Circulatory System
Circulatory System

- Blood
- Heart
- Blood vessels

Cardiovascular System
Heart

- 4 chambers
- Muscular pump
- Size of a fist
- Located between lungs
- Slightly to the left of center
Blood flow through the heart

Pulmonary circuit
Right side of heart

Systemic circuit
Left side of heart
Basic blood vessels

Artery – brings blood away from the heart

Vein – brings blood toward the heart
Blood flow through the heart

Atrium (pl. atria) – receives blood

- Right atrium – from superior and inferior vena cava (big vein)
- Left atrium – from pulmonary vein

Ventricle – ejects blood

- Right ventricle – to pulmonary artery
- Left ventricle – to aorta (largest artery)
Blood flow through the heart

Valve – prevents back flow of blood

- Tricuspid – between right atrium and right ventricle
- Pulmonary – between right ventricle and pulmonary artery
- Bicuspid (mitral) – between left atrium and left ventricle
- Aortic – between left ventricle and aorta
Operation of the Heart valves

Pressure on the back side of a valve closes it.

Pressure on the entry side of a valve opens it.

Heart murmur – back flow of blood through faulty valve.
Structure of Cardiac Muscle

3 kinds of muscle in the body

- **Cardiac muscle cell**: involuntary
- **Skeletal muscle cell**: voluntary
- **Smooth muscle cell**: involuntary
Cardiac Cycle
Principles of pressure and flow

If pull back plunger on syringe
● Volume increases
● Pressure decreases
● Air flows in following pressure gradient

If push on plunger of syringe
● Volume decreases
● Pressure increases
● Air flows out following pressure gradient

Heart chambers work the same way
● If chamber is expanding, blood flows in
● Provided pressure gradient is sufficient
● If chamber is contracting, blood flows out
● Provided pressure gradient is sufficient
Cardiac cycle

1. **Atrial and ventricular diastole**
   - AV valves open
   - Semilunar valves closed

2. **Atrial systole, ventricular diastole**
   - AV valves open
   - Semilunar valves closed

3. **Ventricular systole, atrial diastole**
   - AV valves closed
   - Semilunar valves open
Cardiac cycle

Heart sounds:

<table>
<thead>
<tr>
<th>Name</th>
<th>Atrial Systole</th>
<th>Ventricular Systole</th>
<th>Diastole</th>
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<tr>
<td></td>
<td>atria contract</td>
<td>ventricles contract</td>
<td>atria and ventricles both relax</td>
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<tr>
<td></td>
<td>blood enters</td>
<td>blood enters arteries</td>
<td>blood enters atria and ventricles</td>
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<tr>
<td></td>
<td>ventricles</td>
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<tr>
<td>Events</td>
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<tr>
<td></td>
<td>atrioventricular valves close</td>
<td>atrioventricular valves open</td>
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<tr>
<td>Pressure (KPa)</td>
<td>artery</td>
<td>atrium</td>
<td>ventricle</td>
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<td>2</td>
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Blood pressure

- Force that blood exerts on vessel wall
- Measure close to the heart
- Approximates bp in heart chamber

- Systolic pressure (sp) – arterial bp during ventricular systole
- Diastolic pressure (dp) – arterial bp during ventricular and atrial diastole

- Sp/dp = reported bp
Structure of blood vessels

Artery – brings blood away from the heart

Vein – brings blood toward the heart

artery

vein

artery

vein

venule

Capillary bed

arteriole
Structure of blood vessels

Artery

Endothelium – smooth inner lining, repels blood cells, secretes vasodilators and vasoconstrictors

Elastic tissue

Smooth muscle – responsible for contacting or dilating the vessel

Connective tissue
Structure of blood vessels

Arterioles

- Smaller in diameter than arteries
- No elastic tissue
- Control blood flow to capillary beds via smooth muscle sphincters
- Primary site of blood flow restriction
Control of blood flow into capillaries
Structure of Blood Vessels

● The rest of the circulatory system is to serve these

● Only 1 RBC at a time can fit; some must fold

● Within 3 cells of all cells in the body
● Few exceptions

● Clefts or slits between cells allow material to pass in and out

● Material is exchanged between lumen of capillary and extracellular fluid (ECF)
Capillary Exchange

Arterial end
- Pressure in the capillary is greater than tissue pressure so water and solutes are forced out = filtration

Vein end
- Osmotic pressure in tissue exceeds that in capillary and material is drawn in
Structure of blood vessels

Vein

endothelium

Smooth muscle – Relatively thin compared with arteries

Connective tissue

Valve – prevents backflow
Movement of blood in veins

- **Calf muscle contracts**
- **Muscle squeezes veins**
- **Veins constrict; blood moves; valves open**
- **Open valve**
- **Blood moves through vein as the vein is squeezed by body muscles**
- **Closed valve**
Varicose veins

- Veins stretch
- Stretching pulls valves apart
- Valves no longer function
- Blood is not moved along vein
- Vein stretches further
Circulatory routes

Portal system – has 2 capillary beds
Regulation of Blood Pressure

- Local control
- Neural control
- Hormonal control
Regulation of Blood Pressure
Local control

• control of perfusion based on tissue needs
  • Vasoactive chemicals
    • Secreted by blood platelets, endothelial cells, perivascular tissue
  • Vasoconstriction
    • endothelins
  • Vasodilation (trauma, inflammation, exercise)
    • Histamine, bradykinin, prostaglandins
Regulation of Blood Pressure
Neural control

- Hormones and nervous system (autonomic)
- Vasomotor center = medulla oblongata
Regulation of Blood Pressure
Neural control

- Vasomotor center integrates 3 autonomic reflexes
  - Baroreflexes
  - Chemoreflexes
  - Medullary ischemic reflex
Regulation of Blood Pressure
Neural control

- **Baroreflex**
  - Baroreceptors – stretch receptors in major arteries
  - Short-term regulation
    - Standing up
  - Negative feedback to medulla oblongata
    - Changes heart rate
    - Changes cardiac output
    - Dilates/contricts arteries and veins

![Diagram of Baroreflex](image-url)
Regulation of Blood Pressure
Neural control

- Chemoreflex
  - Respond to changes in blood chemistry
    - pH, O2, CO2
  - Chemoreceptors
    - Aortic bodies
    - Carotid bodies
    - Relay info to vasomotor center
      - Widespread vasodilation or vasoconstriction

Figure 1. Location and innervation of arterial baroreceptors.
Regulation of Blood Pressure
Hormonal control

- **Angiotensin II**
  - Secreted by kidneys and lungs
  - Vasoconstrictor; inc bp
    - Requires angiotensin converting enzyme (ACE) for synthesis
    - ACE inhibitors block this action

- **Aldosterone**
  - Secreted by adrenal cortex
  - Promotes Na+ retention by kidneys; inc bp
    - Promotes water retention

- **Atrial natriuretic peptide (ANP)**
  - Secreted by the heart
  - Increase Na+ excretion; dec bp
    - Promotes water excretion
Regulation of Blood Pressure
Hormonal control

- **Antidiuretic Hormone (ADH)**
  - Secreted by pituitary gland
  - Promotes water retention; inc bp
  - Vasoconstrictor; inc bp

- **Epinephrine and norepinephrine**
  - Secreted by adrenal medulla
  - Stimulates smooth muscle contraction – vasoconstriction; inc bp
  - In coronary blood vessels and skeletal muscle – cause vasodilation during exercise