CIRCULATORY SYSTEM
What is the Circulatory System?

- The system of the body responsible for internal transport. Composed of the heart, blood vessels, lymphatic vessels, lymph, and the blood.

- The Circulatory Systems is a combination of vessels and muscle that help and control the flow of blood around the body.

- This is known as CIRCULATION.
The Main Parts of the Circulatory System

• The main parts of the Circulatory System include:
  • The Heart
  • Arteries (within the heart also)
    – carry blood away from the heart
  • Veins
    – Carry blood to the heart
  • Capillaries
Anatomy of the Heart

• The human heart is a muscular pump composed of cardiac muscle that allows for continued rhythmic contraction.
• Cardiac muscle is a involuntary muscle, meaning it does not need to be told to contract.
• It is located in the middle of your chest right behind the sternum and just to the left.
• It is the size of your fist.
Anatomy of the Heart

• There are four chambers in the heart - two atria and two ventricles.

Assignment: Color the heart diagram
Protective Layers of the Heart

• The heart is encased in two protective layers. The outer layer - the pericardial sac - covers the heart.
• While the **epicardium** forms the outer layer of the heart, the **myocardium** forms the middle layer and the **endocardium** the innermost layer.
• The coronary arteries - arteries that provide blood to the heart's own cells - travel across the **epicardium**.

• The muscular **myocardium** is the thickest layer and the workhorse of the heart.

• The **endocardium** has a smooth inner surface to allow blood to flow easily through the heart's chambers. The heart's valves are also part of the **endocardium**.
Parts of the Heart

• The atria (one is called an atrium) are responsible for receiving blood from the veins leading to the heart. When they contract, they pump blood into the ventricles.

• The ventricles are the real workhorses, they must force the blood away from the heart with sufficient power to push the blood all the way back to the heart.
• Between the atria and the ventricles are valves

• These are overlapping layers of tissue that allow blood to flow only in one direction.
Assignment: Define each of the valves in the heart.
The tricuspid valve is between the right atrium and right ventricle.

The pulmonary or pulmonic valve is between the right ventricle and the pulmonary artery.

The mitral valve is between the left atrium and left ventricle.

The aortic valve is between the left ventricle and the aorta.
Blood Supply to Heart

Aorta

Right coronary artery
- Posterior interventricular artery
- Ventricular walls

Left coronary artery
- Marginal artery
- Walls of right atrium and right ventricle
- Walls of left atrium and left ventricle
- Anterior interventricular artery
- Ventricular walls

Cardiac veins

Coronary sinus

Right atrium
Cardiac Conduction System

- S-A node
- A-V node
- Interatrial septum
- Left bundle branch
- Junctional fibers
- A-V bundle
- Right bundle branch
- Purkinje fibers
- Interventricular septum
Cardiac Conduction System

- Sinoatrial node
- Atrial syncytium
- Junctional fibers
- Atrioventricular node
- A-V bundle
- Bundle branches
- Purkinje fibers
- Ventricular syncytium
ELECTROCARDIOGRAPHY

(ECG)
ELECTROCARDIOGRAPHY
((ECG))

the recording of electrical activities of the heart via electrodes placed on body surface.
Applications of ECG

1) measure automaticity
   HR, rhythmicity, pacemaker

2) measure conductivity
   pathway, reentry, block

3) reveal hypertrophy

4) reveal ischemic damages
   location, size, and progress
Waves and Intervals of ECG

- **P wave:** atrial depolarization
- **QRS complex:** ventricular depolarization
- **T wave:** ventricular repolarization
PR Interval

- P wave
- T wave
- P-R interval
- S-T interval
- Q-T interval

Millivolts

Atria contract
Ventricles contract
Disorders of the Cardiac Conduction System ---- Arrhythmias

- refers to abnormal initiation or conduction of electrical impulses in the heart.

- caused by ischemia, fibrosis, inflammation, or drugs.
**Bradycardia**
slow heart rate ( < 60 beats/min)

**Tachycardia**
fast heart rate ( > 100 beats/min)
Atrial or Ventricular Flutter and Fibrillation

- contract uncoordinatedly and extremely rapidly.

- Ventricular fibrillation is lethal.
**Premature contraction**

is when the heart beat is triggered by ectopic pacemakers (cells other than SA node).
Conduction Block
Artificial Pacemaker

Application:
- sinus abnormality,
- complete AV or ventricular block

Function:
- generate electric pulses
- sensing
- antitachyarrhythmia
Types Of Blood Vessels

Arteries – carry blood away from the heart
Capillaries – smallest blood vessels

The site of exchange of molecules between blood and tissue fluid

Veins – carry blood toward the heart

arteries → arterioles → capillaries → venules → veins
Functions Of Blood Vessels

Arteries - carry blood away from heart
Arterioles - small arteries that deliver blood to capillaries
Capillaries – thin walled vessels allow for exchange between blood and tissue cells
Venules - collect and drain blood into veins
Veins - return blood to heart
Structure Of Blood Vessels

Composed of three layers (tunics)
- Tunica intima – composed of simple squamous epithelium
- Tunica media – sheets of smooth muscle
  - Contraction – vasoconstriction
  - Relaxation – vasodilation
- Tunica externa – composed of connective tissue

Lumen - central blood-filled space of a vessel
**Structural Differences**

Arteries have thicker tunica media and narrower lumens

Veins have thicker tunica externa

Arteries have more elastic and collagen fibers

Veins have larger lumens and valves
Types Of Arteries

**Elastic arteries** – *the largest arteries*

Diameters range from 2.5 cm to 1 cm

Includes the **aorta** and its **major branches**

Sometimes called **conducting arteries**

High elastin content dampens surge of blood pressure
Types Of Arteries

Muscular (distributing) arteries

*Lie distal to elastic arteries*

Diameters range from 1 cm to 0.3 mm

*Includes most named arteries*

Tunica media is thick

Unique features

- Internal and external elastic laminae
Types Of Arteries

Arterioles

Smallest arterioles

Diameters range from 0.3 mm to 10 µm

Larger arterioles possess all three tunics

Diameter of arterioles controlled by:

- Local factors in the tissues
- Sympathetic nervous system

(c) Small arteriole

(Tunica media, Endothelium, Lumen)
Capillaries

Smallest blood vessels
- Diameter from 8–10 µm
- Red blood cells pass through single file
- Endothelial cells – held together by tight junctions and desmosomes
- Routes into and out of capillaries
  - Direct diffusion
  - Through intercellular clefts - gaps of unjoined membrane where small molecules can enter and exit
  - Through fenestrations - pores
Capillaries

Site-specific functions of capillaries

- Lungs – oxygen enters blood, carbon dioxide leaves
- Small intestines – receive digested nutrients
- Endocrine glands – pick up hormones
- Kidneys – removal of nitrogenous wastes

Tendons and ligaments – poorly vascularized
Epithelia and cartilage – avascular, receive nutrients from nearby CT
Capillaries

Three types of capillary

Continuous – most common
Fenestrated – have pores
Sinusoids
Capillary Beds

An interconnected network of vessels running through tissues

Consists of:

- Collateral arteries feeding an arteriole
- Metarterioles
- Arteriovenous anastomoses
- Capillaries
- Venules
Capillary Beds

Precapillary sphincters - regulate the flow of blood to tissues
Veins

Conduct blood from capillaries toward the heart
Blood pressure is much lower than in arteries
Smallest veins – called venules
   Diameters from 8 – 100 µm
Smallest venules – called postcapillary venules
Venules join to form veins
Role Of Veins

To return blood to the heart, veins have special adaptations:
- Large-diameter lumens, which offer little resistance to flow
- Valves (resembling semilunar heart valves), which prevent backflow of blood
- Skeletal muscle pump - muscles press against thin-walled veins
Measuring Pulse Rate

You should know that your "pulse" refers both to the physical thump created in your arteries by the contraction of your heart muscles and the number of these thumps your heart causes per minute.

You have seven pulse points-- places where arteries come close to your skin--on your body:

- a. carotid arteries (located on your neck)
- b. radial arteries (on your wrists)
- c. brachial arteries (on your arms)
- d. aortic arch (by your heart)
- e. abdominal aorta (near your stomach)
- f. femoral arteries (on your thighs)
- g. popliteal arteries (near your knees)
BLOOD

• What is blood made of?

• Blood is a mixture of cells and a watery liquid, called plasma, that the cells float in.

• Plasma is about 90 percent water.
What makes up our blood?

- There are three kinds of cells in the blood: red blood cells, white blood cells, and platelets. Red blood cells carry oxygen from the lungs throughout the body, white blood cells help fight infection, and platelets help in clotting.
What makes up our blood?

- **RED BLOOD CELLS** (Erythrocytes) – The most abundant cells in our blood; they are produced in the bone marrow and contain a protein called hemoglobin that carries oxygen to our cells. Red blood cells are shaped like tiny doughnuts, with an indentation in the center instead of a hole.

- **WHITE BLOOD CELLS** (Leukocytes) – They are part of the immune system and destroy infectious agents called pathogens.

- **PLASMA** – This is the yellowish liquid portion of blood that contains electrolytes, nutrients and vitamins, hormones, clotting factors, and proteins such as antibodies to fight infection.

- **PLATELETS** (Thrombocytes) – The clotting factors that are carried in the plasma; they clot together in a process called coagulation to seal a wound and prevent a loss of blood.
Blood Facts

The average adult has about **FIVE** liters of blood inside of their body, which makes up 7-8% of their body weight.

Blood is living **tissue** that carries oxygen and nutrients to all parts of the body, and carries carbon dioxide and other waste products back to the lungs, kidneys and liver for disposal. It also fights against **infection** and helps heal **wounds**, so we can stay healthy.

There are about **one billion** red blood cells in two to three drops of blood. For every **600** red blood cells, there are about **40** platelets and **one** white cell.

http://www.bloodbankofalaska.org/about_blood/index.html
• What makes our blood RED?

  – The iron in hemoglobin is what makes blood red.
What is HEMOGLOBIN?

• Hemoglobin is a special molecule which carries the oxygen that is found in the blood.
• Where there is a lot of oxygen, in the lungs, the hemoglobin molecules loosely bind with oxygen.
• Each molecule of hemoglobin contains four iron atoms, and each iron atom can bind with one molecule of oxygen, allowing each hemoglobin molecule to carry four molecules of oxygen.
What is HEMOGLOBIN?

Red blood cells contain several hundred hemoglobin molecules which transport oxygen.

Oxygen binds to heme on the hemoglobin molecule.
In the capillaries, where there is little oxygen, the hemoglobin readily sheds the oxygen it is carrying and allows it to be absorbed by the body's cells.
Genetics of Blood Types

• Your blood type is established before you are BORN, by specific GENES inherited from your parents.

• You inherit one gene from your MOTHER and one from your FATHER.

• These genes determine your blood type by causing proteins called AGGLUTINOGENS to exist on the surface of all of your red blood cells.
What are blood types?

There are 3 alleles or genes for blood type: A, B, & O. Since we have 2 genes, there are 6 possible combinations.

Blood Types
AA or AO = Type A
BB or BO = Type B
OO = Type O
AB = Type AB

http://learn.genetics.utah.edu/units/basics/blood/types.cfm
How common is your blood type?

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DISTRIBUTION</th>
<th>RATIOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>O +</td>
<td>1 person in 3</td>
<td>38.4%</td>
</tr>
<tr>
<td>O -</td>
<td>1 person in 15</td>
<td>7.7%</td>
</tr>
<tr>
<td>A +</td>
<td>1 person in 3</td>
<td>32.3%</td>
</tr>
<tr>
<td>A -</td>
<td>1 person in 16</td>
<td>6.5%</td>
</tr>
<tr>
<td>B +</td>
<td>1 person in 12</td>
<td>9.4%</td>
</tr>
<tr>
<td>B -</td>
<td>1 person in 67</td>
<td>1.7%</td>
</tr>
<tr>
<td>AB +</td>
<td>1 person in 29</td>
<td>3.2%</td>
</tr>
<tr>
<td>AB -</td>
<td>1 person in 167</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

http://www.bloodbook.com/type-facts.html
Rh Factors

• Scientists sometimes study Rhesus monkeys to learn more about the human anatomy because there are certain similarities between the two species. While studying Rhesus monkeys, a certain blood protein was discovered. This protein is also present in the blood of some people. Other people, however, do not have the protein.

• The presence of the protein, or lack of it, is referred to as the Rh (for Rhesus) factor.

• If your blood does contain the protein, your blood is said to be Rh positive (Rh+). If your blood does not contain the protein, your blood is said to be Rh negative (Rh-).
Blood Transfusions

A **blood transfusion** is a procedure in which blood is given to a patient through an intravenous (IV) line in one of the blood vessels. Blood transfusions are done to replace blood lost during surgery or a serious injury. A transfusion also may be done if a person’s body can't make blood properly because of an illness.

**Who can give you blood?**

People with **TYPE O** blood are called **Universal Donors**, because they can give blood to any blood type.

People with **TYPE AB** blood are called **Universal Recipients**, because they can receive any blood type.

- **Rh +** → Can receive + or -
- **Rh -** → Can only receive -

Universal Donor

Universal Recipient
What happens when different types of blood mix?

- If two different blood types are mixed together, the blood cells may begin to clump together in the blood vessels, causing a potentially fatal situation. Therefore, it is important that blood types be matched before blood transfusions take place. In an emergency, type O blood can be given because it is most likely to be accepted by all blood types. However, there is still a risk involved.
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 return to red bone marrow
- bilirubin and biliverdin excreted in bile