CHAPTER TWO - BIOLOGY OF THE MIND

Nervous System I-V

I. Function and Structure:
NS
→ CNS (brain and spinal cord)
→ PNS (all nerves outside of CNS)

Signalling Communication:
- Recieves info from environment
- Organizes this info and integrates it
- Uses this info to send messages to muscles and glands → producing emotions, behaviour, etc

Conscious Experience:
- Aware of ourselves and environment

II. Neurons (A-C)

A - The Basics:
- Variety of shapes and sizes
- Basically have same structures
- Highly specialized cells → receive and transfer info

3 Types:
1. Sensory Neurons:
- Receives info from environment → to CNS
2. Interneurons:
- Found in CNS ONLY
- Sensory neurons and other receive it
- Organize and integrate info → sends out orders to other neurons (ie motor)
3. Motor Neurons:
- Receive info from CNS
- Transmit to muscles and glands

Basic Structure:
Cell Body → Soma
- Contain DNA

- Manufacture everything the neuron needs to survive and thrive

Dendrites:
- Receive info from other neurons

Axon:
- When the neurons communicate with another neuron, it fires (electrical impulse → action potential)
- Carries the action potential away from the cell body → all the way down to the terminal buttons

Axon Branches:
- Myelin Sheath
- Some axons are covered by Myelin Sheath
- White fatty like substances
- Provides insulation for axon
- Speeds up transmission of info

Synapse:
- Neurons meet to communicate

Synaptic Cleft or Gap:
- Tiny little gap between two neurons at the synapse

Presynaptic Neuron:
- Neuron that is sending out a message

Postsynaptic Neuron:
- Neuron that is receiving the message

B - Communication (B.1 - B4)

B.1 → IN A NUTSHELL:
- When a neuron decides to communicate with another neuron, it fires electrical impulses → action potential → all the way to the terminal buttons → causes the release of neurotransmitters
- Neurotransmitters → chemicals in the neurons that are used to communicate with each other
- Electrical-chemical process (communication between neurons)

B.2 - Within a Neuron:
- 80% water (brain)
- Dissolved chemicals (ie Na+, k+ → inside/outside of neuron → found in different concentration → will change, depending on what is going on with neuron)

Neuron at Rest:

- Not communicating
- Inside (-ions) negative electric charge
- Outside (+ions) Positive electric charge
- Neuron at rest → -70 mV (inside neuron)
- Membrane in polarized
- Even at rest, still receives messages from neurons → some of these messages are inhibitory (instruct neuron NOT to fire, going to change the concentration of ions so that the inside of the neuron becomes more negative, -76 mV → membrane is hyperpolarized, less likely to fire)

Excitatory Messages:

- Instruct neurons to fire
- Changes the concentration of ions
- Inside will become less negative (-63 mV)
- Membrane is depolarized
- More likely to fire

When?

- About -50/-55 mV (threshold of excitation)

Keep in Mind:

- Action potential is an all-or-nothing phenomenon
- Fires, it fires → NO quarter partial action potential
- Same strength from beginning to end
- Same strength everytime the neurons fire

Domino-Like Effect:

- Travels down the axon in a domino-like effect

B.3 - Between Neurons:

1. The presynaptic neuron fires
2. Action potential will travel down the axon until it reaches the terminal buttons
3. Terminal buttons, synaptic vesicles (little bags with neurotransmitters attach to membrane of neurons and burst open and release neurotransmitters into the synaptic cleft)
4, Neurotransmitter crosses the cleft
5. Attaches to the receptor sites on the postsynaptic neuron (and delivers the message)

Fate of Neurotransmitter:

- Has to be deactivated once the message is delivered

Reuptake:

- Neurotransmitter reabsorbs into the neuron it was released from

Degradation:

- Enzyme breaks down the neurotransmitter

Why?

- If it's NOT, it'll keep delivering the same message over and over
- Over excites or over inhibits the nervous system

B.4 - Neurotransmitters:

- The chemicals used by neurons to communicate with each other
- Released by an action potential
- Deliver messages to postsynaptic neuron
- Healthy levels of neurotransmitters are a MUST
- Imbalance = problem (ie dopamine)

C - Drugs and the Brain

- When it reaches the brain, it produces their effect at the level of the synapses
- Interferes with communication between neurons (messes wit it)
- Can do this at three levels

1. Presynaptic Neuron

- increase/decrease/stop release of neurotransmitter

2. Activity on the Cleft

- Affect degradation or reuptake
- Enhancing, reducing, or blocking them

3. Postsynaptic Neuron

- Can do it in three ways

1. Drug could lock and mimic (will attach to receptor sites, and behaves like neurotransmitters, delivers a message to neuron)
2. Locks and blocks (attach to the receptor site, doesn't do anything else. No delivery, preventing neurotransmitter from delivering its message)

3. Locks and enhances or diminishes (will attach to the receptor site, but does it so the neurotransmitter can also attach. When the neurotransmitter delivers its message, drug will either enhance or weaken in)

Drugs → 2 Major Types

- Agonists = enhance and facilitates the activity of the neurotransmitter
- Antagonist = reduces and diminishes or blocks the activity of the neurotransmitter

The Brain (CNS) A → D

A - Intro

- 2% of body weight
- 20-25% of glucose in body (consumed)
- Brain is the fattest organ, 60% fat
- 100,000 miles of blood vessels
- 80-100 billion neurons
- 1 neuron can have connections to 40,000 other neurons

B - Tools of Discovery (B.1 - B.4)

B.1 - Clinical Observations:

- At some point, was the only method
- Still in use today
- Systematically observe people with brain disease or brain trauma → document what is observed
- Helped a lot

B.2 - Brain Manipulation:

- Many ways, same rational
- Intentionally interfere with the function of the brain
- Systematically document and determine the results of manipulating brain or neurons

1. Surgical (take a part out, cut off connectors)
2. Chemical (inject a chemical in the brain that is of interest to observe it)

3. Electrical (implant electrodes, activate or deactivate the area of interest)
4. Magnetic field (exposed to magnetic field)

B.3 - EEG

- Allows us to see the brain in action, what it is doing
- Electrodes on the scalp, become electrical activity on the brain
- Look at brain waves to inform us on what it is doing

B.4 - Neuroimaging Techniques (1-4)

1. CT or CAT Scan
   - Uses x-ray technology to take multiple images from different angles
   - NOT allowing us to see the brain in action
   - Anatomy and structure only
2. MRI
   - Exposed to a powerful magnetic field
   - Result → tissue emit electromagnetic signals
   - Use those signals to create detailed images of the brain
   - NOT brain in action
   - Shows anatomy and structure
3. PET Scan:
   - Allows us the see the brain in action
   - Consumes glucose for energy (radioactive)
   - More active the brain, more glucose it'll consume
   - Injected with radioactive glucose
   - Machine tacks that glucose
   - Produce colorful images
   - Red and yellow → high energy
   - Blue and violet → low energy
4. F MRI
   - See brain in action
   - Exposed to powerful magnetic field to track blood to the brain
   - More active the part of the brain, more blood flow
   - Produce colorful images

C - Tour of the Brain (C.1 - C.2)

C.1 - Lower Brain Structures:

C1.1 - Brain Stem

- Oldest part
- Over 500 million years old
- Begins with spinal cord
- A relay station
- All info coming/leaving into the brain go through it
- A crossover part
- Considered to be the life center of the brain → contains structures that control vital life functions

Medulla

- Controls breathing, heartbeat, swallowing, vomiting

Reticular Formation

- Arousal, sleep, waitfulness, some cases of coma could be due to damage here

C.1.2 - Thalamus

- Relay station
- All senses, except for smell, sending info to the thalamus
- Receive info from higher brain areas, relay it to lower ones
- It filters info, highlights what is important, regulates motivation, attention, arousal

C.1.3 - Cerebellum

- "Little brain"
- Controls voluntary movement, muscle tone, balance, posture
- Responsible for us learning motor skills that become automatic
- 1/10th of the brain volume
- Over half of the brain neurons are in cerebellum → have 20x more connectors b/w neurons
- Must be involved in complex mental functioning → evidence to support that
- Learning, creativity, creation of cultures, memory, some aspects of language (responsible)
- Can get drunk too

C.1.4 - Limbic System

- 250 million years old

- Consists of multiple structures'
- Linked to multiple functions (ie learning, memory, motivation, emotion) → cover a couple of structures

Amygdala

- 1 on each side
- Limited with aggression, emotions (experience particularly fear, perception of emotional resources, fight or flight, pick up threatening stimuli in the environment even though we aren't conscience of it

Hypothalamus

- Sits under the thalamus
- Size of pea, but tiny (brain within a brain)
- Responsible for drives (hunger, thirst, sexual), homeostasis (internal balance)
- Controls endocrine system (see later), autonomic system (see later)
- Linked with pleasure pathways
- Reward deficiency syndrome (theory) → deficit in dopamine = have sluggish pleasure pathways, going to resort to drugs, over eating, gambling, over-shopping, just to pump up their pleasure pathways

C.2 - Cerebral Cortex (C.2.1 - C.2.3)

Intro:

- Outer layer of the brain
- Responsible higher mental functioning
- ⅓ is visible → rest is hiding in grooves and folds
- Billions of neurons in brain
- Billions of glial cells or glia (out number neurons)
- Nannies of the neurons → provide nutrition, structural support, clean up after neurons, dispose of dead neurons, production of myelin sheath
- More than nannies (modern research) → involved in info processing, high mental functioning (learning, memory, intelligence), seems to be support for this
- Example: Einstein had more glial cells

2 Hemispheres

- Connected to each other via corpus callosum
  → bundle of nerves that 2 hemispheres use to communicate with each other, how they exchange info
  → no communication if disconnected
  REST IN BRIGHTSPACE

C.2.3 - Brain Reorganization

- Believed that once the brain has matured, it stays the same, fixed, no change unless disease, injury, aging (FALSE)
- The brain has plasticity
  → does change with experience
  → everything done or not done could influence and affect the brain
  → healthy area could take over the functional
  → could mean that an area of the brain could increase or decrease its activity based on experience (dendrites)
  → an area could be larger with more synapses connections
  → smaller = less connections

Neurogenesis (part of plasticity)

- Ability of the brain (whole) to produce new neurons

D - Our Divided Brains

Functional Asymmetry

- In the vortex
- While the 2 hemispheres do carry similar functions, it seems that each one has its own thing, it's own expertise
- There is no left or right brain
- 2 hemispheres work together as a team → emotions, behaviour. Etc
- Through clinical, neuroimaging, split brain patients, we know how

Split Brain Patients

- Suffered from epilepsy → researchers cut of corpus callosum
- Seemed totally fine afterwards
- Right visual field and left visual field DOES NOT mean left eye and right eye
- Info from right visual field → left hemisphere
- Info from left visual field → right hemisphere

Normal Brain

- When we flash something to 1 hemisphere, the other hemisphere will know about it because they can communicate to each other via corpus callosum

Split Brain

- When we flash to 1 hemisphere, the other hemisphere is in the dark, won't know about it because they cannot communicate via corpus callosum

LH → control language and right body

RH → control left side of body

Split Brain Experiment

- Manipulate image, asked about what they see

IV - Spinal Cord (CNS)

- Highway of info
- All info has to go through it (what the brain sends)

Rhythmic Movements

- In spinal there's pattern generators → highly specialized cells, under control by brain (active or inhibited)

Spinal Reflexes

- Innate behaviour (born with it)
- Essential for survival

V - PNS

- I connects the body to the CNS
- Main job → carry info b/w the CNS and body
- Consists of all the nerves in the body that are outside CNS

PNS

→ Somatic

→ Autonomic

SOMATIC NS

- 2 main functions

1. Sensory function (collected by our senses → CNS via sensory neurons)
2. Motor function (sent from CNS → skeletal muscles via motor neurons)

AUTONOMIC NS

- Controls organs glands, visceral muscles (muscles not attached to bone)
- 2 main divisions

1. Sympathetic
   → prepares fight or flight
   → mobilize muscles of body
2. Parasympathetic
   → calm down, conserve energy, helps body repair itself

Ω Endocrine System

- Major communication network
- Consist of all the glands in body → release hormones into the bloodstream

Hormones

- Chemical messengers
- Carry info to different parts including the brain
- 3 major types

1. Homeostasis → responsible for helping internal balance of the body within a healthy range
2. Reproductive → testosterone
3. Stress hormones → adrenaline (short-term are better for us) (long-term = toxic for the brain and body)

NS and Endocrine System

- Both are communication networks
- Influences and affect each other

Pituitary Gland

- Master gland → control other glands in ES
- Controlled by hypothalamus

Affect Behaviours

- Change hormones = change behaviours