At the Heart of the Matter:
The Cardiovascular System

THE HEART
three tissue layers (outside to inside):
1) The epicardium, the outermost layer, consists of an outer layer of mesothelial cells (simple squamous) overlying connective tissue (DIACT and adipose tissue). Nerves that innervate the heart run in this layer, as well as the coronary arteries. The mesothelial cells secrete serous fluid which faces the parietal pericardium.

2) The myocardium, the thickest layer, is composed of cardiac muscle arrange into fascicles bounded by connective tissue (Masson’s trichrome, blue-staining collagen fibers). In longitudinal sections of the fascicles, intercalated discs can be seen as red-staining bars perpendicular to long-axis of the fiber. Intercalated discs are sites of adherens junctions and desmosomes where muscle cells are fastened together and gap junctions which permit electrical impulse conduction.

3) The endocardium is the innermost layer and itself consists of three layers:
   a) deep layer – subendocardial layer: loose connective tissue is continuous with myocardium; location of Purkinje fibers. Purkinje fibers are large muscle cells that are specialized for conduction rather than contraction; they branch from the AV bundle of His to innervate the ventricles. Fibers running in the myocardium are encapsulated in connective tissue. The cells stain pale pink due to the high content of glycogen in the sarcoplasm. The cells are also rich in mitochondria and have one or two central nuclei.
   b) middle layer – connective tissue and smooth muscle cells
   c) inner layer – subendothelial layer of connective tissue and endothelium (simple squamous epithelium) which faces the interior of heart

Heart valves are extensions of the endocardium, connective tissue covered by endothelium. The fibrous trigone (blue-staining collagen) is a connective tissue framework which binds the chambers of the heart together and allows attachment of the valves.

THE BLOOD VESSELS
All large vessels are composed of three concentric layers known as tunics:
1) tunica intima – the innermost layer of endothelium and its basement membrane; the endothelium is a very thin layer of simple squamous epithelial tissue; in arteries and arterioles, the outer margin will be bounded by the internal elastic membrane.

2) tunica media – the middle layer composed predominantly of circularly-arranged smooth muscle with varying amounts of reticular and elastic fibers (lamellae); elastin, collagen and proteoglycans are secreted by smooth muscle cells, not fibroblasts! External elastic membrane separates media from adventitia.

3) tunica adventitia – contains collagen and elastic fibers; poorly defined outer boundary; contains the vasa vasorum (blood supply to walls of larger vessels) and nervi vascularis (innervation of vessel)
## Artery vs. Vein

<table>
<thead>
<tr>
<th></th>
<th>artery</th>
<th>vein</th>
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</thead>
<tbody>
<tr>
<td>internal elastic membrane</td>
<td>+++</td>
<td>–</td>
</tr>
<tr>
<td>tunica media</td>
<td>thickest</td>
<td>thin</td>
</tr>
<tr>
<td>tunica adventitia</td>
<td>thin</td>
<td>thickest</td>
</tr>
<tr>
<td>lumen shape</td>
<td>smaller, round</td>
<td>broad, squashed</td>
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<tr>
<td>lumen border</td>
<td>scalloped endothelial cells</td>
<td>smooth</td>
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<tr>
<td>smooth muscle distribution</td>
<td>more in media</td>
<td>more in adventitia, but in all three layers</td>
</tr>
<tr>
<td>valves</td>
<td>–</td>
<td>+/-</td>
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## Artery Types

1. **Elastic** – high elastin content allows for expansion and contraction to deal with pressure changes; thick tunica media; difficult to distinguish internal and external lamina because lots of elastin sheets present; common example: the aorta!

2. **Medium** – not much elastin; can see prominent internal and external elastic laminae; several layers of smooth muscle in tunica media

3. **Arterioles** – no evident external elastic lamina; media has only one layer of smooth muscle cells; pre-capillary sphincter opens and closes in response to the needs of the tissue supplied by the vessel

## Capillaries

Three types of capillaries

1. **Continuous** – found in muscle, lungs and CNS; impermeable; thin cytoplasm promotes diffusion; forms blood-brain barrier with tight junctions; may contain pericytes which are unspecialized cells which are enclosed within the basal lamina and give rise to smooth muscle cells during vessel growth (angiogenesis)

2. **Fenestrated** – found in endocrine glands and sites of fluid and metabolite absorption (gall bladder and GI tract); basal lamina intact and plasma membrane of adjacent cells continuous and attenuated, acting as a diaphragm; allows for diffusion of substances

3. **Discontinuous** – found in liver, spleen, and bone marrow; large gaps between endothelial cells; basal lamina is discontinuous or missing; small enough to prevent rbc’s from passing through, but allows exchange of plasma

*these can only be distinguished by electron microscopy*
**Questions**

1. a) what kind of tissue is this?

   b) what is the structure at the pointer?

   c) what are the components of the structure in b?

   d) what is the function of the structure in b?

2. there are two types of blood vessels in the field
   a) name the vessel at the pointer

      b) name two distinguishing characteristics

      c) name the other vessel

3. a) what is the cell at the pointer?

   b) what is the function of this cell?

   c) why does it stain so lightly?

**Answers**

1. slide #17, pointer at intercalated disc,
   a) cardiac muscle
   b) intercalated disc
   c) desmosomes, fascia adherens, gap junctions
   d) gap junctions electrically couple the cell to its neighbor, allowing the myocardium to contract in unison; fascia adherens and desmosomes hold the cells together

2. slide #113, pointer on muscular artery
   a) artery
      b) internal elastic membrane, endothelial nuclei project into lumen; thick tunica media composed of smooth muscle
   c) muscular vein

3. slide #19, pointer on Purkinje fiber
   a) Purkinje fiber
   b) electrical impulse conduction
   c) contains lots of glycogen