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
Histology of Blood Vessels

- **LARGE VEIN**
  - Adventitia
  - Media
  - Endothelium
  - Intima

- **MEDIUM-SIZED VEIN**
  - Adventitia
  - Media
  - Endothelium
  - Intima

- **VENULE**
  - Adventitia
  - Endothelium

- **ELASTIC ARTERY**
  - Internal elastic layer
  - Endothelium
  - Intima

- **MUSCULAR ARTERY**
  - Adventitia
  - Media
  - Endothelium
  - Intima

- **ARTERIOLE**
  - Smooth muscle cells (Media)
  - Endothelium
  - Basal lamina

- **FENESTRATED CAPILLARY**
  - Pores
  - Endothelial cells
  - Basal lamina

- **CONTINUOUS CAPILLARY**
  - Endothelial cells
  - Basal lamina
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
  – Vasoconstriction/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

Nucleus

Endosomes

Fenestrations, or pores

Boundaries 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
  - Capillary
  - Vein

- Anastomosing 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

Valve closed

Valve opened

Valve closed
<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 O$_2$</td>
<td>Systemic veins = low O$_2$</td>
</tr>
<tr>
<td></td>
<td>Pulmonary arteries = blood</td>
<td>Pulmonary veins = high O$_2$</td>
</tr>
<tr>
<td></td>
<td>low in O$_2$</td>
<td></td>
</tr>
</tbody>
</table>

Arteries vs. Veins

Venules vs. Arterioles
Distribution of Blood

- Large venous networks (liver, bone marrow, skin) 21%
- Venules and medium-sized veins 25%
- Large veins 18%
- Pulmonary arterioles 2%
- Pulmonary capillaries 2%
- Pulmonary veins 4%
- Heart 7%
- Aorta 2%
- Elastic arteries 2%
- Muscular arteries 4%
- Arterioles 5%
- Systemic capillaries 7%
- Systemic venous system 64%

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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
- Tricuspid valve
- Right ventricle
- Pulmonary semilunar valve
- Pulmonary trunk
- Pulmonary arteries
- Capillaries of lungs
The Systemic Circuit

- Capillaries of lungs
- Pulmonary veins
- 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 Circulation

Foramen ovale (open)
Aorta
Ductus arteriosus (open)
Pulmonary trunk
Inferior vena cava
Ductus venosus
Umbilical arteries
Liver
Placenta
Umbilical cord
Umbilical vein

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