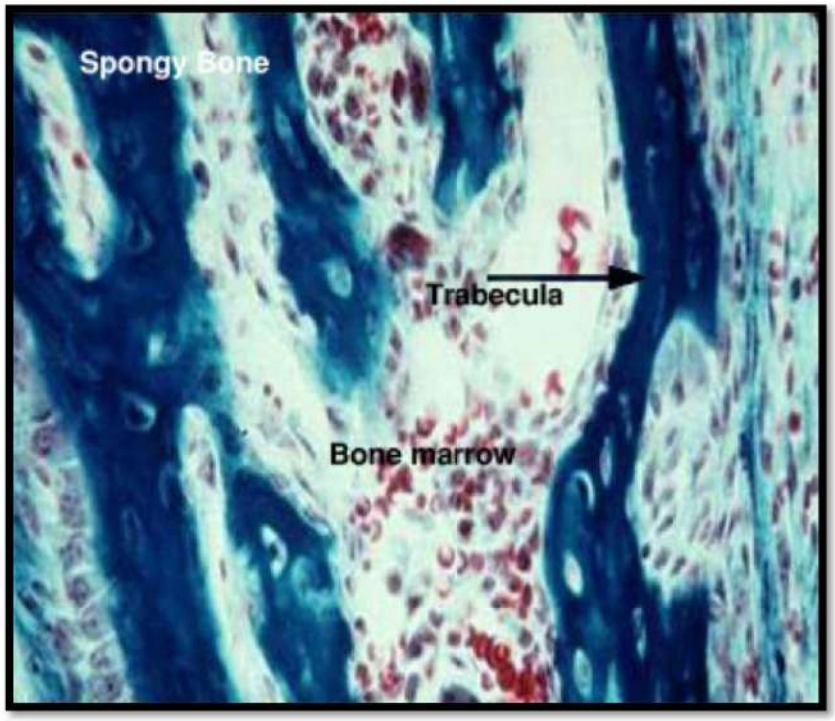
3- Fibro cartilage

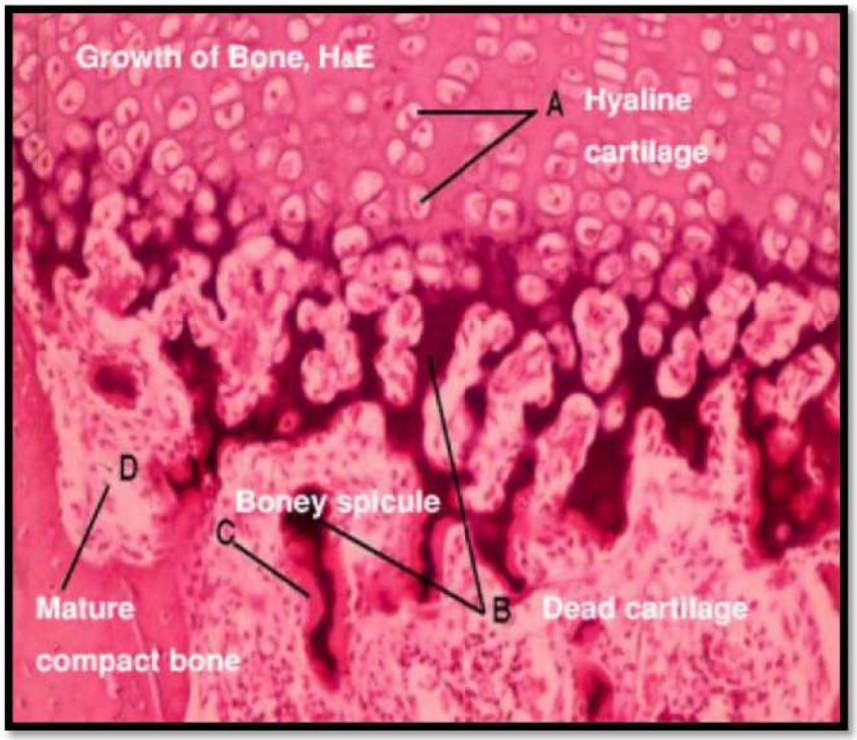




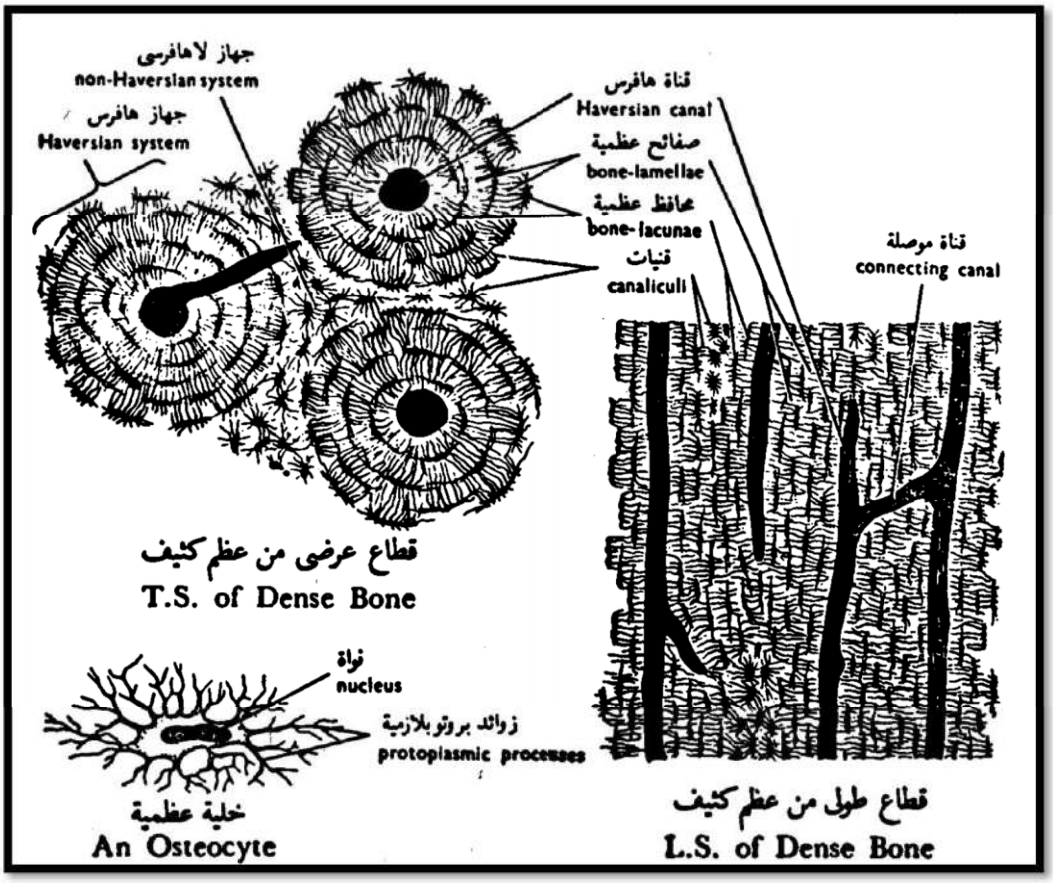
IV-Bones

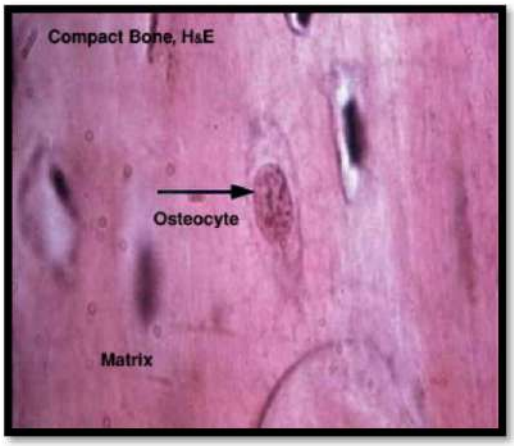
1- Spongy bone

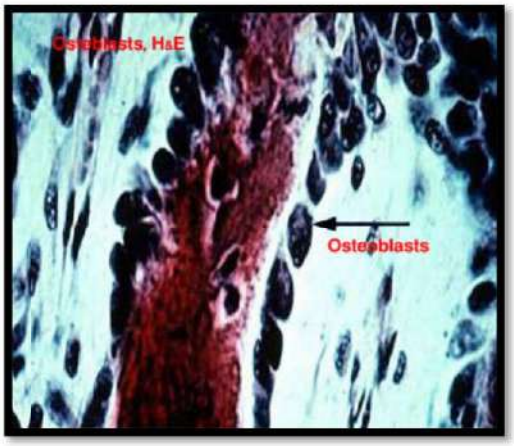




2- Compact bone

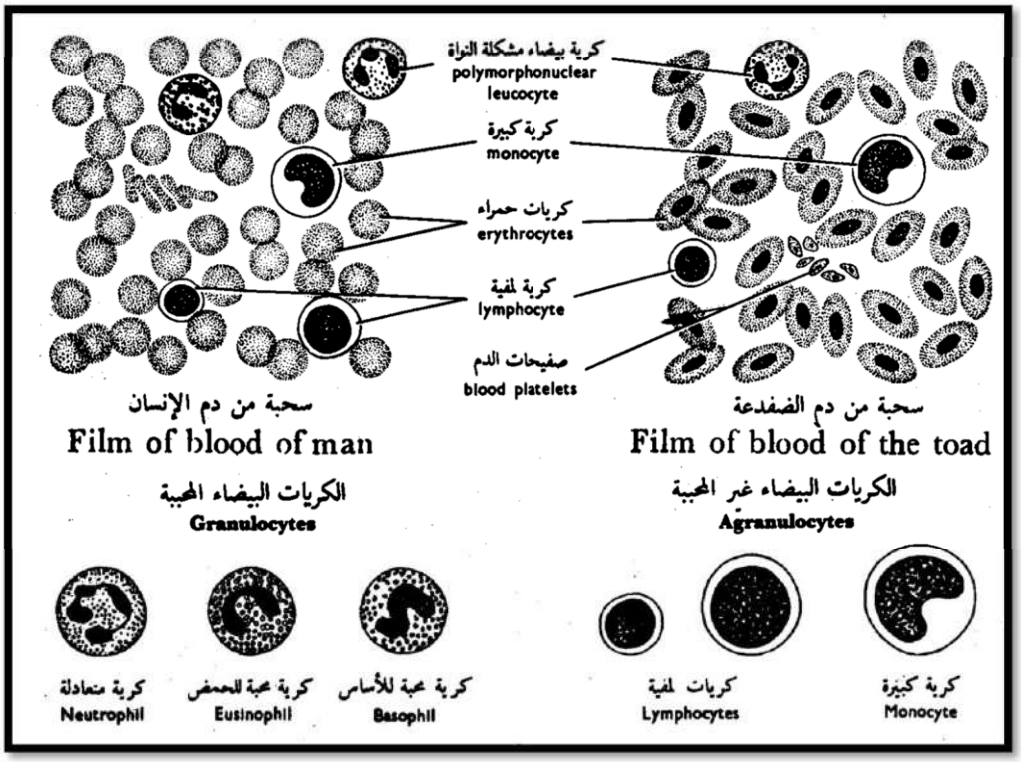


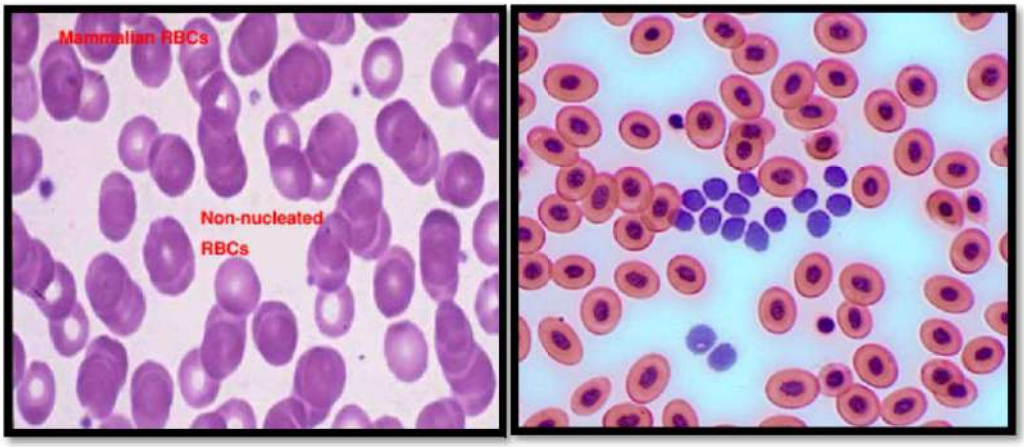


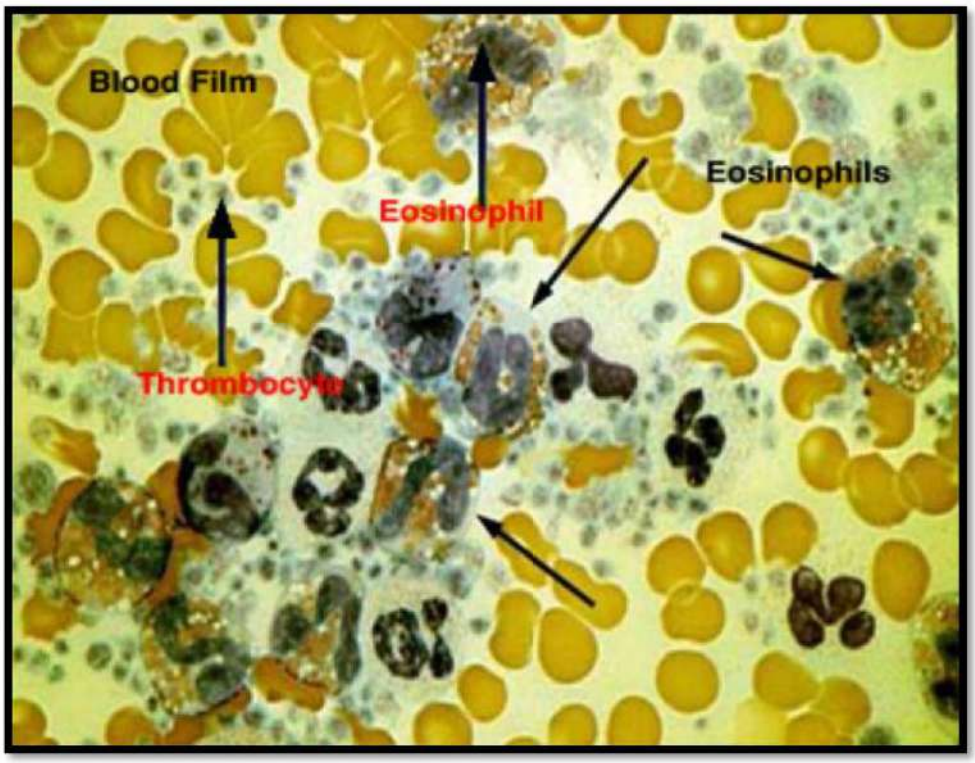


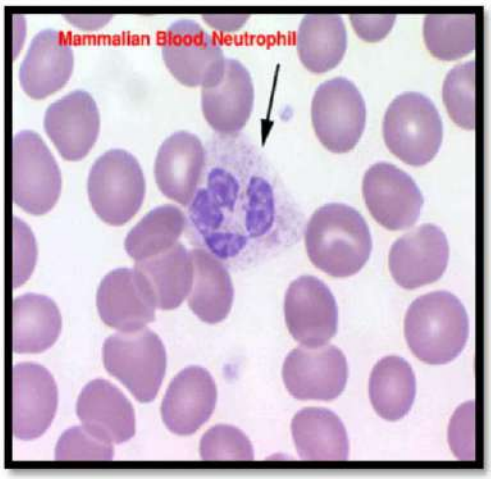
(E) Vascular connective tissue

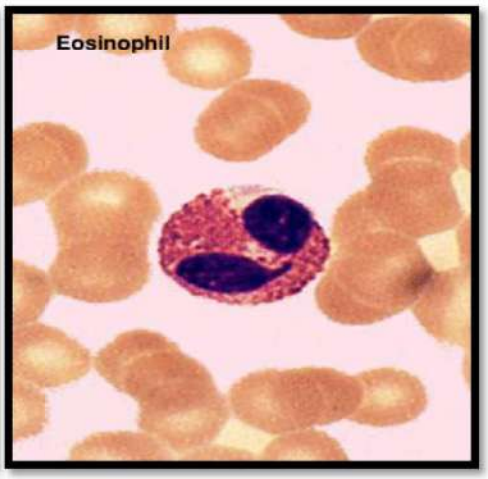
Blood and Lymph

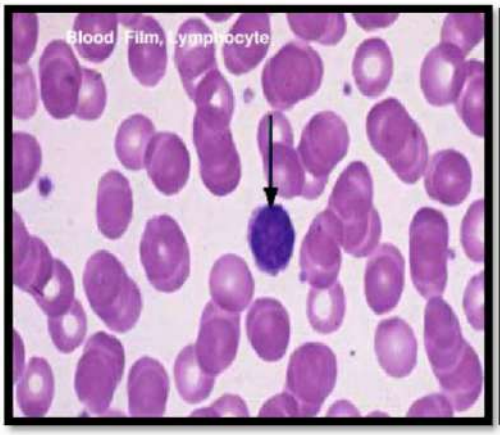


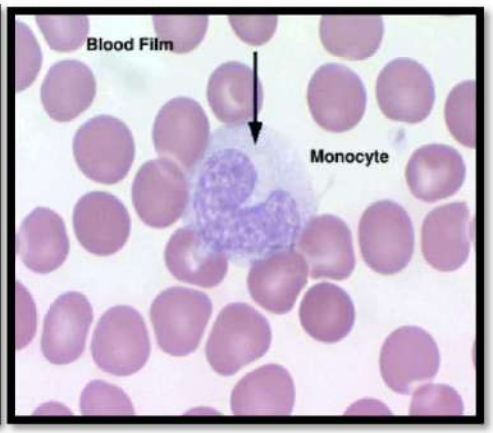



Blood Film
Eosinophil
Eosinophils
Thrombocyte


Mammalian Blood, Neutrophil

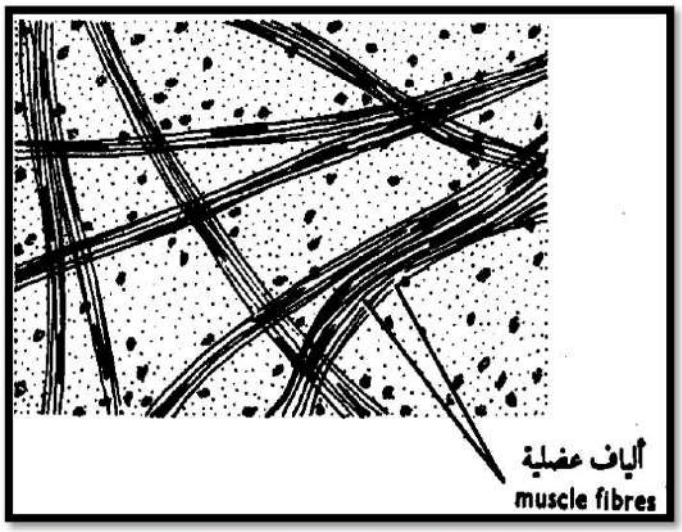

Eosinophil

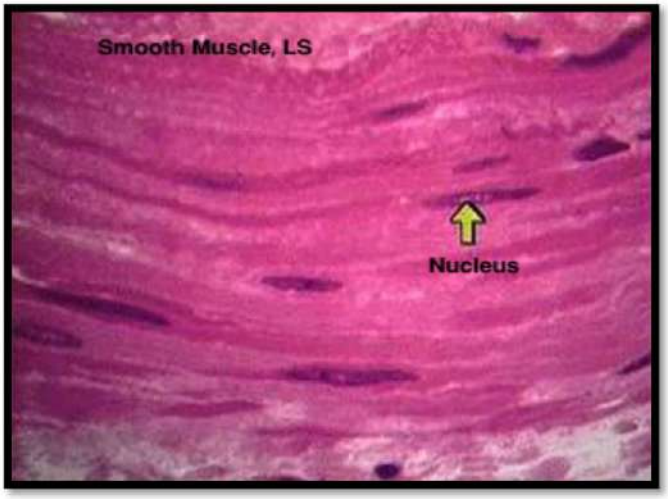

Blood Film, Lymphocyte


Blood Film
Monocyte

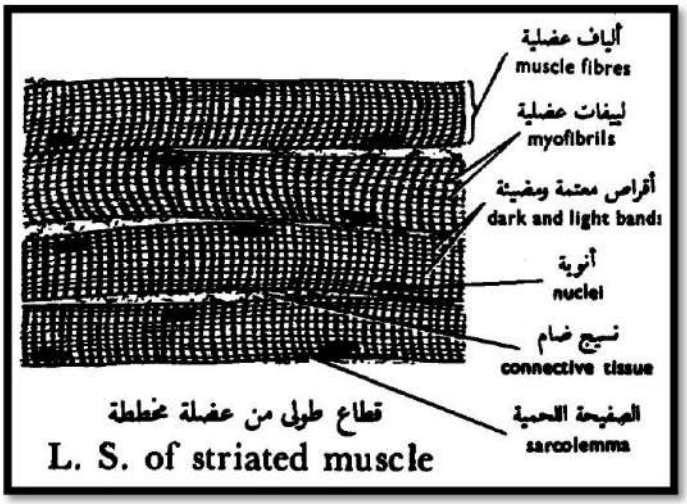
MUSKULAR TISSUES

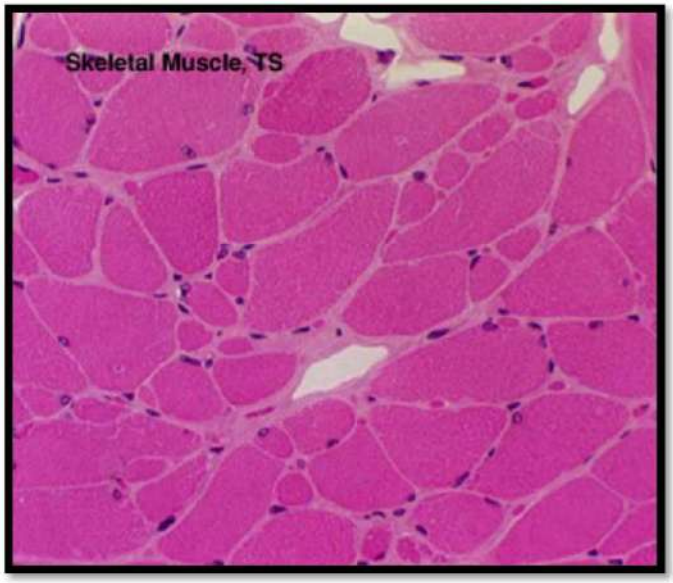
(D) Unstrained or Smooth muscles

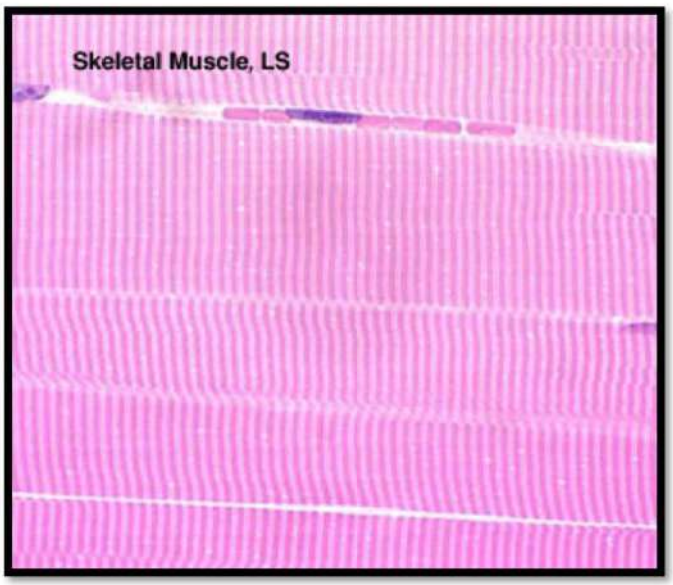




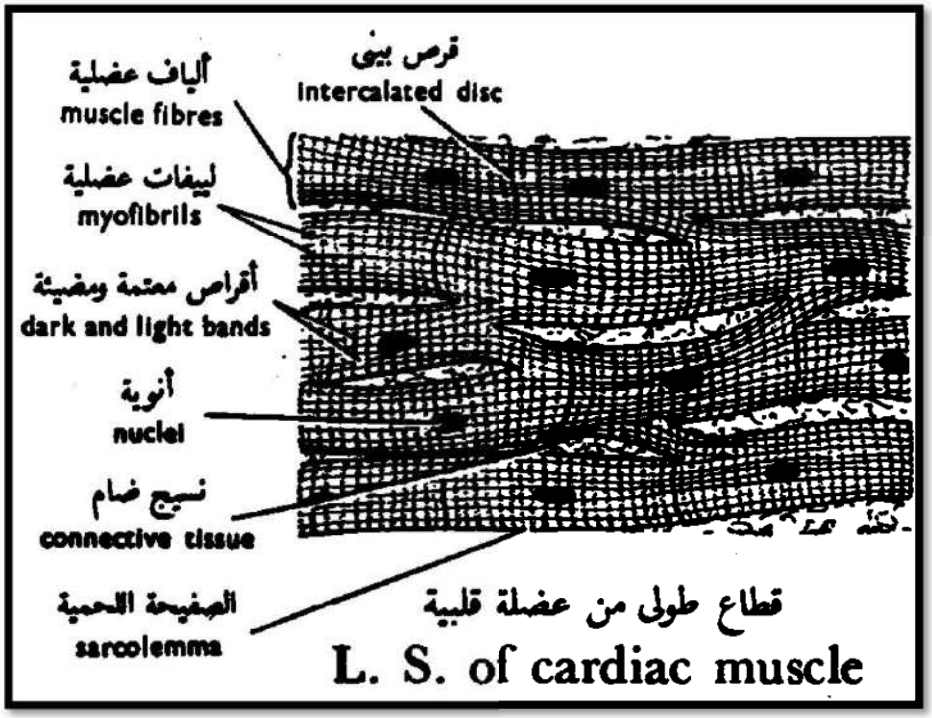
(E) Straited or Skeletal muscles

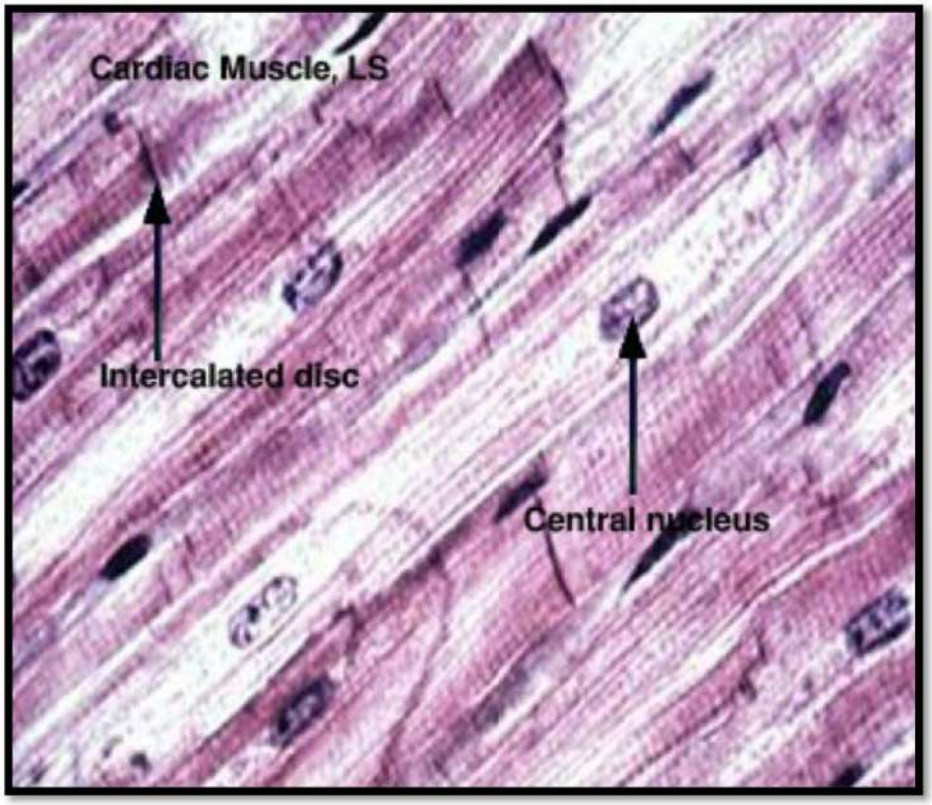






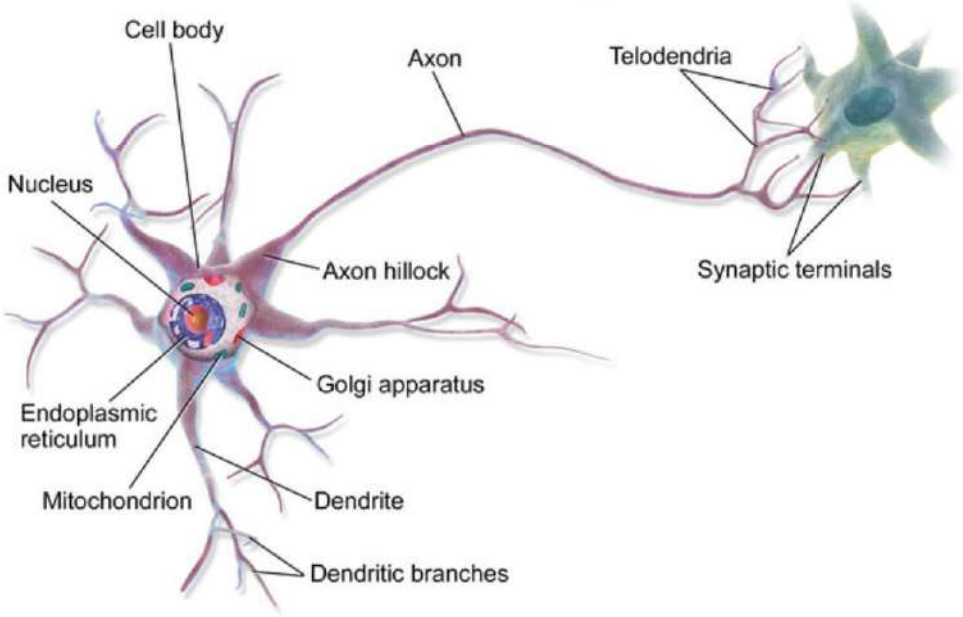
(F) Cardiac muscles

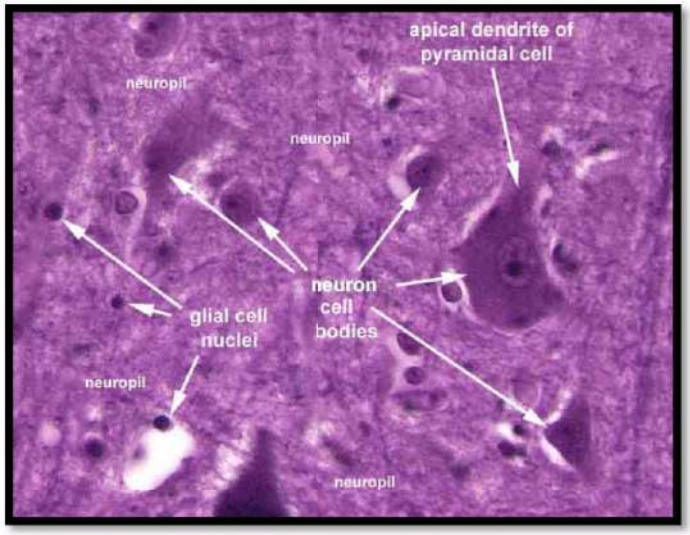


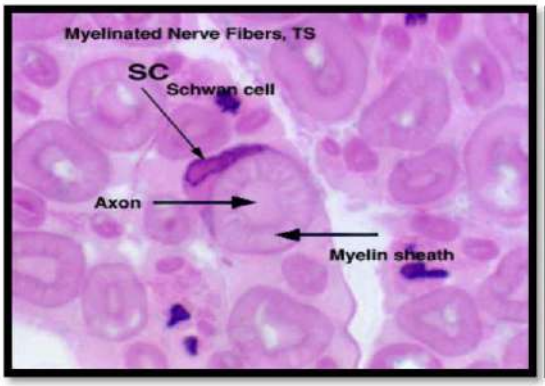


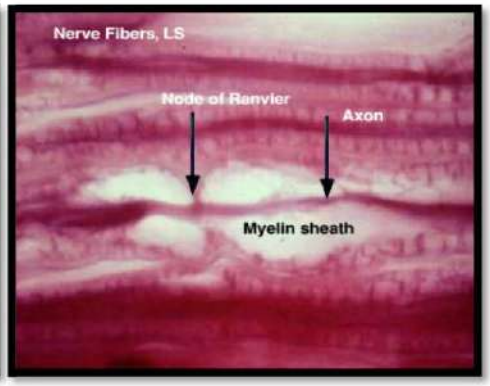
NERVOUS TISSUES

Nerve cell (Neurons) and glia

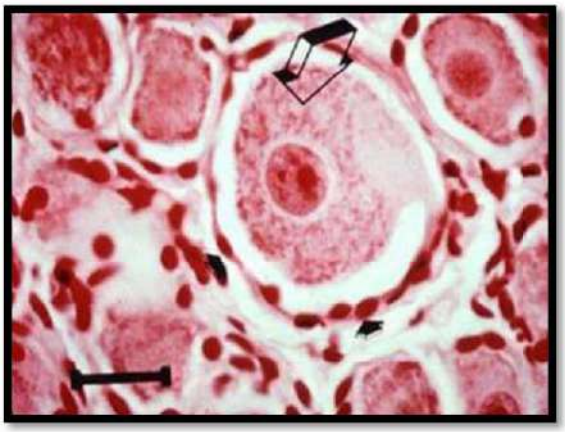


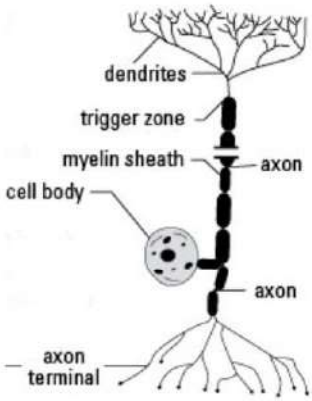






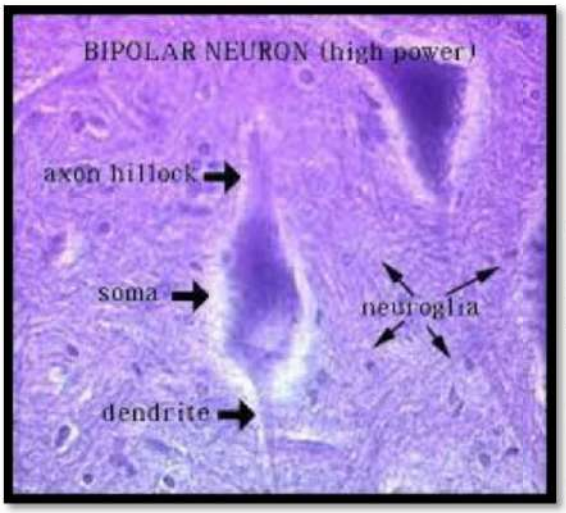
1- Unipolar neurons

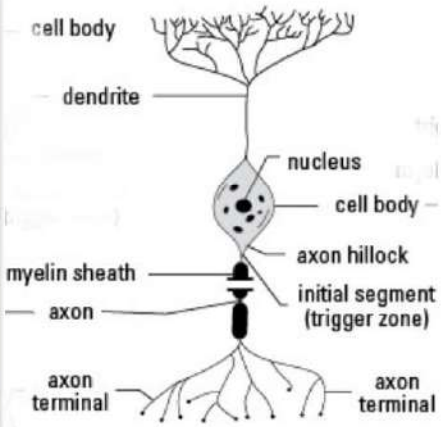




Unipolar Neuron

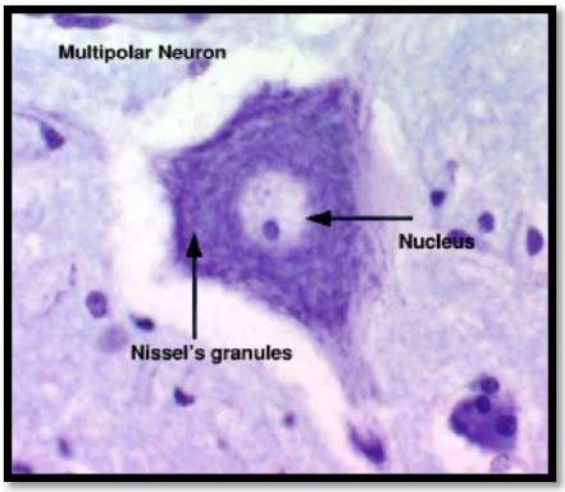
2- Bipolar neurons

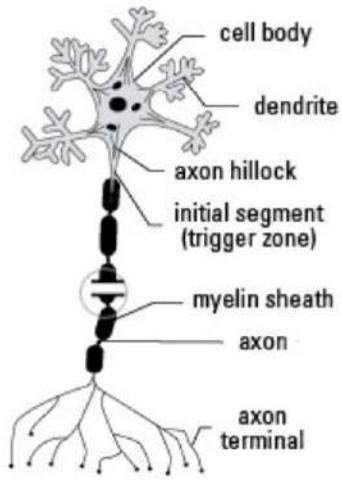




Bipolar Neuron

3- Multipolar neurons



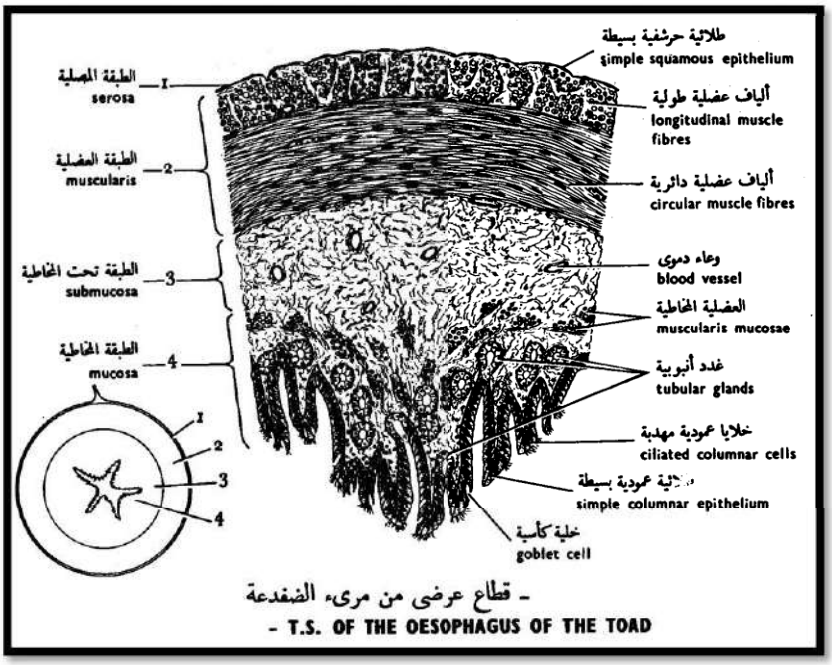


Multipolar Neuron

DIFFERENT ORGANS TISSUES STRUCTURES

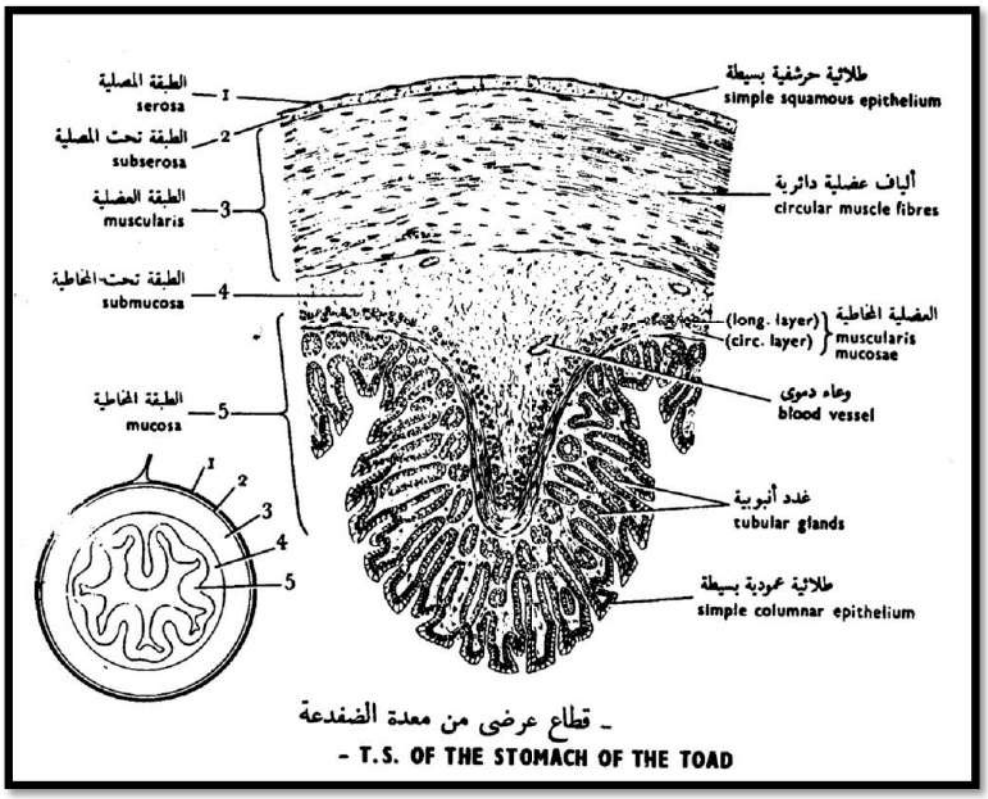
Digestive system

(Esophagus-Stomach- Ileum -Liver)



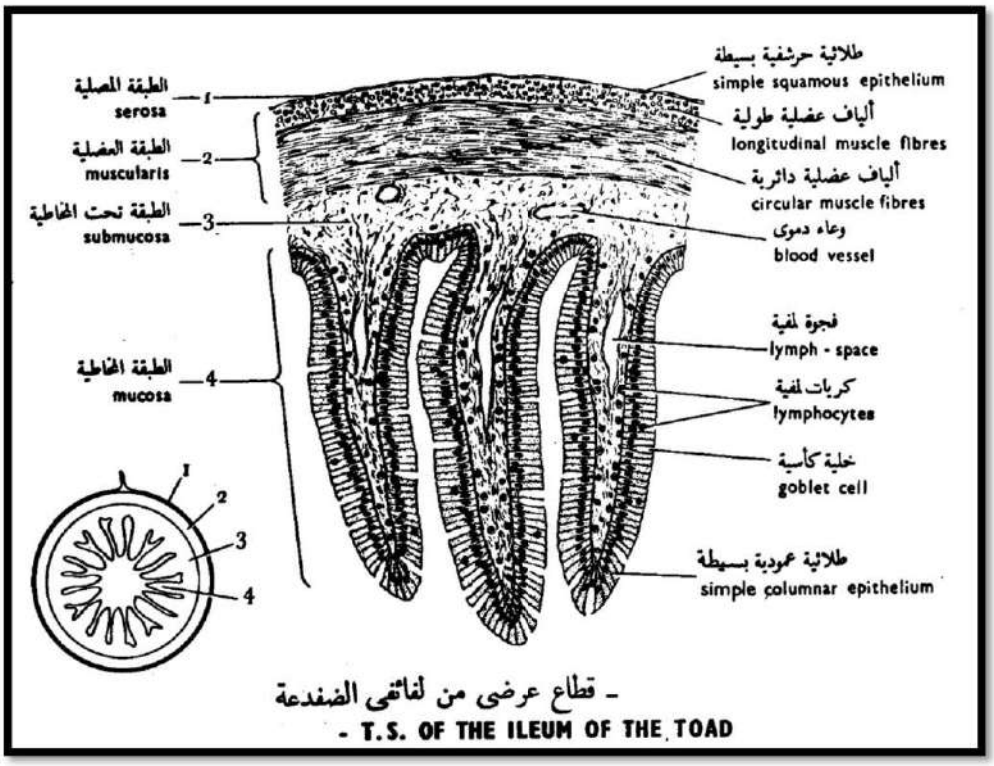
- قطاع عرضى من مرىء الضفدعة

- T.S. OF THE OESOPHAGUS OF THE TOAD



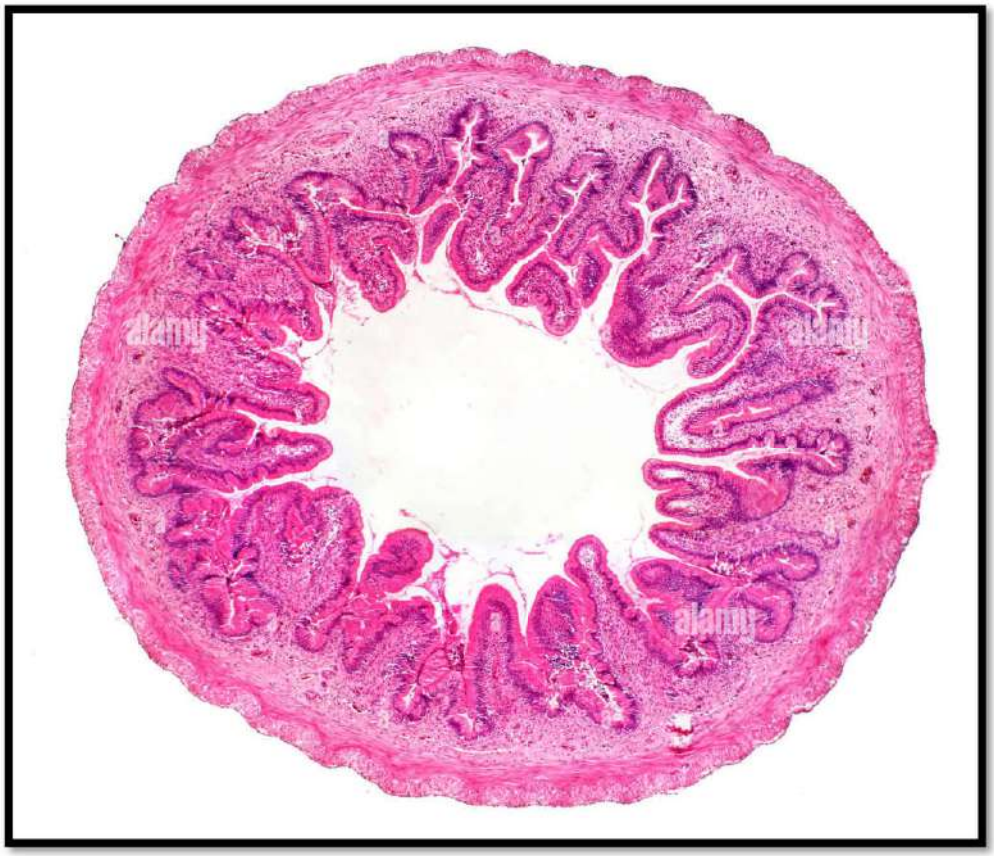
ـ قطاع عرضى من معدة الضفدعة

- T.S. OF THE STOMACH OF THE TOAD



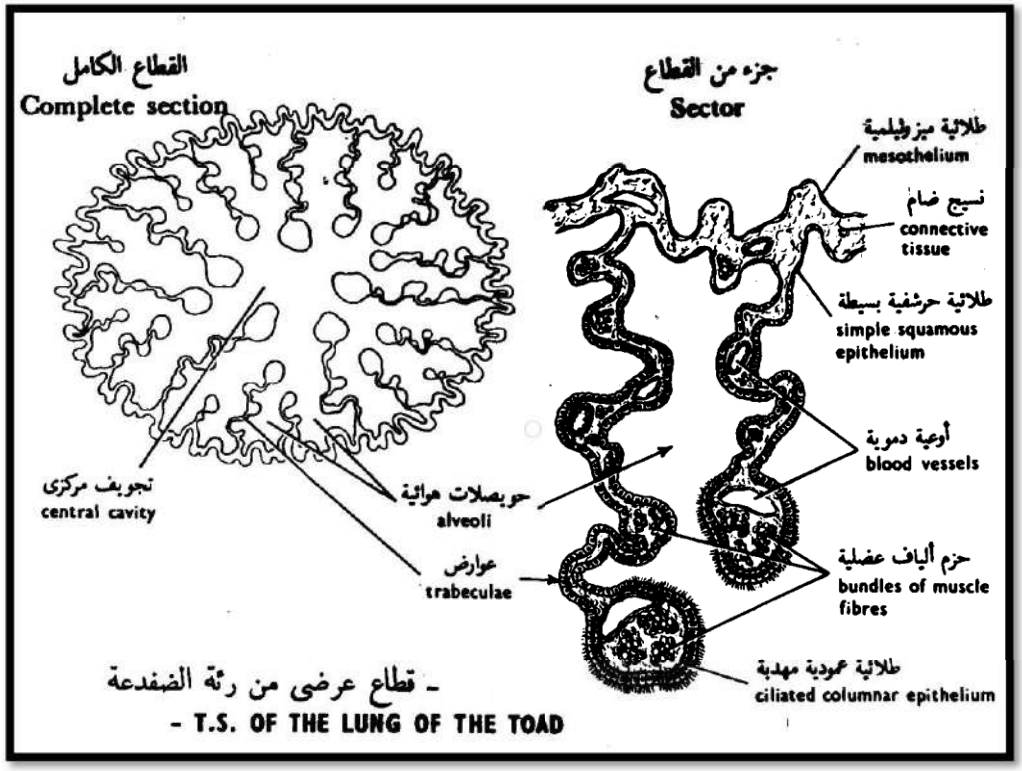
- قطاع عرضى من لفائفى الضفدعة

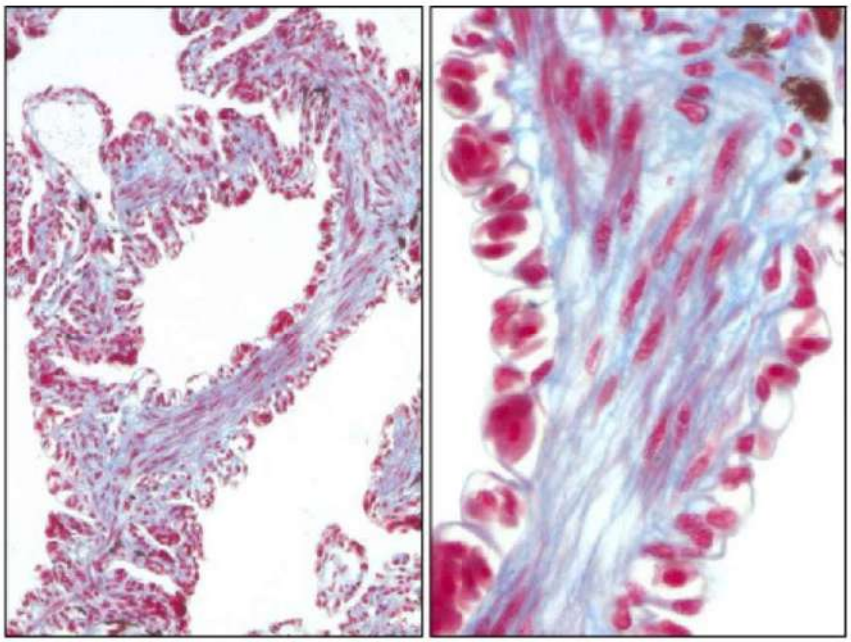
- T.S. OF THE ILEUM OF THE TOAD



8- Respiratory system

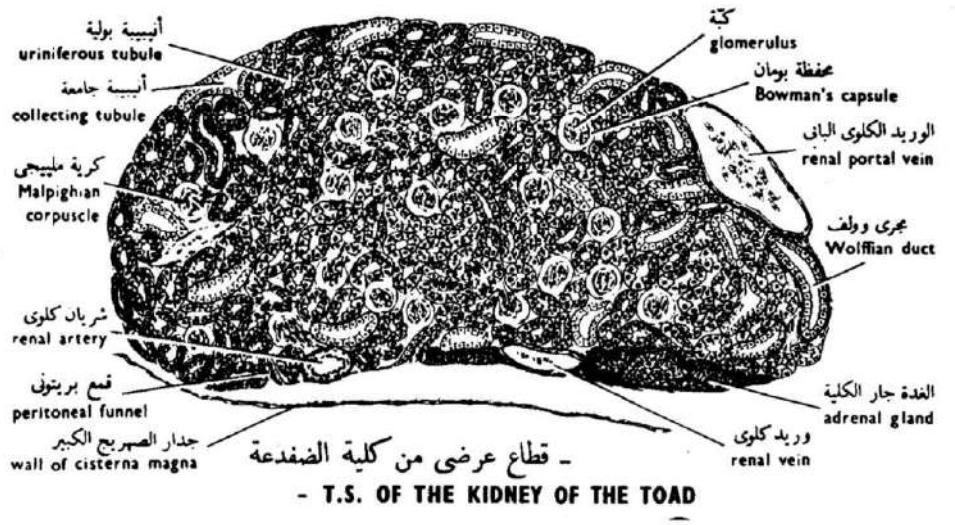
(Trachea - Lung)

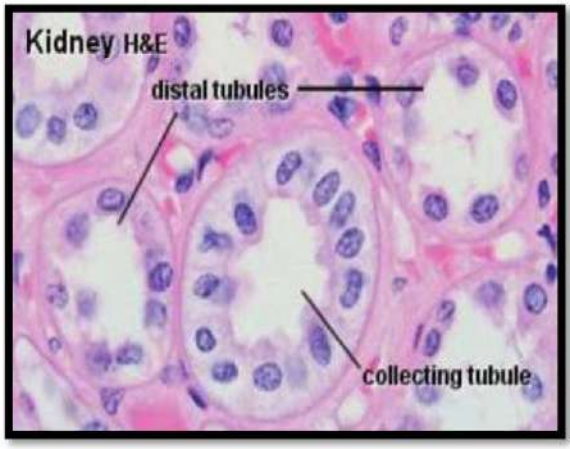


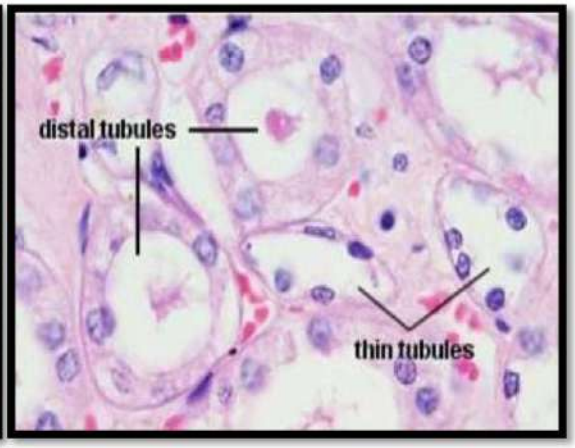


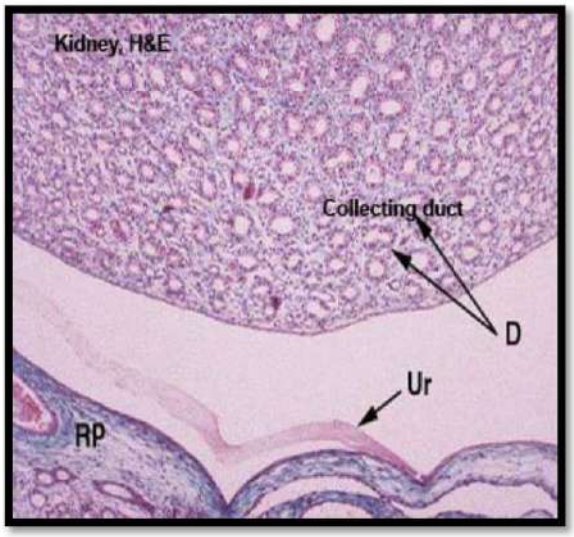
9- Urinary system

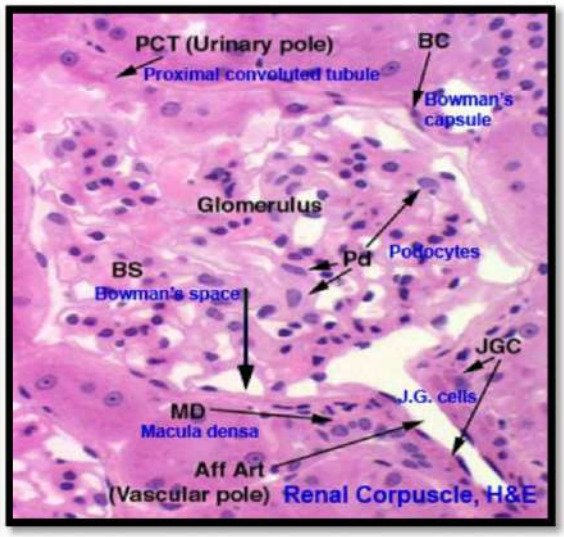
(Kidney)





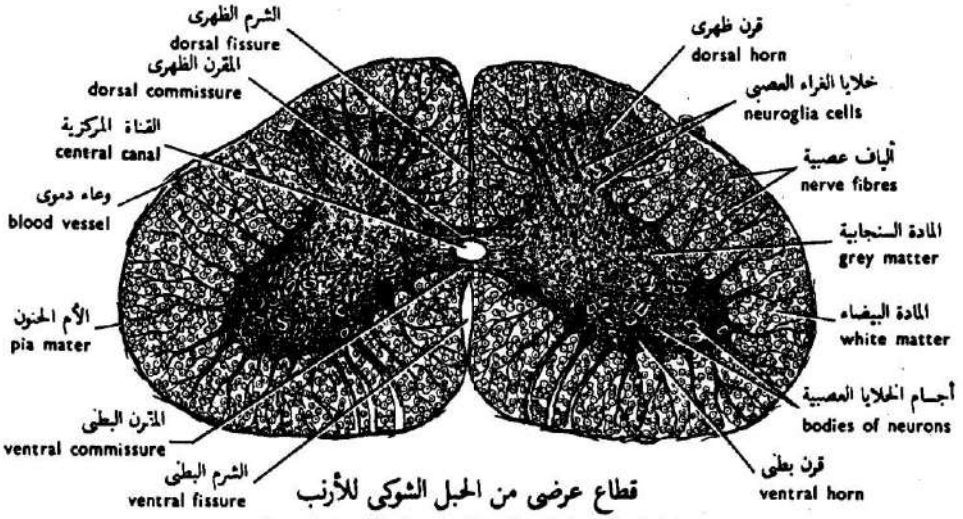






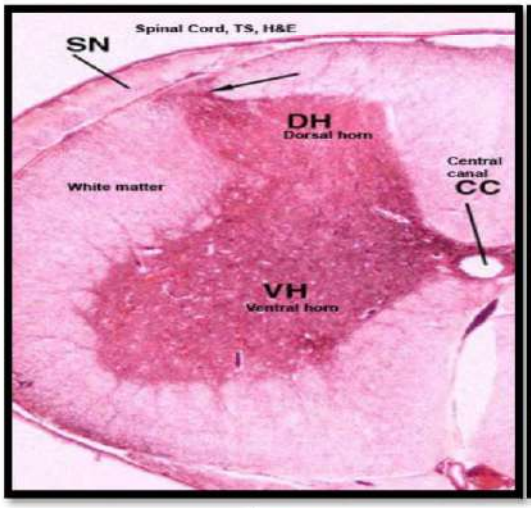
10- Nervous system

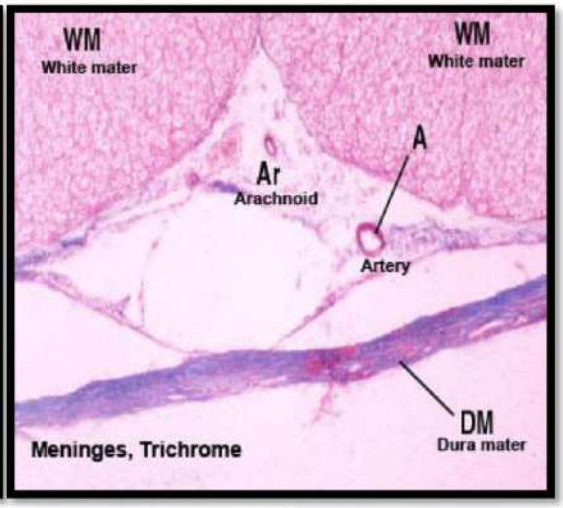
(Spinal cord)

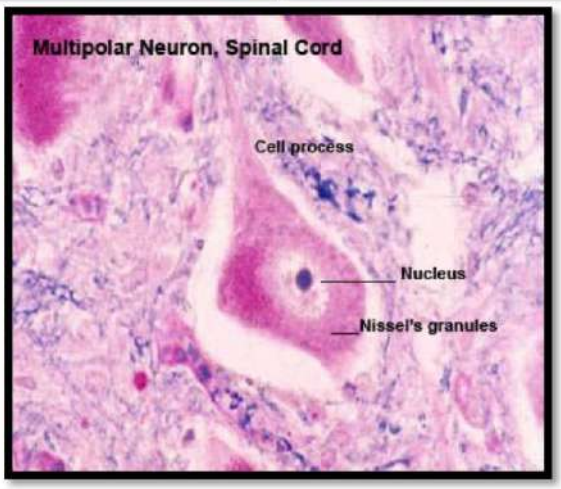


قطاع عرضى من الحبل الشوكى للأرنب

T.S. of the Spinal Cord of the Rabbit

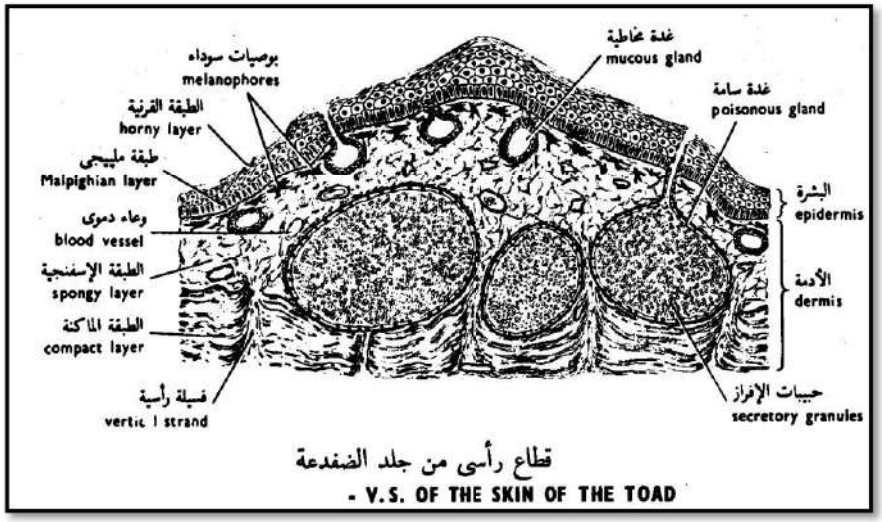






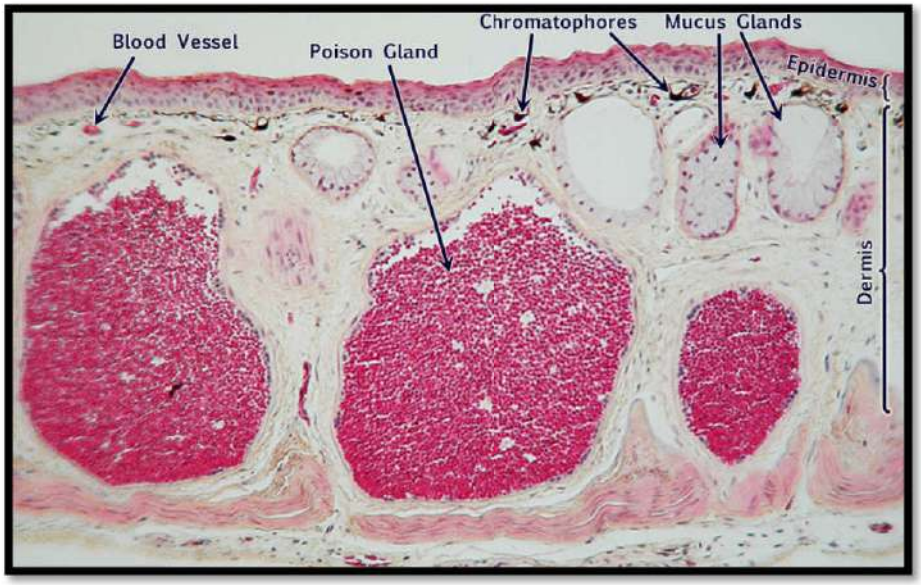
11- Skin

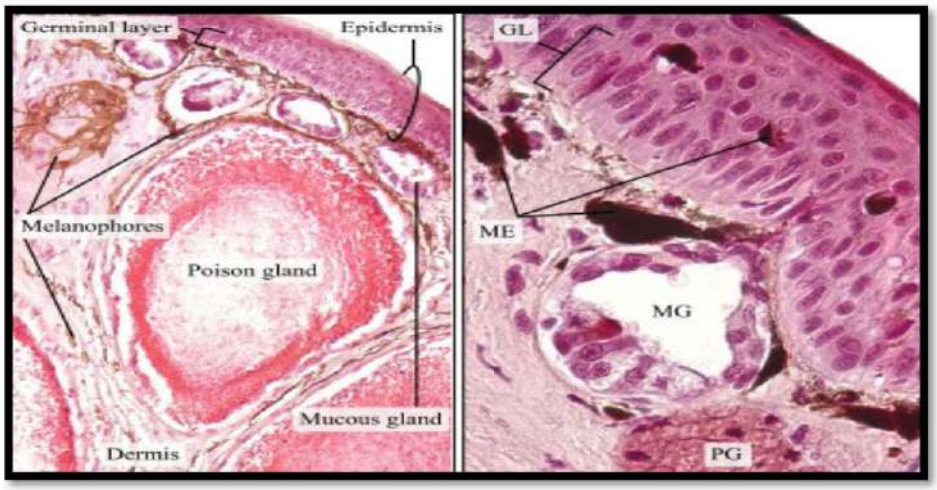
(Toad - Pig)



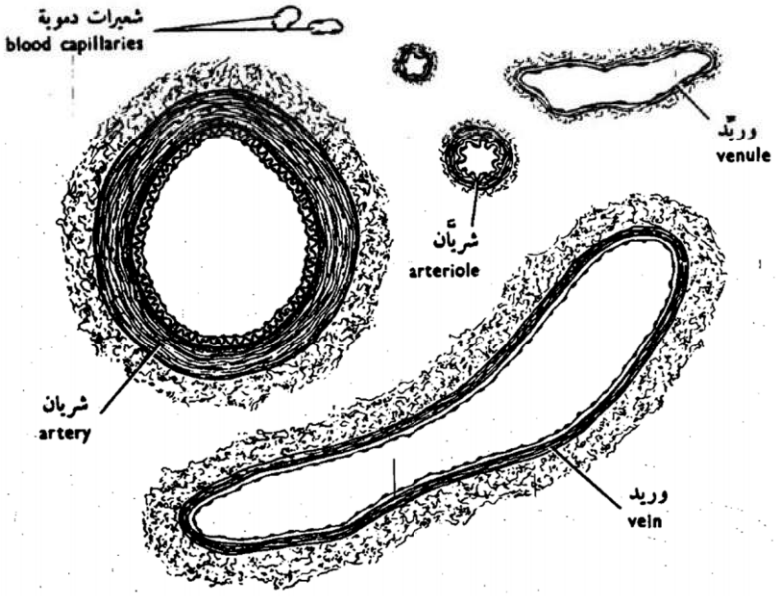
قطاع رأسى من جلد الضفدعة

- V.S. OF THE SKIN OF THE TOAD

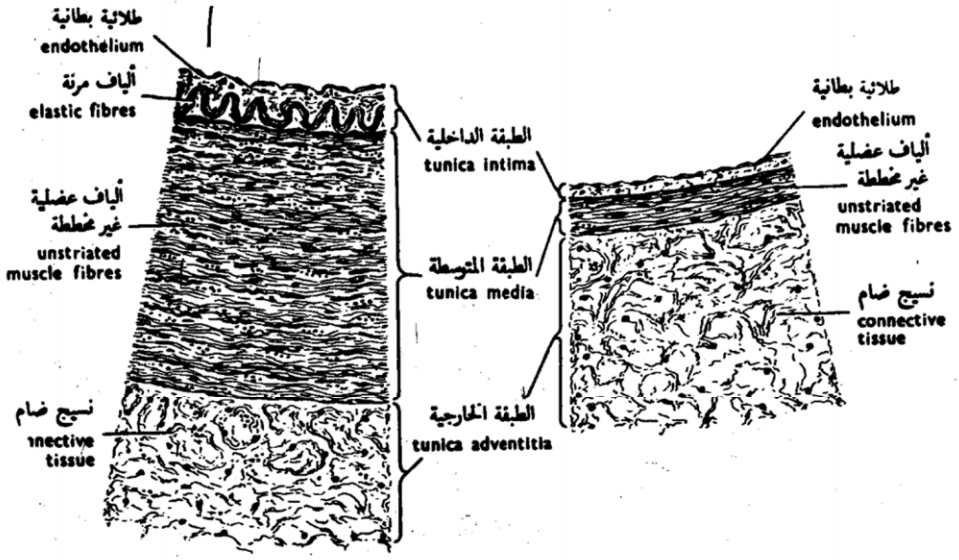




7-Blood vessels



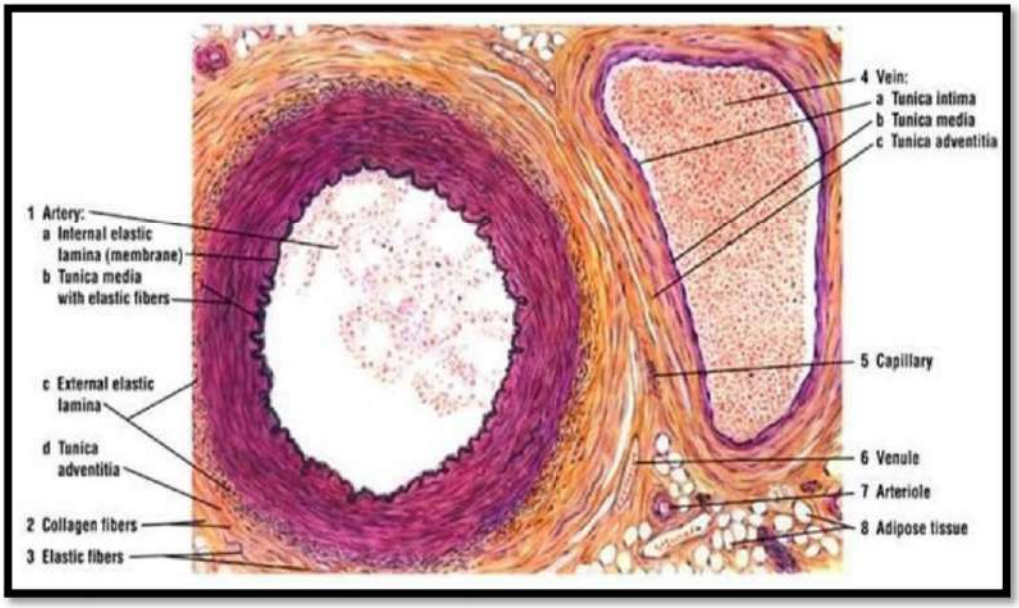
قطاعات عرضية من أوعية دموية مختلفة
T.S. of different Blood Vessels

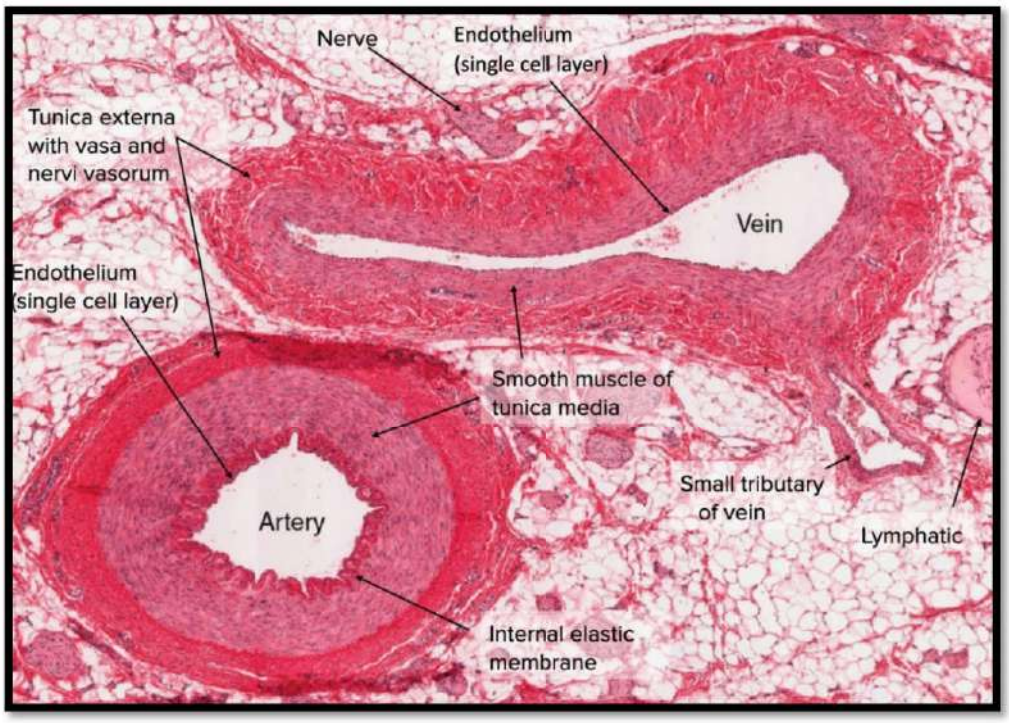


جزء من قطاع عرضى من جدار شريان
Sector of the wall of an Artery

جزء من قطاع عرضى من جدار وريد
Sector of the wall of a Vein

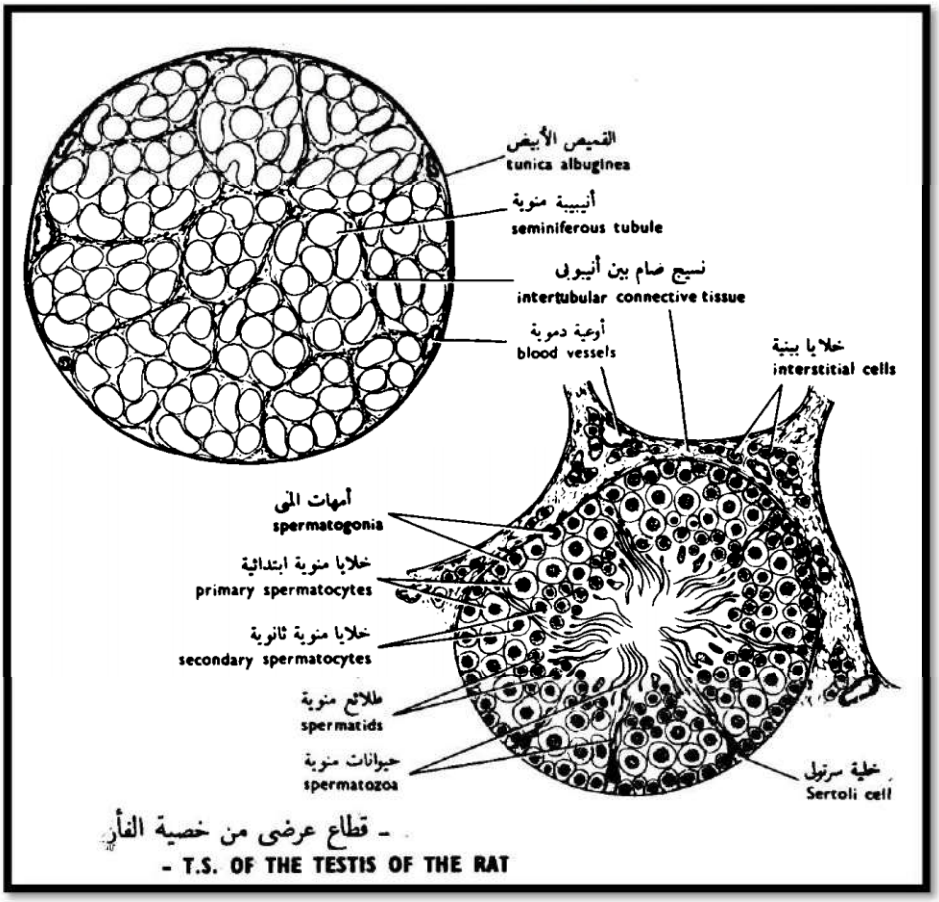
ـ الأوعية الدموية
BLOOD VESSELS

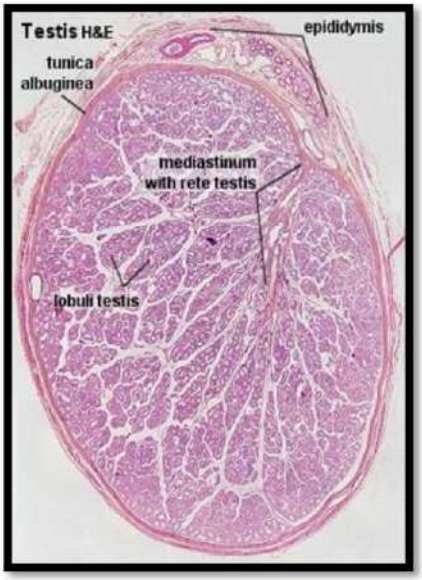

4 Vein:
a Tunica intima
b Tunica media
c Tunica adventitia
1 Artery:
a Internal elastic lamina (membrane)
b Tunica media with elastic fibers
c External elastic lamina
d Tunica adventitia
2 Collagen fibers
3 Elastic fibers
5 Capillary
6 Venule
7 Arteriole
8 Adipose tissue

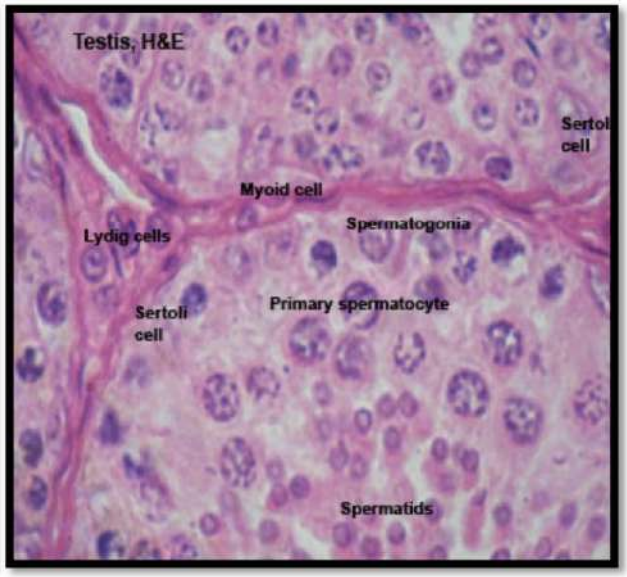

Nerve
Endothelium (single cell layer)
Tunica externa with vasa and nervi vasorum
Vein
Endothelium (single cell layer)
Smooth muscle of tunica media
Small tributary of vein
Lymphatic
Artery
Internal elastic membrane

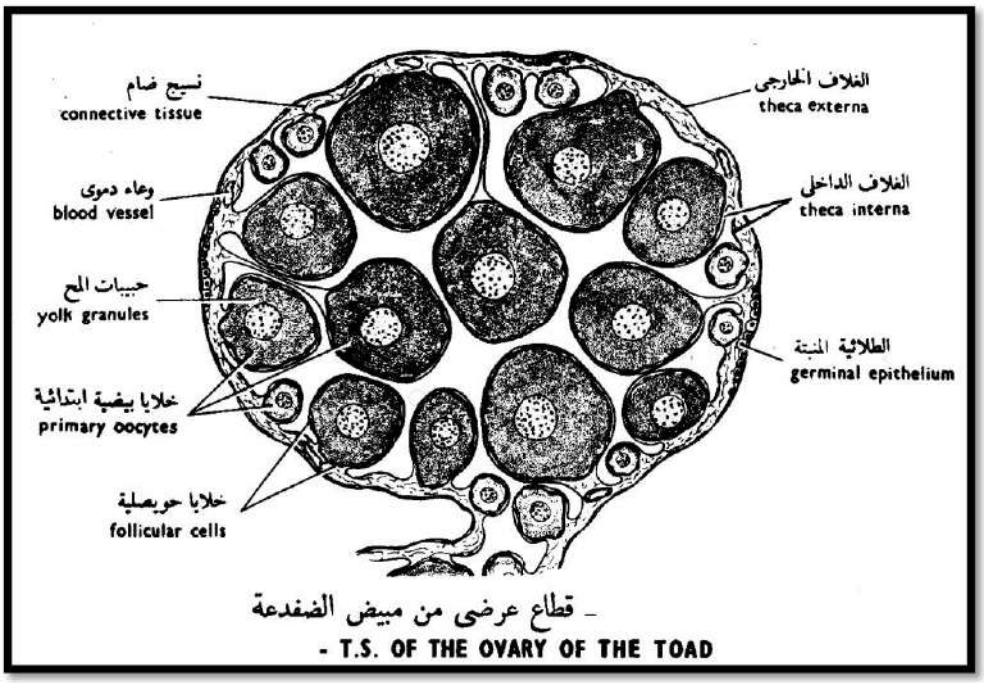
8- Genital systems

(Testis - Ovary)



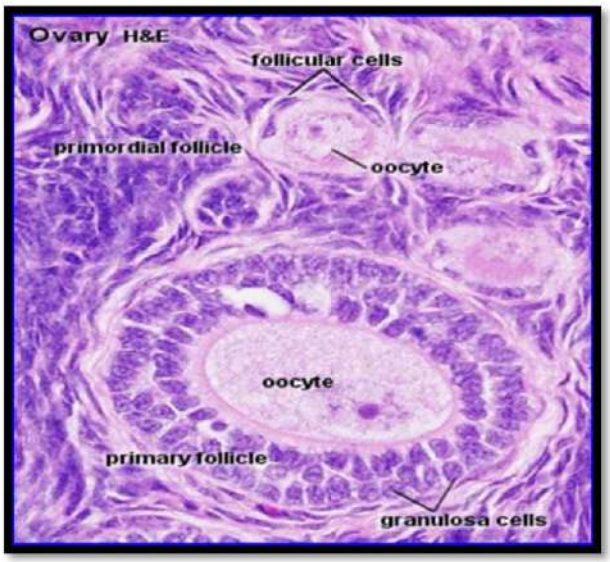


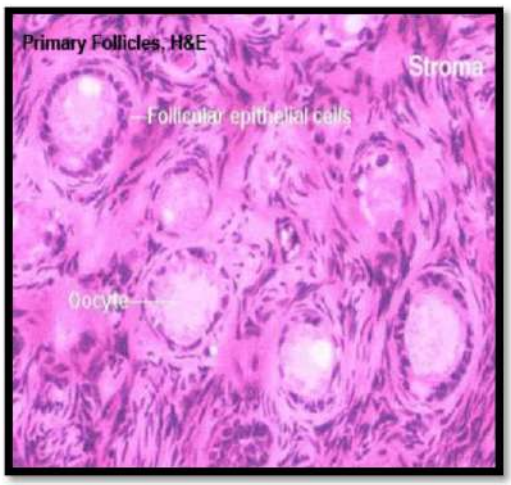


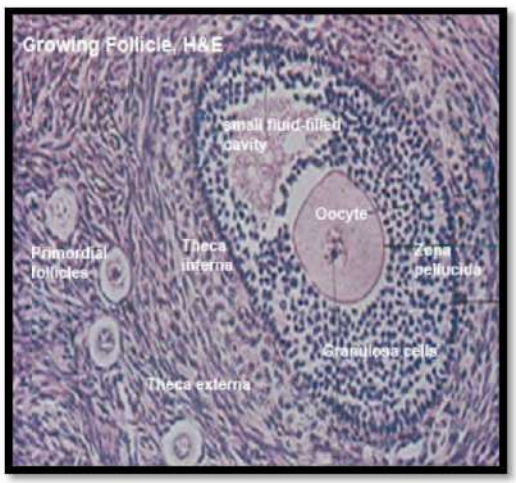


- قطاع عرضى من مبيض الضفدعة

- T.S. OF THE OVARY OF THE TOAD







REFRENCES

- Al-Hussaini A. H. & Demain E. S. (1977). *Practical Animal Biology* (Vol. 1), 10th Edition, Dar Al-Maaref. Cairo, Egypt.
- Bolsover, S. R., Shephard, E. A., White, H. A., & Hyams, J. S. (2011). *Cell biology: a short course* (Vol. 1). John Wiley & Sons.
- Bresinsky, A., Körner, C., Kadereit, J. W., Neuhaus, G., & Sonnewald, U. (2013). *Strasburger's plant sciences: including prokaryotes and fungi* (pp. 1309-1309). Berlin, Germany: Springer.
- Heidcamp, W. H. (1995). Cell biology laboratory manual. *Biology Department, Gustavus Adolphus College, St. Peter, MN*, *56082*.
- https://vetmansoura.com/Histology/epithelium-glands
- https://www.bu.edu/phpbin/medlib/histology
- https://www.histology.leeds.ac.uk/tissue_types