Circulatory System
Cardiac, pulmonary and systemic circulation

**Cardiac circulation:**
route taken by the blood to supply the heart. The heart is a muscle. It needs oxygen and nutrients and the removal of waste.

**Pulmonary circulation:**
pathway of blood from heart to lungs and back

**Systemic circulation:**
route from the heart to the tissues of the body and back
Coronary (cardiac) circulation
Circulatory facts:

- the average adult man has about 5 to 6 litres of blood, while the average woman has about 4 to 5 litres
- of your blood right now 80 – 90 % is in systemic circulation and the rest is in the pulmonary circulation
- three main elements of the circulatory system:
  - A - transport medium (blood)
  - B – transport vessels (arteries, arterioles, capillaries, venules, veins)
  - C – pumping mechanism (heart)
Transport Vessels

3 main blood vessels:

- arteries, capillaries and veins

- small artery = arteriole

- small vein = venule
ARTERIES carry blood away from the heart. Arteries have muscular walls that have a lot of elasticity. They are able to expand when the heart pushes blood out of the heart, and then snap back as the ventricles relax and fill. This helps to direct blood flow in the right direction (away from the heart).

Arteries generally carry oxygenated blood, with the exception of the pulmonary artery, which carries deoxygenated from the heart to the lungs.
ARTERIOLES are small arteries. As the arteries carry blood toward the tissues, the arteries reduce in circumference to become arterioles. This helps reduce the pressure of the blood as it comes to the capillary beds in the body tissues.
These are the **smallest** blood vessels. Their diameter is just large enough to allow a red blood cell to pass through. The walls of capillaries are **one cell thick**. This allows materials to be able to diffuse rapidly through the cells to go into or leave the cells of the body.
A **venule** is a very small blood vessel that allows blood to return from the capillary beds to the larger blood vessels called veins. Venules are formed when capillaries unite (come together). Venules are blood vessels that drain blood directly from the capillary beds. Many venules unite to form a vein.
**VEINS**

**Veins** are large blood vessels that return the blood to the heart to be pumped.

Veins have thinner walls than arteries, but have a larger inner diameter. They are not elastic, so the veins must rely on other mechanisms to ensure blood flows in the correct direction:

a. interior **valves** (one-way) that keep blood flowing against gravity

b. rely on contraction of skeletal muscles around the veins to keep blood moving in the correct direction.

Most veins carry **deoxygenated blood**, except the **pulmonary veins**.
VEINS
<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Direction of blood flow</th>
<th>O$_2$/CO$_2$</th>
<th>Exceptions</th>
<th>valves</th>
<th>walls</th>
<th>Blood pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>arteries</td>
<td>Away from heart</td>
<td>high/low</td>
<td>pulmonary artery</td>
<td>no</td>
<td>thick, elastic, muscular</td>
<td>high</td>
</tr>
<tr>
<td>arterioles</td>
<td>Same as arteries but smaller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>capillaries</td>
<td>Start away then to the heart, true whether in the systemic or pulmonary circulations</td>
<td>Starts high/low in systemic, but then becomes low/high after gas exchange in the systemic; opposite in the pulmonary circ.</td>
<td>no</td>
<td>One cell thin. A rolled sheet of simple squamous</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>venules</td>
<td>Same as veins but smaller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>veins</td>
<td>toward heart</td>
<td>low/high</td>
<td>pulmonary vein</td>
<td>Use unidirectional (one-way)</td>
<td>Thinner, not as elastic – that’s why people can get varicose veins or hemorrhoids – the walls get pushed out and can not spring back</td>
<td>Lower than arteries</td>
</tr>
</tbody>
</table>
Components of the blood

- Blood is considered a tissue because it is specialized to perform a set of specific functions.
- Blood consists of two distinct elements: plasma and cells.
- 55% is plasma, consisting of water, gases, proteins, sugars, vitamins, minerals, waste.
- The remaining 45% is cells.
- When centrifuged (separated), the three layers are (from least to most dense): plasma, white blood cells (leukocytes) and platelets, and red blood cells (erythrocytes).
PLASMA

This is the fluid portion of the blood. It is pale yellow and clear. The plasma is 92% water, 7% dissolved blood protein (albumin, globulin, fibrinogen), and 1% dissolved organic and inorganic materials.

Water – dissolves and transports materials

Plasma protein – albumin - maintain fluid balance in the body
  fibrinogen – important in blood clotting
  globulins – antibodies – important in immunity

Salts – maintain fluid balance, assist in nerve and muscle function, maintain alkaline pH (blood is slightly basic)
WHITE BLOOD CELLS (LEUKOCYTES)

These cells play an important role in the immune function. They make up only about 1% of the total blood volume, but they multiply rapidly during infections.

**Phagocytes (macrophages)** – engulf and destroy **pathogens** (disease or illness-causing agents)

**Lymphocytes** – produce **antibodies** (proteins that incapacitate pathogens)

White blood cell
PLATELETS (THROMBOCYTES)

These are fragments of cells that play a major role in blood clotting. Blood clotting is an important process that helps to prevent blood loss when a blood vessel is broken. It involves a complex series of steps.
Blood clotting

- When a blood vessel is broken, chemicals are released from cells that attract platelets.
- Platelets break open releasing chemicals that combine with some plasma proteins to make the enzyme thromboplastin.
- In the presence of calcium ions (Ca$^{2+}$), thromboplastin reacts with prothrombin (a protein made in the liver) to produce the enzyme thrombin.
- Thrombin reacts with fibrinogen (plasma protein) to form fibrin – insoluble protein that forms the mesh of a clot.
RED BLOOD CELLS
(ERYTHROCYTES)

These cells are specialized for oxygen transport. They have a disc-like shape that allows them to bend slightly as they move through capillaries. Erythrocytes have no nuclei and are packed with iron containing molecules called hemoglobin, to which the oxygen molecules bind chemically. The hemoglobin is also able to carry a small amount of carbon dioxide, though only about 10% of the total blood CO₂ is carried this way.
Flow of blood through the heart – pt 1

- Deoxygenated blood returns from the body tissues to the right side of the heart through the **superior vena cava** and **inferior vena cava**.
- It enters the **right atrium**
- It flows through the **right atrioventricular valve (tricuspid)**
- Blood enters the **right ventricle**
- When the right ventricle contracts, the right av valve closes and the **pulmonary semilunar valve** opens
- Blood is pushed up into the **pulmonary trunk** which branches into 2 **pulmonary arteries (right and left)**, which carries blood to the lungs
- Blood is oxygenated in the lungs
Flow of blood through the heart – pt 2

- Oxygenated blood is carried back to the left side of the heart by 2 sets of **pulmonary veins (right and left)**
- Blood enters the **left atrium**
- It flows through the **left atrioventricular valve (bicuspid, or mitral)**
- Blood enters the **left ventricle**
- When the left ventricle contracts, the left av valve closes and the **aortic semilunar valve** opens
- Blood is pushed out of the left ventricle and into the **aorta**, which carries it toward the body tissues