An Introduction to the Circulatory System and Blood
Circulatory System

• **circulatory system** = heart, blood vessels and blood

• **cardiovascular system** = heart and blood vessels

• **hematology** = the study of blood
Functions of Circulatory System

- **Transport** // $O_2$, $CO_2$, nutrients, wastes, hormones, and stem cells

- **Protection** // inflammation, limit spread of infection, destroy microorganisms and cancer cells, neutralize toxins, and initiates clotting

- **Regulation** // fluid balance, stabilizes pH of ECF, and temperature control
General Properties of Blood

• Adults have 4-6 L of blood *(test benchmark = 5L)*

• **Liquid connective tissue** // consisting of cells (i.e. formed elements) and the matrix (i.e. the extra-cellular material)
  
  – Plasma = matrix of blood

• A clear, light yellow fluid

• Serum = plasma minus the fibrinogen  ///  Note: Fibrinogen is the clotting protein (i.e. fibrinogen is converted into fibrin // turns soluble proteins to insoluble protein fibers)

  – Formed elements = blood cells and cell fragments  /////  red blood cells, white blood cells, and platelets (note: platelets are fragments of cells / not cells)
Blood Smear Viewed with Light Microscope

- White blood cell (leukocyte: neutrophil)
- Blood plasma
- Red blood cell (erythrocyte)
- Platelet
- White blood cell (leukocyte: monocyte)

(b) Blood smear (thin film of blood spread on a glass slide)
Formed Elements of Blood

White blood cell
Platelet
Red blood cell

(a) Scanning electron micrograph
Separating Plasma From Formed Elements of Blood

Hematocrit / the RBC volume

- determined by centrifuging blood to separate components

- erythrocytes are heaviest and first to settle
  - 37% to 52% total volume (45%)

- Buffy coat = white blood cells and platelets = less than 1% total volume
Hematocrit (cont.)

- **Plasma**
  - the remainder of volume
  - 47% - 63% (55%)
  - complex mixture of water, proteins, nutrients, electrolytes, nitrogenous wastes, hormones, and gases
(a) Appearance of centrifuged blood

- Plasma (55%)
- Red blood cells (45%)
- Buffy coat, composed of white blood cells and platelets
Plasma and Plasma Proteins

- **Plasma** = liquid portion of blood

- **Serum** = what remains after formed elements removed and fibrinogen removed (blood clots)

- **Most plasma proteins formed by liver**
  - Globulin proteins (also called immunoglobulins) are the exception (i.e. produced by plasma cells)
  - Poor nutrition reduces liver ability to make proteins
Plasma Proteins

- 3 major categories of plasma proteins
  - albumins
    - smallest and most abundant
    - contributes to viscosity and osmolarity, influences blood pressure, flow and fluid balance
  - globulins (antibodies)
    - provide immune system functions
    - alpha, beta and gamma globulins
  - fibrinogen
    - precursor of fibrin threads that help form blood clots
Factors Changing Properties of Blood

• **Viscosity**
  
  – resistance of a fluid to flow
  
  – This results from the cohesion between the particles
  
  – whole blood 4.5 - 5.5 times as viscous as water
  
  – plasma is 2.0 times as viscous as water
  
  – Conclusion = cells in general and RBC in particular are major factor in determining the viscosity of blood

  • important in circulatory function

  • Therefore any conditions which increase the hematocrit will increase viscosity which then will make the heart work harder
Factors Changing Properties of Blood

- Osmolarity of blood
  - the total molarity of those dissolved particles that cannot pass through the blood vessel wall
  - if too high, blood absorbs too much water
    - increasing the blood pressure // extra stress on blood vessels and heart
  - if too low, too much water stays in tissue
    - blood pressure drops and edema occurs // heart will need to beat faster to reach needed cardiac output
  - optimum osmolarity is achieved by bodies regulation of sodium ions, proteins, and red blood cells.
Nonprotein Components of Plasma

- Nitrogenous compounds
  - free amino acids // from dietary protein or tissue breakdown
  - nitrogenous wastes (urea)
    - toxic end products of catabolism
    - normally removed by the kidneys

- Nutrients // glucose, vitamins, fats, cholesterol, phospholipids, and minerals

- Gasses // dissolved O$_2$, CO$_2$, and nitrogen

- Electrolytes // many different anions and cations // Na$^+$ makes up 90% of plasma cations
Introduction to the Seven Formed Elements

- erythrocytes // red blood cells (RBCs)

- platelets // cell fragments from special cell in bone marrow

- leukocytes // white blood cells (WBCs)
  - leukocyte divided into two categories
    - granulocytes
    - agranulocytes
Red Blood Cells (RBCs) or Erythrocytes

Granular leukocytes
- Neutrophils
- Eosinophils
- Basophils

Agranular leukocytes
- Lymphocytes (T cells, B cells, and natural killer cells)
- Monocytes
- Platelets
(b) Components of blood
Red Blood Cells (RBCs) or Erythrocytes

Granular leukocytes
- Neutrophils
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Agranular leukocytes
- Lymphocytes (T cells, B cells, and natural killer cells)
- Monocytes
- Platelets
Formed Elements of Blood

Monocyte
Platelets
Small lymphocyte
Neutrophil
Eosinophil
Erythrocyte
Young (band) neutrophil
Large lymphocyte
Basophil
Leucocytes (WBC) Divided Into Two Groups

– Granulocytes (with visible granules)
  » Neutrophils
  » Eosinophils
  » Basophils (“mature” into mast cells // avascular)

– Agranulocytes (without visible granules)
  » Lymphocytes (T cells / B cells / NK cells)
  » Monocytes (“matrue” into macrophage // avascular)

– Notes:
  » a complete review of these WBC and their functions will follow
  » all of these cells have the ability to emigrate from the blood into the tissue spaces /// where they spend most of their time
  » memorize ranking concentrations with this saying / high to low / Never let monkeys eat bananas!
(b) Components of blood
Starvation and Plasma Proteins

- **Hypoproteinemia**
  - deficiency of plasma proteins
  - Causes // extreme starvation / liver or kidney disease / severe burns

- **Kwashiorkor**
  - children with severe protein deficiency
  - fed on cereals once weaned from protein rich breast milk
  - thin arms and legs
  - swollen abdomen