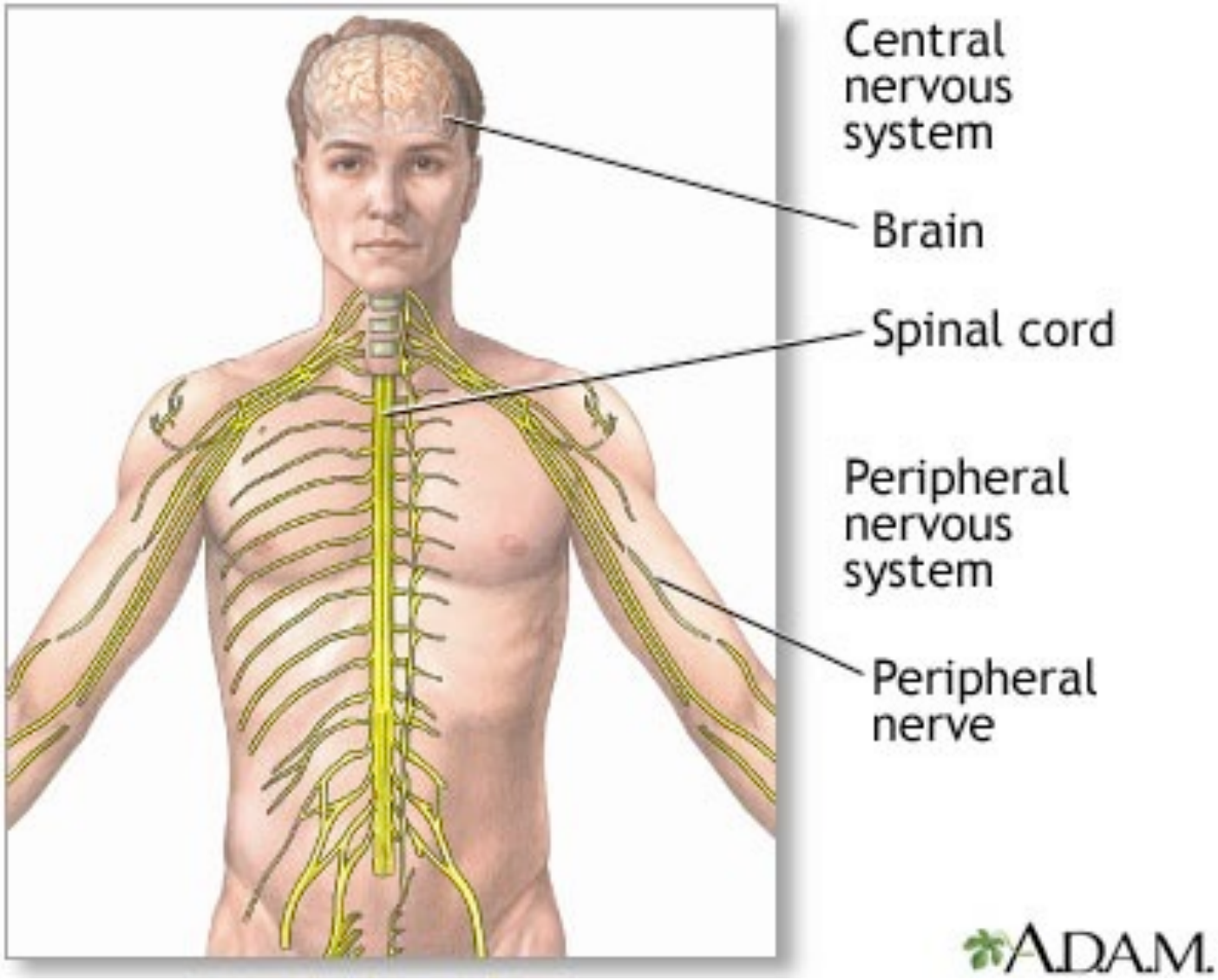
THE HUMAN NERVOUS SYSTEM



THE HUMAN NERVOUS

- **NERVOUS SYSTEM** = the control system that enables animals to detect a stimulus and coordinate response.

A change in the environment (internal OR external) that is detected by your body is called the **STIMULUS**.

Your body's reaction to the change is called a **RESPONSE**.

THE HUMAN NERVOUS SYSTEM

Smell of pizza…

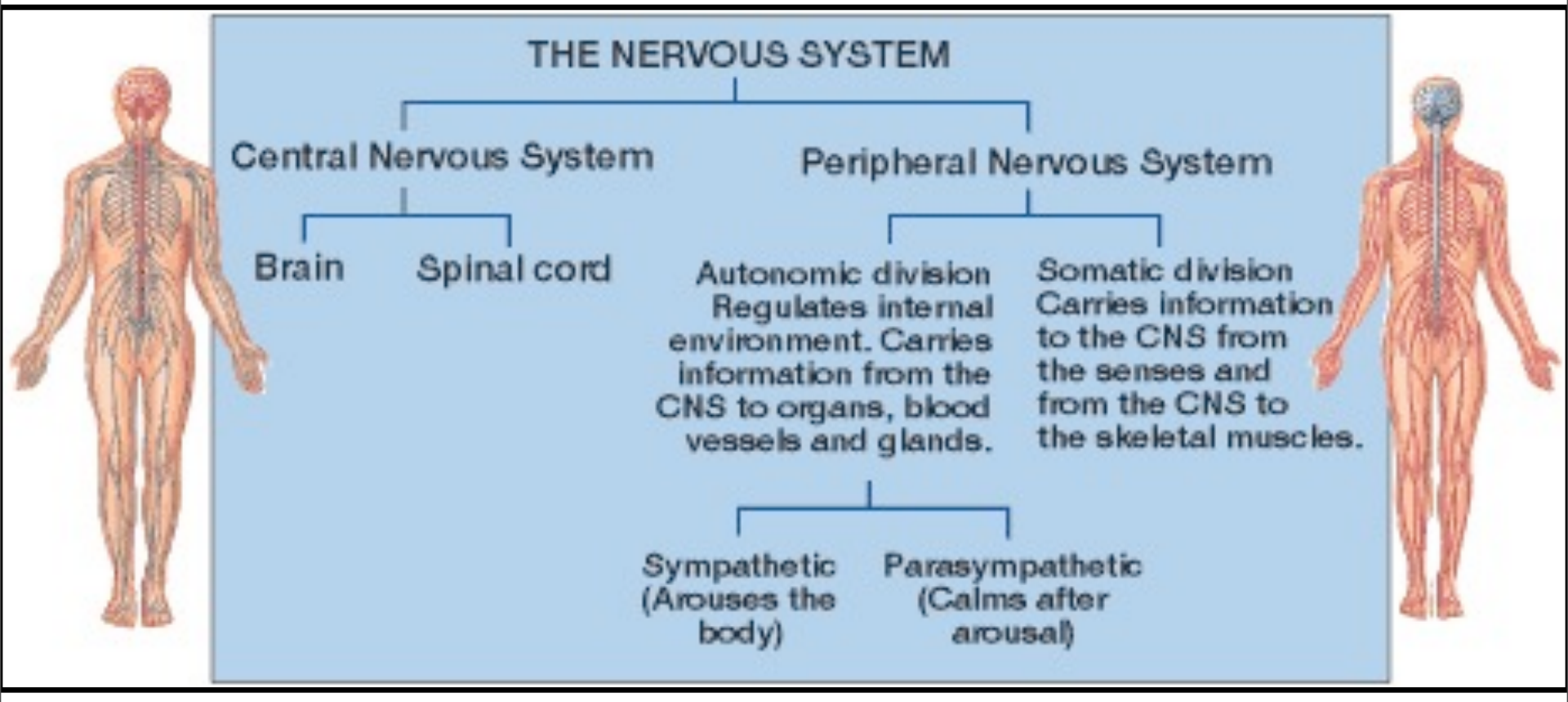
…leads to the secretion of saliva!

Accidentally touching a hot iron…

…you instantly feel pain and quickly pull your hand away!

THE HUMAN NERVOUS SYSTEM

The nervous system has **2 main divisions**: the CENTRAL NERVOUS SYSTEM (CNS) and the PERIPHREAL NERVOUS SYSTEM (PNS). The PNS is further divided into the **somatic** and **autonomic** systems.

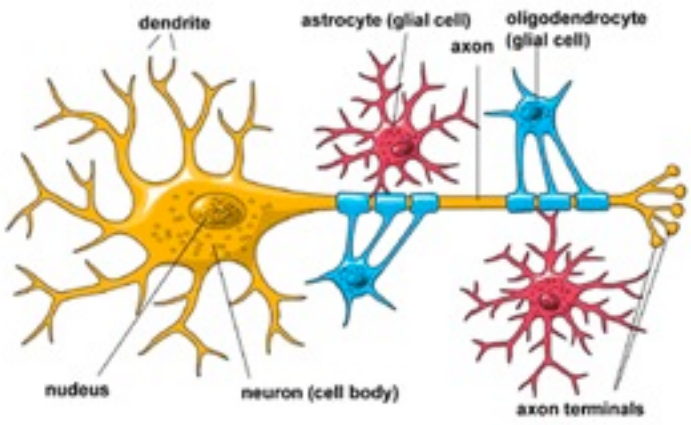


THE HUMAN NERVOUS SYSTEM

- Two different types of cells are found in the nervous system:

  » **GLIAL CELLS** – non-conducting cells important for the structural support and metabolism of the nerve cells.

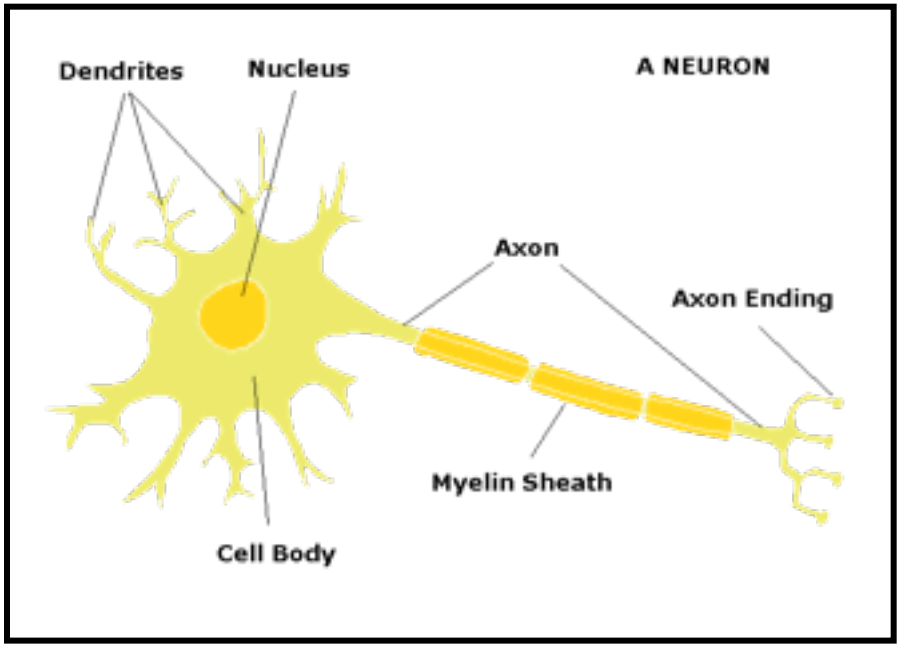
  » **NEURONS** – are the functional unit of the nervous system. These are cells that conduct nerve impulses.



NEURONS

- A **nerve cell** is called a **NEURON!**

NEURON = a specialized cell that uses **electrical signals** to communicate with other cells.

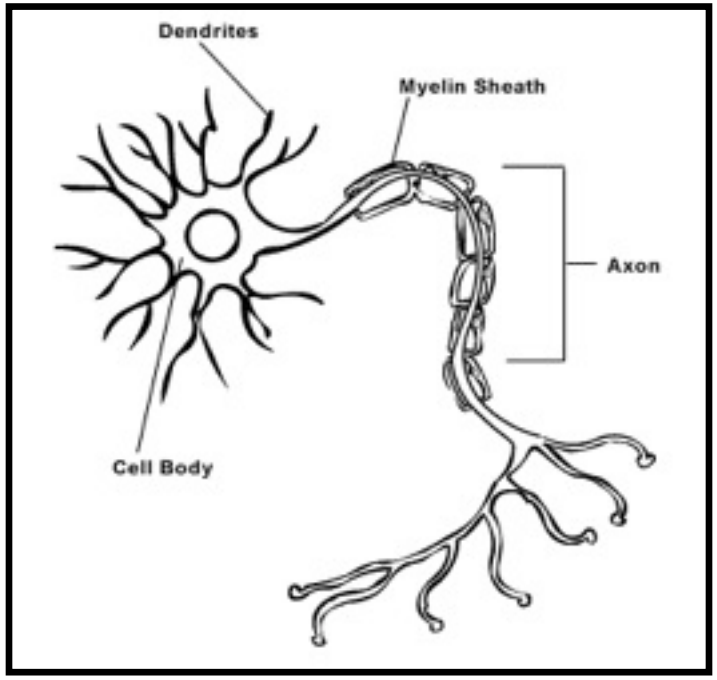


The electrical signal is called an **IMPULSE**.

The IMPULSE moves DOWN the neuron at a very fast rate – to allow for quick responses.

NEURONS

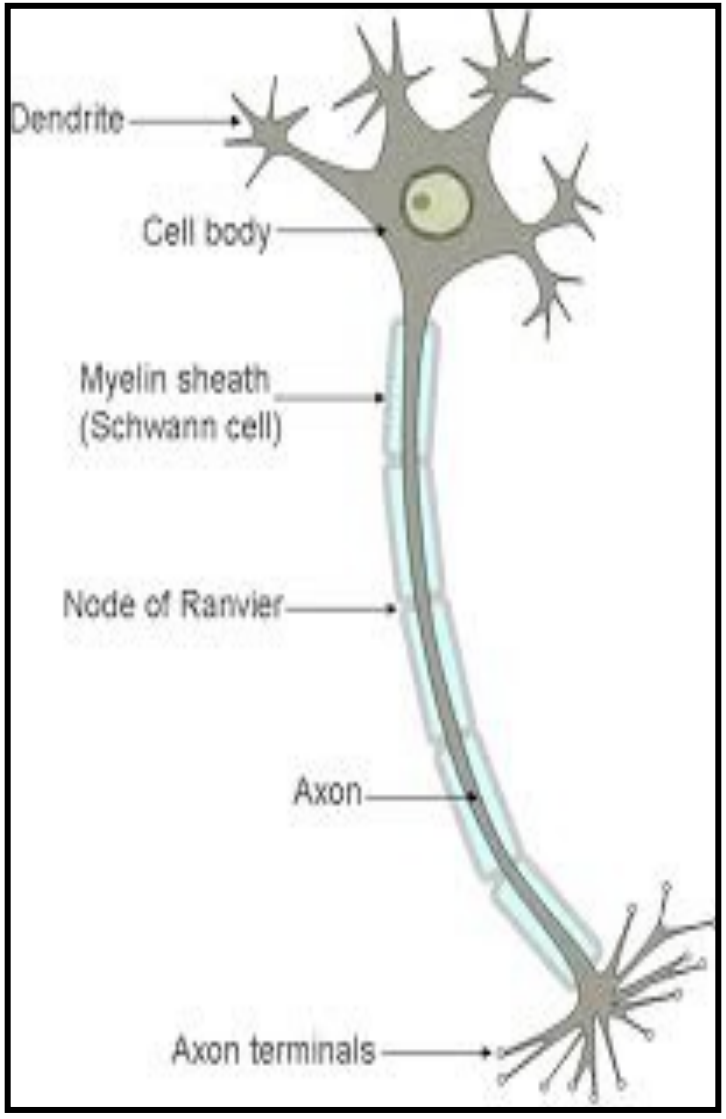
- All neurons have the same basic structure.



Each cell has a large **CELL BODY** and many short **DENDRITES** that carry signals from outside the neuron toward the cell body.

A single, long **AXON** carries impulses ***AWAY*** from the cell body toward other cells.

NEURONS

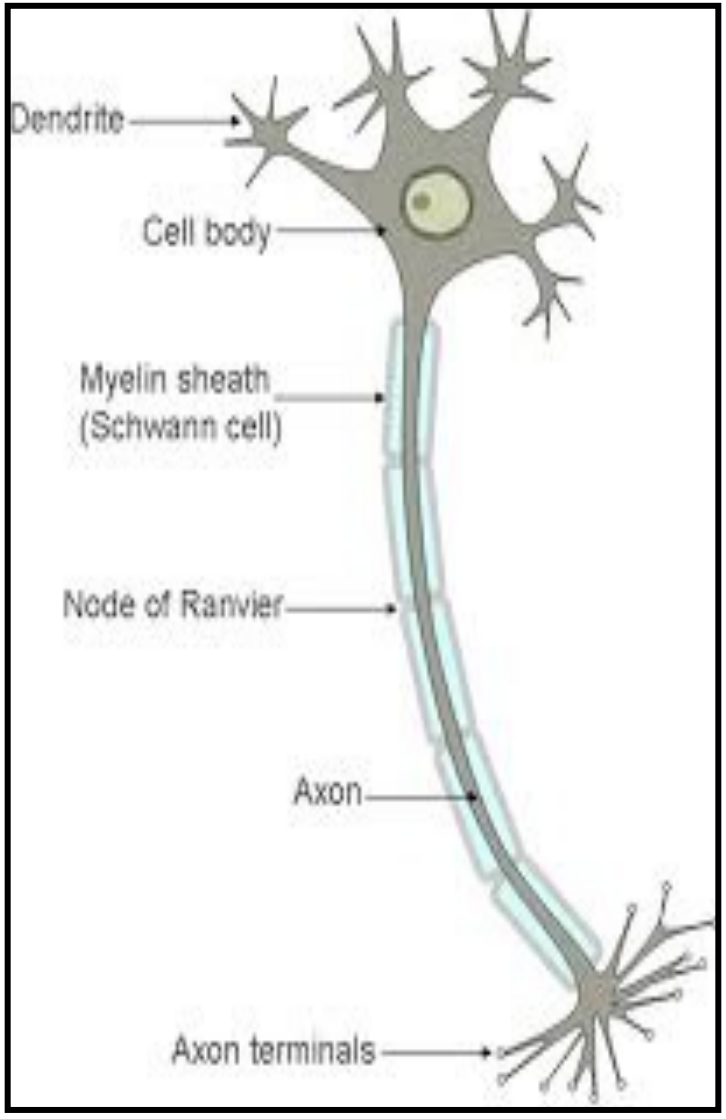


The **AXON** carries impulses ***AWAY*** from the cell body toward other neurons or effectors.

Axons are covered in a fatty, white **MYELIN SHEATH** which acts as insulation for the neurons (by preventing the loss of charged ions from the nerve cell. This sheath is formed by special glial cells called **SCHWAN CELLS**.

The areas between the myelin sheath are known as **NODES OF RANVIER.**

NEURONS

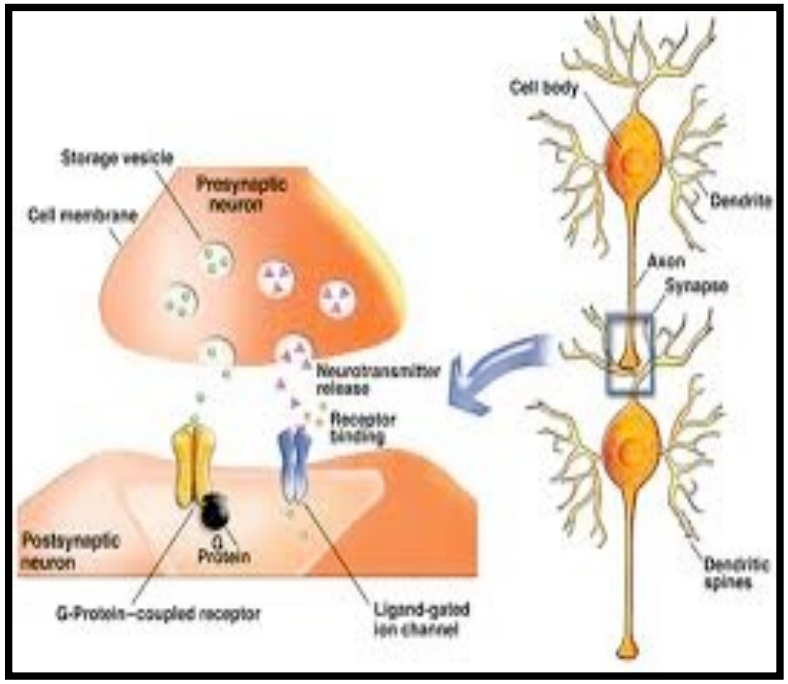


Nerve impulses travel down the axon by jumping from one node to another.

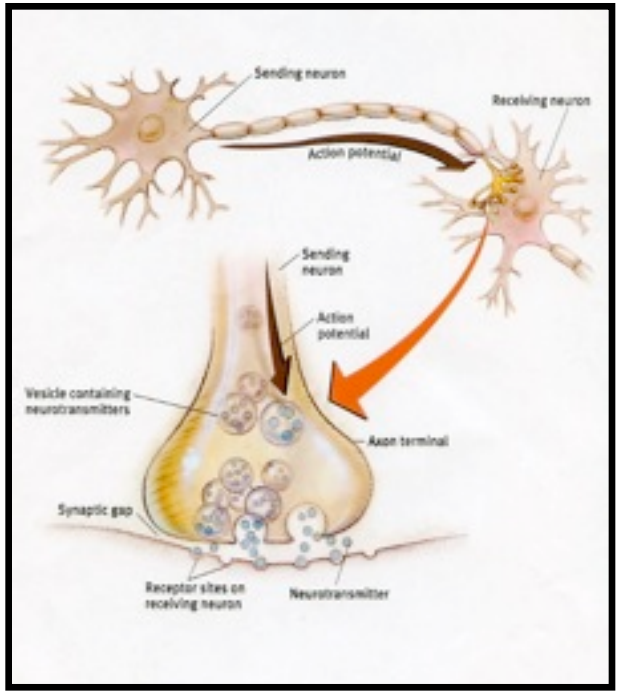
TERMINAL KNOBS at the end of the axon attach the neuron to other neurons OR to other cells.

http://www.youtube.com/watch?v=ob5U8zPbAX4

NEURONS



The connection between the terminal knob of a neuron's axon and a dendrite of another neuron is called a **SYNAPSE**.



A bundle of neurons is called a **NERVE**.

TYPES OF NEURONS

- Animals with a brain have **3 types of neurons**:

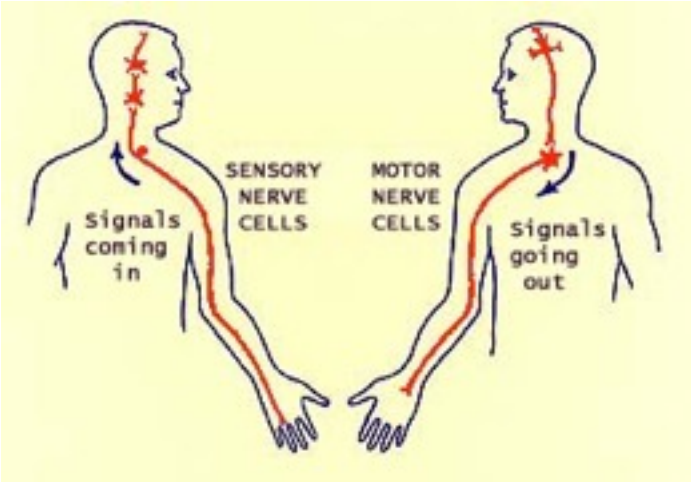
  » **SENSORY NEURONS**

  » **MOTOR NEURONS**

  » **INTERNEURONS**

TYPES OF NEURONS

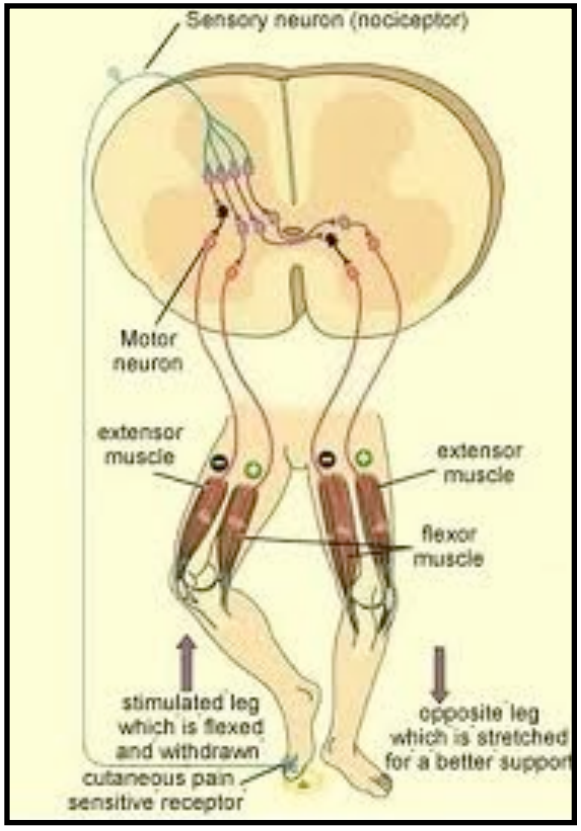
SENSORY NEURONS = carry impulses from the **EYE** (sight), **EAR** (hearing), **TONGUE** (taste), and **SKIN** (pressure and heat) to the brain!

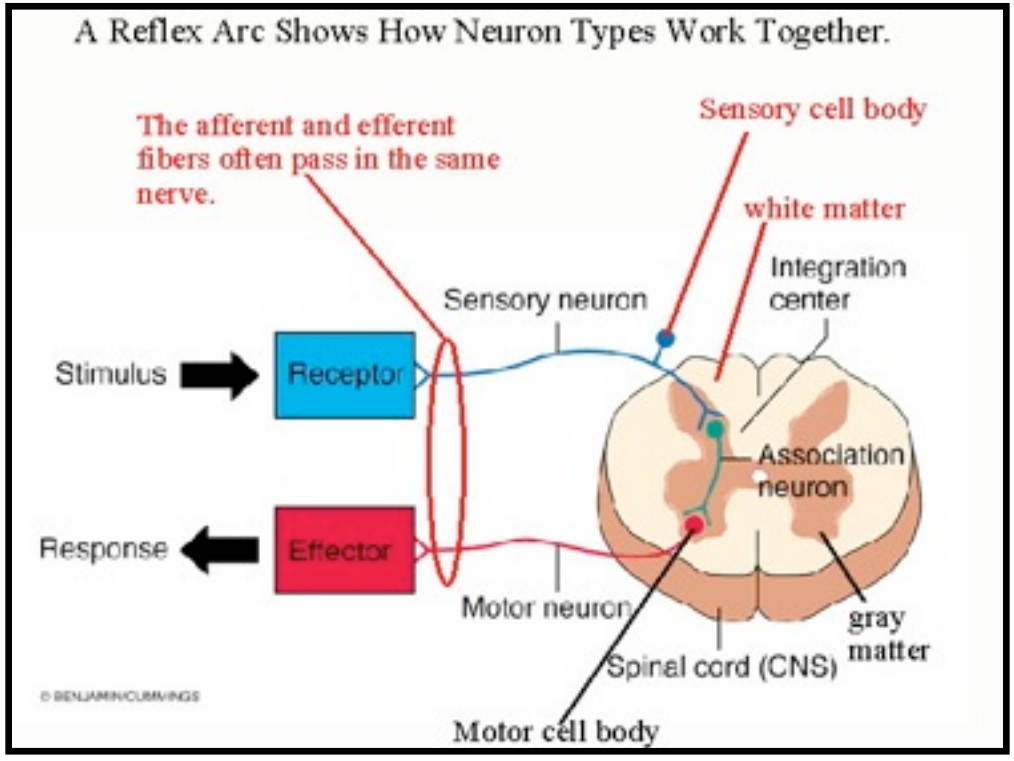


MOTOR NEURONS = carry impulses from the brain to muscles (for movement) or a gland (hormone secretion).

TYPES OF NEURONS

INTERNEURONS = are neurons in the brain and spinal cord that connect **sensory** and **motor** neurons.

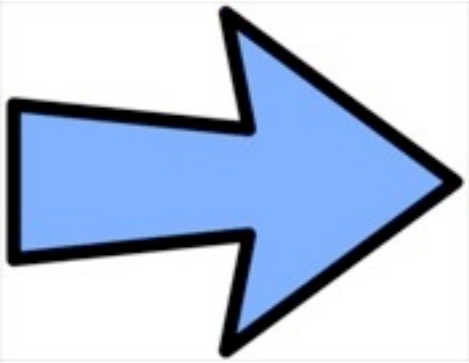




REFLEX ARCS

Smell of pizza…

…leads to the secretion of saliva!

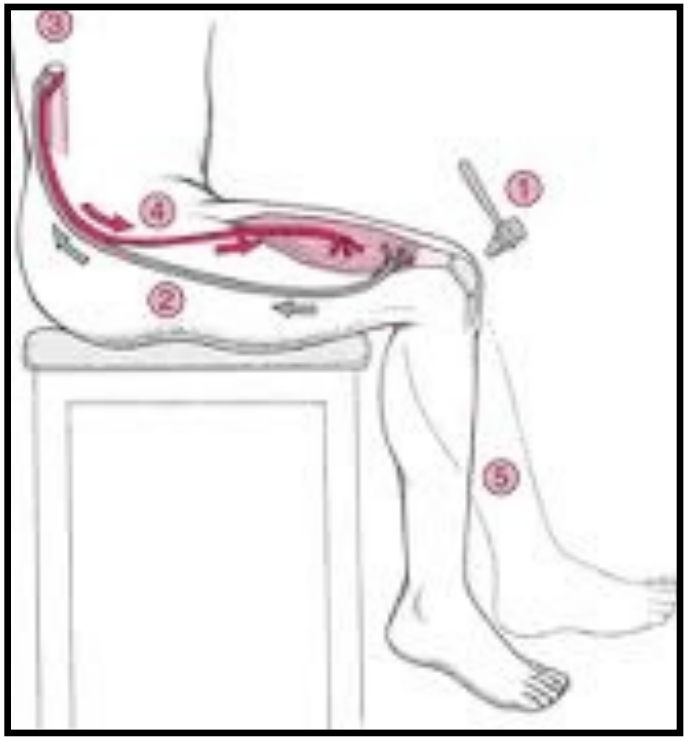


What is happening in the brain????

1. When you smell the smell of pizza, receptors in the NOSE send an impulse through **SENSORY NEURONS** to the brain.
2. The sensory neurons synapse with **INTERNEURONS** in the brain, which connect with motor neurons.
3. The **MOTOR NEURON** sends an impulse to the salivary glands causing them to secrete saliva!

REFLEX ARCS

A **REFLEX ARC** produces very fast responses to stimuli. Reflex actions are predictable, automatic, and unlearned (innate).



1. The doctor's hammer hits the knee just below the knee cap.

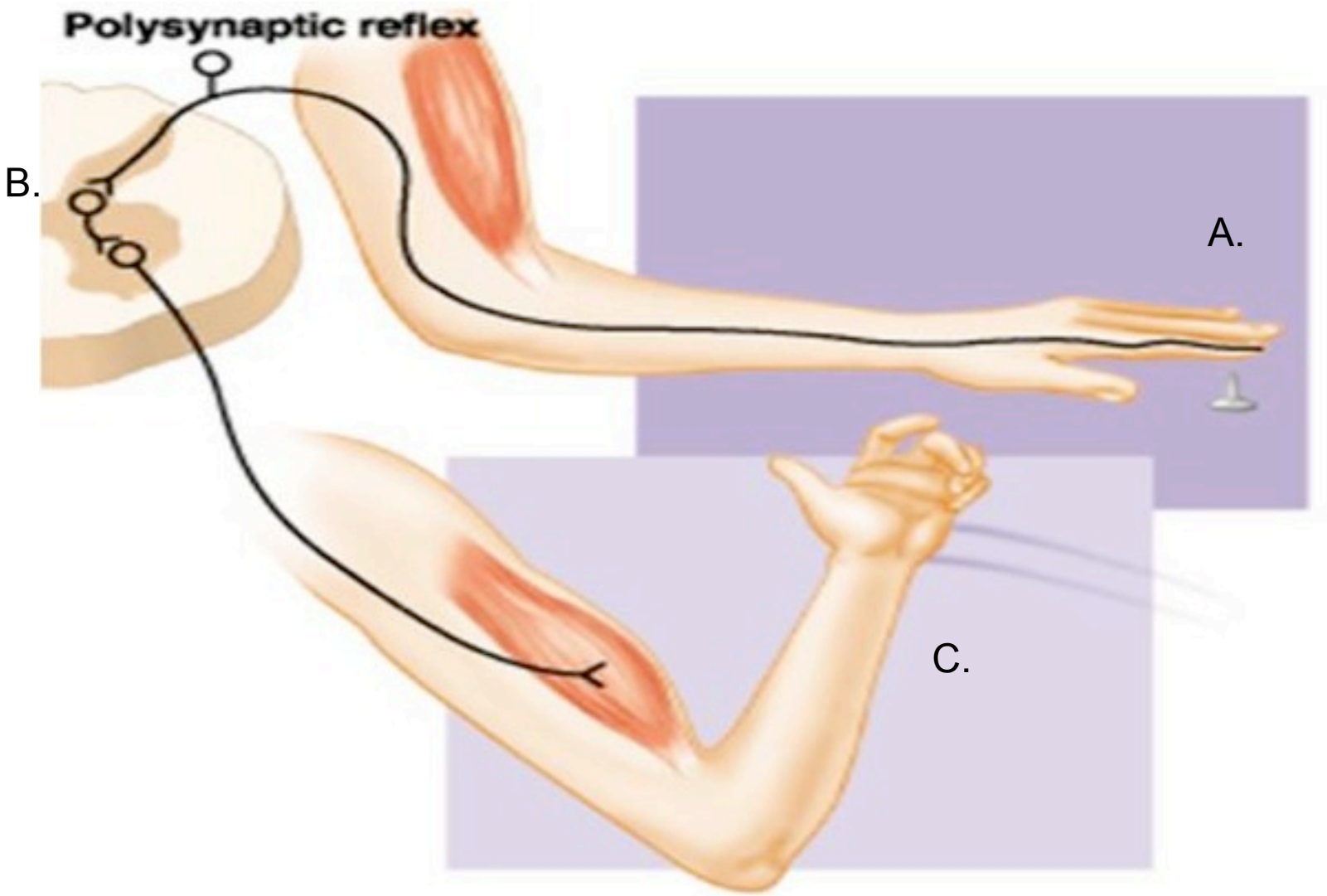
2. This message travels along a sensory neuron to the brain.

3. The sensory neuron synapses in the brain with an interneuron that passes the impulse to a motor neuron.

4. A response impulse travels down a motor neuron and synapses with your leg muscle.

5. Your leg muscle causes your leg to kick a little.

REFLEX ARCS



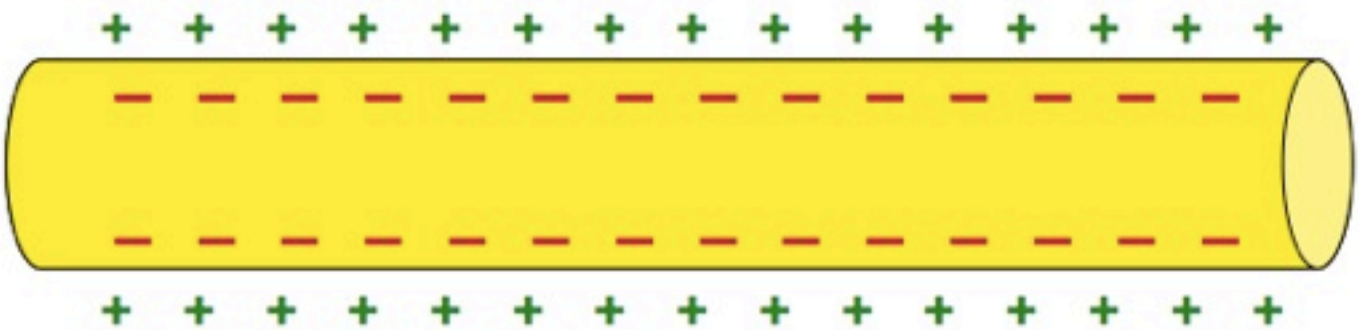
ELECTROCHEMICAL IMPULSE

- nerve impulses are ELECTROCHEMICAL MESSAGES created by the movement of ions through the nerve cell membrane.

- When there is a nerve impulse, a rapid change in the electro-potential difference across the membrane is detected.

Resting Potential Stage

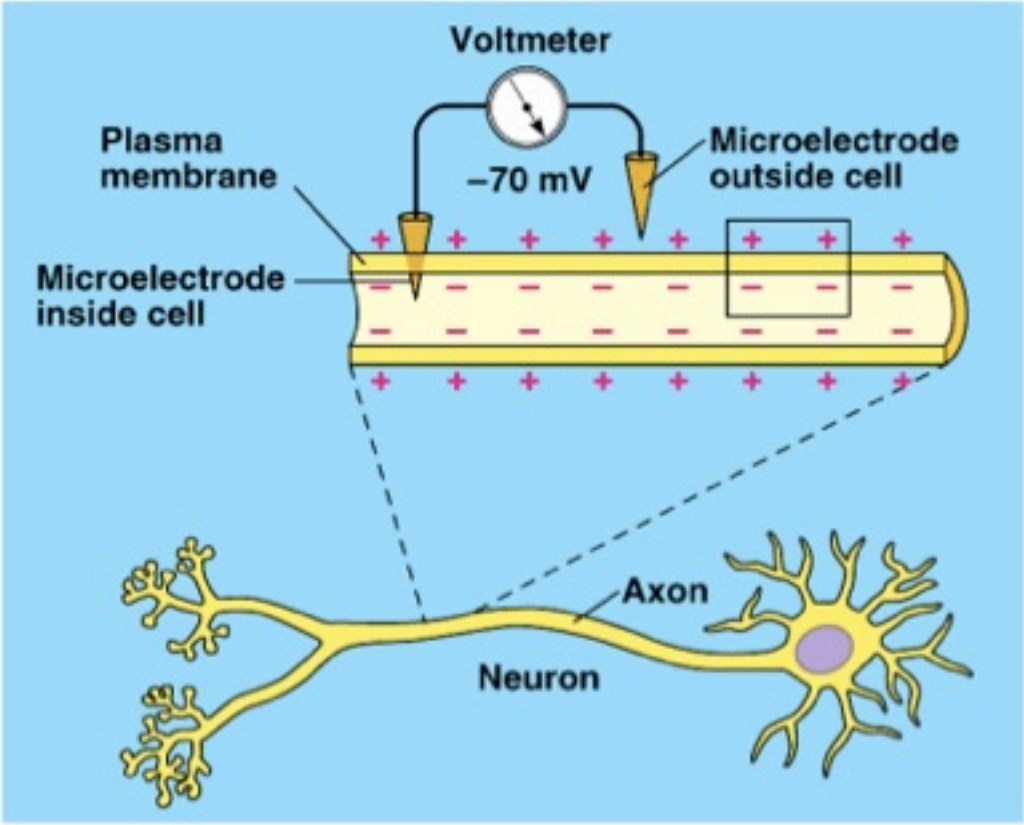
- membrane is **polarized**
- **Inside** of the membrane of the neuron is **negatively** charged compared to the outside
- **Outside** the cell, there is a **higher [Na+]** and **lower [K+]** outside the cell than inside



- the membrane is 50 times more **permeable** to K^+ than to Na^+ so that while Na^+ is moving into the cell, there is more K^+ **diffusing** out of the cell leaving the interior of the cell more **negative** than the exterior

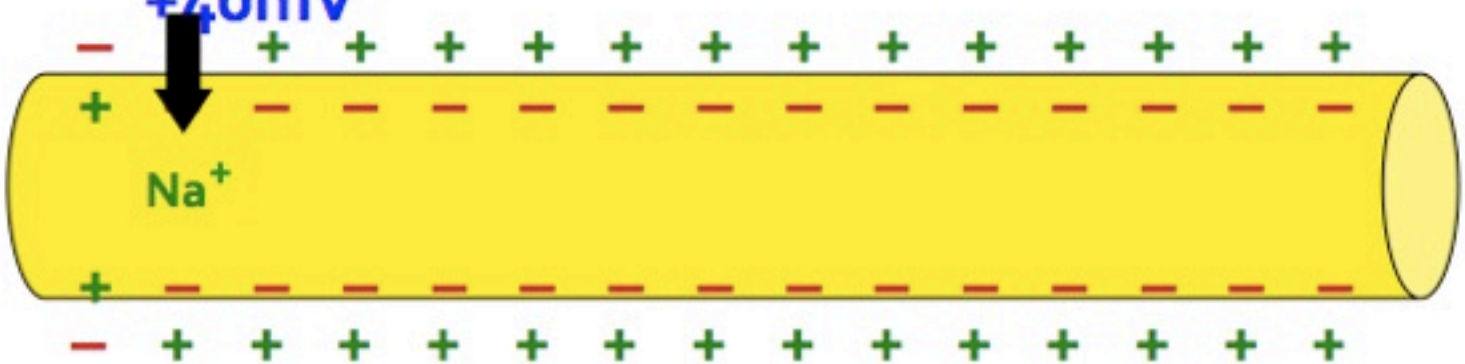
- Difference in concentration of ions across the membranes is maintained by the **sodium-potassium pump.**
- The **resting potential** is measured to be **-70 mV** with respect to the extracellular fluid surrounding the axon.

Resting Potential Stage



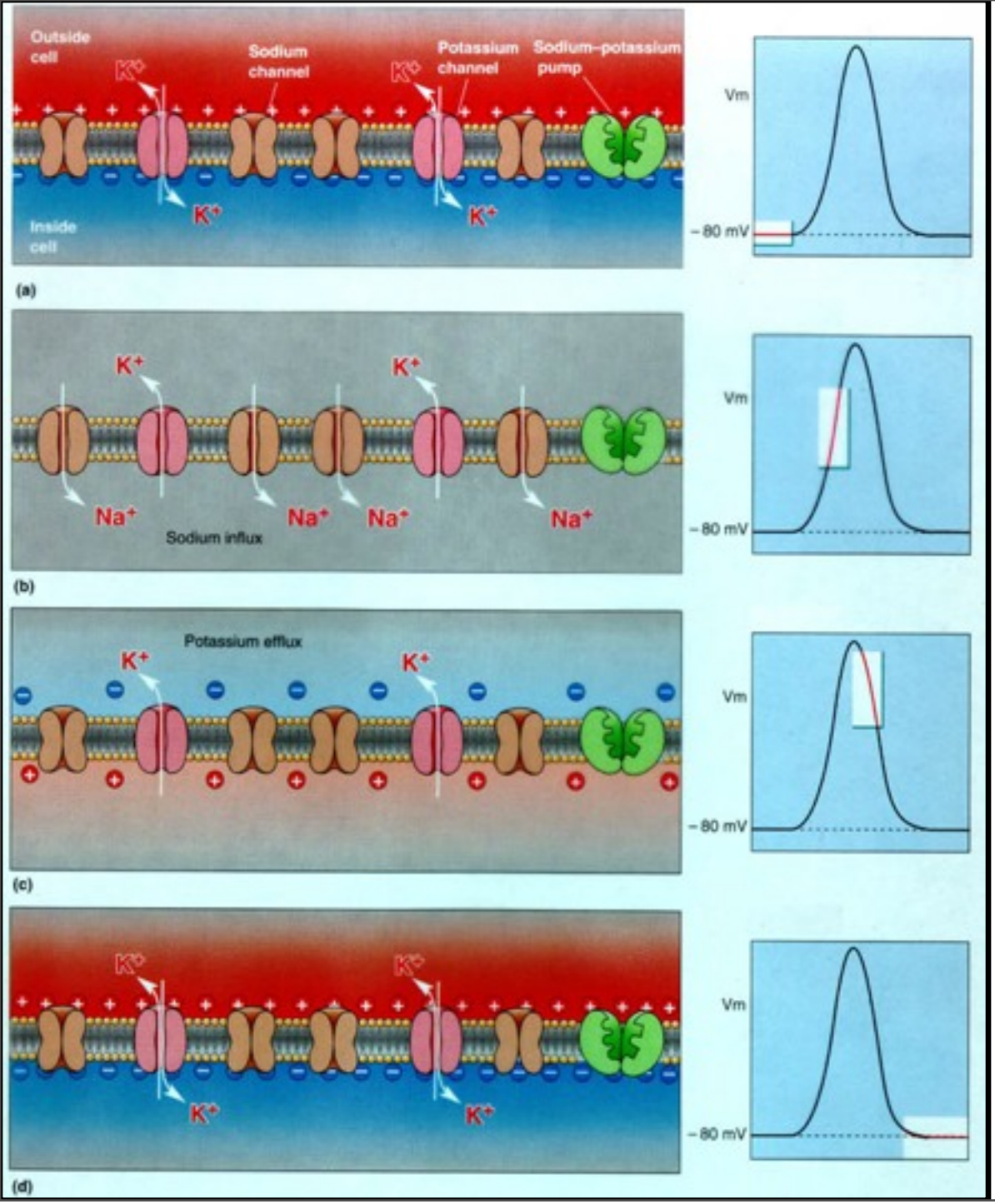
Action Potential

- "wave" of depolarization
- nerve is **stimulated**
- Stimulus causes **Na^+ channels** to open
- Na^+ ions diffuse **into** cell
- Interior becomes **depolarized** (i.e. becomes less negative)
- Membrane potential changes from **–70 mV to +40mV**



Action Potential

- change in charge opens next Na^+ gates down the line
- This wave of depolarization is called the **action potential**
- Initially the Na^+ ions **increase** their own permeability through the axon membrane, a case of **positive** feedback, then as their **concentration increases**, the **permeability** of the membrane **decreases**, because of **negative** feedback.



Resting membrane is more permeable to K+ than to Na+. K+ diffuses out faster than Na+ diffuses in. The outside of the nerve cell becomes positive in relation to the interior.

A wave of depolarization causes sodium gates to open and there is an influx of Na+ ions into the cell. The membrane becomes depolarized.

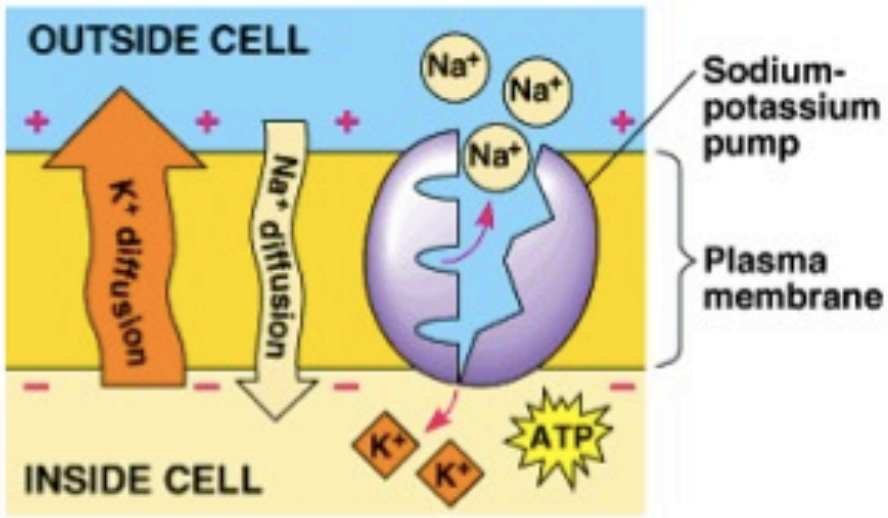
Following depolarization, sodium gates close, while potassium gates are once again opened. K+ moves out of the cell by diffusion Once again, the cell exterior becomes negative in relation to its interior.

The sodium potassium pump restores and maintains polarization by pumping potassium ions in and sodium ions out of the cell.

3. Repolarization

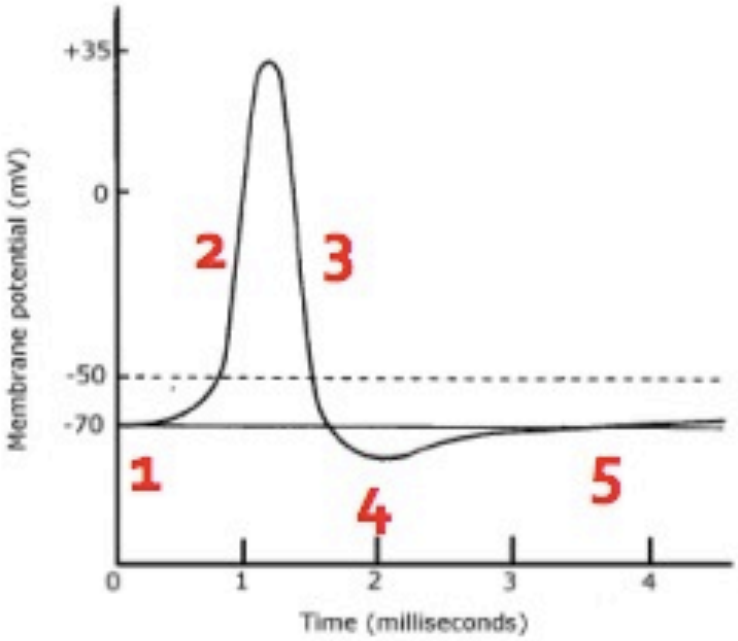
- depolarization causes the sodium gates to **close**, while the potassium gates are **opened**
- this process, combined with the **sodium-potassium pump** **(3 Na^+ out and 2 K^+ in)** re-establishes the electrical potential across the membrane

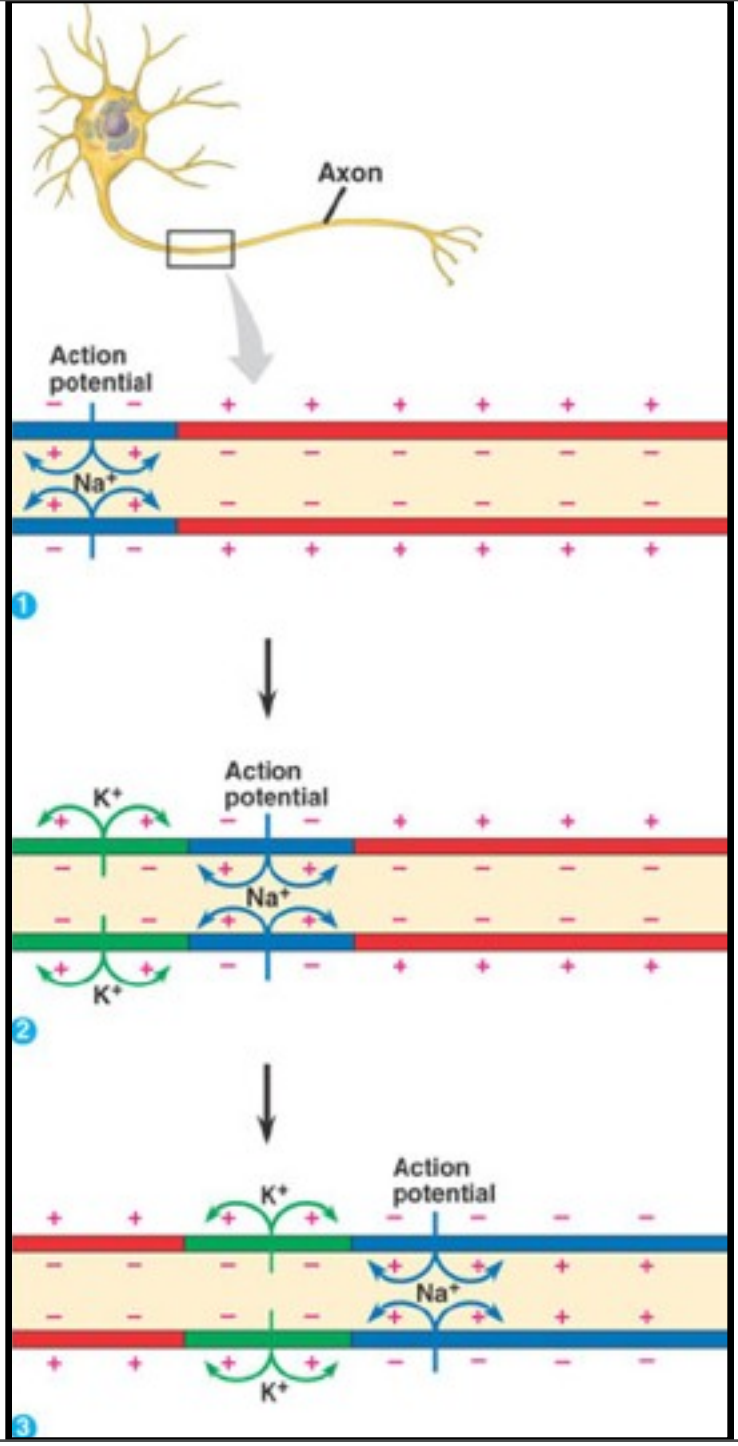
Repolarization



Actional Potential Graph

1. **Resting potential**
2. **Depolarization** -
   Na^+ channels open;
   K^+ channels closed
3. **Repolarization** -
   reset charge gradient
4. **Hyperpolarization**: K^+
   channels close slowly
5. **Refractory Period**





MOVEMENT OF THE ACTION POTENTIAL

The action potential, or wave of depolarization, moves down the nerve membrane.

The wave of depolarization is followed by a wave of repolarization, which is returning the membrane to its resting potential.

Refractory Period

- **Refractory Period** – **recovery** time required before a neuron can produce another action potential (setting up the dominos)

The refractory period usually lasts 1 to 10ms.

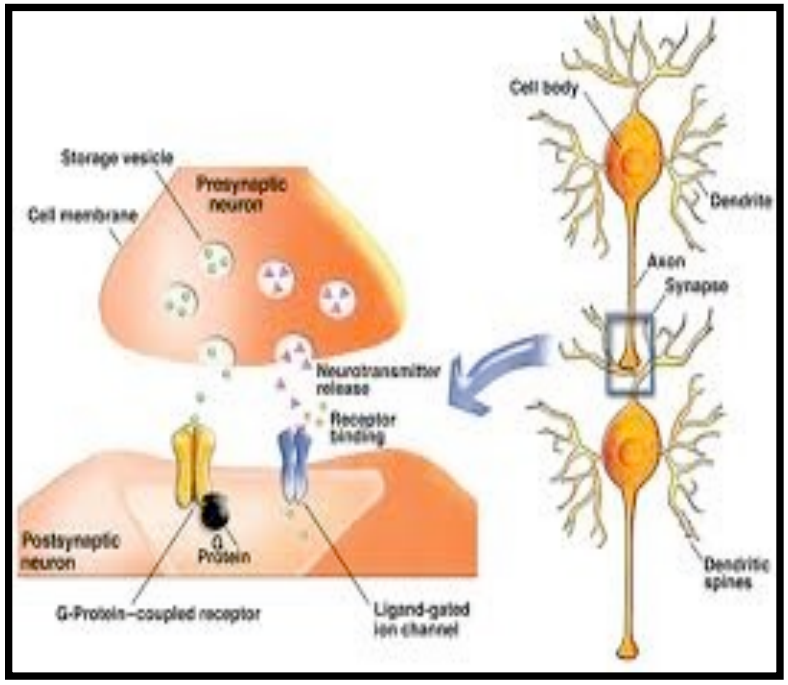
The resting membrane potential must be restored before the next action potential can be conducted.

All-or-None Response

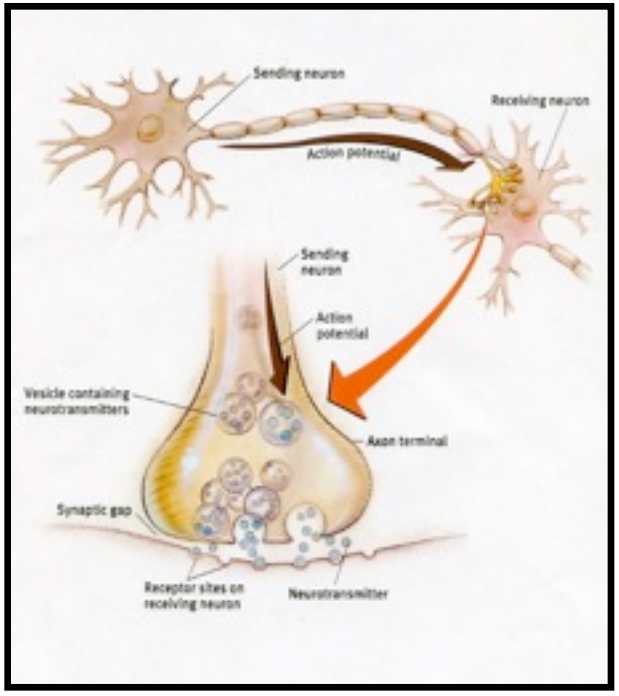
- there is a **minimum level** of stimulus required to cause a depolarization (**threshold level**)
- The **all-or-none response** is the fact that a nerve or muscle fibre responds completely or not at all to a stimulus.

Threshold levels are different for each neuron!!!!!

SYNAPTIC TRANSMISSION

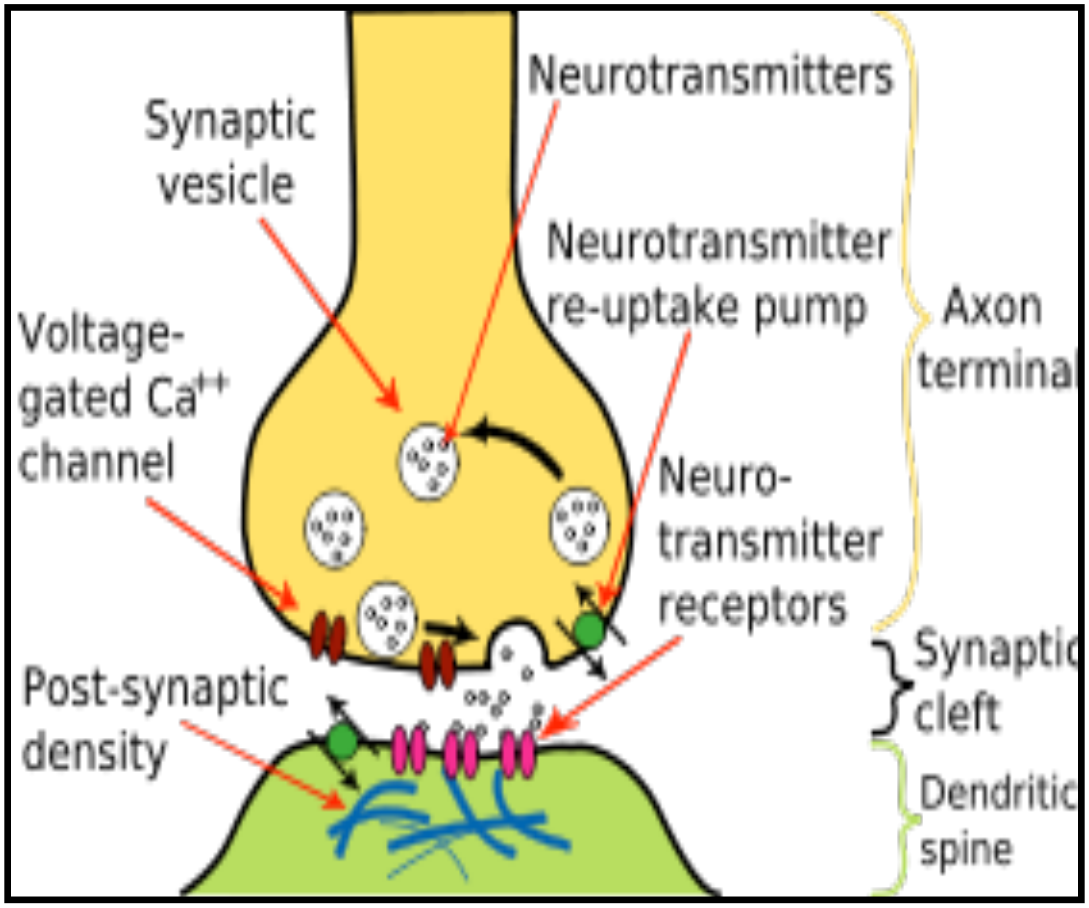


The connection between the terminal knob of a neuron's axon and a dendrite of another neuron is called a **SYNAPSE**.



A single neuron may branch many times and join with many different neurons!

SYNAPTIC TRANSMISSION



Vesicles containing chemicals called **NEUROTRANSMITTERS** are located in the end plate of axons.

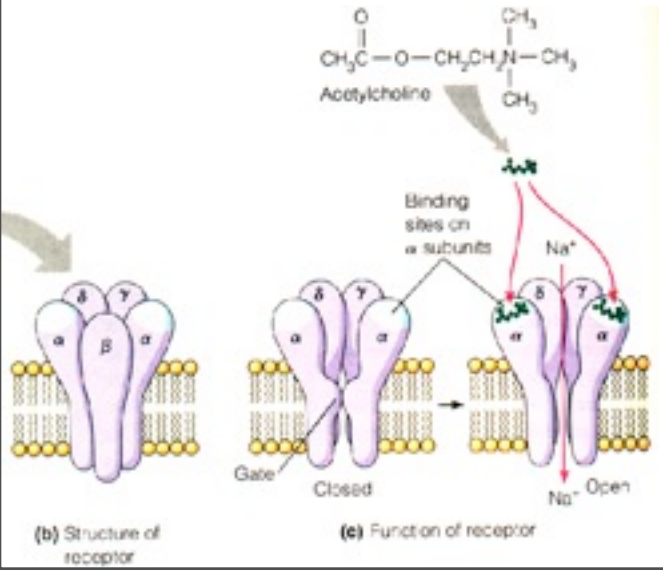
Neurotransmitters are released into the synaptic cleft once the nerve impulse reaches the end plate.

Neurotransmitters are released by the **presynaptic neuron** and diffuse across the **synaptic cleft**, creating a depolarization of the dendrites of the **postsynaptic neuron**.

SYNAPTIC TRANSMISSION

- **ACETYLCHOLINE** is a neurotransmitter released from vesicles in the end plate of neurons.

  » **ACH** **causes the opening of sodium channels** in the postsynaptic membrane – leading to a wave of depolarization



SYNAPTIC TRANSMISSION

- Since the neurotransmitter ACH causes depolarization of the postsynaptic membrane, the neuron will stay in a constant state of depolarization as long as ACH is present.

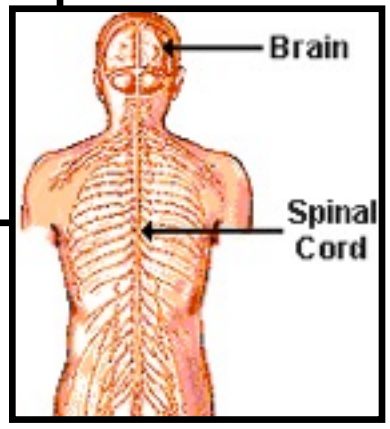
  » The postsynaptic membrane will release an enzyme called **CHOLINESTERASE** which destroys ACH and allows the postsynaptic membrane to return to its resting action potential

NERVOUS CONTROL OF HOMEOSTASIS

- The human nervous system is divided into TWO parts
  - » **1. CENTRAL NERVOUS SYSTEM (CNS)**
  - » **2. PERIPHERAL NERVOUS SYSTEM**

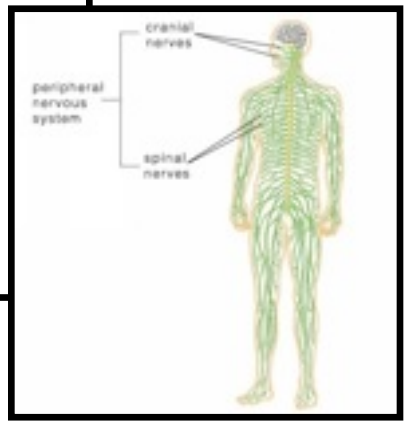
CENTRAL NERVOUS SYSTEM

- BRAIN
- SPINAL CORD



PERIPHERAL NERVOUS SYSTEM

- all other NERVES in the body



***** ALL components of the nervous system are coordinated by the CENTRAL nervous system *****

Central Nervous System

Parts: brain and spinal cord

Functions:

1. Body's control system
2. Receives sensory input
3. Relays motor impulses
4. Centre for higher functions (memory, intelligence, emotion)

The Brain

The Brain

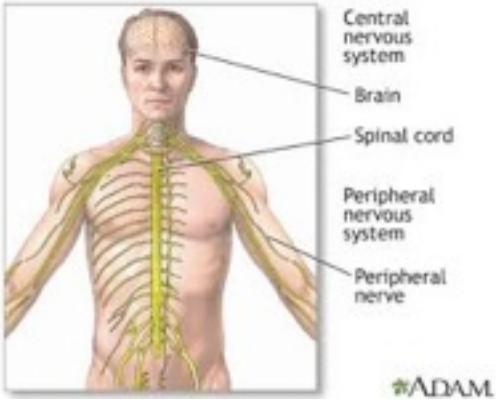
- Is protected by a three-layer membrane called the **meninges**
- **Cerebrospinal fluid** further protects by acting as a shock absorber, transporting nutrients, such as oxygen, glucose, hormones and WBCs
- Doctors can take a spinal tap and identify infections such as meningitis

The Brain

- Composed of:
  - **grey matter** - axon terminals, dendrites and cell bodies
  - **white matter** - myelinated neurons

NERVOUS CONTROL OF HOMEOSTASIS

- The **PERIPHERAL NERVOUS SYSTEM** is all the nerves except those in the brain and spinal cord that relay information between the central nervous system and other parts of the body.



- The **PNS** is further divided into two separate parts:

1. SOMATIC NERVOUS SYSTEM
2. AUTONOMIC NERVOUS SYSTEM

PERIPHERAL NERVOUS SYSTEM

SOMATIC NERVOUS SYSTEM

Includes **MOTOR NEURONS** that are under ***conscious control*** and ALL of the **SENSORY NEURONS** in your body.

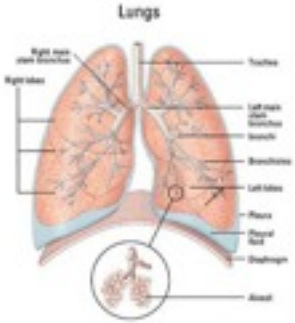
AUTONOMIC NERVOUS SYSTEM

Includes only the **MOTOR NEURONS** that function ***without conscious control.***

A sensory neuron senses that your nose is itchy…

We don't consciously think about making our heart beat…

Your brain consciously decides to scratch the itch and sends a message to motor neurons to do so…



We don't consciously think about breathing…

PERIPHERAL NERVOUS SYSTEM

- The **AUTONOMIC NERVOUS SYSTEM** controls motor neurons that function without conscious control. This system is made up of two different types of nerves…

  » **SYMPATHETIC NERVES** – nerves that prepare the body for danger

  » **PARASYMPATHTIC NERVES** – nerves that return the body to a normal state after a stressful situation

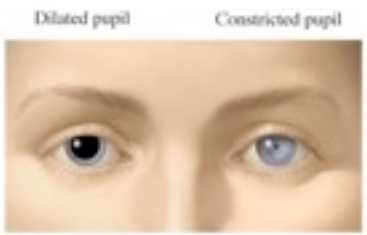
PERIPHERAL NERVOUS SYSTEM

SYMPATHETIC NERVES

Prepares the body for danger!

PARASYMPATHETIC NERVES

Returns the body to a normal state after a stressful situation!



Increase size of pupils

Makes pupils of the eye smaller

Speed up heart rate

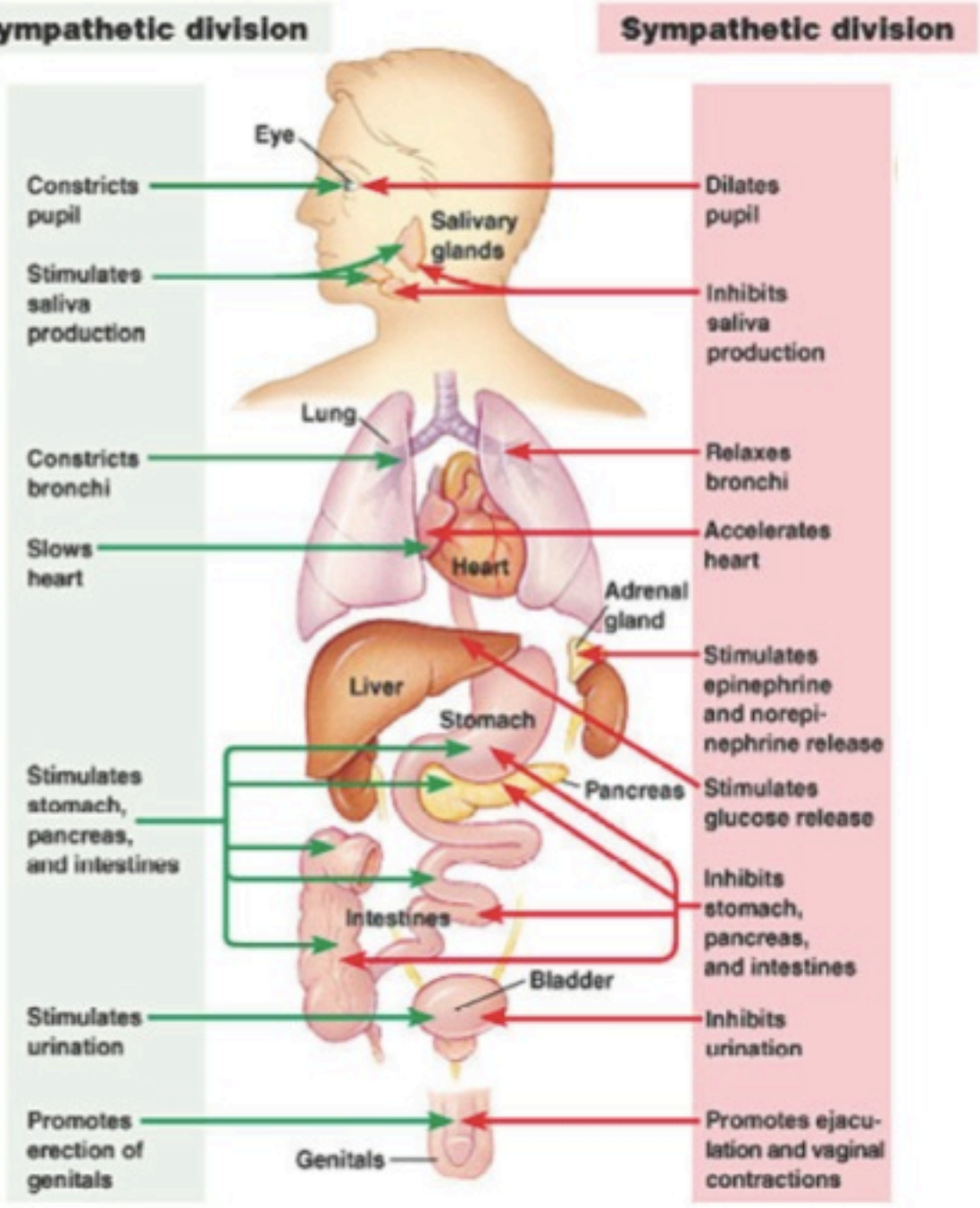
Slows down the heart rate

Slow digestion

Increases rate of digestion

Relax bladder muscles

Contract bladder muscles


Parasympathetic division
Sympathetic division
Eye
Constricts pupil
Dilates pupil
Salivary glands
Stimulates saliva production
Inhibits saliva production
Lung
Constricts bronchi
Relaxes bronchi
Slows heart
Heart
Accelerates heart
Adrenal gland
Liver
Stimulates epinephrine and norepinephrine release
Stomach
Stimulates stomach, pancreas, and intestines
Pancreas
Stimulates glucose release
Intestines
Inhibits stomach, pancreas, and intestines
Bladder
Stimulates urination
Inhibits urination
Promotes erection of genitals
Genitals
Promotes ejaculation and vaginal contractions

Autonomic Nervous System

	Sympathetic	Parasympathetic
Effects on		
heart	Increased heart rate	Decreased heart rate
muscles	Increased contractions	Decreased contractions
bladder	Sphinctors relaxed	Sphinctors contract

Autonomic Nervous System

	Sympathetic	Parasympathetic
Effects		
digestion	Decrease in peristalsis and stomach contractions	Increase in peristalsis and stomach contractions
eyes	Pupils dilate	Pupils constrict (normal)
liver	increases glucose release	Stores glucose

Autonomic Nervous System

	Sympathetic	Parasympathetic
Effects		
Adrenal glands	Increases release of adrenaline	Decreases release of adrenaline
skin	Increases blood flow	Decreases blood flow