References (Textbook - pages 611-630, Lab Manual pages 248-250)

Definition

In animals, the circulatory system is an organ system that moves substances to and from cells and tissues usually via a heart, blood vessels, and blood. In summary it is a transportation system.

In human beings, the blood, kept in motion by the pumping of the heart circulates through the vessels.

Review of Open and Closed Circulatory Systems

1. To follow along with the lecture, see handout of figure 34.2 from page 613 of the textbook.

2. Remember that the grasshopper and certain other invertebrates have an open circulatory system where:
   - There are no veins or capillaries
   - "Blood" actually mixes with other body cavity fluids before being recaptured by the heart.
   - A more accurate term for the "blood" of organisms with an open circulatory system is hemolymph.
   - Hemolymph is a mixture of blood and other fluids from the body cavity

3. Earthworms and humans have a closed circulatory system where:
   - The system is totally enclosed and includes
     1. a heart
     2. blood vessels that include arteries, veins, and capillaries
     3. and blood made of cells and plasma
Human Circulatory System

1. Three Major Components

Follow along using the handout of figure 34.3 from page 614 of the textbook

- **Heart**

  1. The *heart* is a *cone-shaped muscular organ* about the *size* of a *fist*
  2. It is *located between* the *lungs* directly *behind* the sternum or *breast bone*.
  3. *Most* of the heart is made of *cardiac muscle* tissue called *myocardium*.
  4. The heart has *4 chambers* and several *valves* which we will discuss later

- **Vessels** (arteries, capillaries, veins)

  1. There are *three kinds* of *blood vessels*:

    - **Arteries**

      1. arteries are blood vessels that *carry blood away from the heart*
      2. arteries have *thick walls* and those attached *near the heart* can *expand and contract* with each *heart beat*
      3. *smaller arteries* are called *arterioles* and their *diameter* can be *regulated* by the *nervous system*.
      4. *arteriole constriction* and *dilation* affect *blood pressure*. The greater the number of arterioles dilated, the lower the blood pressure
      5. *arterioles branch* into *smaller vessels* called *capillaries*

    - **Capillaries**

      1. are *extremely narrow*, actually *microscopic tubes*
      2. their *walls* may be composed of only *one layer of cells*
3. In areas of the human body capillaries are so numerous and interconnected that they form capillary beds.

4. In fact, in the human body, capillary beds are so numerous that all human cells are within 60 - 80 micrometers (that is about 0.01 millimeter or 0.0004 inch) of a capillary.

5. Here in the capillary beds where the vessel walls are so thin, is where substances are exchanged with the cells and tissues of the body.

6. Body cells are nourished by the blood when exchange takes place across the thin walls of the capillaries.

7. For example

   - here is where nutrients are passed to the muscle and other cells of the body
   - here is where oxygen is passed on to cells
   - here is where cellular waste products are picked up by the blood.

    * Veins

1. Small veins called venules and other veins collect blood after it passes through capillaries.

2. The walls of veins are usually thinner than the walls of arteries.

3. Blood pressure is usually lower in veins and there are valves that prevent backflow of blood.

    * Blood

1. Blood is the liquid, transport medium in the circulatory system.

2. Blood has a host of functions and is composed of cells and a fluid matrix.

3. We will discuss blood in greater detail later.
2. **Circulation of Blood**

Follow along using the *handout of figure 34.8 from page 620 of the textbook*

- **Power source**

  1. In humans the *contraction* (pumping) of the *heart* keeps blood *moving* in the *arteries*

  2. The pumping of the *heart* is *not enough* to keep *blood moving* in *veins* and there are *skeletal muscles* that contract and *press* against *veins* to keep *blood flowing* back toward the heart.

  3. In humans, other mammals, birds, and crocodiles, the heart *pumps* the *blood* into *two separate pathways* or *circuits*. These are called *systemic circulation* and *pulmonary circulation*.

  4. Think of the *heart* as a *double pump*.
     - the *right* side *pumps* to the *lungs*
     - the *left* side to the *rest* of the *body*

- **Systemic circulation**

  1. Blood pumped from the *heart* directly to *body tissues* and returned to the *heart* is called *systemic circulation* or the *systemic circuit*.

- **Pulmonary circulation**

  1. Blood pumped from the *heart* directly to the *lungs* and returned to the *heart* is called *pulmonary circulation* or the *pulmonary circuit*.

3. **Heart**

Follow along using the *handout of page 250 of the lab manual*

- **Heart Anatomy**

  1. The human *heart* is made of *4 chambers*. These are:

    - **Right atrium**
      - thin walled
      - upper part of heart
• **Left atrium**
  a. thin walled
  b. upper part of heart

• **Right ventricle**
  a. thick muscular walls and pump the blood
  b. lower part of heart

• **Left ventricle**
  a. thick muscular walls and pump the blood
  b. lower part of heart

2. The heart also has 4 valves that **direct** the flow of **blood** and **prevent** its **backward** movement. The 4 valves are

• **2 atrioventricular valves**
  a. these two valves lie between the 2 atria and 2 ventricles

• **2 semilunar valves**
  a. one semilunar valve lies between the **right ventricle** and the **pulmonary trunk** (leads to arteries in lungs and is thus part of **pulmonary circulation** or the **pulmonary circuit**)
  b. the other semilunar valve lies between the **left ventricle** and the **aorta** (which leads to the **rest of the body** and is thus part of **systemic circulation** or the **systemic circuit**)

• **Path of blood flow through heart**

1. the heart **receives** the blood from the **body** into the **right atrium** through two large veins called the **superior vena cava** and **inferior vena cava** (**end of systemic circuit**)

   • this blood is **low in oxygen** (O2) and
   • **high in carbon dioxide** (CO2)

2. **right atrium** sends blood through an **atrioventricular valve** to the **right ventricle**

3. **right ventricle** sends blood through a **semilunar valve** (pulmonary) into the **pulmonary trunk** that leads to arteries to the **lungs** (**Beginning of the pulmonary circuit**)
4. **4 pulmonary veins** empty blood from the **lungs** into the **left atrium** of the heart (ending the **pulmonary circuit**)

   - This blood is now **high** in **oxygen** (O2) and
   - **Low** in **carbon dioxide** (CO2)

5. **Left atrium** sends blood through **atrioventricular valve** to **left ventricle**

6. **Left ventricle** sends blood **out of heart** through **semilunar valve** into the **aorta** to be distributed **throughout** the **body** (**beginning** of **systemic circuit**)

   - **Cardiac cycle (heart beat)** – **handout of conducting tissue of heart**

   1. The heart **beats** or contracts about **70 times a minute**.

   2. The term **systole** (Greek for contractions) refers to **contractions** of the heart **chambers**

   3. The term **diastole** (Greek for dilation) refers to **relaxation** of the heart **chambers**.

4. **One heartbeat** consists of **three phases**.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Atria</th>
<th>Ventricles</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Systole</td>
<td>Diastole</td>
</tr>
<tr>
<td>II</td>
<td>Diastole</td>
<td>Systole</td>
</tr>
<tr>
<td>III</td>
<td>Diastole</td>
<td>Diastole</td>
</tr>
</tbody>
</table>

5. The **pulse** is the **wave effect** that passes down the **walls** of **arterial blood vessels** as the heartbeat pushes blood into the aorta.

   - There is **one pulse per heartbeat** - for this reason the arterial **pulse rate** can be used to determine **heart rate**.

6. The **rhythm** of the **heart beat** is **regulated** by the **nervous system** through **two nodes** in the heart

   - **SA node** located in the **dorsal wall** of the **right atrium**
   - **AV node** that is located in the **base** of the **right atrium**

7. The **SA node initiates** a **heartbeat** about every **0.85 seconds** and is called the **cardiac pacemaker** because it keeps the **heartbeat regular**.
4. Blood Pressure

- Human *blood pressure* is the result of the beating *heart forcing blood* through the *arteries*

- *Systolic pressure* results from *blood* being *forced* into the *arteries* during *ventricular systole* (contraction)

- *Diastolic pressure* is the *pressure* in the *arteries* during *ventricular diastole* (relaxation)

- A *blood pressure* reading consists of *two numbers* - for example 120/80
  a. The *high number* represents *systolic pressure*
  b. The *low number* represents *diastolic pressure*

5. Blood

- *Composition*

  1. *Blood* is *composed* of *two main portions*.
    a. *plasma* - the liquid portion
      - *contains* many types of *molecules* including *nutrients, salts, proteins*, and *wastes*
    b. *cells* and *thrombocytes* (or platelets)

- 2 main *types of blood cells* are

  1. *red blood cells* (erythrocytes) *RBC*
    a. *small*, biconcave *discs* that do not normally have an *nucleus* and contain the respiratory pigment *hemoglobin*
    b. *Oxygen* has an *affinity* for and *attaches* to *hemoglobin*
    c. *Red blood cells* are responsible for *distributing oxygen throughout* the *body*
2. **white blood cells** (leucocytes) \( \text{WBC} \)
   a. **white blood cells** are usually **larger** than **red blood cells** and have **a nucleus**.
   b. They **lack hemoglobin**
   c. These are the **cells** that **fight infections** and **diseases** that enter the body.

- **thrombocytes (or platelets)**
  1. Are **small fragments** of **larger cells produced** in the **red bone marrow**
  2. They **play** an important **role** in **blood clotting** or **coagulation**

- **Functions**
  1. The **blood** has **4 main functions**. These are
     - **Transportation** of substances to and from the capillaries, where exchanges with tissue fluids take place
     - **Guard against invasion by pathogens** like disease causing viruses and bacteria
     - Helps **regulate body temperature**
     - **Clotting**, thus preventing loss of blood

- **Blood types** (see handout of table of basic blood types)
  1. Blood **differs chemically** from **person to person**
  2. **Transfusions** of **different types** of blood can lead to **harmful** and even **fatal reactions**.
  3. Based on the **presence** of certain **antigens** in **red blood cells** and **antibodies** in **plasma** there are **4 basic blood types**. These are **O, A, B, and AB**.

- **Antigens** are foreign substances that stimulate the **immune system** to produce **antibodies**
Antibodies are proteins produced as a result of the presence of an antigen. Each antibody combines with a specific antigen.

4. Discuss the blood types using the blood type table from the handout.

- **Type O** blood has neither antigen A nor B in its red blood cells, but does have antibodies A and B in the plasma.

- **Type A** blood possesses antigen A and antibody B.

- **Type B** blood possess antigen B and antibody A.

- **Type AB** blood possesses both antigens A and B, but both antibodies A and B are absent.

- In general, during transfusions where there is mixing of blood types that put an antigen (like A) with its specific antibody (like antibody A), clumping of the blood will occur.

  **Example** would be a Type A donor and Type B recipient.

- With universal donors and universal recipients there appears to be a contradiction to this principal.

  Examples - Type O donor and Type A recipient
  Type O donor and Type B recipient
  Type O donor and Type AB recipient

  This apparent contradiction has been explained by the demonstration that antibodies A and B can lose their effect when diluted as during transfusions.

5. Another antigen that is found in about 85% of the human population is the Rh factor. Individuals with this antigen are Rh+ while the remaining 15% without the factor are Rh-.

6. Functions

   a) Maintenance of body heat.
   b) Carries H2O, electrolytes, hormones to tissues.
   c) Serves as a transportation system for the body, transporting O2 and nutrients to the body and CO2 away from the tissues.
6. Examples of diseases of the circulatory system

- *Hypertension* or high blood pressure

- *Arteriosclerosis* - an accumulation of soft masses of fatty materials, particularly cholesterol beneath the inner linings of the arteries.

- *Heart attack* - usually occurs when a coronary artery (an artery to the heart) is completely blocked and a portion of the heart dies due to a lack of oxygen.

- *Stroke* - occurs when a small cranial artery bursts or is blocked. The lack of oxygen causes a portion of the brain to die.

* pp. 249 + 250 Manual*