HUMAN BIO EXAM REVISION!!!!!!

**CHAPTER 2 – CHEMICAL MESSENGERS:**

~ The endocrine system influences the activity of cells by the release of chemical messengers known as hormones – done to maintain a DYNAMIC EQUILLIBRIUM.

Endocrine Glands (ductless) – Secrete hormones into the extracellular fluid that surrounds the cells that make up a gland – secretion then passes into the capillaries to be transported by the blood. Major endocrine glands include:

* Hypothalamus
* Pituitary
* Pineal gland
* Thymus
* Para/thyroid
* Adrenal glands
* Pancreas
* Ovaries
* Testes

Exocrine glands – Secrete into a duct that carries the secretion to the body surface/cavities – include:

* Sweat glands
* Mucous glands
* Salivary glands
* Alimentary canal

Hormones may be proteins, steroids or amines and are transported through the body via the blood.

Paracrines or (local) hormones are secreted by cells in order to communicate with other cells in the same tissue.

Hormones can only be secreted by specialized cells and travel via bloodstream where paracrines can be secreted by all cells and travel (diffuse) through extracellular fluid.

PROTEIN AND AMINE HORMONES (water soluble) – attach to receptor proteins in the membrane of the target cell – causes a secondary messenger substance to diffuse through the cell and activate particular enzymes. I.E. Insulin binds to receptor protein and this leads to an ^ in glucose absorption by the cell.

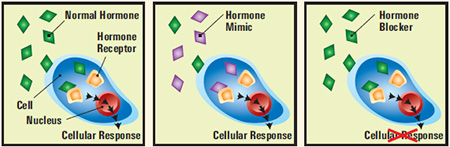
STEROID HORMONES (lipid soluble) – enter target cells and bind to receptor proteins on the inside (this may be on the mitochondria or in the nucleus). The hormone-receptor complex activates the genes controlling the formation of particular enzymes.

\* HORMONES MAY CHANGE THE FUNCTION OF A CELL BY CHANGING THE TYPE, QUANTITY OR ACTIVITY OF THE PROTEINS PRODUCED – THEY ARE NOT ENZYMES BUT CAN EXERT INFLUENCE BY CHANGING THE ENZYME ITSELF OR THE CONCENTRATION OF THE ENZYME \*

HORMONES MAY:

1. Activate certain genes in the nucleus so that a particular enzyme or structural protein is produced.
2. Change the shape or structure of an enzyme so that it is turned on/off.
3. Change the rate of production of an enzyme or structural protein by changing the rate of transcription/translation during protein production.

Endocrine disruptors can:

1. Mimic or partly mimic naturally occurring hormones in the body like oestrogens (the female sex hormone), androgens (the male sex hormone), and thyroid hormones, potentially producing overstimulation.
2. Bind to a receptor within a cell and block the endogenous hormone from binding. The normal signal then fails to occur and the body fails to respond properly. Examples of chemicals that block or antagonize hormones are anti-oestrogens and anti-androgens.
3. 3. Interfere or block the way natural hormones or their receptors are made or controlled, for example, by altering their metabolism in the liver.

HYPOTHALAMUS AND PITUITARY:

The hypothalamus is located at the base of the brain – regulates many of the basic functions of the body such as C.B.T, water balance and heart rate – many of these functions are carried out through the pituitary gland (hypophysis – approx. 13mm in size) which is connected to the hypothalamus through a stalk know as the infundibulum. The pituitary gland is separated into 2 sections – posterior and anterior:

POSTERIOR PITUITARY (neurohypophysis) – not a true gland because it does NOT secret hormones – connected to the hypothalamus by nerve fibres that travel through the infundibulum. The posterior lobe secretes oxytocin and ADH – both of which are produced in the hypothalamus and stored in the lobe ready for release into bloodstream (release of which is initiated by nerve impulses from hypothalamus).

* Oxytocin = stimulates contraction of uterine and mammary muscles, is the ‘happy hormone’/evokes feelings of contentment and joy and is believed to have a role in the healing of external wounds by regulating inflammation of tissues (decreases certain cytokines).
* Antidiuretic hormone (ADH/vasopressin) = stimulates reabsorption of water via nephrons of the kidneys from urine – helps to retain fluid within the body and at higher concentrations can cause constriction of arterioles (hence the alternate name – vasopressin).

ADH production can be inhibited by the consumption of alcohol.

E.g. You’re in the desert and on the brink of dehydration. BUT WAIT! You have a bottle of whiskey with you (60% water) – do you drink the whiskey or not? Why?

~ YOU DON’T DRINK THE WHISKEY!

Whiskey acts as a diuretic – inhibits the secretion of ADH from the posterior lobe which means that when you’re super dehydrated and the body needs to conserve all the water it has, ADH isn’t able to do its job and stimulate the reabsorption of excess water from your urine AND as alcohol is a diuretic (from Greek word diouretikos – to urinate), you basically just pee out all the water your body needs (hence term ‘going out on the piss’ when getting drunk). This creates an increase in the concentration of blood salts in your body – which the osmoreceptors in the hypothalamus would normally detect and stimulate the secretion of ADH as a response BUT THEY CAN’T because your old pal alcohol is inhibiting this secretion. Alcohol is also an irritant to the stomach – especially when the volume of water in the body is depleted – causes the drinker to vomit – 2 things can come of this:

1. Dehydration – many side effects = drowsiness, confusion, decreased CBT – hypothermia, fainting and death.
2. Alcohol poisoning (drunkenness as a result of dehydrated body (depleted water levels – alcohol affects you quicker)) – loss of coordination/control of muscles – lack of control over gag reflex – choke on vomit – die.

ANTERIOR PITUITARY (adenohypophysis) – has no nerves connecting it to the hypothalamus – it is connected by a complex set of blood vessels. The anterior lobe secretes a vast number of hormones:

|  |  |  |
| --- | --- | --- |
| HORMONE | TARGET ORGAN | MAIN EFFECTS |
| Follicle-stimulating hormone (FSH) | Ovaries (female)  Testes (male) | Growth of follicles  Growth of sperm |
| Luteinising hormone (LH) | Ovaries (female)  Testes (male) | Ovulation and maintenance of corpus luteum  Secretion of testosterone |
| Growth hormone (GH) | All cells | Growth and protein synthesis |
| Thyroid-stimulating hormone (TSH) | Thyroid gland | Secretion of hormones from thyroid |
| Adrenocorticotropic hormone (ACTH) | Adrenal cortex | Secretion of hormones from the adrenal cortex |
| Prolactin (PRL) | Mammary glands | Milk production |

PINEAL GLAND

Its actual function is somewhat of a mystery – it secretes melatonin, which is involved in sleep, and its size gradually decreases as you get older.

THYROID GLAND

* Located in the neck, just below the larynx and consists of two lobes that sit on either side of the trachea.
* The main hormone it secretes is thyroxine – made up of iodine and amino acids and is continually produced by the thyroid gland.
* Thyroxine is involved in body metabolism and regulates reactions in which complex molecules are broken down to release energy.
* The overall effect of thyroxine is to bring about a release of energy (some of this takes the form of heat and thus a smaller job of thyroxine is to regulate C.B.T)

\*AN OVER/UNDER PRODUCTION OF THYROXINE RESULTS IN HYPER/HYPOTHYROIDISM AND DISORDERS SUCH AS GOITRE AND CRETINISM\*

CRETINISM

*~* A stupid person (a general term of abuse).

~ A person who is physically deformed and has learning difficulties due to a congenital thyroid deficiency.

Around the world, the most common cause of congenital hypothyroidism is iodine deficiency. Cretinism is therefore most probably due to a diet deficient in [iodine](https://en.wikipedia.org/wiki/Iodine). [Congenital hypothyroidism](https://en.wikipedia.org/wiki/Congenital_hypothyroidism) can be endemic, genetic, or sporadic. If untreated, it results in mild to severe impairment of both physical and mental growth and development. Poor length growth is apparent as early as the first year of life. Adult stature without treatment ranges from 1 to 1.6 metres (3.3 to 5.2 ft). In adults, Cretinism results in mental deterioration, swelling of the skin, loss of water and hair. [Bone maturation](https://en.wikipedia.org/wiki/Bone_maturation) and [puberty](https://en.wikipedia.org/wiki/Puberty) are severely delayed. [Ovulation](https://en.wikipedia.org/wiki/Ovulation) is impeded, and infertility is common. Neurological impairment may be mild, with reduced muscle tone and coordination, or so severe that the person cannot stand or walk. Cognitive impairment may also range from mild to so severe that the person is nonverbal and dependent on others for basic care. Thought and reflexes are slower. Other signs may include thickened skin, enlarged tongue, or a protruding abdomen. Sporadic and genetic cretinism results from abnormal development or function of the foetal thyroid gland. This type of cretinism has been almost completely eliminated in developed countries by early diagnosis by [newborn screening](https://en.wikipedia.org/wiki/Newborn_screening) schemes followed by lifelong treatment with thyroxine. Thyroxine must be dosed as tablets only, even to newborns, as the liquid oral suspensions and compounded forms cannot be depended on for reliable dosing. In the case of dosing infants, the T4 tablets are generally crushed and mixed with breast milk, formula milk or water. Frequent monitoring (every 2–3 weeks during the first months of life) is recommended to ensure that infants with congenital hypothyroidism remain within the high end of normal range. Iodized salt is usually the preferred prophylactic vehicle, but iodized vegetable oil, iodized water, and iodine tablets are also occasionally used.

Doctors are typically able to diagnose endocrine system diseases by measuring your blood and urine for their levels of endocrine hormones. Your doctor might need you to fast, take medication, or eat particular foods for a brief period prior to your blood test. Often, this is done to help stimulate your endocrine system to produce more of a particular hormone or hormones, in order to make it easier for your doctor to evaluate endocrine function. Doctors may also try screening/imaging tests to locate or pinpoint a nodule/tumour.

HORMONES SECRETED BY THINGS OTHER THAN YOUR PITUITARY:

|  |  |  |  |
| --- | --- | --- | --- |
| GLAND | HORMONE | TARGET CELLS | MAIN EFFECTS |
| Parathyroid | Parathyroid hormone | Bones and kidneys | Controls levels of calcium and phosphate in the blood |
| Thymus | Thymosins | T lymphocytes | Development and maturation of T lymphocytes |
| Adrenal medulla | Adrenaline and noradrenaline | Most tissues | Fight or flight response and reinforces effects of sympathetic nervous system |
| Adrenal cortex | Corticosteroids –  Aldosterone  Cortisol | Kidney  Most cells | Increases reabsorption/secretion of calcium/potassium respectively  Promotes normal metabolism/repair of damaged cells and reduces stress |
| Pancreas | Insulin  Glucagon | Most cells  Liver and fat storage tissues | Reuptake of glucose – lowers blood glucose level  Breakdown of glycogen and fat – increase in glucose levels |
| Testes | Androgens | Many tissues | Sperm production, skeletal and muscle growth and male sexual characteristics |
| Ovaries | Oestrogens  Progesterone | Many tissues  Uterus and mammary glands | Development of female characteristics and regulation of menstrual cycle  Regulates menstrual cycle and pregnancy, prepares mammary glands for secretion |

**CHAPTER 3 – NERVE CELLS AND NERVE IMPULSES:**

~ The nervous system is the communication network and control centre of the body – it is involved with maintaining a constant environment in the body – DYNAMIC EQUILLIBRIUM ~

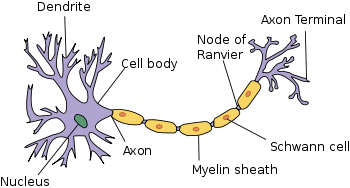
NERVE CELLS (NEURONS)

- Sensory/receptor – carry messages from receptors in the sensory organs (skin, eyes, nose, tongue etc.) to the central nervous system (brain and spinal cord)

- Motor/effector – carry messages from the CNS to the muscles and glands (the effectors)

- Interneurons/association/connector/relay – located in the CNS and are the link between sensory and motor neurons

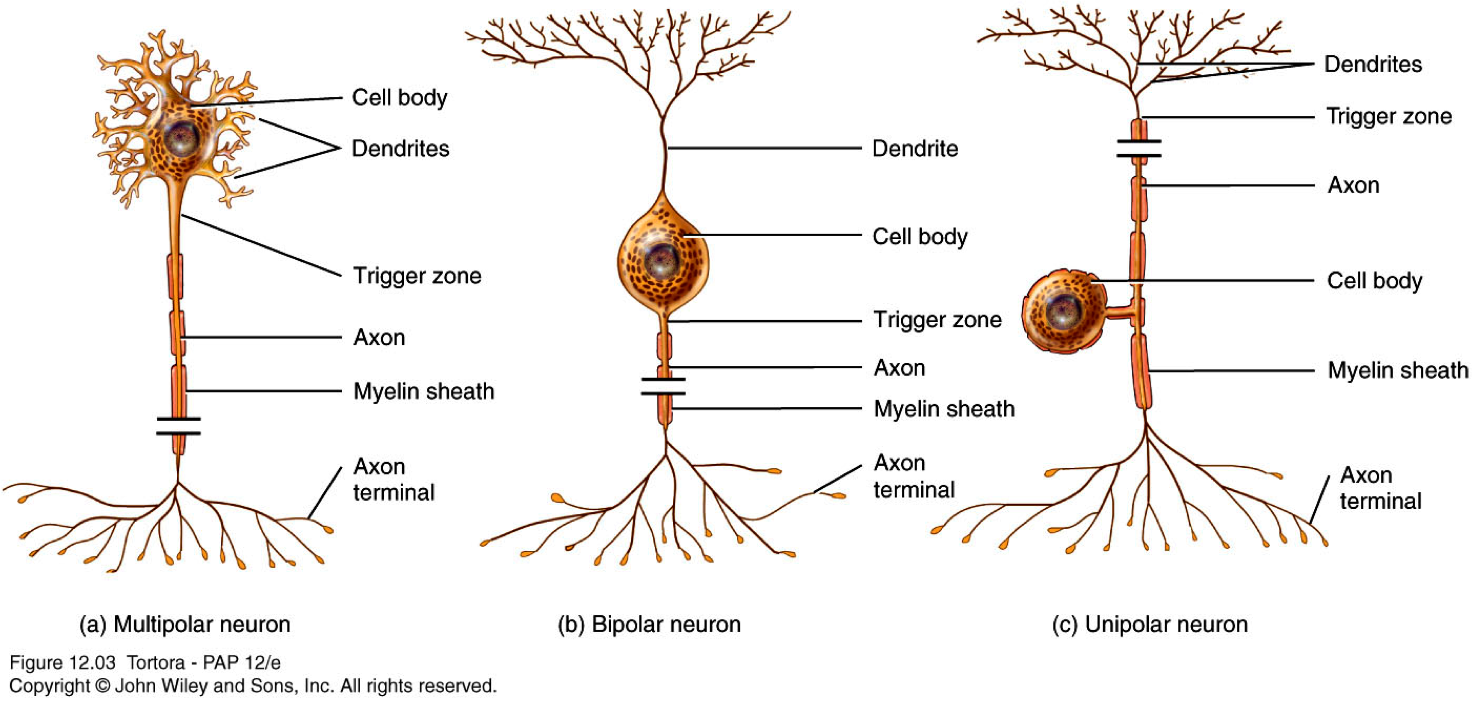
PARTS OF A NEURON



|  |  |  |
| --- | --- | --- |
| PART OF THE NEURON | WHAT IS IT MADE OF | PURPOSE |
| Soma | Nissl granules – composed mainly of rough ER and free polyribosomes | The cell body – nuclear suspension – produces all he proteins for the dendrites, axons etc. |
| Nucleus | Genetic material in the form of chromosomes and the nucleolus, which is made up of RNA and protein. | Archivist and architect – it contains the DNA, which keeps the cell history and synthesizes RNA from DNA and ships it to the cytoplasm for protein synthesis. |
| Axon | Nerve fibres – long slender projections of a neuron | Conducts electrical impulses away from the cell body. |
| Myelin sheath | Schwann (glial) cells, water, lipids and proteins | Electrical insulation – protect the axon from electrically charged ions found in the fluid surrounding the entire nervous system and increase speed at which impulses propagate along the myelinated fibres. |
| Node of Ranvier | A gap in the myelinated sheath between adjacent schwann cells | Saltatory conduction – electrical impulses jump over the separate myelin sheaths, which speeds up electrical neural propagation. |
| Dendrites | Short branched extension of a nerve cell that have receptors for neurotransmitters to bind on to | Receives electrical impulses from other cells |
| Axon terminals | Club shaped endings of an axon – contain neurotransmitters | Synaptic contact with other nerve cells/effectors and to communicate neurotransmitters |

STRUCTURAL TYPES OF NEURONS:

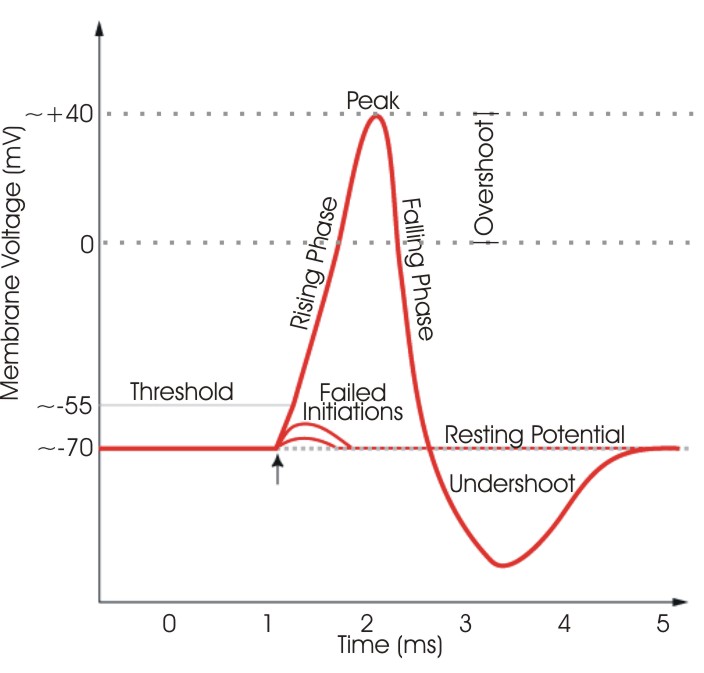
1. Multipolar neurons – Have one axon an multiple dendrites extending from soma – is most interneurons in the brain and spinal cord and also most of the motor neurons that relay messages to skeletal muscles.
2. Bipolar neurons – Have one axon and one dendrite that may have many branches on either end – may be found in eye, ear and/or nose – they take messages from receptor cells to other neurons.
3. Unipolar neurons – Have just one extension – an axon. The soma is to one side of the axon – most sensory neurons that carry messages to the spinal cord are of this type.



PROCESS OF A NERVE IMPULSE

(AN ACTION POTENTIAL)

The neuron at rest is positively charged on the outside (K+ with some Cl-) while the inside is predominantly negatively charged (Na+ and a majority of negatively charged organic substances). When an action potential is stimulated, sodium ion channels and sodium from the inside floods the outside and the neuron depolarizes as the impulse travels down the axon. As the sodium ion channels close, voltage gated potassium pumps open and allow potassium back into the cell, hyperpolarizing it. The refractory period is during the time just before hyperpolarization to the neurons return to resting potential - It is at this point, that no other action potentials can pass through the axon

DEPOLARIZATION ONLY OCCURS IF AN IMPULSE CAN STIMULATE A CHANGE OF AT LEAST 15mV – this is an all-or-nothing response.

1. Slow depolarization of the membrane brings the potential to the threshold.
2. Sodium channels in the membrane open; sodium floods into the membrane and the membrane becomes depolarized/membrane voltage increases.
3. Sodium channels close and membrane repolarizes.
4. Membrane returns to resting state.

EFFECTS OF CHEMICALS ON THE TRANSMISSION OF NERVE IMPULSES

SARIN

When a normally functioning motor neuron is stimulated, it releases the neurotransmitter acetylcholine, which transmits the impulse to a muscle or organ and causes it to contract. Once this impulse has been sent, an enzyme called acetylcholinesterase attaches to the acetylcholine and breaks it down in order to allow the muscle/organ to relax. The nerve agents (e.g. Sarin) disrupt this normal function by forming a covalent bond with the enzyme acetylcholinesterase and inhibiting its ability to break down the neurotransmitter. This causes a build up of the acetylcholine within the synaptic cleft, which continues to act, so that any nerve impulses are continually transmitted and muscle contractions do not stop.

|  |  |  |
| --- | --- | --- |
| Neuromuscular Effects | Autonomic Nervous System Effects | Central Nervous System Effects |
| * Twitching * Weakness * Paralysis * Respiratory failure | * Reduced Vision * Small pupil size * Drooling * Sweating * Diarrhea * Nausea * Abdominal pain * Vomiting | * Headache * Convulsions * Coma * Respiratory arrest * Confusion * Slurred speech * Depression * Respiratory depression |

FUGU

The puffer fish produces one of the most potent toxins inside its eyes, ovaries and liver; Tetrodotoxin specifically binds to voltage gated sodium channels. TTX binding physically blocks the flow of sodium ions through the channel, thereby preventing action potential (AP) generation and propagation. This prevents the transmission of nerve impulses from motor neurons to their target muscles/organs, leading to total body paralysis and eventually death by asphyxiation.

**CHAPTER 4 - DIVISIONS OF THE NERVOUS SYSTEM**

CENTRAL NERVOUS SYSTEM

(brain and spinal cord)

Somatic division – carries messages to the skeletal muscles

EFFERENT DIVISION –

Carries shit AWAY from the CNS

AFFERENT DIVISIONS –

Carries shit TO the CNS

PERIPHERAL NERVOUS SYSTEM

(12 pairs of cranial nerves and 31 pairs of spinal nerves)

Sympathetic NS

Autonomic division – carries messages to the heart/involuntary muscles and glands

Visceral sensory neurons from internal organs

Parasympathetic NS

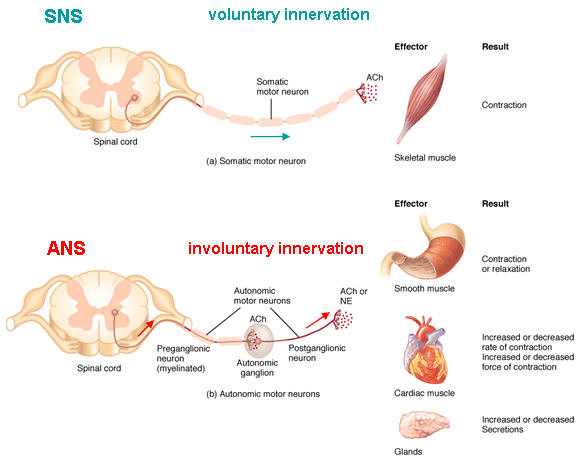
Somatosensory neurons from skin and muscle

THE AUTONOMIC NERVOUS SYSTEM

~ It is studied as a separate system to the PNS but it is actually structurally and functionally part of the same system ~

Controls: Heart rate, blood pressure, body temperature, digestion, release of energy, pupil diameter, airflow to the lungs and excretion.

* It is responsible for the control of the body’s internal environment
* Operates unconsciously – hence AUTONOMOUS
* Regulated by a group of cells in the medulla oblongata
* The pathway travelled by an impulse from the CNS controlled by the ANS consists of two neurons
  + One of these has its soma in the CNS
  + The other is found in the ganglion/ganglia (a group of nerve cell bodies outside of the CNS)

COMPARISON BETWEEN ANS AND SNS:

|  |  |  |
| --- | --- | --- |
| CHARACTERISTIC | AUTONOMIC (ANS) | SOMATIC (SNS) |
| Effectors | Heart muscle, involuntary muscles and glands | Skeletal (voluntary) muscles |
| General function | Adjustment of internal environment to maintain homeostasis | Response to external environment |
| Efferent (outward) pathways | Two nerve fibres from CNS to the effector with a synapse in a ganglion | One nerve fibre from the CNS to the effector; no synapse/ganglion |
| Neurotransmitter at effector | Acetylcholine or noradrenaline | Acetylcholine |
| Control | Usually involuntary | Usually voluntary |
| Nerves to target organ | 2 – Para/sympathetic | 1 set |
| Effect on target organ | Excitation or inhibition | Always excitation |

SUMMARY OF THE EFFECTS OF THE ANS – PARA/SYMPATHETIC SYSTEMS

~ Parasympathetic produces responses that maintain the body when in fairly quiet conditions, and the sympathetic produces responses that prepare the body for strenuous physical activities ~

|  |  |  |
| --- | --- | --- |
| STRUCTURE | EFFECT OF SYMPATHETIC STIMULATION | EFFECT OF PARASYMPATHETIC STIMULATION |
| Heart | Increases rate and strength of contraction | Decreases rate and strength of contraction |
| Lungs | Dilates bronchioles | Constricts bronchioles |
| Stomach, intestines | Decreases movement | Increases movement |
| Liver | Increases breakdown of glycogen and release of glucose | Increased uptake of glucose and synthesis of glycogen |
| Iris of the eye | Dilates pupil | Constricts pupil |
| Sweat glands | Increases sweat production | No effect |
| Salivary glands | Decreases secretion of saliva | Increases secretion of saliva |
| Blood vessels of:  Skin  Skeletal muscle  Internal organs | Constricts vessels  Dilates vessels  Constricts vessels (except in heart and lungs) | Little effect  No effect  Little effect |
| Urinary bladder | Relaxes muscles of wall | Constricts muscles of wall |
| Adrenal medulla | Stimulates hormone secretion | No effect |

COMPARISON OF HORMONAL AND NERVOUS CONTROL

|  |  |  |
| --- | --- | --- |
| CHARACTERISTIC | NERVOUS SYSTEM | ENDOCRINE SYSTEM |
| Nature of message | Electrical impulses and neurotransmitters | Hormones |
| Transport of message | Along the membrane of neurons | By the bloodstream |
| Cells affected | Muscle and gland cells; other neurons | All body cells |
| Type of response | Usually local and specific | May be general and widespread |
| Time taken to respond | Rapid – within milliseconds | Slower – seconds to days |
| Duration of response | Brief – stops when stimulation stops | Longer lasting – may continue long after stimulation ceases |

**CHAPTER 5 – CENTRAL NERVOUS SYSTEM**

~ Place where incoming messages are processed and outgoing messages are initiated ~

Protected by:

* Bone – cranium
* Meninges- tough and fibrous (outer), loose mesh of fibres (middle), blood vessels (inner)
* Cerebrospinal fluid – sits between the middle and inner layer of meninges – made of cells, glucose, protein, urea and salts – acts as a shock absorber.

CORPUS CALLOSUM

A large bundle of nerve fibres that connects the two hemispheres – it cannot be seen outside the brain.

CEREBRUM

The largest part of the brain – outer part is grey matter (cerebral cortex), then white matter below and far below that is further gray matter (basal ganglia). Surface is folded into convolutions (gyri – above and sulci – below = used to further divide the 4 lobes of the brain).

MEDULLA OBLONGATA

Joins the brain to the spinal cord – about 3mm long. It contains the:

* + Cardiac centre – regulates rate and force of heartbeat
  + Respiratory centre – control rate and depth of breathing
  + Vasomotor centre – Regulates diameter of blood vessels

CEREBELLUM

Underneath the rear part of the brain – less prominent folds than those of the cerebrum – exerts control over posture, balance and fine control over voluntary muscle movement.

HYPOTHALAMUS

Lies in the middle of the brain – controls many body activities but is mainly concerned with maintaining homeostasis.

Functions of the hypothalamus include regulation of:

* + The ANS – regulation of heart rate, blood pressure, secretion of digestive juices, pupil of the eye and movements of the alimentary canal.
  + Body temperature
  + Food and water intake
  + Patterns of waking/sleeping
  + Contraction of urinary bladder
  + Emotional responses – fear, anger, pleasure and contentment
  + Secretion of hormones and coordination of parts of the endocrine system
  + Through the pituitary gland – metabolism, growth, reproduction and responses to stress

LONGITUDINAL FISSURE

A deep cleft that separates the cerebrum into two halves.

FUNCTIONS OF THE CEREBRUM

* Thinking
* Reasoning
* Learning
* Memory
* Intelligence
* Sense of responsibility

Three types of functional areas in the cerebral cortex:

Sensory areas – receive and process nerve impulses from the senses

Motor areas – send impulses to muscles, especially for voluntary movement

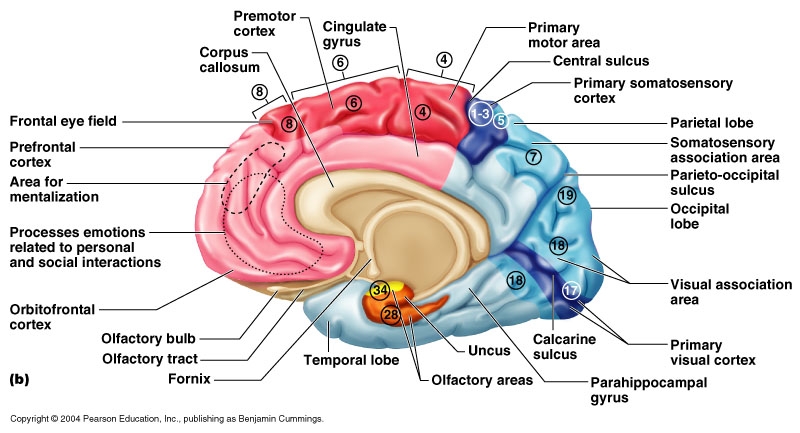
Association areas – interpret information from the senses and make it useful

PRIMARY MOTOR CORTEX – Frontal lobe (reasoning, planning, higher order though processes, emotions, movement and balance)

PRIMARY SENSORY CORTEX – Parietal lobe (touch, pressure, temperature and pain)

PRIMARY VISUAL CORTEX – Occipital lobe (visual-spatial processing, colours and movement discrimination)

PRIMARY AUDITORY CORTEX – Temporal lobe (perception, recognition and processing of auditory stimuli – key in the comprehension of speech)



**CHAPTER 6 – DETECTING AND REGULATING CHANGE**

Receptors:

A receptor is a structure that is able to detect the changes in the internal and external environment of the human body.

Some receptors group together to create sensory organs – i.e. light receptors in eye and sound receptors in the eardrums.

Other receptors a simply nerve endings - possibly spread throughout the parts of the body/ whole body as is the case of pain and temperature receptors in the skin.

Thermoreceptors:

Are able to respond to heat and cold – the thermoreceptors in the skin inform the brain of any changes in the external environmental temperature. This information is received by the hypothalamus/cerebrum so that we are constantly consciously aware of our surrounding temperature. The thermoreceptors in our skin are sensitive to EITHER heat or cold – not both.

Temperature inside the body (core temperature) is monitored and regulated by the hypothalamus – the thermoreceptors within the hypothalamus are able to detect changes in the temperature of the blood flowing around our brain – using its own thermoreceptors as well as the receptors in our skin, the hypothalamus is able to regulate body temperature (maintaining homeostatic temperature of 37 degrees).

* Peripheral thermoreceptors – skin and mucous membranes (hot and cold) for external environmental changes.
* Central thermoreceptors – hypothalamus – the main temperature regulating centre – detect changes in CBT and process and respond to external changes.

Osmoreceptors:

Osmotic pressure is determined by the concentration of dissolved substances within the water of the blood plasma – osmoreceptors are located within the hypothalamus and are sensitive to very small changes in osmotic pressure – they stimulate the hypothalamus so that the body’s water contents is kept within a very slim margin.

Chemoreceptors:

Stimulated by particular chemicals – found within the nose (sensitivity to smell) and on the tongue (sensitivity to tastes) – also found within the body (sensitive to the composition and concentration of body fluids).

Most important of the chemoreceptors are the ones found in blood vessels that are sensitive to the PH balance and balance between concentration of O2 and CO2 in the blood (these are involved in the regulation of heart beat and breathing).

Touch receptors:

Found mainly in the skin – when they are closer to the surface of the skin then they are more sensitive to very light touches i.e. in the lips, finger tips, eyelids, external genitals and hair follicles (these respond to very small movements that bend the hair). Receptors close to the surface of the skin adapt quickly and so we become less aware of the sensation/touch over time

Pain receptors (nociceptors):

Are stimulated by damage to the tissues such as from a cut or a heavy bump or by poor blood flow to the tissue. They are especially concentrated in the skin and mucous membranes – can be found in nearly every organ in the body except the brain – pain receptors adapt very little (if at all) so pain remains present until the stimulation stops with prolonged exposure to stimulus making the pain worse.

REFLEXES:

A reflex is a rapid, automatic response to a change in the internal/external environment. Reflexes have 4 important, distinctive properties:

1. A stimulus is required to trigger a reflex – it is not spontaneous
2. A reflex is involuntary – no conscious thought involved
3. A reflex is rapid – only a small amount of neurons involved
4. It is stereotyped – occurs in the same way each time

BASIC COMPONENTS OF A REFLEX ARC:

1. A receptor is either the ending of a sensory neuron or a specialized cell associated with the end of a sensory neuron.
2. A sensory neuron carries impulses from receptor to CNS
3. There is at least one synapse – the nerve impulse may be passed directly to a motor neuron or there may be one or more interneurons, which direct the impulse to the correct motor neuron.
4. A motor neuron carries the impulse to an effector.
5. An effector receives the nerve impulse and carries out the appropriate response (effectors are muscle cells or secretory cells)

\* **SPINAL REFLEX ARCS BYPASS THE BRAIN – THE REFLEX IS CARRIED OUT BY THE SPINAL CORD ALONE TRAVELLING UP OR DOWN A FEW SEGMENTS BEFORE PASSING OUT TO THE APPROPRIATE MOTOR NEURON** \*

PROCESS OF A SPINAL ARC REFLEX:

1. STIMULUS: Pain receptors in the skin detect the stimulus and produce a nerve impulse.
2. Sensory neuron conducts the impulse from the receptor to the spinal cord.
3. Information is processed in the CNS. One or more interneurons pass the message to the appropriate motor neuron.
4. Motor neuron carries a nerve impulse to the effector.
5. RESPONSE: The effector (in the case of sticking hand on a thumb prick – the biceps muscle) contracts removing hand from painful stimulus.

Homeostasis – the process of maintaining a dynamic equilibrium (input/output of materials and energy are balanced) within the body so that the internal environments remain fairly constant.

Important aspects of the internal environment that need to me maintained:

* CBT
* PH and concentrations of dissolved substances in the blood
* Concentrations of glucose in the blood
* Concentrations of O2 and CO2 in the blood and other body fluids
* Blood pressure
* Concentration of metabolic wastes

NEGATIVE FEEDBACK LOOPS:

* Stimulus – change in environment that prompts a response
* Receptor – detects the change
* Modulator – control centre responsible for processing information from receptor and sending out information to the effector.
* Effector – carries out the response to counteract the stimulus

BASIC MODEL:

Stimulus - change occurs in environment (temperature drops)

|

Receptor – the stimulus is detected by sensory cells (thermoreceptors in the skin and hypothalamus)

|

Message – sensory cells generate a message in the form of a nerve impulse or hormone

|

Modulator – a control centre processes the message received from the receptor – (hypothalamus receives and processes message about drop in temperature

|

Message – a new message is sent out by the modulator

|

Effector- Muscles or glands receive the message from the modulator (muscles and pancreas (to release glucagon – sugar for energy = heat output))

|

Response – The effector organs bring about an appropriate response (shivering, putting more clothes on, increasing metabolic rate for heat waste, vasoconstriction)

|

Feedback – the response changes the original stimulus (CBT increased to optimum level)

POSITIVE VS NEGATIVE FEEDBACK:

Positive feedback – the response to a stimulus reinforces and intensifies the stimulus – for when processes must be completed rapidly to avoid stress and injury (childbirth/blood clotting)

Negative feedback – has the effect of reducing or eliminating the stimulus that caused it.

**CHAPTER 7 – THERMOREGULATION**

“Maintaining the balance between heat production and heat loss/expenditure” – HEAT GAIN MUST = HEAT LOSS

Heat input:

* Body processes (metabolism) especially respiration of muscle and liver cells.
* Gained from surroundings - conduction and radiation.

Heat output:

* Radiation, conduction and convection to surroundings.
* Evaporation of water from skin and lungs: warm air breathed out: warm urine and faeces.

WHAT FACTORS INCREASE HEAT PRODUCTION:

Metabolism of lipids, proteins and carbohydrates releases energy – some used by the muscles and cells for respiration – most is lost as heat waste.

* During exercise (strenuous), muscular activity can increase metabolic rate by 40x.
* Stress (activation of the sympathetic nervous system and release of norepinephrine)
* CBT increase – for every degree increase, metabolic rate increases by about 10%

PREVENTING BODY TEMP FROM FALLING:

* Vasoconstriction
* Stimulation of the adrenal medulla to secrete adrenaline and release noradrenaline – increases metabolic rate
* Shivering – oscillating muscle tremors – 10 to 20 per second
* Stimulation of the anterior pituitary lobe to secrete TSH – causes the thyroid gland to release thyroxine into the blood – slower to act but longer lasting
* Behavioural response – putting more clothes, reducing body surface area by curling into a ball or turning the heater on

PREVENTING BODY TEMP FROM RISING

* Vasodilation
* Sweating (only applicable in places that are hot and ARID (not humid) – sweat has to be able to evaporate for their to be a cooling effect
* Decreased metabolic rate – reduction in the secretion of thyroxine (long term response)
* Increasing body surface area – spreading out
* Decreasing voluntary activity – the less you move, the less hot you become
* Behavioural response – removing clothing, turning on fan/AC

TEMPERATURE TOLERANCE:

42c – dangerous level

45c – death usually occurs

33c – hypothermic level

32c < - death usually occurs but people can survive at lower temperatures

HEAT STROKE - body temperature rises and regulatory mechanisms cease – VERY SERIOUS – treatments include immersing person in cold water to rapidly decrease CBT.

HEAT EXHAUSTION – occurs as a result of extreme sweating (reduces volume of water in blood plasma) and vasodilation (reduces resistance to blood flow)

REGULATION OF THE COMPOSITION OF BODY FLUIDS:

|  |  |  |
| --- | --- | --- |
| TYPE OF BODY FLUID | PROPORTION OF TOTAL BODY FLUID | COMPONENTS OF THE BODY FLUID |
| Intracellular fluid | 2/3 of TBF | Fluid inside the cell – cytosol |
| Extracellular fluid  Plasma  Intercellular fluid | 1/3 of TBF  ¼ of extracellular fluid  ¾ of extracellular fluid | Fluid part of the blood  Lymph, cerebrospinal fluid, synovial joint fluid, fluid of the eyes and ears, fluid in the chest and abdominal cavities and around the heart, fluids of the alimentary canal, kidney filtrate |

FLUID BALANCE:

Water intake (2.5L per/day)

* Food (700mL)
* Metabolic water – by product of metabolism of cells (200mL)
* Drink (1600mL)

Water loss (2.5L per/day)

* Lungs (300mL)
* Skin (500mL)
* Kidneys – urine (1500mL)
* Alimentary canal – faeces (200mL)

FLUID INTAKE MUST = FLUID LOSS

EXCRETION:

The removal of toxic wastes produced by metabolism

ORGANS INVOLVED IN EXCRETION:

1. Lungs – involved in the excretion of CO2 and some water lost as water vapour when we exhale
2. Sweat glands – secrete water containing salts, urea and lactic acid
3. Alimentary canal – passes out bile pigments that enter the small intestine – these are the products of the breakdown of haemoglobin from RBC’s. (Faeces from undigested food is not considered to be a part of excretion because it was not produced by the cells)
4. Kidneys – THE MAIN EXCRETORY ORGAN – involved in maintaining a constant concentration of materials in the body fluid – most important substance excreted by the nephrons is urea which is produced in the liver during the breakdown of proteins

THE KIDNEYS:

Renal vein – takes blood away from the kidney

Renal artery – takes blood to the kidney

Ureter – a tube that drains urine away from the kidney

Bladder – a muscular bag that holds urine until it is passed from the body

Urethra – a tube from the bladder that opens to the outside

PROCESS OF THE NEPHRON:

1. Blood enters the glomerulus under high pressure
2. FILTRATION – The high blood pressure forces water and small dissolved molecules out of the blood and into the glomerular capsule – large molecules are retained in the blood and pumped back into the body systems
3. REABSORPTION – The filtrate passes into the proximal convoluted tubule where water, ions and all organic substances are reabsorbed into the bloodstream.
4. Filtrate travels down the descending limb – permeable only to water ions
5. Further reabsorption of water occurs at the loop of henle – concentration of sodium/salt here is 10x stronger than that of the dead sea
6. Filtrate travels up the ascending limb – permeable only to sodium ions
7. SECRETION – Remaining filtrate passes through the distal convoluted tubule where blood secretes ions, acids, drugs and toxins into the nephron – variable reabsorption of water, sodium ions and hydrogen back into filtrate/bloodstream occurs here depending on bodies needs.
8. URINE – The water and dissolved substances that remain make up urine – which is carried by the collecting ducts to the bladder.

CONTROL OF WATER LOSS BY THE KIDNEYS:

The active level of water reabsorption/secretion by the nephrons is controlled by ADH (antidiuretic hormone) – it is produced by the hypothalamus and secreted by the posterior pituitary lobe.

1. Water concentration of blood plasma decreases; osmotic pressure is increased
2. Osmoreceptors in the hypothalamus are stimulated
3. Posterior pituitary is stimulated to release ADH
4. Permeability to water in the DCT and collecting ducts are increased
5. Increased amount of water is reabsorbed into blood plasma
6. Water concentration of blood plasma is increased; osmotic pressure is decreased

IN ADDITION TO ADH, ALDOSTERONE IS SECRETED BY THE ADRENAL CORTEX – IT ACTS ON THE NEPHRONS TO INCREASE THE AMOUNT OF SODIUM (AND WATER) REABSORBED AND THE AMOUNT OF POTASSIUM EXCRETED IN URINE – INCREASING WATER ABSORPTION ALSO INCREASES BLOOD VOLUME WHICH INCREASES BLOOD PRESSURE THUS ALDOSTERONE INDIRECTLY AFFECTS BLOOD PRESSURE.

REGULATING WATER INTAKE (thirst reflex)

1. Water concentration of blood plasma decreases; osmotic pressure increases
2. Osmoreceptors in the thirst centre of the hypothalamus detect change
3. The person feels thirsty
4. The person responds to the feeling of thirst by drinking water
5. Water drunk is absorbed into the bloodstream via the alimentary canal
6. Water leaves the blood and the extra/intercellular fluids return to their normal concentrations

**CHAPTER 8 – REGULATION OF BLOOD SUGAR**

*NORMAL LEVEL OF BLOOD GLUCOSE IS 4 AND 6 MILLIMOLES PER LITRE (5mmol/L = 90mg)*

All cells need a constant supply of glucose, as it is the cells main energy source for all activities (movement, reproduction, synthesizing molecules, active transport).

CELLULAR RESPIRATION EQUATION

Glucose + oxygen = carbon dioxide + water + energy

C6H12O6 + O2 = CO2 + H2O + energy

Glycogen – the form in which carbohydrates are stored in the body (mainly in the liver (100g) and muscle cells (the rest up to 400g))

Glucagon – hormone secreted by the pancreas to break down glycogen to glucose to increase blood sugar levels

Insulin – secreted by pancreas to build glucose back up to glycogen and reduce blood sugar levels.

ROLE OF THE LIVER:

The hepatic portal vein brings glucose to the liver where a number of things may happen:

* Glucose may be removed from the blood by the liver to provide energy for liver functioning
* It may be removed from the blood by the liver and/or muscles and converted into glycogen for storage
* It may continue to circulate in the blood as a source of energy for body cell absorption
* Glucose in excess levels than required for optimum functioning may be converted into fat for long-term storage

|  |  |
| --- | --- |
| TERM | MEANING |
| Glycogenesis | Formation of glycogen from other carbohydrates, especially glucose |
| Glycogenolysis | Break down of glycogen to glucose (Greek – lysis means to separate) |
| Gluconeogenesis | Conversion of fats or proteins into glucose (Greek – neo means new) |

ROLE OF THE PANCREAS:

Inside the pancreas are clusters of hormone secreting cells known as *ISLETS OF LANGERHANS* – which has two individual types:

Alpha cells – Secrete glucagon (converts glycogen into glucose in the liver and stimulates the liver to produce new sugar molecules from fats and amino acids as well as a mild stimulating effect on protein breakdown)

* Converts liver glycogen into glucose
* Promotes gluconeogenesis

Beta cells – Secret insulin (accelerates the transport of glucose from the blood into the cells (especially skeletal muscle cells) and accelerates the conversion of glucose into glycogen/glycogen into fat in adipose tissue)

* Enables entry of glucose into cells
* Promotes conversion of glucose into glycogen in liver and muscles
* Promotes fat storage
* Promotes protein synthesis

ROLE OF THE ADRENAL GLANDS:

ADRENAL CORTEX –

* Stimulated by adrenocorticotropic hormone
* Secretes glucocorticoids – specifically cortisol
* Regulates carbohydrate metabolism
* Stimulate the conversion of glycogen into glucose in liver
* Increase the rate at which amino acids are removed from muscle cells and transported to the liver – where they may be converted into glucose if glycogen and fat levels are low
* They also promote the mobilization of fatty acids in adipose tissue, which allows muscle cells to switch from glucose to fatty acids for most of their metabolic energy.

ADRENAL MEDULLA –

* Synthesizes epinephrine and norepinephrine
* Stimulate the breakdown of glycogen in liver and release of glucose into blood
* Stimulates the production of lactic acid from glycogen in muscle cells – which can then be used by the liver to manufacture glucose

EFFECTS OF CAFFEINE ON THE BODY:

Increased alertness – high concentrations of caffeine mobilize the calcium in cells and inhibit specific enzymes, increasing energy metabolism throughout the brain while decreasing cerebral blood flow. Stimulates the production of (nor) epinephrine and inhibits serotonin (1 of the main hormones involved in the sleep cycle).

Caffeine antagonizes the adenosine receptors in the brain which control the activity of neurotransmitters such as dopamine and serotonin – by blocking the action of adenosine, caffeine constricts the cerebral blood vessels and increases the release of excitory hormones.

REGULATION OF GAS CONCENTRATIONS:

The diaphragm and the intercostal muscles causes air to move in and out of the lungs – it’s contractions are stimulated by impulses from the phrenic nerve while impulses from the intercostal nerves stimulate the intercostal muscles.

These nerves have their origins in the spinal cord – if these nerves are injured or the area from which these nerves originate then the result is complete paralysis of the of the muscles that move air in and out of the lungs.

The nerve impulses that travel to the diaphragm and intercostal muscles are controlled by the respiratory centre of the medulla oblongata.

OXYGEN CONCENTRATION:

If concentration of oxygen in blood plasma decreases while everything else remains constant then *breathing rate increases* (this is only a very slight increase – oxygen concentration has to fall dramatically for their to be a noticeable change in breathing rate.

The AORTIC and CARTOID BODIES within the aorta contain peripheral chemoreceptors that are sensitive to these changes in oxygen levels – central chemoreceptors are contained within the medulla.

CARBON DIOXIDE CONCENTRATION:

Concentration of CO2 in the blood plasma has a major effect in the regulation of breathing – a relatively small increase in CO2 levels creates a significant change in breathing rate (increase)

An increase in CO2 levels also increases levels of hydrogen ions – this increase is detected by chemoreceptors (inside the medulla) which in turn transmit nerve impulses to the respiratory centre, stimulating an increase in breathing rate.

CO2 increase stimulates the chemoreceptors in the medulla – which communicate with the respiratory centre to increase breathing rate – however *this response can take several minutes.*

The immediate increase in breathing rate is produced by stimulation of the aortic and carotid bodies from the increase in hydrogen ions.

HYDROGEN ION CONCENTRATION:

As H+ increases, pH decreases proportionally which in turn causes an increase in breathing rate via detection of changes by the aortic and carotid bodies.

VOLUNTARY CONTROL OF BREATHING:

By passes the respiratory centre of the medulla oblongata – protective device preventing irritating gases and water into the lungs – only viable for a limited time as the eventual build up of carbon dioxide in the lungs stimulates an autonomic reflex kick-starting the respiratory centre to send impulses to the inspiratory muscles – forcing us to take a breath.

Cerebral cortex

Other centres in the brain

VOLUNTARY BREATHING

Medulla oblongata

(respiratory centre)

Automatic breathing

Spinal cord

(nerves to respiratory muscles)

HEART RATE AND BLOOD PRESSURE:

The force with which blood is pressed on the walls of blood vessels.

Cardiac output (mL/min) = heart rate (b/pm) x stroke volume (mL)

* As cardiac output increases so does blood pressure
* Vasodilation = decrease BP / vasoconstriction = increase BP

**CHAPTER 9 – DISRUPTIONS TO HOMEOSTASIS**

HORMONAL CAUSES OF DISRUPTIONS:

Diabetes:

DIABETES MELLITUS (TYPE 1 – INSULIN DEPENDANT) VS DIABETES TYPE 2 (METABOLIC DISORDER)

TYPE 1 DIABETES – (usually begins in between adolescence and early adulthood / 10-25) - results from the autoimmune destruction of the insulin producing beta cells of the pancreas. Underlying cause is unknown – potentially due to a genetic susceptibility, a diabetogenetic trigger and/or exposure to an antigen. In people with type 1 diabetes, they have absent or malfunctioning beta cells so the hormones insulin and amylin (released with insulin to decrease glucagon levels) are missing which means the hormone GLP-1 (glucagon-like peptide 1) cant work properly. GLP-1 signals beta cells to secrete insulin and amylin and alpha cells to stop/decrease the release of glucagon – also slows the rate at which food passes through stomach – makes you feel full.

Organs involved:

* Pancreas
* Liver
* Kidneys

Treatments:

* Low carbohydrate diet
* Insulin injections/pump – 4 types of insulin; rapid/short/intermediate/long acting
* Pancreas transplant
* Islet cell transplant

TYPE 2 DIABETES – (usually occurs in the middle aged / 45+) - a metabolic disorder characterized by high blood sugar, insulin resistance and a relative lack of insulin. Type 2 diabetes is primarily due to obesity and not enough exercise in people who are genetically predisposed – making up 90% of all diabetes cases. It has also been linked to a lack of sleep – decreases metabolism. Women who suffered from gestational diabetes are also more likely to later on develop type 2 diabetes.

Treatments:

* Exercising – high resistance and aerobic exercise are generally the most successful
* Diabetic diet that promotes weight loss. i.e. low glycemic index/low carbohydrate diet
* Preventative education
* Eventual insulin injections if symptoms don’t improve
* Gastric band/bariatric surgery

EXCESSIVE AND DEFICIENCE OF THYROID HORMONES:

SIGNS AND SYMPTOMS:

Hyperthyroidism:

* Racing/irregular heartbeat
* Restlessness
* Weight loss
* Heat intolerant
* Diarrhoea
* Super massive protruding eyeballs from secondary ‘graves’ disease

Hypothyroidism:

* Weight gain
* Lethargy
* Constipation

For both:

* Enlarged throat
* Trouble breathing

DISEASE DISRUPTS HOMEOSTASIS:

EMPHYSEMA –

(Chronic obstructive lung disease / C.O.L.D)

SIGNS AND SYMPTOMS:

* Chronic cough
* Sputum production
* Shortness of breath
* Barrel chest
* High pressure on lung arteries – strains R.V of heart
* Leg swelling
* Bulging neck veins
* Acute exacerbation – blue tinge to skin
* Oxygen tank
* Tracheostomy – surgical insertion of a tube into the windpipe so breathing can bypass the trachea completely

CAUSES:

* Long term exposure to irritants which cause a chronic inflammatory response – resulting in a narrowing of the small airways and eventual breakdown of lung tissue – irritants include:
* Tobacco smoking
* Air pollution (coal, biomass fuels – wood/animal dung) – specifically in developing countries
* Work place dusts/chemicals – asbestos
* Genetics – specifically a deficiency in ALPHA-1-ANTITRYPSIN (AAT)

**CHAPTER 10 – PROTECTION AGAINST INVADERS**

COMMUNICABLE/INFECTIOUS/TRANSMISSABLE DISEASES:

Diseases caused by foreign organisms invading the body.

PATHOGENS:

Disease causing organisms – most commonly viruses/bacteria – sometimes fungi or parasites.

VECTORS:

How some communicable diseases can be passed from one person to another – mosquitoes, fleas on rats etc.

WHATS ON/IN BACTERIA?

* Slime layer – around the outside of some bacteria
* Cell wall – often made of peptidoglycan – a combined carb/protein.
* Cell membrane – phospholipid bilayer – fluid mosaic model similar to other cells
* DNA – no nuclear membrane so DNA is just a giant jumbled mess – sometimes form loops called plasmids
* Cytoplasm – jelly like substance that organelles are suspended in – appears granular because of the presence of ribosomes
* Flagella – used for movement – not always present

TYPES OF BACTERIA:

Cocci (coccus) – look like chains of balls (staphylococci)

Bacilli (bacillus) – look like sausages with squiggly lines on either end

Spirilla (spirillum) – SPIRALS – have twisted cells

Vibrio – look like commas

WHATS IN/ON VIRUSES?

They have either RNA or DNA – never both

Around the nucleic acid is a protein coat

Some have an additional envelope of lipid and protein molecules

INFLUENZA:

* Lipid outer membrane
* Nucleic acid
* RNA is in segments

HIV:

* Protein coat (internal)
* Lipoprotein envelope
* Nucleic acid

HOW THEY REPLICATE:

Viruses cannot replicate themselves – they attach to the outside of a host cell and the nucleic acid enters the host cell. New viral genes are produced by the host cell and so hundreds of new virus particles are formed.

HIV:

1. HIV binds to the receptor on the T-lymphocyte
2. Uncoated RNA from virus enters lymphocyte
3. Virus contains an enzyme that allows it to make a DNA copy of its RNA
4. Host cell DNA
5. DNA copy of HIV RNA integrates with host cell DNA
6. New viral RNA produced
7. Budding of new virus particle from lymphocyte
8. New HIV able to infect other cells

*BACTERIOPHAGES – VIRUSES THAT MULTIPLY IN BACTERIAL CELLS CAUSING THEM TO DIE.*

TRANSMISSION BY PATHOGENS:

By contact – direct (touching infected) / indirect (touching something the infected touched)

By body fluids – STI’s, Hep B/C and HIV from shared needles

By droplets - sneezing/coughing around non-infected

By ingestion – contaminated food/drink – salmonella and typhoid fever

By air – moisture in exhaled droplets

By vectors – on animals such as household flies, fleas and mosquitoes

NON SPECIFIC DEFENSES

Work against all pathogens - first line of defense

EXTERNAL:

* Skin – sweat, sebum and low pH
* Mucous membranes
* Hair – nose, eyelids and ears (trap 90% of foreign bodies)
* Acids
* Lysozyme – saliva, sweat, nose mucous and tears
* Cerumen – (ear wax) – slightly acidic and contains lysozymes

PROTECTIVE REFLEXES:

* Sneezing
* Coughing
* Vomiting
* Diarrhoea

INTERNAL NON SPECIFIC DEFENSES:

If pathogens get past our external defenses

PHAGOCYTES:

* Cells that engulf microorganisms and cell debris
* Leucocytes secrete substances that destroy pathogens before engulfing them, while others engulf live bacteria and digest them – this is in large part due to the leucocytes ability to migrate away from the blood capillaries.

MACROPHAGES ARE LARGE PHAGOCYTES THAT DEVELOP FROM SOME LEUCOYCTES – SOME WANDER, LOOKING FOR PATHOGENS WHILE OTHERS ARE FIXED IN PLACE AND DEAL WITH PATHOGENS THAT COME TO THEM.

INFLAMMATION (if it ends in ‘itis’ then it indicates swelling):

Purpose is to –

* Reduce spread of pathogens
* Prevent entry of additional pathogens
* Remove damaged tissue and cell debris
* Begin repair to damaged tissues

4 SIGNS OF INFLAMMATION:

1. Redness
2. Swelling
3. Heat
4. Pain

INFLAMMATORY RESPONSE:

1. Mast cells release histamine and heparin
2. Histamine diffuses into capillaries causing them to dilate and become leaky
3. Area becomes red and swells
4. Heparin prevents clotting of immediate area
5. Proteins are activated which attract phagocytes to the area – they engulf and digest dead bacterial cells
6. Phagocytes die and become a yellow liquid – pus
7. Histamine and protein signaling finish
8. Phagocytes are no longer attracted to area
9. New cells are produced by mitosis and damaged tissues begin repair

**CHAPTER 11 – SPECIFIC RESISTANCE TO INFECTION**

Specific immunity protects the body against specific substances (antigens)

2 types of specific immunity:

* Cellular and cell mediated immunity
* Humoral and antibody mediated immunity

Specific immunity is acquired through natural infection or immunization

ANTIGENS:

A toxin or other foreign substance which induces an immune response in the body, especially the production of antibodies.

ANTIBODIES:

A blood protein produced in response to and counteracting a specific antigen. Antibodies combine chemically with substances which the body recognizes as alien, such as bacteria, viruses, and foreign substances in the blood.

* Y in shape
* Disulphide bond connecting the constant and variable portions
* Lower ¾ is the heavy chain
* Top 1/3 of the extensions are the light chains

Attenuated vaccines – microorganisms of a reduced virulence are injected into the bloodstream (longer lasting than dead vaccination)(measles, mumps, TB, yellow fever)

Dead vaccines – dead microorganisms (cholera, bubonic plague, typhoid, hepA, whooping cough)

Toxoids – made from filtrates of bacterial cultures containing toxins (diphtheria and tetanus)

Sub unit – vaccines made of a fragment of an organism (HPV, hepB)

Lymphocyte – Specialized WBC’s that have a spherical nucleus surrounded by a thin granular cytoplasm.

B CELLS

* Humoral and antibody mediated immunity
* Educated in bone marrow
* Chemical based system
* Produce antibodies (Ig – immunoglobulin)
* Effective against extracellular bacteria and some viruses

T CELLS

* Cellular and cell mediated immunity
* Educated in thymus
* Cell based system
* Produce killer, memory and helper cells
* Effective against intracellular viruses, cancer and some bacteria

KILLER T (CYTOTOXIC) CELLS – destroy body cells infected by viruses or transformed by cancer

HELPER T CELLS – perform many immune functions – they are essential for activating killer cells and B cells

MEMORY CELLS - remain in the body and enable the immune system to react rapidly should it encounter the same antigens again

CYTOKINES – stimulate T cells to divide and differentiate into killer, helper or memory cells

ANTIBIOTICS – chemicals specifically designed to kill a certain bacteria – produces by fungi or other microorganisms (penicillin)

AGGLUTINATION - a reaction in which particles (as red blood cells or bacteria) suspended in a liquid collect into clumps and which occurs especially as a serological response to a specific antibody.

ANTIBODY MEDIATED IMMUNITY:

1. Pathogen displaying antigens
2. Antigen recognized by compatible antibody
3. B cells digest antigen and display fragments of antigen
4. T helper cell recognises antigen
5. Activated T helper cell releases cytokines
6. Cytokines cause B cell to mature into plasma cell
7. Plasma cell secretes antibody

CELL MEDIATED IMMUNITY:

1. Internal cell infection is displayed on the cell surface by MHC class one

2. MHC class one molecules bind to cytotoxic T cells

3. Costimulation occurs with helper T cells and CD8

4. T cells are activated, proliferate, and differentiate

5. Some T cells differentiate into cytotoxic T cells

6. Cytotoxic T cells lyse cells and produce cytokines

7. Cytokines kill the cell

8. Memory T cells form

9. Memory T cells remember the antigen and produce faster immune response during subsequent exposures

ACTIVE IMMUNITY:

(antigen activated)

* immune system activated
* memory cells produced = immunity acquired
* protection slow to develop but permanent
* NATURAL – involves B and T cells (natural contact w/disease)
* ARTIFICIAL – vaccines (dead, attenuated, sub unit, toxoid)

PASSIVE IMMUNITY

(antibody activated)

* immune system not activated
* no memory cells formed = not immunity acquired
* protection immediate but only temporary
* NATURAL – IgG (cross placenta) / IgA (cross breast milk)
* ARTIFICIAL – serum (dose of antibody to fight infection)

**CHAPTER 12 – MUTATIONS AND GENE POOLS:**

Species – a group of individuals who share many of the same characteristics and are able to interbreed naturally to create fertile offspring.

Alleles – alternate forms of a gene – the pairs of alleles that offspring inherit from their parents determine the characteristics of that individual – during reproduction, about half of that individuals alleles are passed onto their offspring.

GENE POOLS:

Population – a group of organisms of the same species living together in a particular place at a particular time – geneticists (scientists specializing in inheritance) prefer to look at a population as a whole and not the individuals who make up that population.

Gene pool – the sum of all the alleles in any given population (geneticists pool all the genotypes of a population capable of reproducing, together)

In studying a population, geneticists are interested in how often each allele of a gene occurs the gene pool for that particular population – this is the ALLELE FREQUENCY – knowing the frequency of certain characteristics/mutations appear in a gene pool, the geneticists are able to work out the allele frequency for that particular gene.

- I.E. – Cystic fibrosis is a mutation of chromosome 7 – if the allele frequency of CF is 5%, then among the members of the population, 5 in every 100 people will have cystic fibrosis.

Populations that differ in the characteristics they possess are likely to have different allele frequencies of the various alleles of a gene in their respective gene pools – i.e. Scandinavian people will likely have a higher frequency of the allele for blue eyes than black African American people – who are too, likely to have higher frequencies of the allele for brown eyes than Scandinavian people.

MUTATIONS:

Offspring may show variations that do not resemble either parent and have never occurred before in the history of the family – they may occur quite suddenly of by pure chance – these are called MUTATIONS.

An organism with a characteristic resulting from mutation is called a MUTANT.

There are 2 main types of mutations:

Gene mutations – changes in a single gene so that traits normally produced by that gene are changed or destroyed. They occur during replication of the DNA molecule before separation – the mistake in the structure of the DNA will then be faithfully copied each time the DNA molecule replicates – thus it is passed on from generation to generation. When it was recognized that genetic information is carried in the sequence of bases in the DNA, it became possible to understand the chemical nature of gene mutations. A change in just one base pair – POINT MUTATION – could alter a protein, have no effect at all or prevent a protein from being produced – thus of the DNA of a particular gene is altered, the protein for which it codes may be missing or abnormal.

1. Albinism is the result of one missing protein – marked by the absence of pigment in the hair, skin and eyes.
2. Duchenne muscular dystrophy – may arise through a mutation in the mother, which can then be inherited by her sons or by a mutation in the male zygote so that the child develops the disease. DMD becomes apparent at 3-5 years old and results in the wasting of muscles in the legs, arms, shoulders and chest. Sufferers are unlikely to live past 25.
3. Cystic fibrosis – the mutation occurs on chromosome 7 – this gene has the code for 1480 amino acids that make up the protein that regulates the passage of chloride ions across the cell membrane. Without the correct protein the affected person suffers from symptoms: salty tasting skin, persistent coughing, wheezing or pneumonia and digestive problems. CF is recessive so it has to be inherited from both parents.

Chromosomal mutations – where all or parts of a chromosome are affected – therefore affect not just one but a number of genes. Types of chromosomal mutations are:

1. Deletion – part of a chromosome is lost
2. Duplication – a section of chromosome occurs twice – this may happen if part of a chromatid breaks of and joins onto the wrong chromatid
3. Inversion – breaks occur in a chromosome and the broken piece joins back in but the wrong way around – this changes the order of the genes on the chromosome and may disrupt the pairing of homologous chromosomes during meiosis
4. Translocation – part of a chromosome breaks of and is rejoined to the wrong chromosome
5. Non-disjunction – during meiosis, a pair of chromosomes does not separate and so one daughter cell has an extra chromosome and one daughter has one less chromosome – sometimes referred to as ANEUPLOIDY – a change in chromosome number

Chromosomal mutations cause abnormalities so severe that miscarriage often occurs during early pregnancy. Chromosomal mutation that occurs relatively frequently is DOWN SYNDROME (TRISOMY 21) where the child has 3 copies of chromosome 21. Patau syndrome is trisomy on the 13th chromosome and produces individuals with mental retardation, a cleft lip/palate, malformations of the ears and eyes and an extra finger on each hand – it occurs in 1/5000 live births though more than 80% of affected people die within a month of birth. Trisomy 16 is the most common trisomy in humans occurring in more than 1% of pregnancies – it also usually results in spontaneous miscarriage within the first 3 months of pregnancy. Trisomy can also occur in the sex chromosomes - non disjunction may occur during the 1st/2nd meiotic division resulting in individuals with one extra x (XXY) or one extra y (XYY) chromosome – trisomy XXY sufferers are normal boys but develop Klinefelters syndrome as adults – the have small testes that do not produce sperm, enlarged breasts and sparse body hair – occasionally they may be mentally retarded.

Monosomy is where an individual is missing a chromosome – they only have one copy instead of the normal two. If the entire autosome is missing, this generally produces severe malformations that end in spontaneous miscarriage; if only part of the chromosome is missing, this is referred to as partial monosomy – part of the chromosome has two copies but part only has one – i.e. Cri du Chat (cry of the cat) syndrome – missing portion of chromosome 5 that results in problems with the larynx and nervous system AND monosomy X in females where they only have one x chromosome 0 these females will generally be short in stature, lack secondary sexual characteristics and be infertile.

DIAGNOSIS:

Via analysis of cells from amniotic fluid or placenta – provides the karyotype (test providing details of the size, shape and number of chromosomes) of the foetus.

LETHAL RECESSIVES:

Most gene mutations produce a recessive allele because they prevent the gene from producing a protein able to function in the body. A person could therefore have large numbers of recessive mutations in their genes and be completely unaware of them. Some recessive mutations are lethal if they are not masked by a dominant normal allele – these lethal recessives generally cause the early death of the embryo or foetus (miscarriage or spontaneous abortion).

- Tay-sachs disease (TSD) is a disorder of the lipid metabolism inherited in an autosomal recessive pattern – it is a lethal recessive as the missing enzyme results in the accumulation of a fatty substance in the nervous system – affected people develop normally for the first few months but generally die in early childhood due to the ensuing physical and mental disabilities.

MUTAGENS:

(AKA mutagenic agents) – things that are known to increase the rate at which mutations occur – i.e. mustard gas, formaldehyde, sulfur dioxide, ultraviolet light, x-rays, cosmic rays and radiation. If a pregnant woman is treated with x-rays during the first 3 months, the child may be born with mental retardations, a malformed skeleton or small head in relation to the rest of its body.

SOMATIC AND GERMLINE MUTATIONS:

Somatic – the body cells are involved – only the individual with the mutation is affected. Each time the mutant body is replicated, the mutation is passed onto the daughter cells, the reproductive cells are not affected so once the individual with the mutation dies, the mutation is lost.

Germline – reproductive cells are affected – the mutation can then occur in the gametes and thus be passed onto subsequent generations – in this case, the individual with the original mutation may not be affected. However that individual produces gametes with changed DNA. If reproduction occurs directly on one of those affected gametes, the pregnancy is often aborted naturally. Diseases such as Phenylketonuria (PKU) arise through mutation during the formation of gametes and can be passed onto offspring.

**CHAPTER 13 – BIOTECH:**

Genome: the complete set of genetic information of an organism – for humans this is the full sequence of approx. 21000 genes in our chromosomes.

DNA: Deoxyribonucleic acid – made up of a double helix w/ alternating steps of sugars (deoxyribose) and phosphate groups, with pairs of nitrogenous bases forming cross links between the strands (Adenine/Thymine and Cytosine/Guanine)

~ The order/sequence of these bases is the genetic information that determines the structure of the cell and the way it functions.

DNA SEQUENCING: the determination of the exact order of the nucleotides in a DNA sample.

~ SANGER METHOD – in building a DNA sequence, each new nucleotide is bonded to the hydroxyl group (-OH) of the previous nucleotide.

Sangers method – a synthetic nucleotide (ddTTP) is introduced to the strand – as it lacks an OH group, the elongation of the sequence stops – this allows strands to be compared.

Sanger method requires:

1. Multiple copies of single stranded DNA
2. A suitable primer
3. DNA polymerase (DNA copier – adds new nucleotides to the 3” end of the template strand
4. A pool of normal nucleotides
5. A small portion of ddTTP’s labeled in some way – radioactively/fluorescent dye.

E.G – Spastic paraplegia – symptoms show between 20-50 – segment of chromosome 2 was searched for affected point mutation by comparing to non-affected members of the family.

PROFILING TECHNIQUES: In the 1960’s scientists developed techniques using specific/special enzymes to cut DNA at specific base sequences leaving pieces at various lengths – with the length of such sequences varying between individuals.

DNA profiling depends on regions of non-coding DNA that is polymorphic – shows great variability between individuals – uses STR’s.

~ Electrophoresis (1984) – DNA pieces were placed on a bed of semi solid gel – electrical impulses are passed through the gel from the negative pole where the DNA is placed, through to the positive pole – DNA which is negatively charged reacts to the power pack and travels through the gel toward the positive pole. Larger pieces are heavier and thus travel less that lighter/smaller pieces of DNA – this creates a distinctive banding pattern that varies from person to person allowing the difference sequences to be compared.

STR’s – 99.9% of different people’s DNA is common

The other 0.1% contains non-coding sections (usually in the introns)

These non-coding sections contain sections where 2 to 3 bases repeat (eg CACACACACACA). These are called Short Tandem Repeats (STR)

Due to random mutation these STR areas vary between individuals

The length of specific STR sections can be compared to create an individual DNA profile.

STAGES OF DNA PROFILING:

1. Cells are broken down to release DNA
2. Primers are added which attach to each end of the STR – DNA is cut into fragments using restriction enzymes (each restriction enzyme cuts DNA at a specific base sequence (where the primers have attached))
3. Restriction fragments are separated based on size – using electrophoresis
4. Pattern of fragments distribution is then analysed and compared.

PCR – Polymerase chain reaction – used to amplify minute amounts of DNA using an enzyme called DNA polymerase (developed my Kary Mullis).

1. DENATURING: heating the DNA to 96 degrees to separate the strands – complimentary strand is discarded leaving only the template strand.
2. HYBRIDISATION: Primers (short synthetic DNA fragments) are added to the DNA - they bind to the strand of separated DNA acting as a starting point for replication.
3. SYNTESIS: DNA polymerase/TAQ polymerase is added – binds to the primer, reads the DNA code and then builds a complimentary strand.

RECOMBINANT DNA TECHNOLOGY: (genetic engineering): involves the introduction of DNA into cells where the DNA is foreign or has been modified in some way. It can be used to take genes from one organism and put them into the chromosomes of another.

Stanley Norman Cohen and Herbert Boyer invented the recombinant DNA technique in 1973 – it involves the isolation and amplification of genes or DNA segments to insert them into a bacterial cell – creating a TRANSGENIC BACTERIUM.

Transgenic organisms are those whose genome has been altered by the transfer of a gene/genes from another organism – the introduced genes become part of the transgenic organisms DNA and can be passed on through generations.

BACTERIOPHAGES/PHAGES – Viruses that infect bacteria cells

Certain enzymes in bacteria are able to restrict the duplication of infecting viruses by cutting them up – scientists discovered that such an enzyme ALWAYS cuts the DNA at a point where there is a specific sequence of bases – this is known as the recognition site while the enzyme that cuts the DNA is a restriction enzyme.

Some of the restriction enzymes produce a straight cut at the sequence while others produce a staggered cut. A straight cut is when the restriction enzyme makes a clean break across the two strands of DNA to make a blunt end. A blunt end is when both strands terminate on a base pair. Restriction enzymes that produce a staggered cut create a sticky end. Sticky ends are stretches of unpaired nucleotides in the DNA molecule that overhang at the break in the strands – they are able to combine with sections of DNA that have a complimentary ending.

DNA ligase – found in the E.coli bacterium is the enzyme able to recombine separate pieces of DNA by creating a covalent bond between strands.

PROCESS OF RECOMBINANT DNA:

1. Isolate the gene and cut it out using a restriction enzyme
2. Isolate a plasmid from a bacterial cell and cut it with the same R.E
3. Splice the human DNA into the plasmid using ligase enzymes to join the sticky ends
4. Treat the bacterium so that it takes up the recombinant plasmid – the bacteria will then multiply so that either the human gene or the product of the gene can be used.

RECOMBINANT DNA TECH HAS BEEN USED TO CREATE:

* Insulin – the human gene that contains the code for insulin production was inserted into bacterial cells – these bacterial cells became insulin factories that are now cultured in vats – it is identical to human insulin because the human gene was engineered into the bacteria.
* HGH (human growth hormone)
* FactorVIII – cultured in mammalian cells

VACCINE PRODUCTION USING RECOMBINANT DNA:

* hepatitis B vaccine (1986)
* done by inserting a gene from the HepB virus into the cowpox virus

GENE THERAPY – aims to treat/cure genetic abnormalities by replacing faulty genes with healthy ones – used primarily in single-gene disorders such as cystic fibrosis, Huntington’s disease and sickle cell anemia.

CYSTIC FIBROSIS:

Most common life threatening disease in Australians of European descent.

Characterized by a thick mucous expelled by the mucous glands in the lungs and pancreas – clogs tiny air passages and prevents secretion of digestive enzymes.

Cystic fibrosis transmembrane regulator was identified in 1989, and in 1991 scientist successfully corrected the faulty gene in cultured cells by adding normal copies to the culture.

CF is easiest to treat with gene therapy as it is a single gene disorder the most affected organ – the lungs – is relatively easy to reach and it is slow to progress.

The first experimental CF gene treatment was given to a man in 1993 – scientists modified a rhinovirus cell to act as the vector to carry normal genes to the CFTR cells in the lungs.

HUNTINGTONS DISEASE:

Caused by a mutation on the single gene on chromosome 4 – IT15

Symptoms seldom appear before the age of 40

The mutated form of a protein called huntingtin results in nerve cells in the brain being damaged

French scientists experimented with a modified virus to deliver a corrective gene into the brain cells that boosts a natural shield against the effects of the defective protein

The experiments have up to date, been conducted on rats and primates with positive results.

CELL REPLACEMENT THERAPY AND TISSUE ENGINEERING:

Stem cells are undifferentiated cells that are capable of repeated mitotic divisions and if given the right conditions, specialization.

Any disorder that involves the loss of/damage to normal cells is a potential candidate for cell replacement therapy.

I.E – Parkinsons disease involves the replacement of dying neurons with healthy neuronal tissue – with pilot studies showing that transplanted cells not only grew, but formed connections with other neurons.

Stem cells are also increasingly being used for tissue engineering – the primary objective of T.E is to restore healthy tissues or organs and thus eliminate the need for tissue or organ transplants.

TISSUE ENGINEERING:

Requires an abundant supply of disease free cells of specific types. These cells need to be induced to grow on a scaffold of natural/synthetic material to produce a three dimensional tissue. Tissue scaffolds serve as a template for tissue growth and need to have high pore sizes that enable the cells to grow while at the same time allowing for the diffusion of nutrients through the whole structure. They need to biodegradable so that they can be absorbed by the surrounding tissues. Once a scaffold has been devised, stem cells need to be cultured. These cells are seeded onto the scaffold which enables cell growth and proliferation – the cell covered scaffold is then implanted into the patient. As the new cells continue to grow and divide, the material making up the scaffold begins to degrade or get absorbed.

TISSUE ENGINEERING CAN BE USED TO DEVELOP A WIDE RANGE OF TISSUES INCLUDING BONE, SKIN, CARTLIDGE AND ADIPOSE TISSUE.

**CHAPTER 14 – EVOLUTIONARY MECHANISMS:**

Random assortment – of chromosomes during meiosis results in gametes that have a huge number of possible number combinations of the chromosomes that originally came from the male parent and the female parent.

Crossing over – of chromatids during meiosis may result in pieces of chromatid being broken off and attaching to a different chromatid – this results in a changed sequence or recombination of the alleles along the resulting chromosome.

Non-disjunction – BITCH I ALREADY EXPLAINED THIS IN CHAPTER 13

Random fertilization – each person produces a huge number of different sperm or eggs (in relation to potential variations in alleles) and because any sperm can fertilize any egg, there is almost an infinite number of possible allele combinations.

Mutations – READ CHAPTER 12 U SILLY HUMAN ITS ALL IN THERE

CHANGES TO ALLELE FREQUENCIES IN GENE POOLS:

1. RANDOM GENETIC DRIFT (Sewall Wright effect) - The occurrence of characteristics in a population as a result of chance rather than natural selection – occurs only in small groups. Genetic drift describes random fluctuations in the numbers of gene variants in a population. Genetic drift takes place when the occurrence of variant forms of a gene, called alleles, increases and decreases by chance over time. These variations in the presence of alleles are measured as changes in allele frequencies.

Typically, genetic drift occurs in small populations, where infrequently occurring alleles face a greater chance of being lost. Once it begins, genetic drift will continue until the involved allele is either lost by a population or until it is the only allele present in a population at a particular locus. Both possibilities decrease the genetic diversity of a population. Genetic drift is common after population bottlenecks, which are events that drastically decrease the size of a population. In these cases, genetic drift can result in the loss of rare alleles and decrease the gene pool. Genetic drift can cause a new population to be genetically distinct from its original population, which has led to the hypothesis that genetic drift plays a role in the evolution of new species. I.E. the Dunkers of Pennsylvania that originally came from Hesse Germany – their religion does not allow them to marry outside of their group – in terms of various physical characteristics such as, the frequency of ABO, Rh and MN blood groups, attached or free earlobes, mid-digital hair and left or right-handedness, the Dunkers varied in allele frequency from modern day Hesse Germans and also from the surrounding population (whose environment was the same ruling out natural selection).

Other examples include: - the isolated populations of Bentinck and Mornington islands in Australia – originally they were part of the mainland but rising sea levels cut them off and the populations they contained became isolated (except for mornington who remained in relative contact by using the other islands as stepping stones to the mainland). The blood group frequencies of both Bentinck and Bayley point of the mainland have been compared – the occupants of Bentinck island show a very high proportion of the Ib allele and a complete absence of the Ia allele – direct opposition to the Bayley point inhabitants who have high proportion of the Ia allele and low proportions of the Ib allele – thus the blood group frequencies of the Bentinck islanders fall outside the range for Aborigines in the rest of Australia.

2.THE FOUNDER EFFECT – similar to genetic drift, the founder effect occurs when a small group of people moves away from its homeland to a totally new area and establishes a community which later expands. The migrant group, being such a small sample of the original population, is usually not genetically representative of them. This new community therefore generally shows features that are not typical of the original homeland population. I.E. the inhabitants of the island Pingelap – in 1775, a typhoon reduced the population to only 20 – these survivors formed the founding population for the current inhabitants. Among the survivors was a person heterozygous for a form of recessive total colour blindness – ACHROMATOPSIA - today after a number of generations, the frequency of achromatopsia in Pingelap is 5% of the population, compared to the 0.0033% frequency in the rest of the world. Furthermore, 30% of the population are carriers for the disorder.

3. MIGRATION – gene flow from one population to another – if immigrants to a certain country bring alleles that are not already in the population, the frequencies for the alleles of that gene will be altered. I.E in the past the Chinese population was RH+ - when European countries began trading with China, they introduced the RH- blood group allele into the population – frequency of the RH- blood group is still comparatively low in China compared to other countries. Another situation in which migration has had an enormous influence on the gene pool of a population was the arrival of Europeans to Australia. Prior to british colonization in 1788, the indigenous pop of Australia had no contact with European diseases such a chickenpox, small pox and influenza and thus had very little genetic resistance. The worst hit communities were those with highest population desities – people living in close proximity to one another spread the diseases quicker – these diseases changed the allele frequencies of the survivors – they were likely to have some genetic resistance and this would have been passed onto their offspring – thus natural selection was occurring, but at the same time, interbreeding between aboriginals and colonists would have introduced new alleles into the aboriginal population.

4. BARRIERS TO GENE FLOW – populations are often kept apart by barriers that inhibit the amount of interbreeding between them. As no two environments are exactly the same, the environmental pressures on one may be different to the pressures of another – this results in slightly different characteristics being favoured in one population compared to the other – these changes in each population over many generations result in the populations becoming less and less alike as they develop characteristics better suited to their respective environments. Isolation results in the development of separate gene pools.

Geographical barriers include: oceans, mountain ranges, large lake systems, deserts and expansive ice sheets.

Sociocultural barriers include: language, economic status, educational background, religion and social position.

The Basque people of the Pyrenees in France and Spain have a language that appears unrelated to any other. This has served to unite them and preserve their cultural identity despite sharing the same religion and occupations as their neighbours – they are characterised by broad features such as broad foreheads, narrow jaws and distinctive frequencies in their blood groups – 35% are RH- while in the surrounding European countries, on 16% of people are RH-.

GENETIC DISEASES – The allele that causes tay-sachs is an example of how genetic diseases affect allele frequencies in gene pools. It is a hereditary disorder of lipid metabolism that mostly affects Ashkenazi jewish people. It affects around 1/500000 births worldwide, but around 1/2500 births in Ashkenazi jews. One possible reason for the high frequency of this allele in the population is genetic drft – jewish populations tend to be small and isolated – factors that increase the chances of genetic drift. Another reason is that those who are heterozygous for Tay-sachs have a selective advantage/resistance to tuberculosis – that is, that people who are homozygous for the dominant normal allele (TT) are susceptible to TB, those who are homozygous for the recessive lethal allele (tt) are likely to die very young due to the disease but those who are heterozygous - that is the lethal recessive is masked by the dominant normal allele (Tt), they are not affected negatively by the disease, but still have a specific resistance to TB – and are thus more likely to reproduce and pass their genes on to subsequent generations. Due to discrimination, Ashkenazi Jews often found themselves in overcrowded ghettos that increase the threat of TB – meaning that the frequency of the tay-sachs allele could be maintained. It is interesting to note that the same disorder has been seen in the Cajun population of southern Louisiana – Cajuns are an ethnic group that have been reproductively isolated for several hundred years because of language differences – the mutation may have been introduced when an Ashkenazi family integrated into the society who were carriers/affected – if this was the case it is another example of how migration affects allele frequencies in populations.

**THE PROBABILITY OF HAVING A CHILD (FROM A MARRIAGE BETWEEN FAMILY MEMBERS) WITH GENETIC DISEASE CAUSED BY A RECESSIVE ALLELE IS COMMON – THE RELATED PARENTS HAVE RECEIVED SOME OF THEIR GENES FROM A COMMON ANCESTOR AND THEREFORE HAVE AN INCREASED CHANCE OF BEING CARRIERS OF AN ALLELE FOR THE SAME ABNORMAL CONDITION.**

THE THEORY OF EVOLUTION THROUGH NATURAL SELECTION:

\*Evolution is the gradual change in the characteristics of a species (Charles Darwin and Albert Wallace in 1858)\*

Darwins theory of natural selection was based on three observations:

1. Variation – all members of a species vary with these being passed on down subsequent generations. It is because of variation that survival of the fittest (more organisms with favourable characteristics suitable to survival in their environment survived long enough to reproduce and pass those characteristics on to their children).
2. Birth rate – all living organisms reproduce at a rate which exceed the rate at which their food and resource supply increase – creates a struggle for existence with favourable variations being preserved.
3. Natures balance – although birth rate was high, each species numbers tended to remain at a relatively constant level.

Natural selection can thus be defined as the selection of alleles in a population that give an organism a greater survival advantage. Those organisms that survive will pass on their favourable alleles to their offspring with the characteristics of a population over an extended period of time changing to be better suited to their environment.

EVIDENCE: Body stature – longlimbed/short bodied people in Africa VS. shortlimbed/longbodied people of the Inuit (eskimo).

Sickle cell anemia and Anopholese malaria virus in africa.

SPECIATION:

Isolation was mentioned earlier as a barrier to gene flow – reproductive isolation may lead to the development of separate gene pools. If two populations are isolated for long enough and the environmental influences on each are different enough, major changes in the allele frequencies within each population may become so different that even if the barriers were removed, interbreeding could no longer be possible. Thus the two populations would be considered two separate species. The process of producing two separate species this was is called SPECIATION.

1. VARIATION – a population exists on an island with variations shared among a common gene pool.
2. ISOLATION – a barrier is formed dividing the population in two, no interbreeding occurs and each population has a separate gene pool
3. SELECTION – different selection pressures act on each of the two populations over a number of generations. This brings about a change in the gene frequencies of each gene pool – such changes lead to the evolution of separate subspecies
4. SPECIATION – Over a long period of time the changes in the gene frequencies may become great enough that production of fertile offspring from interbreeding can NEVER AGAIN OCCUR – at this point, two separate species occur

**CHAPTER 15 – EVIDENCE FOR EVOLUTION:**

SPECIATION: When an ancestral species gives rise to two or more species – the new species would have very similar DNA with these similarities decreasing as the species gradually change and mutate.

Chromosomes sometimes have non-coding sequences of bases in the DNA – known as junk DNA as they have no apparent function and serve no purpose.

Examples of non-functional DNA are endogenous retro viruses (ERV). RV’s store their genetic information in the form of RNA – upon entering a cell, a RV copies its RNA genome into DNA (reverse transcription). The DNA then becomes inserted into one of the host cells chromosomes. A retrovirus only becomes endogenous if it gets inserted into one of the host cells sex chromosomes – sperm/ovum – subsequent generations will then have the same virus, in the same place, in the same chromosome in every cell in their body.

Scientists have found 16 instances of the exact same retrovirus in the same places in both humans and chimpanzees – short arms of chromosomes 10, 1 and 6 and the long arm of chromosome 9 – this is compelling evidence of shared ancestry as any retrovirus inserted into the genome of a common ancestor would be inherited by subsequent species branches on the exact same arm of chromosomes.

MITOCHONDRIAL DNA:

* Mitochondria are the organelles in the DNA responsible for aerobic respiration that is required to release energy for use by the cell.
* Most of the cells DNA is found in the nucleus, but a small amount is found in the mitochondria – mtDNA
* mtDNA is found in the form of small circular molecules – there are 5-10 of these molecules in each mitochondrion.
* mtDNA has 37 genes – 24 contain the code for making transfer RNA molecules which are involved in protein synthesis. The other 13 have instructions for making some of the enzymes necessary for cellular respiration reactions
* Some rare diseases are caused by mutations in the mtDNA
* Most cells contain large numbers of mitochondria and therefore around 500-1000 copies of mtDNA molecule – this makes it a lot easier to find and extract than DNA from the nucleus so smaller samples can be used.

INHERITANCE OF MITOCHONDRIAL DNA:

We inherit out mtDNA from our mothers only – the sperm only contain about 100 mitochondria (just enough to provide the energy to reach the egg), and after the sperm has penetrated the egg for fertilization, the mitochondria are rapidly destroyed. DNA found in the mitochondria also has a higher rate of mutation than nuclear DNA – meaning that human mtDNA has been slowly diverging from the mtDNA of our original female ancestor – scientists are thus able to use the similarities between the mtDNA of any 2 individuals to estimate their genetic closeness. Examination of mtDNA has shown that the last common ancestor of modern humans and Neanderthals lived around 600 000 years ago.

PROTEIN SEQUENCES:

Proteins consist of long chains amino acids (from a few hundred – thousands) - linking together particular amino acids in a precise order determined by DNA creates these proteins – thousands of types of proteins exist in all living things created from 20 kinds of amino acids.

By comparing the type and sequence of amino acids in similar protein from different species, the degree of similarity can be determined – animals of the same species have identical amino acid sequences in their proteins while animals from different species have different amino acids/the acids are arranged in a different order. The longer the period of time involved since two given species have evolved from a common ancestor, the more differences there should be in their amino acid sequences.

UBIQUITOUS PROTEINS ARE PROTEINS THAT APPEAR TO BE FOUND IN ALL LIVING SPECIES ON THE PLANET – THEY PERFORM VERY BASIC BUT ESSENTIAL FUNCTIONS THAT ALL ORGANISMS REQUIRE FOR LIFE – THEY ARE FOUND IN EVERYTHING FROM BACTERIA TO HUMANS.

Cytochrome C is one such example of a ubiquitous protein – human cytochrome has 104 amino acids – regardless of the species tested, 34 of these have been found in the same positions in every cytochrome C molecule that’s been sequenced – strongly suggesting that these proteins have descended from an ancestral cytochrome C molecule found in a primitive microbe that existed more than 2000 million years ago.

To compare cytochrome c sequences, they need to be aligned so that the maximum number of positions containing the amino acid can be determined – the higher the similarities there are between two molecules, the more recently they have evolved from a common ancestor. The cytochrome C of chimps and gorillas is the same as that for humans while for rhesus monkeys, it differs by only one amino acid.

BIOINFORMATICS:

The use of computers to describe the molecular components of living things – it has in recent times allowed researchers to compare entire genomes – in doing so, the genes and other biological features of DNA need to be identified (a process called annotation) – this process needs to be computerized because most genomes are too large to be annotated by hand – annotation is made possible by the fact that genes have a recognizable start/stop codon.

COMPARATIVE GENOMICS:

Is a relatively new field of bio-research where the genome sequences of different species are compared – by comparing the sequence of the human genome with the genomes of other organisms, researchers are able to identify regions of similarity and difference. This procedure provide an effective means of studying evolutionary changes among organisms – helping to identify which genes are preserved among species as well as which genes give species their unique characteristics.

By analyzing the genomic features of different species that have been preserved for millions of years, researchers are beginning to be able to tease apart the subtle differences between animal species – it has also been used to reveal the diversity of gene composition in different evolutionary lineages.

COMPARATIVE STUDIES IN ANATOMY:

Comparative anatomy involves comparing the structural features of related animals to ascertain the degree of similarity between them.

EMBRYOLOGY:

* Comparing the very early stages of development of organisms.
* In vertebrates – comparing the embryonic structures reveals remarkable similarities between different species at different times.
* Fish, reptiles, birds, pigs and humans all have gill pouches and arches as early embryos despite the latter four having lungs for breathing air and no aquatic larvae in later life – the presence of these structures is significant if they are viewed as an evolutionary series that began with fish hundreds of millions of years ago with evolution resulting in their divergence later.
* This evolutionary line is well supported by the fact that one of the embryonic gill slits in humans later develops into the Eustachian tube and the surrounding tissue of the other gill slits develops into the thyroid gland and tonsils.
* Common to all vertebrate embryos too are two chambered hearts and similar brain development – adding up to striking evidence for common ancestry with later evolution along different pathways.

HOMOLOGOUS ORGANS:

Homologous structures are parts of the body that are similar in structure to other species' comparative parts. These similarities are evidence that life on Earth has a [common ancient ancestor](http://animals.about.com/od/l/g/lastcommonances.htm) that the diverse species have evolved from over time. The common ancestry of the species can be seen in the structure and development of these homologous structures, even if their function is different.

The more closely the organisms are related, the more similar the homologous structures between organisms. Most examples of homologous structures revolve around the limbs of the species being compared. The bone structure within those limbs are similar between closely related species.

Many [mammals](http://animals.about.com/od/mammals/p/mammals.htm) have similar limb structures. The flipper of a whale, the wing of a bat, and the leg of a cat are all very similar to the human arm. All of the mentioned species have a large upper arm bone (the humerus on the human) and the lower part of the limb is made up of two bones - a larger bone on one side (the radius in humans) and a smaller bone on the other side (the ulna in humans). All of the species also have a collection of smaller bones in the "wrist" area (these are called carpal bones in humans) that lead into the long "fingers" or phalanges.

Even though the bone structure in these limbs of the mammals are very similar, the function of the limb itself is very different. The homologous limbs can be used for flying, swimming, walking, or everything humans do with their arms. These functions evolved through natural selection as the common ancient ancestor underwent [speciation](http://evolution.about.com/od/macroevolution/a/Speciation.htm) to make all of the diversity we have on Earth today. Whales were once classified as a fish since they live in the water and have flippers. However, after it was discovered that those flippers actually contained homologous structures to human legs and arms, they were moved to a part of the tree more closely related to humans. In fact, it seems whales are much more closely related to hippos than fish.

Likewise, since bats fly, they were originally classified as closely related to birds and insects. Everything with wings were put into the same branch of the phylogenetic tree. However, after much more research and the discovery of homologous structures, it was apparent that not all wings are the same. Even though they have the same function, to make the organism be able to get airborne and fly, they are structurally very different. While the bat wing resembles the human arm structure wise, the bird wing is very different, as is the insect wing. Therefore, bats are more closely related to humans than birds or insects and were moved to their corresponding branch on the phylogenetic tree of life.

VESTIGIAL ORGANS:

Structures of reduced size with no apparent function – i.e.

1. Nictitating membrane (pinkish membrane found in inner corner of eye)
2. Muscles to move ears
3. Pointed canine and wisdom tooth
4. Hair on body
5. Nipples on male
6. Segmentation of abdominal muscles
7. Appendix
8. Pyramidalis muscles above pubic area
9. Coccyx (fused tail bone area)

They are what remains of organs that were functional in ancestral forms – over time and with changing environmental conditions, such organs were no longer essential to survival and gradually reduced to vestigial remnants; however as they are not harmful in any way, they have not been completely eliminated.

GEOGRAPHICAL DISTRIBUTION:

Isolated areas or island groups have often evolved their own distinctive plant and animal species – in Australia there were more than 100 species of kangaroos, koalas and other marsupials but none of the other more evolutionary advanced terrestrial placental animals – also with one exception, the living representatives of primitive egg-laying mammals (echidna and platypus) are only found in Australia – the exception being one species of echidna being found in New Guinea (which is close to Aus) – the most likely explanation being that the unique species found in Australia have been evolving for millions of years in isolation from the rest of the world.

**CHAPTER 16 – FOSSIL EVIDENCE FOR EVOLUTION:**

One of the crucial pieces of evidence for evolution, the gradual change in characteristics of organisms over time, is the record of those changes left in the form of fossils. Any preserved trace left by an organism that lived long ago is a fossil – fossils therefore include footprints, burrows, faeces or impressions of all or part of an animal or plant (as well as bones, shells or teeth) - - in the case of humans, fossil remains are usually bones, teeth and sometimes footprints. Other material associated with the bones, such as the rock they were found in and fossils of other plants and animals allows the scientist to develop a picture of life in the past – what they ate, what other things existed at the same time and sometimes even what the climate was like.

One of the best known cases of a fossil record allowing scientists to build up a sequence of evolution is the evolution of the horse – it can be traced through the remains of a small creature not much bigger than a small dog through to the horses we know today.

FOSSILFORMATION:   
Normally dead organisms are decayed by micro-organisms and no trace of their existence is left. Parts of organisms may become fossilised when buried by drifting sand, mud deposited by rivers, volcanic ash or burial by other members of the species (if buried rapidly, conditions may not be suitable for the activity of decay organisms and decomposition may be slowed/prevented.

In wet, acid soils, the minerals of the bone are dissolved and no fossilisation occurs, however if such soil contains no oxygen (i.e. peat) complete preservation of the soft tissues and bones of the organism may occur. Bones buried in alkaline soils produce the best fossils because the minerals in the bones are not dissolved – new minerals (lime/iron oxide) are deposited into the pores of the bones replacing the organic minerals that make up 35% of the bone weight – the bone becomes rock (petrified) but the details of the structure are still preserved.

FOUR CONDITIONS REQUIRED FOR FOSSIL FORMATION:

1. A quick burial of the material
2. The presence of hard body parts
3. An absence of decay organisms
4. A long period of stability – the organism needs to be left undisturbed

DISCOVERY OF FOSSILS:

Small hand tools are used to gently remove the soil so as not to damage any of the material (the soil is usually then sieved). In the case of fossils of human ancestors, artefacts (objects deliberately made by humans) are often found in association with the fossils – including stone tools, beads, carvings, charcoal and cave paintings. In the laboratory, fossils are carefully scraped clean , broken parts are pieced together, measurements are made and plaster casts/latex moulds may be made.

DATING OF FOSSILS:

Knowledge of the age of fossils and artefacts is crucial in finding out the sequences of changes that have resulted in present day humans. Some methods of dating provide absolute dates – the actual age of the specimen in years – or relative dates – which tell us if one sample is older/younger than another.

ABSOLUTE DATING:

POTASSIUM ARGON TECHNIQUE : Is based on the decay of radioactive potassium to form calcium and argon. Potassium is a mixture of three different forms with atomic weights 39, 40 and 41. The isotope K-40 is radioactive and decays to form Ca-40 and Ar-40 – such decay takes place at an extremely slow but constant rate and so determining the amounts of K-40 and Ar-40 allows the age of the rock to be calculated. P-A dating has limited usefulness however as not all rock types are suitable for this method of dating and it can only date rocks older than 100 000 – 200 000 years (at the earlier date of 100 000 years, only 0.0053% of the K-40 in a rock would have decayed to Ar-40, pushing the limits of detection devices currently in use. To determine the age of a fossil using this method, a suitable rock of the same age must be available – this occurs when rocks produced in volcanic eruptions bury bones.

CARBON-14/RADIOCARBON DATING: This method is based on the decay of the radioactive isotope carbon-14 to nitrogen. Carbon 14 is produced in the upper atmosphere by the action of cosmic radiation on nitrogen at about the same rate that it decays. In the atmosphere there is a ratio of one carbon-14 atom to every million million (trillion) atoms of the stable isotope carbon-12. When plants use atmospheric carbon dioxide in photosynthesis, one atom in every trillion of the carbon atoms incorporated is carbon-14. Should an animal eat the plant, the carbon 14 then becomes part of the animals tissues. With death, an organisms intake of carbon 14 ceases, but the carbon 14 already in the tissues continues to decay at a fixed rate – by measuring the amount of radiation liberated by a sample, the ratio of carbon 14 – carbon 12 can be estimated and from this, the age of the sample can be calculated.

5730 +/-40 is the half life of carbon 14 – in other words, every 5730 (+/-40) years, there will be half the amount of carbon 14 than previously – the normal method of radiocarbon dating requires at least 3g of organic material so that the amount of C-14 in a sample can be measured.

A more refined technique called the ACCELORATOR MASS SPECTROMETRY (AMS) RADIOCARBON DATING can be used to date a sample as small as 100micro grams by breaking the sample up into its constituent atoms so that the number of atoms of each isotope of carbon can be counted. Using AMS dating it has become possible to date cave paintings accurately from tiny samples of pigment as some of the pigments contain organic material such as charcoal.

|  |  |  |
| --- | --- | --- |
| DATING METHOD | MATERIAL USED | USEFUL RANGE (YEARS BP) |
| Tree growth rings | Wood | Up to 9000 |
| Carbon -14 | Carbon compounds | Up to 60 000 |
| Protactinium | Sea sediments | Up to 250 000 |
| Uranium-thorium | Sea sediments, coral | Up to 600 000 |
| Potassium-argon | Volcanic deposits | 200 000 and earlier |
| Electron spin resonance | Calcium carbonate, quartz and flint | Between 100 000 and 300 000 |
| Fission tracks | Minerals and glass | 100 years ago to 4550 million |
| Thermoluminescence | Sediments, lava, ceramics | 300 years ago to 100 000 |

After about 70 000 years radiocarbon dating is null and void because the amount of carbon 14 left is negligible – therefore radiocarbon dating cannot be used to date back more than 60000 years – another limitation is that material to be dated must contain organic carbon compounds.

RELATIVE DATING METHODS:

STRATIGRAPHY: The study of layers (strata) can be useful in two ways:

1. Principle of superposition – assumes that in layers of sedimentary rock, the layers at the top are younger than the layers at the bottom – 2 problems with this – distortions in the earths crust do occur and a sequence of rock layers may be turned upside down and it is possible for fossils or artefacts to be buried by animals or humans some time after the deposition of sediment.
2. The correlation of rock strata – involves matching layers of rock from different areas – matching can be done by examining the rock itself and also by studying the fossils it contains. Rocks that contain the same fossils can be assumed to be of the same age. Certain fossils are of great value in correlation studies as they are widely distributed and present for only a limited period of time – they are called index fossils (i.e. a trilobite fossil).

FLUORINE DATING (Pilt down man): It is based on the fact that when a bone is buried/left in soil, fluoride ions which are present in the water in the soil replace some of the ions in the bone itself. All the fossil bones in a particular deposit should have the same amount of fluoride and so fossils that have been displaced can be detected – the older the fossil, the more fluoride it should contain and so the relative ages can be established.

PHYLOGENETIC TREES: Also called a DENDROGRAM represents the evolutionary relationships between a number of organisms derived from a common ancestor where the ancestral organism forms the base of the tree and those organisms that have derived from it make up the branches. Closely related groups are placed on branches close to eachother – keep in mind however that these are only inferred relationships; different researchers may come up with different trees to fit their interpretation of the data.

THE GEOLOGICAL TIME SCALE: Because of the tremendous time span involved, Earths geological history has been divided up into a geological time scale that consists of Eras, broken into Periods and further divided into Epochs. In studying the origins of humans, we are only interested in the Cainozoic era as this is when the primates (the group modern humans belongs to) started to evolve.

**CHAPTER 18 – EVOLUTIONARY TRENDS IN HOMINIDS:**

More than 3 million years ago, the ancestors of modern humans walked over the wet volcanic ash of Laetoli, Tanzania leaving behind their footprints – as the ash dried and hardened it became fossilised and then covered by more ash until its accidental discovery in 1978. - interesting – the ancestors of modern humans that made those footprints were walking much the same way as we do now – BIPEDAL LOCOMOTION – or walking upright on 2 legs – differs from other great apes who used QUADRAPEDAL LOCOMOTION.

APES + HUMANS = GREAT APES = GENUS HOMINIDAE Shared characteristics of the great apes:

1. A brain that is larger and more complex than other primate – bigger cerebral cortex
2. Distinctive molar teeth in the lower jaw which have a ‘Y5’ pattern (5 cusps/ridges in the shape of a y)
3. A shoulder and arm structure that enables it/the arms to rotate freely around the shoulder
4. A ribcage that forms a wide but shallow chest
5. An appendix
6. No external tail

However, humans differ from primate apes in the appearance and majority of their structure – each animal species has adapted/developed characteristics that helped it to survive and reproduce in their respective environment.

Humans as such are classified as HOMININS, belonging to the tribe HOMININI.

A TRIBE – given to a relatively new level of classification between subfamily and genus.

ORANGUTANS AND THEIR EXTINCT ANCESTORS

CHIMPANZEES AND THEIR EXTINCT ANCESTORS

TRIBE GORILLINI

GORILLAS AND THEIR EXTINCT ANCESTORS

HUMANS AND THEIR EXTINCT ANCESTORS

TRIBE PANINI

GIBBONS AND THEIR EXTINCT ANCESTORS

FAMILY HOMINIDAE

SUBFAMILY PONGINAE

FAMILY HYLOBATIDAE

TRIBE HOMININI

SUBFAMILY HOMININAE

EVOLUTIONARY TRENDS:

Apes and humans share a common ancestor – an ape like creature – from these the first hominins evolved – AUSTRALOPITHECINES – hominins classified in the genus Australopithicus. From one or more of these Australopithicene species evolved early members of the genus HOMO – species of early homo gradually evolved into a number of different species including HOMO ERECTUS AND HOMO NEANDERTHALUS and eventually into modern humans – HOMO SAPIENS.

ADAPTIONS FOR ERECT POSTURE:

An adaption is any characteristic that helps an organism survive and reproduce in its natural environment – erect posture helped our human ancestors survive.

1. POSITION OF THE FORAMEN MAGNUM – where the brain meets the spinal cord, there is a hole in the skull called the foramen magnum – in quadrupeds, its situated in the centre back of the skull (creates c shaped spine), whereas in humans its gradually moved forward (to centre bottom of skull) so that the skull can be balanced ON TOP of the vertebral column - gorillas need large neck muscles to hold the head in place as it overhangs the chest whereas in humans, the weight of the skull is borne by the vertebral column and so large neck muscles are not required.
2. CURVATURE OF THE SPINAL COLUMN – humans have a double curvature giving the spine its distinctive ‘s’ shape. The vertebrate in the lower region – LUMBAR –are wedge shaped from front to back forming a forward jutting curve – improves body balance when upright and allows the head to balance on top of the neck – the cervical curve of the spine in the neck brings the vertebral column directly under the centre of gravity of the skull.
3. THE JAW – Prognathism – apes have a protruding jaw whereas humans have a much flatter facial profile – during evolution the size and protrusion of the human jaw was gradually reduced to allow the skull to balance on top of the spine – because the weight in front of the foramen magnum = the weight behind, balance is thus achieved with minimal muscular effort.
4. THE PELVIS – at its lower end, the vertebral column articulates with the pelvis. The pelvis in humans is broader and shorter – from top to bottom – than in apes and bowl shaped. The bowl shape supports the abdominal organs and any developing foetus, the broad hip bones provide space for the attachment of large gluteal muscles which move the legs and keep the upper body erect.
5. THE CARRYING ANGLE – the shape and orientation of the pelvis result in the hip joint being directly under the trunk and head. This allows the weight to be transferred from the pelvis to the legs. The head of the femur is large (and in charge) and fits into the acetabulum (hip socket) of the pelvis. Because the pelvis is broad, the hip sockets are far apart, but the femurs tend to converge inwards at the knee – this arrangement of the femurs forms an angle to the vertical (carrying angle) which ensures that weight distribution remains close to the central axis of the body when walking – this arrangement also allows for greater stability when walking as it enables the body to be rotated around the lower leg and foot AND for each footstep to follow a more-or-less straight line (enabling humans a striding gait rather than the swaying gait of chimps and gorillas).
6. THE KNEE – the weight of the body is transmitted down the outside of the femur to the knee. The knee is a 2 part hinge joint – because the weight is transmitted to the outer hinge – it is bigger and stronger than the inner hinge. Although the weight of the body is transmitted down the outside of each leg, the centre of gravity tends to fall through a line just in front of the knees – this results in a force that bends the knees backwards but is resisted by the ligaments making up the knee joint – this natural resistance produces a joint that requires no energy to support the body in a standing position.
7. THE FOOT – from the knee joint most of the weight of the body is transmitted through the tibia (the larger and stronger of the 2 lower leg bones) to the ankle. At the ankle, the body weight is transmitted from the tibia to the talus (ankle bone) to the other tarsal bone, then to the metatarsals and phalanges via the arches of the foot – in becoming highly specialized for locomotery, the foot has lost its grasping ability (prehensility) – the big toe has become larger and is now in line with the other toes. We have developed the transverse arch (side to side) that apes do not have in addition to the longitudinal arch of all apes (front to back). The ankle has also lost the majority of its flexion – from 45 degrees to around 20 degrees – we cant climb trees no more.
8. STANCE AND LOCOMOTION – striding gait = walking upright with the hip and knee fully straightened – apes when walking upright push their hips forward and bend their knees to counter balance and lower centre of gravity.
9. MUSCLE TONE – the partial contraction of skeletal muscles – i.e. muscles in back of neck remain partially contracted unless asleep/unconscious to prevent head from slumping over to the chest – the NS and a variety of sense organs work together to maintain the tone in these muscles and maintain the equilibrium if the body.

**CHAPTER 19 – HUMAN ANCESTORS:**

AUSTRALOPITHICUS AFARENSIS

ADVANTAGES OF BIPEDAL LOCOMOTION:

1. Increased range of vision for detecting prey and predators at a greater distance
2. Increased size, deterring predators
3. Hands free for carrying food (and perhaps for tool use)
4. Higher reach when picking fruit from trees
5. Improved cooling of the body – less surface are for sun to hit and heat up

WHY DID APES START WALKING??

As the climate changed, becoming colder and drier, rainforest size started to decrease creating larger areas of grass planes – apes who could walk bipedaly for longer distances had a selective advantage over those who couldn’t.

FEATURES OF AUSTRALOPITHICENES (TAUNG MAN EXAMPLE)

1. The face was not as protruding
2. Skull was more rounded
3. No brow ridge
4. More forward position of the foramen magnum
5. Curvature of the spine was closer to modern humans ‘s’ shape
6. More prognathic than modern humans
7. Teeth (particularly molars) were halfway between primate ape and human.

HOMO SAPIENS (in Africa)

HOMO NEANDERTHALUS (in Europe)

HOMO HEIDELBERGENSIS

HOMO ERECTUS

HOMO ERGASTER

HOMO RUDOLFENSIS

HOMO HABILIS

PARENTHROPUS BOISEI

PARENTHROPUS ROBUSTUS

PARENTHROPUS AETHIOPUS

AUSTRALOPITHECUS AFRICANUS

1. Laetoli footprints gave first evidence of Australopithecine bipedalism – big toe was large and in line with the other toes
2. Low forehead
3. Average brain size - 480cm3 (closer to apes than humans)

VARIATION IN AUSTRALOPITHICENES:

ROBUST (Parenthropus robustus) –

* 150-160 cm tall
* 65-75kgs
* large jaws
* small incisors and canines
* large molars
* skull had crests/buttresses for attachment of muscles

GRACILE (A.Africanus/Afarensus – Lucy)

* 120-140 cm tall
* 25-35kgs
* teeth were more in proportion to eachother
* jaw muscles were smaller

HOMO HABILIS (HANDY MAN)

~ thought to be the earliest tool user

~ taller than gracile forms

~ stood more erect

~ belonged to the homo genus and existed/lived along side robust australopithicenes (1.9 mya)

~ brain size approx. 600-775 cm3

HOMO ERECTUS (UPRIGHT MAN)

~ thought to be the first species to use fire

~ average brain size 1075 cm3

~ dental arcade was shorter and more rounded in shape (apes are parabolic)

~ jaw was shorter and more compact w/ evidence of a developing chin

**FOOTPRINTS IN ILERET KENYA – OLDEST RECORDED FOSSILS OF MODERN HUMAN FOOTPRINTS – BELONGED TO HOMO ERGASTAR** **1.5 MYA – PRONOUNCED LONGITUDINAL AND TRANSVERSE ARCHES**

HOMO HABILIS = 1.8-1.44 MYA

HOMO ERGASTAR = 1.6-1.4 MYA

HOMO ERECTUS = 1.8MYA – 250 000 YA

HOMO ANTECESSOR = 750 000 YA

HOMO HEIDELBERGENSIS = 450 000 YA

DENTITION OF THE AUSTRALOPITHICENES:

1. The size of the canines and prominence of ridge cusps were intermediate between apes and early hominins
2. The first premolar was typically more ape like – some specimens only had one cusp rather than two
3. The cheek teeth were more hominin like in that they were very large, broad and comparatively flat

FEMUR AND PELVIS:

1. the femur of the australopithecine was angled so the foot was under the centre of gravity
2. tibia bone was thinner and the angles of the femur/pelvis much shallower (pelvis less bowl shaped)

PRIMITIVE:

Thicker bones forming cranium

Smaller cranial capacity

Heavier brow ridges and sloping forehead

Possible crest on skull and lower cranium

Foramen magnum at back

More prognathic jaw

Heavier, thicker mandible and no chin

Large teeth (molars) w/ diastema

Narrow hips and less wedge shaped lumbar

Shorter thumb, curved fingers

Femurs more parallel

Arms longer than legs

MODERN:

Thinner cranial bones

Larger cranial capacity

Absent brow ridges and more vertical forehead

Dome shaped cranium and no crest

Foramen magnum at base

Flatter face and thinner mandable

Smaller teeth and no diastema

Broader hips and wedge shaped lumbar

Longer thumb and straighter fingers

Angled femurs

Arms shorter than legs

TRANSITION TO MODERN HUMANS:

(skull found in Steinheim, Germany)

~ average brain size 1150 cm3 with convolutions similar to modern humans

~ forehead is more prominent BUT it has a heavier brow ridge

~ back of skull is more rounded

~ cheek molars are more modern

~ 250-300 000 years old – THE TRANSITIONAL BTWN HOMO ERECTUS AND HOMO SAPIENS – THE HOMO HEIDELBERGENSIS (in Africa, old Heidelberg became homo sapiens and in Europe it became Neanderthals)

NEANDERTHALS:

* lived during the last ice age
* big faces
* low, large skulls
* extreme Prognathism
* bun shaped back skull
* robust physical appearance
* lack of definite chin
* short – 1.5m tall
* barrel chest
* slightly larger brain (1485 cm3 compared to our 1350 cm3)

CROMAGNON PEOPLE:

* one of the earliest examples of homo sapiens
* stone tools (AURIGNACIAN TOOLS)
* 40 000-12 000 ya
* skulls were shorter from front-back, higher in the top region of the skull and rounder at the back
* less prominent brow ridges, smaller jaw and less projected
* teeth were smaller and chin had developed

**CHAPTER 20 – CULTURAL EVOLUTION:**

AUSTRALOPITHECINE CULTURE:

* OLDOWAN period
* Home bases
* Range of pebble tools dating back 2.5mya – choppers (tennis ball size), scrapers and flakes (marble size)
* Australopithecines started to diverge from Africa around 2mya – along rift valley system – river nile – into Egypt – then into middle east and asia

EARLY HOMO CULTURE:

Adult male hominins were probably the first hunters, leaving women to gather plant material – markedly changed the structure of hominins (socially) – increases interdependence – making it more close knit and allowing it to function as a social and economic unit.

Early homo had a bulge in the speech production centre of the brain – larynx may not have been capable of making complex sounds.

CULTURE OF HOMO ERECTUS:

Effect of the environment as a selective agent was diminishing – modifying the environment to suit themselves – through use of fire, building of shelters and a range of sophisticated tools – makes them more independent of the environment -ACHEULIAN TOOLS – flaked in one direction, then in another creating a lump approximately teardrop in shape (used as hand axes)

* Preferred to eat deer – sometimes fished
* Tools were made from stone and bones
* Olorgasaeli baboon slaughter – evidence of organized hunt in advance w/ stones and tools carried from up to 33km away
* Evidence in Torralba and Ambrona that they lit fires to drive elephants into traps for slaughter

USE OF FIRE:

1. Keeps away predators
2. Warmth and light
3. Cooking away germs – digestible and taste better
4. Increases community spirit – sharing of stories and tools of the trade

NEANDERTHAL CULTURE:

* MOUSETTARIAN industry
* Side/bifacial/nose ended scraper – stone was trimmed into a disc shaped core and then struck by another rock to create flakes
* THEY BURIED THEIR PEOPLE

CROMAGNON CULTURE:

* Aurignacian tools
* Soulterian culture – willow leaf and laurel leaf points – made by pressure flaking
* Magdalenian culture – dominance of bone and antler tools over flint and stone – blade, burin and needle tools as well as barbed spears
* Mural art appeared around 400 000ya during the aurignacian period – seems crude (line drawings) compared to the art of the cromagnons – sculptures of sandstone and ivory and paintings with colour – during the Magdalenian period they learnt how to shade and highlight to create 3D art

AUSTRALOPITHECINES – 2.6-1.7 MYA – OLDOWAN

HOMO ERECTUS – 1.7 MYA-200 000 YA – ACHEULIAN

NEANDERTHAL – 200 000-40 000 YA – MOUSETTARIAN (FLAKE TOOLS)

CROMAGNON – 43 000 -26 000 – AURIGNACIAN (BLADE TOOLS)

- 22 000-19 000 – SOULTERIAN (PRESSURE FLAKING)

- 18 000-12 000 – MAGDALENIAN (BONE AND ANTLER TOOLS/ARTWORK)

THE BEGINNINGS OF AGRICULTURE:

* Neolithic revolution
* Domestication of plants and animals – sheep were domesticated first – 11 000 ya and the hybridization of wild goat grass and wild wheat to create the fertile Emmer was the first domesticated plant