Bone Marrow

By dr. Ratna Fitri Rahayuningsih

Hemopoeisis Phase

- Prenatal
  - Mesoblastic phase
    - Started at 2 weeks after conseption
    - Yolk Sac
  - Hepatic Phase
    - Started at 6 weeks gestation
    - liver
  - Splenic Phase
    - Started during second trimester
    - Lien

Hemopoeisis Phase

- Prenatal
  - Myeloid phase
    - Started at the end of second trimester (7th month)
    - **After birth becomes primary phase**
    - Bone marrow

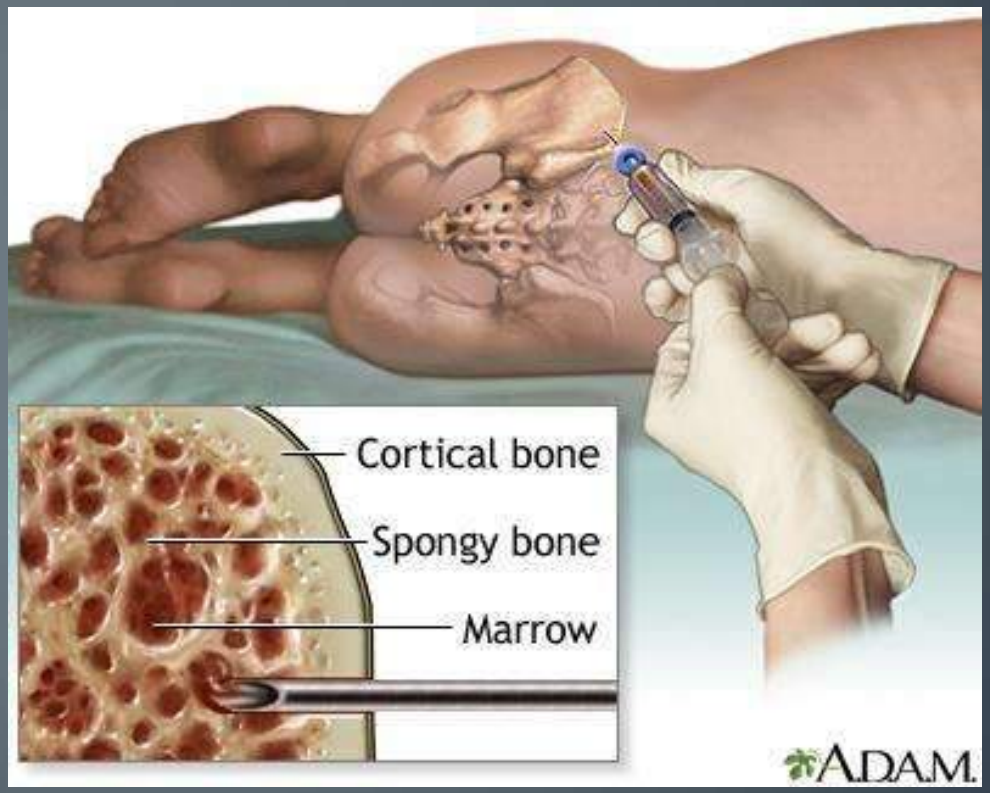
- Note :

  liver and lien helps hematopoeisis in abnormal cases

Types of Bones for Hematopoeisis

- 1. Long Bone
  - Femur, etc
- 2. Cancellous Bone
  - Vertebra, etc

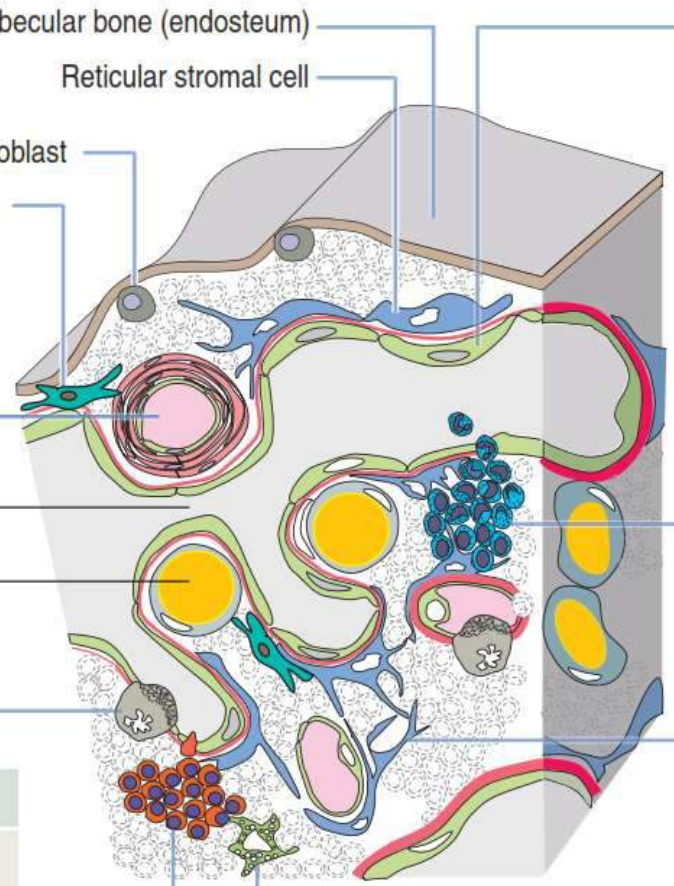
Bone Marrow Puncture



Histological Structure

- Bone:
  - Osteoblast
  - Osteoclast
- Bone Marrow
- Stroma
  - Reticular Stromal Cells: pericytes, MSCs, ARC
- 2. Hematopoeitic cords
  - Contains hematopoeitic cells
- 3. Sinusoid capillaries
  - Very thin walled lined by endothel
- 4. Arteries
  - To nourish the stromal life

Bone Marrow Structure



Endothelial cell

Endothelial cells form a continuous layer of interconnected cells lining the blood vessels. A **basal lamina** separates the endothelial cells from the stromal cells.

Nutrient arteriole

A branch of the nutrient artery is surrounded by hematopoietic cells.

Myeloid progeny

Developing granulocytes are found adjacent to venous sinusoids. Mature granulocytes leave the bone marrow by **diapedesis**.

Reticular stromal cell

Branching reticular stromal cells form a cellular network under the endothelial lining and extend into the hematopoietic tissue. Reticular stromal cells produce **hematopoietic short-range regulatory molecules** induced by colony-stimulating factors.

Megakaryocyte

A megakaryocyte lies against the outside of a venous sinusoid and discharges **proplatelets** into the lumen through an epithelial cell gap.

Macrophage

A macrophage, found near an erythroid progeny, will engulf nuclei extruded from **orthochromatic erythroblasts** before their conversion to **reticulocytes**.

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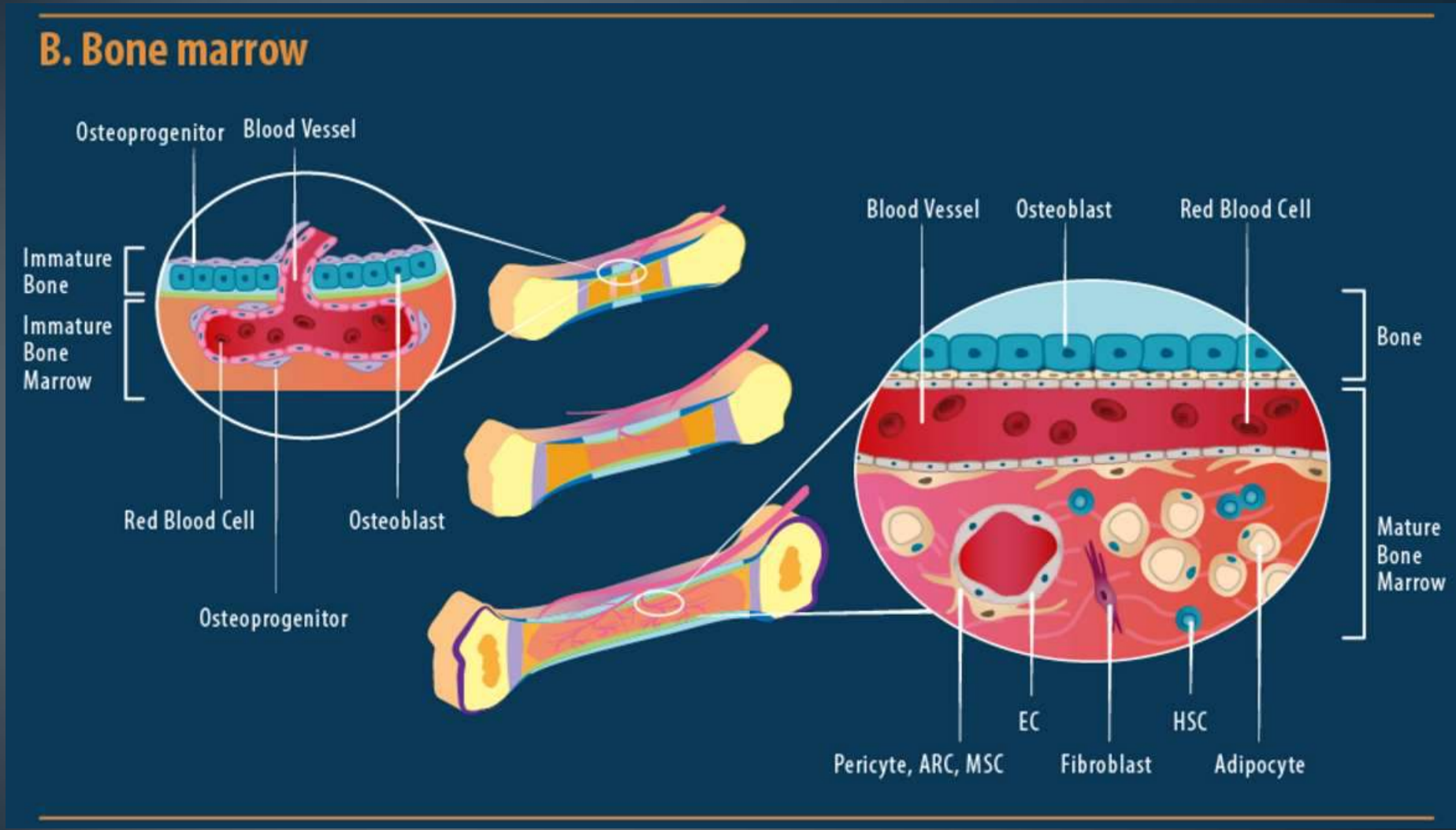
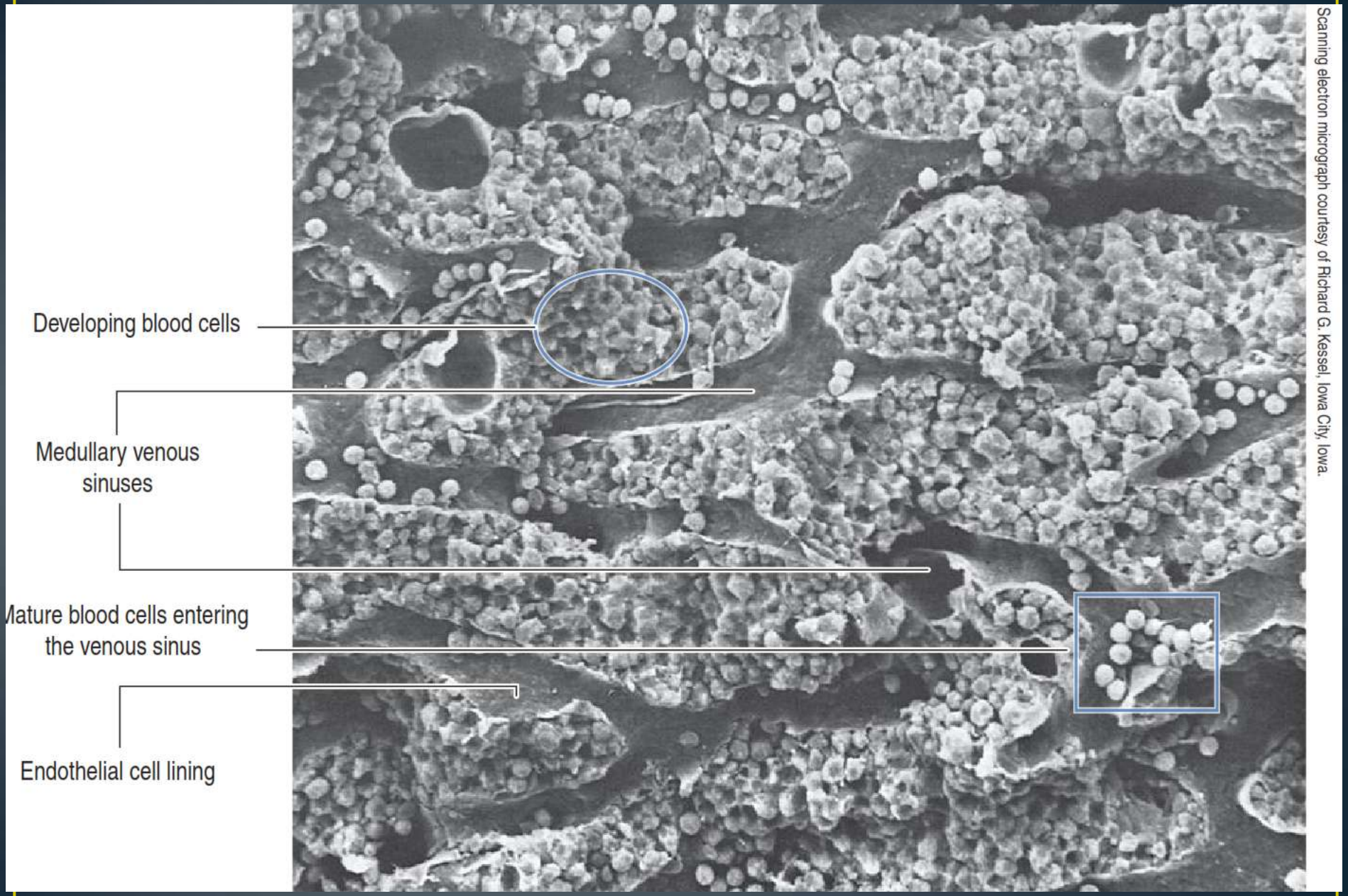
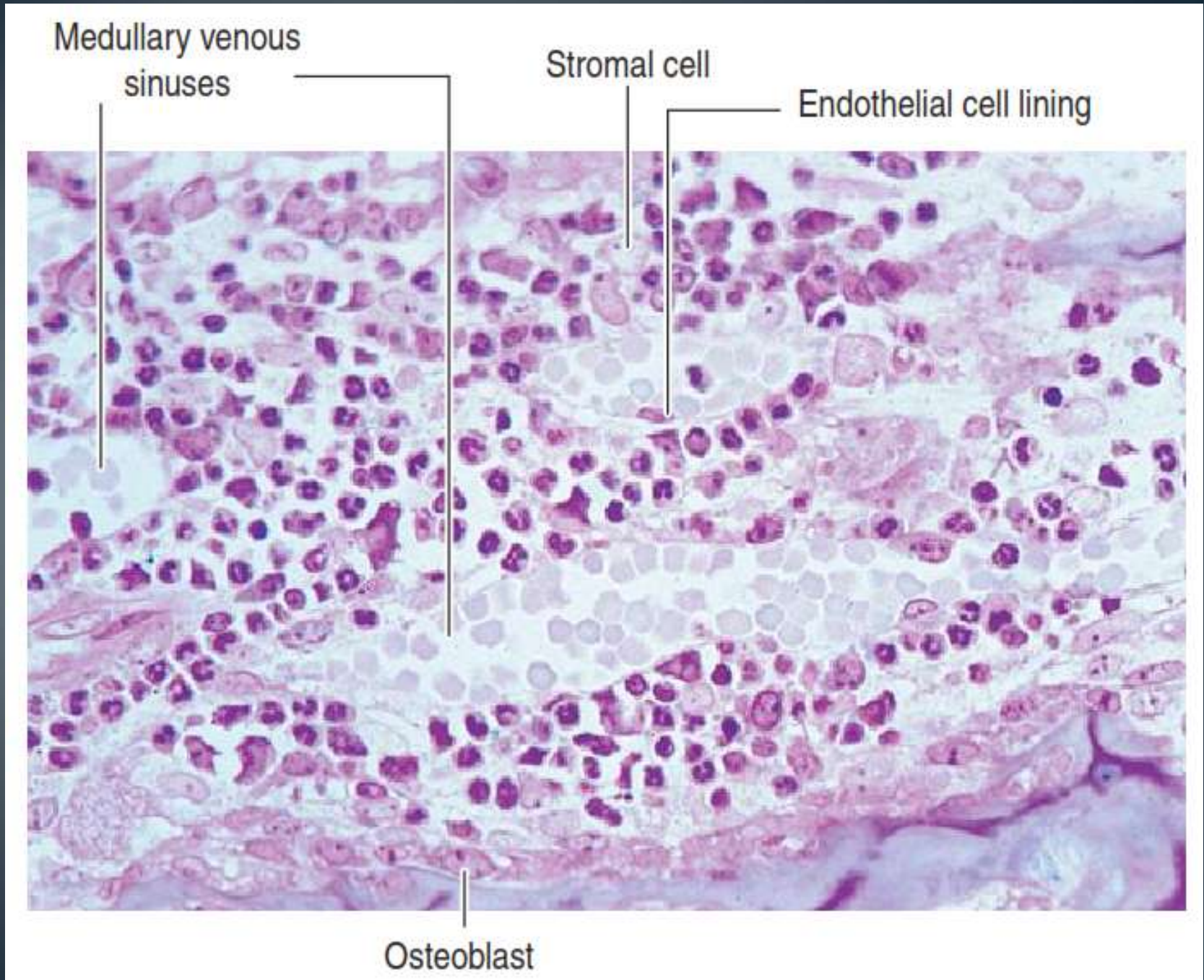
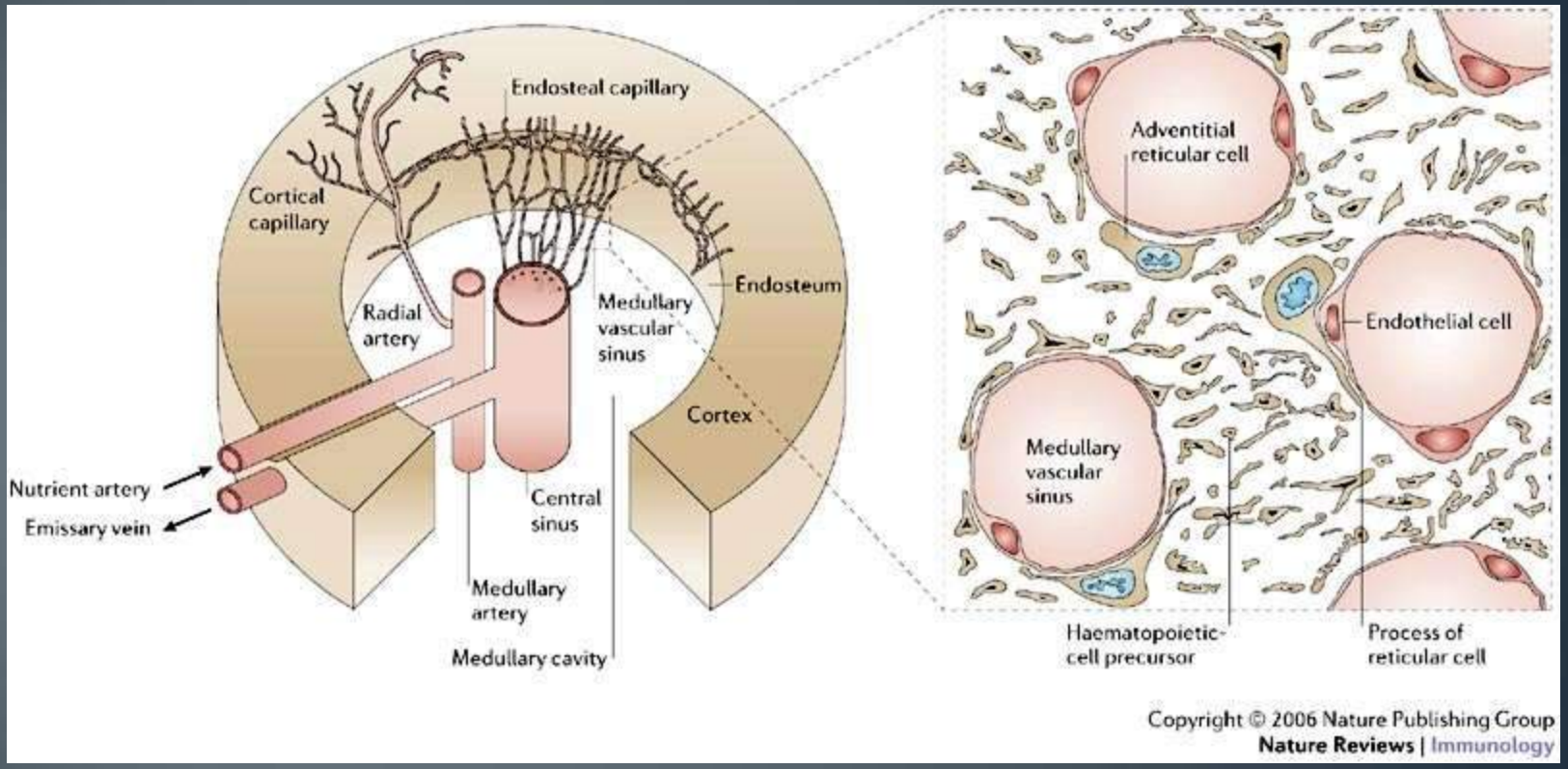


http://discovery.lifemapsc.com/in-vivo-development/bone/bone-marrow/adventitial-reticular-cells#panel_Image



Scanning electron micrograph courtesy of Richard G. Kessel, Iowa City, Iowa.


Medullary venous sinuses
Stromal cell
Endothelial cell lining
Osteoblast



Nagasawa *Nature Reviews Immunology* **6**, 107–116 (February 2006) | doi:10.1038/nri1780

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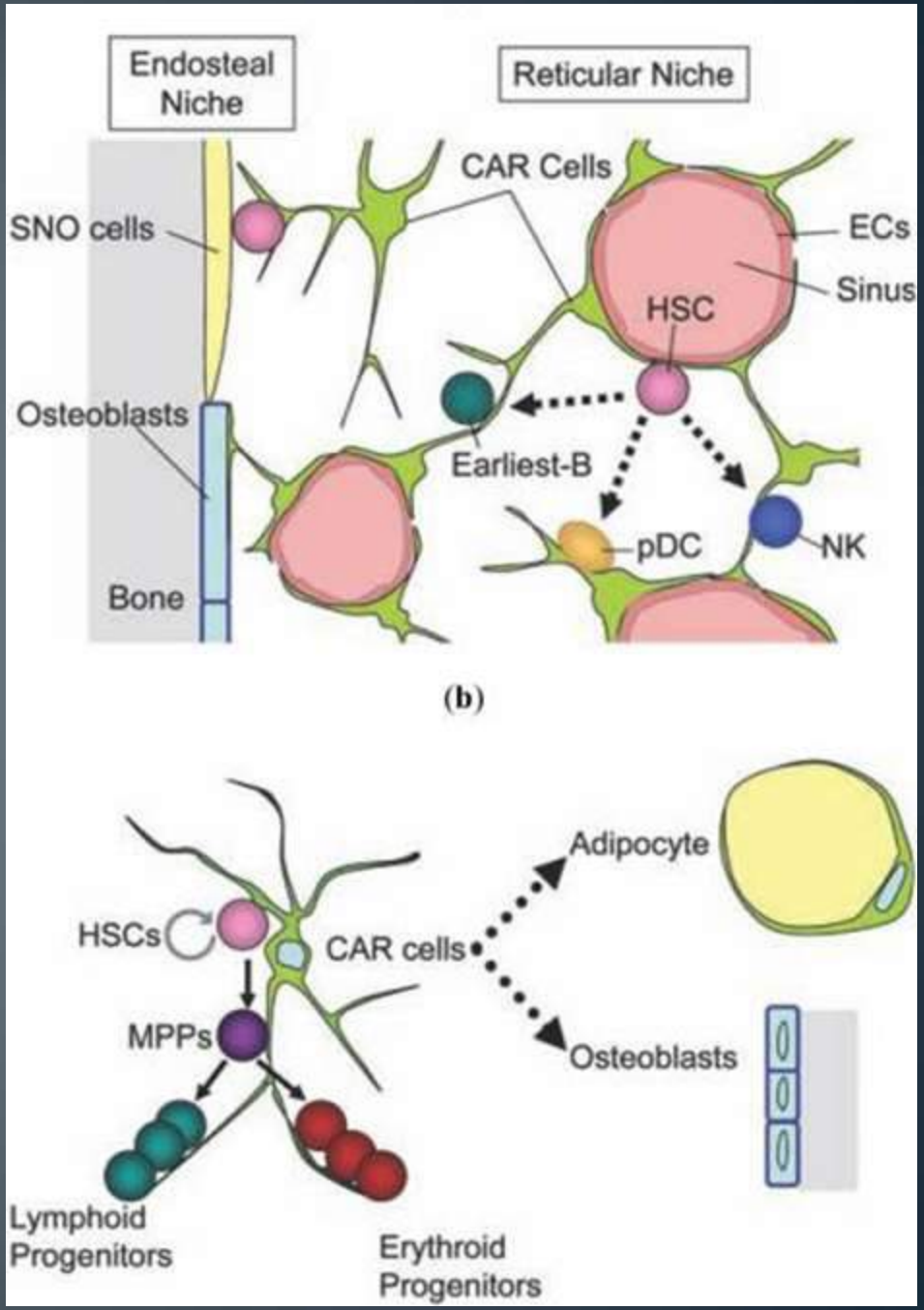
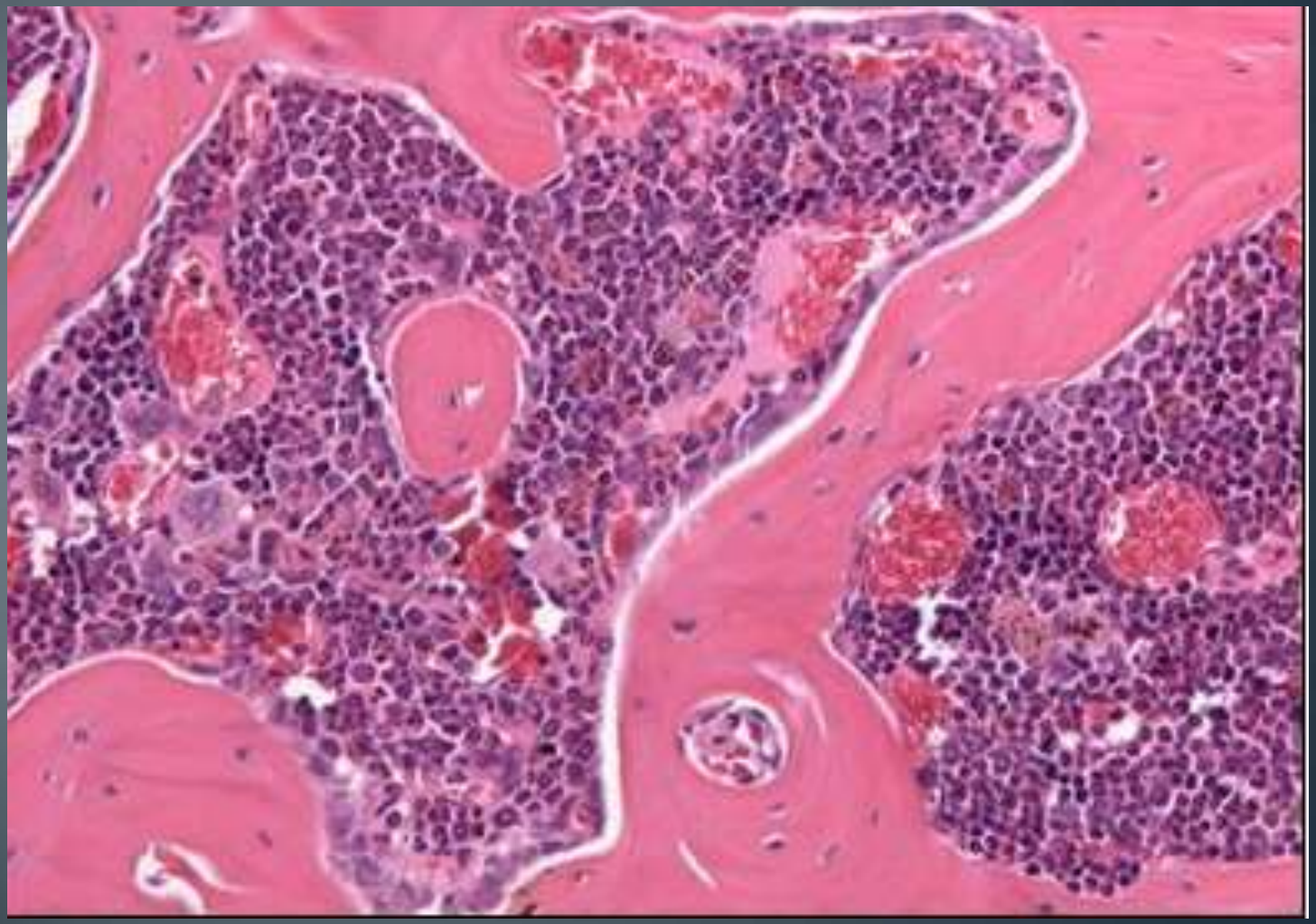
BONE MARROW NICHE



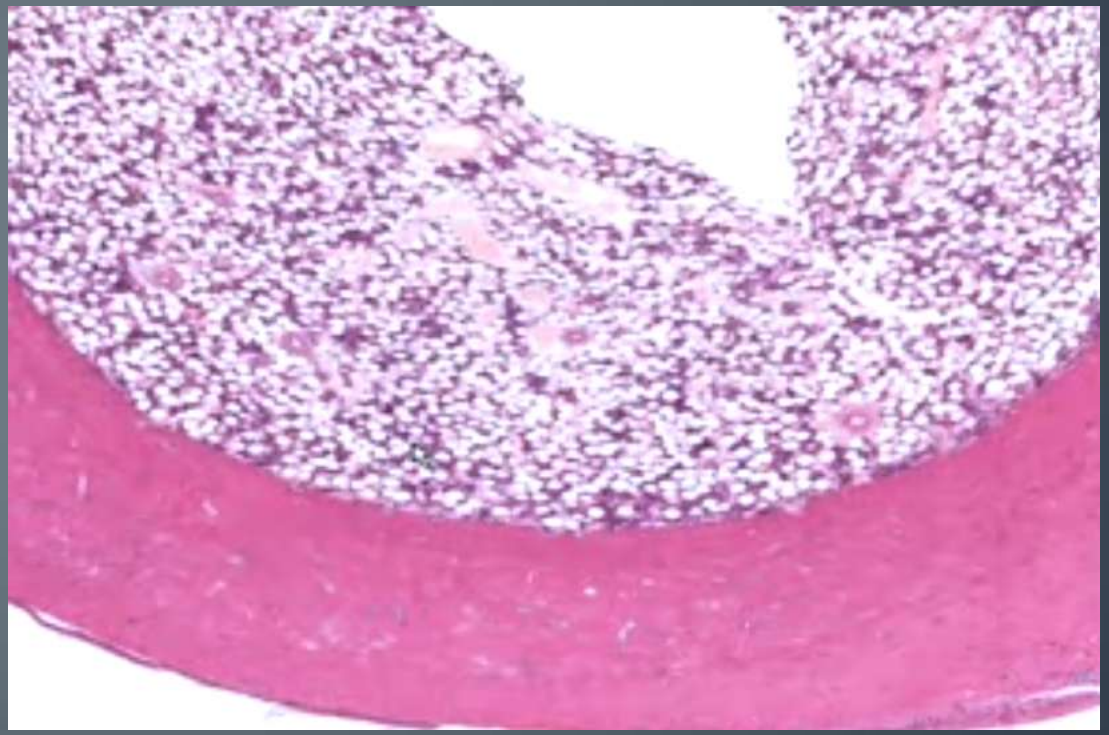
Inflamm Allergy Drug Targets. 2012 Jun; 11(3): 201–206.

Bone Marrow Histology



Taken from WashingtonDeceit, shotgun histology bone marrow, www.youtube.com

Bone Marrow Histology



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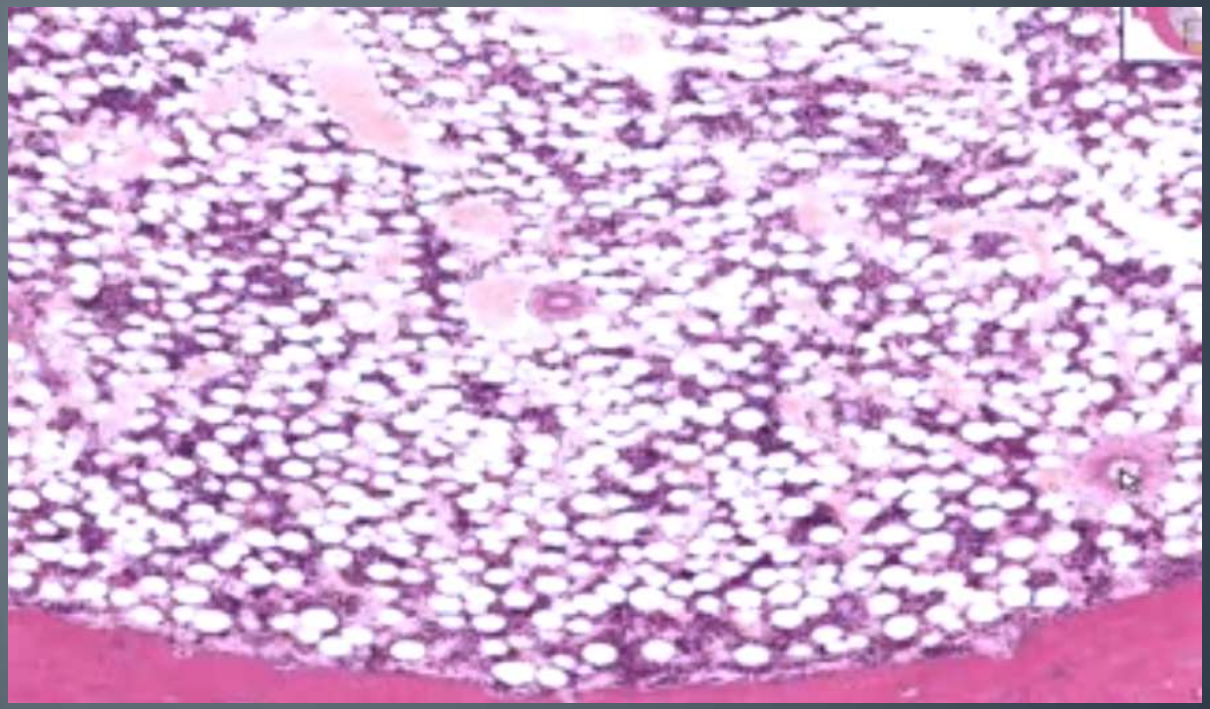

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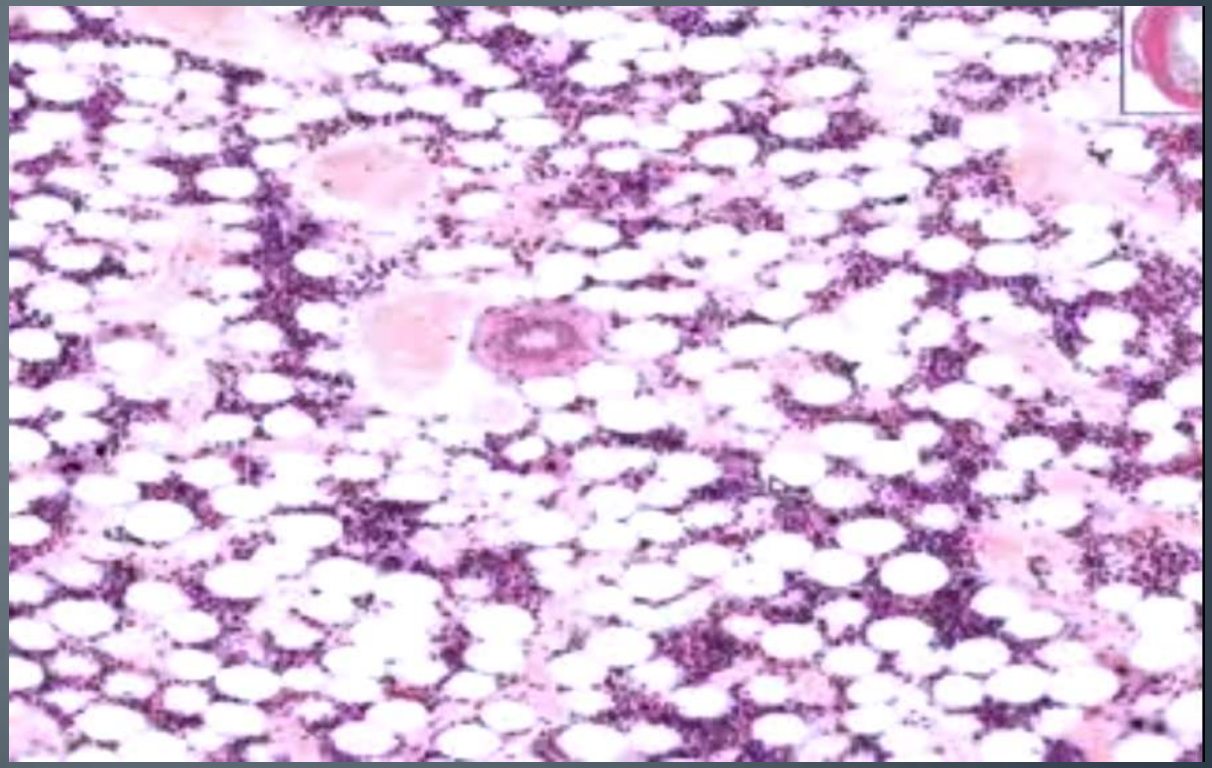

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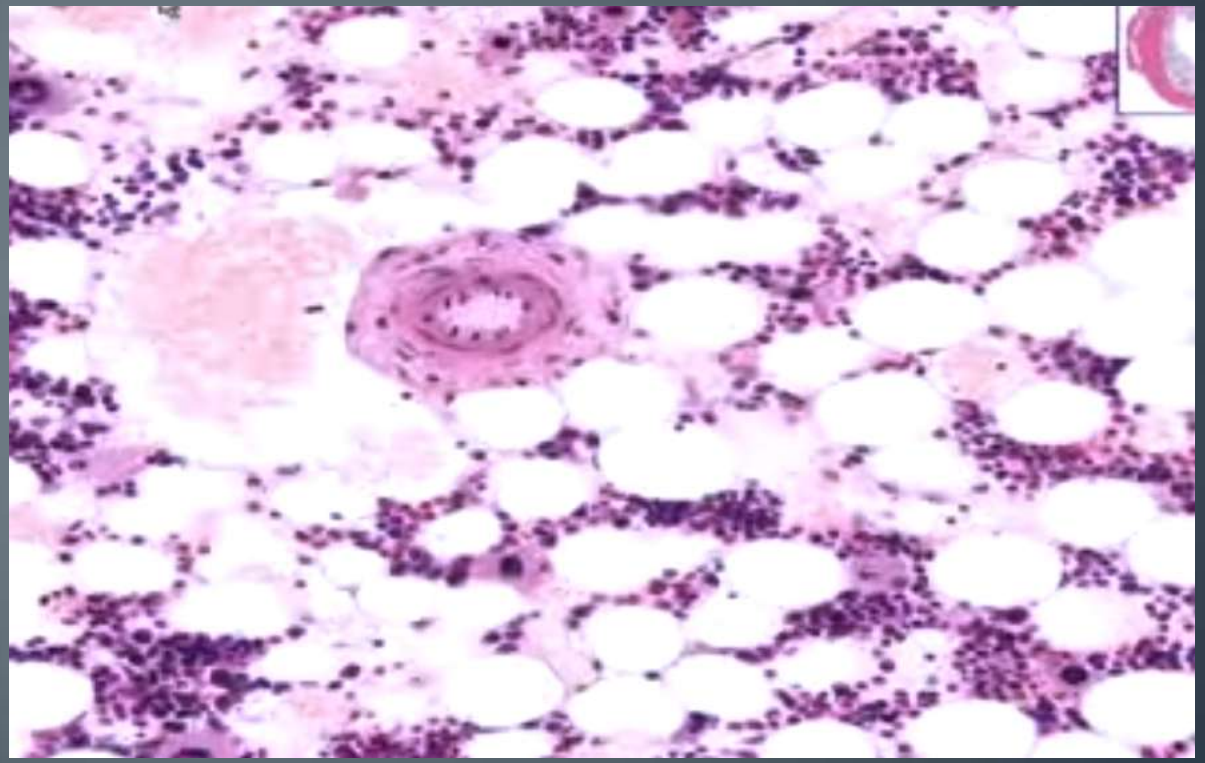
Bone Marrow Histology



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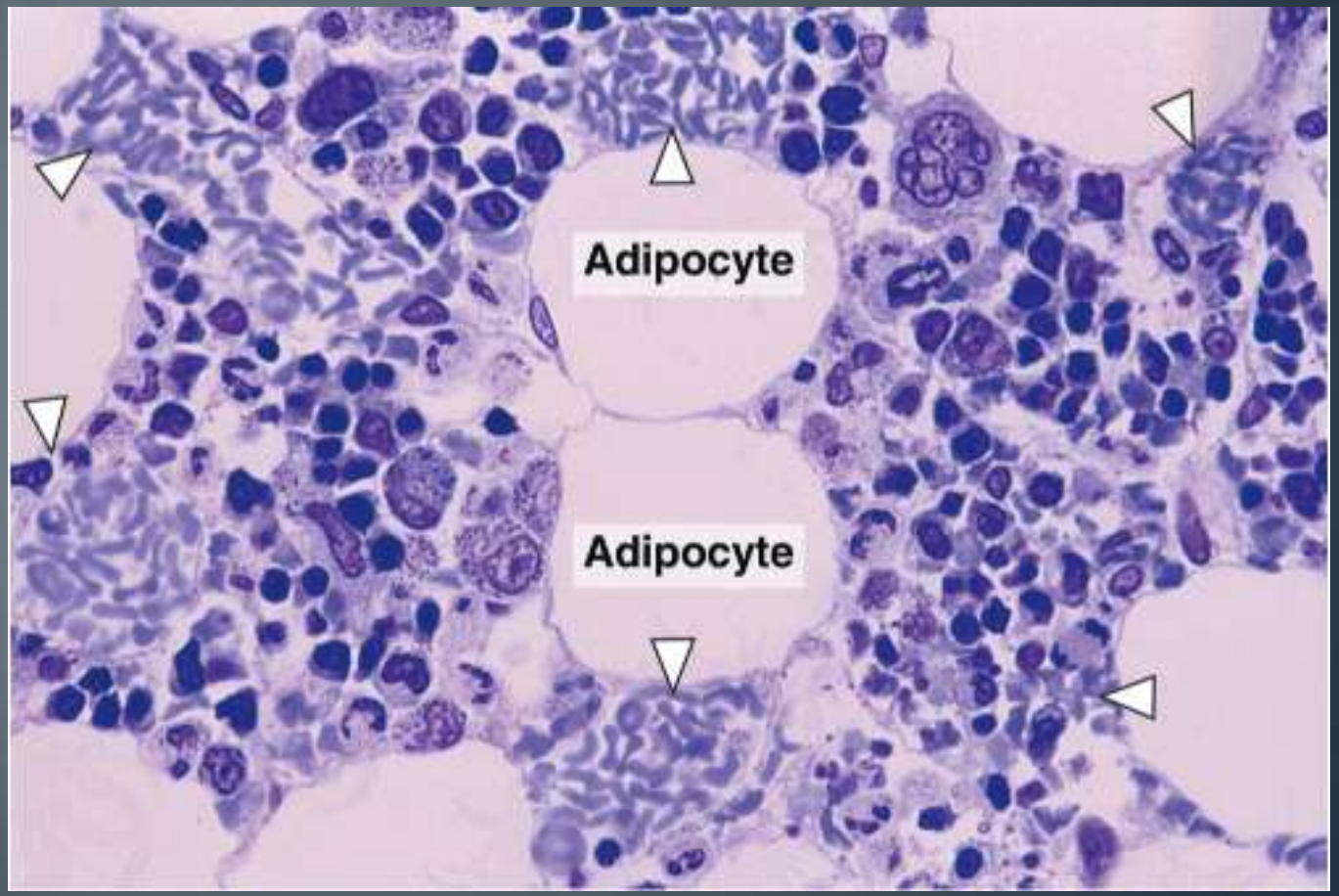
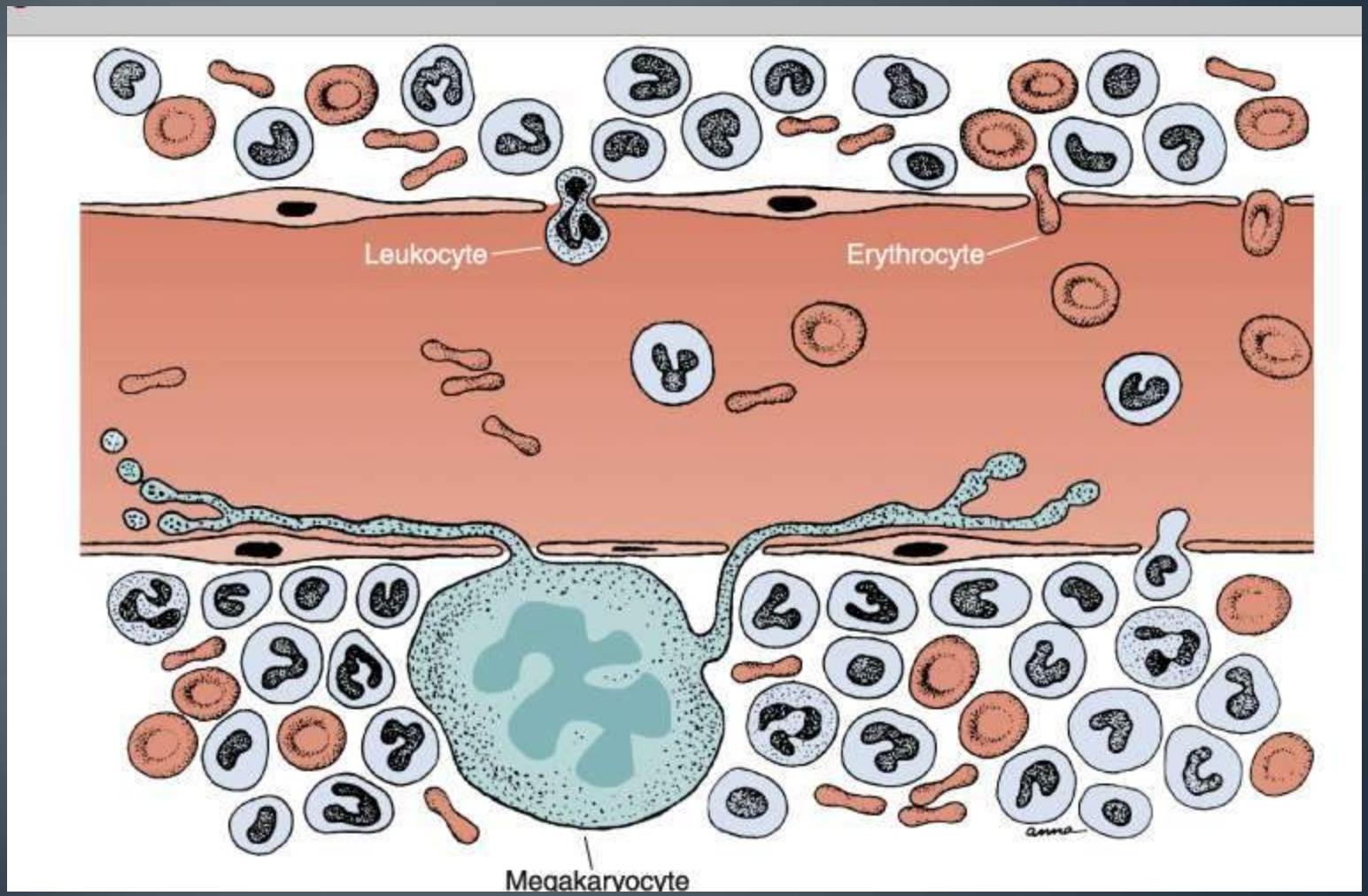
Bone Marrow Histology



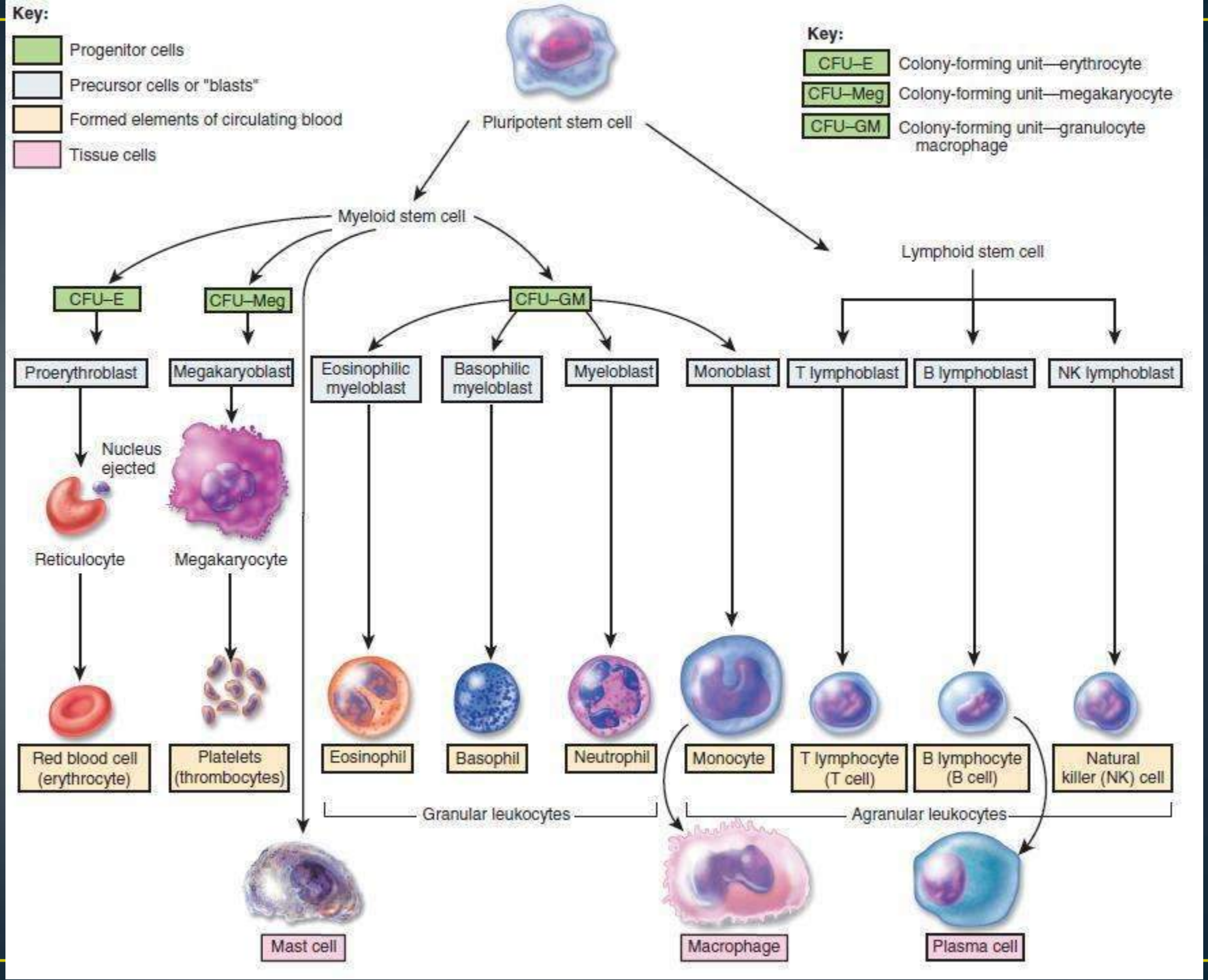
Taken from McGraw Hill, 2006

Entrance of Blood Cells

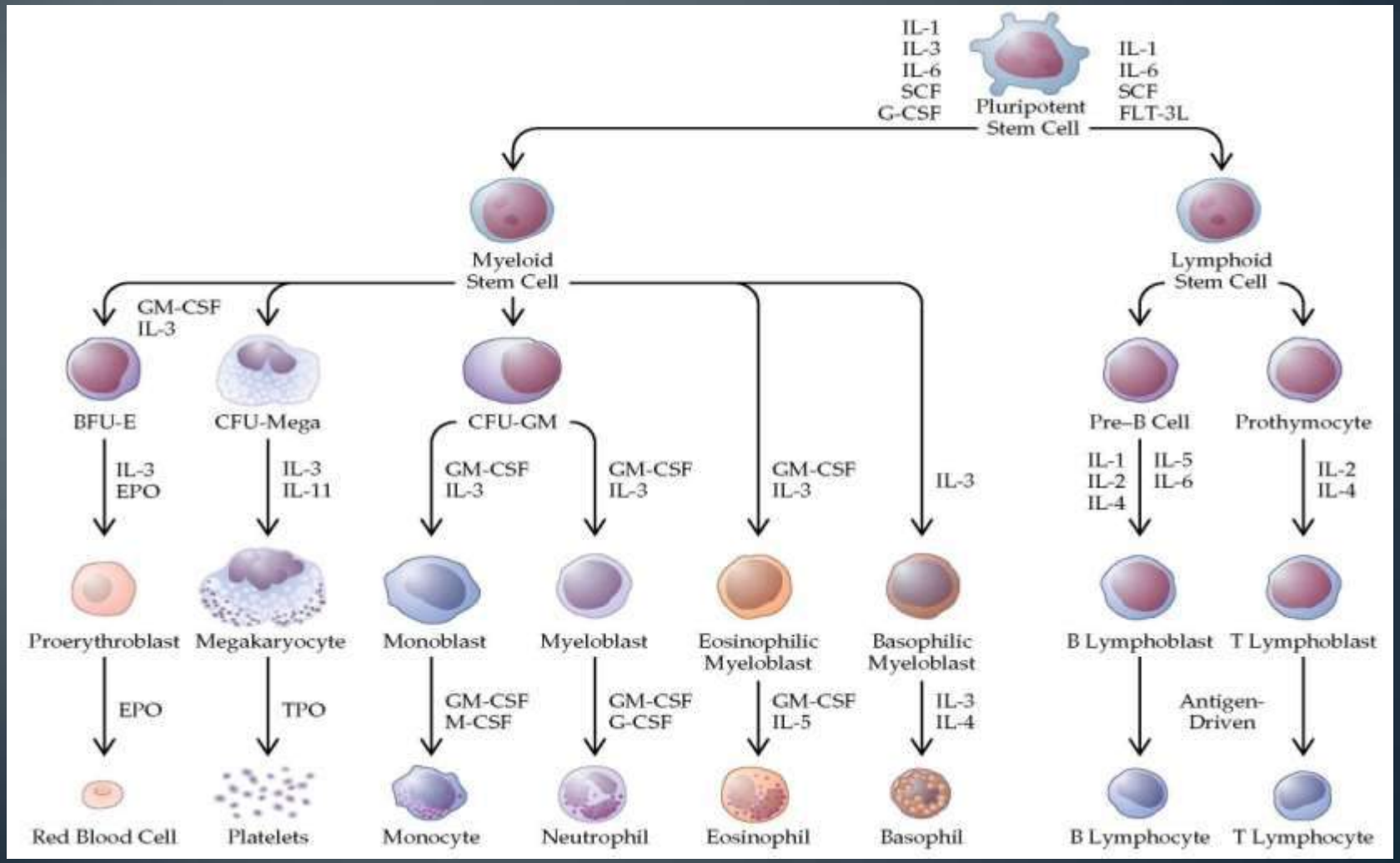


Taken from McGraw Hill, 2006

Hemopoeisis

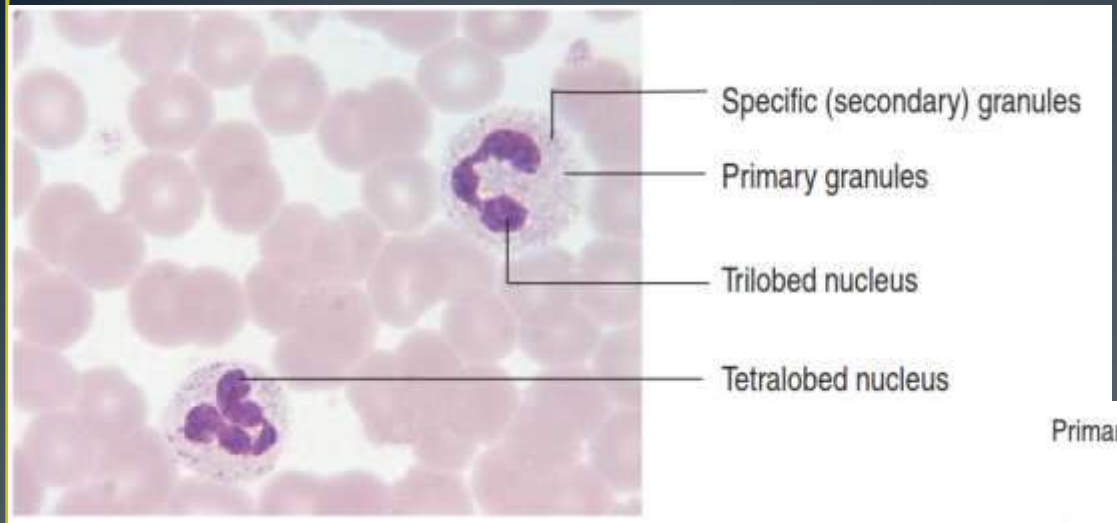

Key:
Progenitor cells
Precursor cells or "blasts"
Formed elements of circulating blood
Tissue cells
Key:
CFU–E Colony-forming unit—erythrocyte
CFU–Meg Colony-forming unit—megakaryocyte
CFU–GM Colony-forming unit—granulocyte macrophage
Pluripotent stem cell
Myeloid stem cell
Lymphoid stem cell
CFU–E
CFU–Meg
CFU–GM
Proerythroblast
Megakaryoblast
Eosinophilic myeloblast
Basophilic myeloblast
Myeloblast
Monoblast
T lymphoblast
B lymphoblast
NK lymphoblast
Nucleus ejected
Reticulocyte
Megakaryocyte
Red blood cell (erythrocyte)
Platelets (thrombocytes)
Eosinophil
Basophil
Neutrophil
Monocyte
T lymphocyte (T cell)
B lymphocyte (B cell)
Natural killer (NK) cell
Granular leukocytes
Agranular leukocytes
Mast cell
Macrophage
Plasma cell

Signals Needed for Differentiation

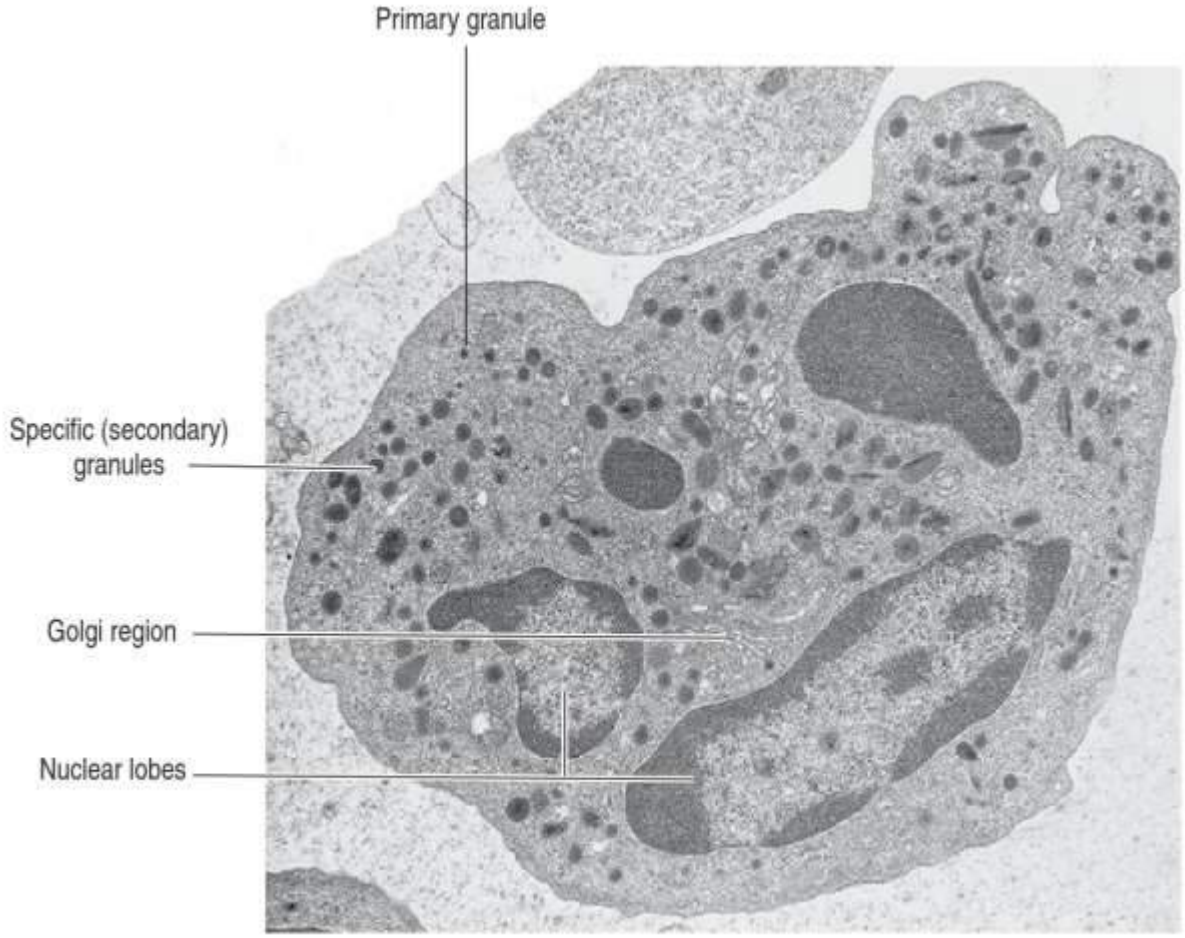


Blood Cells

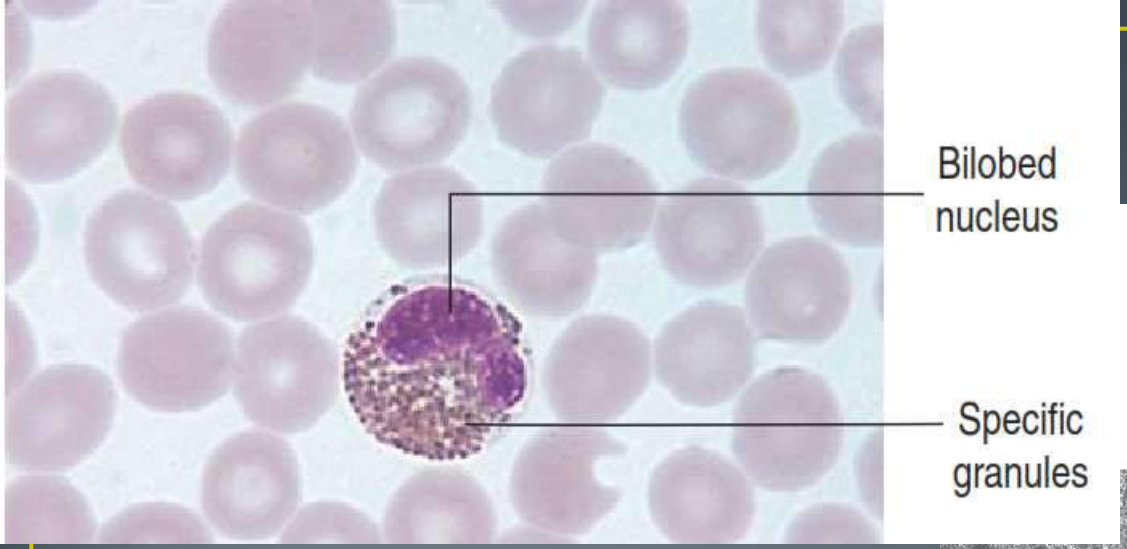
Neutrophil



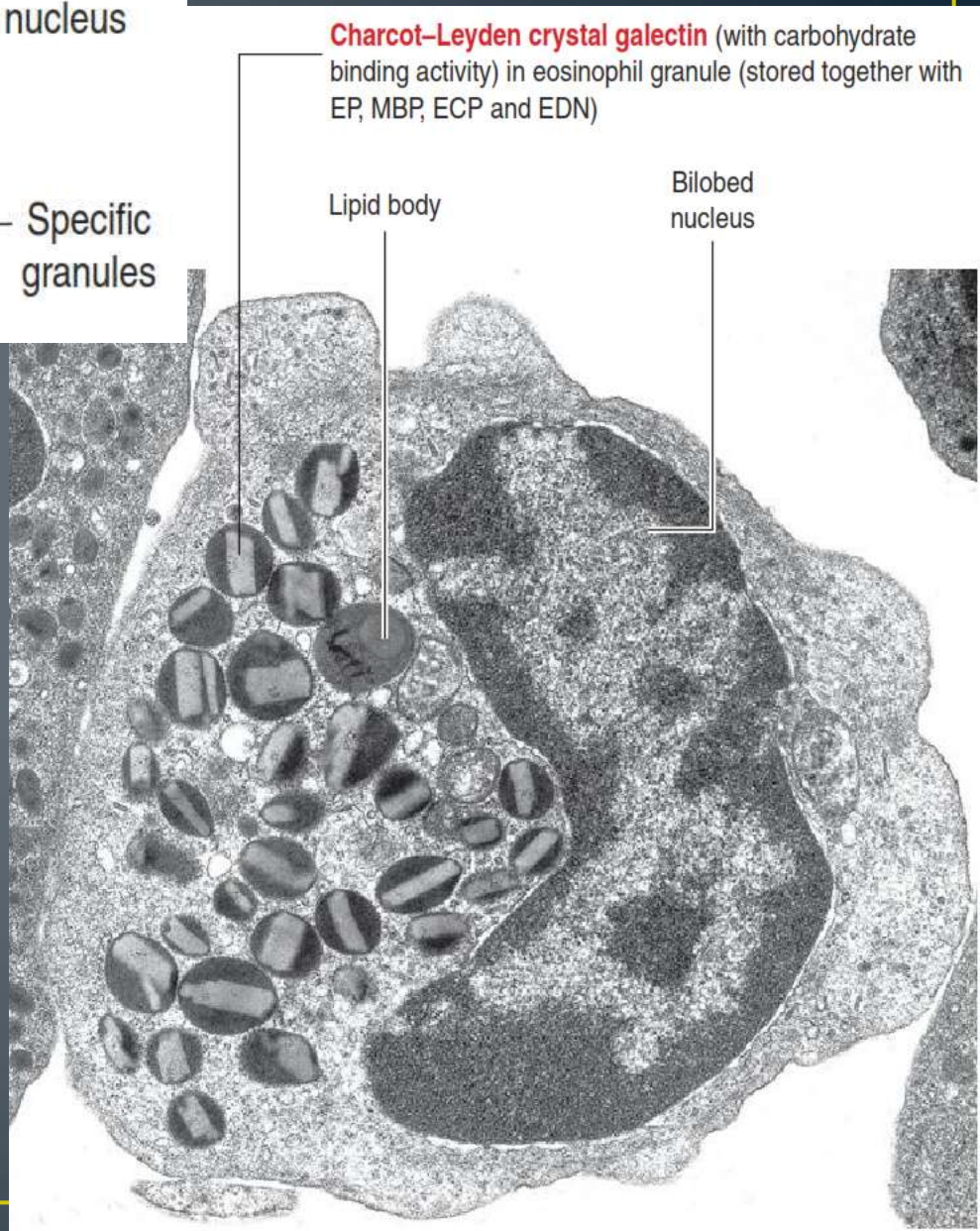
- Primary Granules:
  - Elastase
  - Defensins
  - Myeloperoksidase
- Secondary Granules:
  - Lysozyme
  - Lactoferrin
  - Gelatinase
  - Protease
- Tertiary Granules??



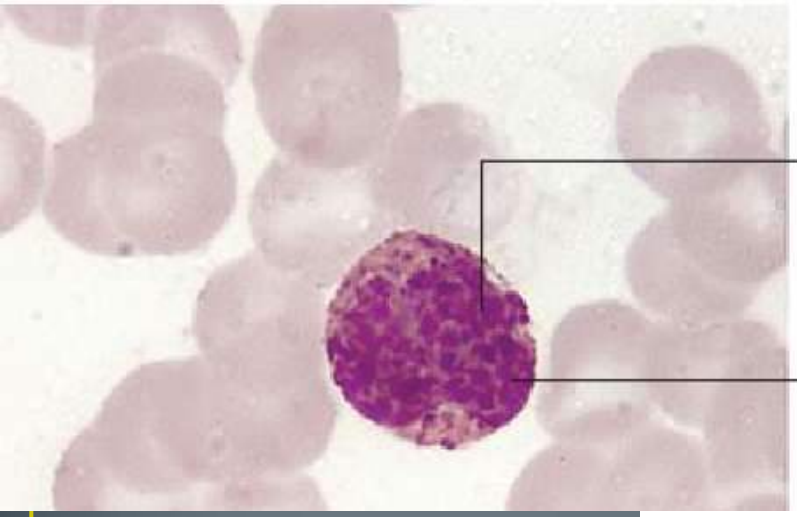
Eosinophil

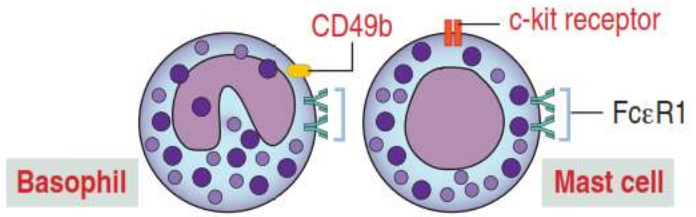


- Granular contents:
  - Eosinophil peroksidase
  - Major Basic Protein
  - Eosinophil cationic protein
  - Eosinophil derived neurotoxin
- Other products:
  - Cytokines
  - Enzymes
  - Lipid bodies
  - Growth factor

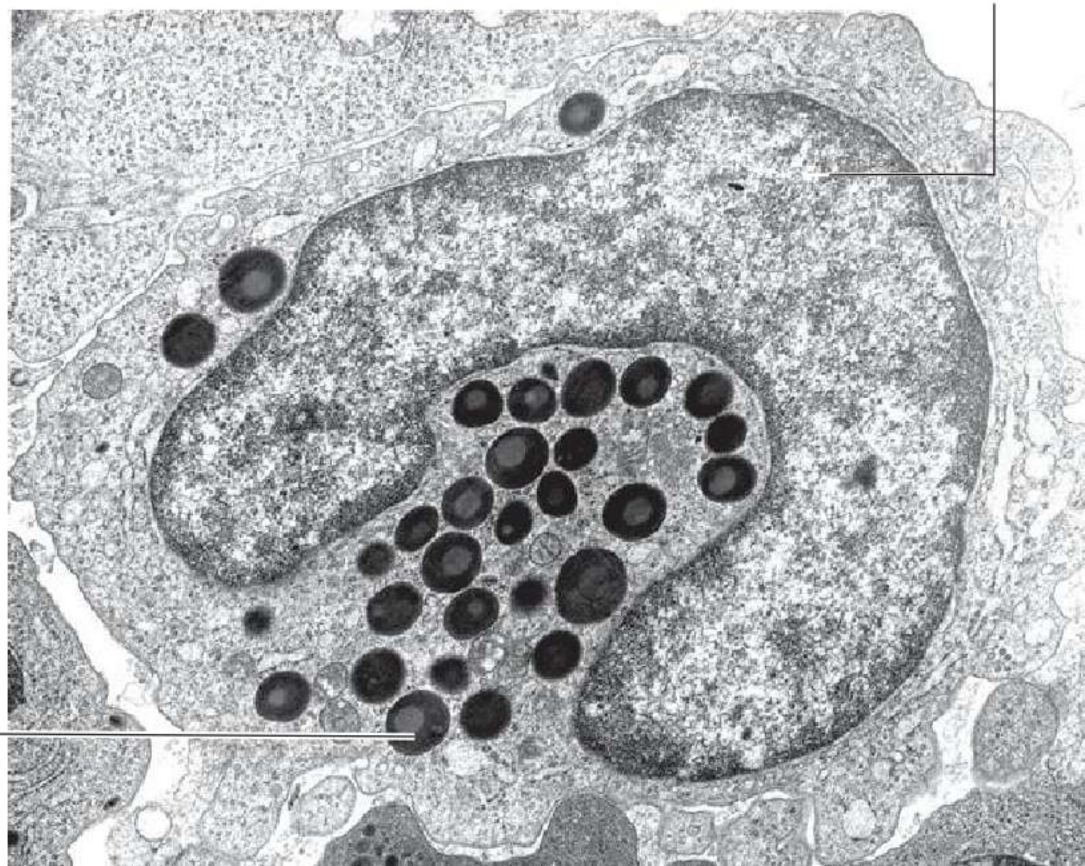


Basophil

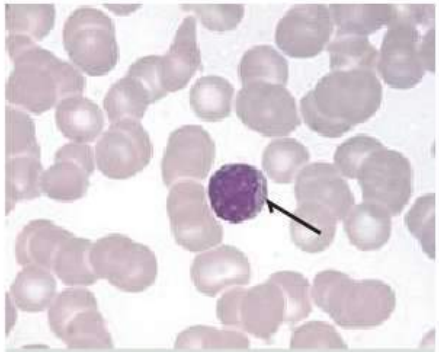




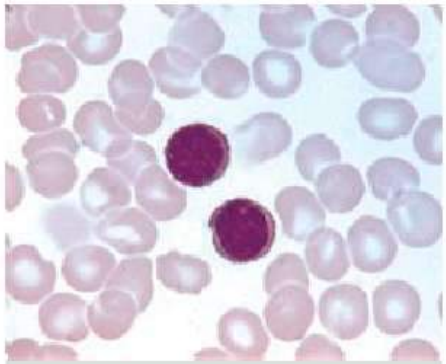
- Express IgE Receptor
- Contains:
  - Heparin
  - Histamine



Lymphocyte



Small lymphocyte

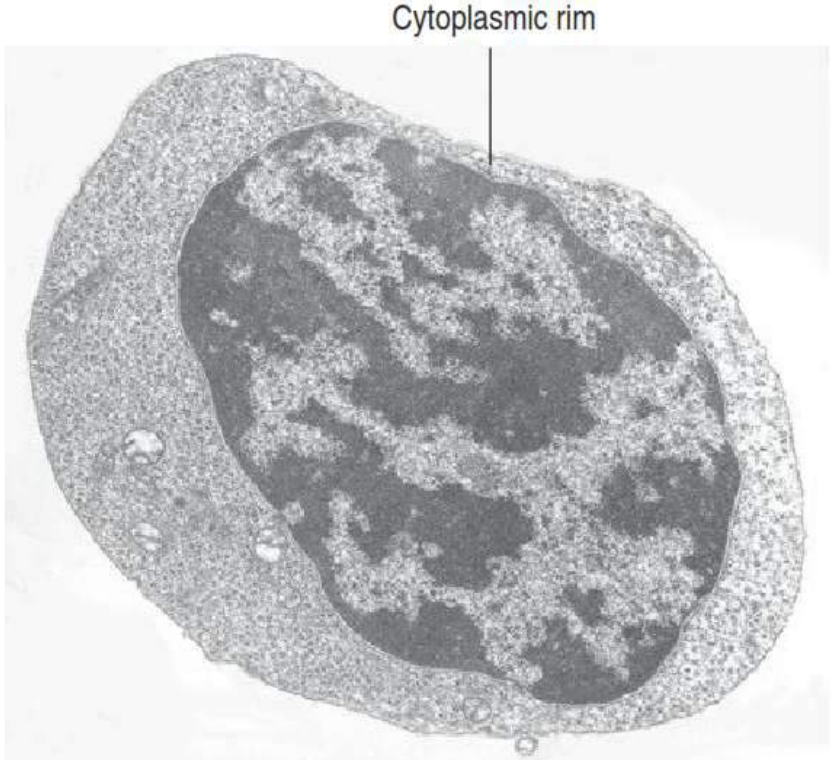


Large lymphocytes

Lymphocytes are relatively abundant, accounting for 20% to 40% of total leukocytes. In circulating blood, lymphocytes may range from approximately 7 to12 μm in diameter. However, the typical lymphocyte in a normal blood smear is small, about the size of a red blood cell.

The nucleus of a **small lymphocyte** is densely stained, with a round or slightly indented shape (*pointer*). The nucleus occupies most of the cell, reducing the cytoplasm to a thin basophilic rim.

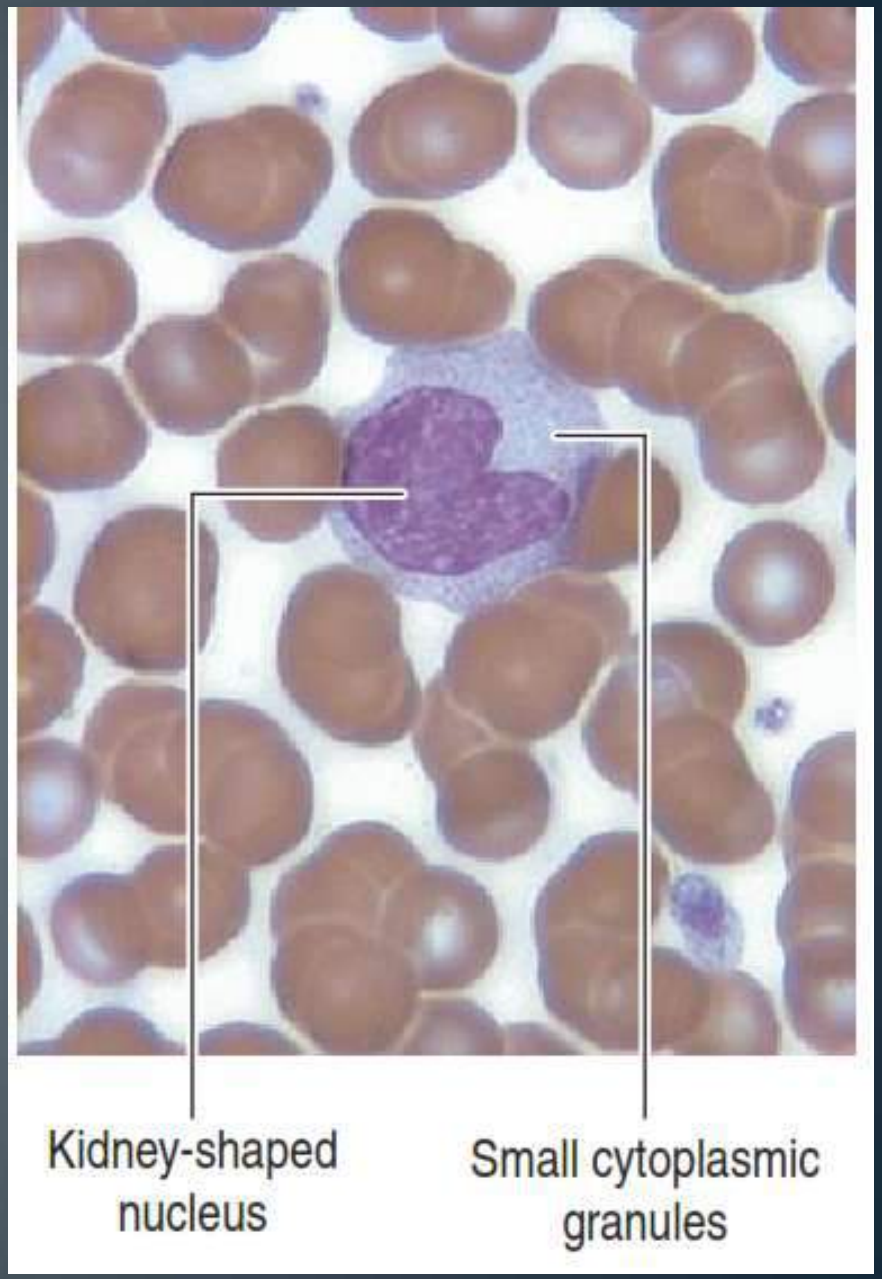
Large lymphocytes have a round, slightly indented nucleus surrounded by a pale cytoplasm. Occasionally, a few primary granules (lysosomes) may be present.



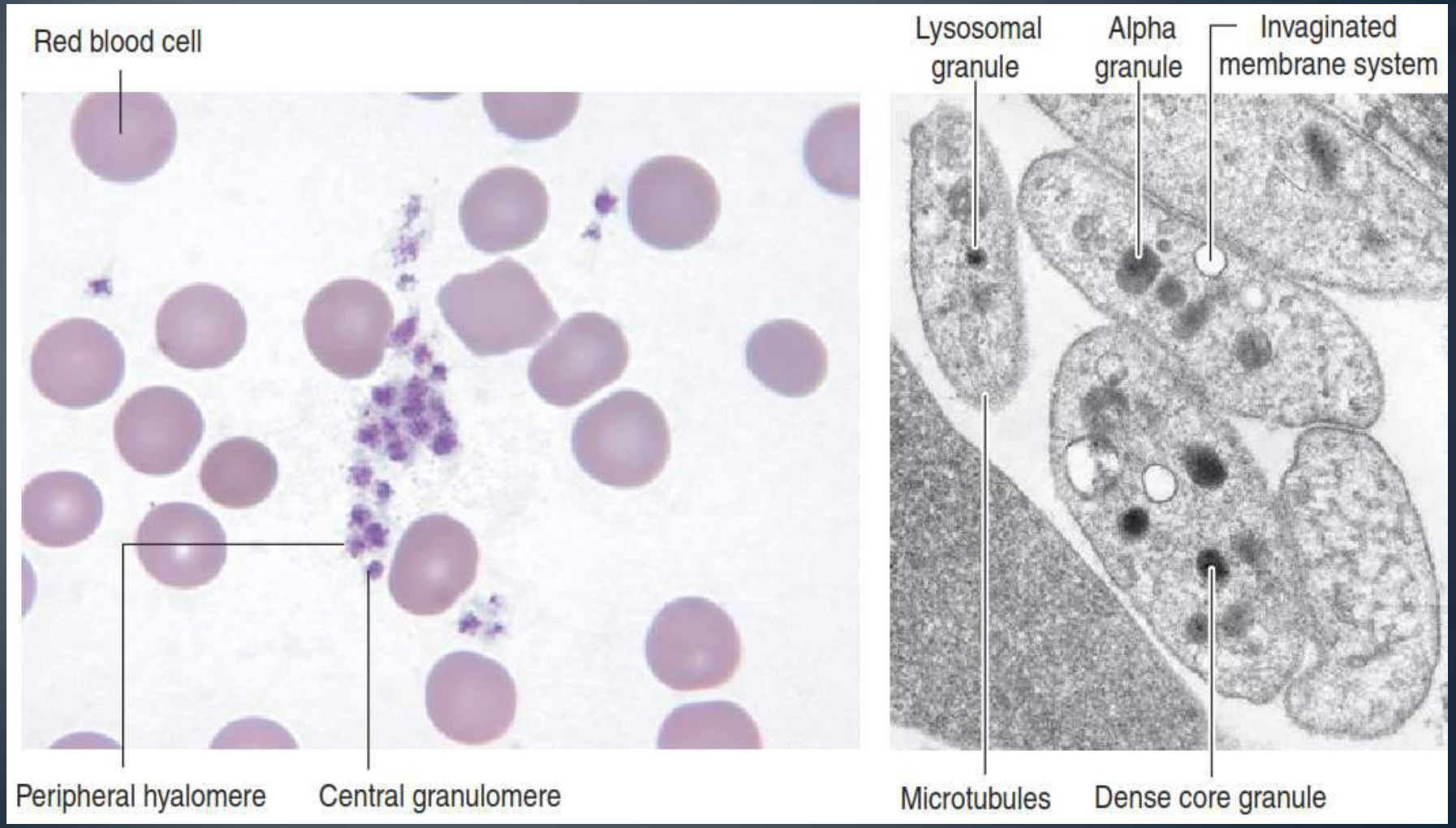
- Colonies: B, T, NK-T

Monocyte

- Differentiate into Macrophage in tissues:
  - Osteoclast
  - Dust cell
  - Kuppfer
  - etc



Platelets


Red blood cell
Peripheral hyalomere
Central granulomere
Lysosomal granule
Alpha granule
Invaginated membrane system
Microtubules
Dense core granule

Other bone marrow cells

Read from the reference

Any Questions?

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- Subject:

  Nama Modul – Nama Mahasiswa – Nim

- Body:

  Salam, Isi

Reading References

- ***Junqueira's Basic Histology, Text and Atlas***-Anthony Mescher - McGraw-Hill Medical – 2013 – Chapter 12-13
- ***Histology and Cell Biology, An Introduction to Pathology, 4e*** - Abraham L Kierszenbaum M.D. Ph.D., Laura Tres M.D. Ph.D - Elsevier - 2016 - Chapter 6

Alhamdulillaah…

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