Edexcel International A Level (IAL) Biology

Your notes

The Brain

Contents

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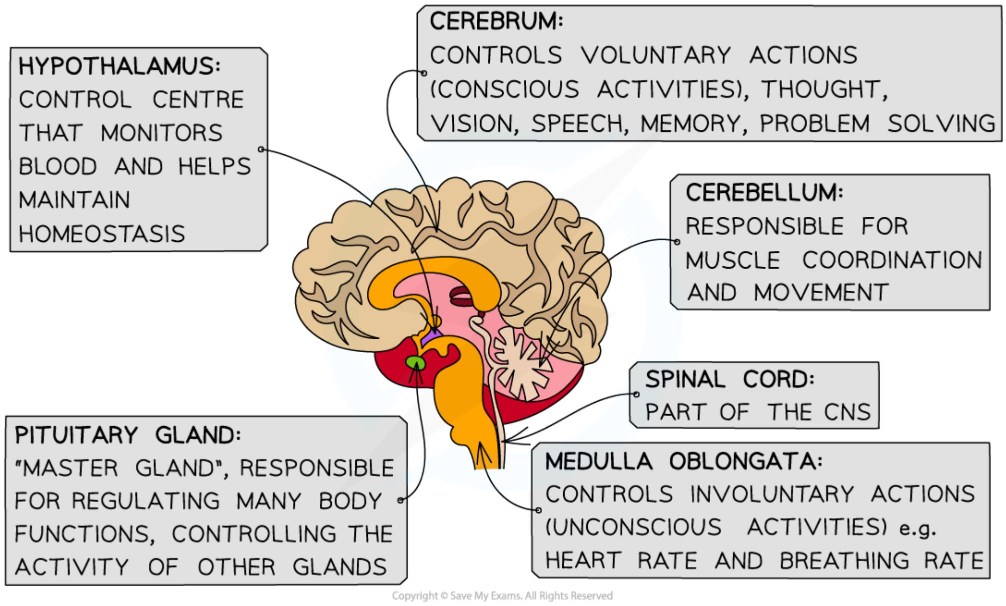
Human Brain Structures & Functions

- The brain, alongside the spinal cord, is part of the **central nervous system** (**CNS**)
- The brain is made of billions of **interconnected neurones**
- Within the brain are **different regions** that carry out **different functions**



Different regions of the brain carry out different functions

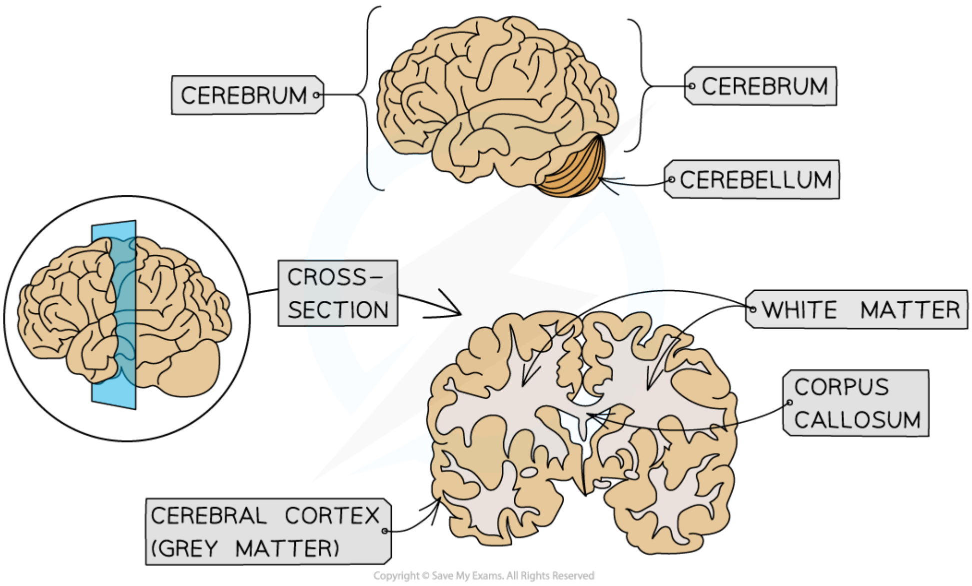
- You need to know the functions of the following brain regions

The cerebrum

- The cerebrum is the **largest part** of the brain in humans, accounting for about 80% of the total mass of the brain
- It carries out a large **variety of functions** involved with **conscious activities**, including:
    - Vision
    - Hearing
    - Speech
    - Thinking
    - Memory
- The cerebrum is divided into **two halves** known as the **cerebral hemispheres**

- The hemispheres are joined together by a **band of nerve fibres** known as the **corpus callosum**
- The **right hemisphere** controls the **left side of the body** and the **left** one controls the **right side**

- The cerebrum has a **thin outer layer** known as the **cerebral cortex** or '**grey matter**'
  - The cerebral cortex consists of the **cell bodies of neurones**
  - It is **highly folded**, which **increases its surface area** and allows it to contain a **greater number of neurones**
    - With more neurones in the brain, **more neurone connections** can be made
    - This is important, as the more connections between neurones in the brain, the **greater the ability of the brain to carry out more complex behaviours**
- Beneath the cerebral cortex or grey matter layer is the '**white matter**'
  - The white matter consists of the **myelinated axons of neurones**



The cerebrum consists of two hemispheres joined by the corpus callosum

The hypothalamus

- The hypothalamus monitors **the blood** as it flows through the brain and, in response, **releases hormones** or stimulates the neighbouring **pituitary gland** to release hormones
  - The hypothalamus plays an important role in some homeostatic **mechanisms**
- Hypothalamus functions include
  - **Regulating body temperature**

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- The hypothalamus **monitors blood temperature** and initiates a homeostatic response if this temperature gets too high or too low
- **Osmoregulation**
    - Cells in the hypothalamus **monitor the water balance of the blood** and releases the hormone ADH if the blood becomes too concentrated
        - ADH increases absorption of water in the kidneys
- **Regulating digestive activity**
    - The hypothalamus regulates the hormones that control appetite as well as the secretion of digestive enzymes
- **Controlling endocrine functions**
    - The hypothalamus causes the pituitary gland to release hormones that control a variety of processes e.g. metabolism, growth and development, puberty, sexual functions, sleep, and mood

Pituitary gland

- The pituitary gland is located **below the hypothalamus**
- Its role is to produce a **range of hormones**
    - Some of these directly influence and regulate processes in the body while some stimulate the release of further hormones from other endocrine glands
- The pituitary gland is divided into two sections; the **anterior pituitary** and **posterior pituitary**
    - The anterior pituitary produces and releases hormones
    - The posterior pituitary stores and releases hormones produced by the hypothalamus e.g. ADH and oxytocin

The cerebellum

- The cerebellum **coordinates movement**
    - This includes **balance;** a highly complex function that requires coordination between multiple parts, including the eyes, semicircular canals in the ears, and many muscles

The medulla oblongata

- Also known as the **medulla**
- The medulla contains co-ordination centres that control different unconscious functions e.g.
    - **The cardiac centre** controls heart rate
    - **The respiratory centre** controls breathing rate

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- The medulla controls functions that are able to maintain life even if other parts of the brain are damaged

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Techniques to Investigate the Brain

- It is extremely difficult for neuroscientists to study the brain and find out how it works
  - The brain is incredibly **complex** and **very delicate** and it is protected by the skull
  - Different regions work together to bring about brain function so can't be studied in **isolation**
- Specialised **scanners** and techniques can be used to study the brain without having to resort to **surgical intervention**

Computerised Tomography

- **Computerised tomography**, or **CT**, scans produce cross-section images of the brain using **x-ray radiation**
  - A beam of x-rays is aimed at a patient from all angles around the body
  - Digital x-ray detectors are used to pick up the x-rays as they exit the patient's body
  - Denser tissue absorbs more of the x-ray radiation so shows up as a lighter region on a scan
- A scan produced in this way shows **physical structures** of the brain and allows visualisation of any tissue damage
  - E.g. blood is less dense than brain tissue so a CT scan can be used to locate damaged blood vessels and areas of bleeding after a patient has had a stroke
- The scans **don't directly show the functions** of the regions of the brain but it is possible to link visible symptoms with the location of any tissue damage
  - This can allow neurologists to work out which regions of the brain are responsible for which functions
- CT scans are not recommended for **pregnant patients or children** due to the risks of exposure to the X-ray radiation, which is given at a **higher level** than in a normal X-ray
  - The risk of damage from such scans is still very low

Magnetic Resonance Imaging

- **Magnetic Resonance Imaging**, or **MRI**, uses a combination of a **magnetic field and radio waves** to generate images through the body
  - The patient being scanned must remain very still while inside a large magnet
- **Soft tissues** can be seen clearly using MRI, and images produced are at a **higher resolution** than those produced from CT scanning
- As with CT scanning, MRI is useful for **identifying areas of abnormal or damaged tissue**, but only enables brain function to be analysed by **linking damage on a scan with visible**

symptoms in a patient

- MRI is especially useful for **tumour diagnosis** as tumours show up clearly in images generated in this way
  - MRI scans can therefore be used to **identify and locate tumours** in the brain
- MRI scans are **considerably more expensive** to carry out than CT scans but **do not carry the risk associated with the use of potentially harmful x-rays**
  - MRI scans are often the imaging method of choice during long-term therapies
- The magnetic field of an MRI scanner can **interfere with medical devices** such as pacemakers and insulin pumps, so patients with such devices cannot have MRI scans

Functional MRI

- **Functional MRI**, or **fMRI**, functions in a similar way to MRI, making use of a magnetic field and radio waves to generate images of brain structure
- The difference between MRI and fMRI is that fMRI scans allow **brain function to be studied in real time**
  - fMRI scans show the **location of oxygenated blood** in the brain, therefore indicating **which brain regions are active** at any one time
    - The scanner measures the **ratio of oxygenated to deoxygenated** haemoglobin
  - Patients can be asked to carry out particular actions, answer questions, or think about a specific topic while inside a scanner and the **change in blood flow to regions of the brain can be assessed**
    - The region of the brain associated with the activity or thought will 'light up' in the scanner
    - This can be used in medical diagnosis e.g. searching for the cause of seizures, or in psychology research

Positron Emission Tomography

- PET scans use **radioactive tracers** which collect in areas where there is **increased blood flow,** metabolism, or neurotransmitter activity
  - The tracer is introduced to the blood in advance of the scan so that it can be detected by the scanner
  - E.g. a radioactive tracer might be **radioactively labelled glucose**; glucose will be transported in the blood and will be present in high concentrations in metabolically active areas of the brain
- The scanner can detect areas of **high radioactivity**, and so the movement of the tracer through the body and any accumulation of tracer in the brain can be seen
- The amount of radioactive tracer present in a brain region can **indicate whether that region is active or inactive**

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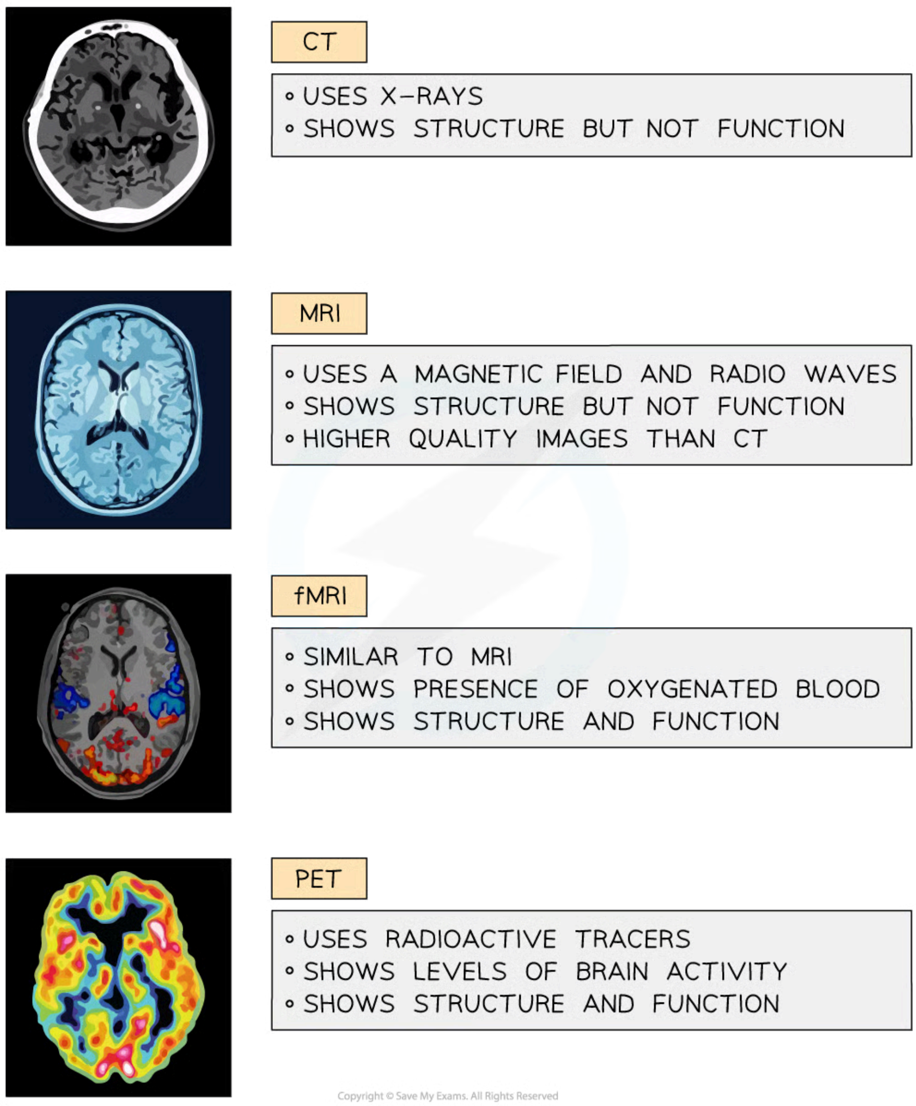
- This has been useful in building an understanding of specific diseases such as Alzheimer's where brain activity in certain regions decreases

- Neurologists can use the images to study the **structure** and **function** of the brain in **real time**



Some types of scan show only structure, while other allow the study of structure and function in real time

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Brain Disease

- **Neurotransmitters** are chemicals that transmit nerve impulses across synapses
- Some disorders and diseases are linked to an **imbalance of neurotransmitters in the brain**
- Two examples are
  - Parkinson's disease
  - Depression

Parkinson's disease

- **Parkinson's disease** is a brain disorder that affects the **co-ordination of movement**, caused by the **loss of neurones** in some parts of the brain
- Symptoms include
  - A tremor to the specific parts of the body
  - Slow movement
  - Stiff and inflexible muscles
  - Difficulties with balance
  - Changes to speech
- The lost neurones normally produce the neurotransmitter **dopamine**
  - Dopamine is involved in **muscle control**
- Individuals that suffer from Parkinson's disease produce **insufficient amounts** of dopamine due to the loss of dopamine-producing neurones
  - **Less dopamine is released** into the synaptic cleft meaning less is able to bind with receptors on the postsynaptic membrane
  - **Fewer sodium channels on the membrane are opened** so depolarisation of the postsynaptic neurone does not occur
  - This leads to **fewer** action potentials which creates the symptoms such as tremors and slow movement
- Different types of **drug** can be used to treat this disease
  - Dopamine **agonists**
    - Produce the same effect as dopamine by binding to and activating the dopamine receptors on the postsynaptic membrane
  - Dopamine **precursors**

- These are chemicals that can be converted into dopamine in the neurones
- E.g. L-dopa
- Enzyme inhibitors
  - Monoamine oxidase B (MAOB) inhibitors inhibit the activity of enzymes that would normally break down dopamine in the synaptic cleft, raising levels of dopamine present in the brain
- Research into other treatments for Parkinson's disease is currently ongoing, with some promising future possibilities in the areas of
  - **Gene therapy**
    - This would involve the addition of genes to the affected cells in the brain to either increase dopamine production or prevent the destruction of dopamine-producing cells
  - **Stem cell therapy**
    - Stem cells could be used to replace the lost dopamine-producing cells in the brain

Depression

- Low levels of the neurotransmitter **serotonin** have been **linked to depression**
  - Serotonin transmits nerve impulses through the **areas of the brain that control mood**
  - Low levels of serotonin increase episodes of depression
- Other brain chemicals linked to depression include **noradrenaline** and **dopamine**
- Some drugs that have been developed for the treatment of depression, known as antidepressants, work by **increasing the levels of relevant neurotransmitters** in the brain
  - SSRIs (selective serotonin reuptake inhibitors) are a class of antidepressant that **prevent the uptake of serotonin at synapses;** this increases the overall levels of serotonin in the brain
  - TCAs (tricyclic antidepressants) **increase levels of both serotonin and noradrenaline** in the brain
  - MAOB inhibitors **inhibit enzymes that would otherwise break down neurotransmitters** in the synaptic clefts in the brain

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