## Terms - Alphabetical

**Cranial Nerves** – Nerves that originate in the brain or brainstem

**Choroid Plexus** - Location in the ventricles of the brain where cerebrospinal fluid is produced

**Dendrites** – Branches from the cell body of a neuron that detect stimuli

**Ganglia** – A collection of neuron cell bodies

**Glial Cells** – Cells that support the neuron function

**Grey Matter** – Tissue of the brain that appears grey and contains cell bodies, dendrites, and axon terminals of neurons

**Interneurons** – Short neurons used to transmit signals within the CNS

**Monosynaptic Reflexes** – Reflex consisting of one sensory neuron and one synapse to the motor neuron

**Motor Neuron** – Cells in the brain and spinal cord that allow us to move, speak, breath by sending commands from the brain to the muscles that carry out these functions.

**Nerve** – A collection of neurons surrounded by connective tissue

**Neuron** – A type of cell that receives and sends messages from the body to the brain and back to the body.

## Terms - Alphabetical (cont)

**Polysynaptic Reflexes** – A reflex that involves more than two neurons

**Preganglionic** - The preganglionic neuron travels from its origin in the brain or spinal cord to a ganglion (collection of cytons outside the CNS).

**Reciprocal Innervation** – Occurs when one muscle contracts and the antagonistic muscle on the opposite side of the body relaxes.

**Reflex Arc** – Pathway taken by a nerve impulse from sensation to effect

**Sensory Neurons** - Send information to spinal cord and brain

**White Matter** – Segments of the nervous system composed of myelinated axons

## Overview

The nervous system has two major divisions:
•The central nervous system (CNS), composed of the brain and spinal cord
•The peripheral nervous system (PNS), composed of cranial nerves, spinal nerves and all the neurons and sensory receptors outside the CNS.

•The neuron is the basic cell type of both systems.

•The major divisions of the PNS are the somatic nervous system and the autonomic nervous system.

## Overview (cont)

•**Somatic Nervous System** – voluntary control of movements – mostly skeletal muscle and skin.
- **Afferent neurons** bring signals from peripheral receptors to the CNS
- **Efferent neurons** bring signals from the CNS to the skeletal muscle fibres

•**Autonomic Nervous System** – involuntary control of smooth and cardiac muscle glands. This system works with the endocrine system to maintain homeostasis.

•**Ganglion (Ganglia is plural)** – a group of body cells (not axons or terminals) in a nerve that bring sensory information to the spinal cord

•**Sensory receptors** – detect specific sensory information
- Can be special cells that connect to a sensory neuron
- Can be extensions of a sensory neuron

## Types of Sensory Receptors

**Chemoreceptor** – Chemical concentrations, such as hormones, neurotransmitters and nutrients

**Photoreceptor** – Light; found in the retina (eye)

**Mechanoreceptor** – Stretch and physical movement

**Nociceptors** – Pain

**Thermoreceptor** – Temperature; found in the PNS and CNS

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## Neuron Structure

• Nervous tissue consists of neurons that convey electrical signal, and glial cells, which support the functioning of the neurons. Both are present In the PNS and CNS. Glial cells divide and go through mitosis but neurons do not.

## Glial Cells in the CNS

**Astrocytes**

•Regulate extracellular fluid (ions and neurotransmitters), guide neuron growth during embryonic development, involved in the formation of blood-brain barrier (tight junctions), store glycogen, and form scar tissue.
•Prevents any unwanted materials from getting into brain fluid
•Regulate ion concentration surrounding neuron, like Na and K are regulated for nerve impulses
•To store glycogen – breaks down glucose to provide neurons with energy when needed.
•Blood-brain barrier – connection between cells, prevents any content from moving through the cells, like a zipper.

**Microglia**

•Phagocytic immune cells, can migrate to infected areas and engulf pathogens and dead cells.
- Fight off infection, use phagocytosis to engulf pathogens or dead cells and debris.

## Glial Cells in the CNS (cont)

**Ependymal Cells**

•Ciliated, produce cerebral spinal fluid (CSF) from contents in the blood.

**Oligodendrocytes**

•Makes up myelin sheath that surrounds the axons of many neurons in the CNS.
•Very high in fat content
•Protect and insulate axons
•Lipid covering that wraps around the axons of the neurons, but not all of them. Long axons have myelin, not short ones. Myelin acts as an insulator and helps speed up nerve impulses

## Glial Cells in the PNS

**Satellite cells**

•Surround neuron bodies located in the PNS (similar to Astrocytes in function regulation of extracellular fluid ions)

**Schwann cells**

•Wrap around axons, have a different structure. Surrounds and forms myelin sheaths around the larger nerve fibres. (similar to oligodendrocytes in CNS)
•Myelin sheath allows for regeneration of neurons - **No regeneration in the CNS**
•**Nodes of Ranvier** - spaces between myelin where action potentials (nerve impulses) can be transmitted

## The CNS: Spinal Cord

• The spinal cord, which is protected by the vertebral column lies within the bony vertebral column,

• Impulses originate from the brain and travel down the spinal cord before reaching the target tissue

• Spinal cord is important for communication between the brain and body tissues

• The central, butterfly-shaped area of **grey matter** is composed of interneurons, the cell bodies and dendrites of efferent neurons, the entering axons of afferent neurons, and glial cells.

• The grey matter is surrounded by **white matter**, which consists of groups of **myelinated axons.**

## The CNS: Spinal Cord

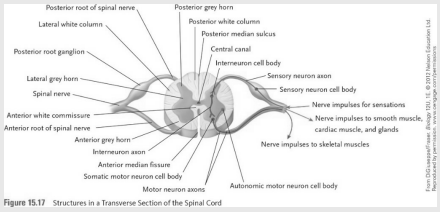

Figure 15.17 Structures in a Transverse Section of the Spinal Cord

## The CNS: Spinal Cord - Reflexes

•A reflex is a rapid and **involuntary response** and nearly instant reaction to a stimulus, also called a **reflex arc.**
•They are protective mechanisms that allow us to respond rapidly without needing to take time to consciously think about how to respond.



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## The CNS: Spinal Cord - Reflexes (cont)

•A **monosynaptic reflex** involves only one synapse connecting the sensory neuron to the motor neuron in the spinal cord.
•Example: Knee-jerk response, called stretch response

•A **polysynaptic reflex** involves more than one synapse
•Example: Withdrawal reflex, touching something hot.
•A withdrawal reflex shields the body from harm, with a sensory nerve detecting pain. For instance, if you touch something hot, your hand moves away before you feel pain because nerves in the spinal cord quickly trigger muscle reactions, like the biceps contracting.

•**Reciprocal innervation** means that when one muscle is stimulated, the antagonistic muscle is inhibited – to ensure the correct muscle contracts.
•Inhibition doesn't happen directly at the muscle level because all neurotransmitters there are stimulative. Instead, inhibition occurs within the spinal cord.

• We can acquire these reflexes through learning. These reflexes are different from the reflex arc – they involve brain and complex movements. Once we learn movements they become like a reflex because of the cerebellum. A portion of the brain that helps learn movements so we don't have to think about them and just perform them.

## The Central Nervous System

• Both the brain and spinal cord are protect by bones – vertebral column protects spinal cord, skull protects brain – as well as:

•**Meninges** - 3 protective membranes that wrap around CNS.
•From external to internal:

• **dura mater** – thick, tough layer that lies next to the skull bones and contains blood vessels
•**arachnoid mater** – Has the same spider web appearance as the layer surrounding the spinal cord
• **pia mater** – Contains blood vessels that branch into and throughout the brain

• **Cerebral Spinal Fluid (CSF)** - Between the arachnoid mater and pia mater is the subarachnoid space that contains the CSF that bathes the brain with nutrients and protects it by absorbing shock when we move around and jump.

## The Central Nervous System II

Function of the **Meninges**:
•Cover and protect the CNS

•Protect blood vessels

•Contains CSF

•Forms partitions in the skull because of how it dips

•Meningitis: Inflammation of the meninges caused by a virus or several bacteria that can be life-threatening without immediate medical attention

## The Central Nervous System II (cont)

**Cerebrospinal Fluid (CSF)**
•CSF is secreted by ependymal cells of the choroid plexus. It circulates through the subarachnoid space and ventricles and is reabsorbed. It also goes down to the central canal of the spinal cord

## The CNS: Brain I

Four major parts:
•Diencephalon
•Brain stem
•Cerebellum
•Cerebral Cortex (cerebrum)

Diencephalon consists of:
•**Hypothalamus** (apart of the endocrine/nervous system) – An integrating centre that helps maintain homeostasis (hunger, growth, temp, water-salt balance) – Endocrine gland that produces hormones.

•**Thalamus** – Integrates visual and auditory information and involved in focusing attention.
•Relays information from spinal cord to other regions of the brain and cerebral cortex.

•**Pineal gland** – secretes melatonin and regulates biological rhythms – sleep-wake cycles.

## The CNS: Brain II

**The Brainstem**
•All neurons that pass through the spinal cord also pass through the brainstem. It's essential for life and is the **most primitive brain region,** found in all animals.

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## The CNS: Brain II (cont)

•It contains midbrain, pons and medulla oblongata.

•**Medulla Oblongata** – Reflex centres for regulation of breathing, heartbeat, and blood pressure (as well as coughing, sneezing, and vomiting).

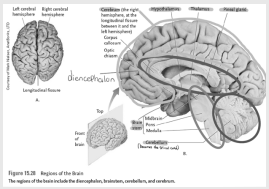
• **Pons** - Relays information between the cerebrum and cerebellum. • Also plays a role in regulation of breathing •**Midbrain** - Regulates muscle (motor) movements

**The Cerebrum**

•Made up of the cerebral cortex and subcortical region

•Grey matter is located in the cortex, white matter in the subcortical region. •Subcortical region contains the basal nuclei, amygdala and corpus callosum (allows the two halves of the brain to communicate with each other.

## The CNS: Brain II - The Cerebrum



## The CNS: Brain III

The Cerebrum: Lobes

**Frontal lobe** – Primary motor area

•Contains the motor cortex and premotor cortex

•Involved in planning and initiating muscle movements

•Also involved higher thinking functions, goal setting, reasoning, decision making, and regulating the limbic system

•**Broca's area** is part of the frontal lobe that **controls muscles involved in speaking**.

**Parietal lobe** – primary somatosensory area

•Contains the sensory cortex and associated areas that interpret sensory information

•Receives input from the skin, muscle, and joins.

•Contains our tasting center

**Temporal lobe**

• Contains auditory cortex and associated areas that interpret sound

•Primary area for smell

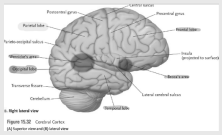
•Responsible for sense of hearing

•Helps understand speech

**Occipital lobe**

•Contains the visual cortex and associated areas that interpret visual simuli

## The CNS: Brain III - Lobes



## Limbic System

• Is like a primitive brain

• Major roles in emotion, learning, memory, and social interactions.

•Includes parts of the thalamus, hypothalamus, amygdala, hippocampus, olfactory bub and more.

• All the them combined act as a primitive brain

• Sense of smell is highly linked to memories

• It functions to protect us by reacting rapidly to stimuli

• Ex. Getting angry and becoming aggressive, feeling sad and wanting to cry.

Note: Amygdala and hippocampus mostly involves – learning, emotions, and memory

## Limbic System

## The PNS: Nerves

•Includes cranial and spinal nerves, and ganglia outside of the CNS

•**Spinal nerves** conduct impulses to and from the spinal cord

•**Cranial nerves** conduct impulses to and from the brain.

• There are **12 pairs of cranial nerves** in the PNS that are attached to the brain

• **31 pairs of spinal nerves** that emerge from the spinal cord



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## The PNS: Nerves (cont)

• Nerves are cable-like bundles of axons, also known as nerve fibres. They are enclosed by a membrane

• **Vagus nerve is in the medulla oblongata. It extends from the medulla in the brainstem through the neck and thorax down to the abdomen.**
•Motor – Muscles of the pharynx and laynx; thoracic and abdominal organs
•Sensory – Taste buds on tongue and pharynx; thoracic and abdominal organs

• Spinal nerves enter and exit the spinal cord through openings in the vertebrae. They take impulses away from most body parts.

## The PNS: Autonomic System

Has 2 divisions:
•Sympathetic and Parasympathetic

• The heart, many glands and smooth muscles are innervated by both division fibres.

• **Whatever effect of one division has on the effector cells, the other division usually has the opposite effect.**

• Moreover, the two divisions are activated the same way

• As the activity of one division increases, the activity of the other decreases.

## Sympathetic (Thoracolumbar Division)

•Important in responses to short-term stress (fight or flight action)
•Ex. Accelerate heartbeat, dilate bronchi for increased muscle activity

• Neurons leave the CNS through the thoracic or lumbar spinal nerves.

• Short preganglionic and long preganglionic synapses

• Neurotransmitter released by post-ganglionic axon is primarily norepinephrine (NE) or epinephrine (adrenaline).

## Parasympathetic (Craniosacral Division)

•Also called 'house-keeping division. This is the 'rest and digest' system.
•It promotes all the responses that are associated with a relaxed body state. Ex. Slowing of heartbeat, digestion of food.

•Neurons leave the CNS through cranial or sacral spinal nerves.
•Long preganglionic and short preganglionic synapses.

• Neurotransmitter acetylcholine (Ach) is released by parasympathetic division.

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