Researchers in Schools

Why are you smarter than a worm?

Pupil Name

Coursebook Designed by **Dr. Cassels**

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1	Monday 9th December	12pm	Launch Event
2	Thursday 9th January	3-4pm	The Street
3	Thursday 16th January	3-4pm	The Street
4	Thursday 23rd January	3-4pm	The Street
5	Thursday 30th January	3-4pm	The Street
6 (Feedback)	Thursday 27th February	3-4pm	The Street
7 (Feedback)	Thursday 12th March	3-4pm	The Street

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	**Essay:** Explain the human nervous system to aliens….	3pm on Friday 13th December
Tutorial 2	**Questions:** Can I trust this information?	3pm Monday 13th Jan
Tutorial 3	**Questions:** Can a computer think like me?	3pm Monday 20th Jan
Tutorial 4	**Task:** Should we use animals in research?	3pm Monday 27th Jan
Tutorial 5	**Essay:** Save the humans! Convince aliens that the human nervous system can be studied using other models.	Draft Due: Thursday 13th February Final: Thursday 5th March

Assignment Submission – Lateness and Plagiarism

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

Contents

Course Rationale **P4**

Mark Scheme **P5**

Glossary of Keywords **P9**

Tutorial 1 – Neuro 101 **P10**

Baseline Assignment **P14**

Tutorial 2 – Error 404: brain not found **P15**

Homework: Can I trust this? **P19**

Tutorial 3 – A brain walked into a scanner... **P21**

Homework: Computer brains **P23**

Tutorial 4 – Are you smarter than a worm? **P26**

Homework: Animal research **P30**

Tutorial 5 – Growing brains in a dish **P32**

Final Assignment **P35**

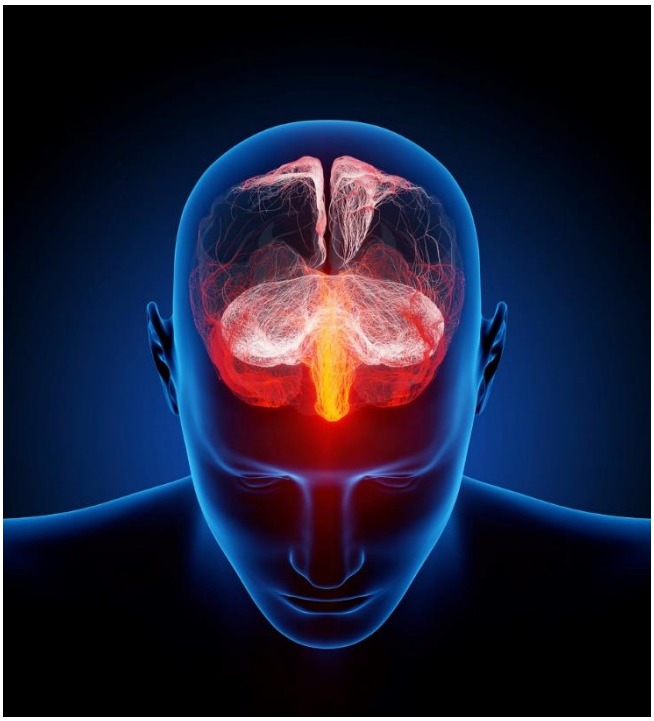
Tutorial 6 – Feedback Tutorial **P37**

Tutorial 7 – Final Tutorial **P39**

Appendices **P41**

1. Referencing correctly **P41**
2. Article 1: Alzheimer's Disease **P43**
3. Article 2: ASD **P45**
4. Article 3: Spinal cord injury **P47**
5. The worm **P49**
6. The fly **P50**
7. The mouse **P51**

Course Rationale



The human brain is made up of one hundred billion (100,000,000,000) cells! To put this in perspective, there are the same number of cells in your brain as the number of stars in the milky way galaxy. All of these cells form connections, like a network of wires, to be able to send signals to control everything in your body, from how you move and speak, to what you think and feel. The brain also controls things that we might not even be aware that it's doing; like breathing or sleeping. Even more incredible is the speed at which the brain functions. It may not always feel like it, but it works very quickly. If you want to move your arm, it only takes milliseconds to reach and grab for the xbox controller next to you once you've had the thought that you want to play a game.

The brain coordinates your body by signalling via the spinal cord and nerves across the body, which all forms the nervous system. However injury and diseases can lead to the nervous system not working properly, which can massively affect someone's life. For example, physical injury to the brain can result in concussions or amnesia, or a dysregulation of chemicals in the brain can result in depression or anxiety. Age-related diseases can kill brain cells in specific brain areas, which results in changes to personality (like in Alzheimer's disease), or loss of ability to move (Parkinson's disease).

To better understand disorders of the brain, or find new treatments, scientists need to be able to study the human brain. Studying donated brains from people who have passed on can only tell us what happens at the end of the disease, not during, and doesn't let us test new drugs because the brain is already dead. So how can scientists study the brain without sacrificing humans?

Through this course you'll find out more about the brain, nervous system, and neuroscience research through a series of university-style tutorials. The final assignment will be similar to essays you could be set at university. You will learn how to conduct literature research, how to work out if you can trust a source, and how to write and reference a scientific essay. Developing these skills before your GCSEs will be a huge achievement, and be really useful for your future exams/coursework. To recognise your hard work, talent and commitment, we will have a celebration event at the end and you will receive an official certificate from the Brilliant Club.

The overall aims of the course are:

- To understand the human nervous system and its role in the body
- To learn what causes the nervous system to stop functioning properly
- To learn how neuroscience research happens using different models

Key actions:

Read Discuss Homework Watch Think Game

Uni Pathways Mark Scheme 2019 – Essay-based assignments

	Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)	3rd (40-49)	Mark /100
Subject knowledge	Knowledge and understanding	o All content included and materials used are relevant to the general topic and to the specific question/title o Good understanding of all the relevant topics. o Technical terms are defined and used accurately throughout o Clear justification of how the material and content included is related to the specific issues that are the focus of the assignment	o Most of the materials used and content included are relevant to the general topic and to the specific question/title o Good understanding of most the relevant topics o Technical terms are mostly defined and used accurately o Adequate justification of how the material used and content included are related to the specific issues that are the focus of the essay	o Some of the materials used and content included are relevant to the general topic and to the specific question/title o Good understanding on some of the relevant topics but occasional confusion on others o Technical terms are sometimes used and defined accurately o Some justification of how the material used and content included are related to the specific issues that are the focus of the essay	o The content included and materials used are not applied to the question/title in a relevant manner o There is confusion in how understanding of the topics is expressed	
Critical thinking	Research and evidence	o Includes rich sources of research findings, data, quotations or other sourced material as evidence for the claims/ideas o Uses evidence/calculations to support claims/assertions/ideas, consistently clearly and convincingly o Evidence of further reading beyond materials provided which were used in an appropriate context	o Includes adequate sources of research findings, data, quotations or other sourced material as evidence for the claims/ideas o Uses evidence/calculations to support claims/assertions/ideas, mostly clearly and convincingly o Evidence of further reading beyond materials provided	o Includes some sources of research findings, data, quotations or other sourced material as evidence for the claims/ ideas o Uses evidence/calculations to support claims/assertions/ideas, at times clearly and convincingly o Limited evidence of further reading beyond materials provided	o Inclusion sources and materials is very limited and mostly not attributed o Applicable sources are rarely used to support ideas. o Data is not used or few appropriate conclusions are drawn from it.	
	Developing an argument	o A point of view or position in relation to the title or question is consistently clear. The position is developed effectively and consistently throughout the essay o Argument is exceptionally well-developed and well-justified o Makes links effectively between subjects that have not previously been associated o Uses concepts from the tutorials in an unfamiliar context and does so accurately and confidently. o Content is analysed effectively to support the argument	o A point of view or position in relation to the title or question is adequately clear. The position is well-developed in most of the essay o Argument is clear and well-developed, and position is justified o Some evidence of linking subjects that have not previously been associated o Uses some concepts from the tutorials in an unfamiliar context, but not always accurately o Analyses content to support the argument	o A point of view or position in relation to the title or question is somewhat clear. The position is well-developed in parts of the essay o Argument is clear but not well-developed o Limited evidence of linking subjects that have not previously been associated o Limited use of concepts from the tutorials in other contexts o Uses some analysis of content to support the argument	o There is not a clear point of view or position taken and sometimes the argument is not clearly established	

	Critical evaluation	○ Moves beyond description to an assessment of the value or significance of what is described ○ Evaluative points are consistently explicit/systematic/reasoned/justified ○ Effectively critiques 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	○ Describes with minimal assessment of the value or significance of what is described ○ Evaluative points are at times explicit/systematic/reasoned/justified ○ Limited evidence of critiques on the reliability of sources provided	○ The work is descriptive in nature and there is a lack of critical engagement in the value of sources	
Written communication	Structure and presentation	○ Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment ○ The introduction clearly outlines how the essay/report 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 adequately describes how the essay/report will deal with the issues ○ The conclusion summarises most of the main points clearly ○ Most sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure ○ The introduction mentions how the essay/report will deal with the issues ○ The conclusion summarises some of the main points clearly ○ Some sources are referenced correctly in the agreed format with occasional errors	○ Ideas are presented in paragraphs but there is a lack of structure in how the work is presented ○ The work lacks an introduction that establishes the scope of the question ○ The work lacks a conclusion that summarise the main points raised ○ Work is not referenced accurately	
	Language and style	○ No spelling, grammar or punctuation errors ○ Writing style consistently clear, tone appropriate and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ Minimal spelling, grammar or punctuation errors ○ Writing style mostly clear, tone appropriate and easy to follow ○ Some attempts of using technical language and vocab alary, but not always accurate	○ Some spelling, grammar or punctuation errors ○ Writing style moderately clear, tone appropriate and easy to follow ○ Use of simple language and vocabulary effectively but struggles to use technical language	○ There are a significant number of spelling, grammar and punctuation errors ○ Use of simple language and vocabulary effectively but a lack of technical language	
Overall Mark (average of the 6 marks from the criteria above)						

Baseline Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	Bristol Metropolitan Academy
Name of RIS teacher	Dr. Cassels
Title of Assignment	Explain the human nervous system to aliens…

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
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

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

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

Mark Breakdown and Feedback

Knowledge and Understanding		Research and Evidence	
	mark		*mark*
Developing an Argument		**Critical Evaluation**	
	mark		*mark*
Structure and Presentation		**Language and Style**	
	mark		*mark*

Final Assignment (essay based): Pupil Feedback Report

Name of Pupil	
Name of School	Bristol Metropolitan Academy
Name of RIS teacher	Dr. Cassels
Title of Assignment	Save the humans! Convince aliens that the human nervous system can be studied using other models.

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
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

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

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

Mark Breakdown and Feedback

Knowledge and Understanding		Research and Evidence	
	mark		*mark*
Developing an Argument		**Critical Evaluation**	
	mark		*mark*
Structure and Presentation		**Language and Style**	
	mark		*mark*

Subject Vocabulary

Word	Definition	In a sentence
Cell Culture	Method of growing cells in a dish under controlled conditions.	"I'm going to do some cell culture for my next experiment."
Central Nervous System	Part of the nervous system that is made up of the brain and spinal cord.	The central nervous system is the most important part of the body.
Differentiation	When an cell gains more specialised features.	Stem cells undergo differentiation to produce neurons.
Nerve	A bundle of neurons.	The longest nerve in the body runs from your spine down to you your knee.
Neuron	A nerve cell that is specialised to transfer electrical signals in the nervous system.	Neurons are the basic building block of the nervous system.
Organoid	A simplified version of an organ that can be grown in a lab.	3D brain organoids can be used to look at how the brain structure forms.
Peripheral Nervous System	Part of the nervous system that is made up of all of the nerves outside the brain and spinal cord.	The peripheral nervous system acts to relay information between the central nervous system and the body.
Pluripotent	An adjective to describe the characteristics of cells that can create lots of different cell types.	Stem cells are pluripotent, meaning that they can form all of the types of cell found in the human body.
Stem Cell	A cell that can make a wide range of other cells, is self-renewing and pluripotent.	Stem cells are now being used to replace cells lost in some diseases.

Tutorial 1 – Neuro 101

What is the Purpose of Tutorial 1?

By the end of this tutorial I will be able to…

- Define what the nervous system is
- Explain why the nervous system is important for humans
- Define what a neuron is

What does the brain do?

In two groups, make a mind map in your workbooks with ideas of what the brain controls. The team with the most correct answers at the end of the activity will win.

What does the nervous system look like?

Read the article on the next page and then complete the tasks in the workbook.

The Brain and Nervous System

Reviewed by: Larissa Hirsch, MD

What Does the Brain Do?

The brain controls what you think and feel, how you learn, and the way you move. But it also controls things you're less aware of — like the beating of your heart and the digestion of your food. It accepts a flood of information about the world around you from your various senses (like sight and touch). It even lets you think, dream, reason and experience emotions. All of these tasks are coordinated, controlled and regulated by an organ that is about the size of a small head of cauliflower.

Think of the brain as a central computer that controls all the body's functions. The rest of the nervous system is like a network that relays messages back and forth from the brain to different parts of the body. It does this via the spinal cord, which runs from the brain down through the back. It contains threadlike nerves that branch out to every organ and body part.

When a message comes into the brain, the brain tells the body how to react. For example, if you touch a hot stove, the nerves in your skin shoot a message of pain to your brain. The brain then sends a message back telling the muscles in your hand to pull away. Luckily, this relay happens in an instant.

What are the parts of the Nervous System?

The nervous system is made up of the central nervous system (CNS) and the peripheral nervous system (PNS) (Figure 1). The brain and the spinal cord form the CNS. The spinal cord is a long bundle of nerves about 50 cm long and 1.5 cm thick. It acts as the main "information motorway" between the brain and body. Along the way nerves branch out to the entire body. The CNS is the information-processing and control centre of the nervous system, and as it is so important, it is protected by the skull and vertebrae. The nerves that go through the rest of body make up the PNS. These are the nerves that relay information between the brain and body through the spinal cord.

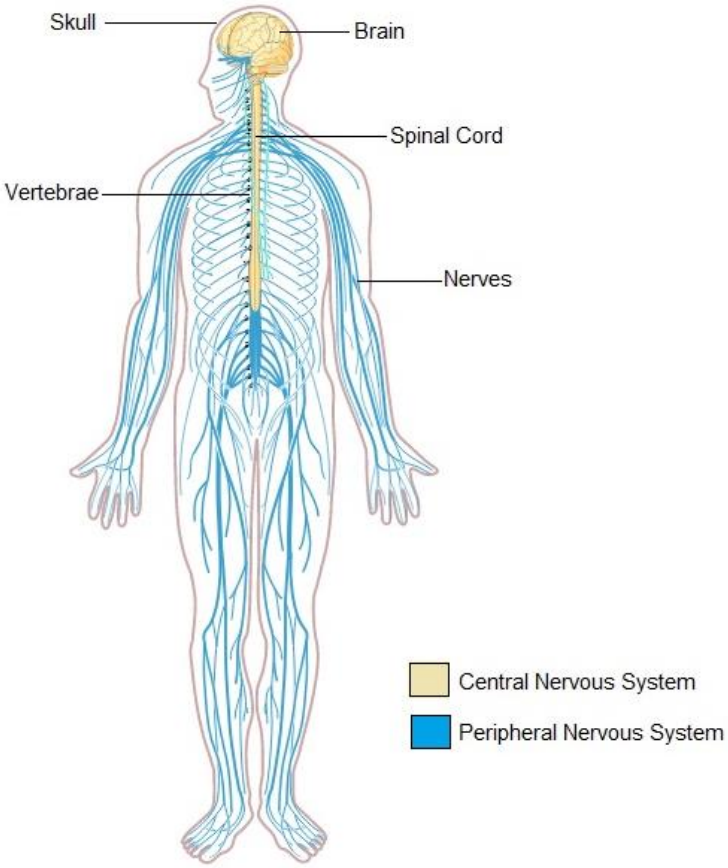


Figure 1. The human nervous system

How do nerves work?

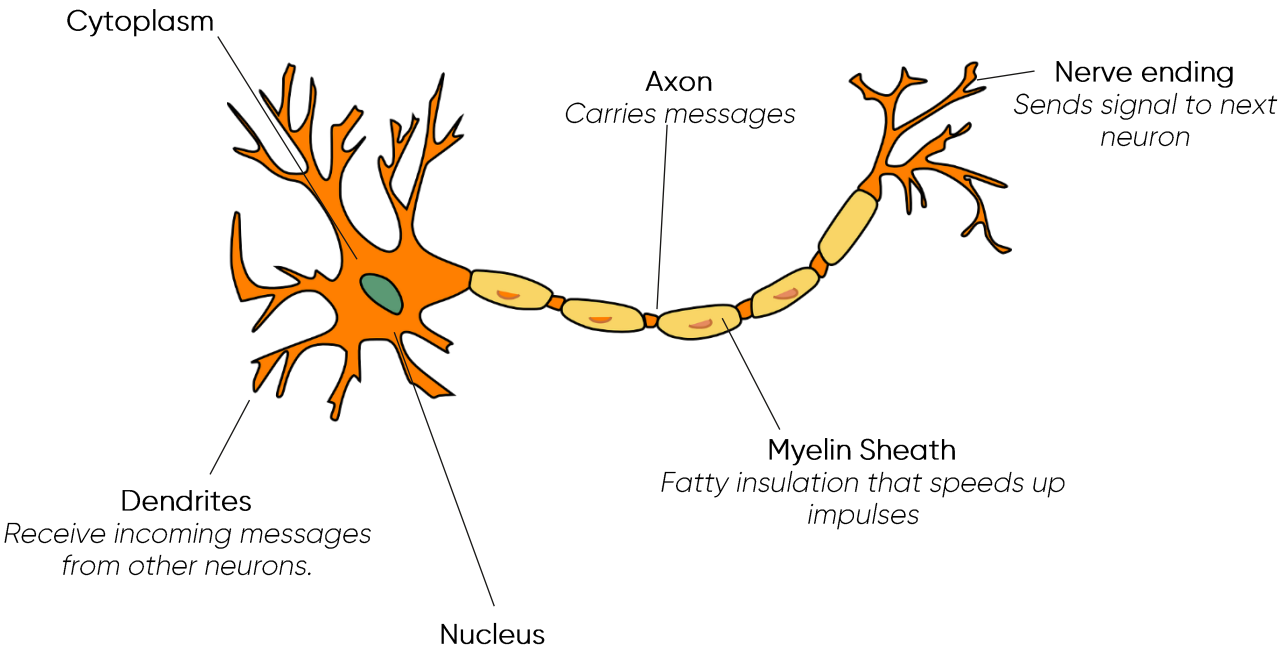
Nerves are bundles of specialised cells called neurons. Neurons share the same characteristics as other animal cells, but they also have the amazing ability to transmit information (think of wires in a computer). *We will learn more about neurons in the next activity.*

After reading the article above, match the words to their definitions in the workbook. You can work in pairs.

Spinal Cord	This is the bone that surrounds and protects the brain.
Nerves	This is the part of the nervous system that is made up of all of the nerves outside of the brain and spinal cord.
Skull	This is the name of the long nerve bundle that connects the brain and body.
Vertebrae	This is the part of the nervous system that is made up of the brain and spinal cord.
Neuron	This is the name for a bundle of neurons.
Peripheral Nervous System (PNS)	This is the organ that acts as the control centre of the body.
Central Nervous System (CNS)	This is a type of specialised cell that is able to transmit electrical signals.
Brain	This is the network of nerves that transmits information across the entire body.
Nervous System	This is the backbone that the spinal cord is protected by.

Can you make a neuron from sweets?

Look at the diagram of a neuron below. Can you make something that resembles all of its parts using the sweets provided? Use the paper provided as a clean work surface (the neuron can be eaten after) and label the main structures.



Homework: Baseline Assignment. Explain the nervous system to an alien.

You have just started working as an intern at the National Space Centre and decide to stay late at work. No one else is around. You hear a loud bang outside the door, and a group of aliens walk through the door. They have landed on Earth and want to learn more about humans. They are interested in our nervous system, and want to know how it works. They want it in writing, as they don't have ears, and in only 500 words because they're busy. You've managed to explain that you are new, and negotiated to have one week before you have to submit.

The aliens have asked you to include:

- What the nervous system is and what it does.
- What it looks like in humans.
- How the nervous system works.

Success criteria:

- Refer to mark scheme on page 5.

Knowledge and understanding

- Include key words from the glossary.
- Reference sources following guidelines in Appendix 1.
- Describe how neurons work to send signals from the brain to body.
- Describe the peripheral and central nervous system.

Research and evidence

- Include findings from a range of sources. (Minimum of three sources).

Structure and presentation

- Organise your ideas in a logical structure (TOP TIP – think about how you will lay out your essay before starting).
- Include a clear introduction that outlines the function of the nervous system.
- Include a conclusion that summarises your main points.
- Keep to the word limit.

Language and style

- Use correct spelling, grammar and punctuation.
- Use a formal writing style.

Tutorial 2 – Error 404: brain not found

What is the Purpose of Tutorial 2?

By the end of this tutorial I will be able to…

- Explain why it is important to study the nervous system
- Give two examples of what causes disorders of the nervous system
- Describe three different nervous system disorders and their symptoms

Why is neuroscience research important?

In pairs, write down why you think it's important to study the nervous system in the space below. We will then discuss the answers as a group.

_____

_____

_____

_____

Neurological and Psychiatric Disorders

Watch the video (link below) and answer the questions in your workbook.

https://www.brainfacts.org/core-concepts/how-research-benefits-human-health

1. How many people are affected by neurological and psychiatric conditions worldwide?

2. How much do the US spend on neurological and psychiatric conditions each year?

3. What do neuroscientists study?

4. After watching the video, why do you think is it important to study the nervous system?

What causes neurological/psychiatric disorders?

Sort the causes below into headings depending on whether you think they can be classified as genetic or environmental causes.

Example causes:

Bacterial infection causing structural changes to the brain

Family history of the disease

A fall that injures the spine

Drug/alcohol abuse

Cells growing too quickly (like in cancer)

Lack of oxygen during birth

Mutation in a gene that causes a build up of protein in the brain

Tripping and bumping your head

Aging

Genetic	Environmental

What are some disorders of the nervous system?

Working in pairs, read the assigned article (found in the appendix) and afterwards write your answers in the table below. You will later share your answers with the other groups to fill in the rest of the table.

Pair	Nervous system Disorder	Is it caused by the environment or genes?	What are the symptoms?	What treatments exist?
1	Alzheimer's Disease			
2	Autistic spectrum disorder			
3	Spinal cord injury			

What other nervous system disorders have you heard of?

Homework: Can I trust this information?

Find the most amazing statistic or fact about the nervous system and answer the following questions:

1. What is the statistic/fact? (2)

2. Where did you find the statistic? (State the source) (2)

3. Do you trust the source? Why? (3)

4. Can you find anywhere else that backs up this statistic/fact? Or do different sources say different things? (4)

5. What do you think you should look for in a source when you quote facts? (4)

_____

_____

_____

_____

_____

_____

Success criteria:

Developing an argument

- Provide clear justification and reasoning for your points.

Language and style

- Write in full sentences using a formal writing style.
- Use correct spelling, grammar and punctuation.

Tutorial 3 – A brain walked into a scanner…

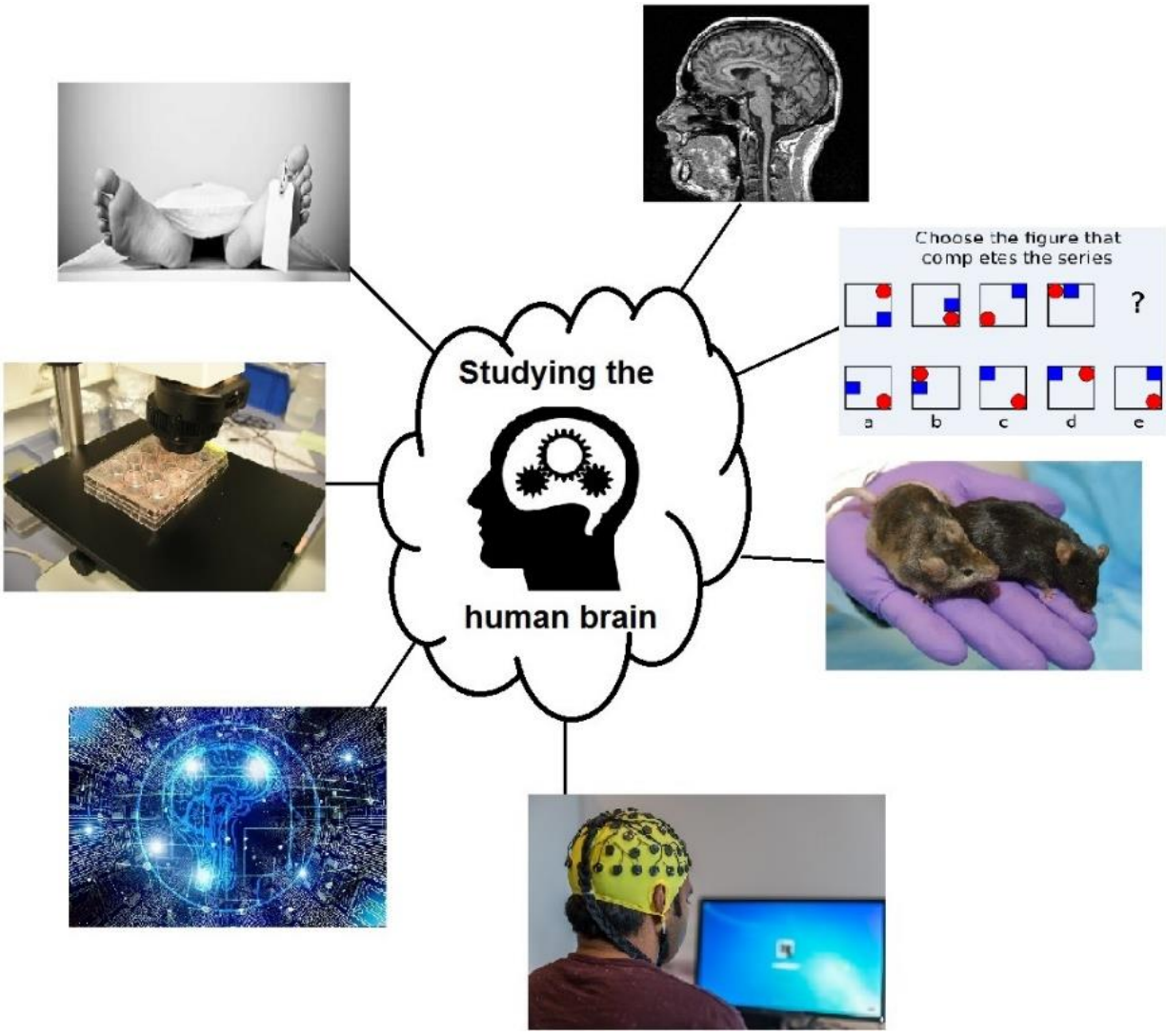
What is the Purpose of Tutorial 3?

By the end of this tutorial I will be able to…

- Define what a scientific model is
- List four different models to study the nervous system
- Describe three different methods of studying the nervous system in a living person

How would you model a human brain without cutting someone open?

How would you study the human brain without just cutting someone's head open. Brainstorm all the things you can think of in two groups using the pictures in your books below as prompts.



What can brain scans tell us that we couldn't get from directly looking at the brain?

Watch the brain in action video and discuss in pairs why you think using functional brain scans may be useful. Write your ideas in the space below.

_____

_____

_____

_____

How do brain scans work?

Watch the video (https://www.youtube.com/watch?v=B10pc0Kizsc).

Watch it once through without making notes. We will watch it a second time and then you can fill in the table below.

Technique	What is it?	What can it be used to look at?	Advantages	Disadvantages
Electro-encephalogram (EEG)				
Functional magnetic resonance imaging (fMRI)		.		
Positron emission tomography (PET)				

What am I?

Write down one of the words or techniques you have learned about in this tutorial onto a post-it note and stick it to your partners head without them seeing the word. They then will ask you questions to guess what the word is. Try to answer their questions without using the word itself. When they have it right, switch and now you try to guess what word they have put on your head.

Homework: Can a computer think like me?

Read the article below and answer the questions in your workbook.

Brain Models and Simulation

(taken from The Human Brain Project website)

Can you imagine a brain and its workings being replicated on a computer? That is what the Brain Simulation Platform (BSP) aims to do. The BSP is available to researchers worldwide, so that they can compare their experimental results with model predictions and conduct investigations that are not possible experimentally.

Simulation also aims to replicate work on animal models, such as the mouse. In addition, the computing environment used for simulation offers the possibility of studying disease processes electronically.

However, the challenge is a complex one, as the human brain contains 86 billion brain cells (known as neurons) each with an average of 7,000 connections to other neurons. Current computer power is insufficient to model a entire human brain at this level of interconnectedness.

A simpler approach has thus been adopted to produce results that are increasingly close approximations to experimental data. Simulation takes place at several separate organisational levels in the brain, ranging from the molecular though the subcellular up to the whole organ. The level of detail decreases as the level rises towards the whole organ.

At the microscopic level and below, the signalling between neurons is the focus. Neurons are electrically excitable cells that transmit messages to each other across the synapses. These messages are crucial to the normal functioning of the central nervous system.
The macroscopic level examines assemblies of neurons, and their roles within the brain.

Coordination is available by interacting with and supporting the community on both the life scientific and technological levels.

Besides the Brain Simulation Platform, the HBP is also conceiving models at the whole-brain level. In these models, the smallest unit is not a neuron but a population of neurons, which corresponds to the resolution of brain imaging. These whole-brain models are done for both mouse and human brain, and they can directly integrate data from the connectome. Such models can be used to predict and study pathologies, such as epilepsy or stroke (https://www.humanbrainproject.eu/en/medicine/).

Why simulate the brain?

In many areas of science and engineering, simulation has proven an invaluable tool for turning mathematical principles, theory and data into new insights.

HBP seeks to bring the bring vital software tools to neuroscience to:

- reduce the need for animal experiments
- study diseases in unprecedented *in-silico* experiments
- improve the validation of data and experiments with computational validation

1. What does in-silico mean? (1)

2. Name three benefits of using computer models to study the brain. (3)

3. Name the main challenge of building computer models to study the brain and describe why it is a challenge. (2)

4. How can neuroscientists study the brain at the microscopic level using computer models? (2)

5. How can neuroscientists study the brain at the macroscopic level using computer models? (2)

6. Were there any words you didn't understand when reading this article? Highlight them and write them below. See if you can find the definitions.

Success criteria:

Answering questions

- Read the question and text carefully.
- Think about your answer before you start writing.

Developing an argument

- Provide clear justification and reasoning for your points.

Language and style

- Write in full sentences using a formal writing style.
- Use correct spelling, grammar and punctuation.

Tutorial 4 – Are you smarter than a worm?

What is the Purpose of Tutorial 4?

By the end of this tutorial I will be able to…

- Describe how the nervous system of humans is more complicated than other animals
- Explain why animal models are useful
- List three different animal models

Are you smarter than a worm?

In pairs, sort the following behaviours or traits into the Venn diagram below to show what you think only you can do vs. the worm, and if you think any of these are shared.

I can communicate with my own species

I have more than 1200 neurons in my body

I have a brain

I can smell

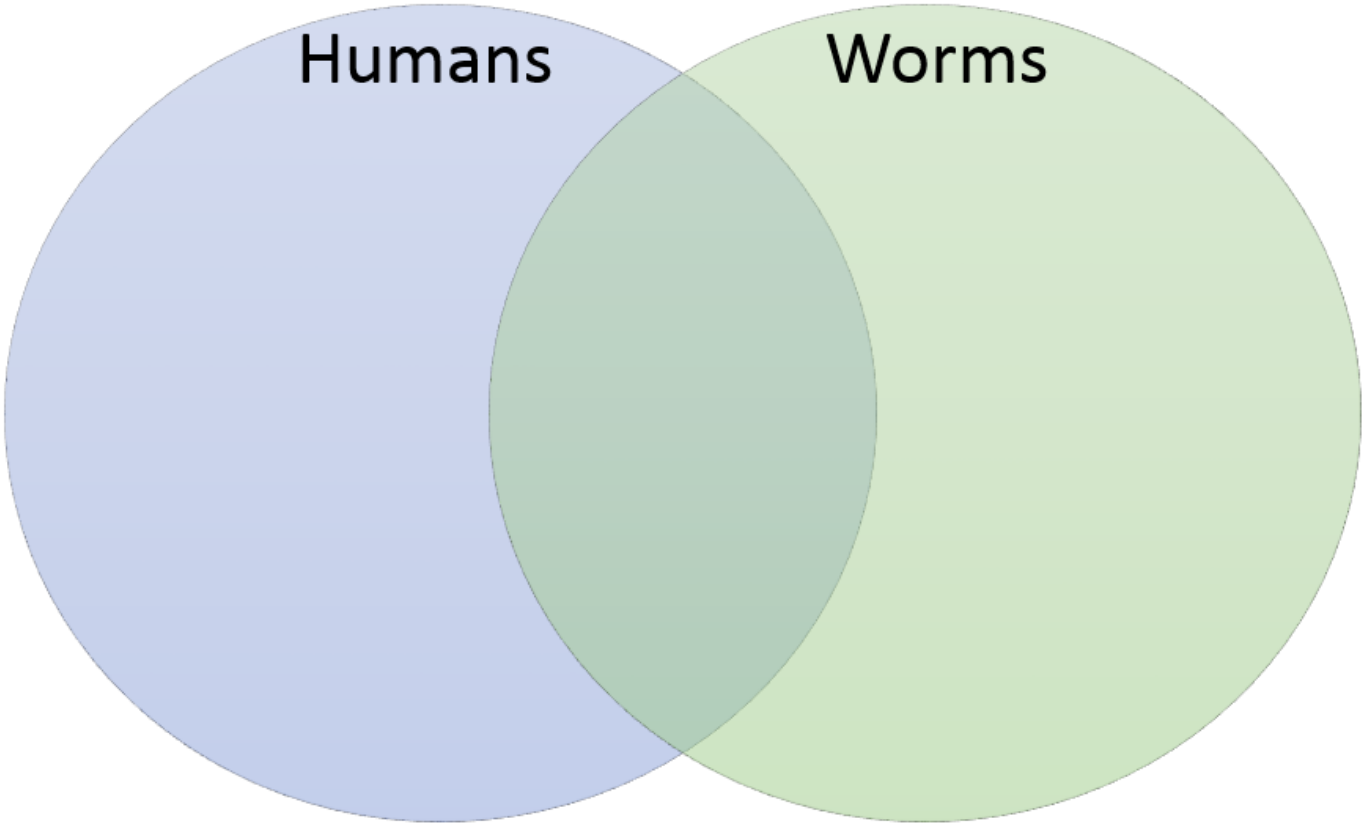
My species can have hermaphrodites

I can swim

I can move towards food

I can move away from danger

I can speak a language



How is your brain different to the brains of other animals?

Look at the pictures (1-3) of brains from different animals below. Underneath each picture, describe the characteristics of the brain.

Top tip: it may help to think about the size, smoothness, colour, shape etc.

1)

2)

3)

Scale: 3 cm

Brain 1 Features:

Brain 2 Features:

Brain 3 Features:

Match-up which brain you think belongs to which animal:

Brain 1	Human
Brain 2	Mouse
Brain 3	Monkey

How can animal models be useful in research?

In pairs, read one of the three stories in the appendix (Appendices 5-7 - you will be assigned to a story). Using the information you read, answer the following questions.

1. How similar is the human nervous system to this model?

2. What characteristics of this animal make it a good model and why?

3. When could this model <u>not</u> be useful for nervous system research?

Homework: Should animals be used in research?

Read the extract below:

"The ethics surrounding animal welfare are particularly tense. Many of us oppose wearing fur, the testing of cosmetics on animals, or are against poor conditions for animals raised for eating. But what about animal testing in the name of medicine?"

Read the statements on page 30 and either cut and glue, or copy them into the table below. If you have any additional arguments – feel free to write them in! Then write a summary on the next page.

Advantages	Disadvantages

Helps researchers to find new drugs and treatments.

Helps scientists to better understand the biology of diseases/health.

Animal-based research can ensure the safety of new drugs before they are tested in humans.

Other research methods (like brain scans) may not give the information needed.

Sometimes we can't test in humans. This can be when we are testing for toxicity as the lives of human volunteers shouldn't be put in unnecessary danger.

There are other methods to use for studying the brain, such as EEG.

Some things tested in animals may never actually be useful (waste of animal lives).

Humans and animals are not the same, so not all animal models can be used for the same question. Sometimes animal models can't be used for the question.

It is cruel to test on animals.

There is (currently) no other way to study the whole body.

Some drugs that pass animal tests and later used in humans aren't actually safe.

Treatments for animals also come from animal testing. This includes vaccines for rabies, or pacemakers.

Animals have shorter life spans, so scientists can study treatments in old age, or across life. Using humans in the same way would take thirty times longer – this would be very hard and expensive.

Research animals are cared for by vets, animal specialists and health technicians to make sure they are healthy. This is important not just to be humane, but because it makes sure the science is reliable.

Some people break the law in animal research, so regulation doesn't always work to protect animals.

Animal-based research is heavily regulated. The amount of harm (be it pain, distress or isolation) must legally be reduced to the lowest level possible.

Summary:

_____

_____

_____

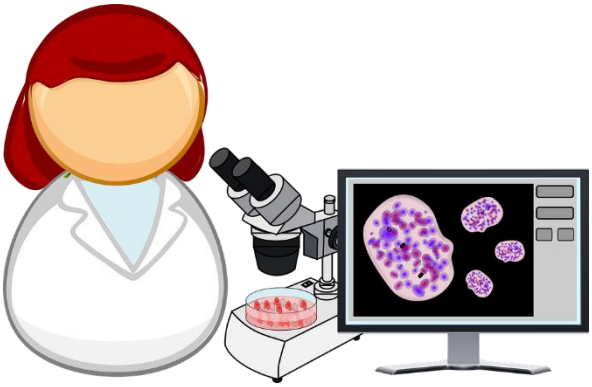
_____

Success Criteria:

Language and style

- Write in full sentences using a formal writing style.
- Use correct spelling, grammar and punctuation.

Tutorial 5 – Growing brains in a dish



What is the Purpose of Tutorial 5?

By the end of this tutorial I will be able to…

- Describe the two main characteristics of a stem cell
- Explain how stem cells can be used to grow neurons
- Understand what I need to do for the final assignment

Specialised cells

Working in pairs, name as many specialised cells as you can… We will share these as a class.

- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____

What are stem cells? – Craig A. Kohn

Watch the stem cell video (https://www.youtube.com/watch?v=evH0I7Coc54) beginning at 0.40 minutes in and fill in the sentences below using the words in bold:

Stem cells are cells that are _____; meaning that they do not have a specialised _____ or _____. However stem cells are _____; meaning that they have the _____ to become any type of cell in the body. Stem cells can be used for research to understand _____ or to replace damaged _____.

Undifferentiated **Structure** **Function** **Pluripotent**

Potential **Development** **Tissues**

How can scientists use stem cells to make a model of the brain?

Read the article below and answer the questions.

Modeling the Human Brain in 3D

JANUARY 25, 2018 / KAREN RING

(Image from Stanford University)

Can you guess what the tiny white balls are in this photo? I'll give you a hint, they represent the organ that you're using right now to answer my question.

You got it. These are brains that have been grown from stem cells to form what we call "3D brain organoids" in a dish. You can think of them as miniature models of the human brain, containing many of the brain's various cell types, structures, and regions.

Scientists are using brain organoids to study the development of the human nervous system and also to model neurological diseases and psychiatric disorders. These structures allow scientists to dissect the inner workings of the brain – something they can't do with living patients.

These technologies are rising in popularity amongst scientists because they make it possible to study human brain tissue in normal and abnormal conditions.

While these advances are exciting and promising, the field is still in its early stages and the 3D organoid models are far from perfect at representing the complex biology of the human brain.

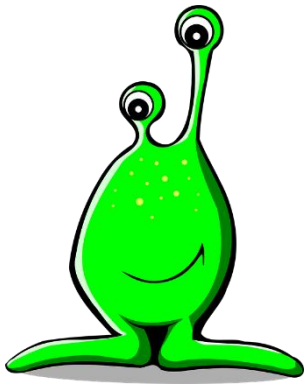
1. What is the main characteristic of stem cells that means they can be used to grow 3D bran organoids and why?

2. What factors do you think scientists need to consider when growing stem cells in a dish to turn into neurons? (Hint: environment and genetics).

Keyword Bingo

Pick three of the words about stem cells from the board and write them in your book. Your teacher will call out the definition of the words, one by one. If the definition matches your word, cross it off. When you have crossed off all three words – shout BINGO!

Final Assignment



You are a research scientist at the National Space Centre. An urgent message has landed on your desk from the Prime Minister.

Subject: SAVE THE HUMANS!

Help! Aliens have landed on Earth (again!) and want to learn more about the human nervous system. They have decided the only way is to cut humans heads open. As the subject expert, we need you to convince them not to! They have asked you to write a report that they will use to make their decision at the next alien council meeting in two weeks time.

They have asked you to make sure the report covers the advantages and disadvantages of studying nervous system disorders in models that don't require cutting open the head.

You are our only hope!

John Borison

Instructions:

Write between 1500-2000 words. Include in your essay:

- Why it is important to study the nervous system.
- Introduce one nervous system disorder you are interested in. Explain its impact on people.
- The advantages and disadvantages of the different types of model used to study this disorder: animals, humans, computers and cells in a dish.
- Which model do <u>you</u> think is best to use for this disease and why?

Success Criteria:

- Refer to mark scheme on page 5.

Knowledge and understanding

- Include key words from the glossary and demonstrate that you understand them by explaining what they mean.
- Check you have referenced all subparts of the question.
- Show understanding of different ways to study nervous system disorders and their limitations.

Research and evidence

- Include findings from a wide range of sources. As well as using the sources provided, find additional sources.
- Reference sources correctly (See Appendix 1 for more information).
- Thinking of what we covered in the homework for tutorial 2 – do you trust the evidence you are referencing?

Developing an argument

- Give reasons and back up the points that you make using relevant research.

Critical evaluation

- Provide clear justification and reasoning for your points.

Structure and presentation

- Organise your ideas into paragraphs with a logical structure (TOP TIP: Plan before you start writing).
- Include a clear introduction that outlines why you are writing about this topic.
- Include a conclusion that summarises your main points.

Language and style

- Use correct spelling, grammar and punctuation.
- Use a formal writing style.

Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on your final assignment
- To respond to the feedback from your Uni Pathways teacher
- To write targets for improvement on your final assignment

Final assignment feedback from your Uni Pathways Teacher

(Remember to look at the mark scheme to help you understand what you have done well so far, and how you can do even better in your final assignment)

Here are three things that my Uni Pathways Teacher thought I did well in my draft assignment
•   •   •

Here are three things that my Uni Pathways Teacher thinks that I could do to get a higher mark in my final assignment
•   •   •

Tasks from my Uni Pathways Teacher to do during the feedback tutorial to help me improve
•   •   •
My response:

Actions I will take to improve my final assignment after this tutorial…
•   •   •

Hand in date for my final assignment:	

Tutorial 7 – Final tutorial

What is the Purpose of Tutorial 7?

- To receive feedback and a grade on your final assignment.
- To reflect on the programme including what you enjoyed and what was challenging.
- To ask any questions you may have about university.

Final assignment feedback from my Uni Pathways Teacher

Final mark:	University style grade:
Feedback: Here are three things that my Uni Pathways teacher thought I did well in my final assignment • • •	

Here are three things that my Uni Pathways teacher thinks I should remember for when I am doing this kind of study in the future
• • •

University

What questions do you still have about University after taking part in Uni Pathways?
•   •   •

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

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:

1. **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].
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.

    a. **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].

    b. **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.

    c. **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

Article 1 – Alzheimer's Disease

What is Alzheimer's disease?

Alzheimer's disease is a nervous system disorder where there is death of brain cells, leading to memory loss. At first, symptoms are mild, but they become more severe over time.

What are the symptoms of Alzheimer's disease?

To receive a diagnosis of Alzheimer's, the person must have experienced a decline in mental or behavioural performance compared with how they were previously. This decline must interfere with their ability to function in usual activities. The cognitive decline must be seen in at least two of the five symptom areas listed below:

1. Reduced ability to remember new information. Examples include asking repetitive questions, misplacing personal belongings, or getting lost.

2. Impairments to reasoning, and exercising judgment. Examples include not understanding danger, and poor decision-making ability.

3. Impaired visual and spatial abilities that are not caused by other problems (like eyesight). Examples include the inability to recognize faces or difficulty doing tasks like putting on clothes.

4. Impaired speaking, reading and writing. Examples include difficulty thinking of common words, hesitations, and writing errors.

5. Changes in personality and behaviour. Examples include out-of-character mood changes, loss of empathy, or socially unacceptable behaviour.

If symptoms begin or worsen over the course of hours or days, you should seek immediate medical attention, as this could indicate an acute illness.

What causes Alzheimer's Disease?

Alzheimer's is caused by brain cell death. There is progressive brain cell death that happens over time.

Researchers do not fully understand why these changes occur. Several different risk factors are believed to be involved. Unavoidable risk factors for developing the condition include aging, a family

history of Alzheimer's and carrying certain genes. Positive factors that may help to prevent Alzheimer's include regular exercise, healthy diet, maintaining a healthy weight, not smoking, and learning throughout life.

How is Alzheimer's Disease treated?

There is no known cure for Alzheimer's. The death of brain cells cannot be reversed. However, there are therapeutic interventions that can make it easier for people to live with the disease such as care, management of any conditions occurring alongside the Alzheimer's, and support groups.

No disease-modifying drugs are available for Alzheimer's disease, but some options may reduce the symptoms and help improve quality of life. Results of a mouse study, published in Nature, suggested in 2016 that It may one day be possible to restore memories for people with early Alzheimer's.

Appendix 3

Article 2 – Autism Spectrum Disorder

What is ASD?

Austism spectrum disorders (ASD) include a number of developmental conditions. These disorders have shared symptoms that include problems with communication and social interaction.

ASD is found in individuals around the world, regardless of race, culture, or economic background. The CDC estimated in 2014 nearly 1 in 59 children have been identified with ASD.

What are the symptoms of ASD?

ASD symptoms typically become obvious during early childhood, between 12 and 24 months of age. However in some cases symptoms may appear earlier or later.

Doctors divide symptoms of autism into two categories: 1) problems with communication and social interaction, and 2) restricted or repetitive patterns of behaviour.

Problems with communication and social interaction include:

- difficulties sharing emotions, sharing interests, or maintaining a back-and-forth conversation
- trouble maintaining eye contact or reading body language
- difficulties developing and maintaining relationships

Restricted or repetitive patterns of behaviour include:

- repetitive movements, motions, or speech patterns
- needing specific routines or behaviours
- an increase or decrease in sensitivity to sensory information from their surroundings, such as a negative reaction to a specific sound
- fixated interests or ideas

Individuals are assessed within each category and the severity of their symptoms is noted. In order to receive an ASD diagnosis, a person must display all three symptoms in the first category and at least two symptoms in the second category. Sometimes ASD can be found with or without accompanying intellectual or language impairments.

What causes ASD?

The exact cause of ASD is unknown. Current research indicates that there's no single cause. There are some suspected risk factors which include:

- having an immediate family member with autism
- genetic mutations
- low birth weight
- exposure to heavy metals and environmental toxins
- a history of viral infections

According to the National Institute of Neurological Disorders and Stroke (NINDS), both genetics and environment may determine whether a person develops ASD.

A controversial 1998 study proposed a link between ASD and the measles, mumps, and rubella (MMR) vaccine. However, that study has been proven wrong by other research and was eventually retracted in 2010.

How is ASD treated?

There is no known 'cure' for ASD. This does not mean, however, that nothing can be done to help a person who is on the autism spectrum. Because ASD is a 'spectrum' of conditions, they affect different people in different ways. It is important to realise that an intervention which works well with one person may not be appropriate or effective with another. Many treatment approaches involve emotional support to teach coping strategies and skills. Treatments also include therapies like behavioural therapy, and physical therapy.

Appendix 4

Article 3 – Spinal Cord Injury

What is spinal cord injury?

Spinal cord injury is damage to the spinal cord. It's a serious type of physical trauma that's likely to have a significant impact on daily life. If the spinal cord sustains an injury, some or all of the signals to and from the brain may not be able to "get through" to the body. The result is a complete or total loss of sensation and mobility below the injury site. A spinal cord injury closer to the neck will typically cause paralysis throughout a larger part of the body than one in the lower back area.

What are the symptoms of spinal cord injury?

Some symptoms of a spinal cord injury include:

- problems walking
- loss of control of the bladder or bowels
- inability to move the arms or legs
- feelings of spreading numbness or tingling in the limbs
- unconsciousness
- headache
- pain, pressure, and stiffness in the back or neck area

What causes spinal cord injury?

Spinal cord injury is often the result of an unpredictable accident such as violence (stabbing or a gunshot), diving into water that's too shallow and hitting the bottom, a car accident, falling from a significant height or spinal injuries during sporting events.

How are spinal cord injuries treated?

Some people lead full and productive lives after a spinal cord injury. However, there can be severe potential effects of a spinal cord injury. The vast majority of people will need assistive devices such as walkers or wheelchairs to deal with loss of mobility, and some may even be paralyzed from the neck

down. You may need assistance with daily living activities and learn to perform tasks differently. Pressure sores and urinary tract infections are common complications. You also may expect to undergo intense rehabilitation treatment for your spinal cord injury.

Appendix 5

The Worm by Dr. Hannah Nichols (Lecturer in Molecular Biology at the University of Sydney, Australia).

One species of worm - *Caenorhabditis elegans* - has contributed more to medical science in the past few decades than you might think possible. Some 50 years ago, South African biologist Sydney Brenner went in search of a model organism that would be suitable for studies of development and the nervous system. A small animal that could be easily kept and that had a short life cycle would be required. Eventually, Brenner landed on *Caenorhabditis elegans*. Measuring only 1mm, growing easily on simple agar plates needing only bacteria for food, and taking only three days to develop from an egg to an adult, the worm fitted the bill. *C. elegans* has proved to be an excellent tool for studying development. The worm is transparent, so these cells can be observed using light microscopy. Unlike our nervous system, which contains many billions of neurons, the worm has only 302 neurons. After sectioning the worm into about 20,000 slices, American biologist John White and colleagues used electron microscopy to build a picture of all worm neurons, and their processes, providing us with a complete wiring diagram of this relatively simply nervous system. As with the developmental cell lineage, this neuronal wiring diagram is an important tool in enabling researchers to address many interesting questions relating to neuronal development and function. The worm also has a 'brain', exhibits behaviour, and is even capable of basic learning. We must, alas, assume that things like consciousness are absent from *the worm*—although this remains to be shown!). Additionally,
Since around 40% of the genes implicated in human disease have equivalents in worms, these tools also make it possible to learn more about the underlying mechanisms of many diseases by examining the function of the related gene in the worm. It is also straightforward to introduce new genes into *C. elegans*, including those from humans. Such disease models can further be exploited to screen for drugs which may ultimately be used to treat human disease.

Appendix 6

The fruit fly by Professor Gary Hime (Associate Professor of Anatomy and Neuroscience at the University of Melbourne).

Research using the fruit fly, *Drosophila melanogaster*, has given us an enormous amount of genetic knowledge. *Drosophila* were first brought into a laboratory by William Castle at Harvard University in 1901. Nobel Prize winner Thomas Hunt Morgan decided to use *Drosophila* for reasons that are depressingly familiar to today's academic researchers – he didn't have much money or space available to him. Here lies the major advantages of working with this organism: they are cheap to raise, breed prolifically in small bottles and have a breeding age of about ten days, so large-scale, multi-generational breeding experiments can be rapidly performed. *Drosophila melanogaster* has simplistic behaviour. They are easily drawn towards light or the smell of any food source, and will almost indiscriminately mate with any individual of the opposite sex. Its brain - roughly the size of a poppy seed - contains about 100,000 neurons; human brains have 100 billion. But only having a life cycle of a few months, scientists can track how the fly's brain ages far more quickly than in humans.

A stunning result from this *Drosophila* work was that the genes that regulate patterning of the body and organ development in *Drosophila* also play the same role in humans! The DNA sequence of the *Drosophila* genome was published in 2000 and showed that *Drosophila* only contain four chromosomes, as opposed to the 23 chromosomes found in humans, and their genome is approximately 1/26th of the size of humans, making genetic analysis much simpler. An additional benefit is that 75% of known human disease genes had an identifiable match in *Drosophila*. This lead to a new paradigm for understanding how human disease genes function – we can analyse their partners in the simpler organism. This has proved to be extremely profitable although we should not be fooled into thinking that fruit flies are simply little people with wings. Many aspects of human biology cannot be studied in *Drosophila*. For example, flies lack blood vessels (but have an open circulatory system where a blood-like lymph is pumped around all of their organs) and they don't generate antibodies to fight disease. So if we are to use *Drosophila* to further our understanding of human disease, we need to know what is useful to study and what is not.

Appendix 7

Of mice and medicine by John Holden

Although other species are still used in specialist labs, mice are by far the most commonly used mammal in scientific research. Why this particular species has become so central to research is partly because they reproduce quickly and have a short lifespan of two to three years, so several generations of mice can be observed in a relatively short period of time. Mice and rats are also relatively inexpensive to buy, take up little space to house humanely with lots of environmental enrichment, and can be bought in large quantities from commercial producers that breed rodents specifically for research.

However the most important factor is that human and mouse genomes have almost the same number of genes, and that about 80% of human genes have a direct counterpart (orthologue) in the mouse genome. Along with its similarity at the genome level the mouse shares anatomical, physiological, and metabolic similarities with humans – many of which are not shared by other experimental organisms (think about problem solving or depression). Additionally, most of the mice used in medical trials are inbred so that, other than sex differences, they are almost identical genetically. This helps make the results of medical trials more uniform as the mice are like a blank canvas, according to the National Human Genome Research Institute. Although mouse brains are much smaller than the brains of humans, they do have a similar structure and have roughly the same number of cell types the outer layer of the brain that controls planning, decision making and even consciousness. Discoveries in mouse research includes treatments for breast cancer, leukaemia and arthritis.

Notes

Notes

Notes

Notes

UNI PATHWAYS

UNI PATHWAYS

researchersinschools.org