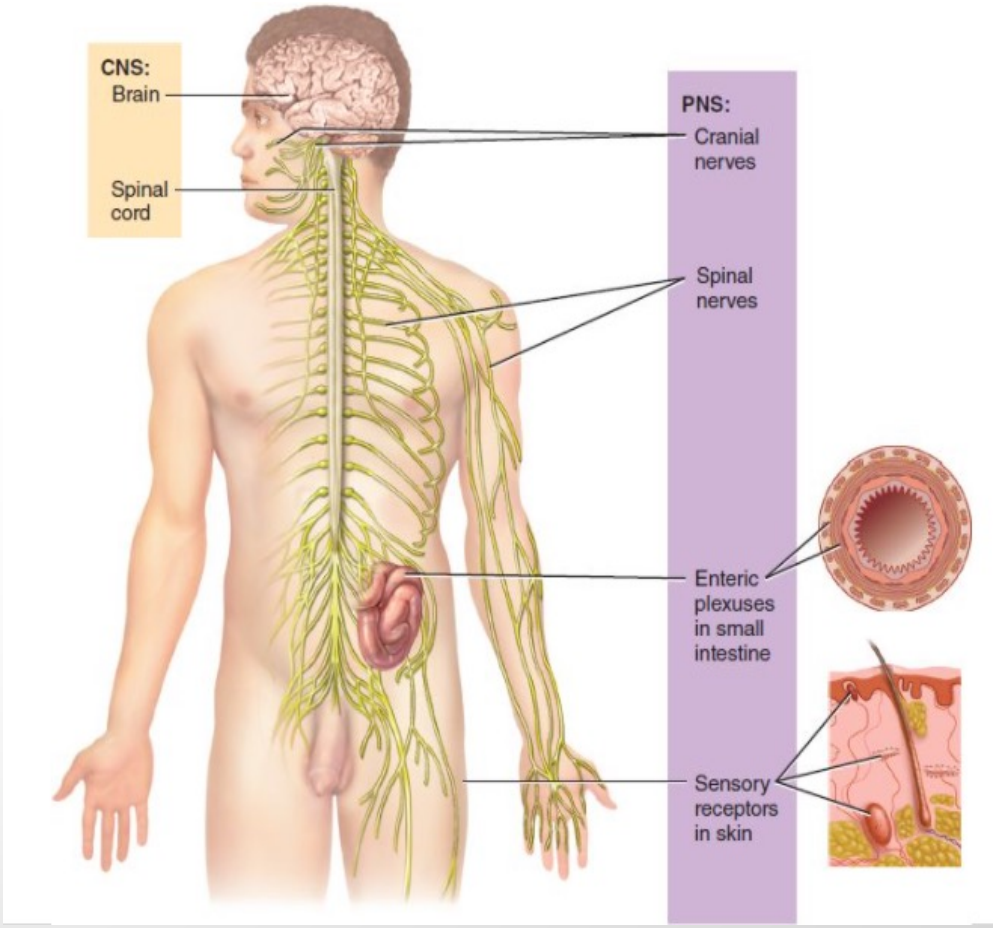
NERVOUS TISSUE

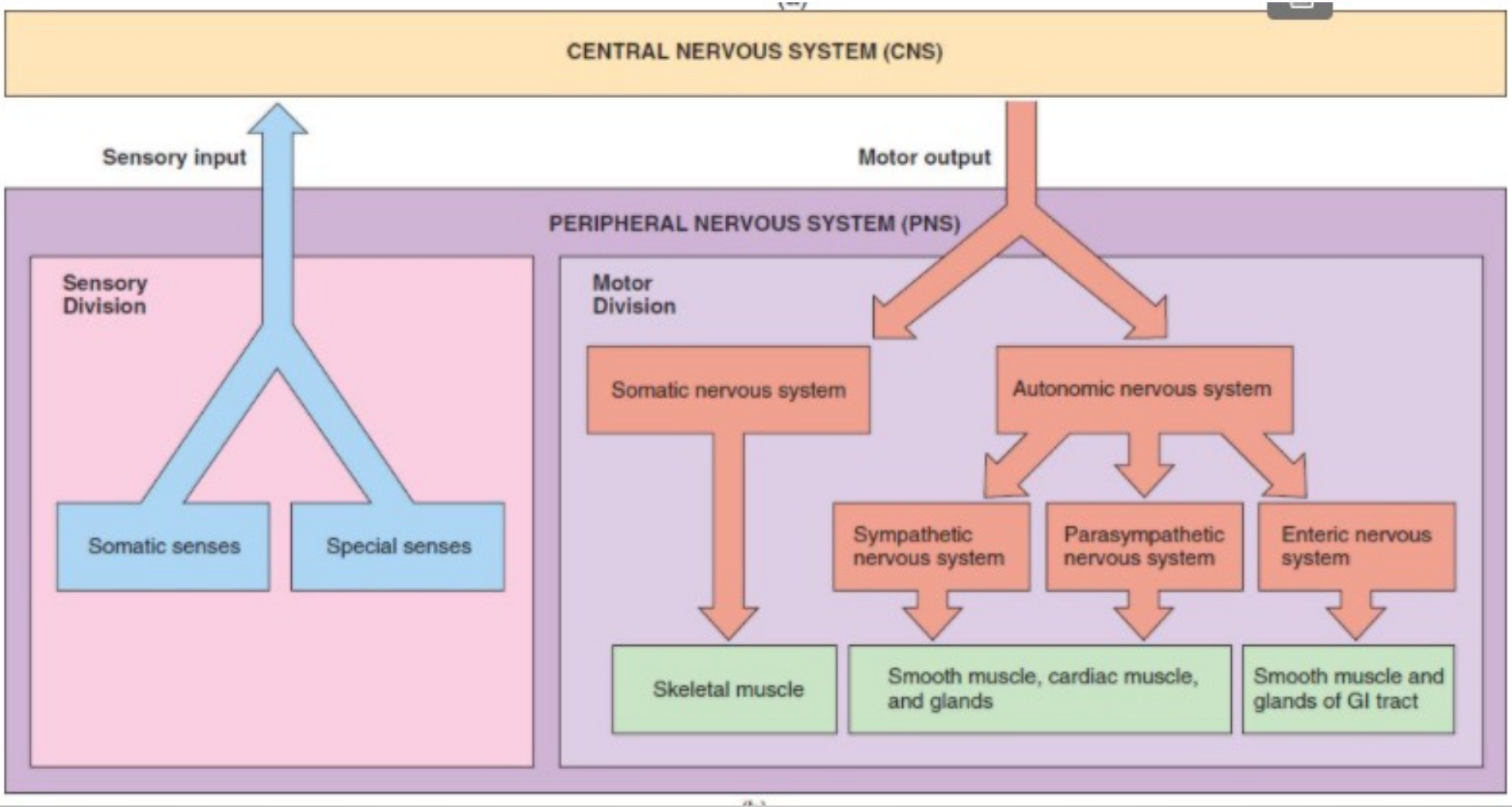
STRUCTURE AND ORGANIZATION

1. **Central nervous system** (CNS): brain and spinal cord
2. **Peripheral nervous system** (PNS): cranial, spinal, and Ganglia: small aggregates of nerve cells outside the CNS.



Cells in both central and peripheral:

- Neurons: have numerous long processes
- Glial cells: short processes: support and protect neurons.


CENTRAL NERVOUS SYSTEM (CNS)
Sensory input
Motor output
PERIPHERAL NERVOUS SYSTEM (PNS)
Sensory Division
Motor Division
Somatic nervous system
Autonomic nervous system
Somatic senses
Special senses
Sympathetic nervous system
Parasympathetic nervous system
Enteric nervous system
Skeletal muscle
Smooth muscle, cardiac muscle, and glands
Smooth muscle and glands of GI tract

DEVELOPMENT OF NERVE TISSUE

- The ectoderm, beginning in the third week of development.
- Epithelial neural plate---neural tube

NEURONS

- The functional unit in both the CNS and PNS

Cell body (perikaryon or soma)

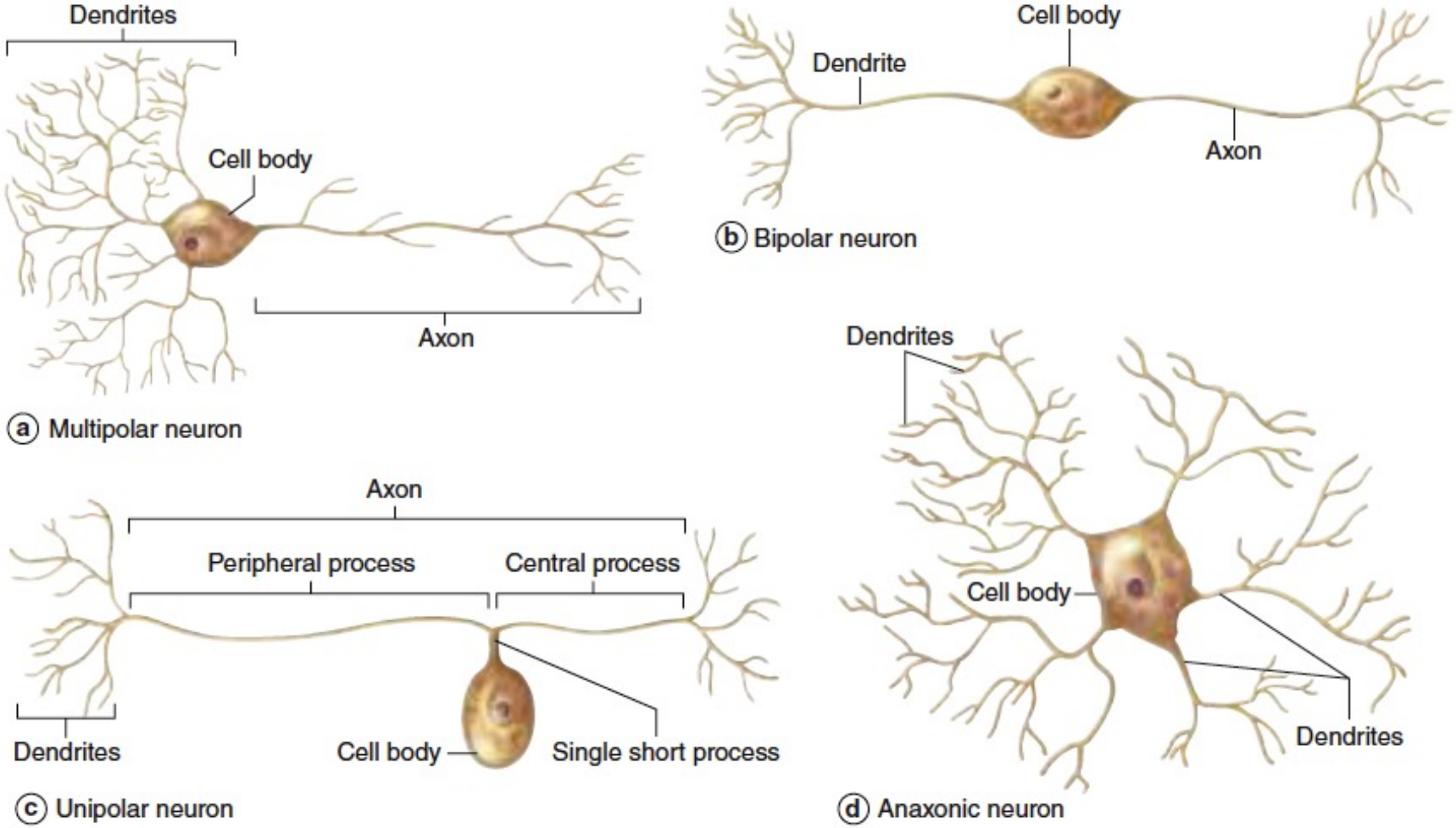
- Contains the nucleus and most of the cell's organelles
- The synthetic or trophic center for the entire neuron.

Dendrites: numerous elongated processes extending from the perikaryon and specialized to receive stimuli from other neurons.

Axon: a single long process ending at synapses specialized to generate and conduct nerve impulses to other cells (nerve, muscle, and gland cells).

NEURON CLASSIFICATION-STRUCTURALLY

1. Multipolar neurons: one axon and two or more dendrites, most common.
2. Bipolar neurons: one dendrite and one axon, sensory neurons of the retina, the olfactory epithelium, and the inner ear.
3. Unipolar or pseudounipolar neurons: single process that bifurcates close to the perikaryon; longer branch extending to a peripheral ending and the other toward the CNS. All other sensory neurons.
4. Anaxonic neurons: many dendrites but no true axon, do not produce action potentials, but regulate electrical changes of adjacent CNS neurons.



Shown are the four main types of neurons, with short descriptions. **(a)** Most neurons, including all motor neurons and CNS interneurons, are **multipolar**. (**b**) **Bipolar neurons** include sensory neurons of the retina, olfactory mucosa, and inner ear. **(c)** All other sensory neurons are **unipolar** or **pseudounipolar**. **(d) Anaxonic** neurons of the CNS lack true axons and do not produce action potentials, but regulate local electrical changes of adjacent neurons.

NEURON CLASSIFICATION-FUNCTIONALLY

- Sensory neurons (afferent), receiving stimuli from receptors throughout the body.
- Motor neurons(efferent): sending impulses to effector organs muscle fibers and glands.

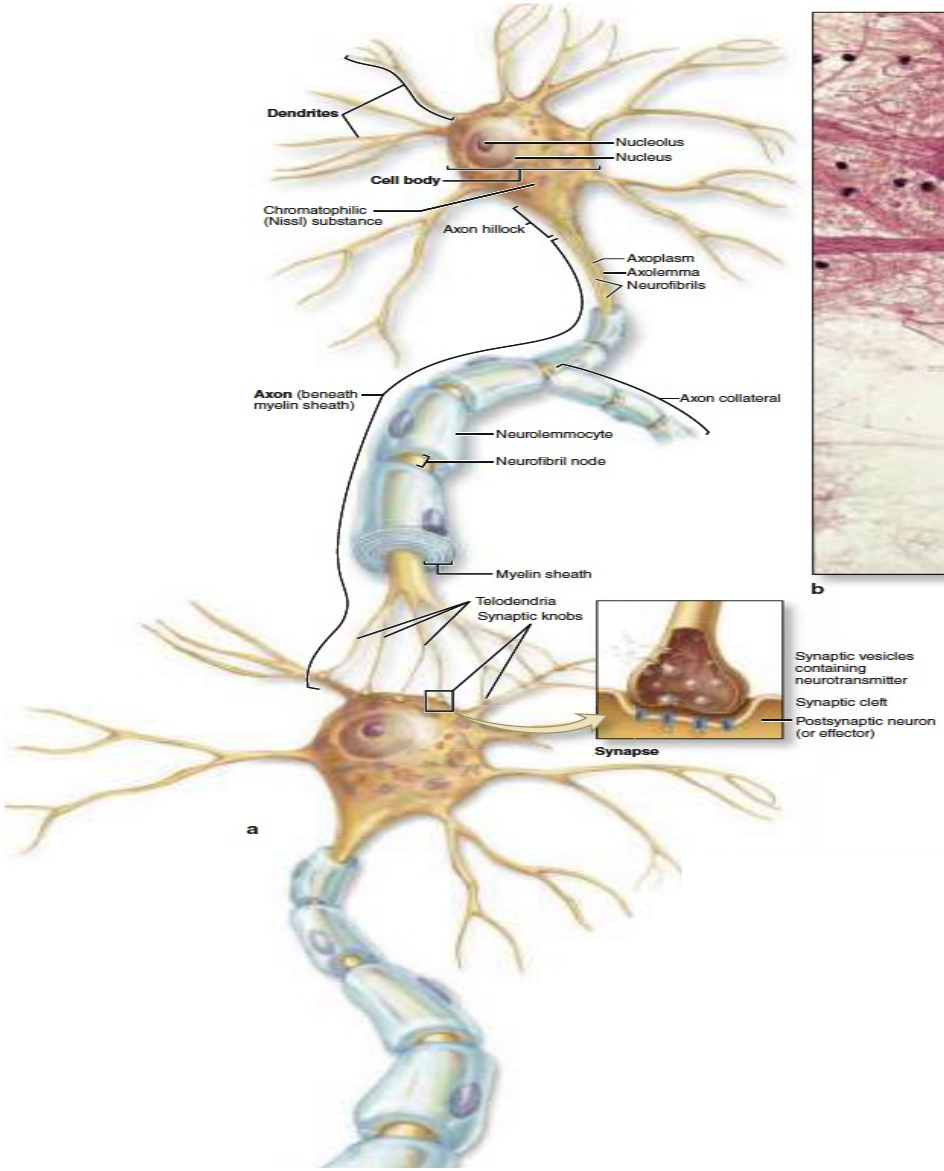
1. Somatic motor nerves--- voluntary -- skeletal muscle;

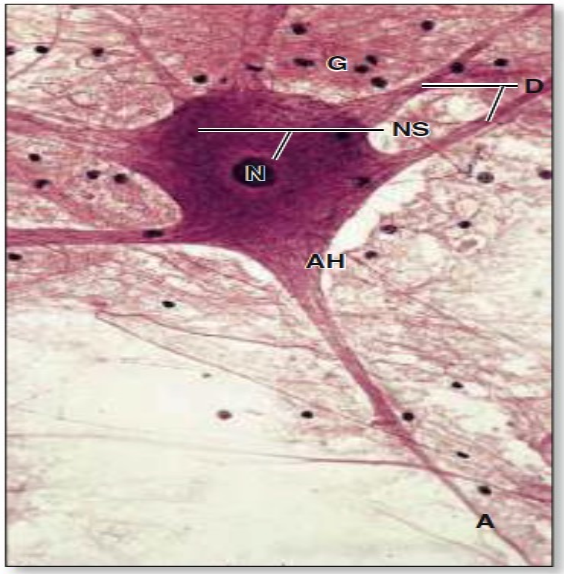
2.Autonomic motor nerves-- involuntary or unconscious--- glands, cardiac muscle, and smooth muscle.

- Interneurons establish relationships among other neurons, forming complex functional networks or circuits in the CNS. Interneurons are either multipolar or anaxonic and comprise 99% of all neurons in adults.

CELL BODY (PERIKARYON OR SOMA)

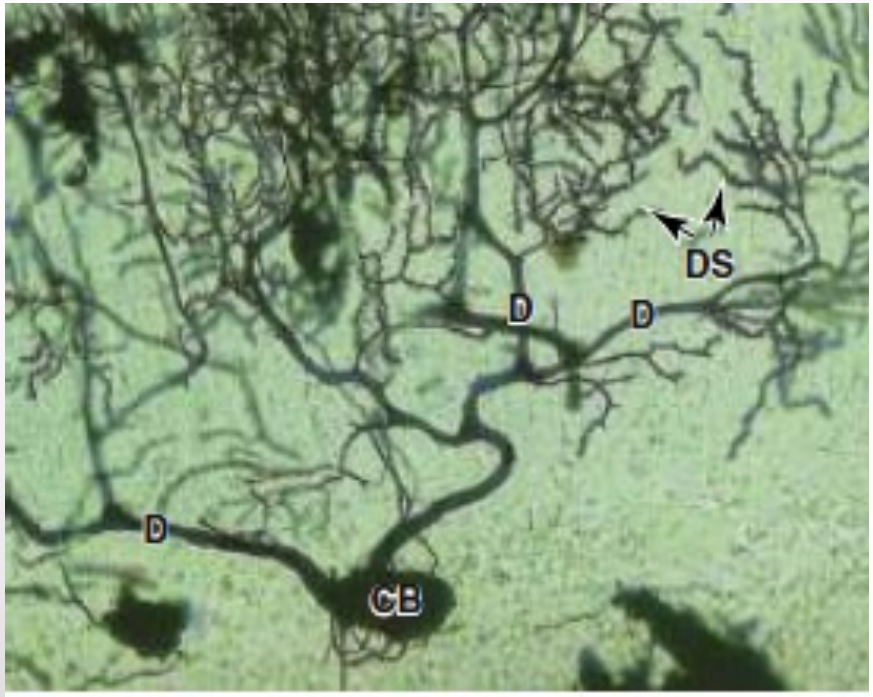
- Contains the nucleus and surrounding cytoplasm.
- It acts as a trophic center.
- Most are in contact with a great number of nerve endings conveying excitatory or inhibitory stimuli.
- Large, euchromatic nucleus with a prominent nucleolus (intense synthetic activity)
- Nissl bodies NB (Nissl substance, chromatophilic substance): numerous free polyribosomes and highly developed RER.
- The amount of NB varies with the type and functional state of the neuron---abundant in large nerve cells (motor neurons)
- The Golgi apparatus is located only in the cell body.
- Mitochondria can be found throughout the cell and are usually abundant in the axon terminals.


Dendrites
Nucleolus
Nucleus
Cell body
Chromatophilic (Nissl) substance
Axon hillock
Axoplasm
Axolemma
Neurofibrils
Axon (beneath myelin sheath)
Axon collateral
Neurolemmocyte
Neurofibril node
Myelin sheath
Telodendria
Synaptic knobs
Synaptic vesicles containing neurotransmitter
Synaptic cleft
Postsynaptic neuron (or effector)
Synapse
a


G
D
NS
N
AH
A
b

DENDRITES

- Short, small processes emerging and branching off the soma.
- Covered with many synapses.
- Are the principal signal reception and processing sites on neurons.
- The large number and extensive arborization--- signals from many other nerve cells.
- Dendrites become much thinner as they branch.
- Dendritic spines: dynamic membrane protrusions along the dendritic branches



AXONS

- Most neurons have only one axon
- Axonal processes vary in length and diameter ---type of neuron.
- Axolemma: plasma membrane, and axoplasm: its contents.
- Axon hillock: pyramid-shaped region of the perikaryon where axons originate from.
- Initial segment: concentrated ion channels which generate the action potential
- Axons branch less than dendrites---but undergo terminal arborization.
- Axons of interneurons and some motor neurons also have major branches called collaterals that end at smaller branches with synapses influencing the activity of many other neurons.
- Terminal bouton: Small axonal branch ends with a dilation-- contacts another neuron or non-nerve cell.

AXONS

- **Axoplasm** contains mitochondria, microtubules, neurofilaments, and transport vesicles, but very few polyribosomes or cisternae of RER (dependence of axoplasm on the perikaryon).
- **Anterograde** transport: away from cell body. Organelles and macromolecules synthesized in the cell body move along axonal microtubules via **kinesin** from the perikaryon to the synaptic terminals.
- **Retrograde** transport: toward cell body. in the opposite direction along microtubules via **dynein** carries certain other macromolecules---endocytosis (including viruses and toxins).
- Anterograde and retrograde transports: 50-400 mm/d.

SYNAPSES

- **Precynaptic cell**

Presynaptic axon terminal (terminal bouton)

Neurotransmotter (synaptic vesicles)

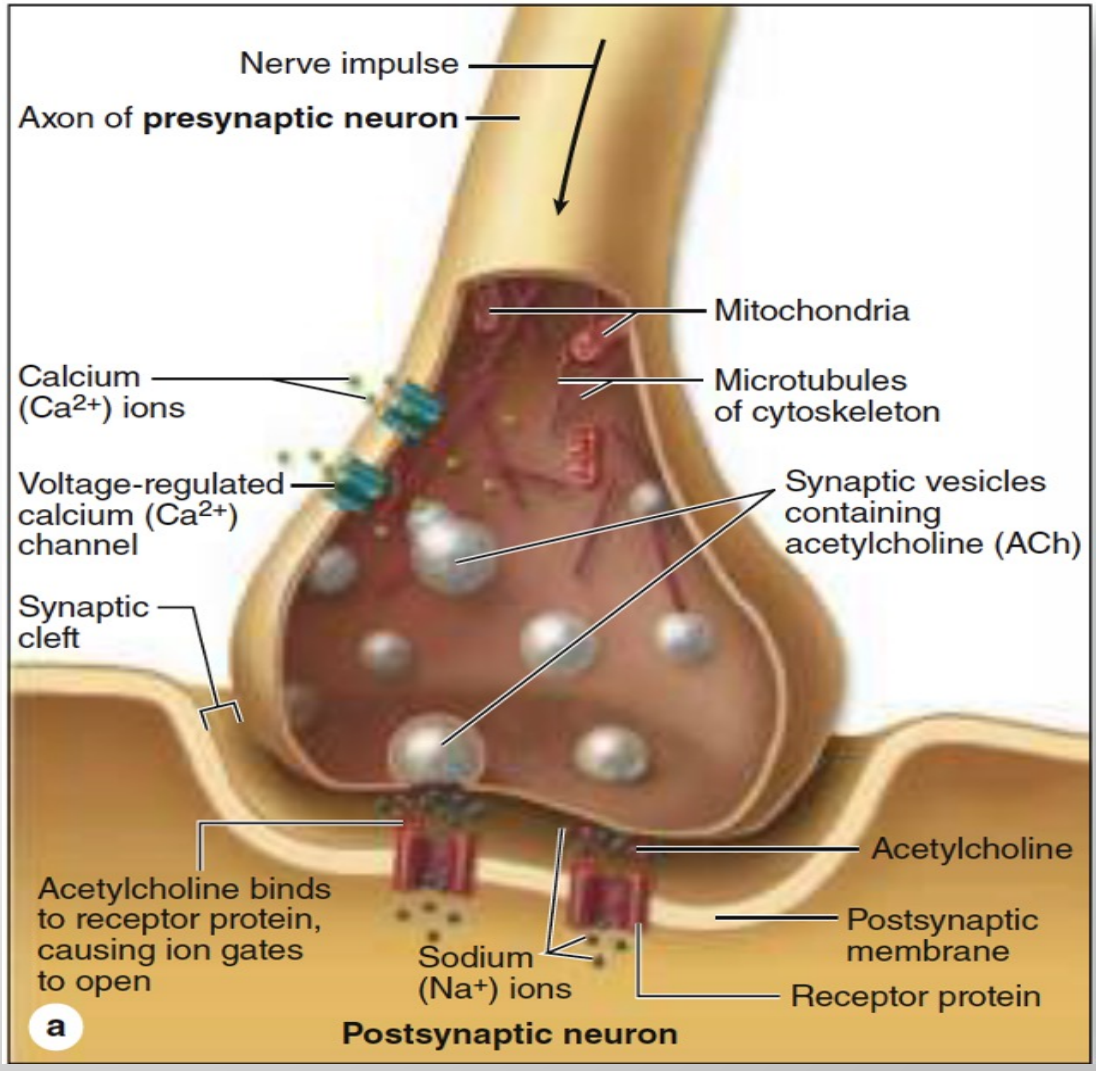
Ca^{2+} !!!

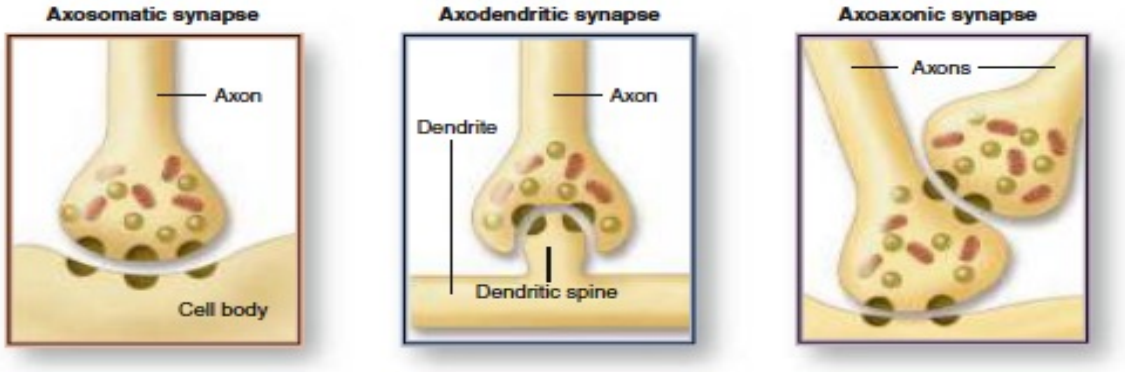
- **Synaptic cleft**

20- to 30-nm-wide intercellular space called the

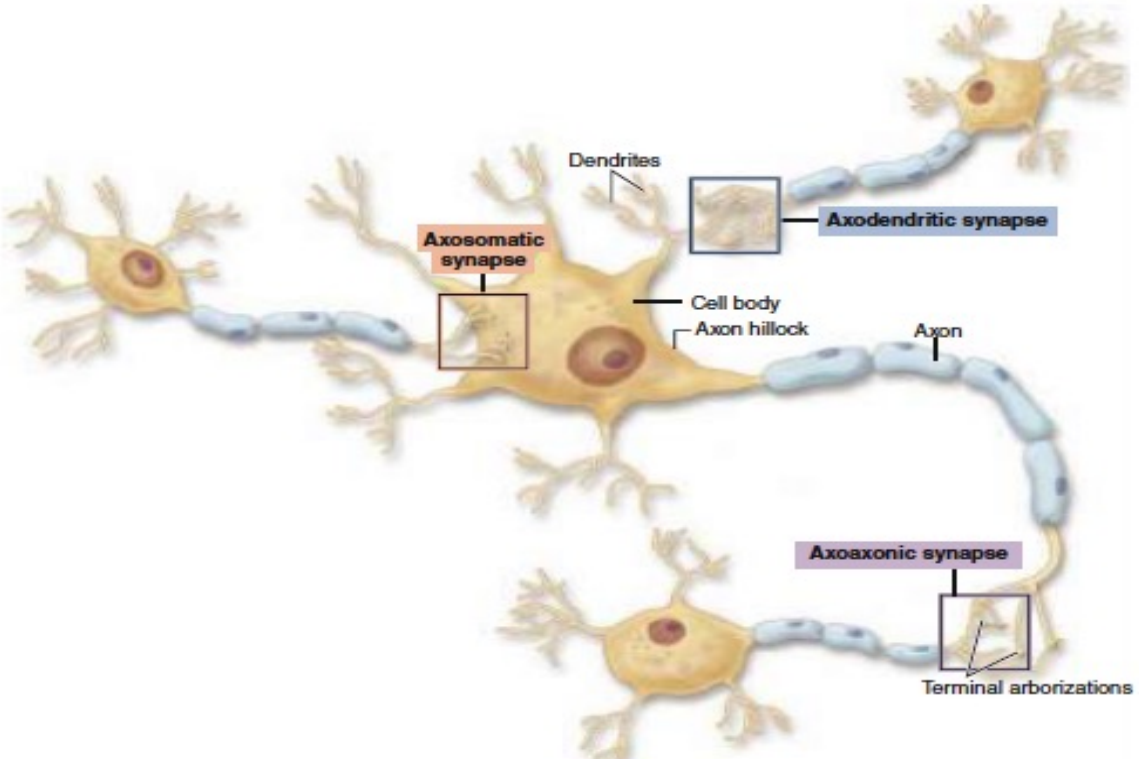
- **Postsynaptic cell**

Postsynaptic cell membrane





The diagrams show three common morphologic types of synapses. Branched axon terminals usually associate with and transmit a nerve impulse to another neuron's cell body (or soma) or a dendritic spine. These types of connections are termed an **axosomatic synapse** and an **axodendritic synapse**, respectively. Less frequently, an axon terminal forms a synapse with an axon terminal of another neuron; such an **axoaxonic synapse** functions to modulate synaptic activity in the other two types.



All three morphologic types of synapses have the features of all true synapses: a presynaptic axon terminal that releases a transmitter; a postsynaptic cell membrane with receptors for the transmitter; and an intervening synaptic cleft.

Synaptic structure usually cannot be resolved by light microscopy, although components such as dendritic spines may be shown with special techniques (Figure 9–5).

TYPES OF SYNAPSES

- **Excitatory** synapses cause postsynaptic Na^+ channels to open--- depolarization wave in the postsynaptic neuron (or effector).
- **Inhibitory** synapses neurotransmitters open Cl^- (or other anion), causing ---influx of anions -----hyperpolarization--- membrane potential more negative--- resistant to depolarization.
- The response in postsynaptic neurons is determined by the **summation** of activity at hundreds of synapses on that cell.

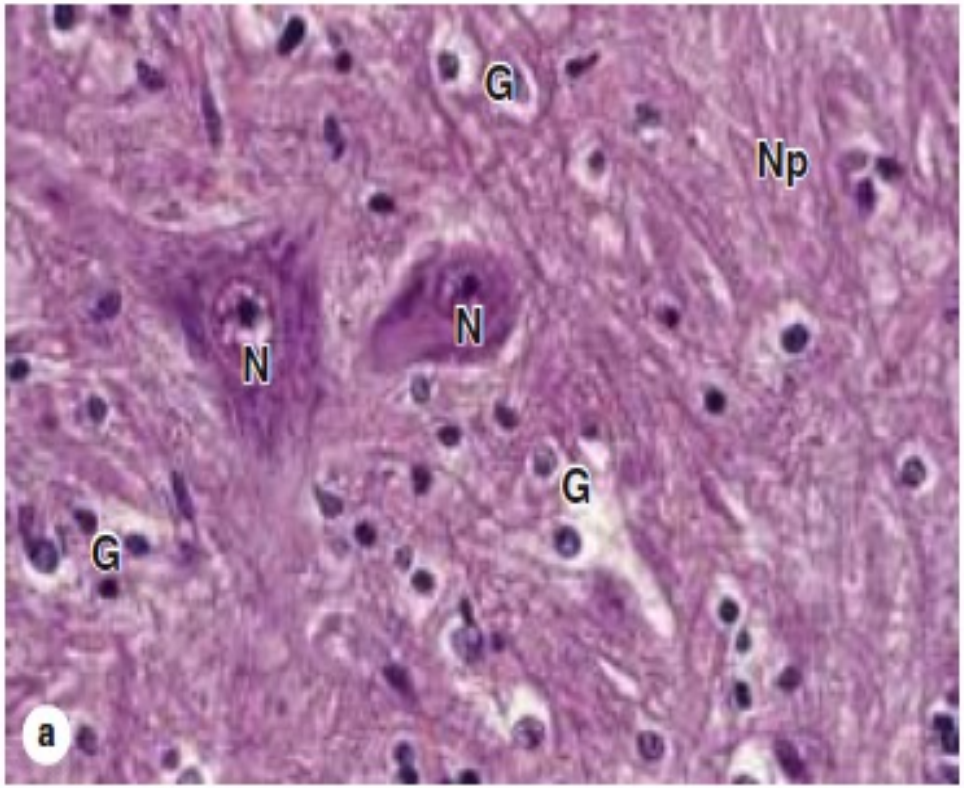
NEUROTRANSMITTERS

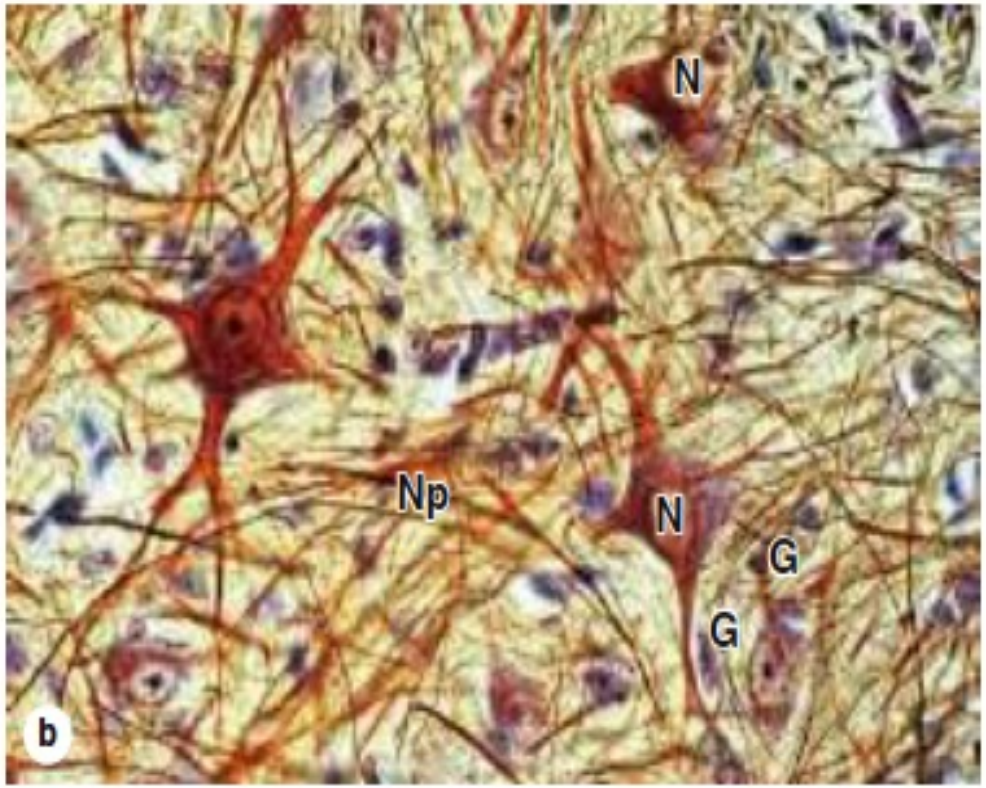
- Acetylecholine (ach)
- Monoamines (serotonin), catecholamines (dopamine)
- Aminoacids (GABA)
- Polypeptides (endorphins)

GLIAL CELLS.

- Support neuronal survival and activities.
- Ten times more abundant.
- Most glial cells develop from neural plate cells
- In the CNS surrounds both the cell bodies and the processes of axons and dendrites (occupying the spaces between neurons).
- Substitute for cells of connective tissue creating immediately around those cells microenvironments that are optimal for neuronal activity.
- Neuropil !!

NEURONS AND GLIAL CELLS





Neuron

Myelinated axon

Myelin sheath (cut)

Oligodendrocyte

Astrocyte

Perivascular foot

Capillary

Ependymal cell

Ventricle of brain

Microglial cell

Functions of Oligodendrocyte

1. Myelinates and insulates CNS axons
2. Allows faster action potential propagation along axons in the CNS

Functions of Astrocyte

1. Helps form the blood-brain barrier
2. Regulates interstitial fluid composition
3. Provides structural support and organization to the central nervous system (CNS)
4. Assists with neuronal development
5. Replicates to occupy space of dying neurons

Functions of Ependymal Cell

1. Lines ventricles of brain and central canal of spinal cord
2. Assists in production and circulation of cerebrospinal fluid (CSF)

Functions of Microglial Cell

1. Phagocytic cells that move through the CNS
2. Protects the CNS by engulfing infectious agents and other potential harmful substances

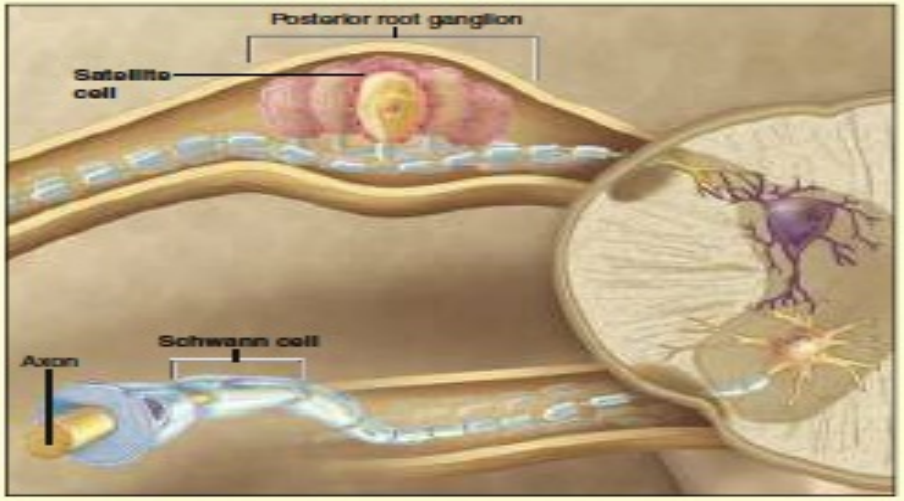
(a)

Functions of Satellite Cell

1. Electrically insulates PNS cell bodies.
2. Regulates nutrient and waste exchange for cell bodies in ganglia

Functions of Neurolemmocyte

1. Surround and insulate PNS axons and myelinate those having large diameters
2. Allows for faster action potential propagation along an axon in the PNS



Posterior root ganglion

Satellite cell

Schwann cell

Axon

NEUROGLIA

Glial Cell Type	Origin	Location	Main Functions
Oligodendrocyte	Neural tube	CNS	Myelin production, electrical insulation
Astrocyte	Neural tube	CNS	Structural and metabolic support of neurons, especially at synapses; repair processes
Ependymal cell	Neural tube	Line ventricles and central canal of CNS	Aid production and movement of CSF
Microglia	Bone marrow (monocytes)	CNS	Defense and immune-related activities
Schwann cell	Neural crest	Peripheral nerves	Myelin production, electrical insulation
Satellite cells (of ganglia)	Neural crest	Peripheral ganglia	Structural and metabolic support for neuronal cell bodies

CENTRAL NEUROGLIA

Astrocytes

- Have a large number of long radiating, branching processes
- Terminal processes of a single astrocyte associate with over a many synaptic sites.
- Astrocytes originate from neural tube cells.
- Most numerous glial cells of the brain.
- Most diverse structurally and functionally.
- Fibrous astrocytes--- white matter ---- long delicate processes
- Protoplasmic astrocytes--- gray matter----- shorter processes.
- Astrocytes communicate directly with one another via gap junctions.

CENTRAL NEUROGLIA

Oligodendrocytes

- Extend many processes---sheet-like and wraps repeatedly around a portion of a nearby CNS axon (myelin:electrical insulation—rabid transmission of impulses)
- Many oligodendrocytes for axon's full length
- Are the predominant glial cells in white matter.
- Appear as small cells with rounded, condensed nuclei and unstained cytoplasm.

CENTRAL NEUROGLIA

Ependymal cells

- Columnar or cuboidal cells that line the ventricles of the brain and the central canal of the spinal cord.

Microglia

- Less numerous.
- Throughout gray and white matter
- Microglia migrate, with their processes
- Constitute the major mechanism of immune defense in the CNS,
- Originate from circulating blood monocytes,

PERIPHERAL NEUROGLIA

Schwann cells

- Are found only in the PNS
- Differentiate from precursors in the neural crest.
- Are the counterparts to oligodendrocytes of the cns,
- Having trophic interactions with axons and most importantly forming their myelin sheathes.
- Forms myelin around a portion of only one axon.

Satellite cells of ganglia

- Derived from the embryonic neural crest,
- Form a thin glial layer around neuronal cell body in the ganglia.