CARDIOVASCULAR SYSTEM:
BLOOD VESSELS
Histology of Blood Vessels

• Tunica intima
  – endothelium
  – loose CT + simple squamous epithelium

• Tunica media
  – smooth muscle (not cardiac)
  – may have elastin

• Tunica externa
  – adventitia
  – fibrous CT with elastin
Histology of Blood Vessels

Artery:
- Adventitia
- Media
- Intima
- Smooth muscle
- Internal elastic membrane
- External elastic membrane
- Endothelium
- Elastic fiber

Vein:
- Adventitia
- Media
- Intima
- Smooth muscle
- Endothelium

Lumen of artery

Lumen of vein
Histology of Blood Vessels
Types of Blood Vessels

• Arteries
  – resistance vessels
  – high pressure
  – carry blood away from heart

• Capillaries
  – exchange vessels

• Veins
  – capacitance vessels
  – low pressure lines
  – carry blood to the heart
Arteries

• Characteristics
  – Smaller diameter than veins
  – thick tunica media
  – Lots of elastin

• Function
  – carry blood away from the heart
  – not always oxygenated
Types of Arteries

• Elastic (Conducting)
  – Transport large volumes of blood
  – abundant elastin
  – Vasa vasorum

• Muscular (Distribution)
  – Skeletal muscle and internal organs
  – distribute to “lobes” of an organ

• Arterioles
  – Vasocontriction/vasodilation
  – Scattered smooth muscle fibers
  – small diameters, branch into capillaries
  – greatest resistance to blood flow
Capillaries

(a) Continuous capillary

(b) Fenestrated capillary

Endosomes
Basal lamina
Boundary between endothelial cells

Endosomes
Fenestrations, or pores
Boundary between endothelial cells
Basal lamina
Capillaries

- **Structure**
  - Tunica intima only (endothelium)
  - Precapillary sphincter
  - Metarteriole
  - Thoroughfare channel

- **Function**
  - Diffusion and exchange of substances with tissues
  - Anastomosis
Sinusoids

- Liver, bone marrow, adrenal gland
- Resemble fenestrated capillaries but have larger pores
- Thinner basal lamina (*)
- Allow for bulk exchange
- Low flow rate
Portal Circuits

- Parallel circuits
  - Artery
  - Capillary
  - Vein

- Portal circuit
  - Artery
  - Capillary
  - Vein

- Anatomosing circuit
Veins

- **Characteristics**
  - Relatively large diameters
  - Thin tunica media
  - Thick tunica externa
  - Large veins have valves (especially in legs)

- **Function of veins**
  - Carry blood back to the heart (not always deoxygenated)
Types of Veins

- **Large Veins**
  - Vena cavae
  - Superior VC and inferior VC
  - Drain blood from most veins

- **Medium Veins**
  - Tributaries to the vena cavae
  - Drain organs and lobes of organs

- **Venules**
  - Smallest of all veins
  - Drain capillaries
Venous Valves
## Arteries vs Veins

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Artery</th>
<th>Vein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>Narrower</td>
<td>Wider, often collapsed</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Thicker</td>
<td>Thinner</td>
</tr>
<tr>
<td>X-section</td>
<td>Keeps circular shape</td>
<td>collapses</td>
</tr>
<tr>
<td>Thickest tunic</td>
<td>Tunica media</td>
<td>Tunica externa</td>
</tr>
<tr>
<td>Fibers</td>
<td>More elastic/collagen</td>
<td>Less</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>&gt;90 mm Hg in larger</td>
<td>Approx 2 mm Hg</td>
</tr>
<tr>
<td>Blood flow</td>
<td>Away from heart</td>
<td>Toward heart</td>
</tr>
<tr>
<td>Oxygen levels</td>
<td>Systemic arteries = high O₂</td>
<td>Systemic veins = low O₂</td>
</tr>
<tr>
<td></td>
<td>Pulmonary arteries = blood low in O₂</td>
<td>Pulmonary veins = high O₂</td>
</tr>
</tbody>
</table>
Arteries vs. Veins

Venules vs. Arterioles
Distribution of Blood

- Large venous networks (liver, bone marrow, skin) 21%
- Large veins 18%
- Venules and medium-sized veins 25%
- Pulmonary circuit 9%
- Pulmonary arteries 3%
- Pulmonary capillaries 2%
- Pulmonary veins 4%
- Heart 7%
- Aorta 2%
- Elastic arteries 4%
- Muscular arteries 4%
- Arterioles 2%
- Systemic capillaries 7%
- Systemic arterial system 13%
- Systemic venous system 64%
Blood Vessel Distribution
Major CVS Circuits

• Systemic
  – high variable resistance circuit
  – Includes coronary circulation
    • the vasa vasorum of the heart

• Pulmonary
  – low, constant resistance circuit
The Pulmonary Circuit

- Venous blood return
  - Vena cavae
  - Coronary sinus
- Right atrium
- Bicuspid valve
- Right ventricle
- Pulmonary semilunar valve
- Pulmonary trunk
- Pulmonary arteries
- Capillaries of lungs
The Systemic Circuit

- Capillaries of lungs
- Left atrium
- Mitral valve
- Left ventricle
- Aortic semilunar valve
- Aorta
- Branches off aorta
- Capillaries of the tissues
Fetal Circulation

• All major blood vessels are in place by the 3rd month of development & flowing in the same direction

• Placenta
  – Fetal structure
  – Exchange surface between fetal and maternal blood
    • Gases
    • Nutrients
    • Waste products
    • Hormones, toxins, etc....
Placenta and Umbilicus

- Umbilical vessels
  - Paired U. arteries (arise from internal iliac a. in fetal pelvis) carry deoxygenated blood from the fetus --> placenta
  - Unpaired U. vein carry oxygenated blood from the placenta into the ductus venosus
Fetal Shunts

• Ductus venosus
  – connected to an intricate network of veins in the fetal liver
  – Shunts away from the liver circulation

• Foramen ovale
  – an opening between the atria to shunt blood from R-L (a valve)

• Ductus arteriosus
  – a shunt between the pulmonary trunk and aorta
  – prevent overload on the immature lungs
Fetal Heart

Aortic arch
Ductus arteriosus
Left pulmonary artery
Interatrial septum
Foramen ovale
Fetal Circulation

(a) Full-term fetus (before birth)
All returning blood to the fetus proceeds to hepatic veins, inferior vena cava and right atrium.