The Scholars Programme

The Making and Breaking of Memories

Key Stage 5 Programme

Pupil Name	
Handbook Designed by	Julia Ravey

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THE SCHOLARS PROGRAMME

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1 (Launch Trip)			
2			
3			
4			
5			
6 (Draft assignment feedback)			
7 (Final assignment feedback)			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Baseline assessment	
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5	Draft assignment	
Tutorial 6	Final assignment	

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on _____	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

KS5 Programme – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to an excellent standard undergraduate level
2:1	60-69	Performing to a good standard at undergraduate level
2:2	50-59	Performing to an excellent standard at A-level
3rd	40-49	Performing to a good standard at A-level
Working towards a pass	0-39	Performing below a good standard at A-level
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor			
Title of Assignment			
Name of Pupil			
Name of School			
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 - ***Enter Key Learning Priority Here***	
What you did in relation to this Key Learning Priority	How you could improve in the future
Enter feedback here	*Enter feedback here*
Learning Feedback Comment 2 – *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority	How you could improve in the future
Enter feedback here	*Enter feedback here*
Learning Feedback Comment 3 – *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority	How you could improve in the future
Enter feedback here	*Enter feedback here*
Resilience Comment	
How you showed learning resilience during the course	How you could build learning resilience in the future
Enter feedback here	*Enter feedback here*

Contents

Course Rationale

It is difficult to imagine not remembering where you live, forgetting your friends and family or not being able to learn any new information. These are some of the issues you would face if your memory was not in tact. Humans have an amazing capacity for remembering important events for many years, which have been fundamental to our evolutionary success. While memory formation has remained a mystery for many years, fantastic advances in neuroscience over the past century mean we can now learn about the biological mechanisms underlying one of the traits key to our survival. Specialised cells in the brain called neurons are able to communicate to each other using electrical signals, and strengthening these connections are pivotal to memory formation. One brain region in particular, the hippocampus, is essential to recalling and retaining information and damage to this region can induce amnesia of past and present events. Fully understanding how memory works may help patients with late-life diseases such as dementia, recovering memories lost in a 'blackout' or even aid students with their exams… but how much would you want to augment your memory?

This course will teach you how to think, talk and write like a scientist whilst learning about the neuroscience of memory. From basic brain anatomy to linking clinical symptoms to neuron biology, you will be able to critically assess scientific evidence to form your own conclusions on the how much we truly understand about memory in the brain and the problems memory loss can cause. By the end of the tutorials, you will complete a university-style essay combining your scientific skills and knowledge on neuroscience, giving you the opportunity to research for a project exactly as an undergraduate student would.

Group Discussions

How do you make the most of a group discussion?

The purpose of discussions is to allow everyone in the group to express their ideas and learn from each other. Often this will involve coming to a group decision about the issue under discussion, though they may of course 'agree to disagree' on certain points.

What we don't want in our tutorials:

Rules:

1. Pronounce clearly what you are saying
2. Use eye contact and facial expression to help to get your idea across or to support what someone else is saying
3. Speak in a way that is right for a discussion (more formal than a chat between friends)
4. Build on other people's ideas, and summarise your own views and the views of others when necessary
5. Give reasons to support your views and critically examine the views expressed by others
6. Organise the discussion and take turns with others
7. Listen carefully and respond to the views of others

Mark Scheme Table

Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Knowledge and Understanding of Neuroscience	○ All content included is relevant to the general topic and to the specific question/ title ○ Thorough understanding of all the relevant topics. ○ Scientific terms are defined and used accurately throughout ○ Clear justification on how the content included is related to the specific issues that are the focus of the assignment	○ All content included is relevant to the general topic and to the specific question/ title ○ Good understanding of all the relevant topics. ○ Scientific terms are defined and used accurately throughout ○ Clear justification on how the content included is related to the specific issues that are the focus of the assignment	○ Most of the content included is relevant to the general topic and to the specific question/title ○ Good understanding of most the relevant topics ○ Scientific terms are used accurately but not always clearly defined. ○ Adequate justification on how the content included is related to the specific issues that are the focus of the assignment
Research and Evidence	○ Inclusion of rich sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Compelling use of evidence/calculations to support claims/ assertions/ideas, consistently clearly and convincingly ○ Evidence of extensive further reading beyond materials provided which were used in an appropriate context	○ Inclusion of well-selected sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/ calculations to support claims/ assertions/ideas, consistently clearly and convincingly ○ Evidence of further reading beyond materials provided which were used in an appropriate context	○ Inclusion of adequate sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas ○ Use evidence/ calculations to support claims/assertions/ ideas, mostly clearly and convincingly ○ Evidence of further reading beyond materials provided
Developing an Argument	○ Argument/proof exceptionally well-developed and well-justified ○ Makes original and effective links between subjects that have not previously been associated ○ Uses concepts from the tutorials in an unfamiliar context, and does so accurately and confidently. ○ Content is analysed effectively to support the argument throughout	○ Argument/proof well-developed and well-justified ○ Makes links effectively between subjects that have not previously been associated ○ Uses concepts from the tutorials in an unfamiliar context, and does so accurately and confidently. ○ Content is analysed effectively to support the argument	○ Argument/proof clear and well-developed and position justified ○ Some evidence of linking subjects that have not previously been associated ○ Use some concepts from the tutorials in an unfamiliar context, but not always accurate ○ Analysis of content to support the argument

Critical Evaluation	○ Consistent assessment of the value or significance of what is described ○ Evaluative points are consistently and convincingly explicit/ systematic/ reasoned/justified ○ Effective critiques on the reliability of sources provided and independently researched	○ Moved beyond description to an assessment of the value or significance of what is described ○ Evaluative points are consistently explicit/ systematic/ reasoned/justified ○ Constantly attempts to critique the reliability of sources provided	○ Mostly description but some assessment of the value or significance of what is described ○ Evaluative points are mostly explicit/ systematic/reasoned/ justified ○ Some evidence of critiques on the reliability of sources provided
Structure and Presentation	○ Ideas are excellently structured in paragraphs and arranged in a logical order that is appropriate for the assignment ○ The introduction effectively outlines how the essay will deal with the issues. ○ The conclusion summarises all the main points clearly and concisely ○ All sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment ○ The introduction clearly outlines how the essay will deal with the issues. ○ The conclusion summarises most of the main points clearly ○ All sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment ○ The introduction adequately outlines how the essay will deal with the issues. ○ The conclusion attempts to summarise the main points clearly ○ Most sources are referenced correctly in the agreed format
Language and Style	○ Writing is clear and fluent with no spelling, grammar or punctuation errors ○ Writing style is focused and clear, appropriate for scientific documents and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ No spelling, grammar or punctuation errors ○ Writing style consistently clear, appropriate for scientific documents and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ Minimal spelling, grammar or punctuation errors ○ Writing style mostly clear, appropriate for scientific documents and easy to follow ○ Some attempts of using technical language and vocab ulary, but not always accurate

Glossary of Keywords

Word	Definition	In a sentence
Abstract	a summary of the contents of a book, article, or speech	The abstract of the paper gives you an overview of the authors work
Action Potential	the change in electrical potential associated with the passage of an impulse along the membrane of a muscle cell or nerve cell.	Action potentials are the signals neurons use to communicate with each other.
Amyloid Plaque	sticky buildup of Abeta which accumulates outside nerve cells, or neurons	Amyloid plaques are extracellular
Anterior	Near the front	The frontal lobe is anterior to the parietal lobe
Antibody	A protein that combines chemically with substances which the body recognizes as alien, such as bacteria, viruses, and foreign substances in the blood.	In Alzheimer's disease drug trials, antibodies against Abeta have been tested.
Brainstem	the central trunk of the mammalian brain, and continuing downwards to form the spinal cord.	The brainstem controls automatic bodily functions such as breathing
Cerebellum	The part of the brain at the back of the skull in vertebrates, which coordinates and regulates muscular activity.	The Cerebellum controls muscle coordination
Cerebrum	(Also known as the cortex) The largest part of the human brain associated with higher brain functions.	The Cerebrum contains the four lobes of the brain
Chromosome	a thread-like structure of nucleic acids and protein found in the nucleus of most living cells, carrying genetic information in the form of genes.	You have 23 pairs of chromosomes in the nucleus of every cell
Conformational Change	spatial arrangements of a molecule which alter due to changes in its environment	Tau undergoes a conformational change when it is phosphorylated
Corpus Callosum	a broad band of nerve fibres joining the two hemispheres of the brain.	The corpus callosum connects the left and right hemispheres of the brain
Correlation	a mutual relationship or connection between two or more things.	The link between smoking and lung cancer has strong positive correlation
Dendritic Spine	a small membranous protrusion from a neuron's **dendrite** that typically receives input from a single axon at the synapse	Dendritic spines are where synapses are formed

DNA	deoxyribonucleic acid, a self-replicating material which is present in nearly all living organisms as the main constituent of chromosomes. It is the carrier of genetic information.	All your genes are coded by DNA
Familial	A condition that tends to occur more often in family members than is expected by chance alone. Can be caused by genetic mutation	10% of Alzheimer's Disease cases are familial.
Gene	a unit of heredity which is transferred from a parent to offspring and is held to determine some characteristic of the offspring.	Parents pass on half their genes to their children
Gene Mutation	a permanent alteration in the DNA sequence that makes up a gene, such that the sequence differs from what is found in most people.	There are specific Gene mutations which cause Alzheimer's disease but these only occur in 3 genes: APP, PSEN1 & PSEN2
Glia	non-neuronal cells that maintain homeostasis, form myelin, and provide support and protection for neurons in the central and peripheral nervous systems	The most abundant cell type is the brain are glia.
Hippocampus	the elongated ridges on the floor of each lateral ventricle of the brain, thought to be the centre of emotion, memory, and the autonomic nervous system.	The hippocampus plays an important role in the consolidation of information into long-term memories.
Hypothesis	a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.	The Amyloid hypothesis suggest Abeta initiates Alzheimer's Disease
Long Term Depression (LTD)	an activity-dependent reduction in the efficacy of neuronal synapses	LTD occurs to weaken no-longer useful connections
Long Term Potentiation (LTP)	a long-lasting strengthening of synapses between nerve cells	LTP occurs when memories are formed
Methods	Techniques used to address a research question	The main method was observing a mouse model with an APP mutation
Microglia	glial cells that function as macrophages (scavengers) in the central nervous system	Microglia destroy toxins and cell debris by engulfing them
Microtubule	a microscopic tubular structure present in numbers in the cytoplasm of cells	Microtubules allow the transport of cargo down the axon.

Motor Cortex	the part of the cerebral cortex in the brain in which originate the nerve impulses that initiate voluntary muscular activity.	The motor cortex maps all the muscles of your body in your brain
Myelin	a mixture of proteins and phospholipids forming a whitish insulating sheath around many nerve fibres, which increases the speed at which impulses are conducted.	A neuron's axon is coated in myelin to increase the speed of signal transmission
Neurodegeneration	Degeneration of the nervous system, especially of neurons in the brain	In Alzheimer's disease, neurodegeneration occurs in the hippocampus
Neuron	A specialised cell transmitting nerve impulses (a nerve cell)	The brain cell involved in sending signals is called a neuron.
Pathologies	the science of the causes and effects of diseases, especially the branch of medicine that deals with the laboratory examination of samples of body tissue for diagnostic or forensic purposes.	The two pathologies in Alzheimer's disease are amyloid plaques and neurofibrillary tangles
Phosphorylation	The addition of a phosphate group to a protein to alter its activity.	Too much phosphorylation of a protein is called hyperphosphorylation
Proteins	Any of a class of nitrogenous organic compounds which have large molecules composed of one or more long chains of amino acids and are an essential part of all living organisms, especially as structural components of body tissues such as muscle, hair, and as enzymes and antibodies.	All cells of your body require proteins to function and survive.
RNA	ribonucleic acid, a nucleic acid present in all living cells. Its principal role is to act as a messenger carrying instructions from DNA for controlling the synthesis of proteins, although in some viruses RNA rather than DNA carries the genetic information.	In order to generate a protein from the DNA code, the gene must be transcribed into an RNA template
Sporadic	a disease which occurs in single and scattered cases.	90% of Alzheimer's Disease cases are sporadic.
Statistics	the practice or science of collecting and analysing numerical data in large quantities, especially for the purpose of inferring proportions in a whole from those in a representative sample.	The statistics for a baby being born a girl is 50%
Tau Tangles	Form inside dying cells. Twisted fibres of protein tau.	Tau Tangles are intracellular

Tutorial 1 – The Brain: Regions, Neurons and Proteins

The main aims of Tutorial 1 are:

- To learn about the different regions of our brain and their functions
- To understand how brain cells have adapted for their function
- To learn about how cellular proteins are made and what they do

Scientist skill: To accurately use neurobiological terminology

Tutorial 1 – The Brain: Regions, Neurons and Proteins

Starter: Facts about our Brains

Sitting inside your skull is an incredibly complex organ which dictates who you are and what you do. From processing information from the world around you to controlling your bodily functions and behaviours, the brain has been a mystery desperate to be solved since the first millennium BC.

Original reporting's of the brain's function were the location of the 'mind', the seat of intelligence and a centre for cooling blood. Nowadays, extensive anatomical studies and advanced scientific techniques means we can delve into the depths of the brain to begin to untangle its most intricate functions.

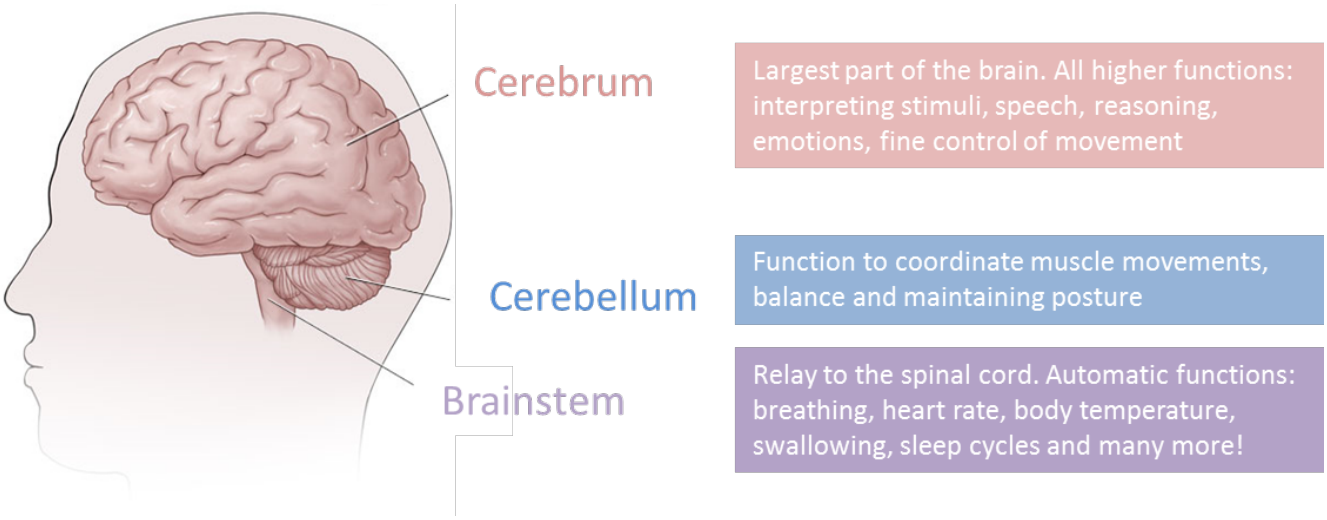
Match the quantities below with their units and state what fact they are describing about the human brain.

Quantity	Units	Fact
1400	watts	When your brain reaches maturity
25	grams	Electricity generated
20	thoughts	Amount of total body's oxygen used
12-25	Percent	Generated every day
50,000	Years	Weight of a human brain

Tutorial 1 – The Brain: Regions, Neurons and Proteins

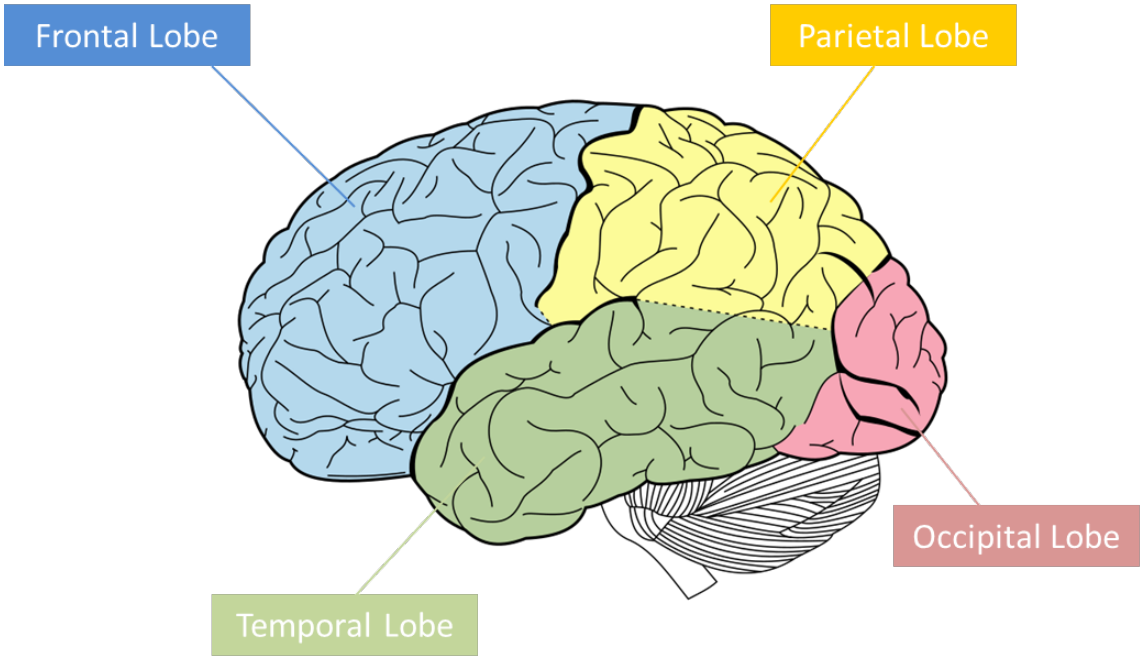
How our Brains are organised: Anatomy and Functions

Our brain is made up of specialised brain cells arranged into distinct regions. Each brain region is responsible for different functions of you as an individual. The brain consists of three sections: the cerebrum, the cerebellum and the brainstem.



The cerebrum is made up of two hemispheres: the left and right. These hemispheres are connected in the middle of the brain by the **corpus callosum** (a "tough body" of nerve fibres); allowing them to communicate with each other. Both contain brain regions responsible for the same function.

The Four Lobes of the Cerebrum



Tutorial 1 – The Brain: Regions, Neurons and Proteins

How our Brains are organised: Anatomy and Functions

Each lobe is responsible for different behaviours, functions and processing.

Frontal	Parietal	Temporal	Occipital
Personality, Emotions, behaviour Body Movement, Problem Solving, Judgement, Planning Intelligence, Concentration	Sense (touch, pain, temperature) Interprets stimuli (vision, hearing, motor, sensory, memory) Interprets languages and words	Memory Emotion Hearing Sequencing and organisation	Visual processing Interprets colour, light and movement from visual stimuli

Which lobe do I live in?

Within each lobe live more specific brain regions which are responsible for controlling individual functions.

Using the information provided, assign each of the area's below to a lobe of the brain.

Brocas Area
Responsible for physically producing speech

Primary Visual Cortex
Responsible for processing visual input from the retina

Wernicke Area
Responsible for understanding speech

Hippocampus
Responsible for long-term memory and spatial navigation

Amygdala
Responsible for response and memory of fearful emotions

Prefrontal Cortex
Responsible for coordinating complex behaviour & personality

Primary Motor Cortex
Responsible for executing movement

Basal Ganglia
Responsible for controlling movement

Primary Somatosensory Cortex
Responsible for processing tactile information

Orbitofrontal Cortex
Responsible for making decisions

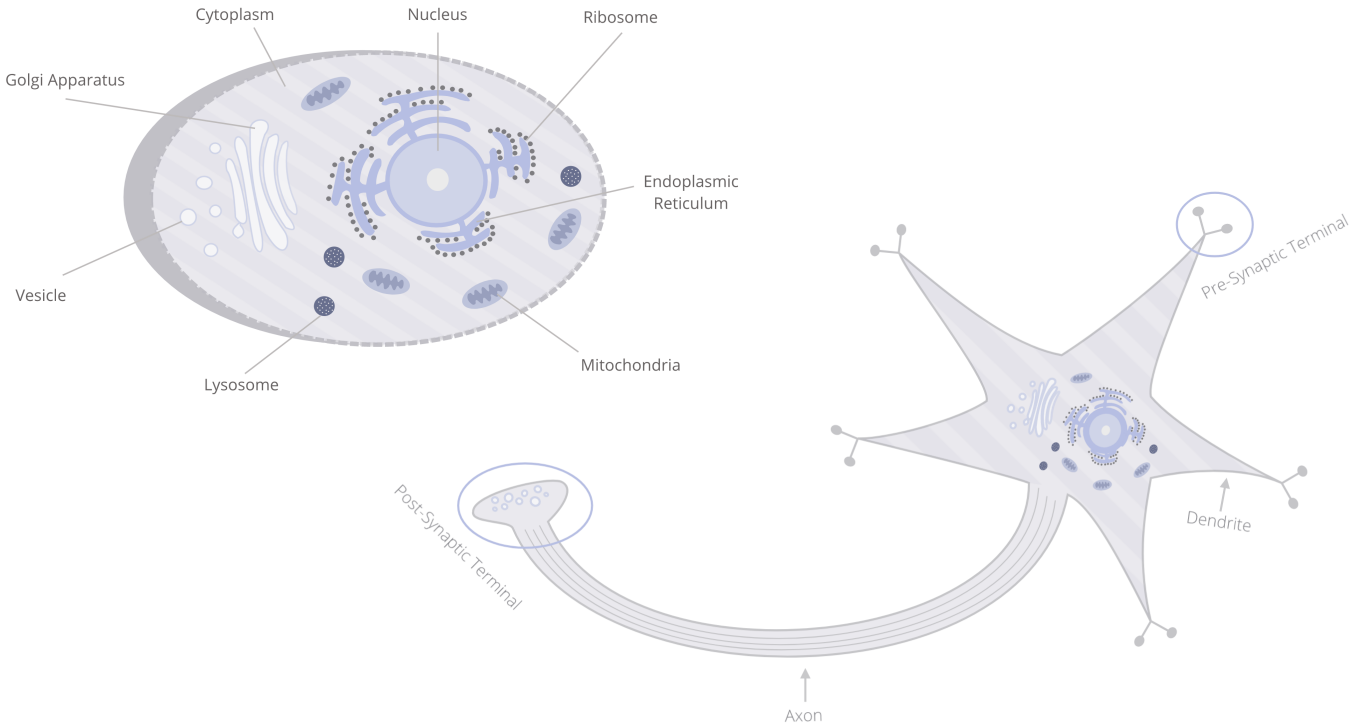
To see these areas mapped out in the brain, see Appendix 3

Tutorial 1 – The Brain: Regions, Neurons and Proteins

Cell Biology and Neurons

Our brains contain approximately 86 billion cells called **neurons.** These are the main cell type for all brain-related activity and are sometimes called "nerve cells".

Neurons are animal cells and possess features such as a nucleus, cytoplasm and organelles like mitochondria.



However, neurons have **adapted** for their main function, which is to **rapidly receive and deliver signals** to other neurons. These signals are called **action potentials**.

Neuronal Adaptations Include:

Dendrites	Processes coming off the main cell body. These structures **receive** signals from other neurons and pass the incoming signals to the cell body.
Axon	Each neuron has a **single** axon. This process projects from the cell body and is responsible for **delivering** signals to other neurons. Axons are **myelinated** (insulated) so signal conductance is rapid.
Synaptic Terminals	These structures are found at the end of the axon and are where the **transmission** of the outgoing signal takes place. There can be many synaptic terminals so a neuron can communicate with many other neurons.

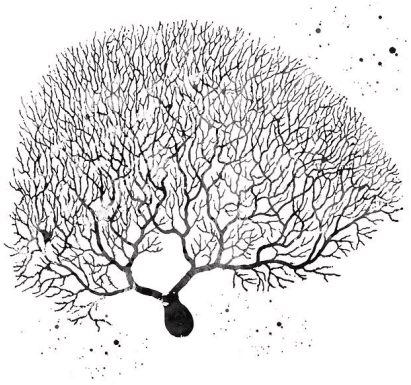
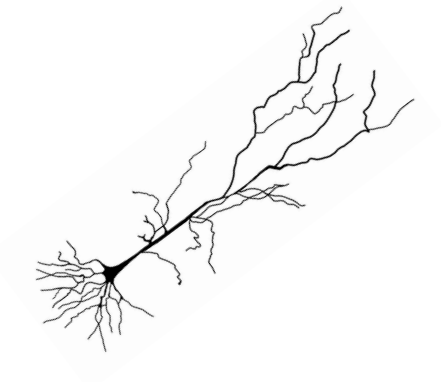
A single neuron can connect to up to **10,000** other neurons! There are also other cells in the brain called **glia** which are responsible for providing support to neurons, supplying nutrients and clearing debris & dead cells.

Tutorial 1 – The Brain: Regions, Neurons and Proteins

Cell Biology and Neurons

Activity

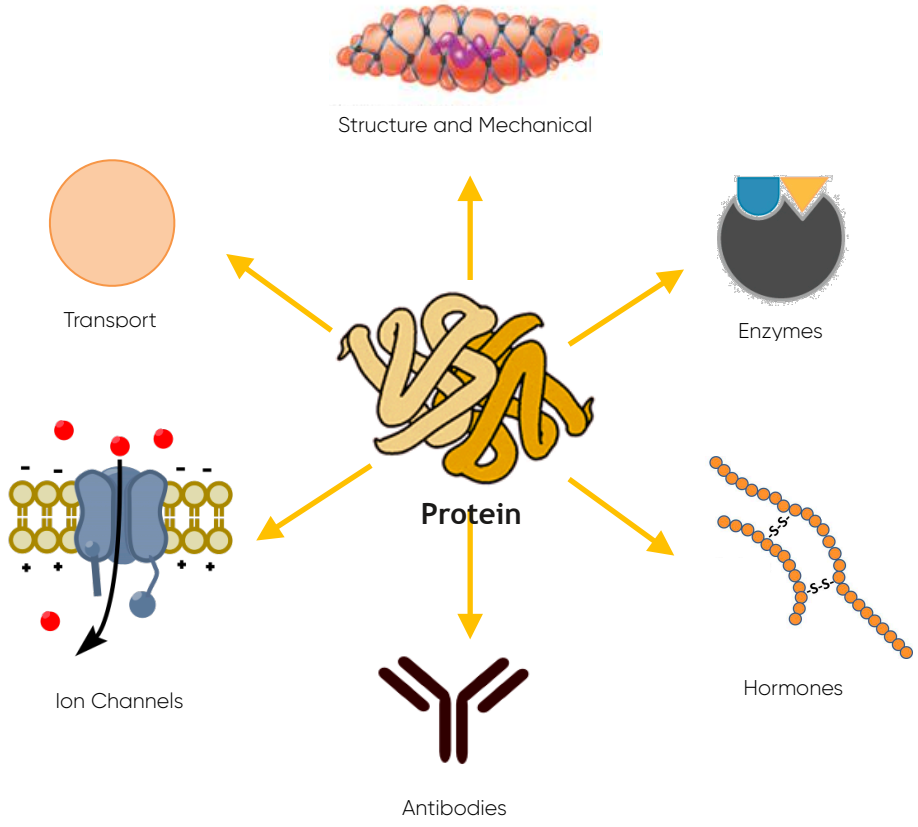
Using your knowledge on brain regions and neurons, state what the adaptation are of neurons from different brain regions and why they may have their specific adaptations.

Neuron	Adaptations	Implications
 Cerebellar Purkinje Neuron		
 Motor Neuron		
 Hippocampal Pyramidal Neuron		

Tutorial 1 – The Brain: Regions, Neurons and Proteins

Proteins: The workers of the Neuron

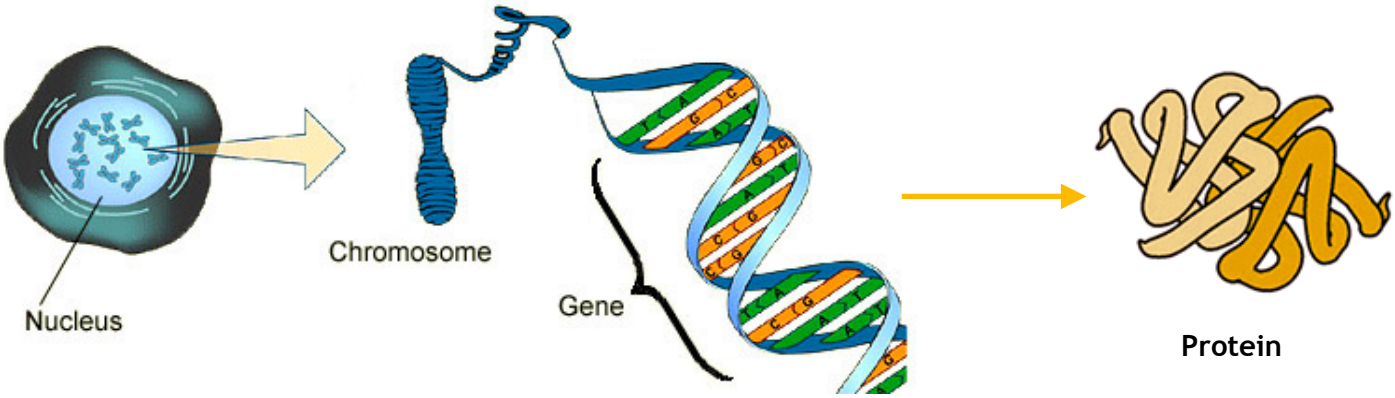
Within the neuron, there are thousands of proteins hard at work to keep you functioning. Proteins have lots of different roles.



Proteins are made from your DNA code. This is found inside the nucleus of the cell and codes for 23,000 proteins. Protein codes are called **genes** and these are inherited from your parents.

Genes are transcribed into a template called RNA, which is then used to create the protein it codes.

Genes can contain small changes to their code. These are called **mutations** and this alters the way a protein works. Mutations are responsible for many inherited diseases.



Tutorial 1 – The Brain: Regions, Neurons and Proteins

Plenary

If I can't see, what lobe is affected?

In two groups, arrange the symptoms on the cards into one of the four quadrants labelled for each lobe of the brain.

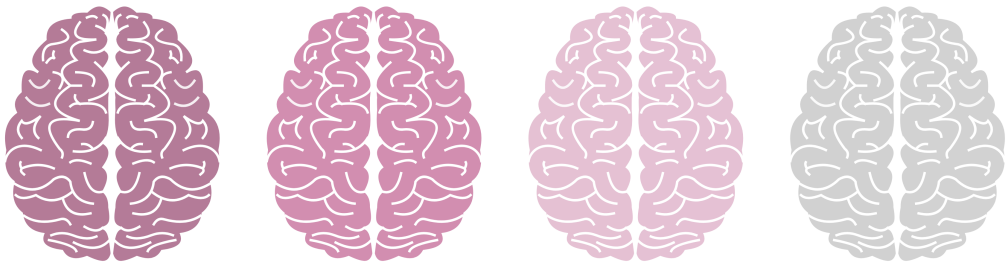
When your team is done, signal and we can check your answers. The team who completes the task in the quickest time with the most accurate answer, wins!

Tutorial 1 – Homework

Baseline Assessment

Word Count: 500 words

Which region of the brain is the most important for human function and why?



In this assignment, you <u>should</u>:

1. Introduce the reader to the brain, describing some of its anatomical features
2. Using **at least 3 brain regions,** argue for and against why they could be considered the most important
3. Conclude with a definitive answer and reason ('The most important region is … because …')

In this assignment, you <u>could:</u>

1. Include diagrams supporting your essay to aid the reader's understanding.
2. Include extra reading from the internet to support your argument (the sources of any extra reading must be added to a bibliography (not included in word count).

Please look over the mark scheme on page 6 whilst writing this assignment as this will be used to give you your grade.

Information, Advice and Guidance Homework – Tutorial 1

UCAS and University League Tables:

You have been given a booklet with a set of Information, Advice and Guidance (IAG) resources on applying to university, provided by Cambridge University and Brightside.

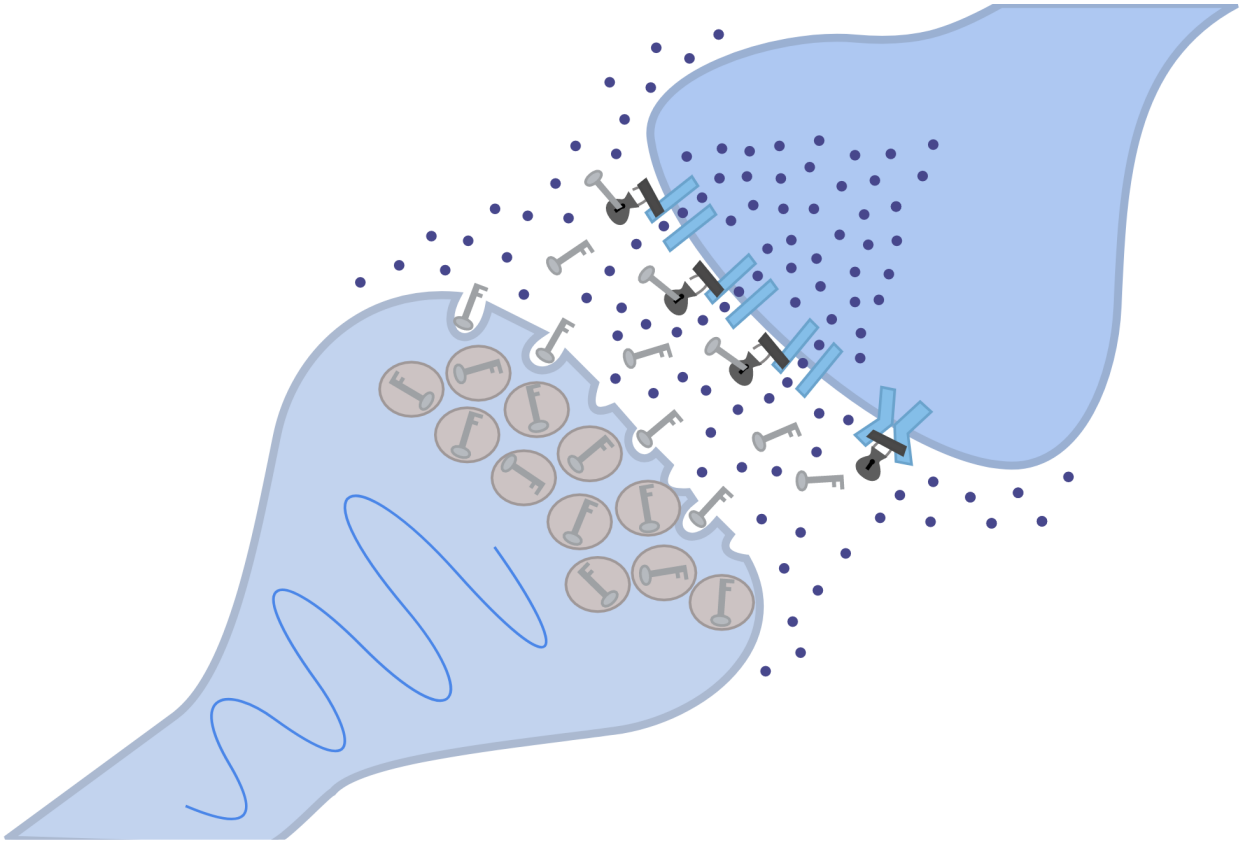
If you have not received this booklet, please let your PhD Tutor know as soon as possible.

Please spend 15 minutes this week on three topics from the resources listed below.

Write down one thing that you already knew, and one thing that you did not know before.

IAG Topics	Something you already knew	Something you did not know before
How to apply to university (p.1)		
UCAS points explained (p.2)		

Tutorial 2 – Neuron Signalling & Synapses



The main aims of Tutorial 2 are:

- To understand the levels of different ions in and around the neuron
- To learn what an action potential is and how they are initiated
- To understand how signals are transmitted at the synapse
- To assess how alterations to different processes in signal transmission affect human function

Scientist skill: To develop for and against arguments

Tutorial 2 – Neuron Signalling and Synapses

Starter: Spell the word!

Decode the clues and use the first letter of each answer to spell out a neuroscience-related word by matching it to its number in the sequence below.

1	2	3	3	4	5	6	7	3	8	9

Clue	Answer
1. The region of the body where the brain is found (4)	
2. A type of protein found in neurons (3, 8)	
3. The lobe of the brain associated with sensory stimuli (8)	
4. The lobe of the brain associated with vision (9)	
5. The bundle of fibres joining the two hemispheres (6, 8)	
6. The region of the brain associated with fear (8)	
7. The “powerhouse” of the cell (12)	
8. The second letter in the ‘brain of the cell’ (7)	
9. The region of the neuron where signal transmission occurs	

Tutorial 2 – Neuron Signalling and Synapses

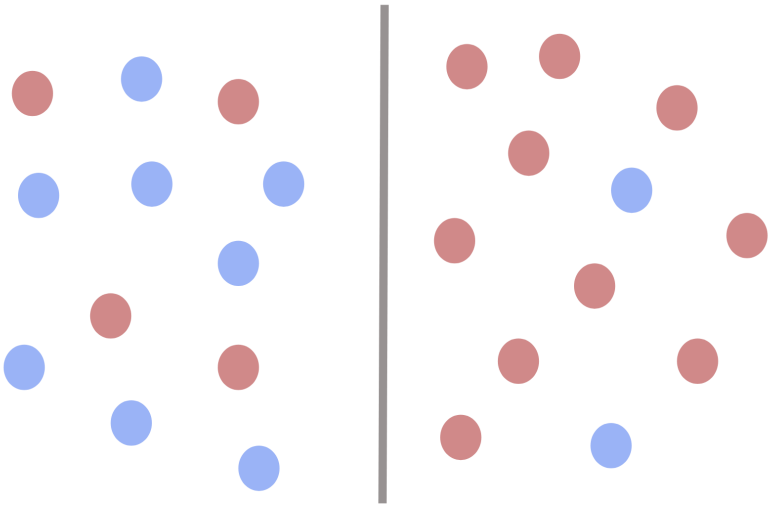
Neuronal Ion Concentrations

Neurons are the chattiest cells in the body; constantly sending and receiving signals from other neurons. This signals are generated by the movement of **ions** in and out the neuron.

Ions are **charged elements**. Therefore, their movement in and out of the neuron generates a current. The direction these ions move depends on their intracellular and extracellular concentrations. This process is similar to **diffusion.**

Mechanism: Diffusion

I



If you put a gate in the wall in between the red and blue particles, the **red** particles would move from right to left and the **blue** from left to right. This is because the particles want to be at **equilibrium;** balanced on both sides of the wall.

Fill in the table below with the direction the ions in and around neurons want to move based on their concentrations.

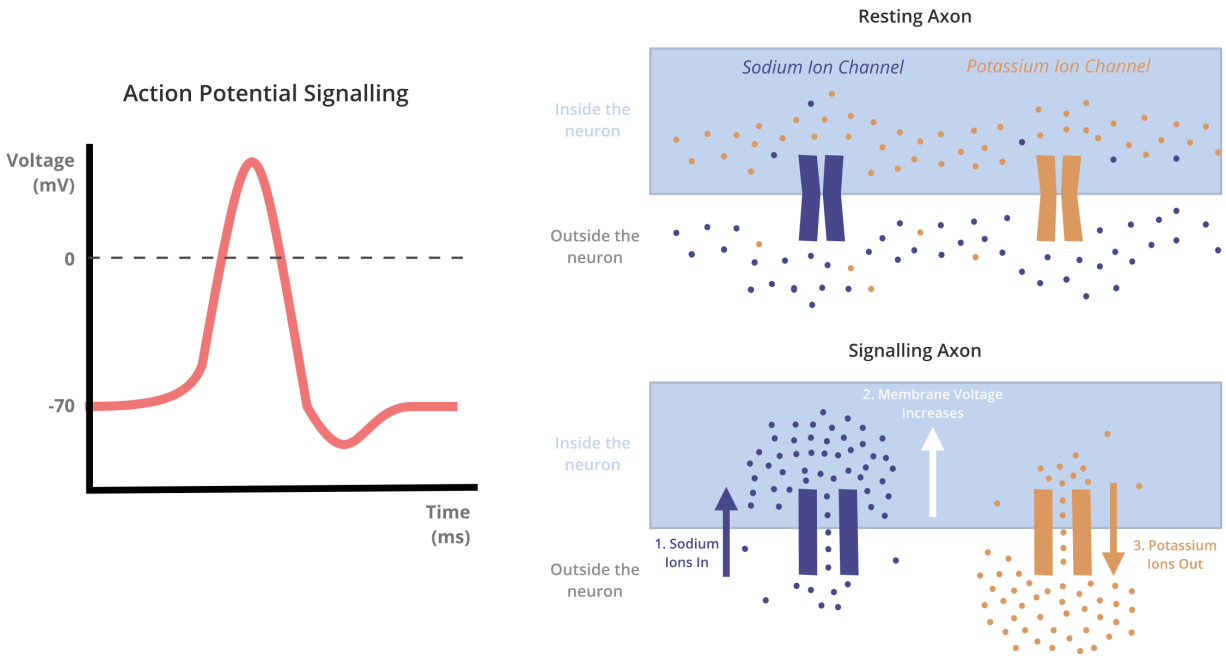
Ion	Level inside	Level outside	Direction
Sodium (Na^+)	↑	↓	
Potassium (K^+)	↓	↑	
Chloride (Cl^-)	↑	↓	
Calcium (Ca^{2+})	↑	↓	

Tutorial 2 – Neuron Signalling and Synapses

Action Potentials

Signals passed generated and passed on by neurons are called **action potentials.** These signals occur in the **axon** and are rapidly transmitted due to axon **myelination.** Action potentials are **all-or-none**, meaning when they happen, they are the exact same size every time.

The main ions involved in generating action potentials are **sodium (Na+)** and **potassium (K+) ions.** Both these ions have individual channels along the axon membrane and the timing of their openings generates the signal.



What happens in a neuron during an action potential?

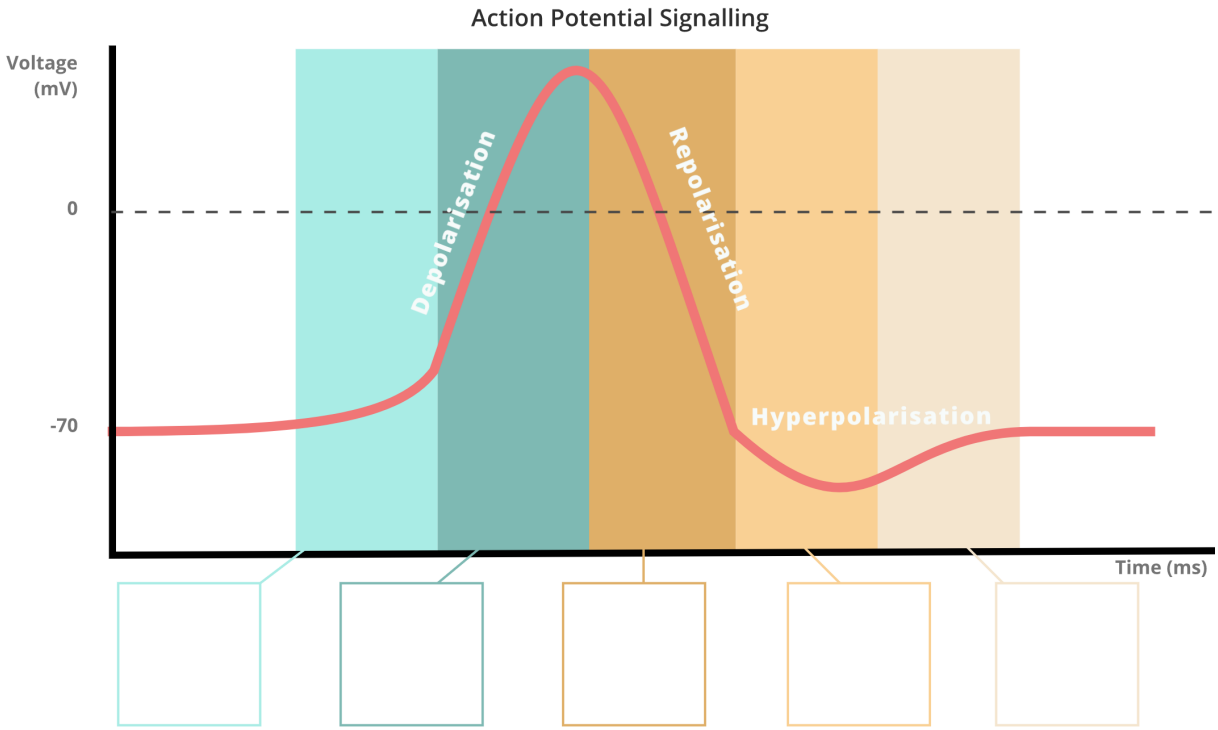
The neurons resting membrane voltage is **-70mV.** An incoming signal leads to a few sodium channels to open, making the membrane voltage more positive. Once this hits **-45mV**, all the sodium channels in the near vicinity open, letting lots of sodium ions inside the neuron. This increases the potential to **+40mV.** At this peak, potassium channels open and positive potassium ions flow out of the neuron. This potassium ion efflux drives the membrane potential down to **-85mV,** creating a refractory period where no new signal can be initiated. This signal moves back to resting **-70mV** as sodium and potassium ions are pumped back to their normal locations.

Tutorial 2 – Neuron Signalling and Synapses

Action Potentials

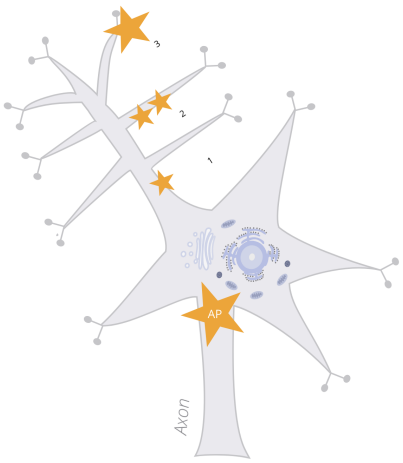
Activity

Based on what you have just learnt about action potential, Complete the information below.



Many Sodium Channels open	Sodium and Potassium pumped back to normal levels	Potassium channels remain open
Sodium Channels close Potassium channels open		A few Sodium Channels open

As action potentials are all-or-none, they are only activated by important signals from dendrites. Using the diagram below, explain 3 mechanisms a neuron uses to tell if a signal is important.



1. _____

_____

2. _____

_____

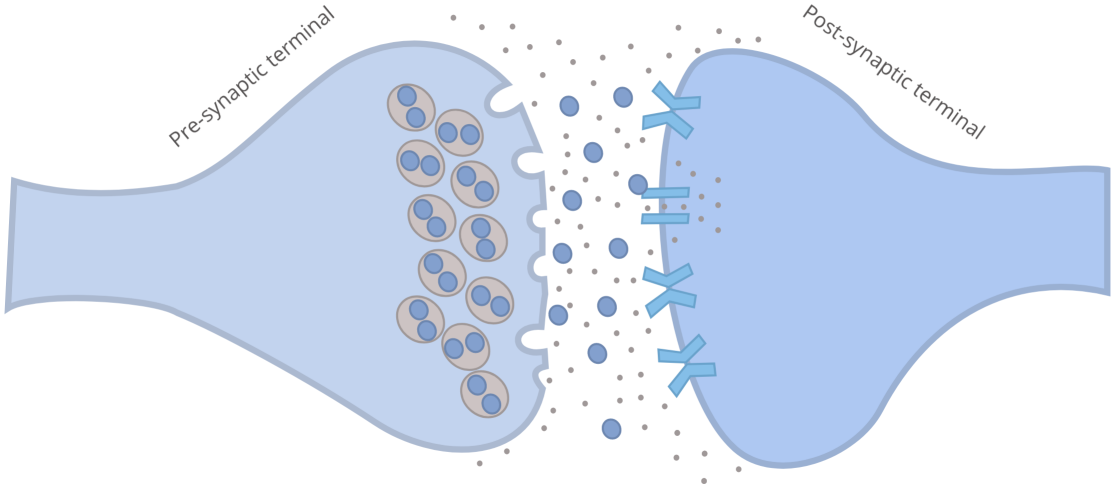
3. _____

_____

Tutorial 2 – Neuron Signalling and Synapses

Synapses

Neurons pass on rapid signals to other neurons at **synapses**. Synapses are chemical junctions between two neurons. The axon of one neuron holds the pre-synaptic terminal and the dendrite of the receiving neuron holds the post-synaptic terminal. These are separated by a **physical gap** and chemicals are used for signal transmission.



The Steps in Signal transmission at the Synapse

1. Action potential is delivered to the presynaptic terminal
2. Vesicles in the presynaptic terminal filled with chemicals fuse with the membrane
3. The chemicals enter the synaptic cleft
4. Chemicals bind to receptors on the post synaptic membrane
5. Receptors open and specific ions can flood into the post-synaptic terminal, initiating a signal
6. Chemicals are removed from the synaptic cleft and signal transmission is terminated

Questions

1. Why do you think chemicals are found in vesicles?

_____

_____

2. What is the main difference between ion channels and receptors?

_____

_____

3. Why do you think it is important chemicals are removed from the synaptic cleft?

_____

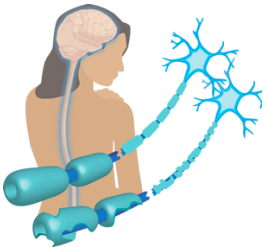
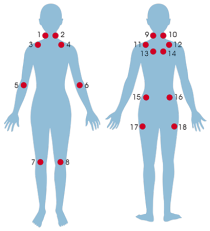
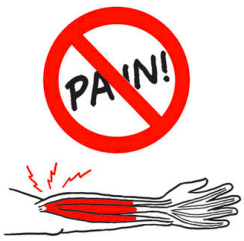
_____

Tutorial 2 – Neuron Signalling and Synapses

When Signalling Goes Wrong

Neuronal signalling is a finely tuned system requiring the cooperation of many different receptors, ions and other proteins to work together effectively. However, in some individuals, certain aspects of this transmission is faulty. This can cause different conditions dependent on the affected process.

Below are some examples of conditions caused by disrupted signal transmission. Can you identify why these problems at the cellular level cause these symptoms?

Disease	Cellular	Symptoms	Why?
 Multiple Sclerosis	Loss of axon myelination	Difficulty walking Numbness in limbs Problems thinking & learning Muscle stiffness	
 Fibromyalgia	Decreased sensitivity of Sodium ion channels in pain axons	Widespread pain throughout body Increased sensitivity	
 CIPA	Reduced expression of Sodium ion channels in pain axons	Insensitive to painful stimuli: extreme hot/ cold, broken bones, sharp objects are not detected as painful	
 Tetanus	Blocking of vesicle release from inhibitory synapses involved in muscle contraction	Jaw and neck muscle spasms Difficultly swallowing Painful whole body spasms	

Tutorial 2 – Neuron Signalling and Synapses

Plenary

Watch the video on Action Potentials:

https://www.youtube.com/watch?v=OZG8M_IdA1M

Did this answer any questions you had about action potential signalling?

Homework

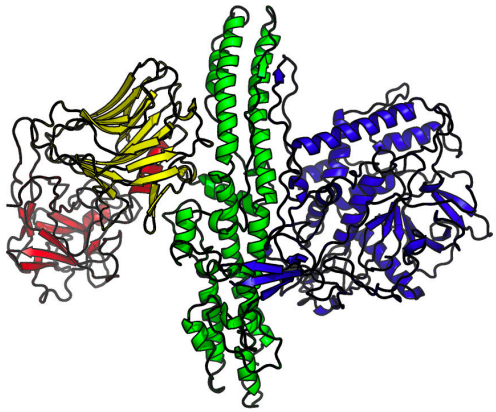
Opinion piece: 500 words

Botox: Wrinkle Smoother or Synaptic Inhibitor?

You have probably heard of botox and think of a cosmetic procedure to wipe away fine lines and crows feet from the faces of those who pay. However, the active ingredient in botox is actually a neurotoxin called **botulinum toxin.**

For your homework this week, read the facts below about the botulinum toxin host (Clostridium botulinum) and complete your own research to write an informative article for your school website about how this toxin works. Include:

- The normal processes involved in neurotransmission
- The mechanism of action behind botulinum toxin function at the neuron
- The pros and cons of using this toxin to paralyse muscles which cause wrinkles.



Botulinum Toxin

Clostridium botulinum is a Gram-positive, anaerobic, rod-shaped bacterium that produces toxins (in particular neurotoxins), which cause the serious disease botulism. The bacteria are found in a variety of environmental sources such as soil, coastal waters and lakes, inside the gills of shellfish and within the intestinal tracts of mammals and fish. C. botulinum thrives in conditions where there are low levels of oxygen which enable them to produce endospores. These heat-resistant spores remain dormant until they are activated by an external change in their conditions which causes them to multiply and release toxins into the host. Only a few nanograms of toxin is needed to cause botulism; a serious illness which can cause death. For Botox, tiny levels of this toxin are injected into the face to prevent muscle movement as this drug acts at motor synapses.

(ThermoFisher https://www.thermofisher.com/blog/food/fact-sheet-on-clostridium-botulinum/)

Information, Advice and Guidance Homework – Tutorial 2

Choosing the Right A-levels and Universities

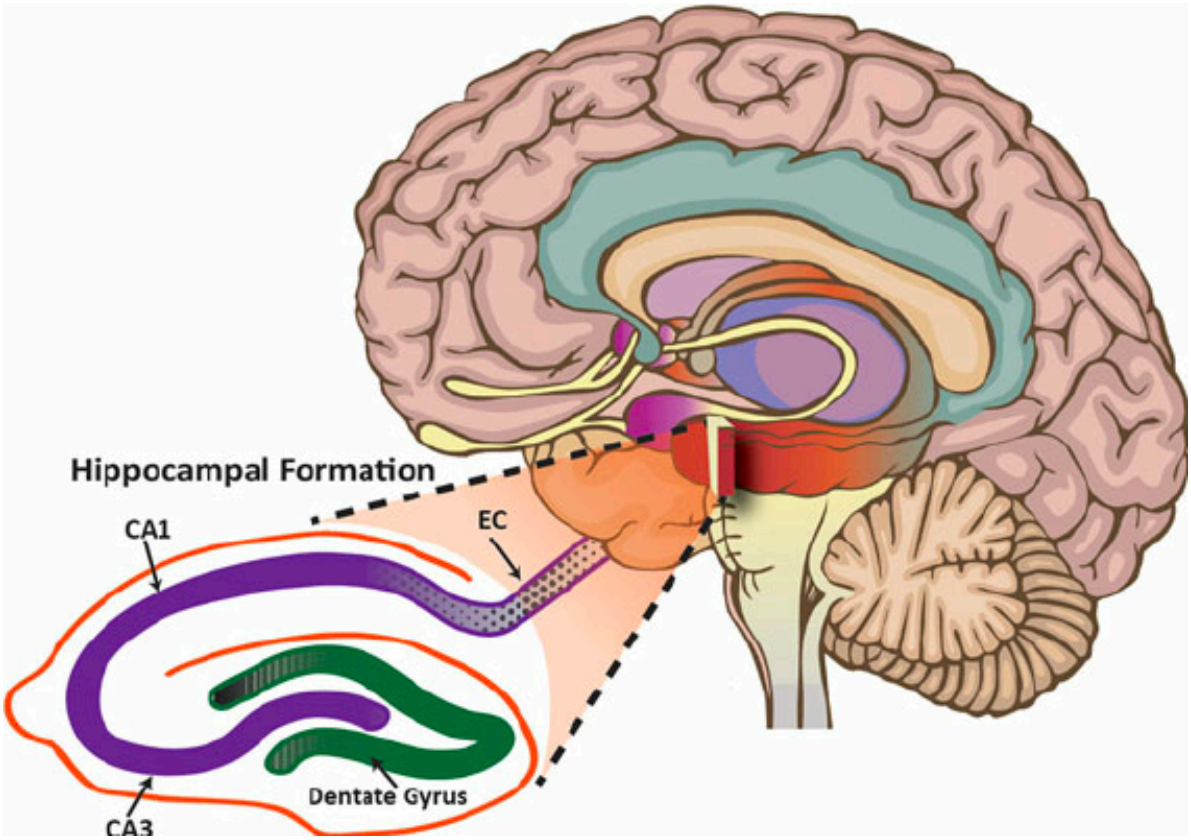
You have been given a booklet with a set of Information, Advice and Guidance (IAG) resources on applying to university, provided by Cambridge University and Brightside.

Please spend 15 minutes this week on two topics from the resources listed below.

Write down one thing that you already knew, and one thing that you did not know before.

IAG Topics	Something you already knew	Something you did not know before
University league tables (p.3)		
Choosing the right university for you: Research institutions (p. 4)		

Tutorial 3 – The Mechanism of Memory



The aims of Tutorial 3 are:

- To understand the function of the hippocampus using a case study
- To define the difference between short and long term memory
- To learn how different receptors at the synapse influence signal transduction
- To assess the synaptic alteration involved in long-term potentiation and depression
- To study how memory is measured in the lab

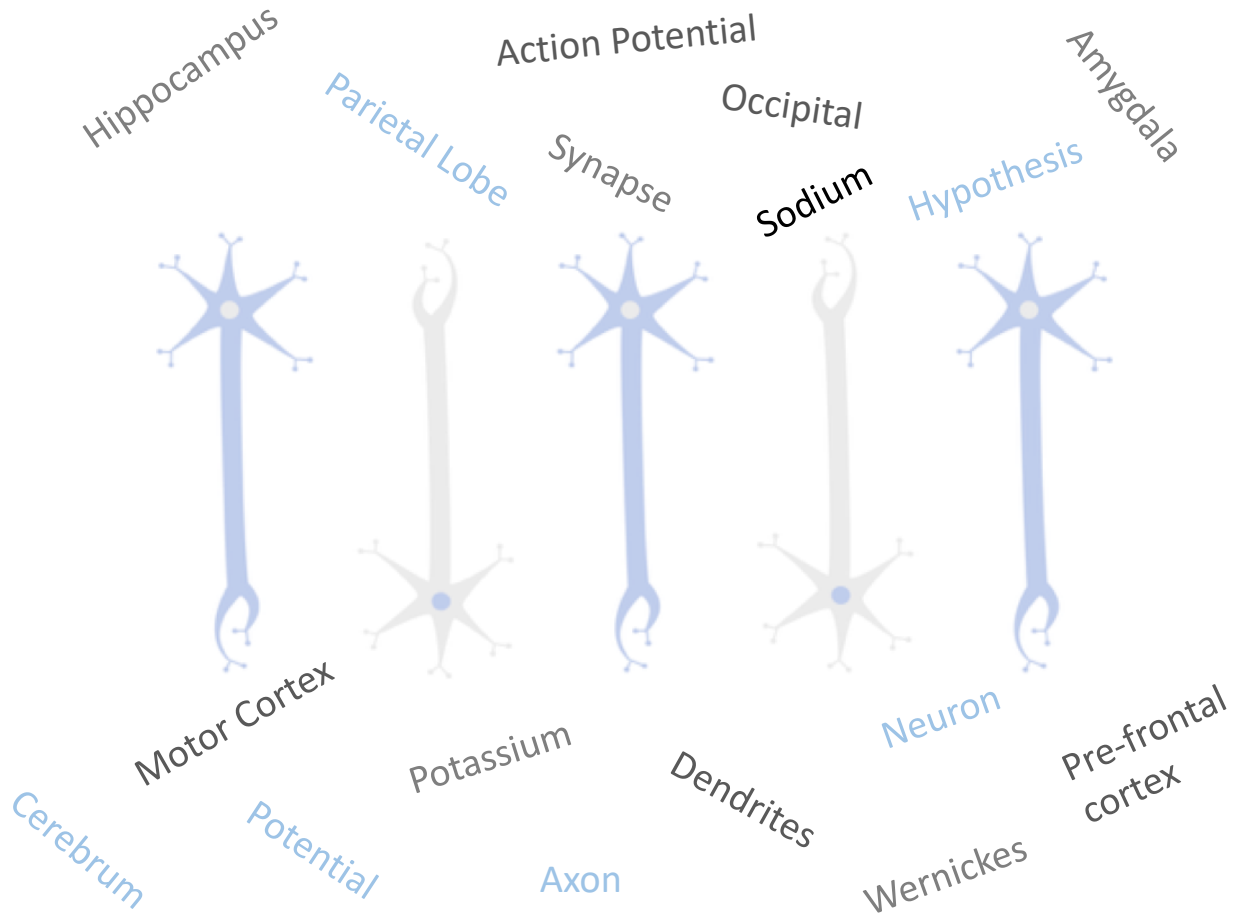
Scientific Skill: To be able to design a scientific experiment

Tutorial 3 – The Mechanism of Memory

Starter

Describe it, Don't say it!

You will be split into two groups. Each person will be given a minute to describe as many key terms from tutorial 1 and 2 without saying the word. Each team member will have a turn to describe. The team with the most correct points are the winners!

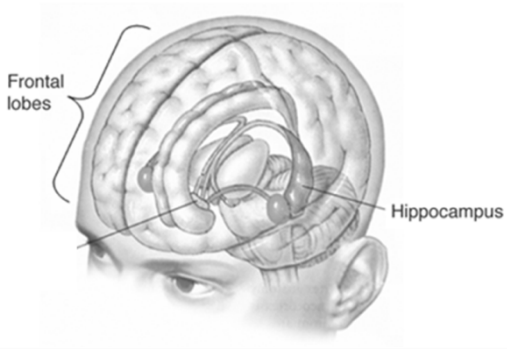


Make a note of any words you missed or would like to go over below.

Tutorial 3 – The Mechanism of Memory

Memory in the Brain

From the case study of patient HM, we have learnt how important the **hippocampus** is for memory. Both the left and right hemispheres contain this structure and it is buried deep in the brain.

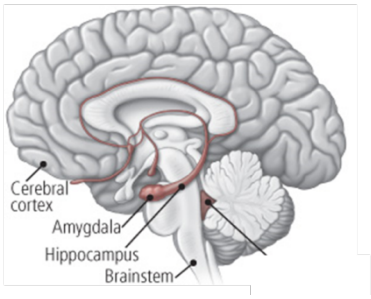


What creature is the hippocampus named after?

_____

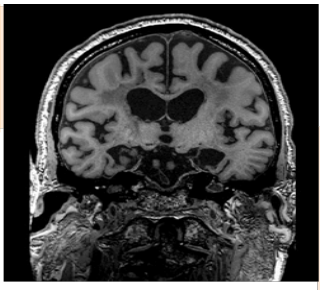
The hippocampus is responsible for:

- Consolidating information from short-term into long-term memory
- Spatial memory and navigation
- Integrating information from multiple brain regions to form a coherent memory



What happens if you do not have a hippocampus?

Case Study: Patient HM



Following a road accident at age 7, a young boy 'HM' developed seizures, with them becoming major after he turned 16. These seizures became progressively worse and left him incapacitated, unable to lead a normal life.

At age 27, HM was offered an experimental procedure to put an end to his seizures. The first visit from his doctor following the surgery revealed that his seizures were under control. However, HM had been left with a severe memory impairment. He forgot daily events as quickly as they happened but his intellect remained intact. He forgot names of people he had just been introduced to and thought he was a lot younger than he was.

He described every day like 'waking from a dream'. He lived like this until he died at age 82 in 2008.

What does the case of patient HM tell you about the role of the hippocampus in memory? Why do you think you could not perform this as an experiment?

_____

_____

_____

_____

Tutorial 3 – The Mechanism of Memory

Types of Memory

There are two main types of memory in the brain:

1. Short Term Memory

Like writing your name in the air with a sparkler

Time: 15-30 seconds

Holds the information you are currently working with: new incoming information or retrieval of old information

Brain region activity: pre-frontal cortex

2. Long Term Memory

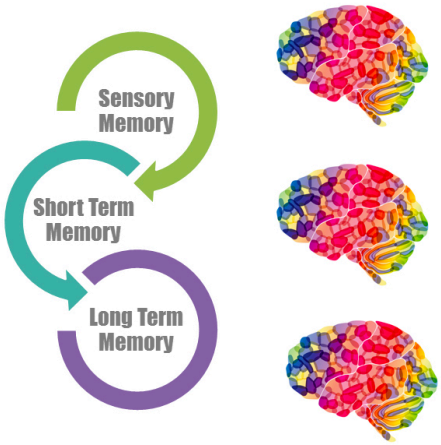
Stored in the 'hard-drive' of your brain

Time: Longer 30 seconds

Physical changes to neurons: new connections and modifying synapses

2 types of Long term memory:

1. Implicit: automatic memory
2. Explicit: activity trying to remember
    1. Episodic:Events that happened to you
    2. Semantic: General Knowledge



Activity: Label the memory

Describe each memory listed below with what type of memory it is.

KEY: ST = Short-term, IP = Implicit, EP = Episodic, SM = Semantic

1. Answering a maths question
2. Eating too many sweets on your 11th birthday
3. Paris is the capital city of France
4. Riding a bike
5. Knowing your way home from school
6. Getting your GCSE results

Can you think of a personal example for each type of memory?

ST:_____

IP:_____

EP:_____

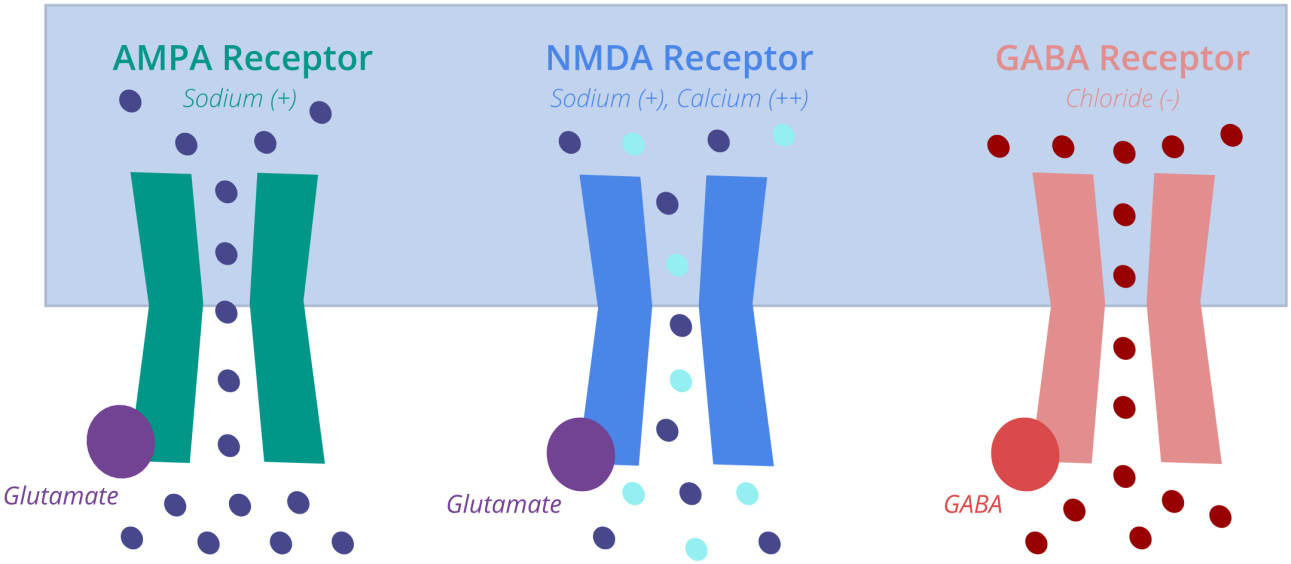
SM: _____

Tutorial 3 - The Mechanism of Memory

Changes at the Synapse

Long-term memories involved **physical alterations** to synapses. These changes normally involve changing the levels and types of receptors on the post-synaptic membrane.

Different receptors are opened by different chemicals (**neurotransmitters**) and allow the influx of different ions which can promote or inhibit signal transmission.



Based on your knowledge of signal transmission, state which receptors promote or inhibit neurotransmission and why.

Receptor	Promote or Inhibit?	Reason

Using your answers above, which neurotransmitter do you think is excitatory and which is inhibitory.

Excitatory: _____

Inhibitory _____

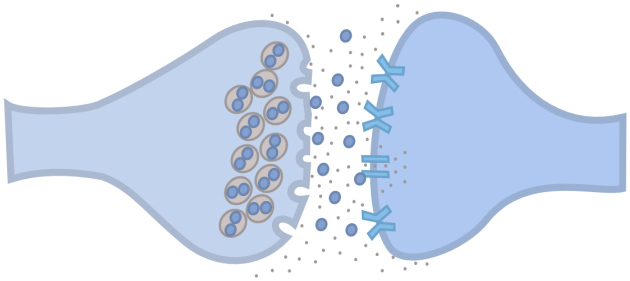
Tutorial 3 - The Mechanism of Memory

Changes at the Synapse

The synaptic membrane is **plastic**, meaning the receptors tethered their can increase or decrease in numbers dependent on synaptic activity. These changes can **strengthen** or **weaken** synaptic connections.

There are two types of synaptic plasticity: Long-term potentiation (LTP) and long-term depression (LTD).

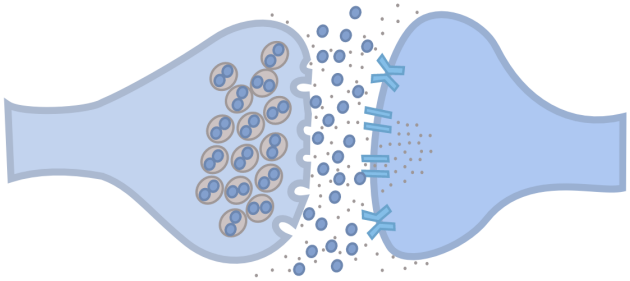
State the changes you can spot to the synapse below and explain how these would change the strength of the synaptic signalling.



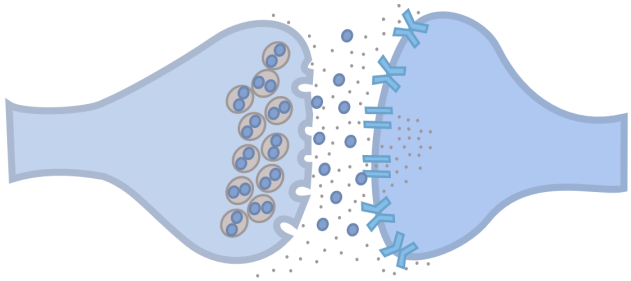
Normal Synapse

Neurotransmitter = glutamate

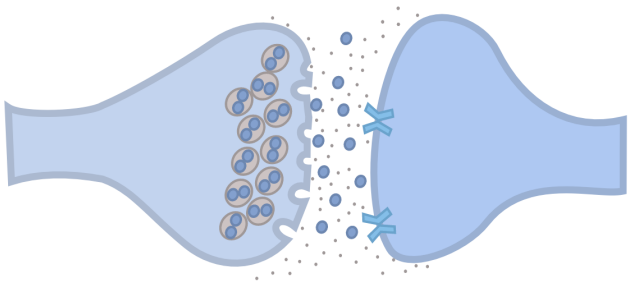
Receptors = AMPA/NMDA



Pre-Synaptic LTP



Post-Synaptic LTP



LTD

If these neurotransmitters were GABA and the receptors were GABAergic, how would these scenarios change?

Tutorial 3 - The Mechanism of Memory

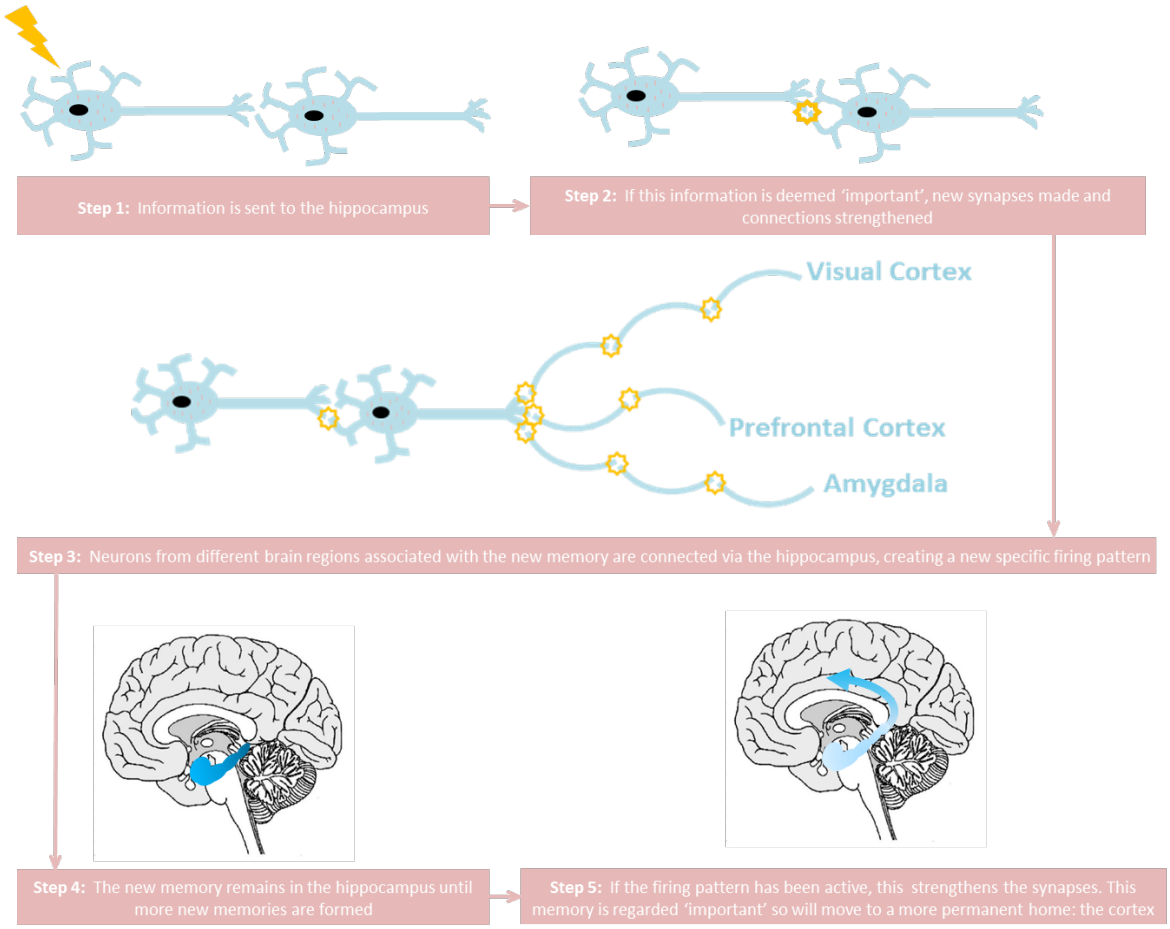
Memory Formation

The basis of long-term memory formation involves the strengthening of synapses between individual neurons and this is initiated in the hippocampus. The hippocampus is one of the only brain regions where **new neurons are made.**

The full process of how a memory is made is still being researched. However, it is thought the initial phases of transforming a new experience into a long-term memory are very fragile as these involved **remodelling networks of neurons**. If the hippocampus stops signalling during this process, the memory will be lost.

The hippocampus is a busy place and only the most **important memories** make it into long term storage. This is why you cannot remember mundane events like what you had for dinner last Tuesday (unless last Tuesday was your birthday).

It is thought that consolidation of a memory takes many weeks, months or years and following this process, the hippocampus is no longer needed to recall the memory as it is stored as a circuit in the **cortex**.



Research over the past 15 years has also showed that once a memory is consolidated, it is not safe from alteration. Recalling a memory reintroduces plasticity into the circuit, which can lead to alterations to the original experience.

Why do you think it is important we do not remember everything? _____
_____
_____
_____

Tutorial 3 - The Mechanism of Memory

Measuring Memory: Lab-Based Techniques

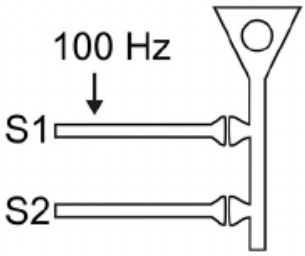
In the lab, we have to model memory in order to look at the cellular mechanisms involved. This is because you cannot look at active neurons in a living persons brain at the molecular level. These models aim to replicate what you would see in humans as closely as possible. Once a model is established, you can try to alter its activity using drugs and other treatments.

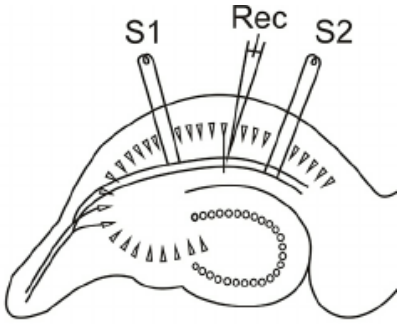
Lab Techniques to measure Memory

LTP induction in hippocampal slices

You can record the conduction potential of a synapse in a sections of mouse brain using a recording electrode.
S1/S2 = stimulating electrodes
Rec = Recording location

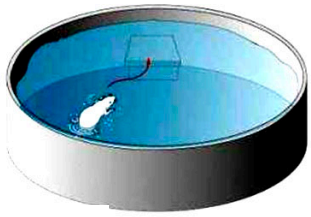
Once the baseline recording of the normal synaptic firing rate has been measure, you can apply high frequency stimulation to the neuron to induce LTP. This is recorded as a larger signal than baseline.



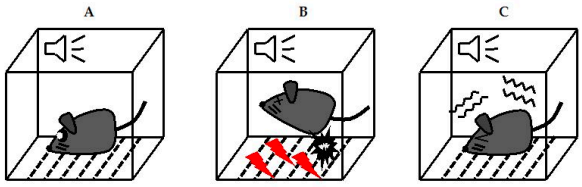


Animal Experiments

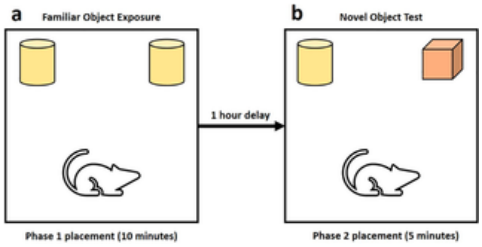
Water Maze: trained to find platform. Platform removed. Track amount of time swimming in area where platform was.



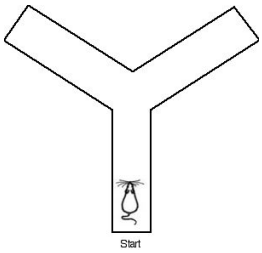
Fear-conditioning: play sound followed by electric shock. When play sound alone, mice should freeze in anticipation of shock.



Novel Object: exposed to 2 objects for a period of time. An hour later, put back into environment with 1 new object. Track time spent exploring new object.



Y-Maze: place reward in one arm of maze and let mice get it. Remove reward and see which arm the mice decide to take.



Activity: Discuss the pros and cons of these techniques. Which do you think is the most accurate model and why?

Tutorial 3 - The Mechanism of Memory

Plenary

Traffic Light Check

Write the following on the three post-it notes:

1. Green Post-it: Something new you have learnt today
2. Yellow Post-it: Something you would like to learn more about from todays class
3. Pink Post-it: Something you would like to go over again so you can really understand it

Homework

Experimental Design: 500 words

How would you test a memory altering drug?

A new memory enhancing drug has been made and your lab has been asked to run a series of experiments to test if this drug actually does what it should.

Write a research proposal for your experimental ideas. This should include:

- The neurobiological mechanisms for memory formation at the synapses
- The mechanism of action of this drug (this is for your to decide)
- The experiment you would do to test this drug in the lab
- What results you would expect.

For good experimental design, it is crucial you include:

- What the hypothesis is you are testing
- The concentration of drug you will test
- The number of samples you will need
- The control samples you will use
- The variables you must control for
- The future experiments from your initial work if it works

Complete your own research to enhance your proposal.

"There's a flaw in your experimental design. All the mice are scorpios."

Information, Advice and Guidance Homework – Tutorial 3

University Applications and Offers

You have been given a booklet with a set of Information, Advice and Guidance (IAG) resources on applying to university, provided by Cambridge University and Brightside.

Please spend 15 minutes this week on three topics from the resources listed below.

Write down one thing that you already knew, and one thing that you did not know before.

IAG Topics	Something you already knew	Something you did not know before
Applying to Oxford or Cambridge (p.5)		
University offers explained (p.6)		
Admission test (p.7)		

Tutorial 4 – Memory Disorders

The aims of Tutorial 4 are:

- To learn about Alzheimer's disease and discuss the hypothesis surrounding the neuron death which disrupts memory
- To read a scientific paper extract in order to learn more about the understanding of amnesia
- To study the effects of alcohol on the hippocampus
- To discuss the positive and negative effects of memory enhancing drugs

Scientific Skill: To critically assess opinions in science

Tutorial 4 – Memory Disorders

Starter

Brain Bingo!

I will read you a series of definitions and if you have the appropriate word on your card, cross it out. The first person to get 10 terms, wins!

Make a note in the table below of any words you were unsure of the definition for.

Tutorial 4 – Memory Disorders

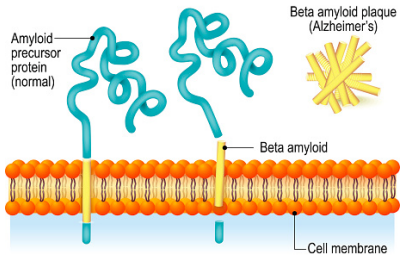
Alzheimer's Disease

Dementia	**A group of disorders** A chronic or persistent disorder of the mental processes caused by brain disease or injury and marked by memory disorders, personality changes and impaired reasoning
Alzheimer's disease	**A type of dementia** A disease that results in the gradual loss of memory, speech, movement, and the ability to think clearly, and that is common especially among older people

Alzheimer's disease (AD) results in neuron death in the **hippocampus** and this spreads to other brain regions like the frontal cortex. In the brain at post-mortem, AD patients have two key **pathologies.**

1. **Amyloid plaques:** Found outside the neuron (extracellular) made up of amyloid beta
2. **Tau Tangles:** Found inside the neuron (intracellular) made up of tau

Both pathologies are formed by **abnormal variations** of proteins which already exist in the brain



Plaques

The protein which makes up plaques is called **amyloid-beta** (**Aβ**), which is a fragment cut off from a large protein called the **amyloid precursor protein** (APP). The normal role of **Aβ is in synaptic signalling.**

Tangles

The proteins which make up tangles is called **microtubule-associated protein tau,** although this protein is generally known as just **tau.** Tau's role is to stabilise structures called **microtubules.**

Microtubules are the **'railway tracks'** down the axon of a neuron. Theses allow the transport of proteins from the neuron cell body all the way to the synaptic terminal for efficient signal transmission.

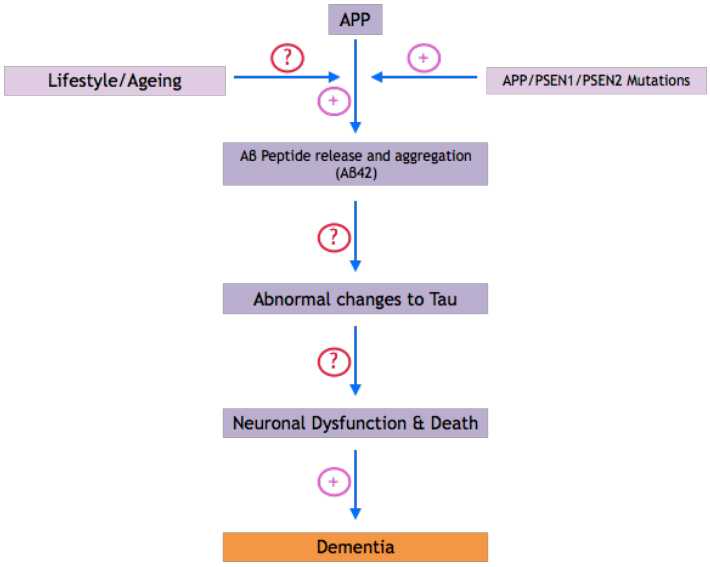
Tau stabilises these microtubules by holding them in place. Therefore, in Alzheimer's disease when tau becomes dysfunctional (as it is **hyperphosphorylated**), microtubules collapse, axonal transport become compromised and signal transmission is inhibited.

Tutorial 4 – Memory Disorders

Theories of Alzheimer's Disease Neurodegeneration

Memory loss in AD is directly caused by the death of hippocampal neurons as these synaptic connections are lost. However, it is still unclear how these neurons die.

Both the normal Aβ and Tau proteins change shape during Alzheimer's disease, which makes them 'sticky' and promotes them clumping together. This is called a **conformational change** and in Alzheimer's disease, these are normally irreversible.



The Amyloid Hypothesis

The main theory behind Alzheimer's disease pathology is called the amyloid hypothesis. This puts the amyloid plaque pathology as the trigger for the disease i.e.. amyloid pathology triggers tau pathology which leads to neuron death.

The question marks (?) in this diagram represent unknown mechanisms in the disease process. This can cause issues when trying to generate new drugs for AD.

Activity: What vital pieces of information are missing from this hypothesis? What problems might some experience trying to cure AD based on this?

At the Synapse

Aβ and LTP impairment

One of the mechanisms thought to contribute towards AD pathogenesis is Aβ toxicity at the synapse. It has been showed that disease-associated Aβ species reduce LTP with no effect or even an enhancement of LTD in hippocampal slices from mouse brains (REFERENCE). It is thought disease-associated Aβ triggers the internalisation of AMPA receptors, which eventually leads to synapse loss and neuron death.

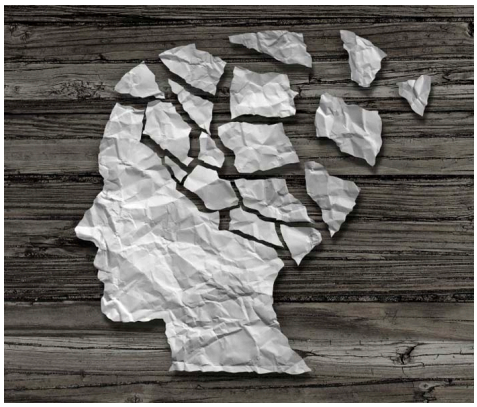
Tau's role at the synapse

Although tau is an intracellular protein involved in microtubule stability, it has been shown to also play a role in learning and memory. Deleting the tau gene (MAPT) from mice, therefore removing all tau protein, produce mice with short-term memory defects and a reduction in LTP (https://www.nature.com/articles/s41598-018-21596-3/)

In addition, LTP reduction caused by Aβ has been shown to require tau for its induction, meaning that without tau, this synaptic impairment cannot happen.

Tutorial 4 – Memory Disorders

Retrograde Memory Loss: Amnesia



A = without, Mnesis = Memory

Amnesia is the partial or total loss of memory and there are two different forms.

2 types of Amnesia

1. Anterograde: cannot form new memories
2. Retrograde: cannot remember past events

Retrograde Amnesia

Retrograde amnesia can be caused by conditions such as traumatic brain injury, encephalitis, stroke and seizures.

This type of amnesia is **temporally coded,** meaning a patient with retrograde amnesia is more likely to remember events in the distant past and forget more recent experiences.

The Neurological Basis of Amnesia

Amnesia is still not fully understood at a cellular level. This is potentially due to the fact scientists are unsure if amnesia is caused by problems in memory storage or in memory recovery.

Study: Lost memories can be recalled by activating neurons.

Ryan et al, 2015 (Science, 348 (6238), 1007-1013)

Aim: to study if memory traces (engrams) in the brain can be 'switched' back on in mice following drug-induced amnesia.

Experiment: Tagged hippocampal with a red fluorescent marker in mice so they could be visualised. They taught the mice to associate a noise with an electric shock; a process called fear-conditioning. They disrupted memory formation in half the mice using a drug which stops protein synthesis. This prevents LTP as no new receptors can be added to the surface of the synapse. The other half were injected with a placebo. The neurons which stimulate hippocampal neurons were manipulated so their firing could be activated by light.

Results: 24 hours after fear-conditioning, the red fluorescent neurons in the placebo animals had formed strong synaptic connections whereas the drugged mice did not, and the number of synapses was higher in the placebo compared to drugged. When noise associated with shock played, placebo mouse showed robust freezing activity whereas the drugged mice showed much less. However, when the cells which stimulate the hippocampus were turned on in the drugged mice, their freezing activity was enhanced.

Does this study provide evidence for retrograde amnesia being an issue with memory storage or memory retrieval? Why?

Tutorial 4 – Memory Disorders

Anterograde Memory Loss: Substance-Induced

Alcohol-induced memory loss

Excessive consumption of alcohol can lead to periods of memory loss. This form of amnesia is mostly anterograde and can occur in two different ways:

- En bloc: cannot recall any events
- Fragmentary: can remember small pieces of information

With en bloc memory loss, the retrieval of these events is much more challenging than fragmentary blackout. When an individual with the latter is reminded of an event or taken back to the location of their blackout, pieces of their memory can be recalled.

During blackout, short-term memory is still active so conversations can be continued as normal. However, the process of transforming these conversations into long-term memories prevented

The Neuroscience of Blackout

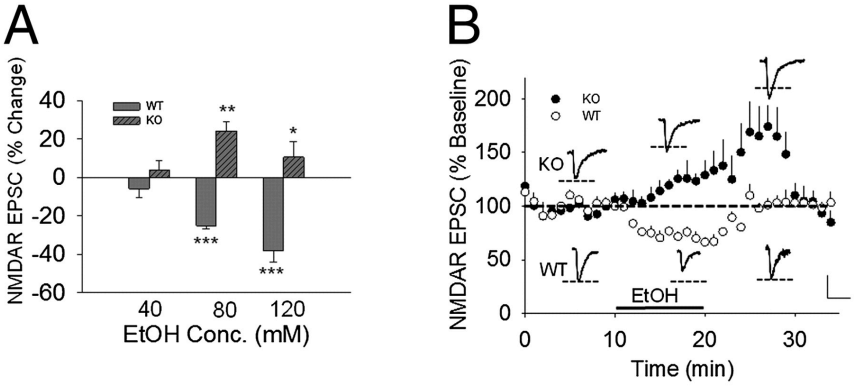
Alcohol stops the main cells in the hippocampus (CA1 pyramidal neurons) from firing and this blockage is dose-dependent.

Q: What does dose dependent mean? What does this mean with regard to alcohol consumption and hippocampal function?

It has been shown that after 1-2 standard drinks, the initiation of LTP is impaired.

Mechanism: NMDA interference

Describe what the graphs below tell us about NMDA signalling and alcohol?



Information about figure
WT = wild-type mice
KO = mice with NMDA resistant to alcohol alteration.
EtOH = ethanol
EPSC = Positive signal

Ref: Hicklin et al, PNAS, 108 (16): 6650-6655

Mechanism: Calcium not sent into the neuron –> long lasting changes cannot occur (gene expression, protein synthesis etc) therefore no morphological alterations to the synapse.

Tutorial 4 – Memory Disorders

Memory Enhancing Drugs

There are drugs which can 'enhance' your cognitive performance. Read the article below about these drugs.

PEOPLE ARE TURNING TO SMART DRUGS TO GAIN AN EDGE OVER THE COMPETITION

We live in an increasingly competitive world where we are always looking to gain an advantage over our rivals, sometimes even our own colleagues. In some cases, it can push people to extreme, unethical and illegitimate methods – something we've seen recently in the doping scandal that has rocked the athletics world.

In a recent review paper, we found that people are using performance-enhancing drugs increasingly for common tasks, ranging from sitting examinations to giving presentations and conducting important negotiations. These "cognitive enhancers" – such as antidepressants, beta blockers (used to treat heart conditions or anxiety) or "smart drugs" – can boost energy and mood, helping us to perform better with less sleep. But is it safe for healthy individuals to take such drugs? And is it right?

Smart drugs include modafinil (commonly used to treat sleep disorders) and methylphenidate, also known as Ritalin (used to treat attention deficit hyperactivity disorder). These drugs make us more attentive, focused and awake, so it's easy to see why they are so popular. In today's knowledge economy, we need dynamic and flexible brains to excel in the workplace. Demanding jobs require us to be adaptable and able to make decisions under time pressure or high levels of risk. We need to be attentive, have good memory and great planning and problem-solving skills, but also the ability to read and understand others' views. Maintaining motivation and resilience in difficult situations and under stress are also key.

We are only starting to understand how widespread the use of smart drugs is. In a 2008 online poll by the journal Nature of 1,400 people in 60 countries, one in five reported they were using cognitive-enhancing drugs to stimulate their focus, concentration or memory. This study looked specifically at the use of beta blockers, Ritalin and modafinil.

Meanwhile, a 2015 survey of some 5,000 workers at a German health insurance company estimated that about 6.7% were using drugs to enhance their performance or cope with anxiety, up from 4.7% in 2009. However the real number could be much higher, as some people may be reluctant to report such use. Studies have also estimated that some 10%-15% of students worldwide use cognitive enhancers including Ritalin and modafinil.

Promising effects

University students and academics typically say they use cognitive enhancers for three main reasons: to gain the competitive edge; to overcome the effects of jet lag or insufficient sleep in order to stay awake and alert and to perform at peak level and to increase work-related motivation. We know that if tasks are boring, it is difficult to get into the flow – and much easier to procrastinate and surf our favourite websites instead.

In my own laboratory, we have assessed the effects of both modafinil and methylphenidate. We saw improvements in a wide variety of cognitive functions, including sustained attention or concentration, memory, planning and problem solving. In addition, modafinil enhanced task-related pleasure or motivation.

But it's not just about improving performance at "everyday jobs". For certain members of our society, such as doctors or those in the the military and air traffic control, cognitive enhancing drugs such as modafinil could turn out to be lifesavers. Indeed, we have found that sleep-deprived doctors might benefit from modafinil in situations that require efficient information processing, flexible thinking and decision-making under time pressure.

In these studies with modafinil, side effects are relatively low. But while this all sounds positive, these are early studies on a limited number of people. Given the increasing use of such drugs, we urgently need long-term studies of their safety and efficacy for use by healthy people.

While there is reason that we should promote improvements in brain health and mental well-being globally, the use of cognitive enhancers that can only be purchased or accessed illegitimately, such as Ritalin, is dangerous and controversial. Some students feel forced to use cognitive enhancing drugs, because they see other students using them and they do not want to fall behind.

In response to concerned students, Duke University in North Carolina, US, amended its honour code in 2011 to state that "the unauthorised use of prescription medication to enhance academic performance" was a form of cheating. Until these cognitive-enhancing drugs are approved for use by healthy people, it is best to use other means to boost cognition. Maybe it is also time to consider how we can best promote mental wellbeing for a more flourishing society.

Independent article, Barbara Sakian, June 2017

Discuss: **Do you agree or disagree with using cognitive enhancing drugs?**

Tutorial 4 – Memory Disorders

Plenary

Just a Minute!

In pairs, each describe what you have learnt in this tutorial in 1 minute. You can't repeat, hesitate or deviate. If you do, you partner takes over and tries to talk for a minute with the same rules.

Homework

Critical Assessment: 500 words

Should curing Alzheimer's disease (AD) and the task to enhance memory be researched in a similar manner or as two separate lines of science?

Read the abstract below and write a critical assessment of their opinion that 'research into MEDs and anti-dementia drugs encourages a reductionistic view of the human mind and of the self'

State whether you believe AD research and memory enhancement research can be combined or not. Also comment on the ethical implications of memory enhancing drugs. Use extra reading to back-up your opinions.

Reductionism: The practice of oversimplifying a complex idea or issue to the point of minimising or distorting it.

Memory enhancing drugs and Alzheimer's Disease: Enhancing the self or preventing the loss of it?

In this paper we analyse some ethical and philosophical questions related to the development of memory enhancing drugs (MEDs) and anti-dementia drugs. The world of memory enhancement is coloured by utopian thinking and by the desire for quicker, sharper, and more reliable memories. Dementia is characterized by decline, fragility, vulnerability, a loss of the most important cognitive functions and even a loss of self. While MEDs are being developed for self-improvement, in Alzheimer's Disease (AD) the self is being lost. Despite this it is precisely those patients with AD and other forms of dementia that provide the subjects for scientific research on memory improvement. Biomedical research in the field of MEDs and anti-dementia drugs appears to provide a strong impetus for rethinking what we mean by 'memory', 'enhancement', 'therapy', and 'self'. We conclude (1) that the enhancement of memory is still in its infancy, (2) that current MEDs and anti-dementia drugs are at best partially and minimally effective under specific conditions, (3) that 'memory' and 'enhancement' are ambiguous terms, (4) that there is no clear-cut distinction between enhancement and therapy, and (5) that the research into MEDs and anti-dementia drugs encourages a reductionistic view of the human mind and of the self

REF: Dekkers and Rickkert, Med Health Care Philos. 2007 Jun; 10(2): 141–151.

The full article is available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2779437/

Information, Advice and Guidance Homework – Tutorial 4

Student Finance and Revision

You have been given a booklet with a set of Information, Advice and Guidance (IAG) resources on applying to university, provided by Cambridge University and Brightside.

Please spend 15 minutes this week on two topics from the resources listed below.

Write down one thing that you already knew, and one thing that you did not know before.

IAG Topics	Something you already knew	Something you did not know before
Student finance for universities (p.8)		
Additional resources (Optional) (p.10)		

Tutorial 5 – Revision Tutorial

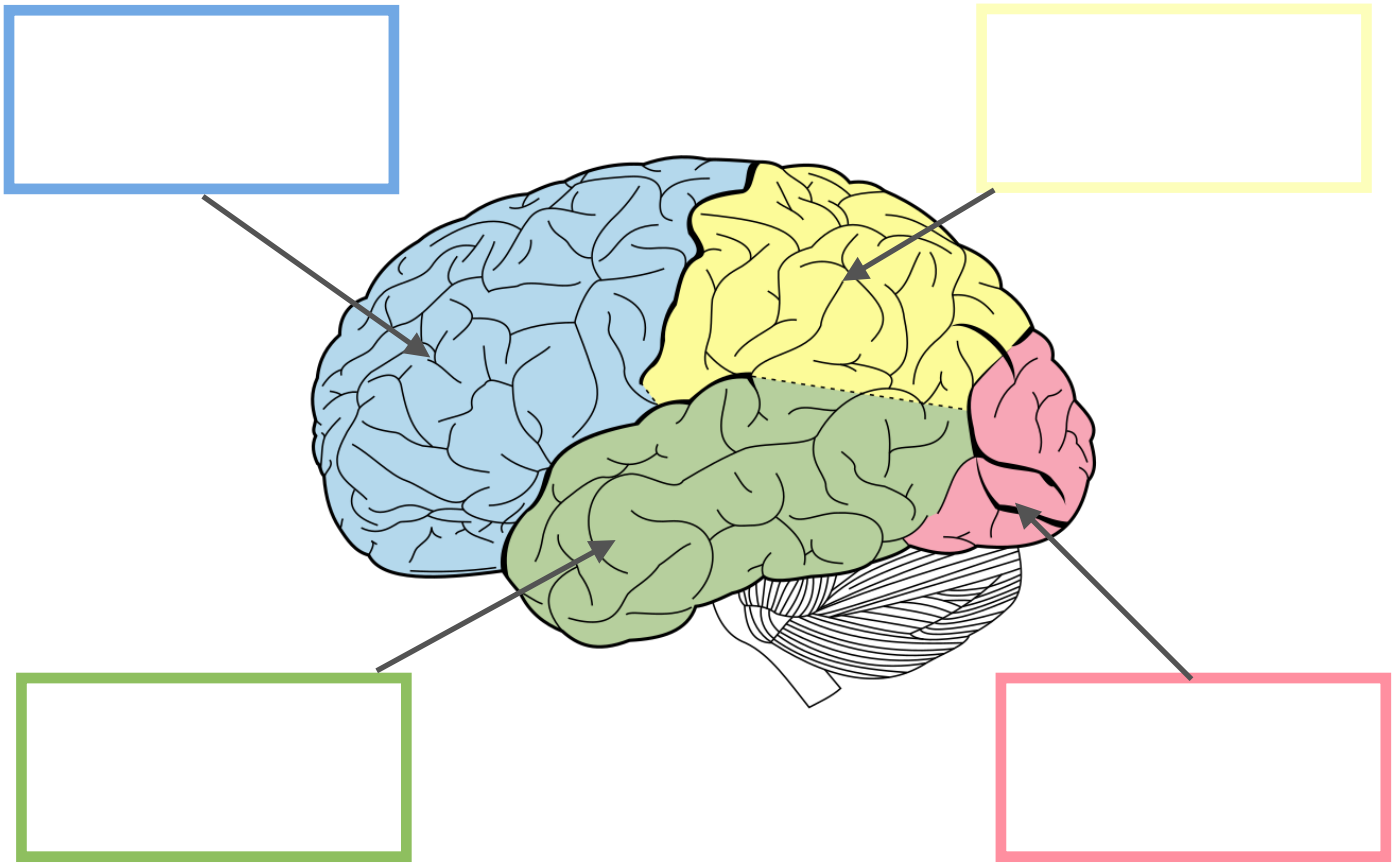
What is the Purpose of Tutorial 5?

- To go over the content from the tutorials on neurons, signalling, synapses, LTP/LTD and memory disorders
- To go through skills required for the final assignment in the context of neurodegenerative diseases
- To start planning the final assignment

Tutorial 5 – Revision Tutorial

Neuroanatomy

Label the 4 lobes of the brain with a brief description of their functions



Name the region the main cell type in the brain and state how this has been adapted for function

Tutorial 5 – Revision Tutorial

Neuron Signalling

State the ion's present in and around the neuron. How do these ions cause action potentials?

Describe what processes occur at the synapse when a signal reaches the presynaptic terminal? How does synaptic transmission give control over neuron signalling?

Tutorial 5 - Revision Tutorial

Memory: LTP & LTD

Name the different receptors at the post-synaptic membrane and their neurotransmitters. How do these receptors influence signal transmission?

Describe the physical alterations to the synapses that occur during LTP and LTD and explain how these alter synaptic strength. State 3 experimental techniques uses to measure memory and how these work.

Tutorial 5 – Revision Tutorial

Memory Loss

Describe the mechanisms that might contribute to neurodegeneration in Alzheimer's Disease

Is retrograde amnesia a problem with recall or retention? Explain your reasons.

During a blackout, what happens to the CA1 pyramidal cells in the hippocampus? How does this disrupt memory formation?

Tutorial 5 - Revision Tutorial

Final Assessment: Skills To Include

1. Knowledge and Understanding

This section of the mark scheme allows you to show off your scientific knowledge on neurodegeneration. Think vocabulary from your glossary and accurate facts. An example of a sentence which would get you top marks in this section would be:

The two key neurological pathologies found in the brain of a patient with Alzheimer's disease are extracellular amyloid plaques and intracellular tau tangles.

Think of a great sentence here: _____

_____

_____

_____

2. Research and Evidence

The research section is for showing the reader you have done extra reading on your subject area. You can then use this research as evidence to support your points. For example:

Activating the neurons which stimulate hippocampal neurons can reverse the effects of amnesia in fear-conditioning experiments (Ryan et al, 2015)

Where are you going to look for evidence? _____

_____

_____

_____

3. Developing an Argument

Potentially one of the most important aspect of being a scientist is to consider all the arguments for and against your decision. You should aim to have an opinion throughout your essay but balance with the arguments against that decision too. Make sure to conclude with you opinion.

Example

For choosing to take memory enhancing drugs: They could prevent loss of important synaptic connections

Against: LTD may become impaired

Think of an example for and against argument here:

For: _____

_____

Against: _____

_____

Tutorial 5 - Revision Tutorial

Final Assessment: Skills To Include

4. Critical Evaluation

It is important you follow up your argument with an assessment of your point. Why is your point important? How does it contribute towards your argument. Following from the example on the previous page:

For: If synapses are pharmacologically strengthening, they may retain their strength following injury or stroke

Against: Synapses need to be plastic so new memories can be made, therefore enhancing memory may interfere with this process

How would you evaluate your for and against argument?

For: _____

_____

Against: _____

_____

As mentioned in Research and Evidence, it is also important to use extra reading to back up your argument. You should also considered the **limitations to your evidence** by critiquing it. Is the source bias? Who wrote the article? Is the data strong?

5. Structure and Presentation

The structure and presentation of your essay holds weight. Write in paragraphs, use subheadings and provide diagrams if you think they will add to your work.

Referencing is hugely important in science so you can give the authors of the work you are talking about **full credit** for their work. This should be done **in text (Author, year)** and also in the **bibliography (First 5 authors, year, title, journal, page number).**

Example

It has been shown tau pathology correlates more with cognitive decline in Alzheimer's disease (Gianakopoulus et al, 2003)

Bibliography: Giannakopoulos P, Herrmann F, Bussière T, Bouras C, Kövari E, Perl D, Morrison J, Gold G, Hof P (2003). Tangle and neuron numbers, but not amyloid load, predict cognitive status in Alzheimer's disease. Neurology. 60:1495–1500

6. Language and Style

Throughout your essay, make sure you are writing in full sentences, using extensive vocabulary and correct punctuation. Always **proofread** your work before submission and try reading it out loud to see if additional punctuation is needed.

Spelling and grammar should also be checked properly before submission. Do not just rely on spell check!

Tutorial 5 – Revision Tutorial

Final Assignment: Planning Sheet

Assignment Title: _____

_____

Opinion: _____

Drug mechanism of action: _____

_____

_____

Experiment to test this drug

_____

_____

Arguments for and against taking memory enhancing drugs

For	Against

List of sources

Why do you still think your opinion is strongest: _____

_____

_____

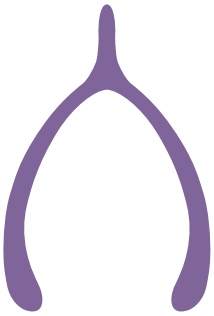
Plenary

Summing Up the Course

You are at a party with some friends and they ask you about what you have learnt during your Brilliant Club tutorials. Write the main points you would tell them.

You can include what you have learnt and what you found difficult. Also describe what skills you have improved on over the past 5 tutorials.

Finally, write down 2 Stars and a Wish for this course.



Final Assignment

Research essay: 2500 words

Would you recommend taking a memory enhancing drug?

A brand new memory enhancing drug has come on the market and many news outlets have jumped onto its discovery saying it can cure Alzheimer's disease, amnesia and improve cognitive performance.

Write an opinion article for Nature Magazine about whether you think a single drug could realistically perform all the above functions from a neuroscience perspective. State the pros and cons of memory enhancement and conclude with your recommendation on taking memory enhancing drugs.

In your essay, please include:

- An introduction to neuroscience and memory problems
- The neuroscience of memory formation
- How this drug might work on a neuron
- Experimental means of testing memory using this drug
- A balanced argument for and against using this drug to enhance memory in Alzheimer's disease, amnesia and cognitive performance.
- A conclusion summarising your recommendation, why you think this and the future directions of memory enhancement

Your article should be structured using appropriate subheadings, including introduction and conclusion.

Include diagrams when they will help explain your point. These must be labeled or commented on in the text

Your opinion is the most important part of this assignment.Think of your point of view before you write the essay and keep this in mind throughout!

Extra reading and research is encouraged. Search for information about the neuroscience of memory on the internet and look out for news articles and scientific websites. Make sure to comment on the reliability of these sources and reference them as stated below.

Referencing style: Harvard (Author name, YEAR) or using a numbering system[1]

Tips for researching

- Back up your points with scientific evidence and reference as this tells the reader which scientific source you have got your statement from
- Use your handbook as guidance for topics to discuss in your assignment
- Use scientific papers, reviews, articles and websites to gain extra knowledge on the topic
- Make sure the reference you are using is relevant: if you do not understand what the scientific paper is saying, don't use it!

Essay writing reflection

Use the checklist below to reflect on your essay writing ability at the moment. Read the statements for each skill and then tick the box that most closely fits how you currently feel about your ability to do that skill.
You will use this to help your PhD tutor give you feedback in your next tutorial. They will give you specific advice on how to improve these areas in relation to your draft assignment so be completely honest.

Addressing the question

I can...

- identify what the title or question is asking me to do
- select relevant information from the course to answer the title or question
- explain why the information I have used is relevant

I feel...

Confident	Partially confident	Not confident
☐	☐	☐

Using evidence

I can...

- select evidence that supports my points
- link evidence to my points and ideas
- clearly and convincingly explain how my evidence supports my points
- use references

I feel...

Confident	Partially confident	Not confident
☐	☐	☐

Developing an argument

I can...

- include a point of view or position in response to the title or question
- develop and explain my point of view
- argue why my point of view or position is correct

I feel...

Confident	Partially confident	Not confident
☐	☐	☐

Critical evaluation

I can...

- ensure I analyse events and information rather than just describe them
- assess the relevance and significance of the ideas and examples I am writing about

I feel...

Confident	Partially confident	Not confident
☐	☐	☐

Structuring

I can...

- arrange my points in to a logical order
- write paragraphs that focus on one idea or point each
- write an introduction that explains how I will deal with the issues of the essay
- write a conclusion that sums up my main points

I feel...

Confident	Partially confident	Not confident
☐	☐	☐

Use of language

I can...

- minimise spelling, punctuation and grammar errors
- ensure my writing makes the meaning clear and easy to follow
- write using and appropriate tone and level of formality

I feel...

Confident	Partially confident	Not confident
☐	☐	☐

Tutorial 6 – Draft assignment feedback and reflection

What is the Purpose of Tutorial 6?

- To received feedback on your draft assignment
- To reflect on your essay writing skills
- To identify practical ways to improve your assignment

What three things can you now do to improve your assignment and your essay writing ability?

1

2

3

Tutorial 7 – Final assignment feedback and reflection

What is the Purpose of Tutorial 7?

- To receive feedback on final assignments.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well...	What I could have improved on...
•	•
•	•
•	•

My target for future work is...

Reflecting on The Scholars Programme

What did you most enjoy about The Scholars Programme?
•
•
•

What did you find challenging about the programme?	How did you overcome these challenges?
•	•
•	•
•	•

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

- **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number
    - e.g. [2].
- **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.
- **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].
    - e.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].
- **Books** – Author, date published, title of book (in italics), pages where the information came from.
    - e.g. S. Dubner and S. Levitt, (2006) Freakonomics, 7-9.
- **Articles** – Author, 'title of the article' (with quotation marks), where the article comes from (newspaper, journal etc.), date of the article.
    - e.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Appendix 2 – Using the VLE

VLE username	
VLE password	

Please remember the following key details...

- You are able log into the VLE either through the link on our website (**www.thebrilliantclub.org**) or going directly to the VLE site at (https://portal.thebrilliantclub.org/sign-in).
- Please update your profile with your full name and email address- this will allow you to retrieve forgotten passwords or usernames
- If you forget your log-in details you can request them to be emailed to you by clicking the link on the VLE home page. (If you are still having problems you can email: **schools@thebrilliantclub.org**)

What is the VLE?

The VLE is a virtual learning environment for all pupils on the Scholars Programme it is used for:

- messaging your tutor
- submitting homework
- submitting your final assignment
- accessing resources for your tutorials
- finding out more information about university and careers

How should I use the VLE?

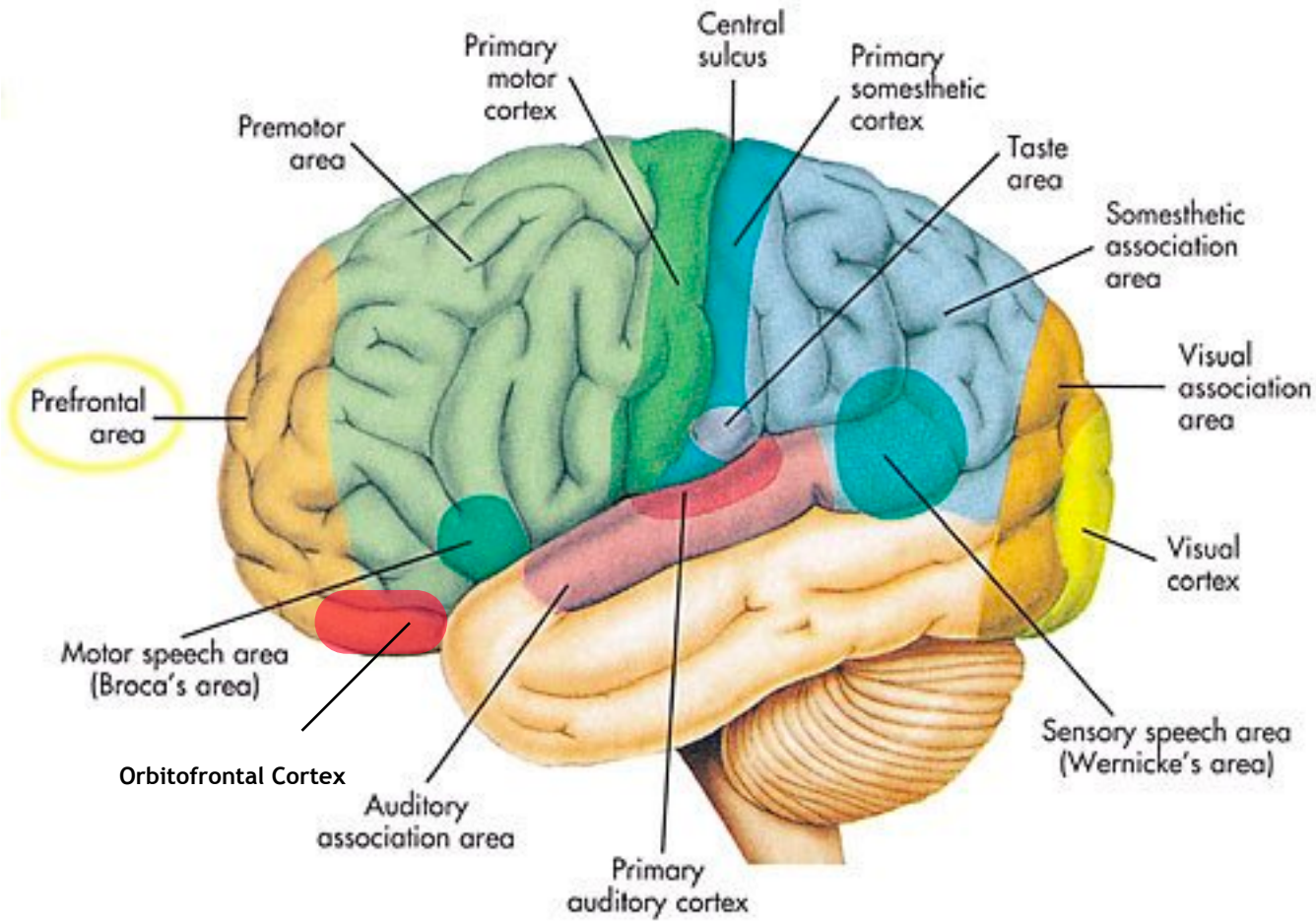
The VLE is a professional academic environment in which pupils are able to message their PhD Tutor. Here are a few things to consider:

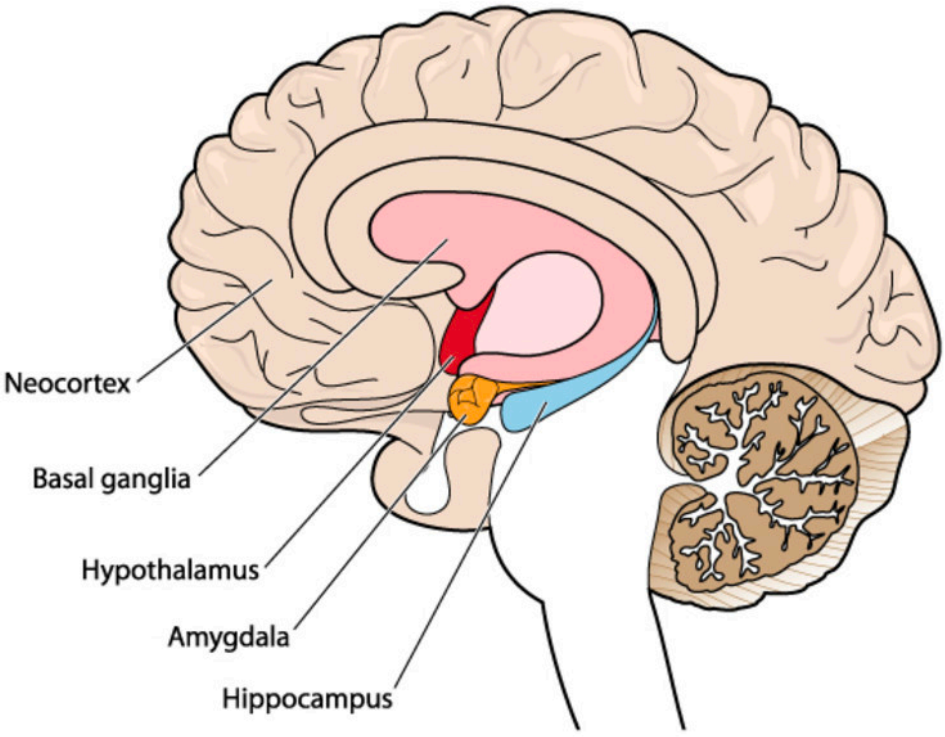
- Ensure you keep a professional tone in the messages you send to your tutors.
- Ensure you always reply to your tutors in a timely manner.
- Thank your tutor for the effort they are putting in to give you your feedback etc.
- Submit all homework to your tutor on time.

IMPORTANT: Final assignment

- When you submit your final assignment, please remember that you need to do so through the **'My Activities'** tab and not as an attachment to a message.

Appendix 3 – Maps of the Brain





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