PHYSIOLOGY

FACULTY OF PHARMACEUTICAL SCIENCES
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LECTURE 3, PART (2): INTRODUCTION OF THE NERVOUS SYSTEM

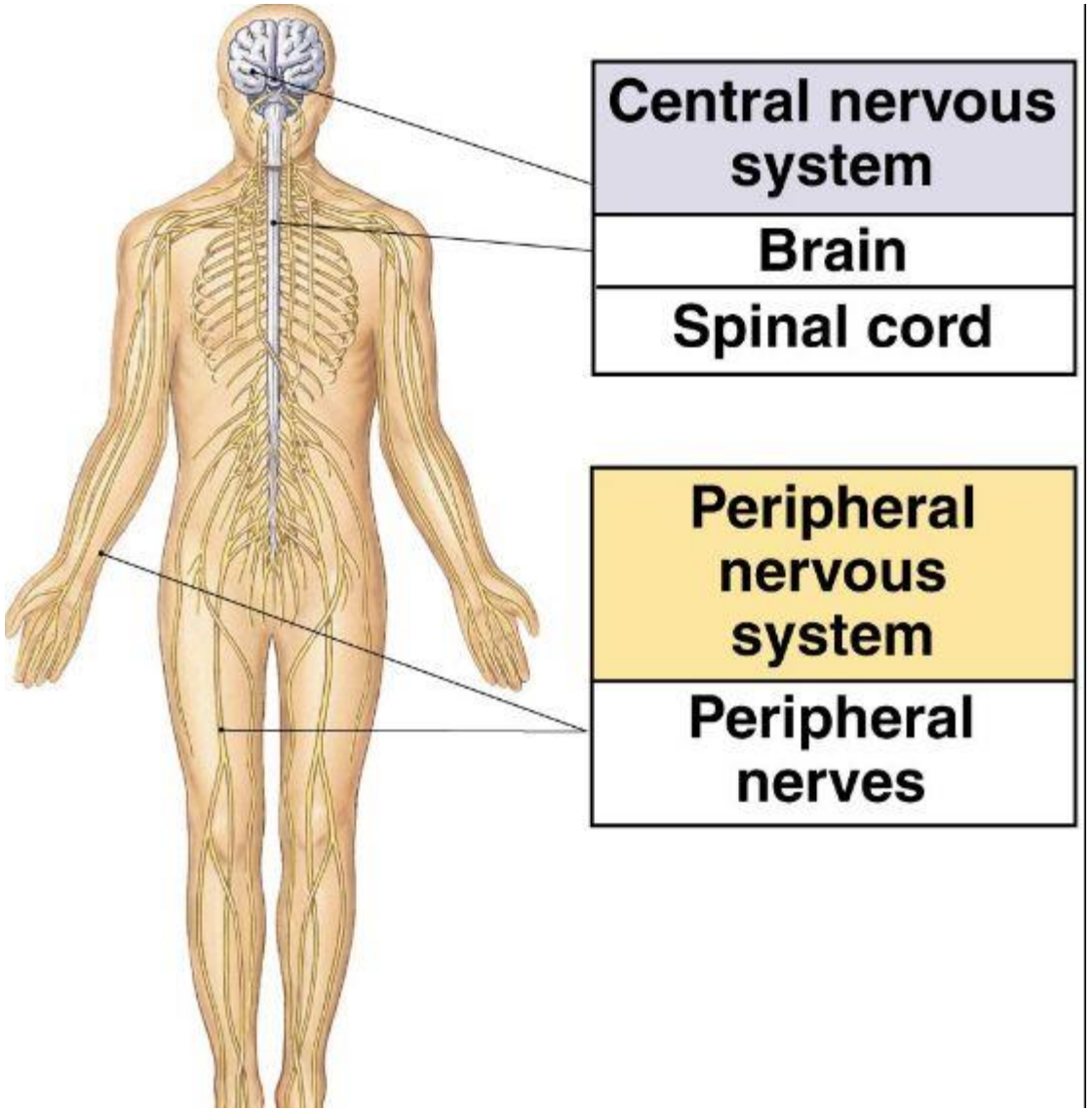
Objectives

1. Discuss **central nervous system (CNS) as well as peripheral nervous system (PNS).**
2. Describe **functions of the nervous system**.
3. Explore **classification of neurons.**

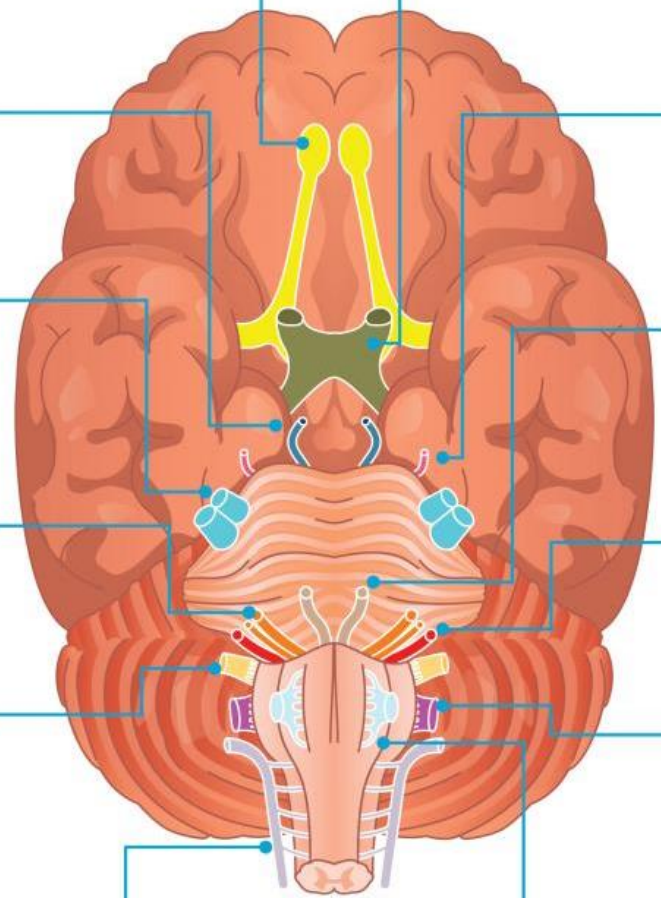
(Pages 400- 408 of the reference)

General Overview

The nervous system is one of the smallest (3% of the total body weight) but the most complex of the 11 body systems.



12 Cranial Nerves



olfactory
smell

optic
vision

oculomotor
eye movement and pupil reflex

trochlear
eye movement

trigeminal
face sensation and chewing

abducens
eye movement

facial
face movement and taste

vestibulocochlear
hearing and balance

glossopharyngeal
throat sensation, taste, and swallowing

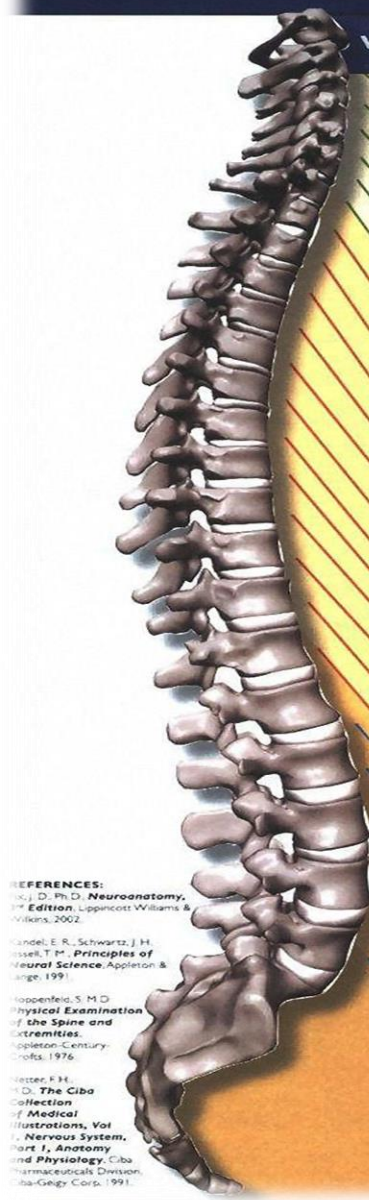
vagus
movement, sensation, and abdominal organs

accessory
neck movement

hypoglossal
movement, sensation, and abdominal organs

Spinal Nerve Function

Every Cell of Your Body Has a Nerve Component



VERTEBRAL LEVEL	NERVE ROOT*	INNERVATION	POSSIBLE SYMPTOMS
C1	C1	Intracranial Blood Vessels • Eyes • Lacrimal Gland • Parotid Gland • Base of Skull • Neck Muscles • Diaphragm	Headaches • Migraine Headaches • Dizziness • Sinus Problems • Allergies • Head Colds • Fatigue • Vision Problems • Runny Nose • Sore Throat • Stiff Neck • Cough • Croup • Arm Pain • Hand and Finger Numbness or Tingling • Asthma • Heart Conditions • High Blood Pressure
C2	C2		
C3	C3		
C4	C4		
C5	C5	• Neck Muscles • Shoulders • Elbows • Arms • Wrists • Hands • Fingers • Esophagus • Heart • Lungs • Chest	
C6	C6		
C7	C7		
	C8		
T1	T1	Arms • Esophagus • Heart • Lungs • Chest • Larynx • Trachea	Wrist, Hand and Finger Numbness or Pain • Middle Back Pain • Congestion • Difficulty Breathing • Asthma • High Blood Pressure • Heart Conditions • Bronchitis • Pneumonia • Gallbladder Conditions • Jaundice • Liver Conditions • Stomach Problems • Ulcers • Gastritis • Kidney Problems
T2	T2		
T3	T3		
T4	T4		
T5	T5	Gallbladder • Liver • Diaphragm • Stomach • Pancreas • Spleen • Kidneys • Small Intestine • Appendix • Adrenals	
T6	T6		
T7	T7		
T8	T8		
T9	T9		
T10	T10		
T11	T11	Small Intestines • Colon • Uterus	
T12	T12	Uterus • Colon • Buttocks	
L1	L1	Large Intestines • Buttocks • Groin • Reproductive Organs • Colon • Thighs • Knees • Legs • Feet	Constipation • Colitis • Diarrhea • Gas Pain • Irritable Bowel • Bladder Problems • Menstrual Problems • Low Back Pain • Pain or Numbness in Legs
L2	L2		
L3	L3		
L4	L4		
L5	L5		
	SACRAL	Buttocks • Reproductive Organs • Bladder • Prostate Gland • Legs • Ankles • Feet • Toes	Constipation • Diarrhea • Bladder Problems • Menstrual Problems • Lower Back Pain • Pain or Numbness in Legs

REFERENCES:
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...ndel, E. R., Schwartz, J. H. ...ssell, T. M.; ***Principles of Neural Science***, Appleton & ...nge, 1991.

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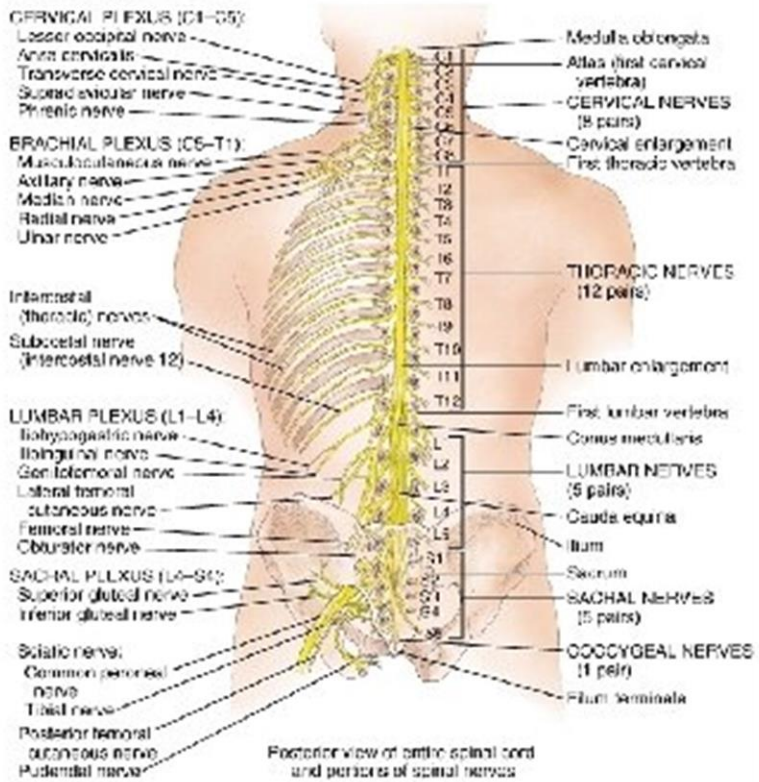
Spinal Nerves

- 31 Pairs of spinal nerves
- Named & numbered by the cord level of their origin
  - 8 pairs of cervical nerves (C1 to C8)
  - 12 pairs of thoracic nerves (T1 to T12)
  - 5 pairs of lumbar nerves (L1 to L5)
  - 5 pairs of sacral nerves (S1 to S5)
  - 1 pair of coccygeal nerves
- Mixed sensory & motor nerves

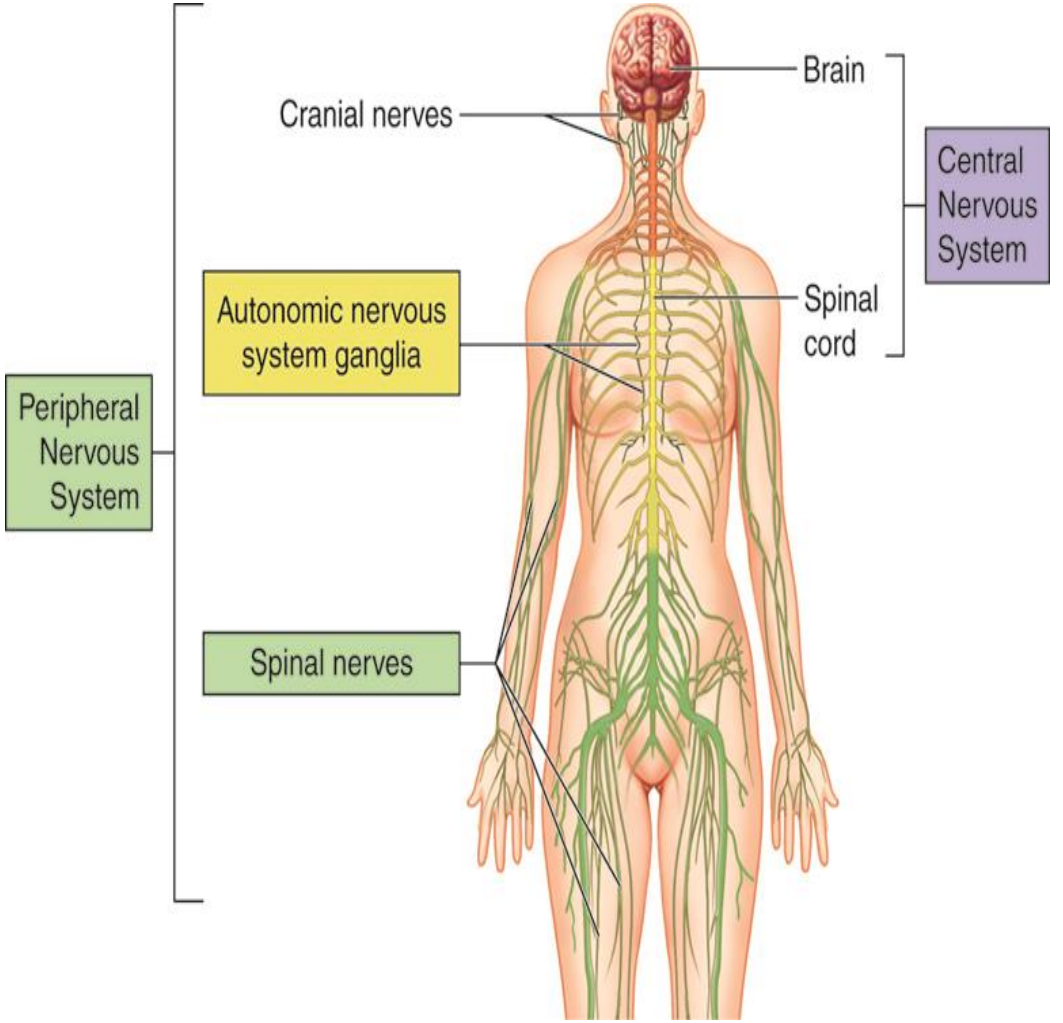


NERVOUS SYSTEM

- It consists of **central nervous system (CNS)** and **peripheral nervous system (PNS).**

- The **CNS** consists of brain (85 billion neurons) and spinal cord (100 million neurons.).

- The **PNS** consists of all nervous tissue outside the CNS, which include nerves, ganglia, enteric plexuses, and sensory receptors.



PERIPHERAL NERVOUS SYSTEM

1. **Nerve** is a bundle of hundreds to thousands of axons plus associated connective tissue and blood vessels that lies outside the brain and spinal cord (i.e., **cranial nerves** emerge from the brain and **spinal nerves** emerge from the spinal cord).

2. **Ganglia** are small masses of nervous tissue, that are located outside of the brain and spinal cord.

3. **Enteric plexuses** are extensive networks of neurons located in the walls of organs of the gastrointestinal tract (regulating the digestive system).

4. **Sensory receptor** refers to a structure of the nervous system that monitors changes in the external or internal environment.

PERIPHERAL NERVOUS SYSTEM

- Somatic nervous system (SNS)
- Autonomic nervous system (ANS)
- Enteric nervous system (ENS)

SOMATIC NERVOUS SYSTEM (SNS) (CONSCIOUSLY CONTROLLED)

1. **Sensory neurons** that convey information to CNS from somatic receptors in the head, body wall, and limbs and from receptors for the special senses of vision, hearing, taste, and smell.

2. **Motor neurons** that conduct impulses from the CNS to skeletal muscles only.

AUTONOMIC NERVOUS SYSTEM (ANS) (INVOLUNTARY)

1. **Sensory neurons** that convey information to CNS from autonomic sensory receptors, located primarily in visceral organs such as the stomach and lungs.

2. **Motor neurons** that conduct nerve impulses from the CNS to smooth muscle, cardiac muscle, and glands.

Note: The motor part of the ANS consists of two branches, the **sympathetic division and the parasympathetic division**.

ENTERIC NERVOUS SYSTEM (ENS) (THE BRAIN OF THE GUT) (INVOLUNTARY)

1. **Sensory neurons** of the ENS monitor chemical changes within the GI tract as well as the stretching of its walls.

2. **Motor neurons** govern contractions of GI tract smooth muscle to propel food through the GI tract, secretions of GI tract organs (such as acid from the stomach and hormones from GI tract endocrine cells).

FUNCTIONS OF THE NERVOUS SYSTEM

Sensory function (detecting internal stimuli or external stimuli through cranial and spinal nerves).

Integrative function (analyzing sensory information and making decisions for appropriate responses).

Motor function (eliciting an appropriate motor response by activating effectors (muscles and glands) through cranial and spinal nerves).

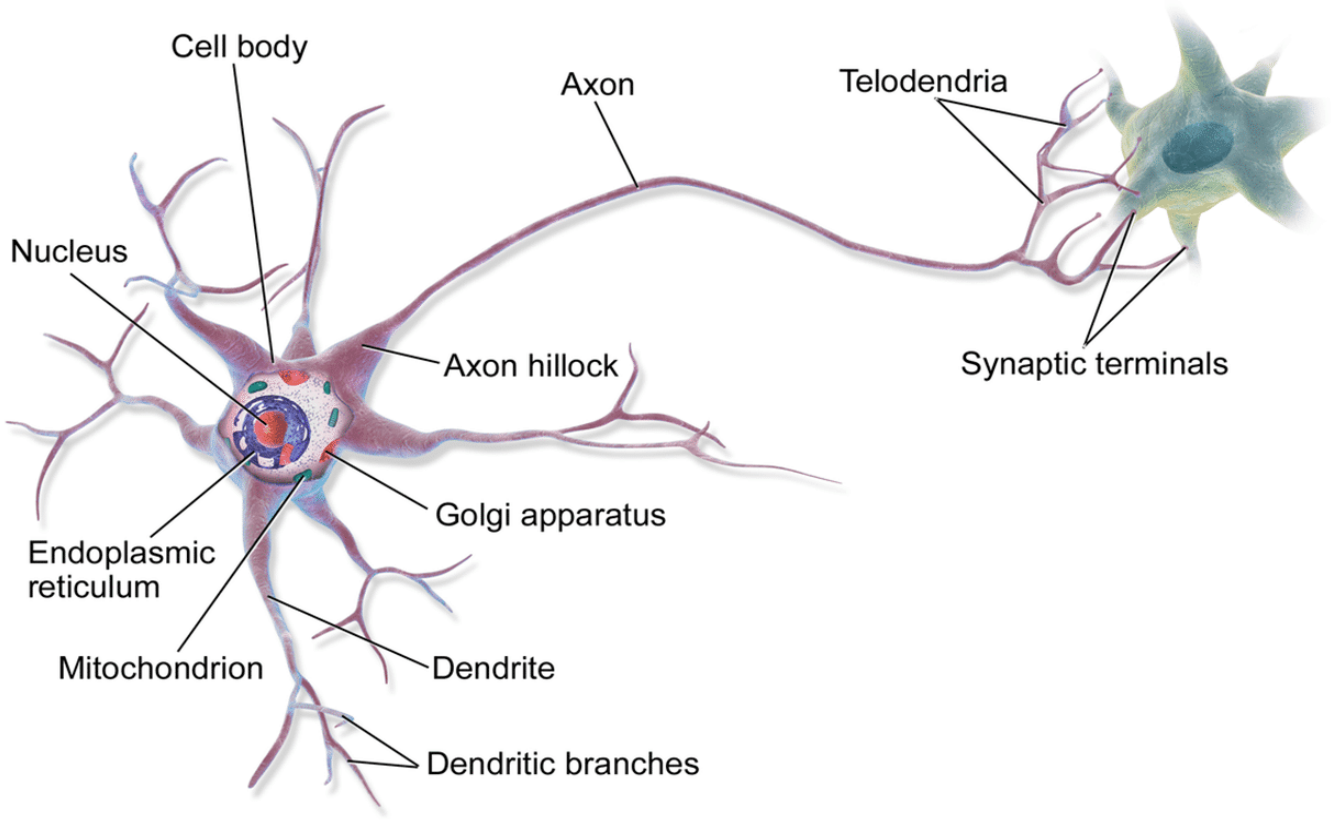
NERVOUS TISSUE

Neurons (provide most of the unique functions of the nervous system, such as sensing as they connect all regions of the body to the brain and spinal cord). No ability to undergo dividing throughout an individual's lifetime.

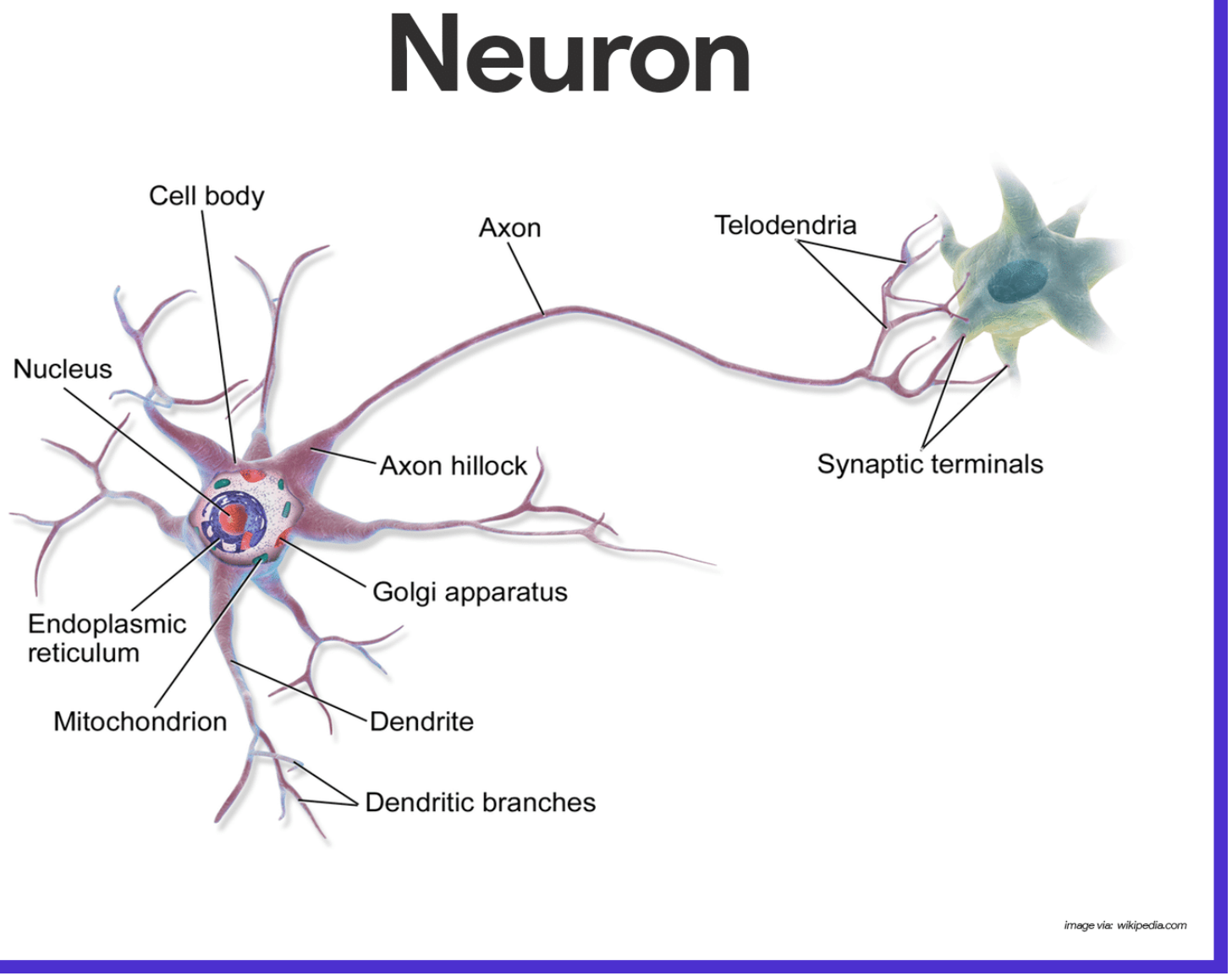
Neuroglia (support and protect neurons, and maintain the interstitial fluid that bathes them) (they outnumber neurons). It has a continuous ability to divide throughout an individual's lifetime.

The neuron has the ability to respond to a stimulus and convert it into an action potential (nerve impulses).

The **cell body** contains free ribosomes and rough endoplasmic reticulum for synthesizing new proteins. .

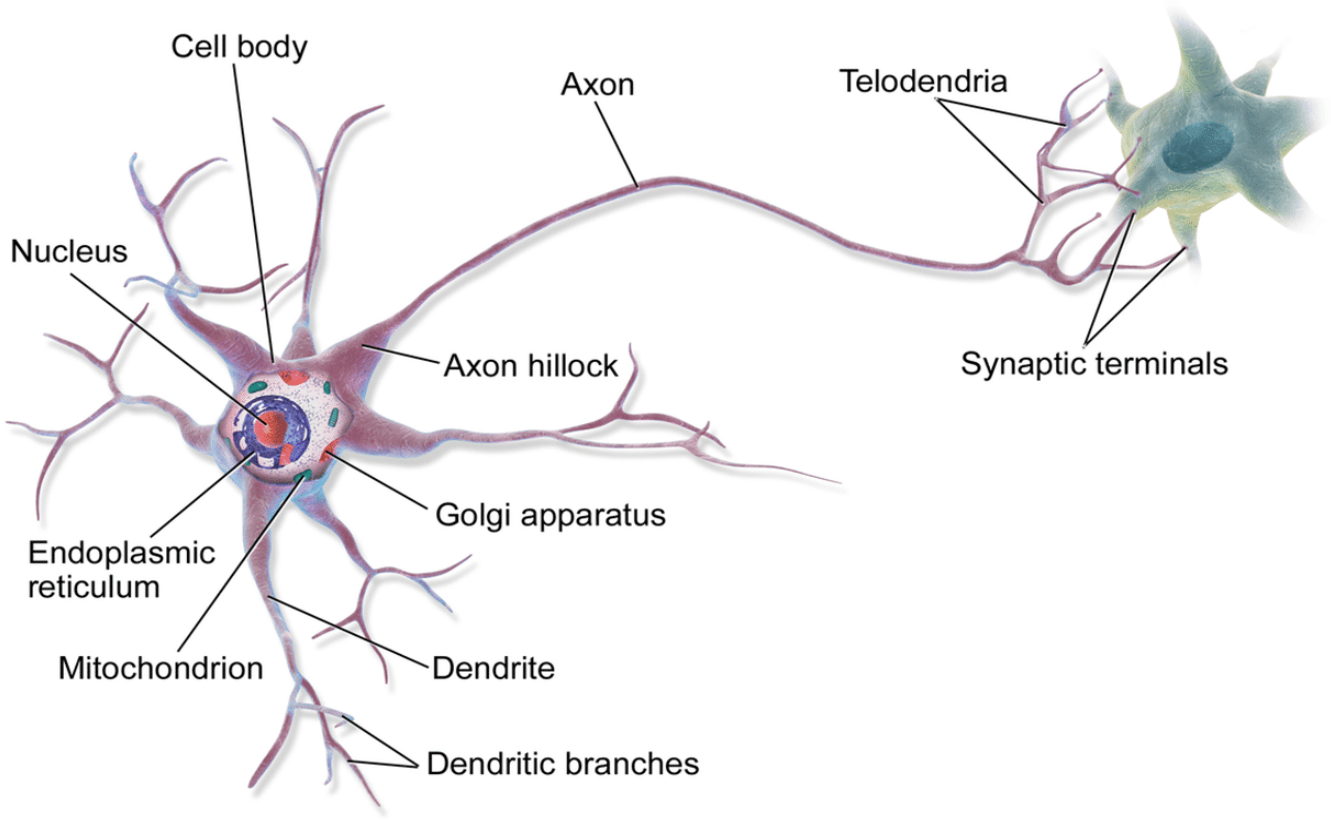


<u>The dendrites (like little trees)</u> are the receiving or input portions of a neuron because they contain numerous receptor sites for binding chemical messengers from other cells.



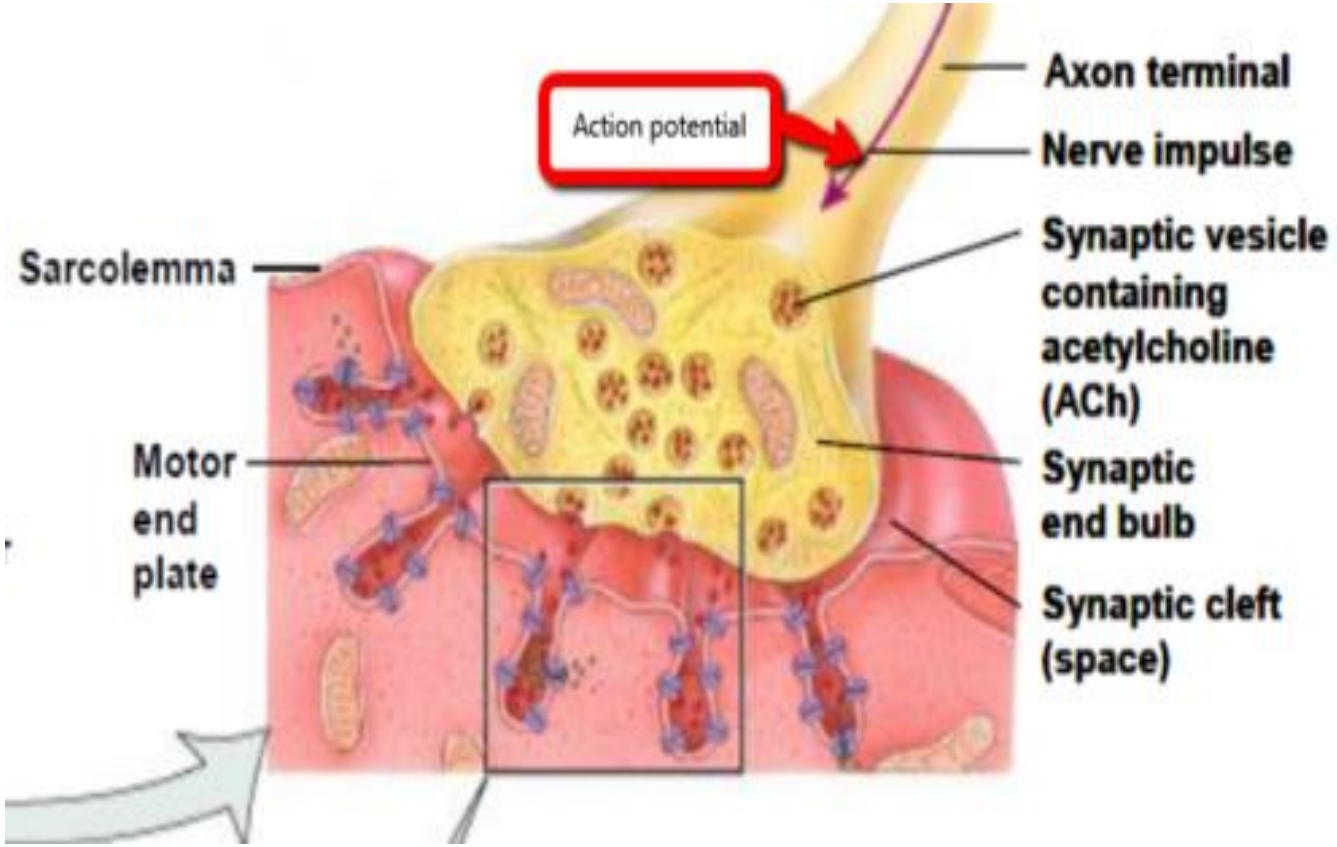
The **single axon** (long and thin projection) of a neuron propagates nerve impulses toward another neuron, a muscle fiber, or a gland cell.

The axon ends by dividing into many fine processes called **axon terminals**.



SYNAPSE

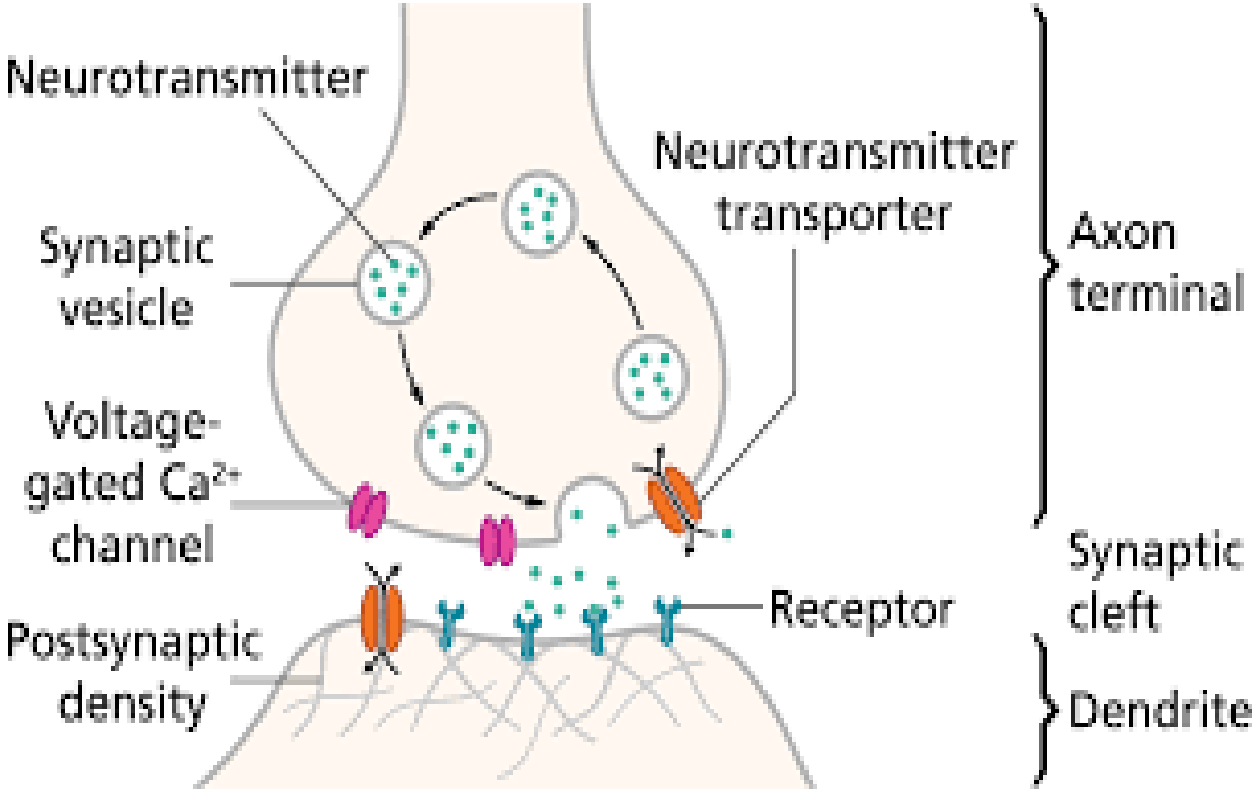
- **Synapse** is the site of communication between two neurons or between a neuron and an effector cell.
- Some axon terminals swell into bulb-shaped structures called **synaptic end bulbs**.
- **Synaptic end bulbs** contain many tiny membrane-enclosed sacs called synaptic vesicles that store a chemical called a neurotransmitter.



SYNAPSE

- **Neurotransmitter** is a molecule released from a synaptic vesicle to excite or inhibit another neuron, muscle fiber, or gland cell.

- Many neurons have two or even three types of neurotransmitters, each with different effects on the **postsynaptic cell**.



CLASSIFICATION OF NEURONS

1. **Structural Classification** (according to the number of processes extending from the cell body).

2. **Functional Classification** (according to the direction in which the nerve impulse (action potential) is conveyed with respect to the CNS).

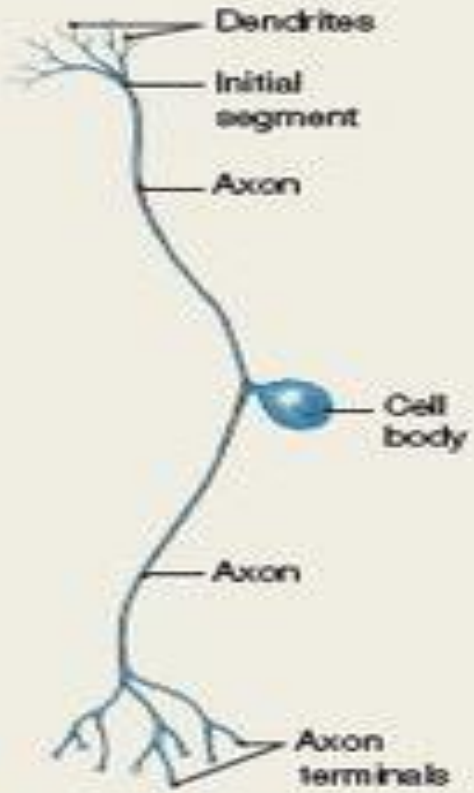
STRUCTURAL CLASSIFICATION

b Bipolar neuron

Bipolar neurons have two processes separated by the cell body.

c Unipolar neuron

Unipolar neurons have a single elongated process, with the cell body located off to the side.



d Multipolar neuron

Multipolar neurons have more than two processes; there is a single axon and multiple dendrites.

STRUCTURAL CLASSIFICATION

- A **multipolar neuron** has many processes extending from the cell body, a **bipolar neuron** has two, and **a unipolar neuron** has one.

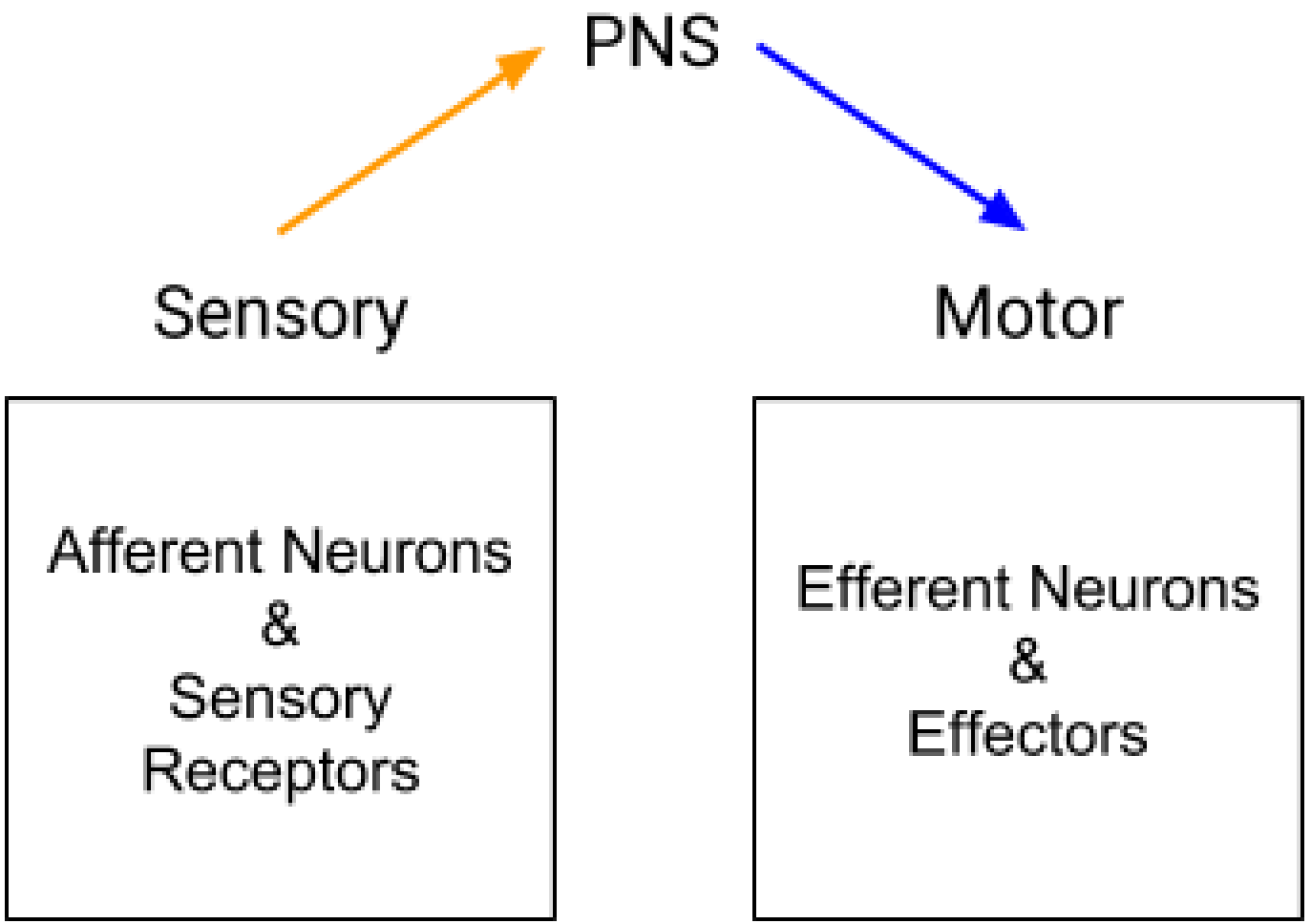
- **Multipolar neurons** have several dendrites and one axon (i.e., neurons in the brain and spinal cord). They are found as motor neurons (all) and interneurons (many).

STRUCTURAL CLASSIFICATION

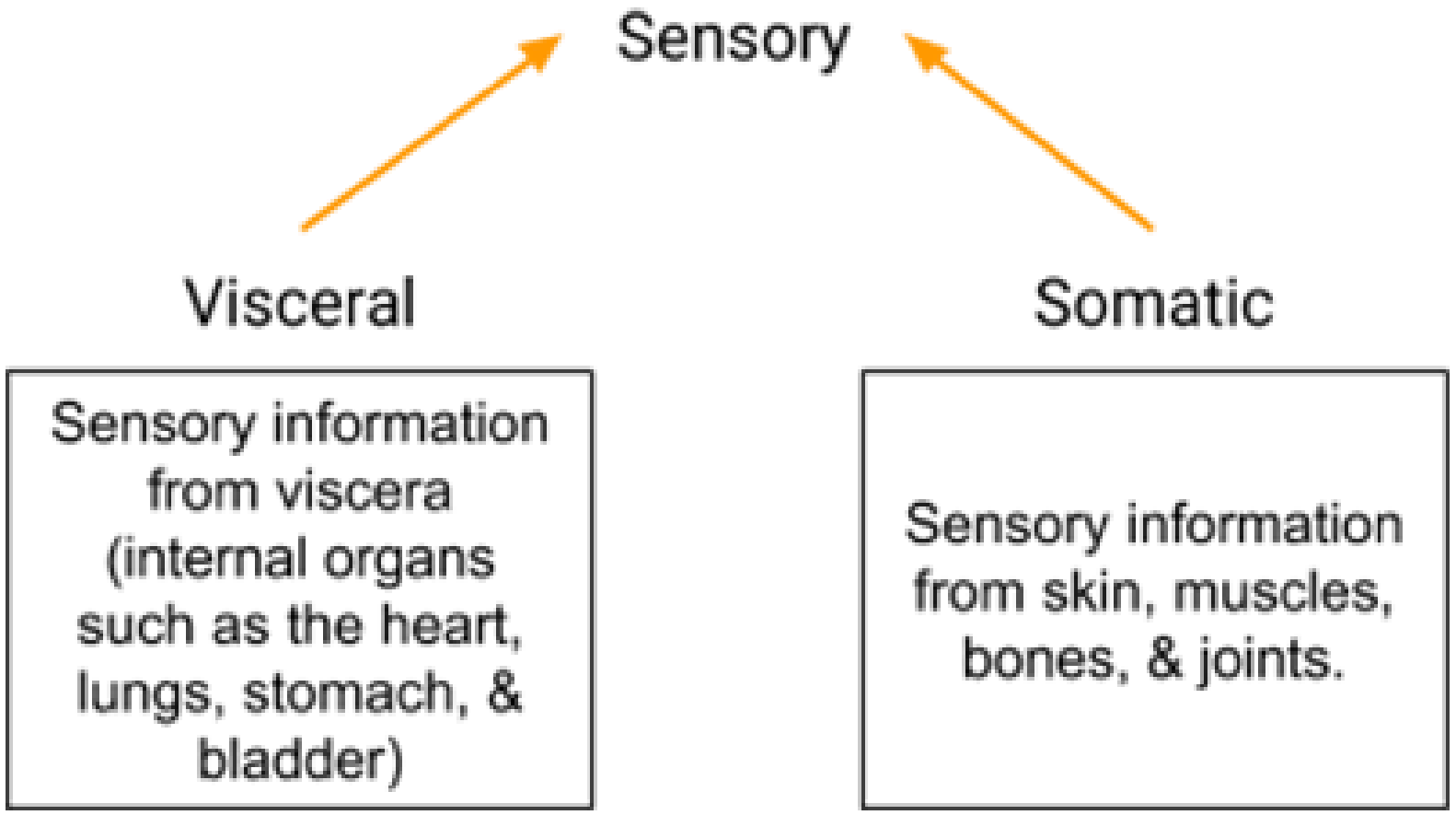
- **Bipolar neurons** have one main dendrite and one axon (i.e., neurons in the retina of the eye, the inner ear, and the olfactory area of the brain. Some of them are found as sensory neurons.

- **Unipolar neurons** have dendrites and one axon that are fused together to form a continuous process that emerges from the cell body. They are found as most of the body's sensory neurons.

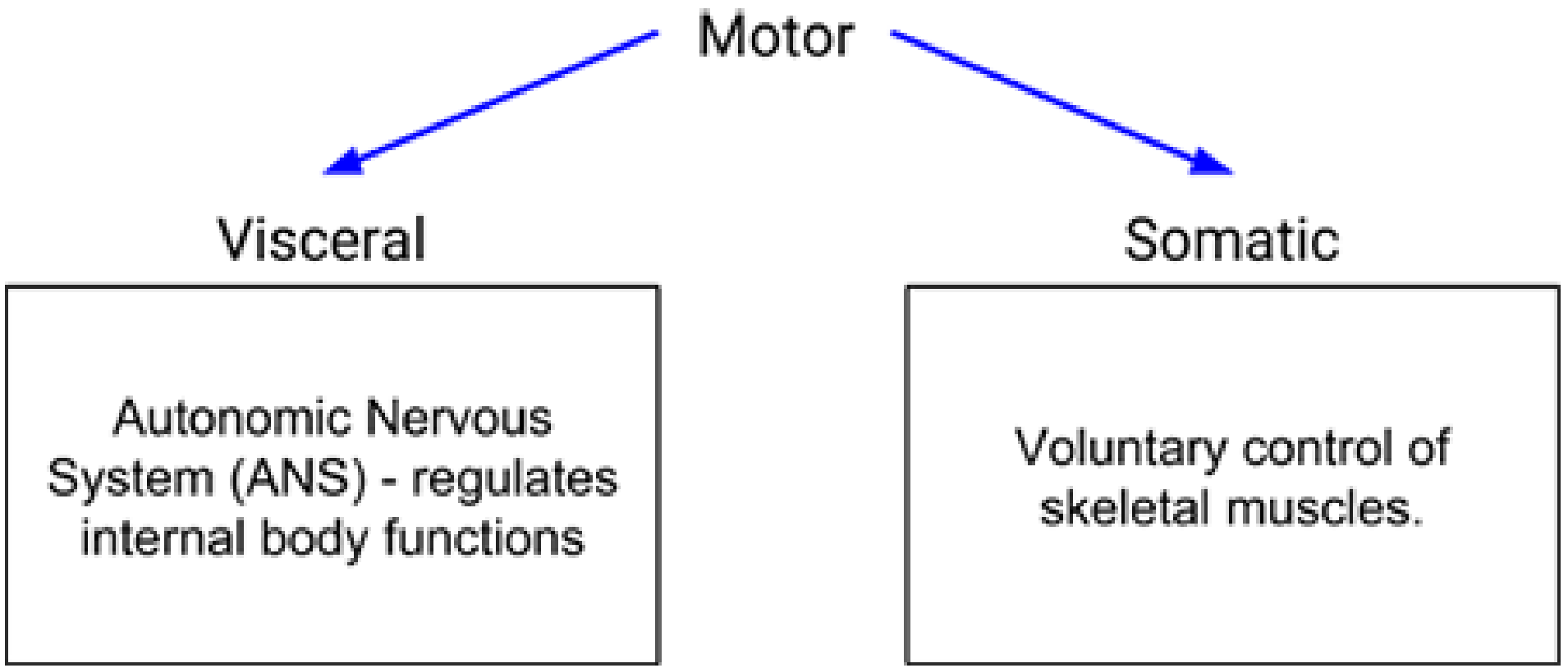
FUNCTIONAL CLASSIFICATION



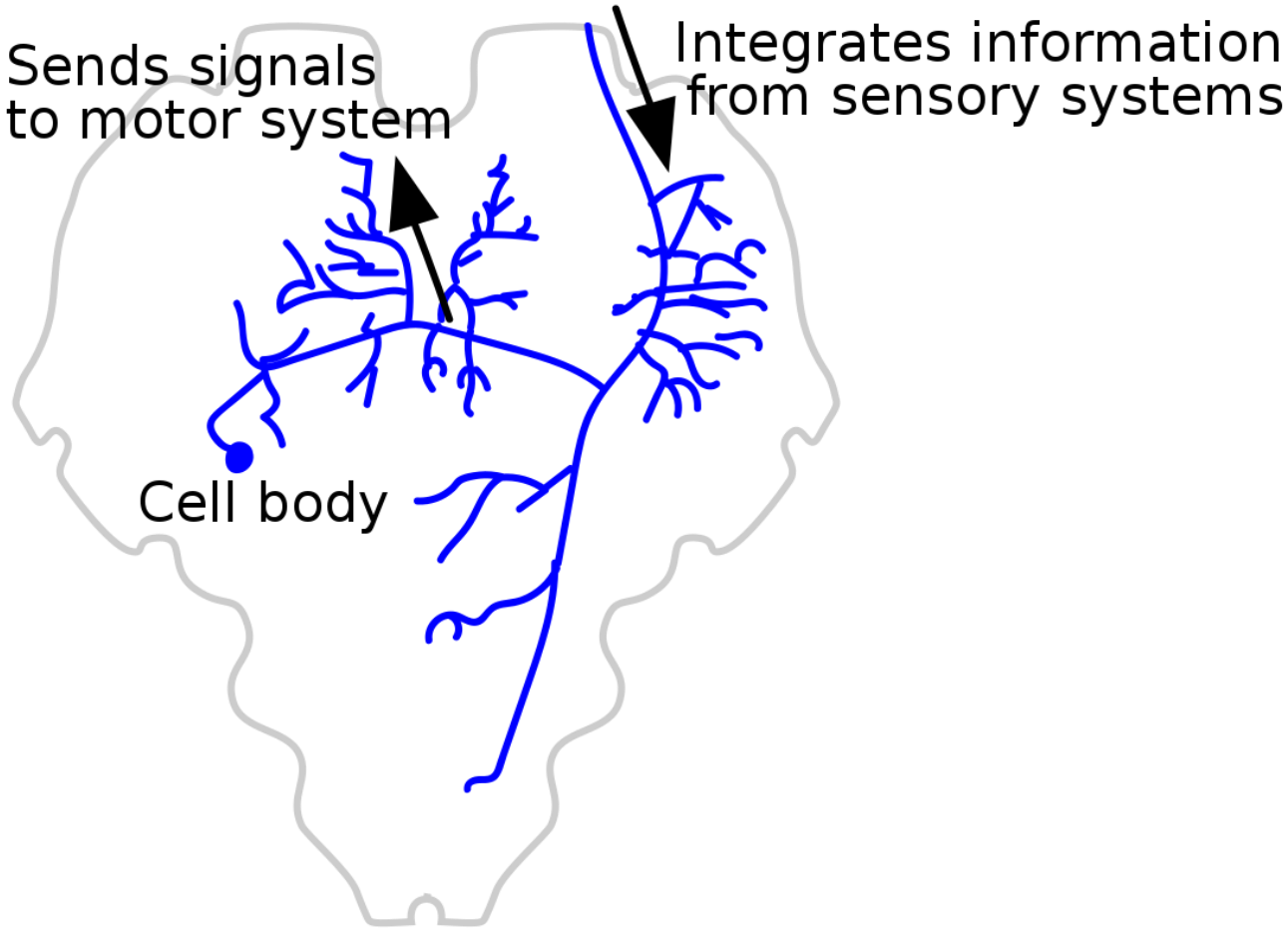
SENSORY OR AFFERENT NEURONS



MOTOR OR EFFERENT NEURONS



INTERNEURONS OR ASSOCIATION NEURONS



FUNCTIONAL CLASSIFICATION

- **Sensory or afferent neurons (most are unipolar):** appropriate stimulus activates a sensory receptor; the sensory neuron forms an action potential in its axon and the action potential is conveyed into the CNS through cranial or spinal nerves. Most sensory neurons are unipolar in structure.

- **Motor or efferent neurons (most are multipolar):** convey action potentials (commands) away from the CNS to effectors (muscles and glands) through cranial or spinal nerves.

FUNCTIONAL CLASSIFICATION

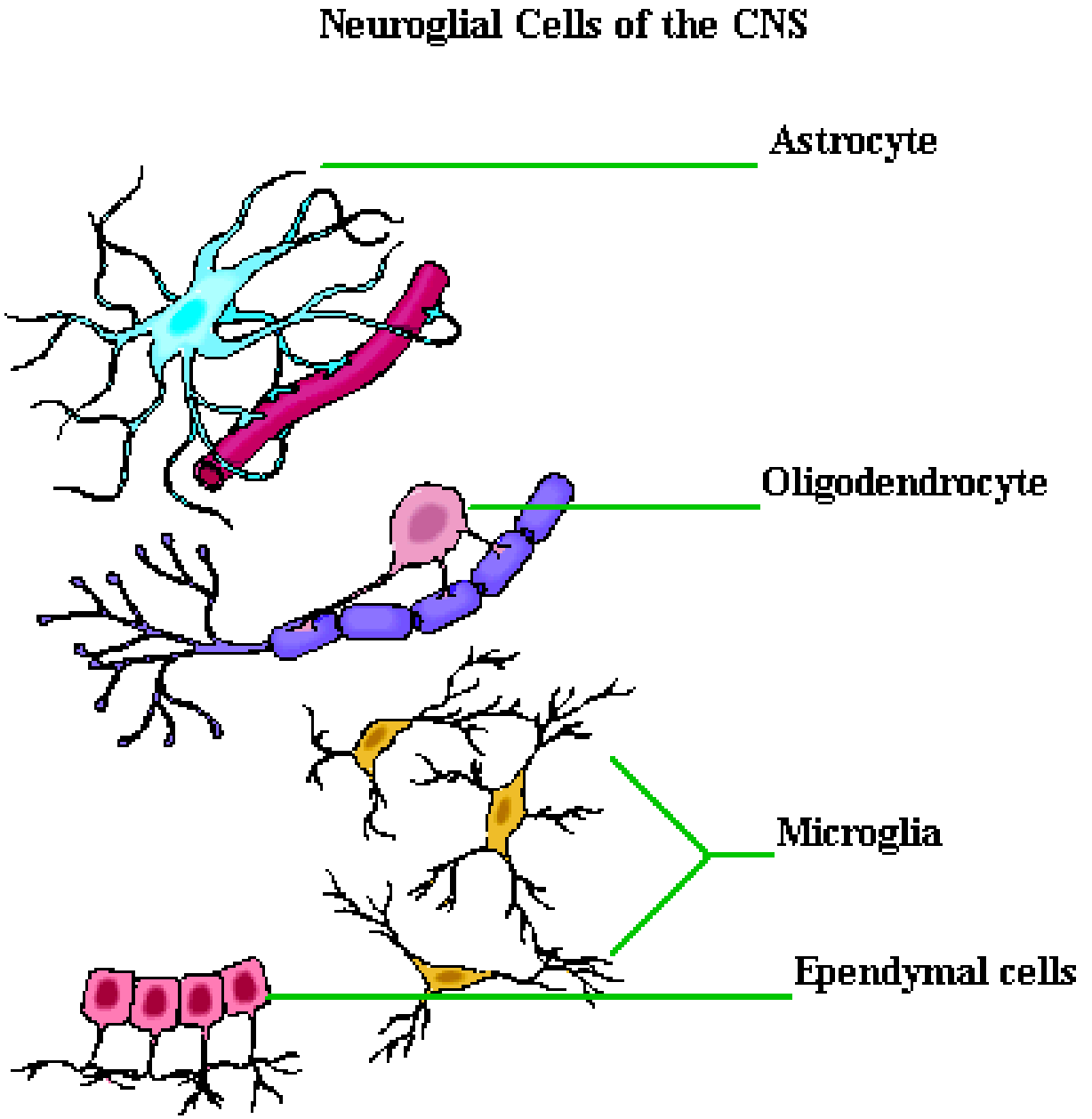
- **Interneurons or association neurons (most are multipolar):**

- They are located within the CNS (brain and spinal cord) between sensory and motor neurons.
- They integrate the incoming sensory information from sensory neurons (transmit action potential from one neuron to another) and then elicit a motor response by activating the appropriate motor neurons.
- Main functions are thinking, memory, decision making.

NEUROGLIA

- In contrast to neurons, neuroglia **do not generate** or propagate **action potentials**, and they **can multiply and divide** in the mature nervous system.

- Neuroglia of the CNS can be classified into four types: **astrocytes, oligodendrocytes, microglial cells, and ependymal cells**.



ASTROCYTES

1. **Support neurons**.
2. **Isolate neurons** of the CNS from various potentially **harmful substances** in blood.
3. **Regulate** the growth, migration, and interconnection among **neurons** in the brain.
4. **Maintain** the appropriate chemical environment for the generation of **nerve impulses**.
5. Play a role in **learning and memory** by influencing the formation of neural synapses.

OLIGODENDROCYTES

- They are forming and maintaining the myelin sheath which increases the speed of nerve impulse conduction around CNS axons. (containing interneurons)

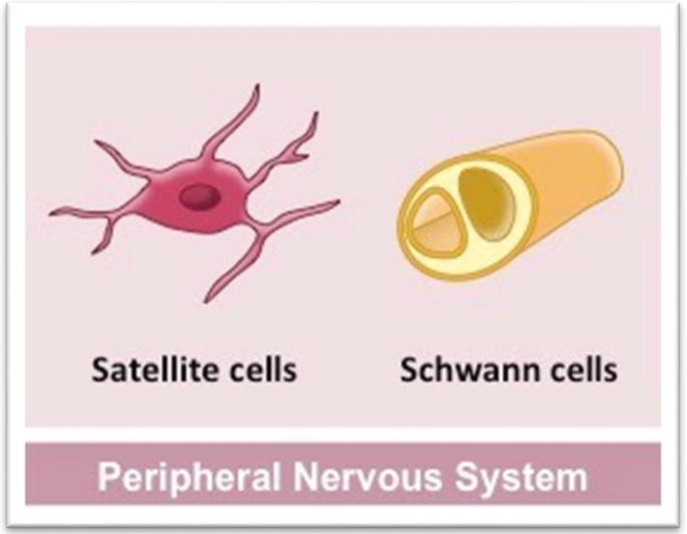
MICROGLIA

- They remove cellular debris formed during normal development of the nervous system and phagocytize microbes and damaged nervous tissue.

EPENDYMAL CELLS

- They produce and assist in the circulation of cerebrospinal fluid.

NEUROGLIA OF THE PNS



- The two types of glial cells in the PNS are **Schwann cells and Satellite cells.**

SCHWANN CELLS

- They form the myelin sheath around axons and participate in axon regeneration. (containing sensory and motor neurons).

SATELLITE CELLS

- They provide structural support and regulate the exchanges of materials between neuronal cell bodies and interstitial fluid.

THANK YOU

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