Chapter 11
Lecture and Animation Outline

To run the animations you must be in Slideshow View. Use the buttons on the animation to play, pause, and turn audio/text on or off.

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See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes and animations.
Functions of Blood

• Transport of gases, nutrients and waste products
• Transport of processed molecules
• Transport of regulatory molecules
• Regulation of pH and osmosis
• Maintenance of body temperature
• Protection against foreign substances
• Clot formation
Characteristics of Blood

• Type of connective tissue
• Sticky
• Heavier than water
• $O_2$ content determines color
• Temp. slightly higher than rest of body
• Males (5-6 L), females (4-5 L)
Percentage by body weight

Percentage by volume

Plasma (percentage by weight)
- Proteins 7%
- Albumins 58%
- Globulins 38%
- Fibrinogen 4%

Water 91%

Other solutes 2%

Plasma (percentage by volume)
- Plasma 55%
- Buffy coat

Formed elements (number per cubic mm)
- Red blood cells 4.2–6.2 million
- White blood cells 5–10 thousand
- Platelets 250–400 thousand

Formed elements
- Neutrophils 60%–70%
- Lymphocytes 20%–25%
- Monocytes 3%–8%
- Eosinophils 2%–4%
- Basophils 0.5%–1%

Buffy coat

Percentage by body weight

(Photograph: © liquidlibrary/PictureQuest RF)
Composition of Blood

• **Plasma:**
  - 55% of total blood
  - pale, yellow liquid that surrounds cells
  - 91% water, 7% proteins, and 2% other

• **Formed Elements:**
  - 45% of total blood
  - cells and cell fragments
  - erythrocytes, leukocytes, thrombocytes
Plasma Proteins

• **Albumin:**
  - 58% of plasma proteins
  - helps maintain water balance

• **Globulins:**
  - 38% of plasma proteins
  - helps immune system

• **Fibrinogen:**
  - 4% of plasma proteins
  - aids in clot formation
Erythrocytes

- Red blood cells (RBC)
- Disk-shaped with thick edges
- Nucleus is lost during development
- Live for 120 days
- **Function:** transport $O_2$ to tissues
Hemoglobin

- Main component of erythrocytes
- Transports $O_2$
- Each globin protein is attached to a heme molecule
- Each heme contains one iron atom
- $O_2$ binds to iron
- **Oxyhemoglobin:**
  hemoglobin with an $O_2$ attached
Production of Erythrocytes

1. Decreased blood $O_2$ levels cause kidneys to increase production of *erythropoietin*.

2. Erythropoietin stimulates red bone marrow to produce more erythrocytes.

3. Increased erythrocytes cause an increase in blood $O_2$ levels.
Fate of Old Erythrocytes and Hemoglobin

• Old rbc’s are removed from blood by macrophages in spleen and liver
• Hemoglobin is broken down
• Globin is broken down into amino acids
• Hemoglobin’s iron is recycled
• Heme is converted to bilirubin
• Bilirubin is taken up by liver and released into small intestine as part of bile
In macrophages, the globin part of hemoglobin is broken down to individual amino acids (*pink arrow*) and metabolized or used to build new proteins.

The heme of hemoglobin releases iron. The heme is converted into bilirubin.

Blood transports iron to the red bone marrow, where it is used to produce new hemoglobin (*green arrows*).

Blood transports bilirubin (*blue arrows*) to the liver.

Bilirubin is excreted as part of the bile into the small intestine.

Bilirubin derivatives contribute to the color of feces or are reabsorbed from the intestine into the blood and excreted from the kidneys in the urine.

**PROCESS Figure 11.5 Hemoglobin Breakdown**

Macrophages break down hemoglobin, and the breakdown products are used or excreted.
Please note that due to differing operating systems, some animations will not appear until the presentation is viewed in Presentation Mode (Slide Show view). You may see blank slides in the “Normal” or “Slide Sorter” views. All animations will appear after viewing in Presentation Mode and playing each animation. Most animations will require the latest version of the Flash Player, which is available at http://get.adobe.com/flashplayer.

When old red blood cells rupture, the released hemoglobin is ingested by macrophages. The globin chains of hemoglobin are broken down to individual amino acids that are metabolized or used to build new proteins.
Leukocytes

- White blood cells (WBC)
- Lack hemoglobin
- Larger than erythrocytes
- Contain a nucleus

**Functions:**
- fight infections
- remove dead cells and debris by phagocytosis
Types of Leukocytes

• **Granulocytes** contain granules

1. **Neutrophils:**
   - most common
   - remain in blood for 10-12 hours then move to tissues
   - phagocytes
2. **Eosinophils:**
   reduce inflammation

3. **Basophils:**
   - least common
   - release histamine and heparin
• **Agranulocytes**
  no granules

1. **Monocytes:**
   - largest
   - produce macrophages

2. **Lymphocytes:**
   - immune response
   - several different types (T cells and B cells)
   - lead to production of antibodies
Platelets

- What are they?
  - blood clotting cells
  - produced in red bone marrow
Hematopoiesis

• What is it?
  process of blood cell formation

• In an infant, occurs in liver, thymus gland, spleen, lymph nodes, and red bone marrow.

• Adults occurs mainly in red bone marrow.

• Stem cell:
  original cell line
Blood Loss

• When blood vessels are damaged, blood can leak into other tissues and disrupt normal function.

• Blood that is lost must be replaced by production of new blood or by a transfusion.
Preventing Blood Loss

1. **Vascular spasm:**
   temporary constriction of blood vessel

2. **Platelet plugs:**
   can seal up small breaks in blood vessels

3. **Blood clotting (coagulation)**
Blood Clotting

• Blood can be transformed from a liquid to a gel

• Clot:
  - network of thread-like proteins called fibrin that trap blood cells and fluid
  - depends on clotting factors

• Clotting factors:
  - proteins in plasma
  - only activated following injury
  - made in liver
  - require vitamin K
Platelet adhesion occurs when von Willebrand factor connects collagen and platelets.

During the platelet release reaction, ADP, thromboxanes, and other chemicals are released and activate other platelets.

Platelet aggregation occurs when fibrinogen receptors on activated platelets bind to fibrinogen, connecting the platelets to one another. The accumulating mass of platelets forms a platelet plug.
Steps in Clot Formation

1. Injury to a blood vessel causes inactive clotting factors to become activated due to exposed conn. tissue or release of thromboplastin

2. **Prothrombinase** (clotting factor) is formed and acts upon prothrombin

3. **Prothrombin** is switched to its active form thrombin

4. Thrombin activates **fibrinogen** into its active form fibrin

5. **Fibrin** forms a network that traps blood (**clots**)
Stage 1
1 Inactive clotting factors are activated by exposure to connective tissue or by chemicals released from tissues. Through a series of reactions, the activated clotting factors form prothrombinase.

Stage 2
2 Prothrombinase converts prothrombin to thrombin.

Stage 3
3 Thrombin converts fibrinogen to fibrin (the clot).

PROCESS Figure 11.9 Clot Formation
Clot formation has three stages.
Control of Clot Formation

• Clots need to be controlled so they don’t spread throughout the body

• **Anticoagulants:**
  - prevent clots from forming
  - Ex. Heparin and antithrombin

• Injury causes enough clotting factors to be activated that anticoagulants can’t work in that particular area of the body
Clot Retraction and Fibrinolysis

• Clot retraction:
  - condensing of clot
  - serum in plasma is squeezed out of clot
  - helps enhance healing

• Fibrinolysis:
  - process of dissolving clot
  - plasminogen (plasma protein) breaks down clot (fibrin)
Thrombin and tissue plasminogen activator convert inactive plasminogen into plasmin.

1. Thrombin and tissue plasminogen activator convert inactive plasminogen into plasmin.

2. Plasmin breaks down the fibrin in a blood clot, resulting in clot fibrinolysis.
Blood Reactions

- Injury or surgery can lead to a blood transfusion
- Transfusion reactions/Aggulination:
  clumping of blood cells (bad)
- Antigens:
  molecules on surface of erythrocytes
- Antibodies:
  proteins in plasma
- Blood groups:
  named according to antigen (ABO)
# ABO Blood Groups

<table>
<thead>
<tr>
<th>Type</th>
<th>A</th>
<th>B</th>
<th>AB</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antigen</strong></td>
<td>A</td>
<td>B</td>
<td>A&amp;B</td>
<td>None</td>
</tr>
<tr>
<td><strong>Antibodies</strong></td>
<td>Anti-B</td>
<td>Anti-A</td>
<td>None</td>
<td>Anti-A&amp;B</td>
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<td>3(^{rd})</td>
<td>4(^{th})</td>
<td>1(^{st})</td>
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<tr>
<td>Red blood cells</td>
<td>Plasma</td>
<td>Type A</td>
<td>Type B</td>
<td>Type AB</td>
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<td>----------------</td>
<td>--------</td>
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</tr>
<tr>
<td>Antigen A</td>
<td>Anti-B antibody</td>
<td>Red blood cells with type A surface antigens and plasma with anti-B antibodies</td>
<td>Red blood cells with type B surface antigens and plasma with anti-A antibodies</td>
<td>Red blood cells with both anti-A and anti-B surface antigens, and neither anti-A nor anti-B plasma antibodies</td>
</tr>
<tr>
<td>Antigen B</td>
<td>Anti-A antibody</td>
<td>Neither Anti-A nor Anti-B antibodies</td>
<td>Anti-A and Anti-B antibodies</td>
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<td>Antigens A and B</td>
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<tr>
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</tr>
</tbody>
</table>

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Type A blood of donor

Anti-B antibody in type A blood of recipient

Antigen and antibody do not match

No agglutination

Type A blood of donor

Anti-A antibody in type B blood of recipient

Antigen and antibody match

Agglutination
• O are universal donors because they have no antigens

• Type A can receive A and O blood

• Type B can receive B and O blood

• Type AB can receive A, B, AB blood

• Type O can only receive O blood
Rh Blood Group

- Rh positive means you have Rh antigens

- 95-85% of the population is Rh+

- Antibodies only develop if an Rh- person is exposed to Rh+ blood by transfusion or from mother to fetus
Example of Rh Reaction

- If mother is Rh- and fetus is Rh+ the mother can be exposed to Rh+ blood if fetal blood leaks through placenta and mixes with mother’s blood.

- First time this occurs mother’s blood produces antibodies against antigens.

- Any repeated mixing of blood causes a reaction.
Hemolytic Disease of Newborn

• What is it?
  - occurs when mother produces anti-Rh antibodies that cross placenta and agglutination and hemolysis of fetal erythrocytes occurs
  - can be fatal to fetus
  - prevented if mother is treated with RhoGAM which contains antibodies against Rh antigens
Figure 11.13

1. Before or during delivery, Rh-positive red blood cells from the fetus enter the blood of an Rh-negative woman through a tear in the placenta.

2. The mother is sensitized to the Rh antigen and produces anti-Rh antibodies. Because this usually happens after delivery, there is no effect on the fetus in the first pregnancy.

3. During a subsequent pregnancy with an Rh-positive fetus, Rh-positive red blood cells cross the placenta, enter the maternal circulation, and stimulate the mother to produce antibodies against the Rh antigen. Antibody production is rapid because the mother has been sensitized to the Rh antigen.

4. The anti-Rh antibodies from the mother cross the placenta, causing agglutination and hemolysis of fetal red blood cells, and hemolytic disease of the newborn (HDN) develops.
Diagnostic Blood Tests

• Complete blood count:
  provides information such as RBC count, hemoglobin, hematocrit, and WBC count

• Hematocrit:
  % of total blood volume composed of RBC

• Hemoglobin:
  - determines amount of hemoglobin
  - indicate anemia
Centrifuge blood in the hematocrit tube

Withdraw blood into hematocrit tube

Hematocrit scale

(a) (b)

Hematocrit tube
Plasma
White blood cells and platelets form the buffy coat
Red blood cells
• Prothrombin time:
  time it takes for blood to begin clotting (9-12 sec.)
• White blood cell count:
  total number of wbc
• White blood cell differential count:
  - Determines the % of each 5 kinds of leukocytes
  - neutrophils: 60-70%
  - lymphocytes: 20-25%
  - monocytes: 3-8%
  - eosinophils: 2-4%
  - basophils: 0.5-1%
White Blood Cell Disorders

• Leukopenia:
  - low wbc count
  - caused by radiation, chemotherapy drugs, tumors, viral infections

• Leukocytosis:
  - high wbc count
  - caused by infections and leukemia