Blood

- Functions
  - Transport of Substances
    - Oxygen
    - Carbon Dioxide
    - Nutrients
    - Heat
    - Wastes
    - Hormones
  - Regulate
    - ph
    - Temperature
    - Hydration of cells
  - Defense Against
    - Blood loss
    - Microbes
    - Toxins
Blood Composition

- Components
# Blood Plasma

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Description and Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>90% of plasma volume; dissolving and suspending medium for solutes of blood; absorbs heat</td>
</tr>
<tr>
<td><strong>Solute</strong></td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td>8% (by weight) of plasma volume</td>
</tr>
<tr>
<td>Albumin</td>
<td>60% of plasma proteins; produced by liver; exerts osmotic pressure to maintain water balance between blood and tissues</td>
</tr>
<tr>
<td>Globulins</td>
<td>36% of plasma proteins</td>
</tr>
<tr>
<td>alpha, beta</td>
<td>Produced by liver; transport proteins that bind to lipids, metal ions, and fat-soluble vitamins</td>
</tr>
<tr>
<td>Gamma</td>
<td>Antibodies released primarily by plasma cells during immune response</td>
</tr>
<tr>
<td>Clotting proteins</td>
<td>4% of plasma proteins; include fibrinogen and prothrombin produced by liver; act in blood clotting</td>
</tr>
<tr>
<td>Others</td>
<td>Metabolic enzymes, antibacterial proteins (such as complement), hormones</td>
</tr>
<tr>
<td>Nonprotein nitorgenous substances</td>
<td>By-products of cellular metabolism, such as urea, uric acid, creatinine, and ammonium salts</td>
</tr>
<tr>
<td>Nutrients (organic)</td>
<td>Materials absorbed from digestive tract and transported for use throughout body; include glucose and other simple carbohydrates, amino acids (digestion products of proteins), fatty acids, glycerol and triglycerides (fat products), cholesterol, and vitamins</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>Cations include sodium, potassium, calcium, magnesium; anions include chloride, phosphate, sulfate, and bicarbonate; help to maintain plasma osmotic pressure and normal blood pH</td>
</tr>
<tr>
<td>Respiratory gases</td>
<td>Oxygen and carbon dioxide; some dissolved oxygen (most bound to hemoglobin inside RBCs); carbon dioxide transported bound to hemoglobin in RBCs and as bicarbonate ion dissolved in plasma</td>
</tr>
</tbody>
</table>
Formed Elements

- Platelets
- Erythrocytes
- Monocyte
- Neutrophils
- Lymphocyte
**Formed Elements**

- **Erythrocytes**
  - Biconcave discs
  - Anucleate
  - Life span – 120 days
  - Normal values
    - Male 5.4 million / mm³
    - Female 4.8 million / mn
Formed Elements

- Contain Hemoglobin (Hb)

- Made up of four protein chains
- Possess and iron containing heme group
- Carries oxygen (oxyhemoglobin) and carbon dioxide (carbaminohemoglobin)
- Normal Values
  - Male 13 – 18 g/dl
  - Female 12 – 16 g/dl
Formed Elements

- Erythrocyte Production

  - Hematopoiesis (hemopoiesis) – takes place where?
  
  - Erythropoiesis
Formed Elements

- Regulation and Requirements for Erythropoiesis

![Diagram showing the cycle of erythropoiesis]

- Normal blood oxygen levels
- Imbalance
- Reduction in O2 levels in blood
- Erythropoietin stimulates red bone marrow
- Enhanced erythropoiesis increases RBC count
- Kidney (and liver to a smaller extent) releases erythropoietin
- Stimulus: Hypoxia due to decreased RBC count, decreased availability of O2 to blood, or increased tissue demands for O2
Formed Elements

- Dietary Requirements/Fate and Destruction of Erythrocytes
  - Typical nutrients
  - Iron
    - Stored in cells bound to proteins (ferritin and hemosiderin)
    - Small amounts lost daily in feces, urine, and perspiration (Women more, why?)
    - B12 and folic acid – needed for DNA synthesis
Formed Elements

- Erythrocyte Disorders

  - Anemias
    - Insufficient number of RBC’s
      » Hemorrhagic - The result of blood loss
      » Pernicious - A deficiency of vitamin B12
      » Aplastic - A disorder of the red bone marrow (x-rays, chemotherapy)
    - Low Hb - Iron deficient

  - Abnormal Hemoglobin
    » Thalassemias
    » Sickle-Cell Anemia

- Polycythemias
  - Primary (Polycythemia vera)
  - Secondary
Formed Elements
• **Leukocytes (WBC’s)**

![Diagram of Leukocytes]

- **Leukocytes**
  - **Granulocytes**
    - Neutrophils
    - Eosinophils
    - Basophils
  - **Agranulocytes**
    - Lymphocytes
    - Monocytes
Formed Elements

- Differential WBC Count

Differential WBC count
(All total 4800–10,800/mm³)

- Formed elements
  - Platelets
  - Leukocytes
  - Erythrocytes

- Granulocytes
  - Neutrophils (50–70%)
  - Eosinophils (2–4%)
  - Basophils (0.5–1%)

- Agranulocytes
  - Lymphocytes (25–45%)
  - Monocytes (3–8%)
Granulocytes

- Neutrophils (Polymorphonuclear Lymphocytes [PMN’s], polys
  - 50 – 70%
  - 2 – 5 lobes
  - Phagocytic – engulf bacteria
Granulocytes

- **Eosinophils**
  - 2 – 4%
  - 2 – 3 lobes
  - Red/orange granules
  - Associated with allergic reactions and parasitic infections
Granulocytes

• Basophils

  – < 1%

  – Dark blue granules, obscure the nucleus (heparin and histamine)

  – Associated with immediate immune response (asthma, hay fever and anaphylaxis)
Agranulocytes

- **Lymphocytes**
  - 20 – 45%
  - Large nucleus with a small amount of cytoplasm
  - Two types
    - B cells - important in humoral immunity, they become plasma cells which produce antibodies [Ab’s])
    - T cells – are important in cell mediated immunity
Agranulocytes

• Monocytes
  – 3 – 8%
  – “U” shaped nucleus
  – Are capable of leaving the blood stream where they become phagocytic macrophages
Formed Elements

- Production and Life Span of Leukocytes
Formed Elements

• Leukocyte Disorders
  – Leukopenia – lower then normal numbers of WBC’s – typically the result of certain drugs (glucocorticoids and anticancer agents)
  – Leukemias
    • Myelocytic Leukemias
    • Lymphocytic Leukemias
    • Acute or Chronic
  – Infectious Mononucleosis
    • Epstein Barr Virus
      – Larger than normal number of atypical agranulocytes
Formed Elements

- **Platelets**
  - Disc-shaped
  - Anucleate
  - Derived from megakaryocytes
  - Function in blood clotting
  - Life span 5-9 days, removed by macrophages in the liver and spleen
  - 250,000 – 400,000 / mm$^3$
Hemostasis

- Vascular spasm – contraction of smooth muscle, produced by the nervous system and chemicals (thromboxanes and endothelin)

- Platelet Plug Formation
  - Von Willebrand Factor – makes collagen fibers very sticky
  - Platelets release
    - Serotonin – enhances vascular spasm
    - ADP – attracts more platelets to the area, which release more of the same

- Coagulation – conversion of fibrinogen to fibrin
Injury to lining of vessel exposes collagen fibers; platelets adhere

Platelet plug forms with trapped red blood cells

Platelets release chemicals that make nearby platelets sticky

Collagen fibers

PF₃ from platelets and tissue factor from damaged tissue cells + Calcium and other clotting factors in blood plasma

Formation of prothrombin activator

Prothrombin

Fibrinogen (soluble)

Fibrinogen (insoluble)

Intrinsic pathway

Vessel endothelium ruptures, exposing underlying tissues (e.g., collagen)

Platelets cling and their surfaces provide sites for mobilization of factors

Ca²⁺

VII

VIIa

TF/VIIa complex

TIa/VIIIa complex

IXIXa

IXa

IXa

Calcium

Platelets

Prothrombin activator

Fibrinogen (II)

Thrombin (IIa)

Ca²⁺

XIII

XIIIa

Cross-linked fibrin polymer

Extrinsic pathway

Tissue cell trauma causes release of

Tissue factor (TF)

Ca²⁺

V

Vₐ

Prothrombin (I)

Fibrin
Hemostasis

- Clot Retraction and Repair

- Fibrinolysis – involves the conversion of plasminogen to plasmin the result of tissue plasminogen activator (TPA)
Hemostasis Disorders

- Thrombocytopenia – a reduced number of platelets

- Hemophilia – genetic disorder resulting in absent or impaired clotting – typically the result of an inability to produce one or more clotting factors

- Von Willibrand’s Disease – most common clotting disorder – a decrease in factor VIII (Von Willibrand’s factor)

- Asprin/Warfarin/Heparin

- Impaired Liver Function

- Thrombus – a stationary blood clot within a blood vessel

- Embolus – a moving blood clot