BLOOD
Chapter 14
Karen Webb Smith

BLOOD

Blood
• connective tissue
• transports vital substances
• maintains stability of interstitial fluid
• distributes heat

Blood Cells
• form mostly in red bone marrow
• red blood cells
• white blood cells
• platelets (cell fragments)

Blood Volume
• varies with
  - body size
  - changes in fluid concentration
  - changes in electrolyte concentration
  - amount of adipose tissue
• about 8% of body weight
• about 5 liters

Blood Composition

Origin of Blood Cells

Characteristics of Red Blood Cells
• erythrocytes
• biconcave discs
• one-third hemoglobin
  - oxyhemoglobin
  - deoxyhemoglobin
• can readily squeeze through capillaries
• lack nuclei and mitochondria
Red Blood Cell Counts

- number of RBCs in a cubic millimeter of blood
  - 4,600,000 – 6,200,000 in males
  - 4,200,000 – 5,400,000 in adult females
  - 4,500,000 – 5,100,000 in children
- reflects blood’s oxygen carrying capacity

Red Blood Cell Production

- low blood oxygen causes kidneys and liver to release erythropoietin which stimulates RBC production
- vitamin B₁₂, folic acid and iron necessary

Dietary Factors Affecting Red Blood Cell Production

<table>
<thead>
<tr>
<th>Substance</th>
<th>Source</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B₁₂, folic acid</td>
<td>Absorbed from small intestine</td>
<td>DNA synthesis</td>
</tr>
<tr>
<td>Iron deficiency anemia</td>
<td>Dietary lack of Iron</td>
<td>Hemoglobin deficient</td>
</tr>
<tr>
<td>Pernicious anemia</td>
<td>Inability to absorb vitamin B₁₂</td>
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Life Cycle of Red Blood Cell

- circulate for about 120 days
- macrophages in spleen and liver destroy worn out RBCs
- hemoglobin is broken down into heme and globin
- iron from heme returns to red bone marrow
- bilirubin and biliverdin excreted in bile

Types of Anemia

<table>
<thead>
<tr>
<th>Type</th>
<th>Cause</th>
<th>Defect</th>
</tr>
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<tbody>
<tr>
<td>Aplastic anemia</td>
<td>Toxic chemicals, radiation</td>
<td>Damaged bone marrow</td>
</tr>
<tr>
<td>Hemolytic anemia</td>
<td>Toxic chemicals</td>
<td>Red blood cells destroyed</td>
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Anemia

Normal RBCs

RBCs of person with hypochromic anemia
**Destruction of Red Blood Cells**

<table>
<thead>
<tr>
<th>TABLE 14.5</th>
<th>Major Events in Red Blood Cell Destruction</th>
</tr>
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<tbody>
<tr>
<td>1. Spreading through the capillaries of active tissues damages red blood cells.</td>
<td></td>
</tr>
<tr>
<td>2. Macrophages in the spleen and liver phagocytize damaged red blood cells.</td>
<td></td>
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<tr>
<td>3. Hemoglobin from the red blood cells is decomposed into heme and globin.</td>
<td></td>
</tr>
<tr>
<td>4. Heme is decomposed into iron and biliverdin.</td>
<td></td>
</tr>
<tr>
<td>5. Iron is made available for reuse in the synthesis of new hemoglobin or is stored in the liver as ferritin.</td>
<td></td>
</tr>
<tr>
<td>6. Some biliverdin is converted to bilirubin.</td>
<td></td>
</tr>
<tr>
<td>7. Biliverdin and bilirubin are excreted in bile as bile pigments.</td>
<td></td>
</tr>
<tr>
<td>8. The globin is broken down into amino acids that are metabolized by macrophages or released into the blood.</td>
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**White Blood Cells**

- **leukocytes**
- protect against disease
- interleukins and colony-stimulating factors stimulate development

<table>
<thead>
<tr>
<th>granulocytes</th>
<th>agranulocytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>neutrophils</td>
<td>lymphocytes</td>
</tr>
<tr>
<td>eosinophils</td>
<td>monocytes</td>
</tr>
</tbody>
</table>

**Neutrophils**

- light purple granules in acid-base stain
- lobed nucleus
- other names
  - segs
  - polymorphonuclear leukocyte
  - bands (young neutrophils)
- first to arrive at infections
- phagocytic
- 54% - 62% of leukocytes
- elevated in bacterial infections

**Eosinophils**

- deep red granules in acid stain
- bilobed nucleus
- moderate allergic reactions
- defend against parasitic worm infestations
- 1% - 3% of leukocytes
- elevated in parasitic worm infestations and allergic reactions

**Basophils**

- deep blue granules in basic stain
- release histamine
- release heparin
- less than 1% of leukocytes
- similar to eosinophils in size and shape of nuclei

**Monocytes**

- largest blood cell
- spherical, kidney-shaped, oval or lobed nuclei
- leave bloodstream to become macrophages
- 3% - 9% of leukocytes
- phagocytize bacteria, dead cells, and other debris
Lymphocytes
- slightly larger than RBC
- large spherical nucleus surrounded by thin rim of cytoplasm
- T cells and B cells
  - important in immunity
- B cells produce antibodies
- 25% - 33% of leukocytes

Diapadesis
- leukocytes squeeze between the cells of a capillary wall and enter the tissue space outside the blood vessel

Positive Chemotaxis
- movement of leukocytes toward the damaged tissue region because of the chemicals that were released by damaged cells

White Blood Cell Counts
- procedure used to count number of WBCs per cubic millimeter of blood
- 5,000 – 10,000 per cubic millimeter of blood
- **leukopenia**
  - low WBC count (below 5,000)
  - typhoid fever, flu, measles, mumps, chicken pox, AIDS
- **leukocytosis**
  - high WBC count (above 10,000)
  - acute infections, vigorous exercise, great loss of body fluids
- **differential WBC count**
  - lists percentages of types of leukocytes
  - may change in particular diseases

Blood Platelets
- **thrombocytes**
- cell fragments of megakaryocytes
- 130,000 – 360,000 per cubic millimeter of blood
- helps control blood loss from broken vessels
Blood Platelets

- Blood Plasma
  - straw colored
  - liquid portion of blood
  - 55% of blood
  - 92% water

Plasma Proteins

Gases and Nutrients

- Gases
  - oxygen
  - carbon dioxide

- Nutrients
  - amino acids
  - simple sugars
  - nucleotides
  - lipids

Nonprotein Nitrogenous Substances

- molecules containing nitrogen but are not proteins
  - urea – product of protein catabolism; about 50% of NPN substances
  - uric acid – product of nucleic acid catabolism
  - amino acids – product of protein catabolism
  - creatine – stores phosphates
  - creatinine – product of creatine metabolism
  - BUN – blood urea nitrogen; indicate health of kidney

Plasma Electrolytes

- absorbed from the intestine or released as by-products of cellular metabolism
  - sodium
  - potassium
  - calcium
  - magnesium
  - chloride
  - bicarbonate
  - phosphate
  - sulfate
  - sodium and chloride are most abundant
Hemostasis

- stoppage of bleeding

Blood Vessel Spasm
- triggered by pain receptors, platelet release, or serotonin
  - smooth muscle in vessel contracts

Platelet Plug Formation
- triggered by exposure of platelets to collagen
  - platelets adhere to rough surface to form a plug

Blood Coagulation
- triggered by cellular damage and blood contact with foreign surfaces
  - blood clot forms

Blood Coagulation

Coagulation
- hemostatic mechanism
- causes the formation of a blood clot via a series of reactions which activates the next in a cascade
- occurs extrinsically or intrinsically

Extrinsic Clotting Mechanism
- chemical outside of blood triggers blood coagulation
  - triggered by thromboplastin (not found in blood)
  - triggered when blood contacts damaged tissue

Intrinsic Clotting Mechanism
- chemical inside blood triggers blood coagulation
  - triggered by Hageman factor (found inside blood)
  - triggered when blood contacts a foreign surface

Blood Coagulation

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<th>Trigger</th>
<th>Extrinsic Clotting Mechanism</th>
<th>Intrinsic Clotting Mechanism</th>
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<tr>
<td>Damage to vessel or tissue</td>
<td>Tissue thromboplastin</td>
<td>Hageman factor</td>
</tr>
<tr>
<td>Extrinsic activator</td>
<td>Prothrombin activator</td>
<td>Prothrombin activator</td>
</tr>
<tr>
<td>Prothrombin to thrombin</td>
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Fate of Blood Clots

• After forming, a blood clot retracts and pulls the edges of a broken vessel together while squeezing the fluid serum from the clot
• Platelet-derived growth factor stimulates smooth muscle cells and fibroblasts to repair damaged blood vessel walls
• Plasmin digests blood clots
• thrombus – abnormal blood clot
• embolus – blood clot moving through blood

Prevention of Coagulation

• The smooth lining of blood vessels discourages the accumulation of platelets and clotting factors
• As a clot forms, fibrin adsorbs thrombin and prevents the clotting reaction from spreading
• Antithrombin inactivates additional thrombin by binding to it and blocking its action on fibrinogen
• Some cells, such as basophils and mast cells secrete heparin (an anticoagulant)

Prevention of Coagulation

Factors That Inhibit Blood Clot Formation

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<th>Factor</th>
<th>Action</th>
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<tr>
<td>Ibuprofen</td>
<td>Decreases adhesiveness of white blood cells</td>
</tr>
<tr>
<td>Penicillin</td>
<td>Increased fibrinolytic activity</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Inhibits thrombin</td>
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Antigens and Antibodies

Agglutination – clumping of red blood cells in response to a reaction between an antibody and an antigen

Antigens – a chemical that stimulates cells to produce antibodies

Antibodies – a protein that reacts against a specific antigen

Antigens and Antibodies

Agglutination

[Diagrams showing agglutination of red blood cells]
ABO Blood Group

Based on the presence or absence of two major antigens on red blood cell membranes

- antigen A
- antigen B

Rh Blood Group

Rh positive – presence of antigen D or and other Rh antigens on the red blood cell membranes

Rh negative – lack of these antigens

Blood Types for Transfusion

<table>
<thead>
<tr>
<th>Blood Type of Donor</th>
<th>Preferred Blood Type of Recipient</th>
<th>Permissible Antigen Type of Donor for an Emergency Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>AB</td>
<td>A or B</td>
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Clinical Application

Leukemia

Myeloid Leukemia
- bone marrow produces too many immature granulocytes
- leukemia cells crowd out other blood cells
- anemia
- bleeding
- susceptible to infections

Lymphoid Leukemia
- lymphocytes are cancerous

Treatments
- drugs
- marrow and umbilical cord transplants
- chemotherapy regimens