The cardiovascular system

- Includes the heart and blood vessels
- Brings nutrients to cells and helps get rid of wastes
- Blood is refreshed in the lung, kidneys, intestine and liver
- Lymphatic vessels help this system by collecting excess fluid surrounding tissues and return it to the cardiovascular system

5.1 Overview of the cardiovascular system

What are the function of the cardiovascular system?

- Generate blood pressure
- Transport blood
- Exchange of nutrients and wastes at the capillaries
- Regulate blood flow as needed

5.2 The types of blood vessels

Arteries and arterioles:

- Carry blood away from the heart
- Their walls have 3 layers:
  - Thin inner epithelium
  - Thick smooth muscle layer
  - Outer connective tissue
- Arterioles are small arteries that regulate blood pressure
Capillaries:

- Microscopic vessels between arterioles and venules
- Made of one layer of epithelial tissue
- Form beds of vessels where exchange with body cells occurs
- Combined large surface area

Exchange at the capillary beds is primarily a result of osmotic and blood pressure.

Veins and venules:

- Venules are small veins that receive blood from the capillaries
- Venule and vein walls have 3 layers:
  - Thin inner epithelium
  - Thick smooth muscle layer
  - Outer connective tissue
- Veins carry blood toward the heart
- Veins that carry blood against gravity have valves to keep blood flowing toward the heart
How can you tell the difference between an artery and vein?

Anatomy of the heart
- A large, muscular organ consisting of mostly cardiac tissue called the myocardium
- It is surrounded by a sac called the pericardium
- Consists of two sides, right and left, separated by a septum
- Consists of 4 chambers: 2 atria and 2 ventricles
- 2 sets of valves: semilunar valves and atrioventricular valves (AV valves)
- The valves give the resulting “lub” and “dup” sound of the heart

External anatomy of the heart
5.3 The heart is a double pump

**Internal anatomy of the heart**

![Heart Diagram]

5.3 The heart is a double pump

**What are the two cardiovascular pathways in the body?**

**Pulmonary circuit**: the right side of the body that brings blood from the body to the heart and the lungs

**Systemic circuit**: the left side of the heart that brings blood to the entire body to deliver nutrients and rid it of wastes

5.5 Two cardiovascular pathways

**How does blood flow through the heart?**

- Inferior and superior vena cava (1) dump blood into the right atrium (2)
- Right ventricle (3)
- 2 pulmonary arteries (4) that lead to the lungs (5) where blood becomes oxygenated
- Pulmonary veins (6) bring blood from the lungs back to the left atrium (7)
- Left ventricle (8) is large and muscular to pump blood into the aorta (9) and to the rest of the body (10)
- Eventually blood will be pumped back to each vena cava (1)
5.3 The heart is a double pump

Visualizing blood flow through the heart

How do the structure of the vessels and heart match their functions?

- The left ventricle is much more muscular than the right ventricle because it must pump blood to the entire body
- The arteries are more muscular than veins to withstand the higher pressure exerted on them
- The veins have a thinner wall and a larger center to store blood

How does the heartbeat occur?

- During systole the atria contract together followed by the ventricles contracting together
- This is followed by diastole, a rest phase, when the chambers relax
- This cardiac cycle, heartbeat, on average occurs 70 times/minute
What is the cardiac cycle?

How is the heartbeat controlled?

Internal control:
- The **SA node** in the right atrium initiates the heartbeat and causes the atria to contract.
- This impulse reaches the AV node, also in the right atrium, to send a signal down the AV bundle and Purkinje fibers that causes ventricular contraction.
- These impulses travel between gap junctions at intercalated disks.

External control:
- Heartbeat is also controlled by a **cardiac center** in the brain and hormones such as epinephrine and norepinephrine.

Visualizing the heartbeat.
5.3 The heart is a double pump

Visualizing the gap junctions at the intercalated disks

5.3 The heart is a double pump

What is an electrocardiogram (ECG)?

- A record of the electrical changes in the heart muscle during a cardiac cycle
- The atria produce an electrical current when stimulated by the SA node called the P wave
- The contraction of the ventricles is the QRS complex
- The recovery of the ventricles is called the T wave
- Looking at these electrical changes allows doctors to detect abnormalities

5.3 The heart is a double pump

How does a “normal” and abnormal ECG compare?
What is blood pressure?

- The pressure against a blood vessel wall, usually measured in an artery in the arm.
- The highest pressure is during blood ejection from the heart called the systolic pressure.
- The lowest pressure is the diastolic pressure when the ventricles relax.
- Average blood pressure is recorded at about 120/80 mmHg (systolic/diastolic).
- Reminder: this is controlled by the arterioles.

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How is blood pressure categorized?

<table>
<thead>
<tr>
<th>Normal Values for Adult Blood Pressure (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic Pressure</td>
</tr>
<tr>
<td>Normal</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Hypotension</td>
</tr>
</tbody>
</table>

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What is important about blood flow?

- Blood flow is under the highest pressure in the arteries but remember the thick, muscular walls.
- Blood flow is slower in the capillaries which is important to allow time for exchange between cells.
- Blood pressure is minimal in the veins and venules but blood flow increases.
If blood pressure is so low in the veins why does the blood flow increase?

- They have help:
  1. Skeletal muscle contraction
  2. Breathing
  3. Valves

The heart’s blood supply: Coronary circulation

- There are small coronary arteries that supply the heart that are separate from the systemic and pulmonary pathways of the body

What is the hepatic portal system?

- A system that brings blood from the digestive tract rich in amino acids and glucose to the liver
- The liver synthesizes blood proteins and stores the glucose as glycogen
- The liver also plays a role in purifying blood from the digestive tract
- Finally, the blood will return to the heart via the inferior vena cava
Cardiovascular Diseases = Most Common causes of death in U.S.A.

Disorders of the blood vessels:
- Hypertension/high blood pressure
- Atherosclerosis
- Stroke
- Heart attack
- Aneurysm

Hypertension
- High blood pressure results when blood moves through vessels at a rate higher than normal often due to arterial plaque
- 140/90 mmHg is considered hypertension
- A silent killer because there are few symptoms
- Can lead to a heart attack, stroke or kidney failure

Atherosclerosis
- A build up of plaque in blood vessels
- Plaque that is stationary is called a thrombus and an embolus when it detaches and can move to distant sites
- Associated with a stroke, heart attack and aneurysm
**Stroke**

Also known as a cerebrovascular accident (CVA)

Usually occurs when a cranial artery is blocked or bursts

Part of the brain dies due to lack of oxygen

Symptoms may occur including numbness of hands or face, difficulty speaking and inability to see in one eye

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**Heart attack**

Also known as a myocardial infarction (MI)

Part of the heart dies due to lack of oxygen

Can begin with angina pectoris, a pain that radiates down the left arm due to a blockage of a coronary artery

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**Aneurysm**

A ballooning of a blood vessel

Atherosclerosis and hypertension can weaken a vessel and cause ballooning

The most commonly affected is the abdominal artery or the arteries leading to the brain
How are disorders of the blood vessels treated?

- Dissolving blood clots:
  - t-PA is a drug that dissolves clots

- Treating clogged arteries:
  - Bypass surgery: usually a vein from the leg is taken and used to bypass a clogged artery
  - Stents: wire mesh cylinder inserted into a clogged artery to hold it open
  - Angioplasty: a tube with a balloon is inserted into the clogged area and the balloon is then inflated to open the vessel
  - A stent and angioplasty may be used in combination

Disorders of the heart and its treatment

- Disorders:
  - Heart failure is when the heart no longer pumps properly

- Treatments:
  - Left ventricular assist device (LVAD)
  - Heart transplant either natural or artificial

Health Focus: The do's and don'ts for prevention of cardiovascular disease?

- Do not smoke
- Do not abuse drugs
- Keep your weight down to decrease chances of hypertension and Type II diabetes
- Eat a healthy diet
  - Low in saturated and trans fats
  - Low in cholesterol
- Know your blood cholesterol
- Exercise