

## Big Picture

The nervous system controls mental and physical activities, whether they are voluntary or involuntary. The nervous system sends electrical signals around the body, allowing the body to react to its surroundings quickly. Without the nervous system, we would not be able to function normally. The ability of the nervous system to monitor and respond to the surrounding depends on the transmission of signals from one neuron to the next and within the neuron itself.

## Key Terms

**Nervous System:** The organ system that carries electrical messages throughout the body.

**Central Nervous System (CNS):** Includes the brain and spinal cord.

**Peripheral Nervous System (PNS):** Nerves that connect all parts of the body to the brain.

**Nerve:** A cable-like bundles of axons that make up the peripheral nervous system.

**Autonomic Nervous System (ANS):** Controls all involuntary activities not under conscious control like breathing.

**Somatic Nervous System (SNS):** Controls voluntary activities that are under conscious control.

**Neuron:** The structural and functional units of the nervous system. Consists of three parts:

**Cell Body:** Contains the nucleus and other cell organelles.

**Dendrite:** Extends from the cell body and receives nerve impulses from other neurons.

**Axon:** An extension of the cell body that transmits nerve impulses to other cells.

**Myelin Sheath:** Outer layer of the axon that serves as an insulator for the axon. There are gaps on the myelin sheath that allow the electrical signal to move along the axon quickly.

**Glial Cells:** Support neurons and produce myelin.

**Nerve Impulse:** Electrical signal transmitted by a neuron.

**Synapse:** Where an axon terminal meets another neuron cell.

**Neurotransmitter:** Chemical that transmits signals across synapses from the axon terminal of one neuron to the dendrites of the next neuron.

## Parts of the Nervous System

The **nervous system** is divided into two parts:

1. **Central nervous system (CNS):** The brain and spinal cord.
  - The spinal cord connects the brain to the rest of the body, moving from the brain stem down the back to the pelvis.
2. **Peripheral nervous system (PNS):** All the neurons and sensory organs in the body not included in the central nervous system.
  - The PNS is connected to the CNS by **nerves**. This nervous system is divided into the sensory (sends information to the central nervous system) and motor (sends information to muscle and glands) systems.

The motor system can be divided into:

- **Autonomic nervous system (ANS):** Controls all involuntary actions (breathing, heart beating, digestion, etc). This nervous system is divided into two divisions: the sympathetic division puts the body in "fight or flight mode," and the parasympathetic division controls non-emergency bodily functions such as digestion.
- **Somatic nervous system (SNS):** Controls all voluntary and conscious actions. Also controls reflexes – a very fast response that never goes through the brain and is directly executed (such as moving your hand away from a hot object).

## Parts of the Brain

The brain has three major parts:

1. **Cerebrum:** the main part of the brain, divided into 4 lobes, controlling conscious functions:
  - Frontal lobe: speech, reasoning, touch
  - Parietal lobe: speech, taste, reading
  - Temporal lobe: hearing, smell
  - Occipital lobe: vision
2. **Cerebellum:** Controls body movement
3. **Brain stem:** The lowest part of the brain that connects the brain to the spinal cord, sending nerve impulses between the two. It also controls unconscious functions, including the heart rate and breathing.

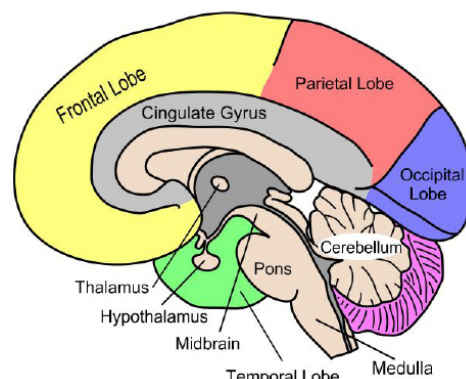


Image Credit: NEUROtiker, CC-BY-SA 2.5

Figure: Cross-section of a brain

# NERVOUS SYSTEM CONT.

## Nerve Cells

Nervous tissues consist of **neurons** and **glial cells**. Neurons transmit electrical signals called **nerve impulses**.

### Parts of a neuron

- **Dendrites** receive nerve impulses and pass them along the **axon**.
- The axon serves as a roadway, allowing neurons to travel along it before it branches off at the end, called the axon terminal.
- Axons are covered in a **myelin sheath**, which increases the speed of impulse transmission.
- The myelin sheath acts as an insulator, much like the plastic around an electrical cord. Gaps in the myelin (called nodes of Ranvier) allow impulses to travel along the axon quickly.
- Schwann cells are a type of glial cells that supply myelin to the axons
- The axon terminal is where the neurons communicate with the cells. It passes impulses onto the next nerve cell.

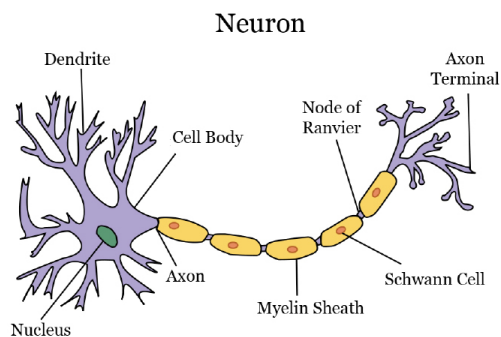


Image Credit: Dhp1080, CC-BY-SA 2.5

### Types of neurons:

- Sensory neurons: Carry impulses from sensory organs to the brain.
- Motor neurons: Carry impulses from the brain to certain muscles and glands, and signals for them to carry out actions.
- Interneurons: Carry impulses between sensory and motor neurons.

### Steps of a reflex arc:

- Signal is received
- Sensory neuron is activated
- Interneuron passes the info to a motor neuron
- Motor neuron is activated and causes a reaction
- The signal never goes through the brain—it's just directly executed; that's what makes reflexes so fast

## Nerve Impulses

Nerve impulses occur when there is a change in electrical charge across the membrane of a neuron.

- All cells have an electrical charge based on concentration on ions inside and outside of the cell.
- Sodium ions ( $\text{Na}^+$ ) and potassium ions ( $\text{K}^+$ ) are important in transmitting nerve impulses.
- When a neuron is in its resting state (not transmitting any nerve impulses), it has a negative charge at around -70 millivolts (its **resting potential**). The sodium-potassium pump maintains a difference in charge across the cell membrane—the inside of the neuron is negatively charged compared to outside the cell.
- During an **action potential**, the charge of a neuron suddenly reverses from negative to positive. Steps of an action potential:
  - Dendrites receive a stimulus (usually from the previous neuron).
  - If the stimulus is strong enough, the first sodium channel opens up, allowing  $\text{Na}^+$  ions to flow into the cell along the concentration gradient.
  - This causes other sodium channels to open up one by one, and the nerve impulse is transmitted down the neuron like a wave.
  - To prevent the signal from going backwards, each sodium channel closes after the next one opens.
  - The neuron becomes positively charged, which signals the next neuron to open its sodium channels and pass on the signal.

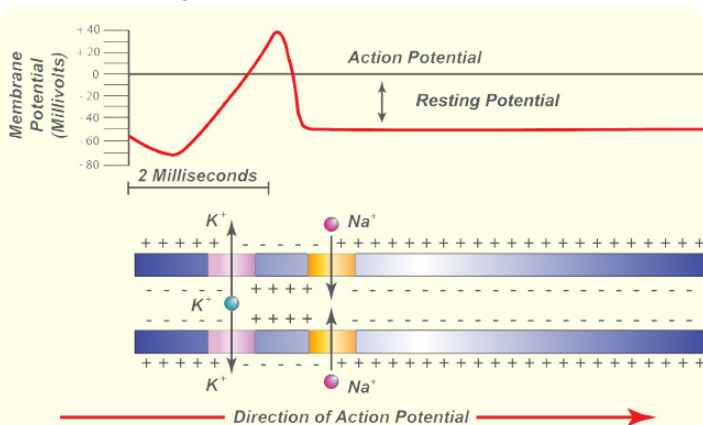


Image Credit: CK-12 Foundation, CC-BY-NC-SA 3.0

## Communication Between Neurons

Neurons communicate with each other at **synapses**. Types of synapses:

- Chemical synapses: chemical signaling molecules are used as messengers
  - Once a signal reaches the axon terminal, a **neurotransmitter** is released across the synapse
  - The neurotransmitter binds to receptors on the next neuron and passes on the signal
- Electrical synapses: ions are messengers

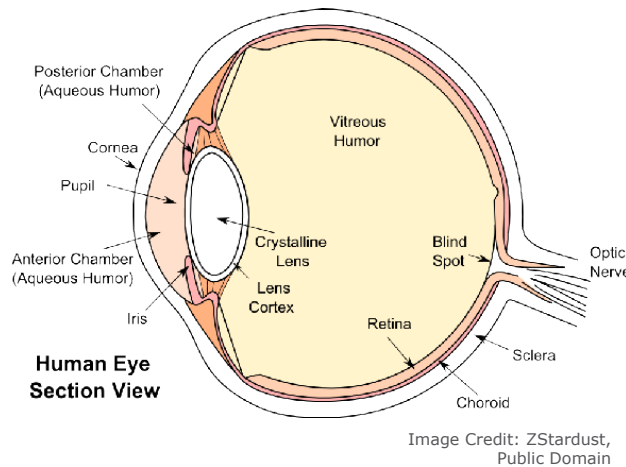
## NERVOUS SYSTEM CONT.

## Sense Organs and Sensory Perception

Sensory receptors are special cells on every sense organ (eyes, ears, mouth, nose, and skin) that respond to a particular stimulus. Upon noticing a stimulus, the sensory receptors send nerve impulses to sensory nerves that then carry the nerve impulses to the brain to be interpreted.

## Sight

Light passes through the eye, which senses light, by passing through the cornea, pupil, lens, and then the retina, which contains receptor cells. These receptor cells send nerve impulses to sensory nerves that then goes to the brain.



## Taste and Smell

Both of these senses pertain to the body's ability to recognize chemicals. The taste receptors are the taste buds on the tongue, and the odor receptors inside the nose sense chemicals in the air. Both of these receptors send nerve impulses to the brain, which then interprets these chemicals.

## Drugs and the Nervous System

Psychoactive drugs, which include alcohol, caffeine, nicotine, and marijuana, affect the central nervous system by influencing the transmission of nerve impulses. Drug abuse is when people use psychoactive drugs without the approval of a medical professional or for reasons the drug was not intended for, and drug addiction is the continued use of these types of drugs.

## Notes

## Hearing

Sound waves enter the auditory canal, then the eardrum, and the cochlea. The sound waves move around the hairs inside the ear, which send nerve impulses to the auditory nerve.

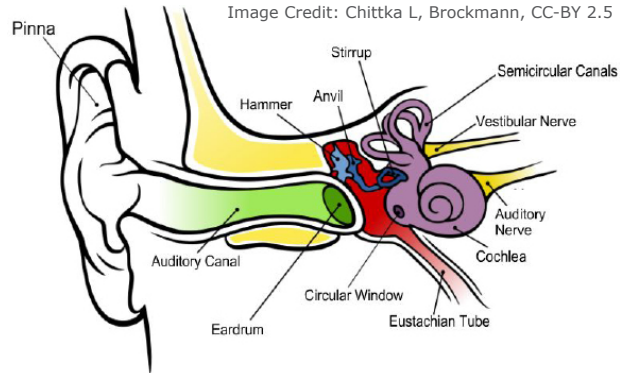


Figure: Cross-section of the ear.

## Balance

This system, which maintains the body's balance, is also controlled by the ears. When your body moves, there is fluid in the ear that moves with your head. Tiny hairs in your ear sense this movement and sends messages to the peripheral nervous system, which then controls your body and makes sure you do not lose your balance.

## Touch

Because your sense of touch is your body's ability to sense pressure, the pressure receptors on your skin, tongue, lips, palms, and feet serve to send nerve impulses to the brain. Moreover, some of these receptors can also note differences in temperature.