Systemic Circulation

- Arteries
- Arterioles
- Capillaries
- Venules
- Veins

- Role is to direct the flow of blood from the heart to the capillaries, and back to the heart.

Exterior (to the heart) circulation

- Aorta
- Arteries
- Arterioles
- Capillaries
- Venules
- Veins
- Pulmonary Trunk
- Pulmonary Arteries
- Pulmonary Veins

Effect of tube radius

Radius of A \( r_A = 2 \)

Radius of B \( r_B = 1 \)

\[ R_d = \frac{1}{2^2} + 1 = 0.0625 \]

\[ R_B = \frac{1}{1^2} + 1 = 1.0 \]

Therefore \( R_B = 16 \times R_A \)

Flow in \( B = \frac{1}{16} \) of flow in \( A \)
The systemic “blood highway”

- Aorta and arteries
- Arterioles
- Capillaries (venules)
- Veins
Arteries

• Elastic arteries:
  – Walls of smooth muscle and elastin.
  – Expand when the pressure of the blood rises.
  – Acts as recoil system when ventricles relax.

• Muscular arteries:
  – Are less elastic and have a thicker layer of smooth muscle.

Arteries

• Arterioles:
  – Contain highest % smooth muscle.
  – Greatest pressure drop.
  – Greatest resistance to flow.

Aterial Blood Pressure and associate definitions.

• Compliance - how easily a structure is stretched.
  – Compliance = Δ volume/Δ pressure

• Systolic pressure (SP) - maximum arterial pressure reached during peak ventricular contraction.

• Diastolic pressure (DP) - minimum arterial pressure occurring just before ventricular ejection begins.

• Pulse Pressure = SP - DP.

• Mean Arterial Pressure (MAP) = DP + 1/3 (pulse pressure)
Factors determining magnitude of the pulse pressure

- Stroke volume.
- Speed of ejection of stroke volume.
- Arterial compliance.
Aterioles

- In individual organs - responsible for determining relative blood flow to those organs.
- Major factor in determining mean arterial pressure.
- Controlled by
  - Local controls
  - Extrinsic controls.
Importance of Arterioles to Blood Flow.

- Differences in flow between organs depends on relative resistances of arterioles in those organs.
- Vasodilation vs. vasoconstriction.

Systemic blood flow

<table>
<thead>
<tr>
<th>Organ</th>
<th>Rate (mL/min)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>980</td>
<td>12.6%</td>
</tr>
<tr>
<td>Lungs</td>
<td>240</td>
<td>3.1%</td>
</tr>
<tr>
<td>Kidney</td>
<td>560</td>
<td>7.2%</td>
</tr>
<tr>
<td>Adipose</td>
<td>120</td>
<td>1.6%</td>
</tr>
<tr>
<td>Total</td>
<td>596</td>
<td>8%</td>
</tr>
</tbody>
</table>

Capillaries

- Smallest blood vessels.
- 1 endothelial cell thick.
- Provide direct access to cells.
- Permits exchange of nutrients and wastes.

Capillaries

- Continuous:
  - Endothelial cells tightly joined.
  - Intercellular channels that permit passage of molecules between capillary blood and tissue fluid.
  - Muscle, lungs and adipose tissue.
- Fenestrated:
  - Wide intercellular pores.
  - Provides greater permeability.
  - Kidneys, endocrine glands and intestines.
- Discontinuous (sinusoidal):
  - Have large, leaky capillaries.
  - Liver
**Capillaries: Important Points**

- Movement across capillaries
  - Diffusion
  - Vesicle transport
  - Bulk flow
  - Mediated transport (in brain capillaries).

**Movement of fluid across capillary wall**

- Difference between capillary blood hydrostatic pressure and interstitial-fluid hydrostatic pressure favors filtration out of the capillary.
- Water-concentration difference between plasma and interstitial fluid, which results from differences in protein concentration, favors filtration of interstitial fluid into the capillary.
Veins

- Venules:
  - Formed when capillaries unite.
  - Very porous.
- Veins:
  - Little smooth muscle or elastin.
  - Capacitance vessels (blood reservoirs).
  - Contain 1-way valves ensure blood flow to the heart.

Total blood volume

- Pulmonary circulation — 12%
- Heart — 9%
- Arteries — 11%
- Arterioles and capillaries — 7%
- Veins — 51%

Skeletal Muscle Pump

- The rate of venous return is dependent in part on the action of skeletal muscle pumps.
- Skeletal muscles contract, forcing blood out of the veins toward heart.
Atherosclerosis

- Most common form of arteriosclerosis (hardening of the arteries).
- Mechanism of plaque production:
  - Begins as a result of damage to endothelial cell wall.
  - Cytokines are secreted by platelets, macrophages and lymphocytes.
  - Attract more monocytes and lymphocytes.
Atherosclerosis

- Macrophages engulf lipids and transform into foamy cells.
- Smooth muscle cells synthesize connective tissue proteins.
- Smooth muscle cells migrate to tunica interna and proliferate forming fibrous plaques.

Cholesterol and Plasma Lipoproteins

- Lipids are carried in the blood attached to protein carriers.
- Cholesterol is carried to the arteries by LDLs (low-density lipoproteins).
  - LDLs are produced in the liver.
- Cells in various organs contain receptors for proteins in LDL.
  - The cell engulfs the LDL and oxidizes it.
Cholesterol and Plasma Lipoproteins

- Oxidized LDL contributes to endothelial cell wall injury.
- Excessive cholesterol is released from the cells and travel in the blood as HDLs (high-density lipoproteins) and removed by the liver.
  - Artery walls do not have receptors for HDL.

Ischemic Heart Disease

- Ischemic:
  - Oxygen supply is deficient.
  - Most common cause is atherosclerosis of coronary arteries.
  - Increased concentrations of lactic acid.
- Referred pain:
  - Substernal pain.
- MI:
  - Myocardial infarction (heart attack).
  - Increased plasma CPK and LDH.

Arrhythmias Detected on ECG

- Arrhythmias:
  - Abnormal heart rhythms.
- Flutter:
  - Extremely rapid rates of excitation and contraction of atria or ventricles.
- Fibrillation:
  - Contractions of different groups of myocardial cells occur at different times.
  - Coordination of pumping impossible.
Arrhythmias Detected on ECG

- First-degree AV nodal block:
  - Rate of impulse conduction through AV node exceeds 0.2 sec.
- Second-degree AV nodal block:
  - AV node is damaged so that only 1 out of 2 – 3 atrial AP can pass to the ventricles.
- Third-degree (complete) AV nodal block:
  - None of the atrial waves can pass through the AV node.
  - Ventricles paced by ectopic pacemaker.

Lymphatic/cardiovascular system

Fig similar to 13.35

Lymph Nodes

Fig. 13.36
Lymphatic System

- 3 basic functions:
- Transports interstitial (tissue) fluid back to the blood.
- Transports absorbed fat from small intestine to the blood.
- Help provide immunological defenses against pathogens.