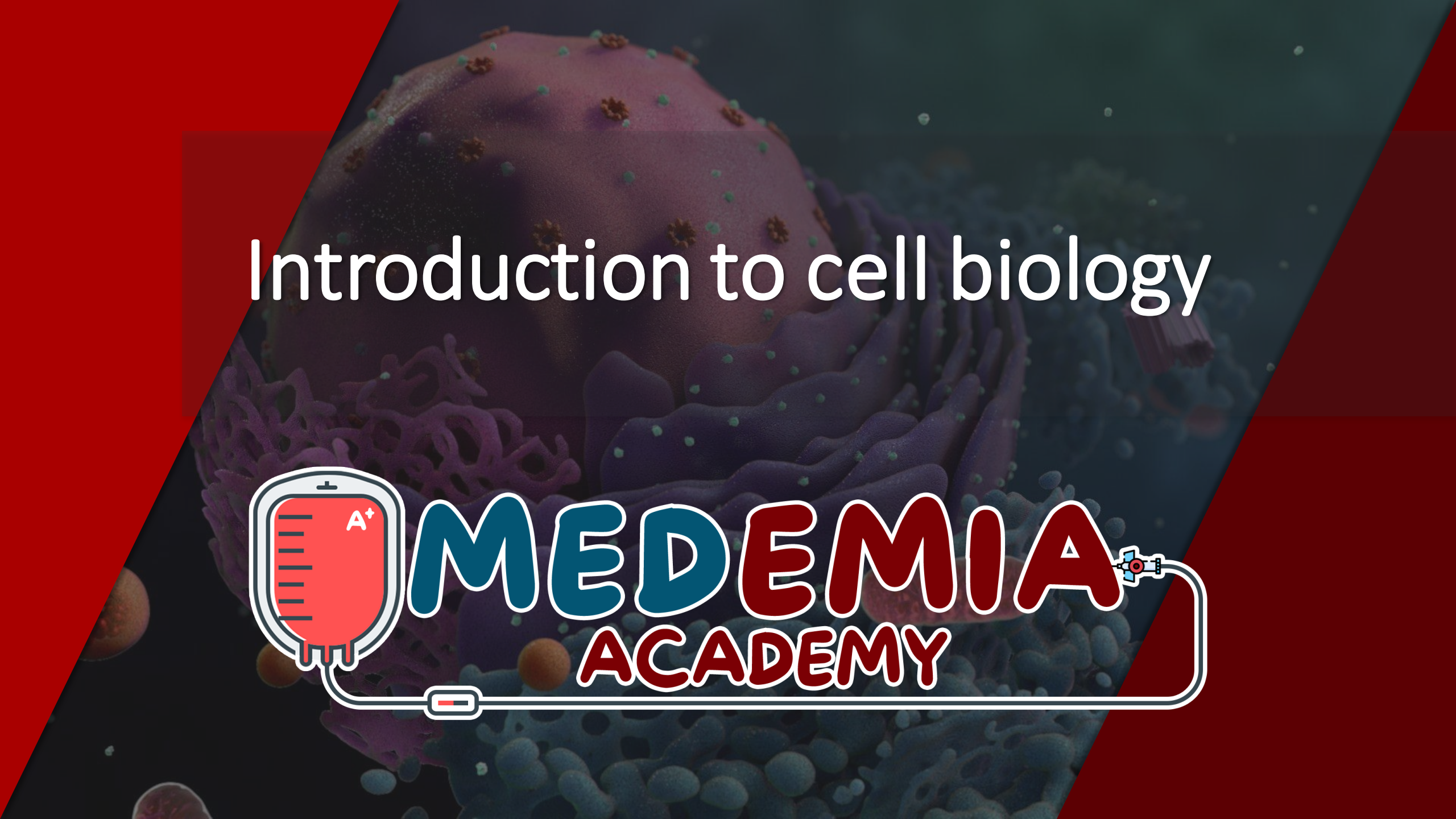
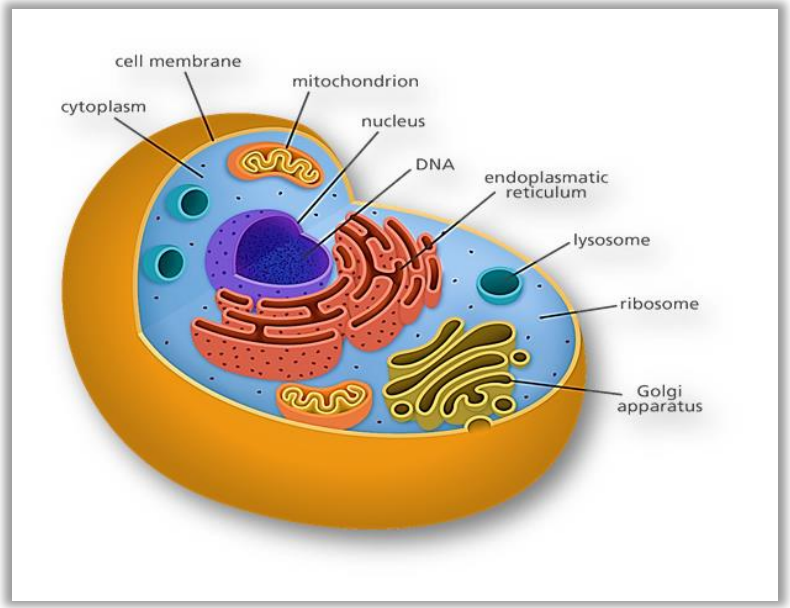
Introduction to cell biology



MEDEMIA ACADEMY

Introduction to cell biology

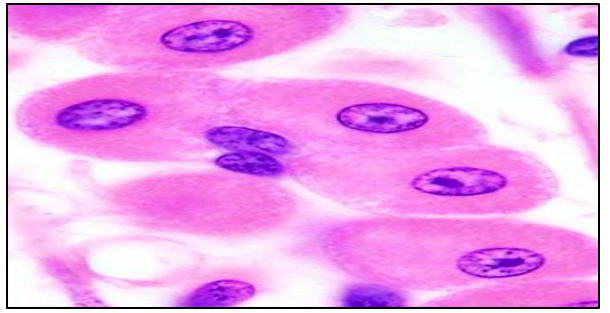
- **Cell biology:** Study of normal cell structures and functions at the cellular and molecular levels.
- The cell is the smallest and basic unit of life.
- All living organisms are made of cells, which can vary in size from 4 to 200 microns.
- Organisms can be unicellular (single-celled) or multicellular (many cells).
- Cells are too small to see with the naked eye; a microscope is needed.



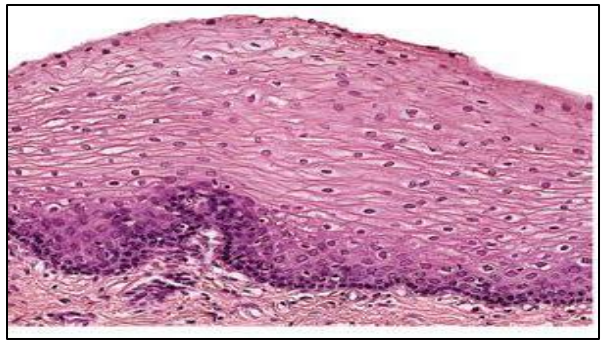
Intro..

- **Histology (Histo: tissue, -ology: study):** the microscopic study of body tissues and how they combine to form organs.

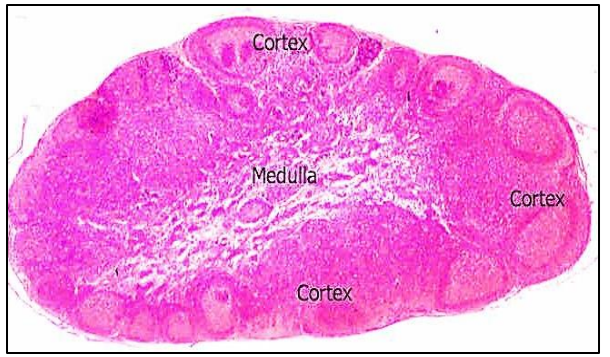
Cells



Tissue



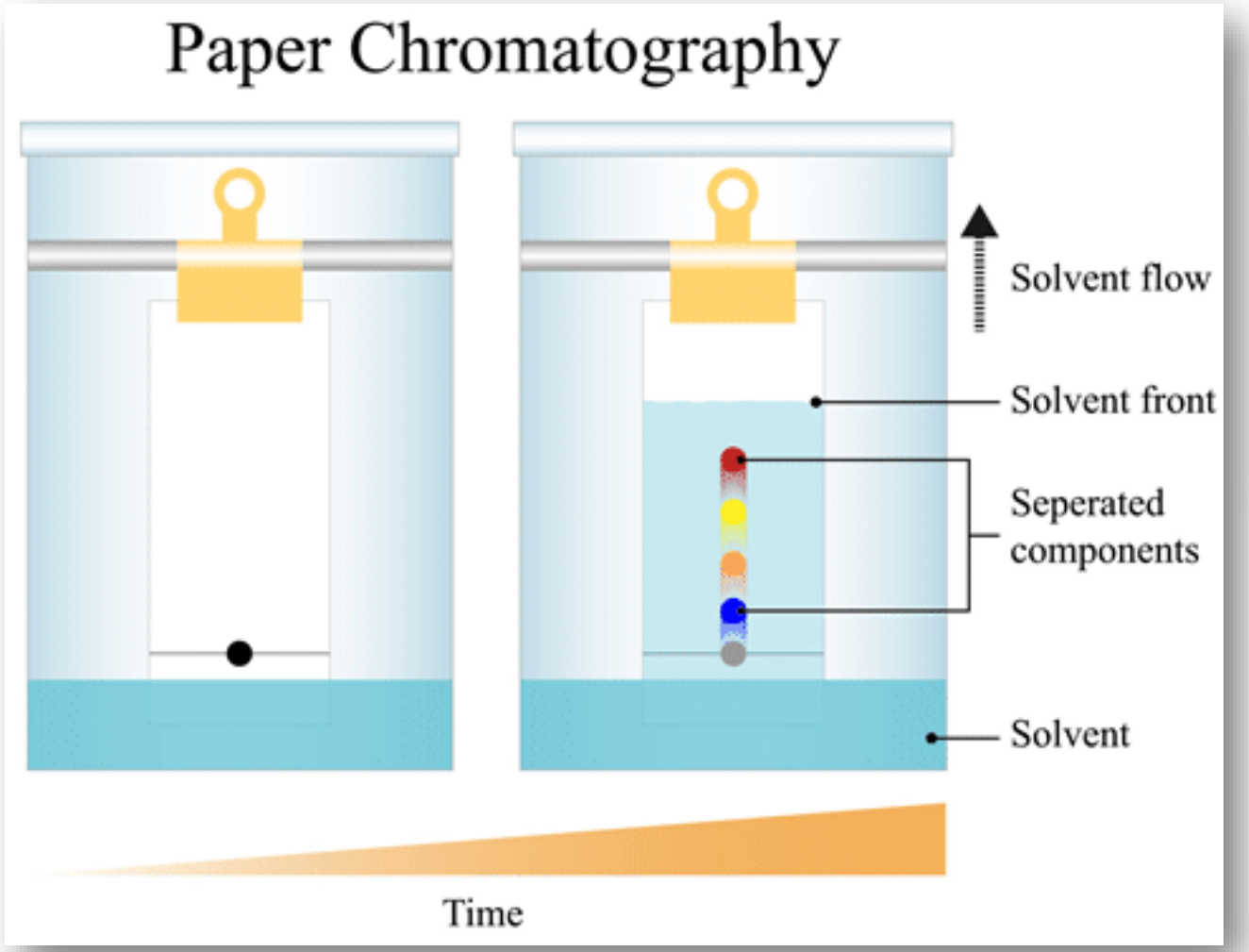
Organ

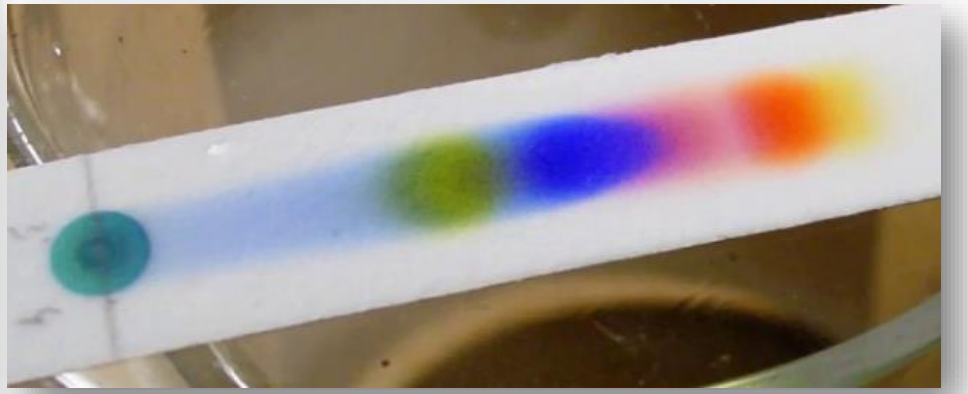


Methods of studying cell biology

- **Cell culture:** isolating the cells to study under controlled conditions (i.e. preserved homeostatic conditions)
- **Cell fractionation:** breaking the cells subsequently to their components by centrifugation
- **Chromatography:** separating the molecules in a mixture based on their physical & chemical properties (in case of proteins we uses gel instead of paper)

Chromatography



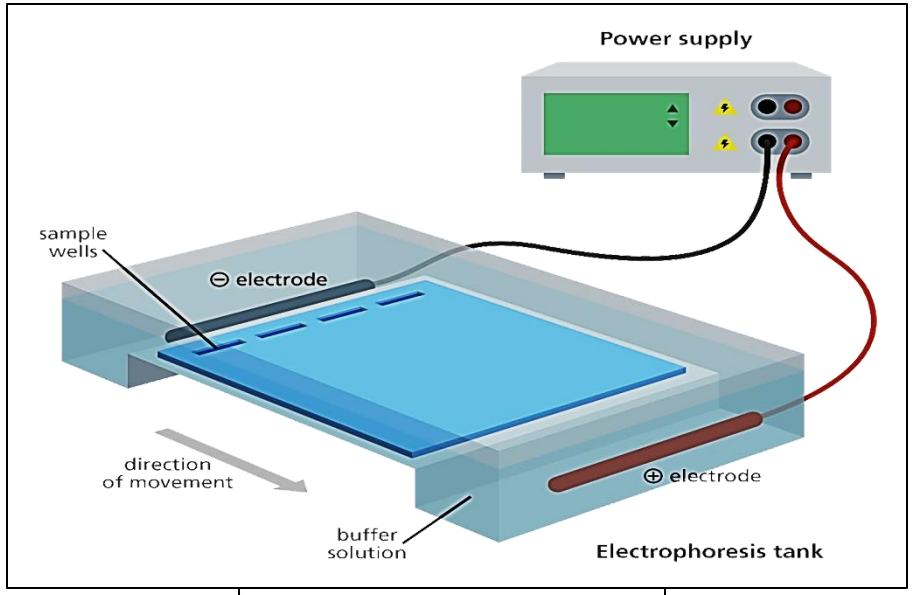


Chromatography

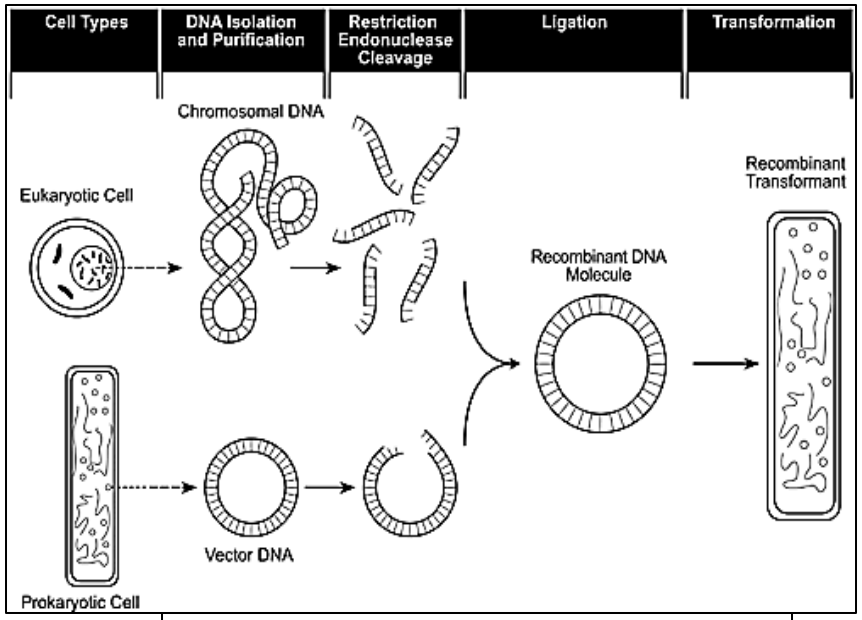
- **The mobile phase** is usually a gas or liquid that moves through the **stationary phase**, while **the stationary phase** is a solid, like chromatography paper.
- Separation happens because different components of a mixture move through the stationary phase at different rates.
- How dose it work?
  - A sample mixture is placed on the stationary phase.
  - The mobile phase moves through the stationary phase, carrying the mixture's components with it.
  - Substances that dissolve well in the mobile phase travel faster and further.

Methods of studying cell biology..

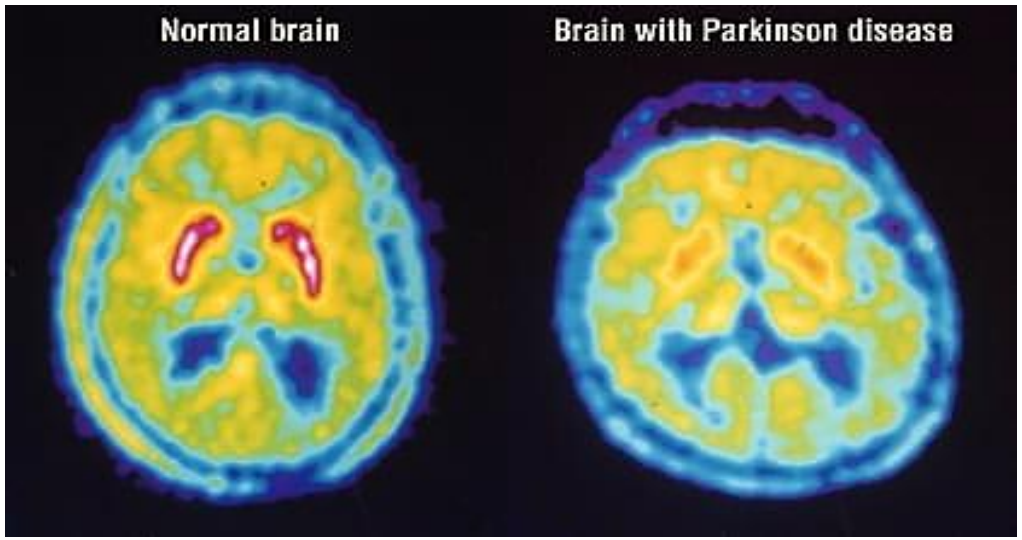
- **Electrophoresis**: used to separate charged molecules using an electric field based on their size and charge.
- **Genetic Technology:** studies gene structure and function, including Isolating genes, determining unknown DNA sequences and Cloning (copying genes and DNA sequences).
- **Small Animal Imaging (SAI):** examine the biological processes from the molecular to the organ system level in living animals.
  - It's important for preclinical studies e.g. Positron emission tomography (PET /sca), MRI, CT.



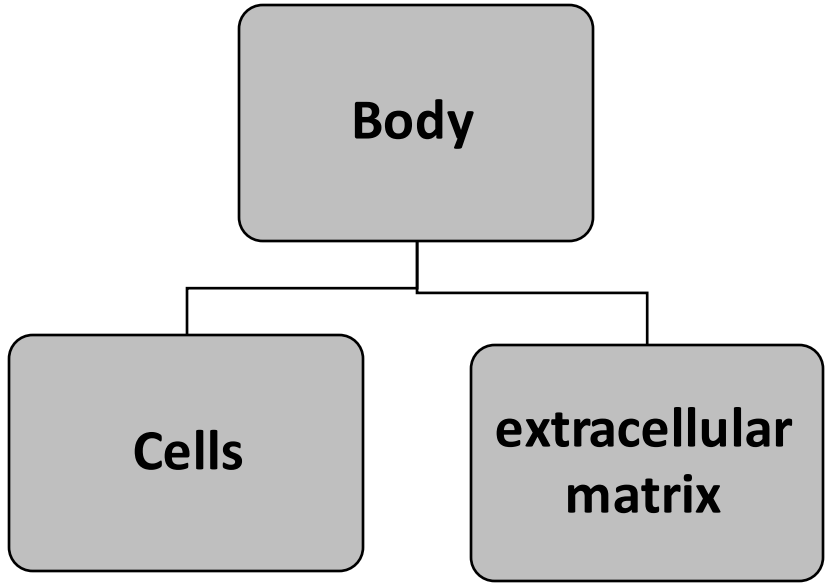
Gel electrophoresis



recombinant DNA technology



Positron emission tomography (PET/Scan)



Classification of Cells

1. Prokaryotic Cells

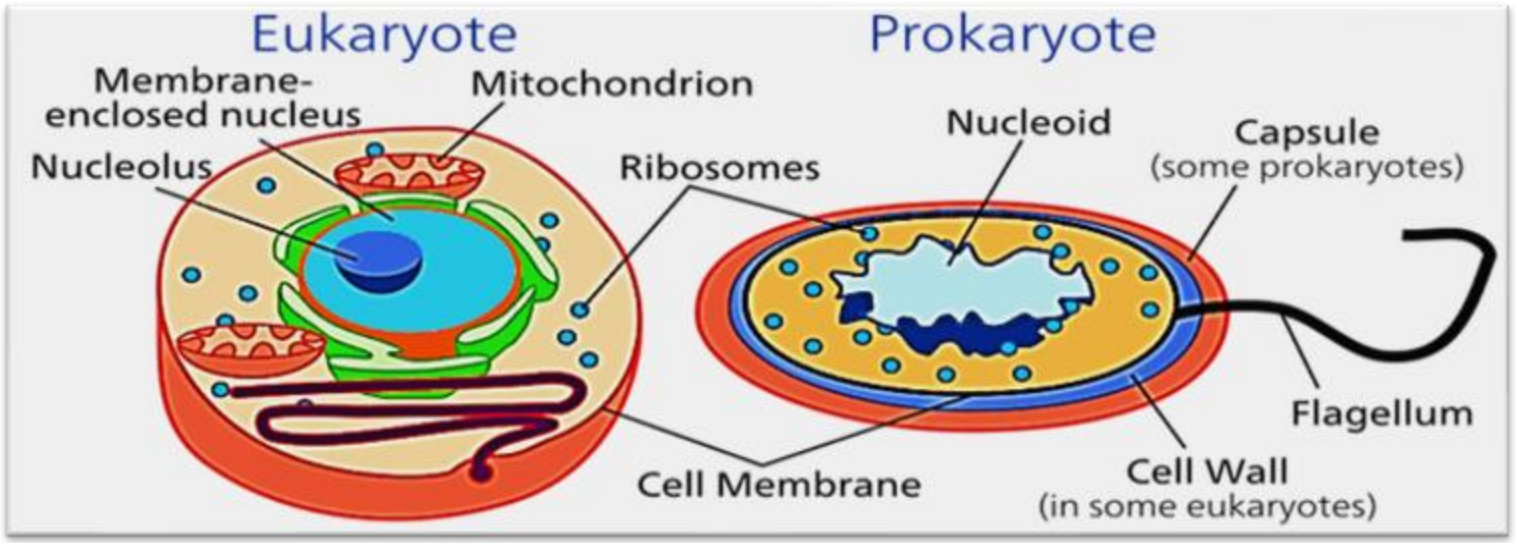
- Lack a nucleus; genetic material is dispersed in the cytoplasm Genophore (**nucleoid**).
- No membrane-bound organelles.

2. Eukaryotic Cells

- Have a nucleus and membrane-bound organelles.

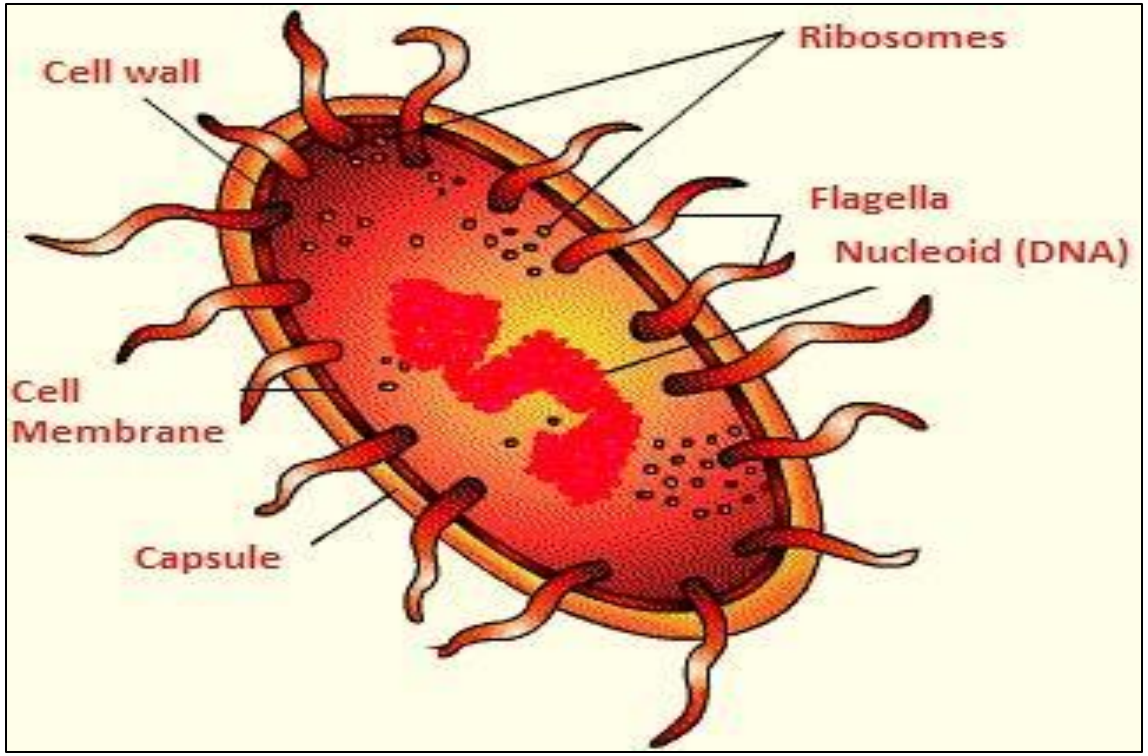
❖**Common Features** (Prokaryotes & Eukaryotes):

- Cell membrane
- Cytoplasm
- Genetic material
- Ribosomes

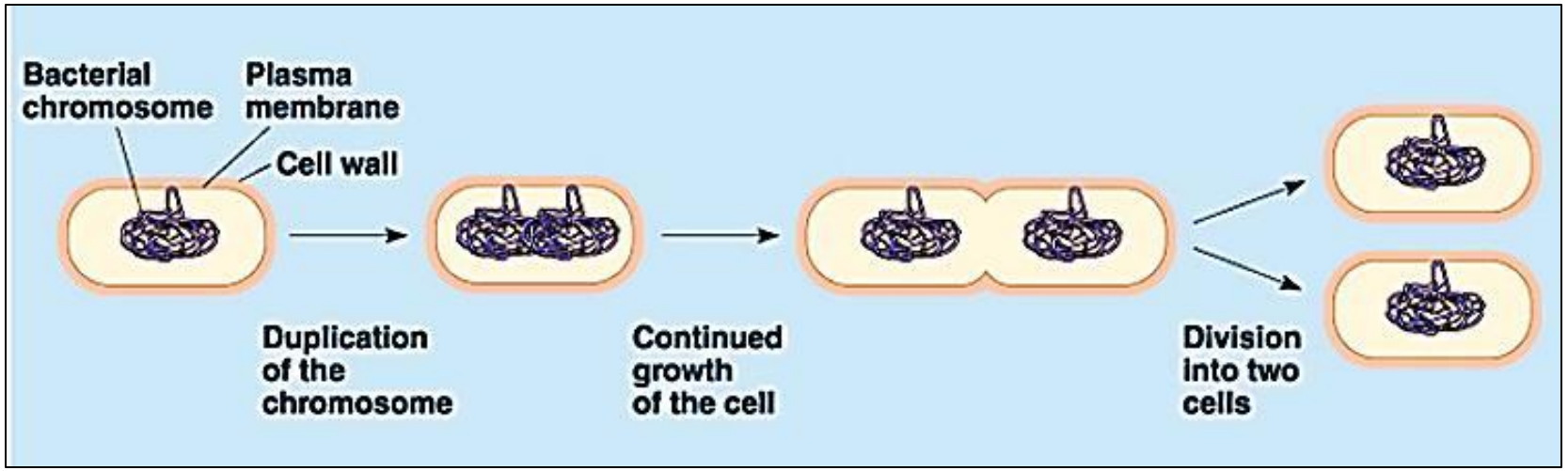


	PROKARYOTE	EUKARYOTE
Meaning of name	Pro means before Karyon means nucleus	Eu means after Karyon means nucleus
Evolution of first cells	3.5 billion years ago (older type of cell)	1.5 billion years ago
Size of cells	Smaller (1-10 µm)	Larger (100-1000 µm)
Uni-/multicellular	Unicellular (less complex)	Multicellular (more complex)
Organelles	Absent	Present
Location of genetic information	Nucleoid region	Nucleus
DNA structure	Circular (usually one chromosome)	Not circular (more than one chromosome)
Reproductive strategy	Asexual	Sexual
Oxygen requirement	Anaerobic (doesn't require oxygen)	aerobic

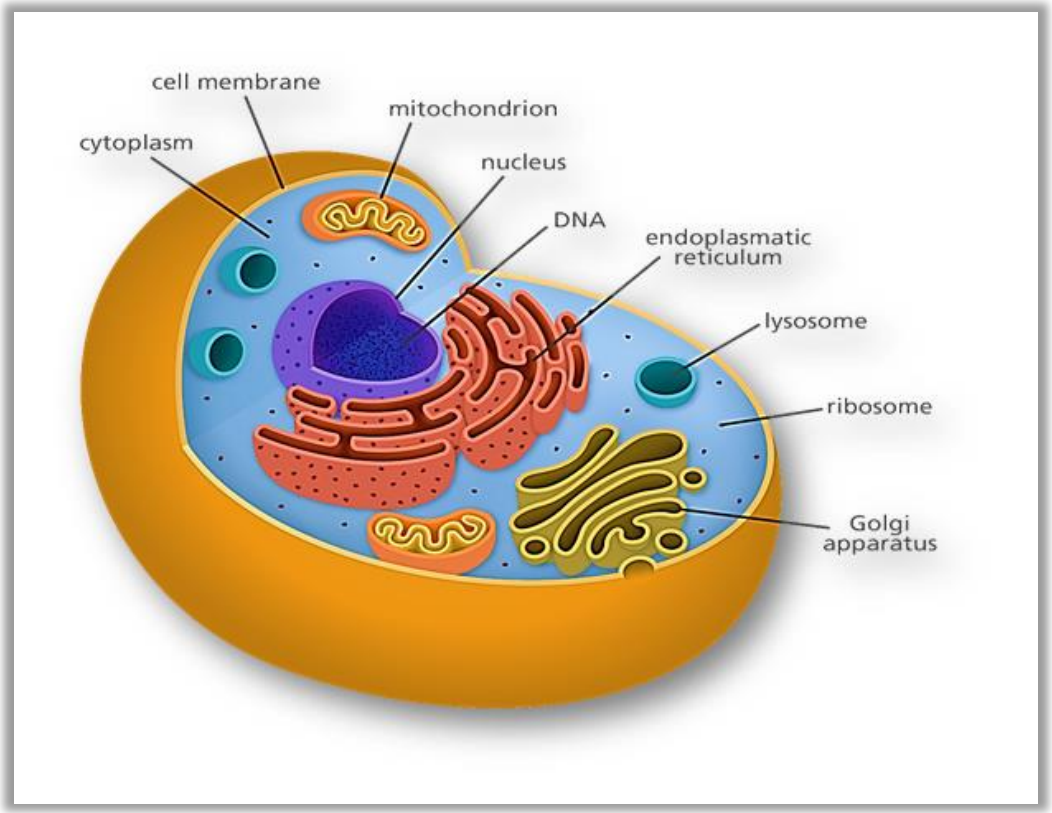
The DNA strand is circular and is called genophore and found in area called nucleoid



Binary fission



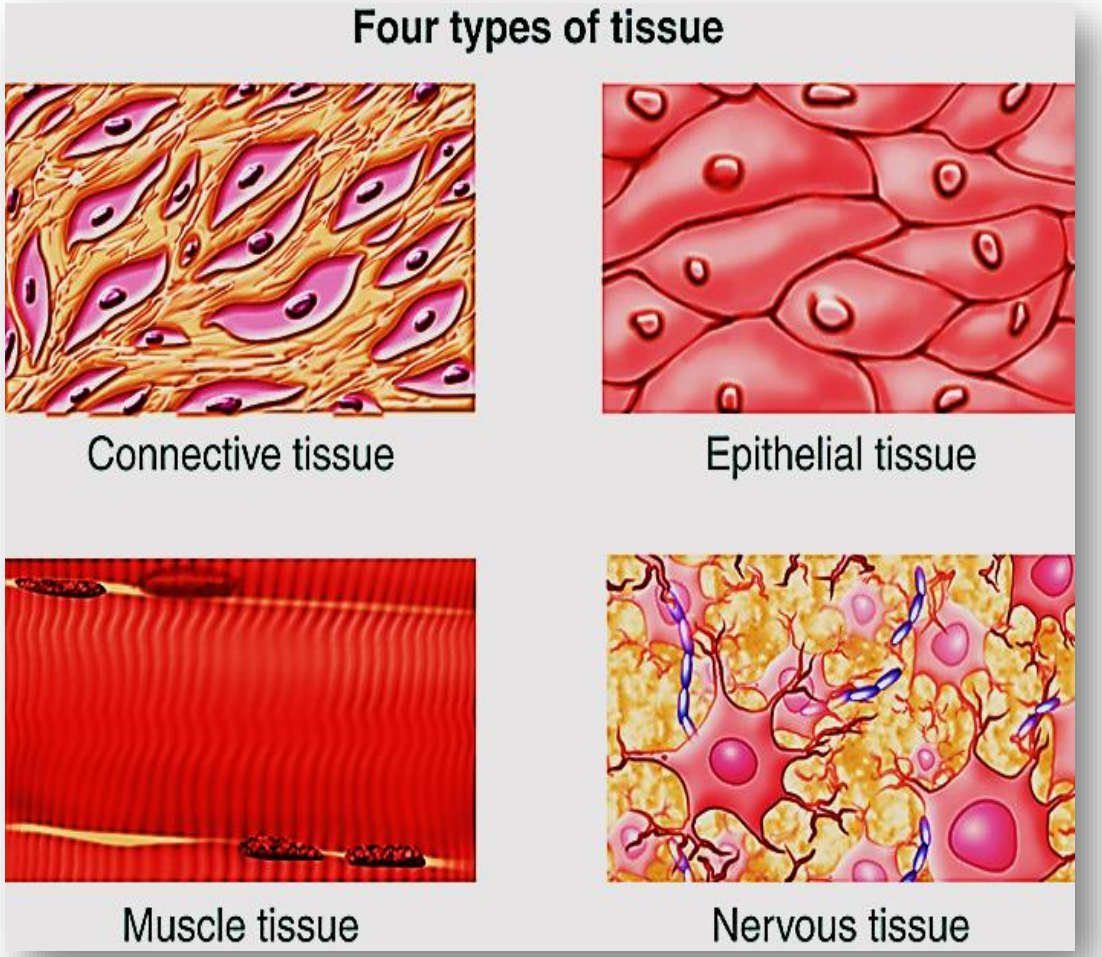
Prefix	In words	Multiply by	Factor
nano (n)	Billionth	1/1000000000	$1*10^{-9}$
micro (μ)	Millionth	1/1000000	$1*10^{-6}$
milli (m)	Thousandth	1/1000	$1*10^{-3}$
centi (c)	Hundredth	1/100	$1*10^{-2}$
deci (d)	Tenth	1/10	$1*10^{-1}$
		1	
deca (da)	Ten	10	$1*10^{1}$
hecto (h)	Hundred	100	$1*10^{2}$
kilo (k)	Thousand	1000	$1*10^{3}$
mega (M)	Million	1000000	$1*10^{6}$
giga (G)	billion	1000000000	$1*10^{9}$

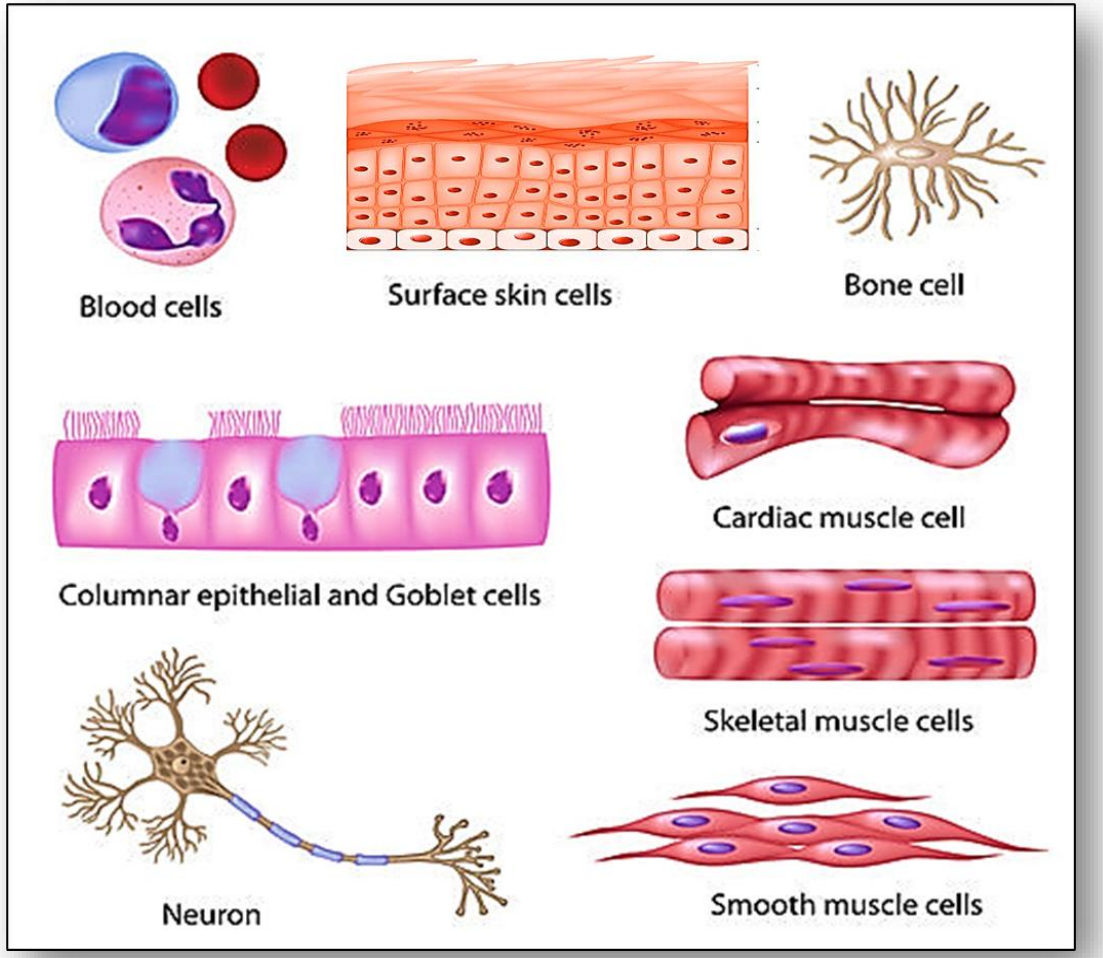


Equivalent lengths:

1 millimeter (mm) = 1000 micrometer (micron)
1 micrometer (um)= 1000 nanometer
1 nanometer(nm)= 10 angstrom

Different cells of the body





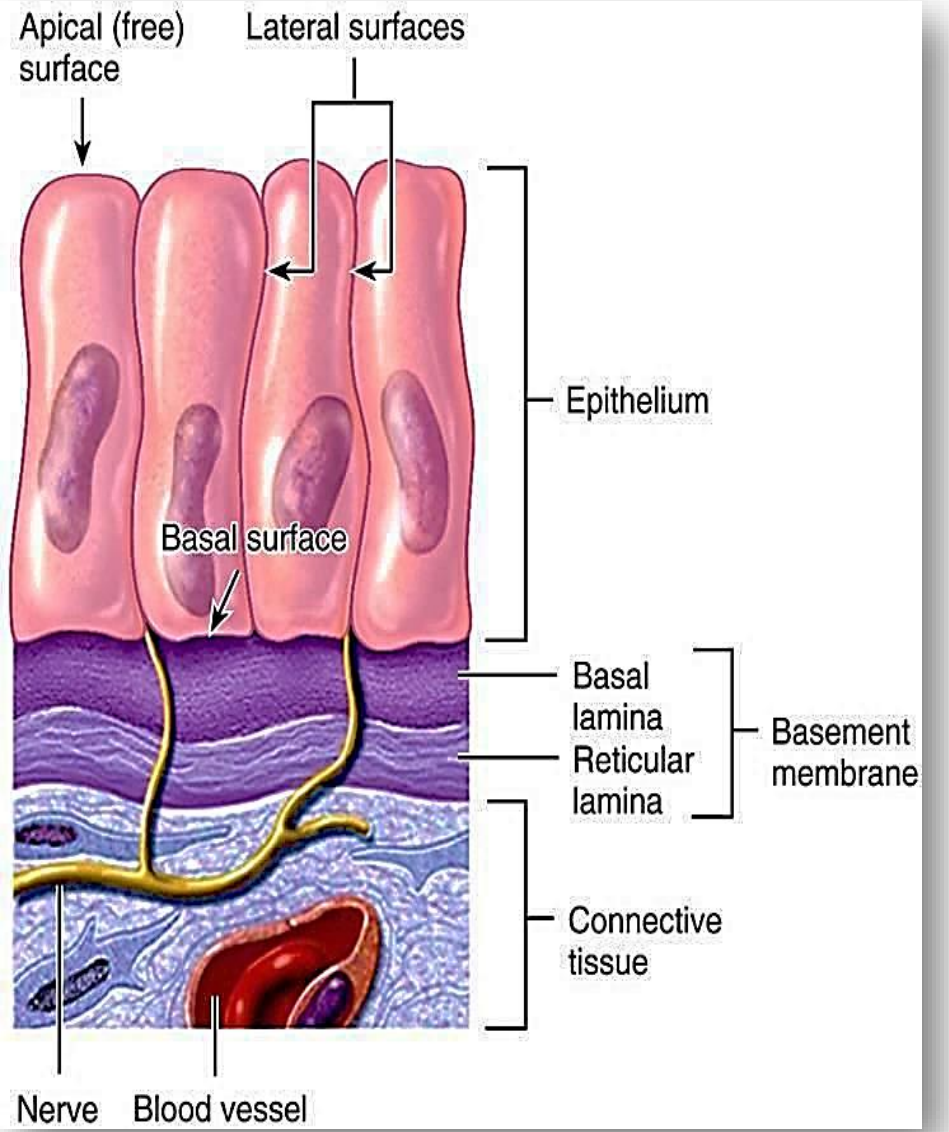
Extracellular Matrix (ECM)

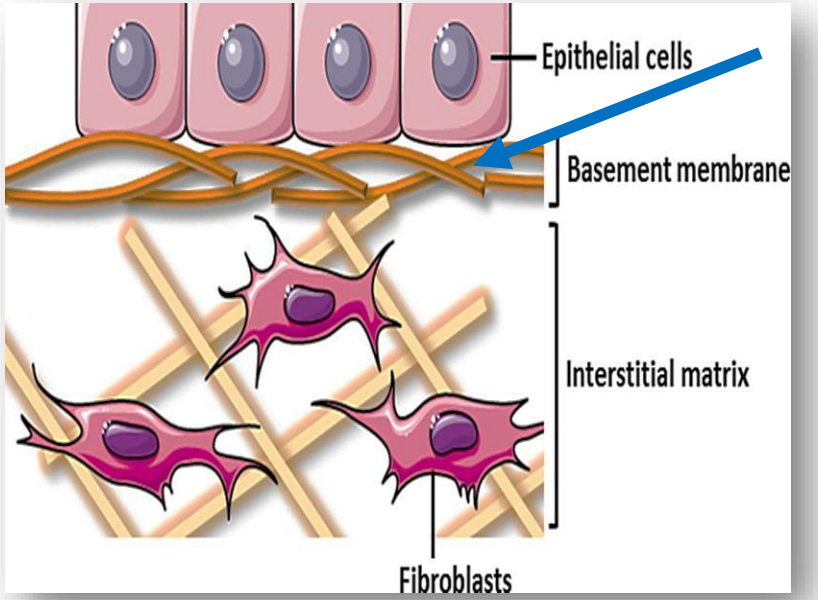
- A non-cellular component that fills spaces between cells and is secreted by the tissue's cells.
  - **Functions**: Supports tissue structure, aids in tissue morphogenesis, communication, differentiation, and homeostasis.
- Types of ECM:
  1. **Interstitial Fluid**:
     - A thin layer of fluid surrounding body cells.
     - Contains **water (H_2O)**, **proteins**, **electrolytes**, **acids**, **hormones**, and **waste materials**.
  2. **Basement Membrane**:
     - A sheet-like ECM layer at the base of cells, found **only** under epithelial cells.

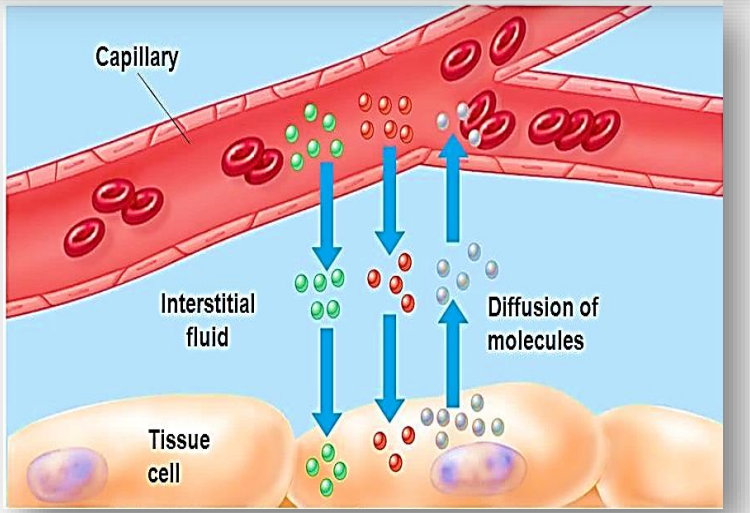
❖*(Note: Plasma membrane vs. Basal lamina vs. Basement membrane)*

- Plasma Membrane: also called cell membrane surrounds the cell &separates the interior of the cell from the outside & providesprotection for the cell

Interstitial matrix & basement membrane







Basement Membrane

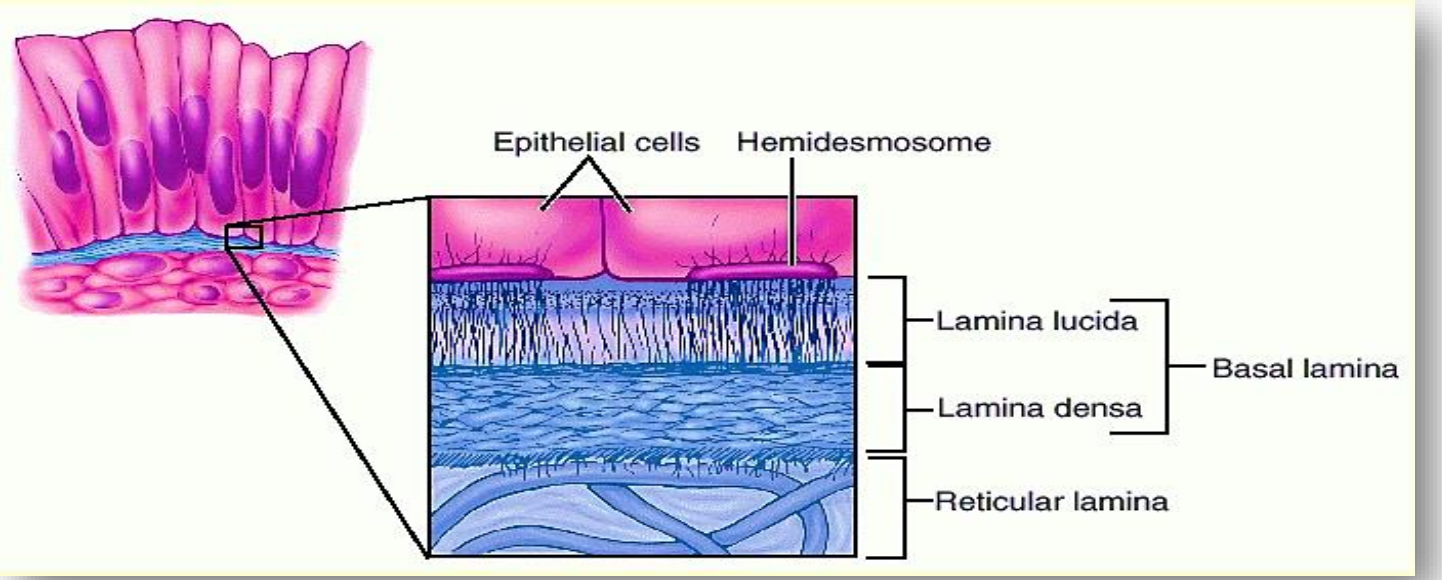
- Separates most epithelial cells from the underlying connective tissue and visible under a light microscope.
- Composed of **two layers**:
  - **Basal Lamina**
  - **Reticular Lamina**

❑**Functions of the Basement Membrane:**

1. **Anchors** epithelial cells to underlying tissue.
2. Serves as a **pathway for cell migration**.
3. Aids in **wound healing**.
4. Acts as a **barrier** between epithelial cells and connective tissue.
5. **Filters blood** in the kidneys.
6. Involved in the **early stages of cancer** (carcinoma in situ, limited to the epithelial layer).

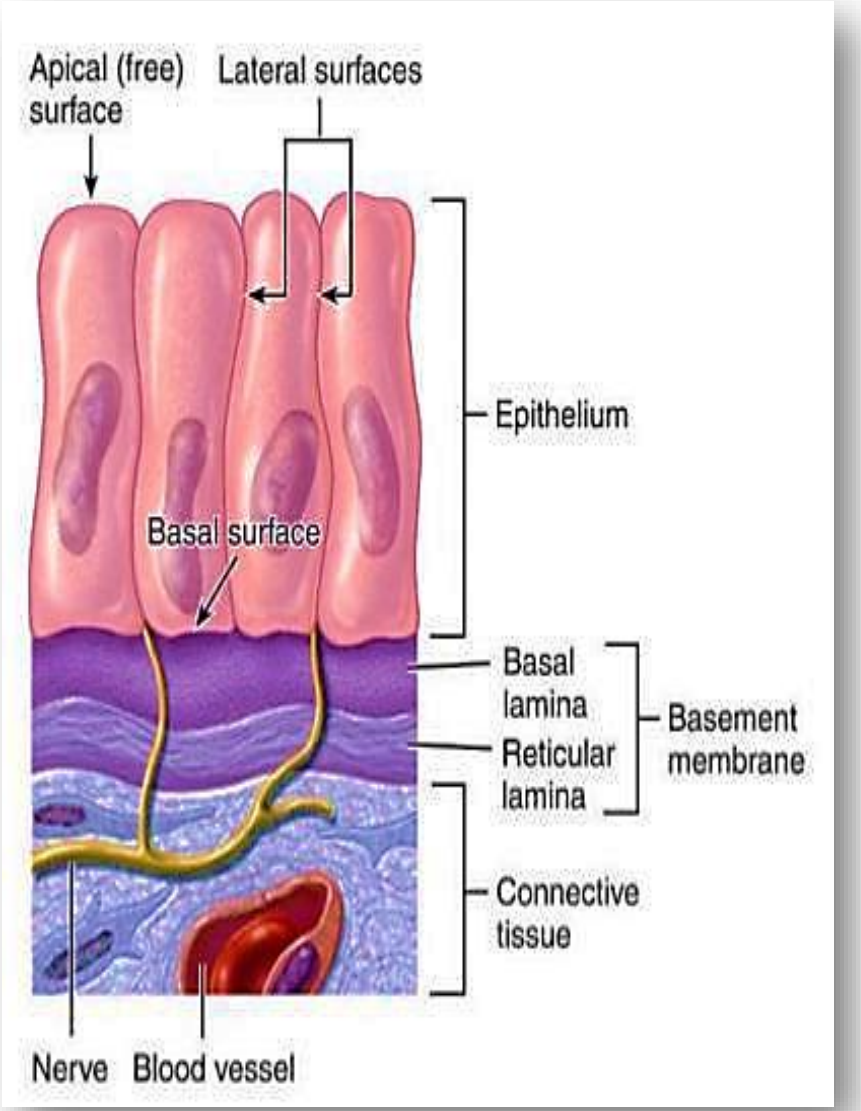
Basement Membrane…

- **Basal Lamina:** visible under an **electron microscope (EM)**, with a thickness of **20-100 nm** secreted by **epithelial cells**.
- Composed of:
  - **Lamina densa**: A delicate network of fine filaments.
  - **Lamina lucida**: An electron-lucent layer on one or both sides of the lamina densa.
- **Note:** In **diabetes mellitus**, the **basement membrane** of small blood vessels, particularly in the **retina** and **kidneys**, becomes **thicker**.



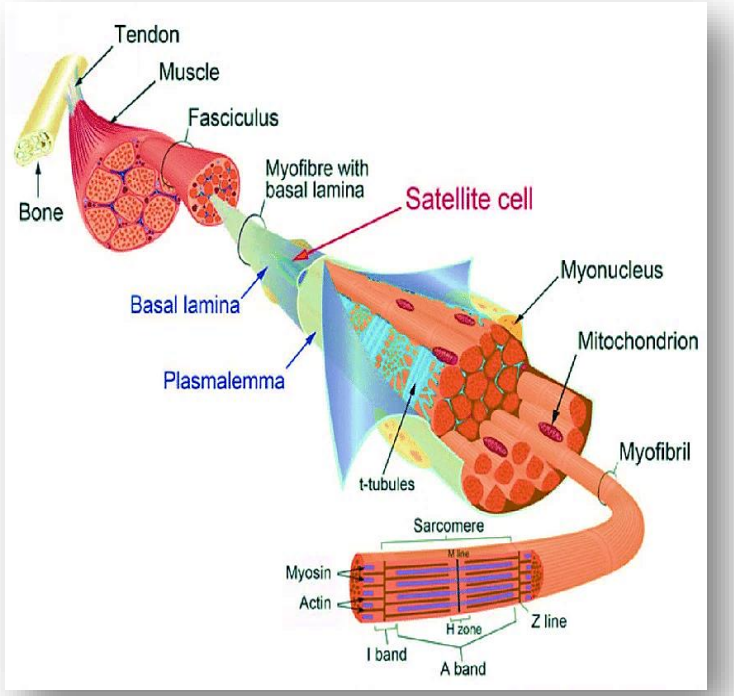
Basement Membrane…

- **Main Components of the Basal Lamina**
  - Type IV Collagen
  - Laminin (a glycoprotein)
  - Entactin
  - Proteoglycans
- **Reticular Lamina**
  - Made of thicker reticular fibers
  - Secreted by connective tissue cells (fibroblasts)
- **Epithelial Cells** are tightly bound together with minimal ECM, mostly consisting of the basal lamina.



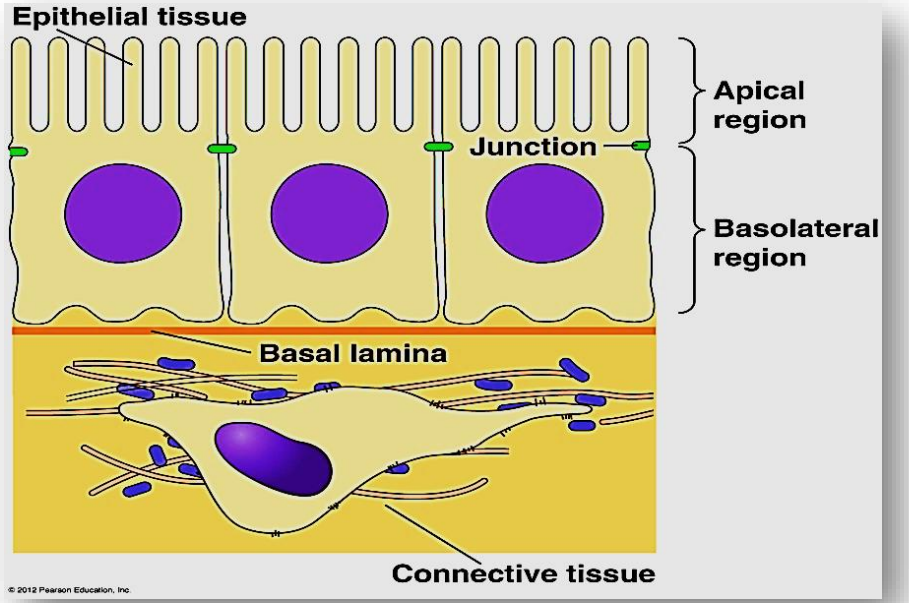
Basement Membrane of Muscle Fiber

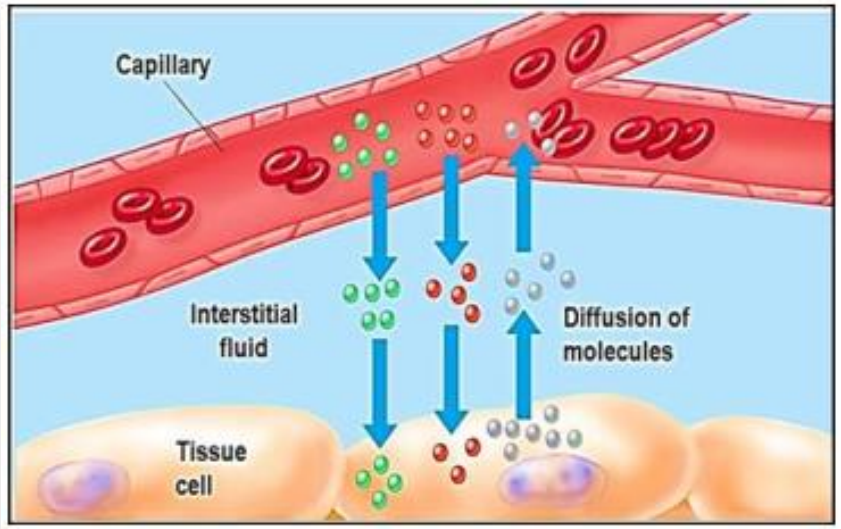
- The muscle fibers are coated by an extracellular matrix material [Basement Membrane] that is made of two layers:
  - **Basal Lamina**: internal layer, directly attached to the sarcolemma (plasma membrane of myofibrils).
  - **Reticular Lamina**: Outer layer.
- Extracellular Matrix (ECM) Around Muscle Fibers Composed of Type IV Collagen, Laminins, Fibronectin, and Proteoglycans.
- Functions:
  - Provides mechanical support during contraction.
  - Supports nerves and blood vessels in muscle tissue.
  - Acts as a barrier between endothelium and muscle cells, and helps in signaling.



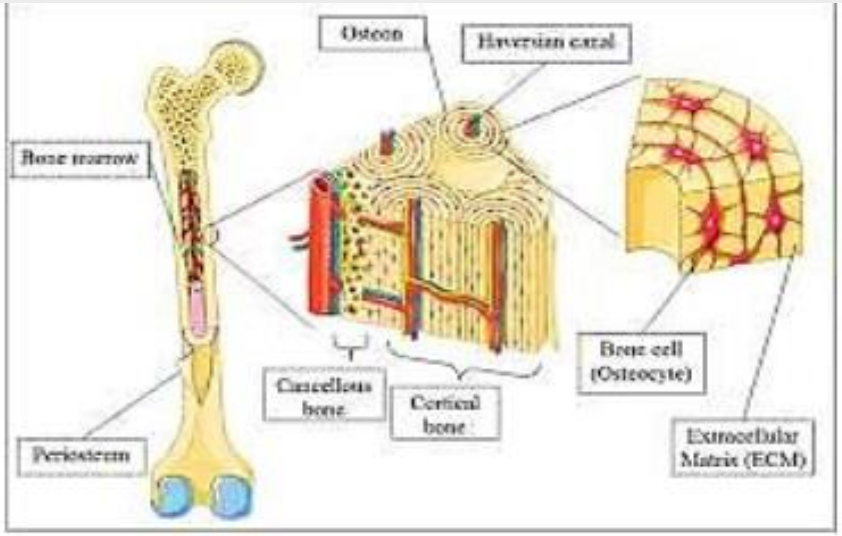
Extracellular Matrix (ECM) Overview

- **Amount of ECM** varies by tissue type:
  - Minimal in epithelium
  - plenty in connective tissue
- **ECM Consistency** can differ:
  - Jelly-like (e.g., connective tissue proper)
  - Rubbery (e.g., cartilage)
  - Hard (e.g., bone)
  - Fluid (e.g., blood)
- **Functions of ECM**
  1. Provides structural support to cells
  2. Delivers nutrients and oxygen, and aids in communication
  3. Removes waste product

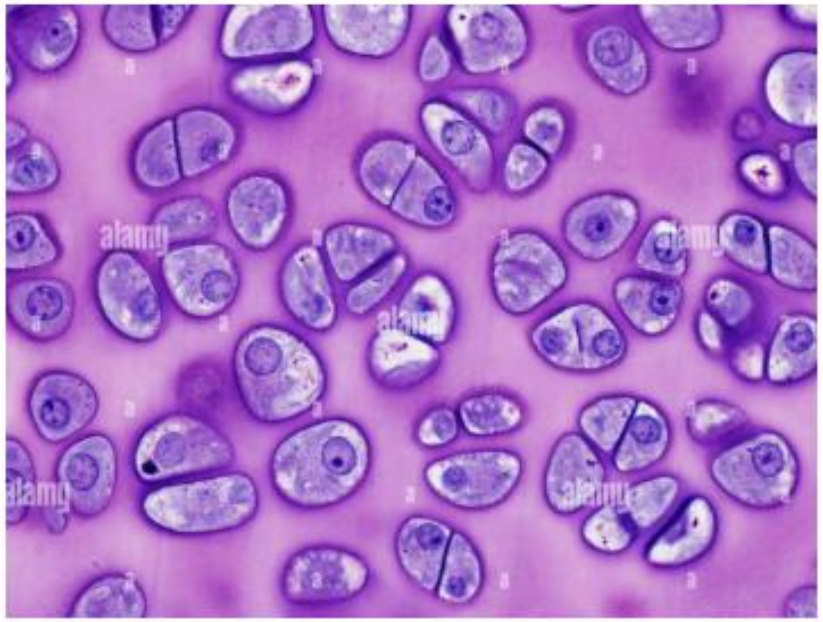




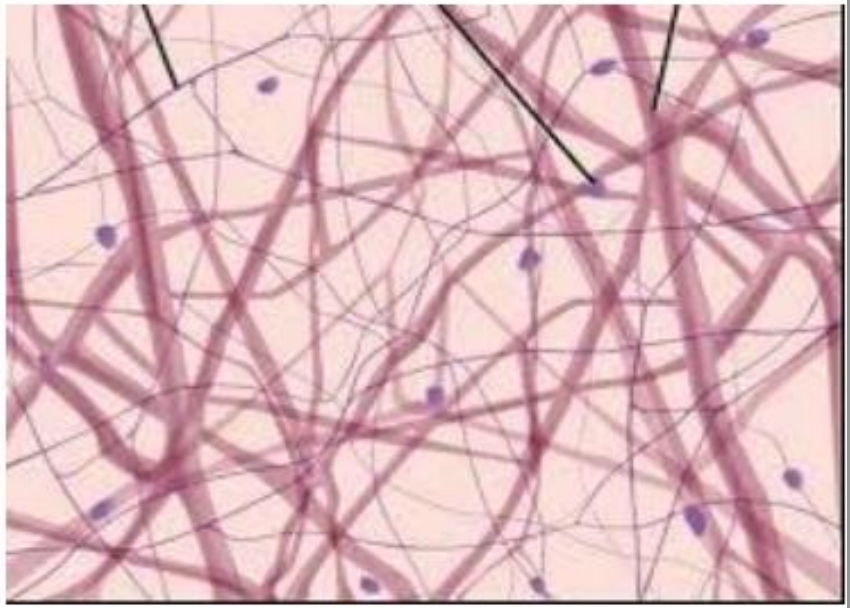
ECM in blood



ECM in bone



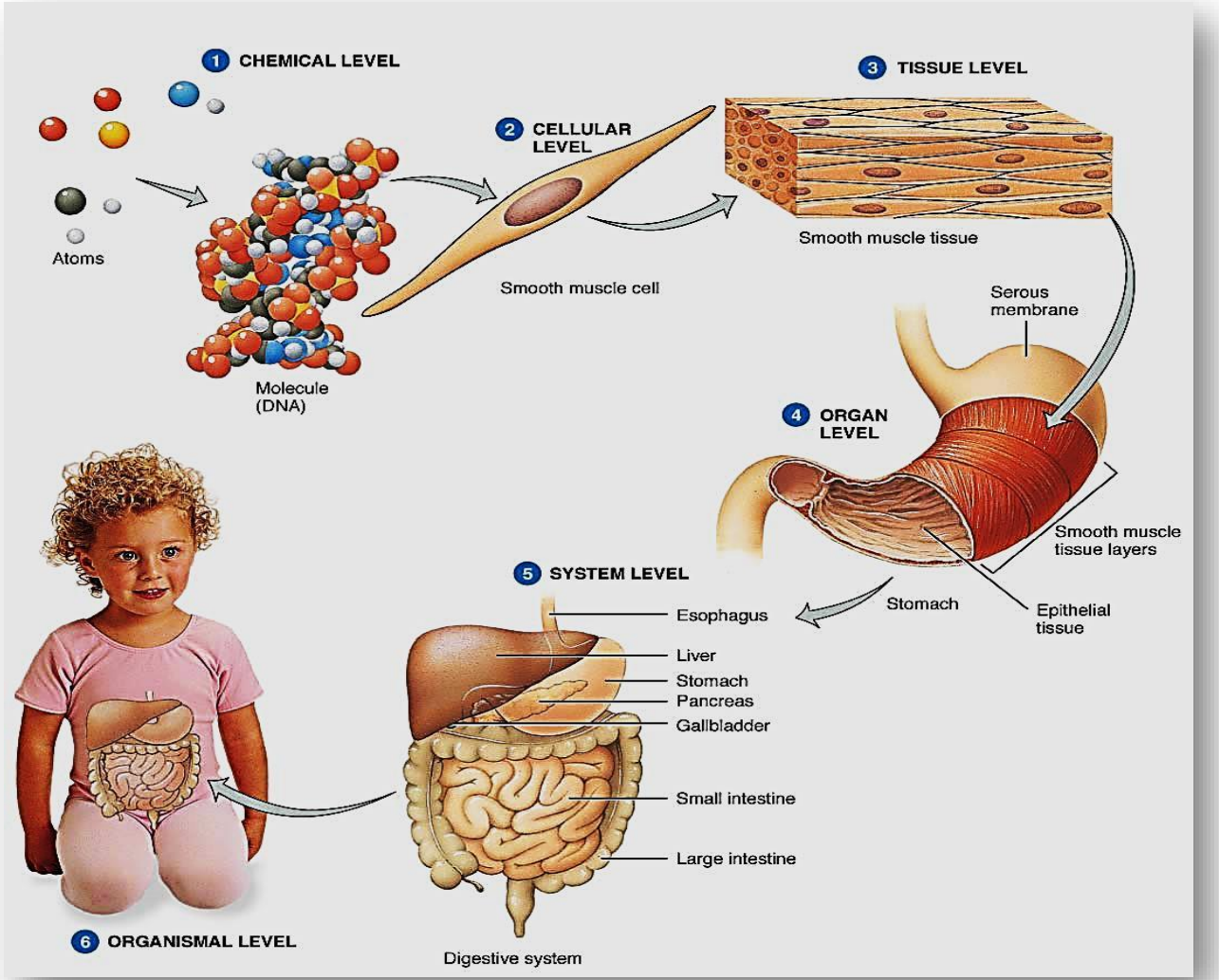
ECM in cartilage



ECM in CT proper

Organization of Human Body

- Human Body Organization
  1. Cells
  2. Tissues
  3. Organs
  4. Systems



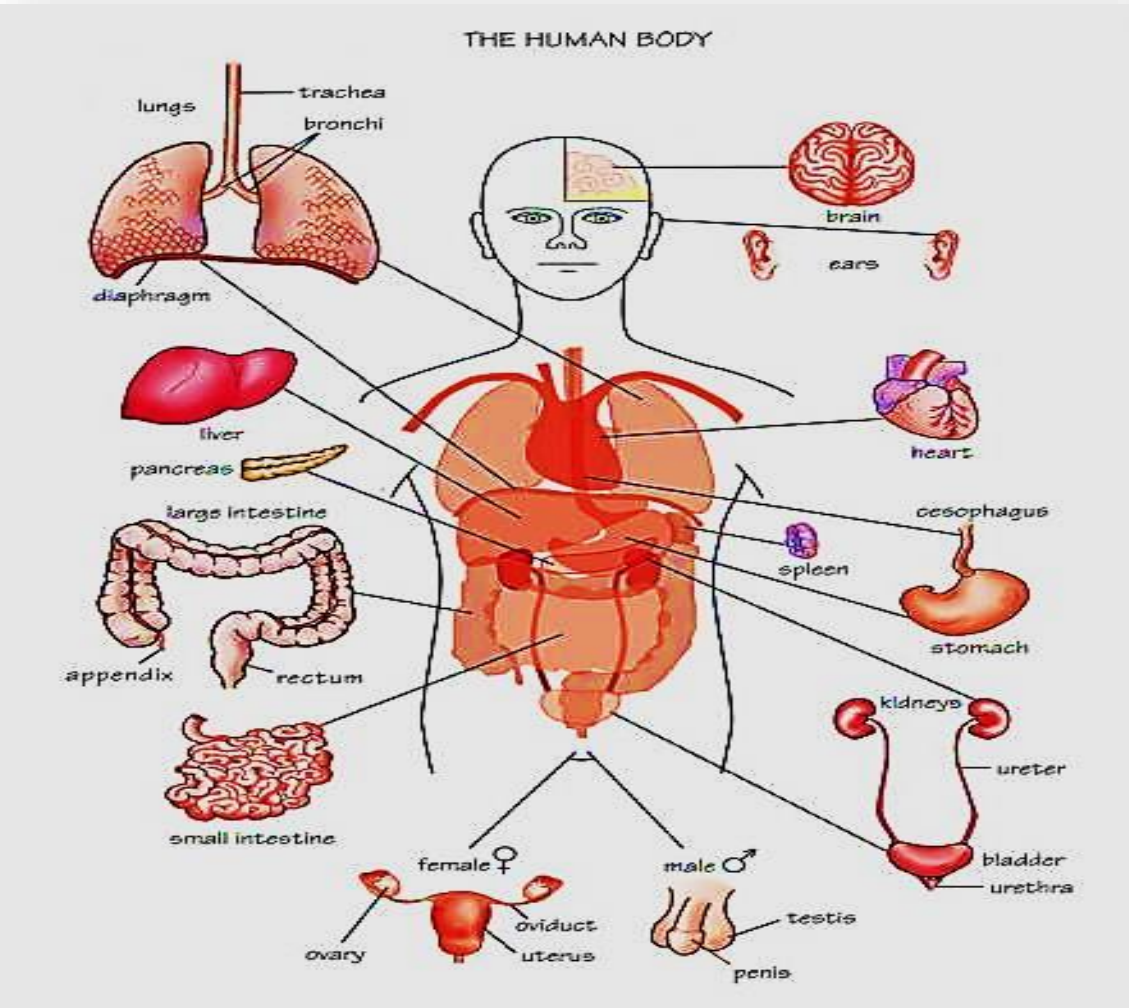
Tissues

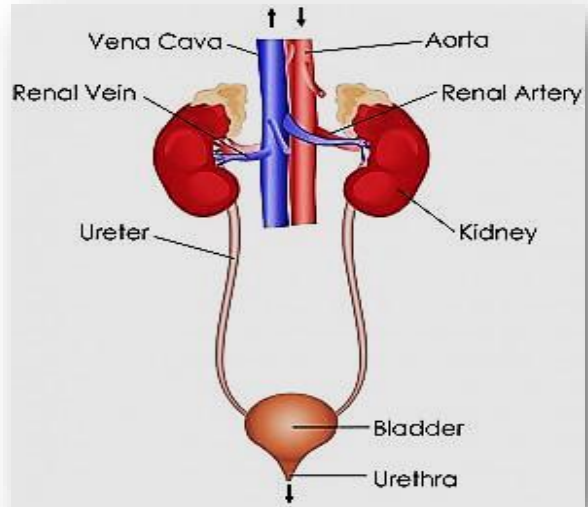
- Basic Tissues in the Body: all organs are made of 4 basic tissues in different combinations.
- Each basic tissue is formed of special types of cells that have the same general features and perform specific functions.
- **The Four Basic Tissues**
  1. Epithelial Tissue
  2. Connective Tissue
  3. Muscle Tissue
  4. Nervous Tissue

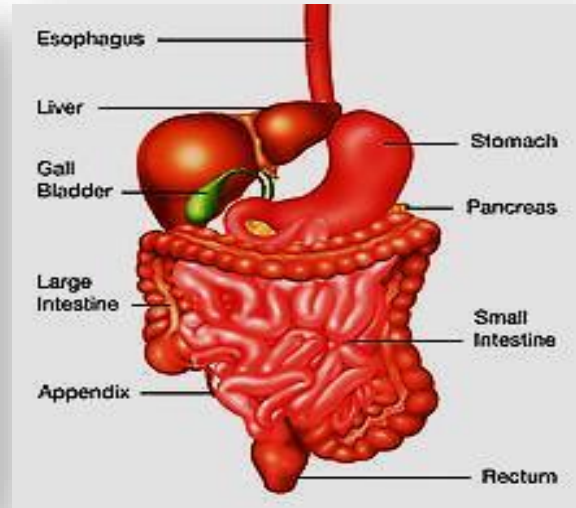
Organs & Systems

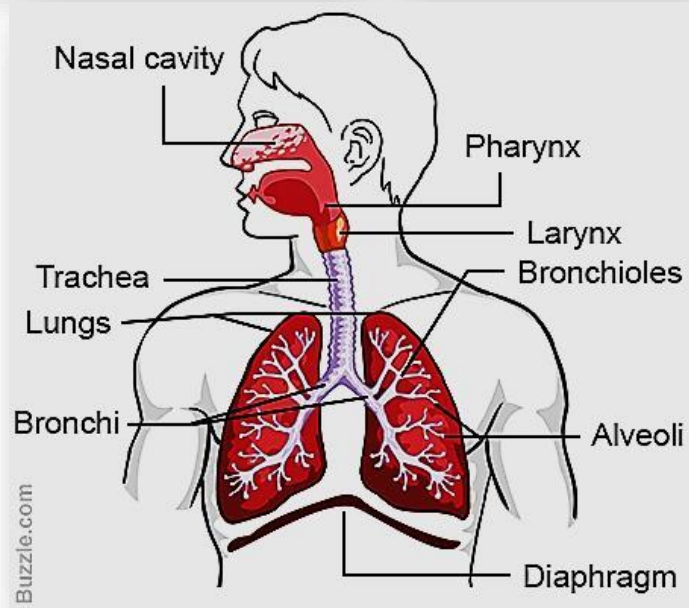
- Each organ is formed of different kinds of tissues that perform together a special function.
- **Examples of organs :**
  - The kidney
  - The liver
  - The lung
  - The stomach…..etc

- A system is an organization of different organs that together perform integrated complex functions of the body.
- Examples of systems :
  - The urinary system
  - The digestive system
  - The respiratory system…..etc.


THE HUMAN BODY
lungs
trachea
bronchi
diaphragm
brain
ears
liver
pancreas
heart
large intestine
oesophagus
spleen
stomach
appendix
rectum
kidneys
ureter
small intestine
bladder
urethra
female ♀
male ♂
oviduct
ovary
uterus
testis
penis


Vena Cava
Aorta
Renal Vein
Renal Artery
Ureter
Kidney
Bladder
Urethra


Esophagus
Liver
Gall Bladder
Stomach
Pancreas
Large Intestine
Small Intestine
Appendix
Rectum

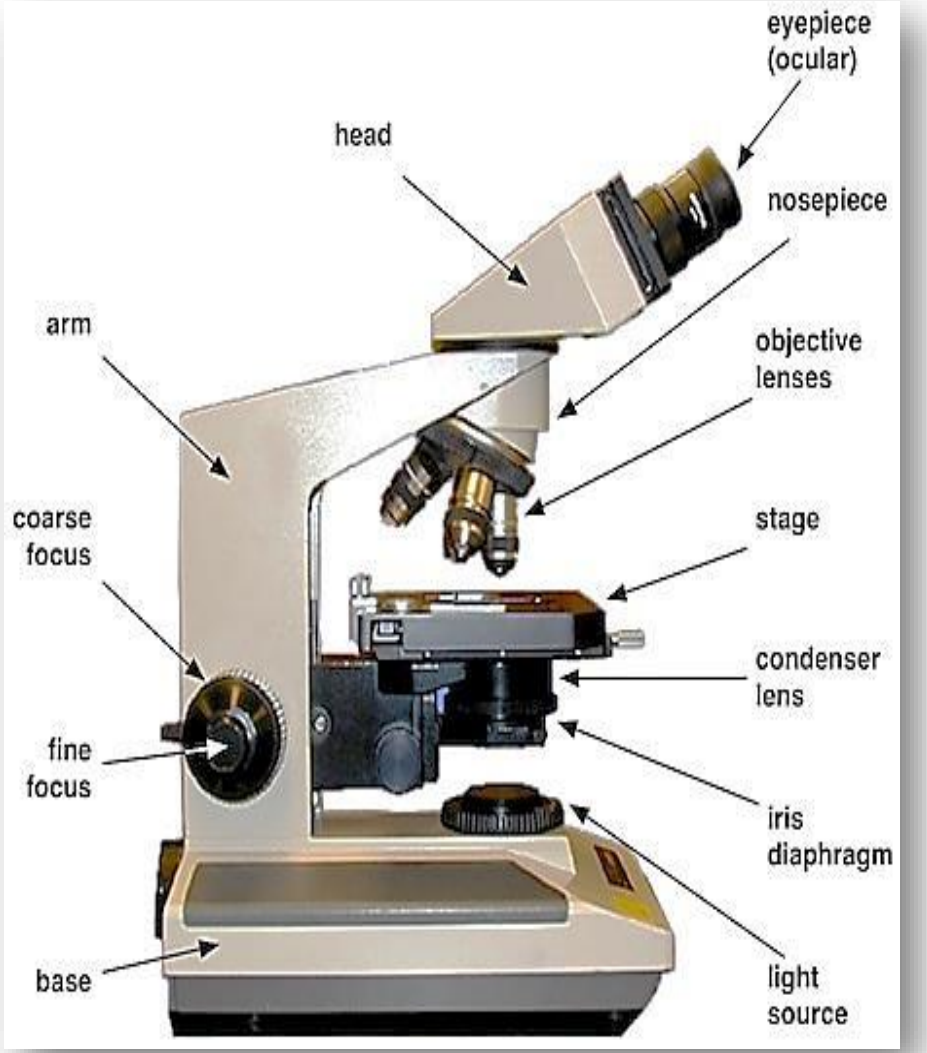

Nasal cavity
Pharynx
Larynx
Trachea
Bronchioles
Lungs
Bronchi
Alveoli
Diaphragm
Buzzle.com

Microscopy

- Microscopy Is Standard Optical Instruments for Histological Examination used to generate magnified images for studying tissues.
- Types:
  - Light microscope (LM)
  - Phase contrast microscope
  - Differential interphase microscope
  - Fluorescence microscope
  - Confocal microscope
  - Electron microscope (Transmission and scanning)

Light microscopy (LM)

- The widely used microscope uses a visible light source and a condenser lens to direct light through the specimen.
- image Magnification magnified by two sets of lenses:
  - **Ocular Lens**: 10x magnification
  - **Objective Lenses**: 5x, 10x, or 40x magnification
- Total magnification = Ocular lens x Objective lens
  - Example: 10x (ocular) x 40x (objective) = 400x total magnification

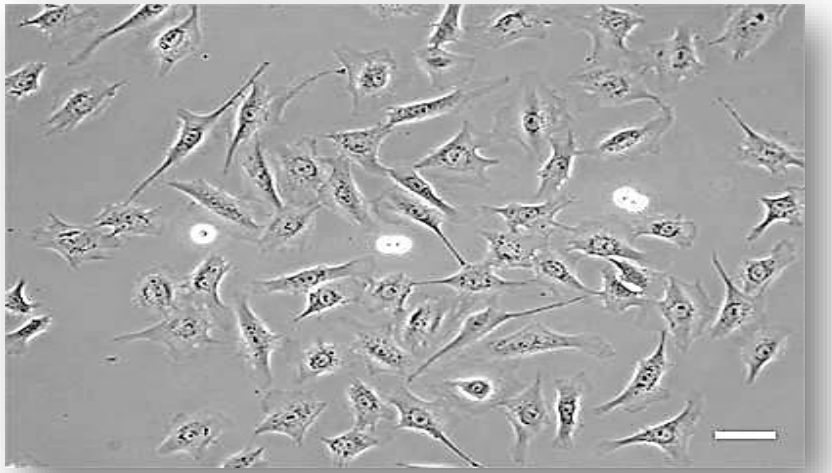


Light microscopy (LM)

- Microscope Capacity Depends on:
  1. **Magnification Power**: The ability to enlarge objects.
  2. **Resolution Power**: is the smallest distance between two particles that can still be seen by eye or camera as two separate entities and not a as single object (done by : lenses)
- The magnification is of value only when accompanied by high resolution.
- **Resolution Power**
  - **Naked Eye**: 0.2 mm
  - **Light Microscope (LM)**: 0.2 µm
  - **Electron Microscope (EM)**: 0.2 nm

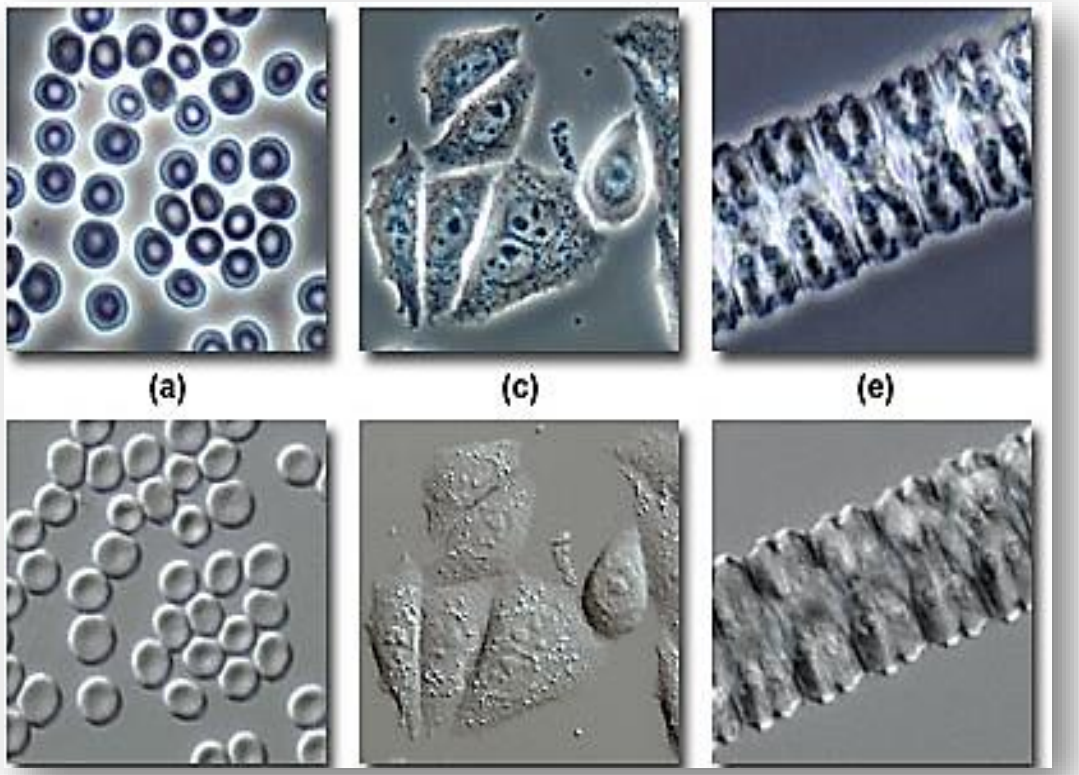
Phase contrast microscope

- It depends on the idea that some lens systems produce visible images from transparent, unstained objects.
- Works by detecting changes in light speed as it passes through cellular and extracellular structures with different refractive indices.
- Objects appear lighter or darker relative to one another.
- **Uses:** useful for examining living cells and tissue cultures (e.g., blood cells, sperm).



Differential interphase contrast microscope

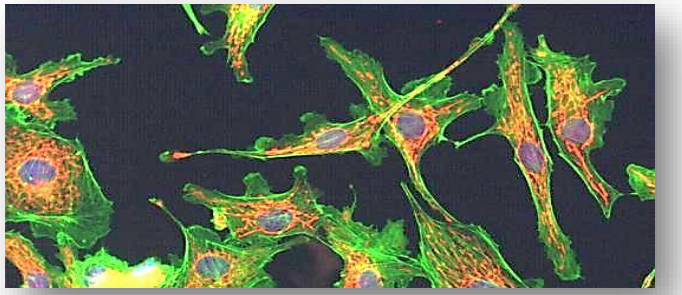
- The interphase microscope (Nomarski microscopy) is a version of phase contrast microscope (used for transparent or unstained samples).
- The obtained image appears to have three dimensional characters.
- It utilizes two separate beams of light.



DIC Microscopy

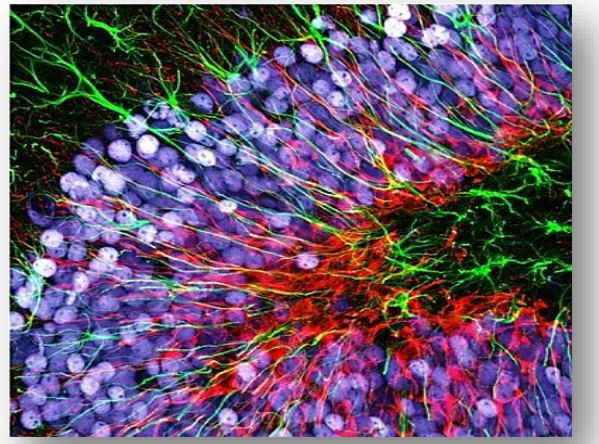
Fluorescence microscopy

- Certain substances absorb invisible ultraviolet (UV) light (short wavelength) and emit (reflect) visible light (long wavelength) — a physical property called **fluorescence**.
- Fluorescence microscopy is equipped with a **special UV lamp** that passes light through the tissue.
- **Fluorescent Stains:** Acridine Orange, DAPI (used in immuno-histological techniques).
- **Uses:** Visualizes DNA, RNA, proteins, and antigen-antibody complexes (fluorescently labeled antibodies).



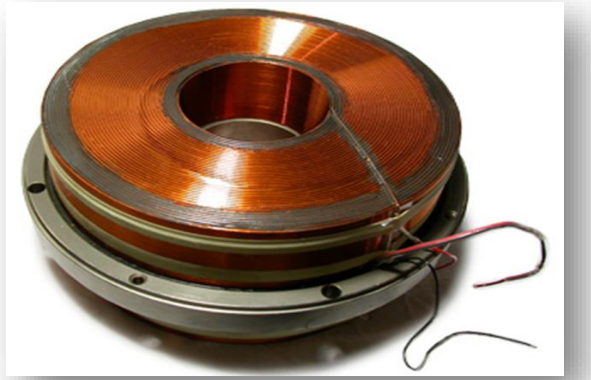
Confocal laser microscope (3D)

- Uses a laser light source for illumination and the specimen must be labeled with **fluorescent molecules**.
- **Advantages/uses:**
  - Increases optical resolution and contrast for clearer better images.
  - Laser light **passes through a small hole to avoid photo bleaching** to examine fine details
- It is connected to a computer system to reconstruct detailed 3D images of the specimen.



The Electron Microscope (EM)

- Technique is used to obtain high resolution images as a **beam of electrons** is used as source of light.
- The image is formed from **the interaction** of the electrons with the specimen as the beam travelling through it.
- **Beam passes through a vacuum tube.**
- The **lenses are electromagnetic coils** instead of glass lenses.
- Components:
  - Electron Gun: Generates the electron beam.
  - **Condenser Lens:** Creates a circular magnetic field that **focuses** the electron beam onto the specimen



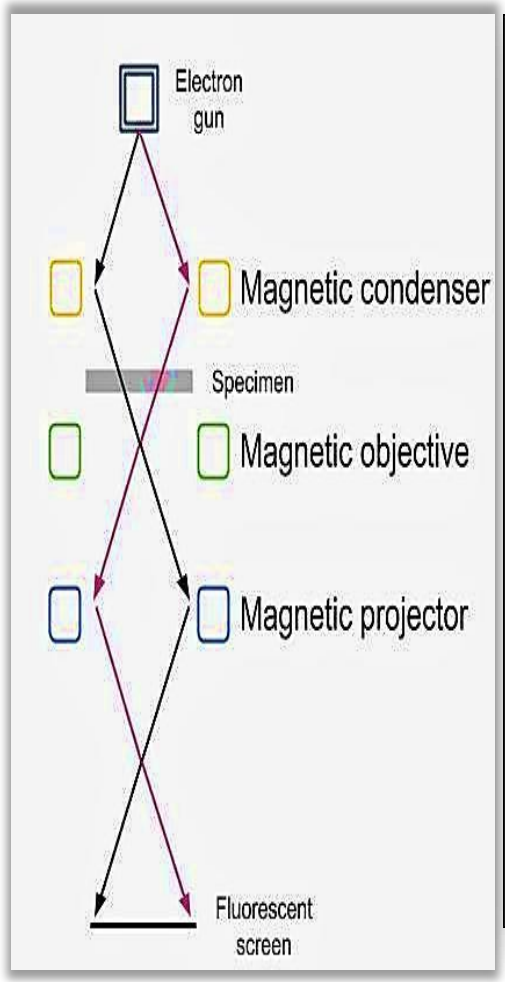
The Electron Microscope (EM)

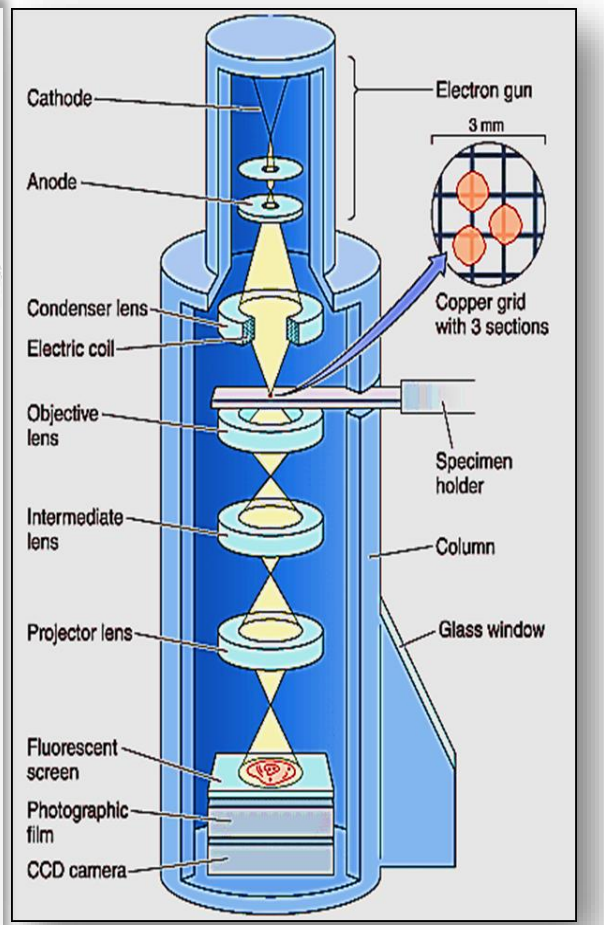
- Imaging system consists of :
  - Another electromagnetic lenses (2-3)
  - Screen

➢ **The objective lens** is used **to refocusing** the electrons after they pass through the specimen & **form image**

➢ **The projector lens** is **to enlarge** the image of the object and projecting it into the fluorescent screen

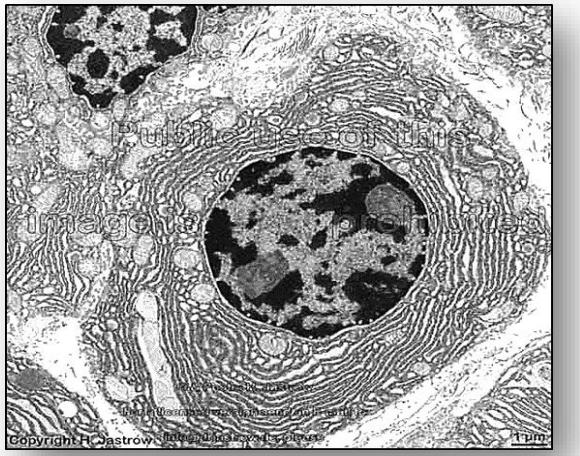
➢ The image appears on screen plate which glows when being hit by electrons.

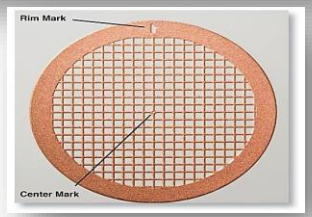




The Electron Microscope (EM)

- Images can be detected as: **Light areas** (electron lucent) & **dark areas** (electron dense) Corresponding to areas through which electrons readily passed
  - EM can **magnify** the image thousands of times(up to 200.000 times).
  - The **resolution power** = 0.2 nanometer(nm)
  - For permanent records, photos are made
- The tissues and cells need special preparation & then cut into very thin sections (ultra thin sections = 0.01 of the micron) then collected on a copper metal grid.
- During preparation sections are stained with salts of heavy metals like lead nitrate and uranyl acetate that precipitate in tissues.





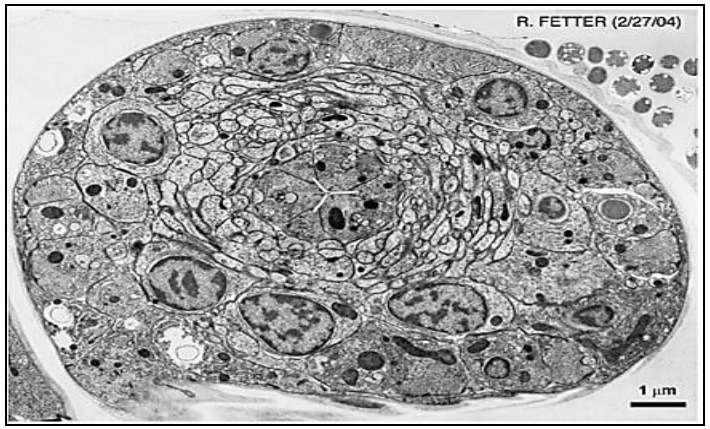
Copper grid slides

Embedding in resin

The Types of Electron Microscope

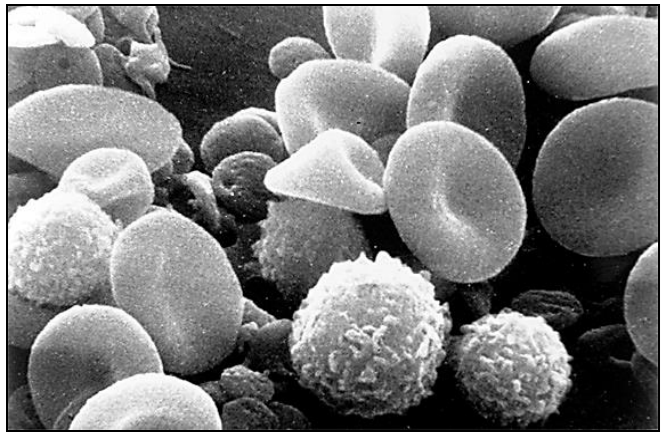
- **Transmission EM (TEM)**: where electron beams pass through the specimen. It shows the **details of internal structures of cells**.
- Resolution power: 0.2 nanometer

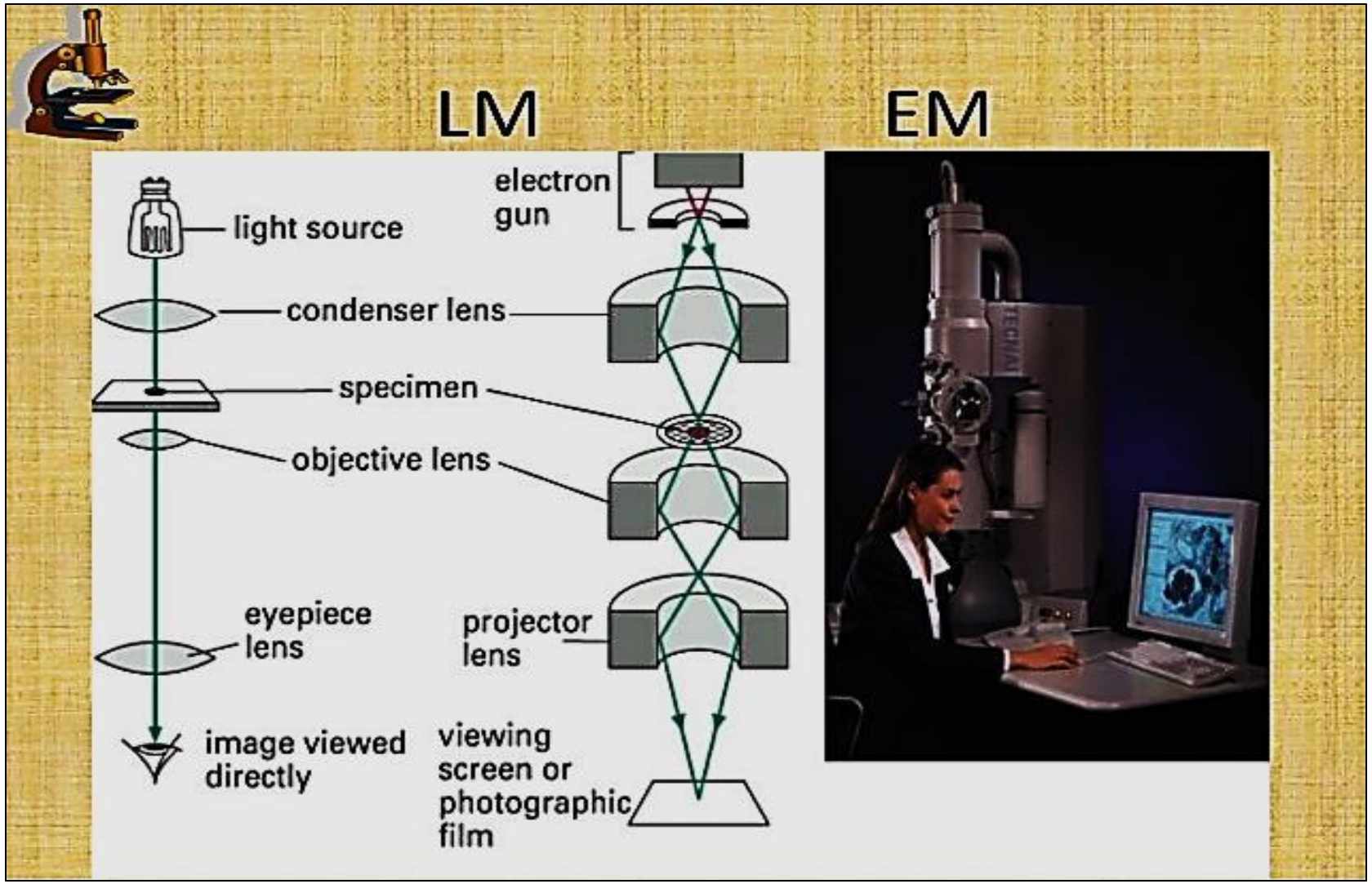
TEM



- **Scanning EM (SEM):** a special type of EM where electron beams are **reflected** from the surface of coated specimen, this gives **a three dimensional image of a specimen.**
- Resolution power: 10 nanometer

SEM



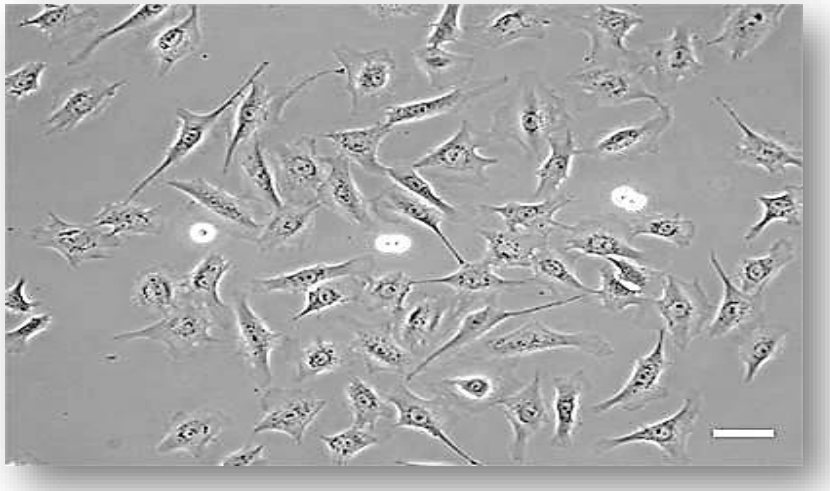

LM
EM
electron gun
light source
condenser lens
specimen
objective lens
eyepiece lens
projector lens
image viewed directly
viewing screen or photographic film

Archive MCQ

MEDEMIA ACADEMY

MCQS

1. **What type of microscopes is used?**
   a. Phase contrast microscope
   b. Differential interference microscope
   c. Fluorescence microscope



2. **All of the following are the four basic tissues except**:
   a. Nervous
   b. Connective
   c. Epithelial
   d. Lymphatic
   e. Muscula

MCQS

3. **Resolution power of healthy naked eye is:**
   a. 0.2 mm
   b. 2.0 mm
   c. 0.2 um
   d. 0.2 nm
4. **Choose the CORRECT statement regarding the cell:**
   a. The genophore is scattered in the cytoplasm of eukaryotes
   b. Eukaryotic cell has membranous cell organelles
   c. The genetic materials are in the nucleoid region of eukaryotes
   d. The prokaryotes replicate by mitosis
   e. Prokaryotic cell contains nuclear envelope

MCQS

5. **Responsible for high resolution in LM?**
   a. Condenser lens
   b. Coarse focus
   c. Objective lens
   d. Fine focus
6. **One millimeter equals?**
   a. 1000 micrometer
   b. 10 micrometer
   c. 100 micrometer
   d. 1 micrometer

MCQS

7. **In centrifugation, organelles are separated in which order?**
   a. Microsome, nucleus, mitochondria
   b. Microsome, mitochondria, nucleus
   c. Nucleus, microsome, mitochondria
   d. Mitochondria, microsome, nucleus
   e. Nucleus, mitochondria, microsome
8. **A structure made of two or more tissues that work together is called:**
   a. Organ
   b. Organelles
   c. Cells
   d. Organ system
   e. Organism

MCQS

9. The main purpose of using the microscope is:

a. Mounting
b. Resolution
c. Staining
d. Clearing
e. Fixation

10. The resolution power of light microscope equals:

a. 0.2 nanometer
b. 10 angstroms
c. 0.2 millimeter
d. 0.2 micrometer
e. 0.5 micrometer

MCQS

11. Which of the following statements best describes the extracellular matrix?

a. Provides an impermeable barrier between cells
b. Is a non-cellular component present within all tissues and organs
c. Always contain equal amounts of water, proteins, and electrolytes
d. Bone extracellular matrix is rubbery in consistency
e. It is physiologically inactive and only serves to separate the cells of tissues

12. If you want to examine a tissue composed of different types of cells. The cells to examine can be distinguished by external shape, size, and three-dimensional characteristics. Which would be the optimum method for your study?

a. Transmission electron microscopy
b. Light microscopy using living unstained samples
c. Light microscopy using the routine stains "Hematoxylin and Eosin"
d. Cell fractionation
e. Scanning electron microscopy

MCQS

13. Which microscope would be the best for viewing surface features of a cell?

a. Phase contrast microscopy
b. Transmission electron microscopy
c. Light microscopy
d. Scanning electron microscopy

ANSWERS

1. A
2. D
3. A
4. B
5. C
6. A
7. E
8. A
9. B
10. D
11. B
12. E
13. D