بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

HISTOLOGY

MID | Lecture 9

Connective Tissue Pt.1

وَلَقَدْ خَلَقْنَا الْإِنسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ ۖ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ

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Color coding used in the modified:

- *Black: the original slides*
- *Maroon: the doctor's explanation/words*
- *Gray: additional information and explanation*
- *Red: important information*

Connective Tissue

- Connective tissue is cells surrounded by extracellular matrix.

Extracellular matrix = fibers + ground substance.

- Connective tissue is the most abundant tissue in our bodies

Connective tissue could be :

- Connective tissue proper, a general connective tissue that has types but doesn't have names, found nearly everywhere in the body like in tendons, ligaments or under the epithelium tissue.
- Specialized connective tissue, like bones, cartilages, adipose and blood tissue.

General Features

- Connective tissue provides a matrix that supports and physically connects other tissues and cells together to form the organs of the body.

The connective tissue acts as a glue that binds and provides support to tissues and organs of the body.

- The interstitial fluid of connective tissue gives metabolic support to cells as the medium for diffusion of nutrients and waste products.

The interstitial fluid is located around the cells in the body, when the capillaries exchange the gases and nutrients with the cells and take wastes from the cells, it needs a medium fluid to diffuse the molecules, which is the interstitial fluid from the surrounding connective tissue of the capillaries .

EXTRA: Ground substance is the noncellular, gel-like part of the extracellular matrix that fills the space between cells and fibers in connective tissue, and it is mainly composed of glycosaminoglycans (such as hyaluronic acid), proteoglycans, and adhesive glycoproteins. Its main role is to provide structural support, resist compression, and act as a medium through which substances can pass between blood and cells. Interstitial fluid, on the other hand, is the tissue fluid that occupies the spaces within this ground substance and bathes the cells directly. It is mostly water with dissolved ions, nutrients, gases, waste products, and signaling molecules.

General Features

- Composed of cells (fixed and wandering), fibers and ground substance.

This means you might always see these cells and you might not depending on factors related to the connective tissue and the body (example: white blood cells) you might see these cells in large numbers or in small numbers .

- Variable vascularity.
  Some connective tissue types are vascular whereas other types (like cartilages) are avascular.
- Variable regenerative power.

(Not a general rule): usually vascular tissues have good regenerative power and vice versa (with some exceptions like epithelium (except glands) which are avascular but has a good regenerative power because there is a blood supply which the connective tissue helps to deliver it to the epithelium.)

- Usually tissues with limited blood supplies (avascular tissues USUALLY) tend to go to low metabolic rates, these cells are alive and do small amount of functions but it can't divide because cell division requires high metabolic rates. So if the cartilage is massively damaged then we can't regenerate a new cartilage because the cells can't divide into enough numbers to compensate the damaged or lost cells.

Functions

1. Structural framework for body. Example: skeleton, cartilages, ligaments
2. Transportation of fluids and dissolved substances. The blood is a special type of connective tissue that does this function
3. Protection of delicate organs.
   The capsules that cover that organs protect them, which is formed of dense irregular connective tissue
4. Supports, surrounds, and connects other tissues. Example: the connective tissue connects bones with muscles
5. Storage of energy in the form of lipids.

The adipose tissue (a type of connective tissue) does this role

6. Defend the body against microorganisms.
   White blood cells does this role

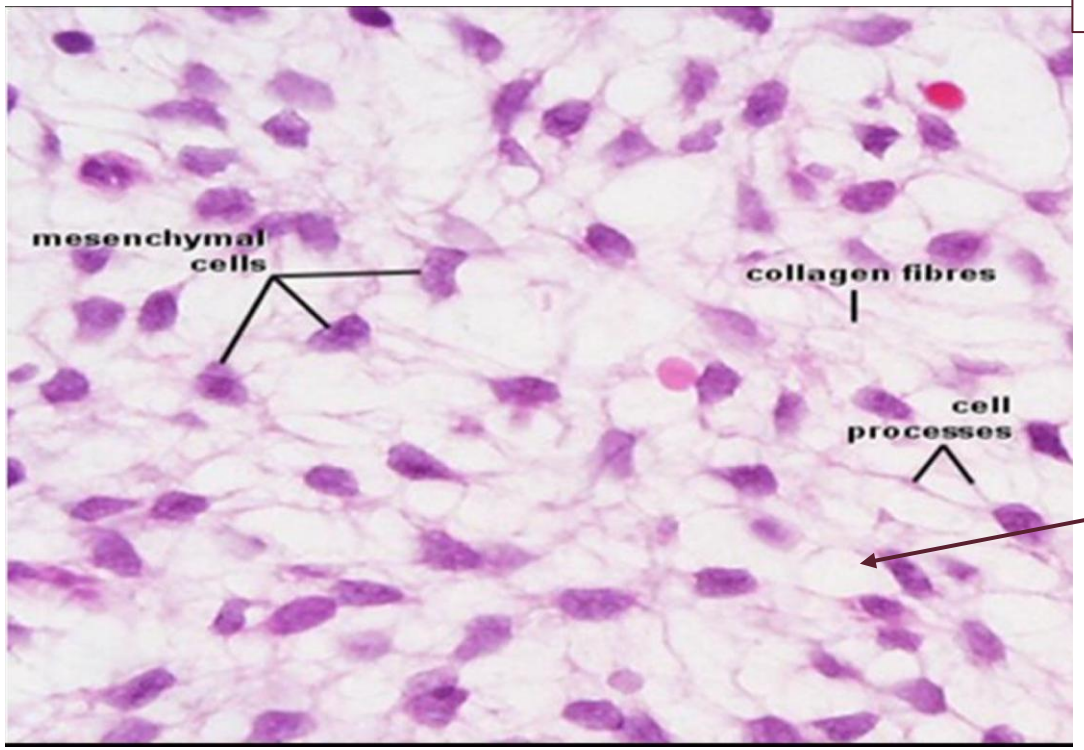
Origin

- All connective tissues originate from embryonic mesenchyme, a tissue developing mainly from the middle layer of the embryo, the mesoderm.
- Mesenchyme consists of viscous ground substance with few collagen fibers.
- Mesenchymal cells are undifferentiated and have large nuclei, with prominent nucleoli and fine chromatin.

Mesenchymal cells are undifferentiated because it will generate (when it differentiates) massive types and amounts of cells, most importantly:
1. the fibroblast (general connective tissue type), it's found in a lot of places like in the dermis under the skin or capsules.
2.osteoblast, young and active bone- forming tissue.
3. chondroblasts, young and active cartilage-forming tissue.

Origin

These cells are euchromatic (active cells), the genetic material is quite dispersed so it has access to all the genetic materials and makes copies of them, unlike heterochromatic cells which are inactive (low metabolic rate)



This tissue has a small amount of collagen around the cells and a big amount of ground substance (most importantly hyaluronic acid)

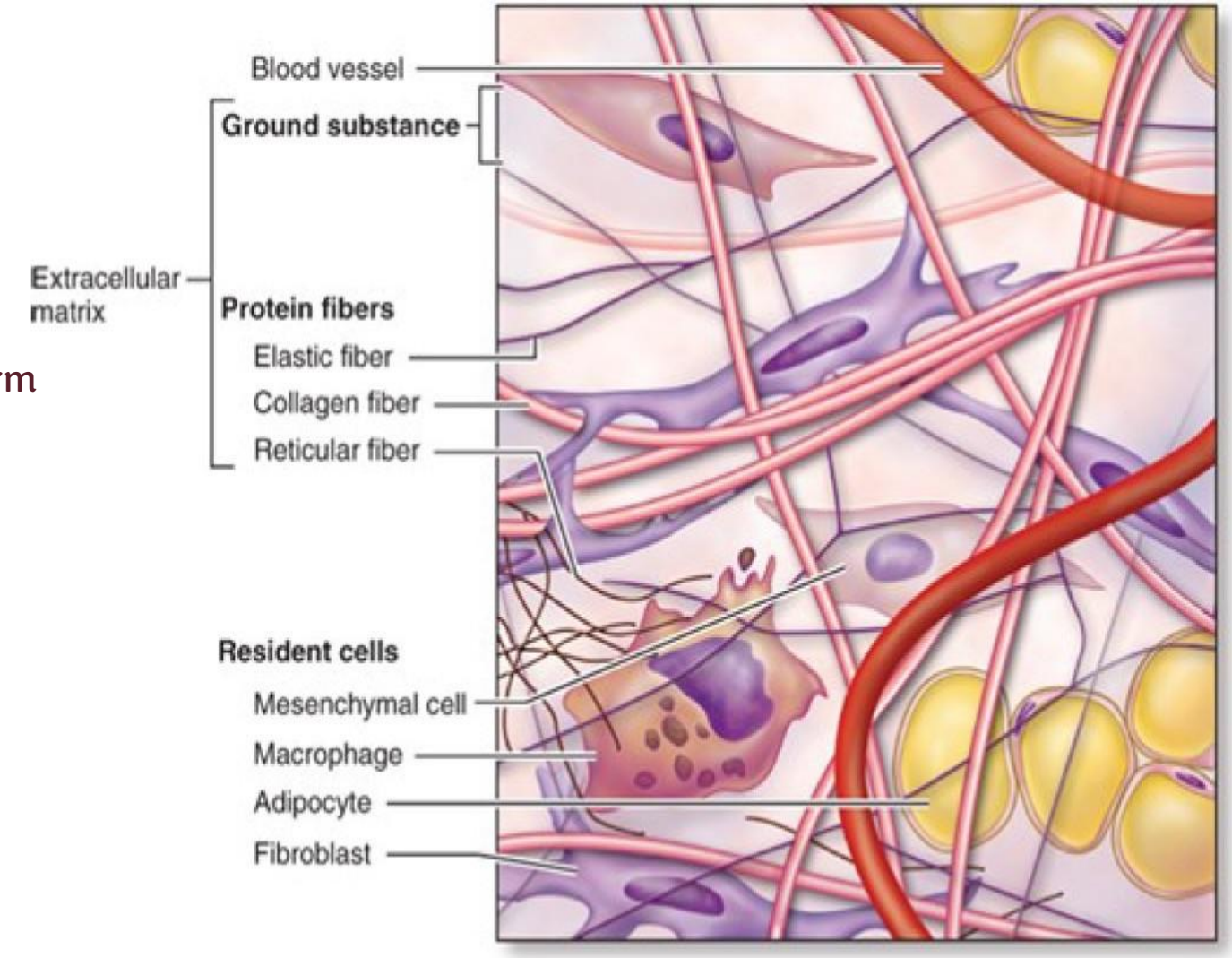
The white-ish part is the ground substance

- Mesenchyme tissue (embryonic connective tissue) stained with H&E under the bright-field light microscope.
- it looks like cells quite dispersed from each other and surrounded by matrix.

Components

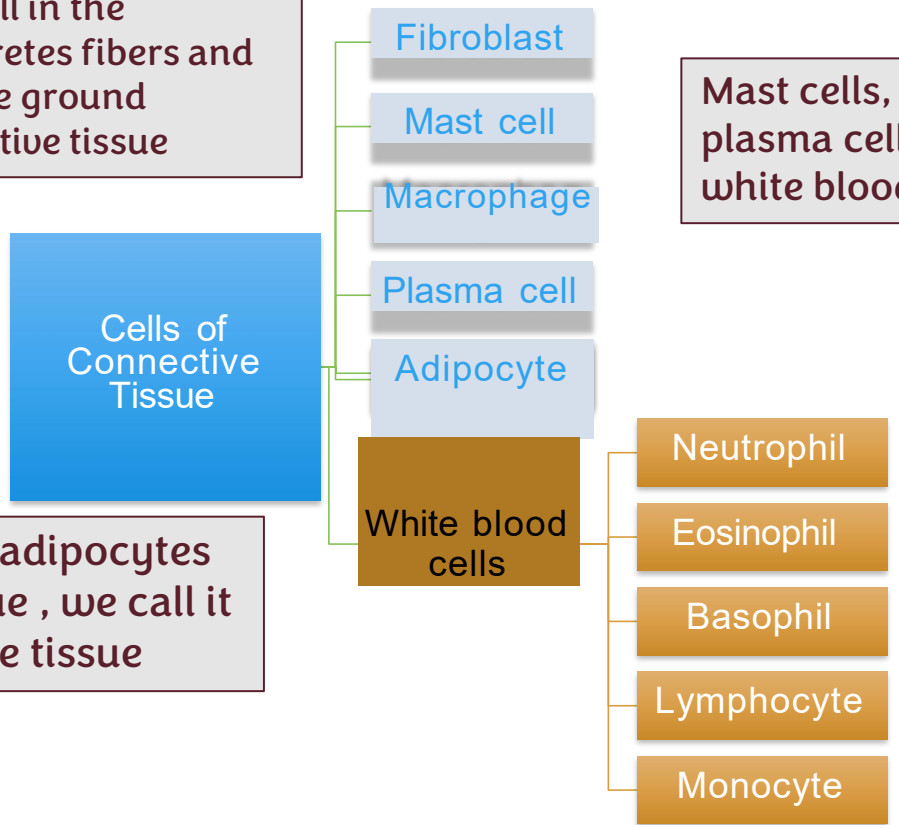
- Cells — They are versatile (different cells form together the connective tissue)
- Fibers
- Ground substance

The differences between the extracellular matrix (fibers and ground substance) give us different types of connective tissue.



Components-cells

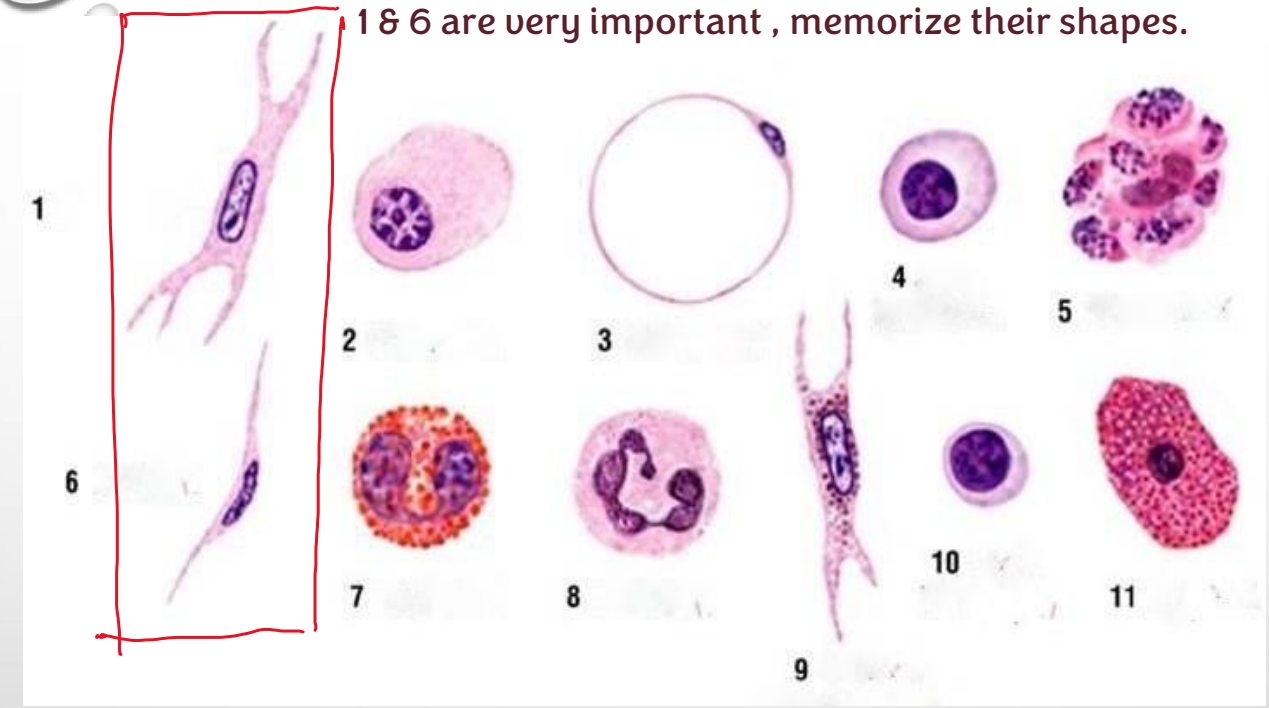
Fibroblast is the main cell in the connective tissue, it secretes fibers and substances related to the ground substance in the connective tissue



Mast cells, macrophages , plasma cells are considered as white blood cells.

If we have a lot of adipocytes in connective tissue , we call it adipose connective tissue

1 & 6 are very important , memorize their shapes.



adipocyte (3), the hole in the center isn't lumen, but there was a fat vacuole in the center and during tissue processing the fat will be dissolved so it looks empty .

Plasma cells (2), WBCs that synthesise antibodies

1. **Fibroblast** 2. Plasma cell 3. Adipocyte 4. large lymphocyte
5. Macrophage 6. Fibrocyte 7. Eosinophil 8. Neutrophil
9. Cell with pigment granules 10. Small lymphocyte
11. Mast cell

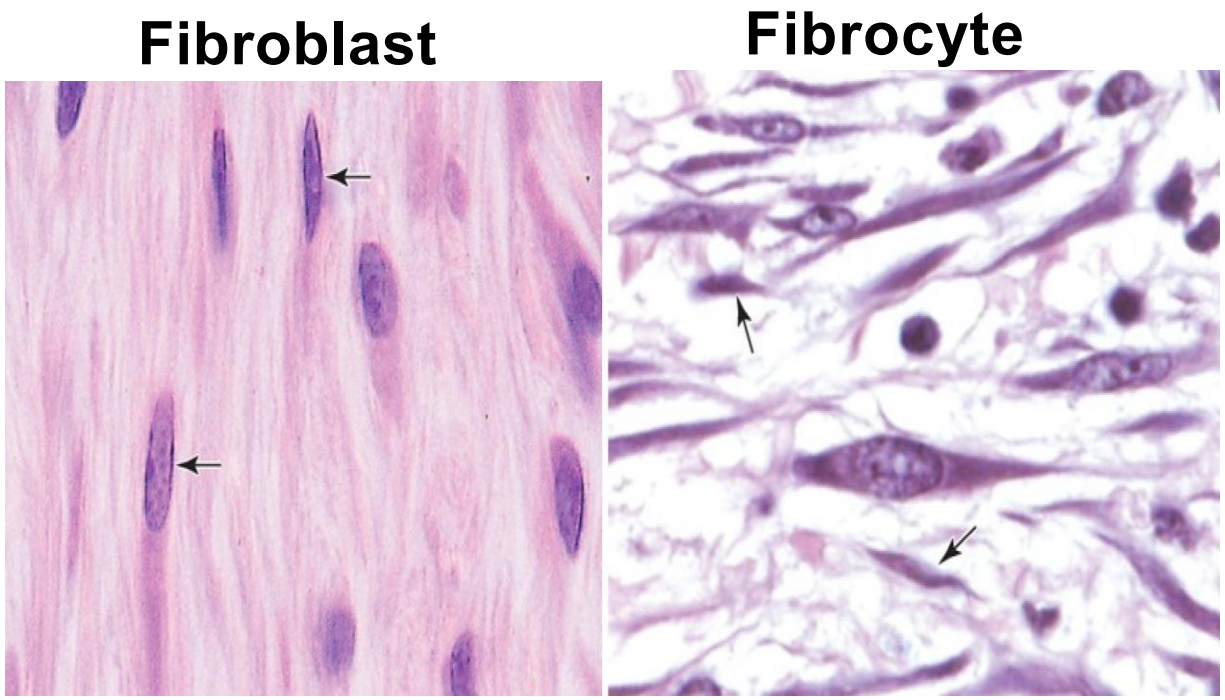
- Blasts = active and young cells
- Cytes = inactive, dormant or quiescent cells, these cells are alive but their metabolic rates are low, when they are poked (activated) they come back to the active form. An example of activation is when you have a cut in your skin (dermis) , the fibrocytes will be activated and they will become fibroblasts

Connective tissue cells

Cell Type	Major Product or Activity
Fibroblasts (fibrocytes)	Extracellular fibers and ground substance
Plasma cells	Antibodies • It originates from B-lymphocytes • Plasma cells are rich in RER and Golgi apparatus
Lymphocytes (several types)	Various immune/defense functions
Eosinophilic leukocytes	Modulate allergic/vasoactive reactions and defense against parasites These are quite unique because the are related to specific types of infections
Neutrophilic leukocytes	Phagocytosis of bacteria One of the first line defenders of the body
Macrophages	Phagocytosis of ECM components and debris; antigen processing and presentation to immune cells; secretion of growth factors, cytokines, and other agents
Mast cells and basophilic leukocytes	Pharmacologically active molecules (eg, histamine)
Adipocytes	Storage of neutral fats

Fibroblast

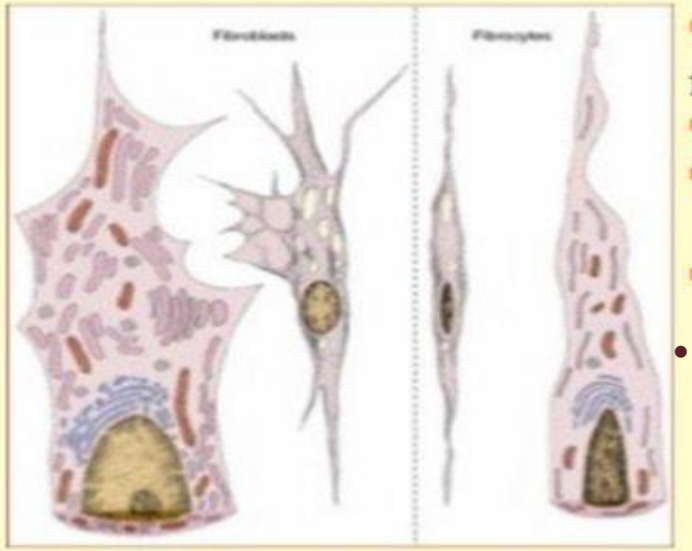
- The most common cells in connective tissue proper
- Produce and maintain most of the tissue's extracellular components (fibers+ground substance).
- Most of the secreted ECM components undergo further modification outside the cell before assembling as a matrix.



Fibroblasts _ Fibrocytes

✓ Fibroblasts

- the most common cells in connective tissue
- cells responsible for the synthesis of extracelullar matrix components
- an abundant and irregularly branched cytoplasm
- ovoid, large and pale staining nucleus with nucleolus
- rich in RER and well developed Golgi complex
- produce the growth factors → influence growth and cells differentiation
- proliferate when the additional fibroblasts are required



✓ Fibrocytes

- smaller than fibroblasts
- fewer processes
- smaller, darker, elongated nucleus
- small amount of RER

Two stages of activity

The active cells → Fibroblasts

The quiescent cells → Fibrocytes

- The nucleus of the fibrocyte is heterochromatic
- The nucleus for the fibroblasts are euchromatic

Connective Tissue Cells-Macrophage

Blood is synthesized in the bone marrow in our bodies, if a monocyte cell (WBC) left the blood vessels then it becomes a macrophage.

- Macrophages have highly developed phagocytic ability and specialize in turnover of protein fibers and removal of apoptotic cells, tissue debris, or other particulate material
- Being especially abundant at sites of inflammation.
- Size and shape vary considerably, corresponding to their state of functional activity.
- A typical macrophage measures between 10 and 30 µm in diameter and has an eccentrically located, oval or kidney- shaped nucleus.
- They generally have well-developed Golgi complexes and many lysosomes.

- **Macrophages wander between the different elements in the connective tissue so they're able to catch the invaders.**

Connective Tissue Cells-Macrophage

- Monocytes are a bit smaller than macrophages, it has a kidney shaped nucleus and it's rounded all around but once the monocytes transform into macrophages some changes happen like:

1. The cell and nucleus increase in size.
2. The amount of the cytoplasm increases, which means it will have more organelles in the macrophages like Golgi complexes, RER, mitochondria and lysosomes.

- Macrophages perform phagocytosis (A process where the cell "swallows" foreign substances by creating phagocytes and rounding the foreign substances with a vacuole, then the lysosomes fuse with the vacuole and release lysozymes which breakdowns the substance.)

- Macrophages also perform Antigen presentation (A process where the macrophage presents an antigen (from a foreign substance) to the other immune cells in the body to notify the immune system of a foreign substance. It happens by placing the antigens on the macrophages surface, then the other WBCs will recognize that there was an invader in the body). This process is very important and it's considered one of the first steps for the initiation, optimization and completion of the immune reaction.

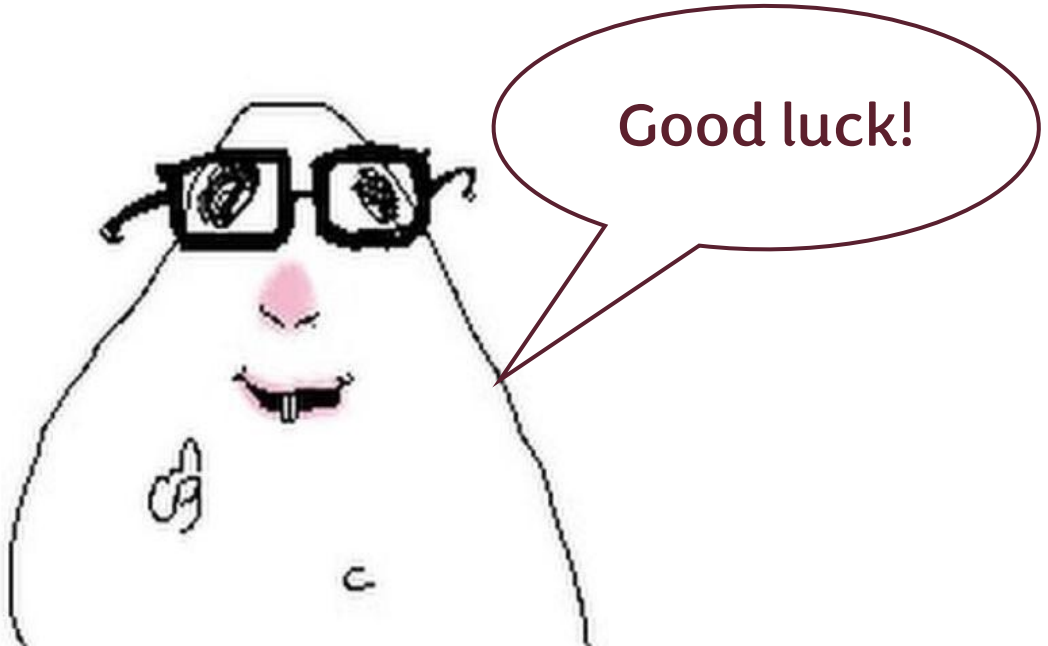
Mononuclear Phagocyte System

Cell Type	Major Location	Main Function
Monocyte	Blood	Precursor of macrophages
Macrophage	Connective tissue, lymphoid organs, lungs, bone marrow, pleural and peritoneal cavities	Production of cytokines, chemotactic factors, and several other molecules that participate in inflammation (defense), antigen processing, and presentation
Kupffer cell	Liver (perisinusoidal)	Same as macrophages
Microglial cell	Central nervous system	Same as macrophages
Langerhans cell	Epidermis of skin	Antigen processing and presentation
Dendritic cell	Lymph nodes, spleen	Antigen processing and presentation
Osteoclast (from fusion of several macrophages)	Bone	Localized digestion of bone matrix
Multinuclear giant cell (several fused macrophages)	In connective tissue under various pathological conditions	Segregation and digestion of foreign bodies

The osteoclast is the only cell type that doesn't have an immune function. It functions in breaking bone matrix, releasing calcium and other minerals, And it maintains and the calcium amounts in the bones and body.

Test yourself with this quiz:

https://forms.gle/P2hGXy191kmnw3si8



Additional Resources:

رسالة من الفريق العلمي:

وَقُل رَّبِّ زِدْنِي عِلْمًا (114)

سورة طه - آية 114

اللهم ثبتنا على دينك و حسن عبادتك، وثبتنا على طريق العلم وعلمنا ما ينفعنا في الدنيا والآخرة.

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Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			