Chapter 11 —> Animal physiology

11.1 Self versus Non-self

- The immune system can distinguish between body cells (self) and foreign materials (non-self)
- It will react to the presence of non-self —> immune response eliminates material from the body
- All nucleated cells of the body have unique + distinctive surface molecules that identify it as self
    —> self makers are called Major histocompatibility complex molecules (MHS class 1)
    —> they act as identification tags —> the immune system will not react to those cells
    —> they are genetically determined markers
- Antigen —> any substance that is recognised as foreign + triggers a immune response (non-self)
    —> are recognised by lymphocytes which bind to and detect the epitope
    —> lymphocytes trigger antibody production (adaptive immunity) —> antibodies specifically bind to epitopes via complementary paratopes
- Epitope —> characteristic shape of an expose portion

Antigenic determinants:

- Surface markers present on foreign bodies in the blood and tissue – including bacterial, fungal, viral and parasitic markers
- Self markers of cells from a different organism (transplantation often results in graft rejection)
- Proteins in food may be rejected if not first broken down into component parts by the dig. Syst.
- Transplantation of tissues is easier when there is a very close genetic match

Red blood cells:
- Not nucleated —> do not possess the same distinctive and unique self markers as all other cells
- They possess basic antigenic markers which limit the capacity for transfusion (ABO blood syst.)

Pathogenesis:

- Disease —> any condition that disturbs the normal functioning of the body (homeostasis)
- Illness —> deterioration in the normal state of health of an organism (can be due to a disease)
- Pathogen —> an agent that causes disease —> either a microorganism, virus or prion
    —> are generally species-specific —> cause disease to particular species
    —> polio, syphilis, measles and gonorrhoea —> specifically affect human hosts
- Zoonoses —> diseases from animals that can be transmitted to humans (zoonotic diseases)
    —> rabies (dogs), certain strains of influenza (bird flu), and the bubonic plague (rats)

Disease transmission:

- Direct contact —> via physical association or the exchange of body fluids
- Contamination —> ingestion of pathogens
- Airborne —> via coughing and sneezing
- Vectors —> intermediary organisms that transfer pathogens without dev. disease symptoms

Clonal selection:

- When the body is challenged by a foreign pathogen it will respond with both a non-specific (macrophages) and a specific immune reaction
- Macrophages engulf pathogens non-selectively and break them down internally —> some of them (dendritic cells) will show the antigenic fragments of the pathogen to specific lymphocytes
- The body contains millions of different T lymphocytes and B lymphocytes —> each recognise a single specific antigen
- Polyclonal activation —> pathogens typically contain multiple distinct antigenic fragments on their surface —> likely stimulates several different T and B lymphocytes

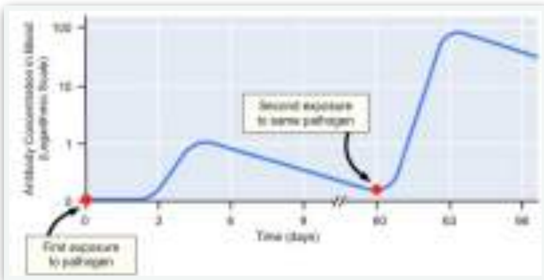
1) the antigenic fragments are presented to specific helper T lymphocytes which when activated release cytokines
2) cytokines stimulate a specific B cell that produces antibodies to the antigen to divide + clone
3) most clones are short-lived plasma cells that produce large quantities of specific antibody
4) a small proportion will differentiate into long-lived memory cells —> long-term immunity

Antibodies:

- When a specific B lymphocytes is activated, it decides into plasma cells and memory cells
- Plasma cells —> short-lived and secrete many antibodies specific to a particular antigen
  —> will secrete 2000 antibody molecules per second into blood for 4/5 days
- Antibodies aid in the destruction of pathogen by:
  —> precipitation —> soluble pathogens become insoluble and precipitate
  —> agglutination —> cellular pathogens become clumped for easier removal
  —> neutralisation —> antibodies may occlude pathogenic regions
  —> inflammation —> may trigger an inflammatory response within the body
  —> complement activation —> complement proteins perforate membranes (cell lysis)
- Antibodies enhance the immune system by aiding the detection and removal of pathogens by the phagocytic leukocytes of the innate immune system —> the constant region of antibodies can be recognised by macrophages, improving opsonisation (pathogen identification)

Immunity:

- The adaptive immune system relies on clonal expansion of plasma cell to produce antibodies
- There is a delay between the initial exposure to a pathogen and the production of antibodies —> if pathogens can reproduce rapidly during this delay period, they can impede normal body functioning —> can cause a disease
- Memory cells are produced to prevent this delay in subsequent exposures and hence prevent disease symptoms



Allergens:

- An environmental substance that triggers an immune response despite not being intrinsically harmful —> response tends to be localised to the region of exposure
- Anaphylaxis —> severe allergic reaction which can be fatal if left untreated

- An allergic reaction requires a pre-sensitised immune state
- When a specific B cell first encounters the allergen, it differentiates into plasma cells and makes large quantities of antibody (IgE) —> the IgE attach to mast cells —> upon re-exposure, the IgE-primed mast cells release large amounts of histamine which causes inflammation
- The inflammatory response results in allergic symptoms —> redness, heat, swelling and localised pain

Vaccination:

- Vaccinations induce long-term immunity to specific pathogenic infections by stimulating the production of memory cells
- Vaccine —> a weakened form of the pathogen containing antigens (does not result in a disease)
- The antigenic determinants in a vaccine may be conjugated to an adjuvant —> functions to boost the immune response
- The body responds to an injected vaccine by initiating a primary immune response —> results in memory cells being made —> when exposed to the actual pathogen they will trigger a stronger secondary immune response —> disease symptoms do not develop
- Memory cells may not survive a lifetime and individuals may require a booster shot

- Herd immunity —> vaccination confers immunity to vaccinated individuals but also indirectly protects non-vaccinated individuals
- Vaccinations programmes are implemented to reduce the outbreak of particular infectious diseases within population
- Epidemic —> substantially increased occurrence of a particular infection within a given region
- Pandemic —> an epidemic that has spread across a large geographical area

- Smallpox —> first infectious disease of humans to have been eradicated via vaccination (1967)
- Eradication was successful because —> smallpox was easily identifiable due to overt symptoms
  —> transmission only occurred via direct contact and there were no animal vectors
  —> the infection period was short lived (3/4 weeks) and the virus didn't mutate
  —> there was global cooperation and immunity was long-term
- Epidemiology —> the study of the patterns, causes and effects of health and disease condition
  —> it can be used to compare the incidence of a disease over time
  —> it can be used to compare the incidence of a disease in different regions

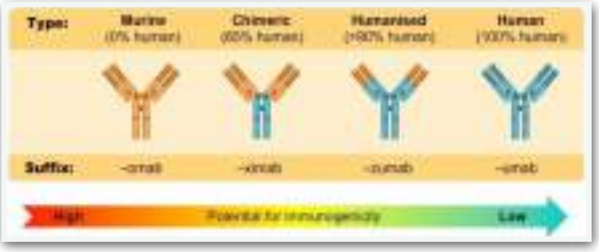
Monoclonal antibodies:

- Antibodies artificially derived from a single B cell clone
- Can be used for both therapeutic treatment (treatment of rabies) and clinical detection of disease (detection of pregnancy)

1) An animal is injected with an antigen and produces antigen-specific plasma cells
2) Plasma cells are removed and fuse (hybridised) with tumour cells capable of endless divisions
3) The resulting hybridoma cell is capable of synthesising large quantities of monoclonal antibody

Treatment use:

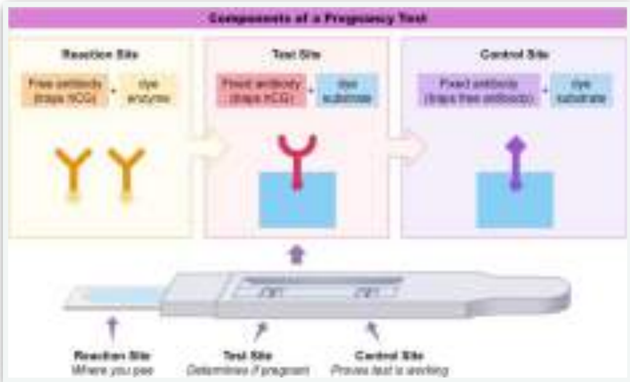
- Monoclonal antibodies are commonly used to provide immune protection for individuals who contract harmful diseases —> the rabies virus can potentially be fatal —> injecting purified antibodies functions as an effective emergency treatment



-Can be used to target cancer cells that the body's own immune cells fail to recognise as harmful
-Therapeutic monoclonal antibodies are named according to the source organism

Diagnostic use:

- Can be used to test for pregnancy via the presence of human chorionic gonadotrophin (hCG)
- hCG —> hormone produced during foetal develop.
- ELISA —> enzyme-linked immunosorbent assay —> used by test to identify a substance via a colour change —> free monoclonal antibodies specific to hCG are conjugated to an enzyme that changes the colour of a dye



11.2 Movement

Skeletal framework:

- The ability to move is controlled by a number of interacting body systems:
  —> skeletal system —> bones that act as levers + provide a structure for the muscle to pull
  —> muscular system —> muscles deliver the force required to move one bone
  —> nervous system —> delivers signals to the muscles which cause them to contract
- Skeletons are a rigid framework that function to provide support and protection for body organs
  —> internal (endoskeletons) or external (exoskeletons) —> depends on the organism
  —> endoskeletons are usually numerous bones while exoskeletons are connected segments
- Skeletons provide a surface for muscle attachment and facilitate the movement of an organism
- Ligaments —> how bones are connected to other bones
- Tendons —> how bones are connected to muscles

Joints:

- Joints —> function to maintain structural stability by allowing certain movements but not others
- Synovial joints —> capsules that surround the articulating surfaces of two bones —> 3 parts

—> joint capsule —> seals joint space and provides stability by restricting possible movement
—> cartilage —> lines the bone surface to facilitate smoother movement + absorbs shocks and distributes load
—> synovial fluid —> provides oxygen and nutrition to cartilage + acts as lubricant

Human elbow joint:

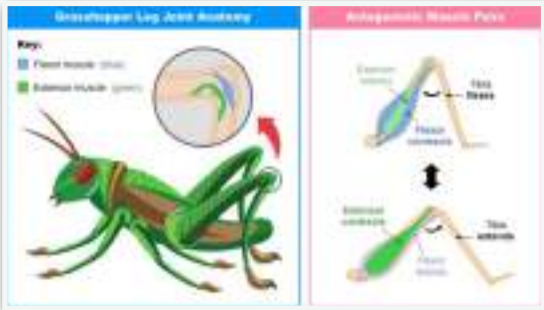
- Hinge joint located between the humerus and radius
- Capable of angular movement in one direction

Structure	Function
Bones	
Humerus	Anchors muscle (muscle origin)
Radius	Acts as forearm lever for biceps
Ulna	Acts as forearm lever for triceps
Muscles	
Biceps	Bends the forearm (flexion)
Triceps	Straightens the forearm (extension)
Joint	
Joint capsule	Seals joint space and limits range of movement to promote stability
Synovial fluid	Provides food, oxygen and lubrication to the cartilage
Cartilage	Allows smooth movement (reduces friction), absorbs shock and distributes load

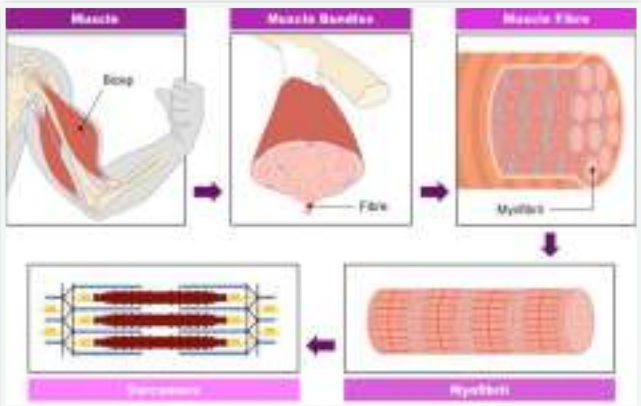
Muscles:

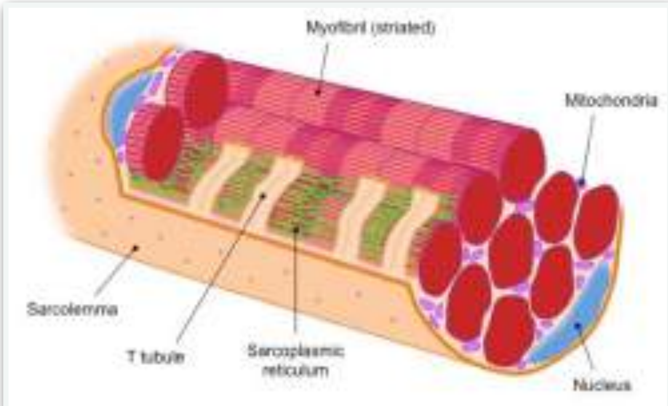
- Muscles connect bones and contract to provide the force required to produce movement
- Static bone —> where the muscle connects —> point of origin
- Moving bone —> point of insertion
- Skeletal muscles exist in antagonistic pairs (one contracts and the other relaxes)

- Many types of insects have hind legs that are specialised for jumping (grasshoppers, …)
- The jointed exoskeleton of the hind leg is divide into —> femur, tibia and tarsus



Muscle fibres:

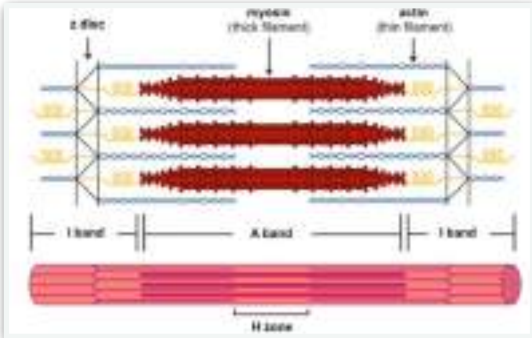




- Muscular bundles (fascicles) are surrounded by connective tissue (perimysium)
- Each individual muscle fibre has the following specialised features:
  - —> multicucleanted —> fibres form from the fusion of individual muscle cells
  - —> they have a large number of mitochondria —> for more energy
  - —> specialised endoplasmic reticulum (sarcoplasmic reticulum) —> stores calcium ions
  - —> contain tubular myofibrils made up by two myofilaments (thin actin and thick myosin)
  - —> sarcolemma —> continuous membrane surrounding the muscle fibre
  - —> T tubules —> invaginations in the sarcolemma

Sarcomeres:

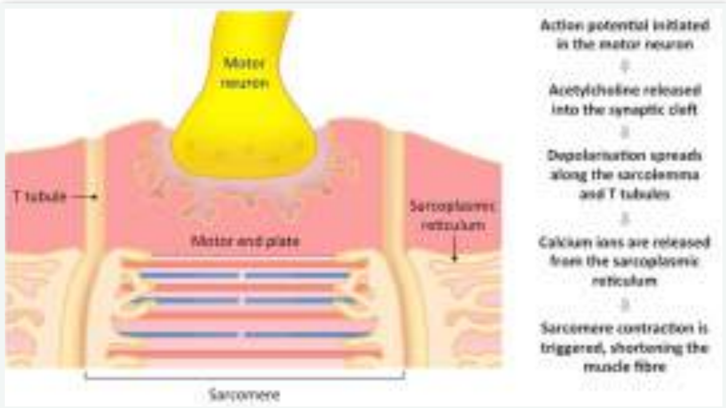
- Myofibrils consist of repeating contractile units called sarcomeres
- Are made of two protein myofilaments
- Myosin is thick and contains small protruding heads which bind to regions of the thin actin
- Movement of these two filaments relative to one another causes the lengthening and shortening of the sarcomere



- Z lines —> dense protein disc which holds the myofilaments in place
- The actin filaments radiate out from the Z discs and help to anchor the central myosin filaments in place
- The recurring sarcomeres produce a striated pattern along the length of the skeletal muscle fibres
- The I bands appear lighter than the A band

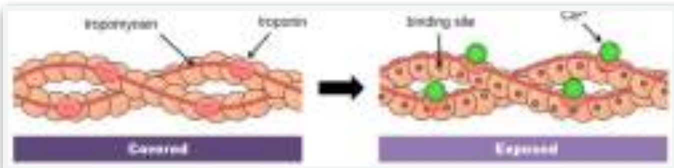
Muscle contraction:

1) Depolarisation and calcium ion release:

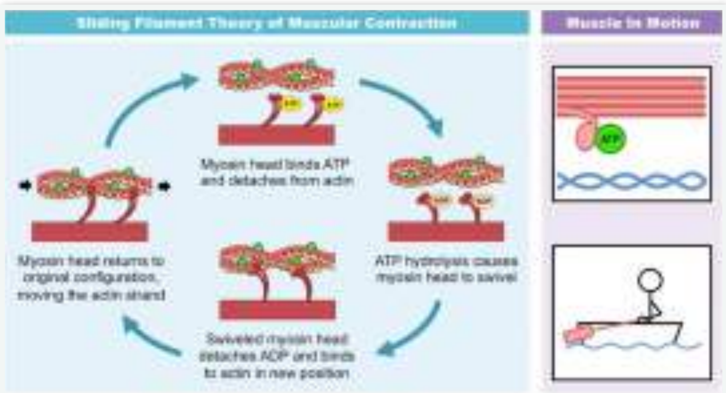


2) Actin and Myosin cross-bridge formation

- On actin, the binding sites for the myosin heads are covered by a blocking complex (troponin and tropomyosin) —> calcium ions bind to troponin and reconfigure the complex —> exposes binding sites for myosin heads
- The myosin heads then can form a cross-bridge with the actin filaments

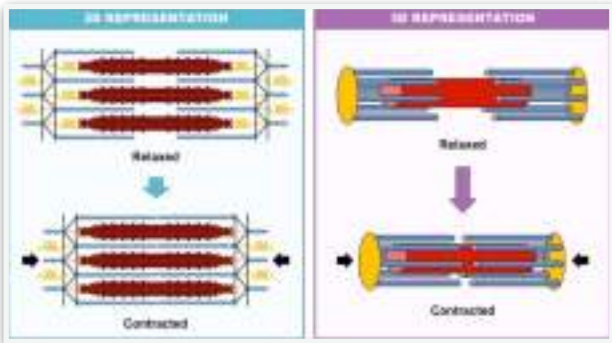


3) Sliding mechanism of actin and myosin



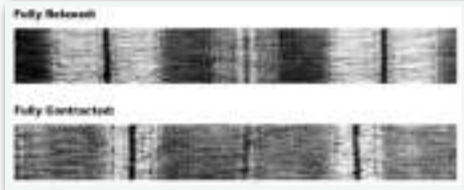
4) Sarcomere shortening

-The repeated reorientation of the myosin heads drags the actin filaments along the length of the myosin —> dragging pulls Z lines closer
- As the individual sarcomeres become shorter, the muscle fibres as a whole contract



State of contraction:

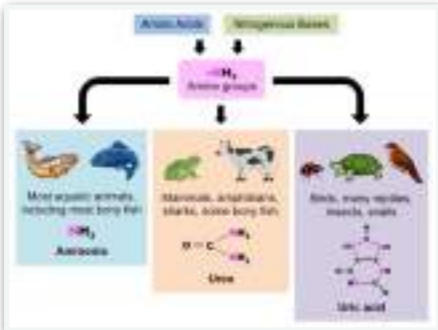
- The arrangement of myofilaments within a sarcomere give a skeletal muscle fibre a striated appearance



11.3 The kidney

Excretory systems:

- Excretion is the removal from the body of the waste products of metabolic activity
- Defecation is not considered part of excretion as faeces are undigested food remnants and not metabolic waste products
- Excretory system performs:
  —> removes nitrogenous wastes that may be toxic to the body if too many
  —> removes excess water to maintain a suitable osmolarity within the tissues and cells

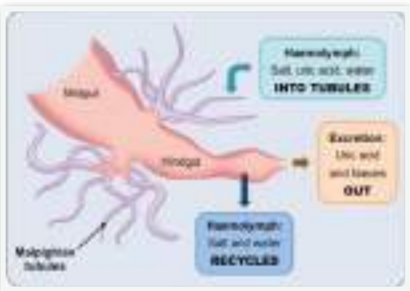


Removing nitrogenous waste:
- Are produced from the breakdown of nitrogen-containing compounds (amino acids and nucleotides, …)
- Ammonia —> aquatic animals use it —> is highly toxic but also very water soluble
- Urea (mammals) and uric acid (reptiles and birds) —> are less toxic

Removing excess water:
- Water levels within an organism are constantly changing as a result of metabolic activity
- Osmolarity (concentration of water within cells) will impact tissue viability
- Osmoconformers —> maintain internal conditions that are equal to the osmolarity of the environ.
  —> minimise water movement in and out of cells
  —> less energy is used to maintain internal osmotic conditions
- Osmoregulators —> keep their body's osmolarity constant regardless of conditions
  —> more energy-intensive process but optimal internal conditions

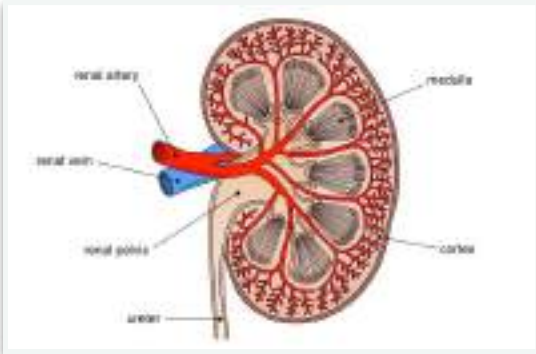
Malpighian tubules:

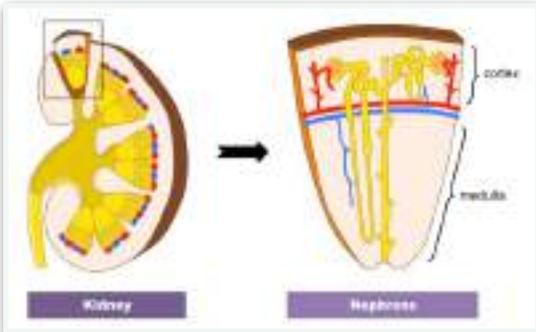
- All animals possess a specialised excretory system for osmoregulation and removal of nitrogen
- Malpighian tubules —> in insects —> connects to the digestive system of the animal



-Hemolymph —> circulating fluid in insects (as blood in mammals)
-Tubules branch off from the intestinal tract and actively uptake nitrogenous wastes and water from the hemolymph
-Tubules pass material into gut to combine with digested food products
-Solutes, water and salts —> reabsorbed into hemolymph at the hindgut, while nit. wastes and undigested food materials are excreted via the anus

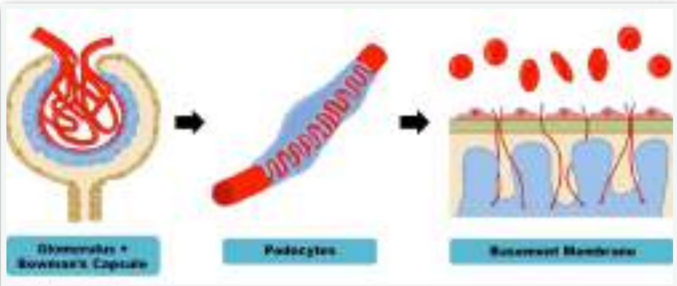
Kidneys:





- Kidneys —> in mammals —> are separate from the digestive system of the animal
- Function as blood filtration and water balancing system —> it removes metabolic wastes for excretion
- Blood enters kidneys via the renal artery and exits via the vein
- Blood is filtered by specialised structure called nephrons —> produce urine —> urine then transported away via the ureter to the bladder

- Nephrons —> specialised structures in the kidneys —> filter blood and eliminate wastes
- Blood in the renal vein will have —> less urea
  —> less water and solutes / ions
  —> less glucose and oxygen —> not eliminated but used by kidney for energy
  —> more CO_2 —> produced metabolic reactions



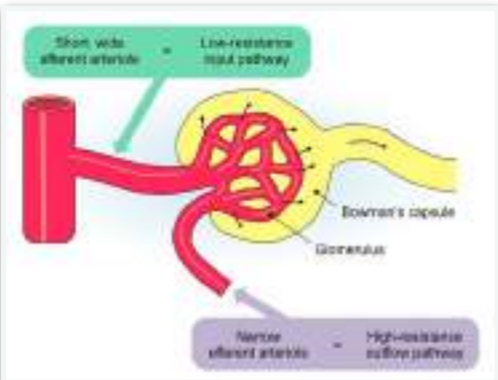
Ultrafiltration:

-The first of 3 processes by which metabolic wasted are separated from the blood to form urine
-Non-specific filtration of blood at high pressure —> occurs in Bowman's capsule of the nephron
-Glomerulus —> knot-like capillary tuft after the arterioles in the kidney
—> encapsulated by Bowman's capsule

- Podocytes —> inner surface of cells in the Bowman's capsule

Basement membranes:

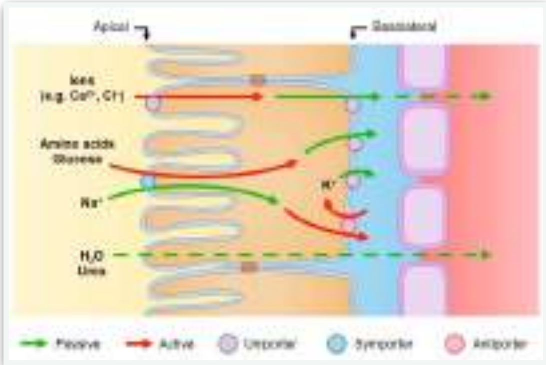
- Glycoprotein matrix between podocytes and glomerulus (filters blood)
- Glomerular blood vessels are fenestrated —> blood can exit
- The podocytes of the bowman's capsule have gaps between their pedicels —> allow fluid to move freely into the nephron
- Size-selective + restricts passage of blood cells + large proteins



Hydrostatic pressure:

-Ultrafiltration involves blood being forced at high pressure against the basement membrane
-Pressure is created in the glomerulus by having a wide afferent arteriole and a narrow efferent arteriole —> blood can easily enter the glomerulus, but difficultly exits —> increases pressure
-Extensive narrow branches in the glomerulus —> increases SA available for filtration

Selective reabsorption:

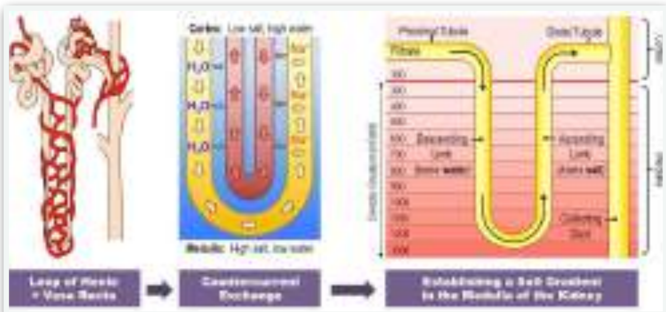


- The second of the 3 process by which blood is filtered and urine is formed
- The retake of useful substances from the filtrate and occurs in the convoluted tubules (proximal and distal) —> the majority will happen in the proximal tubule because it extends from the Bowman's capsule
- The proximal tubule has a microvilli cell lining —> to increase SA for material absorption from the filtrate
  —> tubule is a single cell thick and is connected by tight junctions —> no gaps
- Reabsorption involves active transport —> large number of mitochondria within tubules cells
- Substances are actively transported across the apical membrane, to then passively diffuse across the basolateral membrane (membrane of tubule cells facing the blood)
- The tubules reabsorb all glucose, amino acids, vitamins, hormones and water + 80% of minerals
  —> minerals ions and vitamins —> actively transported by carrier and proteins pumps
  —> glucose and amino acids —> co-transported across the apical membrane with sodium
  —> water follow the movement of the mineral ions passively via osmosis

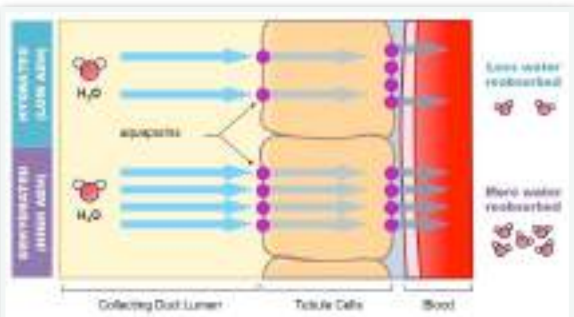
Osmoregulation:

- The third of the 3 processes by which blood is filtered and urine is formed
- The control of the water balance of the bloods, tissue or cytoplasm of a living organism
- Occurs in the medulla of the kidney and involves
  —> the loop of Henle establishes a salt gradient (hypertonicity) in the medulla
  —> anti-diuretic hormone (ADH) regulates level of water reabsorption in the collecting duct

Establishing a salt gradient:



- Loop of Henle —> creates hypertonicity in the tissue fluid of the medulla
- Descending limb of the loop —> permeable to water but not salts
- Ascending limb of the loop —> permeable to salts but not water
- As loop descends into medulla —> interstitial fluid becomes more slaty and hypertonic
- The vasa recta blood network flows oppositely



Water Reabsorption:

-The medulla will draw water out by osmosis due to the hypertonic conditions

-ADH controls the amount of water released from the collecting ducts to be retained by the body

—> is released from the posterior pituitary in response to dehydration (detected by osmoreceptors in hypothalamus)

—> increases the permeability of the collecting duct to water by up regulating production of aquaporins

—> less water in the filtrate —> urine + concentrated

Water balance:

- Maintaining an appropriate water balance within the body's tissues and cells is critical to the survival of an organism —> homeostasis cannot be maintained if water levels drop (dehydration), or are raised (overhydration) without regulation
- Water conservation can be improved by having a longer loop of Henle —> increases salt gradient in the medulla —> more water is reabsorbed by the collecting ducts and urine is concentrated
- Cortical nephrons —> short loops of Henle that don't descend deeply into medulla (moist env.)
- Juxtamedullary nephrons —> long loops of Henle (descend deeply into medulla) (arid environ.)

Dehydration:
- Loss of water from the body such that body fluids become hypertonic
- Effects —> thirst and excrete small quantities of heavily concentrated urine
  —> blood pressure will drop (less water in plasma) —> higher bpm
  —> individual becomes lethargic + inability to lower body temperature (no sweat)
  —> seizures, brain damage and death in severe cases

Overhydration:
- Less common occurrence —> over-consumption of water makes body fluids hypotonic
- Effects —> production of excessive quantities of clear urine —> to try and remove water
  —> cells will swell —> can lead to cell lysis and tissue damage
  —> can lead to headaches and disrupted nerve functions in mild cases
  —> blurred vision, delirium, seizures, coma and death in severe cases

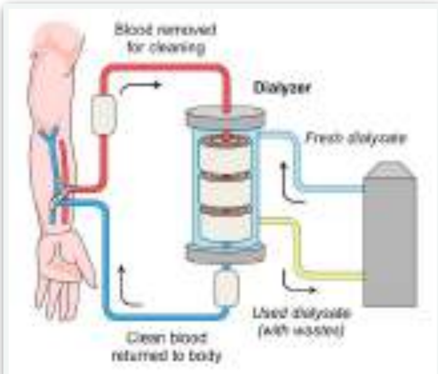
Kidney disease:

- Conditions which incapacitate the kidney's ability to filter waste products from the blood
- Result into reduced glomerular filtration rate (GFR)
- If untreated can lead to kidney failure —> is life threatening

Urinary analysis:

- Kidneys prevent excretion of blood cells, proteins and glucose —> present of them in urine indicated a disease
- Glucose —> indicates diabetes
- Proteins —> hormonal conditions (hCG) or diseases
- Blood cells —> variety of diseases + infections + cancer
- Drugs/toxins —> can be detected in urine

Hemodialysis:



- Kidney dialysis involves external filtering of blood —> to remove metabolic wastes in patients with kidney failure
- Blood removed and pumped through a dialysed —> contains a porous membrane that is semi-permeable and it introduces fresh dialysis fluid and removes wasted to maintain an appropriate concentration gradient
- Lasts about 4 hours for 3 times a week —> effective for years

Kidney transplant:

- Hemodialysis ensures continued blood filtering —> does not address the underlying issue affecting kidney function
- Kidney transplant —> best long-term treatment
  —> transplanted kidney is grafted into the abdomen (arteries, vein and ureter connected)
  —> donors must typically be a close genetic match in order to minimise graft rejection
  —> donors can survive with one kidney —> can donate the second to relatives suffering

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11.4 Sexual reproduction

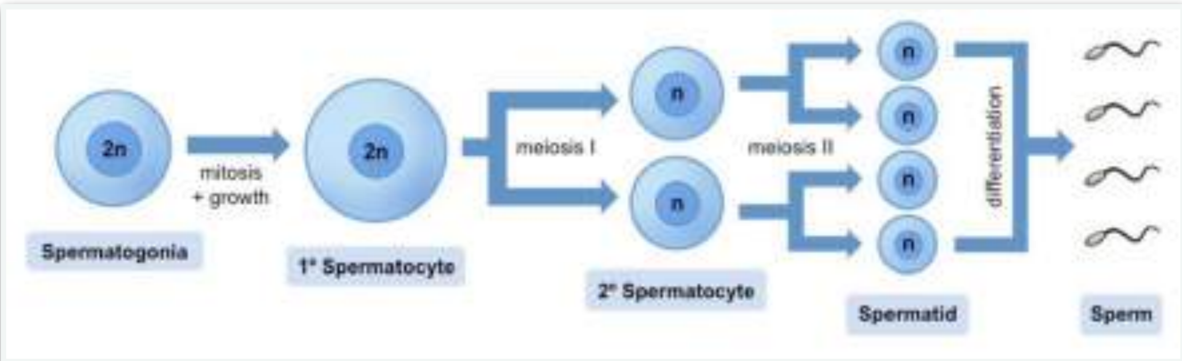
Gametogenesis:

- The process by which diploid precursor cells undergo meiotic division to become sex cells
  —> spermatogenesis in males —> produces a spermatozoa
  —> oogenesis in females —> produces an ova
- Occurs in the gonads and involves:
  —> multiple mitotic divisions and cell growth of precursor germ cells
  —> two meiotic divisions to produce haploid daughter cells
  —> differentiation of the haploid daughter cells to produce functional gametes

Spermatogenesis:

- Describes the production of spermatozoa in the seminiferous tubules of the testes

1) Begins at puberty when the germline epithelium of the seminiferous tubules divide by mitosis
2) Spermatocytes —> cells (spermatogonia) undergo a period of cell growth
3) Spermatids —> spermatocytes cells have two meiotic division —> 4 haploid daughter cells
4) Spermatozoa —> spermatids then differentiate in order to become functional sperm cells



Oogenesis:

- Describes the production of female gametes (ova) within the ovaries

1) Begins during foetal development —> a large number of primordial cells (oogonias) are formed by mitosis (40.000)
2) Oogonias undergo cell growth until they are large enough for meiosis (now primary oocytes)
3) Primary oocytes begin meiosis but are arrested in prophase I —> granulosa cells surround them to form follicles —> remain arrested until puberty
4) FSH will trigger each month the. Continued division of some of the primary oocytes

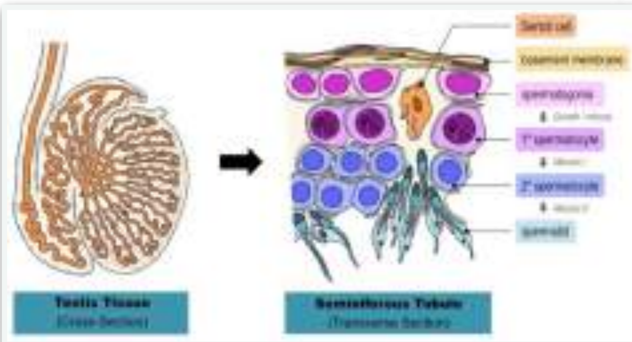
5) These cells will complete the first meiotic division to for two cells of unequal size —> one cell has all cytoplasm to form secondary oocytes, the other cell forms a polar body
6) The polar body remains trapped into the follicle —> degenerates later
7) Secondary oocytes begins the second meiotic division —> arrested in metaphase II
8) Secondary oocyte is released from ovary (ovulation) and enters into the fallopian tube/oviduct
9) The follicular cells surrounding the oocyte form a corona radiate —> nourish the oocyte
10) If the oocyte is fertilised by a sperm —> chemical changes will trigger meiosis II completion and the formation of another polar body
11) Ovum formation —> once meiosis II is complete —> before fusing its nucleus with the sperm

	Spermatogenesis	Oogenesis
Process		
Location	Occurs entirely in testes	Occurs mostly in ovaries
Meiotic divisions	Equal division of cells	Unequal division of cytoplasm
Germ line epithelium	Is involved in gamete production	Is not involved in gamete production
Gametes		
Number produced	Four	One (plus 2 – 3 polar bodies)
Size of gametes	Sperm smaller than spermatocytes	Ova larger than oocytes
Timing		
Duration	Uninterrupted process	In arrested stages
Onset	Begins at puberty	Begins in foetus (pre-natal)
Release	Continuous	Monthly from puberty (menstrual cycle)
End	Lifelong (but reduces with age)	Terminates with menopause

Reproductive tissue:

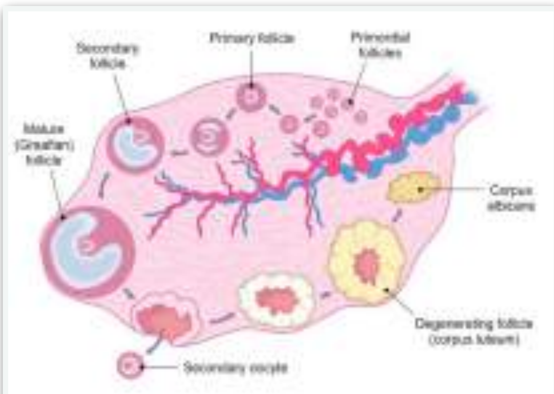
Seminiferous Tubule:

- Produce sperm
- Each tubule is surrounded by a basement membrane lined by germline epithelium
- The germline epithelium will divide by mitosis to make spermatogonia, which then make spermatids
- When spermatids differentiate into spermatozoa, they are released into the lime of the tubule and are nourished by Sertoli cells residing in the tubule lining
- Blood capillaries and interstitial cells (Leydig cells) are outside of the tubules —> produce testosterone



Ovary:

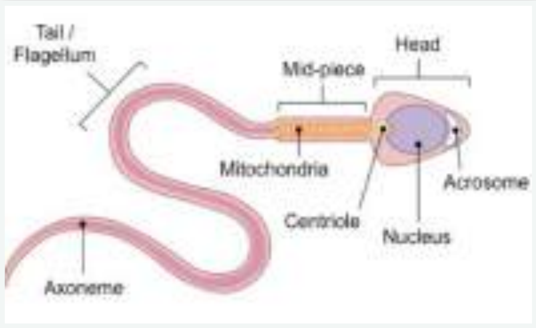
- Contains follicles in various stages of development
- Follicles will develop over the course of a menstrual cycle
- Primordial follicles —> contain egg cells that have been arrested in prophase I (primary oocytes) —> will become secondary follicles and then dominant Graafian follicles —> rupture to release the secondary oocyte
- Ruptured follicle will develop into a short-lived corpus luteum —> secretes key ovarian hormones —> then will become a corpus albicans



Sperm:

- A typical human spermatozoa can be divided into three sections

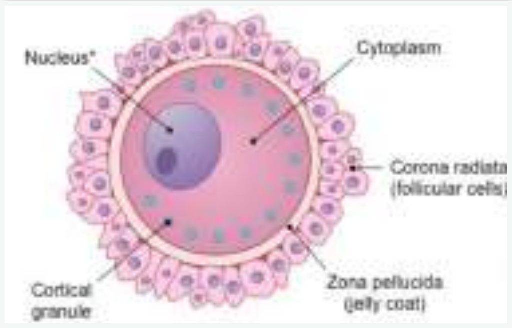
1) Head region —> has three structures —> haplоid nucleus, acrosome cap and paired centrioles
—> haploid nucleus —> contains the paternal DNA
—> acrosome cap with hydrolytic enzymes —> help penetrating jelly coat of egg
—> centrioles —> needed by a zygote in order to divide (egg cells expel them)



2) Mid-piece —> contains high numbers of mitochondria —> provides energy needed for the tail

3)Tail —> flagellum —> composed of a microtubule structure Calle axoneme —> bends to move

Egg:



-A typical egg cell is surrounded by two distinct layers

1) Zona pellucida —> glycoprotein matrix which acts as a barrier to sperm entry

2) Corona radiata —> external layer of follicular cells —> provide support and nourishment to the egg cell

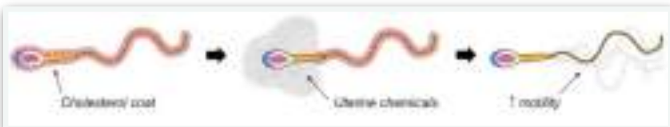
- Numerous cortical granules are in the egg cell —> release their contents upon fertilisation to prevent polyspermy
- The egg cells have no nucleus until after fertilisation

Animal fertilisation:

- External fertilisation —> involves the fusion of gametes outside of the body of a parent
—> most common in aquatic animals —> spawning
—> susceptible to environmental influences (pH changes, predators, …)
—> species that reproduces this way usually relate large quantities of gametes to compensate for losses
- Internal fertilisation —> involves the fusion of gametes inside of the body of a parent
—> requires copulation —> the gamete of one parent inside the other
—> common in terrestrial animals —> prevents exposure and desiccation
—> offers more protection to gametes, but is endangering to parent

Human fertilisation:

1) **Capacitation** —> occurs after ejaculation, when chemicals released by the uterus dissolve the sperm's cholesterol coat
—> improves sperm motility
—> destabilises the acrosome cap —> necessary for the acrosome reaction to occur upon egg and sperm contact



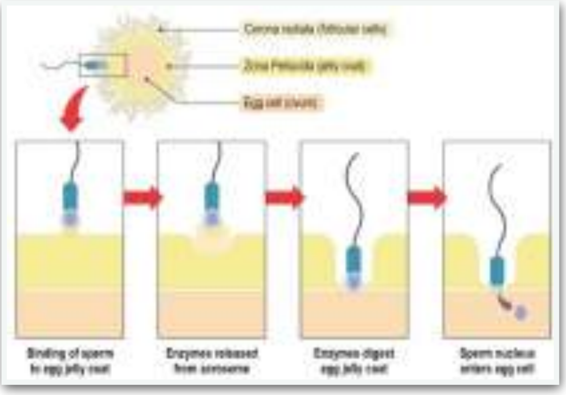
2) **Acrosome reaction** —> allows the sperm to break through the surrounding jelly coat

—> sperm pushes through the follicular cells of the corona radiata and binds to the zona pellucida

—> Acrosome vesicle fuses with jelly coat and releases digestive enzymes —> soften glycoprotein matrix

—> Sperm then pushes through softened jelly coat and binds to exposed docking proteins on the egg membrane

—> The membrane of the egg and sperm then fuse and the sperm nucleus (and centriole) enters the egg

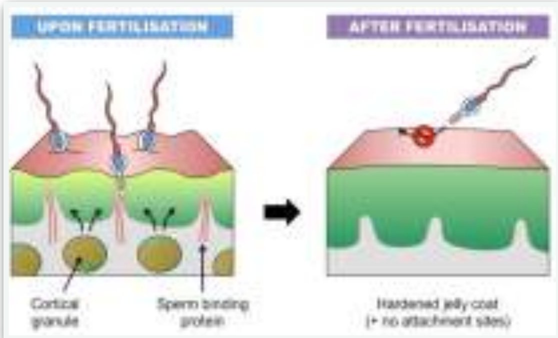


3) **Cortical reaction** —> occurs once a sperm has successfully penetrated an egg —> prevents polyspermy

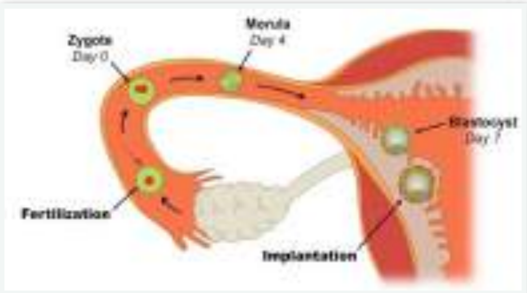
—> Cortical granules in the egg's cytoplasm release enzymes (via exocytosis) into the zona pellucida (jelly coat)

—> These enzymes destroy sperm binding sites + thicken and harden the glycoprotein matrix of the jelly coat

—> prevents other sperm from being able to penetrate the egg (polyspermy), ensuring zygote is diploid



Blastocyst formation:



-Following fertilisation, an influx of CA2+ into the ova prompts the completion of meiosis II —> zygote has formed

-Morula —> solid ball resulting from zygote undergoing several mitotic divisions —> forms a blastocyst as it differentiates and cavitates (forms a cavity)

-Blastocysts —> three distinct sections:

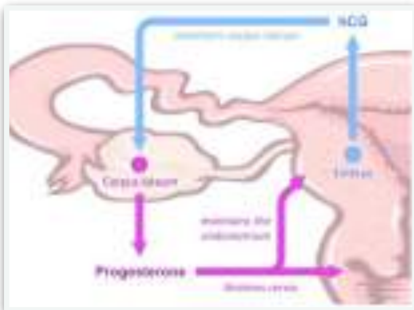
—> inner cell mass —> will develop into the embryo

—> trophoblast —> surrounding outer layer —> will develop into the placenta

—> blastocoele —> fluid filled cavity

- Blastocyst implantation into the endometrial lining —> final stage of early embryo development
  - —> blastocyst breaches the jelly coat surrounding it and preventing attachment to endometrium
  - —> digestive enzymes are released —> degrade the endometrial lining
  - —> autocrine hormones are released —> trigger its implantation into the uterine wall
- From fertilisation to implantation takes roughly 6 / 8 days

Human Chorionic Gonadotropin:



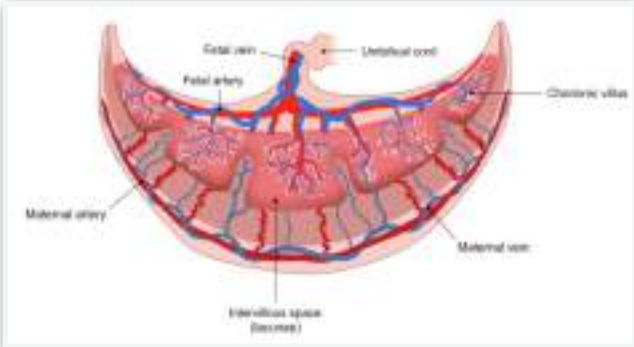
- Secreted by a blastocyst when implanted in the endometrial lining —> promotes the maintenance of the corpus luteum within the ovary + prevents its degeneration
- Corpus luteum will continue to produce both oestrogen and progesterone
- Levels of hCG are maintained for 8 - 10 weeks while the placenta develops —> when placenta becomes responsible for progesterone secretion + nourishing the embryo, corpus luteum no longer required + degenerates as hCG drops

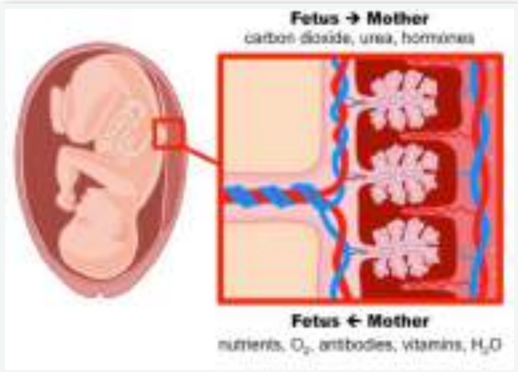
Placenta:

- Functions as the life support system for the foetus and has two key functions
  —> facilitates the exchange of materials between the mother and foetus
  —> secretes hormones to maintain the pregnancy after the corpus luteum has degenerated

Structure:

- Disc-shaped structure that nourishes developing foetus
- Formed from the development of the trophoblast upon implantation and invades the uterine wall
- Maternal bloods pools via open ended arterioles into intervillous spaces (lacunae)
- Chorionic villi extend into these pools of blood and mediate the exchange of materials between mom and foetus —> exchange material is transported from the villi via and umbilical cord —> connects foetus to placenta
- Upon birth, placenta is expelled from uterus with infant



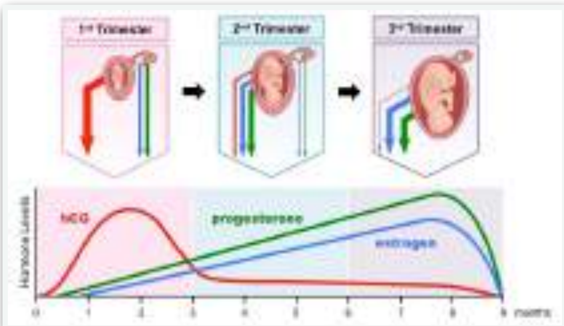


Material exchange:

- Chorionic villi extend into the intervillous space (lacuna) and exchange materials between the mother and foetus
- Chorionic villi are lined by microvilli to increase SA
- Foetal capillaries within the chorionic villi lie close to the surface to minimise diffusion distance from blood in the lacunae
- Materials such as oxygen, nutrients, vitamins, antibodies and water will diffuse from the lacunae into foetal capillaries
- Foetal waste (such as carbon dioxide, urea and hormones) will diffuse from the lacunae into the maternal blood vessels

Hormonal role:

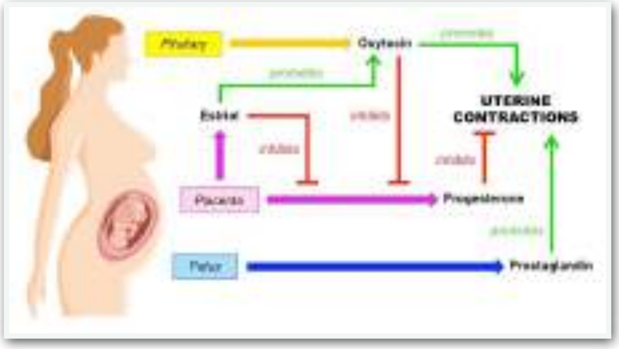
- Placenta takes over the hormonal role of the ovaries at ~12 weeks and begins producing estrogen and progesterone
- Estrogen stimulates the growth of uterine muscles (myometrium) and the development of the mammary glands
- Progesterone maintains the endometrium, as well as reducing uterine contractions and potential maternal immune responses
- Both estrogen and progesterone levels drop near birth



Birth process:

- Parturition —> process of childbirth —> occurs via positive feedback under hormonal control
- Fetal growth causes stretching of the uterine walls (detected by stretch receptors) —> will trigger the release of hormone oxytocin that induces uterine muscles to contract —> cycle will continue until the foetus is removed by giving birth

Hormonal control:



- After 9 months, the stress by the baby induces the release of chemicals which trigger a rise in the levels of estrogen (estriol in particular)
- Estriol prepares the smooth muscle of the uterus for hormonal stimulation by increasing sensitivity to oxytocin + inhibits progesterone (was preventing uterine contractions from occurring while the foetus developed)
- When uterus is primed for childbirth, the brain triggers the release of oxytocin from the posterior pituitary gland
- Oxytocin stimulates uterine muscles to contract, initiating birth + inhibits progesterone secretion
- The foetus responds to this uterine contraction by releasing prostaglandins, which triggers further uterine contractions —> positive feedback loop
- Contractions will stop when labour is complete and the baby is birthed (no more stretching of the uterine wall)

Gestation periods:

- The time taken for a foetus to develop — from fertilisation to birth
- Duration will differ between different species of animal
- Two main determining factors —> animal size and mass
  —> the level of development at birth

Level of development:
- Altricial mammals —> give birth to relatively helpless, undeveloped offspring
  —> need extended rearing
- Precocial mammals —> give birth to more developed offspring that are mobile and independent
  —> require minimal rearing

Extra:

Lymphatic system:

- Secondary transport system —> protects and maintains body by producing and filtering lymph
  —> also absorbs fats from the gut and extra fluid from all over the body
- Lymph —> clear fluid that contains white blood cells and arises from the drainage of fluid from the blood and surrounding tissues
  —> filtered at points called lymph nodes —> pathogens are removed before the fluid is returned to venous circulation

Types of immunity:

- Active —> involves the production of antibodies by the body itself —> later memory cells
- Passive —> from the acquisition of antibodies from another source —> no memory cells
- Both immunities can be induced by either natural (infection or vaccination) or artificial (maternal or monoclonal) mechanisms

Immune pathways:

- Humoral immunity —> describes the pathway by which antibodies are produced by B lympho.
  —> macrophages engulf exogenous pathogens and digest them within lysosomes to release antigenic fragments
  —> fragments are presented on MHC class II receptors and to helper T cells
  —> T cells secrete cytokines to activate the appropriate B lymphocytes
- Cell-mediated immunity —> describes a pathway that targets endogenous antigens
  —> cancerous + virus-infected cells are the body's own cells and are not recognised foreign
  —> present antigenic fragments as a complex with their own self markers (MHC class I)
  —> When helper T cells identify these cells, they stimulate a second type of T lymphocyte – cytotoxic T cells —> show specificity to particular antigens and will bind to the presented antigen and release perforating enzymes
  —> cause the infected / cancerous cell to by lysed, preventing the further spread of infection

Immune disorders:

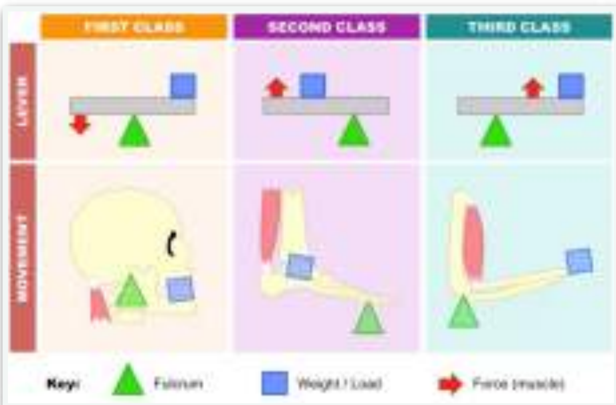
Hypersensitivity disorders:
- Excessively immune response to a substance that is not inherently harmful (allergen)
- Require a pre-sensitised immune state (prior exposure) —> excessive reaction at re-exposure

Autoimmune disorders:
- Immune system fails to recognise body cells as self and begins targeting them
- Pathogens can evade immune detection by producing antigens that closely resemble host markers
  —> detection of these pathogens leads to antibodies that will recognise body cells as targets
  —> diabetes type I, rheumatoid arthritis and multiple sclerosis

Immunodeficiency disorders:
- The immune system's capacity to fight infection is compromised or absent entirely
- Can be inherited, pathogenic (AIDS) or caused by drug treatments
- Cytotoxic drugs —> cause immunosuppression and are used during transplant operations

Types of levers:

- Muscles and bones act together to achieve a variety of movement by forming different types of levers
- 4 parts —> Bones —> lever arm
  —> Joints —> fulcrum
  —> Muscles —> provide the force
  —> Load —> weight of the body part moved
- Different classes based upon where the fulcrum is



Types of Muscles:

- Skeletal —> found attached to the skeleton —> responsible for the voluntary movement of bones
  —> its fibres run in parallel tracts and are multinucleate and heavily striated
- Smooth —> found in the lining of internal organs —> involuntary constriction of regions
  —> not striated and have a spindle shape —> each fibre has a single central nucleus
- Cardiac —> found in the heart and is responsible for the rhythmic contraction of the heart
  —> fibres are branching, intercalated, lightly striated and have a single nucleus per fibre

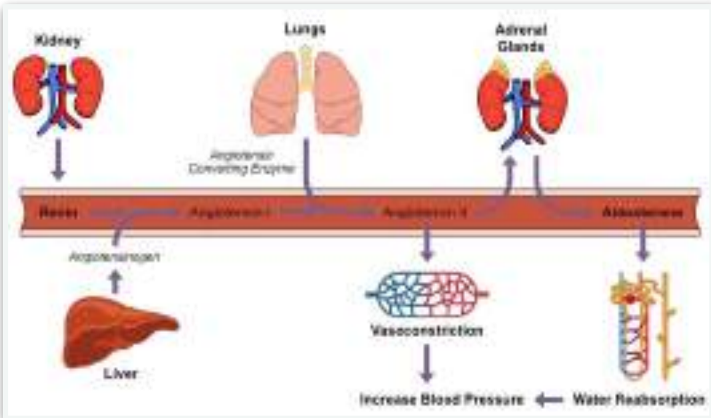
Slow vs Fast twitch:

- Slow twitch fibres —> used for muscular endurance —> contract slowly but do not fatigue easily
  —> oxygen for aerobic respiration —> many mitochondria and blood vessels
  —> typically red in colour due to dense supply of capillaries
- Fast twitch fibres —> used for muscular strength —> contract rapidly but fatigue easily
  —> respire anaerobically —> possess less mitochondria and blood vessels
  —> typically lighter in colour

Kidney stones:

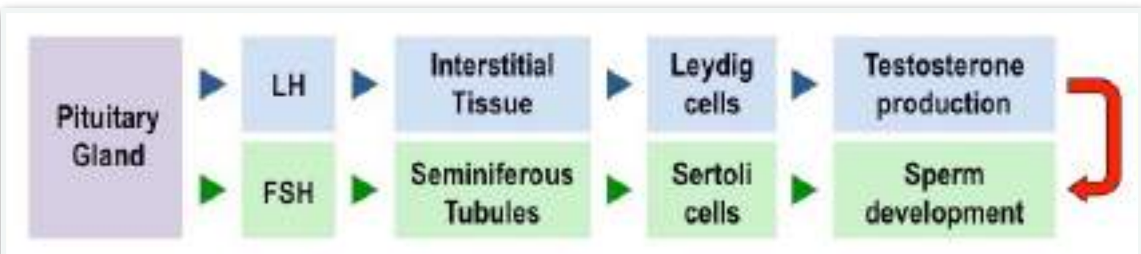
- Kidney stone or renal calculus —> solid piece of material formed in the kidneys from the minerals in urine —> may block the ureter —> decreases kidney function + painful urination
- Dehydration is a common contributing factor, but no known reason exists
- May be prevented by limiting the dietary intake of minerals which form the stones (calcium)
- Shock wave lithotripsy —> ultrasounds to shatter the stones into smaller fragments and urinated

Renin:



- Hormone produced by the kidneys that regulates blood pressure in response to changes in blood volume
- Renin is released from the juxtaglomerular apparatus (JGA) when the kidneys detect a drop in blood pressure
- When an individual is dehydrated, water levels in the blood plasma decrease – leading to lower blood pressure —> Renin is released from the kidney in response to low blood pressure and increases water reabsorption to raise blood volume
- Renin converts angiotensinogen (released from the liver) into angiotensin I
- In the lungs, angiotensin converting enzyme (ACE) converts angiotensin I into angiotensin II
- Angiotensin II causes vasoconstriction, which functions to increase blood pressure by reducing the diameter of blood vessels
- Angiotensin II also triggers the adrenal glands to release the hormone aldosterone
- Aldosterone stimulates sodium uptake in the distal convoluted tubules
- With more sodium reabsorbed into the bloodstream, more water is reabsorbed from the collecting ducts via osmosis
- This functions to raise blood volume and hence increases blood pressure

Hormonal control of male reproduction:



Amniotic sac:

- The foetus develops in a fluid-filled space that is encased by an amniotic sac —> separates the foetus from the mother and hence functions as a barrier against infection
- Protective fluid —> largely incompressible and good at absorbing pressure —> protects the foetus from impacts to the uterus
  —> creates buoyancy so that the foetus does not have to support its own weight while a skeletal system develops
  —> finally, amniotic fluid prevents the dehydration of foetal tissues
- Water breaking —> when amniotic sac ruptures while a women comes to term during labour

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