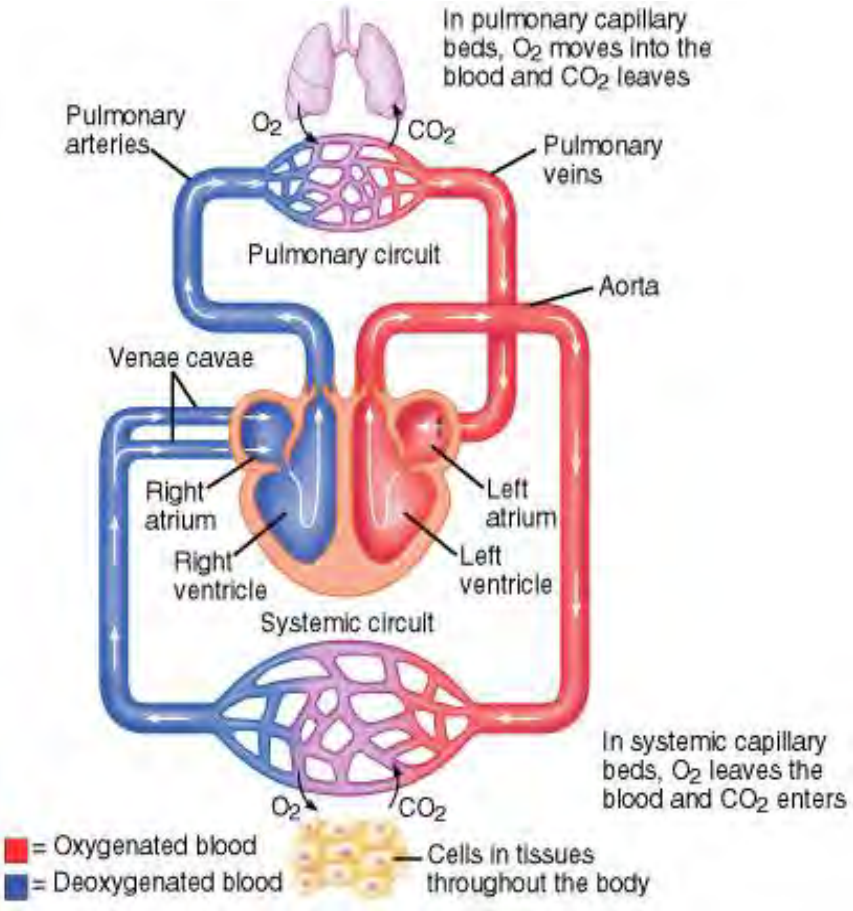
HUBS192: Human Body Systems

Cardiovascular System

1. Design of the Circulation and Hemodynamics
Monday, July 6

Understand the basic function of the cardiovascular system	
	Arteries carry blood AWAY from the heart so they are highly oxygenated. These get smaller and smaller as they branch off. Vessels carry blood TO the heart so they have low oxygen levels. These get larger and larger as they combine.
Know the difference between blood flow in series and in parallel	
	The heart is a four-chambered organ. Blood flows in one direction. Arterial blood flows AWAY from the heart. Venous blood flows TOWARDS the heart. Systemic and pulmonary circuits lie 'in series with one another. This means that the blood flows through the lungs then flows through the systemic circulation and to all organs. Systemic circuits lie in parallel with each other. So within the system circuit, it lies in parallel. So once the blood enters an organ it will travel back to the heart → this makes sure that deoxygenated blood doesn't go to multiple organs and no organ receives the carbon dioxide-rich blood leaving another organ (except the liver). The systemic and pulmonary circuits move blood in series, while individual organs and tissues receive blood in parallel.

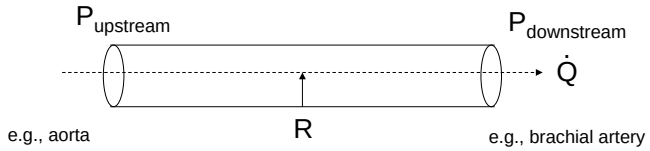


Define the variables that determine blood flow

Haemodynamics: how blood flows in a single vessel

Flow=Pressure Difference/Resistance

$$\dot{Q} = \frac{\Delta P}{R}$$



Blood flow is influenced by pressure generated by the heart and by the total resistance of the vessels.

Because blood flows (overall) in a series circuit, if blood is leaving the heart at 5L/min, it will return to the heart at 5L/min.

If you are trying to control the flow of the blood, the 2 variables involved are the resistance of the vessels and the pressure generated by the heart.

VEINS AND ARTERIES

Arteries pump blood under high pressure and high velocity whilst the cross sectional area of veins is at least twice that of arteries in order to achieve the same volume flow rate per second but at a lower pressure and velocity.

2. Anatomy of the Heart (Part 1)

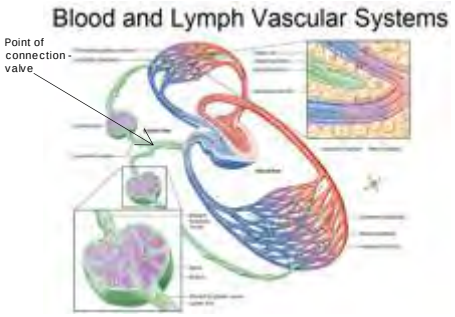
Tuesday, July 7,

Describe the general organization of the cardiovascular system

The Cardiovascular System is made up of 2 systems:

- Blood vascular system: A closed supply and drainage system – continuous loop.
- Lymphatic (vascular) system): An open entry drainage system – one way system.

During oxygen exchange at the capillary beds, some blood can be lost. Fluid that leaves blood vessels and moves into tissue drains back to the heart via the lymphatic system. The lymphatic vessels rejoin large veins and re-enter the blood flow.



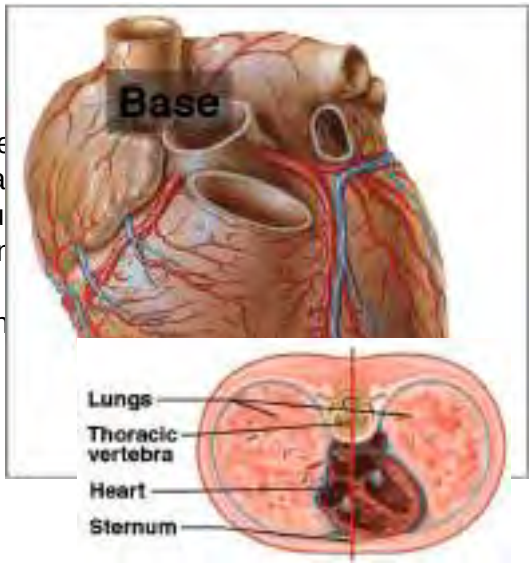
SUPPLY	EXCHANGE	DRAINAGE
Arteries – located deep in trunk/flexor aspect of limbs to avoid damage. Pump under high pressure and high velocity.	Capillaries – these have varying degrees of permeability depending on the endothelial cells Continuous (controlled) Fenestrated (leaky) Sinusoidal (very leaky)	Veins and Lymphatic – 3 pathways: Deep veins, Superficial veins or Lymphatics

Orientate the heart within the thorax

Size: approximately that of a closed fist
Apex – pointed (lower) end of the heart
Base – broad (upper) end of the heart

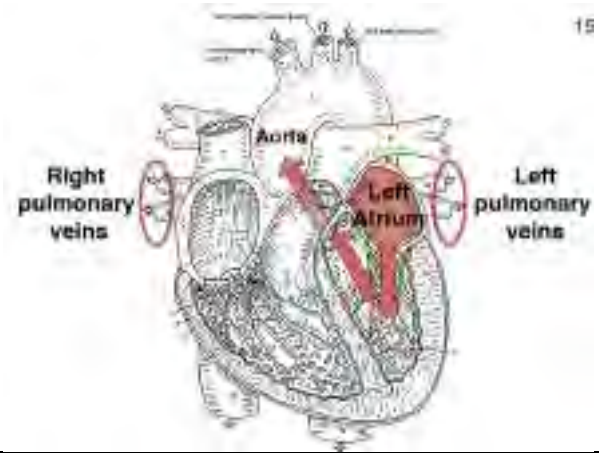
Orientation: the heart is rotated to the left and tilte
posteriorly Hence the apex sits in the midclavicula
As the apex point superficially this is where the lou
beat sounds are heard (PMI – Point of Maximum Ir

Position: The Heart sits in-between the left and righ
cavities, the thoracic vertebrae and the sternum.
2/3 of the heart is on the left side, hence the left
plural cavity is smaller than the right.

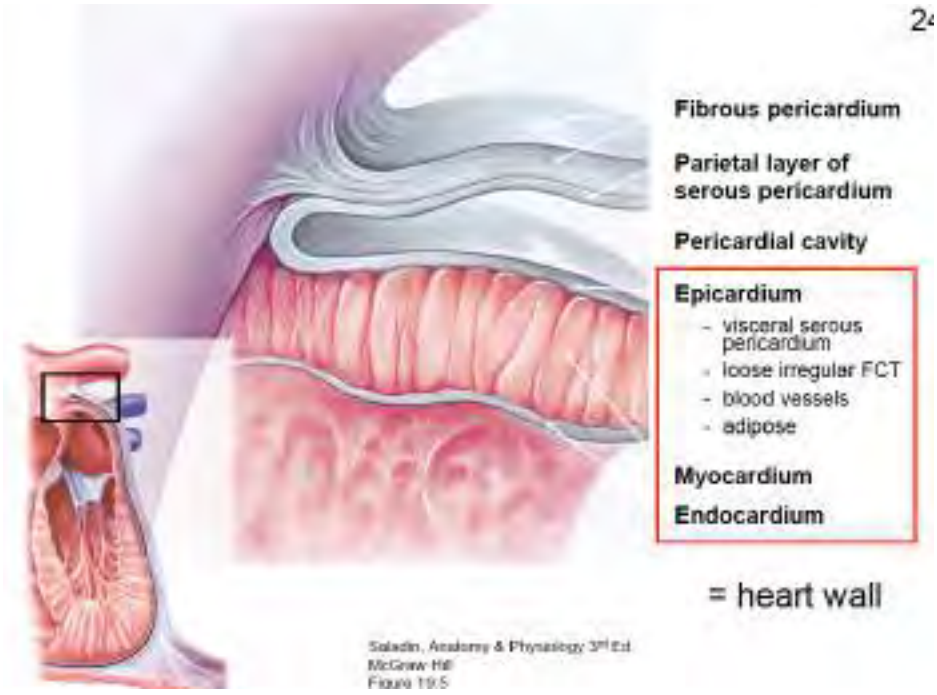


Describe the chambered structure of the heart and relate this to the pumping action of the organ

Atria: the left and right atria are thin walled receiving chambers.
Right Atrium: receives the superior vena cava (head and neck), the inferior vena cava (all veins below the diaphragm) and the coronary sinus (blood from the heart).

	Left atrium: receives four pulmonary veins (containing oxygenated blood from the lungs) – 2 left and 2 right. The left and right ventricles are separated by the interventricular septum.  
Name the layers of the heart wall	

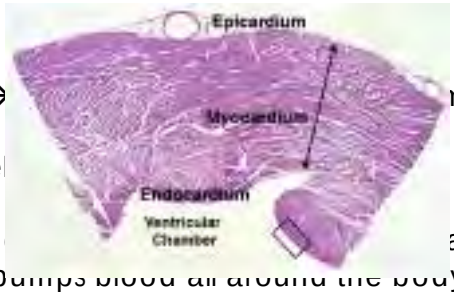
There are three layers to the heart wall: the endocardium, myocardium and



epicardium. The pericardium is an outer layer like a leathery sack, which is not part of the wall of the heart.

Endocardium:

- Squamous epithelium – this is a single layer of flat cells which lines the entire cardiovascular system.
- Above this is a pad of loose irregular FCT, which also contains small blood vessels and Purkinje fibres.



Epicardium:

- The outer layer is the visceral layer of pericardium → n.
- Contains large blood vessels
- Made up of loose irregular FCT – same as endothe

Left and right ventricles: the heart wall of the left ventri at of the right ventricle. This is because the left ventricle pumps blood all around the body, so requires more presure and force than the right ventricle which only has to pump the blood to the lungs. Same volume, higher pressure.

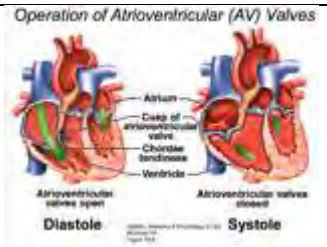
Pericardium:
The pericardium is a loose fitting membranous sac.
It has a tough fibrous outer layer (the fibrous pericardium) and a folded inner layer (the serous pericardium). The outer layer (of the folded layer) is the parietal layer of the serous pericardium and the inner layer is the visceral layer of the pericardium.
Between the two layer is the pericardial cavity which contains pericardial fluid, secreted by the serous membrane.

3. Anatomy of the Heart (Part 2)

Thursday, July 9

Describe the heart valves & relate this to the flow of blood through the heart chambers

There are two types of heart valves: Atrioventricular and semilunar.



Atrioventricular (AV) valves:
Function is to prevent blood returning to the atria during ventricular contractions.
There is one on the right and left sides.

Right side: tricuspid valve – has three leaflets. | Left side: mitrial (bicuspid) valve –two leaflets.

Papillary muscles control the closing of the valve leaflets. There is one papillary muscle per leaflets of the AV valve. The papillary muscles are attached to the leaflet by chordae tendonae – strong tendonous cords "heart strings". This tendonous attachment stops the flaps from prolapsing (going back to far resulting in regurgitation) tendonae DO NOT pull the valve shut, they m ey c event backflow.

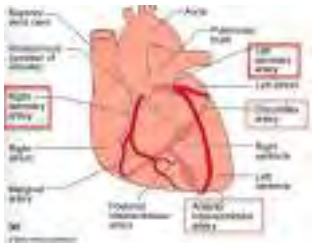
Operation of the AV valves:

Diastole: Filling ventricles from the blood in the atria.
During this phase AV valves are <u>open</u>.
Systole: Contraction of the ventricles causes an increase of pressure, this forces the AV valves to close and opens the semilunar valves.

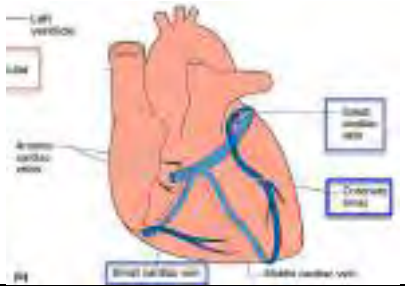
Semilunar valves:
Function: Prevent blood returning to the ventricles during filling (diastole). These valves are pushed open as blood flows out of the heart (ventricular contraction) and close as blood starts to backflow due to passive recoil of the artery.
Aortic semilunar valve: one the left side, has three cusps.
Pulmonary semilunar valve: on the right side, also has three cusps.

Identify the vessels of the cardiac circulation

Left coronary artery: Comes of the aorta, first branch. Goes behind the pulmonary tract and supplies blood to the left side of the heart. It then branches into the circumflex artery which runs around in groove between LA and LV, and also forms branch called the Anterior intraventricular artery. The anterior ventricular artery runs over the IV septum. It has lots of branches to the left side as this side has more muscle thus requires more blood.



Right coronary artery: Comes off the aorta and supplies a lot of the right side of the heart.
The coronary arteries run along the epicardium, then branch off at the point where blood is needed, then the branch dives down into the muscle.

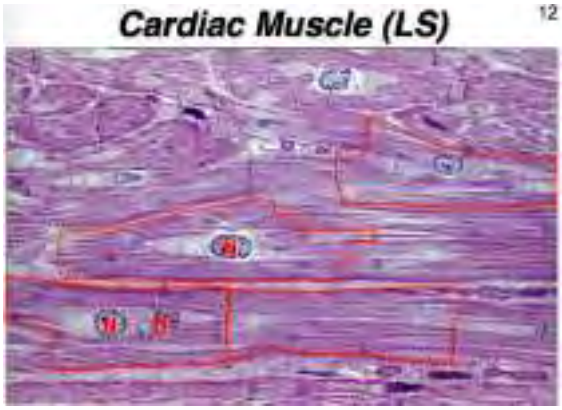


Cardiac veins: The Great cardiac veins and the small cardiac vein drain blood back to the heart. They join to form the coronary sinus, which flows back into the right atrium via the superior vena cava.

Compare and contrast the structural features of cardiac muscle with that of skeletal muscle

Capillaries: Cardiac muscle has a rich network of capillaries to ensure that the cardiomyocytes are well supplied with oxygenated blood. Capillaries are long thin structures which run between the cardiomyocytes. The red blood cells travel in single file – 8-10 microns in diameter.
Endothelial cells form the wall of the capillaries. This is a continuous wall as the endothelial cells send out enxtension to form a circular wall.

<u>Cardiac muscle</u>



Has features of smooth & skeletal muscle, plus specific cardiac features. The function of cardiac muscle is to always maintain beating of the heart.
Cardiac muscle structure:
Striated (like skeletal), short, fat, branched cells. Has one (or occasionally two) nuclei per cell (unlike skeletal which has multiple). The nucleus is found in the centre of the cell (unlike skeletal) and the cytoplasmic oranelles are packed at the poles of the cell.