Lab 29A. Blood

**Whole Blood**

- **Plasma**: Fluid component
  - Water (90%)
  - Dissolved plasma proteins
  - Other solutes
- **Formed elements**: Cells and fragments
  - RBCs (carry Oxygen)
  - WBCs (immunity)
  - Platelets (cell fragments involved in clotting)

**Plasma**

- Makes up 50–60% of blood volume
- More than 90% of plasma is water

**Formed Elements**

- These are the cells (and quasi-cellular) constituents of blood
- Red blood cells (RBCs) make up 99.9% of blood's formed elements
- White blood cells and platelets make up the rest
Why do RBCs look hollow?

RBC Structure

- Small and highly specialized disc
- Thin in middle and thicker at edge

Why this structure?

RBC characteristics

- Shaped like biconcave discs
- Function primarily to carry oxygen
  - contain hemoglobin (95% of RBC protein)
- Lack a nucleus and contain few organelles
  (no mitochondria, ribosomes)
- Life span approx. 120 days

Importance of RBC Shape and Size

1. High surface-to-volume ratio:
   - Increase surface area for gas exchange
2. Discs form stacks:
   - Smoothes flow through narrow blood vessels
3. Discs bend and flex entering small capillaries:
   - 7.8 μm RBC passes through 4 μm capillary

Measuring RBCs

- Red blood cell count: reports the number of RBCs in 1 microliter whole blood
  - Male: 4.5–6.3 million
  - Female: 4.2–5.5 million
- Hematocrit (packed cell volume, PCV):
  - percentage of RBCs in centrifuged whole blood
    - Male: 40–54 (avg = 46)
    - Female: 37–47 (avg = 42)

RBCs make up about 1/3 of all cells in the body!
Anemia

- Hematocrit or hemoglobin levels are below normal, caused by several conditions
- Several types exist

Pernicious Anemia

- Low RBC production due to lack of vitamin \( \text{B}_12 \)
- Vitamin \( \text{B}_12 \) absorption requires Intrinsic factor (IF) from cells in the stomach. No IF, no \( \text{B}_12 \).

Sickle-Cell Anemia

- Mutation in beta globin gene resulting in production of \( \text{HbS} \)
- At low oxygen, cells with \( \text{HbS} \) become rigid and adopt a “sickle” shape: makes them fragile and can become stuck in small capillaries (last 10 days in blood)
- One bad copy: sickling trait
- Two bad copies: SCA
- Treatments? Transfusions, hydroxyurea, butyrate

Hemolytic Disease of the Newborn (Erythroblastosis Fetalis)

- Mother is Blood type \( \text{Rh}^- \)
- Father and fetus are \( \text{Rh}^+ \)
- First pregnancy = sensitization at delivery due to hemorrhage
- Second pregnancy = Anti-Rh IgG antibodies can cross placenta to attack fetal RBCs → hemolysis and excess presence of erythroblasts

Hemolytic Disease of the Newborn
Rh⁺ Fetal cells enter mother’s circulation at delivery

Second pregnancy is attacked by maternal antibodies

Erythroblastosis Fetalis

White Blood Cells (WBCs)

- **Leukocytes**: have nuclei and other organelles, not involved in oxygen transport.
- **Functions**:
  - Defend against pathogens
  - Remove toxins and wastes
  - Attack abnormal cells

WBC in blood vs. tissue

- Very small numbers in blood:
  - 6000 to 9000 per microliter
  - Outnumbered 1000:1 by RBCs
  - But only 1% of WBC are in blood
- Most WBCs are not found in blood but instead in connective tissue proper and in lymphatic system organs

Circulating WBCs

- WBCs can migrate out of bloodstream into tissues
- Have amoeboid movement (using actin)
- Attracted to chemical stimuli (*positive chemotaxis*)
- Some are phagocytic: neutrophils, eosinophils, and monocytes
**5 Types of WBCs**

1. Neutrophils
2. Eosinophils
3. Monocytes
4. Basophils
5. Lymphocytes

**Neutrophils**
- Also called polymorphonuclear leukocytes
- 50–70% of circulating WBCs
- Pale cytoplasm granules with lysosomal enzymes and bactericides (hydrogen peroxide and superoxide)
- Phagocytes that are the first to attack bacteria, engulf and digest pathogens with defensins
- Release prostaglandins and leukotrienes (inflammation and alarm call)
- Form pus

**Eosinophils**
- Also called acidophils
- 2–4% of circulating WBCs
- Attack large parasites by excreting toxic compounds
- Sensitive to allergens
- Control inflammation with enzymes that counteract inflammatory effects of neutrophils and mast cells

**Basophils**
- Less than 1% of circulating WBCs
- Small cells that accumulate in damaged tissue
- Release histamine to dilate blood vessels and heparin prevent blood clotting
- Similar to mast cells (found in the tissues)

**Monocytes**
- 2–8% of circulating WBCs
- Are large, irregular shape
- Kidney shaped nucleus
- Can have processes
- Enter peripheral tissues and become macrophages
- Engulf large particles and pathogens
- Secrete substances that attract immune system cells and fibroblasts to injured area

**Lymphocytes**
- T cells, B cells and NK cells
- 20–30% of circulating WBCs
- Note the small amount of cytoplasm
- Small, just slightly larger than RBCs
- Migrate in and out of blood
- Most of them are in connective tissues and lymphatic organs (spleen, lymph nodes)
- Respond to specific antigens
- Can’t tell difference among them on slide
The Differential Count of Circulating WBCs

• Detects changes in WBC populations during infections, inflammation, and allergic reactions

WBC Disorders

• **Leukopenia:**
  – abnormally low WBC count

• **Leukocytosis:**
  – abnormally high WBC count

• **Leukemia:**
  – extremely high WBC count

Blood disease nomenclature

• -penia (poverty): too little of a cell type in the blood
• -cytosis: too much of a cell type in the blood
• -emia: referring to the presence of something (anything) in the blood

Platelets

• Cell fragments involved in human clotting system (cf. thrombocytes)

Leukemia

• Blood cancer of WBCs – no solid tumor (cf. lymphoma)
• Can by myeloid or lymphoid
• Lymphoid more common in children
• Myeloid more common in adults

Infectious mononucleosis

• Also called “mono”
• Caused by the Epstein-Barr virus (EBV), which infects B cells producing a reactive lymphocytosis and atypical T cells.
• Increases numbers of “mononuclear leukocytes” hence the name. What cells are mononuclear?
• EBV rarely, causes Burkitt’s lymphoma
Atypical leukocyte

Today: Blood Slides

• Normal Wright Stain
  – RBCs
  – WBCs: neutrophil, lymphocyte, monocyte
  – RBC diameter
  – WBC diameters
• Sickle cell anemia slide
  – Draw and label
• Erythroblastosis slide
  – Draw and label

Today: Blood Slides

• Lymphocytic Leukemia
  – Draw and label
  – What type of WBCs do you see?
• Infectious Mononucleosis
  – Draw and label
  – What cells are affected?

Today’s Lab

• Draw examples of each of the five slides following instructions on the lab handout
• Review Sheet 29A questions 1-8 only
• Due next Tuesday