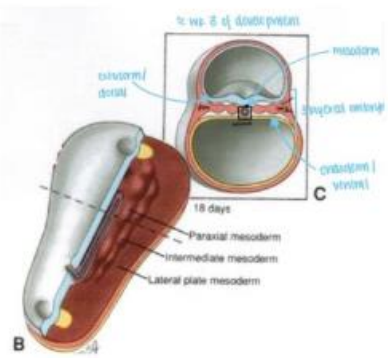
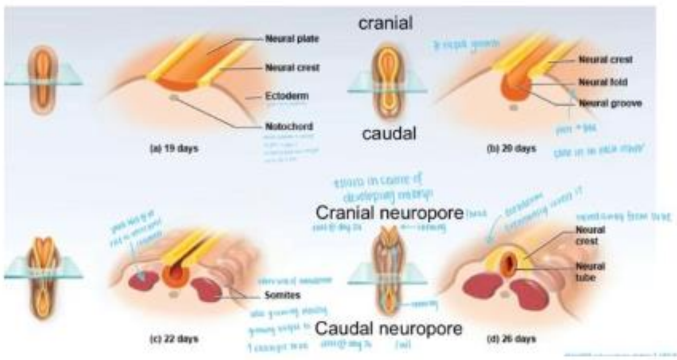
ANHB1102 LEARNING OUTCOMES

- ◊ Describe the basic structure and function of the human body at the level of organs and systems
- ◊ Explain how the nervous and endocrine systems interact to maintain homeostasis
- ◊ Explain the processes of nutrition, growth, development & ageing
- ◊ Describe genetic & evolutionary processes which determine human differences between and within populations
- ◊ Relate the biology of humans to their evolutionary history

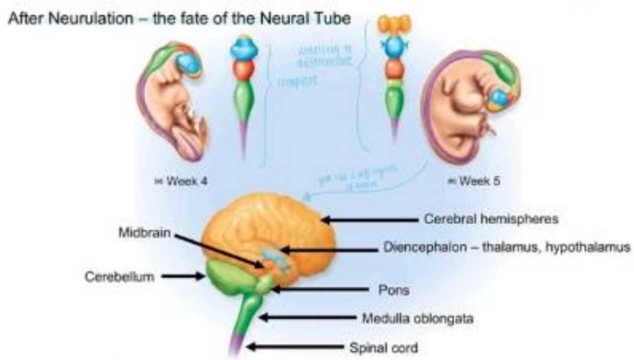
NERVOUS SYSTEM

- ◊ Describe the embryological development of the nervous system (lecture 03, slide 4-5)
  - ⇒ Neurulation – embryological development of the nervous system
    - o Approx. week 3 of development
    - o Begin in centre of developing embryo with neural plate, neural crest, ectoderm & notochord
    - o Notochord changes fate of ectoderm to give rise to CNS & PNS instead of epidermis
    - o Begin to close in on each other (neural plate turns into neural fold)
    - o Somites (from mesoderm) give rise to vertebral column
    - o Rapid growth to close tube
    - o Cranial neuropore closes at day 24 (head)
    - o Caudal neuropore closes at day 26 (tail)
    - o Neural crest moves away from neural tube & everything is covered by ectoderm





- ⇒ Endoderm = ventral (internal organs and shit)
- ⇒ Ectoderm = dorsal (epidermis and hair)
- ⇒ Mesoderm = middle (notochord)
- ⇒ Neural tube – brain and spinal cord
  - o After neurulation, complete neural tube begins to differentiate into different regions of the brain & spinal cord



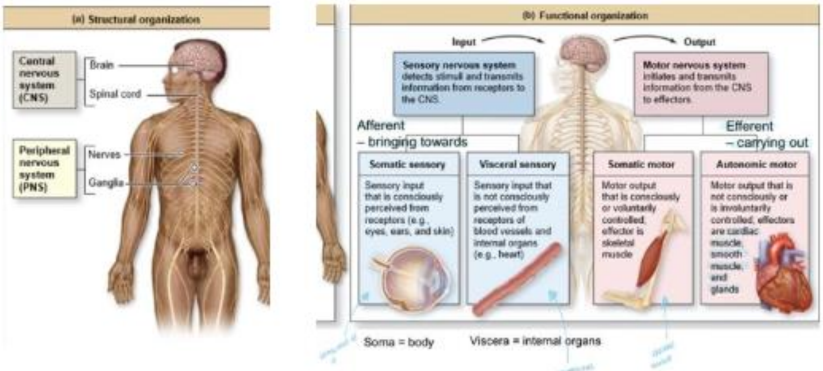
- ⇒ Neural canal – fluid-filled spaces in CNS (ventricles & CSF)
  - o 4 ventricles formed & filled with CSF
    - → 2 lateral ventricles – 1 in each hemisphere
    - → Third ventricle separated from lateral ventricles via interventricular foramen
    - → Fourth ventricle separated from third via cerebral aqueduct

- CSF constantly produced & reabsorbed
- Produced by choroid plexuses
- Lateral & medial aperture allow CSF to leak out of brain into spinal cord & circulate
- Function of CSF:
  - → Buoyancy
  - → Protection
  - → Chemical stability

⇒ Neural crest cells – most of PNS (sensory & autonomic nerves, ganglia, Schwann cells)

◊ Describe and identify gross anatomical features of the nervous system
- ⇒ CNS – brain and spinal cord
- ⇒ PNS – (cranial & spinal) nerves & ganglia

◊ Describe the functional divisions of the nervous system
- ⇒ Sensory input (afferent)
  - o Somatic sensory (conscious)
  - o Visceral sensory (not conscious)
- ⇒ Motor output (efferent)
  - o Somatic motor (conscious/voluntary control)
    - → Effectors: skeletal muscle
  - o Autonomic motor (not conscious/involuntary control)
    - → Effectors: cardiac & smooth muscle, glands
    - → Sympathetic nervous system (fight or flight)
    - → Parasympathetic nervous system (rest & digest)



◊ Identify & understand the role of the basic cell types of the nervous system
- ⇒ Neurons
  - o Excitable (respond to environmental stimuli)
  - o Conductive (produce electrical signals)
  - o Secretory (neurotransmitters secreted at the end of the nerve fibre to stimulate next cell)
- ⇒ Glial cells
  - o PNS
    - → Schwann cells/neurolemmocytes – myelination of axons
  - o CNS
    - → Oligodendrocytes (chippy) – myelination of axons
    - → Astrocytes (maintenance) – supportive framework, blood-brain barrier, maintenance, formation of synapses
    - → Microglia (cleaner) – removes dead nervous tissue, foreign matter & microorganisms
    - → Ependymal cells (idk plumber) – ciliated, circulate fluid in cavities of brain and spinal cord

◊ Understand the structure of a nerve cell (neuron)
- ⇒ Dendrites
  - o Signal input (receiving end)
  - o Short

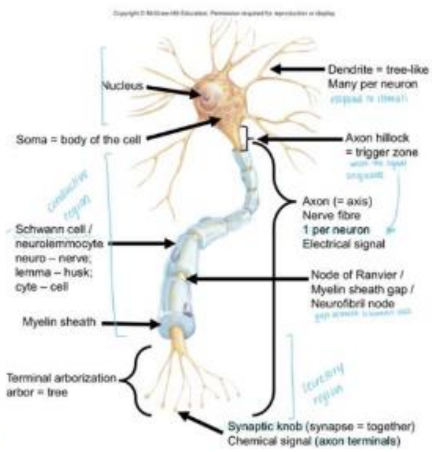
- Thick
- Unmyelinated

⇒ Axons
- Signal output (transmitting end)
- Long
- Slender
- Unmyelinated or myelinated

⇒ Unipolar – only sensory

⇒ Bipolar – CNS sensory (smell, hearing, sight)

⇒ Multipolar – most neurons of CNS (interneurons) & motor PNS



◊ Explain how electrical signals are propagated

⇒ Neurons are polarised therefore have electrical potential
- Polarised = different properties on different sides

⇒ Stimulation of a neuron (via chemicals, light, heat, mechanical forces etc.) occurs at dendrite/soma and travels to axon

⇒ Stimulation opens channels in cell membrane that allow positive ions to flow into the cell (momentarily change balance) – creates a local potential

⇒ Inside of cell becomes less negative (moves towards zero)

⇒ Local potential:
- Varies according to strength of stimulus
- Gets weaker as it spreads from point of origin
- Can be excitatory (depolarisation) or inhibitory (hyperpolarisation)

⇒ If excitatory local potentials strong enough & arrive at trigger zone of axon hillock, action potential initiates a current that is sent to the end of the axon

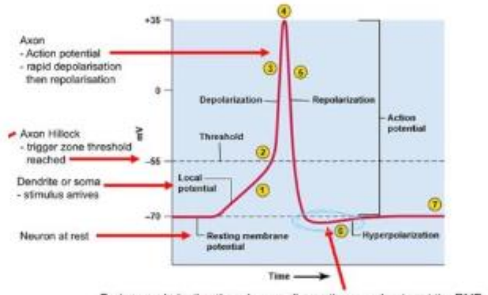
⇒ AP requires a critical voltage threshold that must occur at the trigger zone (-55mV)

⇒ When threshold is met neuron fires = massive depolarisation & reversed polarity
- Inside of cell membrane becomes very positive very quick

⇒ Once peak is reached, cell membrane starts to repolarise

⇒ Hyperpolarisation past the resting membrane potential must occur after an action potential to maintain progress of action potential in one direction

⇒ Nerve signal = chain reaction of APs
- AP stimulates new AP in cell membrane in front



During repolarisation there is a small negative overshoot past the RMP
Hyperpolarisation = critical to maintain AP progress in one direction only

◊ Understand terms such as resting membrane potential, action potential, refractory period

⇒ Resting membrane potential = charge difference across a cell membrane
- Resting membrane potential in an unstimulated neuron = approx. -70mV
  - → Negative value = more negatively charged ions on inside of membrane than outside

⇒ Electrical potential = differences between concentration of charged particles on either side of the membrane (Na^+, K^+, Cl^- etc.)

⇒ Depolarisation = voltage shifts to less negative value

⇒ Hyperpolarisation = voltage shifts to more negative value

⇒ Action potential = rapid up and down shift in voltage

⇒ Trigger zone = specialised area of neuron cell membrane that allows to change in voltage

⇒ Refractory period = during/after AP it is impossible to restimulate the region to fire
- Absolute RF = during huge depolarisation, impossible to trigger new AP
- Relative RF = during hyperpolarisation, new AP possible but need stronger stimulus

- ◊ Explain how a synapse occurs
  - ⇒ Synapse = when nerve meets nerve
  - ⇒ Occurs from axons to dendrites or axons to axons
  - ⇒ Arrival of AP at axon terminal (synaptic knob) triggers release of neurotransmitters (NT) from synaptic vesicles (via exocytosis)
  - ⇒ NT travels across synaptic cleft
  - ⇒ Binds to NT receptors on post synaptic neuron
  - ⇒ NT depolarises postsynaptic neuron = local potential/post-synaptic potential
  - ⇒ AP generated if signal is strong enough
  - ⇒ Can be thousands of presynaptic neurons at a postsynaptic neuron
  - ⇒ Not all postsynaptic potentials are excitatory (some inhibitory)
    - o EPSP = excitatory postsynaptic potential (less -ve/depolarisation)
    - o IPSP = inhibitory postsynaptic potential (more -ve/hyperpolarisation)
  - ⇒ EPSP & IPSP like quick maths rules
    - o EPSP + EPSP = greater EPSP
    - o IPSP + IPSP = greater IPSP
    - o EPSP + IPSP = 0 (cancels out)
- ◊ Understand the concept of summation
  - ⇒ Summation = addition of postsynaptic potentials
  - ⇒ Calculations to determine whether an action potential will be produced
- ◊ Explain why nervous transmission can occur at different speeds
  - ⇒ Speed of transmission depends on:
    - o Myelination
    - o Sensory nerve size
    - o Sense type
  - ⇒ Myelin sheath
    - o Insulation around nerve fibre
    - o Made of cell membrane glial cells & approx. 80% lipids
    - o Thick and dense (minimal cytoplasm between up to 100 layers)
    - o Nodes of Ranvier in gaps of myelin sheath that the nerve impulse can travel on
    - o Not all nerve fibres are myelinated
    - o Unmyelinated fibres in PNS are enveloped with Schwann cells because more vulnerable to damage than CNS fibres
  - ⇒ Myelinated nerve fibres = faster speed of transmission of nerve signal
    - o Nerve signal 'jumps' between nodes of Ranvier = saltatory conduction
    - o Eg. walking normally
  - ⇒ Unmyelinated nerve fibres = slower speed of transmission
    - o Nerve signal travels along entire length of nerve fibre
    - o Eg. walking but touching your toe to your heel
  - ⇒ Larger axon diameter = easier for ions to flow = faster electrical current
    - o Larger axons have larger surface area, so more charge accumulates at the membrane therefore increasing speed of transmission

Sensory nerve size	Sense type	Speed of transmission (m/s)	Analogous to
Largest / myelinated	prevent from injury Proprioception	80-120m/s	Shanghai Maglev Train (430km/hr)
Medium / myelinated	Touch	33-75m/s	Bullet Train (250km/hr)
Small / myelinated	Pain & cold temp.	3-30m/s	Speeding on the freeway (126km/hr)
Small / unmeylinated	Pain, warm temp & itch	0.5-2m/s	Middle aged female maximum walking speed (7.2km/hr)

Proprioception = sense of self movement and body perception.

- ◊ Explain axonal transport
  - ⇒ Passage of proteins, organelles & other materials along an axon
  - ⇒ Nerve cell bodies make all materials

- ⇒ Two-way passage:
  - Anterograde transport = soma → end of axon (mitochondria, vesicles, proteins)
  - Retrograde transport = end of axon → soma (waste, materials for recycling)
- ⇒ Materials travel along axonal microtubules = guide to destination (walking man)
- ⇒ Fast axonal transport:
  - Anterograde/retrograde
  - 200-400mm/day
- ⇒ Slow axonal transport:
  - Retrograde only
  - 0.2-0.5mm/day

◊ Describe and identify the components of a simple reflex arc

- ⇒ Features:
  - Require stimulation
  - Quick (few neurons, no interneurons)
  - Involuntary (no registration at brain – awareness comes later because protection > awareness)
  - Stereotyped (same response every time)
  - Protective
- ⇒ Somatic reflex arc:
  - Somatic receptors (skin, muscles etc.)
  - Afferent nerve fibres into dorsal horn
  - Integrating centre synapse into ventral horn
  - Efferent nerve fibres
  - Effector muscles
- ⇒ Autonomic reflex arc:
  - Stimulus (stretch, pressure, pH, temperature etc.)
  - Receptors (nerve endings to internal stimuli)
  - Afferent/sensory neurons to CNS
  - Integrating centre in hypothalamus & brain stem (interneurons)
  - Efferent/motor neurons in spinal cord & peripheral ganglia via cranial & spinal nerves
  - Effectors carry out end response (negative feedback)

◊ Describe and identify the components of sensory and motor pathways

- ⇒ All nerve fibres (axons) in a named tract have a similar origin, destination & function
- ⇒ Ascending tracts carry sensory information up the spinal cord
- ⇒ Descending tracts carry motor information down the spinal cord
- ⇒ Sensory tracts:
  - Prefix – spino
  - First order neuron – cell body located in dorsal root ganglion, detects stimulus
  - Second order neuron – cell body located in dorsal horn or brainstem, synapses at thalamus
  - Third order neuron – cell body located in thalamus, carries signal to postcentral gyrus
- ⇒ Motor tracts:
  - Suffix – spinal
  - Upper motor neuron – cell body located in cerebral cortex (precentral gyrus) or brainstem
  - Lower motor neuron – cell body located in ventral horn or brainstem nucleus
  - Upper motor neurons can excite/exhibit lower motor neurons
- ⇒ Corticospinal tract
  - Largest descending tract in humans
  - Lateral = innervates skeletal muscle for skilled limb movements, 85% of direct pathway to limbs
  - Ventral = 15% of pathway to trunk