**What are the functions of blood?**

- **Transportation:** oxygen, nutrients, wastes, carbon dioxide and hormones
- **Defense:** against invasion by pathogens
- **Regulatory functions:** body temperature, water-salt balance and body pH

**What is the composition of blood?**

- Remember: blood is a fluid connective tissue
- **Formed elements:** produced in red bone marrow
  - Red blood cells/erythrocytes (RBC)
  - White blood cells/leukocytes (WBC)
  - Platelets
- **Plasma:**
  - 92% water and 8% salts and organic molecules
  - Plasma proteins are the most abundant molecules

**3 major types of plasma proteins**

- **Albumins** - most abundant and important for plasma's oncotic pressure as well as transportation
- **Globulins** - also important in transportation
- **Fibrinogen** - important for the formation of blood clots
Where do the formed elements come from and what are they?

6.1 Blood: An overview

The structure of red blood cells is important to their function

- Lack a nucleus and few organelles
- Biconcave shape increases surface area
- Contain about 280 million hemoglobin molecules that bind 4 molecules of O₂ each

6.2 Blood: Red blood cells and transport of oxygen

How is carbon dioxide transported?

- 68% as a bicarbonate ion in the plasma (this conversion takes place in RBCs)
- 25% in red blood cells
- 7% as carbon dioxide in the plasma
Production of red blood cells

- Produced in the red bone marrow
- Lifespan of about 120 days
- Erythropoietin (EPO) is excreted by kidney cells and moves to red marrow when oxygen levels are low
- Old cells are destroyed by the liver and spleen

What is blood doping?

- Any method of increasing the number of RBC’s to increase athletic performance
- It allows more efficient delivery of oxygen and reducing fatigue
- EPO is injected into a person months prior to an athletic event
- Is thought to be able to cause death due to thickening of blood that leads to a heart attack

What disorders involve RBC’s?

- **Anemia** – a condition resulting from too few RBC’s or hemoglobin that causes a run-down feeling
- **Sickle-cell anemia** – genetic disease that causes RBC’s to be sickle shaped that tend to rupture
- **Hemolytic disease of the newborn** – a condition with incompatible blood types that leads to rupturing of blood cells in a baby before and continuing after birth
6.3 White blood cells and defense against disease

**White blood cells**

- Derived from red bone marrow
- Large blood cells that have a nucleus
- Production is regulated by colony-stimulating factor (CSF)
- Can be found in the blood as well as in tissues
- Fight infection and an important part of the immune system
- Some live days and others live months or years

**Movement of WBC's out of circulation**

**How are white blood cells categorized?**

- **Granular** - contain noticeable granules, lobed nuclei
  - Eosinophil
  - Basophil
  - Neutrophil

- **Agranular** - no granules, nonlobed nuclei
  - Lymphocyte
  - Monocyte
**Neutrophils**
- About 50-70% of all WBC's
- Contain a multi-lobed nucleus
- Upon infection they move out of circulation into tissues to use phagocytosis to engulf pathogens

**Eosinophils**
- Small percentage of WBC's
- Contain a bilobed nucleus
- Many large granules function in parasitic infections and play a role in allergies

**Basophils**
- Small percentage of WBC's
- Contain a U-shaped or lobed nucleus
- Release histamine related to allergic reactions
Lymphocyte

- About 25-35% of all WBC's
- Large nucleus that takes up most of the cytoplasm
- Develop into B and T cells that are important in the immune system

Monocyte

- Relatively uncommon WBC's
- Largest WBC with horseshoe-shaped nucleus
- Take residence in tissues and develop into macrophages
- Macrophages use phagocytosis to engulf pathogens

What disorders involve WBC's?

- **Severe combined immunodeficiency disease (SCID)** - an inherited disease in which stem cells of WBC's lack an enzyme that allows them to fight any infection

- **Leukemia** - a group of cancers that affect white blood cells in which cells proliferate without control

- **Infectious mononucleosis** - also known as the "kissing disease" occurs when the Epstein-Barr virus (EBV) infects lymphocytes resulting in fatigue, sore throat and swollen lymph nodes
Platelets

- Made of fragments of large cells called megakaryocytes made in the red bone marrow
- About 200 billion are made per day
- Function in blood clotting
- Blood proteins named thrombin and fibrinogen are important for blood clotting by leading to fibrin threads that catch RBCs

How do platelets clot blood?

What disorders involve platelets (Etc.)?

- Thrombocytopenia - a disorder in which the number of platelets is too low due to not enough being made in the bone marrow or the increased breakdown outside the marrow
- Thromboembolism - when a clot forms and breaks off from its site of origin and plugs another vessel
- Hemophilia - a genetic disorder that results in a deficiency of a clotting factor so that when a person damages a blood vessel they are unable to properly clot their blood both internally and externally
Health Focus: What do you need to know about donating blood?

- Donating blood is a safe and sterile procedure
- You will donate about a pint of blood
- You will replace the plasma in a few hours and the cells in a few weeks
- A few people may feel dizzy afterwards so sit down, eat a snack and drink some water
- Your blood will at least be tested for syphilis, HIV antibodies and hepatitis and if any of them come back positive you will be notified
- Your blood can help save many lives
- You should not give blood if:
  - You have ever had hepatitis, malaria or been treated for syphilis or gonorrhea within 12 months
  - If you risk for having HIV or have AIDS

6.4 Platelets and blood clotting

Terminology to help understand ABO blood typing?

- **Antigen** - a foreign substance, often a polysaccharide or a protein, that stimulates an immune response
- **Antibody** - proteins made in response to an antigen in the body and bind to that antigen
- **Blood transfusion** - transfer of blood from one individual into another individual

6.5 Blood typing and transfusions

What determines the A, B, AB or O blood type?

- Presence and/or absence of 2 blood antigens, A and B
- Type of antibodies present
- Antibodies are only present for those antigen lacking on the cells
6.5 Blood typing and transfusions

How can you remember what each blood type means?

► Blood types are named after the protein antigens that are present on the surface of their cells, except type O that entirely lacks A and B proteins.

► Blood types only have antibodies to antigens they do not have on the surface of their cells.

► For example: Type A blood
  - Have A proteins on its surface
  - Has B antibodies

► What can you say about someone with type AB blood?

6.5 Blood typing and transfusions

Looking at each blood type in the ABO blood system

6.5 Blood typing and transfusions

How can you determine if blood types are compatible for a blood transfusion?

► First, consider the antigens found on the blood transfusion recipient.

► Second, consider the antibodies found in the donor blood.

► If the antibodies in the donor blood can recognize the antigen on the recipient's blood, then the blood will agglutinate (clump) and cause rejection.
6.5 Blood typing and transfusions

Testing your understanding

► Can a person with blood type O accept blood type A without agglutination occurring? Why or why not?

► Why can people with AB blood type accept more blood types than people with type O, A or B?

► Which blood type is able to be used most often as a donor blood type? Why?

6.5 Blood typing and transfusions

What about Rh blood groups?

► The Rh factor is often included when expressing a blood type by naming it positive or negative

► People with the Rh factor are positive and those without it are negative

► Rh antibodies only develop in a person when they are exposed to the Rh factor from another’s blood (usually a fetus)

6.5 Blood typing and transfusions

Visualizing how hemolytic disease of the newborn happens?

6.5 Blood typing and transfusions

Visualizing how hemolytic disease of the newborn happens?
How can hemolytic disease of the newborn be prevented?

► Rh- women are given an injection of anti-Rh antibodies (Rhogam) no later than 72 hours after birth to an Rh+ baby.

► These antibodies attack fetal red blood cells in the mother before the mother’s immune system can make antibodies.

► This will have to be repeated if an Rh+ mother has another Rh+ baby in case she has later pregnancies.

How does the heart, blood vessels and blood work with other systems to maintain homeostasis?