Blood
Kristine Krafts, M.D.
The most beautiful thing we can experience is the mysterious. It is the source of all true art and science.

-Albert Einstein
Blood Lecture Objectives

• Be able to identify and describe the major function(s) of the following:
  • Erythrocytes (RBCs)
  • Granulocytes (neutrophils, eosinophils, basophils)
  • Agranulocytes (lymphocytes, monocytes)
  • Platelets

• Know the approximate percentage of each type of leukocyte present in normal blood.

• Be able to describe the differences between plasma and serum.
Blood Lecture Outline

- Introduction
- Erythrocytes
- Platelets
- Leukocytes
  - Granulocytes
  - Agranulocytes
Blood Lecture Outline

• Introduction
Blood is a Specialized Connective Tissue

Composed of:

- Cells
- Plasma
Cells

- Red cells (erythrocytes)
- White cells (leukocytes)
- Platelets
**Plasma contents**

- Water: 92%
- Proteins: 7%
  - Albumin: 58%
  - Immunoglobulins: 37%
  - Fibrinogen: 4%
  - Other proteins: 1%
- Other stuff: 1% (electrolytes, nutrients, respiratory gases, waste products)
Plasma vs. Serum

- Plasma clots, serum does not clot
- Serum = plasma minus clotting factors (it’s what’s left after plasma clots)
Blood Lecture Outline

• Introduction

• Erythrocytes
Erythrocytes (Red Blood Cells)

- Life span: 120 days
- Derived from red cell precursors in bone marrow
- Normal numbers
  - Male: $4.5-6 \times 10^{12}$/L
  - Female: $4-5 \times 10^{12}$/L
Normal red blood cells
Red Blood Cell Morphological Features

- Nicely designed biconcave disk shape
- Roughly 7 µm wide and 2 µm thick
- Cytoskeleton: spectrin, ankyrin, actin
- No nucleus
- Cytoplasm: water (65%); organelles (1%); hemoglobin (34%)
Pliable membrane allows cells to squeeze through tiny spaces.
Main red cell function: transport oxygen using hemoglobin

Hemoglobin

Heme molecule (carries $O_2$)
Blood Lecture Outline

- Introduction
- Erythrocytes
- Platelets
Platelets

- Life span: 8-10 days
- Derived from megakaryocytes in bone marrow
- Normal number: 150-450 x 10^9/L
- About 2 μm in diameter
- Granulomere and hyalomere regions
- No nucleus
- Function: help blood to clot
Normal Platelets

- granulomere
- hyalomere
Platelets look boring but have a ton of stuff inside (granules) and outside (receptors)
Platelets forming a clot
Blood Lecture Outline

• Introduction
• Erythrocytes
• Platelets
• Leukocytes
White blood cells (nice drawing)
White blood cells (real blood smear)
White blood cells (another real blood smear)
White blood cell count (WBC)
Just gives you the total number of white blood cells (normal is about 4-11 x 10⁹/L).
White blood cell differential ("diff")
Tells you how many of each type of white cell are present (normally, neutrophils are the most numerous, and basophils are the least numerous).
Leukocytes

- Granulocytes
  - Neutrophils
  - Eosinophils
  - Basophils

- Agranulocytes
  - Lymphocytes
  - Monocytes
Wait, agranulocytes have granules?!

- Yes! Both granulocytes and agranulocytes have cytoplasmic granules called azurophilic granules.
- But granulocytes also have specific granules that define them as cells (neutrophilic, eosinophilic and basophilic granules)
Blood Lecture Outline

• Introduction
• Erythrocytes
• Platelets
• Leukocytes
  • Granulocytes
Neutrophils

- 45-75% of differential count (between 2-8 x 10⁹/L)
- About 15 µm in diameter
- Multi-lobed nucleus...
- ...hence their other name: “polymorphonuclear leukocyte” (PMN)
- Two kinds of granules:
  - Azurophilic (primary, purple) granules (a few)
  - Neutrophilic (secondary, pink) granules (lots)
Neutrophil: azurophilic vs. neutrophilic granules (hard to see on screen!)
Azurophilic granules become much more prominent during bacterial infection.
Azurophilic granules first appear in less mature neutrophils called promyelocytes. Promyelocytes divide, distributing their azurophilic granules evenly (which means more mature neutrophils have fewer azurophilic granules).
Neutrophil Functions

- First line of defense against invaders (bacteria, foreign objects)
- Spend a few hours in blood, then migrate quickly to site of infection where they spend a few days
- Kill invaders by phagocytosis and by enzymatic destruction (nasty!)
- Then take off and let others (macrophages) clean up the mess
Eosinophils

- 1-4% of differential count (about 0.5 x 10⁹/L)
- About 15 µm in diameter
- Large, gorgeous, orange-red (eosinophilic) granules in cytoplasm
- Greek *eos* = first blush of dawn
- Bi-lobed nucleus
Eosinophil in real life
Eosinophil Functions

- Major cell involved in allergic reactions (like hay fever and asthma)
- Good at killing parasites (granules contain major basic protein)
- Also involved in drug reactions
- Help modulate immune responses
Basophils

• Less than 1% of differential count (less than 0.3 x 10⁹/L)
• About 10 µm in diameter
• Tons of large, deep blue (basophilic) granules in cytoplasm
• Irregularly-shaped nucleus (hard to see under all those granules)
• Functions: fight infection, mediate allergic responses
Basophil in real life
Blood Lecture Outline

• Introduction
• Erythrocytes
• Platelets
• Leukocytes
  • Granulocytes
  • Agranulocytes
Lymphocytes

- 20-50% of differential count (between 1-4 x $10^9$/L)
- Most lymphocytes are small (6-12 µm) but some are larger (up to 20 µm)
- Nucleus: dark staining; “clumpy and smudgy”
- Two main types (which look pretty much the same):
  - B-lymphocytes
  - T-lymphocytes
Normal lymphocytes
Small lymphocyte in real life
Lymphocyte chromatin pattern: clumpy *and* smudgy
Neutrophil chromatin: distinct clumps (with white space between clumps)

Lymphocyte chromatin: clumpy but also smudgy (no white space between clumps)

Monocyte chromatin: not really clumpy
B-Lymphocytes

• 15% of circulating lymphocytes

• Develop in bursa of Fabricius (in birds) and in bone marrow (in humans)

• Further maturation occurs in lymphatic tissues (lymph nodes and spleen)

• Ultimately, become either plasma cells (which make antibodies) or memory cells (which “remember” previous infections)
T-Lymphocytes

• About 85% of circulating lymphocytes
• Develop and mature in thymus
• Also found in bone marrow and lymphoid tissues, along with B cells
• Ultimately, most become either cytotoxic T cells (which kill infected cells) or helper T cells (which help other immune cells do their jobs)
Monocytes

- 1-8% of differential count (between 0.1-0.8 x 10^9/L)
- 12-20 µm in diameter
- Cytoplasm: “dishwater” (gray-blue) color, sometimes with little vacuoles and/or tiny azurophilic granules
Monocyte: large cell with “dishwater” cytoplasm and “raked” chromatin
Monocyte Function

- Differentiate into macrophages (histiocytes) in different organs
  - Foreign body giant cells (anywhere)
  - Kupffer cells (liver)
  - Microglial cells (brain)
  - Alveolar macrophages (lung)
- Second line of defense against invading organisms
- Help lymphocytes do their job; also phagocytic (eat up invaders and either get rid of them or present bits of them to lymphocytes)
Blood Lecture Outline

• Introduction
• Erythrocytes
• Platelets
• Leukocytes
  • Granulocytes
  • Agranulocytes