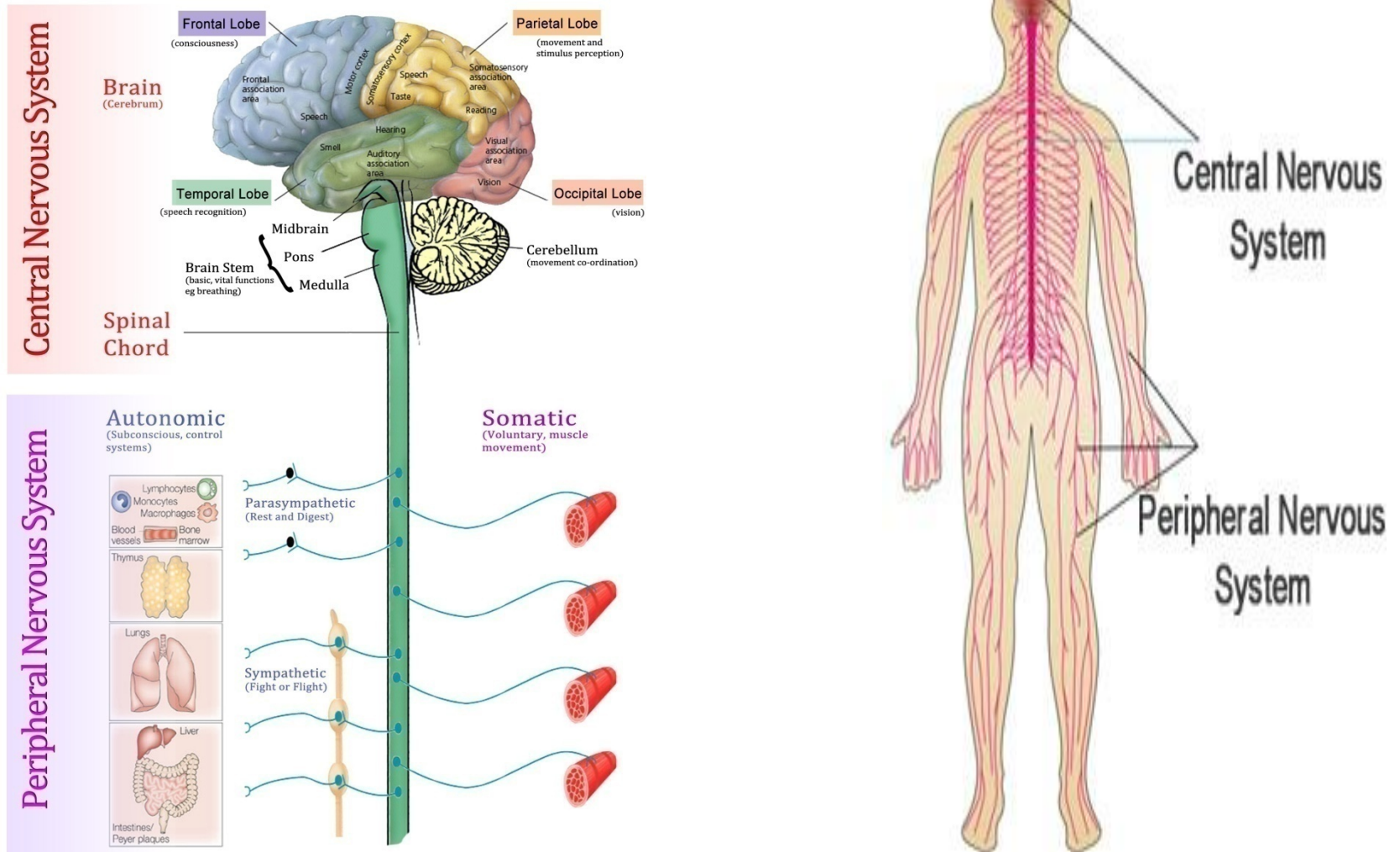


Human Nervous System

The Nervous System



1-9 Nervous system

The nervous system is essential to the functioning of the human organism. It regulates our automatic control systems, integrates and assimilates data from the outside world and our internal organs, and regulates and controls the locomotor system. It has been compared to a computer with an electrical communications system.

The *autonomic nervous system* is responsible for regulating the automatic functions of the body—heartbeat, gland secretions, GI system, and so forth. The autonomic nervous system operates at a subconscious level—you are not generally aware of its functioning.

The *sensory nervous system* receives data from the outside world and certain internal organs through cells that function as sensory receptors (i.e., transducers, in electrical terminology). The eyes and ears are sensory receptors for light and sound, respectively. But there are also other sensory structures that are sensitive to pain, heat, and pressure.

The *central nervous system* (CNS) gathers, assimilates, and integrates data from the outside world, information on the state of internal organs, etc. The brain is the principal organ of the CNS, and, like a computer, it can store, process, and generate information and react to stimuli. The CNS also includes the spinal cord.

Human Nervous System

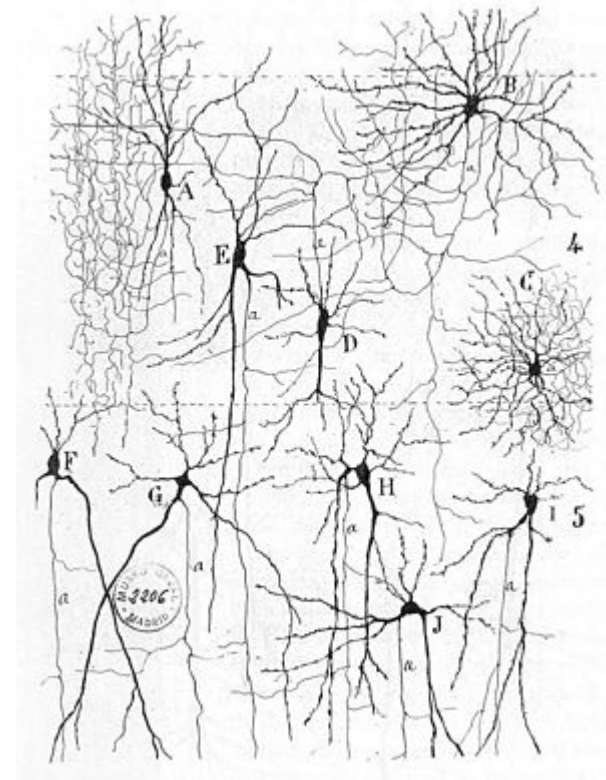
- Derives its name from nerves, which are cylindrical bundles of fibers (the axons of neurons), that emanate from the brain & central cord, & branch repeatedly to innervate every part of the body
- The nervous system has **3 main functions**: sensory, integration, and motor.
- It includes **Central Nervous System (CNS)** and the **Peripheral Nervous System (PNS)**
- It acts as a **highway** for information to travel
- Neurons function through the generation and propagation of electrochemical signals known as **action potentials (APs)**.

So what is the number?

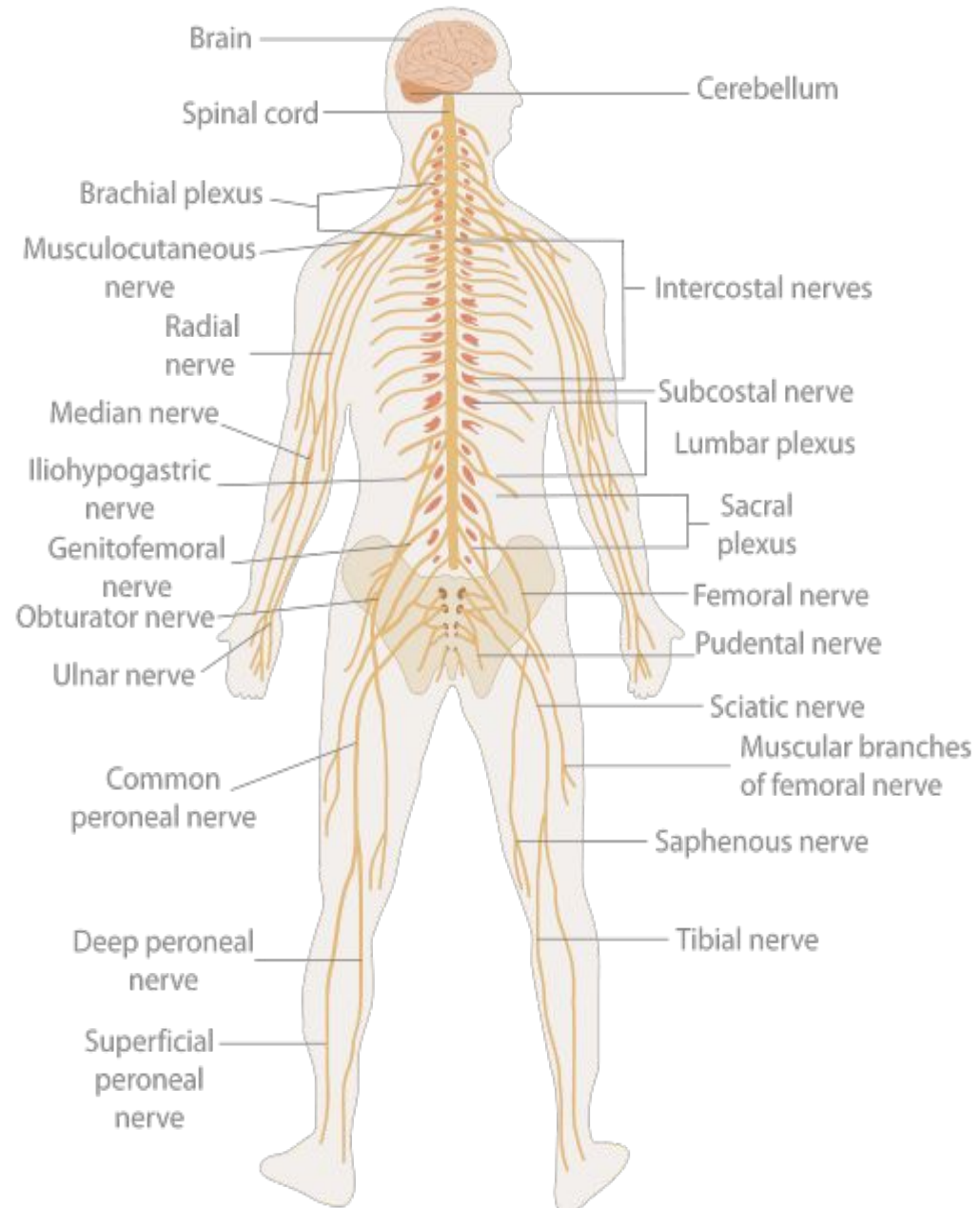
- On average the human brain has **86bn** neurons.
- And not one [of the brains] that we looked at so far has the **100bn**.
- Even though it may sound like a small difference the **14bn neurons** amount to pretty much the number of neurons that a baboon brain has or almost half the number of neurons in the gorilla brain.
- So that's a pretty large difference actually."

- **The nervous system is essentially the body's electrical wiring.**
- **It is composed of nerves, which are cylindrical bundles of fibers that start at the brain and central cord and branch out to every other part of the body.**

- In [neuroscience](#), a biological neural network (sometimes called a [neural pathway](#)) is a series of interconnected [neurons](#) whose activation defines a recognizable linear pathway.
- In contrast, a neural circuit is a functional entity of interconnected neurons that is able to regulate its own activity using a [feedback loop](#) (similar to a [control loop](#))
- In [computer science](#) and related fields, **artificial neural networks** are computational [models](#) inspired by animals' [central nervous systems](#) (in particular the [brain](#)) that are capable of [machine learning](#) and [pattern recognition](#).

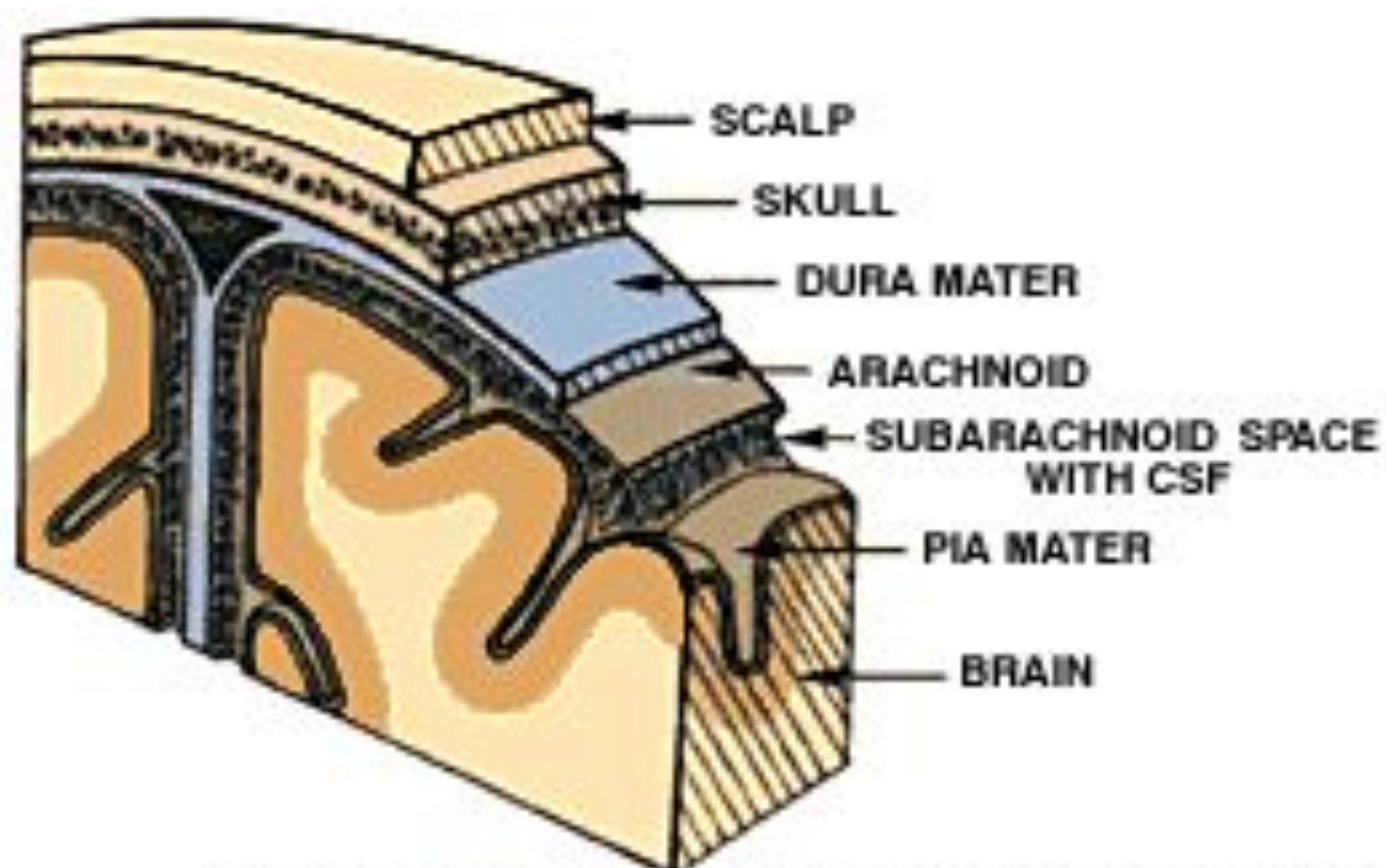


Nervous system diagram



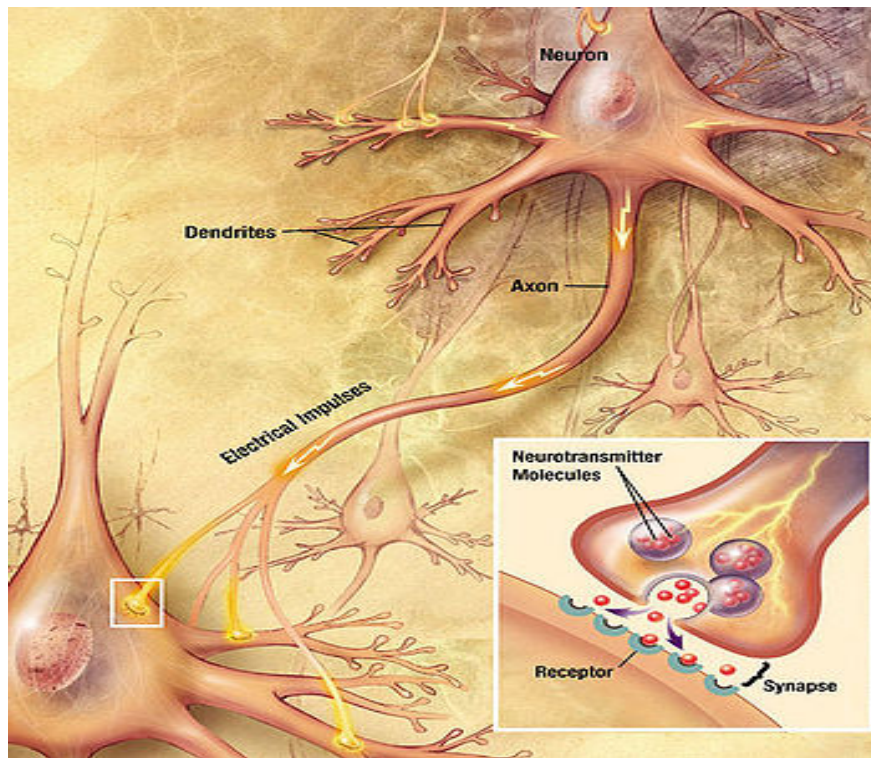
Protections

- **Skull and Vertebrae**
- **3 protective layers called meninges**
- 1. Dura Mater (outer layer): consists of connective tissues, blood vessels, and nerves.**
- 2. Arachnoid Layer (middle layer): elastic and weblike**
- 3. Pia Mater (inner layer): contains nerves and blood vessels.**
- 4. Cerebrospinal fluid**
 - a clear watery liquid**
 - separates the middle and inner layers**
 - Acts as shock absorber**
 - exchange of nutrients between blood and nervous system**

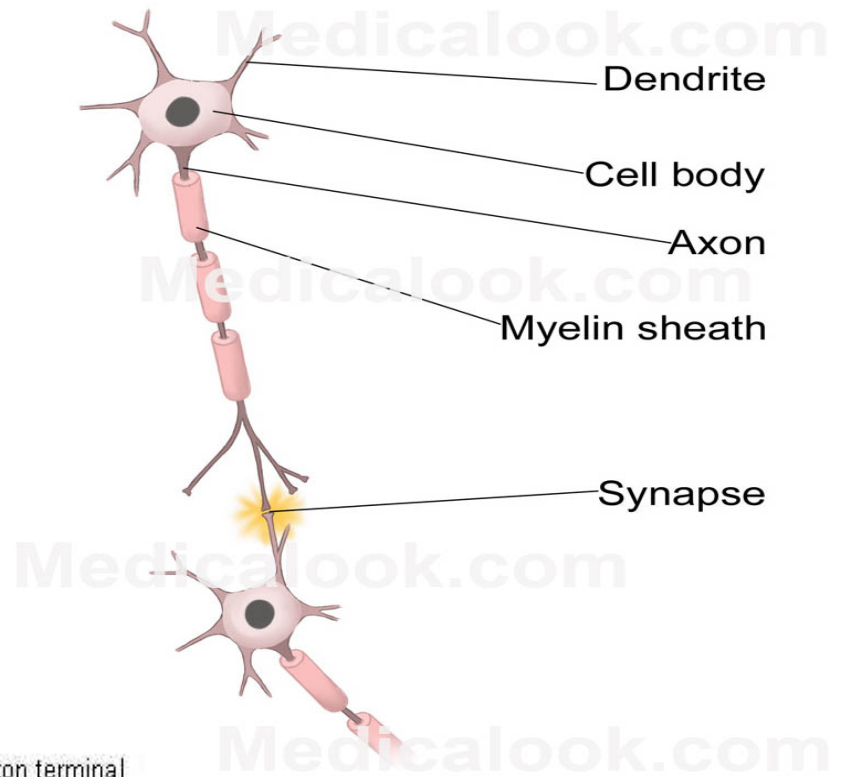
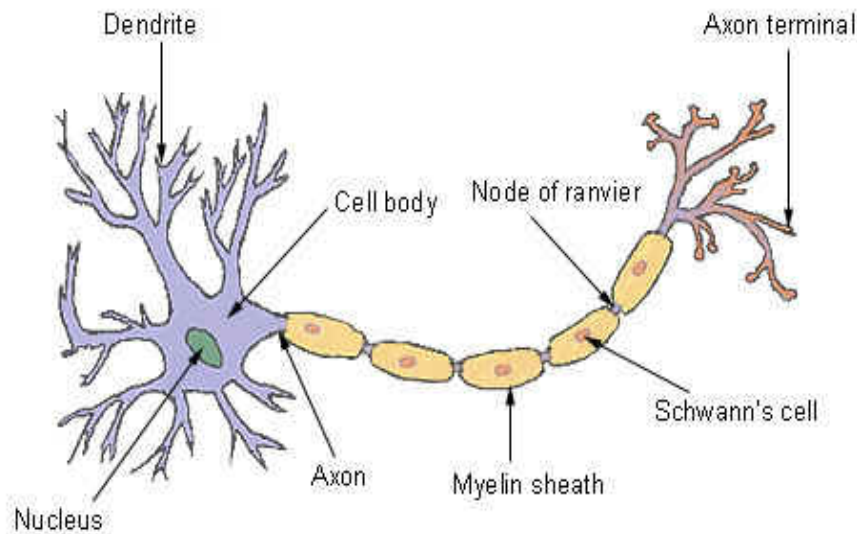


The brain's protective barriers (Section shown is from top, center of head)

- The nervous system is the part of an animal's body that coordinates its voluntary and involuntary actions and transmits signals between different parts of its body.
- Nervous tissue first arose in wormlike organisms about 550 to 600 million years ago.
- In most animal species it consists of two main parts, the central nervous system (CNS) and the peripheral nervous system (PNS).



Structure of a Typical Neuron



Neuron

- A neuron also known as nerve cell is an electrically excitable cell that processes and transmits information through electrical and chemical signals.
- These signals between neurons occur via synapses, specialized connections with other cells.
- Neurons can connect to each other to form neural networks.
- Neurons are the core components of the nervous system

There are 3 basic **classes of neurons**: afferent neurons, efferent neurons, and interneurons.

- **Afferent neurons.** Also known as sensory neurons, afferent neurons transmit sensory signals to the central nervous system from receptors in the body.
- **Efferent neurons.** Also known as motor neurons, efferent neurons transmit signals from the central nervous system to effectors in the body such as muscles and glands.
- **Interneurons.** Interneurons form complex networks within the central nervous system to integrate the information received from afferent neurons and to direct the function of the body through efferent neurons.

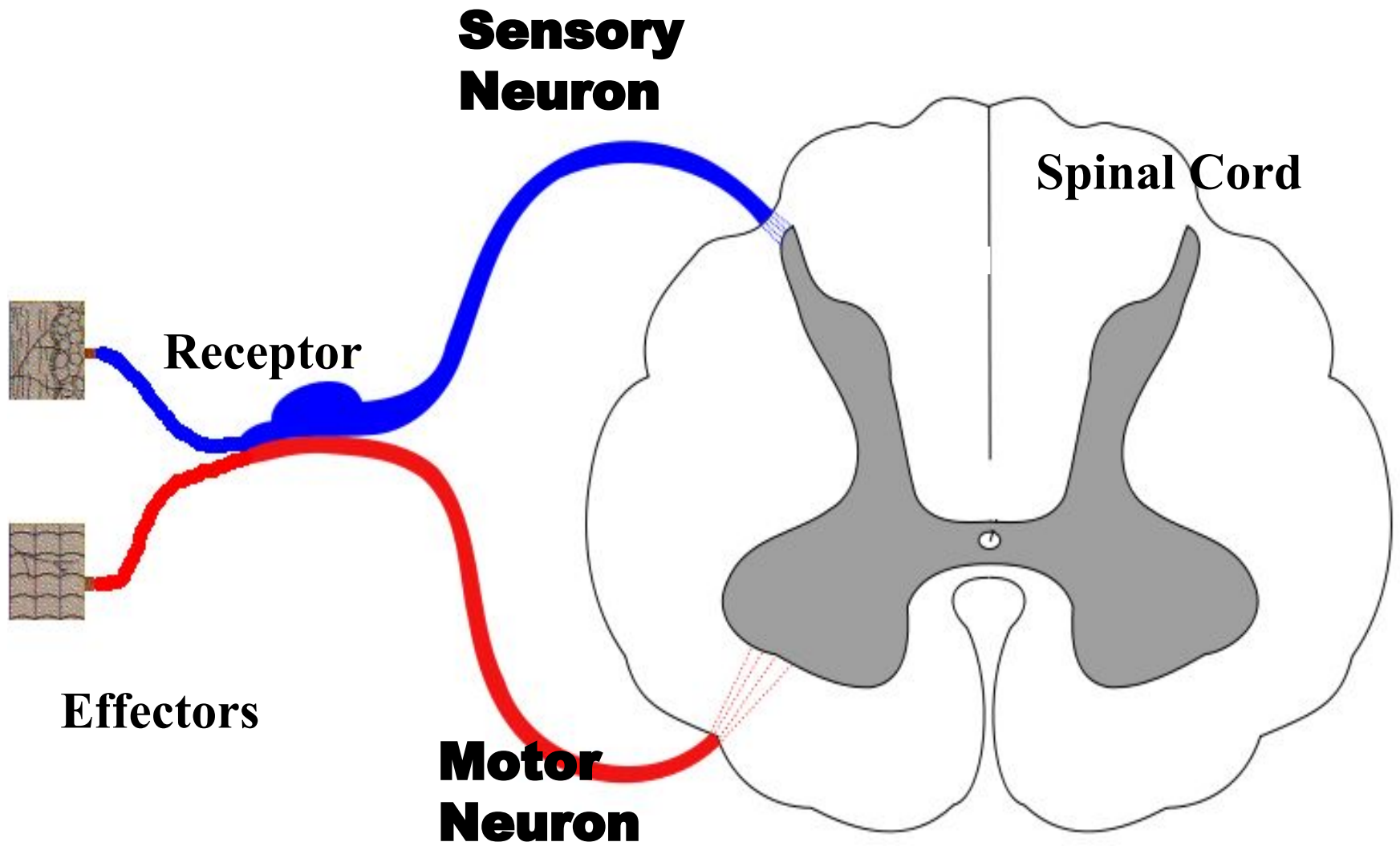
Neurons

Sensory Neurons

- Sensory Neurons are neurons which only allow information to travel one way. T
- They can transmit information from Receptors (skin, eyes, ears) to the brain and to motor neurons.

Motor Neurons

- Motor Neurons are neurons which only allow information to travel one way.
- The transmit information from the brain and the spinal cord to the Effectors (Muscles and Glands)

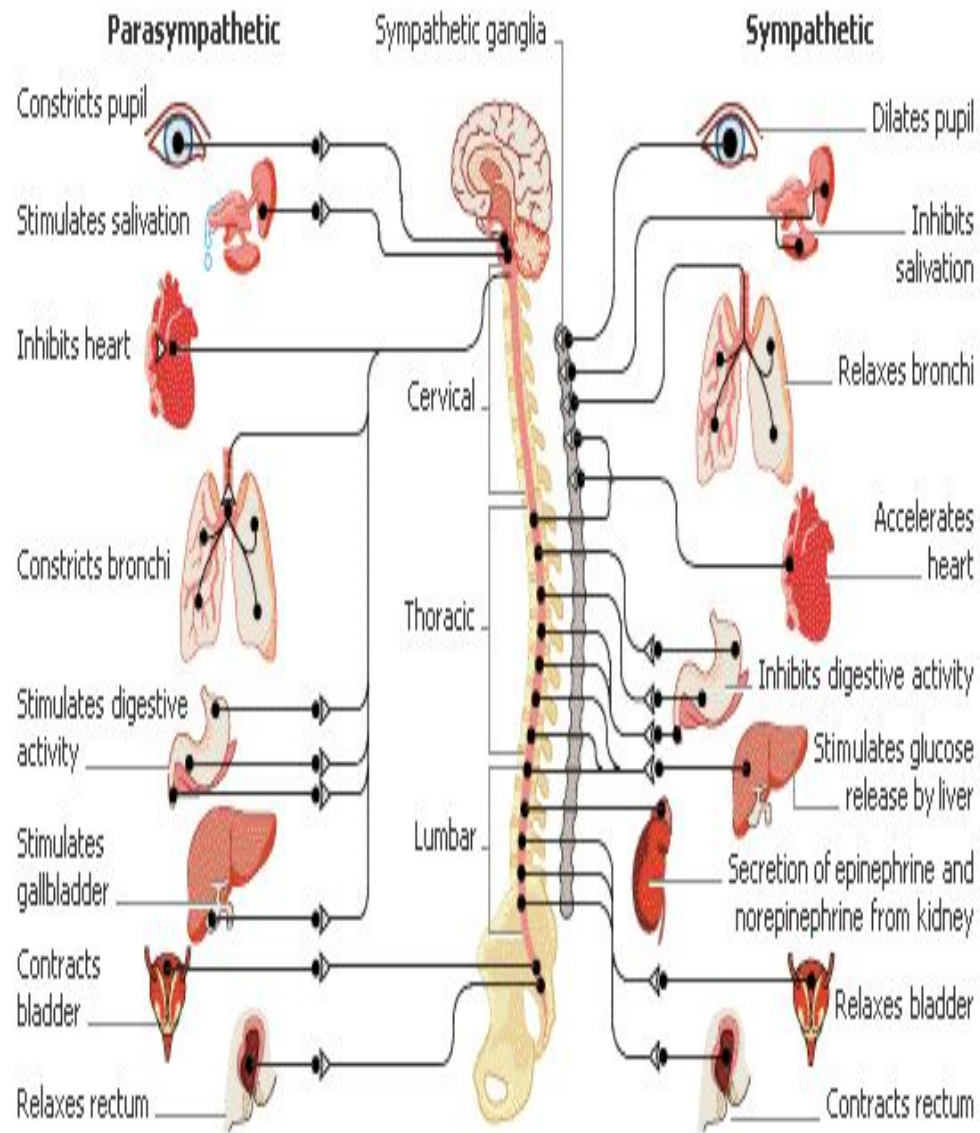


- **Human nervous system** divided into CNS & PNS
- The CNS contains the brain and spinal cord.
- The PNS consists mainly of nerves, which are enclosed bundles of the long fibers or axons, that connect the CNS to every other part of the body.
- The PNS includes motor neurons, mediating voluntary movement; the autonomic nervous system, comprising the sympathetic nervous system and the parasympathetic nervous system, which regulate involuntary functions

The **autonomic nervous system** (ANS or visceral nervous system or involuntary nervous system) is the part of the peripheral nervous system that acts as a control system, functioning largely below the level of consciousness, and controls visceral functions

The ANS is classically divided into two subsystems: the parasympathetic nervous system (PSNS) and sympathetic nervous system (SNS), which operate independently in some functions and interact co-operatively in others

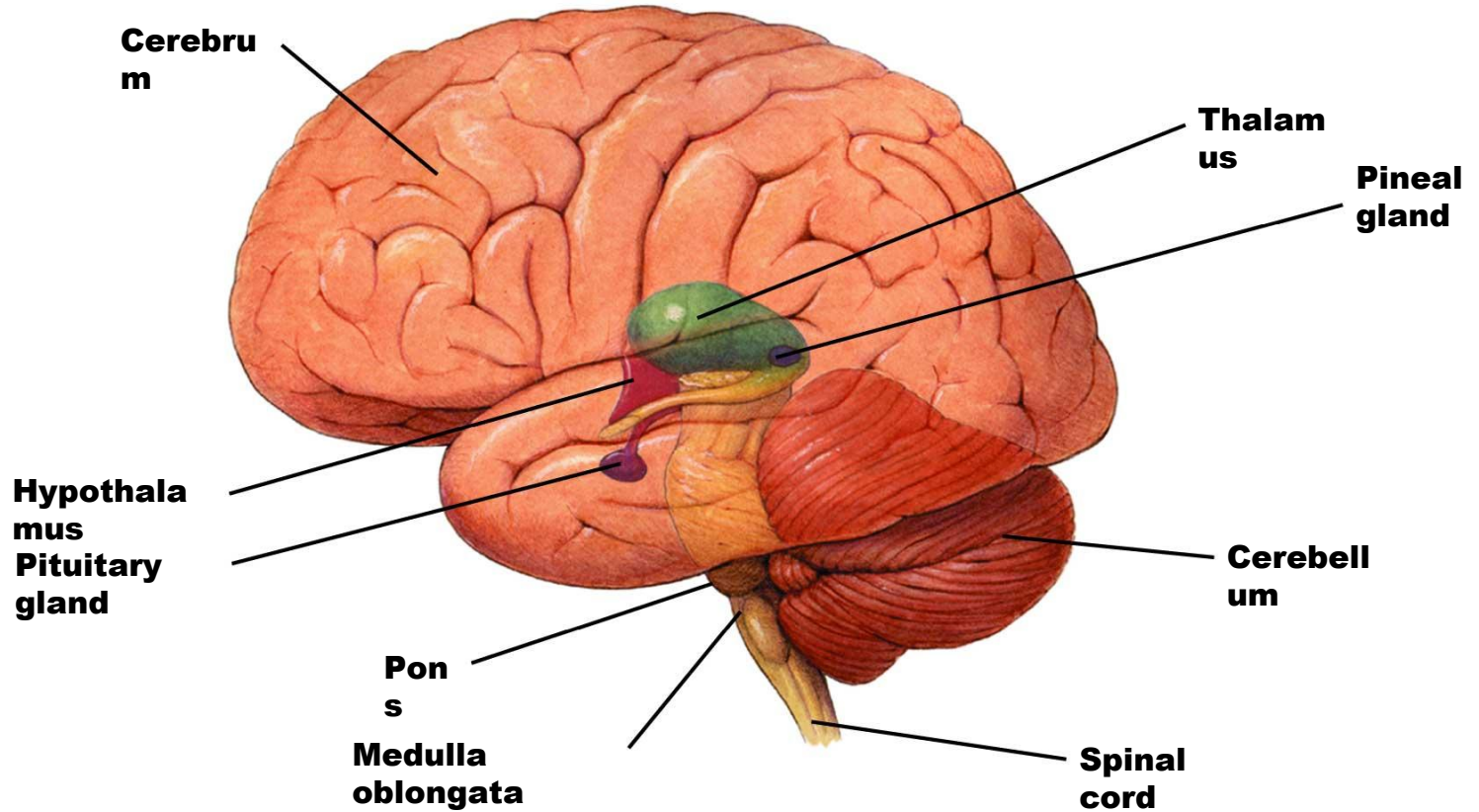
- The parasympathetic nervous system (PSNS) is one of three main divisions of the autonomic nervous system (ANS), the other two being the sympathetic and enteric systems.
- The ANS is responsible for regulation of internal organs and glands, which occurs unconsciously.
- The (ortho-) sympathetic nervous system (SNS) is one of three major parts of the autonomic nervous system (the others being the enteric and parasympathetic systems).
- Its general action is to mobilize the body's nervous system fight-or-flight response. It is, however, constantly active at a basic level to maintain homeostasis



Central Nervous System

- The central nervous system (CNS) is the part of the nervous system consisting of the brain and spinal cord.
- It is opposed to the peripheral nervous system (PNS), which is composed of nerves leading to and from the CNS, often through junctions known as ganglia.
- The CNS integrates information it receives from, and coordinates and influences the activity of all parts of the bodies

Brain

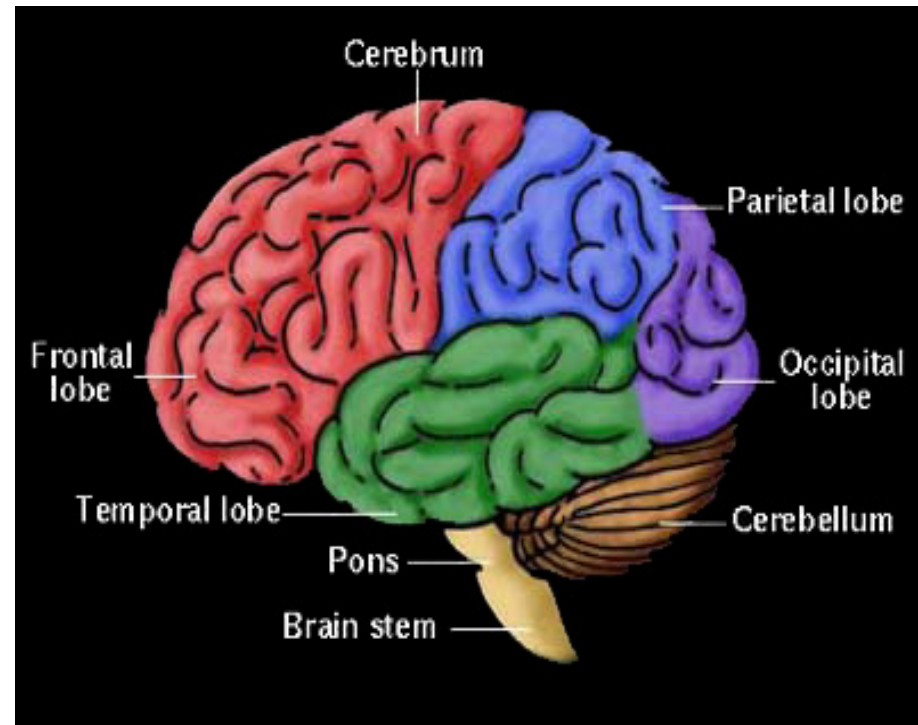


- The brain is the control center of the body
- It is about 2% of your body weight and uses 20% of your body's oxygen

Divided into three parts

- Cerebrum
- Cerebellum
- Brain Stem

The Brain



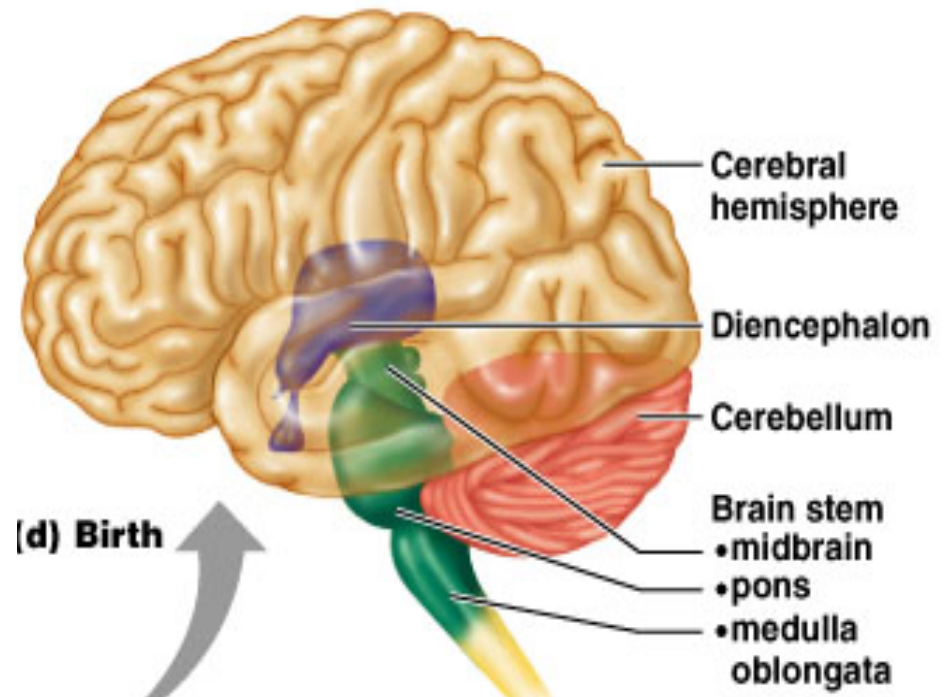
Parts of the Brain

- **Divided into three parts**
 - **Cerebrum**
 - **Cerebellum**
 - **Brain Stem**

- The brain, a soft, wrinkled organ that weighs about 3 pounds, is located inside the cranial cavity, where the bones of the skull surround and protect it.
- The approximately 100 billion neurons of the brain form the main control center of the body.

Anatomical Classification

- Cerebral hemispheres
- Diencephalon
 - Thalamus
 - Hypothalamus
- Brain stem
 - Midbrain
 - Pons
 - Medulla
- Cerebellum
- Spinal cord



Central Nervous System

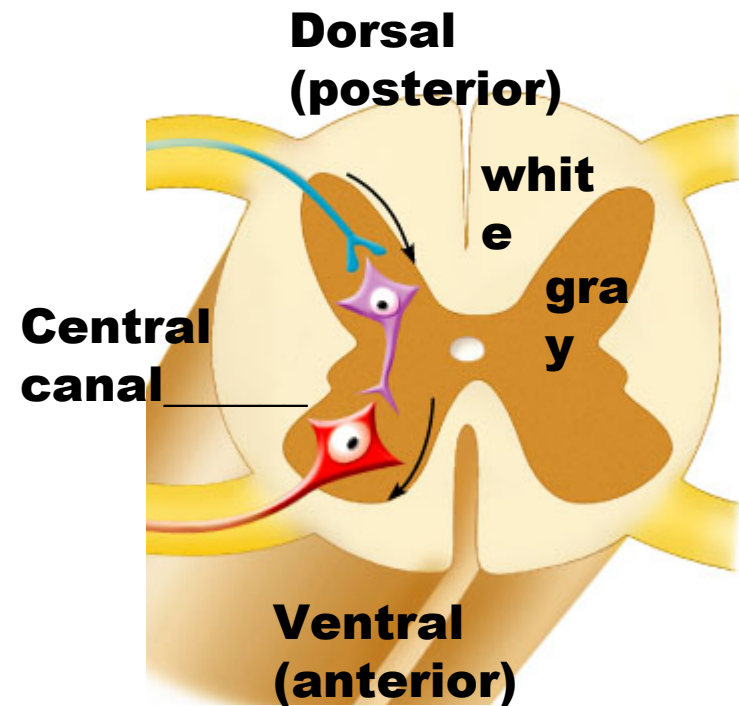
Brain: Cerebral Cortex

- The cortex is the layer of tissue which covers the entire brain. The Cerebral Cortex appears to have a number of lumps and bumps
- The Cerebral Cortex controls thought, language, reasoning, perception & voluntary movement



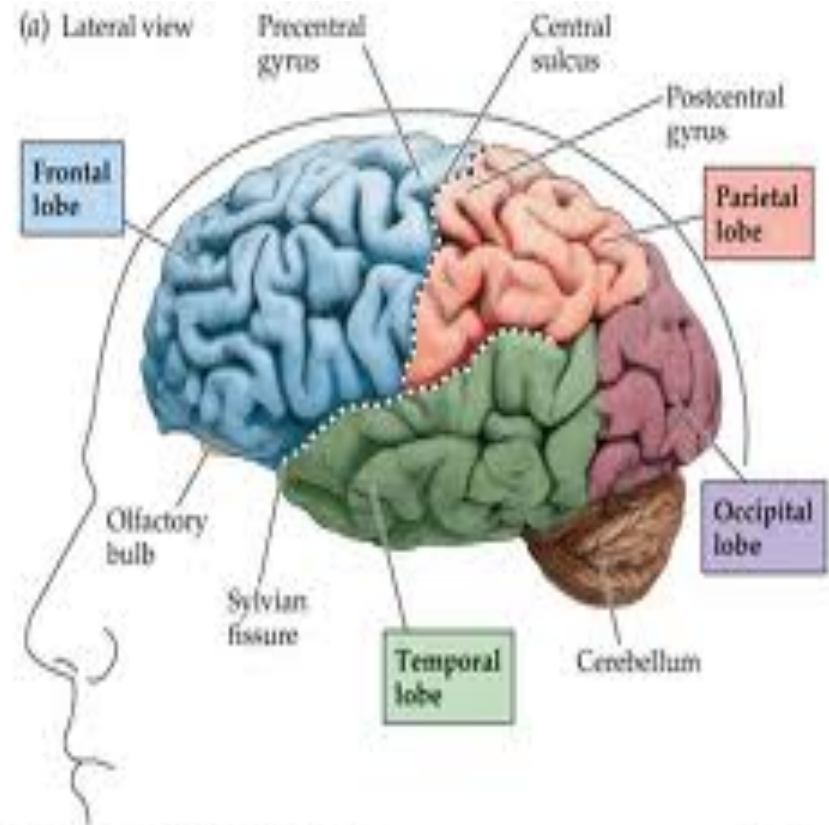
Gray/White in spinal cord

- Hollow central cavity (“central canal”)
- Gray matter surrounds cavity
- White matter surrounds gray matter (white: ascending and descending tracts of axons)
- “H” shaped on cross section



Cerebral Hemispheres

- **Lobes:** under bones of same name
 - Frontal
 - Parietal
 - Temporal
 - Occipital
 - Plus: Insula
(buried deep in lateral sulcus)



Cerebellum

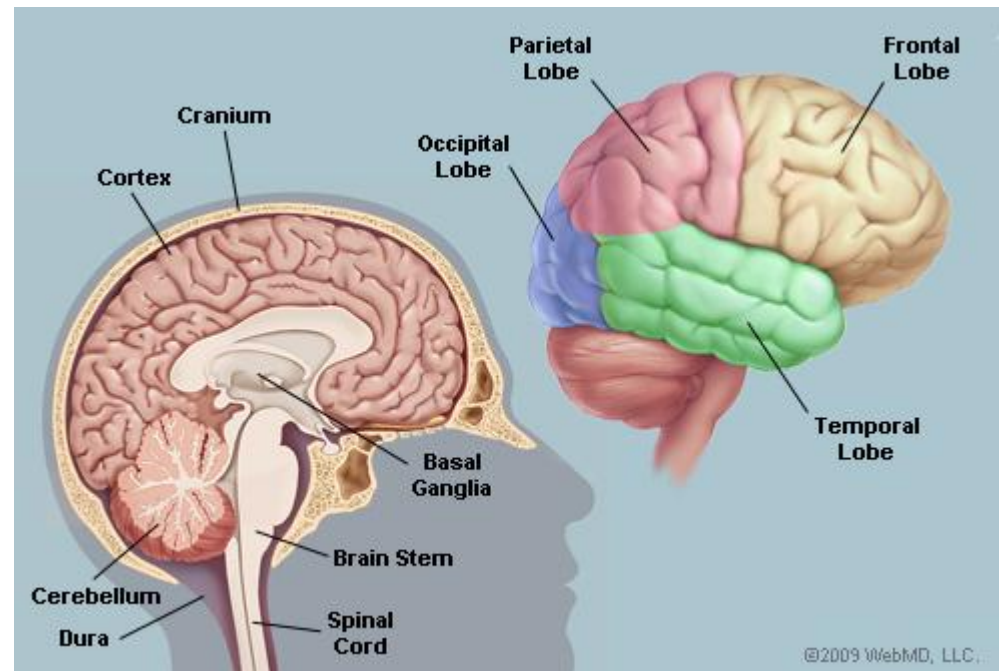
- The Cerebellum controls movement, balance and posture

Brain Stem

- It includes the medulla, pons and midbrain.
- It controls most of the basic functions of life like breathing, heart rate and blood pressure.

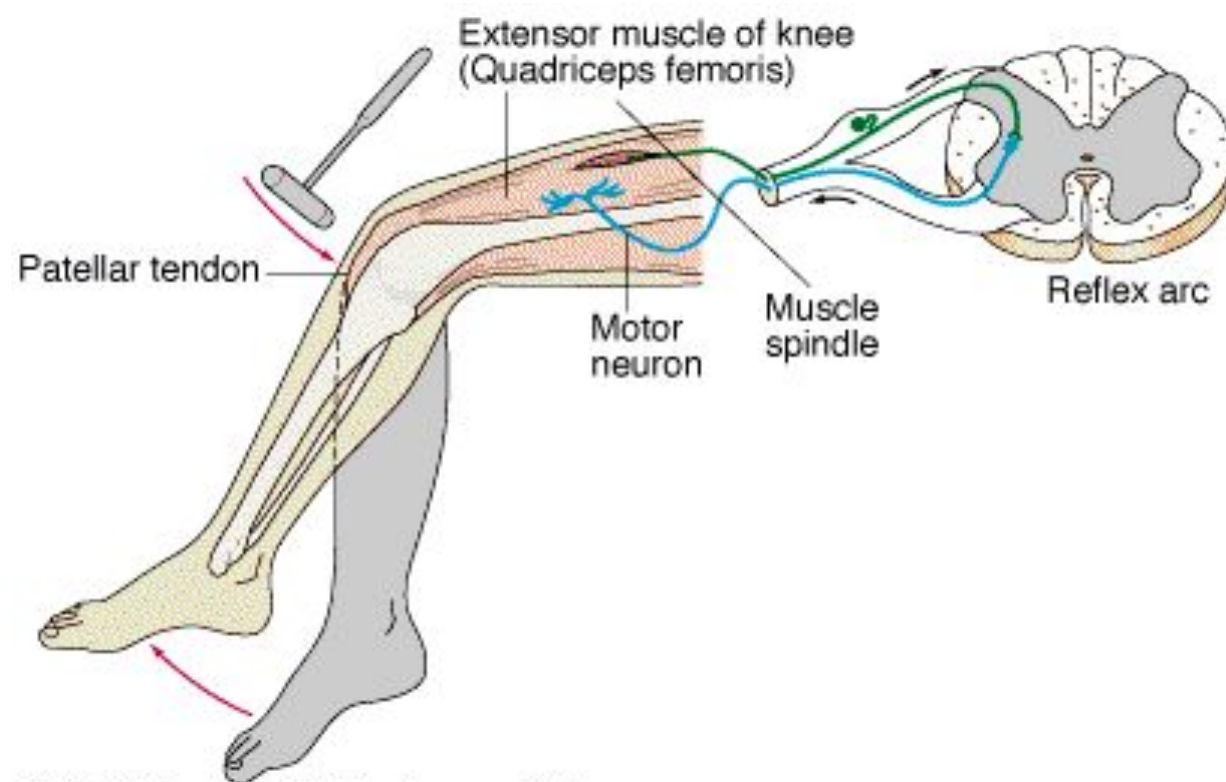
Basal Ganglia

- Basal Ganglia controls & coordinates movement



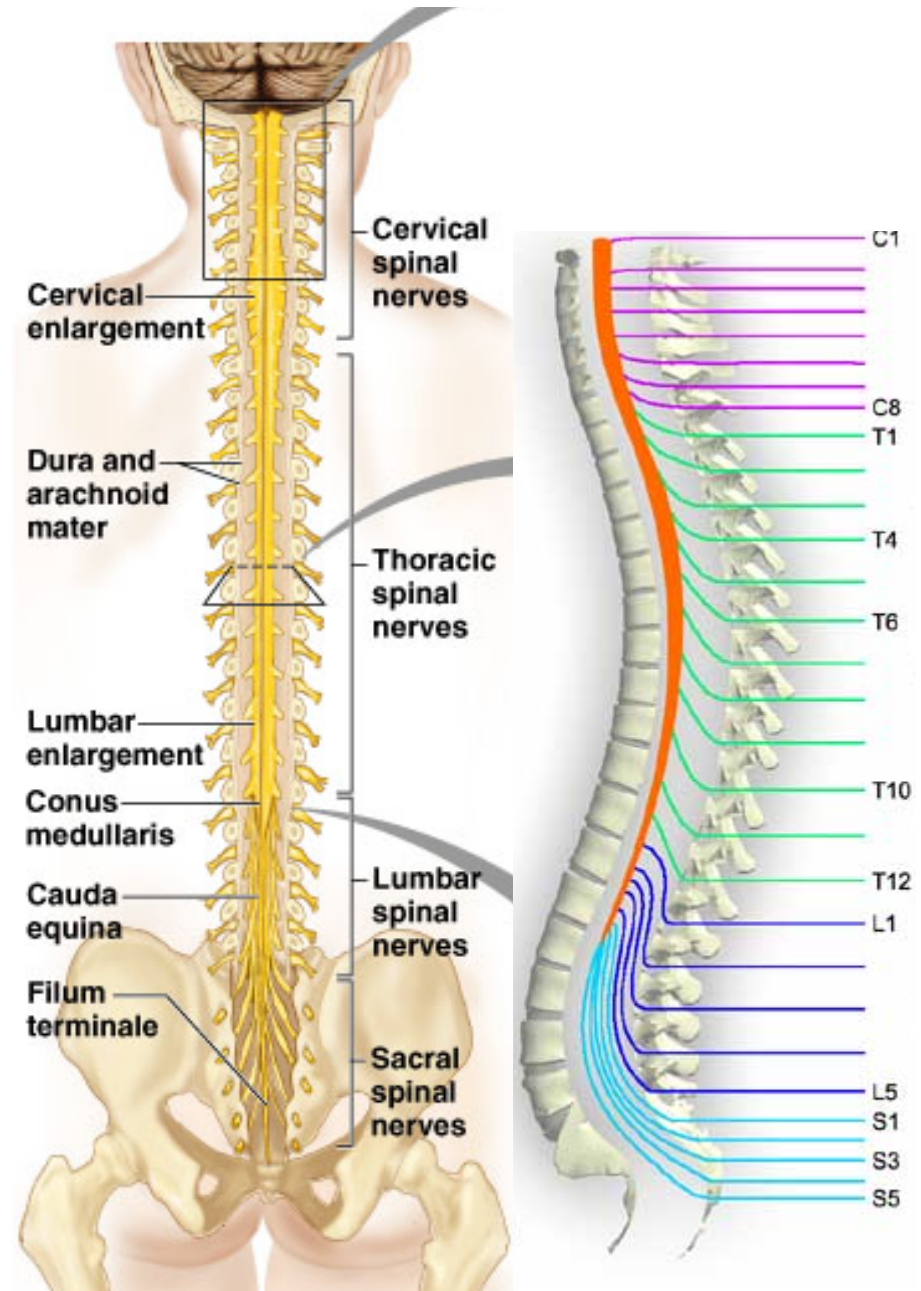
Simplified...

- Back of brain: **perception**
- Top of brain: **movement**
- Front of brain: **thinking**

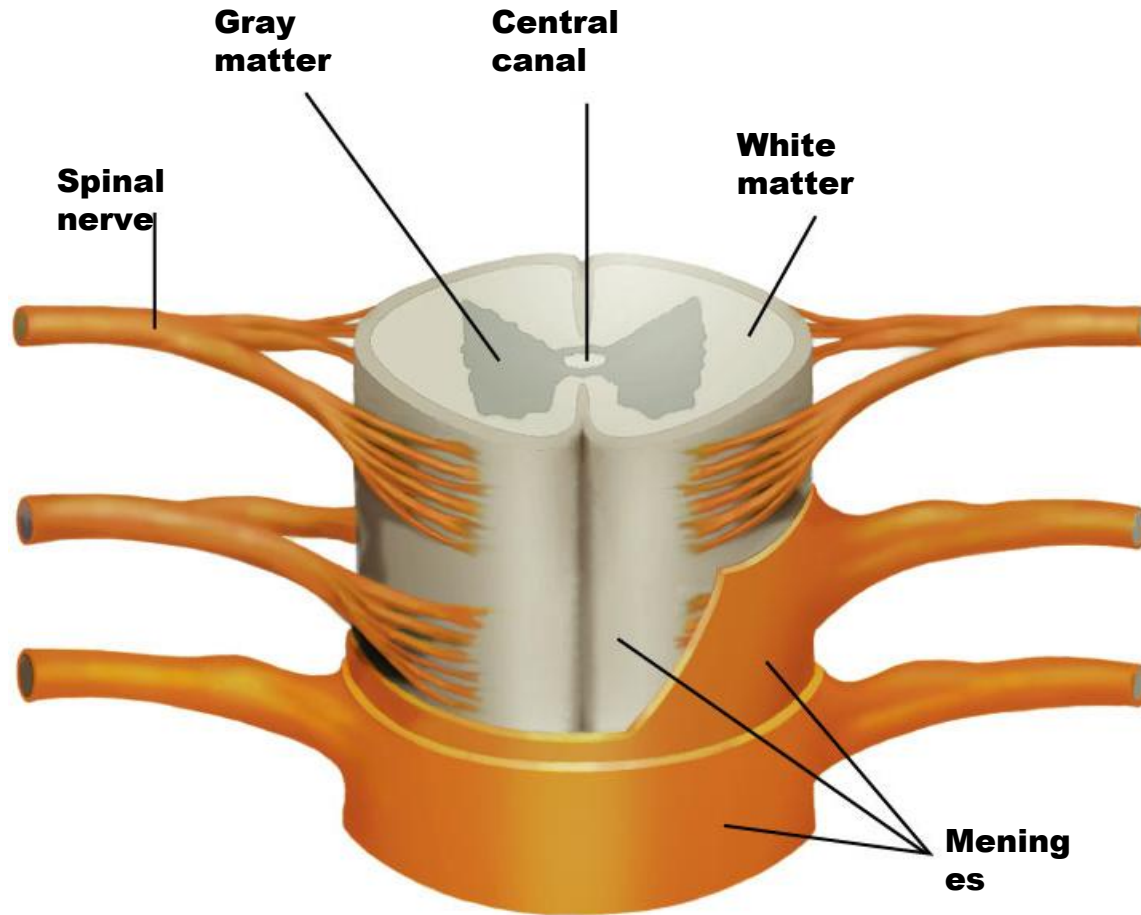


Spinal cord

- Fetal 3rd month: ends at coccyx
- Birth: ends at L3
- Adult position at approx L1-2 during childhood
- End: *conus medullaris*
- Spinal cord segments are superior to where their corresponding spinal nerves emerge through intervertebral foramina



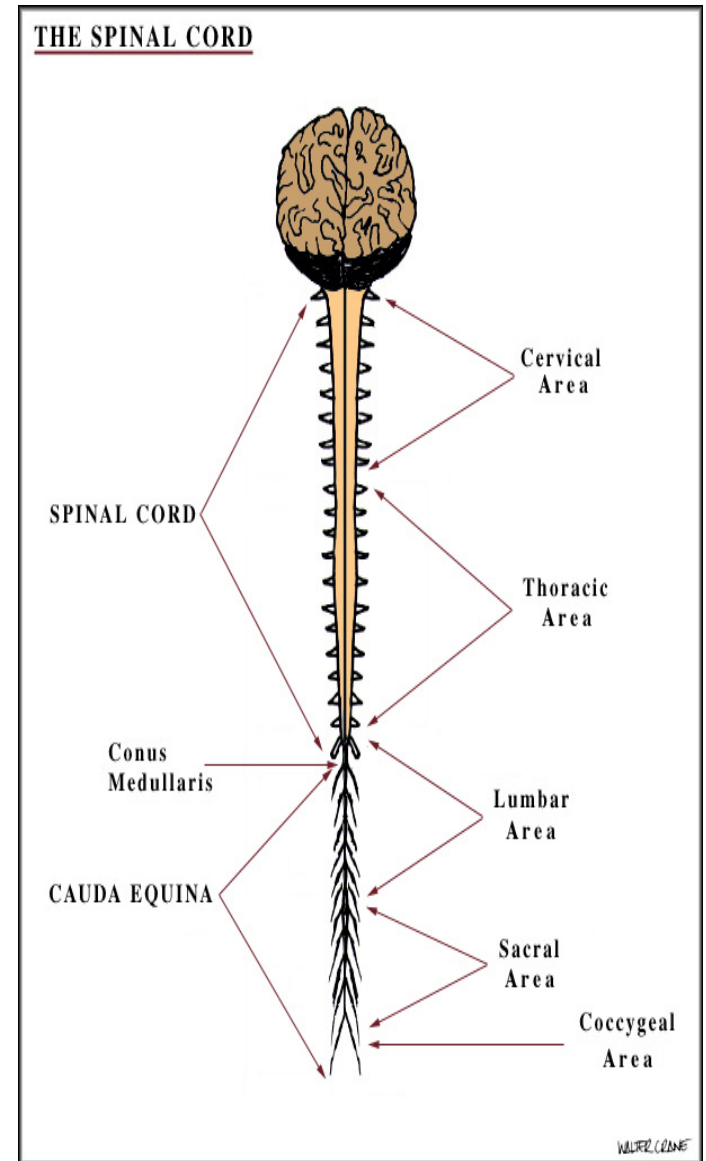
Cross Section of the Spinal Cord



Spinal Cord

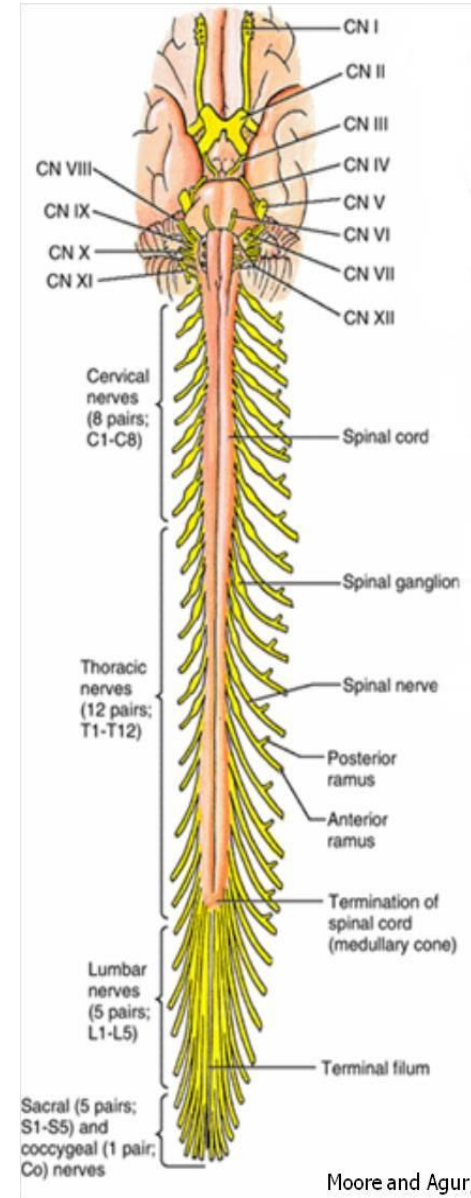
- **Structure**

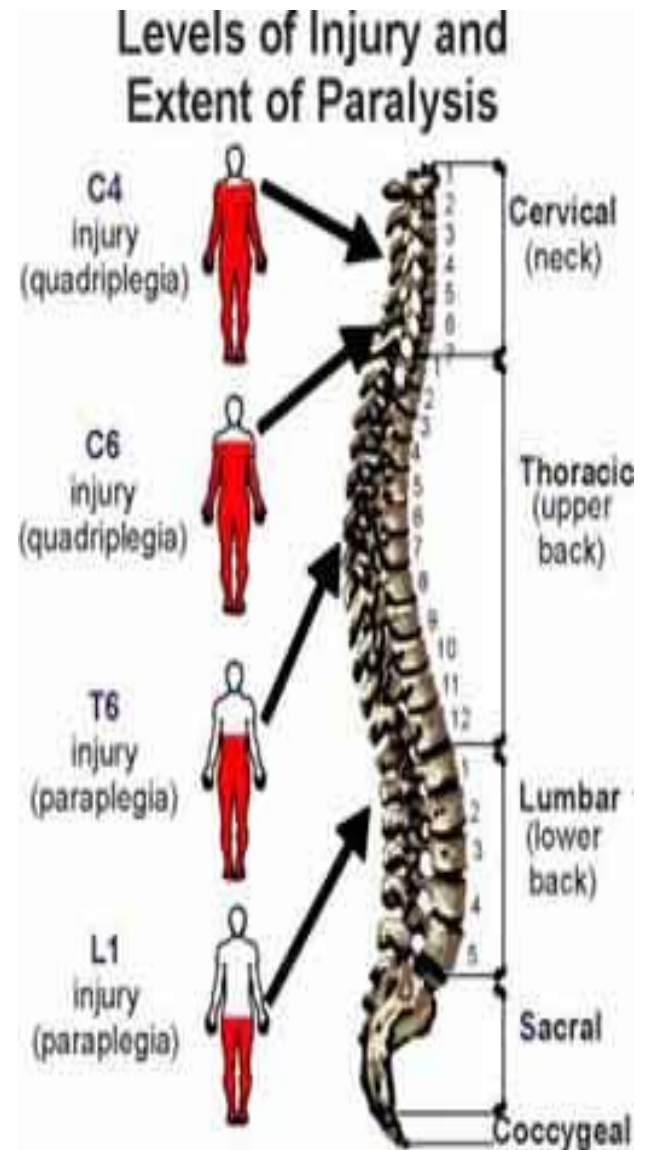
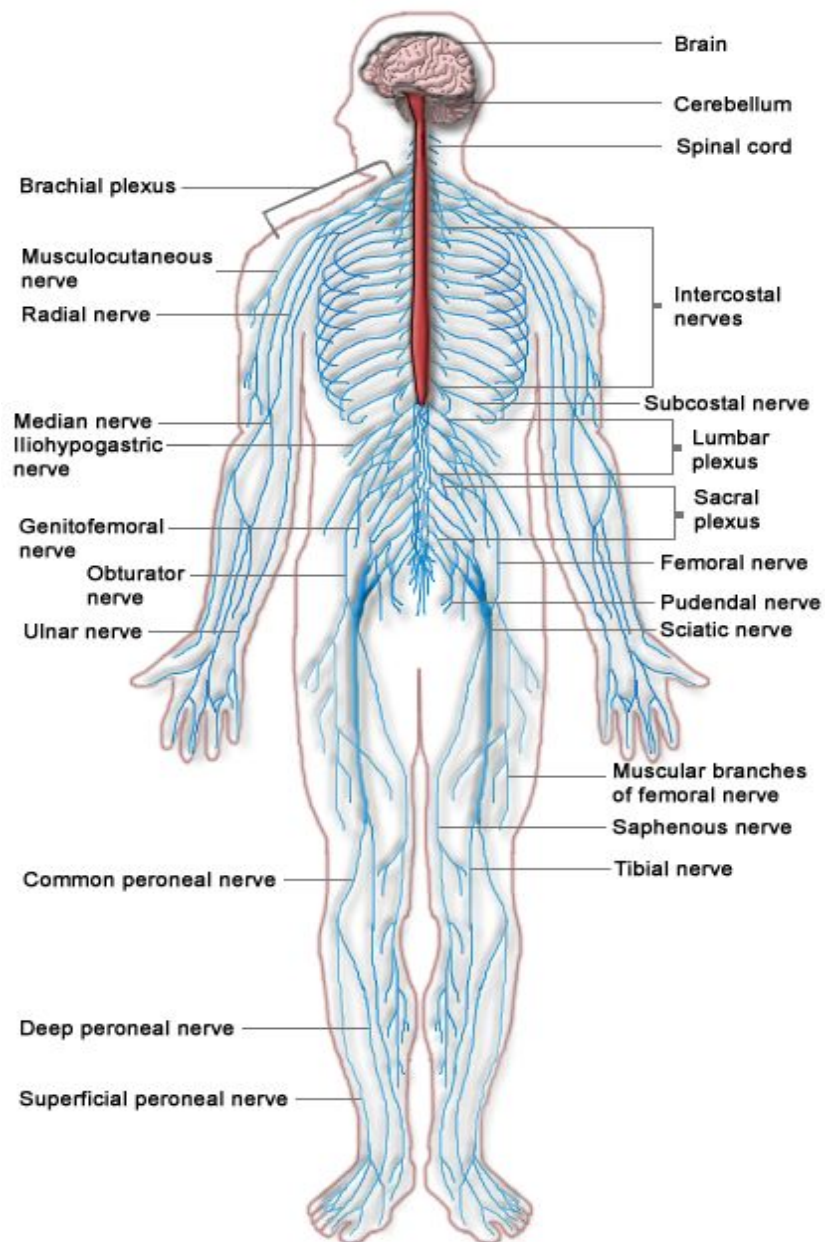
- **31 pairs of spinal nerves which run through the spinal cord. These nerves are called “mixed” nerves because each nerve contains a sensory and a motor axon.**
- **Information entering from the left side of the spinal cord will eventually go over to the right side of the brain and vice versa.**



The spinal cord is used for two main functions:

- It acts as a pathway for information to travel from receptors (skin, eyes, mouth...) to the brain and from the brain to effectors (muscle)





Peripheral Nervous System

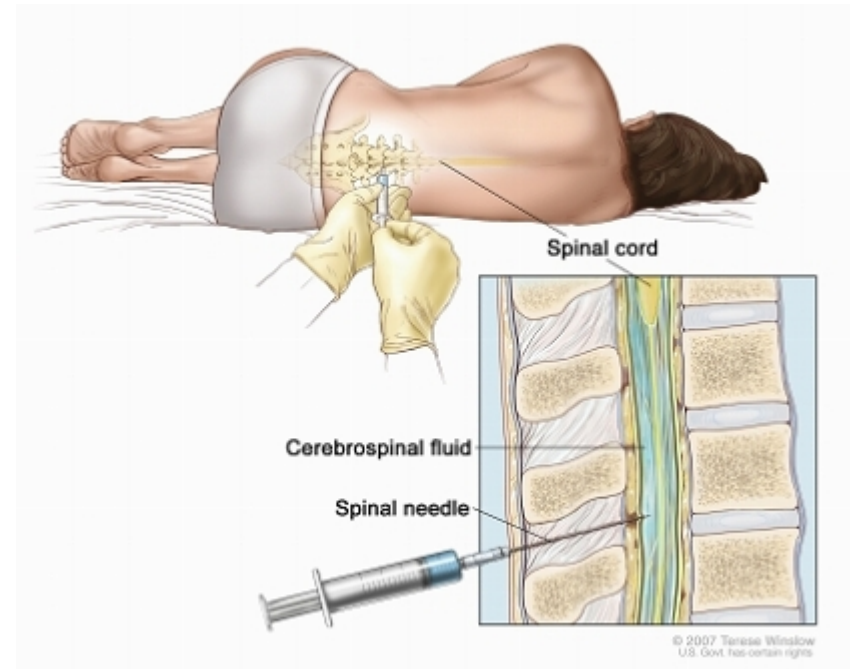
- The peripheral nervous system (PNS) is the part of the nervous system consisting of the nerves and ganglia outside of the brain and spinal cord.
- The main function of the PNS is to connect the CNS to the limbs and organs
- Essentially serving as a communication relay going back and forth between the brain and the extremities.

Example of a Reflex Arc

- A reflex arc is the pathway that a nerve reflex, such as the knee jerk reflex, follows.**
- 1. A tap on the knee stimulates sensory receptors (tendon), generating a nerve signal.**
- 2. The signal travels along a nerve to the spinal cord.**
- 3. In the spinal cord, the signal is transmitted from the sensory nerve to a motor nerve.**
- 4. The motor nerve sends the signal back to effectors (muscle) in the thigh.**
- 5. The muscle contracts, causing the lower leg to jerk upward. The entire reflex occurs without involving the brain.**

- **Primary central nervous system (CNS) lymphoma** is a disease in which malignant (cancer) cells form in the lymph tissue of the brain and/or spinal cord.

- **Lumbar puncture**: A procedure used to collect cerebrospinal fluid (the fluid in the spaces around the brain and spinal cord) from the spinal column. This is done by placing a needle into the spinal column.



Alcohol

- **Depressant**
- **Slows down CNS**
 - 40% of 50,000 highway deaths are caused by drinking and driving
 - 1/3 of homicides attributed to effects of alcohol
 - \$150 billion dollars of U.S. economy alcohol abuse treatment

- An **artificial neuron** is a mathematical function conceived as a crude model, or abstraction of biological **neurons**.
- Artificial neurons are the constitutive units in an **artificial neural network**.
- Depending on the specific model used, it can receive different names, such as semi-linear unit, Nv neuron, binary neuron, linear threshold function or McCulloch–Pitts (MCP) neuron.
- The artificial neuron receives one or more inputs (representing the one or more **dendrites**) and sums them to produce an output (representing a biological neuron's **axon**).

Lifespan Changes

- Brain cells begin to die before birth
- Over average lifetime, brain shrinks 10%
- Most cell death occurs in temporal lobes
-
- By age 90, frontal cortex has lost half its neurons
- Number of dendritic branches decreases
- Fading memory
-
- Slowed responses and reflexes
- Increased risk of falling
- Changes in sleep patterns that result in fewer sleeping hours

Drug Abuse

- Intentional misuse of any drug for nonmedical purposes
- **Addiction** – uncontrollable dependence on a drug

Alcohol and Disease

- **Long-term alcohol use or bouts of excessive consumption**
 - **Destroys liver cells**
 - **Cirrhosis of liver – formation of scar tissue that prevents blood flow through liver**

Only Way to Prevent Addiction and Effects of Drugs

- NOT taking them to begin with

A central nervous system **disease** can affect either the spinal cord (myelopathy) or brain (encephalopathy), both of which are part of the central nervous system

A number of nerve disorders can affect the nervous system, including:

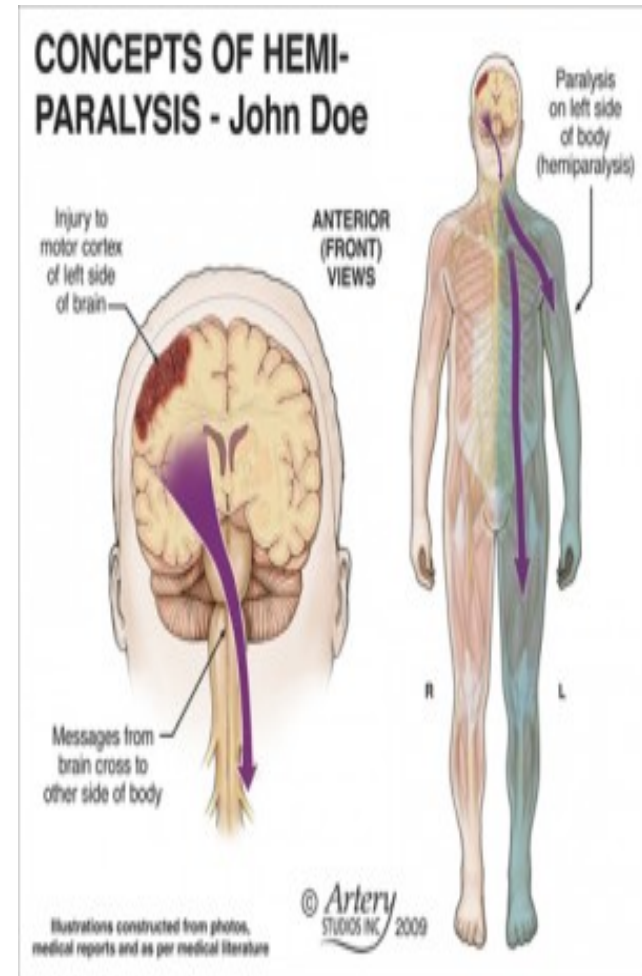
Vascular disorders: stroke, transient ischemic attack (TIA), hematoma, and extradural hemorrhage.

Functional difficulties: result in conditions such as epilepsy, Parkinson's disease, multiple sclerosis, and Alzheimer's disease.

Infections such as meningitis, encephalitis, polio, and epidural abscess can also affect the nervous system.

Structural disorders such as brain or spinal cord injury, Bell's palsy, cervical spondylosis, brain or spinal cord tumors, peripheral neuropathy, and Guillain-Barré syndrome also strike the nervous system.

- **Hemi Paralysis** or **Hemiplegia** is a condition paralyzing or severely weakening one side of a person's body.
- Results of illness, **stroke**, or spinal cord injury.
- **Paraplegia** is paralysis in both legs, below the waist.
- **Quadriplegia** is paralysis below the neck and is also usually the result of a spinal cord injury.





Hydrocephalus

Also known as "water on the brain", is a medical condition in which there is an abnormal accumulation of cerebrospinal fluid (CSF) in of the brain.

This may cause increased intracranial pressure inside the skull and progressive enlargement of the head, convulsion, tunnel vision, and mental disability. Hydrocephalus can also cause death.

Although it does occur in older adults, it is more common in infants

Outcomes to be Assessed

Introduction

- ✓ **Describe the general structure of the brain.**
- ✓ **Describe the relationship among the brain, spinal cord.**

Spinal Cord

- ✓ **Describe the structure of the spinal cord and its major functions.**
- ✓ **Describe a reflex arc & reflex behavior.**

Brain

- ✓ **Name the major parts of the brain and describe the functions of each.**
- ✓ **Distinguish among motor, sensory, association areas of the cerebral cortex.**

Outcomes to be Assessed

- ✓ **Explain hemisphere dominance.**
- ✓ **Explain stages in memory storage.**

Peripheral Nervous System

- ✓ **Describe the structure of a peripheral nerve and how its fibers are classified.**
- ✓ **Name the cranial nerves and list their major functions.**
- ✓ **Explain how spinal nerves are named and their functions**

Autonomic Nervous System

- ✓ **Distinguish between the sympathetic and the parasympathetic divisions of the autonomic nervous system.**