Topic 1: Behavioural Neuroscience

Week 1, lecture 1: introduction to psychology

- **Psychology**: scientific study of the human mind and behaviour.
- **Neuroscience**: scientific study of the nervous system and the brain.
- **Behavioural neuroscience**: division of psychology that seeks to describe how the structure and function of the central nervous system (CNS) and the brain can give rise to psychological phenomena such as perception, attention, language, learning, memory and emotion. It is the bridge between psychology and neuroscience.
- Phineas Gage case study:
    - *Phineas Gage*: a railway foreman in Virginia (mid-19th century) who survived a horrific brain injury with changes to his personality.
    - Used a tamping iron to lay charges in rock for a railway road → created a spark that ignited the gunpowder → caused the tamping iron to shoot back up from the hole → penetrated right into Phineas' head.
    - Skull was placed into a *computerised tomographic (CT) scanner*: created a three-dimensional reconstruction that revealed the most likely path taken by the tamping iron as it passed underneath the left eye and out the top of the skull.
    - The left frontal lobe of the brain was damaged.
    - Phineas resumed work after a few months but suffered from changes to his personality due to brain injury.
    - Contractors described him as now irreverent, profane and showing little deference for his workmates and did not give him any more work.

Week 1, lecture 2: understanding the link between mind and brain

- The **brain**: in ancient times, was not believed to be the seat of the mind and soul. Ancient cultures such as Egyptian, Indian and Chinese believed that the heart was the seat of thought and emotion.
- **Hippocrates** (Ancient Greece, 460 BC):
    - The father of modern medicine.
    - The *brain*: the centre of control for the body.
    - Introduced *four bodily humours*: earth, air, fire and water.
    - Imbalance of the humours → mind disorders.
- **Galen** (Ancient Rome, 130 AD):
    - *Vivisection*: the experimentation on live animals for scientific purposes. Used this technique to study the anatomy of the nervous system and discovered two different types of nerves.
    - *Sensory nerves*: nerves carrying information from the body to the brain.
    - *Motor nerves*: nerves carrying information from the brain to the muscles.

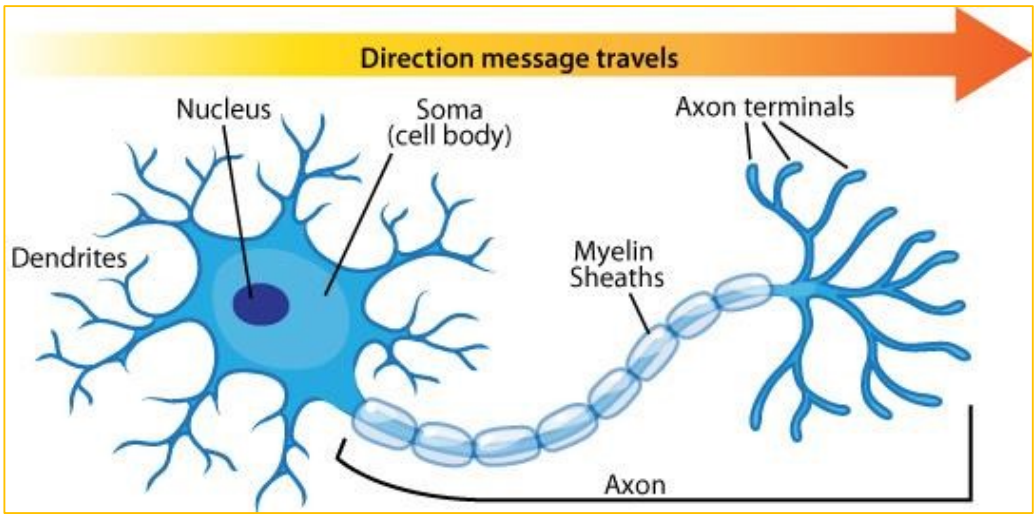
    - Introduced the idea of *pneumata* (spirits): 'natural' (liver), 'vital' (heart) and 'animal' (brain). Believed that animal spirits travelled in hollow nerves.
- **Andreas Vesalius** (Brussels, 1514):
    - Revived dissection and vivisection after the Dark Ages.
    - Created the first detailed drawings of the human brain.
    - Advanced the knowledge of brain structure but failed to replace the concept of pneumata.
    - His dissections revealed many important anatomical features of the human brain, such as the *cortex* (the folded outer layer of brain tissue), the network of blood vessels over the brain's surface and the *meninges* (the outer coverings of the brain).
- **René Descartes** (France, 1596):
    - *Reflexes*: used to describe the automated abilities of animals.
    - Proposed that humans alone possessed a *mind*: allows the performance of voluntary, thoughtful, conscious acts.
- **Thomas Willis** (England, 1621):
    - Rejected the idea that the mind resides in the ventricles.
    - The *cortex*: the outer tissue of cerebral hemispheres that generates thought.
    - Believed that the cortex contained animal spirits that were transported via the white matter.
- **Luigi Galvani** (Italy, 1737):
    - Rejected the idea of animal spirits flowing through hollow nerves.
    - Discovered that an electrical charge applied to a frog's leg would make the muscle contract.
    - Suggested that nerves must be coated in fat to prevent electricity from leaking out.
- **Franz Joseph Gall** (Germany, 1758):
    - Influenced by *physiognomy*: the art of judging a person's character from their facial features.
    - The brain: composed of several distinct 'organs of thought' (faculties) reflected by characteristic patterns of bumps on the skull.
    - Introduced *phrenology*: a map of the skull used to understand a person's character based on the size of the cranium.
- **Paul Broca** (France, 1824-1880):
    - Described a patient named Leborgne who could not speak after receiving damage to the left frontal lobe (*Broca's area*).
    - Leborgne retained regular chewing capacities and comprehension.
- **Gustav Fritsch** and **Eduard Hitzig** (Germany, 1870):
    - Electrically stimulated part of the frontal cortex in dogs that induced contractions of specific muscles on opposite sides of the bodies.
    - Discovered that surgical removal of these 'motor' regions of cortex led to impairments of actions performed by the relevant limb.
- **Egas Moniz** (1874-1955):
    - Introduced *prefrontal leucotomy*: surgical interruption of nerve tracts to and from the brain's frontal lobe for the relief of psychiatric disorders.

    - Based on observations of personality change in monkeys (Becky) and humans following frontal lobe damage.
- **Walter Freeman** (1940s-50s):
    - Became a celebrity for his prefrontal leucotomies without the use of *anaesthesia*: a controlled state of temporary loss of sensation or awareness for medical purposes.
    - Eventually had to desist operations due to an outraged public.

Week 1, lecture 3: neurons, glia and communication within the neuron

- **Multiple sclerosis** (MS): neurological disorder that attacks the myelin surrounding the axons of neurons, which causes interference with nerve impulses within the brain, spinal cord and optic nerves.
    - *Symptoms*: visual impairment, problems with eye movements, numbness, slurred speech and muscle weakness. Can eventually leading to paraplegia in many cases.
    - Characterised by occasional attacks (on average one every couple of years) where symptoms worsen, punctuated by periods where the symptoms disappear or become less severe.
    - It is an *autoimmune disorder*: the body's immune system selectively attacks the myelin surrounding the axons of neurons.
- The **withdrawal reflex**: spinal reflex that occurs when we touch something that is considered damaging to protect the body.
- The dendrites of a sensory neuron respond to a noxious stimulus in the environment → this signal is sent back along the axon to the terminal buttons, which are located in the spinal cord → the terminal buttons release a neurotransmitter into the synapse to excite an interneuron → the interneuron sends a message down its axon that releases a neurotransmitter to excite the motor neuron → the axon of the motor neuron joins a nerve and travels to a muscle in the arm, causing the muscle to contract and pull away from the damaging stimulus.
- The **role of inhibition**: counteraction by the brain against a withdrawal reflex. It can be illustrated by imagining that the surface of your mother's hot casserole dish produces the noxious stimulus. The excitation to drop the dish can be counteracted by the brain: information to not drop the dish.
- The **neuron**: basic information-processing and information receiving unit of the nervous system. They form complex networks within the nervous system that are not directly connected with one another as they are separated by tiny gaps called **synapses**. It is across these synapses that chemicals called **neurotransmitters** are passed. Neurons contain these four basic structures:
    - *Cell body*: contains the nucleus and internal organelles necessary for cell maintenance.
    - *Dendrites*: tree-like branches that allow neurons to communicate with one another by receiving information from other neurons.
    - *Axon*: a long, slender fibre that carries signals from the cell body. The signal carried by an axon is called an action potential.

- *Terminal buttons*: small knobs at the ends of the many branches of axons that play a critical role in transmitting information from one neuron to another by secreting a chemical called a n*eurotransmitter*. This chemical passes across the synaptic gap and can either excite or inhibit subsequent neurons.



- Located inside the cell body are the organelles tasked with cell maintenance and functioning:
  - *Cytoplasm*: jelly-like substance inside the cell. Contains the *mitochondria*, which utilises glucose to produce energy.
  - The *nucleus*: contains the cell's chromosomes consisting of *deoxyribonucleic acid* (DNA), which are the genes that form the chromosomes providing the recipes for creating proteins.
- Neurons make up 50% of the CNS. The other half is made up of various other cells, collectively known as **glial cells** (glia): cells that play an important role in providing physical support for neurons and supplying them with oxygen and nutrients. Types of glial cell:
  - *Astrocytes*: provide physical support for neurons, clean up waste and provide nutrients to neurons.
  - *Oligodendrocytes*: provide physical support to neurons and the insulating myelin sheath that surrounds the axon. This stops unwanted cross-talk between neighbouring axons.
  - *Microglia*: small glial cells that act as the brain's immune system by attacking invading micro-organisms. Also, largely responsible for inflammation after brain damage.
  - *Schwann cells*: perform the same function as oligodendrocytes but in the peripheral nervous system (PNS). They create a myelin sheath around the axons of neurons in the PNS.
- Neurons transmit signals across the axon membrane of electrically-charged molecules called **ions**. This process is electrical.
- As the inside of the neuron is negatively charged, adding a positive electrical current through an **electrode** (a conductor for electricity) causes