Chapter 4: Neuroscience and Behaviour

Nervous system

- Nervous system: Interacting network of neurons that conveys electrochemical information throughout the body
- Two main sections
  - Central nervous system (CNS)
    - Brain and spinal cord (runs down the centre of the body)
    - Spinal cord and the brain collaborates in complex tasks
    - Spinal reflexes: Simple pathways in the nervous system that rapidly generate muscle contractions
    - Pain is a reflexive activity controlled by the spinal cord
      - Painful sensations (such as the heat of fire) travel directly to the spinal cord via sensory neurones, which then issue an immediate command to motor neurone to retract the hand
      - Spinal cord
        - Divided in four main sections that each control a part of the body
          - Cervical nerves(head, diaphragm,arms)
          - Thoracic nerves (chest, abdominals)
          - Lumbar nerves (legs)
          - Sacral nerves (bowels, sexual functions)
        - Damage higher on the spinal usually means greater impairment
  - Peripheral nervous system (on the side)
    - Everything to the side of the brain and the spinal cord
    - Connects the CNS to the body's organs and muscles
      - Somatic (body movements) > voluntary movement (operational conditioning skinner)
        - Conveys information into and out of the central nervous system; controls voluntary movements of skeletal muscles (conveys info between voluntary muscles and the central nervous system)
        - Use it to perceive, think, coordinate behaviour
        - Largely voluntary body responses (skeletal and motor responses)
      - Autonomic (classical conditioning pavlov)
        - Largely involuntary > reflexive > glandular(salivary gland), visceral (heart and lungs)
        - Conveys involuntary and automatic commands that control blood vessels,body organs, and glands
        - Sympathetic and Parasympathetic can be activated at the same time
          - Sympathetic (arousing)
            - Set of nerves that prepares the body for action in challenging or threatening situations
            - Activating nervous system > someone scares or surprise you > fear response
            - Prepares the body for action in a threatening situation
            - Dilates pupils
            - Relaxes bronchi(to breath faster)
            - Accelerates heart beat
            - Inhibits digestive activity (to save energy)
            - Stimulates glucose release
            - Stimulates secretion of epinephrine/norepinephrine

        - Relaxes bladder
        - Stimulates ejection in male
      - Parasympathetic (calming)
        - Helps the body returns to a normal resting state
        - Conservation system > return body to a steady state
        - Helps the body return to a normal resting state
    - 4 F's (behaviors associate with sympathetic and parasympathetic)
      - Fleeing
      - Fighting
      - Feeding
      - Fornicating

Neurons

- Definition: Cells in the nervous system that communicate with one another to perform information-processing tasks
- 100 billion in body
- Use the same ways to communicate between each other
- Basic neurons
  - Unmyelinated neuron
    - Cell body (Soma): Protect the nucleus (keeps cell alive), coordinates information-processing tasks
      - Functions:
        - Protein synthesis
        - Energy production
        - Metabolism
      - Surrounded by porous cell membrane that allows molecules to flow into and out of the cell
    - Nucleus: Contains DNA
    - Dendrites: Receiving part of the neuron, relays it to the cell body, have receptors on them
      - Receptors: Part of the cell membrane that receives the neurotransmitters and initiates or prevent a new electric signal
    - Axon: Has tails at the end of it (Axon terminals) > has tiny pores that doesn't let the positive enter, transmits information to other neutrons, muscles or glands
    - Axon terminal has Axon knob/Terminal Buttons/Terminal Boutons: Knoblike structures that branch out from an axon
    - Axon knob/Terminal Buttons/Terminal Boutons: Sends informations (filled with tiny vesicles that contain neurotransmitters)
    - Synapse
      - The synapse is the junction between dendrites of not neutron and the axon or cell body of another
      - 100-500 trillion synaptic junctions
      - The communication it allows allows us to think, feel and behave
        - Neurons don't touch each other
        1. Action potential travels down the axon the sending neuron (presynaptic neuron)
        2. Stimulates the release of neurotransmitters from vesicles
        3. The neurotransmitters are released into the synapse, where they float to bind with receptor sites on a dendrite of a postsynaptic neutron, initiating a new action potential
        4. The neurotransmitters are cleared out of the synapse by

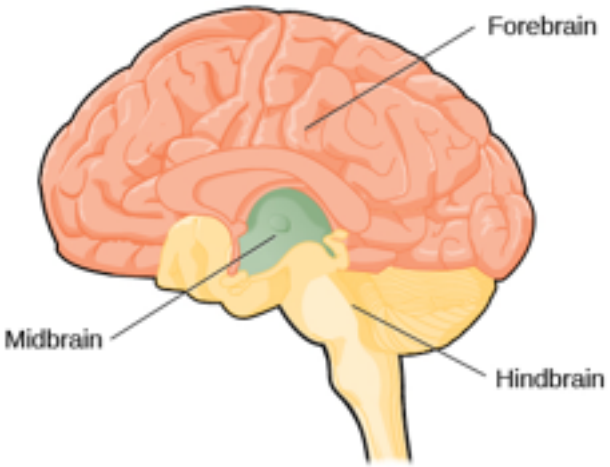
1. Reuptake into the sending of neurons
2. Being broken down by enzymes in the synapse
3. Binding to autoreceptors on the sending neuron (detect how much neurotransmitters were sent out and signal the neuron to stop releasing neurotransmitters when an excess is present

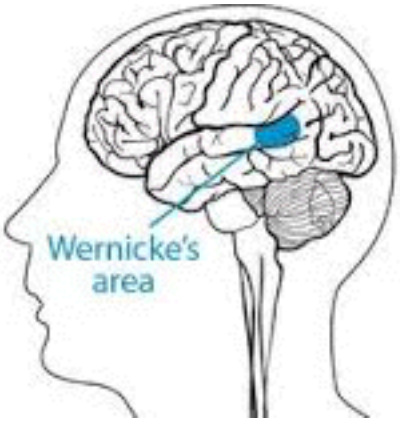
- The electrochemical actions of neutrons: information processing
  - Communication of information within and between neutrons proceeds in two stages (electrochemical action)
    - Conduction (information travels inside of neutron via an electrical signal)
    - Transmission(signal passed from on neuron to another via chemical messengers travelling across the synapse)
  - When cell is at rest (just receiving information) > more negative inside > resting potential
    - Resting potential: Difference in electric charge between the inside and the outside of a neutron's cell membrane
      - K+ and A- inside
      - Na+ and Cl- outside
      - At resting state the K+ can roam freely in and out of the open pores of the membrane, but Na+ is kept out > different electric charge inside and out
      - Since the inside has a high concentration of K+, some move out which leaves a charge of about -70 millivolts inside the neuron relative to the outside
      - Resting potential is resting energy
  - When received enough information the electrical charge changes[small electrically charged molecules {ions}] (wants to send a message)> the pores open up on the axon and the positive charges enter and then get pushed out > when neutron wants to send a message (flow of ions across the neuron cell membrane that creates the conduction of an electric signal within the neuron
    - Action potential: Electrical signal that is conducted along the neurones axon to a synapse
      - Occurs when there us a change is the state of the axon's membrane channel caused by an electric stimulation (receiving neurotransmitters from another neuron)
      - Threshold is reach: all-or-none
      - Refractory period: Time following an action potential during which a new action potential cannot be initiated
      - Neuron shuts K+ channels and opens Na+ channels who rush in and increase a positive charge compared to outside which triggers a reaction
      - Action potential becomes +40 millivolts
      - After reaching it's maximum and sending a message it returns to resting potential, however the inside is unbalanced (refractory period)> extra Na+ inside and K+ outside
      - Imbalance of ions from action potential causes an active chemical "pump" in the cell membrane that pushes out the Na+ and moves the K+ inside
      - Only occurs when reaches a threshold where the action potential is all or none
      - Electric stimulation below the threshold doesn't produce an action potential, but at or above always does produce an action potential
      - Electric charge moves down neuron by domino effect, spread on a short distance that generates an action potential there and so on and so on until it goes down the length of the axon
  - All-or-none response: either release a message or doesn't
  - Neurotransmitters: Chemicals that transmit information across the synapse to a receiving neutron's dendrites
  - Neurotransmitters come out > are in a pocket in the knobs

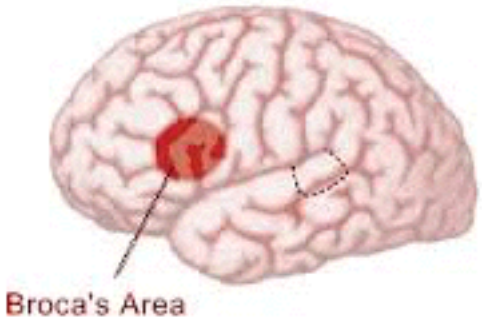
- Neurons don’t touch each other (space between neurons called synapse)
- Neurotransmitters spill out in the synapse
- Some neurotransmitters find their way on the receptors of the dendrites
- The ones who don’t manage to find a receptor get sucked back up the knobs (Re-uptake)
- Some get destroyed by enzymes

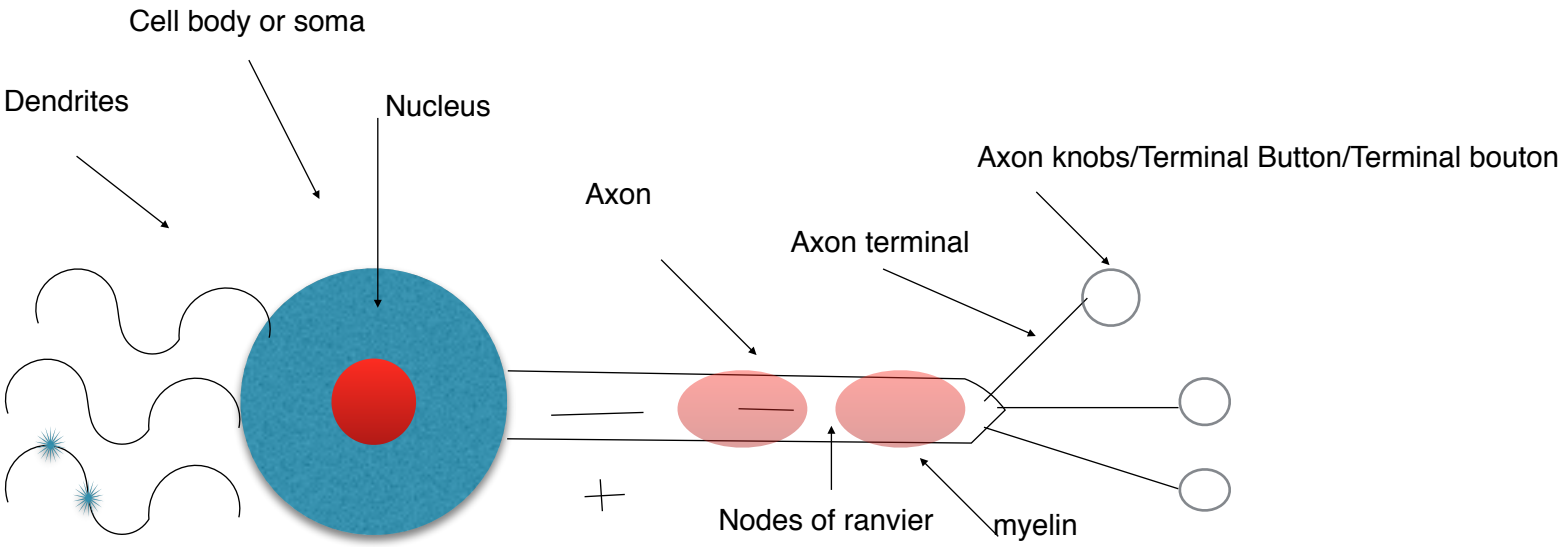
- Types of neurons
  - Sensory neurons
    - Receive information from the external world and convey this information to the brain via the spinal cord
    - Receive signals for light, sound, taste,touch and smell
  - Motor neurons
    - Carry signals from the spinal cord to the muscles to produce movements
    - Long axons that can stretch to muscles
  - Interneurons
    - Connect sensory neurons, motor neurons, or other interneurons
    - Carry information from nervous system to motor neurons
    - Carry information from sensory neutrons to nervous system
    - Other information processing function
- Myelin neuron
  - Clumps of myelin (fatty substance > group of cells [glial cells]) next to each other on the axon
  - Glial cells: form the myelin cells > Support cells found in the nervous system
    - Other uses
      - Digest parts of dead neutrons
      - Physical and nutritional support for neuron
      - Form myelin that permits the information to transmit more efficiently
  - Demyelinating disease such as multiple sclerosis are a result of the myelin sheath deteriorate which slows the transmission of information from one neurone another
    - Loss of feelings in limbs
    - Partial blindness
    - Difficulties in coordinated movement and cognition
  - Positive charges can come in the axon because they are blocked by the myelin
  - Positive ions can only be sucked in, in the nodes of ranvier
  - The space between myelin called nodes of ranvier
  - Shorter action time to send a message > less places to go in > don’t have to go through the full length of the axon > jumping/bypassing the space cover in myelin
  - Electric current jumps from node to node instead of going through the full axon (saltatory conduction)
  - Myelin neuron are faster
  - Protection for the axon
  - Myelin is formed by type of glial cell, and it wraps around a neuron’s axon to speed the movement of the action potential along the length of the axon. Breaks in the myelin sheath are called the nodes of Rainvier. The electrical impulse jumps from node to node, thereby speeding the conduction of information down the axon
- Resting potential
  - There is a more negative charge inside the axon
- Action potential
  - Pores on the membrane start to open and the positive get sucked in
  - Myelin: Positive only rush in at the nodes of ranvier (fast communication)

- All or none (can’t be stopped)
- Refractory period: Time following an action potential during which a new action potential cannot be initiated (can’t continuously send out neurotransmitters)
  - Resting potential is in the refractory period









Neurotransmitters

- Each of neurotransmitters affects thought, feelings, and behaviour in different ways (each have different shape)
- We know of 60 neurotransmitters who play a role in transmitting information
- Lock and key system
  - Some neurotransmitters only go to specific receptor sites
  - Endorphins: Natural pain killers > lock and key system > neutron transmitters who receive endorphins and some send > specific endorphin neuron
    - Gives euphoric effect > runner's high
    - Natural drug
    - Heroine or Morphine smallest particules will fit into receptor sites that fit in for endorphins
    - Need bigger and bigger doses since they become used to the feeling > overdose for taking a little too much
    - When running > endorphins are released to deal with the pain of the pounding of the knee
  - Acetylcholine
    - Voluntary motor responses
    - Found in brain and axons connected to muscles or organs
    - Regulation od attention, learning, sleeping, dreaming, and memory
    - Associated to Alzheimer
  - Dopamine
    - Motor behaviour, motivation, pleasure, and emotional arousal
    - Associated with a reward actions
    - Depressions
    - Drug addiction
    - High level linked to schizophrenia
    - Low levels Parkinson's disease
    - Increase results in euphoria, wakefulness and a burst of energy
  - Glutamate
    - Excitatory neurotransmitter > enhances transmission of information between neurons
    - Too much cause seizures
  - Norepinephrine
    - Understand depressions
    - Influence mood and arousal
    - Vigilance

    - Increase results in euphoria, wakefulness and a burst of energy
    - Increases heart rate
- Serotonin
    - Prozac
    - Affect mood and arousal
    - Regulation of sleep, wakefulness,eating,aggressive behaviour
- GABA
    - Inhibitory neurotransmitter > stop the firing of neurons
    - Too little can cause seizure
- How drugs mimic neurotransmitters
    - Altering balance of neurotransmitters in their brain
    - Increase, interfere with or mimic the manufacture or function of neurotransmitters
    - Agonists: Drug that increases the action of a neurotransmitter
    - Antagonists: Drugs that block the effect of a neurotransmitter

<u>Brain</u>

- The brain can be three parts, moving from the bottom to the top, from simpler functions to the more complex; the hindbrain, the midbrain, and the forebrain
    - Hindbrain: Coordinates information coming into and out of the spinal cord and controls the basic functions of life (respiration, alertness, motor skills)
        - Medulla(Heart rate, circulation and respiration),
        - Pons(means bridge, connects information from the cerebellum to the brain),
        - Cerebellum (hand-eye coordination),
        - Reticular Formation/Reticular Activating System[RAS](Help send information from the spinal cord to the midbrain[regulates sleep wakefulness, levels of arousal])
    - Midbrain: Important for orientation and movement
        - Very small
        - Tectum: Locate things in time and space
        - Tegmentum: Area rich with dopamine neurons area (important for parkinson)
    - Forebrain: Highest level of the brain; critical for complex cognitive, emotional, sensory, and motor functions
        - Cortex: Highest level of the brain (part of the forebrain) > right and left hemisphere (two hemispheres of the cerebral cortex) > emotion, movement and thought,perception
            - Left and Right hemisphere
                - contralateral control: Each hemisphere controls the functions of the opposite side of the body
                - Nerve finders that connect left and right hemisphere (corpus callosum: Thick band of nerve fibres that connects large areas of the cerebral cortex on each side of the brain and supports communication of information across the hemisphere)
                    - Left> verbal, Right> draw(visual)[spatial skill]{left hand can draw it}
                    - Michael Gazzaniga > special in brain split
                - Four lobes in each lobes
                - Left hemisphere controls the right side and vice versa
                    - Frontal lobe: Specialized area for movement (***motor cortex[initiates voluntary movements and sends messages to the basal ganglia, cerebellum and spinal cord])***, abstract thinking, planning, memory, and judgement, speech production **<u>(broca's area)</u>** (left hemisphere),(right hemisphere > left hand)

        - Parietal lobe: Body sensation (sensory cortex) > lips+tongue and finger take a big part > processes information about touch
            - ***Somatosensory cortex***: Represents skin areas on the contralateral surface of the body> more sensitive bigger part of it
            - Homunculus: Rendering of the body in which each part is shown in proportion to how much of the somatosensory cortex is devoted to it
        - Occipital lobe: processes visual information (vision)>primary visual area
        - Temporal lobe: Responsible for hearing and language >close to the ears > **Wernicke's area (language comprehension)** > primary auditory cortex> information based on frequency> help us recognize common objects
    - Associated areas help provide meaning to information registered in cortex> neutrons in these areas are less specialized and more flexible , can be shaped by environment to do job more effectively
    - Mirror neurons: Active when an animas performs a behaviour such as reaching for or manipulating and objects and they are also activated when the other animal observes the first animal as it performs the same behaviour > found in frontal lobe and parietal lobe
- Subcortex
    - Subcortical structures: Areas of the forebrain housed under the cerebral cortex near the centre of the brain
    - Limbic system: Group of forebrain structures involved in motivation, emotion, learning, and memory
        - Thalamus: Relays and filter information from senses and transmits the information to the cerebral cortex (everything but smell)
            - Filters sensory information
            - Receives inputs from all the major senses except smell
        - Hypothalamus: motivation, sex, hunger, thirst,
            - Regulates body temperature hunger, thirst, and sexual behaviour; also part of limbic system
        - Hippocampus: Critical for creating new memories and integrating them into a network of knowledge so that they can be stored indefinitely in other parts of the cerebral cortex
            - Everyday memory
        - Pituitary gland: "Master grand" of the body's hormone-producing system, which releases hormones that direct the functions of many other glands in the body
            - Send hormonal signals to control stress,digestive activity, reproductive processes
        - Amygdala: Plays a central role in many emotional processes, particularly the formation of emotional memories
            - Fear
        - Basal ganglia
            - Set of subcortical structures that directs intentional movements
            - Striatum: Control of posture and movements
- To analyze the human brain
    - We analyze the brain problem and the areas in which they lose function in
    - We use medical scans and test
- Brain plasticity: Sensory cortices can adapt to change (brain adapting itself for parts who are not functioning well)

- The brain is plasticity: Functions that were assigned to certain areas of the brain may be capable of being reassigned to other areas of the brain to accommodate changing input from the environment
- Greater use of a function may allocate greater space in the cortical map
- Physical exercise can benefit the strength and connections of a synapses in the brain
- Phantom limb syndrome (still feel the pain of the missing limb > brain reacts like you still have the limb)