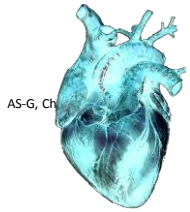
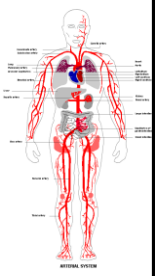


AS-G, Ch

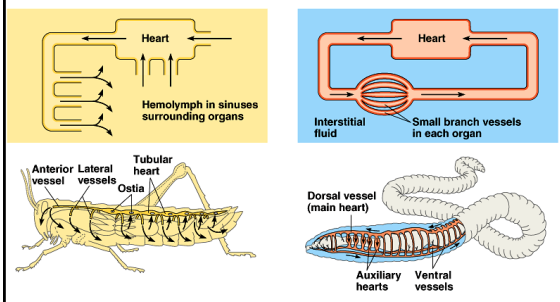
Mammalian Transport and The Heart

Cardiovascular System

- Blood flows through the body in a closed system (circuit) driven by the pumping power of the heart
- Closed vs open: does the system have vessels contained the entire way?
- Single vs. Double systems: One or two sides to the system?



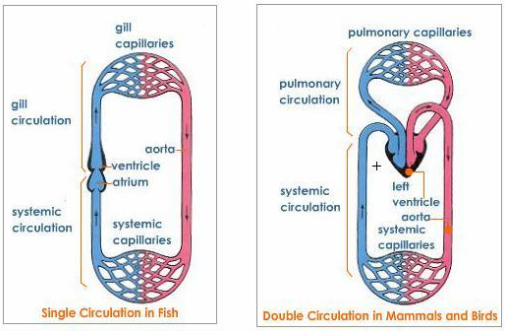
Open vs. Closed

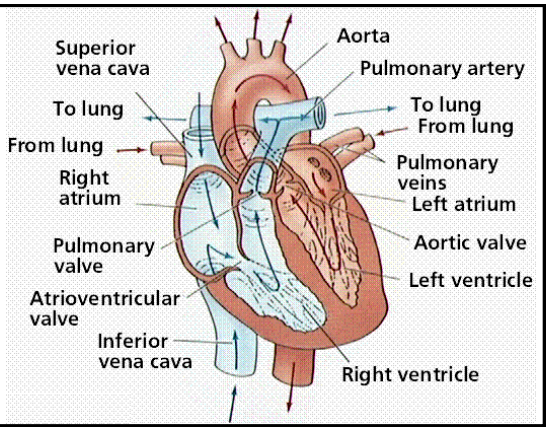


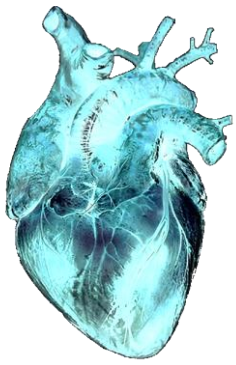
(a) Open circulatory system

(b) Closed circulatory system

Single vs. Double

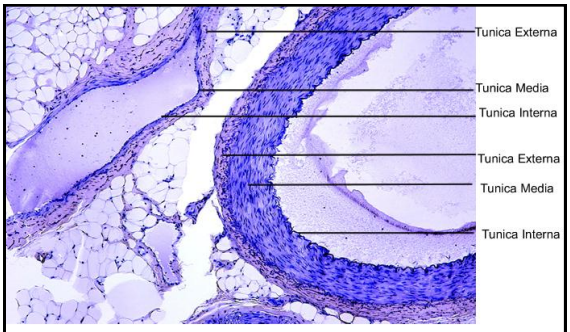






Blood Vessels

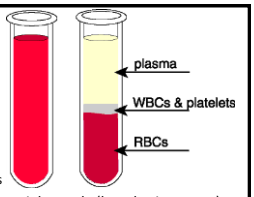
- Both A+V have three tissue layers (from o to in):
  - tunica externa (elastic fibre and collagen)
  - tunica media (smooth muscle, collagen, elastic fibres)
  - tunica intima/interna (squamous epithelium)
- Arteries- high pressure, blood to tissues/lungs. Have highly thickened tunica media to support pressure, carry blood away from the heart. Branch into arterioles
- Veins- much lower pressure, take blood back to heart
  - Muscles squeeze low pressure blood towards the heart and semilunar valves prevent backwards flow
- Arteries carry oxygenated blood, Veins carry deoxygenated blood EXCEPT IN THE LUNGS
- Capillaries-branch from arterioles to take blood as close to the cells as possible
  - Made of epithelial lining only with lots of gaps
  - Gas exchange = simple diffusion!



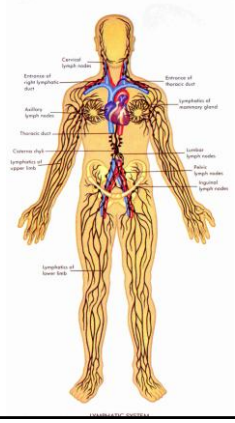
Artery, Vein (100x)

Photo of a vein on the left and an artery on the right. Note the difference in thickness of the tunica media.

Tissue fluid

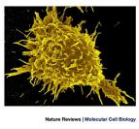


- Plasma: yellowish liquid that is mostly water that suspends cells
  - Plasma is what fills your intercellular spaces
- Lymph: plasma that is pumped through special vessels (lymphatic system) to ultimately return plasma to the blood
  - Can be used as part of the immune system
  - Can filter and kill bacteria
  - Can transfer metastatic cancer cells
  - Can help with various metabolic processes (liver, ie)

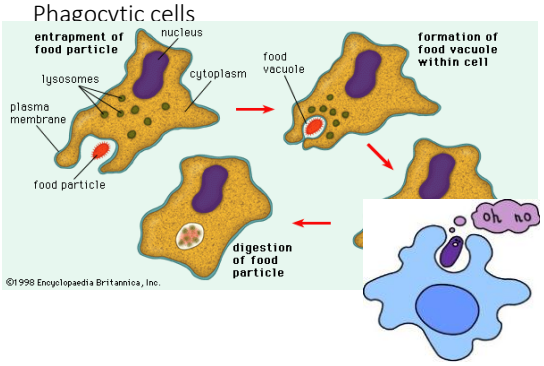


Non-Red Blood Cells

- Leucocytes: (WBCs) round or irregular, have a nucleus, serve immuno and regulatory purposes such as…
  - Phagocytes: "feeding cells"—kind of like engulfing attack cells that destroy cardiovascular invaders via phagocytosis
  - Lymphocytes: generate antibodies and chemically attack body invaders (more to come next week!)

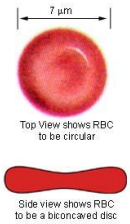


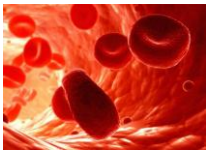
Phagocytic cells



Blood—Erythrocytes

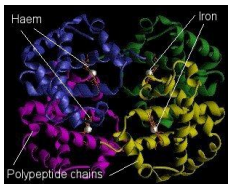
- Haemoglobin rich cells that transport oxygen from lungs to rest of body
- Fetal RBCs are made in liver, once born they're made in red bone marrow
- Short lived cells (3-4 months at most)
- No nucleus, mitochondria, ER—gives a biconcave shape and provides more room for haemoglobin

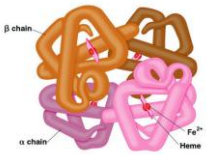




Haemoglobin

- Four protein polypeptides each with a haem (iron ion complex) at its center
- High affinity for oxygen—1 molecule of O_2 per haem, so 4 molecules of O_2 per molecule of haemoglobin
- Fetal haemoglobin has a higher affinity for O_2, so it picks up oxygen from mother's adult haemoglobin



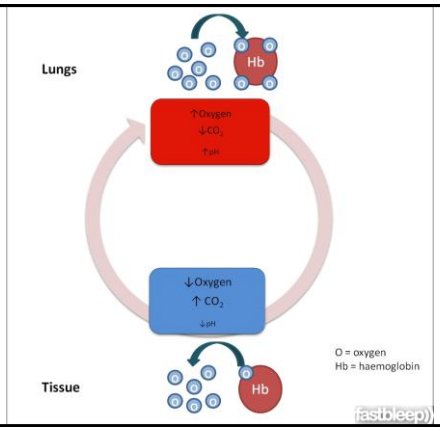


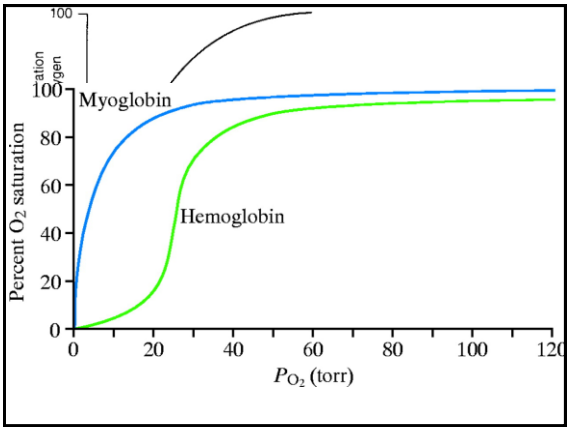
Myoglobin

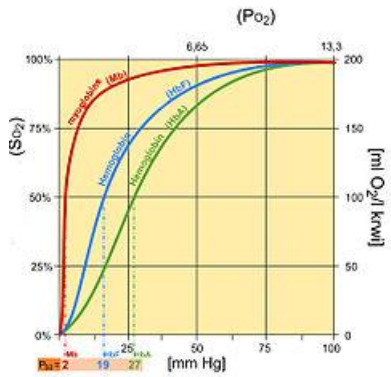
- Another oxygen associating molecule found in muscle tissue, gives meat its red color
- Only one polypeptide and one haem, so on associated.
- Oxymyoglobin is incredibly stable, however, and need s VERY low O_2 PPs to release O_2

Haemoglobin Dissociation Curve

- Partial pressures (concentrations) of oxygen influence how much O_2 is bonded to haemoglobin
- Higher PP of O_2 means more O_2 bonded to haemoglobin
- As haemoglobin cycles through the body to areas of progressively lower O_2 concentrations, O_2 dissociates from haemoglobin to diffuse into tissues

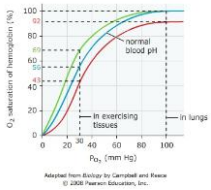


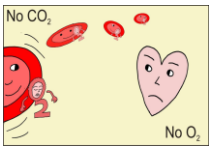




The Bohr Shift

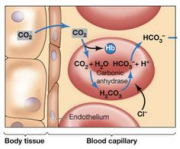
- Haemoglobin picks up and drops of O_2 based on O_2 PPs—dissociation is also affected by CO_2 PPs.
- Haemoglobin releases more O_2 when CO_2 concentrations are high
- Haemoglobin absorbs hydrogen ions that are released in the dissociation of CO_2 gas—acts as a buffer for the blood





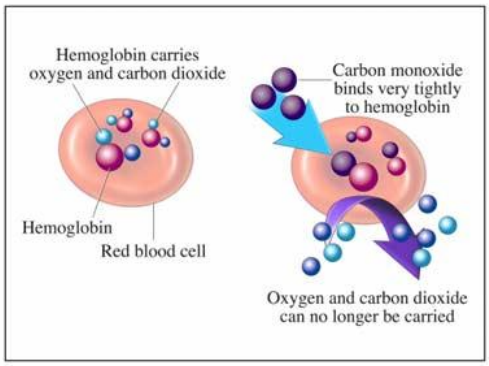
Carbon Dioxide Uptake and Transport—Three types of transport

- RBCs are responsible for both oxygen delivery and CO_2 disposal—CO_2 couldn't diffuse alone
- 1. Enzyme inside of RBCs, **carbonic anhydrase**, dissociates CO_2 into H+ and HCO_3-
  - HCO_3- diffuse into plasma and are transported back to lungs for exhalation (80% of CO_2 transport)
- 2. Some CO_2 dissolves (not dissociates) in blood and transports that way
- 3. Other CO_2 binds to terminal amine in haemoglobin and creates carbamino-haemoglobin

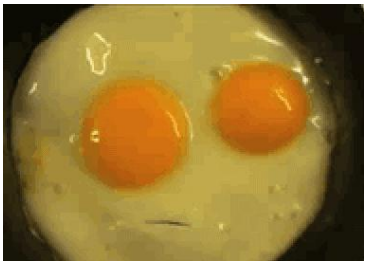


Issues with Haemoglobin

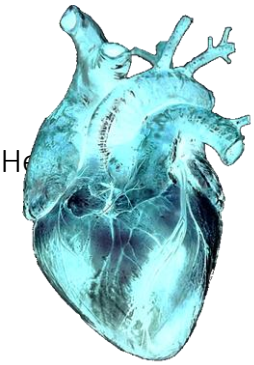
- Associates readily with Carbon Monoxide (toxic)—reaction is virtually irreversible
  - Reaction is 250x more favorable than reaction with O2
  - Eventually leads to asphyxiation—RBCs can't get enough O2 to tissues and tissues start to die.
- Doesn't function as well in low PPs of Oxygen (such as at high altitudes)



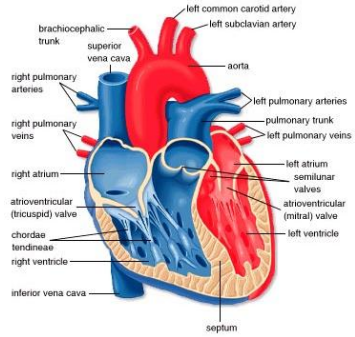
QUESTIONS?!



The He

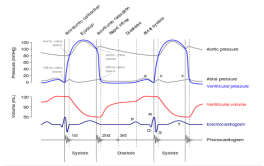


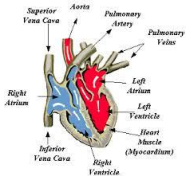
Anatomy



The Cardiac Cycle

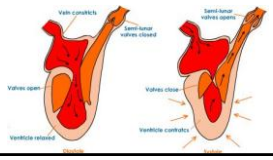
- Cycle of one heart beat—moves deoxygenated blood from body and oxygenated blood into body
- Three main stages: Atrial systole, Ventricular systole, Ventricular diastole





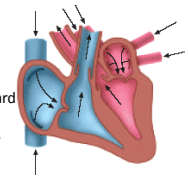
Atrial Systole (Atrial contraction)

- Heart fills with blood and atrial walls contract
- Both atria contract—
  - Right atrium contracts to force blood into the right ventricle.
  - Thicker left atrium contracts and forces blood into left ventricle for distribution to body
- Valves close to prevent backwards flow
  - Tricuspid valve (R)
  - Mitral valve (L)



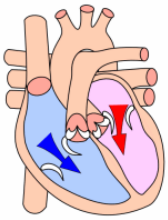
Ventricular Systole (Ventricle contraction)

- Both ventricles contract about 0.1 sec after the atria contract
- Muscular ventricles force blood out of the heart, by increasing pressure on blood
- On right side, deox. blood flows into pulmonary artery towards lungs
- On left side, oxy blood flows into aorta toward body
- Semilunar valves shut and prevent backflow
- Lasts ~0.3 seconds

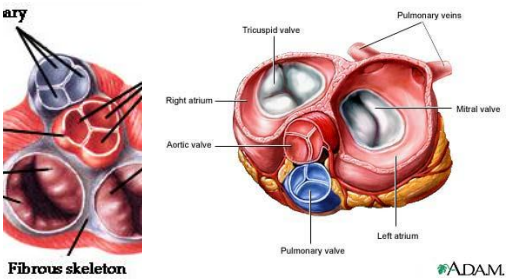


Ventricular Diastole

- Entire heart muscle relaxes
- Pressure in atria drops
- Blood snaps the semilunar valves shut via cusps to prevent flowback of high pressure blood into the ventricles
- The heart is just chillin'

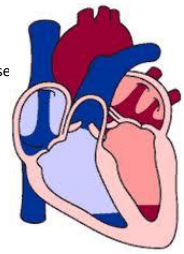


Valves



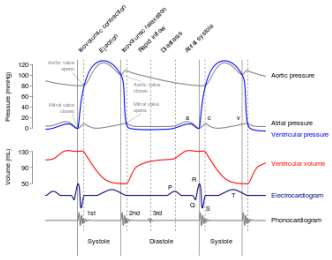
Pressure Changes

- Atrial pressure < Ventricular pressure because the ventricles push blood much farther
- Pressure in right ventricle < left ventricle because blood just needs to go through the lungs.
  - In the left ventricle, blood must flow to the entire body (whoa!)



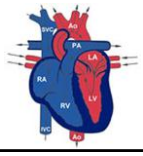
Cardiac Cycle Summary

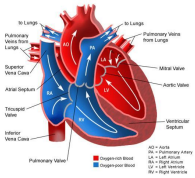
- http://www.youtube.com/watch?v=rguztY8aqpk



Path of Blood:

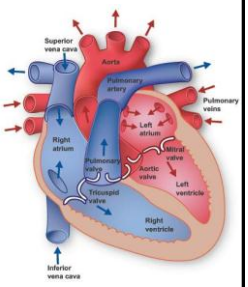
- 1. Deoxygenated blood from body flows through superior and inferior vena cava into right atrium (RA).
- 2. Atrial systole causes atria to contract, and RA forces blood through the tricuspid valve into the RV
- 3. Ventricular systole causes ventricles to contract, RV forces high pressure blood through a semilunar valve into the pulmonary artery to go to the lungs.
- 4. Ventricular diastole—blood flows back in

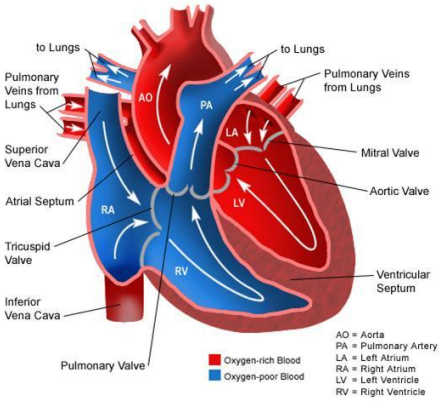




Path of Blood:

- 5. Blood becomes oxygenated in lungs
- 6. Oxy blood enters LA via the pulmonary vein
- 7. Atrial systole contracts atria and LA forces blood into the LV through the bicuspid (mitral) valve
- 8. Ventricular systole contracts ventricles and LV forces incredibly high pressure blood into the aorta.
- 9. Semilunar valve closes and heart goes through Ventricular diastole again.



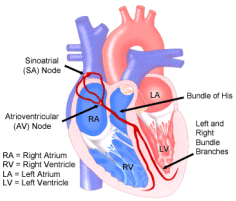


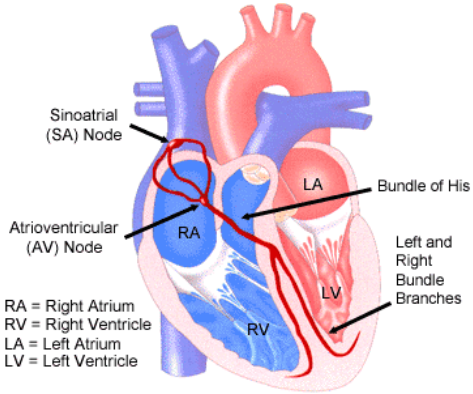
The Cardiac Cycle Song

- http://www.youtube.com/watch?v=xVofKdXOa4M

Control of the Heart

- All muscles are ultimately controlled by electrical nerve impulses
- Cardiac cycle starts at the sinoatrial node (SAN)
  - The pacemaker of the heart that kickstarts atrial contractions
  - Electrical impulses spread out
- Electrical impulse spreads to the atrioventricular node (AVN) which then starts ventricular contraction
- Impulse travel to ventricles via the purkyne tissue in the septum
- This is so everything doesn't contract at once!





Questions?