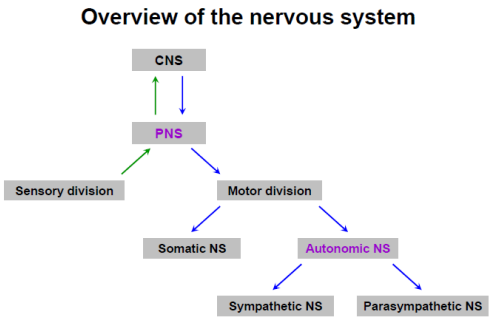
NEUROSCIENCE NOTES

Basic Structure

- ***Identify the divisions and functions of the nervous system***
  - The function of the nervous system is to be able to respond to changes in the environment and bring about appropriate responses in muscles, organs and glands.
  - Includes detecting changes (sensory receptors), analysing information (CNS) and executing a response (motor system), in the internal environment too (loss of oxygen during exercise).
  - The motor division comprises of the somatic and autonomic nervous systems. The somatic controls body movement (skeletal muscle), autonomic is smooth muscle.



  - The brain is the command centre and the spinal cord is located beneath. Both are delicate tissues that need protection.
  - Brain has two hemispheres, lateral aspect curved like a sphere, medial is on a flat plane. Surface of the brain is bumping which increases surface area without taking up extra space (less oxygen). Energy-saving design.
  - The increased surface area allows more cell bodies to connect to fibre. Fibres travel long distances connecting to other body parts or neurons.
  - Space inside the brain are called the ventricles, which contain choroid plexuses that produce 90% of CSF.
  - Brain connected to SC via medulla (end-portion of brainstem) at the bottom of the brain.
  - Brain has 3 major parts: cerebrum, cerebellum and the brainstem. There is a central canal inside the brain, a little hole filled with CSF.
  - Cerebellum is at the back of the brain, controls musical capacity, and balance, coordination.

- ***Identify the components and functions of a neuron***
  - Receptors are dendrites that detect different changes (eg. Ears- changes in vibration, eyes- light).
  - A neuron is a nerve cell, that comprises the PNS.
  - The function of a neuron is to receive and integrate incoming information from sensory receptors and to transmit information to other neurons or structures under neuronal control (effector organs).
  - Neurons vary in size and shape, but all share common characteristics:
    - Dendrites: receptive parts of a neuron such that the direction of information flows towards the cell body. Possess synapses to receive information from other nerve cells.
    - Cell body: from which a variable number of branching processes emerge, many of which are dendrites.
    - Axon: a long process which attaches to the cell body and the direction of information flows from the cell body towards the axon terminal (i.e carries information away from the cell body). Conduction velocity increases with axon diameter.
    - At the end of the axon are synaptic specialisations called nerve terminals (boutons) from which information is transferred, usually to dendrites of other neurons.
    - Nerve fibre: dendrite for sensory neuron, axon for motor neurons.
    - Nerve: formed by nerve fibres

- ***Classify neurons in terms of structure and function***
  - Alpha motor neurons are neurons with large cell bodies that innervate the skeletal muscle of the body. They are contained in lamina IX in the ventral horn.
  - Nerve cells that carry information from the peripheral receptors to the CNS are afferent neurons, and if info reaches consciousness they're called sensory neurons.
  - Efferent neurons carry impulses away from the CNS, if innervate skeletal muscle, they are motor neurons.
  - Majority of neurons are located in CNS and called interneurons.

- Sensory neurons have cell bodies very close to the vertebral column, so are protected by vertebrae or the skull. Nerve fibres vary in length.

- ***Describe the role of myelin and identify cells responsible for the production of myelin***
  - Each axon is myelinated for insulation.
  - All nerve fibres are myelinated except for type C.
  - Myelinated axons conduct action potentials much faster than unmyelinated axons, and so conduct senses that need to be fast, while unmyelinated conduct pain, temperature.

- ***Identify the components and functions of a synapse***
  - Synapses form communication between cells. It has a number of constituents:
    - Vesicle: packet of neurotransmitters. Since the vesicle is made of the same material as the membrane, the transmitter can diffuse across and attach to receptors.
    - Synaptic cleft: gap between pre- and post- synaptic cells (10-20nm wide)
    - Receptor: macromolecule in postsynaptic membrane, to which transmitter attaches.
  - Chemical synapses are one-way (from cell to cell) and comprise of a presynaptic, postsynaptic cell. The presynaptic cell releases the transmitter, a small molecule which acts on the postsynaptic membrane to produce depolarisation or hyperpolarisation.
  - Transmitters are typically amines, many are amino acids or their derivatives.
  - Examples:
    - Acetylcholine is the excitatory transmitter released by motor neurons.
    - Glutamate is the main excitatory transmitter in the CNS
    - GABA (gamma amino butyric acid) is the main inhibitory transmitter in the CNS.
  - Some neurotransmitters, particularly amino acids and Ach are fast (bring rapid changes in postsynaptic membrane permeability to certain ions, resulting in changed membrane potential).
  - Others have slower action as they act though an intermediary (eg. Dopamine).
  - Neurotransmitter effects must be terminated once has acted on the membrane, achieved by either enzymatic destruction or by active re-uptake into nerve endings and glia.
  - Drugs influencing synaptic transmission:
    - Blockage of action potential propagation, eg. Local anaesthetic- Cut on the arm, this drug blocks the synapse so that the action potential is generated but not conducted (i.e won't feel the pain).
    - Blockage of transmitter release, eg. Botulism (botox), toxin that blocks the release of Ach at the neuromuscular junction. It paralyses wrinkly muscles, results in nice smooth skin. Can also use to relieve spasms, such as twitching eyelid.
    - Altered transmitter metabolism g. anticholinesterase prolongs action of Ach
    - Reduced number of receptors, eg. Myasthenia gravis can be treated with anticholinesterase
    - Blockage of postsynaptic receptor, eg. Curare. Binds to the post-synaptic receptor over Ach. Some tribes put on arrow tips to paralyse muscles.

- ***Classify synapses in terms of structure and function***
  - Neuronal communication can be:
    1. Axo-dendritic: axon to dendrites (most synapses are)
    2. Axo-somatic: axon to cell body (soma)
    3. Axo-axonic: axon to axon
    4. Dendro-dendritic: dendrite to dendrite

- ***Describe the components of a simple reflex***
  - A simple reflex won't go straight to the brain, it will simply go from the dorsal horn to th ventral horn via a synapse that acts as a site of analysis.

- In the reflex arc, a sensory stimulus travels via a sensory pathway to the CNS. Once the information is analysed, a response travels via a motor pathway to initiate a muscle contraction.
- Eg. Movement in peripheral vision, sound of opening door, causes muscle contraction- turn eyes and head.
- Reflexes involve sensory and motor cranial nerves connected by reticular formation (interneurons of the intermediate grey matter of the SC).
- A reflex is an involuntary, stereotyped pattern of response brought about by a sensory stimulus.

- ***Describe the different types of glial cells***

- Glial cells are supporting cells that surround neurons, hence are in greater numbers. Unlike neurons, don't have a direct role in information processing, but do other essential roles for normal functioning.
- If we damage neural cells, the neurons die, but glial cells divide when damaged, and multiply causing tumours.

Astrocytes	▪ Supportive and protective, they wrap around capillaries of the brain and are involved in controlling the exchange of chemicals between the circulatory system and nervous tissue. Hence the BBB, which selectively restricts the access of circulating chemicals between circulatory system and the CNS. ▪ Cling to neurons and their synaptic endings, and processes cover capillaries forming the blood-brain barrier (BBB) ▪ The Blood-Brain Barrier is very important, controlling what enters the brain and spinal cord. Certain things are designed to cross the barrier (eg. Drugs that are mind-altering substances). ▪ Our BBB is very tight when we're healthy, but loosens when we're sick, so must be careful what we take when we're ill.
Microglia	▪ Supportive and protective. ▪ Phagocytose and digest microorganisms or neuronal debris, much like macrophages in the rest of the body which engulf bacteria, foreign bodies and digest rubbish to make the environment safe.
Oligodendrocytes	▪ Myelination of CNS- production of myelin is their main role, to surround many axons in the CNS. ▪ Branched, wrap CNS nerve fibres ▪ Myelin sheaths: insulate nerve fibres
Ependymal	▪ Line the central cavities of the CNS- line the ventricles and cover the choroid plexus. ▪ Their ventricular surface is ciliated, which is said to aid the circulation of CSF. ▪ They form the CSF (10% whilst other 90% by choroid plexuses)

- There are 2 types of cells in the PNS:
    - Schwann Cells: supporting cells which surround PNS fibres. Function to produce myelin. Important in regeneration of damaged peripheral nerve fibres.
    - Satellite cells: protect cells at the periphery.

- ***Identify structures that support and protect the CNS and PNS***

- Bone is the toughest tissue in the body, so skull protects the brain, vertebral column, the SC.
- The CNS is surrounded by connective tissue (MENINGES) that protect the structures. They are located in the space between the skull and the brain, as well as the space between the vertebral column and SC.
- Meninges have several layers:
    - Dura mater: outermost layer, very strong and tough.
    - Arachnoid: webbed, contains cerebrospinal fluid in the subarachnoid space.
    - Pia mater: thin and delicate, follows contour on surface of brain (into sulci).
    - Meningitis is inflammation of the meninges. It can be solved with a lumbar puncture (spinal tap) , where a long needle is inserted into the subarachnoid space, to sample CSF for diagnosis/getting fluid out (L3, 4, 5).
    - Dura mater has a lot of pain nerve endings, so must be numbed with anaesthetic (epidural).

- ***Describe the formation and functions of cerebrospinal fluid***

- CSF is a liquid similar to blood plasma, but containing no red blood cells.
- It is produced by the choroid plexuses (network of capillaries) and ependymal cells.
- The functions of CSF include:
  - Mechanical protection: cushions, buoyancy to CNS so brain not as heavy (since fat, so must be constantly suspended because can't resist gravity, would tear).
  - Circulates nutrients and removes waste products
  - Chemical protection: optimal ionic concentration for action potentials (eg. pH).