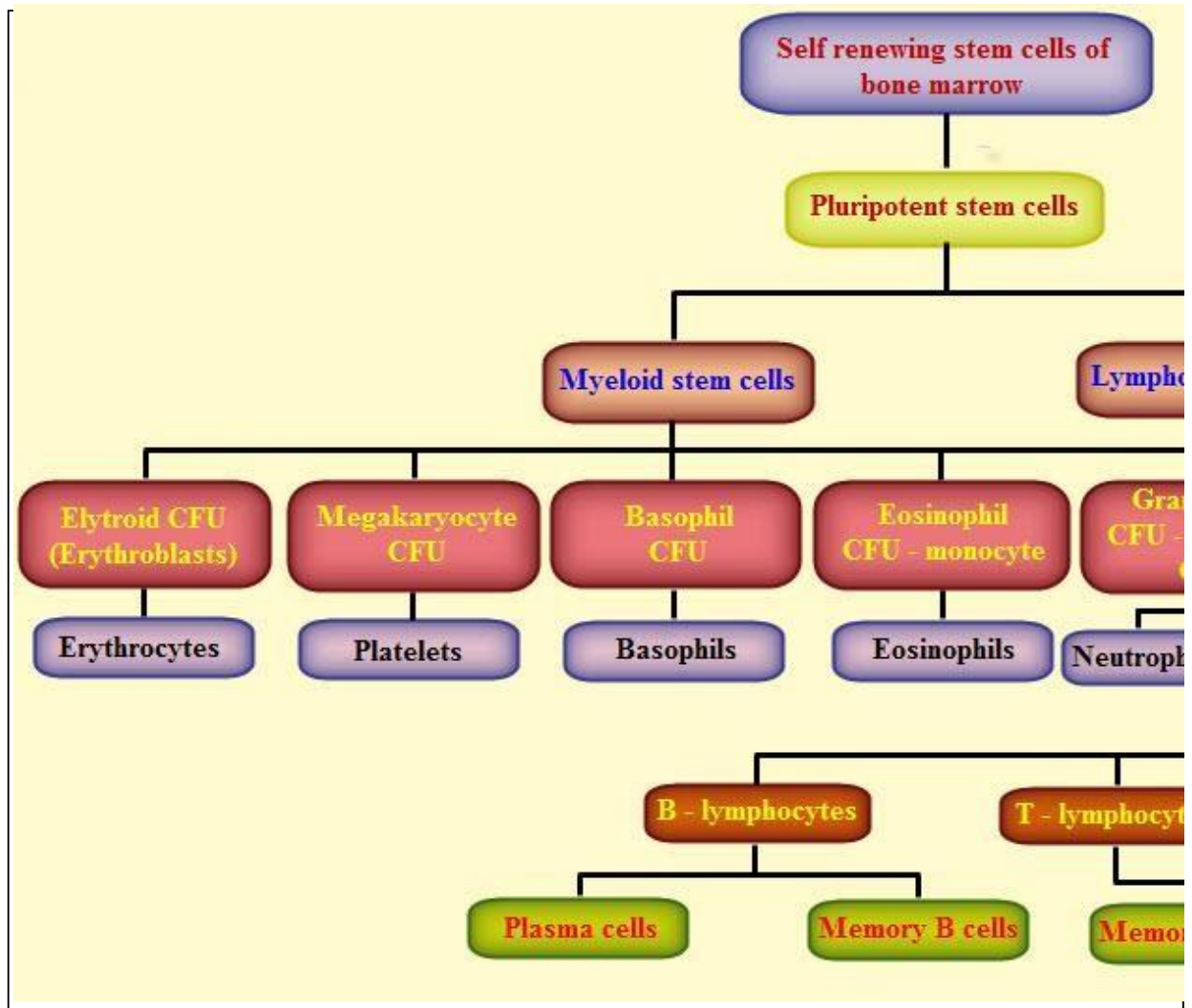


CELLS OF IMMUNE SYSTEM

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CELLS OF IMMUNE SYSTEM

- The cells of immune system are normally present as circulating cells in the blood and lymph, as anatomically defined collections in lymphoid organs and a scattered cell in almost all tissues.
- Stem cells are undifferentiated cells that divide continuously and give rise to additional stem cells and to cells of multiple different lineages of hematopoietic system.
- Origins of cells of hematopoietic and immune systems are as below



CELLS OF NON-SPECIFIC IMMUNE SYSTEM

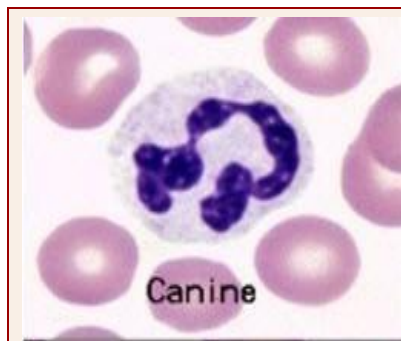
(Myeloid lineage)

- Non-specific immune response is the first line of defense to remove the infection.
- When a microorganism enters the body, it is trapped and destroyed by phagocytes.
- Phagocytes belong to two complementary system: neutrophils and macrophages.

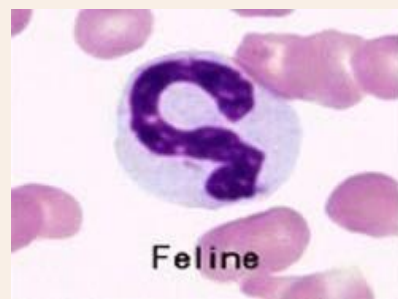
NEUTROPHILS

- Neutrophils are considered as the first line of defense against pathogenic microorganisms and called as martyrs of immune system.
- Neutrophils are attracted to the site of invasion by chemotactic signals and they engulf and kill the invading organisms.
- About 5-6 hours later macrophages are attracted to the site of infection.
- Neutrophils are the major cell type of myeloid system.
- They originate from bone marrow and their development in bone marrow takes about two weeks time.
- During their development (stem cells to myelocytes), they acquire cytoplasmic granules hence they are called polymorphonuclear (PMN) leucocytes.
- Mature neutrophils circulate in the blood for a short period of 10-12 hours later move in tissues.
- Total life span is only a few days.
- Neutrophils do not have capacity to multiply or replicate.
- In blood, neutrophils are about 12 μm in diameter, nucleus is segmented and cytoplasm contains many granules.
- When viewed under electron microscope, two types of granules are there.

Neutrophils of different species



Segmented neutrophils have an irregularly lobed nucleus without the true filaments connecting the lobes.



Segmented neutrophils similar to those of canine, having an irregular nucleus with a thin membrane with only occasional cells having distinct filament formation.

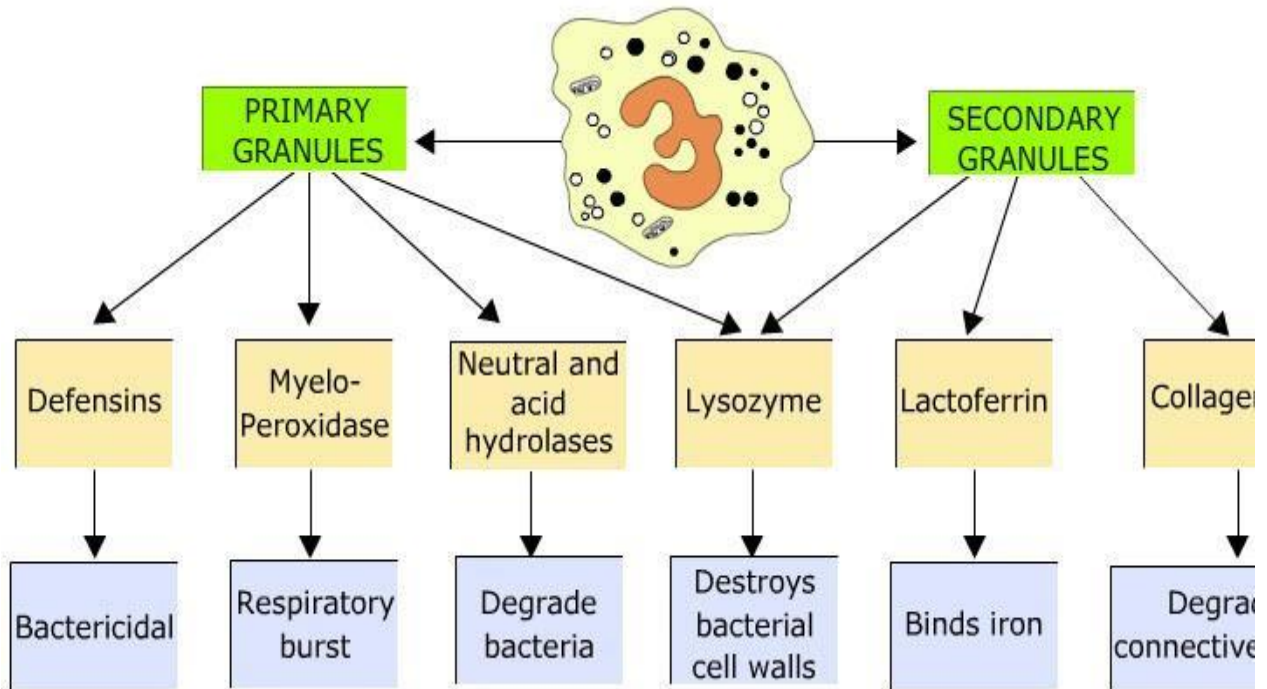


Neutrophils of mature type having filaments connecting the lobes, although segmented neutrophils are identified only by an indentation of nucleus.

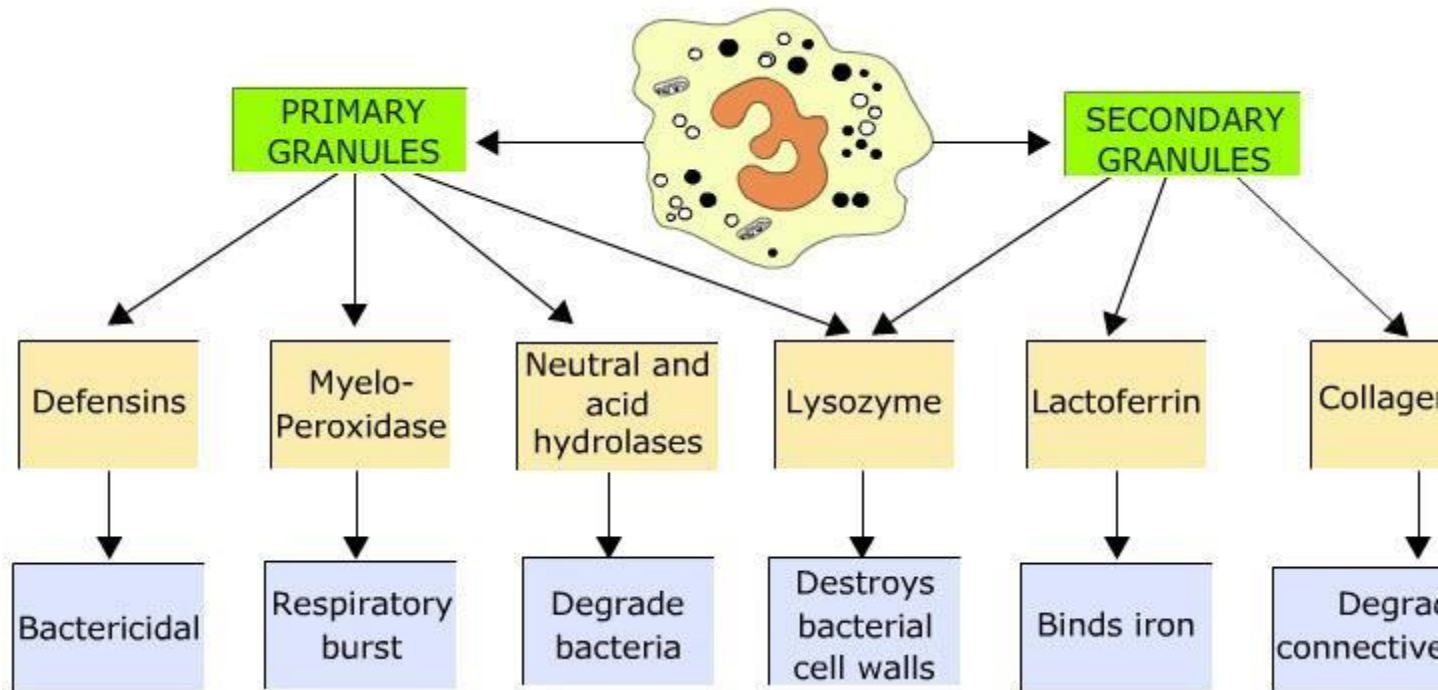


Segmented neutrophils, nuclear chromatin arrangements characterized of dark staining plaques that make the nucleus appear almost granular.

- **Primary granules (azurophilic granules)** - contain defensins and bactericidal enzymes such as myeloperoxidase and lysozyme; neutral proteases such as elastase; acid hydrolases such as β -glucuronidase and cathepsin B.
- **Secondary granules (specific granules)** - contain lysozyme, collagenase and lactoferrin (iron binding protein), gelatinase etc.
- Neutrophils also contain a small Golgi apparatus, some mitochondria and very few ribosome or rough endoplasmic reticulum. Because of this they can not synthesize large amount of proteins. Neutrophils constitute 60-75% of blood leucocytes in carnivores; 20-30% in ruminants and 50% in horse.



FUNCTION OF NEUTROPHILS



[Click here...](#)

Function

- They move to the site of infection (during inflammation).
- Phagocytosis.
- The contents of primary granules perform many functions like,
 - defensins kill gram-positive bacteria;
 - myeloperoxidase cause respiratory burst;
 - neutral and acid hydrolyses degrade bacterial products;
 - lysozyme destroy bacterial cell wall.
- The contents of secondary granules lysozyme (both from primary and secondary granules) destroy bacterial cell walls, lactoferrin binds iron and collagenase degrades connective tissue.
- Neutrophil destroy all ingested foreign materials and they cannot process antigen for presentation to antigen sensitive cells.

MACROPHAGES

- Immature macrophages are produced in the bone marrow and released into blood stream as monocytes.
- Monocytes constitute about 5% of total blood leukocytes.
- After circulating for several days they migrate into tissues and mature into macrophages.
- Macrophages rarely divide and are not destroyed by radiation.
- They have life of 3-4 months but influenced by antigenic stimulation.
- In suspension, they are round cells of 15-20µm in diameter with a bean shaped or round single nucleus.
- Cytoplasm is rich in mitochondria, lysosomes, rough endoplasmic reticulum and Golgi apparatus.
- Because of their various habitats they are of various shape and sizes.

- They differentiated into microglia (CNS), kupffer cells (liver), alveolar macrophages (lung), osteoclasts (bone), splenic macrophages, peritoneal macrophages, dendritic cells in lymphoid organs, Langerhans cells in skin and mesangial cells in kidneys etc.





Functions

- Destroy foreign particles (phagocytosis).
- Process antigen for the immune response.
- Secrete several biologically reactive molecules.
- Regulate immune response.
- Antitumor activity.
- Helps in wound healing.
- **Phagocytosis:**
 - Phagocytosis is the process of engulfment of a foreign particle. Macrophages act as phagocytes.
- **Macrophages as secretory cells:**
 - Macrophages secrete several bio reactive molecules (over 100 products have been identified).
 - Some important factors released by macrophages include:
 - **Enzymes:** Lysozyme, collagenase, proteases, and elastases.
 - **Immune mediators:** Interleukin-1, interferon- α and complement components.
 - **Inflammatory mediators:** Prostaglandins, thromboplastins, plasminogen activators etc.
- **Regulate immune response:**
 - Macrophages regulate immune response mainly in three different ways
 - They present antigen to lymphocytes in correct fashion. Lymphocytes recognize antigen when it is correctly presented.
 - Macrophages regulate the doses of antigen presented to lymphocytes.
 - Macrophages also secrete monokines and that also regulates immune response.
- **Antitumor activity:**
 - Activated macrophages possess increased tumoricidal activity. Secrete tumor necrosis factor (TNF α), hydrolytic enzymes, hydrogen peroxide, super oxide, singlet oxygen, hydroxyl radicals and interleukin-I which are toxic to tumor cells and microbes.
- **Tissue reorganization and Wound healing:**
 - Macrophages secrete proteases that breakdown connective tissue.
 - Once the damaged tissue is removed, macrophages secrete growth factors for fibroblast and stimulate them to secrete collagen.
 - They also secrete molecules that promote the growth of new blood vessels.

EOSINOPHILS

- The second major polymorphonuclear granulocyte and it is named so because its cytoplasmic granules stain intensely with eosin.
- Eosinophils originate from bone marrow and leave bone marrow in a relatively immature state to spleen where they mature.
- Life span is short.
- In blood circulation half life is about 30 minutes then enter into tissues where they have half life of about 12 days.
- Tissue Eosinophils are about 500 times more than as observed in blood.
- Eosinophils are slightly larger than neutrophil with bilobed nucleus.

Eosinophils of different species

 <p>Canine</p>	<p>Eosinophils contain pink cytoplasmic granules of variable size</p>
 <p>Feline</p>	<p>Rod shaped granules, partially cover the nucleus.</p>
 <p>Bovine</p>	<p>Eosinophils are characterized by small, round eosinophilic granules in the cytoplasm.</p>
 <p>Equine</p>	<p>Large round irregular sized orange red stained granules. (Pomegranate seeds like).</p>

- Cytoplasm contains two major types of granules
 - Primary granules - contain arylsulfatase, peroxidase and acid phosphatase
 - Crystalloid granules- have a core of major basic protein surrounded by a matrix containing eosinophil cationic protein, eosinophil peroxidase and eosinophil-derived neurotoxin.

Function

- Although eosinophils can phagocytose small particles, but they are more suited for the extracellular killing of parasites by the process of antibody dependent cellular cytotoxicity (ADCC).
- Since it contains Fc receptors specific for Ig E, it can kill IgE coated parasites especially helminths by the process of ADCC. Helminths are relatively resistant to lysosomal enzymes of neutrophils and

macrophages. Eosinophils release major basic protein and cationic protein which are toxic to the parasites.

- They participate in type I– hypersensitivity reaction mediated by IgE antibody and cause tissue damage.

BASOPHILS AND MAST CELLS

Basophils

- Derived from bone marrow and have many of the same properties as tissue mast cells. It is the smallest of the granulocytes.
- Like mast cells, they bear Fc receptors for IgE and contain histamine rich cytoplasmic granules.
- They are not normally seen in the extra vascular tissues, but may infiltrate tissues under the influence of lymphocytes.

Mast cells

- Bone marrow derived, resident cells essential for IgE mediated inflammatory reactions. Cytoplasm is densely packed with granules.
- Granules have large amounts of histamine, heparin, TNF- α and other inflammatory mediators.
- Also contain enzymes like super oxide dismutase, peroxidase and acid hydrolases.
- Mast cells are scattered in connective tissues in large numbers beneath skin, lung alveoli, gastrointestinal mucosa and nasal mucous membranes.