

Chapter 2: The Biology of Mind

The nervous system

I. Functions and structure

The nervous system composes of:

1. Central nervous system (Ex. Brain/Spinal cord)
2. Peripheral nervous system (Ex. Nerves)

◆ The two systems must work in an integrated unit!

Function:

- Serves as a communication network
 - Receives information from the senses
 - Organizes, analysis, and integrates the information in a meaningful manner
 - Uses the information along with existing info to send out messages that produce behaviors
 - Creates conscious experience

II. Neurons

A. Basic function and structure of neurons

Over 1 trillion neurons, at least 10 000 types organized based on function

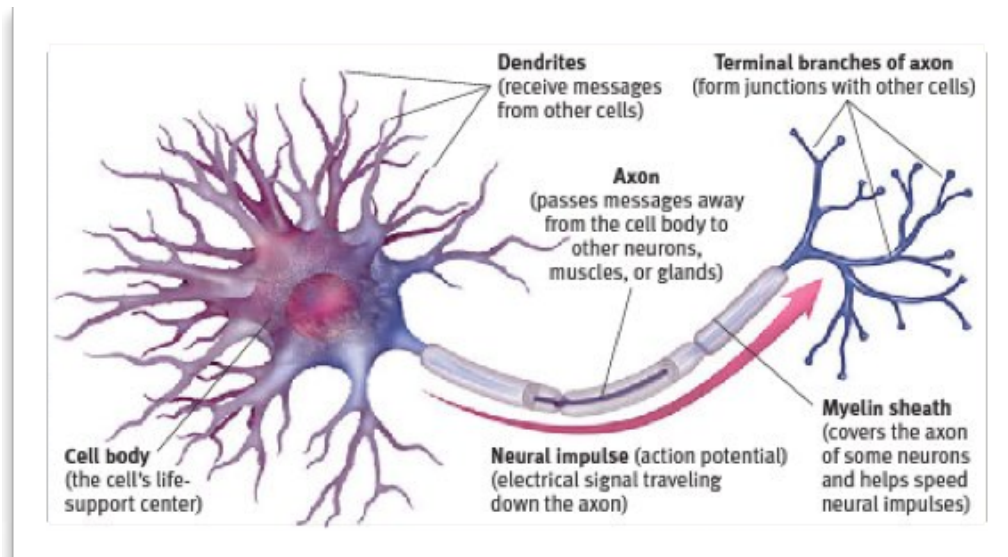
3 types:

- **Sensory neurons**
 - Receive sensory information and send it to central nervous system
- **Interneurons**
 - Found in central nervous system
 - Communication with other neurons
 - Organizes and integrates other information
- **Motor neurons**
 - Carry messages from brain/spinal cord to muscles and glands via nerves

Basic structure

- **Stoma:** cell body; has everything the cell needs to grow
- Dendrites
- Axon
- Terminal buttons/axon terminals
- Myelin sheath
 - Acts as insulation
 - Speeds up the transmission of the electrical impulse (20x faster)

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Synapse: where neurons meet to communicate

Synapse cleft: tiny distance between the two neurons

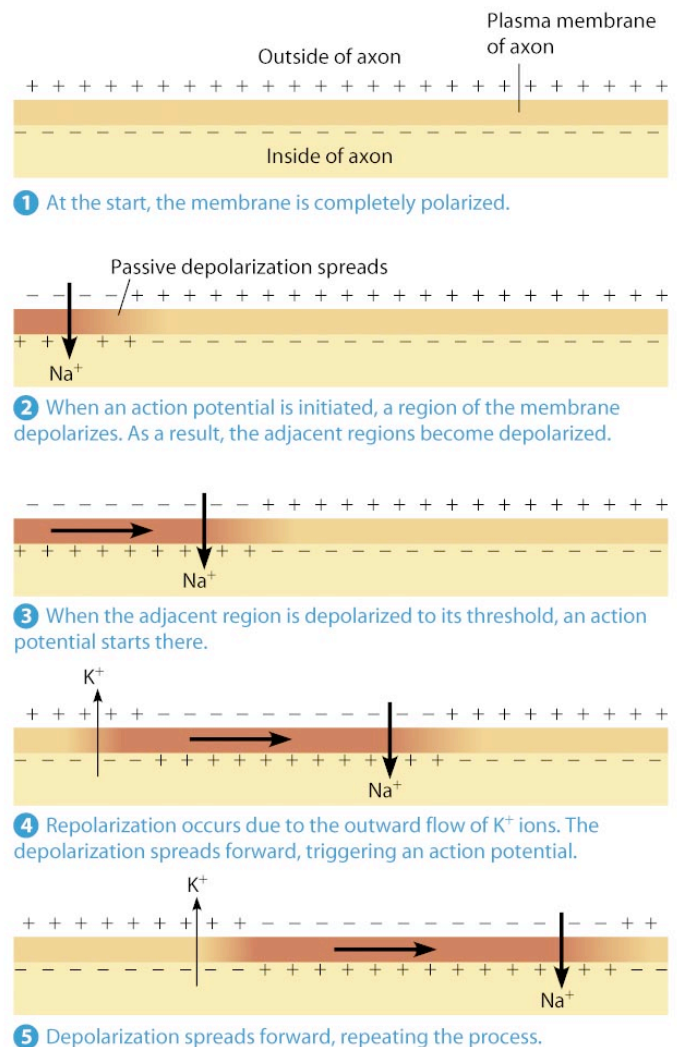
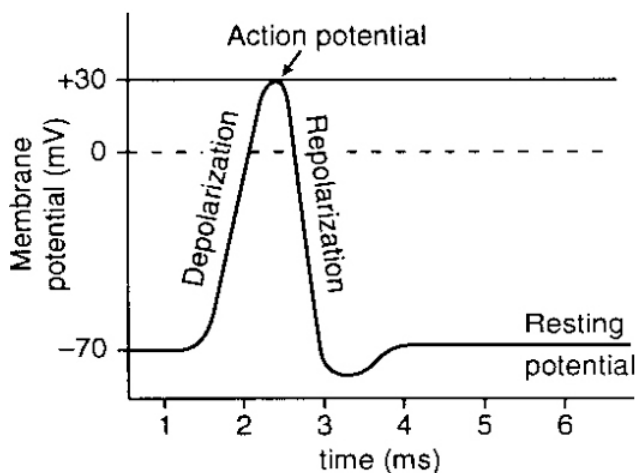
Presynaptic neuron: the neuron that is sending a message

Postsynaptic neuron: the neuron that is receiving the message

B. Communication

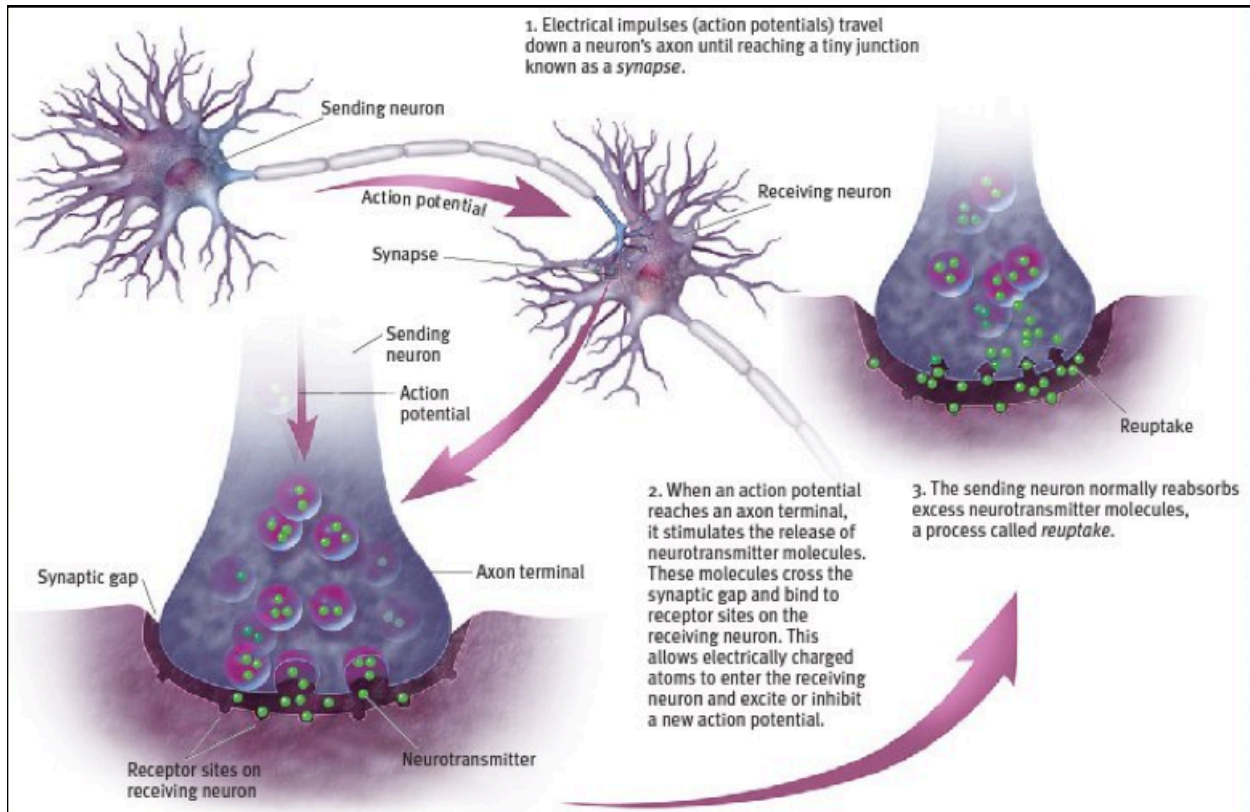
B.1 Communication within a neuron

- Brain is 80% water
- **Intercellular fluid:** water within a cell
- **Extracellular fluid:** water outside a cell
- Dissolved chemical within the water include:
 - Sodium ions
 - Chloride ions
 - Potassium ions
 - Protein ions



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- Action potential is an all or none phenomenon
- Every single time the neuron fires its the same strength
- Action potential travels in a domino effect



B.2 Communication neurons

Neurotransmitters: chemical messages

Synaptic vessels: little sacs that contain neurotransmitters

Receptors: structures found on the post synaptic neuron

- Neurotransmitters when delivering a message attach to the receptors
- Specific neurotransmitters have specific receptors

Presynaptic:

Action potential--> terminal buttons--> synaptic vesicles--> neurotransmitters--> binding to receptor sites

C. Neurotransmitters

- Healthy levels are needed
- When neurotransmitters are out of balance there are devastating effects
- There are at least 75 neurotransmitters

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- **Acetylcholine (ACh)**

- linked to memory/learning/concentration
- every muscle in the body is controlled by this
 - too high --> violent contractions
 - too low --> paralyzing
 - **Example:** Botox blocks neurotransmitters

- **Gaba**

- Inhibitory
 - sends messages to neurons not to fire
 - 1/3 neurons use gaba
 - healthy levels of gaba means your nervous system is relaxed
 - low levels of gaba are predictors of alcoholism
 - alcohol enhances gaba

D. How drugs and other chemicals affect the brain

- Produce affects at the level of the synapse
- 3 levels
 - Influence the activity at the presynaptic neuron
 - inhibit the release of the neurotransmitter, or facilitate the release
It's suppose to release more or release it when it's not needed
 - Activity in the cleft
 - Block the re-uptake or speed it up or slow it down
 - affect degradations
 - block it or speed it up or slow it down
 - Postsynaptic neuron
 - **Lock and mimics**
 - locks itself on the receptor side and act like the neurotransmitters
 - **Locks and blocks**
 - locks onto the receptor side but its not going to mimic the neurotransmitter
 - but blocks the receptor side so the neurotransmitter cant deliver its message
 - **locks and enhance or diminishes**
 - drug molecules locks into receptor side and makes it stronger or weaken the effects of the neurotransmitter

Drugs can be a an:

- **Agonist:** a drug that is going to either mimics the neurotransmitter or going to enhance and facilitate its activities
- **Antagonist:** Blocks the neurotransmitter or diminish and weaken the activity of the neurotransmitter

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III. The Brain (CNS)

A. Introduction

The ancient Greeks

- Aristotle thought the brain was there to cool the blood, he thought the heart was responsible for thinking, behaviors, and thinking.
- Hypocrates: the father of modern medicine. Thought the brain was the center of it all

B. Tools of discovery

B.1 Clinical Observation

- The only way to discover the brain was brain dissection and clinical observation

B.2 Brain Manipulation

- On purpose going to interfere with the brain and observe how it affects behavior

Methods:

- **Surgical:** remove, destroy, or break the connection within an area. Then observe
- **Chemical:** inject a drug that affects a specific part of the brain
- **Electrical:** insert electrode and delivered weak electrical current and observe to see what happens
- **Magnetic stimulation:** expose the area to a magnetic field that interferes with the function of the area
- **Optogenetics:** Genetically engineer neurons to response to light. Then they expose them to a laser light to see what happens

B.3 EEG

- place electrodes on the scalp and the electrodes are going to pick up the electrical activity of the brain
 - by using this technology they can see the brain in action

B.4 Neuro-imaging techniques

1. CT of CAT scan

- Invasive because they use radiation
- take multiple x-rays of your brain at multiple angles and stitch the images together
- shows structure

2. MRI

- Expose the brain to powerful magnetic fields
 - the tissue starts releasing electromagnetic signals, those signal are picked up by sensors in the MRI
 - shows structure

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3. PET scans

- Inject you with a radioactive substance - invasive
- inject with radioactive glucose: when an area of the brain is active its going to consume glucose
 - the area undergoing the most work consumes glucose
 - show brain in action

4. fMRI (functional MRI)

- Exposed to powerful magnetic fields that track blood flow and oxygen levels in the brain.
 - If an area of the blood is active more oxygenated blood is going to go there
 - show brain in action

C. Tour of the brain

C.1 Lower Brain Structures

C.1.1 Brain stem

- Relay station
- A cross-over point: Left part of the brain crosses the message to the right of the body
- Life centre of the brain: structures that control vital body processes
 - Medulla: controls reflexes, heart rate, breathing
If damages you can not survive
 - Reticular formation: alertness, attention, consciousness, arousal

C.1.2 Thalamus

- relay station: information from all the senses except smell, and relays information to higher brain structure
- The higher brain structures send motor information to thalamus which sends it to lower brain structure
- It also filters processes and integrates this information in addition it highlights some of this info and de-emphasizes others.
- Recent studies show that the thalamus is part of a system that directs attention/ conscious to important

C.1.3 Cerebellum

- it controls voluntary muscle movements, coordinated muscle movements, muscle tone and balance
- 20x more connection than other parts of the brain
- involved in learning and memory
- cerebellum is affected when you drink alcohol

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C.1.4 Limbic system

- Consists of different structures
- links to learning/memory/motivation
- **Amygdala:**
 - involved in emotional processes
 - linked to rage and aggression and fear
 - involved in perception of emotion
 - involved in detecting threatening stimuli and those that you are not consciously aware of
- **Hypothalamus**
 - control many vital functions
 - Drives: hunger, thirst, sex
 - homeostasis: maintaining the internal balance of the body
 - **Example:** blood pressure
 - Endocrine system
 - autonomic system
 - pleasure centers in the brain: essential for survival
 - **Reward deficiency syndrome:** people become addicted to drugs because they're using the drugs to help their pleasure centers

C.2 Cerebral cortex

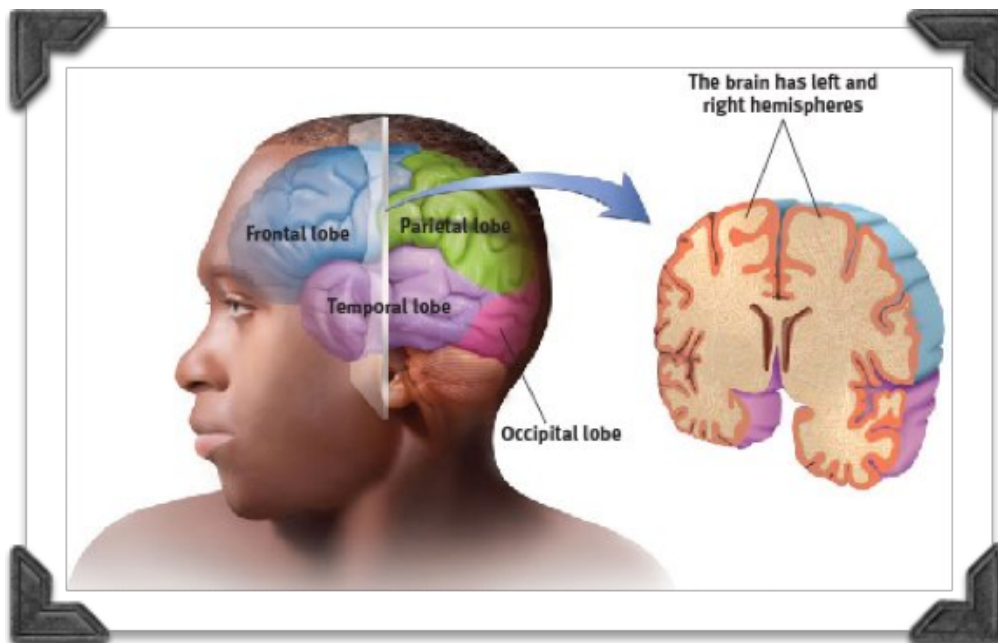
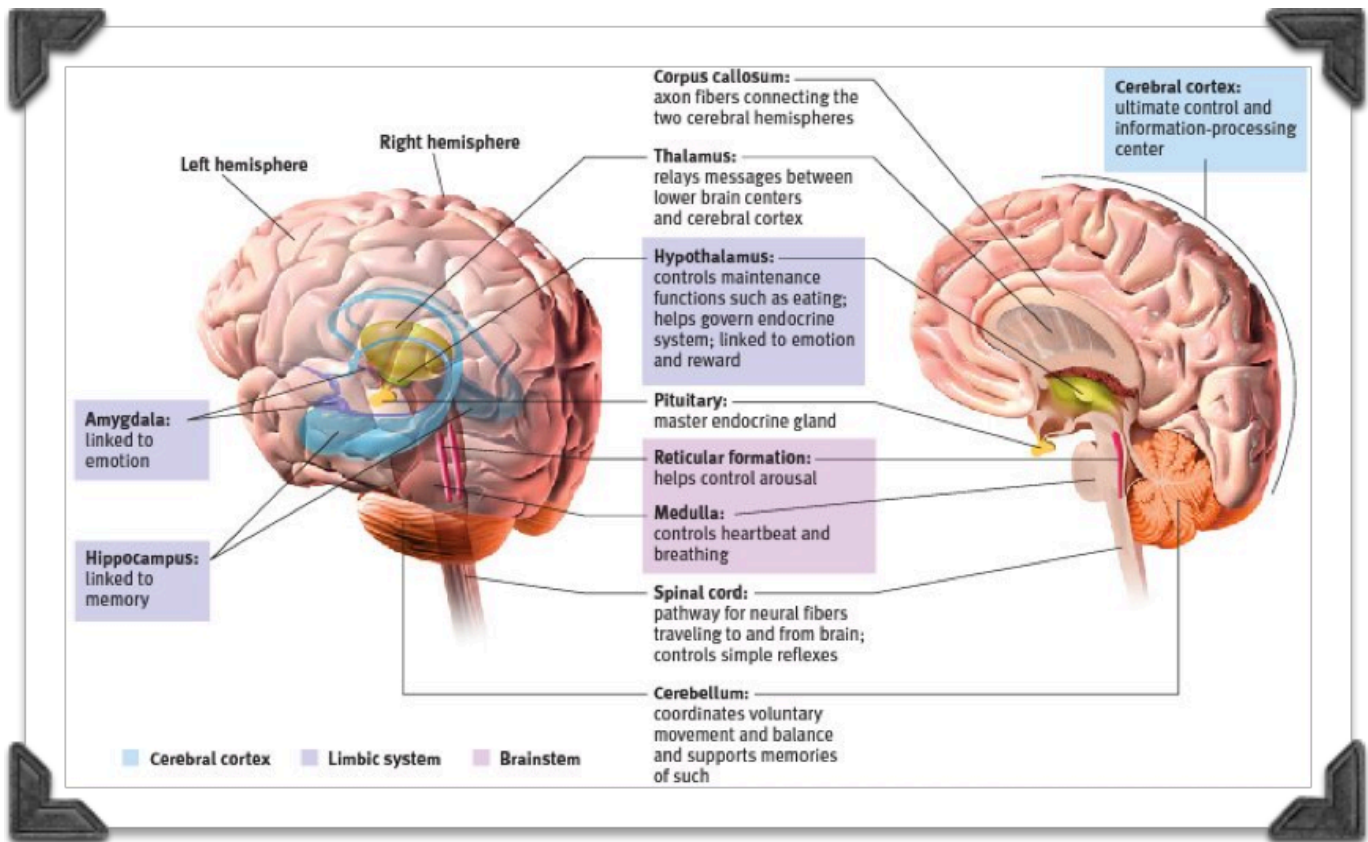
C.2.1 Cerebral cortex and function

- the youngest part of the brain
- gives us our mental superiority
- 1/3 visible
- billions of neurons
- **glial cells** (nanny of the neuron)
 - provide functional/structural support
 - clean up waste of neurons
 - deliver nutrients
 - produce Schwann cells
 - protect neurons from invaders
 - 9X more
 - information processes/memory

In the brain, each lobe consists of:

- **Primary area:** processes sensory or motor information
- **Association area:** processes higher mental functioning, perception, decision making. Also processes complex sensory or motor information

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Primary areas:

Lobes

- Frontal
- Parietal
- Temporal
- Occipital

Primary Cortex

- Motor
- Somatosensory
- Auditory
- Visual

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Primary motor cortex:

Location: frontal lobes

Function: controls voluntary movements

- Stimulating parts of this region in the left or right hemisphere causes movements of specific body parts on the opposite side of the body.
- Discovered by Fritsch and Hitzig
- Adjacent body parts are serviced by areas of the brain adjacent to each other
- The size of the body part does not determine how much brain is associated with it

Primary somatosensory cortex:

Location: Parietal lobe

Function: skin, touch receptors all over your body, muscles and joints (receive info from them). Processes info on touch, temperature, vibration, pressure, and the location and position of vital parts. Processes pain.

Auditory cortex:

Location: temporal lobes

Function: processes hearing

- auditory information travels a circuitous route from one ear to the auditory receiving area above your opposite ear.

Association areas

- Neurons in association areas integrate information.
 - link sensory inputs with stored memories
 - electrically probing the association areas doesn't trigger any observable response
- Association areas are found in all four lobes
- Damaged frontal lobe leads to:
 - intact memories
 - high scores in intelligent tests
 - great baking skills
 - altered personality
 - lack of person's inhibitions

C.2.2 Brain reorganization

Brain plasticity: the brain's ability to modify itself after some types of damage

- our brains are most plastic when we're children

Constraint-induced therapy: aims to rewire brains by restraining a fully functioning limb and forcing use of the "bad hand" or uncooperative leg.

Neurogenesis: the formation of new neurons

- the adult brain continues to form new neurons

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Examples:

- Monkey brains form thousands of new neurons each day.
- Master stem cells that can develop into any type of brain cell have been discovered in the human embryo

D. Our divided brains

Functional asymmetry

- hemispheres in the brain don't carry out the same functions

In 1961, two LA neurosurgeons speculated that seizures were caused by an amplification of abnormal brain activity bouncing back and forth between two cerebral hemispheres. So, they cut the corpus callosum and the seizures were eliminated with hardly any affect.

In attached brain hemispheres there is communication between the two even though if only the right or left hemisphere of the brain is the one to process something. While in split brain patients this does not happen.

Right hemisphere

- processes information from the left side of the body
- non-verbal
- understands simple requests
- perceives objects
- quick/intuitive responses
- perceives emotions
- when a person performs a perceptual task brain waves, blood flow and glucose consumption activity increases here
- construct our sense of self

Left hemisphere

- processes information from the right side of the body
- language
- decision making
- when speaking or calculating activity increases here
- deaf people use this hemisphere for process of sign language

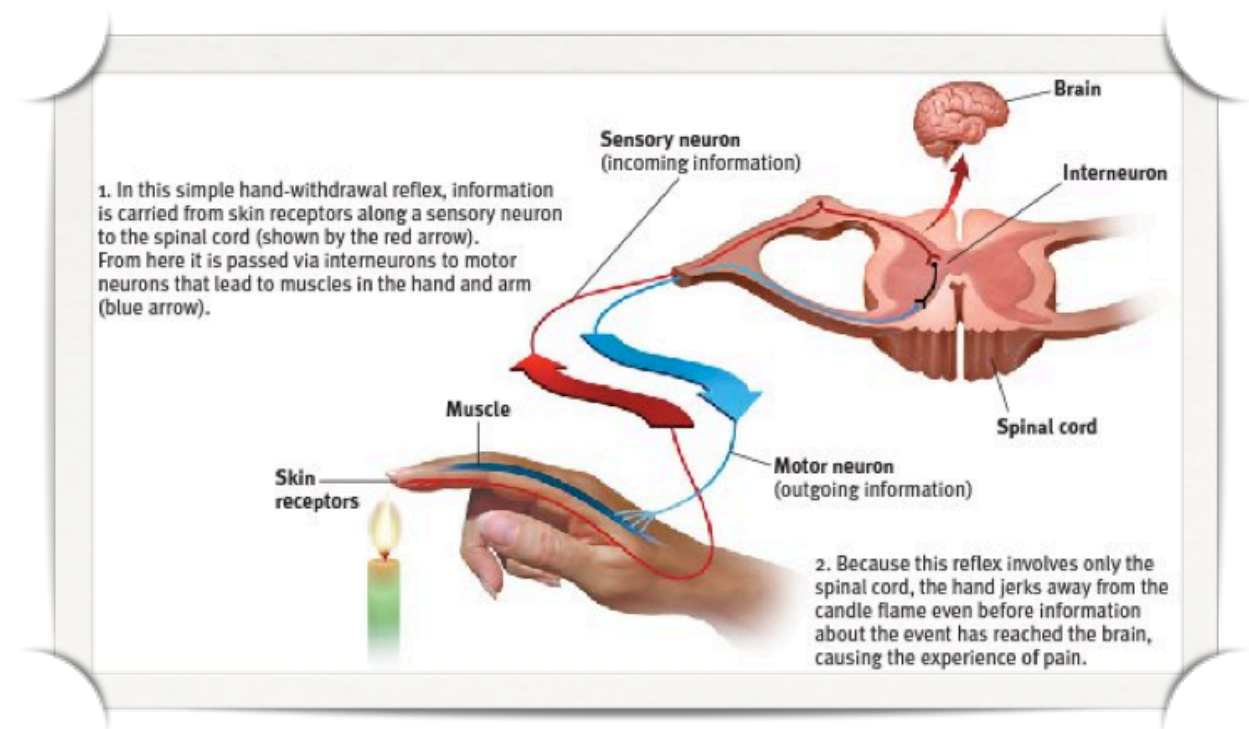
Note: information that is presented in the right visual field goes to the left hemisphere and vice versa.

Almost all right-handers process speech primarily in the left hemisphere, which tends to be slightly larger. 7/10 left handers process speech on the left too and the rest either process it on the right or both hemispheres.

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IV. Spinal cord (CNS)

- **Spinal cord:** an information highway connecting the peripheral nervous system to the brain
- Connects brain to rest of the body
- Functions as a relay station
 - all information must cross spinal cord, thus damage here is bad.
 - the part below the spinal cord will be paralyzed if it is severed
- Controls rhythmic components of movements
 - pattern generators
- **Reflexes:** automatic responses to stimuli
 - automatic
 - unlearned
 - involuntary behaviors



V. Peripheral nervous system

Consists of two components:

- Somatic
- Autonomic

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Somatic nervous system:

- enables voluntary control of our skeletal muscles
- reports to your brain the current state of your skeletal muscles
 - and carry instructions back

Autonomic nervous system:

- controls our glands
- controls muscles of our internal organs
 - influencing glandular activity, heartbeat, and digestions

Autonomic nervous system

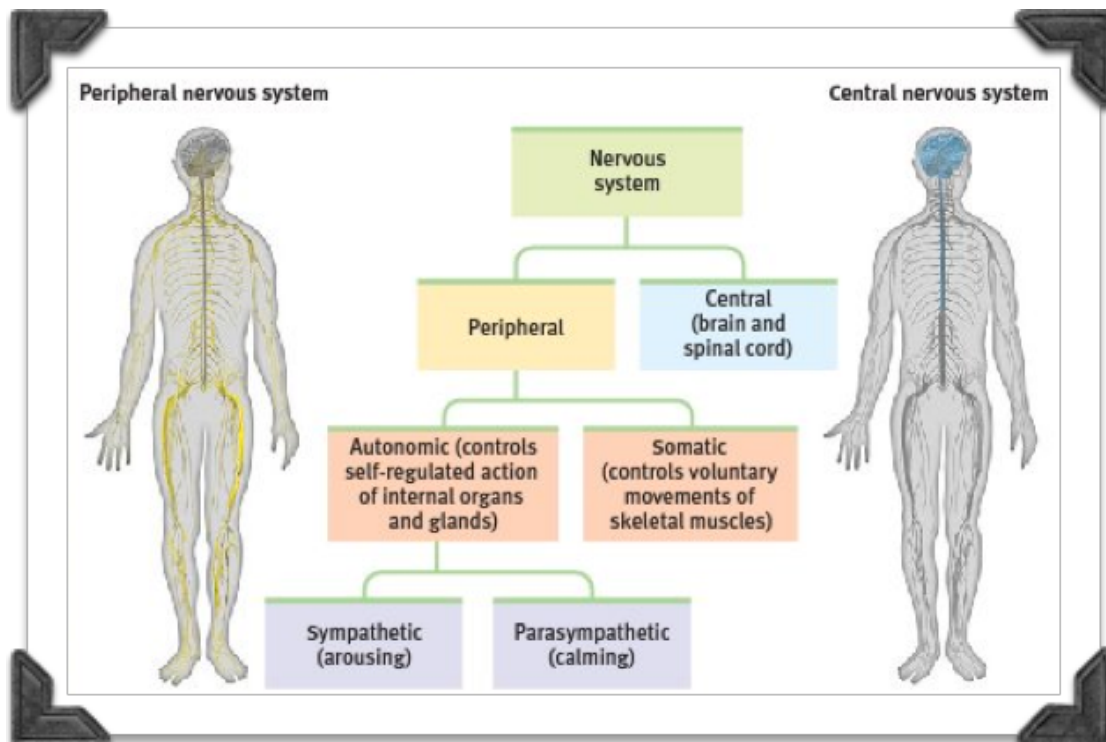
Sympathetic nervous system: arouses and expends energy

Example: Is something alarms you, your sympathetic system will accelerate your heartbeat, raise your blood pressure, slow you digestion, raise your blood sugar, and cool you with perspiration.

Parasympathetic nervous system: produces opposite effects when stress subsides

Examples: conserves energy as it calms you by decreasing your heartbeat, lowering blood sugar, etc.

◆ In everyday situations, the sympathetic and parasympathetic nervous system work together to maintain an internal balance



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Endocrine system

- communication network
- consists of glands that release hormones directly into the blood stream

Hormone: chemical messengers released by endocrine glands into the blood stream.

- deliver messages to different tissues including the brain

3 major type of hormones:

Homeostasis hormones:

Example: insulin keeps blood sugar steady, renin released by kidneys to maintain blood pressure within a range

Reproductive hormones: in charge of body changes, related to pregnancy

Stress hormones: released by the body when we're under physiological changes

Example: adrenaline/epinephrine - dilates pupils, raises blood pressure, cortisol helps you heal the wound

The relationship between the nervous and endocrine system.

- the nervous system controls the endocrine system via the hypothalamus
- once hormones are released in the blood stream they will effect the nervous system

Pituitary gland (master gland)

- controls other glands
- Hypothalamus control this gland

Hormones affect behaviors and thats why we study them