Hematopoietic System
Kristine Krafts, M.D.
Hematopoietic System Lecture Objectives

• Describe the developmental stages of erythropoiesis.
• Describe the developmental stages of granulopoiesis.
• Describe the differences between red marrow and yellow marrow.
• List the components of bone marrow stroma.
• Explain the concept of colony forming units (CFUs).
Hematopoietic System Lecture Outline

- Introduction
- Erythrocytes
- Platelets
- Leukocytes
  - Granulocytes
  - Agranulocytes
Hematopoietic System Lecture Outline

• Introduction
Hematopoietic Tissue

Specialized connective tissue.
Derived from mesenchyme.

Function: produce new blood cells and remove old ones.

Two types of hematopoietic tissue

- **Myeloid tissue** (in bone marrow): produces everything except lymphocytes
- **Lymphoid tissue** (in lymph nodes, spleen): produces lymphocytes (different lecture!)
Prenatal Hematopoiesis

Months gestation:
1 2 3 4 5 6 7 8 9

Hematopoiesis:
- Yolk sac
- Liver
- Spleen
- Bone marrow

Birth
Myeloid Tissue (Bone Marrow)

• Bone marrow in adults is found between trabeculae of cancellous (spongy) bone and in the marrow canal of long bones.

• **Red (hematopoietic) bone marrow** is found in flat bones of skull, vertebrae, ribs, pelvis, and ends of long bones.

• **Yellow bone marrow** is found in long bone diaphyses. It is composed of fibrous CT, adipose tissue (yellow color), nerves, and blood vessels.
Components of Bone Marrow

• **Stroma**: a connective tissue network which supports the blood-forming cells.

• **Sinusoids**: wide, thin-walled vessels with discontinuous endothelial cells which allow new blood cells to gain access to the bloodstream.

• **Developing blood cells**: red cell precursors, white cell precursors (except lymphoid precursors), and megakaryocytes.
Stroma

**Cells**
- Fibroblasts
- Macrophages
- Adipocytes (fat cells)
- Osteogenic cells
- Endothelial cells

**Fibers**
- Type I collagen fibers
- Type III collagen (reticular) fibers
Bone marrow is present between trabeculae of spongy (cancellous) bones
Bone marrow: trabeculae, hematopoietic tissue and sinusoids
Hematopoiesis

• All blood cells arise from a single type of pluripotent stem cell (which is self-renewing).

• Pluripotent stem cells divide, forming committed stem cells, which divide and eventually mature into red cells, white cells and platelets.

• You need growth factors called “colony stimulating factors” for this process.
Hematopoiesis

Hematopoietic stem cell (self-renewing)

B-cell

T-cell

Red cells

Platelets

Eosinophil

Neutrophil

Monocyte
Don’t memorize these specific growth factors! Just know they are necessary.
Hematopoietic System Lecture Outline

• Introduction

• Erythrocytes
Erythrocyte Maturation

• The main jobs: make hemoglobin and form red blood cell with no nucleus.

• 2,500,000 red cells released into blood per second!

• Start with big cell and big nucleus; size of both decreases as cell matures.

• Also: chromatin starts out “fine” (see-through), and becomes progressively more condensed (dark). Nucleus eventually removed.
Morphologic Changes in Erythropoiesis

Immature --> Mature

Large cells, gorgeous basophilic cytoplasm --> Small cells, with red (eosinophilic) cytoplasm

Large, violet-blue nucleus --> Small, dark blue-black nucleus

Fine chromatin (see nucleoli) --> Coarser, then pyknotic nucleus (eventually extruded)

Proerythroblast* --> Basophilic erythroblast
Basophilic erythroblast --> Polychromatophilic erythroblast
Polychromatophilic erythroblast --> Orthochromatophilic erythroblast
Orthochromatophilic erythroblast --> Reticulocyte
Reticulocyte --> Mature red cell
**Basophilic erythroblast**

**Proerythroblast***

**Polychromatic erythroblast**

**Orthochromatric erythroblast**

**Reticulocyte**

**Mature red cell**

* Kristine’s favorite cell

Whole process takes only 7 days!
Proerythroblast: Big cell, gorgeous sky-blue cytoplasm, very fine chromatin.
Proerythroblast: WOW.
Basophilic erythroblast: a little smaller, with more condensed chromatin and darker cytoplasm. Meh.
Polychromatatic erythroblasts: even more condensed chromatin, cytoplasm grey-blue (has a little hemoglobin)
Orthochromatic erythroblast: chromatin very condensed, cytoplasm is grey-pink-lavender (has more hemoglobin)
Orthochromatic erythroblast extruding its nucleus
Reticulocytes: no nucleus, cytoplasm is still a little more lavender than mature red cell
Reticulocytes (special stain)
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Thrombopoiesis

• Platelets come from giant (up to 100 µm) nucleated cells called megakaryocytes.

• The megakaryocyte nucleus undergoes endomitosis (replicates DNA without undergoing cell division)
  • Up to 32 copies of normal DNA!
  • Multilobed nucleus

• Small fragments of megakaryocyte cytoplasm bud off, forming platelets.
Megakaryocyte: huge cell with large, polypoid multilobed nucleus
АННННННННН!
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Granulocyte Maturation

- 1,250,000 granulocytes (mostly neutrophils) released *per second* into blood!
- Maturation in bone marrow takes about 2 weeks.
- Cells spend a few hours in the blood, then leave and stay where needed for a few days, then die.
Morphologic Changes in Granulopoiesis

Cytoplasm loses its basophilic color. Chromatin becomes more condensed. Specific granules increase in number.
Promyelocyte: biggest cell of the myeloid lineup. Lots of azurophilic (primary) granules.
Myelocyte: has specific granules (and a few azurophilic granules)
Metamyelocyte: nucleus indented.
Band cell: almost a mature neutrophil – just doesn’t have a segmented nucleus yet.
Neutrophil: segmented nucleus (3-5 lobes)
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Lymphopoiesis

- B lymphocytes develop in the bone marrow.
- T lymphocytes develop in the thymus.
- B and T cells then leave and populate secondary lymphoid organs (lymph nodes, spleen).
- We’ll discuss these later in a different lecture.
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