The Central Nervous System
CNS: What is it?

- Two parts to the CNS:
  - The Brain
  - The Spinal Cord (connects the brain to the peripheral nervous system)
The Brain

- Sends and receives messages via the spinal cord
- Involved with information processing activities
- The ‘master’ organ – responsible for virtually everything you think, feel and do
- Has a complex structure of billions of neurons and trillions of connections between the neurons
- Divided into two hemispheres
The Cerebral Cortex – Involved with information processing of perception, language, learning, memory, thinking, problem-solving, planning and controlling voluntary bodily movements

- 2-4 mm thick
- Contains ¾ of the entire brain’s neurons
  - **Primary visual cortex**: Receives and processes visual information
  - **Sensory cortex areas**: receive and process info from our different senses
  - **Motor cortex area**: receives, processes and sends info about voluntary bodily movements
  - **Association cortex areas**: integrate sensory, motor and other info

It is believed that the bigger the cerebral cortex, the more intelligent the species
Cortical Areas of the Brain
The Brain - Hemispheres

• Two halves of the cerebral cortex separated by a deep groove called the Longitudinal Fissure

• **Left hemisphere**
  • receive sensory information from the right side of the body and controls movement on the right side.

• **Right hemisphere**
  • receives sensory information from the left side of the body and controls movement on the left side.

• Two halves are connected by the corpus callosum

• **Corpus Callosum** - Band of nerve tissues that connect the left and right cerebral hemispheres
Corpus Callosum

- Video – Agenesis of the corpus callosum
  
  [http://www.youtube.com/watch?v=roKV8XJHXKc&feature=related](http://www.youtube.com/watch?v=roKV8XJHXKc&feature=related)
The Four Lobes

• **Cortical Lobes – Areas of the brain associated with different functions**
  • Frontal lobe
  • Parietal lobe
  • Temporal lobe
  • Occipital lobe

• **Each lobe contains areas of the cortex that have specialised functions**

• **Sensory areas**: receive and process info from sensory receptors in the body

• **Motor areas**: receive and process info about voluntary bodily movements

• **Association areas**: integrate info from different brain areas and are mainly involved in complex cognitive processes
<table>
<thead>
<tr>
<th>Brain Lobe</th>
<th>Function</th>
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| FRONTAL LOBE     | ▪ PLANNING  
                   ▪ INITIATIVE  
                   ▪ SELF AWARENESS  
                   ▪ EMOTIONAL BEHAVIOUR  
                   ▪ PERSONALITY  
                   ▪ MOVEMENT  
                   ▪ SMELL                                                                 |
| PARIETAL LOBE    | ▪ RECEIVES SENSORY INFORMATION REGARDING TOUCH, PRESSURE, TEMPERATURE  
                   ▪ RECEIVES INFORMATION FROM MUSCLES & JOINTS                                                                                       |
| OCCIPITAL LOBE   | ▪ RECEIVES VISUAL INFORMATION  
                   ▪ VISUAL RECOGNITION                                                                                                                 |
| TEMPORAL LOBE    | ▪ RECEIVES & PROCESSES SOUND  
                   ▪ INVOLVED IN CERTAIN MEMORY TASKS, eg. Face recognition; memories of personal experiences such as birthdays & holidays. |
The Frontal Lobe

Frontal lobe

Broca’s area (speech production)

Temporal lobe

Primary auditory cortex (hearing)

Primary motor cortex (voluntary movements)

Primary somatosensory cortex (bodily sensations)

Parietal lobe

Occipital lobe

Primary visual cortex (vision)

Wernicke’s area (speech comprehension)
The Frontal Lobe

• Largest lobe
• Takes up the upper front half of each hemisphere

**Primary Motor Cortex**: controls voluntary bodily movements through its control of skeletal muscles
  • The motor cortex on the left hemisphere controls the right side of the body
  • The motor cortex of the right hemisphere controls the left side of the body

• Known as Executive - Frontal Lobe co-ordinates many functions of the other lobes

• Association areas: in the forward section of each frontal lobe, receives info from other lobes to enable us to perform complex mental functions
Map of the Primary Motor Cortex
The Frontal Lobe – Broca’s Area

- Only in the LEFT hemisphere
- In the left frontal lobe next to the motor cortex
- Controls the muscles of the face, tongue, jaw & throat
- Involved in the production of clear and fluent speech.
- Linked to word meanings, sentence structure and parts of speech
- Damage includes speech impairments
Case Study: Phineas Gage

http://www.youtube.com/watch?v=yXiM-nDYzX0

http://www.youtube.com/watch?v=FrULrWRLGBA&NR=1&feature=fvwp
The Parietal Lobe
The Parietal Lobe

• Located behind the frontal lobe and takes up the upper back half of the brain
• Receipts and processes sensory information called somatosensory information
• Primary Somatosensory Cortex receives and processes sensory information from the skin and body, enabling us to perceive bodily sensations.
  • The somatosensory cortex of the left hemisphere detects info from the right side of the body
  • The somatosensory cortex of the right hemisphere detects info from the left side of the body
  • Different parts of the Primary Somatosensory Cortex detect info from different parts of the body
• Association areas: integrate info from other lobes
Map of the Somatosensory Cortex
Case Study: Phantom Limb Syndrome

http://www.youtube.com/watch?v=sq6u4XVrr58&feature=related
• Part 1 – start at 3.20 mins

http://www.youtube.com/watch?v=PpEpj-JgGDI&feature=related
• Part 2 – first 6 mins only

Vilanyur Ramachandran

The Mirror Box – used as therapy for people with pain in their ‘phantom limb’
The Temporal Lobe
The Temporal Lobe

• Located in the lower central area of the brain around the top of each ear

• Involved in hearing, speaking and understanding language and memory formation

• Contains the hippocampus which is involved in aspects of visual perception and recognising faces

• Primary Auditory Cortex: receives and processes sounds from both ears
  • Processed in different areas according to frequency (pitch), amplitude (loudness) and type

• Association Areas: Turns meaningless sounds into recognisable words, links memory with emotions, determines emotional responses, storing memories of facts, object identification and face recognition.
The Temporal Lobe – Wernicke’s Area

• LEFT hemisphere only
• In the left temporal lobe, next to the primary auditory cortex
• Involved in the comprehension of speech; interpreting the sounds of human speech.
• Damage cause impairment in understanding speech and speaking
The Occipital Lobe

- Primary motor cortex (voluntary movements)
- Primary somatosensory cortex (bodily sensations)
- Primary visual cortex (vision)
- Broca’s area (speech production)
- Temporal lobe
- Primary auditory cortex (hearing)
- Wernicke’s area (speech comprehension)
- Occipital lobe

Frontal lobe

Parietal lobe
The Occipital Lobe

- Located at the rear of each cerebral hemisphere in the back of the head
- Involved in processing visual information
- **Primary Visual Cortex**: info comes to the primary visual cortex from each eye.
- Each hemisphere receives and processes half of the visual information.
- **Association Areas**: interact with the primary visual cortex to select, organise and interpret visual information.
- Damage can cause a person to see an object but not recognise it
Parts of the Cerebral Cortex

Label the following key structures and areas of the cerebral cortex.
The Hemispheres

Right cerebral hemisphere controls left-side motor coordination

Left cerebral hemisphere controls right-side motor coordination
Hemispheric Specialisation

**LEFT HEMISPHERE**
- Verbal Tasks
- Maths skills
- Analytical functions
- Self recognition
- Sensory, motor, visual, auditory info from the right side
- Positive emotions

**RIGHT HEMISPHERE**
- Non-verbal Tasks
- Spatial activities
- Recognising others
- Sensory, motor, visual, auditory info from the left side
- Negative Emotions
The Spinal Cord

• The cable-like column of nerve fibres that extend from the base of the brain to the lower back.
• It is encased in a series of bones called the vertebrae that extend further than the actual cord.
• The major functions of the spinal cord:
  • **Ascending tracts**: Receive sensory information from the body and transmit it to the brain
  • **Descending tracts**: Receive information from the brain and relay it to the body.
• When the spinal cord is damaged, the brain loses its messenger to the body and vice versa.
• The higher up the spine that the damage occurs, the more nerve connections between the brain and the body that are severed
Neurons of the CNS

- **NEURONS** - cells that receive, process and transmit information (nerve cells)

**PARTS OF THE NEURON:**

- **Axon**: part of the neuron that send information away from the SOMA (cell body)
- **Myelin Sheath**: fatty substance that covers axons as a protective coating
- **Dendrites**: thin extensions of a neuron that receive information from other neurons and transmit it to the cell body.

- **White matter**: made solely of axons that run the length of the spinal cord uninterrupted and are bundled together
- **Grey matter**: contains cell bodies, axons and dendrites, and is mainly located near the centre of the spinal cord
Pinky & The Brain
Parts of the BRAIN
The Peripheral Nervous System
Nervous system

Central nervous system (CNS)
Transmits and receives messages to and from the PNS

Brain
Organises, integrates and interprets information

Spinal cord
Connects brain and PNS

Peripheral nervous system (PNS)
Carries messages to and from the CNS

Autonomic nervous system
Connects CNS to internal organs and glands; self-regulating

Sympathetic nervous system
Prepares body for action

Parasympathetic nervous system
Calms body after action

Somatic nervous system
Carries messages from sensory receptors in the body to the CNS, and motor messages from the CNS to skeletal muscles
The Peripheral Nervous System

• Carries information between the Central Nervous System and the rest of the body
• Includes all other nerves that extend from the spinal cord and brain
• Carries messages to and from various muscles, glands and senses throughout the body
The Peripheral Nervous System

• Divided into two subdivisions:
  
  • **Somatic Nervous System**: conveys sensory information to the CNS and motor messages to the muscles
  
  • **Autonomic Nervous System**: serves basic life functions (e.g. heart rate) and connects the CNS to internal organs that are regulated by the brain
Peripheral Nervous System

SOMATIC NERVOUS SYSTEM
- Detects sensory info & controls skeletal muscles

AUTONOMIC NERVOUS SYSTEM
- Controls visceral muscles, organs & glands
The Somatic Nervous System

- Controls the **skeletal muscles** attached to our bones—VOLUNTARY movements.
- Messages get sent from the CNS and are carried along a network of motor neurons to the muscles.
- When the neural message reaches the muscle a **neurotransmitter** (chemical substance) is released which causes the muscle to expand or contract resulting in the required movement.
Motor Function of the SNS

*Message initiated at the CNS*

*neural impulse travels along a motor neuron*

*message received at target muscle*

*neural impulse stimulates the release of neurotransmitters*

*neurotransmitters cause the muscle to expand or contract, resulting in movement*
The Autonomic Nervous System

- Controls the **visceral muscles** of the **internal organs** and **glands** (such as sweat, salivary and adrenal glands)
- Provides feedback to the brain about the activities of these organs and glands
- The ANS is an automatic system that controls **involuntary bodily activities**
Biofeedback

• A process by which a person receives information about the state of an internal bodily activity that normally occurs automatically and then uses thought processes to exert control over the activity

• The person uses a strategy such as relaxation or visualisation in order to control the particular autonomic response

• Biofeedback training has been used to help people manage health problems such as high blood pressure, chronic pain and headaches.
The Autonomic Nervous System

- Two divisions:
  - **Sympathetic Nervous System**: responsible for *increasing* the activity of most visceral muscles, organs and glands in times of vigorous activity, stress or threat
  - **Parasympathetic Nervous System**: responsible *decreasing* the activity and keeping the body functioning in its normal state
Autonomic Nervous System

Parasympathetic Nervous System
- DECREASE bodily activities
- Keep body functions at a normal rate

Sympathetic Nervous System
- INCREASE bodily activities (fight/flight)
Parasympathetic

- Constricts pupil
- Stimulates salivation
- Inhibits heart
- Constricts bronchi
- Stimulates digestive activity
- Stimulates gallbladder
- Contracts bladder
- Relaxes rectum

Sympathetic ganglia

Sympathetic

- Dilates pupil
- Inhibits salivation
- Relaxes bronchi
- Accelerates heart
- Inhibits digestive activity
- Stimulates glucose release by liver
- Secretion of epinephrine and norepinephrine from kidney
- Relaxes bladder
- Contracts rectum
The Sympathetic Nervous System

• Is the part of the ANS that activates internal muscles, organs and glands to prepare the body for vigorous activity

• Activates in response to threats

• “Fight or flight response”: gets ready for engaging in action (fight) or running away (flight)
Response by Sympathetic Nervous System

**EMERGENCY**
situation detected

sympathetic n.s.
sends message to
adrenal glands

hormones secreted
into blood stream

ADRENALIN &
NORADRENALIN

hormones activate muscles,
organs & other glands

Body is prepared to deal
with potential emergency

RESULTS IN: increased heart rate &
blood pressure, increased breathing rate,
pupils dilate, increased perspiration,
digestion rate decreased
The Parasympathetic Nervous System

• Counterbalanced the activities of the sympathetic nervous system

• Has two main functions
  ➢ Keeps the systems of the body functioning efficiently
  ➢ Helps maintain the internal body environment in a steady balanced state of normal functioning (called homeostasis)

• Returns body back to normal state
The Autonomic Nervous System

**SYMPATHETIC NERVOUS SYSTEM**
- Dilates pupil
- Inhibits salivation
- Relaxes bronchioles
- Speeds up heart beat
- Inhibits digestion
- Stimulates glucose levels
- Relaxes
- Inhibits

**PARASYMPATHETIC NERVOUS SYSTEM**
- Constricts pupil
- Stimulates salivation
- Constricts bronchioles
- Slows heart beat
- Enables digestion
- Stimulates bile production
- Contracts
- Enables stimulation

**KEY**
- Red: Parasympathetic NS nerves
- Blue: Sympathetic NS nerves

- Eye
- Salivary gland
- Bronchioles
- Heart
- Stomach and intestine
- Gall bladder
- Bladder
- Sex organs