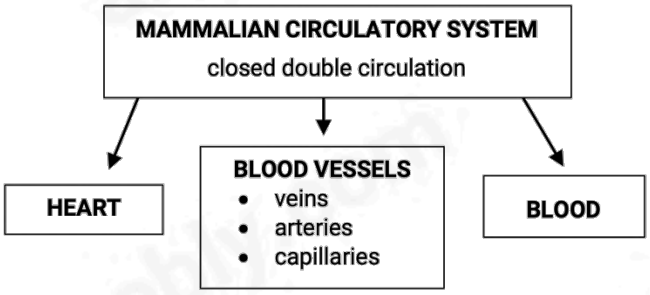
8 Transport in mammals

8.1 The circulatory system



It's called **closed** circulation as the blood remains within blood vessels.

DOUBLE CIRCULATION	
SYSTEMIC CIRCULATION	**PULMONARY CIRCULATION**
left ventricle → **AORTA** → body (except lungs) → **VENACAVA**	right ventricle → **PULMONARY ARTERIES** → lungs → **PULMONARY VEIN** → left atrium

Blood vessels

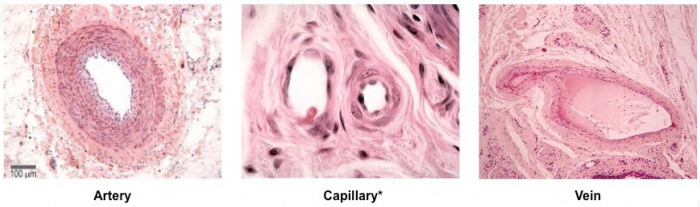


Image: https://ib.bioninja.com.au/

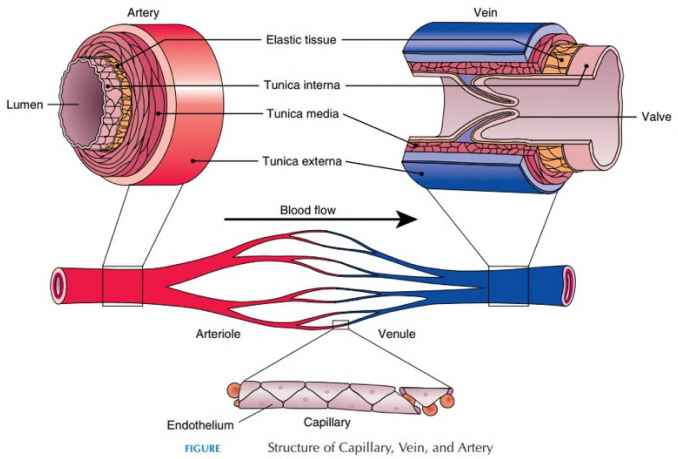


Image: https://www.brainkart.com/

a) arteries

- transports oxygenated blood at high pressures to tissues
- pulmonary artery and aorta have semilunar valves in the beginning
- **tunica intima/interna** – very smooth, single layer of flat cells
- **tunica media** – smooth muscle, collagen fibres, elastic fibres
- **tunica externa** – collagen fibres, elastic fibres

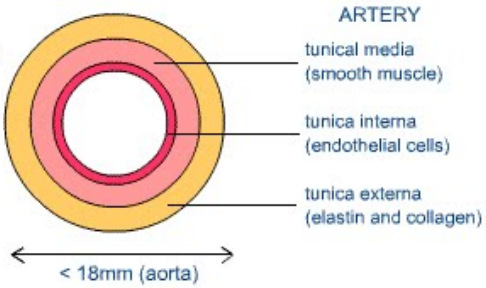


Image: http://www.hcc.ac.uk

- tunica media is the thickest in arteries
- depending on the pressure, thickness of arteries' walls differs
- tunica media contains large amounts of elastic fibres to allow the artery wall to stretch as blood surges through at high pressure
- artery wall can recoil inwards if the pressure drops
- as blood at high pressure enters, it can widen, reducing pressure slightly and vice versa
- arteries branch out into arterioles
- arteriole walls have more smooth muscle which can contract, narrowing the diameter and reducing blood flow

b) veins

- **tunica intima** – flat cells, smooth
- **tunica media** – smooth muscle, collagen, and elastic fibres
- **tunica externa** – elastic and collagen fibres

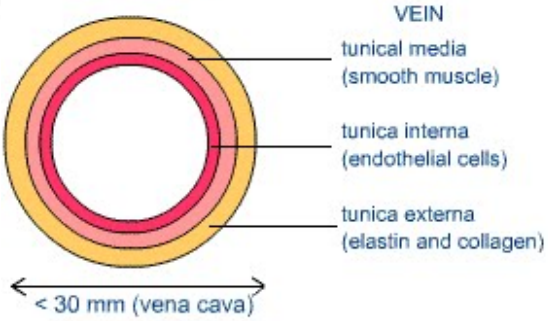


Image: http://www.hcc.ac.uk

- tunica externa is the thickest in veins
- thin tunica media
- tunica intima is smooth and not crinkly

- blood is transported at low pressures, no need for thick walls
- contain semi-lunar valves (formed from their endothelium)
- large lumen
- irregular shape

c) capillaries

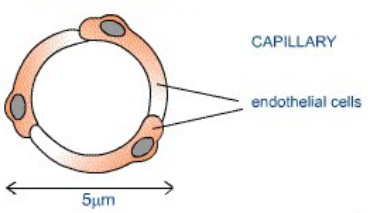
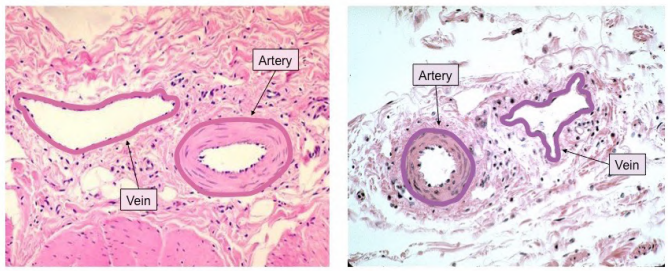


Image: http://www.hcc.ac.uk

- takes blood really close to cells allowing exchange of materials
- network of capillaries is called the capillary bed
- wall made of endothelial cells and is one cell thick
- gaps are present between individual cells that form the endothelium
- gaps allow some components of blood to seep through into spaces between cells (tissue fluid)



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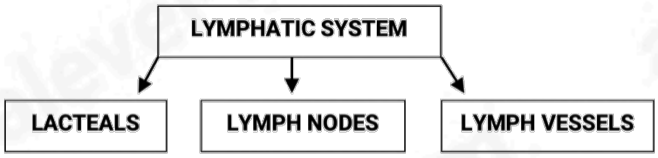
Blood plasma & tissue fluid

- as blood flows through capillaries within tissues, some plasma leaks out due to the pressure and seeps out into places between the cells of the tissues
- this plasma that leaks out is called tissue fluid
- if blood pressure is too high, too much fluid may be forced out of capillaries and the fluid may accumulate, this results in oedema
- it's through tissue fluid that the exchange between cells and blood occurs

Lymphatic system

- drainage system
- digestive (assimilation of fatty acids)
- immunity – produces lymphocytes



- lymphatics are tiny, blind-ended vessels
- they contain valves which allow to tissue fluid to flow in but not out
- walls are wide enough to allow larger protein molecules to pass through
- fluid inside lymphatics is called lymph
- lymph is transported to subclavian vein
- lymph vessels have smooth muscle in their walls which contract to push lymph along

Blood

a) red blood cells (erythrocytes)

- contain haemoglobin which gives red colour and transports oxygen
- produced in the bone marrow
- have a biconcave, disc shape – dent increases surface area in relation to volume
- spongy and flexible – have specialised cytoskeleton made of protein filaments that allow them to be squashed
- have no nucleus, endoplasmic reticulum, mitochondria – more space for haemoglobin, maximising amount of oxygen which can be carried
- broken down in spleen

b) white blood cells (leucocytes)

Refer to Chapter 11, Immunity.

c) platelets (thrombocytes)

8.2 The heart

- consists of 2 atria/auricles and 2 ventricles
- right and left side separated by septum
- made of cardiac muscle
- papillary muscles contract to pull on valve tendons to prevent inversion of valves during systole
- atria and ventricles have valves between them called atrioventricular valves:

RIGHT SIDE – TRICUSPID
LEFT SIDE – BICUSPID / MITRAL

- 2 types of valves:

ATRIOVENTRICULAR – TENDONS
SEMI-LUNAR – POCKETS

The cardiac cycle

SYSTOLE – CONTRACTION, DIASTOLE – RELAXATION

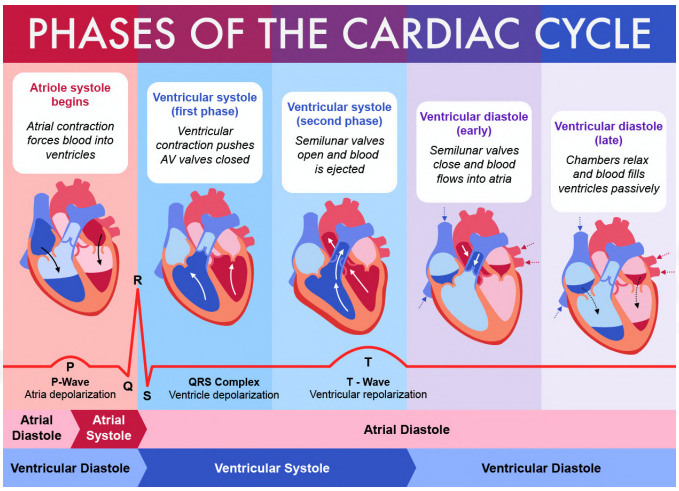


Image: https://www.artstation.com/

Atrial systole

- heart is filled with blood and the muscle in atrial wall contracts
- pressure is higher in atria than ventricles here so blood forces the atrioventricular valves open
- blood flows from atria to ventricles
- pressure developed isn't very high due to atrial walls being not very thick
- semi-lunar valves in pulmonary veins and venacavae prevent backflow from the atria

Ventricular systole

- occurs about 0.1s after atria contract
- ventricles contract increasing pressure and pushing blood out of the heart
- blood in ventricles is at higher pressure so atrioventricular valves are pushed shut, preventing blood from going back to atria
- blood rushes upwards into aorta and pulmonary artery as pressure forces aortic semi-lunar valves open

Ventricular diastole

- muscle relaxes, therefore pressure in the ventricles drops
- presence of semi-lunar valves prevents backflow of blood from aorta and pulmonary artery
- during diastole, whole of the heart muscle relaxes
- blood from the veins flow into atria
- some blood leaks down into ventricles
- the atrial muscle then contracts, forcing blood into ventricles
- atrioventricular valves close
- forced produced in the right ventricle must be relatively small as –
  1) blood goes only to the lungs which are at a shorter distance + less resistance to overcome
  2) if a too-high pressure was developed, tissue fluid would accumulate in lungs hampering gas exchange

Cardiac cycle

Cardiac muscles are myogenic which means it naturally contracts and relaxes without receiving impulses from a nerve.

1) SAN (sinoatrial node)/pacemaker sends out waves of excitation which stimulates atria to contract
2) non-conducting tissue between atria and ventricles prevents atria and ventricles from contracting at the same time
3) AVN (atrioventricular node) delaying the impulse allows atria to completely into ventricles
4) AVN sends impulse down to the bundle of his and along purkine fibres
5) this causes ventricles to contract from the base upwards

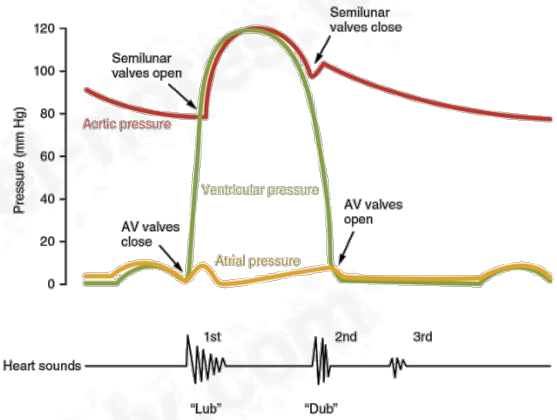


Image: https://teachmephysiology.com/

Oxygen dissociation curve

- once an O_2 molecule combines with haemoglobin, it becomes easier for more molecules to combine therefore, the curve rises very steeply
- a small change in the partial pressure O_2 causes a very large change in amount of O_2 carried by haemoglobin

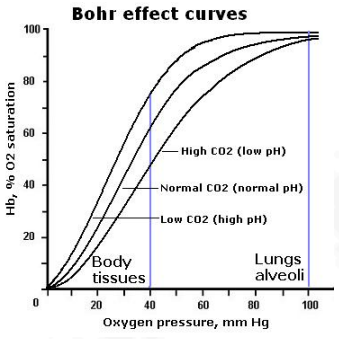
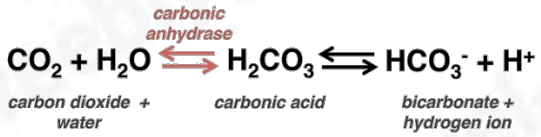


Image: https://www.onlinebiologynotes.com

Bohr shift

- shift in the curve of oxyhaemoglobin due to concentration of CO_2 at a given partial pressure of O_2 is Bohr effect
- the amount of O_2 haemoglobin carries is affected by the partial pressures of both O_2 and CO_2
- the presence of high partial pressure of CO_2 causing Hb to release O_2 is the Bohr's effect

In the cytoplasm of red blood cells, CO_2 is catalysed by carbonic anhydrase enzyme when it reacts with water to form carbonic acid



- 2hen the carbonic acid dissociates; haemoglobin combines with H^+ ions forming haemoglobunic acid (HHb) and releases the O_2 it's carrying
- Haemoglobin combining with H^+ ions maintains blood pH as if the ions were left in solution, pH of the blood would've been less and turns acidic

- presence of high partial pressures of CO_2 causes haemoglobin to release O_2
- high concentration of O_2 is found in respiring tissues which need O_2
- high concentration of CO_2 causes Hb to release O_2, curve lies below and to the right

- 85% of CO_2 – diffuses out of RBC into blood plasma and are carried in solution
- 5% of CO_2 – CO_2 that hasn't dissociated and remains as CO2 dissolves in blood plasma
- 10% of CO_2 – CO_2 diffuses to RBC and combines directly with amine groups ($-NH_2$) of some haemoglobin molecules forming carbaminohaemoglobin