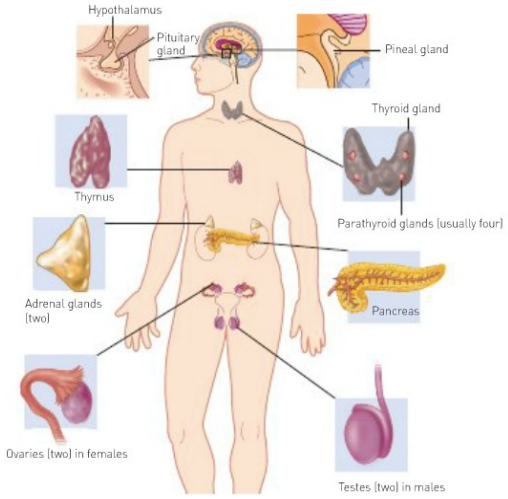
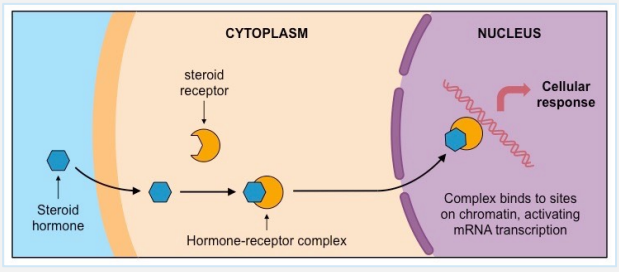
ENDOCRINE SYSTEM

ENDOCRINE	EXOCRINE
Secretions enter blood	Secretions exit the body
Control long term activity for target organ	Control short term activity
Secretes hormones into extracellular fluids	Transports secretions to target tissues
Ductless	Via ducts



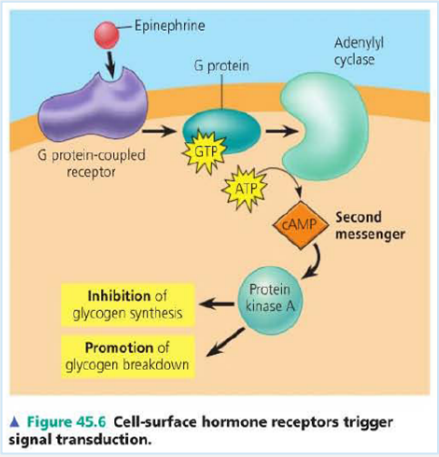
AMINE HORMONE ACTION

1. Non-lipid soluble protein hormones bind to a cell surface receptor
2. Results in an activation of a signalling pathway by first messenger
3. Activates G-protein converting ATP to cAMP
4. Activates second messenger in cytoplasm (cAMP)
5. cAMP activates a cell-specific response
6. Enzyme (phosphodiesterase) breaks down cAMP and terminates signal



STEROID HORMONE ACTION

1. Lipid soluble enters target cell
2. Combines with receptor protein on an organelle or in nucleus
3. Hormone receptor complex binds to DNA
4. Activates formation of particular proteins
5. Affects transcription and translation



▲ Figure 45.6 **Cell-surface hormone receptors trigger signal transduction.**

AMINE HORMONES

- Non-lipid soluble/ water soluble
- Cannot diffuse straight through membrane
- Attach to receptor on membrane
- Secondary messenger is sent to receptor inside of cell

STEROID HORMONES

- Lipid soluble
- Diffuse straight through cell membrane
- Binds to receptor inside cell
- Activates hormone receptor complex

PITUITARY GLAND

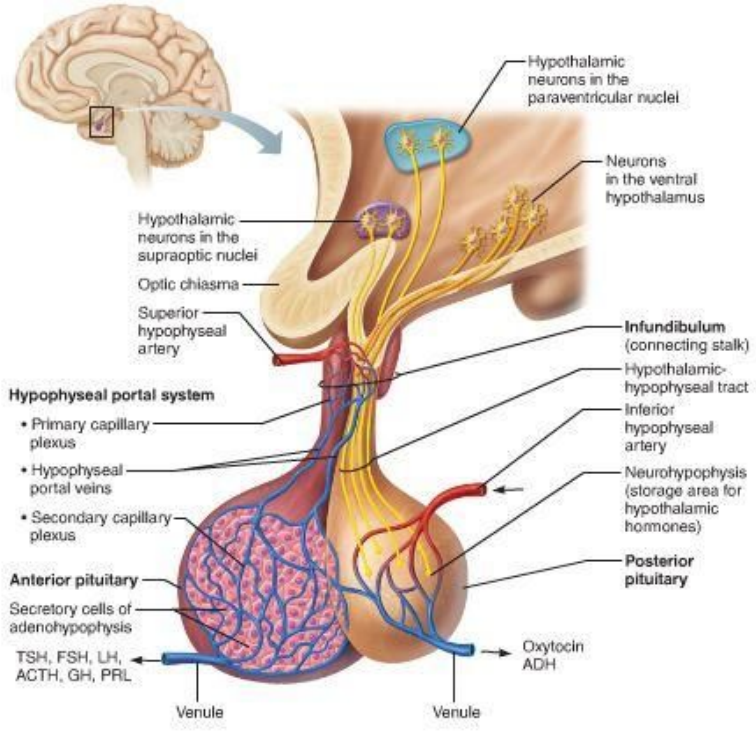
ANTERIOR PITUITARY

HORMONE	TARGET ORGAN	EFFECTS
FOLLICLE STIMUATING HORMONE (FSH)	- Ovaries - Testes	- Growth of Follicles - Sperm production
LUITENISING HORMONE (LH)	- Ovaries - Testes	- Ovulation and corpus leutem formation - Secretion of testosterone
GROWTH HORMONE (GH)	All cells	Growth and synthesis
THYROID STIMULATING HORMONE (TSH)	Thyroid gland	Secretes hormones such as thyroxine from thyroid
ADRENOCORTICOTROPHIC HORMONE (ACTH)	Adrenal Cortex	Secretes hormones such as cortisol from adrenal cortex
PROLACTIN (PRL)	Mammary Glands	Milk production

POSTERIOR PITUITARY

HORMONE	TARGET ORGAN	EFFECTS
ANTIDIURETIC HORMONE (ADH)	Kidneys	Increase the reabsorption of water
OXYTOCIN (OT)	- Uterus - Mammary Glands	- Uterine contractions - Release of milk

ANTERIOR PITUITARY	POSTERIOR PITUITARY
- Controlled by releasing and inhibiting factors - Produces its own hormones - Connected to hypothalamus by network of blood vessels	- Stored and release hormones - Hormones from hypothalamus - Connected to hypothalamus by nerve fibres - Produced in neurosecretory cells



ENDOCRINE DISRUPTIONS

DISEASE	CAUSES	SYMPTOMS	TREATMENT	DIAGNOSIS	PREVENTIONS
HYPERTHYROIDISM	thyroid gland produces too much hormone thyroxine	Cells are overstimulated, rapid heartbeat, weight loss, increased appetite, fatigue, sweating, anxiety	- Drugs that block the thyroid gland's use of iodine - Surgery to remove thyroid gland	- Blood tests to test iodine, TSH and thyroxine levels in blood	- Genetic
HYPOTHYROIDISM	Insufficient amount of thyroxine produced by the thyroid gland	Metabolic processes are decreased, slow heart rate, weight gain, fatigue, lack of tolerance to the cold, swelling of the face and 'goitre'	- Iodine tablets if due to iodine deficiency - Recombinant DNA technology used to make T3 & T4		- Diet high in iodine

DISEASE	CAUSES	DIAGNOSIS	TREATMENT	PREVENTIONS
TYPE 1 DIABETES	Due to fault in immune system causing destruction of beta cells in pancreas (no insulin is produced)	Blood fasting test and finger prick test to test blood glucose levels	- No cure - Regular injections of insulin - Recombinant DNA used to insert insulin cells into body	- Genetic, no prevention
TYPE 2 DIABETES	Beta cells produce insulin but the body cells are unresponsive to it		- No cure - Medication	- Physical exercise - Healthy diet - No smoking

ENDOCRINE GLANDS

GLANDS	FUNCTION	SECRETION	REGULATION
PINEAL	Happiness levels Influence sexual development/ sleep	Serotonin Melatonin	
THYROID		Thyroxine Calcitonin	Maintain body temp/ metabolic rate ↓Calcium and phosphate in blood
PARATHYROID		Parathormone	↑Calcium and phosphate in blood
THYMUS	Production and maturation of T-lymphocytes	Thymosin's	
ADRENAL		Medulla: (Nor)epinephrine (Nor)adrenaline Cortex: Aldosterone Cortisol	 ↑Sodium ↓Potassium Blood pressure/ metabolism
PANCREAS		Glucagon Insulin	Increase blood glucose Decrease blood glucose
GONADS	For growth and masculinity/ femininity	Testosterone Oestrogen/ progesterone	

NERVOUS SYSTEM

CLASSIFICATION OF NEURONS

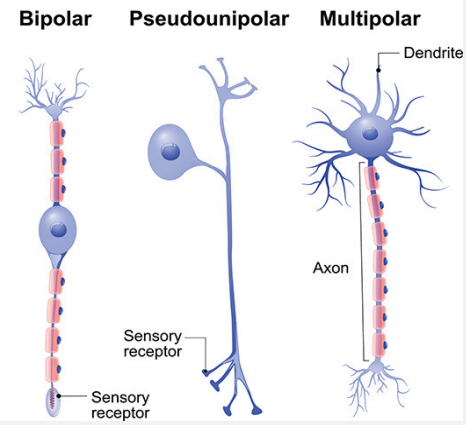
STRUCTURE

Bipolar - distinct axon and dendrite separated from each other by a cell body

Multipolar - single axon, multiple dendritic fibres. All somatic motor neurons are multipolar.

Pseudo unipolar - fake unipolar, found in human body

Axon comes out of cell body and splits in 2, no dendrites

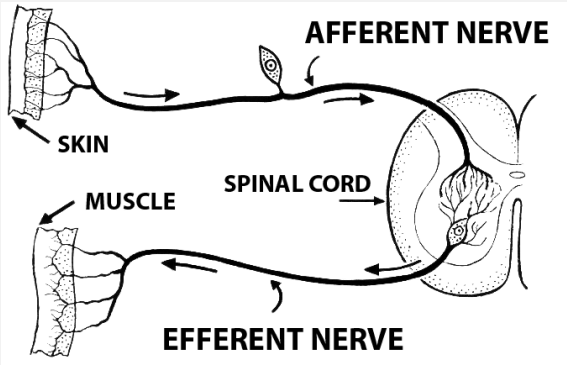


FUNCTION

Afferent (sensory) - take nerve impulses from receptors to CNS
Occur at the end of dendrites

Efferent (motor)- take nerve impulses from CNS to effector structures

Interneurons/ connector neurons- receive and send messages from adjacent neurons

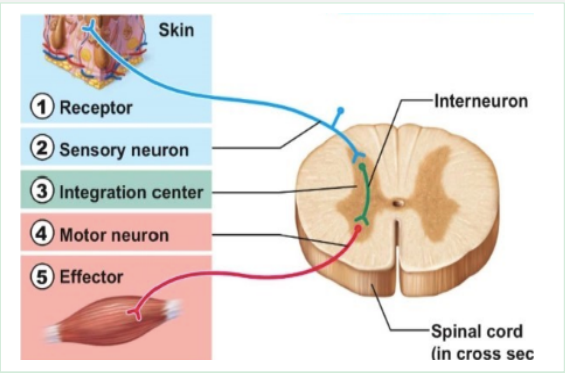


REFLEX ARC

The rapid, autonomic response to a change in the internal or external environment

Properties:

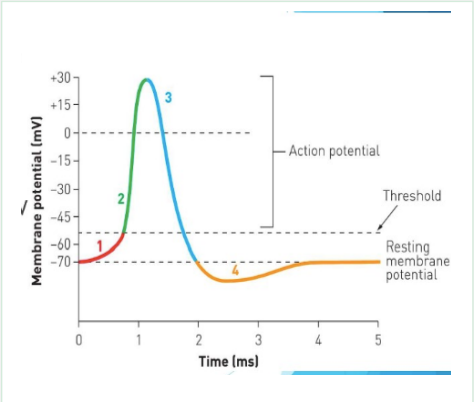
-stimulus is required
-involuntary
-rapid and small no of neurons
-stereotyped and same way each time



1. Receptor – detecting the change: end of a sensory neuron
2. Sensory neuron – carries impulse from receptor to the CNS
3. Synapse – passed to motor neuron or interneuron: only one synapse
4. Motor neuron – carries nerve impulses to an effector
5. Effector – receives impulses and carries out response

ACTION POTENTIAL

1. Stimulus is applied – membrane becomes permeable and sodium moves into the cell causing depolarisation: an all or none response occurs if decrease is more than a 15mV (threshold) so more sodium ions are allowed into the cell
2. Depolarisation – when action potential is created from sodium ions allowed into the cell
3. Repolarisation – ion channels on the inside of the membrane allow potassium ions out: this restores the electrical balance
4. Hyperpolarisation – returning to the resting membrane potential there is more potassium on the outside than sodium on inside: causes membrane potential to drop and then returns to normal state
5. 1-4 steps refractory period – the brief time during and after-action potential when the neuron cannot be stimulated



MYELINATED FIBRES

Faster process

Action potential generated between each node of Ranvier

Exchanges of ions generated at each node of Ranvier (saltatory conduction)

UNMYELINATED FIBRES

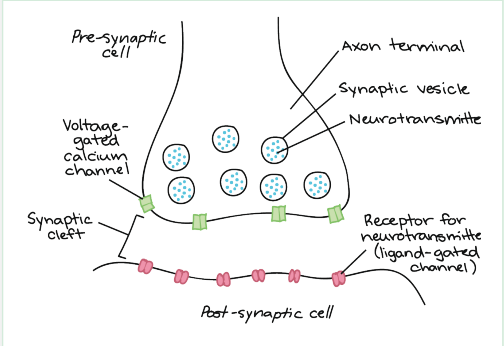
Slower process

Action potential generated immediately adjacent to its original stimulus

Exchange of ions generated along entire length of axon

SYNAPSES

1. Membrane depolarises – the end of an axon, calcium gates will open, letting calcium ions enter the cell
2. Synaptic vesicle release neurotransmitters – relay message between neurons
3. Neurotransmitters bind with receptors – bind on the neuron (acetylcholine, dopamine, adrenaline)
4. Excitation or inhibition – occurs depending on the neurotransmitter
    - Excitation – sending message – nerve impulse is generated when sodium enters the cell and depolarisation occurs
    - Inhibition – nerve impulse is not sent because potassium moves out of cell: hyperpolarisation is reached



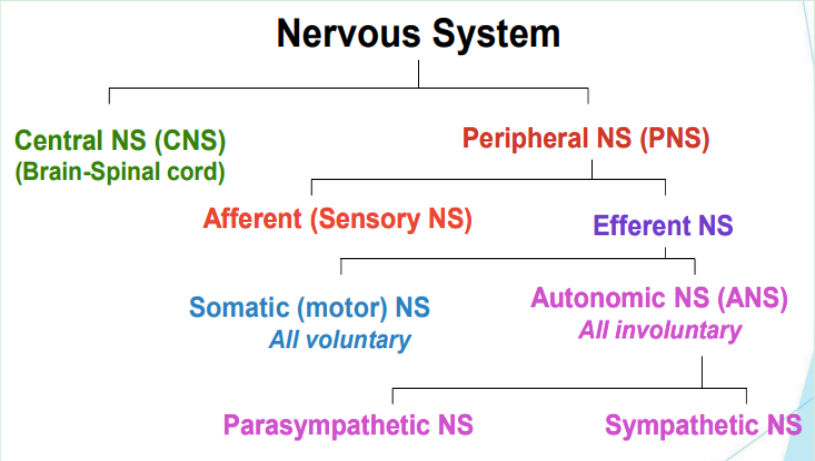
Peripheral Nervous System

Somatic motor NS – takes nerve impulses from CNS to skeletal muscles(voluntary)

Autonomic motor NS – takes nerve impulses from CNS to heart muscle involuntary muscles and glands (involuntary)

Sympathetic NS – preparing for strenuous activity: fight or flight (noradrenaline)

Parasympathetic NS – produces responses to maintain conditions: rest & digest (acetylcholine)



DIFFERENCES BETWEEN THE AUTONOMIC AND SOMATIC NERVOUS SYSTEM

CHARACTERISTIC	AUTONOMIC DIVISION	SOMATIC DIVISION
Effectors	Heart muscle, involuntary muscle, glands	Skeletal muscles
General function	Homeostasis	Response to external environment
Efferent pathways	Two nerve fibres	One nerve fibre
Neurotransmitter at effector	Acetylcholine or noradrenaline	Acetylcholine
Control	Involuntary	Voluntary
Nerves to target organ	Sympathetic and parasympathetic	One set
Effect on target organ	Excitation or inhibition	Always excitation

EFFECTS OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

STRUCTURE	EFFECT OF SYMPATHETIC	EFFECT OF PARASYMPATHETIC
Heart	Increase heart rate and contraction	Decreases heart rate and contraction
Lungs	Dilates bronchioles allowing more air	Constricts bronchioles
Stomach/intestines	Decreases peristalsis	Increases peristalsis
Liver	Increase breakdown of glycogen and release of glucose	Increases uptake of glucose and synthesis of glycogen
Iris of the eye	Dilates for sight	Constricts pupil
Sweat glands	Increases sweat	No effect
Salivary glands	Decreases saliva	Increases saliva
Blood vessels of:		
- *skin*	Constricts vessels	Little effect
- *skeletal muscle*	Dilates vessels	No effect
- *internal organs*	Constricts vessels	Little effect
Urinary bladder	Relaxes muscles of wall	Constricts muscles of wall
Adrenal medulla	Hormone secretion	No effect

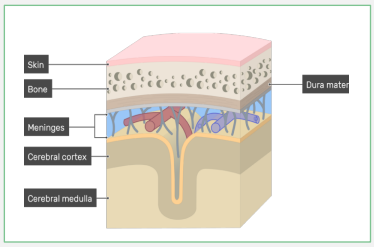
Central Nervous System

PROTECTION OF THE CNS

1. Bone – brain protected by cranium and the spinal cord is protected by vertebral canal
2. Meninges – tough, fibrous protective layer covering the entire CNS
3. Cerebrospinal fluid – acts as a shock absorber to prevent blows

THE MENINGES

- Dura mater: outer layer
- Arachnoid mater: middle layers
- Pia mater: inner layers



AREA OF THE BRAIN	PART OF THE BRAIN	STRUCTURE	FUNCTION
Forebrain	Cerebrum	Largest part Surface is folded into convolutions	Controls learning, reasoning & memory Voluntary & involuntary activities
	Hypothalamus	Deep inside the middle of the brain	Maintains homeostasis Controls autonomic NS Releases releasing & inhibiting factors
Hindbrain	Medulla oblongata	Joining the brain to the spinal cord	Controls basal functions Regulates heart rate and blood pressure
	Cerebellum	Underneath the rear part of the brain	Controls muscular movement and posture Coordinates fine muscle contraction

CEREBRUM

1. Frontal – voluntary control
2. Temporal – smell and hearing
3. Occipital – visual areas
4. Parietal – sensory information

- Outer surface – cerebral cortex
  Contains grey matter and is folded to increase surface area

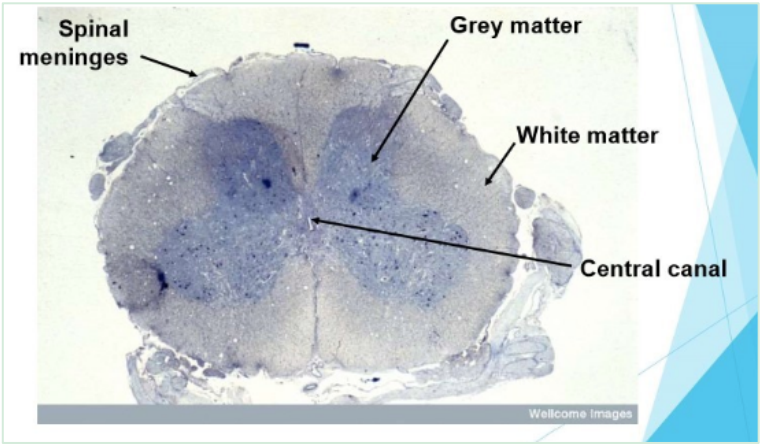
- Inner – basal ganglia
  Contains grey matter

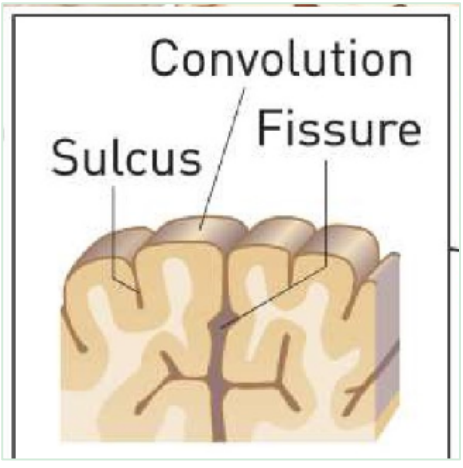
FISSURES

Grooves in the brain
Longitudinal – separates cerebrum in halves
Corpus callosum – joins halves together

TRACTS

Bundles of nerves
- Connect areas together
- Carry impulses between hemispheres
- Connect cortex to brain or spinal cord





NERVOUS SYSTEM DISORDERS

PARKINSONS AND ALZHEIMER'S DISEASE

DISEASE	CAUSES	SYMPTOMS	TREATMENT	EFFECTS	PREVENTIONS
PARKINSON'S DISEASE	Reduce neurotransmitter dopamine, resulting in death of nerve cells	Slow physical movement and spasmodic muscle tremors	- No cure - Increasing body's dopamine levels - Cell replacement of dying neurons with healthy ones	- Impaired hearing and vision - Short term memory loss - Slow reaction times - Loss of fine motor skills	- Lower alcohol consumption - Physical stimulation - Healthy diet
ALZHEIMER'S DISEASE	Loss of neurons due to abnormal accumulations of amyloid plaques which interferes with synaptic transmission	Memory loss, paranoia, moodiness and disorientation	- No cure - cholinesterase inhibitors - Cell replacement of dying neurons with healthy ones		

COMPARISON OF NERVOUS SYSTEM AND ENDOCRINE SYSTEM

BASIS FOR COMPARISON	NERVOUS SYSTEM	ENDOCRINE SYSTEM
The rate of response	Quick response, by the action potentials and neurotransmitters.	Responds slowly by secreting hormones, traveling through the circulatory system to the target tissue
Kind of response	Localised response.	The response is spread widely.
Duration	Short lasting effects	Long lasting effects
Transmission of signal	Neurotransmitters along neurons transmit electrochemical signals.	Hormones are chemical signals through the blood stream
Transmission	Neurons	Bloodstream

HOMEOSTASIS

Maintaining a constant internal environment

Needs:

- be at a particular temperature

- constant supply of oxygen

- constant removal of wastes

Transduction: the translation of an arriving stimulus into an action potential by a sensory neuron

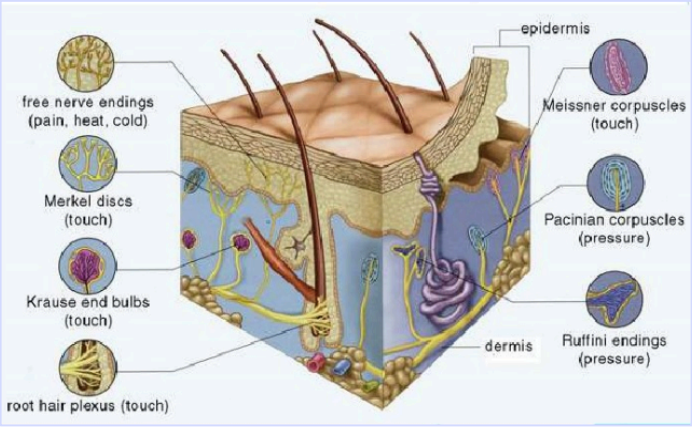
Nociceptors – skin and mucous membranes

Osmoreceptors – hypothalamus

Thermoreceptors – peripheral in skin and mucous membranes, central in hypothalamus

Mechanoreceptors – skin

Chemoreceptors – peripheral in carotid and aortic bodies, central in medulla oblongata



HYPERVENTILATION

Results in the increase in O2 and decrease of CO2 with rapid, deep breathing

- When there is less CO2 in the blood, the vessels connected to the brain will narrow resulting in light headedness
- Can be voluntary or because of stress – emotional and physical

Gas Concentrations

Stimulus

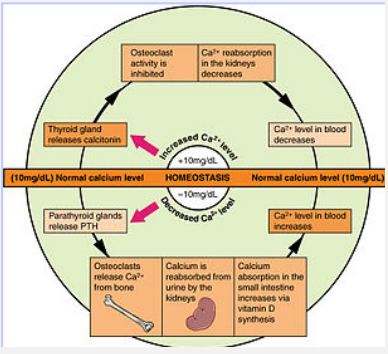
↑ CO2

↓ pH

Negative feedback

↓ CO2

↑ pH



Receptor

Central: medulla oblongata

Peripheral: carotid and aortic bodies

Response

1+2) ↑ rate of contraction
↑ rate of depth and breathing

Modulator

Respiratory centre in the medulla oblongata

Effector

1) Intercostal muscles (intercostal nerves)
2) Diaphragm (phrenic nerves)

Thermoregulation

Stimulus

↑ Body temp

Negative feedback

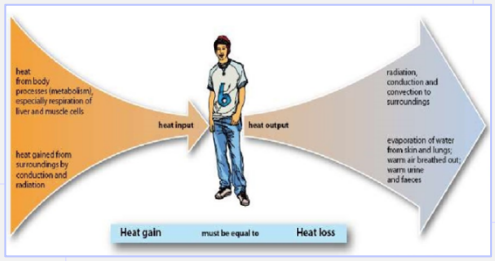
↓ Body temp

Receptor

Hot and cold thermoreceptors

Peripheral: skin/ mucous membranes

Central: hypothalamus



Response

1) Vasodilation of SMSA
   ↑ Heat loss and radiation
2) ↓ Thyroxine secretion
   ↓ Metabolic rate and heat
3) ↑ Sweat secretion
   Heat loss via evaporation

Modulator

Hypothalamus

Effector

1) Smooth muscle surface arterioles
2) Thyroid gland
3) Sweat glands

TSH to the thyroid gland

Thermoregulation

Stimulus

↓ Body temp

Negative feedback

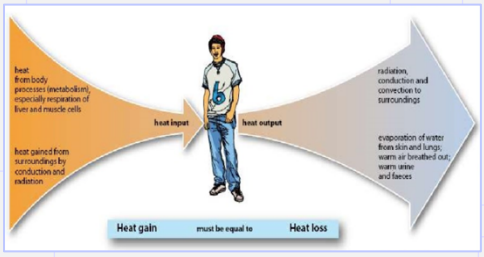
↑ Body temp

Receptor

Hot and cold thermoreceptors

Peripheral: skin/ mucous membranes

Central: hypothalamus



Response

1) Vasoconstriction of SMSA
   ↓ Heat loss via radiation
2) Shivering
   ↑ Muscle tone, oscillations & heat production
3) ↑ Thyroxine secretion
   ↑ Metabolism and heat

Modulator

Hypothalamus

Effector

1) Smooth muscle surface arterioles
2) Skeletal muscle cells
3) Thyroid gland

TSH secretion to the thyroid gland

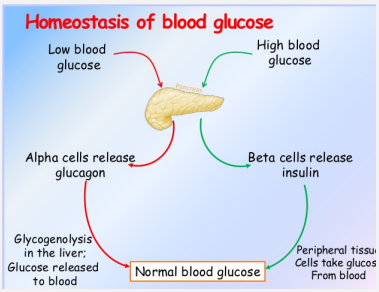
Glucose Regulation

Stimulus

↑ Blood glucose levels

Negative feedback

↓ Blood glucose levels



Receptor

Beta cells (islets of Langerhans) in the pancreas

Response

1+2) ↑ Uptake of glucose: glycogenesis

3) ↑ uptake for cellular respiration & protein synthesis

4) lipogenesis: conversion of glucose to fat

Modulator

Beta cells

Effector

1) Liver
2) Skeletal cells
3) All body cells
4) Adipose cells

Secrete insulin

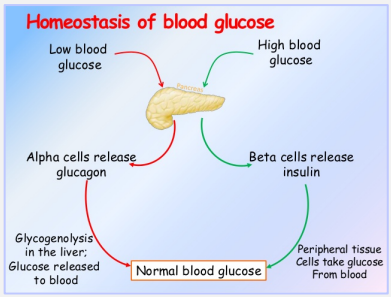
Glucose Regulation

Stimulus

↓ Blood glucose levels

Negative feedback

↑ Blood glucose levels



Receptor

Alpha cells (islets of Langerhans) in the pancreas

Response

1+2) glycogenolysis: breakdown of glycogen to release glucose

1) Gluconeogenesis: creation of new glucose from lipids and amino acids

Modulator

Alpha cells

Effector

1) liver
2) skeletal cells

Secrete glucagon

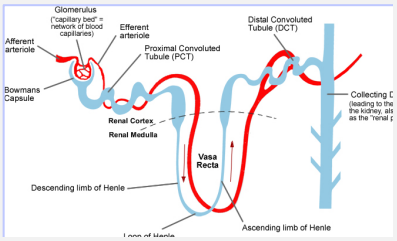
Osmoregulation

Stimulus

↑ Osmotic pressure in blood

Negative feedback

↓ Osmotic pressure in blood



Receptor

Osmoreceptors in the hypothalamus

Response

↑ Permeability of DCT & collecting tubules

↑ Reabsorption of water and concentrated urine

Modulator

Hypothalamus

Effector

Distal convoluted tubules& collecting tubules

Posterior lobe releases ADH

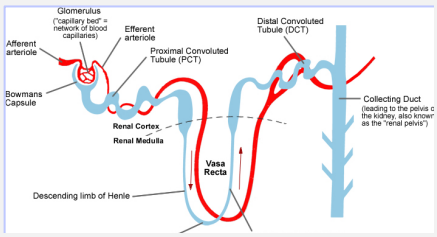
Osmoregulation

Stimulus

↓ Osmotic pressure in the blood

Negative feedback

↑ Osmotic pressure in the blood



Receptor

Osmoreceptors in the hypothalamus

Response

↓ Permeability of DCT & collecting tubules

↓ Reabsorption of water and dilute urine

Modulator

Hypothalamus

Effector

Distal convoluted tubules & collecting tubules

Posterior lobe released low levels of ADH

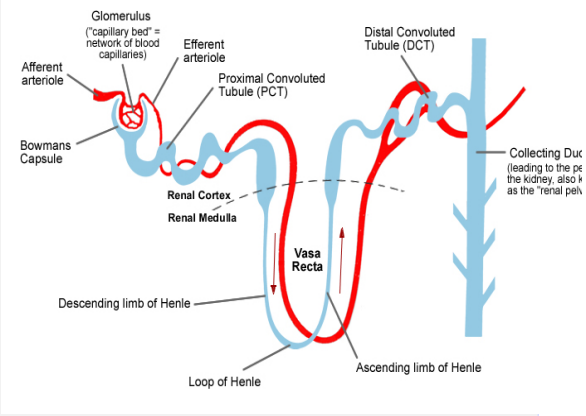
The Nephron

URINE FORMATION

1. Glomerular filtration
   High blood pressure forces water and small molecules out into the capsule

2. Reabsorption
   Filtrate goes through PCT, loop of Henle, DCT and collecting duct
   Loop of Henle and PCT is where osmosis of substances occurs back into the peritubular capillaries
   DCT is where the active reabsorption of water by ADH

3. Secretion
   Some materials needed to be removed are secreted from capillaries into the tubules



ANTI-DIURETIC HORMONE

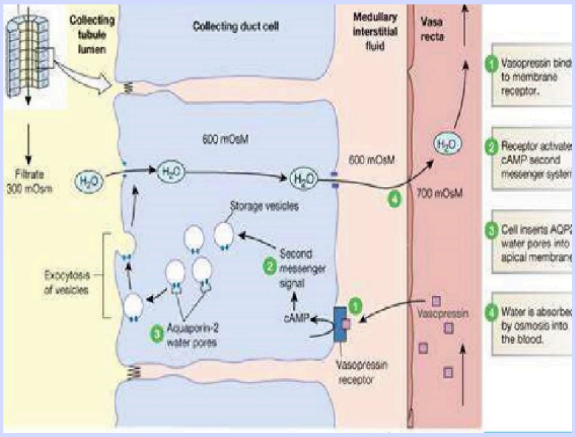
Amine hormone

Controls reabsorption of water

Decreases osmotic pressure

Increased ADH – increased permeability and water moves into capillaries = high concentration of urine (less urine)

Released from the posterior pituitary



ALDOSTERONE

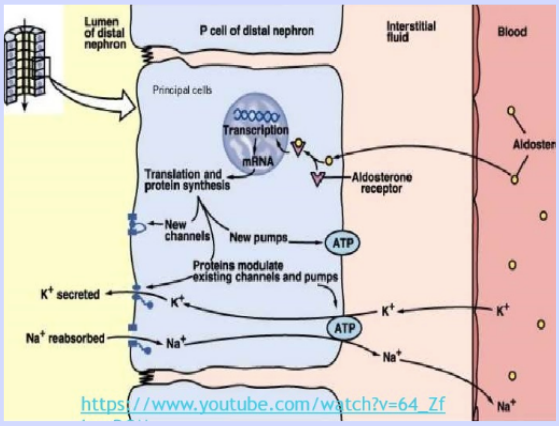
Steroid

Controls reabsorption of sodium

Decreases osmotic pressure

Increased aldosterone – increases reabsorption of sodium in the blood as well as obligatory reabsorption of water

Released from the adrenal cortex



IMMUNE SYSTEM

NON- SPECIFIC DEFENSES

EXTERNAL DEFENSE

BODY'S EXTERNAL DEFENCE AGAINST PATHOGENS

	LOCATION	SPECIFIC FEATURE	ACTION
SKIN	SKIN	water-proof barrier	- prevents pathogens penetrating and entering the internal system - bacterial colonies on surface make entrance of pathogens difficult
	SEBUM	oily secretion that is slightly acidic	- acidity makes environment hostile to may pathogens
	SWEAT	secretion of water, salts, wastes and fatty acids from skin	- salt and fatty acid prevents growth of pathogens
DIGESTIVE TRACTS	MUCOUS MEMBRANES	secretes mucus onto inner lining of digestive tract	- prevents bacteria entering the organs of the body
	ACID SECRETIONS	acidity kills bacteria and reduces their growth	- creates a hostile environment for bacteria's
URINOGENITAL TRACTS	URETHRA HAS HCL	prevents build-up of pathogens	- creates a flushing or cleansing action that eliminates bacteria
THE MOUTH	SALIVA	contains lysozyme, an enzyme that kills bacteria	- creates a flushing or cleansing action that eliminates bacteria
	MUCUS	secretes mucus into nasal cavity	- traps pathogens
THE NOSE	CILIA AND HAIRS	tiny hairs that trap micro-organisms	- move pathogens out of respiratory tract with wave-like contractions
THE EAR	CERUMEN	slightly acidic and contains lysozyme	- breaks down bacteria and prevents entry
THE EYE	FLUSHING ACTION	contains lysozyme	- tears prevent bacteria from growing

The Inflammatory Response

A generalised response to all pathogens in response to all tissue infections or injuries

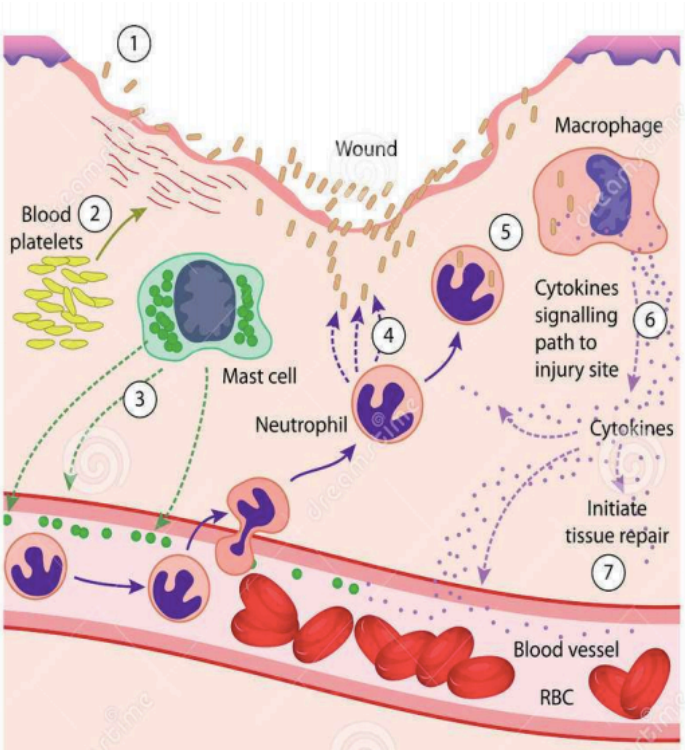
Purpose and Signs

Purpose:

- To reduce the spread of pathogens
- Destroy and prevent entry of more pathogens
- Repair or remove damaged tissue

Signs:

- Redness: increased blood flow
- Swelling: fluid seeping out of cells
- Heat: blood flows at 37°
- Pain: mechanical break



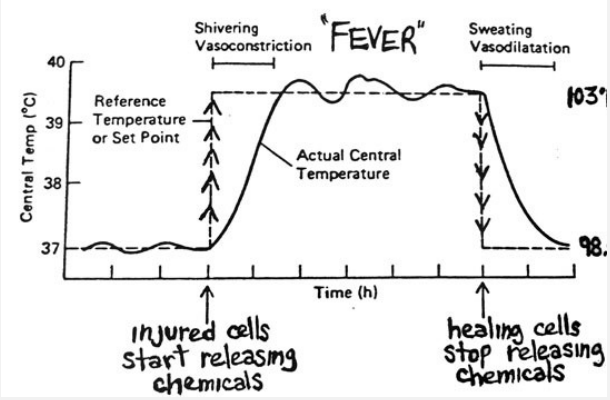
Response

1. Break or tear in skin causing mast cells to release histamine and heparin
2. Histamine increases blood flow and permeability of capillaries to help fluid filter in blood
   Heparin prevents clotting anywhere other than the infected area
3. Histamine releases phagocytes (macrophages) to digest micro-organisms and cell debris
4. Pain receptors are stimulated (signs of inflammation occur)
5. Phagocytes (macrophages) die and form yellow substance called pus
6. Mitosis occurs to produce more cells and repair old ones

The Fever

Occurs during infection to increase body heat in order to stop and kill bacteria from growing

1. Feelings cold because the body resets the body temperature to 39.5°
   Vasoconstriction of capillaries and shivering of skeletal muscle cells occurs, so the body temperature goes up
2. Fever breaks – body temperature goes back to original 37°
   Sweat glands produce sweat and bacteria has been destroyed
3. Body temperature goes back to normal

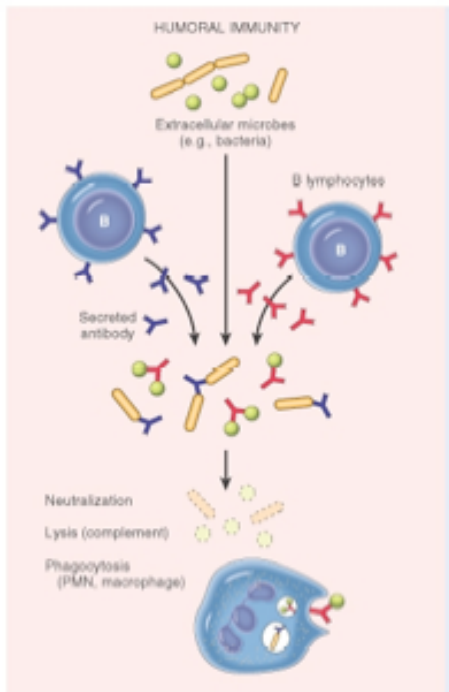


SPECIFIC DEFENSES

Humeral/ Anti-Body Mediated Response

Response

1. Antigen present in the blood or lymph
2. Bacteria is engulfed by macrophage (phagocytosis)
3. Lysosome is within vesicle, joins with bacteria
4. Enzymes will break down bacteria and broken into tiny pieces
5. Cell debris, exocytosis
6. (presents antigen to surface)
7. Helper T-cell attaches and reads antigen: Antigen-antibody complex
8. Releases and sends cytokines to activate B cells
9. B cells become sensitized
10. Specific B-cells enlarge and divide- creating clone
11. Creates memory B-cells and Plasma cells
    Plasma cells create antibodies which bind to antigens
    Memory cells remember antigen for next time

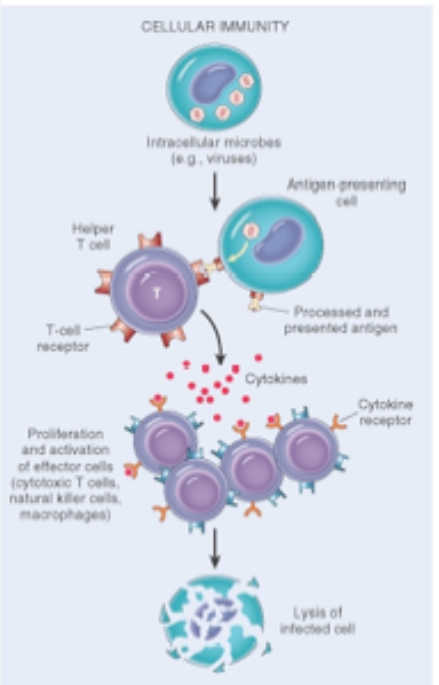


Memory cells:
- Inactivate substances (make a soluble substance insoluble)
- Prevent virus from entering cells
- Coat bacteria for macrophages to come and engulf
- Agglutination (all clump together)

Cell Mediated Response

Response

1. Pathogen/antigen is present in a cell
2. Bacteria is engulfed by macrophage (phagocytosis)
3. Lysosome is within vesicle, joins with bacteria
4. Enzymes will break down bacteria and broken into tiny pieces
5. Cell debris, exocytosis
6. (presents antigen to surface)
7. Helper T-cell attaches and reads antigen: Antigen-antibody complex
8. Releases and sends cytokines to activate T-cells
9. T-cells become sensitized
10. T-cells enlarge and divide to create clone
11. Creates memory cells, killer T-cells, Helper T-cells and suppressor T-cells



- *Killer T-cells:* attaches to antigens and destroy them (lysis of a pathogen)
- *Helper T-cells:* secrete substance to attract more macrophages/lymphocytes
- *Memory T-cells:* remember antigen for next time
- *Suppressor T-cells:* lowers immune response once
- pathogens are killed

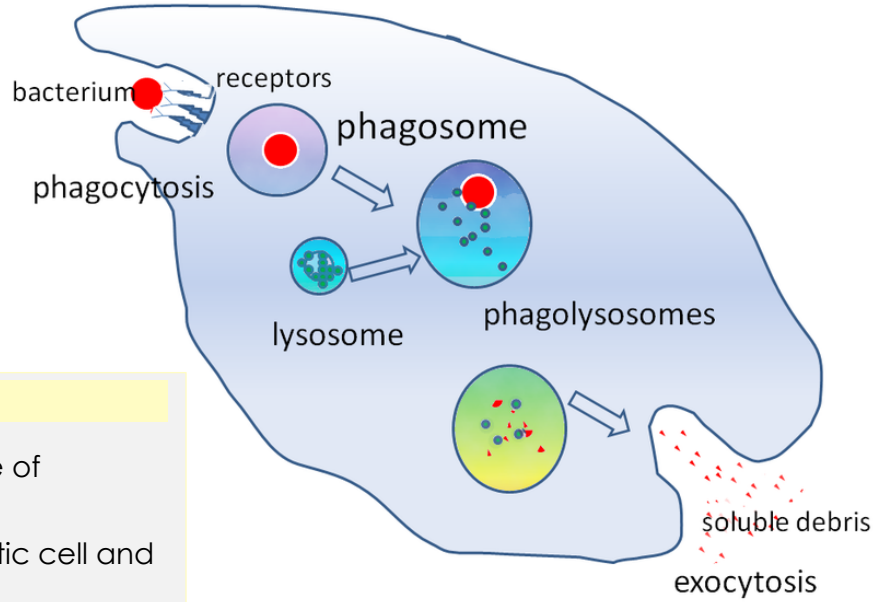
PHAGOCYTES

Cells that undergo phagocytosis (cell eating)

- Macrophages
- B-cells
- Dendritic cells

Protect against:

- Foreign organisms
- Alien chemicals
- Cancerous/ abnormal cells



Phagocytosis

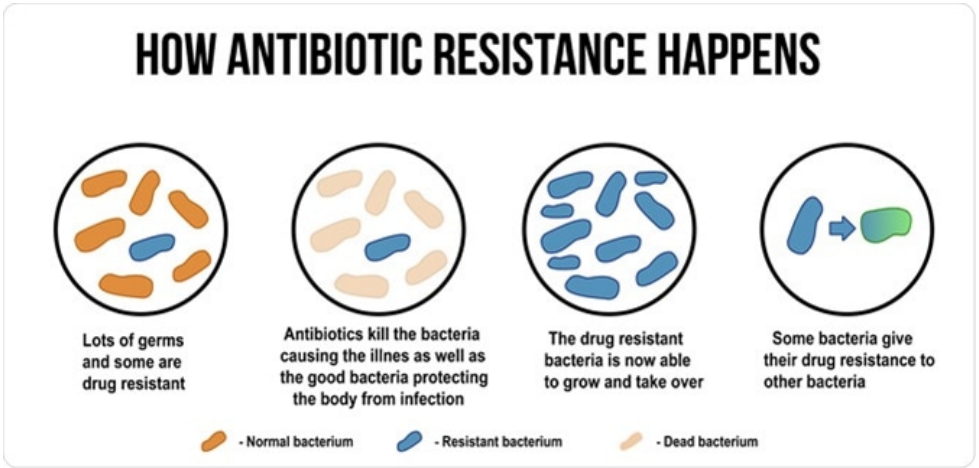
1. Phagocyte is attracted to surface of bacteria
2. Vacuole forms inside of phagocytic cell and lysosome binds to vacuole
3. Digestive system breaks down microbe
4. Soluble debris leave by exocytosis

ANTIBIOTICS

Mode of action

- Cell wall synthesis inhibiters: antibiotics will stop cell wall from producing
- Interfering protein synthesis
- Cell membrane inhibiters: destruct the cell membrane
- Effect on nucleic acids
- Competitive inhibitors: completely inhibit reactions on the metabolic pathway

Bactericidal	Bacteriostatic
Kills the organism	Inhibits the growth
Changes structure of cell wall	Disrupts protein synthesis
	Relapses can occur



IMMUNITY

The resistance to infection by invading micro-organisms. The body's ability to respond quickly to pathogens may be natural (without human intervention) or artificial (given an antibody or antigen).

	NATURAL IMMUNITY (occurs without human intervention)	ARTIFICIAL IMMUNITY (results from people being given either an antigen or antibody)
PASSIVE (given antibodies produced by someone else)	- person is given antibodies from someone else - immune system NOT activated - NO memory cells formed (= NO immunity acquired) - protection immediate but only temporary - (Not long lasting ~ 2 weeks) - Eg: mothers breast milk/ placenta passes antibodies to foetus	- person is given antibodies from someone else - immune system NOT activated - NO memory cells formed (= NO immunity acquired) - protection immediate but only temporary - (NOT long lasting) - Eg: influenza/tetanus/rabies antibodies injected into bloodstream to combat an infection
ACTIVE (exposed to foreign antigen, makes own antibodies)	- Immune system IS activated - Body makes own antibodies in response to foreign antigen - memory cells ARE created - Long lasting immunity - Eg: chicken pox	- Person is given antigens - Body makes own antibodies in response to foreign antigen - memory cells ARE created - Long lasting immunity - Eg: antigens given in vaccination: living attenuated MMR injected into bloodstream

Vaccinations

The process where a person is made immune or resistant to an infectious disease by artificial administration of antigens of pathogenic organism, causing individual to produce antibodies without suffering the disease.

Types of vaccines

1. Attenuated: contains living organisms with reduced ability for disease
2. Dead micro-organisms: not long lasting but provide immune response
3. Toxoids: toxins produced by bacteria are inactivated and then injected
4. Sub-unit: fragment of organism used to provoke immune response

Risks with vaccinations

- Allergic reaction: vaccine or medium it is cultured in an egg or yeast
- Live-tissue cultures: risk of cross-species disease introduction
- Chemicals used: preservatives in manufactures or vaccines like aluminium or phosphate

BACTERIA VS VIRUSES

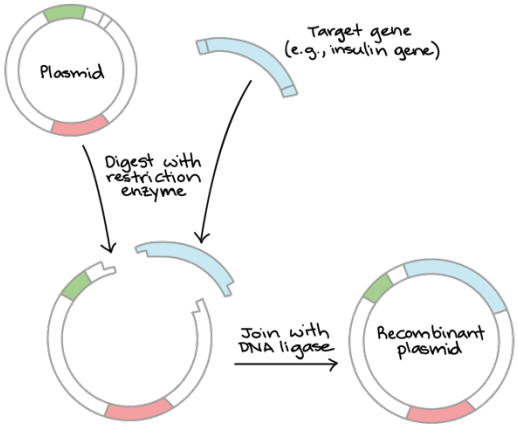
	BACTERIA	VIRUSES
LIVING/NON LIVING	Living organisms, live independently	Non-living organisms as they cannot reproduce by themselves (need host)
SIZE	- Single celled - 200 to 5000nm	- 20 to 40nm in diametre - Not seen under normal light microscope
STRUCTURE	- Has a cell wall made of carbohydrate-protein (peptidoglycan) - Contains slime layer - Granular due to ribosomes - No nucleus or organelles	- True protein coat over nucleic acid - Lipid-protein envelope - No cell wall, nucleus or organelles
RNA OR DNA	- Contains both - Forms a tangle inside the cell called plasmid	Has either DNA or RNA not both
DISEASES	- Syphilis - Salmonella - Bubonic Plague - Chlamydia - Tuberculosis	- Influenza - HIV/AIDS - Measles - Ebola - Chickenpox
TRANSMISSION	- Touching infected surfaces - Direct contact - In water droplets	- Person to person via body fluid - Environment to person - Animal to person
REPRODUCTION TYPES	Binary Fission	Host cells
	- Cocci (spherical) - Bacilli (Rod shaped) - Spirilla (twisted cells) - Vibrio (tear shaped)	N/A

RECOMBINANT DNA

Genome that has been altered by the transfer of a gene or genes from another organism

Process

1. HBsAg (viral surface antigen) gene is isolated
2. Plasmid DNA is extracted from E. coli and cut with restriction enzymes (Eco RI)
3. This plasmid will serve as the vector
4. HBsAg inserted into bacterial plasmid vector forming recombinant DNA
5. This recombinant DNA is introduced into yeast cell
6. Recombinant yeast cell multiples in the fermentation tank and produces HBsAg
7. Yeast cells are ruptured to free HBsAg
8. HBsAg purified
9. HBsAg mixed with preserving agents and other ingredients and bottled ready for vaccinations



Ethical considerations

Economical – potential for ecological harm on environment
Social – what is sustainability and how can it be measured?
Religious – playing god with artificial termination of pregnancy
Safety – how to protect researchers working with it from infection

BIOTECHNOLOGY

The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for human purposes.

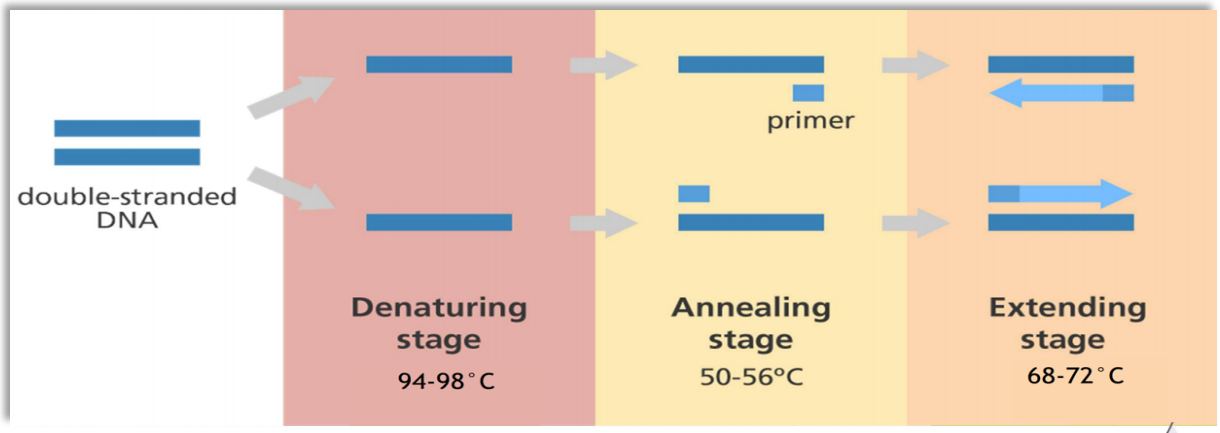
Polymerase chain reaction (PCR)

Series of repeated cycles to artificially multiply DNA

1. Denaturing stage – 94°
- Heating of double stranded DNA
- Disrupts hydrogen bonds between complementary bases
- Separation of the strands

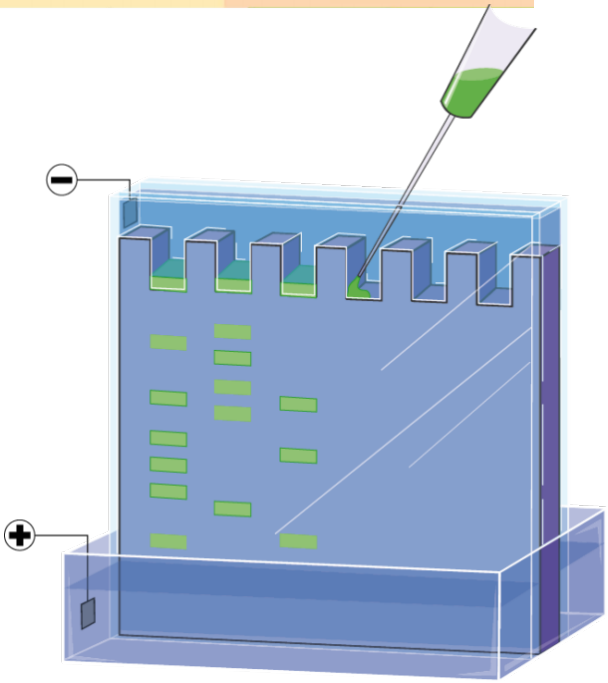
2. Annealing stage – 55°
- Lowered temperature
- Primer is a small single strand of DNA
- Binds complementary base sequences
- Starts DNA replication process

3. Extending stage – 72°
- DNA polymerase can't withstand repeated cycles and undergoing the denaturing stage, therefore Taq polymerase is added
- Taq polymerase binds to the primer
- Taq polymerase synthesizes complementary DNA strand



Gel Electrophoresis

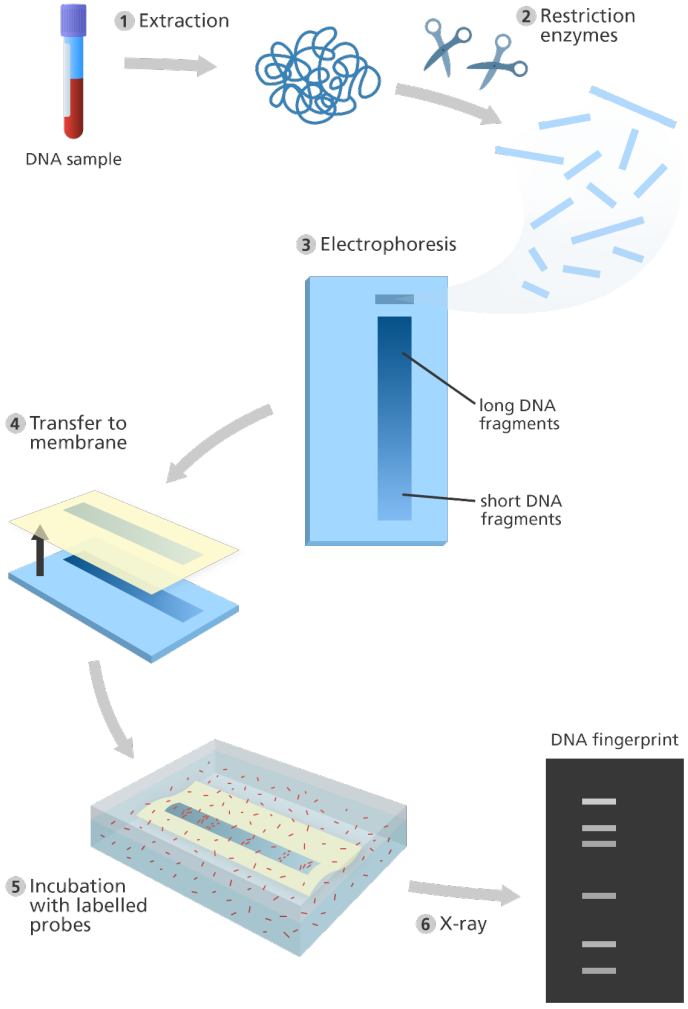
1. An electric current is passed through an agar gel to separate fragments of different sizes of DNA (negatively charged)
2. The negatively charged DNA moves towards the positive electrode (smaller fragments travel further, and larger fragments travel less)
3. Comparisons are made by different individuals (only if same restriction enzyme was used)
4. Banding pattern formed during gel electrophoresis forms a DNA profile for that individual called a genetic fingerprint



DNA profiling

Used to identify individuals based on the banding pattern of fragments of DNA

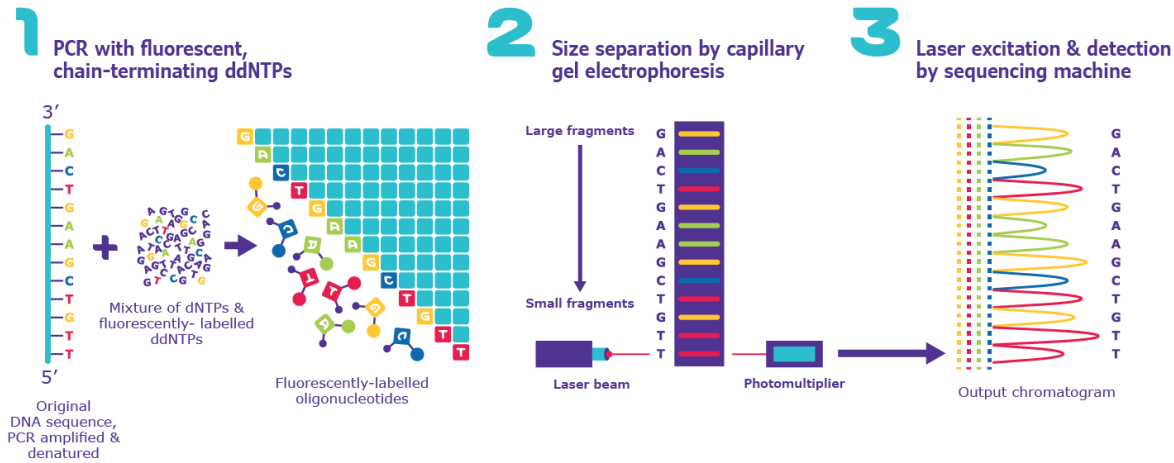
1. Separate white and red blood cells with a centrifuge
2. Extract DNA from nucleus of the white blood cells – done by heating cells
3. Cut DNA stand into fragments using a restriction enzyme
4. Place fragments into one end of a bed of agarose gel with electrodes in it.
5. Use an electric current to sort the DNA segments by length – called gel electrophoresis when negatively charged molecules move through the gel with electricity. The shorter strands will move farther away from their location whereas longer strands will move slower and stay closer to original location.
6. Use a sheet of nitrocellulose to blot the DNA, to create an autoradiograph – the DNA profile.



DNA sequencing

Determining the precise order of nucleotides in a sample of DNA

1. DNA is denatured by heating to a high temperature (96°) - form single stranded DNA
2. Primer is attached to DNA template strand and is equally distributed into 4 tubes. DNA polymerase is added
3. Different DNA nucleotides are placed as well as dideoxy nucleotides (minus hydroxyl)
4. Process is repeated, the dideoxy inserted at different points, forming different lengths of DNA strands
5. Gel electrophoresis is used for fragments of different lengths. Shorter travel the furthest
6. Sequence can be determined by going from longest strand, (3' end) to shortest strand (5' end).



Gene Therapy

Therapy which aims to replace faulty genes with healthy ones (not treat symptoms, cure disease)

In-vivo

1. Gene inserted into a viral/non-viral vector
2. Vector is injected into a patient
3. Vector unloads genetic information into defective cells

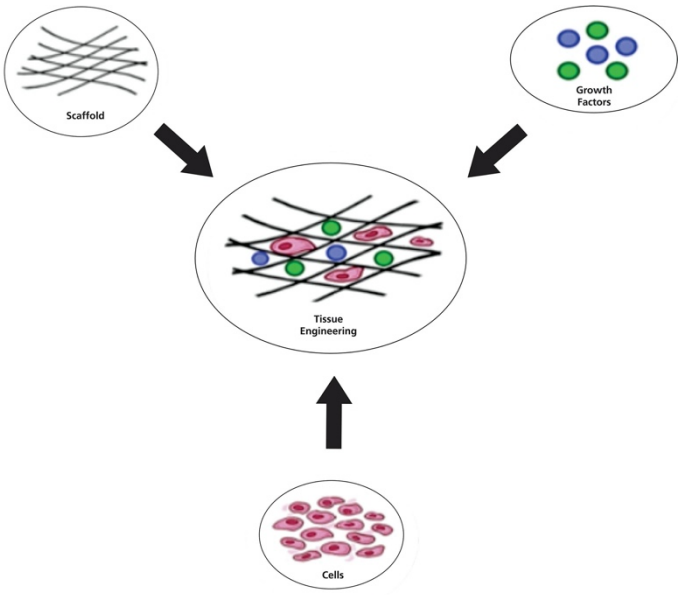
Ex-vivo gene therapy

1. Collection of cells from the patient – removed from the body
2. Healthy gene (replacement gene) for beta cells packaged within a virus that acts as a vector
3. Virus is inserted into stem cells
4. Genetically modified cells are multiplied in the laboratory
5. Corrected cells administered in patient
6. Cells continue to multiply to produce insulin

Tissue Engineering

The use of a combination of cells and factors to improve and replace functions of old cells, and repair damaged tissues and organs.

1. Disease free cells are induced to grow on a scaffold
   Scaffold – provides nutrients and are highly porous
2. Cells manufacture own matrix structure on the scaffold
3. Scaffold is implanted into the patient where new tissue is required
4. Scaffold degenerates leaving the new tissue



Cell Replacement Therapy

Where cellular material is injected into a patient

Alzheimer's Disease – forms of dementia and damaged nervous tissue

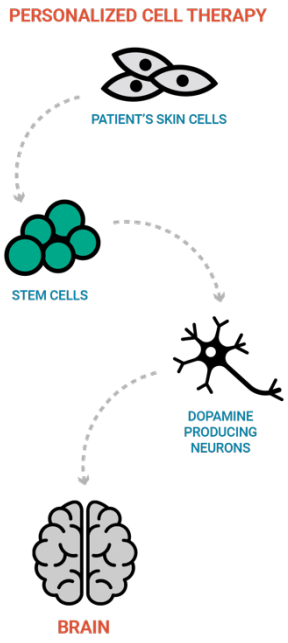
There are no stem cell treatments that are approved for this disease

- Neural stem cell transplants have been given to mice with diseases similar with positive feedback – the progress

Parkinson's Disease – shaking, slow movement and muscle stiffness

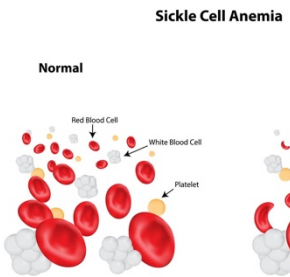
Replacing people's dopamine levels with sympathetic relief

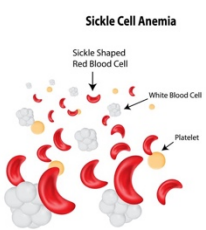
- Using pluripotent stem cells to induce and differentiate stem cells to create dopaminergic neurons

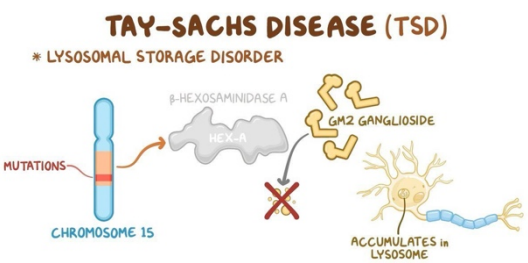


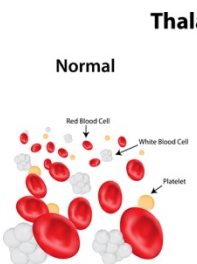
Genetic diseases

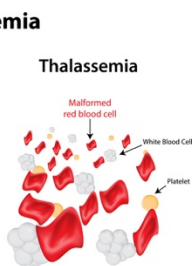
	POPULATION IN WHICH PREVALENT	CAUSE	MAIN SYMPTOMS	HOW INHERITED	EFFECT ON GENE POOL
Sickle Cell Anaemia *A recessive gene mutation which is fatal*	Black Africans	-Mutation in chromosome 11 that causes production of haemoglobin -Erythrocytes fold over into sickle shape and stick to each other -Not enough healthy RBC's	-Anaemia – body can't get enough oxygen -Pain – blocked veins	Recessive autosomal allele Areas where malaria is prevalent, tropical areas	-Protection against malaria
Tay-Sachs Disease *Hereditary disorder of lipid metabolism*	Eastern European Jews (Ashkenazi Jewish Population)	-Deficiency of enzyme hexosaminidase A -Accumulation of fatty substance in NS	-Muscular stiffness/ no strength – signals not to motor neurons -Accumulation of lipid in retinal ganglion cells – red spot on eye	Recessive autosomal allele Overcrowded, isolated conditions	-Sometimes resistance against TB -Little effect
Thalassemia (alpha and beta) *Inherited blood disorder, less haemoglobin than normal*	Mediterranean's, African Americans, Southeast Asians, Middle Easterners	-Changes in HBB gene (beta) and deletion of HBA1 and HBA2 genes (alpha) -Mutations in the DNA of cells that make haemoglobin -Fewer haemoglobin / RBC's	-Anaemia/ fatigue – lack of oxygen being transported to tissues and organs -Dark urine - bilirubin from broken down red blood cells	Recessive autosomal allele Passed from parents to children – ancestry	-Resistance to malaria





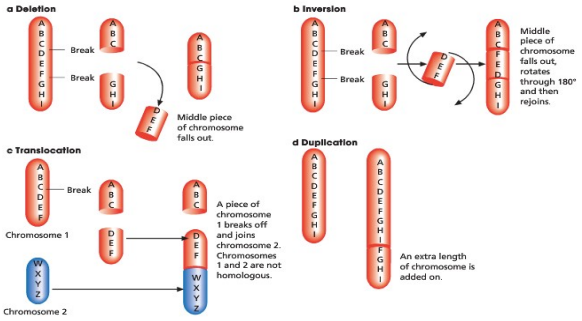






MUTATIONS

Are variations in offspring that occur suddenly and by change



Caused by:

- Errors in DNA replication
- During cell division
- Damage caused by mutagens

1ST WAY TO CLASSIFY MUTATIONS:

Gene Mutations

Changes in a single gene so that the traits normally produced are changed or destroyed during DNA replication. The simplest form of mutation is point mutation in which only a single nucleotide is affected.

- Substitution: a base is substituted with an incorrect base
- Insertion: a base is added causing a frame shift
- Deletion: one nitrogen base is deleted causing a frame shift

Cystic Fibrosis - caused by gene mutation on chromosome 7 coding for protein that regulates passage of chloride ions across cell membrane,

Muscular dystrophy – mutation in the mother inherited by sons.

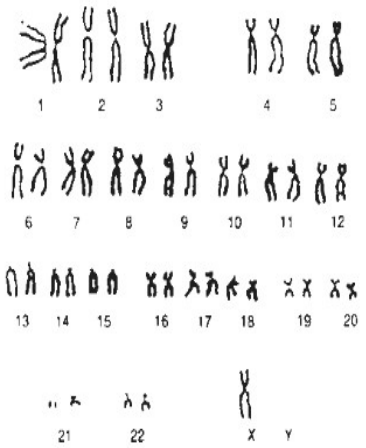


Figure 12.7 Karyotype for Turner's syndrome

Chromosomal Mutations

Involves all or part of chromosomes are affected and occurs during cell division.

1. Deletion – double strand breaks cause sections of chromosomes to drop and two ends re-join to make shorter chromosomes
2. Inversions – chromosome breaks and flips 180° before it re-joins, reversing normal sequence
3. Translocation – a section of the chromosome breaks off and reattaches with another
4. Duplication – occurs when an extra copy of a DNA sequence is made and inserted into the chromosome
5. Non-disjunction – during meiosis, chromosome pairs don't divide evenly, and daughter cell has more and the other has less

Trisomy is the addition of an extra chromosome into a daughter cell which then becomes a zygote.

- Down syndrome - (trisomy 21) occurs when a when a child has an extra chromosome 21. Many of the symptoms of down syndrome may occur when partial trisomy occurs
- Patau Syndrome - when an extra chromosome 13 produces individuals with mental retardation, small head, cleft lips and extra digit on each hand.

Monosomy is when an individual is missing a chromosome, only having one copy instead of two. In some cases this can result in a miscarriage.

- Turner's Syndrome - monosomy X, these females are short in stature, lack secondary sex characteristics and are infertile

Mutagens

- Resemble proteins and be incorporated into DNA
- Can trigger DNA replication errors
- Can cause DNA breakages/ lengthening
- Can block DNA replication and damage DNA structure
- Can chemically react and modify DNA
- Cells with damaged DNA multiply

Physical mutations:

- Distortions of double helix
- X rays' gene and chromosome aberrations
- UV light causes structural distortion

Chemical mutations:

- Substitution of one base or another
- Blocks DNA repairing
- Disrupts the packing of DNA

2ND WAY TO CLASSIFY MUTATIONS:

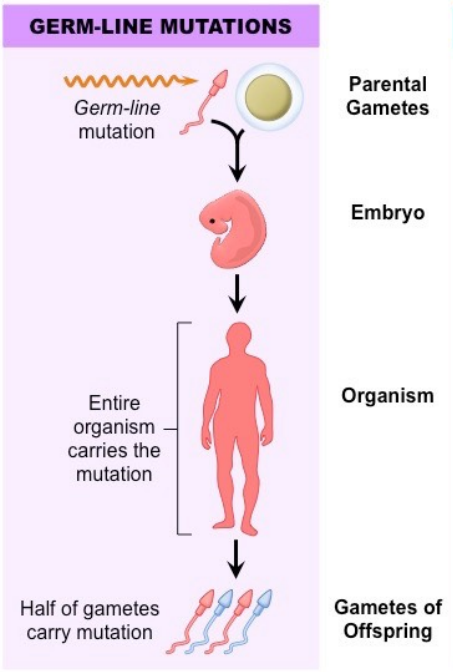
Germline Mutations

Mutation of the gametes

The individual in whom the mutation occurs is not affected though the gametes have changed DNA

The mutation is passed onto the daughter cells and often the zygote fails to develop.

e.g. phenylketonuria (PKU)



Somatic Mutations

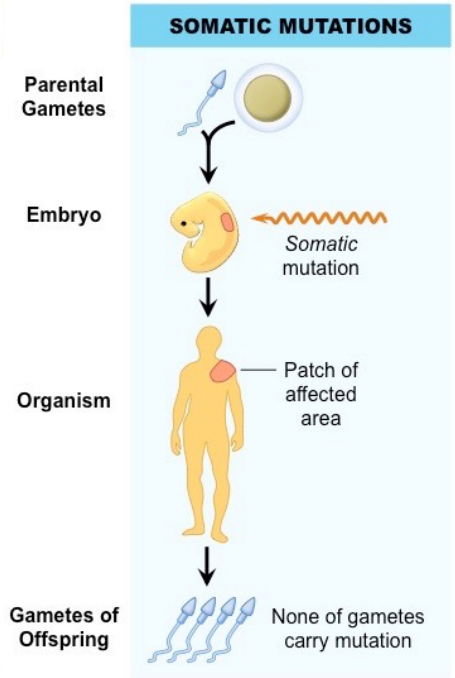
Mutation of the body cells

Results in the individual being affected by the mutation.

Somatic cells divide and pass mutation onto the daughter cells and once this individual dies the mutation is lost

Cannot be passed onto offspring because they don't affect the reproductive cells.

e.g. cancer



GLOSSARY

Species – a group of individuals that share characteristics and can interbreed under natural conditions for fertile offspring

Alleles – alternative forms of a gene

Population – groups of organisms of the same species living together in the same place at the same time

Geneticists – characteristics of the population are studied and not those of the individuals in the population

Gene pool – sum of all the alleles in a given population

Allele frequencies – how often each allele of a gene occurs in the gene pool

Mutagens – agents that are known to increase the rate pf mutations

GENE POOLS

A sum of all the alleles in a population. Populations reflecting the frequency of alleles of a particular gene and are used to compare populations at different times and locations.

Changes are caused by:

- Mutations
- Different selection pressures
- Random genetic drift or founders' effect
- Changes in gene flow between adjoining groups

Evolution

The gradual change in a species characteristic in a long period of time

- Random assortment – of chromosomes during meiosis
- Crossing over – of chromatids during meiosis resulting in a changed sequence
- Non- disjunction
- Random fertilization – there is an infinite number of possible combinations of alleles
- Mutations

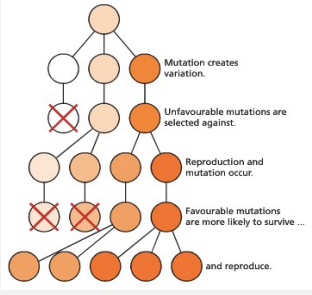
Darwin's observations of evolution

1) Variation – members of a species vary, and the variations are passed from one generation to the next
2) Birth rate – all living organisms reproduce at a rate greater than food supply increases
3) Natures balance – species number remained at a relatively constant rate

Natural selection

Survival of the fittest when nature favours on a set of alleles at the expense of the others. The alleles best suited to their environment will survive and are passed on to next generations.

1. There is variation of characteristics within a species
2. More offspring are produced than can survive to maturity
3. Struggle for existence due to excessive birth rate and limited resources
4. Individuals with characteristics best suited to environment are advantaged – survival of the fittest
5. Favourable characteristics are passed on to the next generation
6. Allele frequency for favourable characteristics increases in population



Speciation

Occurs when a single population becomes 2 separate populations that are unable to breed

1. Variation – within the population that share a common gene pool
2. Isolation – a barrier has formed, dividing the population into 2, no interbreeding occurs (have their own gene pools)
3. Selection – different selection pressures act on the 2 populations bringing a change in the gene frequencies
4. Speciation – over long period of time, 2 groups can no longer interbreed for fertile offspring and a new species has been formed

Types of Evolution

Random genetic drift

In small populations there is random, non-directional variation, known as genetic drift, which is purely a chance occurrence. It affects smaller and isolated populations where changes in allele frequencies are more noticeable and % change is more drastic

- Example: The Islands of Bentinck and Mornington were once connected to the mainland, but rising sea levels cut them off = isolated their populations
- Islander populations had allele frequencies HIGH in I^B blood types, I^A was absent.
- Mainland population had allele frequencies low in I^B blood types, I^A occurred in higher frequency

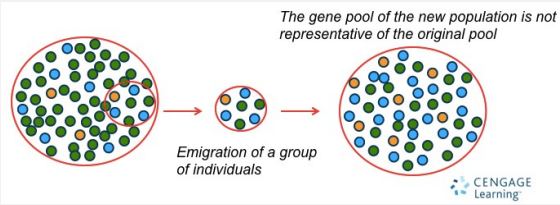
Bottleneck effect

The extreme example of genetic drift when size of population reduces due to catastrophic events, adverse conditions and when the original gene pool cannot be recovered.

Example: when the cheetahs survived bottleneck effect

The founders effect

When a small group moves away from the original population, founding a new area. The migrant group is small and usually their alleles do not express all of the alleles of the original population.
Example: Amish people who have moved to remote areas, at least one of the 200 had the recessive allele for Ellis-Van Creveld syndrome, making it more common amongst this small population as they interbreed



Migration

The gene flow, or movement of genes, from one population to another. Gene flow may occur if migrants breed with one another.

- Immigrants may add new alleles to one gene pool and immigrants may remove some alleles from another

Example: The increase in B blood group in Indigenous Australians due to migration of people from Asia and Europe

Barriers to Gene Flow

Populations are separated from each other and different selective environmental pressures exist, some traits are favourable over others. Separate gene pools develop and allele frequencies show differences between the separate populations

Geographical barriers - created by physical isolation and boundaries such as oceans, mountains, lake systems, deserts or ice

Sociocultural barriers - created by religion, culture, education, ethnicity and status which may prevent some people from breeding and cause inbreeding in other populations

EVIDENCE FOR EVOLUTION

- Comparative biochemistry
- Comparative anatomy
- Fossils

COMPARATIVE BIOCHEMISTRY

Comparative Genomics

Comparing the genomes of organisms of different species
Effective for:

- Studying evolutionary changes amongst organisms
- Identifying genes that are preserved in a species
- Identifying genes that give an organism traits

This is found by using bioinformatics to get comparison and can be used to create phylogenetic trees

Mitochondrial DNA

Circular molecules containing 37 genes

- There is higher rate of mutation in mtDNA
- Easier to access and locate
- Can track ancestry of many species
- Can track migration routes

Comparing mtDNA from one person to another (maternal inheritance) the more similar mtDNA, more related they are

Protein Sequences

Comparing the type and sequence of amino acids in a protein from different species to determine the degree of similarity.

Ubiquitous proteins – proteins that are in all species
The more similarity between 2 molecules the more recently they have evolved from a common ancestor

e.g. cytochrome C (how many AA's out of 104 are similar)

Bioinformatics

Uses computers to describe the molecular components of living things
Annotation: when genes and biological features in a DNA sequence are analysed
Used for:

- Measuring changes in DNA to determine evolution
- Comparison of entire genomes
- Using various programs and databases to determine shared data

Comparing DNA

All living things use the same nucleotides to construct DNA so species more closely related will share portions of DNA.

Endogenous retrovirus – only endogenous if inserted into gamete – so inherited by next generation so offspring will have ERV in same location

DNA hybridization – when strands are heated to separate as cooling – the attraction make them bond back together

COMPARATIVE ANATOMY

Embryology

Embryos of different vertebrates show similar stages in embryonic development. Compares early stages of development in organisms to show common ancestors

Vestigial organs

Entirely functionless structures

- Had a purpose at one time in ancestry
- Reduced in size over time

e.g. coccyx

Homologous & analogous structures

Homologous – divergent
Similar in structure but differ in function. Same bones appear in different forms to use for different function
Analogous – convergent
Structures that evolve separately but similar functions

FOSSILS

Fossils

Any preserved trace left by a previously living organism

Used for:

- Determining what extinct species were like
- Develops picture of what life was like
- Develops sequence of evolution in certain organism

Needs:

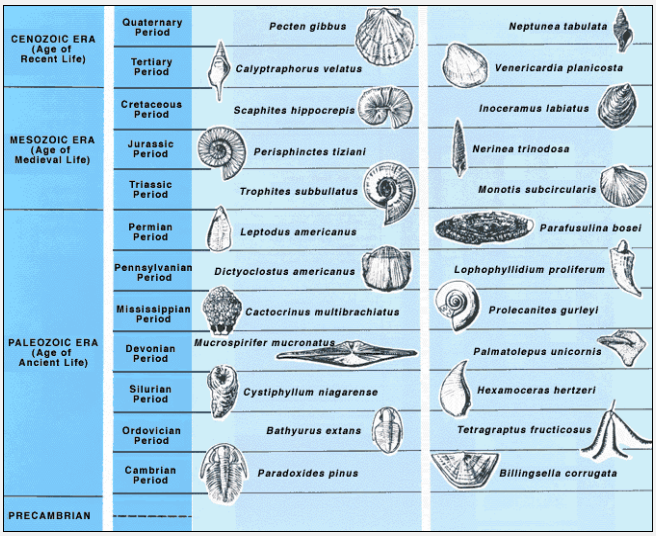
- Rapid burial by drifting sand, mud or volcanic ash
- Presence of hard body parts
- Bone preservation – alkaline soils
- Long periods of stability
- Soft tissue preservation – wet acidic soil w/ no oxygen

Conditions:

- Shallow lakes, marshes or swamps
- Trapped in ice – low temp stop decay
- Dry cave deposits – soft parts decay

Problems with fossil record

- Conditions for fossilization rarely occur
- Problems with dating techniques
- Seldom find complete fossils
- Fossils have been disturbed
- Fossils are not found yet



DATING MECHANISMS

Determining the age of a fossil or artefact. BP = before present

ABSOLUTE DATING

Carbon 14 dating

Compares the radioisotope C14 to normal C12 in a fossil
Half-life – 5730 years
Can date organic material up to 60 000 years old
Can only date small amounts

Potassium argon dating

Counts the Ar40 atoms trapped inside minerals and compares this to the K40 ratio
Half-life – 1.25-1.3 billion years
Can date after 100-200 million years
Slow yet constant rate

Tree ring dating

Counting the rings in the layers of wood to determine the age of trees. Comparing rings in fossil trees with living trees so age can be determined.

- Rings differ in width according to how favourable the growing season was

RELATIVE DATING

Stratigraphy

Study of layers or strata

- Principle of superposition: assumption that in layers of sedimentary rock, the layers on top are younger)
- Correlation of rock strata: matching rocks from different areas
  Fossils or artefacts can be buried by animals after deposition of sediment

Index fossils: were widely distributed and present for a short period of time

Fluorine dating

Fluoride ions in soil water move into bone and replace ions in the bone

Fossils with the same amount of fluorine In them can be assumed that they are the same age
The more fluorine = the older the specimen

EVOLUTIONARY TRENDS

Characteristics that enables an organism to survive and reproduce in its natural environment

EVOLUTIONARY TRENDS IN PRIMATES

	CHARACTERISTIC	TREND
DIGITS	Mobility	Increasing mobility in digits and ability to move independently, increase prehensility for climbing
	Opposability	First digit opposable to allow for manipulation
	Claws/nails	Nails instead of claws increases grasping technique
	Friction ridges and precision grip	Allows better grip & handle small objects effectively
DENTITION		36 teeth in lemurs, lorises and New World monkeys
		32 teeth in Old World monkeys, apes and humans
		Monkeys and apes have large projecting canines with diastema
		4 cusped molars in monkeys, 5 cusped in apes and humans
SMELL		Sense of smell reduced with gradual reduction in snout
VISION	Eyes	• Increasing efficiency in vision • Gradually forward-facing eyes for stereoscopic vision
	Eye socket	Eyes gradually become enclosed in bony socket to give protection
	Visual area of brain	• Increasing areas of cerebrum devoted to vision • Rods and cones which allow for light and colour
BRAIN	Size	Increase in size relative to body size and complexity
	Convolutions	Gradual increase in number of folds in surface of cerebrum to increase surface area of brain
	Cerebral cortex	Makes up increasingly large proportion of the brain
GESTATION		Increasing length between fertilisation and birth
DEVELOPMENT	Dependence	Increasing length of time offspring are dependent on parents
	Sexual maturity	Later development of sexual maturity

ADAPTATIONS FOR BIPEDALISM

LOCATION	FEATURE	DESCRIPTION	ADVANTAGE
SKULL	Foreman Magnum	Centrally placed at bottom of skull	- Better balance of skull, allows supported by vertebral column - Brings centre of gravity over feet
	Prognathism	Flatter face	Allows better balance of skull
PELVIS	Size	Shorter in length and wider, bowl shaped	Supports weight of upper body when standing erect Supports foetus during pregnancy Provide larger SA for attachment of buttocks muscles for walking
	Position	Tilted to vertical position	Lowers centre of gravity and brings balance over feet
CURVATURE OF SPINE	S-shaped curve	Lumbar curve	Positions trunk of body over the feet Carries weight of upper body
		Cervical curve	Positions head over the neck for smaller spinous processes Head is forward facing
	Femur	Carrying angle	Distributes weight and brings it towards outside of femur, over feet to allow for greater stability
		Long legs compare arms	Longer legs lower centre of gravity which increases stability Increase stride length when walking - Ability to hold tools whilst walking
	Knee	Strong outer hinge/ condyles	Supports weight due to carrying angle
		Can be straightened	- Allows for striding gait - Centre of gravity falls infant of knees
FEET	Toes	Larger calcareous bone	- Improves flexion - Takes weight when standing and walking
	Arches	Transversal arch	Shock absorber
		Longitudinal arch	Transfers weight distribution and energy efficiency

HOMININ ADAPTATIONS – PRIMATES TO HOMINIDS

Characteristics that enable an organism to survive and reproduce in its natural environment

Stance & Locomotion

FEATURE	DESCRIPTION	ADVANTAGE
MUSCLE TONE	Partial contraction of skeletal muscles	- Allows to keep head erect - Maintains equilibrium of the body
	Nervous system and sense organs work with spine, hip, knee, ankle and abdominal muscles	- Sustained muscle tone in muscles which support an upright position
STRIDING GAIT	Walking where hip and knee fully straighten	Allows to walk in straight line
	Big toe in line with other toes	Weight is transmitted from heel, to along outside of foot, across ball of foot and then propelled from big toe
SWINGING OF ARMS	Forward swinging of arms compensates for natural rotation of trunk around pelvis	- Less energy is expended - Keeps shoulders at right angle to direction of travel
CARRYING ANGLE	Femurs converge towards knees	- Allows weight distribution to remain close to central axis of body - Stability during walking as body can be rotated about lower leg - Walk in straight line

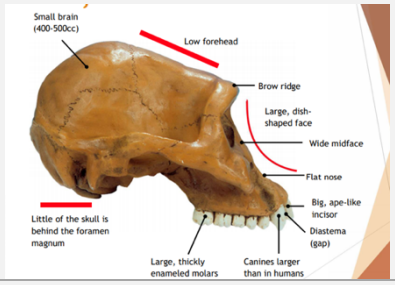
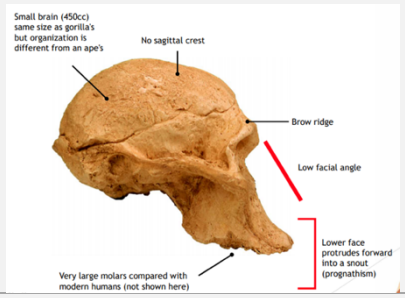
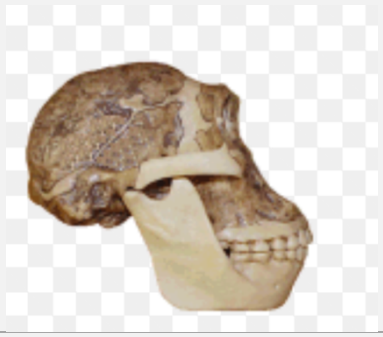
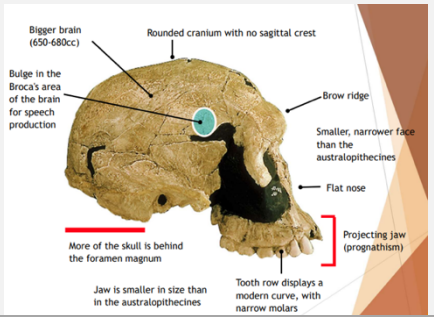
Size of Cerebral Cortex

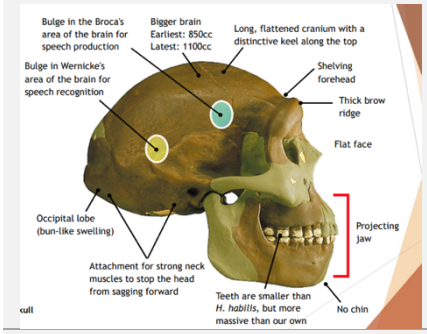
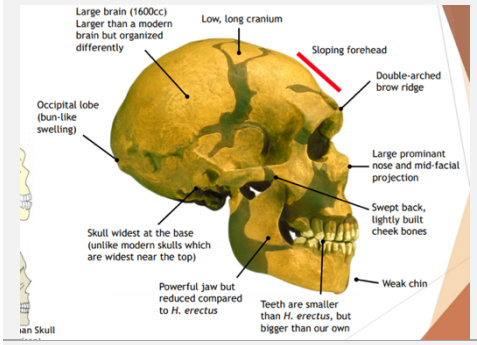
FEATURE	DESCRIPTION	ADVANTAGE
LARGE BRAIN SIZE	Human brain size is average of 1350cm whereas apes are between 400cm-500cm	- Increases cranial capacity (volume inside cranium) - Increased thinking capacity and abstract thinking - Higher proportions of cerebral cortex increases mobility
	Convolutions	Give a 50% increase in surface area which gives greater development of frontal lobe
	Frontal lobe	- Higher order of thinking, reasoning, planning and processing - Increase in size and convolutions
	Cerebral cortex	• Have much a larger cerebral cortex area than our direct ancestors and great apes • Site of higher function; vision, memory and reasoning • Allows development of special skills such as tool making
SKULL	Increased rounding of cranium and skull sized	More of skull is used to protect the brain and accommodate for larger frontal lobe
ENDOCASTS	Impression from inside of brain made from rock or other solid material	Reveals trends in number of convolutions and size of frontal lobe

Prognathism & Dentition

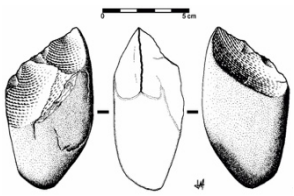
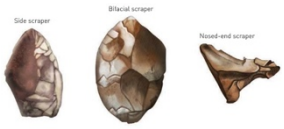
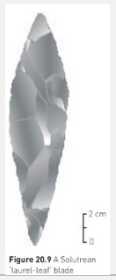
FEATURE	DESCRIPTION	ADVANTAGE
DENTAL ARCADE	U shaped in primates and more V shaped in humans	
SIZE OF TEETH	Absence in diastema	Allow more space in mouth to articulate speech
	Teeth size and molars reduced	No longer needed due to use in tools and softer foods developments
PROGNATHISM	Flattening of face, development of chin and more prominent nose	Allows frontal lobe to increase in size for higher order of thinking
BROW RIDGE	Sagittal crest disappeared	Humans able to hold neck up without large neck muscles
	Distinct forehead and reduction in brow ridge	Enlargement of cranial portion of brain to accommodate increasing size of frontal lobe

HOMININ TRENDS

	FEATURE	TREND
AUSTRALOPITHECUS AFARENSIS *(4-2.5mil years ago)* 	Structure of skull	• No forehead • Large brow ridge
	Cranial capacity	• Small cranial capacity • 430cm3
	Dentition	• Diastema • Large molars • Large canines
	Prognathism	• Large prognathic jaw
AUSTRALOPITHECUS AFRICANUS (3-2mil years ago) 	Structure of skull	• Small brow ridge • Round shaped head
	Cranial capacity	• Small cranial capacity • 457cm3
	Dentition	• Large teeth • Large molars
	Prognathism	• Large prognathic jaw
PARANTHROPUS ROBUSTUS (1.9-1mil years ago) 	Structure of skull	• Mohawk shaped head • Sagittal crest • No forehead • Large brow ridge
	Cranial capacity	• Small cranial capacity • 542cm3
	Dentition	• Large premolars
	Prognathism	• Wide jaw
HOMO HABILIS *(2-1.5mil years ago)* 	Structure of skull	• Smooth rounded cranium • Weak forehead • Small brow ridge
	Cranial capacity	• Small cranial capacity • 590cm3
	Dentition	• Smaller teeth
	Prognathism	• Small prognathism • Small jaw

HOMO ERECTUS *(1.8-250k years ago)* 	Structure of skull	• Chunky head • Occipital bun • Thick cranium • Chunky brow ridge • Weak forehead
	Cranial capacity	• Large cranial capacity • 1004cm3
	Dentition	• Large teeth
	Prognathism	• Projecting jaw • Large prognathism
HOMO NEANDERTHALENSIS *(300-30k years ago)* 	Structure of skull	• Occipital bun • Weak forehead
	Cranial capacity	• Large cranial capacity • 1485cm3
	Dentition	• Large teeth
	Prognathism	• No chin • Large jaw
HOMO SAPIENS *(30k-present)* 	Structure of skull	• True forehead • No brow ridges • Nose present •
	Cranial capacity	• Large cranial capacity • 1350cm3
	Dentition	• Small teeth • No diastema
	Prognathism	• No prognathism • True chin • Small jaw

TOOLS AND CULTURE

HOMININ	TOOL CULTURE	DESCRIPTION	IMAGE
AUSTRALOPITHECINES & *HOMO HABILIS*	OLDOWAN TOOLS • Simple, primitive, no predetermined design • Made from stones and pebbles	• Basic pebble tools • Choppers, scrapers, flakes and chisels • Used to smash open bones • Precision grip must have been employed with one round edge	
HOMO ERECTUS	ACHEULEAN TOOLS • Manufacturing of tools influenced social organisation • Included tools made from bones and stones	• Hand axes • Teardrop in shape flaked all around the edges • Worked on both sides – helped hunting	
HOMO NEANDERTHAL	MOUSTERISN INDUSTRIES • Production of stone flakes that could be trimmed to create various cutting, scraping, piercing and gouging tools	• Stones trimmed into disc-shaped core and struck by another piece to produce flakes • Aided in clothes making for cooler climates	
	AURIGNACIAN CULTURE • Used bone and stone to prepare finely and crafted tools	• Rectangular 'stone' blade tool with one or two sharp edges • Made by pressure flaking • Attached to branches to make axes	
HOMO SAPIENS	SOLUTREAN CULTURE • More of a decorative use, served little practical purposes	• Laurel leaf or willow leaf shaped flake stone tools • Intricate flaking on every edge Used as spears or cutting	
	MAGDALENIAN CULTURE • First tools made by bone, antlers and ivory	• Usually pointed, sometimes with barbs • Included fish hooks, spearheads, harpoons and needles • Burin, chisel like cutter was used to make