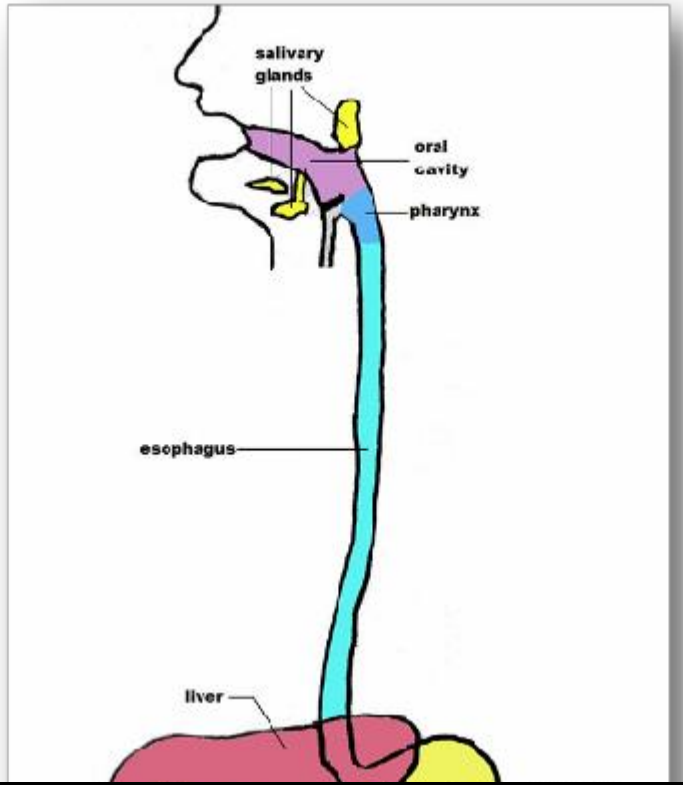
6.1 Digestion and absorption:

Nature of science: Use models as representations of the real world—dialysis tubing to model absorption in the intestine.

Understandings:

β - Skill: Production of an annotated **diagram of the digestive system**.

Diagram	Structure	Function
	Mouth/ Oral Cavity	
	Esophagus	
	Stomach	
	Small Intestine	
	Pancreas	
	Liver	
	Gall Bladder	

	Large Intestine	

Check out the Inner Body website to see where everything fits into your body. You can also use this site the fill in the boxes above.

∑ - The contraction of *circular* and *longitudinal muscle* of the small intestine mixes the food with enzymes and moves it along the gut.

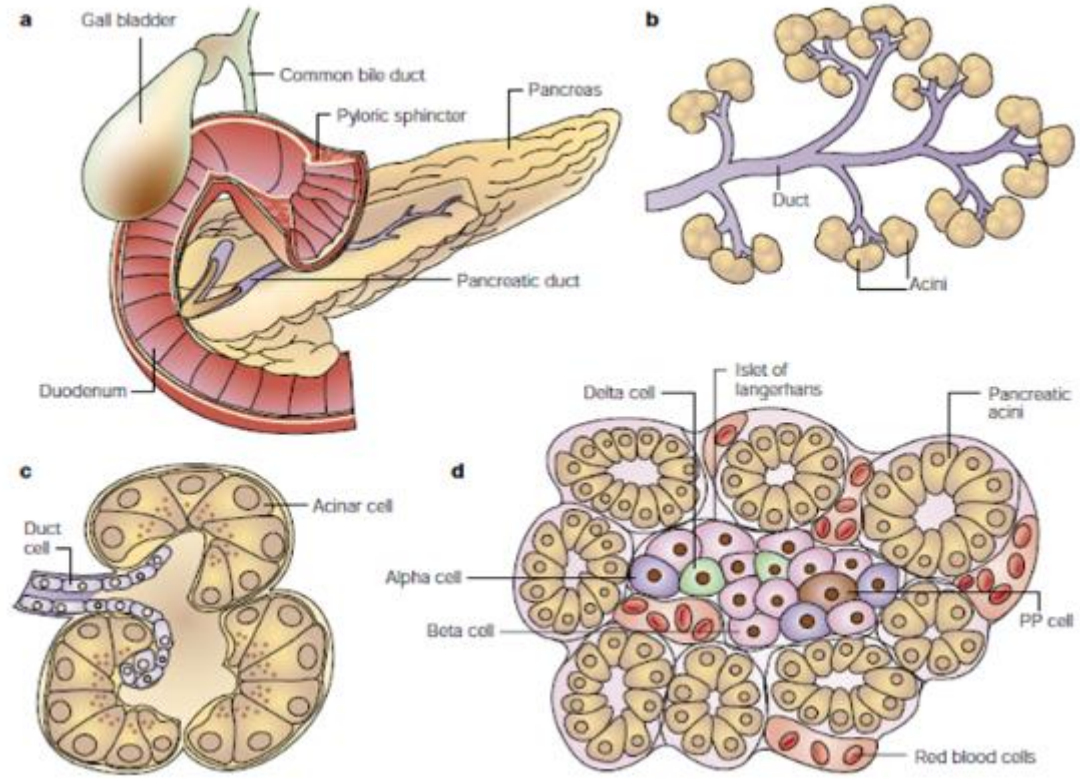
- The contraction of circular and longitudinal muscle of the small intestine helps mix (mechanical digestion) the food with enzymes and moves the semi-digested food (bolus) along the gut in a process called peristalsis
- These muscles are made up of smooth muscle
- The process by which continual waves of contraction and relaxation (peristalsis) of the circular and longitudinal muscle occur along the muscle layers surrounding the small intestine is controlled by the autonomic nervous system
- Food is transported slowly through the small intestine to allow for maximum digestion and absorption of nutrients

Video showing peristalsis https://www.youtube.com/watch?v=o18UycWRsaA (turn off the music as it is terrible)

Smooth muscle function https://www.youtube.com/watch?v=yzQAgfivX74

∑ - The pancreas secretes enzymes (*amylase, lipase and an endopeptidase*) into the lumen of the small intestine.

- Enzymes are biological catalysts that speed up the rate of reaction in chemical digestion.
- Enzymes in digestion catalyze hydrolysis reactions.
- Pancreatic juice secreted into small intestine contains enzymes such as:
- **Endopeptidases** – example trypsin (breaks apart the peptide bond between amino acids in polypeptides)
- **Lipases** – catalyzes the hydrolysis of lipids (triglycerides and phospholipids)
- **Amylases** - digestion of starch.
- Pancreatic juice is alkaline (basic) to allow enzymes to work at an optimal pH (around 7-8 in the small intestine).
- The pancreas is controlled by the enteric nervous system and through hormones produced and released by the stomach.
- Enzymes are produced by ribosomes in the pancreatic gland cells, excreted by exocytosis into smaller ducts, which converge to form the pancreatic duct. Pancreatic juice flows through the pancreatic duct into the lumen of the small intestine



http://2010.igem.org/wiki/images/5/57/ESBS-Strasbourg-pancreas1.png

∑ - Enzymes digest most macromolecules in food into monomers in the small intestine (*starch, glycogen, lipids and nucleic acids* are digested into monomers and that cellulose remains undigested). Some hydrolytic enzymes have economic importance, for example amylase in production of sugars from starch and in the brewing of beer.

- Enzymes released by the small intestines break down macromolecules into smaller molecules called monomers through catabolic reactions (hydrolysis is the type of specific reaction)
- The following is a table showing the enzyme, source, substrate, products

Enzyme	Source	Breaks Down (substrate)	Products Formed (products)	pH
Amylase	Salivary glands and pancreas	STARCH	MALTOSE	Neutral to slightly basic
Maltase	Walls of the epithelial cells of the SI	MALTOSE	GLUCOSE	Slightly Basic
Lactase	Walls of the epithelial cells of the SI	LACTOSE	GLUCOSE AND GALACTOSE	Slightly Basic

Sucrase	Walls of the epithelial cells of the SI	SUCROSE	GLUCOSE AND FRUCTOSE	Slightly Basic
Lipase	Pancreas	LIPIDS	FATTY ACIDS AND GLYCEROL	Slightly Basic
Phospholipase	Pancreas	PHOSPHOLIPIDS	FATTY ACIDS, GLYCEROL AND PHOSPHATE	Slightly Basic
Proteases/Peptidases **Such as Trypsin**	Pancreas	POLYPEPTIDES	SHORTER PEPTIDES OR DIPEPTIDES	Slightly Basic
Dipeptidases	Walls of the epithelial cells of the SI	DIPEPTIDES	AMINO ACIDS	Slightly Basic
Nucleases	Walls of the epithelial cells of the SI	NUCLEIC ACIDS SUCH AS DNA AND RNA	NUCLEOTIDES	Slightly Basic

- Please note that some carbohydrates such as cellulose cannot be digested by humans as we lack the enzymes needed to break down cellulose
- This is why a number grass eating animals have specialized digestive systems to breakdown cellulose
- Cellulose is insoluble dietary fibre that helps move waste through our digestive system and prevents constipation

- Hydrolytic enzymes such as amylase are used in the brewing of beer to breakdown the starchy endosperm of barley seeds to produce maltose (malt sugar) thus having a great economic importance
- Here is a video on the process https://www.youtube.com/watch?v=OWX7a6waHX8 (just watch the first few minutes)

∑ **- Villi increase the surface area of epithelium over which absorption is carried out.**

- Villi are finger-like projections that make the surface of the small intestine look highly folded. These projections increase the **surface area** (by about 10X) available for**absorption** (the process of taking substances into the cells and blood).
- Microvilli are small hair-like projections attached to the villi to further increase surface area.
- The outermost layer of the villi is thin epithelial cells to allow nutrients to easily move across a short distance into the blood.

- A dense network of capillaries close to the epithelium allow a large amount of nutrients to move into the blood.
- Lacteals, which are a part of the lymphatic system, run up the middle of the villi. The lacteal allows for the absorption of the products of lipid digestion which are not easily absorbed by the capillaries.

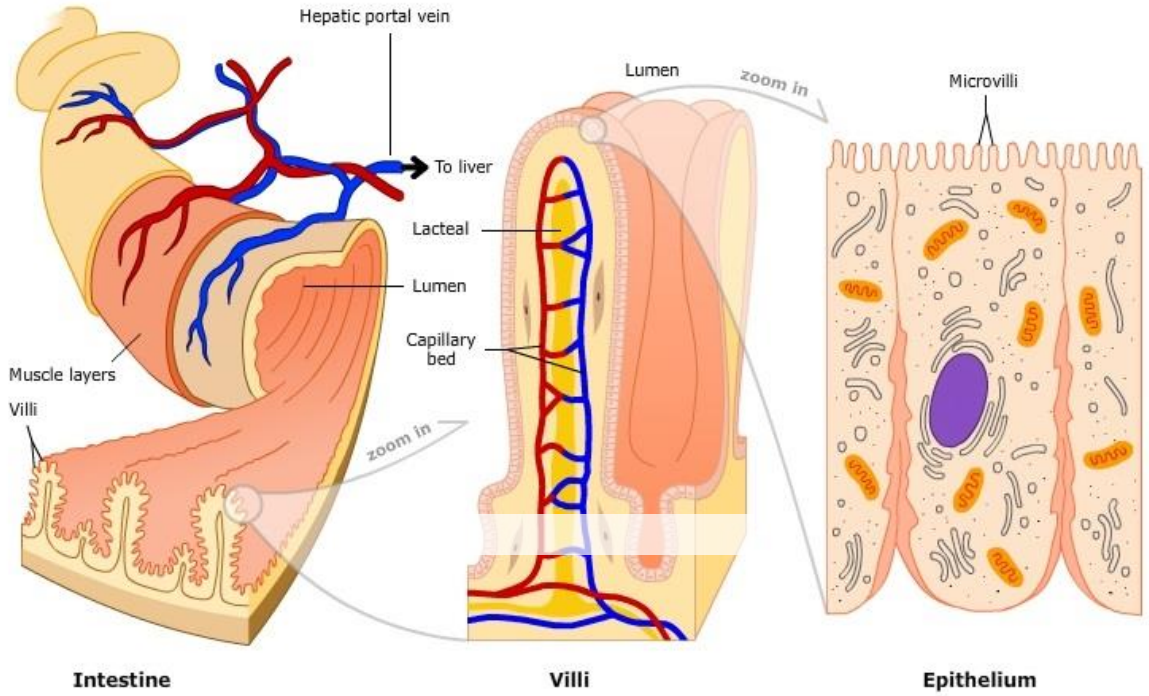
∑ **- Villi absorb monomers formed by digestion as well as mineral ions and vitamins.**

- **Absorption** – process where small molecules and nutrients pass into the blood vessels (capillary beds) in the wall of the intestine.

- **Assimilation** – products of digestion that are absorbed into the blood are transported to the various tissues. These molecules are used to build up larger molecules that become part of the structure of the tissue or body.

These products include the following monomers:

- **Monosaccharides** such as glucose, fructose, and galactose
- **Amino acids** from the breakdown of proteins
- **Nitrogenous bases** from the breakdown of nucleotides
- **Glycerol and fatty acids,** which are the products of lipids are absorbed by the lacteal inside the villi.
- **Mineral ions** such as sodium, potassium and calcium, and **vitamins** such as vitamin C, are also absorbed by the villi in the small intestine



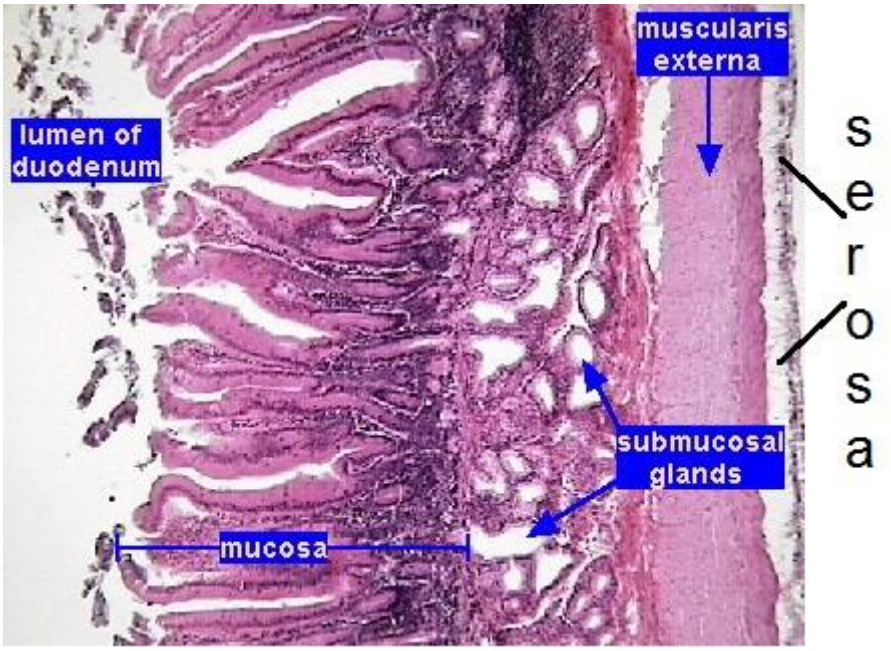
http://sciencelearn.org.nz/

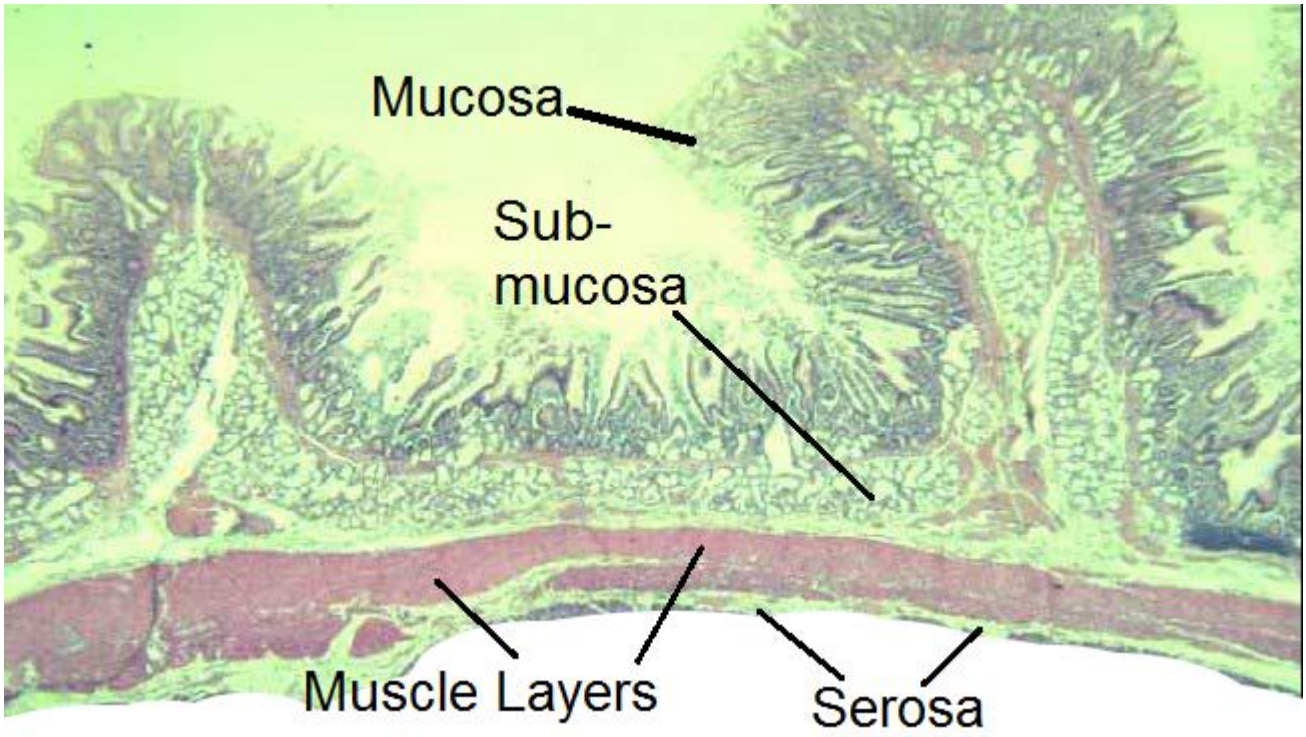
∑ - Tissue layers should include longitudinal and circular muscles, mucosa and **epithelium.**

- The epithelial layer is the inner tissue layer, that is in contact with the lumen
- The next layer is the mucosa layer; in between the epithelial cells near the lumen and the sub-mucosa layer
- Circular muscle is on the inside of the longitudinal muscle towards the lumen of the small intestine. The longitudinal muscles are at a right angle to the circular muscles.

<u>β - Skill</u>: Identification of tissue layers in transverse sections of the small intestine viewed with a microscope or in a micrograph.

- Here are some examples of micrographs with transverse sections of the small intestine



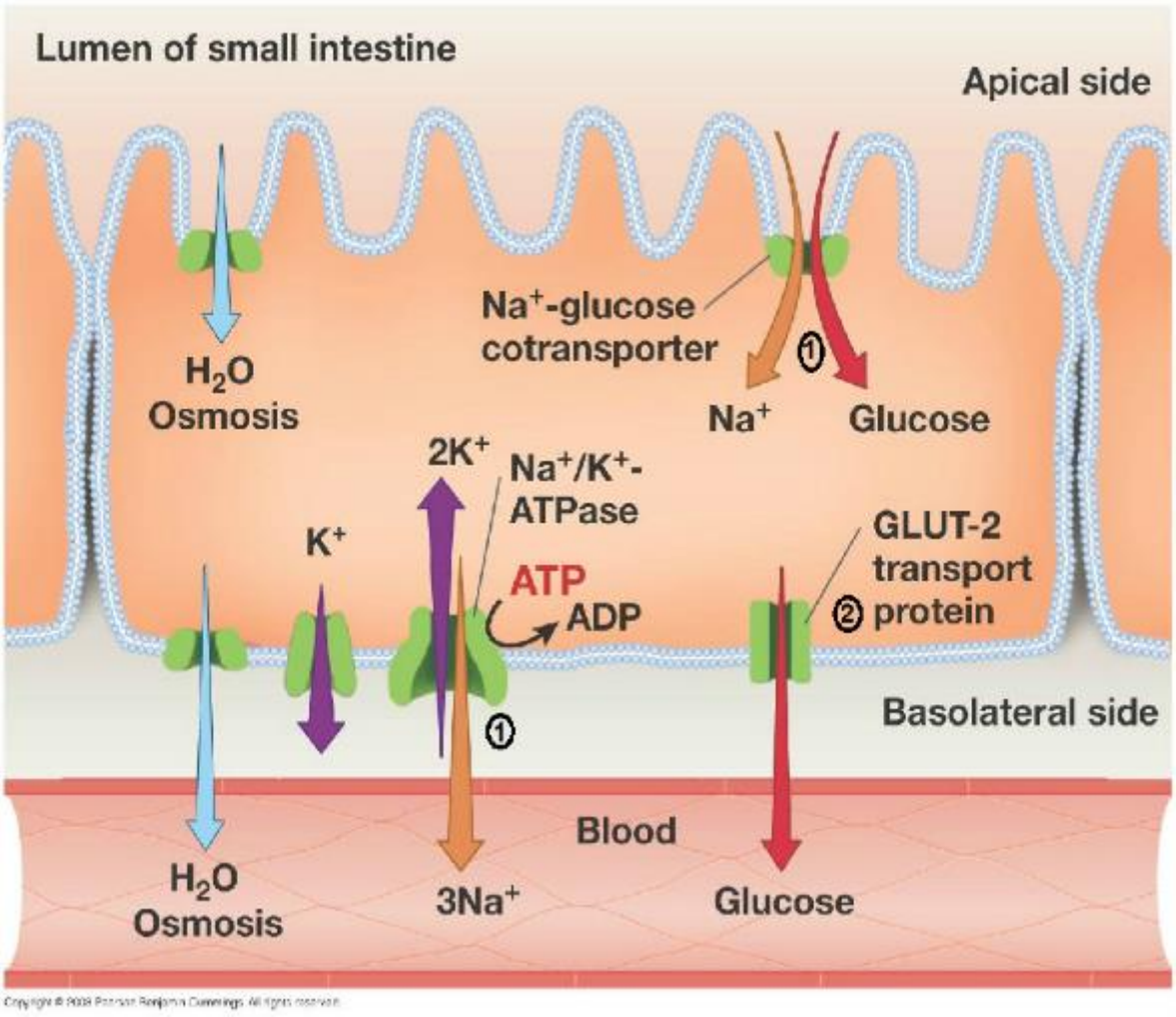


∑ - Different methods of membrane transport are required to absorb different nutrients.

- During absorption nutrients from food must pass from the lumen of the small intestine to the cells in the capillaries or lacteals in the villi.
- Many types of transport are used to move different nutrients into and out of the epithelium cells of the villi

These modes of transport will be outlined using two products of digestion.

Glucose



http://www.uic.edu/classes/bios/bios100/lectures/circ.htm

Since glucose has many hydroxyl groups it is a polar molecule and cannot pass through the cell membrane by simple diffusion and therefore relies on different types of facilitated diffusion in order to move into and out of the epithelial cells of the villi. (The numbers 1-4 here, match with numbers on the two diagrams above and below).

1) As seen above Na^+ is pumped out of the cytoplasm of the epithelial cells into the interstitial space inside the interstitial by sodium/potassium pumps.

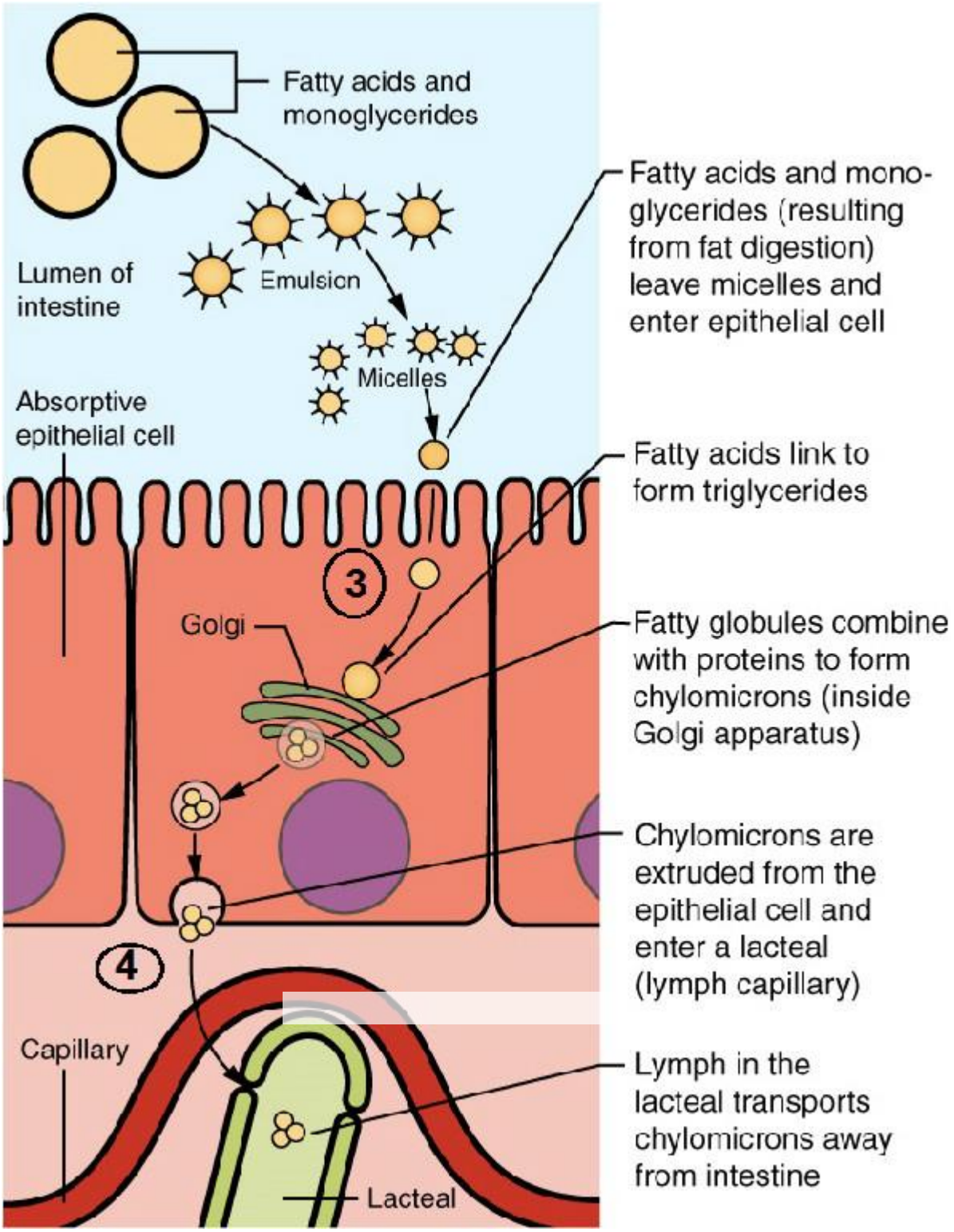
- This creates a concentration gradient between the lumen and the cytoplasm of the epithetical cells.

- This means Na^+ ions want to diffuse into the epithelial cells.

- **Co-transport** proteins in the membrane of the microvilli, allow a sodium ion and a glucose molecule to be transported together into the epithelial cell.

This type of **facilitated diffusion** is passive, but requires active transport of the Na^+ ions out of the cell to create the concentration gradient.

2) Specific glucose channels allow glucose to diffuse from the epithelial cells into the blood cells of the capillaries



https://courses.candelalearning.com/anatomyphysiology2/chapter/23-7-chemical-digestion-and-absorption-a-closer-look/

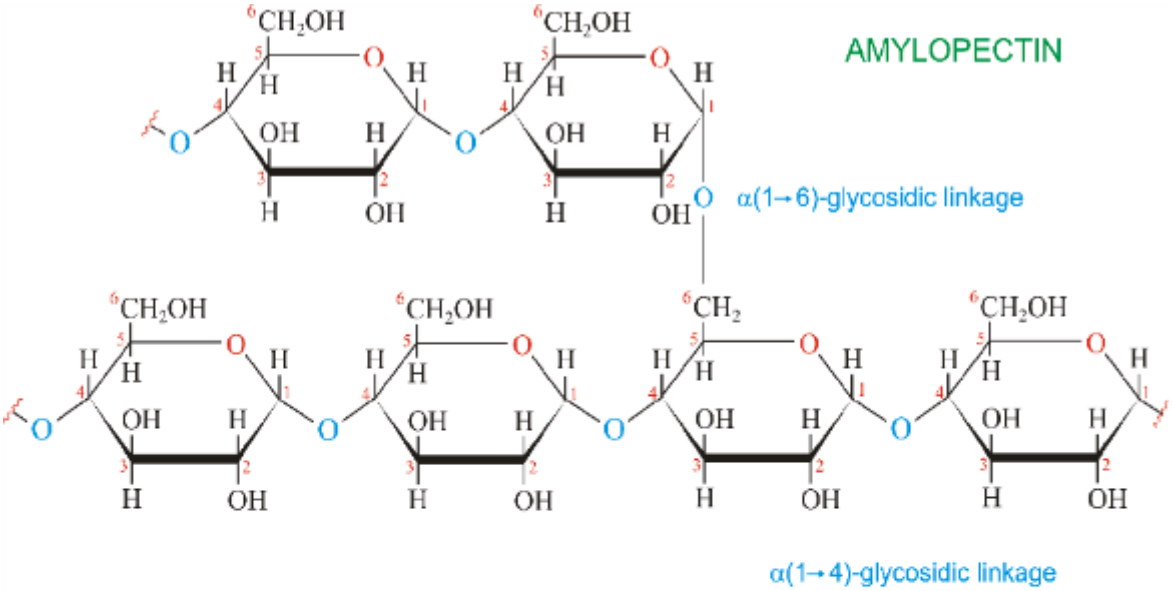
3) Fatty acids, glycerol and monoglycerides, which are products of lipid digestion can diffuse into epithelial cells from the lumen by passive diffusion

4) Inside the epithelial cells, fatty acids and monoglycerides reform into triglycerides, and therefore can't move back out into the lumen because of their size. These lipids combine together with proteins and phospholipids to form lipoproteins. The lipoproteins are then excreted by exocytosis, enter the lacteal and are carried away by the lymph

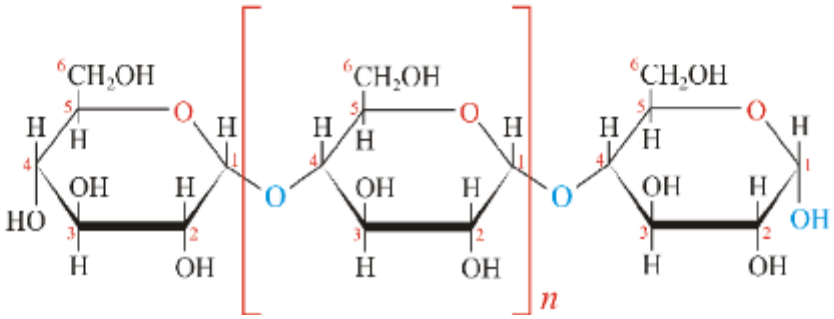
Applications and skills:

β - Application: Processes occurring in the **small intestine** that result in the*digestion of starch* and *transport of the products* of *digestion to the liver*.

- Many catabolic reactions take place in the small intestine
- These reactions are catalyzed by a number of enzymes that break down starch into smaller disaccharides and trisaccharides, which are further broken down into monosaccharides.
- These reactions need to occur since the starch molecule is much too large to pass through the membranes of the small intestine
- Starch-a long chain of α (alpha) glucose molecules used as a glucose storage by plants
- Starch consists of two types of molecules, amylose which linear and amylopectinwhich is branched (look at your notes from topic 2)



AMYLOSE



- Amylose 1,4 bonds can be broken apart by amylase to form the disaccharide maltose and the trisaccharide maltotriose
- Amylose cannot break the 1,6 bond seen in amylopectin
- These larger fragments containing this 1,6 bond of amylopectin are called dextrins
- These dextrins are further broken down by another enzyme into maltose
- Finally, all the maltose is hydrolyzed into glucose by maltase in order for it to be transported from the lumen of the small intestine into the blood in the capillaries surround the small intestine

β - Application: Use of dialysis tubing to model absorption of digested food in the intestine.

See handout on Manage Bac

Review

Build a body https://www.brainpop.com/games/buildabodydigestivesystem/

Click on the above link and drag and drop digestive system parts to build a body for review. After this is complete, click on game quiz and do the multiple choice quiz.

Crash Course on Biology. https://www.youtube.com/watch?v=s06XzaKqELk

Cartoon on digestion https://www.youtube.com/watch?v=VwrsL-lCZYo

6.2 The blood system: The blood system continuously transports substances to cells and simultaneously collects waste products.

∑ Understandings

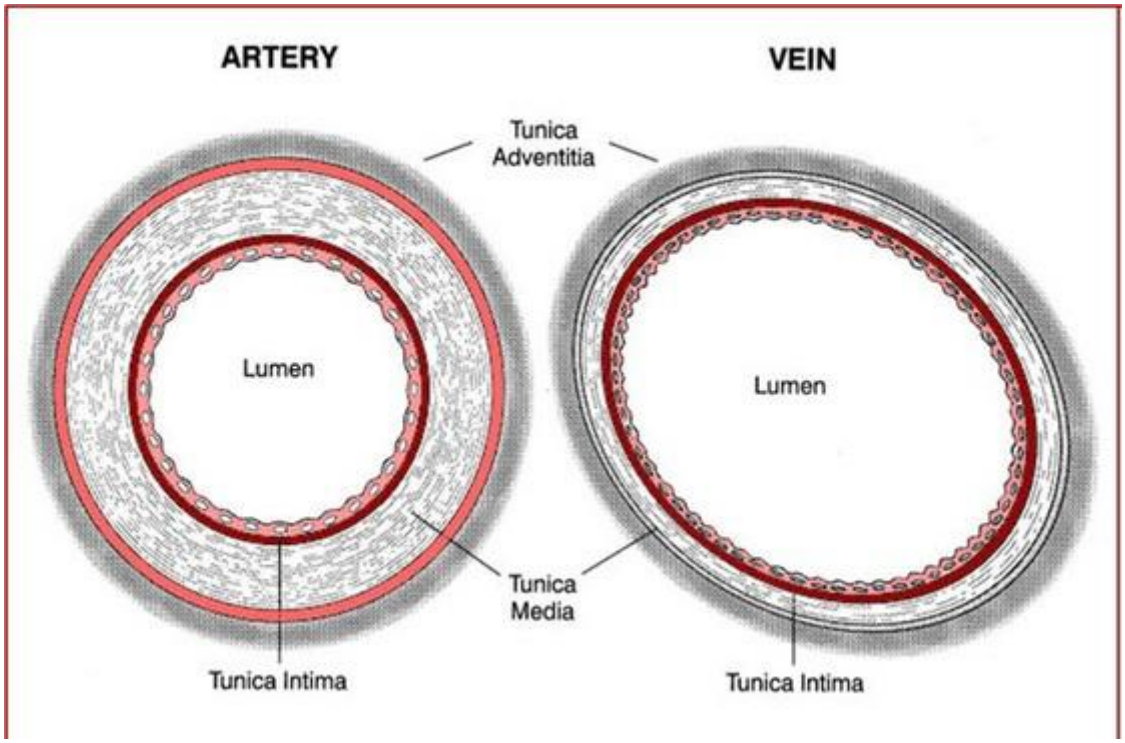
β - Applications and skills:

∑ - Arteries convey blood at high pressure from the ventricles to the tissues of the body.

Arteries

- Take blood away from the heart to tissues around the body
- Because large volumes of blood are flowing directly out of the heart, arteries must be able to withstand the high pressure and high blood volume created when the ventricles contract.
- **Very thick wall of smooth muscle** tissue surrounding arteries makes them strong and elastic in nature with a narrow lumen (area where the blood flows).
- Elastin fibres store energy when they are stretched by the flow of blood. As they recoil the blood is further propelled through the artery.
- The thick smooth muscle layer in the arteries can be used to help regulate blood pressure by changing the diameter of the arteries.

∑ - Arteries have *muscle cells* and *elastic fibres* in their walls.



http://loretocollegebiology.weebly.com/blood-vessels.html

- **Tunica externa –** outer layer made from connective tissue
- **Tunica media –** thick layer containing smooth muscle and elastin fibres
- **Tunica intima –** endothelium layer that lines the inside of the artery

Video on structure https://www.youtube.com/watch?v=VMwa6yC3r-s

∑ - The *muscle* and *elastic fibres* assist in maintaining blood pressure between pump cycles.

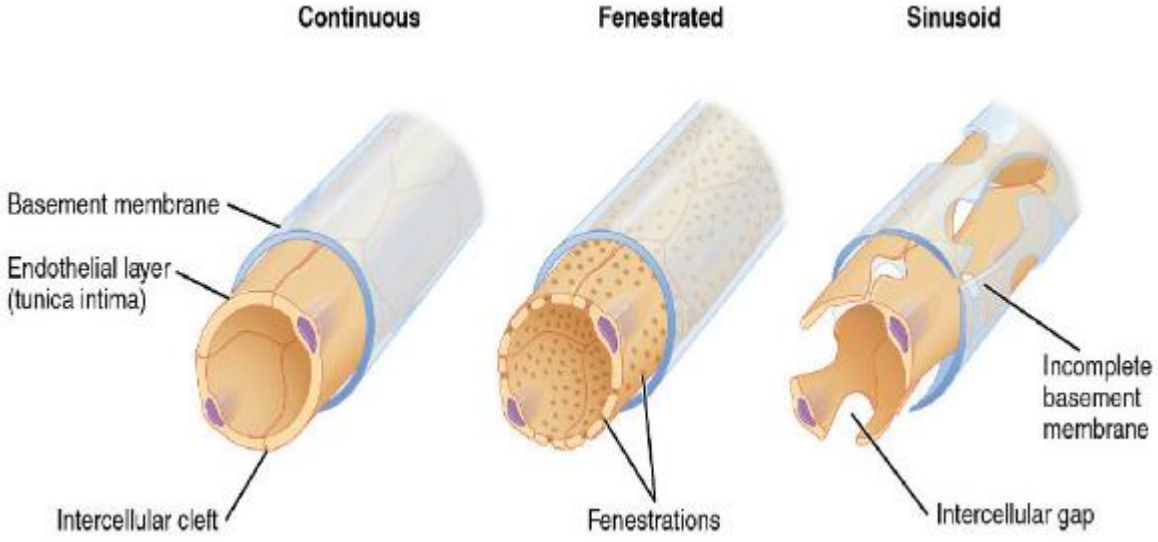
- When the ventricles of the heart contract (systole), the blood leaves the heart through the arteries at a very high pressure
- The blood pushes the walls of the arteries outwards, thus increasing the diameter of the lumen and creating potential energy within the elastic walls of the artery
- As the blood passes after the heart has contracted, the pressure drops and the stretched elastic walls snap back, squeezing the blood in the lumen to conserve energy and preventing the pressure from becoming too low inside the arteries (the minimum pressure is called the diastolic pressure)
- However, since this pressure still relatively high, blood flow in the arteries is fairly consistent and steady, even though the heart pumps in pulsating manner

∑ - Blood flows through tissues in capillaries. Capillaries have permeable walls that allow exchange of materials between cells in the tissue and the blood in the capillary.

- Capillaries have a very narrow diameter (10 μm) with thin surrounding endothelium cells to allow the shortest distance for O_2 to diffuse into the blood from the alveoli in the lungs and from the blood into the body tissues. CO_2 also can easily diffuse out of

the blood into the alveoli in the lungs and from the tissue into the blood after respiration.

- The walls have pores, making them very permeable allowing plasma to leak out and form tissue fluid, which contains oxygen, glucose and all other substances contained in the blood plasma, except proteins (too large to fit through the pores in the capillary wall)
- Highly branched networks of capillaries increase the surface area, maximizing the amount of nutrients and gases that can move in and out of the capillaries.
- Because they are highly branched, the blood slows down to allow efficient transfer of O_2 and CO_2 into and out of the capillaries.
- Below are examples what capillaries look like. The pores or holes that allow certain substances to leave get larger from left to right, with Sinusoid capillaries having the largest openings. Specific names of these types of capillaries is not required.



http://cnx.org/content/col11496/1.6/,

∑ - Veins collect blood at low pressure from the tissues of the body and return it to the atria of the heart.

- Transport blood back to the heart from the capillary beds in tissues.
- Very low blood pressure and therefore the walls can be thin. Blood is pushed back to the heart through the contraction of skeletal muscles. As the muscles contract, the veins are squeezed, pushing the blood back towards the heart
- Large lumen allows large amounts of blood to slowly return to the heart because the blood has to slow down as it passes through the capillary beds.

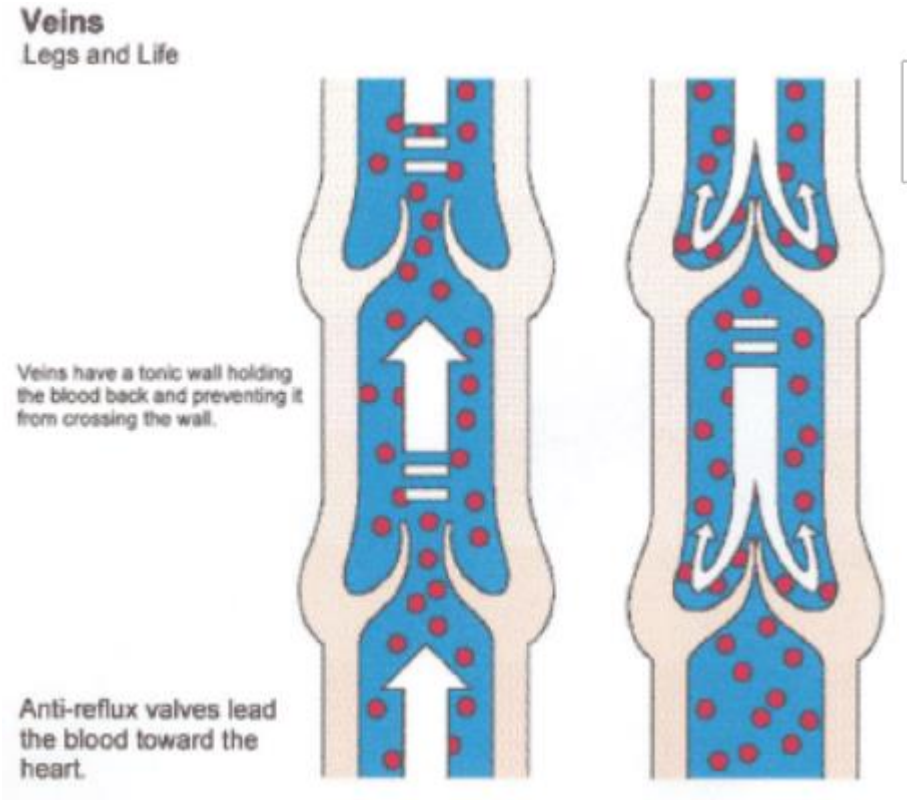
β - Skill: **Identification** of **blood vessels** as *arteries*, *capillaries or veins* from the **structure of their walls**. (Make sure you look at the pictures above as well)

	Arteries	**Veins**	**Capillaries**
Size (diameter)	Larger than 10µm	Variable but much	Approx.. 10µm

		larger than 10μm	
Thickness of the wall and diameter of the lumen	Thick walls Narrow lumen	Fairly thin walls, large lumen diameter	Very thin walls, one cell thick
Layers of the walls	3 (tunica externa, media and intema)	3 (tunica externa, media and intema) Thinner than arteries	One layer – tunica intima
Muscle and Elastic Fibres	Large amounts of these fibres	Small amounts of these fibres	none
Valves	none	yes	none

∑ **- Valves in veins and the heart ensure circulation of blood by preventing backflow.**

- Since the blood pressure in the veins is quite low because the blood slows down considerably when it reaches the capillary bed and there is not another pump like the heart to speed up the flow and increase the pressure, veins have a series of **valves to prevent backflow**.
- Valves are flaps of tissue that form pockets to prevent blood from flowing backwards in the wrong direction
- If the blood starts to flow backwards, it gets caught in the pocket valves causing that section of the vein to fill.
- When another contraction occurs and the blood starts to flow in the correct direction, the valves open allowing the blood to continue its movement towards the heart.



∑ **- There is a separate circulation for the lungs.**

- Humans and other mammals have a two different circulations of blood (blood is pumped twice).
- One circulation (systemic circulation) goes from the left ventricle to the rest of the body and back to the right atrium.
- The second circulation (pulmonary circulation) goes from the right ventricle to the lungs and returns to the left atrium of the heart.

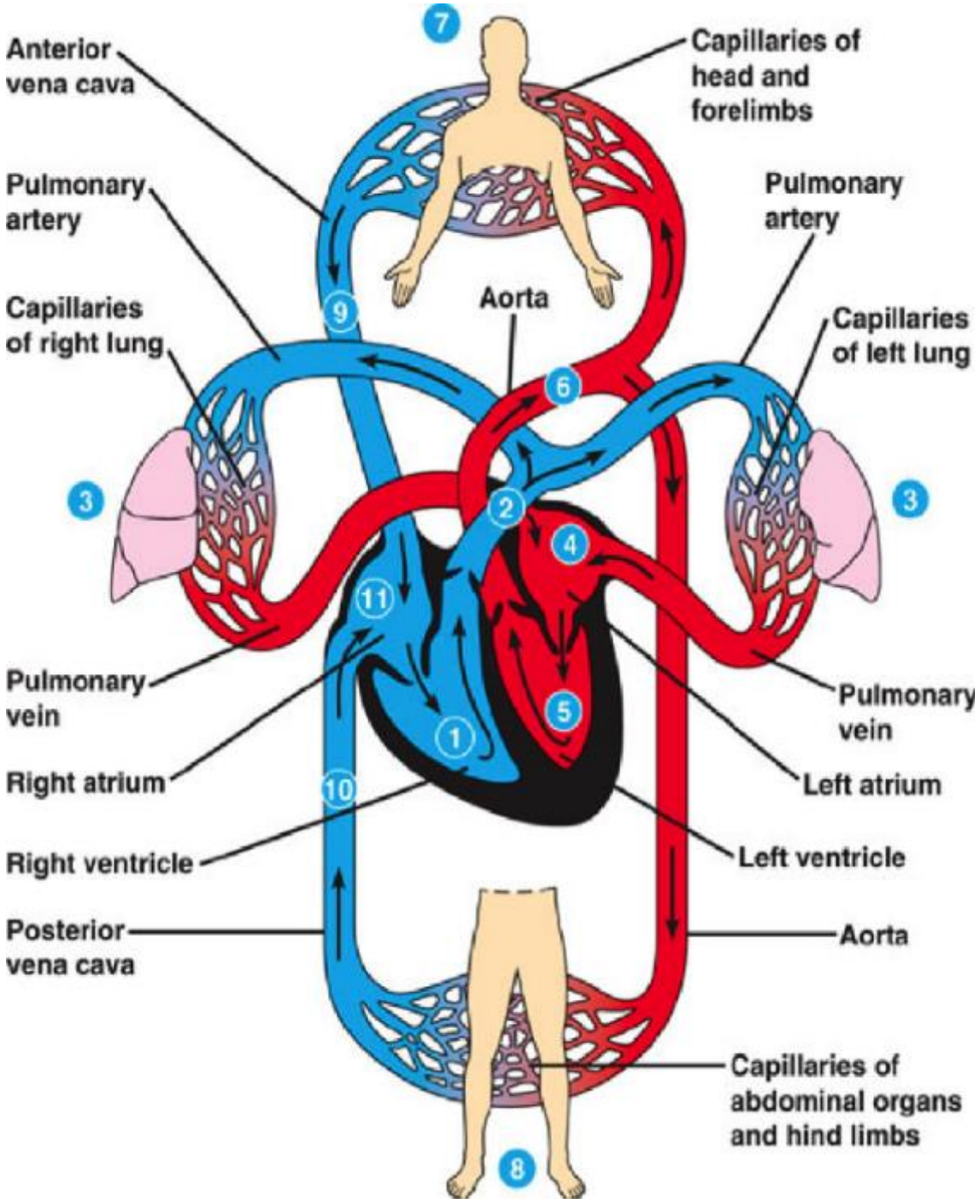
Below is a more in depth description of the circulation of blood in humans

Pulmonary Circulation

- Blood flows from the right atrium into the right ventricle through the R.atrio-ventricular valve. The right atrium contracts right when the ventricle is almost full in order to push the rest of the blood into the ventricle.
- The right ventricle contracts sending the blood out of the ventricle (past a semi-lunar valve), through the pulmonary arteries to the lungs.
- The atrio-ventricular valve shuts preventing back flow into the atrium.
- The blood flows through capillaries obtaining oxygen from the lungs and returning to the heart by the pulmonary veins; which empty into the left atrium.
- This blood is actually returning to the heart from the lungs at the same time as the blood that returns to the right atrium from the rest of the body.

Systemic Circulation

- The blood then flows into the left ventricle through an L atrio-ventricular valve.
- The left ventricle contracts, sending the blood through another semi-lunar valve and out through the biggest artery in the body called the aorta.
- Again the atrio-ventricular valve shuts, preventing backflow into the atrium.
- The oxygenated blood flows to all the tissues and organs in the body to be used in aerobic respiration. (Arteries à Arterioles à Capillaries)
- Blood then flows from the capillaries to the numerous venules and then through the different veins in the body
- These will all eventually dump the blood into the inferior and superior vena cava
- Blood returns to the right atrium of the heart flowing from the inferior vena cava (blood from lower body) and the superior vena cava (blood coming upper body and head).
- Note: Both ventricles contract at the same time sending blood to the lungs and the other parts of the body.



Nature of science: Theories are regarded as uncertain—William Harvey overturned theories developed by the ancient Greek philosopher Galen on movement of blood in the body.

β - <u>Application</u>: William Harvey's discovery of the circulation of the blood with the heart acting as the pump.

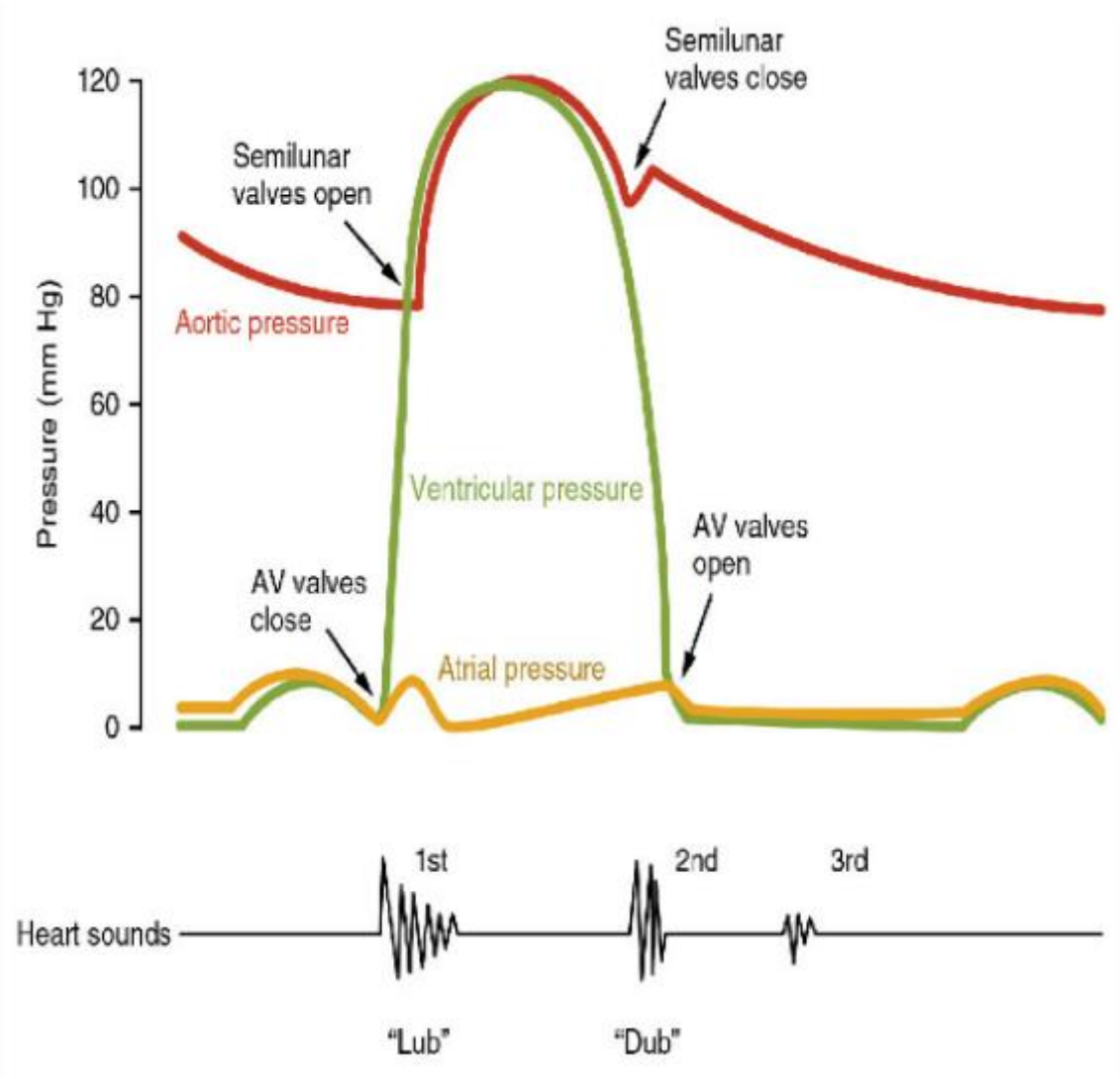
- How the blood circulates around our body was discovered in the seventeenth century by a man named William Harvey

- Before this, much of the theories of how the circulation of the blood in the body worked were from Greek philosopher named Galen
- He had theorized that blood was formed in the liver and then is pumped to back and forth between the right ventricle and the liver.
- Some of the blood seeps into the left ventricle, where is meets the air from the lungs and becomes vital spirits and are distributed around the body by arteries. When some of the vital spirts reach the brain, they become animal spirits; which are then distributed throughout the body by the nervous system
- Harvey studied medicine at Cambridge University
- Harvey showed for the first time that the arteries and veins circulate blood through the whole body. He showed that the heart's beat produces a constant circulation of blood through the whole body.
- He showed that blood flow through the body was one-way and backflow was controlled by a series of valves
- During systole, the heart acts as a muscular pump
- The left ventricle supplies the rest of the system of arteries around the body and the right ventricle supplies the lungs

Interesting video on Harvey - http://www.smithsonianmag.com/science-nature/meet-william-harvey-misunderstood-genius-human-anatomy-180953682/?no-ist

For further details please read this article onlinehttp://www.famousscientists.org/william-harvey/

β - <u>Application</u>: Pressure changes in the ***left atrium, left ventricle and aorta*** during the cardiac cycle.



http://cnx.org/contents/14fb4ad7-39a1-4eee-ab6e-3ef2482e3e22@6.4:128/Cardiac-Cycle

Atrial Systole (0 to 0.1 s)

- Atria contract, pressure increases in the left and right atria, and the remaining blood is pumped into the ventricles (left atrium into left ventricle)
- Ventricle walls relaxed and therefore the pressure is low
- AV valves are open and semi-lunar valves are shut

Ventricular Systole (approx. 0.1 – 0.5 s)

- Ventricles contract and the pressure increases dramatically in the ventricles
- AV valves close (because of the pressure) preventing backflow and the semi-lunar valves open.
- Blood is pumped out of the left ventricle into the aorta through the left semi-lunar valve
- Pressure in the aorta increases
- Pressure falls in the atria

Atrial and Ventricular Diastole (approx. 0.5 to 0.8)

- Muscles in the walls of the ventricles and atria relax
- The semi-lunar valves close
- Since the pressure drops in the atria, blood flows into the left atrium from the pulmonary veins and into the right atrium via the vena cava
- AV valves also open as the pressure in the ventricles drops below the pressure in the atria and blood flows from the atria into the ventricles (left atrium into the left ventricle through the left AV valve)
- Pressure in the aorta drops but remains quite high throughout the cycle because of the elastic and muscle fibres in the walls

Do Data-based questions on page 301

∑ **- The heart beat is initiated by a group of specialized muscle cells in the right atrium called the sinoatrial node.**

∑ **- The sinoatrial node acts as a pacemaker.**

∑ **- The sinoatrial node sends out an electrical signal that stimulates contraction as it is propagated through the walls of the atria and then the walls of the ventricles.**

- Myogenic muscle contraction means the contraction is initiated by the cell itself, not an outside stimulus such as nerve impulse.
- A cluster of these myogenic cells exist in the wall of the right atrium, which is collectively known as the sinoatrial node (SA node)
- Since these cells initiate each heartbeat, they control the rate of a human's heartbeat and are therefore called the pacemaker
- When the pacemaker cells contract, because they are myogenic, they cause the muscle cells around them to contract as well spreading the action potential across the cardiac tissue of the heart
- This causes the right and the left atria to contract, pushing the remaining blood into the ventricles
- This electrical signal reaches another node called the AV node, causing a slight delay (approx. 0.1 seconds) before the signal is sent out to the rest of the heart, causing the ventricles to contract slightly later than the atria.
- The electrical impulses are conducted by tiny bundles of muscle fibres called Purkinje Fibres, collectively known as the bundles of His

∑ **- The heart rate can be increased or decreased by impulses brought to the heart through two nerves from the medulla of the brain.**

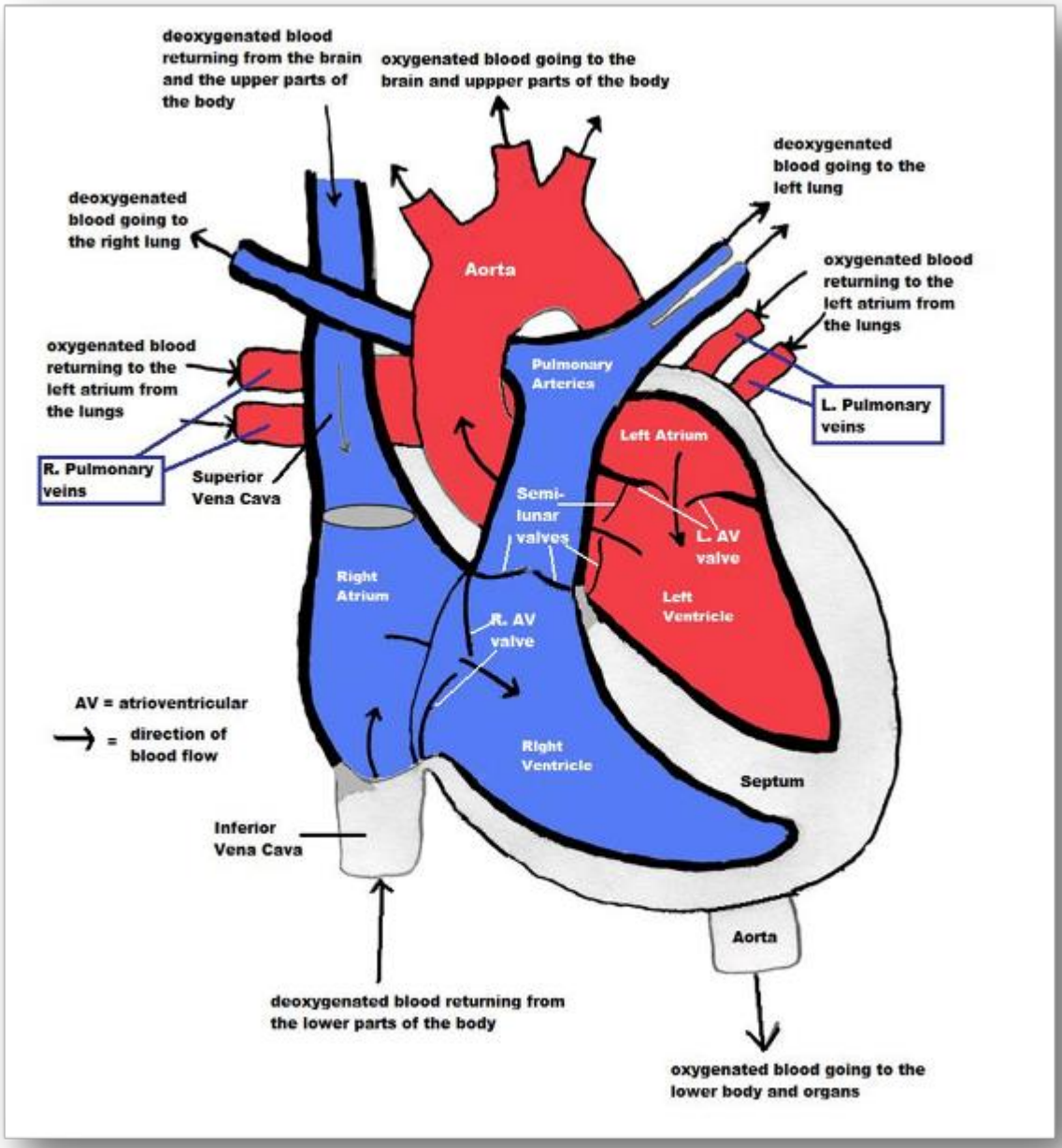
- The rate of the pacemaker can be affected by nerves connected to the medulla region of the brain.
- Low blood pressure, high levels of CO_2 (low pH) and low levels of oxygen, stimulate the heart to increase its rate and therefore deliver more oxygen to the tissues and remove more carbon dioxide
- High blood pressure, low levels of CO_2 (high pH) and high levels of oxygen, cause the heartrate to slow down.

- Cardiac nerves which are part of the sympathetic nervous system the heart rate to increase.
- The Vagus nerve that is part of the parasympathetic nervous system causes the heart rate to slow down
- The medulla of the brain controls most of the autonomic functions of the body such as breathing, heart rate and blood pressure.

∑ **- Epinephrine increases the heart rate to prepare for vigorous physical activity**.

- Cardiac nerves also cause the release of norepinephrine (adrenalin) from the adrenal glands during strenuous physical activity or times of high levels of stress. This is also known as the fight or flight response
- The Vagus nerve causes the heart rate to slow down through the release of acetylcholine, which has an inhibitory action on the heartrate

β - Skill: **Recognition** of the **chambers** and **valves** of the **heart** and the blood vessels connected to it in dissected hearts or in diagrams of heart structure. A heart dissection will be carried out in class. The instructions are uploaded to Manage Bac.



How the heart works **https://www.youtube.com/watch?v=H04d3rJCLCE**

Crash Course – Circulatory – Respiratory https://www.youtube.com/watch?v=9fxm85Fy4sQ

β - Application: **Causes** and **consequences** of **occlusion of the coronary arteries**. The social implications of coronary heart disease could be discussed.

- Blood vessels that deliver oxygen and nutrient rich blood to the cardiac muscle tissue of the heart to allow it to pump blood around the body are known as coronary arteries.

Causes

- Artery walls become damaged as fat (low-density lipoproteins) are deposited under the endothelium and fibrous tissue builds up
- Can result from a poor diet, over-eating, constant high blood glucose levels or smoking
- The flow of blood is impeded and the heart has to work harder to pump blood to the tissue, increasing blood pressure
- The smooth lining of the arteries begins to break down and form lesions called atherosclerotic plaques
- Platelets can bind to these lesions, causing an inflammatory response creating a blood clot
- The blood clot formed is called a thrombus and an embolus if it breaks free to travel through the bloodstream.

Consequences

- If an embolus breaks free, it can get stuck in a smaller arteriole and cause a blockage of blood supply to that tissue, eventually causing that tissue to die
- If this happens to the coronary arteries or arterioles in the heart, and enough of the tissue is deprived of oxygen, a myocardial infarction (heart attack) can occur
- If an embolus reaches the brain, and enough of the brain is deprived of oxygen and nutrients, a stroke can occur
- If coronary arteries are damaged, by-pass surgery can be performed, that takes an artery typically from a patient's leg , replacing the damaged coronary artery
- Coronary Angioplasty (balloon angioplasty) can be an alternative to a by-pass operation. A catheter (with attached balloon) is inserted in the arm or the leg of a patient and is guided to the obstructed artery by x-ray and tv monitors
- A harmless dye is injected into the patient to determine exactly where is the blockage
- The balloon is inflated to reestablish blood flow stretching the arterial wall and squashing the plaques

Theory of knowledge: Our current understanding is that emotions are the product of activity in the brain rather than the heart. Is knowledge based on science more valid than knowledge based on intuition?

6.3 Defence against infectious disease: The human body has structures and processes that resist the continuous threat of invasion by pathogens.

Nature of science: Risks associated with scientific research—Florey and Chain's tests on the safety of penicillin would not be compliant with current protocol on testing.

Aims: The social as well as the economic benefits of the control of bacterial diseases around the world should be stressed. Science has limited means in the

fight against pathogens, as shown by the spread of new diseases and antibiotic-resistant bacteria.

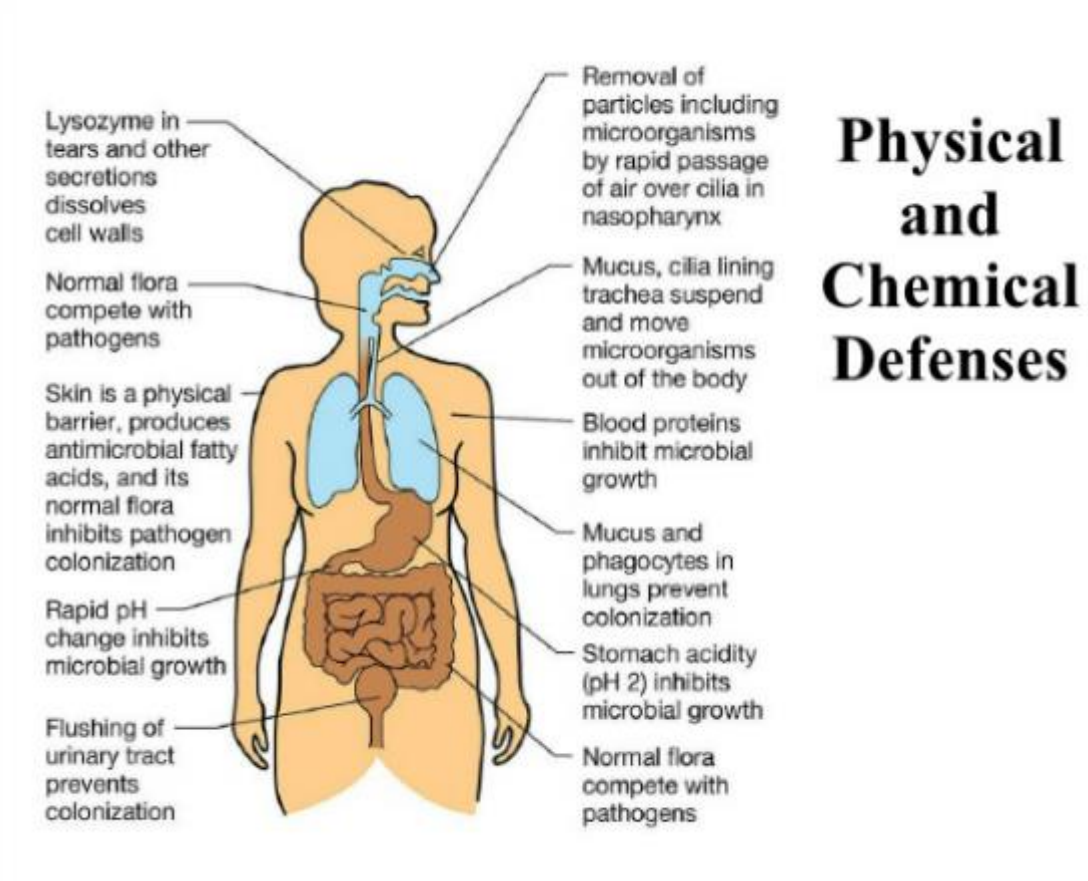
Understandings:

Good Introduction to the Immune System:

https://www.youtube.com/watch?v=zQGOcOUBi6s

∑ - The skin and mucous membranes form a primary defence against pathogens that cause infectious disease.

- Skin and mucous membranes are physical barriers against infection from pathogens.
- Skin is constantly replacing its outermost epidermal layer of skin. These dead cells provide effective protection against foreign pathogens.
- Skin also secretes a substance called sebum to lubricate the skin. The sebum also lowers the pH of the skin, which effectively helps inhibit bacterial growth.
- Mucous membranes line the surfaces of the nasal cavity, trachea, bronchi, and bronchioles (surfaces that are exposed to the outside environment).
- Mucous traps foreign particles and pathogens contained in the air before they reach the lungs.
- Mucous contains lysozymes (enzymes) that can damage and kill pathogens.
- Trapped pathogens can also be expelled through the mouth or nose, or swallowed and destroyed by the high acidity of the stomach.
- Skin and mucous membranes are examples of non-specific immunity.



Video on non-specific immune https://www.youtube.com/watch?v=Non4MkYQpYA

∑ - Cuts in the skin are sealed by blood clotting.

- Blood clotting is the process in which cuts or broken blood vessels are repaired and sealed to prevent excessive blood loss.
- When a blood vessel is broken or cut, blood platelets collect at the site of the damaged blood vessel forming a platelet plug.

∑ - Clotting factors are released from platelets.

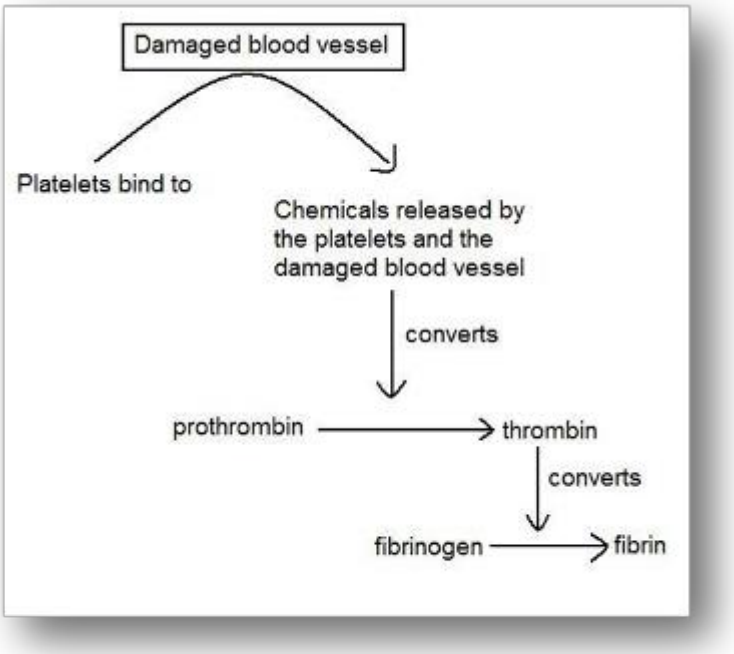
- The platelets and the damaged tissue release chemical factors called clotting factors.

∑ - The cascade results in the rapid conversion of fibrinogen to fibrin by thrombin.

- The clotting factors convert the clotting protein prothrombin to its active form thrombin (enzyme).
- The enzyme thrombin converts clotting protein fibrinogen (which is soluble) into the insoluble fibrous protein fibrin.

- Fibrin forms a mesh at the point of the broken vessel further trapping other platelets sealing up the damaged vessel and forming a stable clot.
- Once the damaged vessel has fully healed, the blood clot dissolves in the blood.

Diagram of Blood Clotting



∑ - **Application**: **Causes and consequences** of **blood clot formation** in**coronary arteries**.

- Coronary arteries are arteries that branch from the aorta and supply oxygen to the heart.
- Individuals that have coronary heart disease sometimes form blood clots in these arteries
- If the arteries are blocked, that part of the heart becomes deprived of oxygen and vital nutrients.
- The heart can no longer produce the amount of ATP (through aerobic respiration) needed for the heart to work properly
- The individual is therefore at a high risk of having a possible fatal heart attack
- Atherosclerosis is a disease of the arteries characterized by the deposition of plaques of fatty material on their inner walls.
- The arteries become damaged and coarsened and the wall of the arteries is hardened by calcium salts.
- This blocking of the arteries can lead to a heart attack

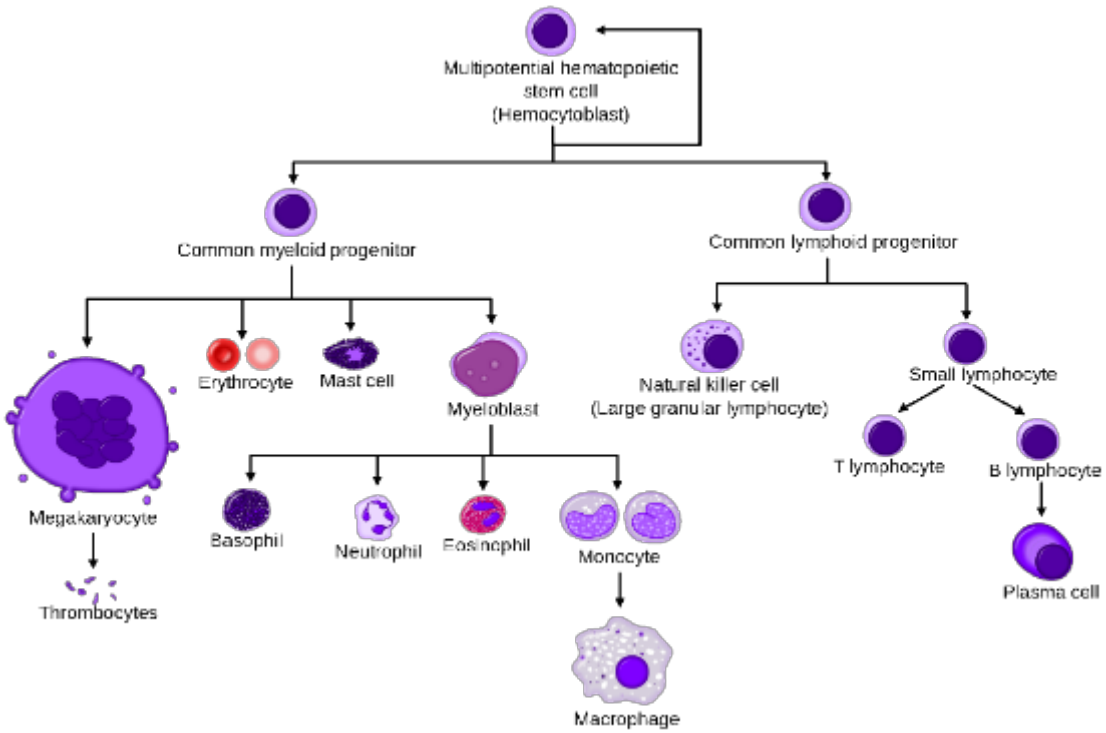
Some Causes

- Smoking
- Obesity and lack of exercise

- Hypertension (high blood pressure)
- Diabetes

∑ - Ingestion of pathogens by phagocytic white blood cells gives non-specific immunity to diseases.

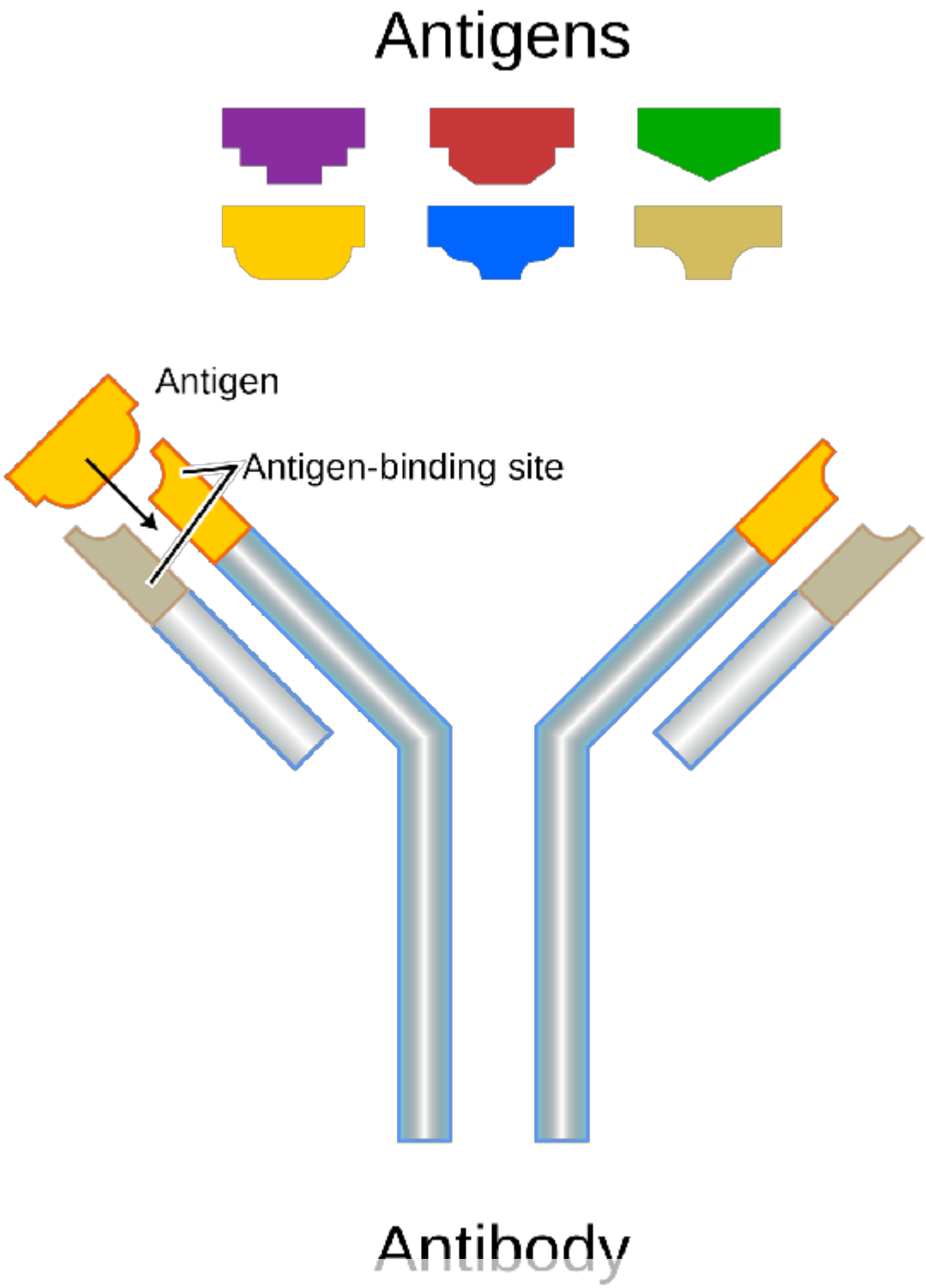
- Another type of non-specific immunity (not antigen specific and response is immediate) occurs when phagocytic leucocytes ingest and destroy foreign pathogens.
- The main types of phagocytic leucocytes are called macrophages. When pathogens get past the physical barriers, macrophages will engulf foreign pathogens through endocytosis.
- Pathogens are recognized as non-self cells by the structure of their protein coat.
- Once the pathogen is engulfed, lysosomes within the macrophage contain hydrolytic enzymes that will digest and destroy the foreign pathogens.
- Macrophages are the large white blood cells in the diagram below. Basophils, neutrophils and eosinophils are also involved in the non-specific immune response



∑ - Production of antibodies by lymphocytes in response to particular pathogens gives specific immunity.

- When a pathogen enters the blood, the specific antigen on the surface of the membrane is identified as being foreign or non-self
- This stimulates a specific immune response in which antibodies are produced that are specific for that particular antigen
- B-lymphocytes are white blood cells that produce antibodies that bind to the antigen on the invading pathogen

- Each lymphocyte is able to produce one type of antibody; however, we have a vast diversity of lymphocytes that are able to respond to millions of foreign antigens
- Once an antigen has been encountered the B-lymphocytes are stimulated to divide to produce a large amounts of clones of themselves (clonal selection)
- The active B-lymphocytes that are produced are called plasma cells which will begin to produce antibodies.
- The plasma cells created, produce and release mass amounts of antibodies into the bloodstream.
- These antibodies surround and bind to the antigens on the foreign pathogens.
- Through a variety of different methods the pathogens are destroyed by the antibodies and other white blood cells.



∑ - Some lymphocytes act as memory cells and can quickly reproduce to form a clone of plasma cells if a pathogen carrying a specific antigen is re-encountered.

- Some of these divisions also produce B-cells called memory cells, which stay in the blood in case of a second infection to provide a quick response to the new infection.
- The primary response is the production of antibodies to the initial challenge bythe invading antigen.
- The secondary response which is much quicker because memory cells are still in the blood occurs after a subsequent challenge by the same antigen.

Antigens

- Chemicals that induce an immune response inside the body.
- Antigens are actually proteins, glycoproteins or other macromolecules on the surface of the cell membrane of the pathogen that are recognized by a specific antibody, to stimulate the immune response.

Antibodies

- Protein molecules produced by B-lymphocytes that recognize and bind to the antigens on the foreign pathogens.
- Each antibody is specific to each type of antigen.
- For example, a different antibody is produced in response to the influenza virus when compared to the antibody produced when a person is infected by the common cold.
- Antibodies make the pathogen more recognizable to macrophages so that they are easily engulfed and destroyed
- Antibodies also stop viruses from spreading by binding to host cells preventing the viruses from entering

The Cell Secret Immune System https://www.youtube.com/watch?v=v1MnNO4I9aU

Immune System Gamehttp://www.nobelprize.org/educational/medicine/immunity/game/index.html

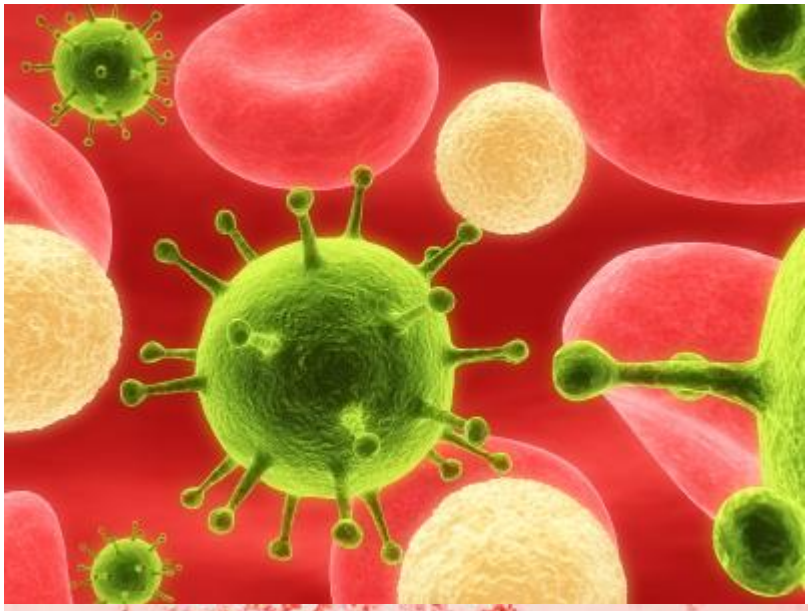
Pandemic 2 http://www.learn4good.com/games/high-school-students-games/science-health.htm

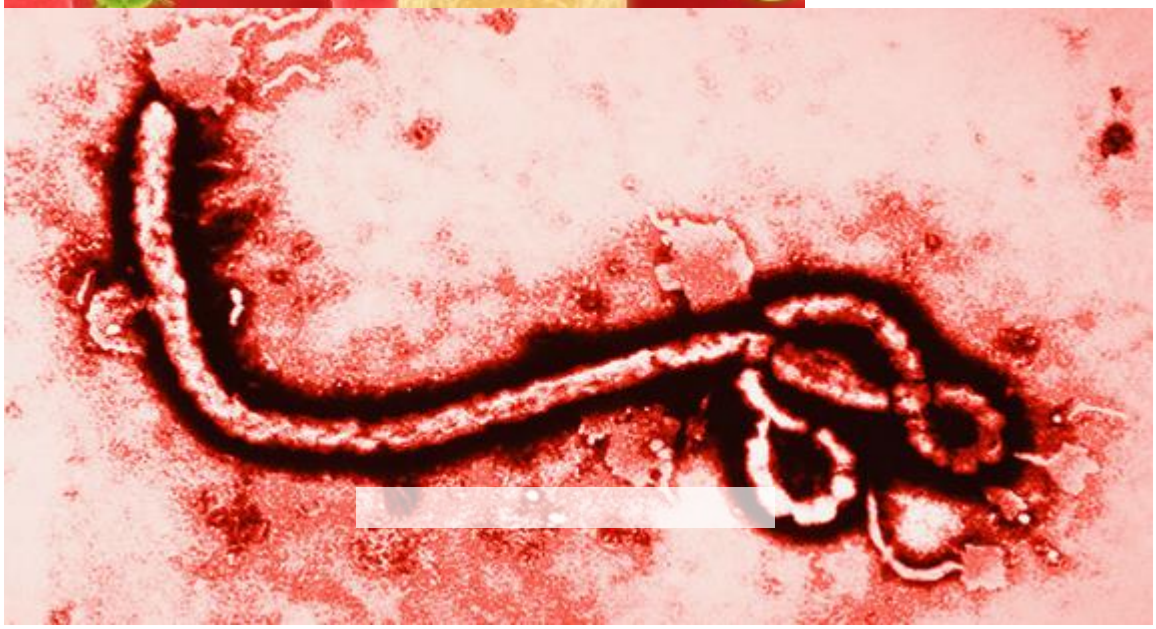
∑ - Antibiotics block processes that occur in prokaryotic cells but not in eukaryotic cells.

- Antibiotics are a type of drug or chemical that inhibits the growth of microorganisms; mainly bacteria
- Antibiotics block cellular processes such as DNA replication, transcription, translation, and cell wall formation
- The first antibiotic discovered by Alexander Fleming was identified as penicillin

- Fleming was working on a culture of disease-causing bacteria when he noticed the spores of little green mold (fungi) on one of his culture plates.
- He observed that the presence of the mold killed or prevented the growth of the bacteria by excreting antibacterial antibiotics

∑ - Viruses lack a metabolism and cannot therefore be treated with antibiotics. Some strains of bacteria have evolved with genes that confer resistance to antibiotics and some strains of bacteria have multiple resistance.





- Since viruses lack their own metabolism, they have to use the chemical processes of a cell from a host that they infect
- They are unable to reproduce on their own and cannot perform protein synthesis, transcription and other metabolic functions

- Antibiotics work by blocking these vital processes in bacteria, killing the bacteria, or stopping them from multiplying
- Since viruses do not perform their own metabolic reactions antibiotics such as penicillin and streptomycin, are ineffective in treating viral infections
- Therefore treating viruses with antibiotics is not only useless and ineffective, it can also create antibiotic resistance in bacterial strains eg. Methicillin-resistant Staphylococcus aureus
- Video on Staph Infections: http://www.webmd.com/a-to-z-guides/video/truth-about-mrsa
- Video on Antibiotic Resistance - Last line of Defence Breached in China http://www.cbc.ca/news/health/antibiotic-resistance-colistin-1.3325942

Applications and skills:

∑ - **Application**: **Florey and Chain's experiments** to **test penicillin on bacterial infections** in mice.

Video on Penicillin discovery https://www.youtube.com/watch?v=7qeZLLhx5kU

Another video https://www.youtube.com/watch?v=5RGs-2eNnjM

- A bacteriologist named Alexander Fleming originally discovered Penicillin in 1928
- Later on, two scientists named Florey and Chain were able to develop a method of growing the Penicillin in liquid cultures and purifying the Penicillin in these cultures.
- They started by testing on mice infected with Streptococcus bacteria which would cause death in the mice if left untreated
- Four mice were given Penicillin shots and four were left untreated
- Within one day, all of the untreated mice were dead
- Human trials on five individuals commenced when enough of the penicillin was created. All of these people survived their initial infection; however, a small child died when an artery behind his eye burst
- After this, penicillin became widely produced and used by pharmaceutical companies

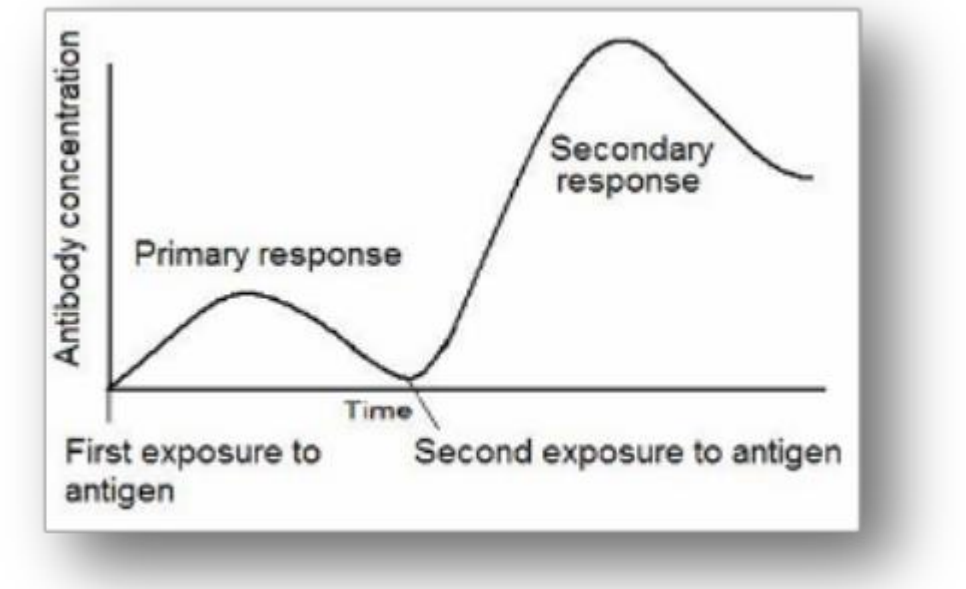
∑ - **Application:** An **understanding** of **immunity** has led to the **development of vaccinations**.

- Active immunity can be acquired through vaccination.
- A vaccine is a weakened version of a pathogen.
- It is introduced to the body through an injection, which causes a primary immune response to the pathogen.
- This will create the plasma B-cells necessary to fight off the initial infection from the vaccine and the memory B-cells necessary for a secondary immune response if the person is exposed to the real pathogen.
- This secondary response is much quicker and more intense producing more antibodies in less time

- Sometimes “booster shots” are given which is a second round of vaccination that causes a secondary immune response.

Meningitis - http://www.scidev.net/sub-saharan-africa/children/news/vaccine-blow-meningitis-africa-path.html

Graph of a Primary and Secondary Immune Response Resulting from Exposure to an Antigen



Measles Immunity: http://fred.publichealth.pitt.edu/measles/

Herd Immunity: http://www.software3d.com/Home/Vax/Immunity.php

Another Simulation: http://www.theguardian.com/society/ng-interactive/2015/feb/05/-sp-watch-how-measles-outbreak-spreads-when-kids-get-vaccinated

∑ - **Application: Effects of HIV on the immune system** (a reduction in the number of active lymphocytes and a loss of the ability to produce antibodies, leading to the development of AIDS) and methods of transmission.

- HIV (human immunodeficiency virus) is a retrovirus that causes AIDS, which is a condition in humans where the immune system fails and is susceptible to life-threatening opportunistic infections.
- HIV targets helper-T cells because HIV can bind to the proteins on the T cells.

- Helper-T cells play an important role in the production of clonal B lymphocyte cells, which produce antibodies for immune response.
- Therefore the reduction of T cells will reduce the amount of antibodies produced needed to fight off infection from invading pathogens.
- This inability to fight off disease is what eventually causes the person to die.

Virus Evolution - https://www.youtube.com/watch?v=3Ms04x6MvMY

International-mindedness: The spread and containment of diseases such as bird flu require international coordination and communication.

Aims: The social as well as the economic benefits of the control of bacterial diseases around the world should be stressed. Science has limited means in the fight against pathogens, as shown by the spread of new diseases and antibiotic-resistant bacteria.

Crash course
Immunity: https://www.youtube.com/watch?v=CeVtPDjJBPU

6.4 Gas exchange: The lungs are actively ventilated to ensure that gas exchange can occur passively.

Understandings:

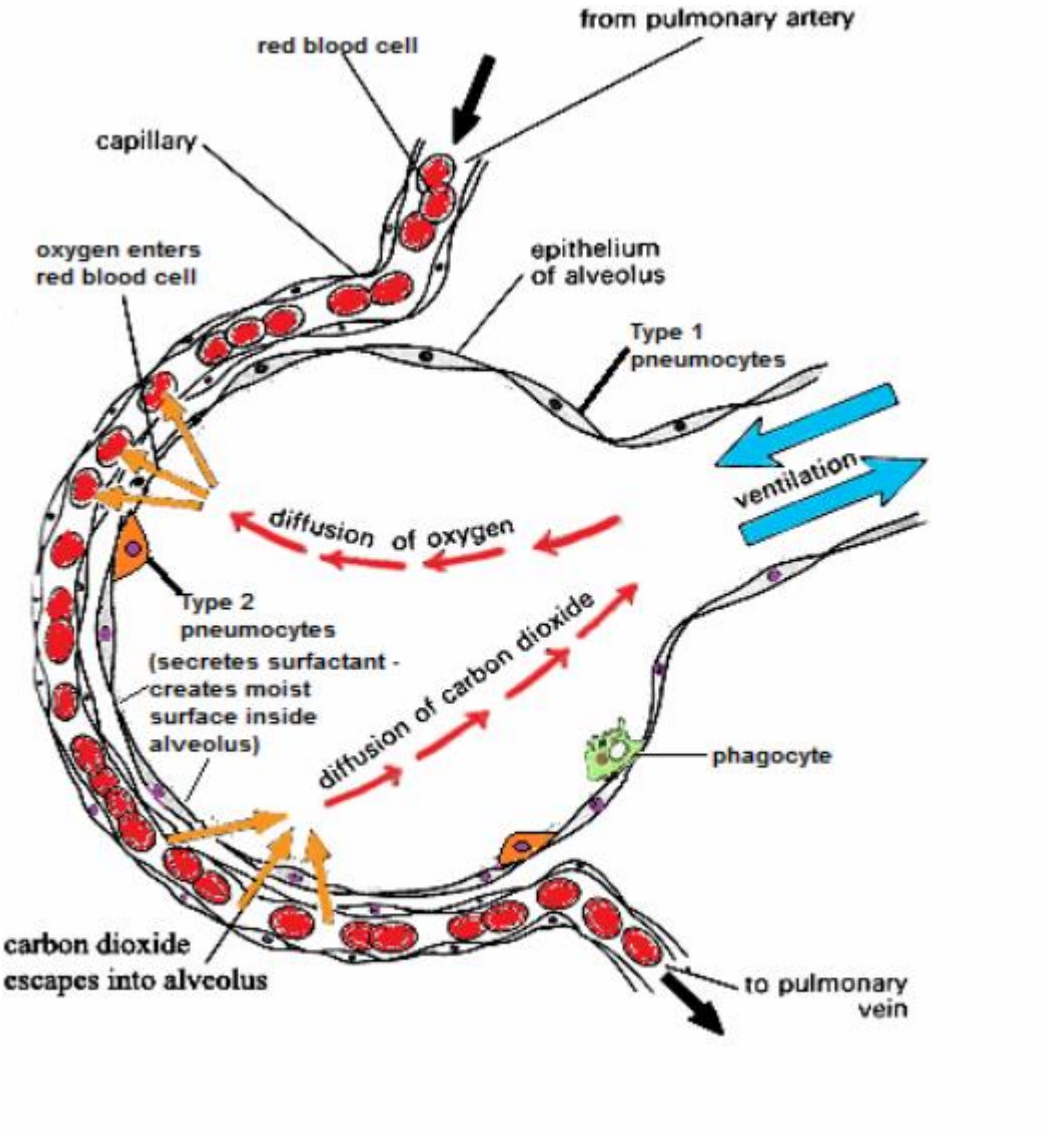
∑ - Ventilation maintains *concentration gradients of oxygen* and *carbon dioxide* between air in alveoli and blood flowing in adjacent capillaries.

- Small single celled organisms can easily diffuse gas in and out of the cell as long as they are in an environment where concentration gradients exist for passive diffusion. For example, O_2 in water can diffuse into a protist as long as the concentration of oxygen in the surrounding water is greater than the oxygen levels inside the protist cell.
- On the other hand human bodies are surrounded and protected by layers of skin. Thecells in the tissue that need oxygen for respiration are too far away, too protected, and too numerous to allow direct diffusion with their environment.
- Therefore, humans need a system to keep a fresh supply of O_2 and to get rid of excess CO_2.
- The ventilation system provides a fresh supply of O_2 in the alveoli, allowing the oxygen to diffuse into the blood capillaries surrounding them
- The oxygen is then transported to all the tissues in the body.
- The CO_2 in the tissues is transported by the blood to the lungs, where it diffuses into the alveoli and is exhaled into the surrounding atmosphere.
- This fresh supply of O_2 also makes sure that a steep concentration gradient existswhere gas is exchanged to allow efficient exchange of O_2

- The blood arriving at the alveoli via the pulmonary arteries, arterioles and then capillaries, is rich in $\underline{CO_2}$, thus creating a concentration gradient between the capillaries and the alveoli, allowing CO_2 to rapidly diffuse out of the alveoli into the blood in the capillaries

*****Do data based questions on page 312*****

β - Draw a diagram to show the **structure** of an *alveolus* and an adjacent *capillary*.



PRACTICAL

Monitoring of **ventilation** in humans at *rest* and after *mild* and *vigorous exercise*(*ventilation rate* and *tidal volume* should be measured).

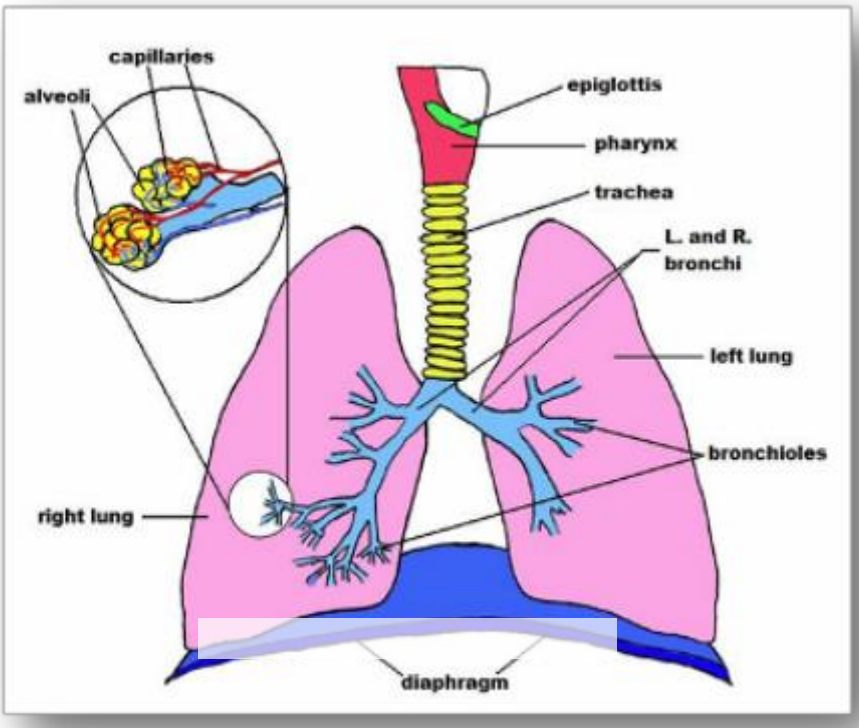
∑ - *Type I pneumocytes* are extremely thin alveolar cells that are adapted to carry out gas exchange.

- The walls of the alveoli are predominately made from a single layer of epithelial cells called Type I pneumocytes
- These are ***flattened cells*** that are approximately 0.15 μm thick
- Since the alveoli are surrounded by capillaries that are also only one cell thick, oxygen and carbon dioxide have a **very short distance to diffuse** into the blood from the alveoli and out of the blood into the alveoli respectively
- This adaptation allows for a rapid rate of gas exchange

∑ - *Type II pneumocytes* secrete a solution containing surfactant that creates a moist surface inside the alveoli to prevent the sides of the alveolus adhering to each other by reducing surface tension.

- About 5% of the inner surface of the alveoli consists of Type II pneumocytes
- These cells secrete a liquid made of proteins and lipids called surfactant
- This liquid allows oxygen to dissolve into the surfactant and then diffuse into the blood
- It also provides a medium for carbon dioxide to evaporate into the air inside the alveoli in order to be exhaled

∑ - Air is carried to the lungs in the trachea and bronchi and then to the alveoli in bronchioles.



- Air enters the respiratory system through the nose or mouth and travels through the pharynx and then the trachea (made from rings of cartilage)
- The trachea divides into two bronchi (left and right)
- Inside each lung the bronchi divide into many smaller tubes called bronchioles

- These numerous bronchioles form a tree root-like structure that spreads throughout the lungs
- Each bronchiole ends in a cluster of air sacs called alveoli

∑ - Muscle contractions cause the pressure changes inside the thorax that force air in and out of the lungs to ventilate them.

β -Application: *External* and *internal intercostal muscles*, and *diaphragm* and *abdominal muscles* as **examples of antagonistic muscle action**

Ventilation consists of inhalation (inspiration) and exhalation (expiration)

Inhalation

- External intercostal muscles contract pulling the ribs upwards and outwards.
- The diaphragm which is a flat sheet of muscle extending across the bottom of the rib cage contracts and flattens out.
- These two actions enlarge the thoracic cavity surrounded the lungs, thereby increasing the volume of the lungs.
- When the volume of the lungs increases, the pressure inside the lungs decreases and becomes lower than the pressure in the surrounding atmosphere.
- Since gas moves from higher pressure to lower pressure, air rushes into the lungs from the surrounding atmosphere to equalize the pressure.

Exhalation

- The external intercostal muscles relax and the diaphragm snaps back to its original shape (domed shape).
- This moves the ribs back down and inwards and decreases the volume of the thoracic cavity and the lungs.
- This decrease in volume increases the pressure inside the lungs.
- Since the pressure inside the lungs is now greater than the atmospheric pressure, and gas moves from high pressure to low pressure, air rushes out of the lungs into the surrounding environment.
- NOTE: If there is a forced exhalation (push and squeeze the air out of the lungs) the internal intercostal muscles will also contract along with the abdominal muscles to pull the rib cage down and squeeze the organs in the abdomen

Summary

Inspiration	Structure	Expiration
contracts and flattens out	diaphragm	relaxes and returns to domed shape

relax	abdominal muscles	contracts – pressure formed in abdomen pushes organs up and helps push diaphragm into a dome shape
Contract moving ribcage up and out	external intercostal muscles	relax
relax	internal intercostal muscles	contract, moving ribcage down and in
increases	volume of the thoracic cavity and lungs	decreases
Decreases to below atmospheric pressure and therefore air flows in	pressure of the thoracic cavity and lungs	Increases to above atmospheric pressure and therefore air flows out

∑ **- Different muscles are required for *inspiration* and *expiration* because muscles only do work when they contract.**

- When different muscles work together to perform opposite movements, they do so in an antagonistic fashion; when one muscle contracts the other will relax
- When muscles contract and shorten (do work), they exert a pulling force that causes movement
- The antagonistic muscle will relax and lengthen because of the pulling force of the other muscle; therefore no work is done
- For example, when one breaths in air, the external intercostal muscles contract, moving the ribcage up and out and the internal intercostal muscles relax (biceps and triceps work in similar fashion in our arms). The opposite occurs during expiration.
- Muscles therefore only cause movement in one direction while contracting (antagonistic pair relaxes). Movement in the other direction occurs when the other muscle of the pair contracts and the first muscle relaxes

Short video on antagonistic pairs https://www.youtube.com/watch?v=NoFxgMrjR_U

Applications and skills:

Nature of science: Obtain evidence for theories—epidemiological studies have contributed to our understanding of the causes of lung cancer.

Answer the following questions on epidemiological studies and lung cancer.

1) What is epidemiology and why are these studies generally observational and not experimental?

2) If you had to carry out an epidemiological study, how would you test the theory that smoking is a major cause of lung cancer?

3) What are confounding factors, why are they a problem with epidemiological studies and how can you compensate for these factors?

β - Application: Possible **Causes and consequences** of *lung cancer and emphysema*.

Lung Cancer

Smoking

- is the number one cause of lung cancer
- there is an extremely high correlation with the number of cigarettes an individual smokes in a day and the incidence of lung cancer
- Cigarettes contain a high number of carcinogens, such as polycyclic aromatic hydrocarbons and nitrosamines
- Second-hand smoke can also be considered a cause of cancer in non-smokers

Air Pollution

- Air pollution from exhaust fumes containing nitrogen oxides, fumes from diesel engines and smoke from burning carbon compounds such as coal are a minor cause of lung cancer. This depends on where in the world you live and the air quality.

Radon Gas

- In some parts of the world, this radioactive gas can leak out of certain rocks such as granite, accumulating in poorly ventilated buildings

Asbestos

- Construction sites, factories and mines can have dust particles in the air. If steps aren't taken to properly protect the workers, lung cancers can develop.

Lung cancer is a very serious disease and the **consequences** can be severe, especially if the cancer is not recognized early on.

If the tumour is large when it is discovered, metastasis might have occurred (cancer spreads to other parts of the body and forms secondary tumours). In these cases, mortality rates are very high. If the tumour is found early on, parts of the affected

lung with the tumour can be removed and chemotherapy can be used to help kill the rest of the cancer cells. Re-occurrence of the disease is quite common.

Emphysema

- Emphysema is another respiratory disease that is often linked to smoking
- Emphysema is characterized by the loss of elasticity of the alveoli in the lungs, resulting in the destruction of lung tissue over time
- Phagocytes (white blood cells that engulf foreign bacteria) usually prevent lung infections and produce a hydrolytic enzyme called elastase
- An enzyme inhibitor usually prevents elastase from digesting lung tissue
- Smokers lungs generally contain a high number of these phagocytes/macrophages in their blood
- Since there is a higher level of phagocytes, more elastase is produced;however, not enough of the inhibitor that prevents elastase from digesting lung tissue
- This results in the destruction of elastic fibres of the alveolar walls by the enzyme elastase
- The alveoli can become over-inflated and fail to recoil properly
- Small holes can also develop in the walls of the alveoli
- The alveoli can merge forming huge air spaces and a lower surface area.
- This destruction cannot be reversed

β - Application: The **social consequences** of *lung cancer and emphysema* could be discussed.

Some interesting videos to discuss in class.

Social smoking campaign funny commercials https://www.youtube.com/watch?v=C8JoQ7_aYPw

Nine year old chain smoker from Indonesia https://www.youtube.com/watch?v=woVcHfnhBqI

Do e-cigarettes cause the same chronic lung problems?http://www.dailymail.co.uk/health/article-3073502/E-cigarettes-lead-chronic-lung-conditions-Vapour-gadgets-disrupts-cells-way-tobacco-smoke.html

Are all these things true? http://www.dailyrx.com/smoking-goes-beyond-lungs-affect-body-head-toe

The Doctors talk about smoking https://www.youtube.com/watch?v=JC5yWEyw7bs

Good anti-smoking commercial https://www.youtube.com/watch?v=2oHkTR4fXhE

Top 40 scary anti-smoking https://www.youtube.com/watch?v=9kKN8_aa38A

6.5 Neurons and synapses:

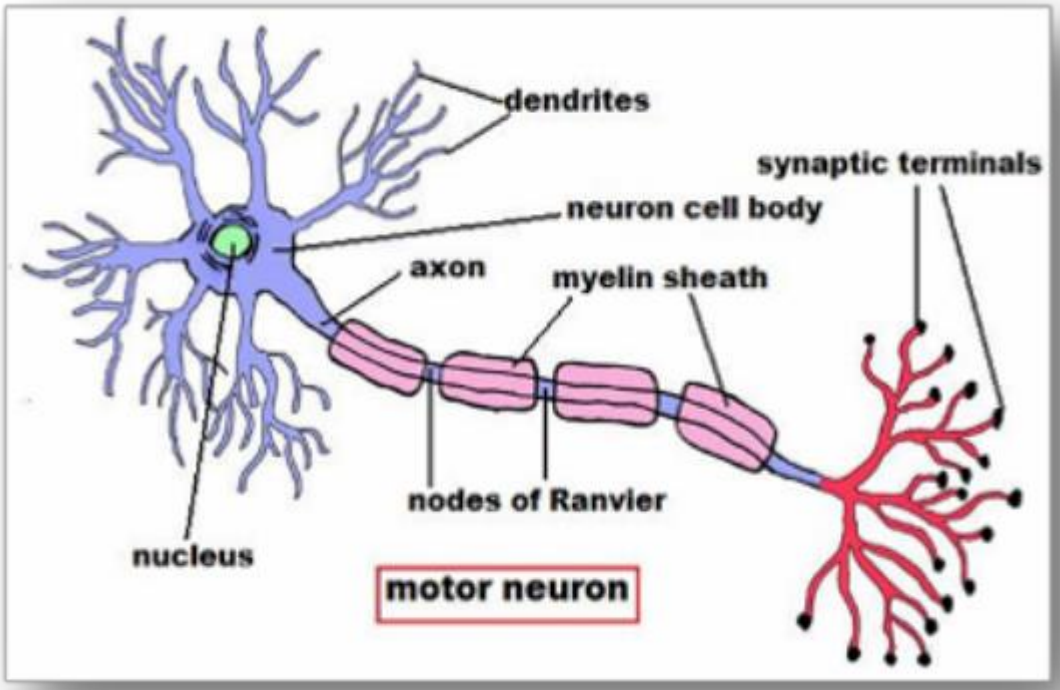
Neurons transmit the message, synapses modulate the message.

Nature of science: Cooperation and collaboration between groups of scientists—biologists are contributing to research into memory and learning.

Understandings:

∑ - Neurons transmit electrical impulses.

- One form of internal communication in the body occurs through nerve impulses in the nervous system
- Neurons transmit electrical impulses by allowing the passage of charged ions across their membranes in response to stimuli
- Neurons consist of a cell body with a nucleus and cytoplasm, an elongated nerve fibre called an axon, and short-branched nerve fibres called dendrites



∑ - The myelination of nerve fibres allows for saltatory conduction.

- Nerve fibres conduct electrical impulses along the length of their axons. Some of these axons such as interneurons are unmyelinated, and therefore the impulse travels much slower
- The greater the diameter, the greater the speed of the nerve impulse

- Some axons are surrounded by a mixture of protein and phospholipids called myelin that collectively form a myelin sheath
- Many layers of myelin are deposited around the axon by special cells called Schwann cells
- The myelin sheath insulates the axon and greatly increases the speed of the nerve impulse
- In between the myelin are gaps called the nodes of Ranvier
- In myelinated neurons, the impulse can jump from one node to the next. This is called saltatory conduction
- This allows myelinated neurons to conduct impulses up to 100x faster than unmyelinated axons

MS effect on neuron - http://www.nebraskamed.com/health-library/3d-medical-atlas/35/multiple-sclerosis

∑ - Neurons pump *sodium* and *potassium* ions across their membranes to generate a resting potential.

- The time period when a neuron that is not conducting a nerve impulse, but is ready to conduct one, is called the resting potential.
- This membrane potential is due to an imbalance of positive and negative charges across the membrane
- Sodium-potassium pumps pump Na+ out of the axon and K+ into the axon
- Three Na+ are pumped out of the neuron and two K+ are pumped into the neuron
- This creates a concentration gradient of Na+ (outside to in) and of K+ (inside to out)
- The membrane is also much more permeable to K+ as Na+, so K+ leaks back out of the neuron through leak channels
- This means the Na+ concentration is much greater outside the neuron
- There are also negatively charged ions permanently located in the cytoplasm of the neuron
- These conditions create a resting membrane potential of -70 mV inside the neuron

Sodium/potassium pump video - https://www.youtube.com/watch?v=P-imDC1txWw

∑ - An action potential consists of *depolarization* and *repolarization* of the neuron.

- Action potentials are rapid changes in membrane potentials
- This consists of a rapid depolarization (change from negative to positive when sodium diffuses into the neuron) and a rapid repolarization (change from positive to negative when potassium diffuse out of the neuron)
- The arrival of an action potential caused by a stimulus causes a depolarization of the membrane as Na+ channels begin to open.
- If the membrane potential reaches a threshold level of -50mV. Many more voltage-gated Na+ channels open and Na+ rapidly diffuses into the neuron

- The inside of the neuron becomes more positively charged than the outside of the neuron (depolarization)
- K+ channels open and K+ ions diffuse out of the neuron making the inside negative again (repolarization)
- After the action potential, there is a refractory period where the impulse cannot go back in the same direction. This ensures a one-way nerve impulse

Action potential - http://highered.mheducation.com/sites/0072943696/student_view0/chapter8/animation__voltage-gated_channels_and_the_action_potential__quiz_1_.html

http://www.psych.ualberta.ca/~ITL/ap/ap.htm

http://highered.mheducation.com/sites/0072495855/student_view0/chapter14/animation__the_nerve_impulse.html

∑ - Nerve impulses are action potentials propagated along the axons of neurons.

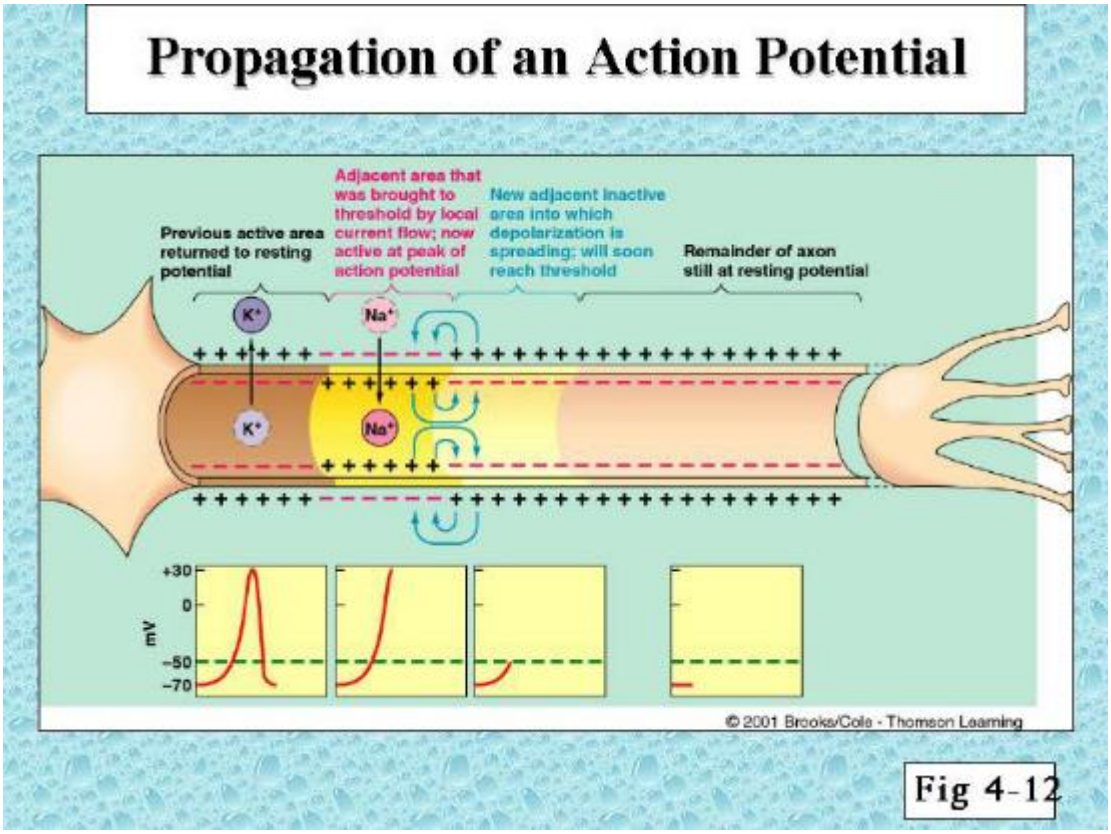
- As a depolarization occurs in one part of the neuron, the positive charge triggers the Na+ channels to open in the nearby regions causing an action potential to occur.
- This action potential will cause a depolarization in the next region.
- The propagation of action potentials will continue along the axon of the neuron.
- Nerve impulses move in one direction along the neuron from one end of the neuron to the other end
- A refractory period occurs after depolarization which prevent the electrical impulse from traveling backwards along the axon

Propagation - https://www.youtube.com/watch?v=pbg5E9GCNVE

∑ - Propagation of nerve impulses is the result of local currents that cause each successive part of the axon to reach the threshold potential.

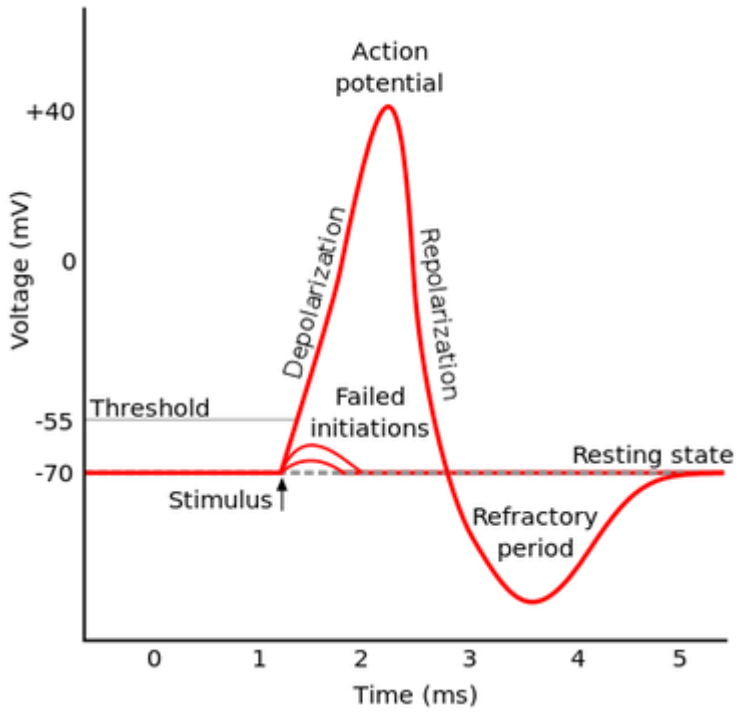
- Propagation of nerve impulses along the axon results from the diffusion of Na+ ions from the area that was just depolarized to the neighbouring area that is still polarized inside the axon
- When a part of the axon depolarizes, the localized are inside the axon becomes more positive as Na+ diffuses into the axon through voltage gated channels
- Outside the axon the concentration of Na+ is less in the depolarized region, so sodium diffuses from the polarized region towards the depolarized region
- The adjacent area inside the axon that is still polarized (more negative)
- The higher concentration of Na+ inside the depolarized region diffuses towards the polarized (more negative) region inside the axon
- These local currents causes the adjacent region to become more positively charged.

- When this happens, the membrane potential of the adjacent region becomes more positive from -70mv to -50mV (threshold potential)
- This results in a depolarization in the neighbouring region, as Na+ voltage-gated channels open and Na+ diffuses into the axon



Good video - https://www.youtube.com/watch?v=Sa1wM750Rvs

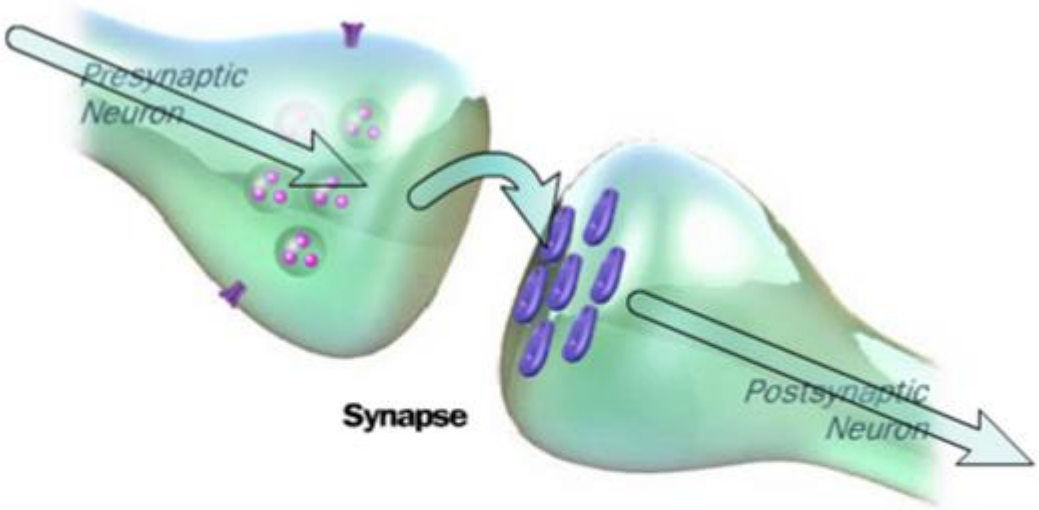
β - Skill: Analysis of oscilloscope traces showing *resting potentials and action potentials*.

	Membrane potentials can be measured by using electrodes on the inside and the outside of the membrane of the neuron These potentials can be measured by using a oscilloscope, which displays a graph, similar to the one on the left Time is put on the x axis and membrane potential in terms of voltage s placed on the y-axis The rising and falling spike shows the depolarization and repolarization periods of the action potential
Action Potentialhttp://www.codeproject.com/KB/recipes/1035958/300px-Action_potential.svg.png	

Do data based questions on page 324

∑ - Synapses are junctions between neuron; between neurons and receptor; effector cells.

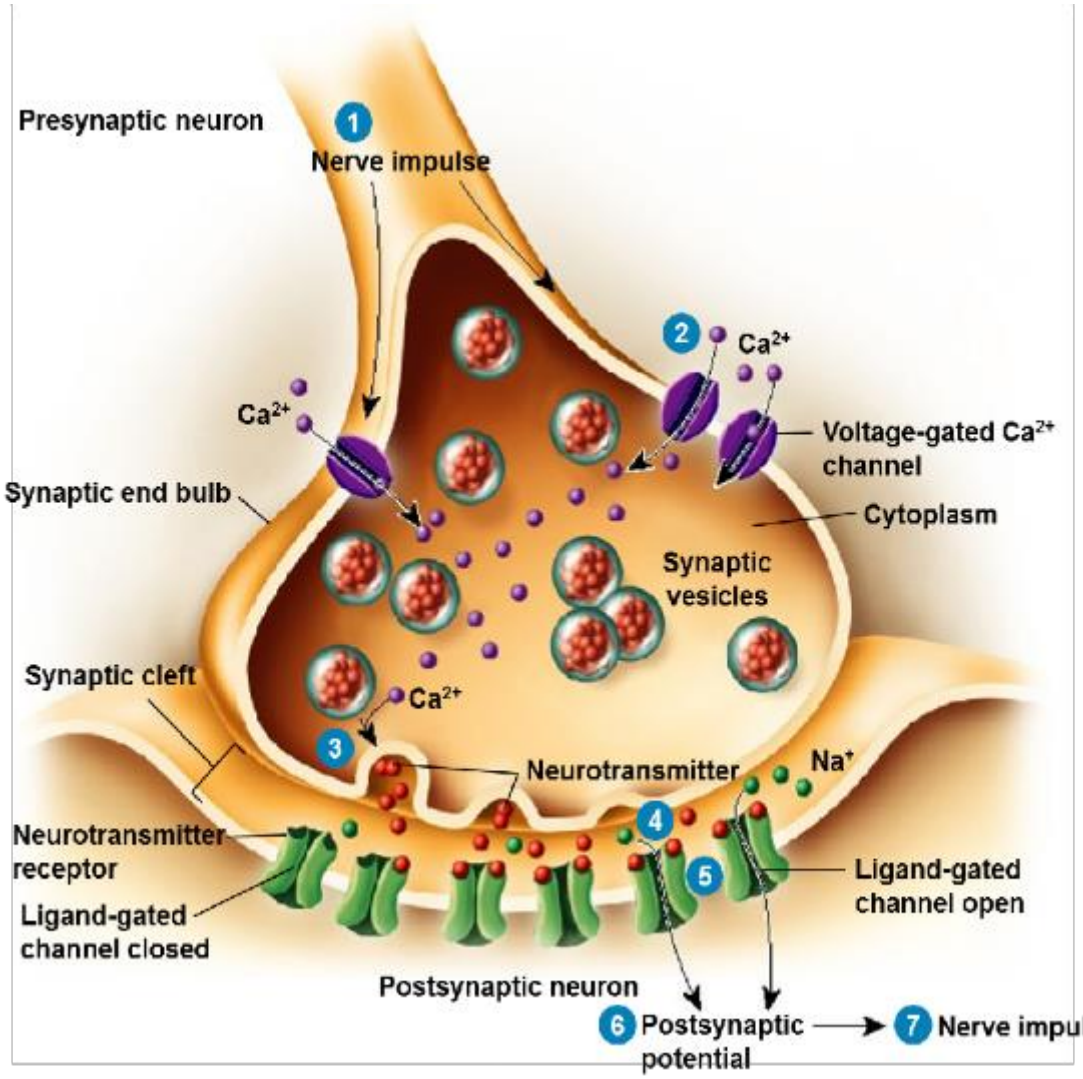
- Synapses are junctions or structures between the pre-synaptic and post-synaptic membrane of two cells in the nervous system
- The junction can be between a neuron and an effector such as a muscle or a gland
- It can be between two different neurons. Many of these connections occur in the CNS (brain and spinal cord)
- A junction also exists between the sense receptor cells and the sensory neurons
- Neurotransmitters are chemicals diffuse across a synapse from pre-synaptic membrane to post-synaptic membrane to send a signal to the next cell



In order to transmit a signal between two neurons, an electrical impulse must be communicated over a synapse.

∑ - When presynaptic neurons are depolarized they release a neurotransmitter into the synapse.

- As the nerve impulse reaches the axon terminal of the presynaptic neuron, thepositive charge from the depolarization causes voltage-gated channels permeable to Ca^{2+} to open.
- Ca^{2+} flows into the presynaptic neuron increasing the amount of Ca^{2+} in the presynaptic neuron.
- This Ca^{2+} causes vesicles containing neurotransmitters to bind to the membrane and release their neurotransmitters into the synaptic cleft (space between pre and post synaptic neuron).
- These neurotransmitters diffuse across the synaptic cleft and bind to receptor sites on the membrane of the post synaptic neuron.
- The binding of these neurotransmitters open ion channels allowing ions such as Na^{+} to diffuse into the post synaptic neuron.
- This influx of positive charge possibly leads to an action potential and adepolarization in the post synaptic neuron.
- The neurotransmitter is reabsorbed by the presynaptic neuron or broken down in the synapse by enzymes.



Animation: http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter14/animation__transmission_across_a_synapse.html

Crash course - https://www.youtube.com/watch?v=x4PPZCLnVkA

Data based questions page 325

∑ - A nerve impulse is only initiated if the threshold potential is reached.

- The threshold potential is the critical level to which a membrane potential must be reach in order to initiate an action potential
- Neurons fire or a nerve impulse is generated by an “all or nothing”
- When a stimulus occurs, some Na+ channels open causing the membrane potential to become more positive
- If enough Na+ diffuses into the neuron (-50mV to -70mV) and action potential is generated

- At a synapse, binding of a neurotransmitter at the post-synaptic membrane causes Na+ to diffuse into the neuron (if excitatory)
- This can cause a depolarization of the neuron if enough neurotransmitters are released

β - Application: *Secretion* and *reabsorption* of **acetylcholine** by neurons at**synapses**.

- Acetylcholine is a neurotransmitter
- It is largely used at the neuromuscular junction, meaning it is released by motor neurons and binds to receptors on muscles
- It is also used in the autonomic nervous system
- Acetylcholine is created in the presynaptic terminal by combining a water soluble nutrient called choline with an acetyl group
- Acetylcholine is secreted by the presynaptic membrane of a neuron
- The neurotransmitter diffuses across the synapse and binds to a receptor on the post synaptic membrane (causing an action potential if a threshold is reached)
- Once it has released from the receptor, an enzyme called acetylcholinesterase breaks t down into choline and acetate
- Choline is reabsorbed back into the pre-synaptic neuron where it is combined with another acetyl group to form another acetylcholine neurotransmitter

Two videos on Acetylcholine –

https://www.youtube.com/watch?v=o4Srx4mUmaI

https://www.youtube.com/watch?v=0-KmO0Lg7Kw

β - Application: Blocking of synaptic transmission at cholinergic synapses in insects by **binding of neonicotinoid pesticides** to **acetylcholine receptors**.

- Neonicotinoids bind to acetylcholine receptors in cholinergic synapses in the CNS of insects
- Acetylcholinesterase does not break down neonicotinoids therefore binding is irreversible
- Acetylcholine now can't bind and neural transmission is stopped
- The insects go through paralysis and then death
- A benefit to this pesticide is that it is very effective in killing pests and it is not highly toxic to humans and mammals
- The problem is that it also effects beneficial insects such as honey bees. There is conflicting evidence if this is the case or not
- Many places such as the EU and Ontario, Canada has banned neonicotinoid pesticides

http://www.huffingtonpost.ca/2014/11/25/ontario-bees-pesticide-neonicotinoids-neonics_n_6221800.html

http://www.bbc.com/news/science-environment-22346626

β - Application: The **social effects** of the **abuse of psychoactive drugs** could be considered, as could the use of the neurotoxin *Botox* for cosmetic treatments.

http://www.coastreporter.net/community/columnists/alcohol-consumption-in-canada-1.2170791

http://addictions.about.com/od/substancedependence/g/psychoactive.htm

http://www.examiner.com/article/cannabis-use-linked-to-substance-use-disorders

https://www.youtube.com/watch?v=hnJvolWXmZc

Utilization: An understanding of the workings of neurotransmitters and synapses has led to the development of numerous pharmaceuticals for the treatment of mental disorders.

6.6 Hormones, homeostasis and reproduction

Hormones are used when signals need to be widely distributed.

Understandings:

∑ - *Insulin* and *glucagon* are secreted by *β and α cells* of the pancreas respectively to control blood glucose concentration.

- Blood glucose concentration is carefully monitored by negative feedback mechanisms.
- Cellular respiration is constantly lowering blood glucose levels.
- Receptors in the pancreas sense when the blood glucose level is too low.
- Alpha (α) cells in the islets of Langerhans in the pancreas secrete glucagon into the bloodstream.
- Glucagon stimulates the liver to breakdown stored glycogen into glucose which is released into the bloodstream.
- Blood glucose levels rise back to their normal limits.
- After a person eats, digestion breaks large carbohydrates into glucose molecules.
- Glucose levels rise in the blood.
- If the glucose levels get too high, receptors sense the increased glucose levels causing the pancreas to secrete insulin by the Beta cells (β) of the islets Langerhans.
- Insulin stimulates the absorption of glucose from the blood into skeletal muscles and fat tissue, and thus allowing the liver to convert glucose into glycogen (animal carbohydrate storage molecule).
- Glucose levels decrease back to the normal range.

β - Application: **Causes and treatment** of *Type I and Type II diabetes*.

The doctors video: https://www.youtube.com/watch?v=yENeJ70S5QE

Type I diabetes: https://www.youtube.com/watch?v=Qi6LYIhlFdw

- Is an autoimmune disease characterized by the inability of the pancreas to produce insulin. The insulin producing β-cells of the pancreas are attacked and destroyed by one's own immune system.
- This type of diabetes usually develops in children, but can occur at any age.
- Therefore, the body loses the ability to take up glucose into its cells and convert glucose into glycogen.
- People that have type I diabetes must take insulin shots or injections.

Type II diabetes

- Occurs when the insulin receptors on certain body cells lose their ability to process or respond to insulin.
- Pancreas still produces insulin.
- Type II diabetes is usually a result of obesity, age, lack of exercise and/or genetic predisposition.
- Type II diabetes is usually considered late onset as it usually occurs later on in life.
- Insulin injections are not needed. Diabetes II can be treated by lifestyle and diet changes.
- Most common form of diabetes.

*****Do the data based questions on page 331*****

∑ - *Thyroxin* is secreted by the *thyroid gland* to regulate the metabolic rate andhelp control body temperature.

- Thyroxin is a hormone secreted by the thyroid gland of the endocrine system
- Thyroxin contains iodine; therefore, prolonged deficiency to iodine in the diet prevents the production of thyroxin
- Thyroxin is important in the regulation of the body's metabolic rate
- The body's metabolic rate is the amount of energy a body uses at rest; combination of the catabolic and anabolic reactions
- Since thyroxin causes an increase in the body's metabolic rate, there is an increase in oxygen consumption and the hydrolysis of ATP; thereby causing an increase in the body's temperature
- Increase in thyroxin stimulates the breakdown of lipids and the oxidation of fatty acids
- Thyroxin also stimulates carbohydrate metabolism, including the uptake of glucose and the breakdown of glycogen into free glucose
- In a regular person, if the bodies temperature drops, a release in thyroxin will stimulate heat production causing the body's temperature to rise

- If there is an excessive amount of thyroxin in the body, hyperthyroidism can occur
- If there is an insufficient amount of thyroxin in the body, hypothyroidism can occur
- Some of the symptoms of hypothyroidism are weight gain, loss of energy, feeling cold all the time, forgetfulness and depression

∑ - *Leptin* is secreted by cells in *adipose tissue* and acts on the hypothalamus of the brain to inhibit appetite.

- Leptin is a hormone made by adipose cells that helps to regulate energy balance by inhibiting hunger.
- Leptin acts on the receptors in the arcuate nucleus (collection of neurons) of the hypothalamus to regulate appetite in order to achieve energy homeostasis
- The concentration of leptin in the blood is controlled by food intake and the amount of adipose tissue in the body
- If the amount of adipose tissue in an individual increases, then their concentrations of leptin also increases, leading to long term suppression of appetite and reduced food intake
- In obese individuals a decreased sensitivity to leptin can occur, resulting in an inability the recognize when they are full
- Journal article on Leptin and regulation of body weight in mammals http://www.nature.com/nature/journal/v395/n6704/full/395763a0.html
- Article shows that mice containing a recessive/recessive allele (ob/ob) produce a truncated version of the leptin hormone
- This led into severe obesity in these mice as the signal that tells the brain of the mice they are full (leptin) didn't work anymore

β - Application: **Testing** of **leptin** on **patients** with **clinical obesity** and reasons for the failure to control the disease.

Leptin and obesity: https://www.youtube.com/watch?v=oN3woHJ7ZDY

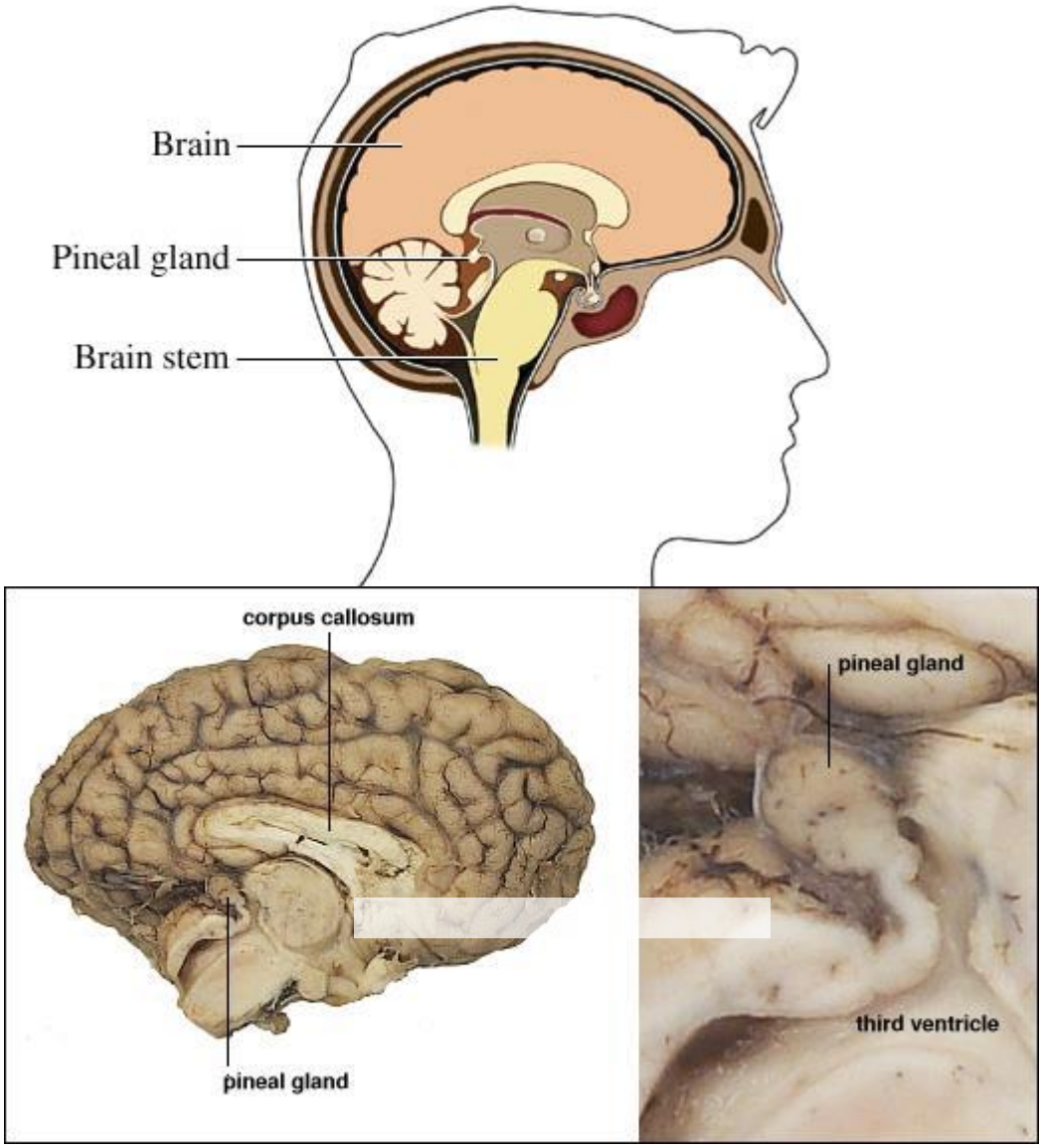
Shorter version http://www.hhmi.org/biointeractive/leptin-feedback-control-system

- The discovery of how mice become obese because of the lack of the hormone leptin and the subsequent treatment of the mice with leptin injections, led to human trials to decrease obesity
- However, trials with humans have had mixed response since the physiology of humans is much different then mice
- Since most humans have quite a high leptin concentration, it was determined that the many of obesity cases where caused by a change in the receptor protein for leptin, not in the production of leptin
- A double blind study was conducted by the biotech company Amgen, showed that injections of leptin to many of these individuals, since their receptors didn't work, failed to control obesity. In individuals that experienced weight loss, there was a big discrepancy in the amount of weight that was lost

- There also were other side effects such as skin irritation and swelling.

∑ - *Melatonin* is secreted by the *pineal gland* to control circadian rhythms.

- Melatonin is a hormone made by the pineal gland, a small gland in the brain.
- The secretion of melatonin by the pineal gland is controlled by cells in the hypothalamus
- Light exposure to the retina is relayed to the suprachiasmatic nucleus (SCN) of the hypothalamus. These fibers from the hypothalamus relay a message to the nerve ganglia of the spinal cord which is relayed back to the pineal gland to release melatonin.
- Melatonin helps control your sleep and wake cycles (circadian rhythms).
- Very small amounts of melatonin are found in foods such as meats, grains, fruits, and vegetables.



http://www.vivo.colostate.edu/hbooks/pathphys/endocrine/otherendo/pineal.html

- An internal 24- hour clock controls your natural cycle of sleeping and waking hours.

- Melatonin levels generally begin to rise in the mid to late evening, remaining high for most of the night, and then drop in the early morning hours.

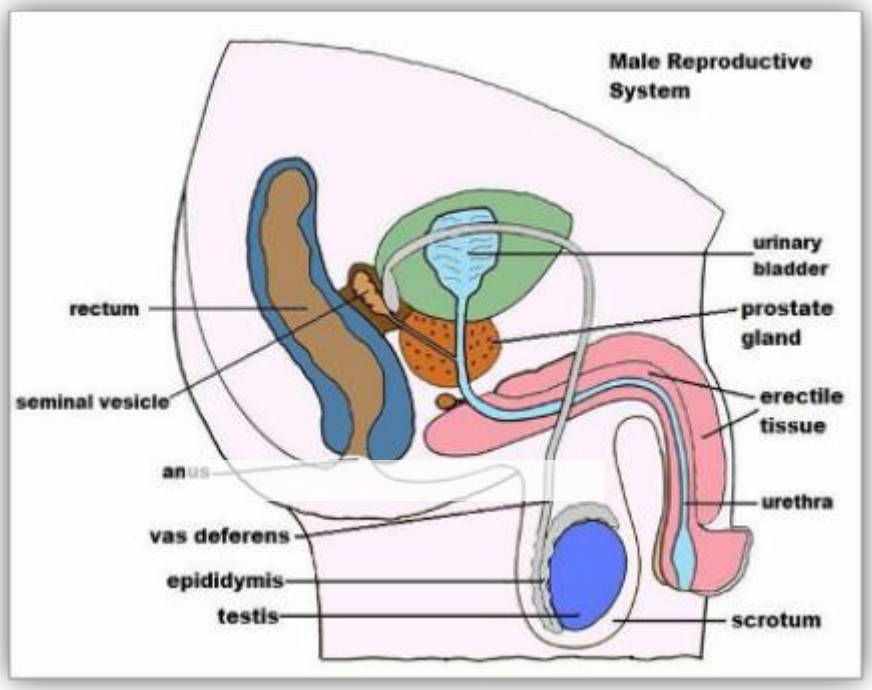
- Light from the sun can also affect how much melatonin your body produces. During the shorter days of the winter months, your body may produce melatonin either earlier or later in the day than usual. This change can lead to symptoms of seasonal affective disorder (SAD), or winter depression.

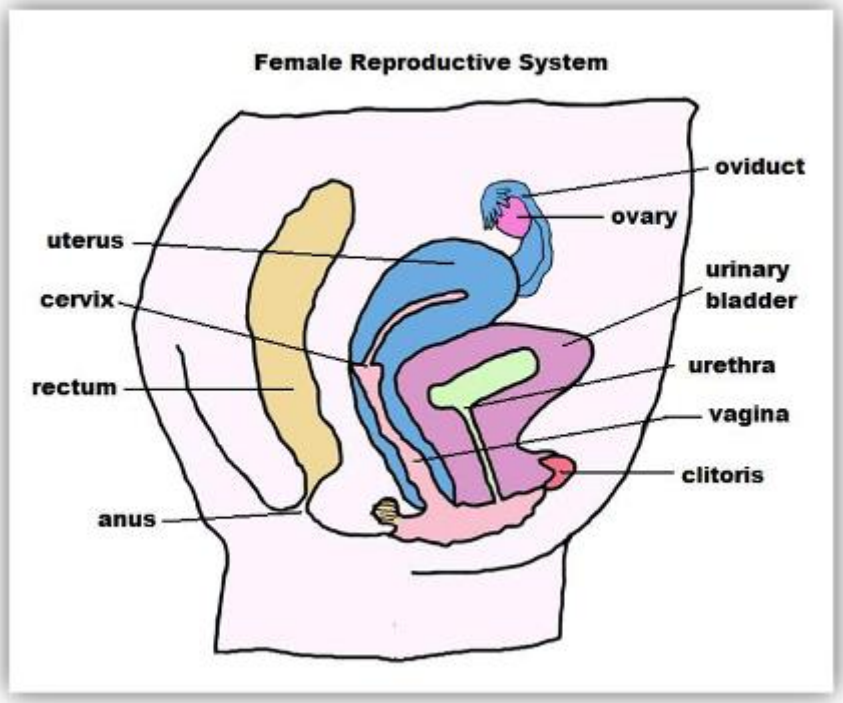
- Natural melatonin levels slowly drop with age. Some older adults make very small amounts of it or none at all.

β - Application: **Causes of jet lag** and **use of melatonin** to alleviate it.

- The SCN of the hypothalamus and the pineal gland continual set the circadian rhythm of the place the person is departing from.
- Therefore, when a person lands in a country that is many time zones different than the origin, they feel sleepy in the day and awake at night
- Jet lag will only last a few days, as the body adjusts to the new times when the light is detected by the cells in the retina during a different time period

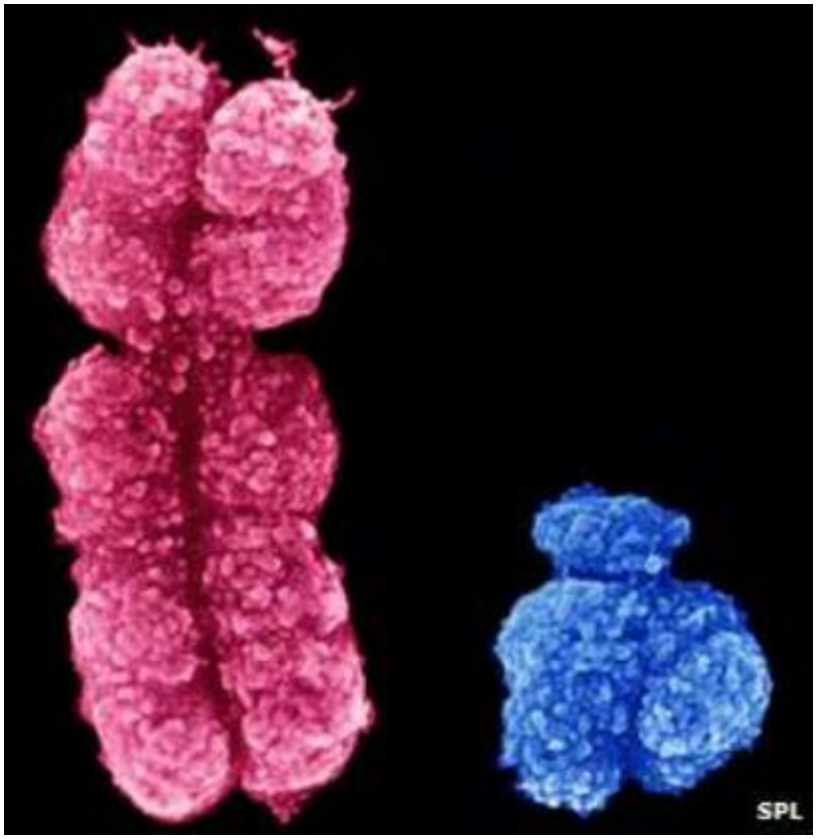
Skill: Annotate **diagrams** of the *male and female reproductive system* to show names of structures and their functions.





∑ - A gene on the Y chromosome causes embryonic gonads to develop as testes and secrete testosterone.

- The Y chromosome (small one below) has a gene called the SRY gene that causes the embryonic gonads to become testes and begin secreting testosterone
- SRY codes for a protein called TDF (testis-determining factor) that stimulates the expression of other genes located on the Y chromosome that cause testis development
- If there are two X chromosomes, the gonads develop as ovaries



∑ - *Testosterone* causes *pre-natal development of male genitalia* and both*sperm production* and development of male *secondary sexual characteristics*during puberty.

Testosterone

- Secreted in the testes of males or the early stage testosterone-secreting cells that will become testes.
- Aid in the development and maturation of the male genitalia as a fetus at about the 8th to 9th week.
- During puberty, testosterone aids in the development of male secondary sexual characteristics such as pubic and facial hair, enlarged penis, broad shoulders, muscle mass, deepening of voice and bone density.
- Stimulates production of sperm and promotes the male libido (sex drive).

∑ - *Estrogen* and *progesterone* cause pre-*natal development of female reproductive organs* and female *secondary sexual characteristics* during puberty.

- If the SRY gene on the Y chromosome is not present in the embryo, the gonads develop into ovaries
- Estrogen and progesterone which are secreted by the mother's ovaries and then by the placenta, will cause the female reproductive organs to develop in the absence of testosterone

- During puberty, estrogen and progesterone cause the development of secondary sexual characteristics in females, including breast development, menstrual cycle and pubic and armpit hair

∑ - The menstrual cycle is controlled by *negative* and *positive feedback*mechanisms involving ovarian and pituitary hormones. The roles of *FSH, LH, estrogen and progesterone* in the menstrual cycle are expected.

FSH (Follicle stimulating hormone)

- Produced and secreted by the anterior pituitary gland.
- Stimulates the growth of the follicles in the ovaries to create a mature Graafian follicle.
- Promotes the thickening of the follicle wall.
- Stimulates the secretion of the hormone estrogen.

LH (luteinizing hormone)

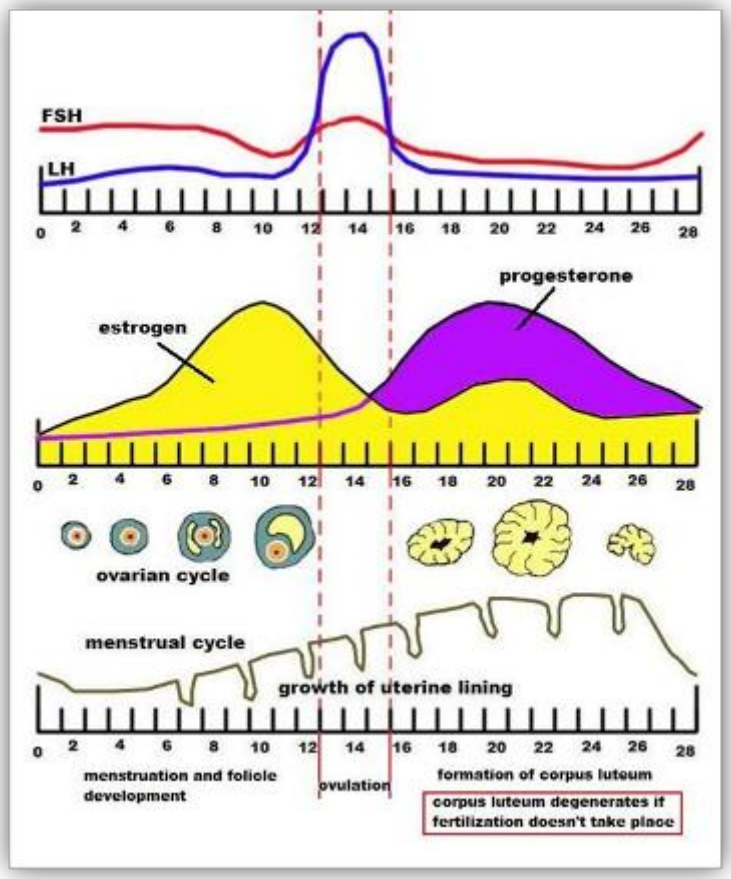
- Produced and secreted by the anterior pituitary gland.
- Triggers the release of the egg (ovulation).
- Stimulates the growth of the corpus luteum (secretes estrogen and progesterone).
- Stimulates the secretion of hormone estrogen and progesterone.

Estrogen

- Produced by the developing follicles in the ovaries and the corpus luteum.
- Promotes the thickening of the uterine wall (endometrium) and the growth of blood vessels, in preparation of egg implantation.
- Inhibits FSH and LH when the estrogen levels are high (around same time as ovulation). This would prevent the development and release of another egg.

Progesterone

- Produced by the ovaries and the corpus luteum.
- Helps maintain the thickening of the uterine wall for egg implantation.
- Inhibit the production of FSH and LH.



****Do data-based questions on page 338****

β - Application: The use in **IVF** of drugs to suspend the normal secretion of hormones, followed by the use of artificial doses of hormones to induce superovulation and establish a pregnancy.

- Generally, IVF treatment begins by taking drugs to halt the regular secretion of the hormones FSH and LH. This in turn stops the secretion of progesterone and estrogen and effectively allows the doctor to take control of the timing and egg production of the woman's ovaries
- The woman is then injected with large amounts of FSH to induce the production of many Graafian follicles.
- LH is also injected to promote the release of many ovules (eggs)
- This is called superovulation, which can produce between 10 and 20 eggs
- The eggs are then stimulated to mature by an injections of HCG (Human Chorionic Gonadotrophin), a hormone usually secreted by the developing embryo
- The eggs are surgically removed from the ovary of the woman.
- Sperm is collected from the male individual.
- Many sperm (50,000-100,000) are mixed with the eggs in a petri dish.
- The sperm and eggs in the petri dish are incubated at 37ºC (body temperature).

- The eggs are analyzed for successful fertilization (two nuclei inside the egg).
- Healthy embryos are selected and are transferred into the female uterus for implantation (up to 3 healthy embryos are transferred into the uterus to increase chance of implantation).
- Pregnancy test is given after about 2 weeks.

IVF - https://www.youtube.com/watch?v=GeigYib39Rs

Nature of science: Developments in scientific research follow improvements in apparatus—William Harvey was hampered in his observational research into reproduction by lack of equipment. The microscope was invented 17 years after his death.

β - Application: **William Harvey's investigation** of **sexual reproduction** in**deer**.

- William Harvey was best known for his discovery of the circulation of the blood, also was interested in sexual reproduction and how life is formed.
- Aristotle's theory was called the seed and soil theory, which stated that the male produces a seed (sperm) which then forms an egg when it mixes with menstrual blood of the mother. The egg then develops into a fetus inside the mother and eventually "voila" you have a baby
- Harvey studied the uterus of the deer during mating season by killing them and then dissecting them expecting to find eggs; however, Harvey only found signs of fetal development 2 to 3 months after mating season
- He concluded that Aristotle's theory of seed and soil was incorrect, but then he was also incorrect in stating that the fetus doesn't come from the mixture of the male and female seeds.
- He knew he had not come up with the correct method of sexual reproduction

Interesting video on Harvey - http://www.smithsonianmag.com/science-nature/meet-william-harvey-misunderstood-genius-human-anatomy-180953682/?no-ist

Utilization: Hormones are used in a variety of therapies such as replacement therapies.

Aims: Scientists are aware that the drugs women take in fertility treatment pose potential risks to health. Should scientific knowledge override compassionate considerations in treating infertile couples?

Review Questions

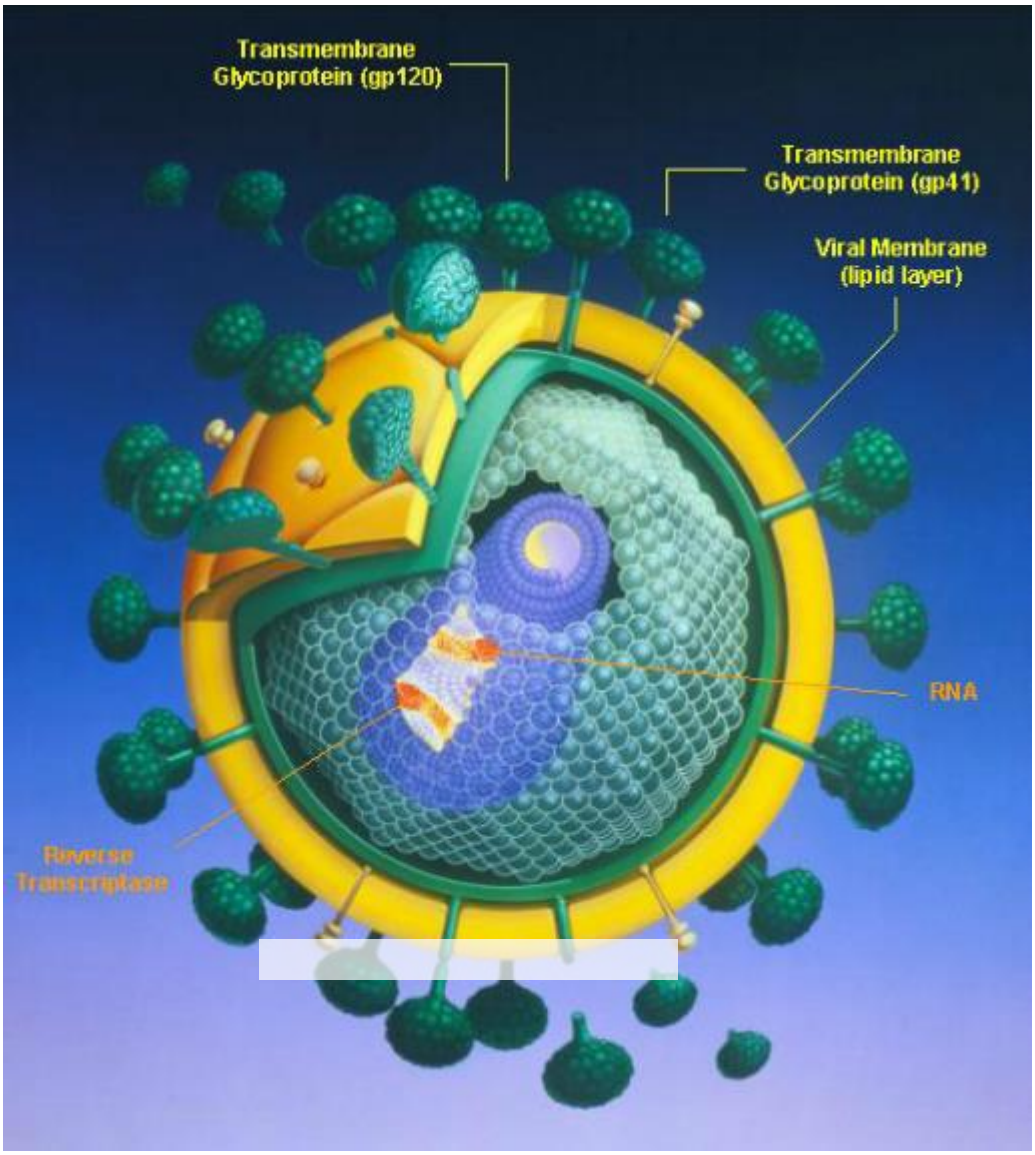
Topic 11: Animal physiology (16 hours)

11.1 Antibody production and vaccination: Immunity is based on recognition of self and destruction of foreign material.

Understandings:

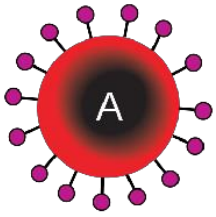
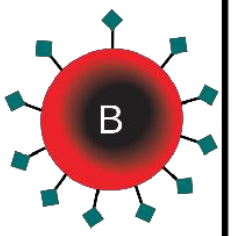
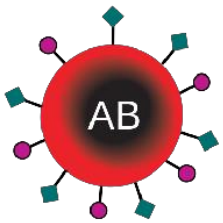
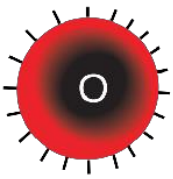
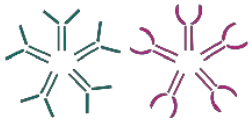
∑ - Every organism has unique molecules on the surface of its cells.

- All organisms have unique molecules or markers on the outer surface of the plasma membrane of their cells
- These highly variable molecules are generally glycoproteins and they identify a cell as being "self" or "non-self"
- These markers are called major histocompatibility complexes (MHC)
- These MHC proteins are genetically determined and are unique to that individual



Cell surface glycoproteins on the HIV virus above(http://www.apsubiology.org/anatomy/2020/2020_Exam_Reviews/Exam_2/CH21_Diseases_of_the_Immune_System.htm)

β - Application: Antigens on the surface of red blood cells stimulate antibody production in a person with a different blood group.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

http://www.sciencetopia.net/sites/default/files/Antigen-antibody-relationship.png

- Blood groups such as A, B, AB and O are identified by cell surface antigens
- Rhesus (Rh) is another antigen that can be present on the surface of the blood cells, being either Rh positive (has antigen) or Rh negative (doesn't have antigen)
- A blood transfusion given to an individual with the wrong blood type can stimulate an immune response called **agglutination** (clumping or clotting of the blood cells)
- This is followed by the destruction of the RBC (**hemolysis**)
- For example, someone with blood type A (antigen A on the surface) contains anti-B antibodies in their plasma. If they get a transfusion with blood type B, their immune system will attack and destroy the foreign blood cells with the B-antigen on the surface
- People with blood type O just have the basic antigen sequence that all blood cells have and are therefore not attacked by A or B antibodies; therefore, blood type O is known as the universal donor (O negative has no Rhesus factor)

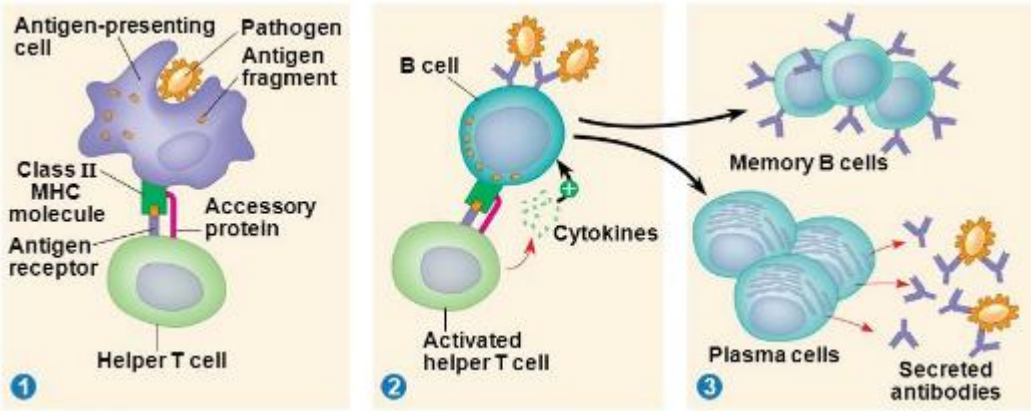
∑ - Pathogens can be species-specific although others can cross species barriers.

- Invading organisms such as a virus or bacterium that enters the body and causes a disease are known as pathogens
- Pathogens are generally **species specific,** for example, humans are the only known organisms susceptible to pathogens such as polio, syphilis, measles and gonorrhea but are resistant to many pathogens that infect other organisms

- However, there are pathogens that can cross this species barrier and infect a range of hosts, such as the Rabies virus, bird flu and the Bubonic plague
- Diseases from other animals that can infect or be transmitted to humans is called**Zoonosis**
- The passing of diseases from different species is a growing global health concern
- Video on Zoonosis: https://www.youtube.com/watch?v=PSQPikvU6pc

∑ - ***B lymphocytes*** **are activated by** ***T lymphocytes*** **in mammals.**

- When a pathogen enters the blood, the specific antigen on the surface of the membrane is identified.
- Specific phagocytes known as macrophages recognize a pathogen as a foreign entity because of the antigens on the surface.
- The macrophage engulfs and partially destroys the pathogen.
- The macrophage takes the antigens from the destroyed pathogen and displays them on the surface of the cell bound to a membrane protein called a MHC protein (called antigen presentation).
- Specific T-lymphocytes receptors recognize and bind to the antigen presented by the macrophage, thus activating the T-lymphocyte.
- The activated T-cell binds to a B-lymphocyte specific to the antigen; activating the B-cell through the binding and the release of a signaling protein

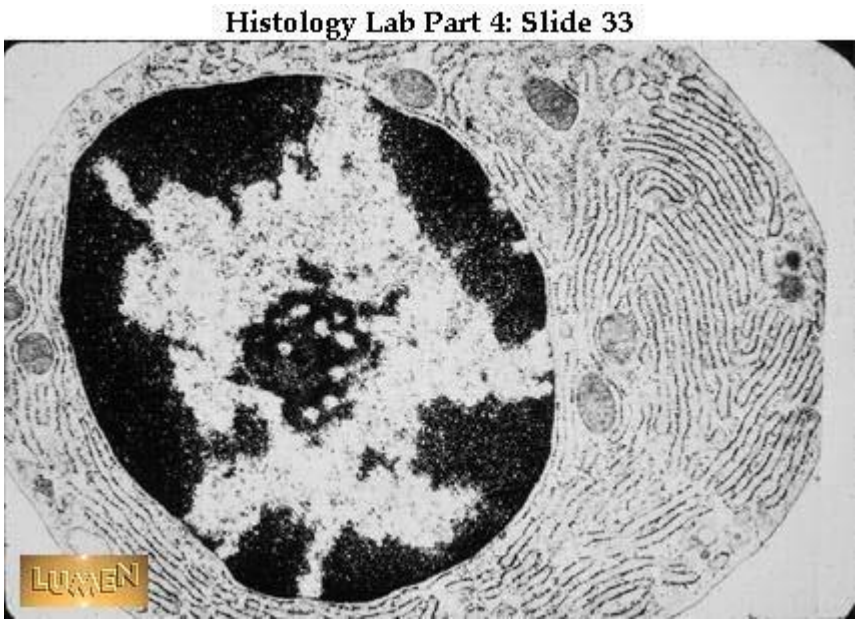


∑ - **Activated B cells multiply to form clones of** ***plasma cells*** **and** ***memory cells*****.**

- The active B-cells begin to clone themselves producing cloned plasma B cells thatproduce antibodies and memory cells. Memory cells remain in the blood in case a second infection occurs to provide long term protection and a quick response to the new infection.
- The plasma cells created produce and release mass amounts of antibodies into the bloodstream.
- These antibodies surround and bind to the antigens on the foreign pathogens.
- Through a variety of different methods the pathogens are destroyed by the antibodies and other white blood cells.

∑ - **Plasma cells secrete** ***antibodies*****.**

- As stated above, plasma cells are specialized B lymphocytes (called B cells as they develop in the bone marrow) that secrete a large amount of antibodies during a selective immune response
- Since they are a cell that produces and secretes a large number of antibodies (proteins), they contain an **extensive amount of rER, ribosomes and mitochondria (for energy)**



http://www.meddean.luc.edu/lumen/Meded/Histo/HistoImages/hl2A-33.jpg

∑ **- Antibodies aid the destruction of pathogens.**

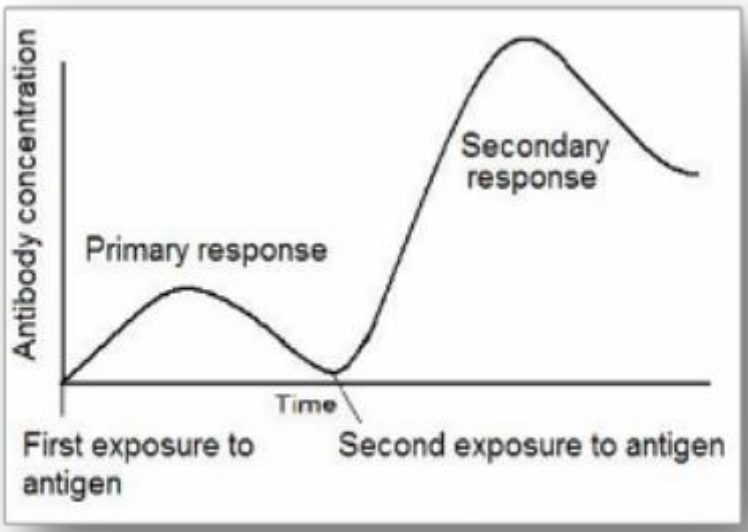
- **Antibodies aid in the destruction of pathogens in a variety of ways**

1. **Agglutination** – antibodies cause the sticking together of pathogens by attaching to the antigens on the surface. These clumped masses of pathogens are then easily ingested and destroyed by phagocytes
2. **Opsonization** – antibodies make pathogens recognizable by binding to them and linking them to phagocytes
3. **Toxin Neutralization** – Antibodies bind to toxins produced by pathogens in the blood plasma preventing them from affecting susceptible cells.
4. **Complement Activation** – After a pathogen is identified by antibodies, complement proteins in the blood plasma form a membrane attack complex that destroys the cell membrane in the pathogen causing the cell to lyse
5. **Bacteria and Virus Neutralization** – Antibodies can bind to the surface of viruses, preventing them from entering host cells

∑ **- Immunity depends upon the persistence of memory cells.**

- Long term specific immunity depends upon the presence of memory cells created during a previous infection from the same pathogen

- Memory cells are long-lived cells that make an effective response to a **reinfection of the body by the same antigen (on the pathogen)**



∑ **- Vaccines contain antigens that trigger immunity but do not cause the disease.**

- Vaccines are introduced to the body usually through an injection but can be administered through orally or through a nasal spray
- Vaccines contain a live attenuated (weakened) or killed version of the pathogen, itstoxins or one of its surface antigens.
- Vaccines stimulate a primary immune response
- If the body encounters the actually pathogen, it will be destroyed right away by theantibodies during a secondary immune response
- Vaccines has made great contributions towards public health through the prevention of many deadly or dangerous **diseases such as tuberculosis, measles and smallpox**

Herd Immunity - http://www.cbc.ca/news/health/measles-vaccinations-of-toddlers-at-89-below-herd-immunity-level-1.3161617

*****Do Data Based questions on page 473****

β - Application: **Smallpox** was the **first** infectious **disease** of humans to have been**eradicated by vaccination**. Human vaccines are often produced using the immune responses of other animals.

Good video on smallpox https://www.youtube.com/watch?v=yqUFy-t4MlQ

Eradication of smallpox in South-East Asia https://www.youtube.com/watch?v=Y6gkStkVSd8

- In 1959 a global initiative was undertaken by the WHO in order to eradicate smallpox
- The effort had mixed results until a well-funded Smallpox Eradication Unit was formed in 1967
- The last known case of smallpox was recorded in Somalia in 1977
- It was successful because of the following reasons

1. **Patients were easily identified by obvious clinical features**
2. **Transmission was through direct contact only**
3. **There were no animal vectors or reservoirs where the disease could remain and reemerge**
4. **Contacts of the patients identified were quickly identified and vaccinated**
5. **Immunity was long term so reinfection was unlikely**
6. **The infection period was short-lived (3 to 4 weeks)**
7. **The virus was stable and didn't mutate**
8. **There was international cooperation organized by the WHO**

Nature of science: Consider ethical implications of research—Jenner tested his vaccine for smallpox on a child.

- Edward Jenner was a scientist who infected a small child with cowpox
- After the boy recovered he then affected the child with the more virulent and possibly fatal smallpox, as he believed the child would be immune because of the original cowpox infection
- He did this on a young child well below the age of consent

Jenner's Story **http://www.sciencechannel.com/tv-shows/greatest-discoveries/videos/100-greatest-discoveries-the-beginning-of-vaccination/**

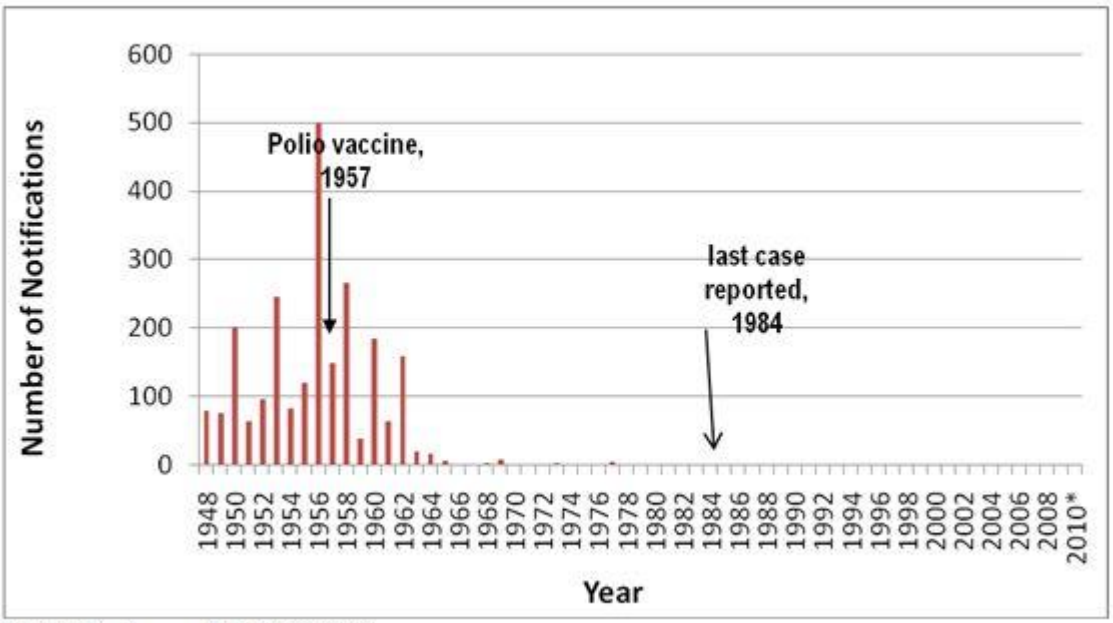
Ethics in medicine: **http://study.com/academy/lesson/ethical-issues-in-medicine-psychology.html**

β - Skill: Use databases to **analyse epidemiological data** related to **vaccination**programmes

Epidemiological Studies on Vaccinations

Vaccines and Autism http://www.ageofautism.com/2011/05/vaccines-and-autism-what-do-epidemiological-studies-really-tell-us.html

Figure 1. Polio notifications, Ireland 1948-2010 (as of 14/10/2010)

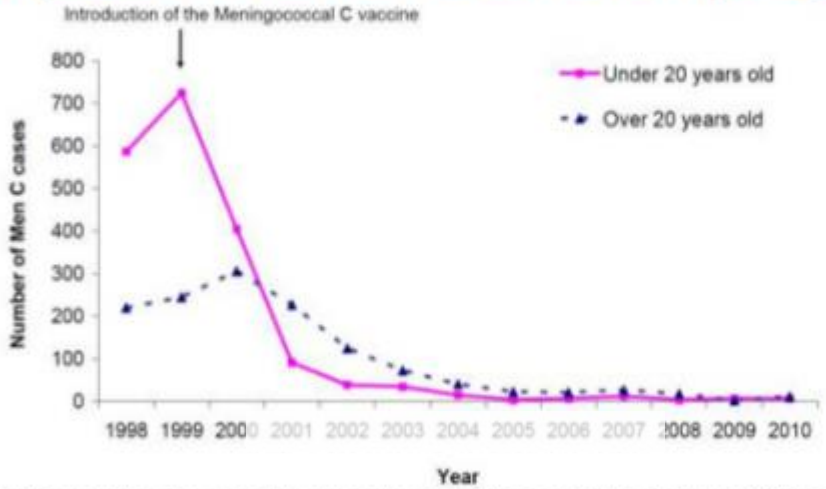


*2010 data as of 15/10/2010

Public Health England

oxford vaccine group

Impact of MenC vaccination programme



Number of laboratory confirmed serogroup C cases in England and Wales, 1998-2010

Source: Public Health England, Infectious Disease Epidemiological Data
http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1234859709051?p=1201094595391

18

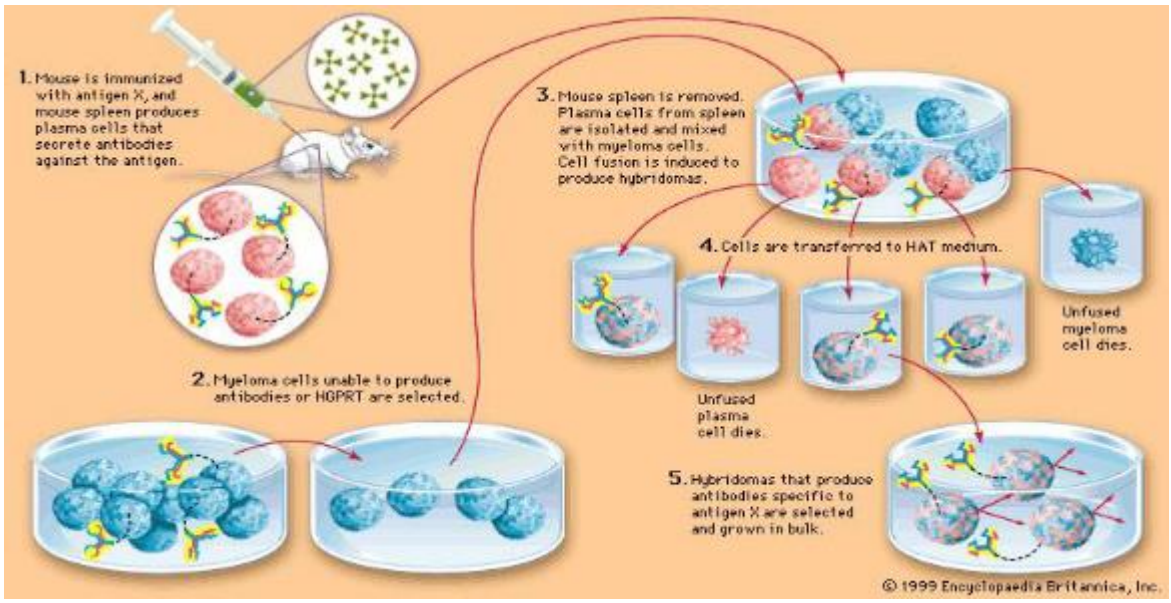
∑ - White cells release *histamine* in response to allergens.

- Mast cells found in connective tissue and Basophils circulating in the blood **secrete histamine** in response to antigens from an infection or response to an allergen
- Histamines cause the blood vessels of the infected area to dilate and increase flow of fluid containing immune components to the infected area
- Some of these immune components leave the blood vessels resulting in non-specific and specific immune response

∑ - Histamines cause allergic symptoms.

- A number of symptoms from allergic reactions are caused by histamines
- Cells throughout the body have histamine receptors
- The release of histamine causes many of the symptoms from an allergic response such as inflammation, sneezing, itching and mucous secretion
- Histamines play a role in the formation of rashes and swelling known as anaphylaxis
- Anti-histamine drugs, counteract these affects by blocking histamine receptors

∑ - Fusion of a *tumour* cell with an *antibody-producing plasma cell* creates a *hybridoma*cell.



http://media-2.web.britannica.com/eb-media/39/21139-004-1BC93D10.jpg

∑ - Monoclonal antibodies are produced by hybridoma cells.

- Monoclonal antibodies are identical antibodies produced by clones of a single parent immune cell that are specific to one type of antigen.
- A laboratory animal such as a mouse is injected with a specific antigen thatcorresponds with the needed antibodies.
- After the animal goes through a primary immune response, a plasma B-cell cell that produces the required antibody is removed from the spleen.
- Myeloma (cancer) cells are cultured in a petri dish.

- These dividing myeloma cells are mixed together with the plasma B-cells and aretreated to promote a fusion between the two cells, forming a cell called a hybridoma.
- The successful hybridomas have characteristics of both cells; produce antibodies and divide rapidly for a long time.
- These hybridoma cells are cultured and allowed to divide, producing many clone cellsthat are able to produce large amounts of antibodies.
- Monoclonal antibodies can be extracted and used for many different applications.

Video on Monoclonal Antibodies https://www.youtube.com/watch?v=kcxQyIfca4I

β - Application: Monoclonal antibodies to **HCG** are used in **pregnancy test kits**.

Use in diagnosis of pregnancy

- Human chorionic gonadotrophin (HCG) is produced by an embryo in early pregnancy.
- Monoclonal antibodies can be produced by injecting a lab animal with HCG, as it recognizes this as antigen.
- *HCG Antibodies* are combined with color-changing enzymes.
- When the mixture is introduced into a blood sample of a woman that is pregnant, theantibodies will bind to the HCG in the blood, causing a change in color.
- If the woman is not pregnant, no HCG will be present in her blood, and therefore there will be no color change.

Use in treatment of rabies

- Monoclonal antibodies are produced using the method described in 11.1.5.
- The antibodies are injected directly into the person after a possible rabies infection.
- The antibodies will control and fight the infection, giving time for the body to produce its own antibodies.
- If not treated with antibodies after a rabies infection, death can result.

Other examples are treatment of cancer cells and detection of HIV

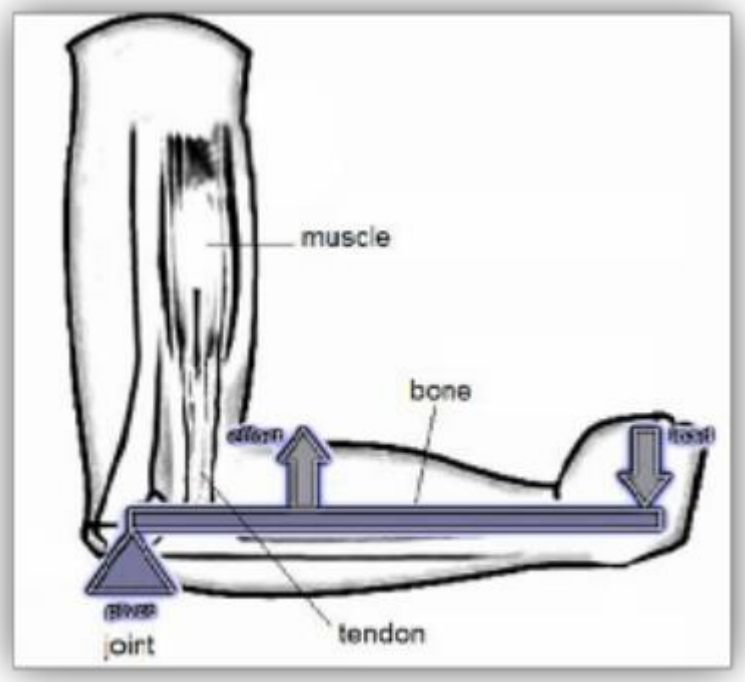
11.2 Movement: The roles of the musculoskeletal system are movement, support and protection.

Understandings:

∑ - *Bones* and *exoskeletons* provide *anchorage* for muscles and act as *levers*.

- Bones act as levers so the body can move and provide structural support (skeleton).
- Ligaments are strong bands that connect bone to bone strengthening the joint during movement.
- Tendons have dense connective tissue that connects muscles to bones, allowing movement of the bone when a muscle contracts.

- Muscles provide the force for movement by contracting (shortens the muscle fibers)



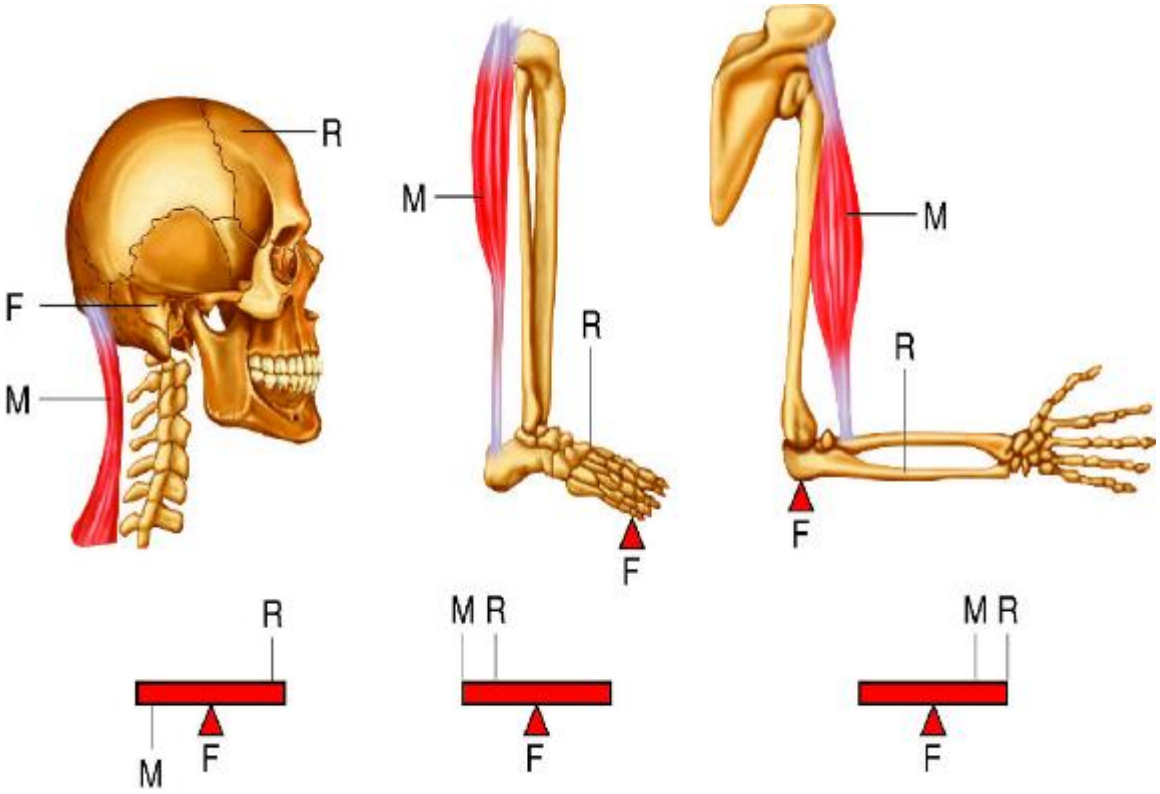
- The joint acts as a **pivot point or a fulcrum**
- The **force applied** (when the muscle contracts) is called the **effort**
- The force or load needed to overcome for movement to take place is called the **resistance**
- Levers are classified by first, second, and third class, depending upon the positions among the fulcrum, the effort, and the resistance.

- **First-class levers** have the fulcrum in the middle, like a seesaw. An example of a first class lever is when a human nods their head (top of the spinal column is the fulcrum, the effort force is provided by the muscles in the back of the neck, and the resistance is weight of the head).

- **Second-class levers** have a resistance in the middle, like a load in a wheel-barrow. The body acts as second class lever when engaged in pushup or calf raise. During a calf raise ball of foot is fulcrum, the body's mass is the resistance and the effort is applied by calf muscle.

- **Third-class levers** have the effort from the muscle in the middle of the lever. The majority of the human body's musculoskeletal levers are third class.

These levers are built for speed and range of motion. Muscle attachments are usually close to the fulcrum. In the example of the arm, the effort force is provided by the contraction of the biceps, the fulcrum is the elbow joint and the resistance would be provided by whatever weight is being lifted.



https://courses.candelalearning.com/olianp/wp-content/uploads/sites/167/2014/11/Muscle_22b.jpg

- Exoskeletons in insects and crustaceans can facilitate the movement by providing an anchorage for muscles; similarly to how bones provide anchorage for animals with internal skeletons

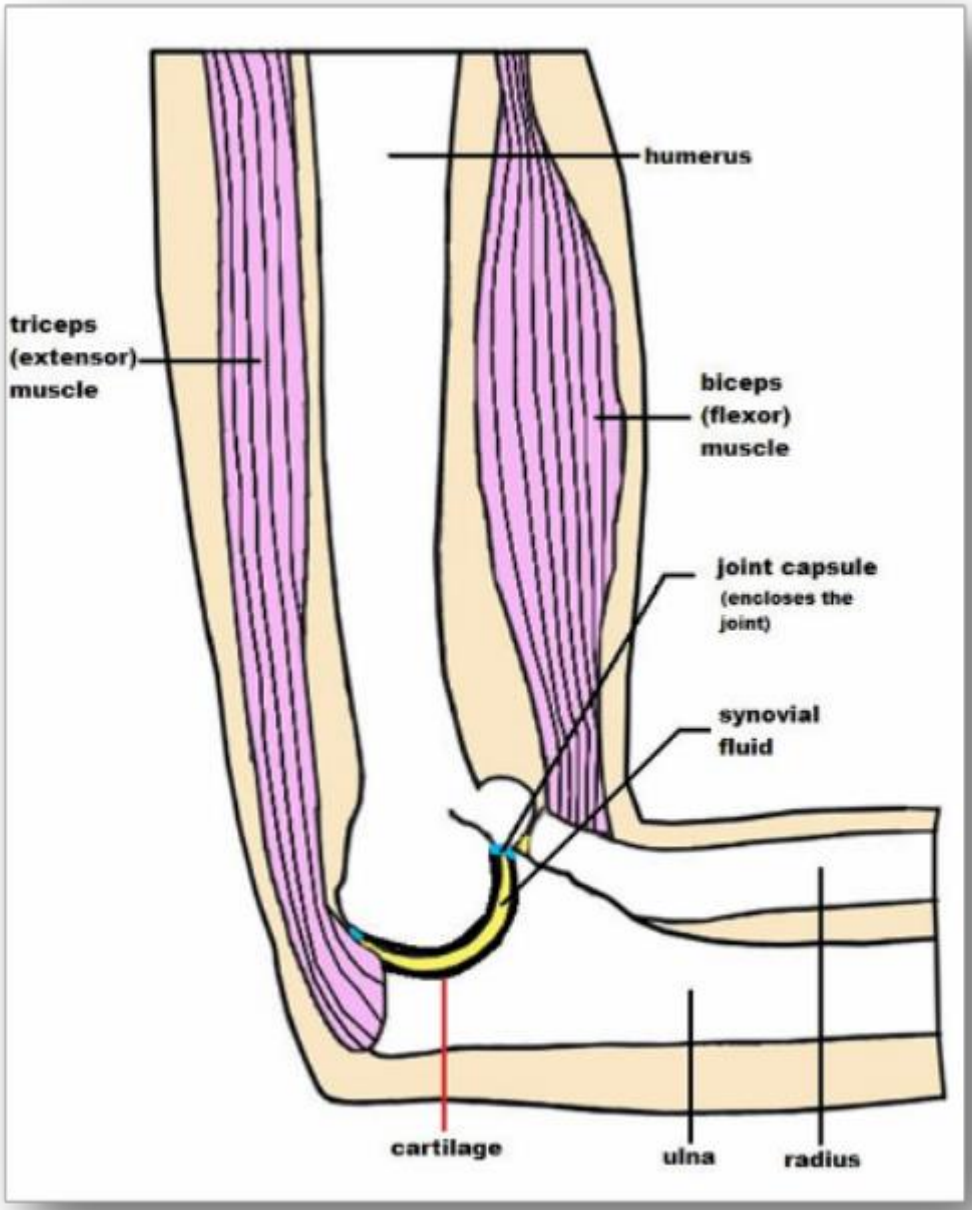
∑ - ***Synovial joints*** **allow certain movements but not others.**

- The type of joint determines the amount of movement that is possible
- For **ball and socket joints**, such as the hip or the shoulder, movement through all three planes are possible. At the hip joint, the head of the femur is the ball the fits into the socket of the pelvis. The movements possible at the joint are flexion, extension, rotation, abduction and adduction.
- For **hinge joints**, such as the knee, **flexions (bending) and extensions (straightening)** are the possible movements (movement in one plane); however, slight side to side movements are possible
-

• Hip Joint	• Similarities	• Knee joint

(differences)		(differences)
• Ball and socket joint	• Synovial joints separated by a fluid-filled cavity	• Hinge joint
• Free movement in all three planes	• Fluid is called synovial fluid that lubricates the joint.	• Allows movement in one plane (although there can be slight side to side movement)
• Greater range of motion than the knee joint (flexion, extension, adduction, abduction and rotation). Muscles involved are the quads, hamstrings, gluteus maximus and many other smaller muscles	• Ends of bones covered in cartilage, a smooth connective tissue which absorbs shocks more easily.	• Motions are flexion (contraction of hamstring muscle) and extension (contraction of quadriceps muscles)

β -Skill: Annotation of a **diagram** of the human **elbow**: include *cartilage*, *synovial fluid*, *joint capsule*, *named bones* and *named antagonistic muscles*.



Structure	Function
• cartilage - stiff yet flexible connective tissue found in many areas in the bodies such as the joints between bones, nose and ear	• cartilage reduces friction in the joint, provides high tensile strength and support, and absorbs compression
• synovial fluid – thick, viscous fluid found in the cavity of the synovial joints	• synovial fluid reduces friction by providing lubrication between the cartilage and other tissues in joints during movement • supplies oxygen and nutrients to and removes carbon dioxide and

	wastes from the cartilage cells
• joint capsule – two-layered sac surrounding the joint made from fibrous tissue	• The joint capsule seals the joint space and provides stability to the joint by limiting movements
• radius – smaller forearm bonethat extends from the lateral side of the elbow to the thumb part of the wrist	• Lever attached to the biceps. When the biceps contract, the radius provides a solid structure for lifting
• ulna – longer forearm bone on the medial side	• Lever connected to the triceps. When the triceps contract, the ulna provides support as a lever as the arm straightens out
• biceps – muscle connected to the radius	• contracts and causes flexion (arm bending)
• triceps – muscle attached ulna	• contracts and causes extension (arm straightening)

*****Data Based questions on page 477*****

∑ **- Movement of the body requires muscles to work in *antagonistic pairs***.

- Skeletal muscles occur in antagonistic pairs; therefore, when one muscle contracts, the other relaxes
- These antagonistic pairs produce opposite movements at the joint
- Examples are 1) biceps and triceps 2) quadriceps and hamstring

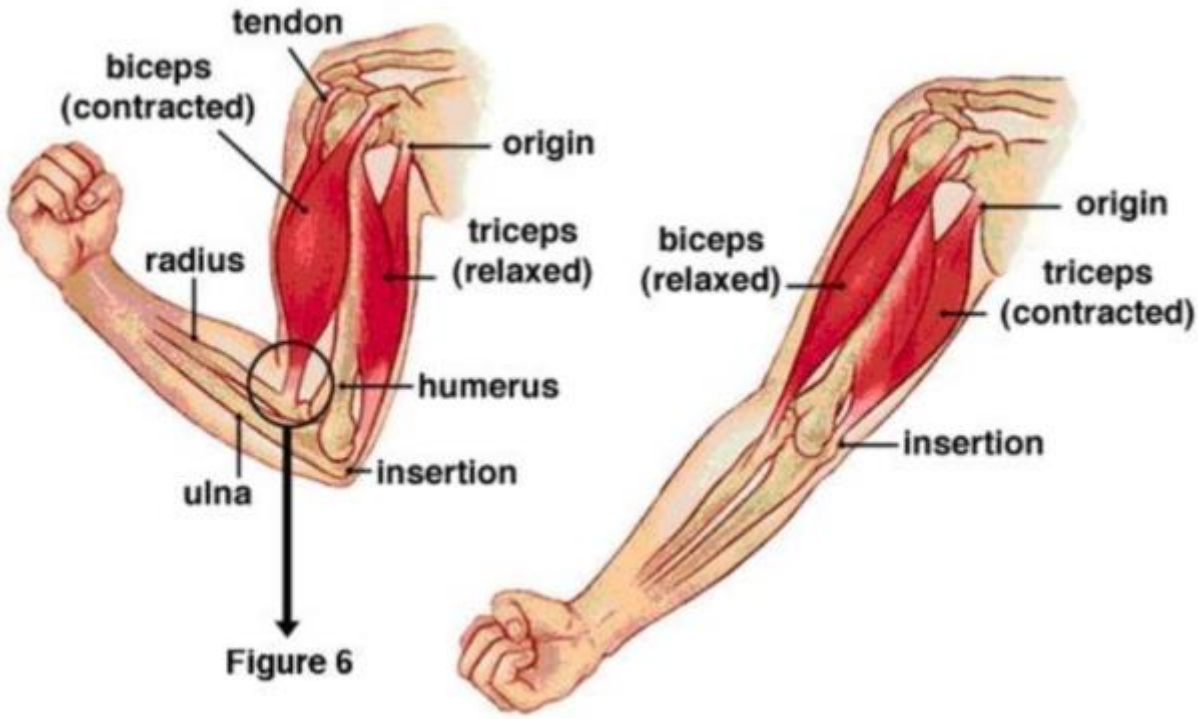
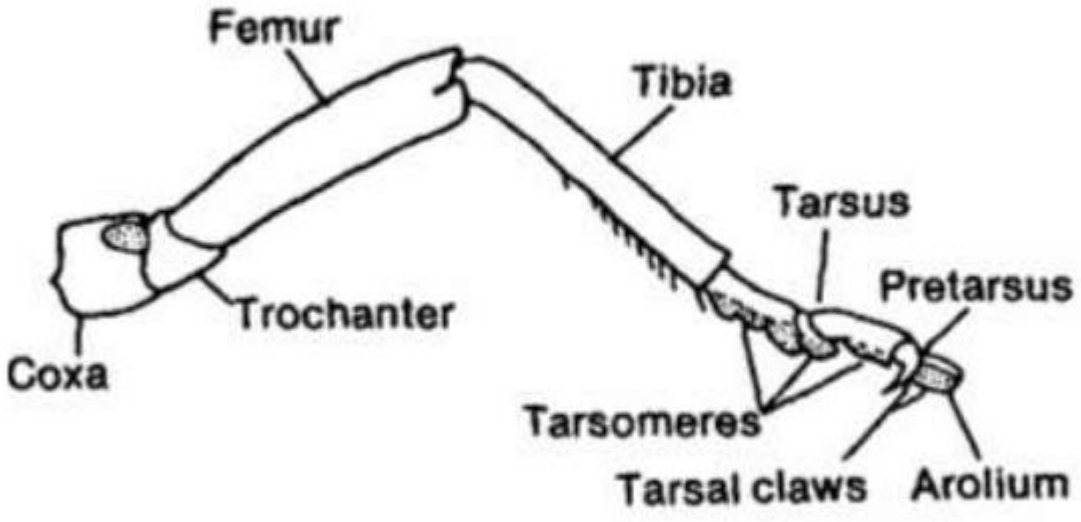


Figure 6

β - Application: Antagonistic pairs of muscles in an insect leg.

Grasshoppers

Ambulatory or walking leg



- The hind limbs of grasshoppers are specialized for jumping
- It has a jointed appendage with three parts
- Below the **joint is the tibia**, and at the base of the tibia is a**nother joint called the tarsus**
- Above the **joint is the femur**
- When the grasshopper jumps, **the flexor muscles contract**, and t**he femur and tibia are brought closer together (flexing)(extensor muscles are relaxed)**
- As the grasshopper jumps the **extensor muscles contract, extending the tibia, creating a powerful jump force**

Grasshopper jumping https://www.youtube.com/watch?v=cevL1RWcmqQ&list=PL0LFUbJiCoV67pVzNYsDnRE3roiMeCX3c&index=5

Interesting video http://www.smithsonianmag.com/science-nature/this-insect-has-the-only-mechanical-gears-ever-found-in-nature-6480908/?no-ist

∑ - Skeletal muscle fibres are *multinucleate* and contain *specializedendoplasmic reticulum*.

- Skeletal muscles are composed of bundles of muscle fibers and have a striped appearance because of areas of thick and thin filaments (myosin and actin)
- Muscle cells have many nuclei and are long because the embryonic muscle cells fuse together.
- Muscle fibers are composed of many parallel elongated fibers called myofibrils.
- A modified endoplasmic reticulum, called the sarcoplasmic reticulum (fluid-filled membranous sacs), extends throughout the muscle fibre, wrapping around each myofibril, sending a signal to the all parts of the muscle fibre to contract at the same time

∑ - Muscle fibres contain many *myofibrils*.

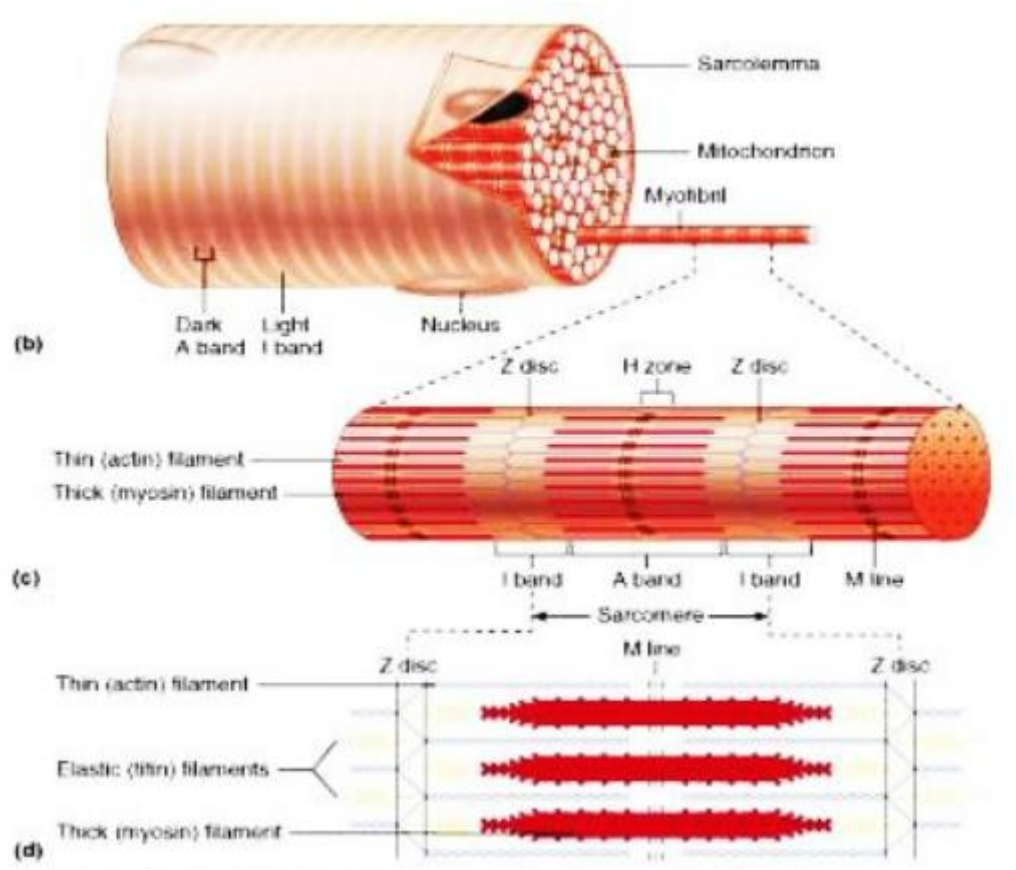
∑ **- Each myofibril is made up of contractile sarcomeres**.

Myofibrils – rod-shaped parallel bodies consisting of actin and myosin filaments

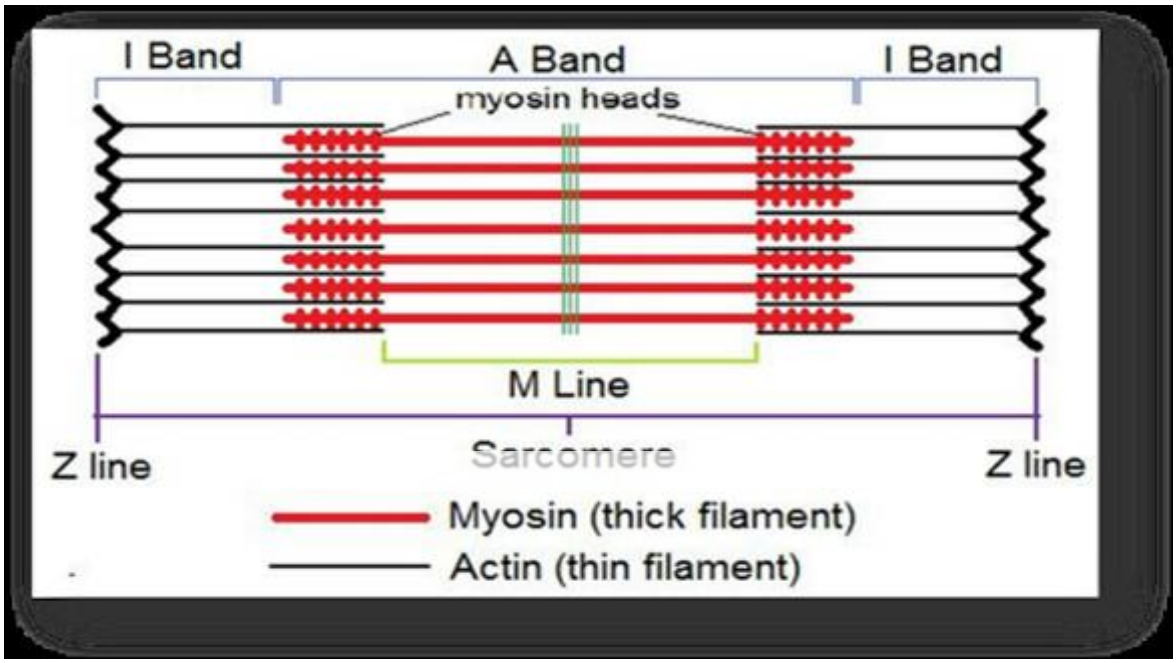
- *Sarcolemma* – plasma membrane of the muscle cell.
- *Mitochondria* – large numbers; found dispersed around individual myofibrils.

Sarcomere

- Lies between two Z lines which are dense protein discs.
- Contains the **thick filament (myosin) and thin filament (actin).**
- Myosin contains a head which binds to the **binding site on the actin**; interaction between **myosin and actin (cross-bridge) is responsible for muscle contraction.**
- Myosin is seen as **dark bands while actin is seen as light bands.**
- **A bands** contain a full length **of myosin and some of the actin filaments**.
- **I bands** contain only **actin filaments**.



<u>β - Skill</u>: **Drawing** labelled **diagrams** of the structure of a **sarcomere**: include *Z lines*, *actin filaments*, *myosin filaments with heads*, and the *resultant light and dark bands*.



*****Do data-based questions on page 481*****

∑ - The contraction of the skeletal muscle is achieved by the sliding of *actin*and *myosin* filaments. Use animations to visualize contraction.

- During a **muscle contraction**, **myosin filaments pull actin filaments**towards the centre of the sarcomere
- This shortens the sarcomere and the overall length of the muscle fibre
- When this occurs, the myosin heads bind to sites on the actin filaments, creating cross-bridges, pulling (sliding) the actin filaments along the myosin filaments with energy from ATP
- This is called sliding filament theory and is explained further below

Good videos on cross-bridge formation and muscle contraction:

https://www.youtube.com/watch?v=7wM5_aUn2qs

https://www.youtube.com/watch?v=Ct8AbZn_A8A

∑ - Calcium ions and the proteins tropomyosin and troponin control muscle contractions.

The first part in green is a lead up to the calcium binding to the troponin in the control of muscle contractions enhancing your understanding of what is occurring; however, it is probably not necessary to answer the understanding above*

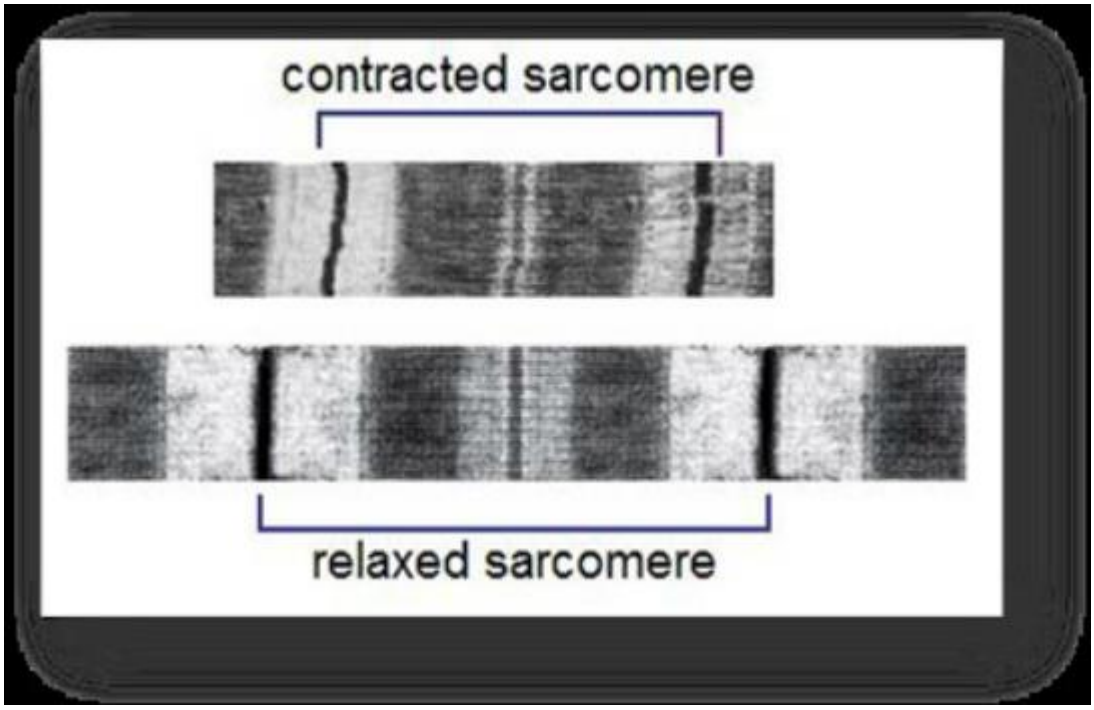
- An action potential propagated along a motor neuron arrives at the neuromuscular junction.
- This causes the release of the neurotransmitter acetylcholine into the synapsebetween the terminal axon of the motor neuron and the sarcolemma of the skeletal muscle.
- The acetylcholine binds to receptors on the sarcolemma, causing voltage-gated channels to open and Na^+ ions to flow into the muscle cells.
- This creates an action potential in the striated muscle.
- The action potential is further propagated along the sarcolemma of the skeletal muscle.
- The action potential moves into the interior of the muscle cell through folds called *t tubules*.
- The depolarization of the *t tubules* causes voltage-gated Ca^+ channels on the sarcoplasmic reticulum to open, causing an influx of Ca^+ ions into the sarcoplasm.
- Ca^+ ions bind to troponin which causes tropomyosin to move exposing the myosin binding sites (troponin and tropomyosin are regulatory proteinsblocking the myosin binding sites).

∑ - ATP hydrolysis and cross bridge formation are necessary for the filaments to slide

- ATP attaches to the myosin heads breaking the cross-bridges between the myosin heads and actin binding sites
- The ATP undergoes a hydrolysis reaction forming ADP + P_i.
- This causes a positional change in the myosin head (cocked back).
- The myosin heads bind to actin filaments forming cross-bridges at a site one position further from the centre of the sarcomere
- When the ADP + P_i are released the myosin heads change conformational position, sliding the actin filaments towards the center of the Sarcomere.
- This is called the "power stroke".
- After the power stroke ATP again binds to the myosin head, causing it to detach from the actin filament ready for another cycle.

β - Skill: Analysis of electron micrographs to find the state of contraction of muscle fibres. Measurement of the length of sarcomeres will require calibration of the eyepiece scale of the microscope.

Muscle Fiber (contracted and relaxed)



- Notice in the fully contracted sarcomere the actin filaments slide along the myosin causing the light bands to shorten, even though the dark bands stay the same length.
- The Z lines get closer together as the sarcomere contracts.
- The muscle also can be in various states of partial contraction.

β - Skill: Use of **grip strength data loggers** to assess muscle fatigue

Nature of science: Developments in scientific research follow improvements in apparatus—fluorescent calcium ions have been used to study the cyclic interactions in muscle contraction.

Read through article and make notes

Crash Course on Muscles: https://www.youtube.com/watch?v=jqy0i1KXUO4

11.4 Sexual reproduction: Sexual reproduction involves the development and fusion of haploid gametes.

Nature of science: Assessing risks and benefits associated with scientific research—the risks to human male fertility were not adequately assessed before steroids related to progesterone and estrogen were released into the environment as a result of the use of the female contraceptive pill.

Understandings:

∑ - *Spermatogenesis* and *oogenesis* both involve *mitosis*, *cell growth*, *two divisions of meiosis* and *differentiation*.

- Spermatogenesis is basically the production of sperm (male gametes) through meiosis.
- Spermatogenesis starts when **2n cells in the germinal epithelium (spermatogonia) divide by mitosis to form more 2n cells** that begin to move towards the middle of the **seminiferous tubules.**
- These cells grow and replicate their DNA to prepare for meiosis. These are now called **primary spermatocytes**.
- Oogenesis is basically the production of female eggs (female gametes) through meiosis.
- **Germ cells (2n)** in the fetal ovary divide by **mitosis to produce many 2n germ cells** called **oogonia.**
- Oogonia will grow in the cortex until they are large enough and ready to go through meiosis; they are called **primary oocytes**.
- The primary oocytes begin to go through the first division of meiosis, which is arrested (stopped) in prophase I when follicle cells surround the dividing oocyte.

- This is called the **primary follicle** (about 400,000 in a female when she is born).

- These follicles remain in the first stage of meiosis until the girl reaches puberty and begins her menstrual cycle.

- These **primary spermatocytes** undergo their first meiotic division resulting in two haploid (n) cells called **secondary spermatocytes**.

- Cells in between the developing spermatocytes called **interstitial cells (Leydig cells) produce testosterone in the presence of LH** (luteinizing hormone) to aid in the development of the sperm

- Secondary spermatocytes undergo a second meiotic division resulting infour spermatids (n).

- **Sertoli cells nourish** the spermatids as they **mature and differentiate into spermatozoa**.

- Sertoli cells are activated by **FSH**

- **Spermatozoa are released** into the **lumen of the seminiferous tubules**where they are transported to the **epididymis**. The sperm attain full motility in the epididymis.

- Every month a **primary follicle finishes meiosis I to form two haploid (n) cells** (one haploid cell is much larger than the other cell). This development is stimulate by FSH.

- The large cell is a **secondary oocyte** and the small cell is called the polar body.

- The secondary oocyte develops inside what is known as the **mature follicle**

- As the large secondary oocyte begins to go through the second meiotic division, it is **released from the ovary**. It will not complete the second meiotic division unless the oocyte is fertilized.

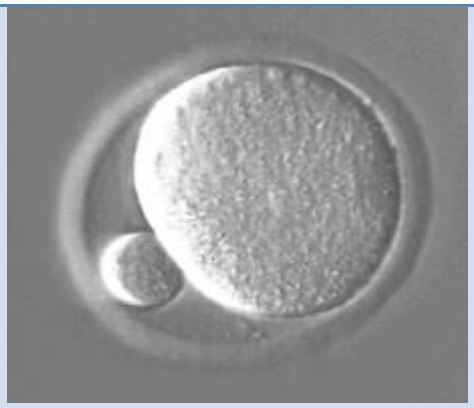
- When meiosis II is complete you have an ovum and another polar body.

Similarities between Spermatogenesis and Oogenesis (use the above information to fill in the table below)

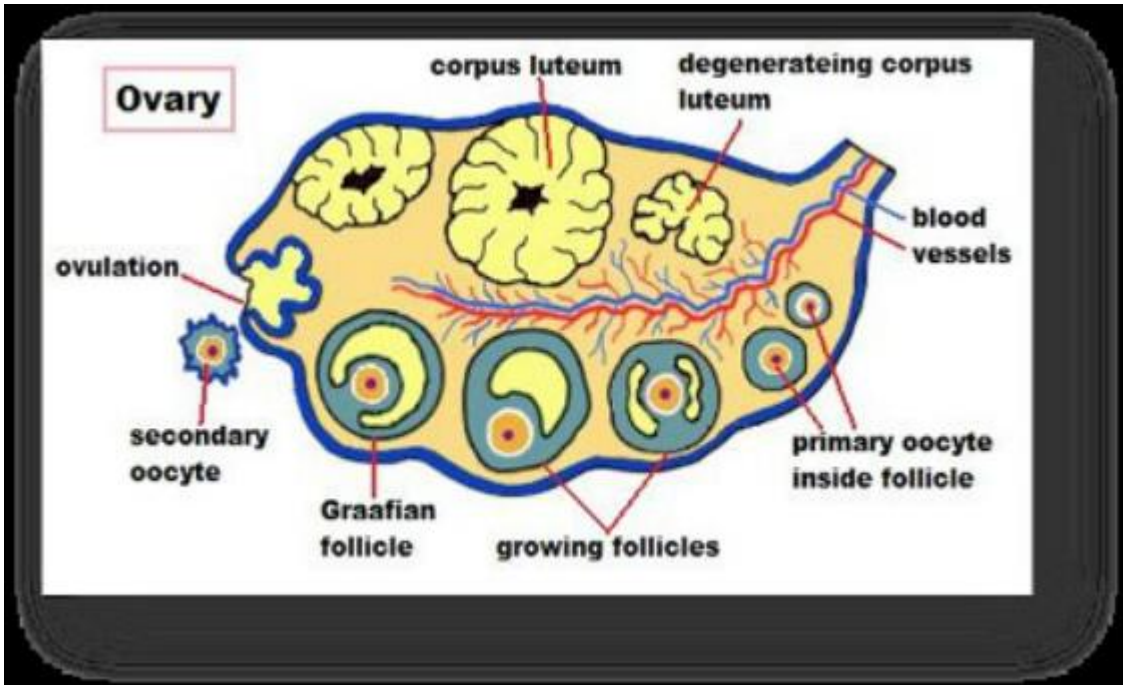
Spermatogenesis	Oogenesis

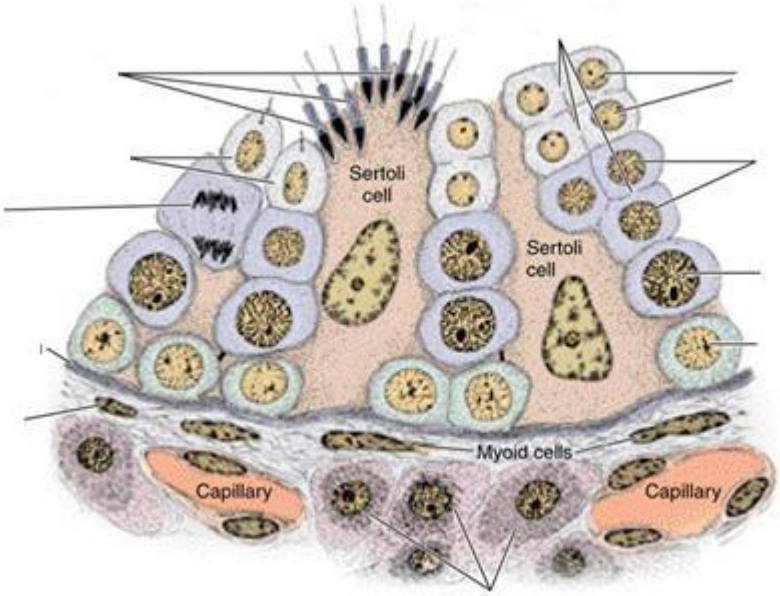
∑ - Processes in spermatogenesis and oogenesis result in different numbers of gametes with different amounts of cytoplasm. (Differences in the outcome of spermatogenesis and oogenesis

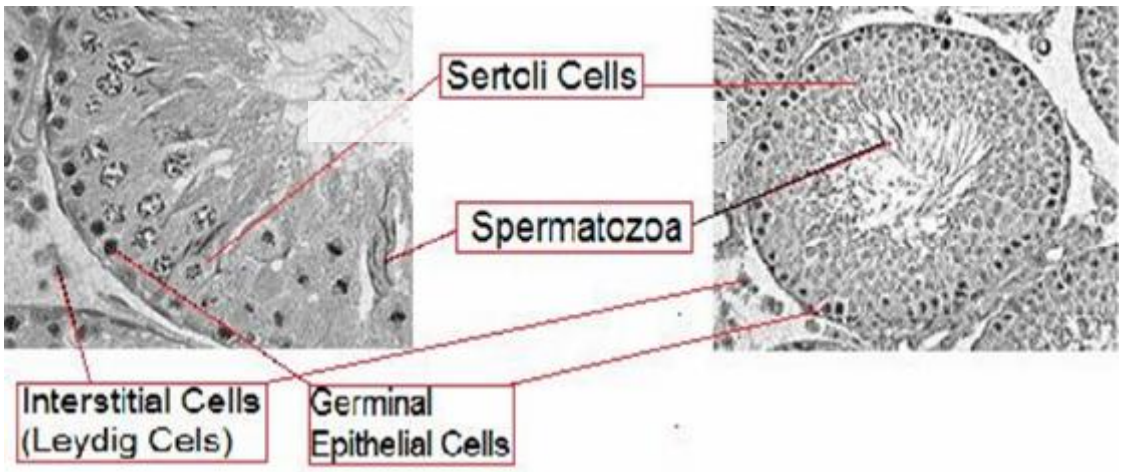
Spermatogenesis	Oogenesis

• Occurs in males (testis)	• Occurs in females (ovaries)
• Four male gametes (spermatids) are produced through meiosis for every germ cell.	• One female gamete (ovum) and 3 polar body cells for every germ cell are produced through meiosis.
• Each sperm cell is small and contains little cytoplasm	• The large egg cell contains large amounts of cytoplasm and the 3 polar bodies produced degenerate
• Millions of sperm produced every day from puberty until a man dies.	• One secondary oocyte is ovulated every month during the menstrual cycle until a woman reaches menopause.
	
• Spermatozoa are released during ejaculation.	• Secondary oocytes are released during ovulation.
•	•

Skill: **Annotation** of **diagrams** of **seminiferous tubule** and **ovary** to show the**stages** of **gametogenesis**.

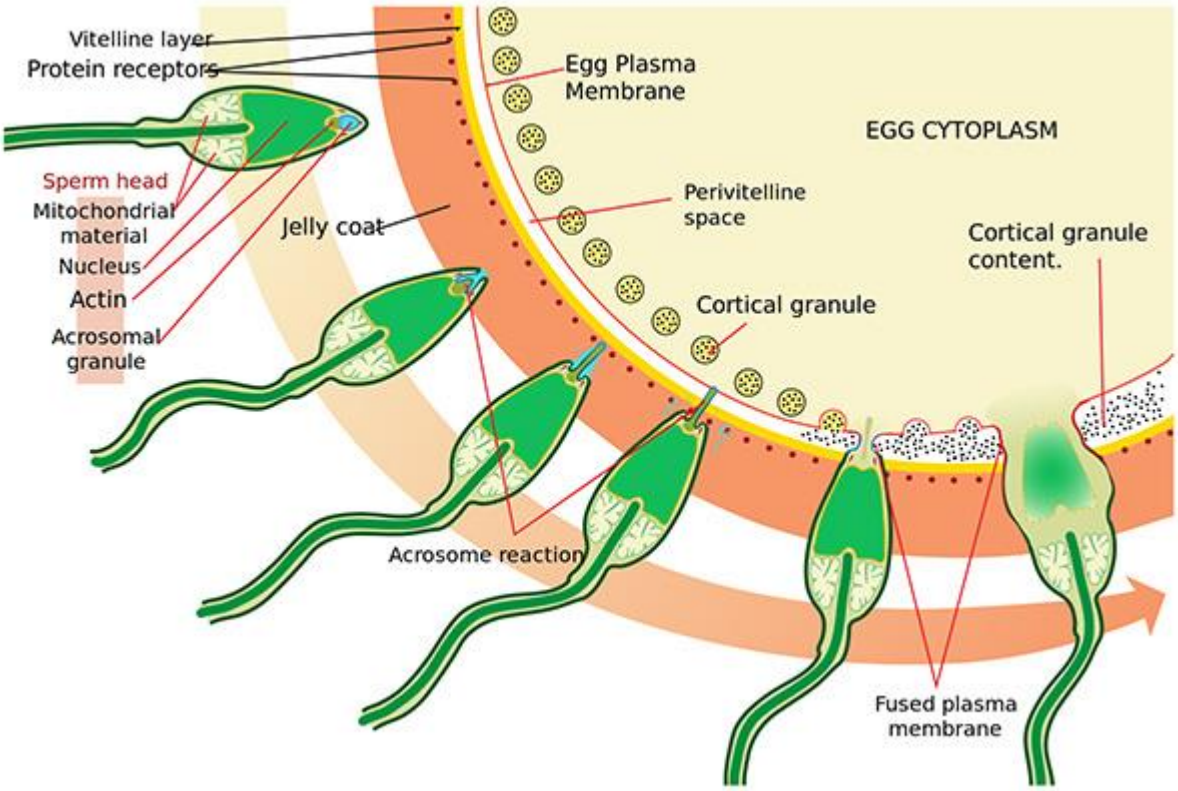

Ovary
corpus luteum
degenerateing corpus luteum
blood vessels
ovulation
secondary oocyte
primary oocyte inside follicle
Graafian follicle
growing follicles


Sertoli cell
Sertoli cell
Myoid cells
Capillary
Capillary


Sertoli Cells
Spermatozoa
Interstitial Cells (Leydig Cels)
Germinal Epithelial Cells

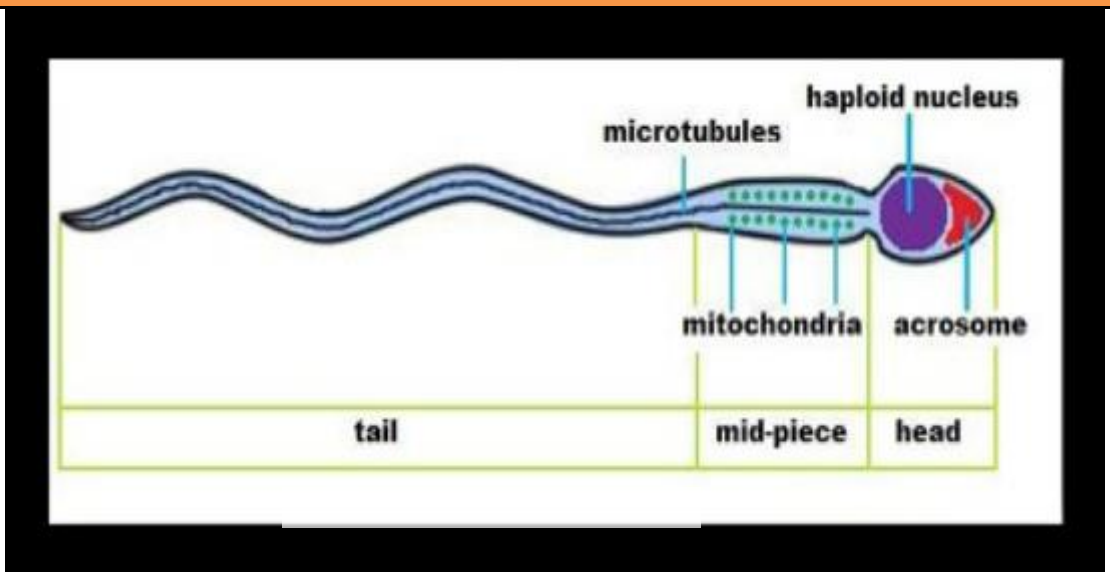
∑ - Fertilization involves the *acrosome reaction*, fu*sion of the plasma membrane of the egg* and *sperm* and the *cortical reaction*.

- Fertilization is the combining of the male and female gametes to produce a zygote.
- Sperm are ejaculated into the vagina of a female and are stimulated to swim by calcium ions in the vaginal fluids.
- The sperm follow chemical signals produced by the egg, until they reach the fallopian tubes, which is where the majority of fertilizations take place.
- When the sperm reaches the egg, a reaction called the ***acrosome reaction***takes place that allows the sperm to break through the layer of glycoproteins.
- The acrosome in head of the sperm **releases hydrolytic enzymes** onto the **glycoprotein layer** surrounding the egg **called the zona pellucida.**
- This digests the layer allowing the sperm to force their way through the zona pellucida through vigorous tail beating.
- The first sperm that makes it through comes into contact and fuses with the egg's membrane (The membrane at the tip of the sperm has special proteins that can bind to the now exposed membrane of the egg),releasing the sperm's nucleus into the egg cell.
- When the membranes fuse together, **cortical granules** near the surface of the egg membrane are **released by exocytosis**.
- The **chemicals in the granules combine with the glycoproteins** in the zona pellucida.This causes the glycoproteins in the zona pellucida to cross-link with each other, **creating a hard layer impermeable to the other sperm**.
- This prevents fertilization of an egg by more than one sperm.

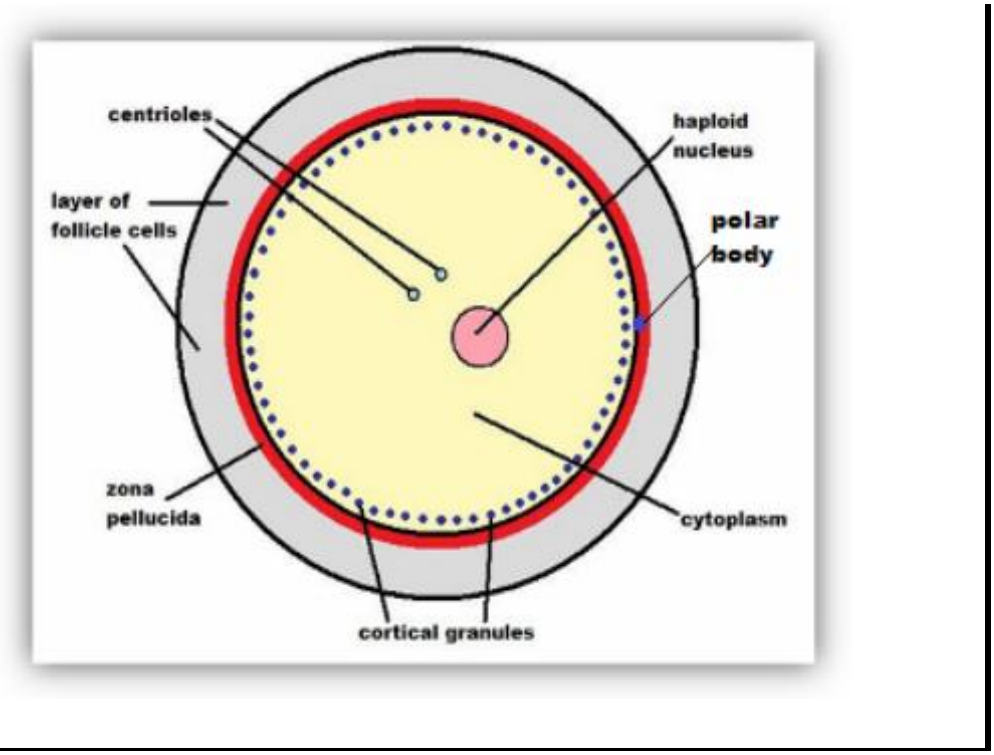


Skill: **Annotation** of **diagrams** of **mature sperm** and **egg** to indicate**functions**.

Sperm Diagram



Egg Diagram



∑ **- Fertilization in animals can be internal or external.**

- Without water to prevent drying out of the egg and sperm, terrestrial animals rely on internal fertilization
- This insures the close proximity of the sperm and egg in order to insure fertilization takes place
- Most aquatic organisms generally rely on external fertilization, which involves releasing the sperm and egg at a close proximity, into the water outside the female's body
- External fertilization increases the increases the risk of successfully creating offspring
- Several risks include predation and changes to the external environment (pH, pollution and temperature etc.)

External Fertilization Internal Fertilization

∑ **- Fertilization involves mechanisms that prevent polyspermy.**

- The membranes of the sperm have receptors that detect chemicals that the egg releases in order to move in that direction

- Once the sperm reaches the egg, the events explained above involving fertilization, the acrosome reaction and then the cortical reaction prevent multiple sperm from entering the egg (polyspermy)

∑ **- Implantation of the blastocyst in the endometrium is essential for the continuation of pregnancy.**

- After the male and the female gametes combine to form a **zygote**, thezygote divides by mitosis to form a **two-cell embryo**.

- They two cells grow and replicate their DNA, and undergo another cell division through mitosis to form a four-cell embryo.

- As the embryo is developing, it is moving along the fallopian tube towards the uterus.

- The four-cell embryo continues to divide by cell division until it reaches**16 to 32 cells**; called the morula.

- After continued cell divisions a blastocyst consisting of **100 to 128 cells**is formed and is ready for **implantation into the endometrium**.

- The blastocyst consists of an **inner cell mass** that will develop into the body of the embryo, a group of cells surrounding the embryo called thetrophoblast that will develop into the placenta, and a fluid-filled cavity called the blastocoel.

- The outer layer of cells will develop finger-like projections that will allow the embryo to penetrate the uterine wall during **implantation**.

  Video: - https://www.youtube.com/watch?v=3u251OXfsRU

∑ - HCG stimulates the ovary to secrete progesterone during early pregnancy

- When a human embryo is implanted into the endometrium or the uterine lining, it starts to produce the hormone, human chorionic gonadotrophin (HCG).

- HCG promotes the maintenance of the corpus luteum and prevents its disintegration.

- This allows for the continued production of progesterone which is critical for pregnancy.

- Progesterone enriches the uterus with a thick lining of blood vessels and capillaries so that it can sustain the growing fetus.

- HCG might repel the immune cells of the mother thus protecting the fetus during early development.

∑ - The placenta facilitates the exchange of materials between the mother and fetus.

- The placenta develops from the trophoblast layer of the blastocyst.

- When developed three blood vessels contained within umbilical cord connect the placenta to the growing fetus.

- Two umbilical arteries carry deoxygenated blood and waste away from the fetus to the placenta.

- As maternal blood enters the placenta it leaves the arteries and enters theinter-villous space, where it pools and surrounds the placental villi.

- The placental villi are finger-like fetal tissues that have **a large surface area for the exchange of materials** such as gases, nutrients and wastes.

- Fetal blood that circulates in capillaries within the villi and microvilli isvery close to the surface, allowing for **efficient exchange of materials**between the fetal and maternal blood.

- Materials such as oxygen, nutrients and vitamins diffuse into the fetal capillaries from the maternal blood in the inter-villous space, whilecarbon dioxide and wastes diffuse out of the fetal capillaries into the inter-villous space.

- One umbilical vein **carries oxygenated and nutrient rich blood back to the fetus** from the placenta.

- The cells that separate the fetal and maternal blood form a semi-permeable **placental barrier**

Materials are exchanged between the maternal and the fetal blood in the placenta.

Note: maternal and fetal blood is never mixed together.

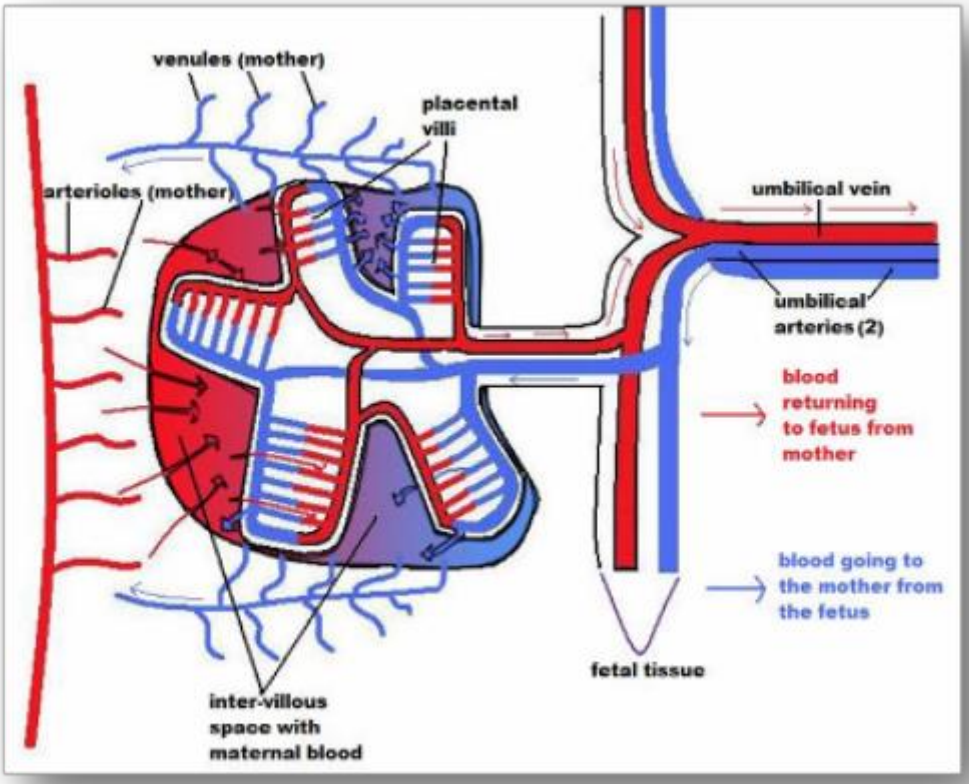
Materials passed from fetus to mother	**Materials passed from mother to fetus**
• **Carbon dioxide**	• **Oxygen**
• **Water**	• **Nutrients (i.e. glucose and amino acids)**
• **Urea**	• **Water**
• **Hormones (i.e. HCG)**	• **Vitamins and minerals**
	• **Hormones**

Good animations –

Fetal Circulation - https://www.youtube.com/watch?v=r0947ywQwos

Placenta - https://www.youtube.com/watch?v=bped-RVWsLk

Diagram of Placenta



∑ - Estrogen and progesterone are secreted by the placenta once it has formed.

- The placenta also starts to produce progesterone and estrogen after about 9 weeks taking over from the corpus luteum. The placenta produces enough of these steroids to maintain the pregnancy and the corpus luteum is no longer needed.

- These hormones are necessary to maintain the rich blood supply needed by the placenta.

*****Do data based questions on page 507 and 508*****

∑ **- Birth is mediated by positive feedback involving estrogen and oxytocin.**

- When the pregnancy is at term, the **fetus secretes hormones** that **signal the placenta** to **stop producing progesterone** (progesterone inhibits the secretion of oxytocin by the pituitary gland).

- **Oxytocin secreted** by the **anterior pituitary gland** stimulates the muscle fibers in the uterus to begin to contract.

- As the muscles in uterus contract, **mechanoreceptors in the uterinewall** signal the pituitary to **produce more oxytocin.**

- **More oxytocin increases the frequency** and intensity of the contractions, thus stimulating the production of even more oxytocin.

- This is an example of **positive feedback**.

- Contractions of the muscles of the uterus will cause the amniotic sac to break, releasing the amniotic fluid (This is when the "water breaks" in childbirth).

- Relaxation of the muscles in the cervix causes it to dilate, eventually allowing the increasing contractions to push the baby out through the vagina and the cervix.

- The placenta is expelled "afterbirth" about 15 min after the baby is born.

*****Do the data analysis questions on page 508 and 509*****

β -Application: The average **38-week pregnancy** in humans can be positioned on a graph showing the **correlation** between **animal size** and the **development of the young** at birth for other mammals.

- There is a correlation with animal size (mass) and the development of their young (viewed as length of gestation period)

- In many cases, the longer the gestation period, the greater the mass size and development at birth

- Species of mammals that give birth to smaller, immature and somewhat helpless offspring are called altricial species

- Species of mammals that give birth to more mature offspring that are generally larger, have their eyes open at birth and are immediately mobile. These offspring are precocial.

  Do the data analysis on page 510

β -Application: Disputes over the **responsibility** for **frozen human embryos**.

- http://www.creatingfamilies.com/intended-parents/?Id=169

- http://www.cnn.com/2014/03/24/living/frozen-embryos-elle-relate/