Studying human brains

- Brain surgery patients allow their brain to be artificially stimulated. The patient describes sensations relating to the stimulation. This shows what areas of the brain are associated with certain features

Phineas Gage

- Phineas Gage was a likeable, reliable and hardworking man
- An iron bar went through his head but didn't kill him
- After the accident, his personality changed. He became irresponsible, foul mouthed and unpleasant
- The bar had destroyed the connection between the leftside of his frontal lobe and the midbrain. He had lost control of his emotional behaviour

Newborn babies with cataracts

- If cataract removed early on then sight develops normally
- If left for a few years then sight cannot be restored. This suggests a critical period
- If cataract removed within 6 weeks, then future sight issues are minimised

Newborn babies and face recognition

- Babies at 2 days old can recognises the difference between movement by a living biological organism and a non biological organism. This suggests that nature plays a large part in facial recognition
- Babies prefer looking at biological movement and could distinguish between objects that were upside down.
- Babies able to tell the difference between faces of monkeys. As they get older they lose this ability. It is suggested that as babies look at human faces more often, their cerebral cortex becomes sensitive to human faces. Lack of exposure to animal faces results in babies losing this ability. Adults who work with animals are able to tell the difference between the faces of animals. This suggests there are many environmental influences on the development of the human brain.

Twins

- Twin studies suggest there is a very strong genetic factor in face recognition
- There was similar amount of brain activity when identical twins were looking at the same face. When fraternal twins looked at the same face, brain activity varied. This shows that nature plays an important part in facial recognition.
- fMRI scans were used to measure the brain activity

Cross cultural studies

- Tthe brain uses visual clues around your surroundings as well as past experiences to give you depth perception
- The experiences of an individual depends on the individuals culture. This is way peoples depth perception can be different.
- Zulu people are able to tell the difference in length of straight lines than people from European backgrounds. Some scientists argue that this is because Zulu people have a circular culture with little or no straight lines in their buildings or roads. Therefore, they have no hardwired interpretation of straight lines. Other scientist believe that the difference in perception is due to different levels of retinal pigmentation. People with higher levels of retinal pigmentation are not as good at detecting contours. Other studies back up the idea of a critical window when depth perception develops

14 Describe how animals, including humans, can learn by habituation.

- Habituation is learning to ignore stimulus and make no response when the stimulus is repeated many times with no apparent reward of punishment associated with it

How animals learn by habituation

- With repeated stimulation, Ca^{2+} channels become less responsive so less calcium ions cross the pre-synaptic membrane
- This means fewer neurotransmitter vesicles fuse with the membrane and release transmitter substance into the synaptic cleft
- Less neurotransmitter diffuses across the synaptic cleft and bind to receptors on the post-synaptic membrane
- Fewer sodium channels open resulting in less membrane depolarisation

15 Describe how to investigate habituation to a stimulus.

Touching Snails

- Place a giant African snail on a clean firm surface
- Allow the snail to acclimatise to its new surroundings
- Firmly touch the snail with a dampened cotton wool bud between its eyes

- Measure the time it takes for the snail's stalks to fully extend after its been touched
- Draw a suitable graph

16 Discuss the moral and ethical issues relating to the use of animals in medical research from two ethical standpoints.

For

- Clinical trials stage 1 involves animals. Without animals we would be unable to discover new drugs
- Animal testing is better than nothing and does, in some cases avert potential loss of human life
- Animal testing is for the greater good
- Machines like MRI were tested using animals
- Animal testing has advanced our understanding of human physiology

Against

- Computer simulations can be used in clinical trials
- Animal physiology is different to human physiology. Therefore animal testing is unhelpful
- Animals have rights too
- Animals have no informed consent
- Testing on animals when potential side effects are unknown is immoral
- Animals can't tell you if they are suffering
- Animals are often treated poorly in labs

17 Explain how imbalances in certain, naturally occurring, brain chemicals can contribute to ill health (eg dopamine in Parkinson's disease and serotonin in depression) and to the development of new drugs.

Parkinsons disease

- Dopamine producing cells in the substantia nigra are lost. These cells are closely involved in the coordination of movement.
- The brain compensates for the loss of dopamine cells so symptoms of the disease are not shown until 80% of the cells are gone
- Symptoms of parkinson's include: tremor; slowness of movements; stiffness of muscles
- Other problems associated with parkinsons are: poor balance; difficulty in walking; problems with sleeping; depression; difficulties with speech and breathing

Developing new treatments for Parkinson's

<u>Gene Therapy</u>

- Results from the Human Genome Project help to develop gene therapies
- Scientists are investigating inserting healthy genes into the affected cells
- The two main approaches are: adding genes to prevent cells from dying; adding genes to enhance dopamine production
- The problems are that safety is of prime concern, so gene therapy like this is still years away

<u>Stem Cell Therapies</u>

- Aims to cure rather than relieve symptoms
- Embryonic stem cells will be used to replace failing dopamine producing cells.
- Ethical issues with the use of Embryonic cells remains
- Risks of uncontrolled growth of the stem cells, resulting in cancers
- Can be a valuable tool in developing further and more effective drug therapies

Serotonin & Depression

- Serotonin is a neurotransmitter involved in the cortex, cerebellum and spinal cord.
- Low levels of serotonin result in low levels of brain activity due its widespread influence
- People suffering from depression have abnormal serotonin pathways
- Depression can be triggered by: work, stress or bereavement; chemical changes in the brain (using illegal drugs?)
- Dopamine and noradrenaline are also involved in depression

18 Explain the effects of drugs on synaptic transmissions, including the use of L-Dopa in the treatment of Parkinson's disease and the action of MDMA in ecstasy.

Treating Parkinson's

L-dopa: Dopamine cannot cross the blood brain barrier but L-dopa can. L-dopa is the precursor to dopamine so is converted to dopamine in the brain. This means there is as much dopamine in the brain as possible. As dopamine producing cells die off, they become less effective.
Dopamine Agonists: Bind to dopamine receptors mimicking the effect of dopamine. They are used at the beginning of the disease when they are most effective
MAOB Inhibitors: MAOB breaks down dopamine in the brain synapses. MAOB inhibitors reduce the destruction of the little dopamine that is made

Treating Depression

- Selective Serotonin reuptake inhibitors (SRIs) inhibit the uptake of serotonin.This leaves more serotonin in the synaptic cleft. Therefore, more impulses travel along the post synaptic axon. This results in the relief of the symptoms
- Tricylic antidepressants (TCAs) increase the levels of serotonin and noradrenalin in the brain.
- Monoaminooxidase inhibitors inhibit the enzymes that break down serotonin

Action of MDMA

- Ecstasy blocks the reuptake of serotonin so synapses are flooded with serotonin
- High levels of serotonin stimulates the release of dopamine

19 Discuss how the outcomes of the Human Genome Project are being used in the development of new drugs and the social, moral and ethical issues this raises.

The Human Genome Project (HGP) was an international project that aimed to map out the location of all the genes on human chromosomes in order to determine the base sequence

Pharmacogenomics

Drugs are usually produced to suit the majority of individuals. In the future, scientists want to tailor drugs to suit certain individuals or particular ethnic groups. This means drugs could work more efficiently; lower doses with fewer side effects. Genetic factors have an effect on the efficiency. Knowing the details about the human genome could mean that scientists could tailor drugs that only target cancerous cells or pathogens but do no damage to healthy human cells. If scientists are able to identify what genes cause certain diseases, it may be quicker to identify what drug would be suitable. Can save health service money as many drugs are prescribed to people and the drugs either have no effect or have adverse effects. It is possible that their genes play a part in their response to drugs. In clinical trials knowing the genome of the participants means that people with genes that stop the drug from working are not tested on. This saves time and money. All these reasons mean that it could be possible to treat more diseases and treat them more efficiently.

Ethics of the human genome project

If everyone's genome is analysed and stored, there will be a DNA database. People are unsure of who has access to their information and what they are doing with it. The DNA database can be used for crime fighting
Currently time consuming and costly identifying what gene has an effect on what drug. It is possible that several genes interacting have an effect on the action of the drug rather than a single gene.
New drugs made to suit individuals may only benefit a small amount of the population. Absolutists argue that the drug should be made available regardless of the cost. Relativists argue that if the money spent on the could be of more benefit elsewhere then the money should be spent elsewhere instead of on the drugs.
Difficult and costly to train all doctors and pharmacists to recognise what drugs suit people with certain genes

20 Describe how drugs can be produced using genetically modified organisms (plants and animals and micro organisms).

Microorganism

- The required gene is isolated and cut with a restriction endonuclease enzyme
- Using plasmid DNA as vector, cut the plasmid using the same endonuclease enzyme
- Attach the gene to the plasmid using DNA ligase.
- Use vector to introduce gene into host cell

Plants

- Plasmid extracted from bacteria
- The gene that is to be inserted in the plant is inserted into the plasmid which is then returned to the bacterium
- The plant is infected with modified bacterium. The new gene becomes part of the plants chromosomes
- The bacterium causes a tumour to develop on the plant.
- The tumour cells are cultured and frown into new plants

Animals

Ways genes are inserted into host cell

- Microinjection – DNA injected into cell with a fine micropipette
- Microprojectile – DNA is shot into the cell at high speed carried on a minute gold, tungsten pellet
- Virus – Infects the cells with the desired gene
- Liposome wrapping – gene is wrapped in liposomes which fuse to membranes and pass through cell

21 Discuss the risks and benefits associated with the use of genetically modified organisms.

Benefit	Risk
It is not always easy to get vaccines to people who need it due to storage, cultural and practical difficulties. Putting the vaccine in the food means it is possible to immunise people on a large scale	The safety of genetically modified organisms is not clear. There may be unforeseen longterm effects
Instead of using genetically modified animals, genetically modified plants can be used instead	Gene transfer to the environment. Antipesticide gene in GM plants could be transferred to weeds and other unwanted plants
Genetically modified plants are usually cheap and easy to grow. No trained healthcare professional is require to administer the vaccine	Genetically modification infringes on the rights of the organism being modified
Using genetically modified plant with vaccines in them is dealing with two problems at the same time. Providing immunity as well as dealing with hunger.	Genetically modified plants are normally made infertile so they need to be bought each time. To what extent is this cost effective?
It would be immoral not to use GM products if we know they are able to help	

Keywords for Topic 8

Tropism – Plant growth response to environmental cues
Red light – Light with wavelength 500-600 nm
Far red light – Light with wavelength between 700 – 730 nm
Phytochrome – Blue/green pigment sensitive to different wavelengths of light which affect plant responses
Etiolated – The condition of a plant grown in the dark. Tall thin with fragile stems, long internodes and small, pale, yellowish leaves
Critical Day length – The length of daylight which appears to be needed to trigger flowering in plants
Short day plants – Plants which need long periods of darkness to trigger flowering
Long day plants – Plants which require short periods of darkness to trigger flowering
Day neutral plants – Plants where the flowering is not affected by the length of the periods of dark or light
Florigen – Hypothetical plant hormone associated with photoperiodism. Evidence is growing for its existence
Phototropism – Plant movements in response to unilateral light
Unilateral light –Light which shines from one side only
Positively phototropic – Grows away from the light
Coleoptile – The protective sheath surrounding the growing shoot of a young monocotyldenous plant such as grass or cereal
Plant growth substance – Plant hormone – Chemical which controls growth in plants
Auxin – A plant hormone
Indolacetic acid (IAA) – First plant hormone (auxin) discovered
Neurone (nerve cells) – cells specialised for the transmission of impulse
Receptor cells – Specialised cells which detect changes in the body or the external environment
Effector cells – cells which respond to stimulation by the motor nerves and work to reverse a change or increase it
Sensory organs – specialised organs which detect changes in the body or in the external environment
Sensory neurones – neurones which only carry information from the internal or external environment into the central processing areas of the nervous system
Central Nervous System – Specialised concentration of nerve cells where incoming information is processed and outgoing messages sent to effectors. In human beings, the brain and the spinal cord
Motor neurones – carry impulses to the effector organs
Spinal cord – Large bundle of sensory and motor nerves running from the brain through the vertebrae. Part of the central nervous system
Nerve fibre – Long fibre which extends from a nerve cell
Nerve – Bundles of nerve fibres
Axon – Nerve fibres carrying impulses away from the cell body
Dendrons – Nerve fibres which carry impulses towards the cell body
Motor nerves – Nerves which only contain motor neurones
Sensory nerves – Nerves which only contain sensory neurones
Mixed nerves – Nerves which contain both sensory and motor neurones
Impulses – electrical signals which ass along neurones
Dendrites – Slender, finger-like processes found on nerve cell bodies
Schwann cell – Cell which produces the myelin sheath
Myelin sheath – Fatty layer made of the membrane of a Schwann cell wrapped around myelinated nerves which speeds up the speed of transmission
Nodes of Ranvier – Gaps between the Schwann cells making the myelin sheath. The nerve impulses jumps from node to node
Polarised – Maintenance of the inside of the neurone membrane slightly negative compared with the external fluid
Resting potential – Potential difference across the membrane of a neurone at rest, with the inside more negative than the outside, around -70mV
Stimulus – change in the environment
Sodium ion channels – Protein channels which control the movement of sodium ions into and out of the cell
Depolarisation – The reversal of the resting potential across a nerve cell membrane from negative to positive
Action potential – The depolarisation of the membrane of a nerve fibre due to an influx of sodium ions from about -70mV to around +40mV. This is propagated along the fibre as a nerve impulse
Threshold – level below which no response is elicited

Refractory period – Recovery time of an axon after an action potential has passed
Absolute refractory period – The period of time following an action potential when a nerve fibre cannot be restimulated
Relative refractory period – The period of time following an action potential which a nerve fibre cannot be restimulated but will only respond to a much stronger stimulus than before
Saltatory conduction – The jumpingof action potentials from one node of ranvier to another in a myelinated nerve
Synapse – The joining point between two neurones, or a neurone and a muscle cell or a glandular cell, across which an impulse must pass
Synaptic knob – the swollen end of a neurone at a synapse
Calcium ion channels – Protein channels in the membrane which allow the passage of calcium ions. They can be opened or closed
Synaptic vesicles – The vesicles inside the synaptic knob which contain the neurotransmitter
Neurotransmitter – The transmitter substance which carries the impulse across the synaptic cleft, and binds to receptors on the post synaptic membrane
Synaptic cleft – the gap between the cells on the two sides of a synapse
Receptor sites – Binding sites on the post synaptic membrane sensitive to molecules of neurotransmitter
Excitatory post synaptic potential (EPSP) – Changes the potential difference across the post synaptic membrane and contributes to the setting up of a new post synaptic potential
Inhibitory post synaptic potential – Results from the inward movement of negative ions as a result of certain neurotransmitters which in turn reduces the likelihood of an action potential occurring in the post – synaptic fibre
Acetylcholine – A common neurotransmitter
Spatial summation – when two or more synaptic knobs are stimulated and release neurotransmitter at the same time onto the post synaptic membrane, triggering an action potential which neither would have achieved alone
Temporal summation – impulses are received in a presynaptic knob in quick succession and the rapid repeated release of neurotransmitter triggers an action potential in the post synaptic nerve fibre
Facilitation – When the arrival of one impulse at a synapse makes it easier for the next impulse to trigger an action potential in the post synaptic fibre
Accommodation – The process by which a response is lost as all the neurotransmitter is discharged from the vesicles of a synapse as a result of repeated stimulation. The response returns once more neurotransmitter is synthesised. Also known as fatigue
Sensory receptor – specialised cell, tissue or organ which detects changes in the body or the external environment
Primary receptor – simple sensory receptor where a stimulus results directly in an action potential in the nerve fibre of the neurone
Secondary receptor – this involves a sensory receptor cell which responds to a particular stimulus and then synapses with a sensory neurone, triggering an action potential in that nerve fibre which carries the impulse to the central nervous system
Sense organs – Groups of sensory receptors working together with other tissue to provide information about changes in the environment
Photoreceptors – sensory receptors which respond to light
Generator current – small current set up in a receptor cell on reception of a stimulus due to the movement of sodium ions into the cell
Generator potential – Produced in response to generator currents in sensory receptor cells
Convergence – several sensory receptors synapsing with a single sensory neurone
Adaptation – The process by which most sensory receptors show a gradual decline in the generator potentials produced in response to a steady stimulus. In the eye, the level of bleaching of the visual pigment determines the responses depending on the levels of light entering the eye
Rods – Photoreceptors cells found in the retina of the eye which respond to low light intensity. They contain the visual pigment rhodopsin
Cone – Light sensitive cells in the eyes containing the visual pigment iodopsin. They respond to high light intensity and give colour vision
Visual pigment – pigments found in the sensory cells of the eyes which respond to light
Rhodopsin – the visual pigment found in rods. In light, it splits into opsin and retinal
Opsin – molecule produced when the pigment rhodopsin splits in the presence of light
Retinal – Pigment formed when the visual pigment rhodopsin is exposed to light

Bleaching – The splitting of rhodopsin into opsin and retinal in the presence of light
Hyperpolarisation – The increasing negativity of the inside of the sensory rod cell following the formation of trans-retinal and the change in permeability of the membrane to the sodium ions
Generator potential – Produced in response to generator currents in sensory receptor cells
Light adapted – The state of the rods of the eyes after a period in the dark when all of the rhodopsin has fully reformed and the eye is once more sensitive to dim light
Reflexes – Fast, fixed unconscious responses to a particular stimulus
Unconditioned – Reflexes which have not become associated with a particular cue
Central Nervous system – specialised concentration of nerve cells where incoming information is processed and outgoing messages sent to the effectors. In human beings, the brain and spinal cord
Anterior – front
Cerebral hemisphere – Thin very folded layer of cells over the surface of much of the brain. Site of many of the higher functions of the brain
Cerebral cortex – cerebral hemisphere
Corpus callosum – band of axons connecting the left and right hand side of the brain
Visual cortex – The area of the brain involved with processing visual information. Also known as the occipital lobe
Hypothalamus – small area of the brain which regulates many biological processes and also controls hormone production by the pituitary gland
Cerebellum – Area of the brain involved in the coordination of smooth movements and in the maintenance of balance and posture
Medulla Oblongata – Area of the hindbrain, the most primitive part of the brain, which controls basic functions such as breathing rate and blood pressure
Computerised tomography (CT scans) – A technique that can be used to produce images of the brain which involves the use of thousands of xray beams passed through the area to be scanned
Magnetic resonance imaging (MRI) – Technique which produces images which give a lot of fine detail of soft tissues, produced using magnetic fields and radio waves
Functional magnetic resonance imaging (fMRI) – Imaging technique which enables scans of the brain to be made while people are carrying specific tasks
Innate/species characteristic behaviour – collection of responses producing behaviour seen in every member of a species. Not learned
Learned/ individual characteristic behaviour – Behaviour which is learned by an individual as a result of experience
Habituation – Learning to ignore a stimulus and make no response when the stimulus is repeated many times with no apparent reward or punishment associated with it
Conditioned reflexes – The association of a particular stimulus with an existing reflex
Trial and error (operant) learning – Learning which occurs when a piece of behaviour is either rewarded or punished, and becomes more or less frequent as a result
Imprinting – Learning which occurs in young animals when they identify and relate strongly to another organism, usually the patient
Exploratory (latent) learning – Learning which takes place when an individual explores new surroundings or experiences and learns about them without immediate punishment or reward.