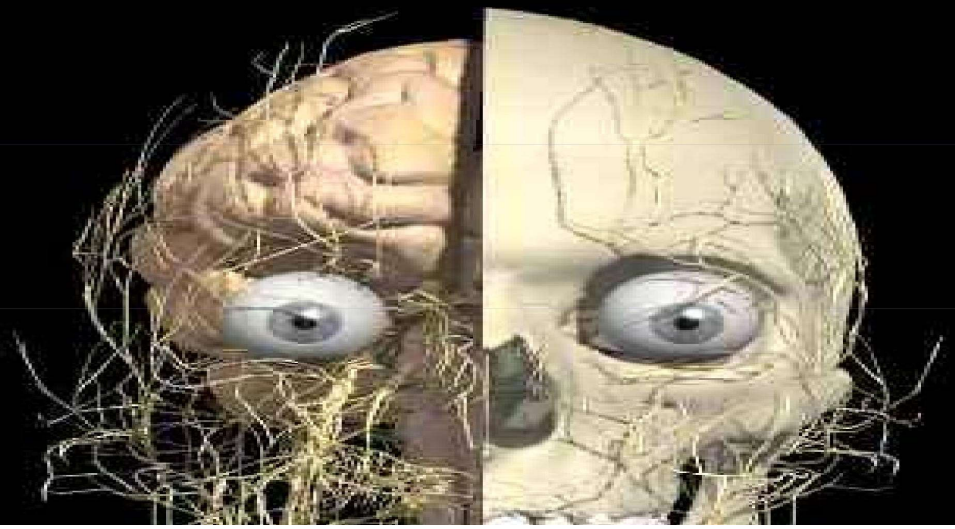
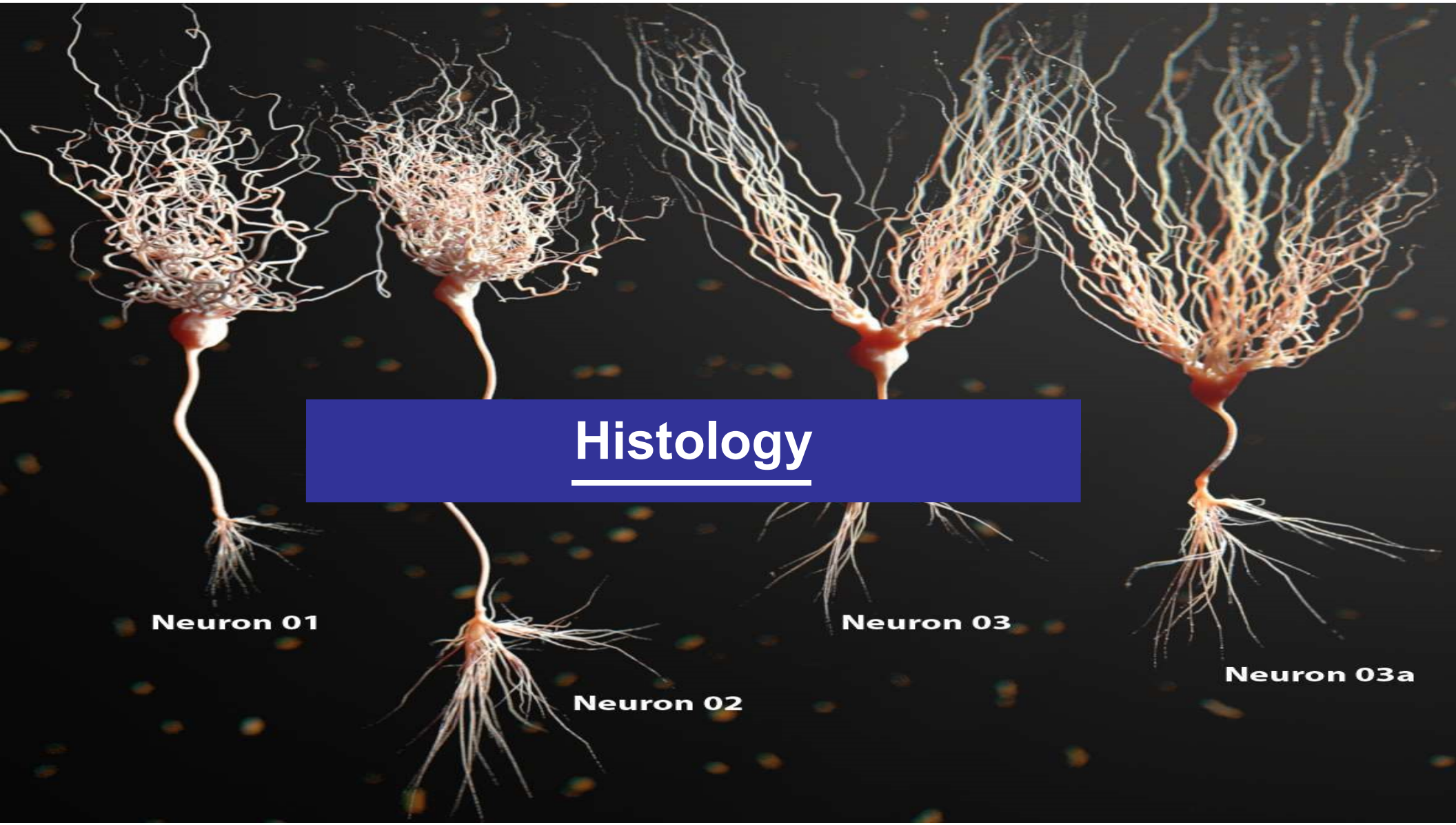


NERVOUS SYSTEM GENERALITY

INTRODUCTION-HISTOLOGY

Part 2

D.HAMMOUDI.MD

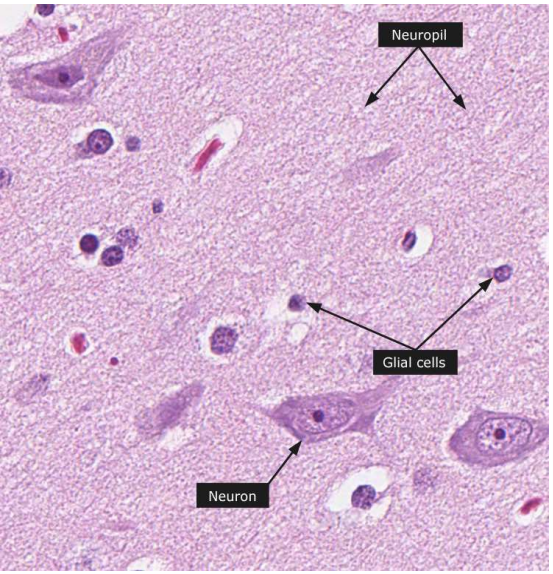

Histology
Neuron 01
Neuron 02
Neuron 03
Neuron 03a

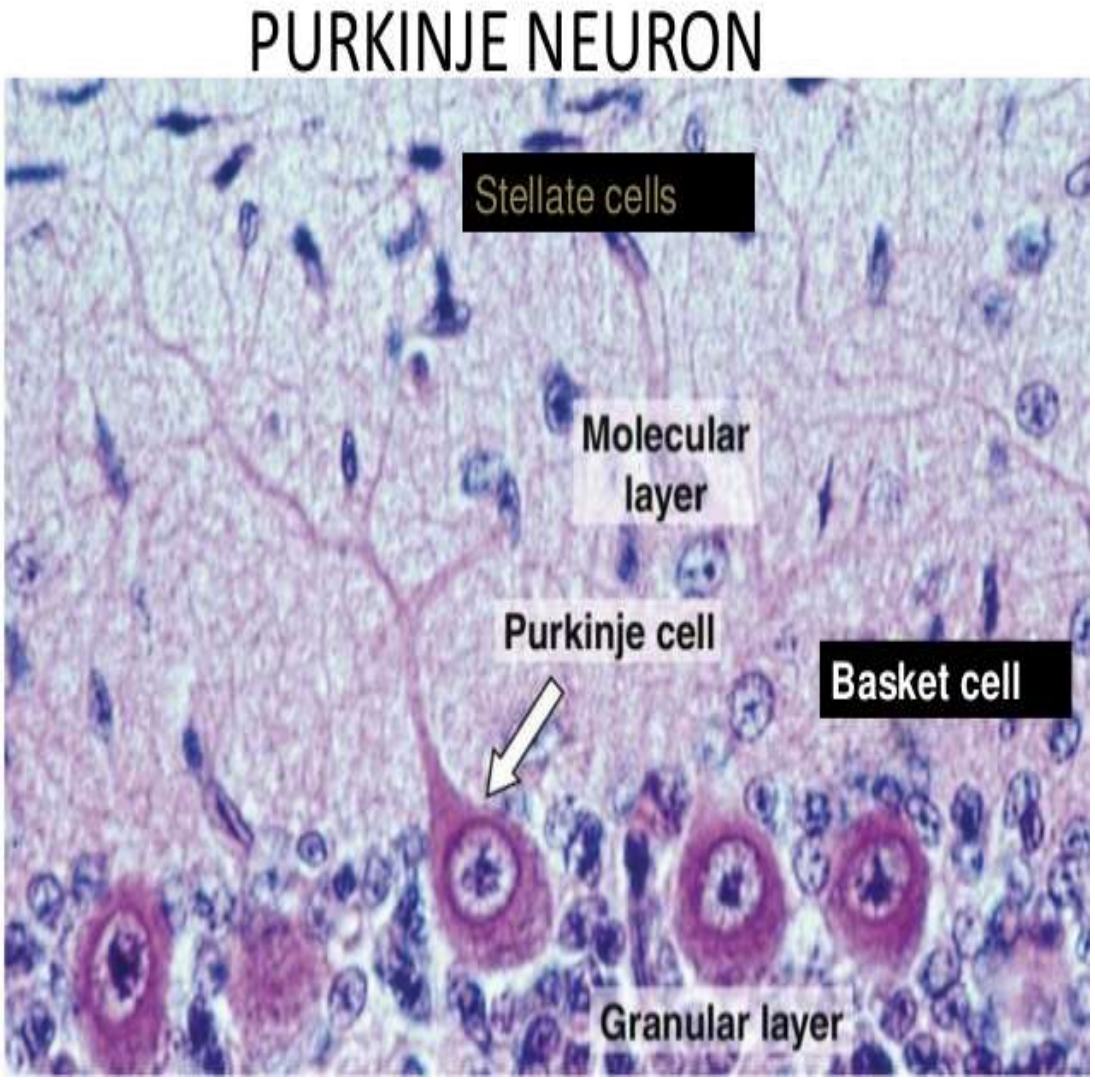
Nervous Tissue

- Highly cellular
- 2 cell types
  1. **Neurons**

     Functional, signal conducting cells
  2. **Neuroglia**

     Supporting cells



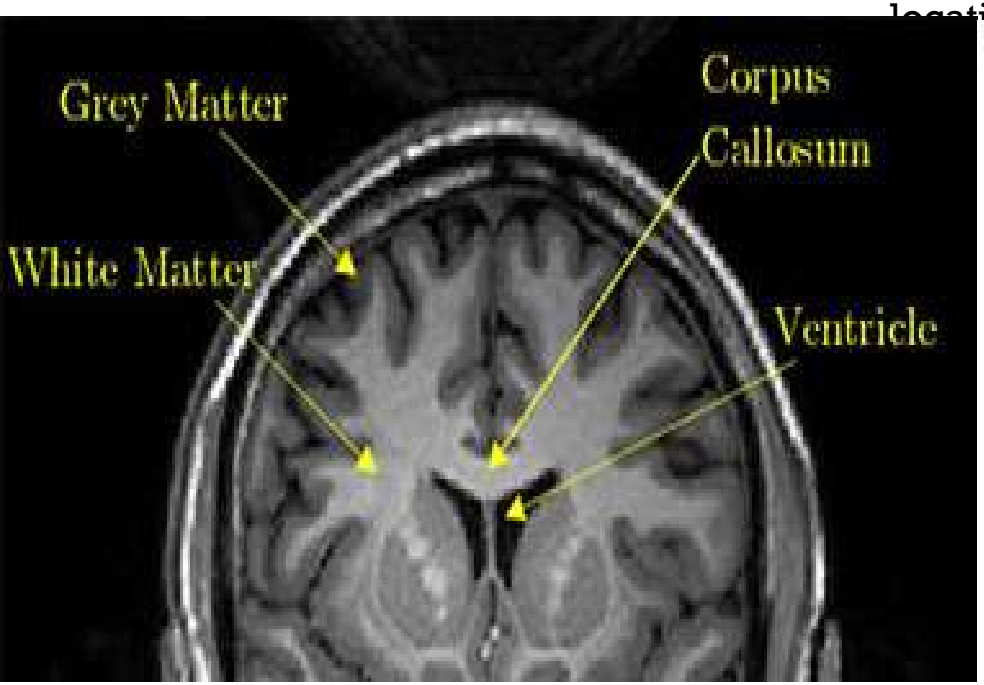


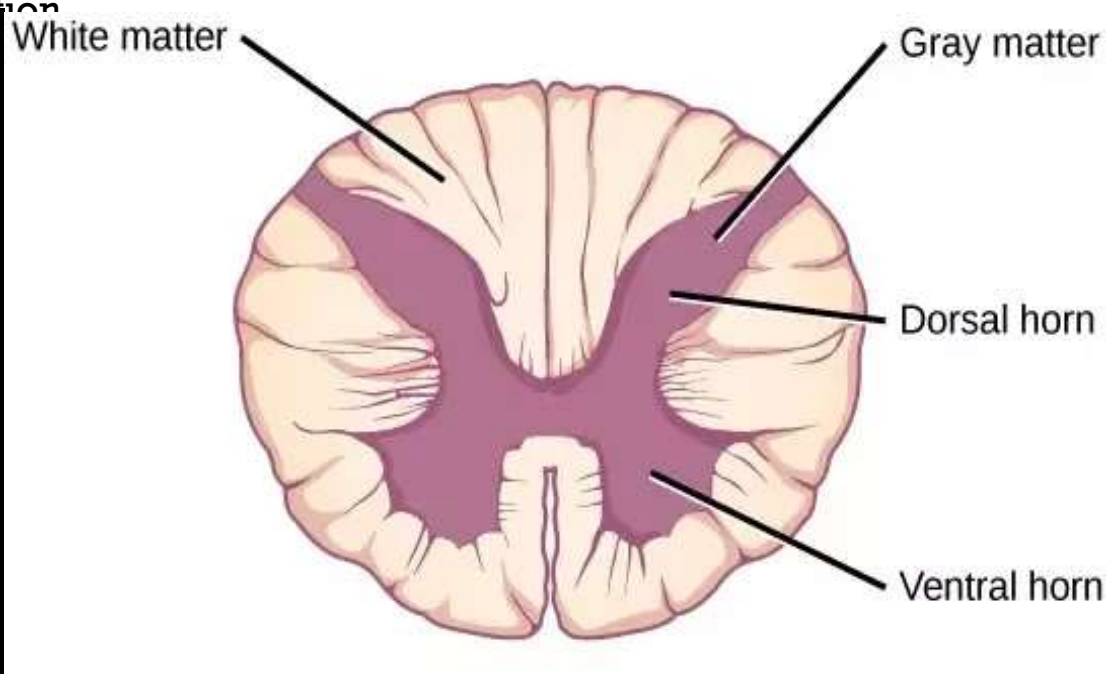
Grey matter → Brain outside location → Body or soma or the neurons

Grey matter → Spinal cord inside location → Body or soma or the neurons

White matter → Brain inside location → Axones

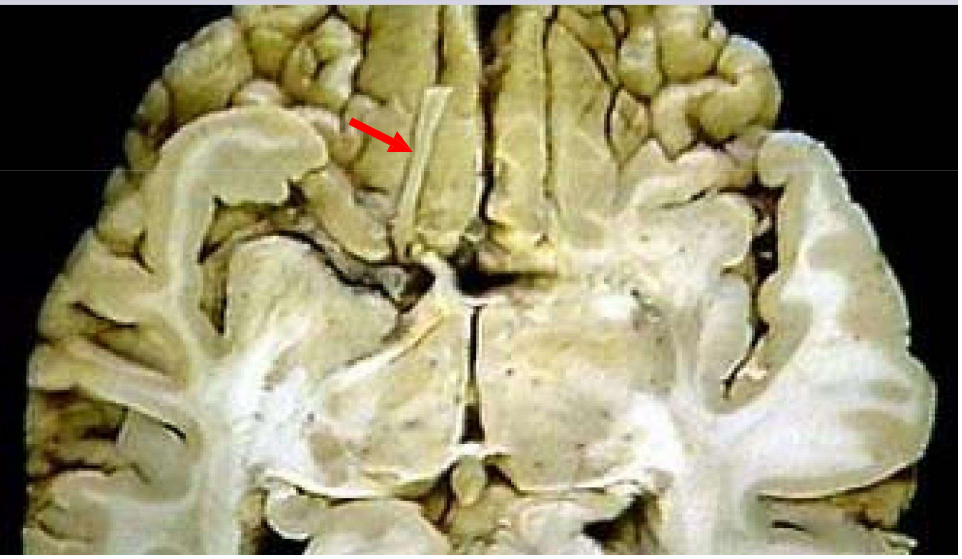
White matter → Spinal cord location → Axones

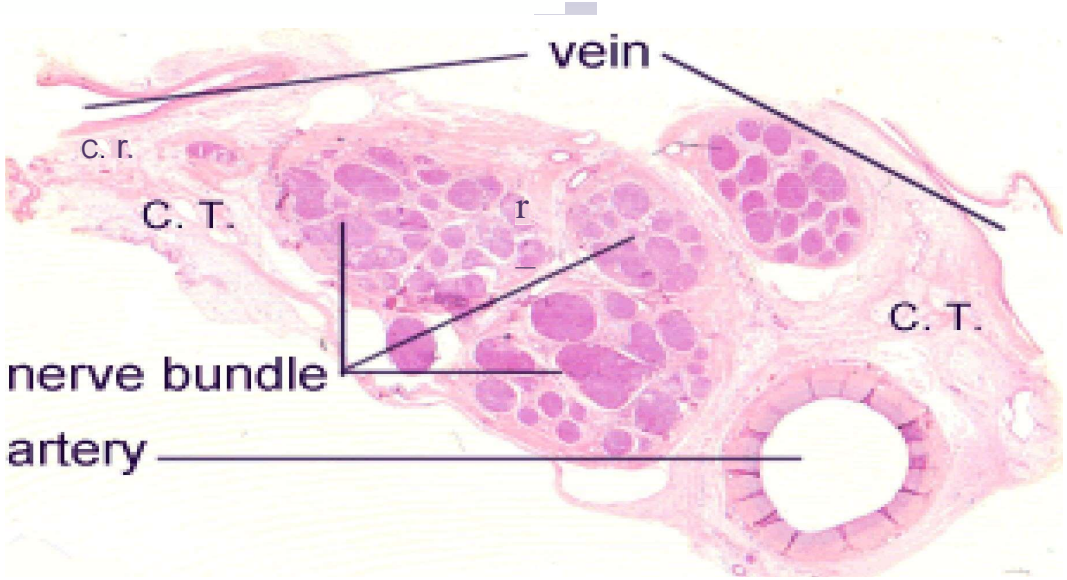


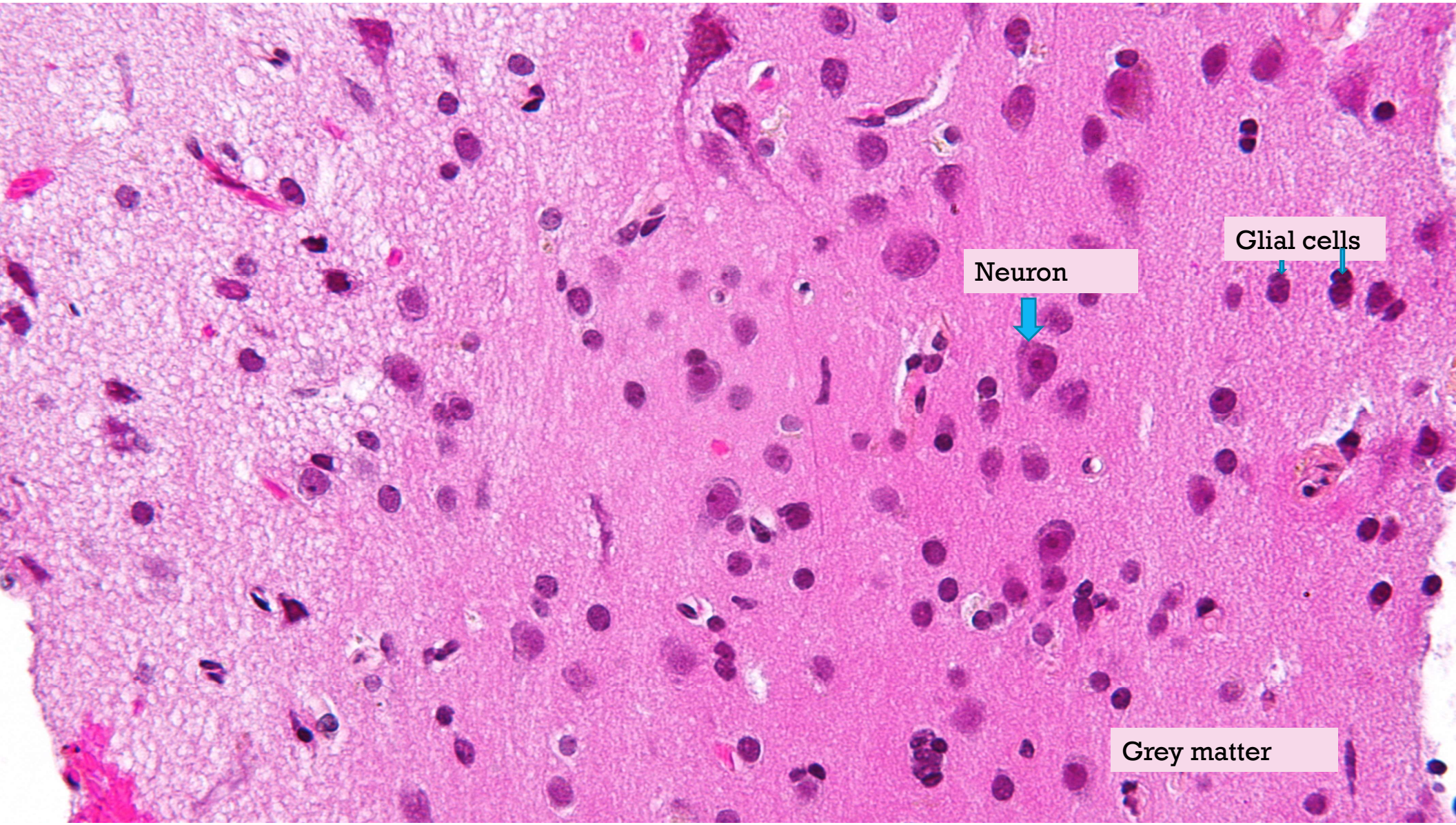


Neuronal Processes

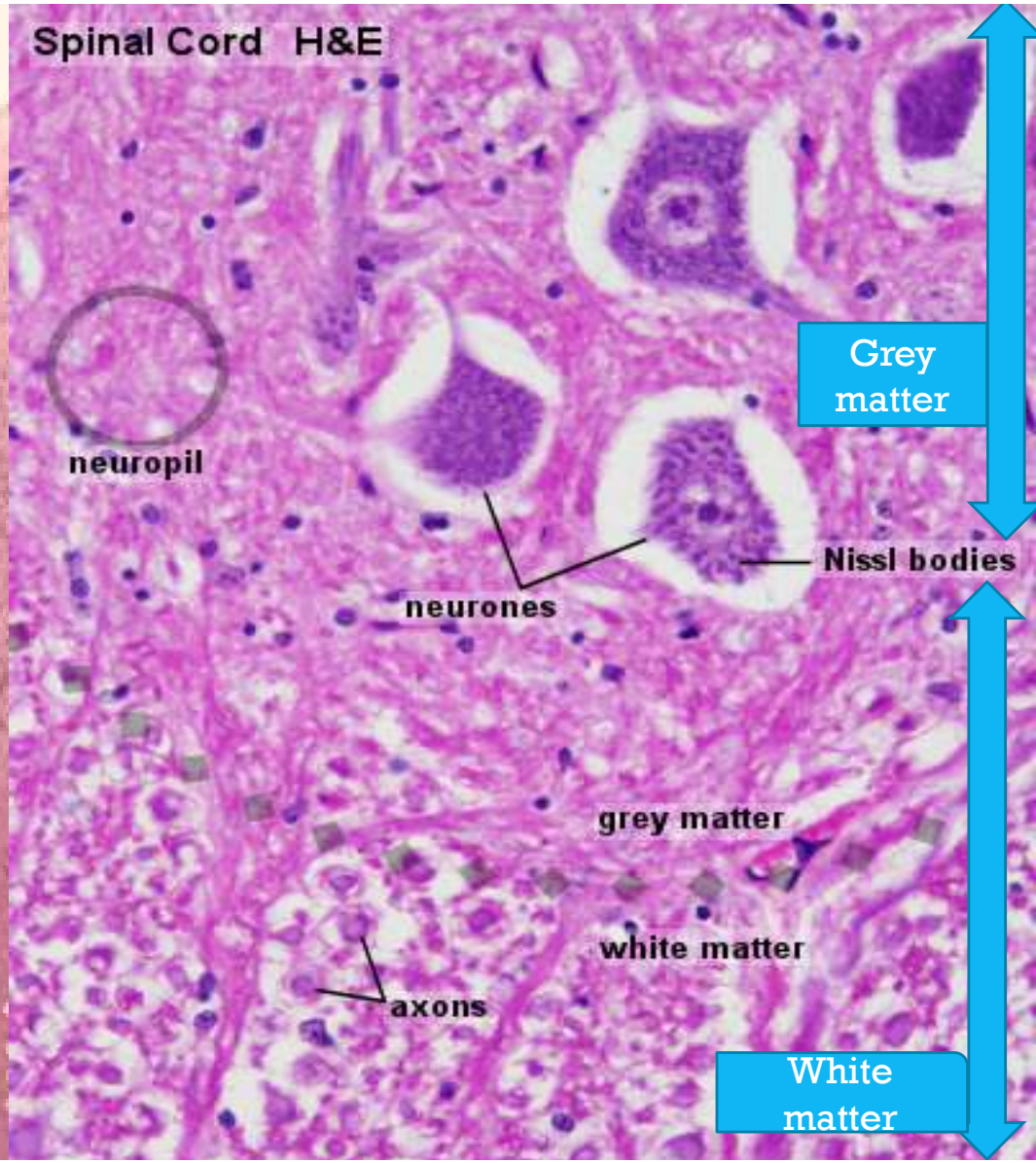
- Armlike extensions emanating from every neuron.
- The CNS consists of both somata and processes whereas the bulk of the PNS consists of processes.
- Tracts = Bundles of processes in the CNS (red arrow)
  Nerves = Bundles of processes in the PNS
- 2 types of processes that differ in structure and function:
  - Dendrites and Axons






Neuron
Glial cells
Grey matter


Slide 7 Cerebrum
Pia mater
Gray matter
White matter


Spinal Cord H&E
neuropil
neurones
Nissl bodies
Grey matter
grey matter
white matter
axons
White matter

Part A
NEURONS

Neurons are similar to other cells in the body because:

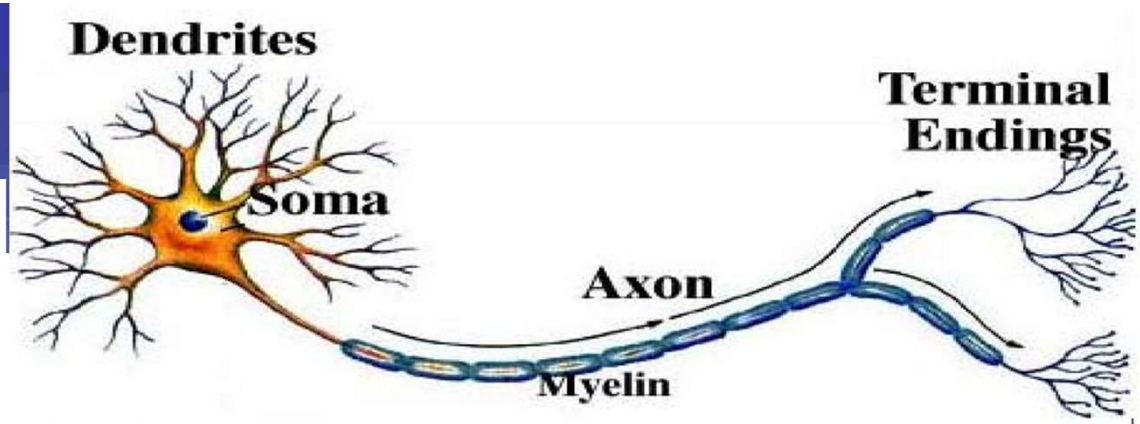
1. Neurons are surrounded by a cell membrane.
2. Neurons have a nucleus that contains genes.
3. Neurons contain cytoplasm, mitochondria and other organelles.
4. Neurons carry out basic cellular processes such as protein synthesis and energy production.

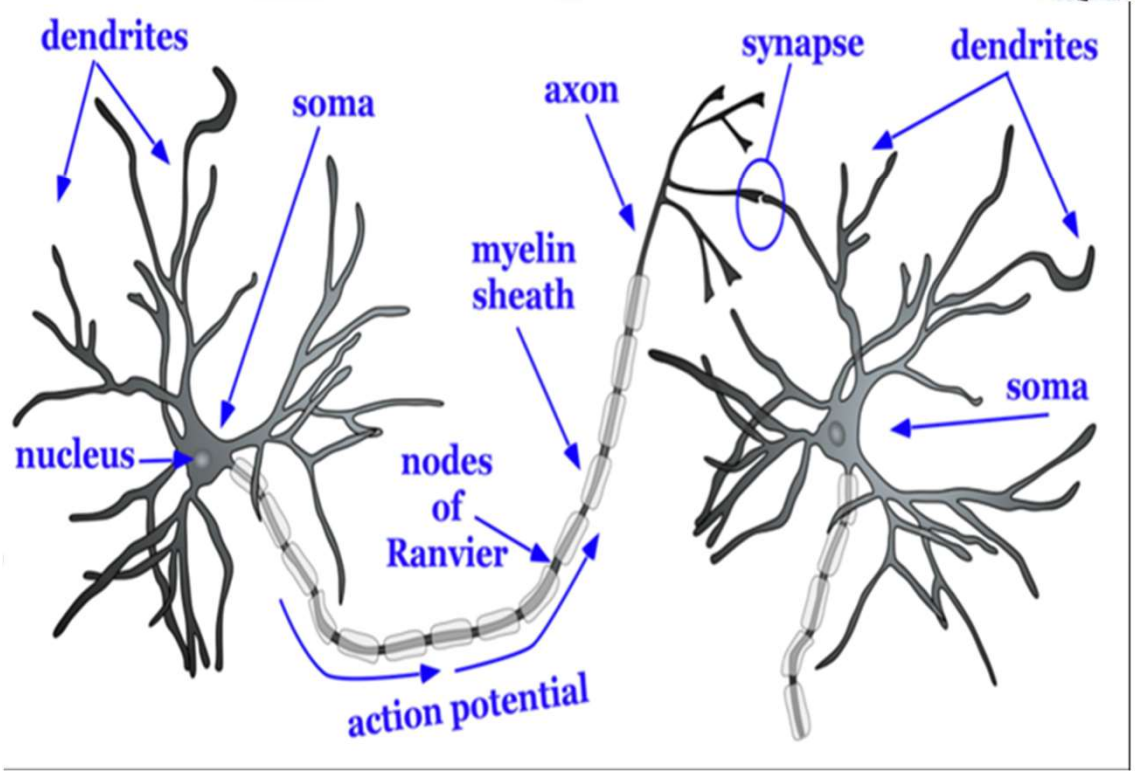
Neurons differ from other cells in the body because:

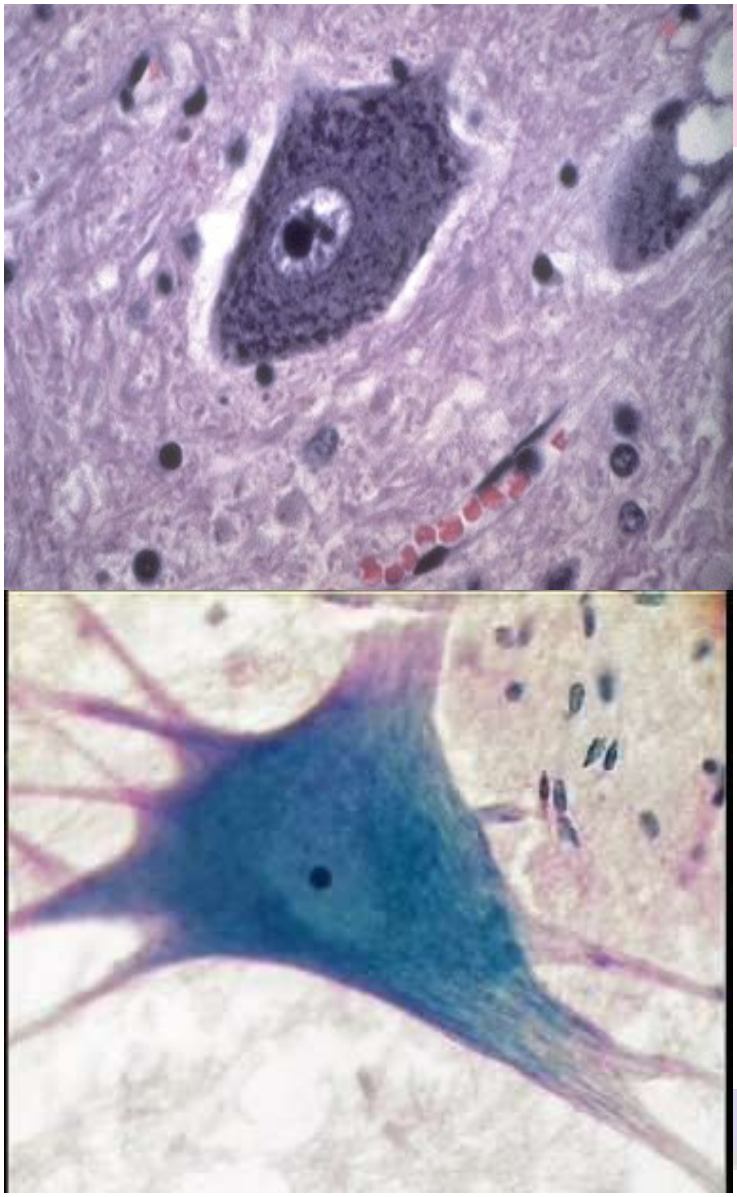
1. Neurons have specialised extensions called dendrites and axons. Dendrites bring information to the cell body and axons take information away from the cell body.
2. Neurons communicate with each other through an electrochemical process.
3. Neurons contain some specialized structures (for example, synapses) and chemicals (for example, neurotransmitters).

Neurons

- There are many types of neuron based on:
  - **the size**
  - **shape of the cell body**
  - **the arrangement of the processes.**
- Based on their staining neurons could be seen to be :
  - **Unipolar**
  - **bipolar**
  - **multipolar.**
- **Most of the neurons within the CNS are multipolar.**
- The processes extending from the cell body are either axons or dendrites.
- Neurons usually have **only one axon but many dendrites.**

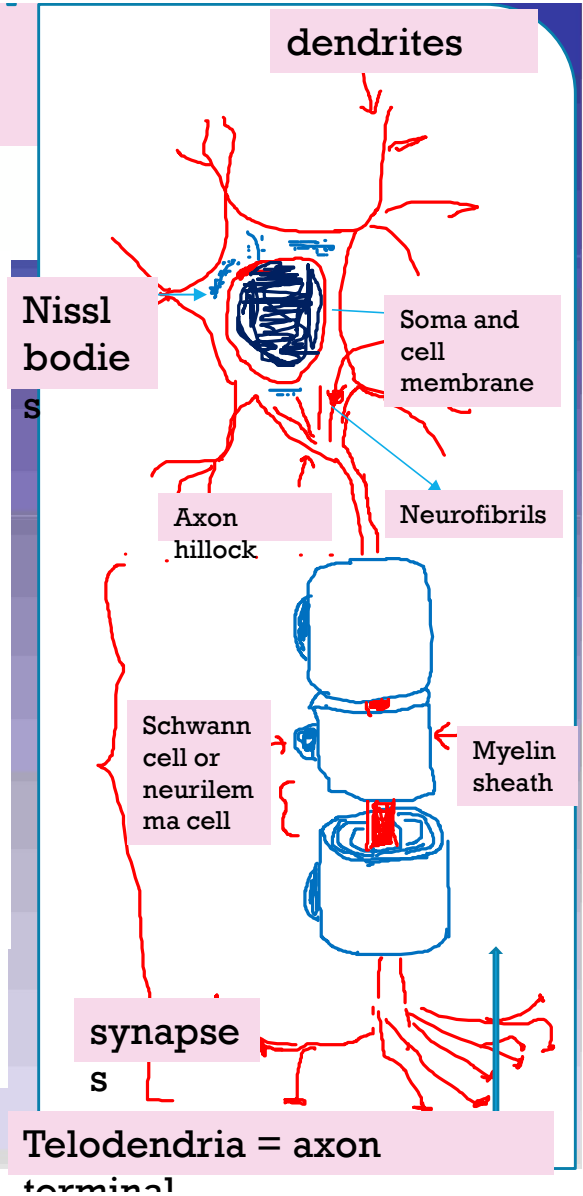






Neuron structure

- Typically large, complex cells, they all have the following structures
  - **Cell body**
    - Nuclei
    - Chromatophilic (Nissl) bodies
    - Neurofibrils
    - Axon hillock
  - **Cell processes**
    - Dendrites
    - Axon
    - Myelin sheath or neurilemma



Neuron structure

- **Neurofibrils** are bundles of intermediate filaments (neurofilaments) that run in a network between the chromatophilic bodies
- **Neurofibrils keep the cell from being pulled apart when it is subjected to tensile stresses**

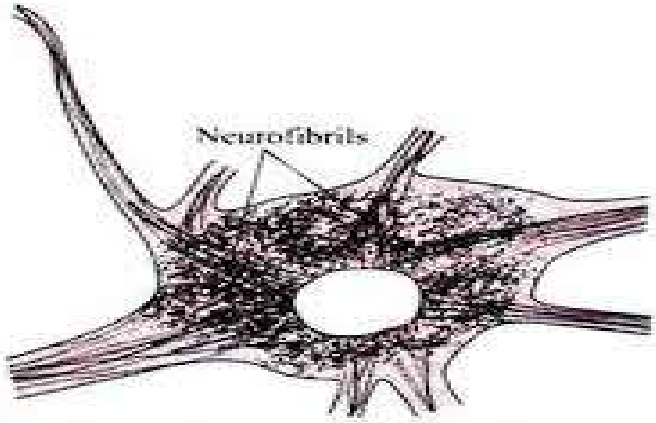
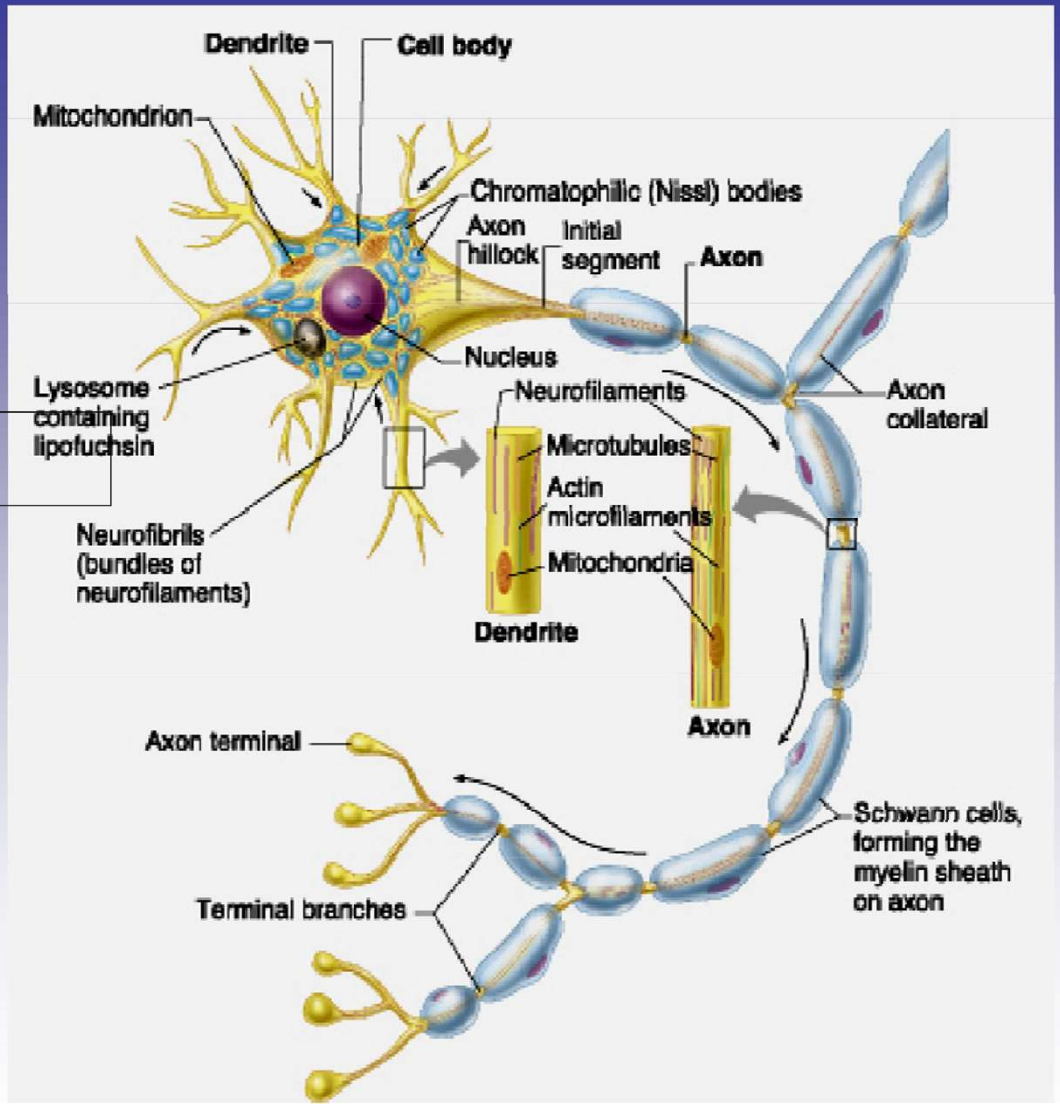
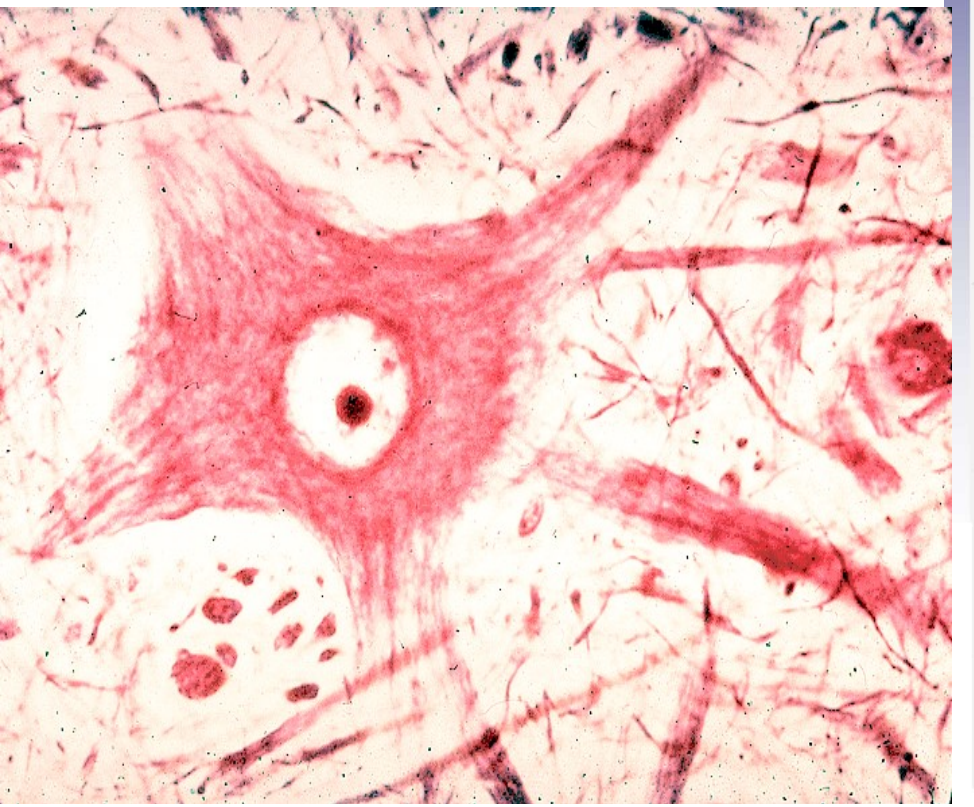


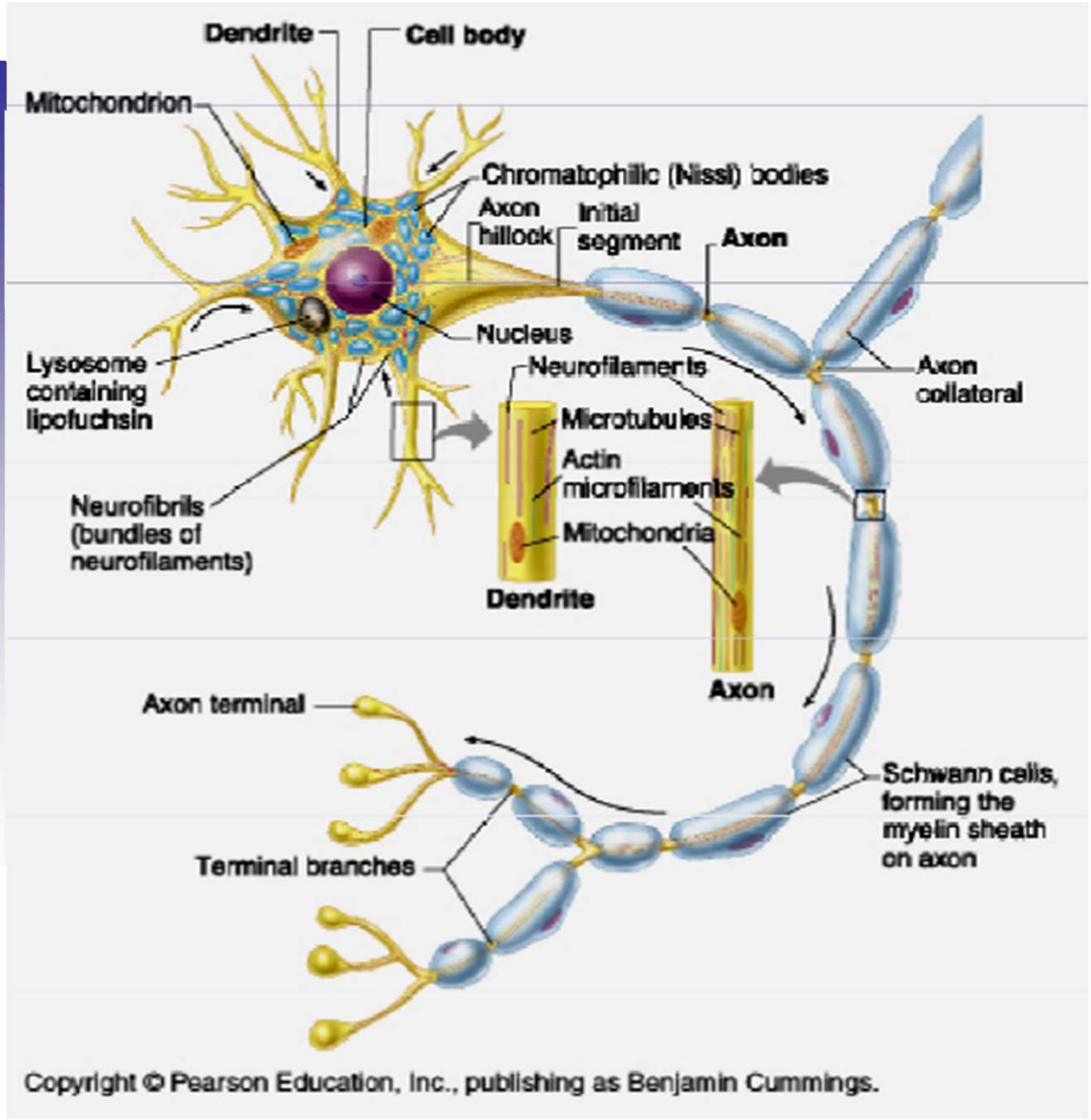
Fig. 1.74 Nerve cell showing neurofibrils (diagrammatic representation).

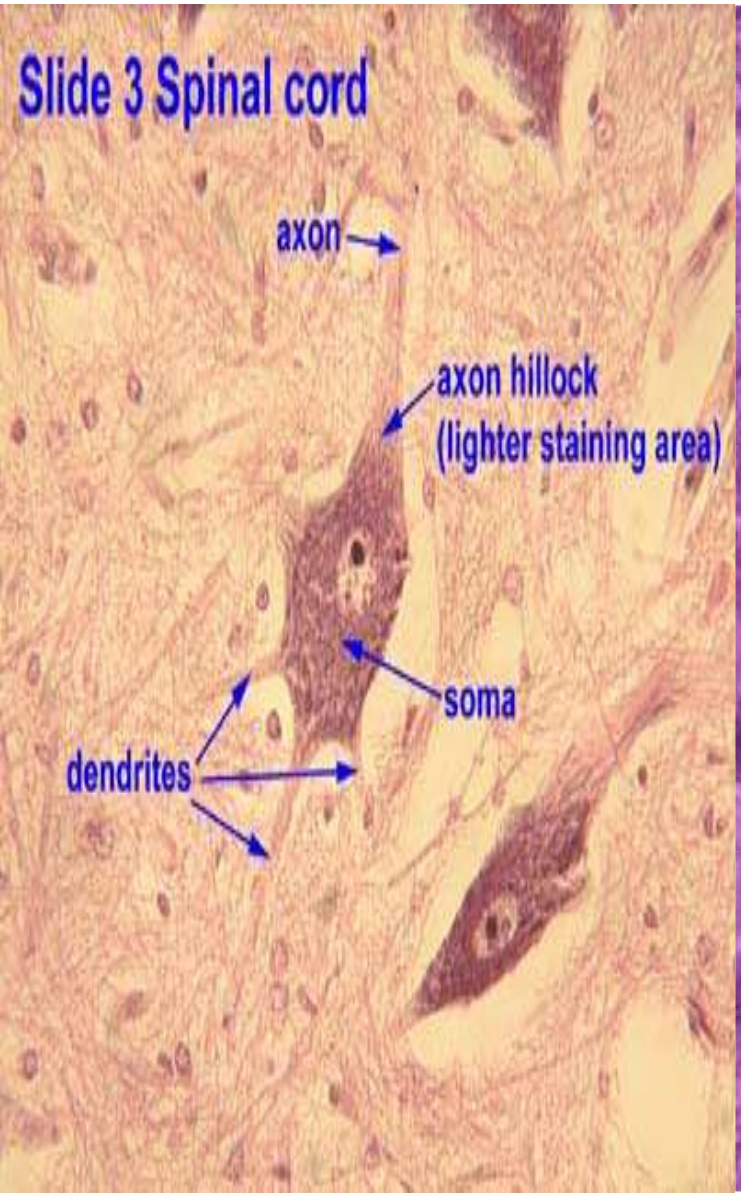


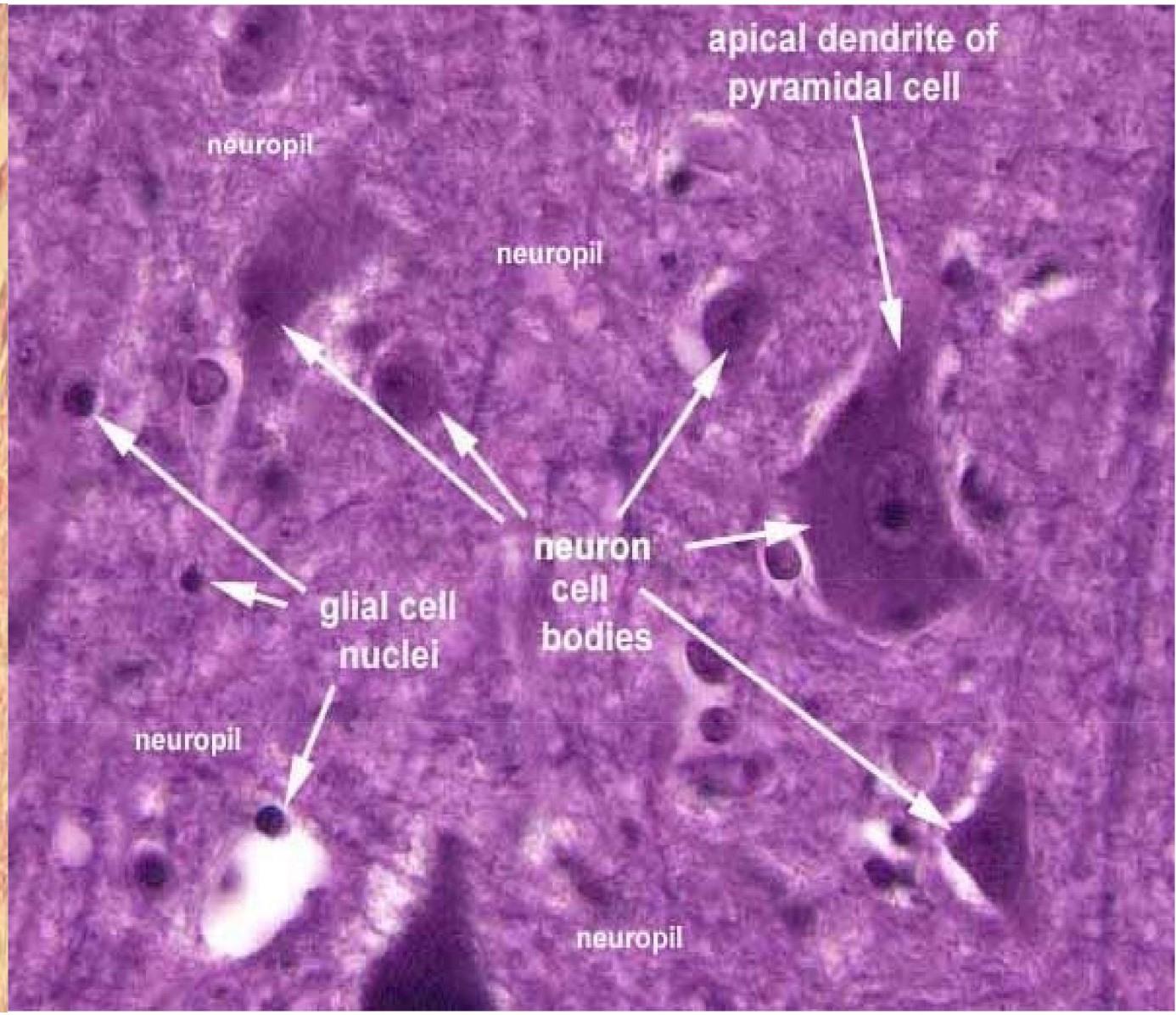
Neuron structure

- In most neurons, the plasma membrane of the cell body acts as a receptive surface that receives signals from other neurons





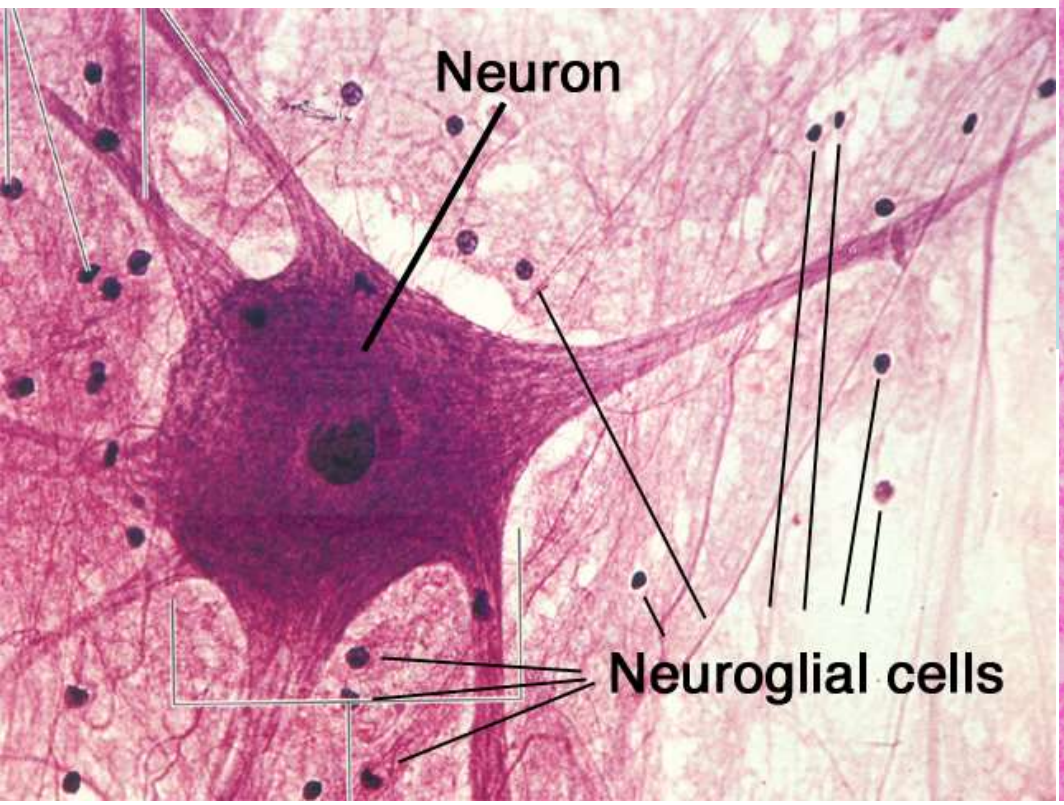

Slide 3 Spinal cord
axon
axon hillock
(lighter staining area)
soma
dendrites

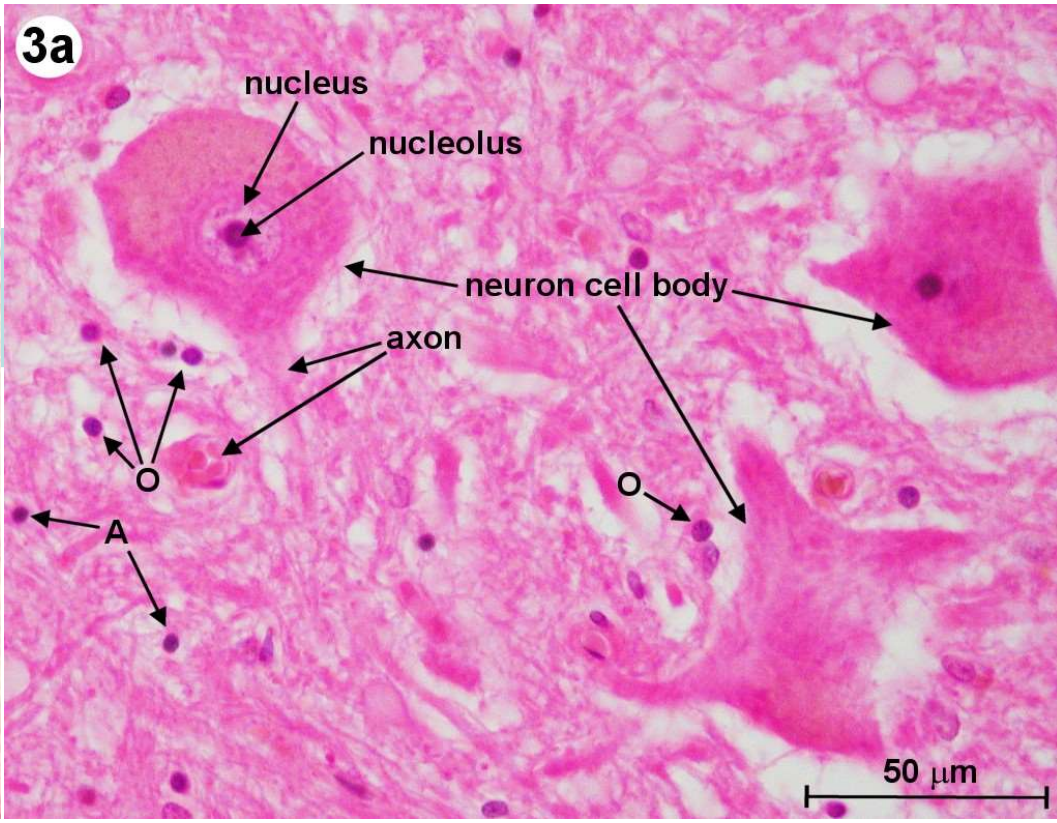

apical dendrite of
pyramidal cell
neuropil
neuropil
neuron
cell
bodies
glial cell
nuclei
neuropil
neuropil

The cytoskeleton with neurofilaments and neurotubules (in place of microfilaments and microtubules)

Bundles of neurofilaments called neurofibrils support the dendrites and axon.

- most nerve cells do not contain centrioles and cannot divide





The long axon carries the electrical signal (*action potential*) to its target.

The structure of an axon is critical to its function.

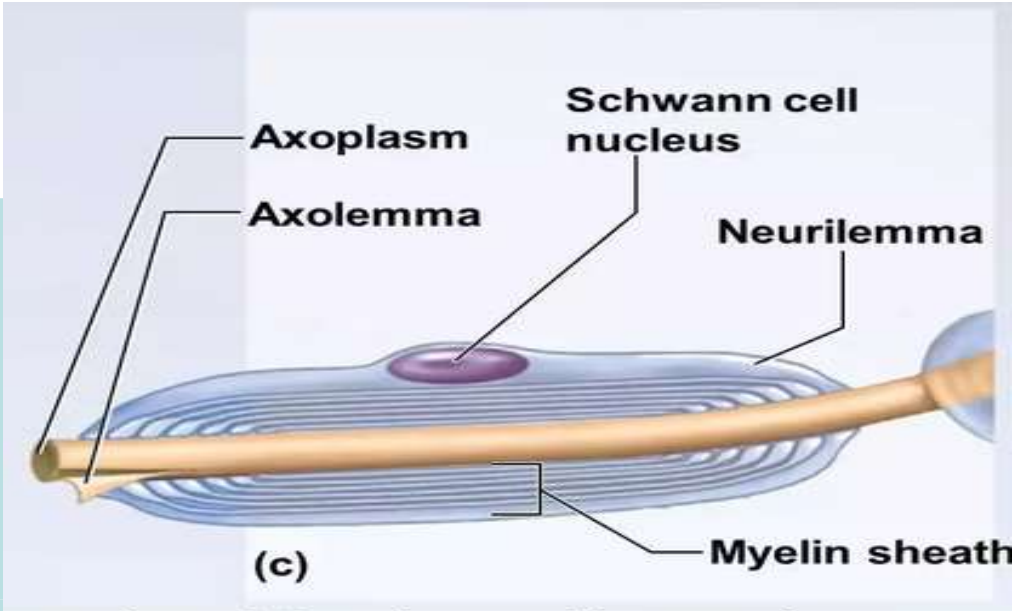
- Axoplasm: the cytoplasm of the axon, which contains neurotubules, neurofibrils, enzymes and various organelles

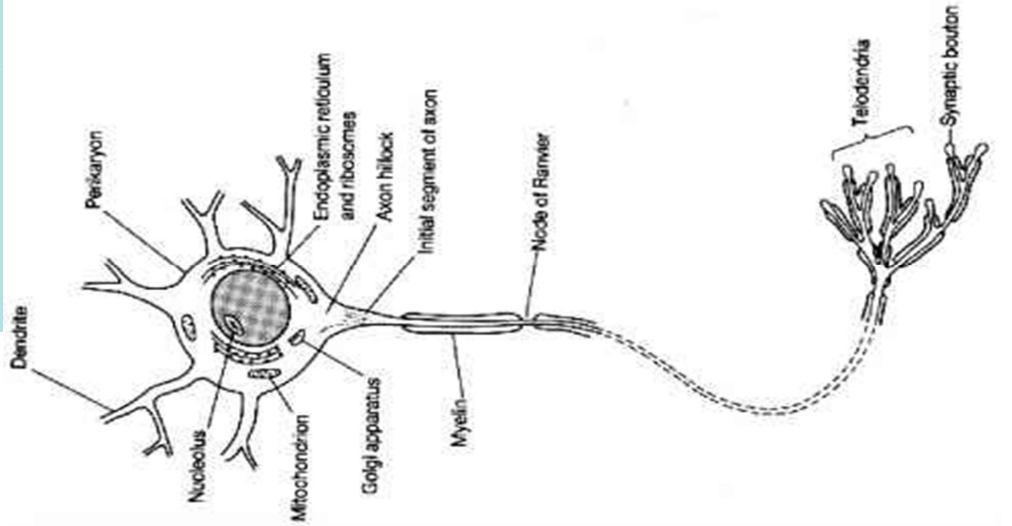
-Axolemma : a specialized cell membrane, covers the axoplasm

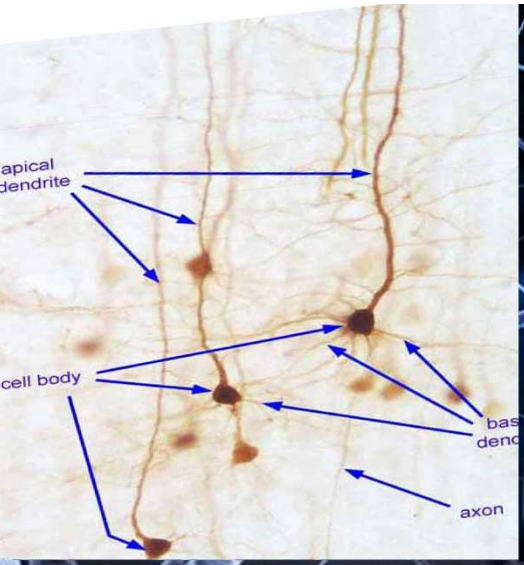
-the initial segment of the axon attaches to the cell body at a thick section called the axon hillock

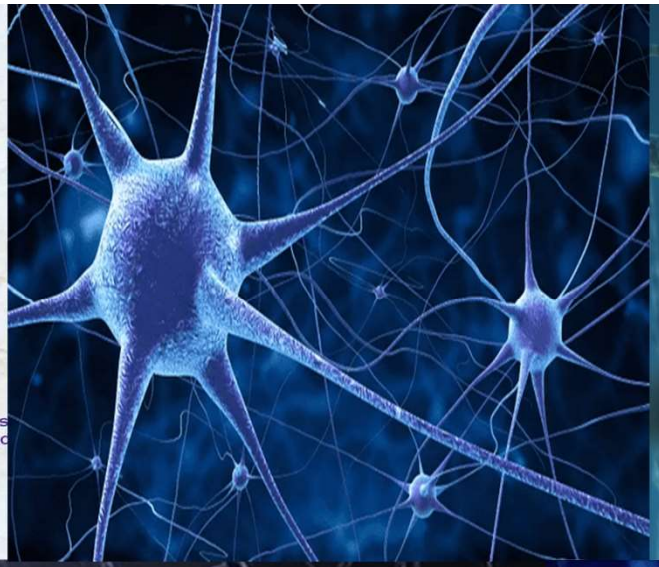
- collaterals are branches of a single axon

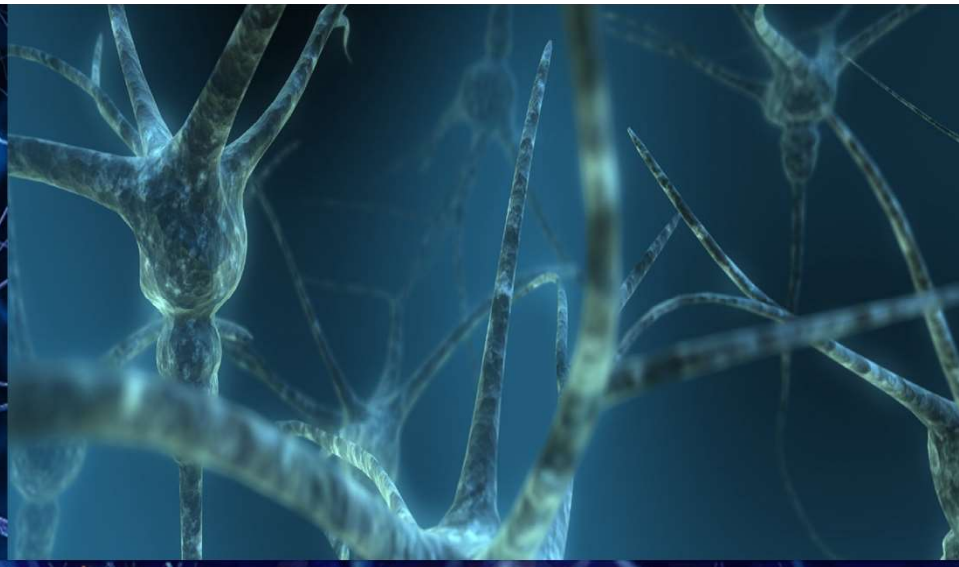
- Telodendria are the fine extensions at the synaptic terminal of the axon

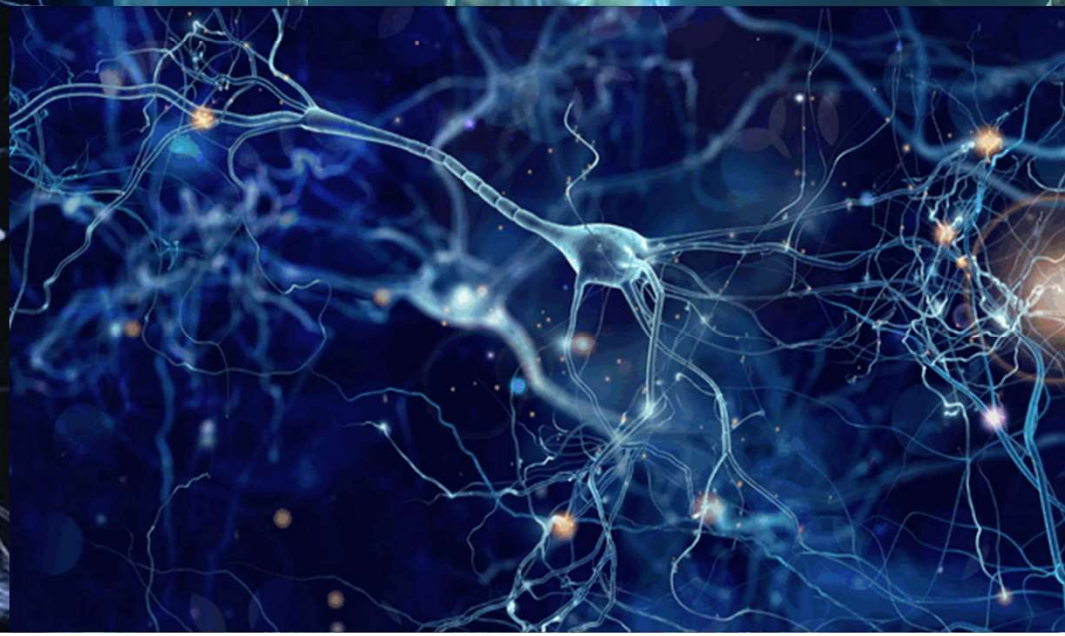





apical
dendrite
cell body
axon

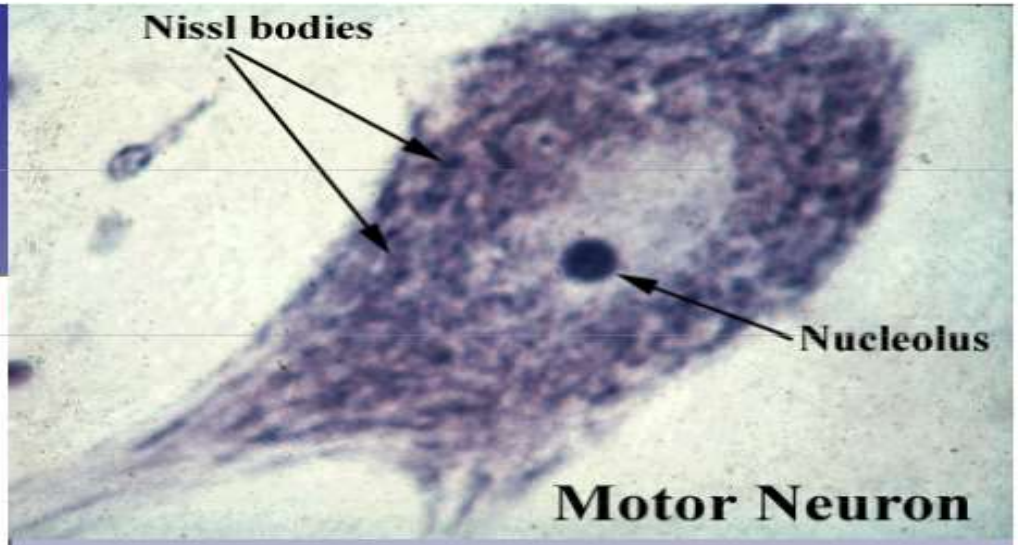






Soma

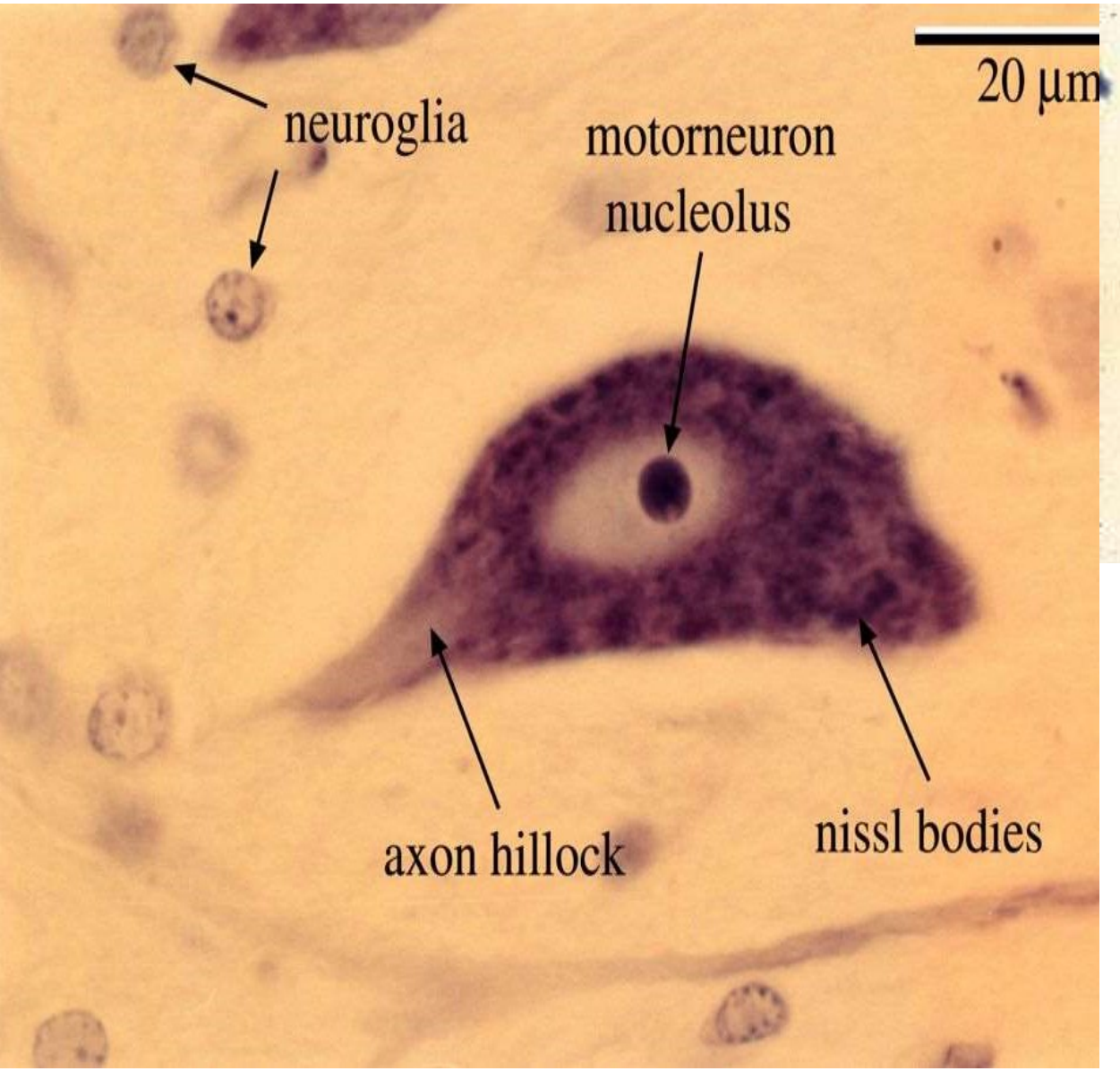
- Contains nucleus plus most normal organelles.
- Biosynthetic center of the neuron.
- Contains a very active and developed rough endoplasmic reticulum which is responsible for the synthesis of _____.
  - The neuronal rough ER is referred to as the Nissl body.
- Contains many bundles of protein filaments (neurofibrils) which help maintain the shape, structure, and integrity of the cell.

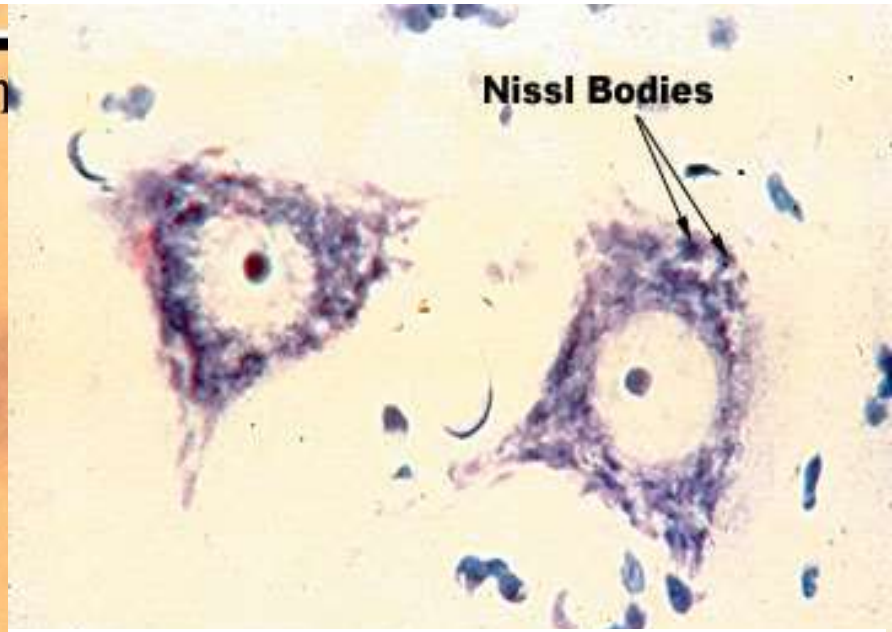


In the soma above, notice the small black circle. It is the nucleolus, the site of ribosome synthesis. The light circular area around it is the nucleus. The mottled dark areas found throughout the cytoplasm are the Nissl substance.

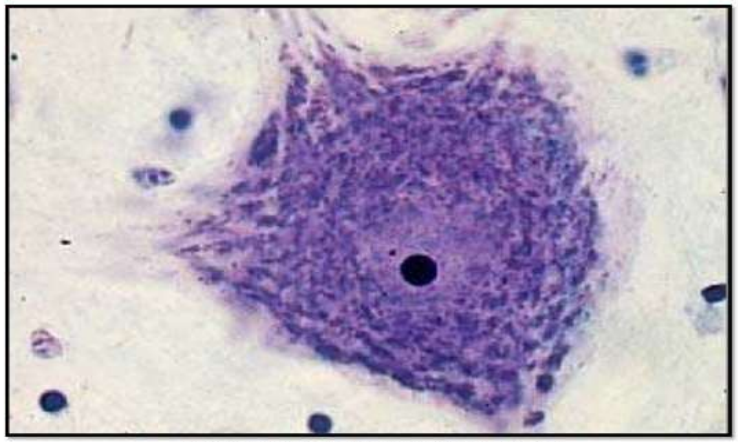
A Nissl body (or Nissl granule or tigroid body) is a large granular body found in nerve cells.

- These granules are rough endoplasmic reticulum (with ribosomes) and are the site of protein synthesis.
- Nissl bodies show changes under various physiological conditions and in pathological conditions they may dissolve and disappear (karyolysis).





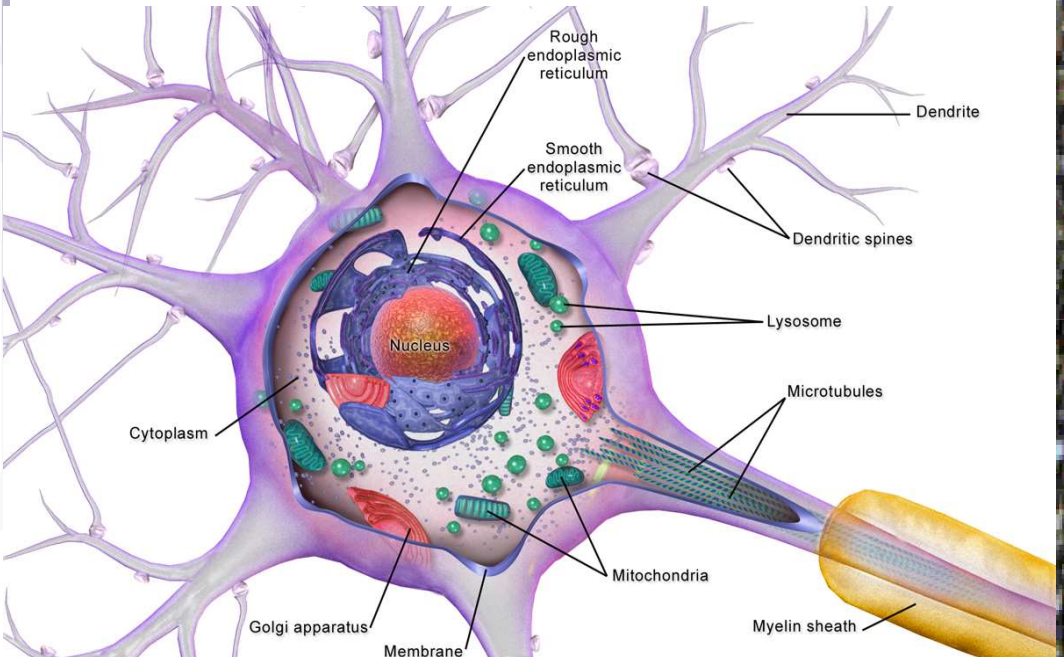
Nissl´s Granules in Nerve Cells

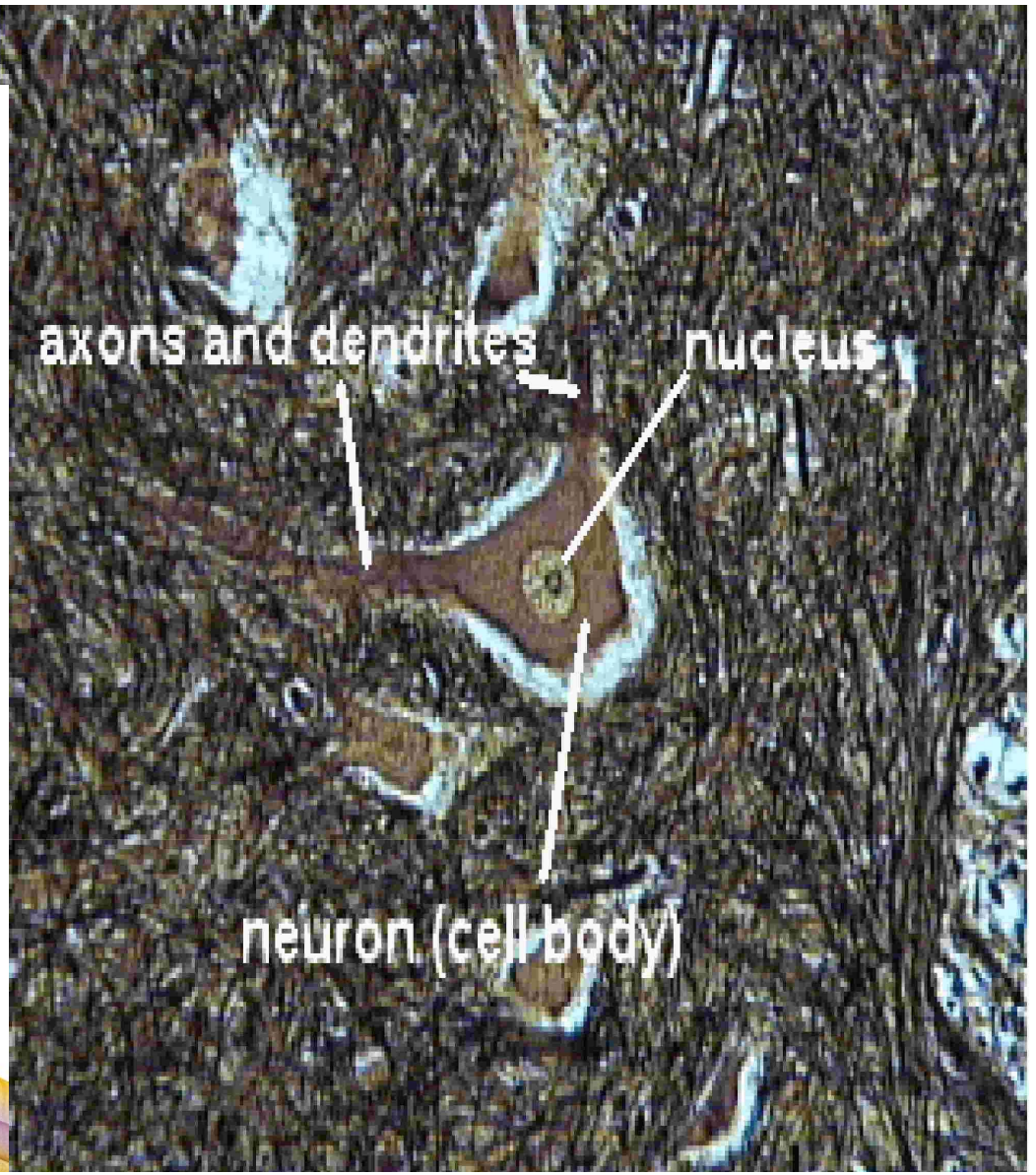


Histology Department / Faculty of Medicine / Cairo University

Somata or somas

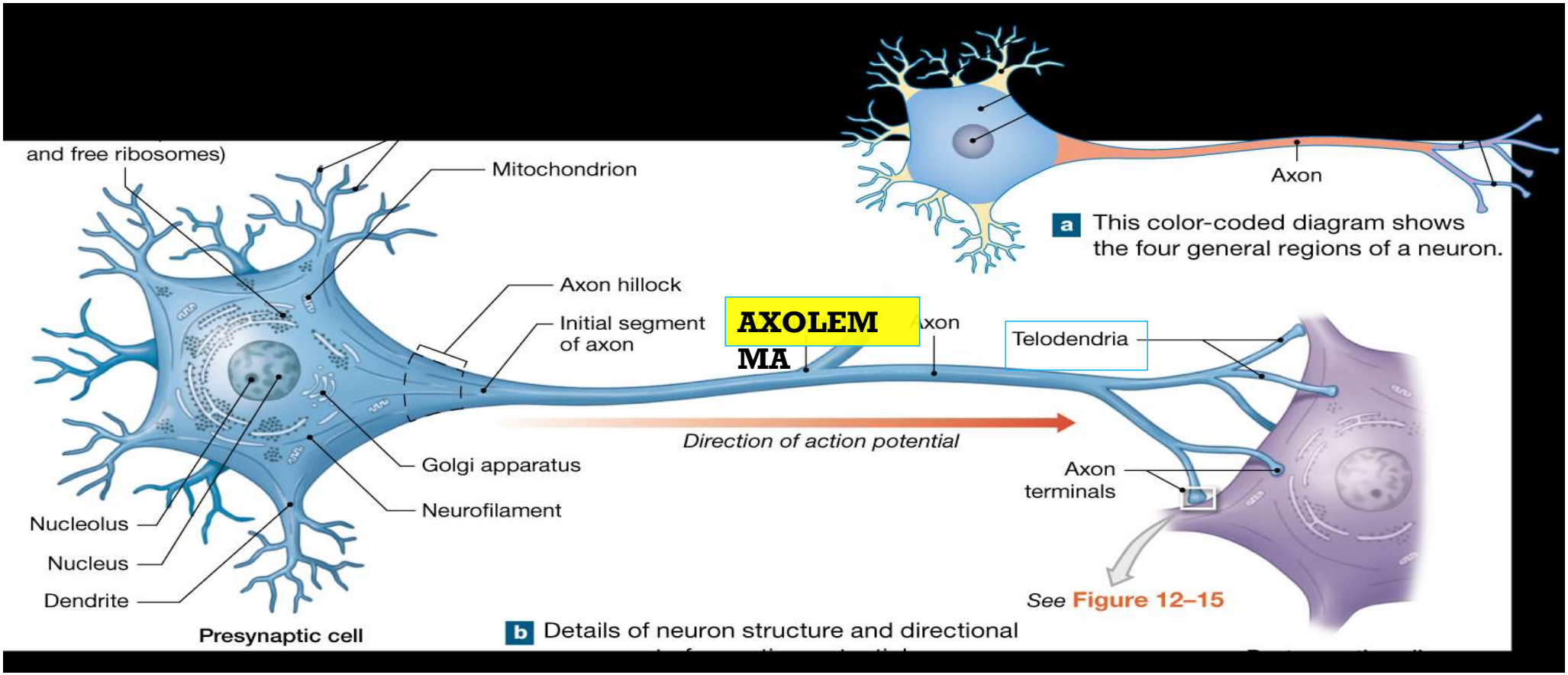
- Contain multiple mitochondria.
- Acts as a receptive service for interaction with other neurons.
- Most somata are found in the bony environs of the CNS.
- Clusters of somata in the CNS are known as nuclei.
- Clusters of somata in the PNS are known as ganglia.

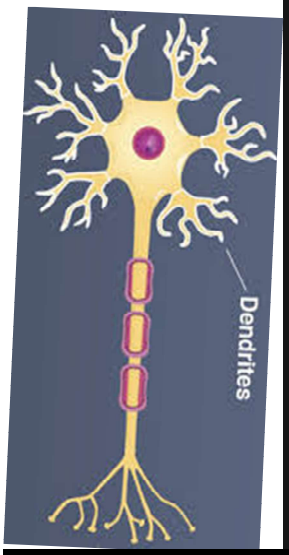




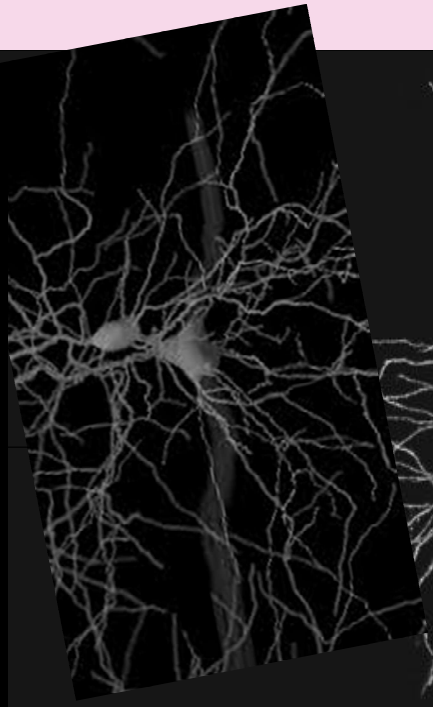
The **axolemma** is the membrane of a neuron's axon.

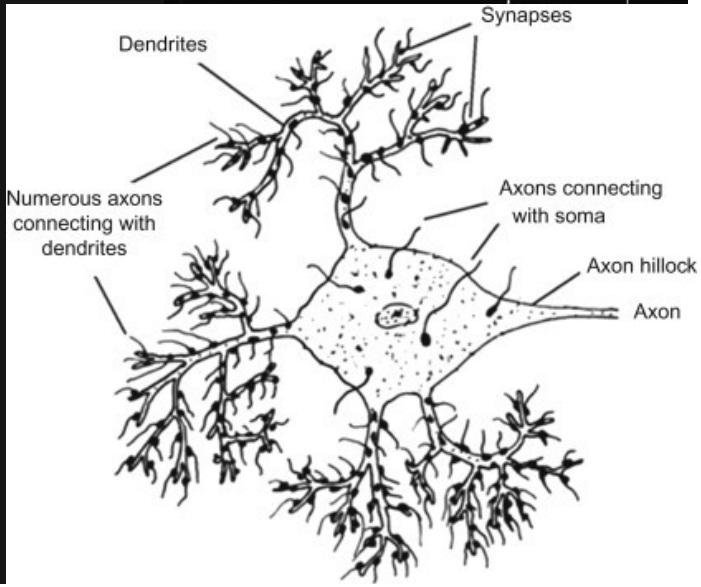
It is responsible for **maintaining the cell's membrane potential**, and it contains channels through which ions can flow.

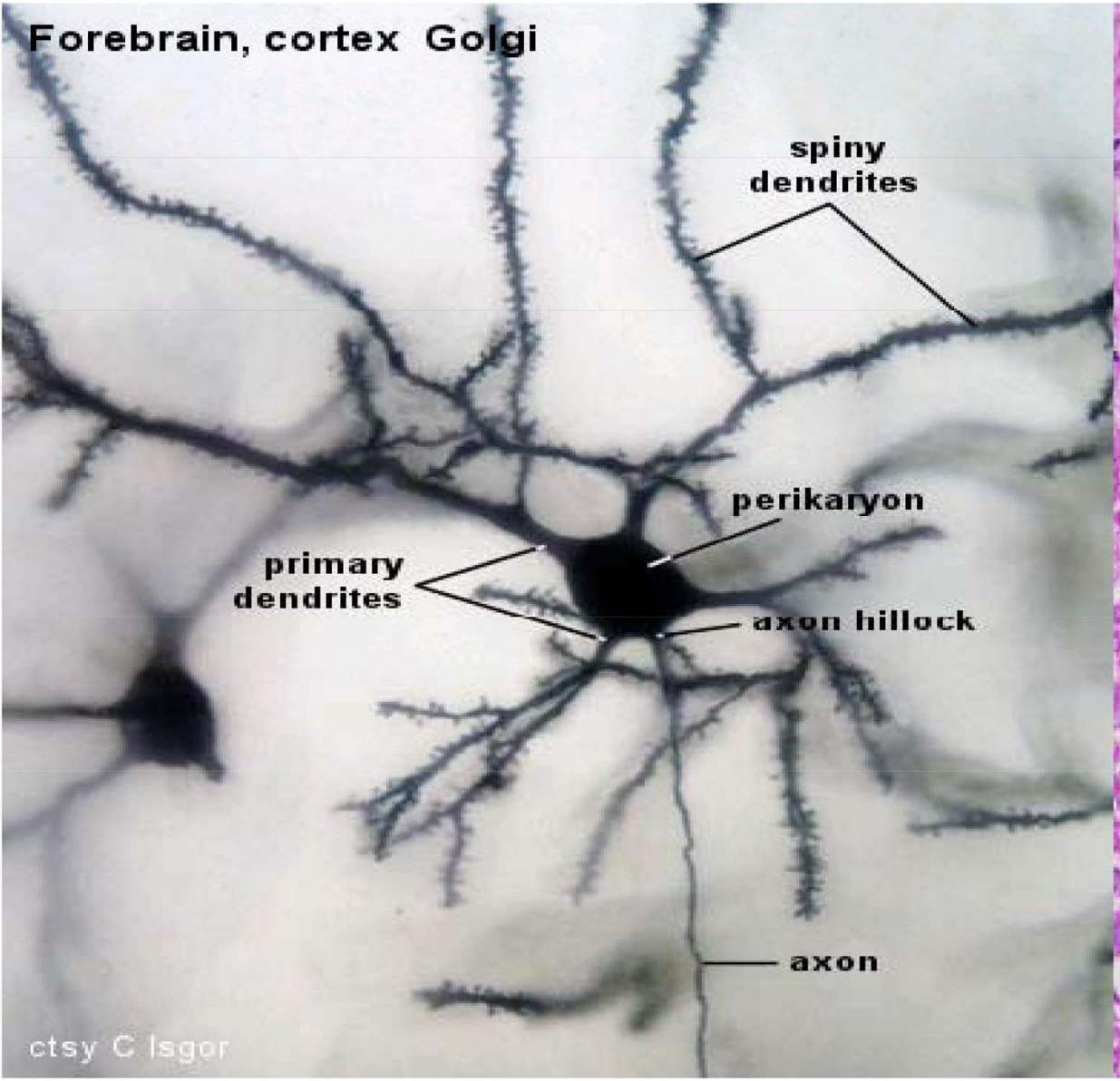


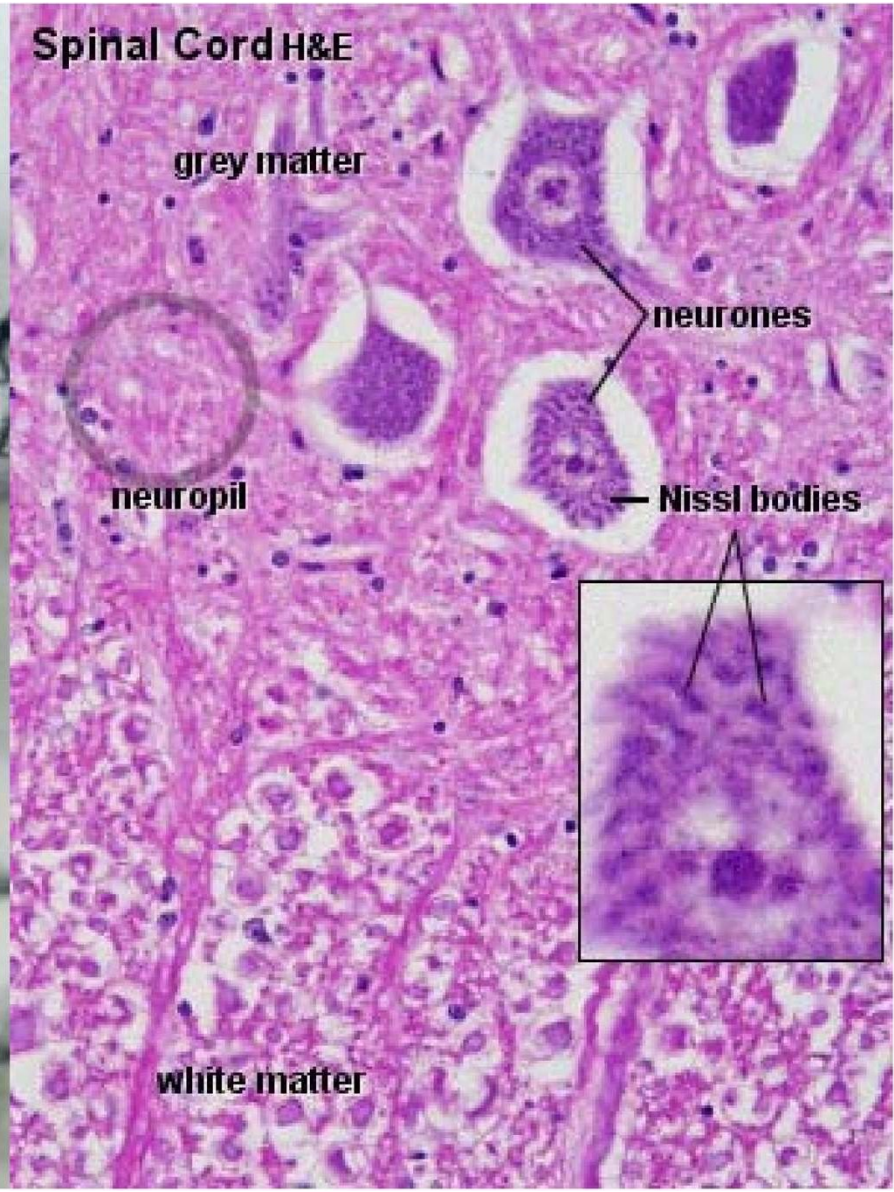


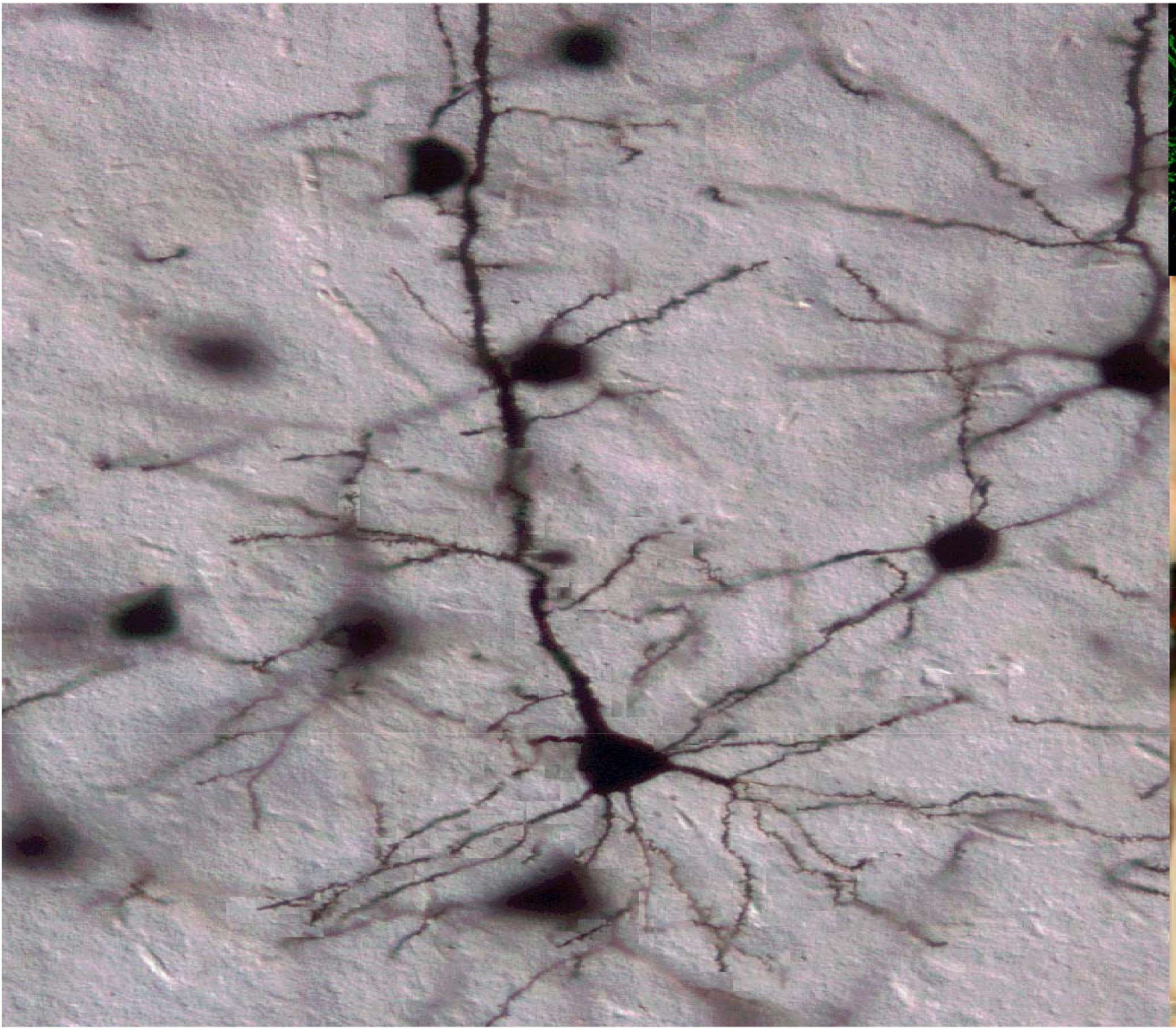
- **Dendrites** are thin, branched processes whose main function is to **receive incoming signals**.
- They effectively increase the surface area of a neuron to increase its ability to communicate with other neurons.
  - Small, mushroom-shaped dendritic spines further increase the SA
- Convey info towards the soma thru the use of graded

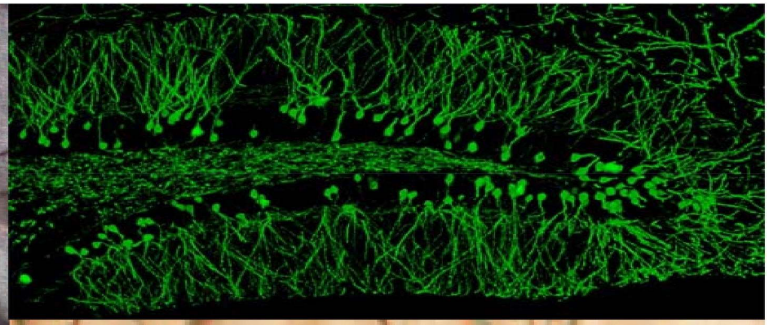




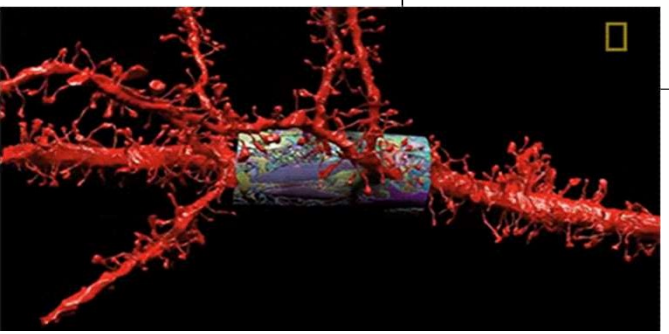

Forebrain, cortex Golgi
spiny dendrites
perikaryon
primary dendrites
axon hillock
axon
ctsy C Isgor

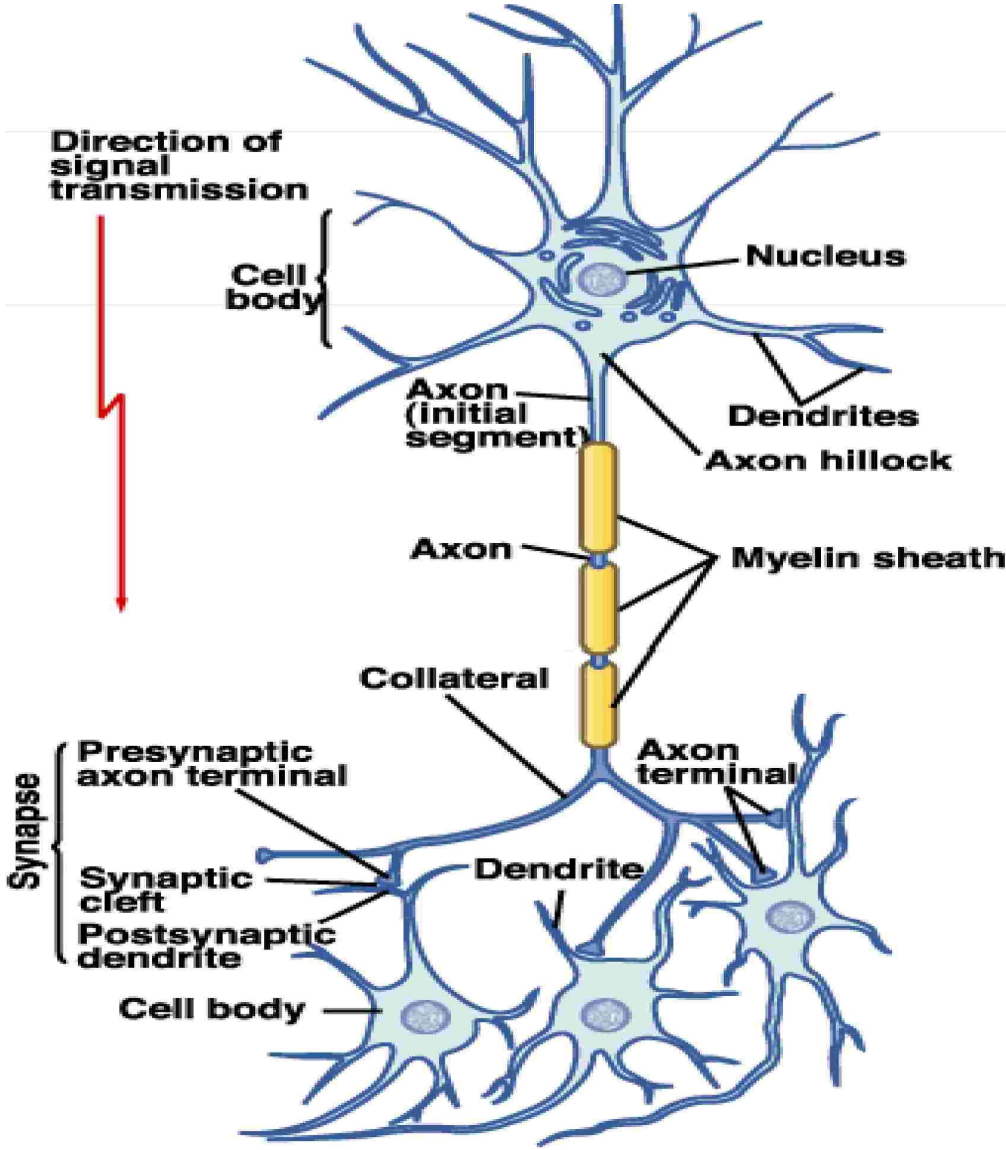

Spinal Cord H&E
grey matter
neurones
neuropil
Nissl bodies
white matter



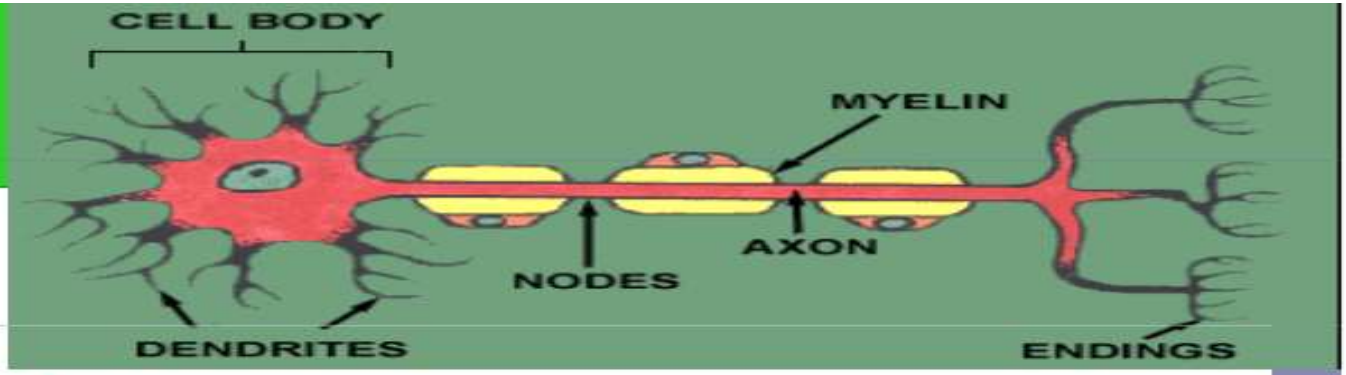


- Most neurons have a single axon – a long (up to 1m) process designed to convey info away from the cell body.
- Originates from a special region of the cell body called the axon hillock.
- Transmit APs from the soma toward the end of the axon where they cause NT release.
- Often branch sparsely, forming collaterals.
- Each collateral may split into telodendria which end in a synaptic knob, which contains synaptic vesicles – membranous bags of NTs.





Axons



- Axolemma = axon plasma membrane.

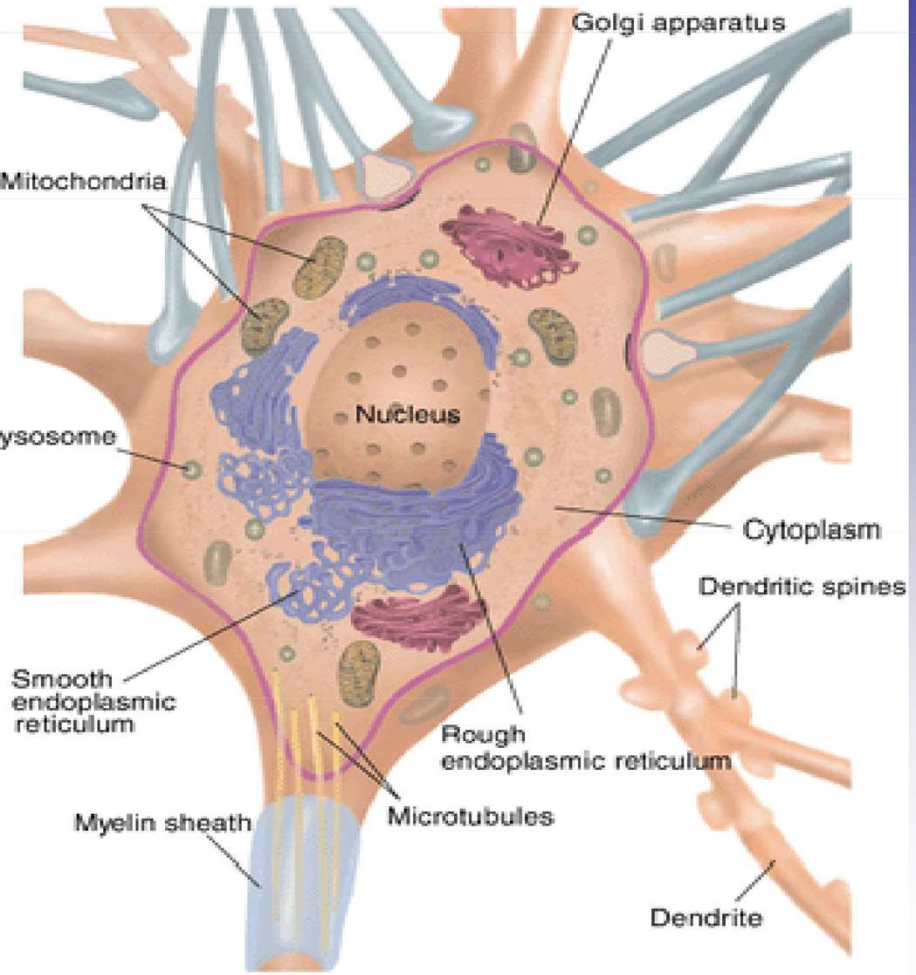
- Surrounded by a myelin sheath, a wrapping of lipid which:
  - Protects the axon and electrically isolates it
  - Increases the rate of AP transmission

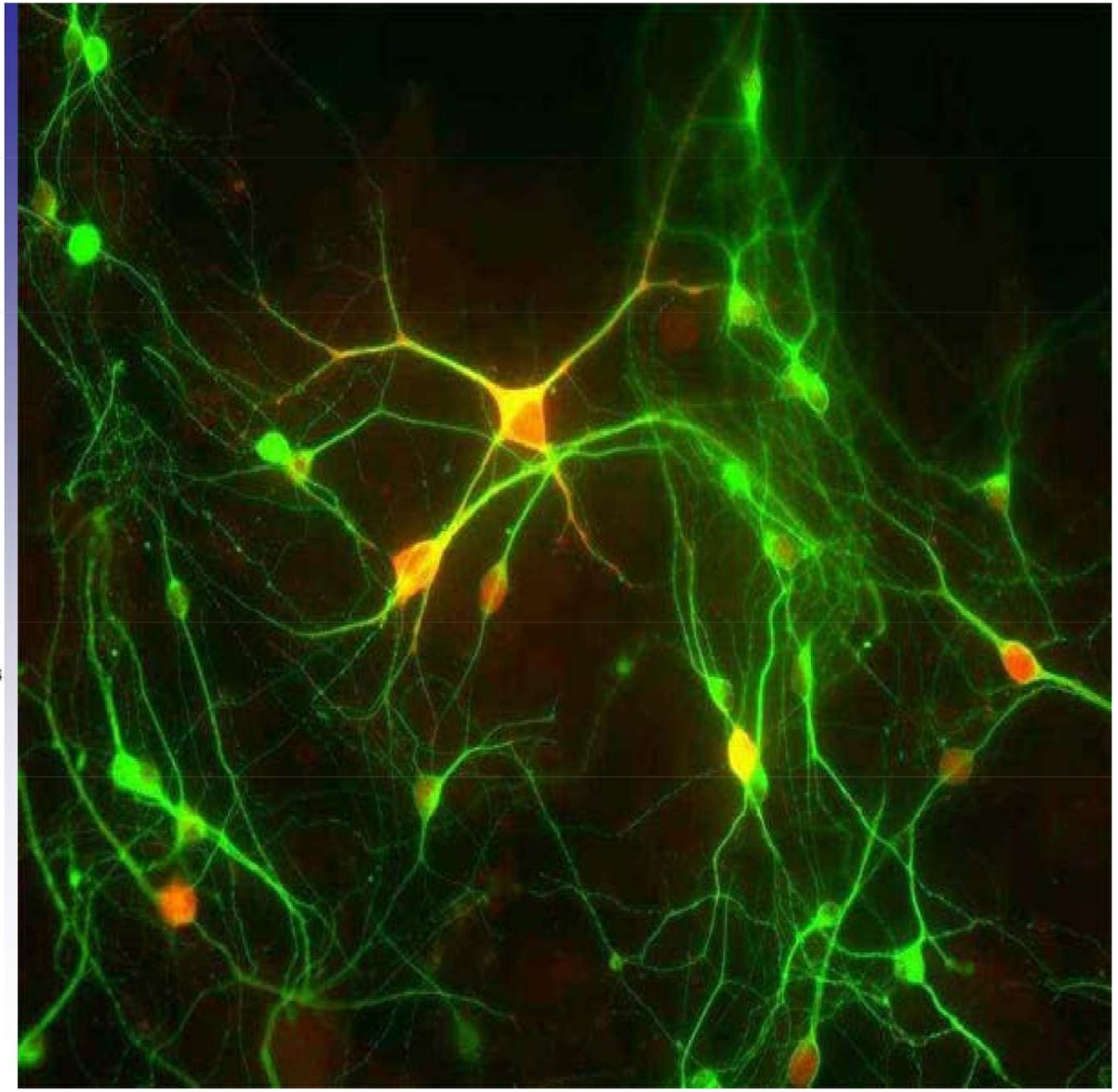
- The myelin sheath is made by _____ in the CNS and by _____ in the PNS.
- This wrapping is never complete. Interspersed along the axon are gaps where there is no myelin – these are nodes of Ranvier.
- In the PNS, the exterior of the Schwann cell surrounding an axon is the neurilemma

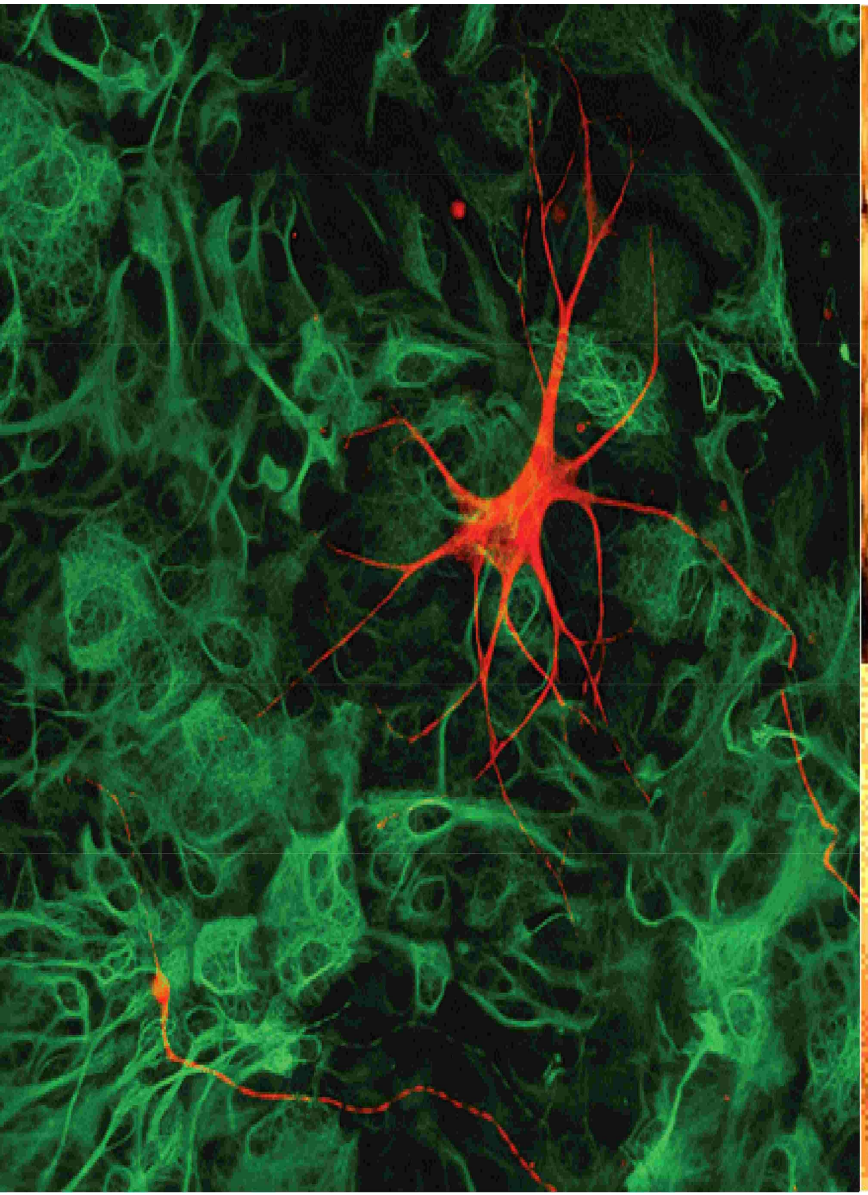
Axons: Function

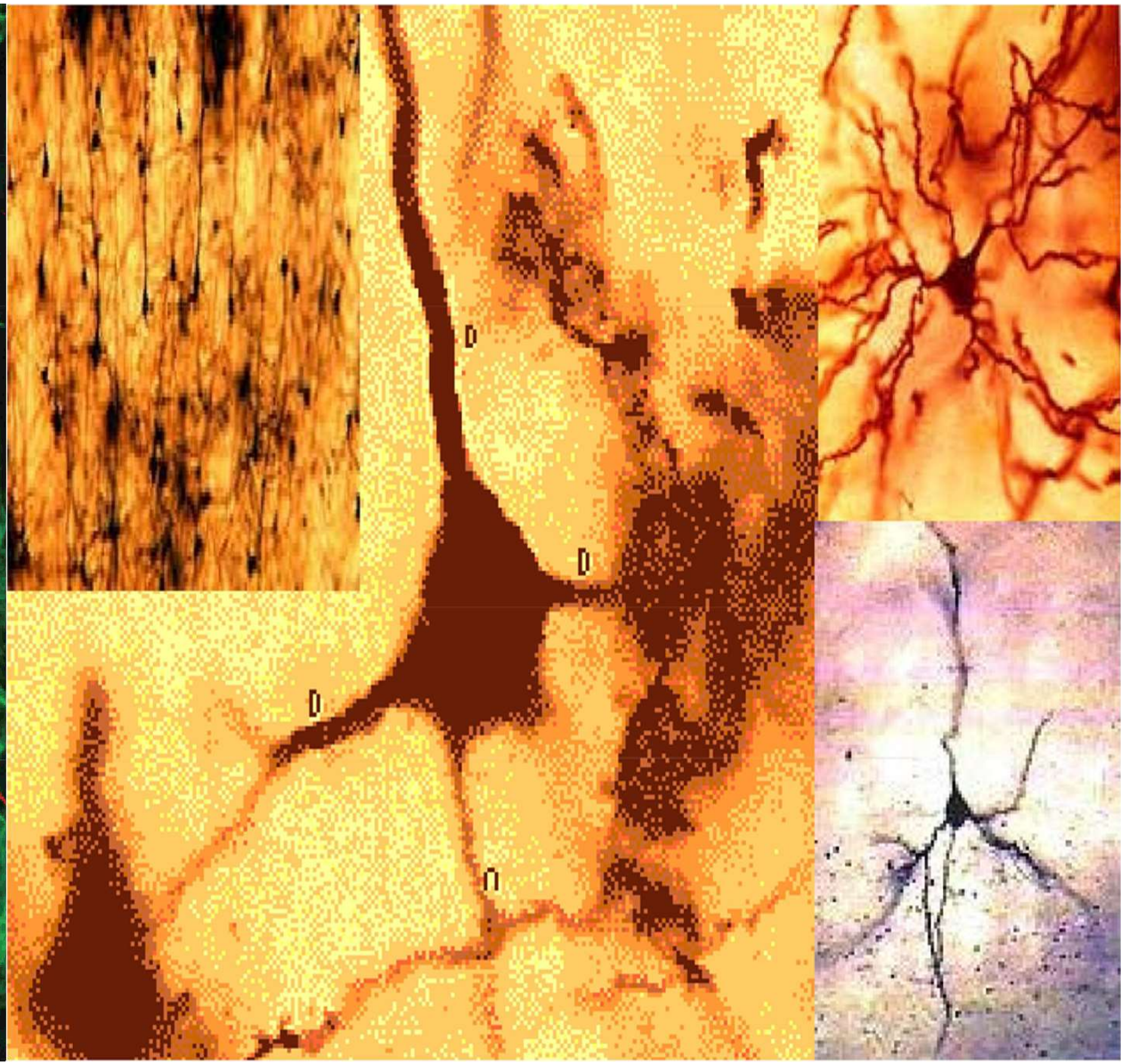
- Generate and transmit action potentials
- Secrete neurotransmitters from the axonal terminals
- Movement along axons occurs in two ways
  - Anterograde — toward axonal terminal
  - Retrograde — away from axonal terminal

Structures of a Multipolar Neuron

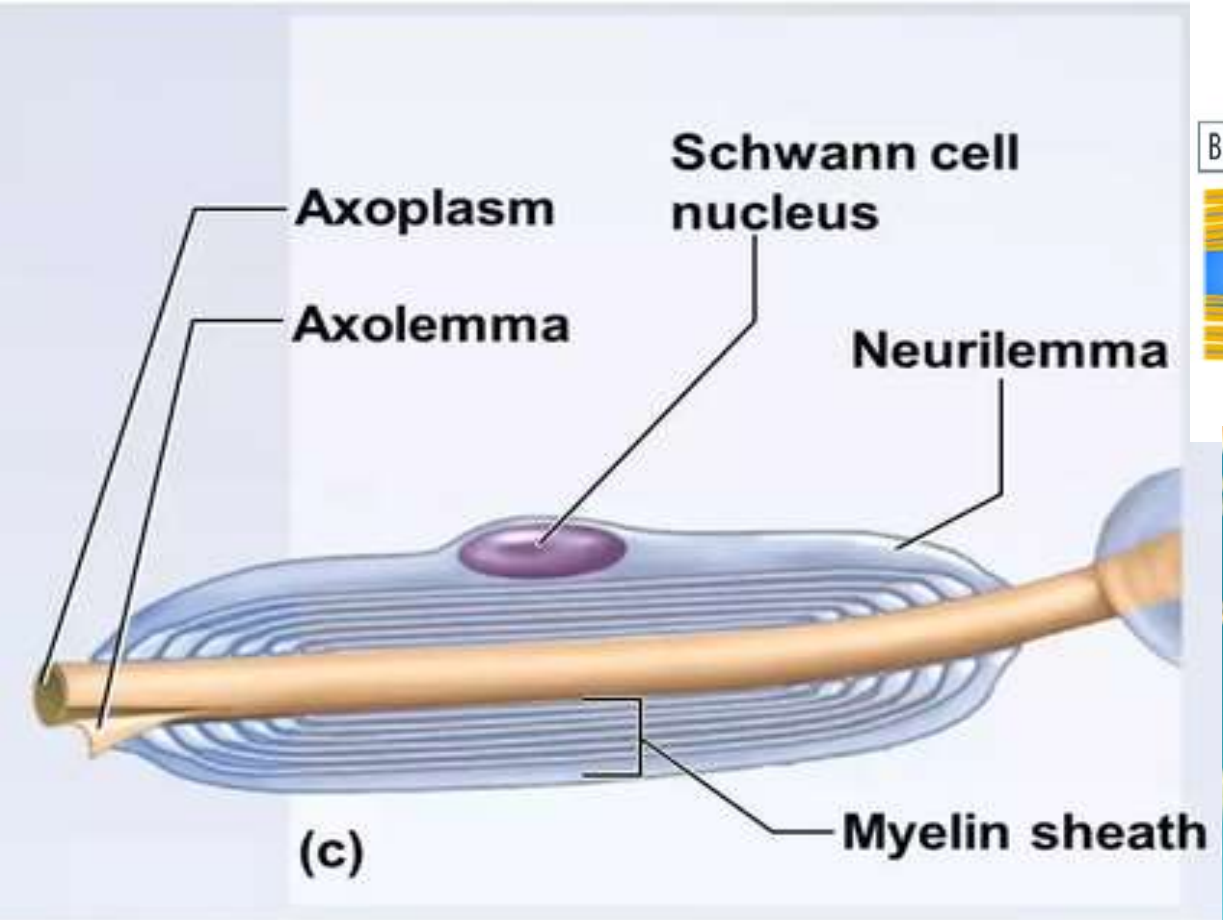


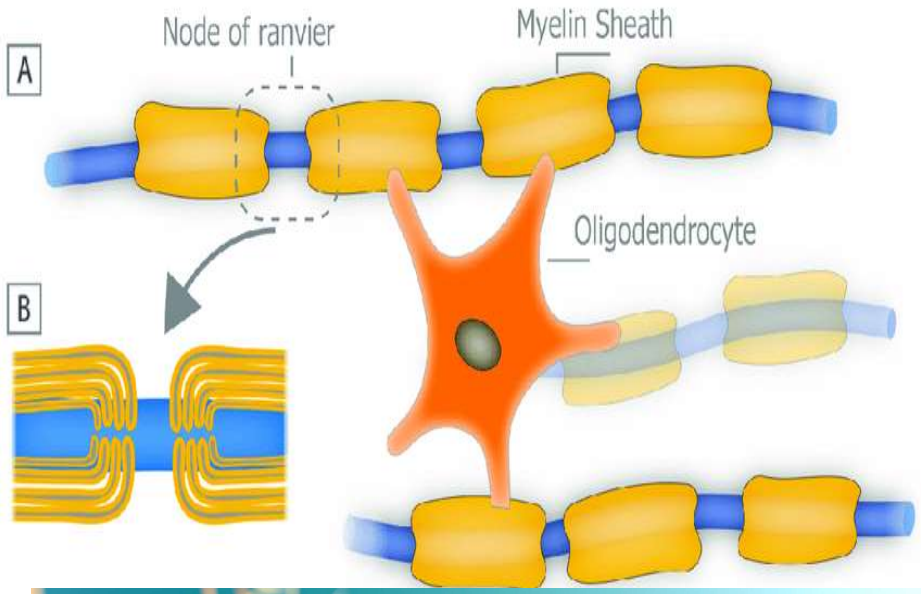






Myelin Sheath in PNS





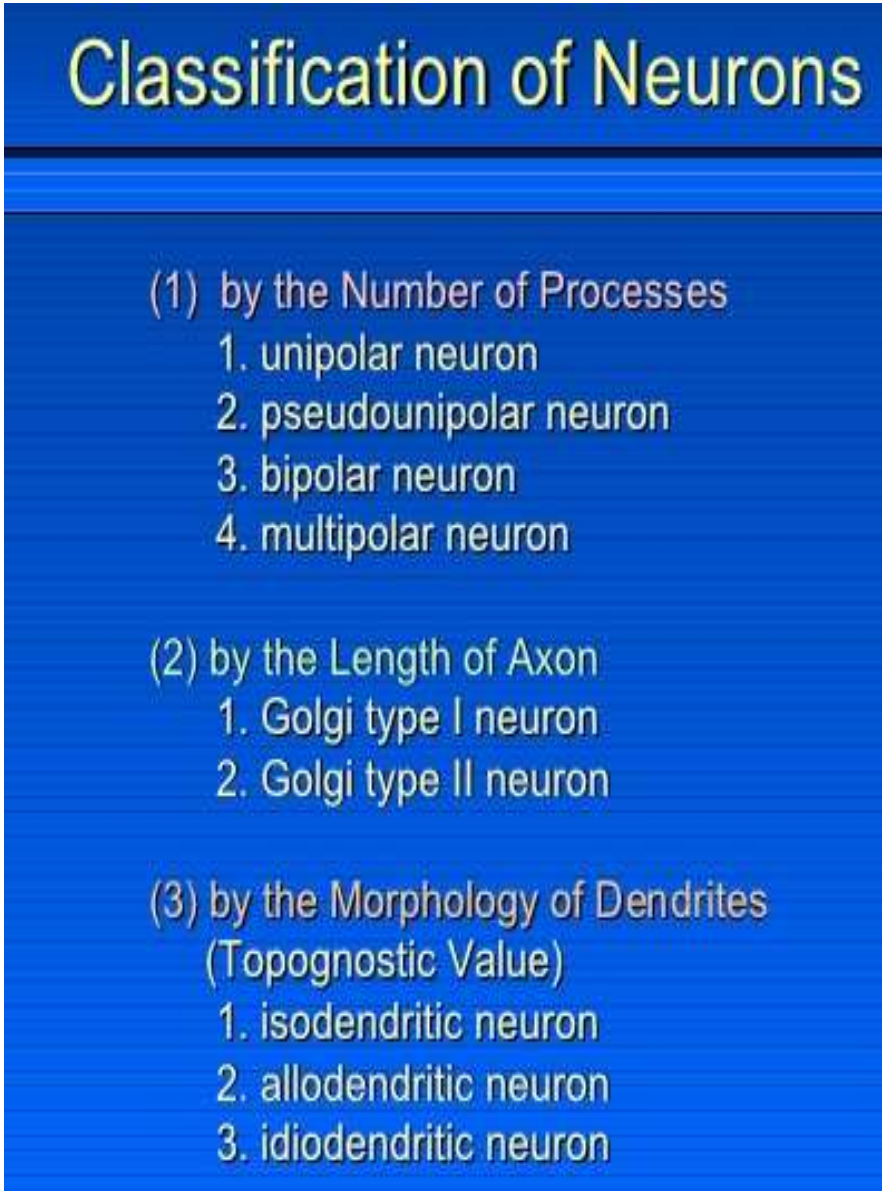
nodes of Ranvier and internodes

Axons	Dendrites
•Take information away from the cell body •Smooth Surface •Generally only 1 axon per cell •No ribosomes •Can have myelin •Branch further from the cell body	•Bring information to the cell body •Rough Surface (dendritic spines) •Usually many dendrites per cell •Have ribosomes •No myelin insulation •Branch near the cell body

Structural classification

Most neurons can be anatomically characterized as:

- **Unipolar or Pseudounipolar-** dendrite and axon emerging from same process.
- **Bipolar -** single axon and single dendrite on opposite ends of the soma.
- **Multipolar** - more than two dendrites
  - **Golgi I-** neurons ***with long-projecting*** axonal processes.
  - **Golgi II-** neurons whose ***axonal process projects locally***.



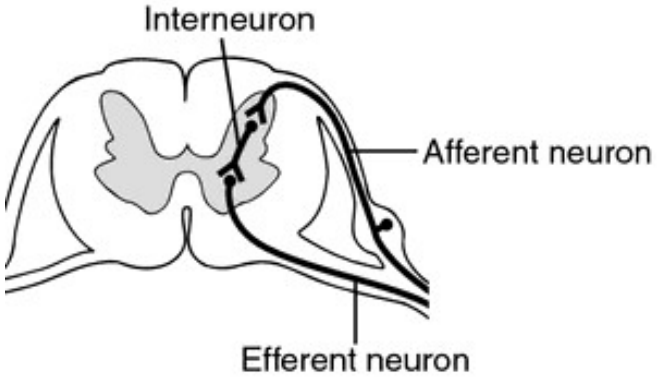
Functional classification

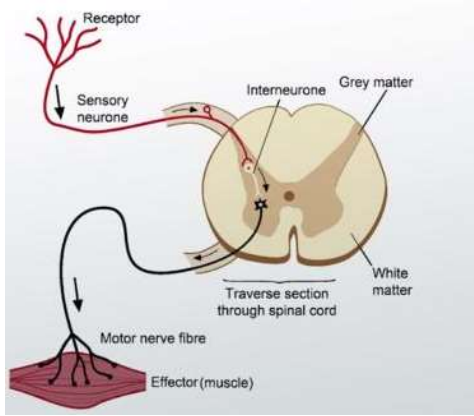
- **Afferent neurons** convey information from tissues and organs into the central nervous system.

- **Efferent neurons** transmit signals from the central nervous system to the effector cells and are sometimes called motor neurons.

- **Interneurons** connect neurons within specific regions of the central nervous system.

Afferent and *efferent* can also refer to neurons which convey information from one region of the brain to another.





***There are 4 classifications of neurons based on structure*:**

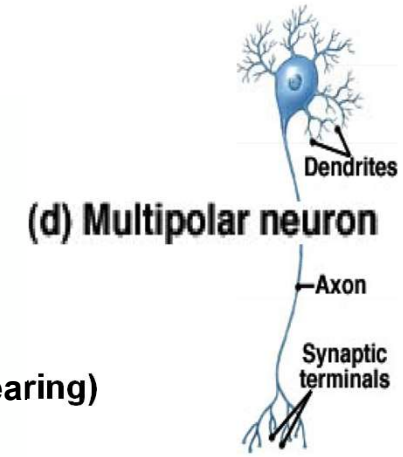
<u>1. Anaxonic neurons:</u>
- small
- all cell processes look alike
-found in brain and sense organs

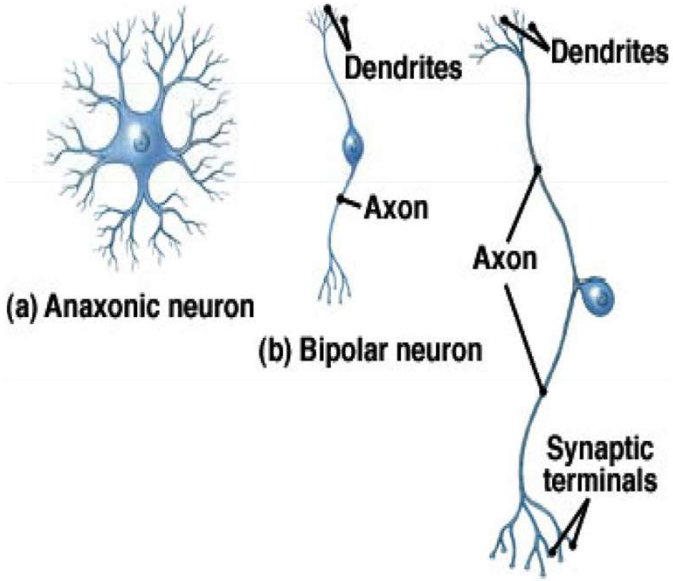
<u>2. Bipolar neurons</u>:
- small
- one dendrite and one axon
-found in special sensory organs (sight, smell, hearing)

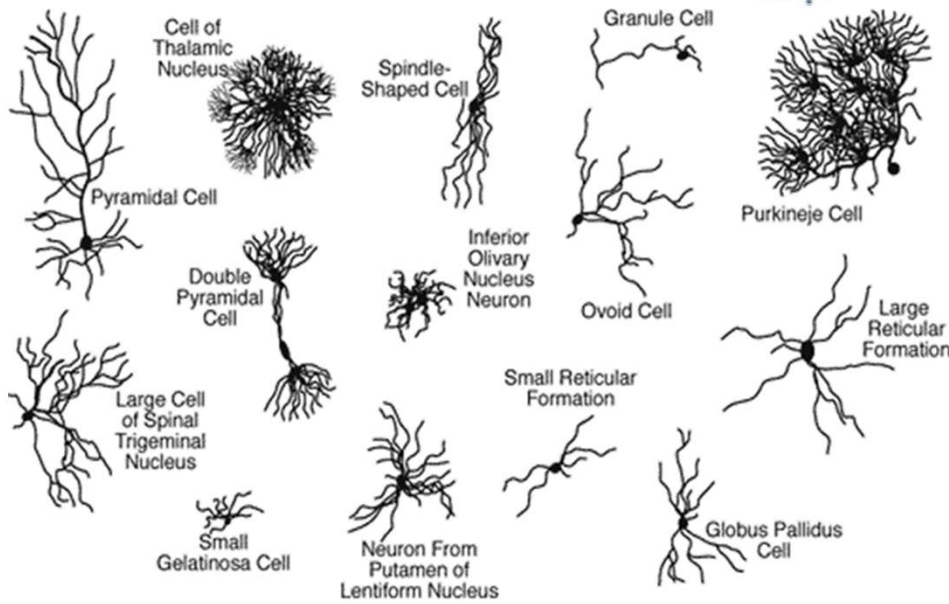
<u>3. Unipolar neurons:</u>
- very long axons
- dendrites and axon are fused, with cell body to one side
-found in sensory neurons of the peripheral nervous system

<u>4. Multipolar neurons:</u>
- very long axons

- **2 or more dendrites and 1 axon**
- **common in the CNS**
- **includes all motor neurons of skeletal muscles**

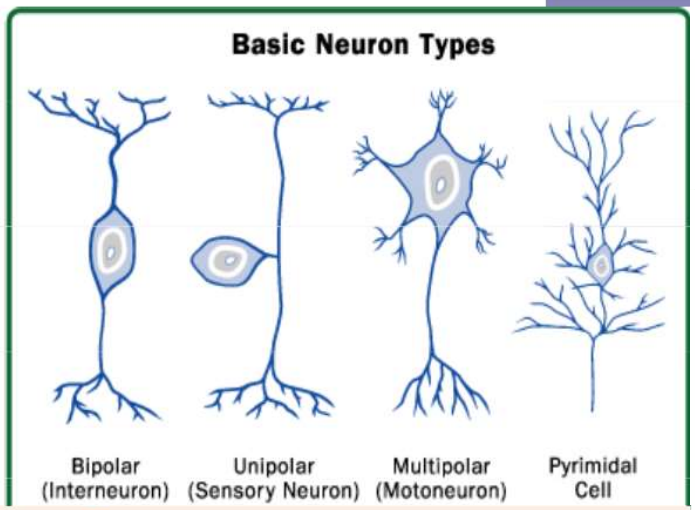


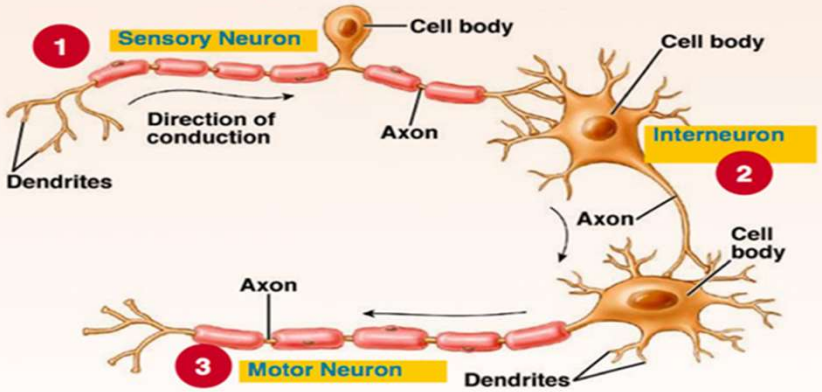




Type of Neurons

- Sensory neurons:
- Interneurons
- Motor neurons





There are 3 classifications of neurons based on function:

1. Sensory neurons or *afferent neurons.* (the afferent division of the PNS):

- Cell bodies of sensory neurons are grouped in *sensory ganglia*.
- Sensory neurons collect information about our internal environment (visceral sensory neurons) and our relationship to the external environment (somatic sensory neurons).
- Sensory neurons are unipolar. Their processes, called afferent fibers, extend (deliver messages) from sensory receptors to the CNS.

- Sensory receptors are categorized as:

a. interoceptors:

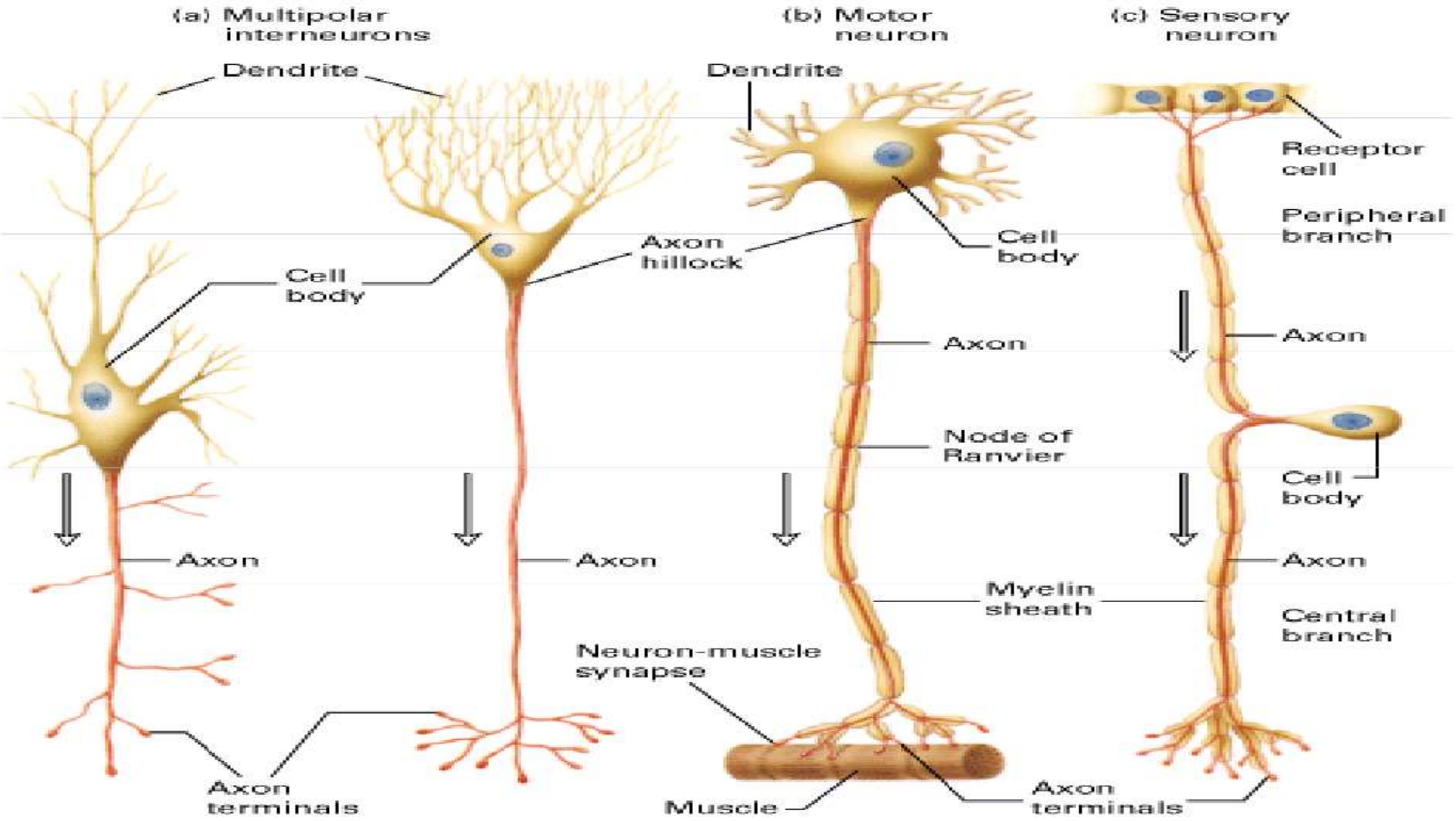
- monitor digestive, respiratory, cardiovascular, urinary and reproductive systems
- provide internal senses of taste, deep pressure and pain

b. exteroceptors:

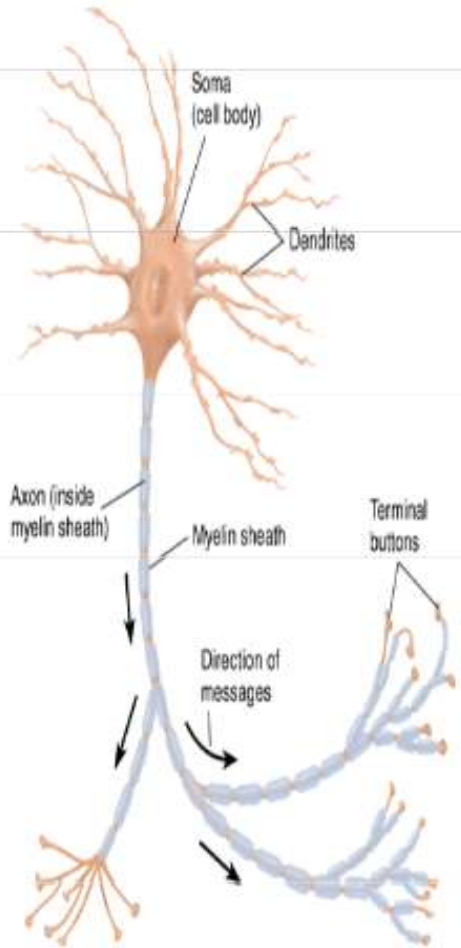
- external senses of touch, temperature, and pressure
- distance senses of sight, smell and hearing

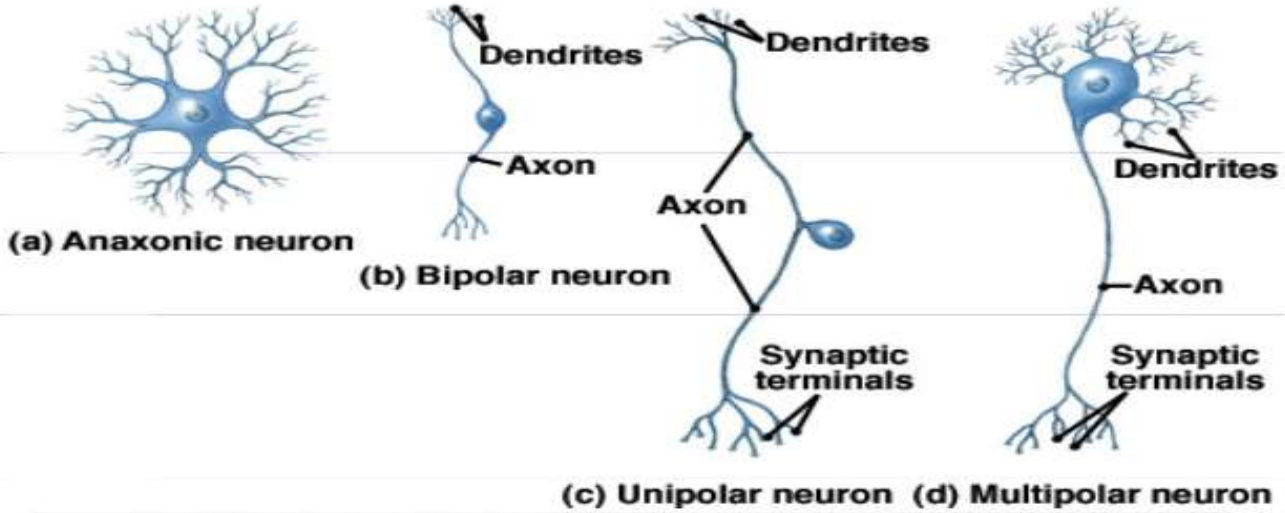
c. proprioceptors:

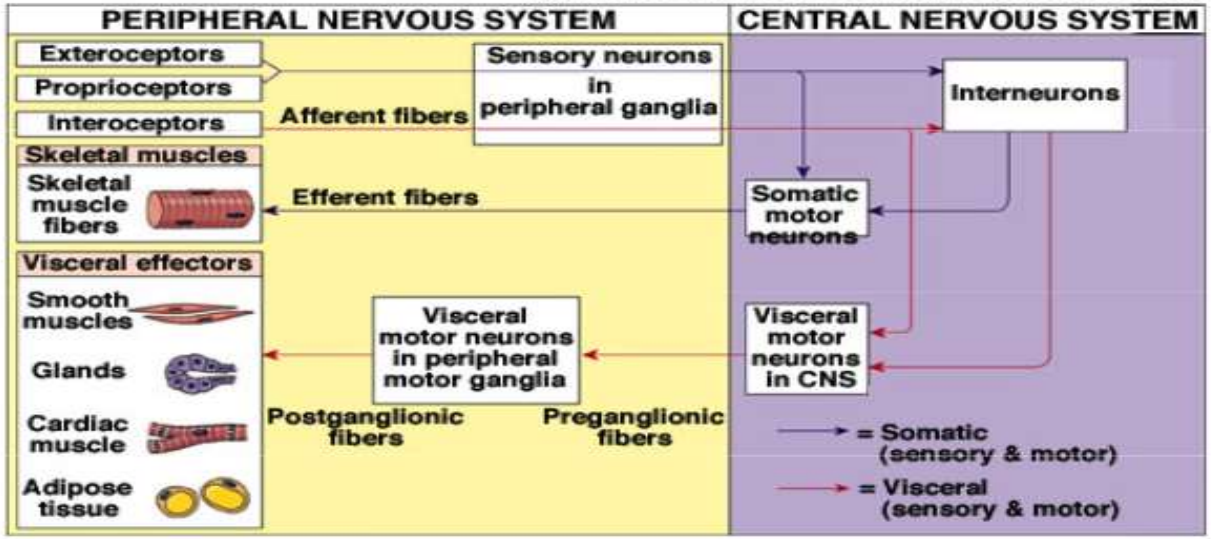
- monitor position and movement of skeletal muscles and joints


(a) Multipolar interneurons
Dendrite
Cell body
Axon
Axon terminals
Axon hillock
Axon
(b) Motor neuron
Dendrite
Cell body
Axon
Node of Ranvier
Myelin sheath
Neuron-muscle synapse
Muscle
Axon terminals
(c) Sensory neuron
Receptor cell
Peripheral branch
Axon
Cell body
Axon
Central branch

▸ Multipolar Neuron

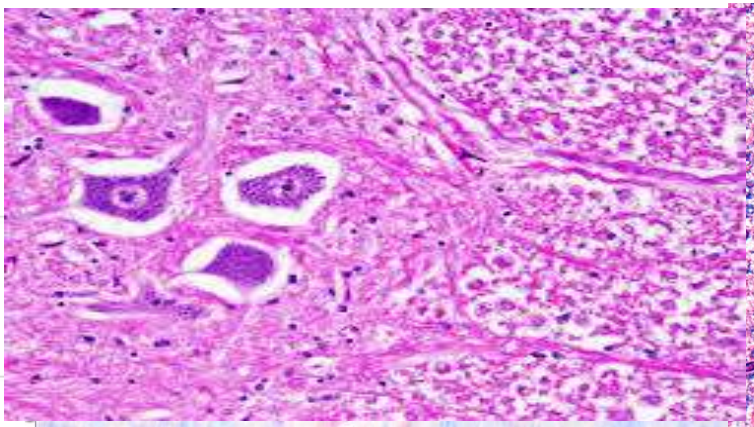


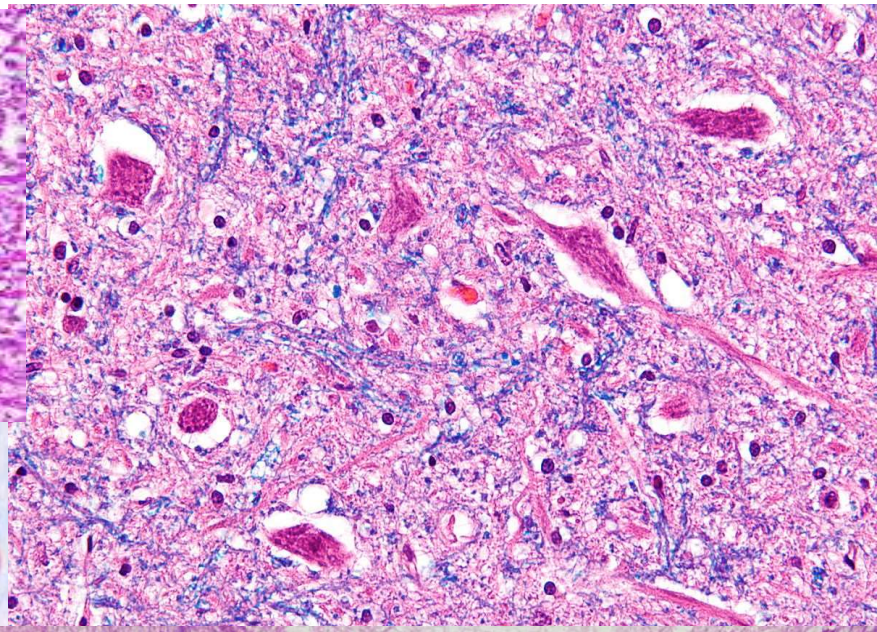


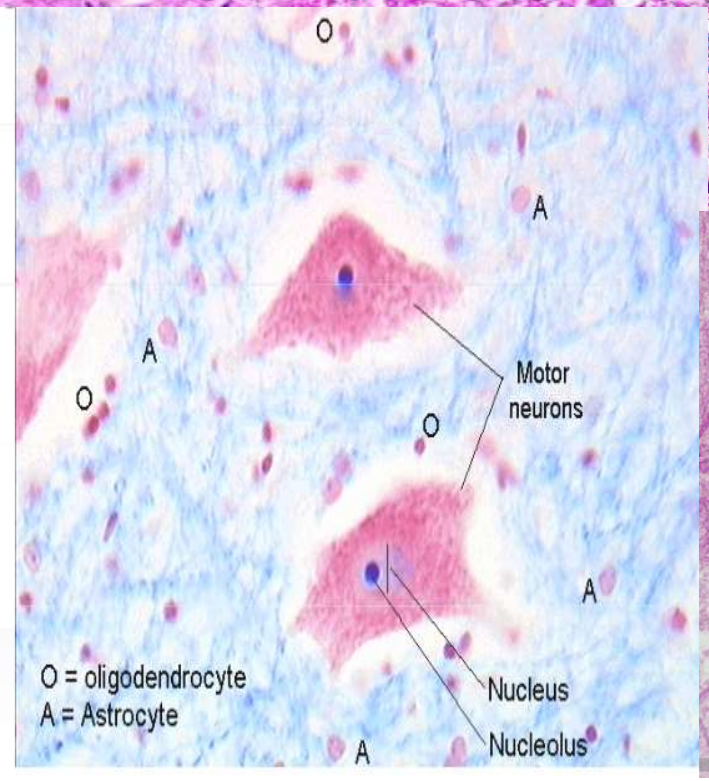


Motor neurons

- These transmit impulses from the central nervous system to the
  - muscles and
  - glands
- that carry out the response.
- Most motor neurons are stimulated by interneurons, although some are stimulated directly by sensory neurons.







2. **Motor neurons or *efferent neurons* (the efferent division of the PNS):**

- carry instructions from the CNS to peripheral effectors of tissues and organs via axons called efferent fibers.
- **the 2 major efferent systems are:**

1. the somatic nervous system (SNS), including all the somatic motor neurons that innervate skeletal muscles.

2. the autonomic nervous system (ANS), including the visceral motor neurons that innervate all other peripheral effectors (smooth muscle, cardiac muscle, glands and adipose tissue).

- signals from CNS motor neurons to visceral effectors pass through synapses at *autonomic ganglia*, dividing efferent axons into 2 groups:

1. *preganglionic fibers*

2. *postganglionic fibers*

•**Anterior horn cells**, motoneurons located in the spinal cord.

some unique neuronal types can be identified according to their location in the nervous system and distinct shape.

Some examples are:

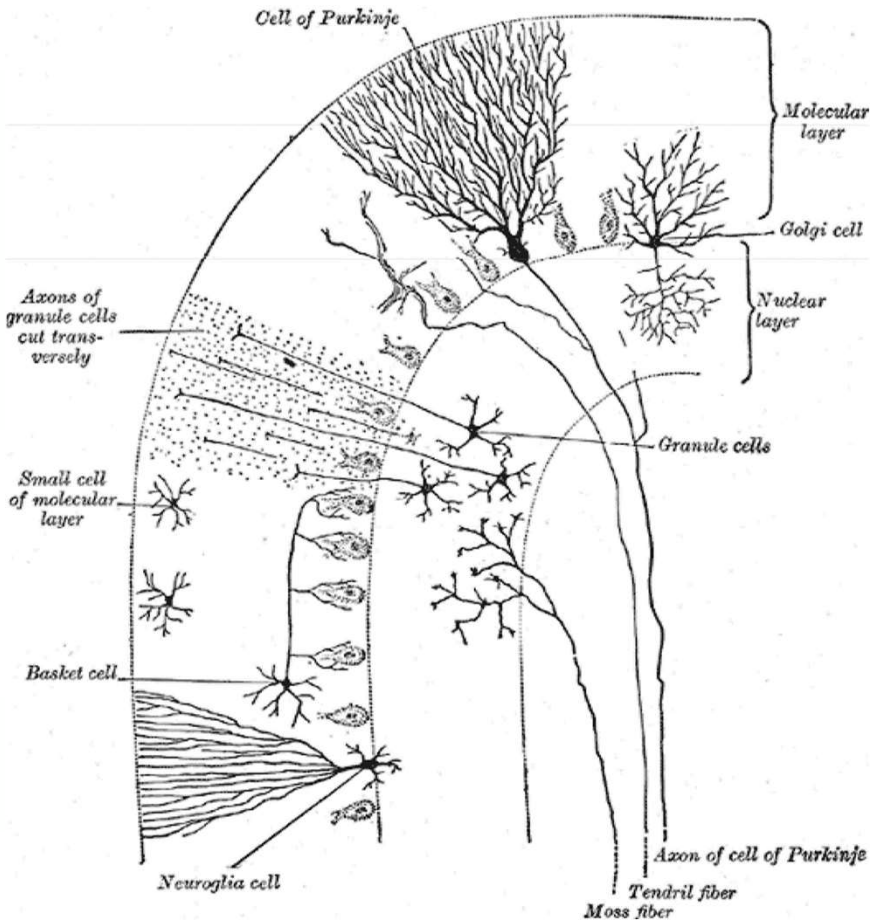
•**Basket cells,** interneurons that form a dense plexus of terminals around the soma of target cells, found in the cortex and cerebellum.

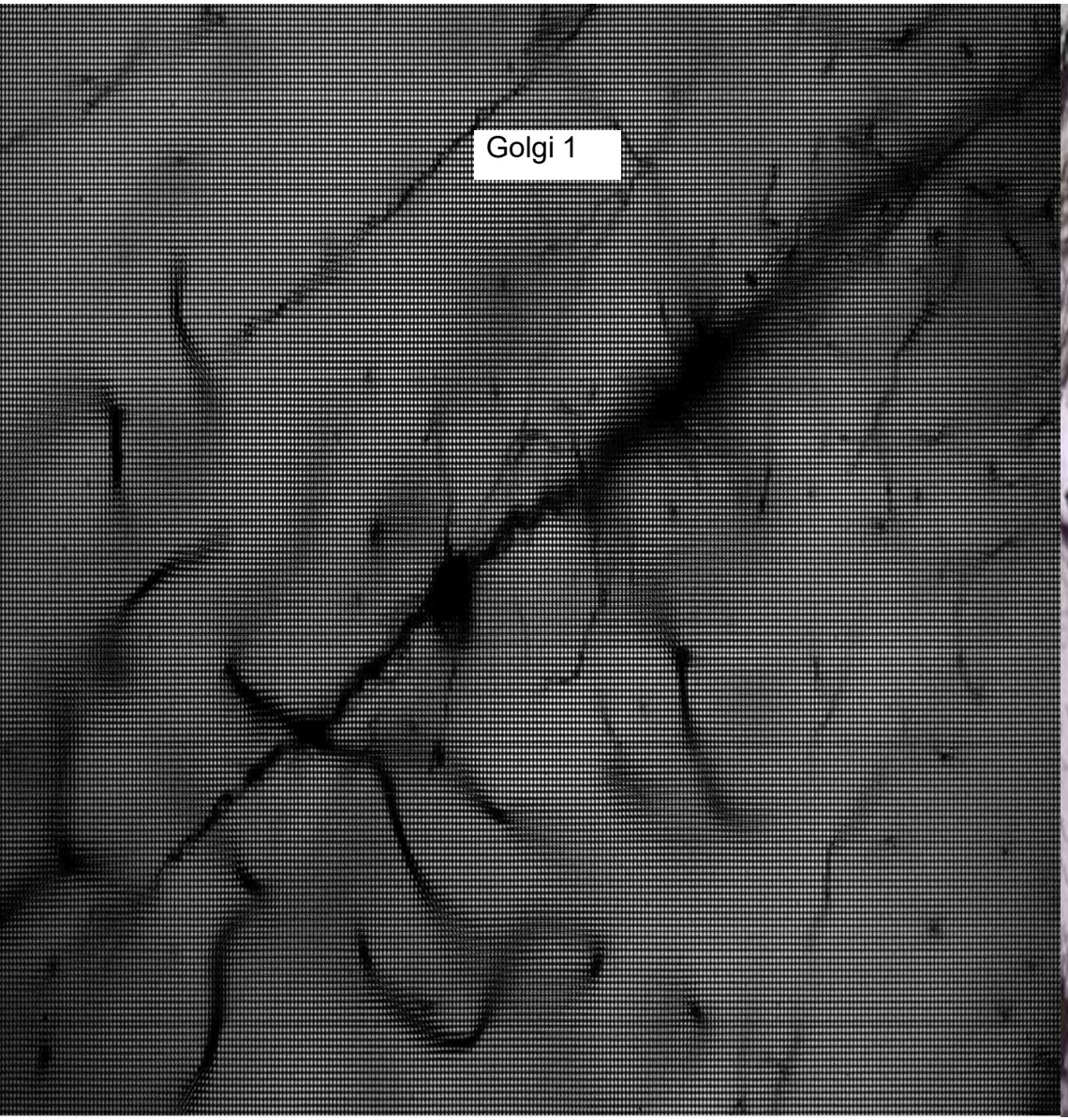
•**Betz cells**, large motor neurons.

•**Medium spiny neurons,** most neurons in the corpus striatum.

•**Purkinje cells,** huge neurons in the cerebellum, a type of Golgi I multipolar neuron.
•**Pyramidal cells,** neurons with triangular soma, a type of Golgi I.

•**Renshaw cells,** neurons with both ends linked to alpha motor neurons.
•Granule cells, a type of Golgi II neuron.



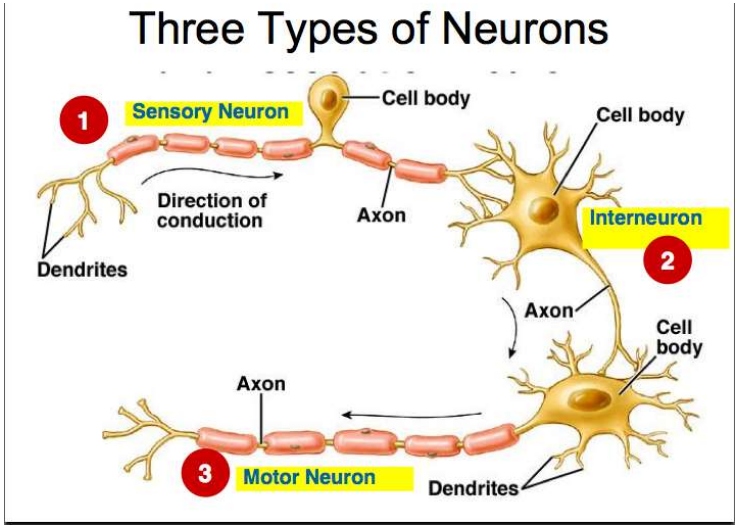

Golgi 1

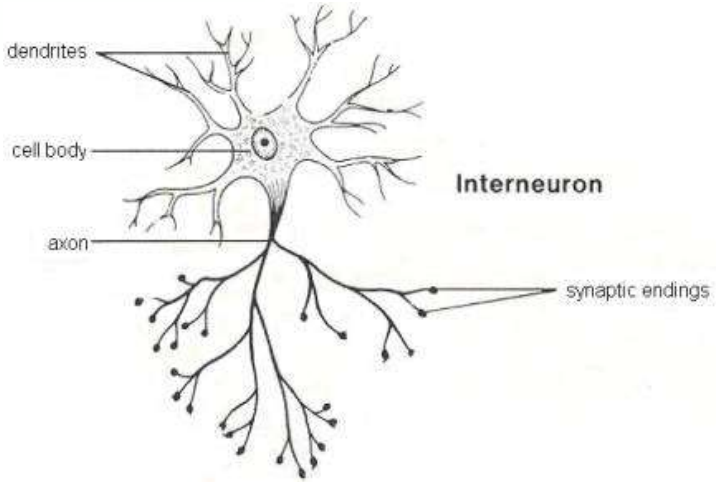
Interneurons or *association neurons*:

-located in the brain, spinal cord and some autonomic ganglia, between sensory neurons and motor neurons

-responsible for distribution of sensory information and coordination of motor activity

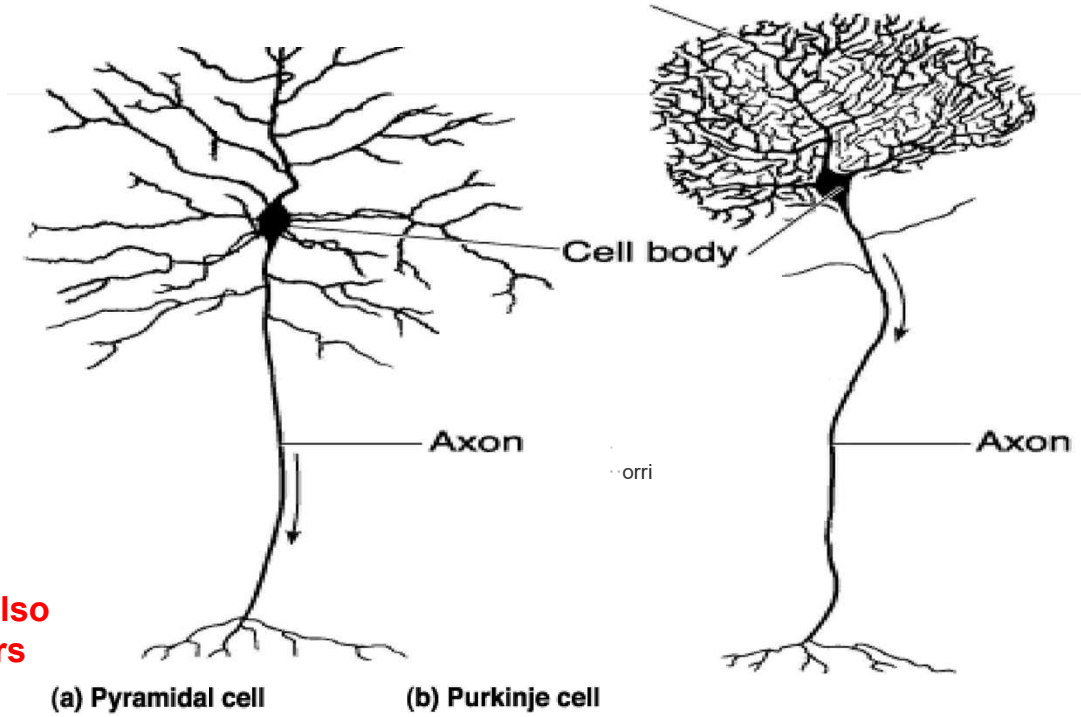
- involved in higher functions such as memory, planning and learning





Interneurons

- The Pyramidal cell is the large neuron found in the primary motor cortex of the cerebrum
- The Purkinje cell from the cerebellum

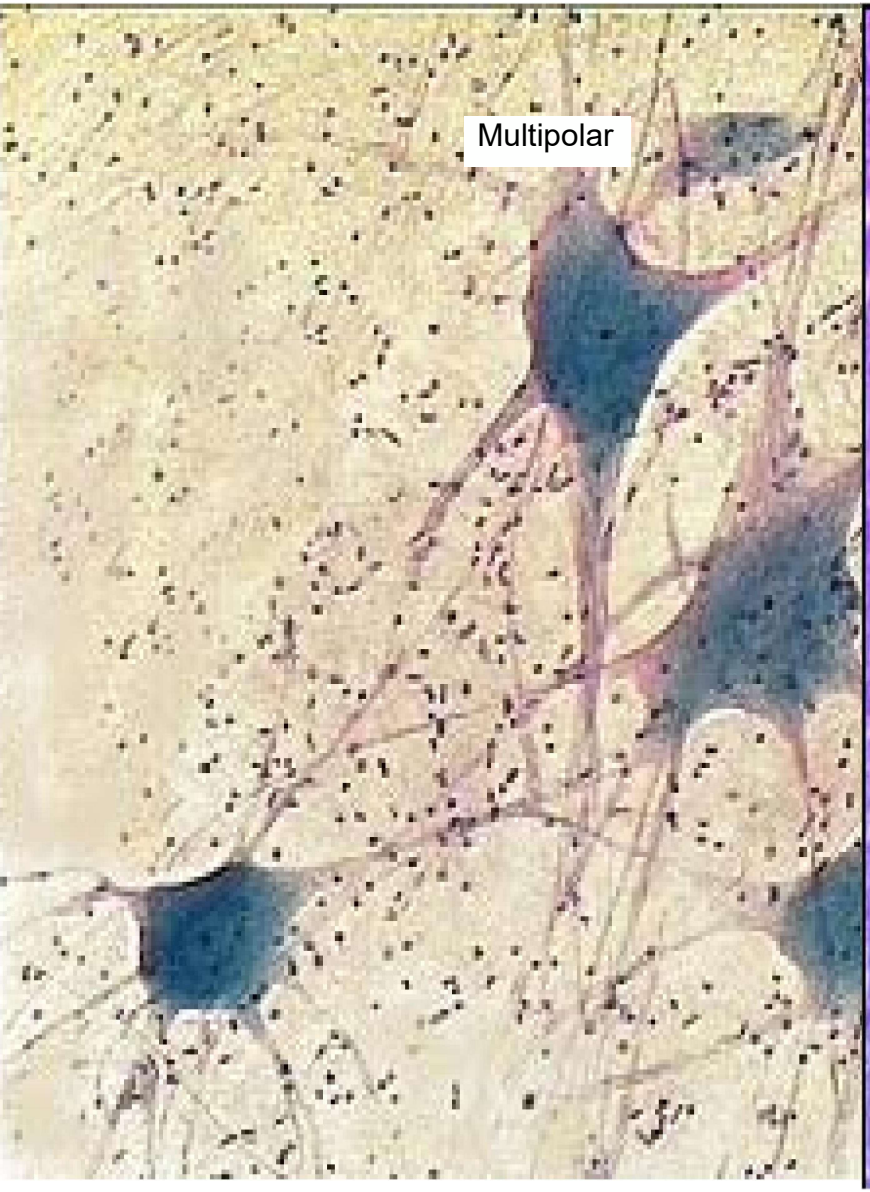


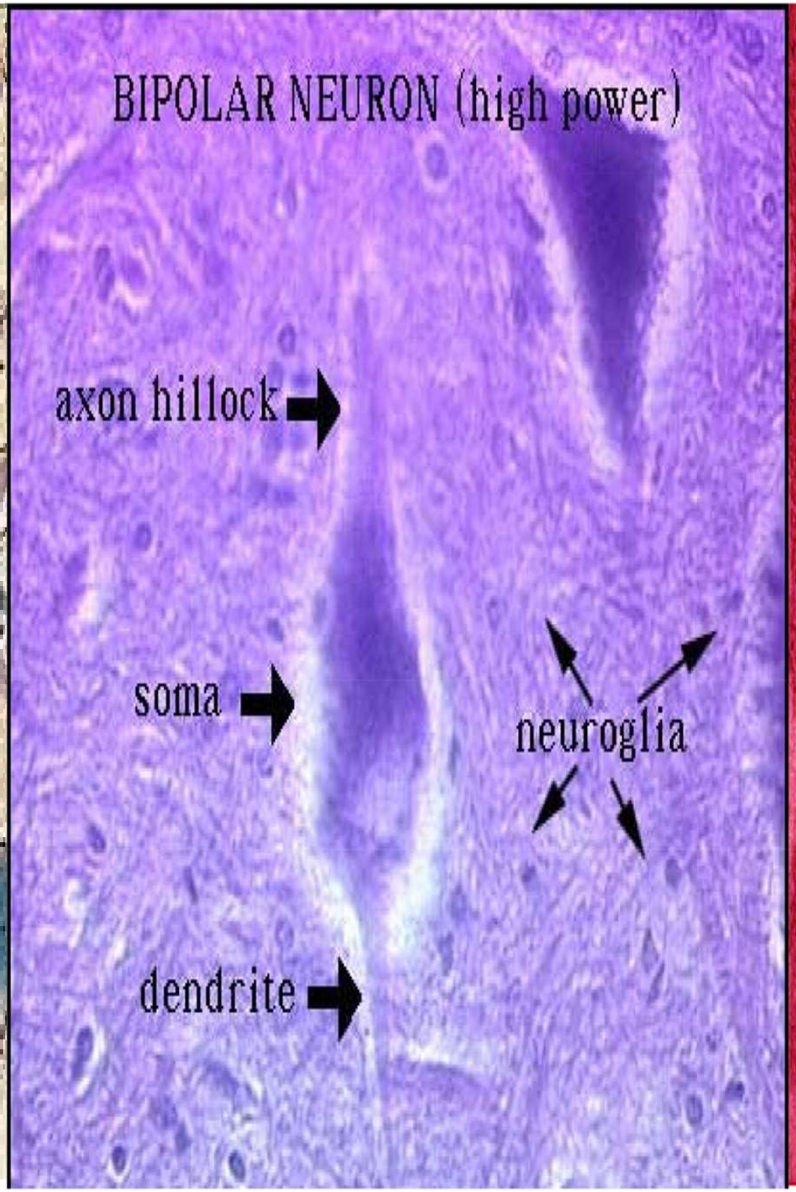
- **CNS interneurons are typically inhibitory, and use the neurotransmitter GABA or glycine**.

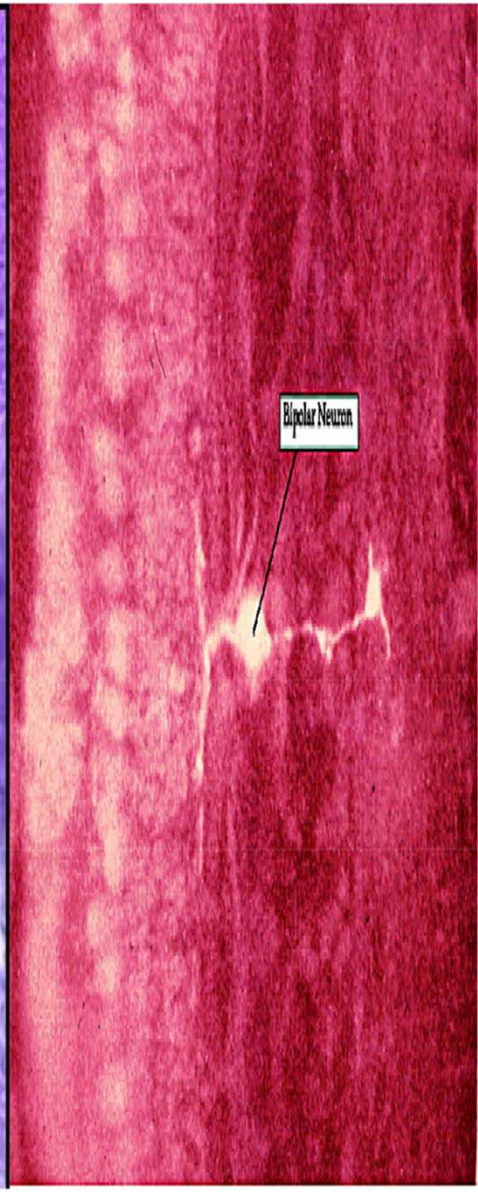
- However, **excitatory interneurons using glutamate also exist, as do interneurons releasing neuromodulators like acetylcholine.**

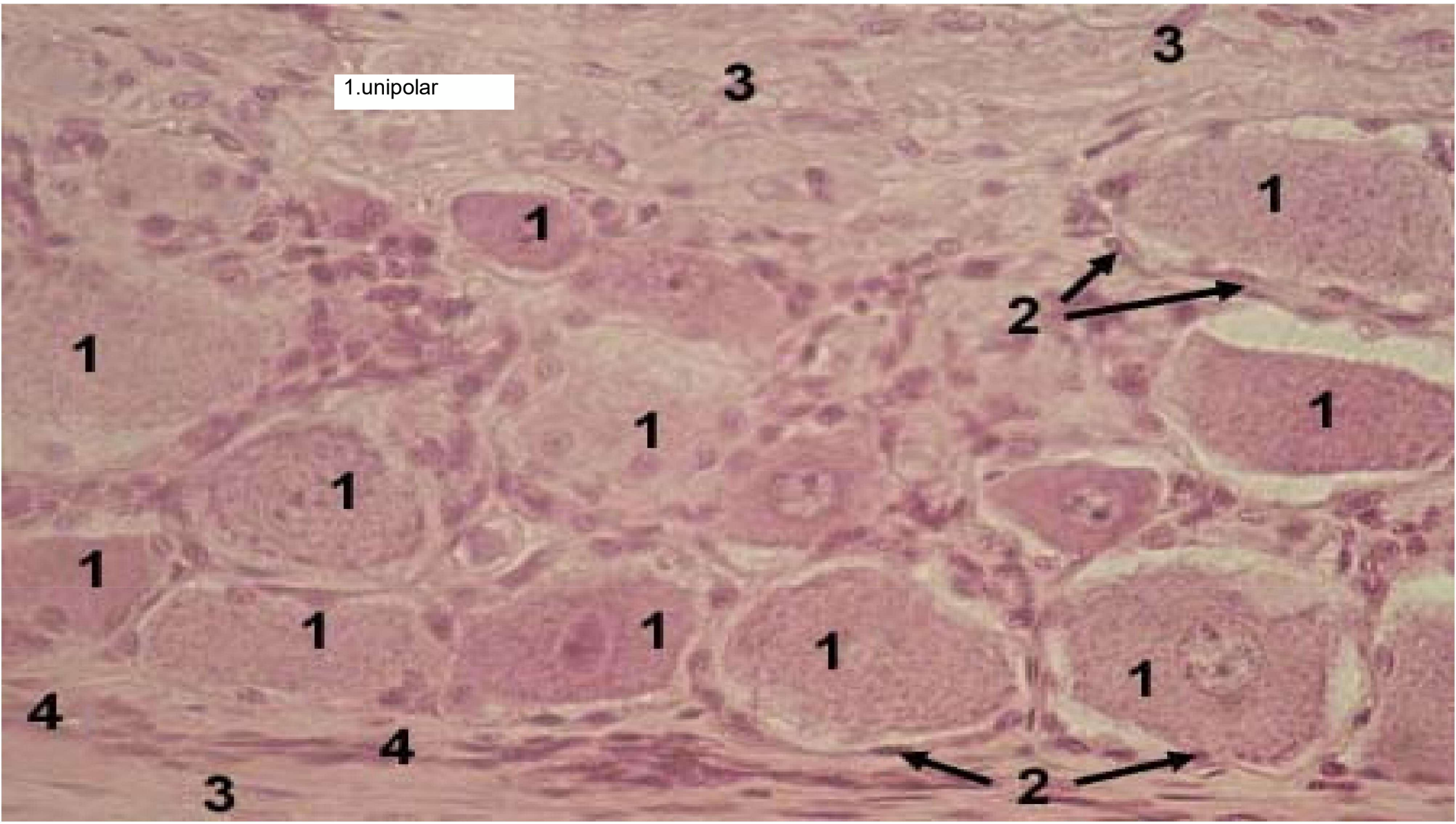
Cerebellar interneurons

- Molecular layer interneurons (basket cells, stellate cells)
- **Golgi cells**
- Granule cells


Multipolar

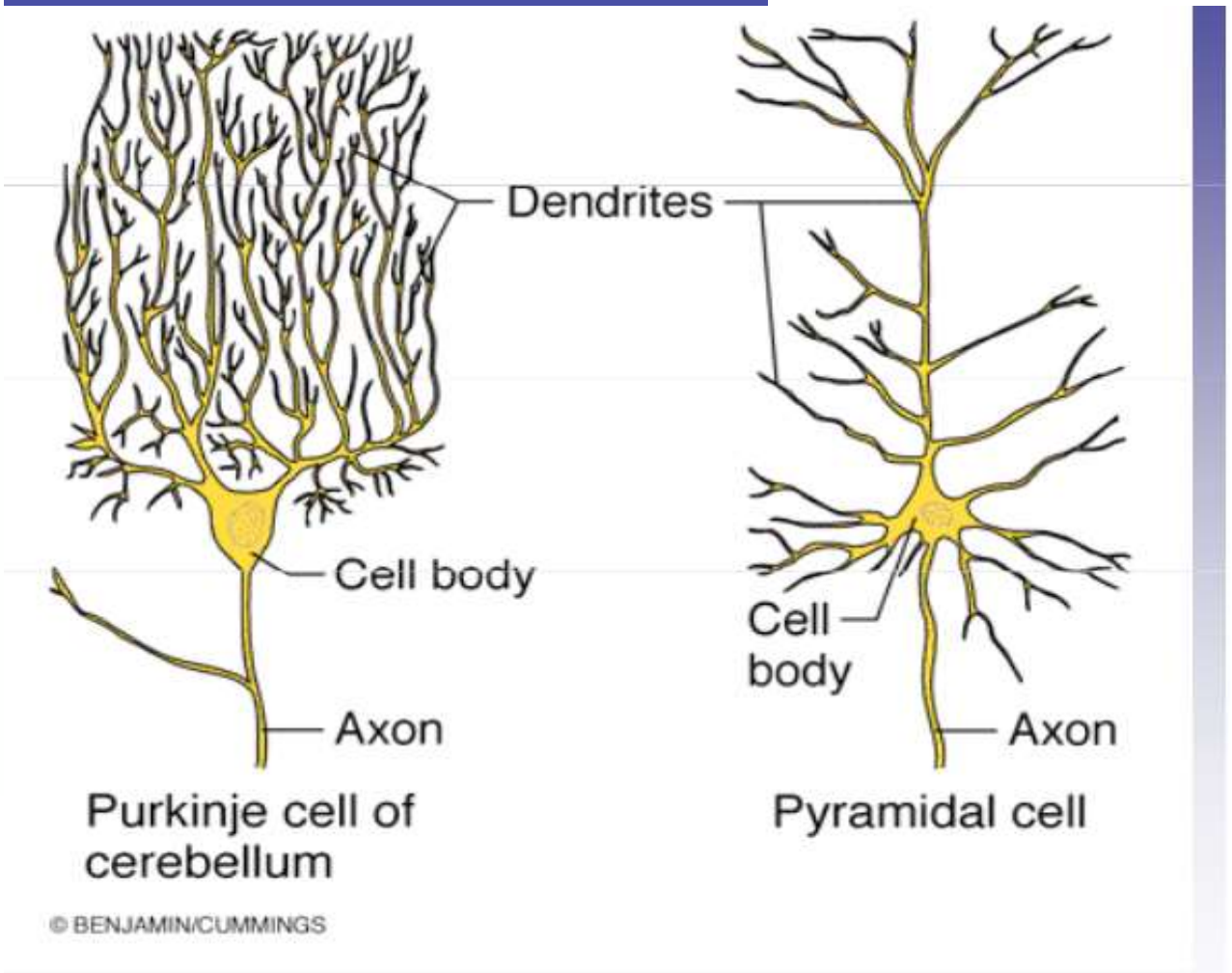

BIPOLAR NEURON (high power)
axon hillock
soma
neuroglia
dendrite

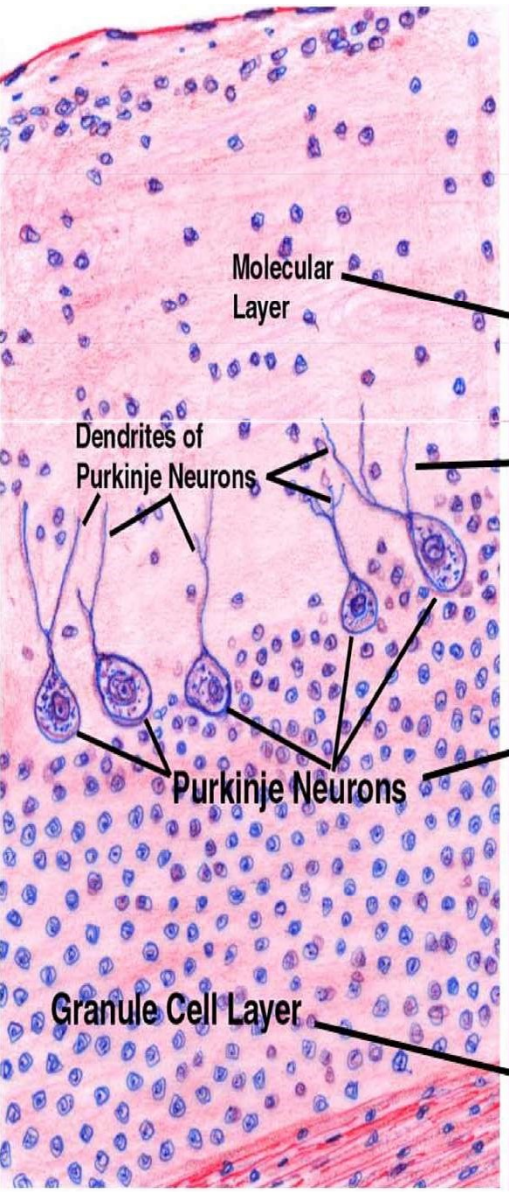

Bipolar Neuron

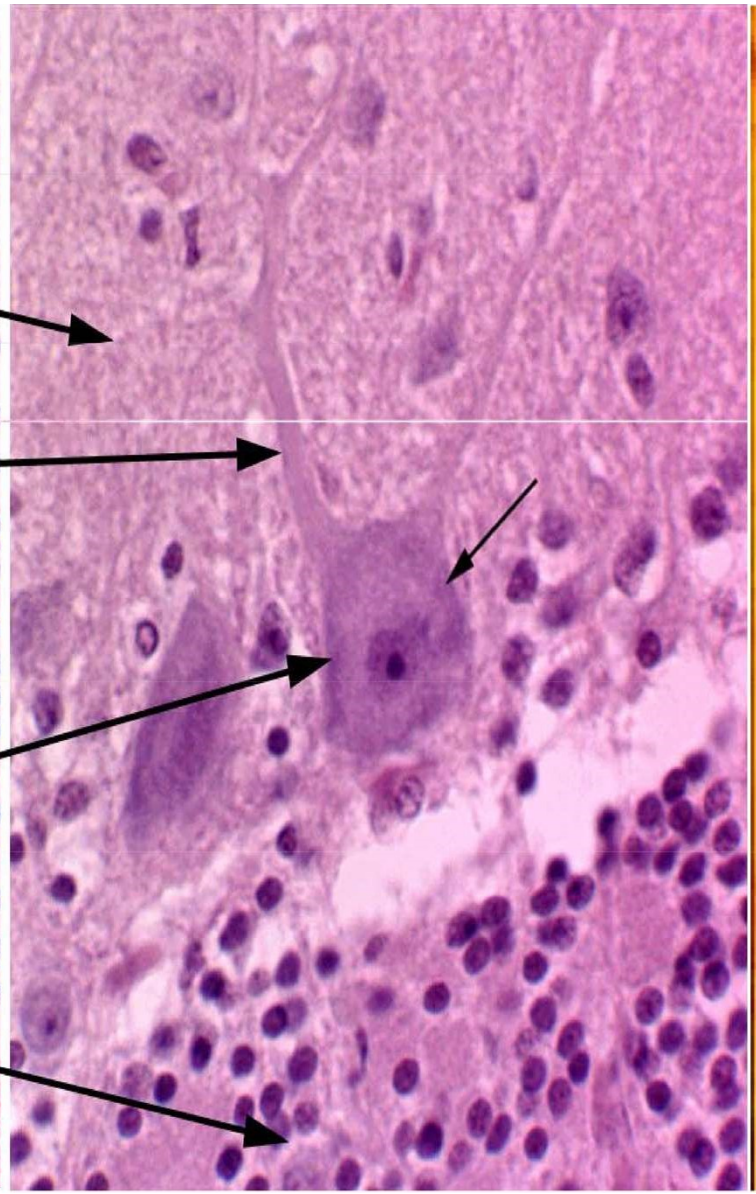

1.unipolar
3
3
1
1
2
1
1
1
1
1
1
1
1
1
1
4
4
3
2

- **Multipolar neurons have more than two processes**
- **Most common type in humans**
- **Major neuron of the CNS**
- **Most have many dendrites and one axon, some neurons lack an axon**

Multipolar Neurons




Molecular
Layer
Dendrites of
Purkinje Neurons
Purkinje Neurons
Granule Cell Layer




Pyramidal cells

Sensory receptors

may be the processes of specialized sensory neurons or cells monitored by sensory neurons.

Receptors are broadly categorized as follows:

Exteroceptors provide information about the external environment in the form of touch, temperature, or pressure sensations and the more complex senses of sight, smell, and hearing.

Proprioceptors monitor the position and movement of skeletal muscles and joints.

Interoceptors monitor the digestive, respiratory, cardiovascular, urinary, and reproductive systems and provide sensations of taste, deep pressure, and pain.

Classification by neurotransmitter released

Some examples are

- **cholinergic,**
- **GABA-ergic,**
- **glutamatergic**
- **dopaminergic neurons.**

Neurosecretory Cells:Secrete hormones and similar substances

Hypothalamus of brain, adrenal medulla gland, etc

Classification by action on other neurons

- **Excitatory neurons**
  - evoke excitation of their target neurons.
  - Excitatory neurons in the brain are often **glutamatergic**. Spinal motoneurons use acetylcholine as their neurotransmitter.
- **Inhibitory neurons**
  - evoke inhibition of their target neurons. Inhibitory neurons are often interneurons.
  - The output of some brain structures (neostriatum, globus pallidus, cerebellum) are inhibitory.
  - The primary inhibitory neurotransmitters are **GABA** and glycine.
- **Modulatory neurons**
  - evoke more complex effects termed neuromodulation.
  - These neurons use such neurotransmitters as dopamine, acetylcholine, serotonin and others.

Classification by discharge patterns

Neurons can be classified according to their electrophysiological characteristics:

- **Tonic or regular spiking.** Some neurons are typically constantly (or tonically) active. Example: interneurons in neurostriatum.

- **Phasic or bursting.** Neurons that fire in bursts are called phasic.

- **Fast spiking.** Some neurons are notable for their fast firing rates, for example some types of cortical inhibitory interneurons, cells in globus pallidus.

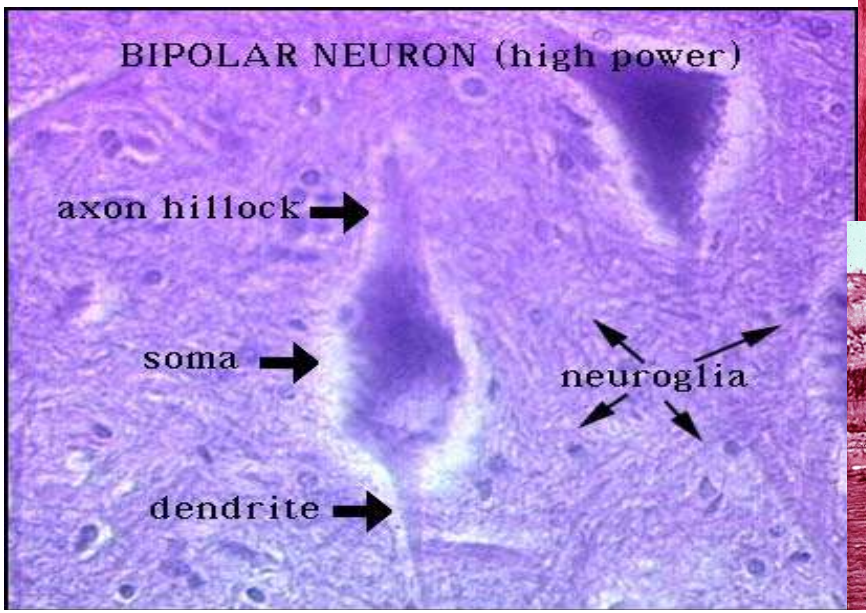
- **Thin-spike.** Action potentials of some neurons are more narrow compared to the others. For example, interneurons in prefrontal cortex are thin-spike neurons.

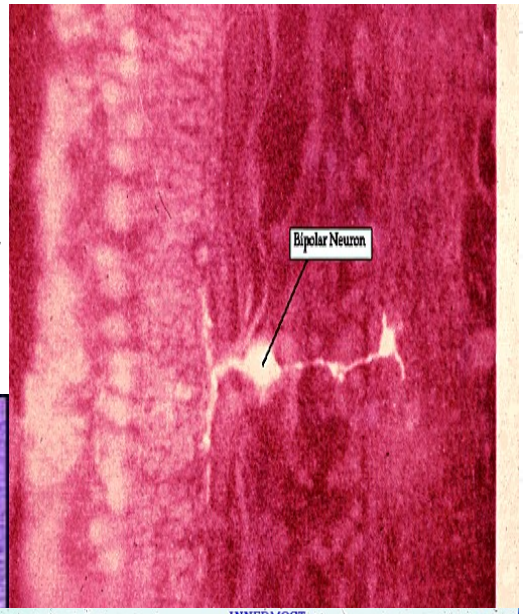
.

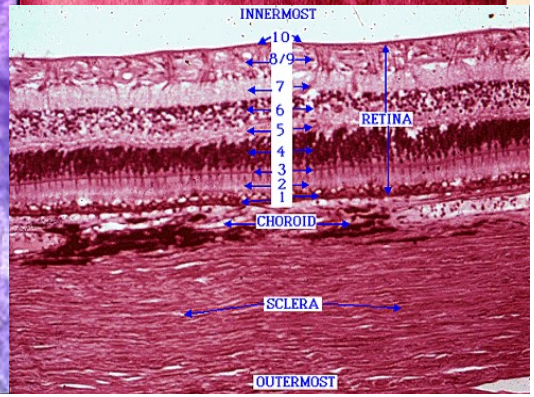
Bipolar Neurons

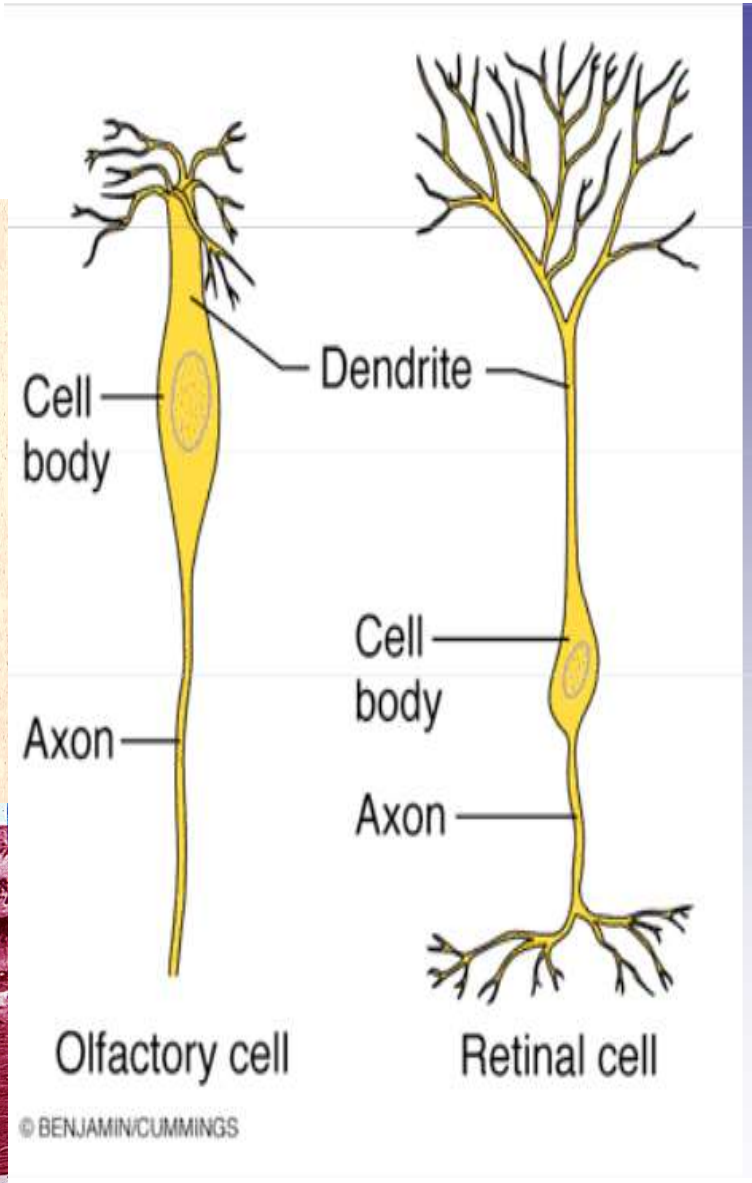
- Bipolar neurons are rare in the human body
- Found only in special sense organs where they function as receptor cells
  - Examples include those found in the retina of eye, inner ear, and in the olfactory mucosa

They are primarily sensory neurons



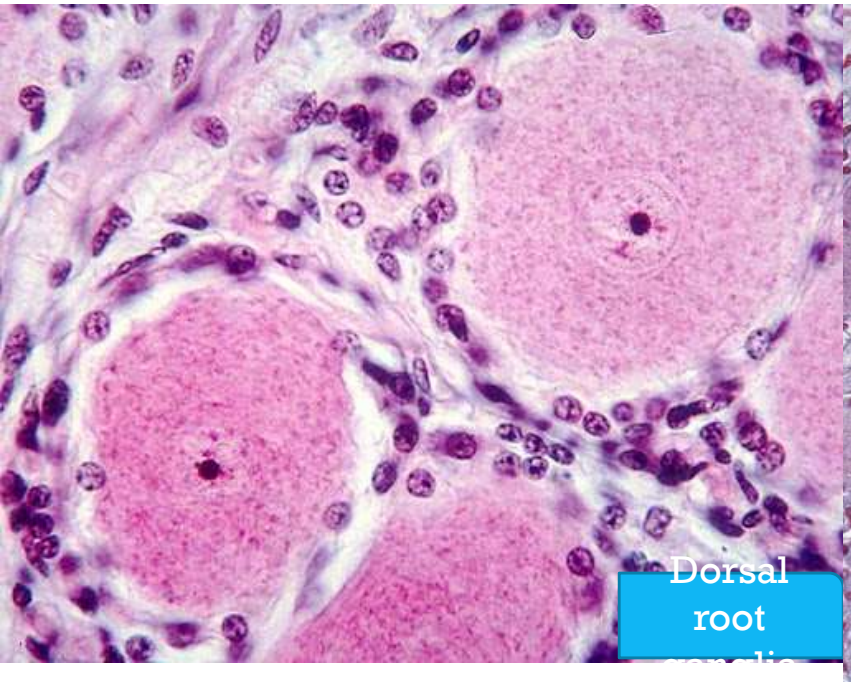


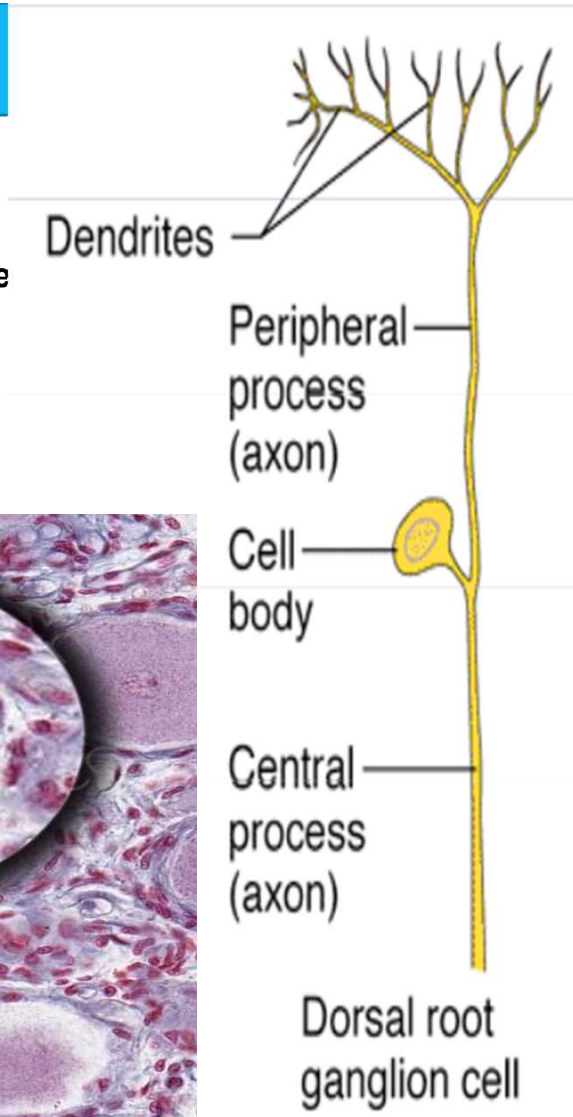


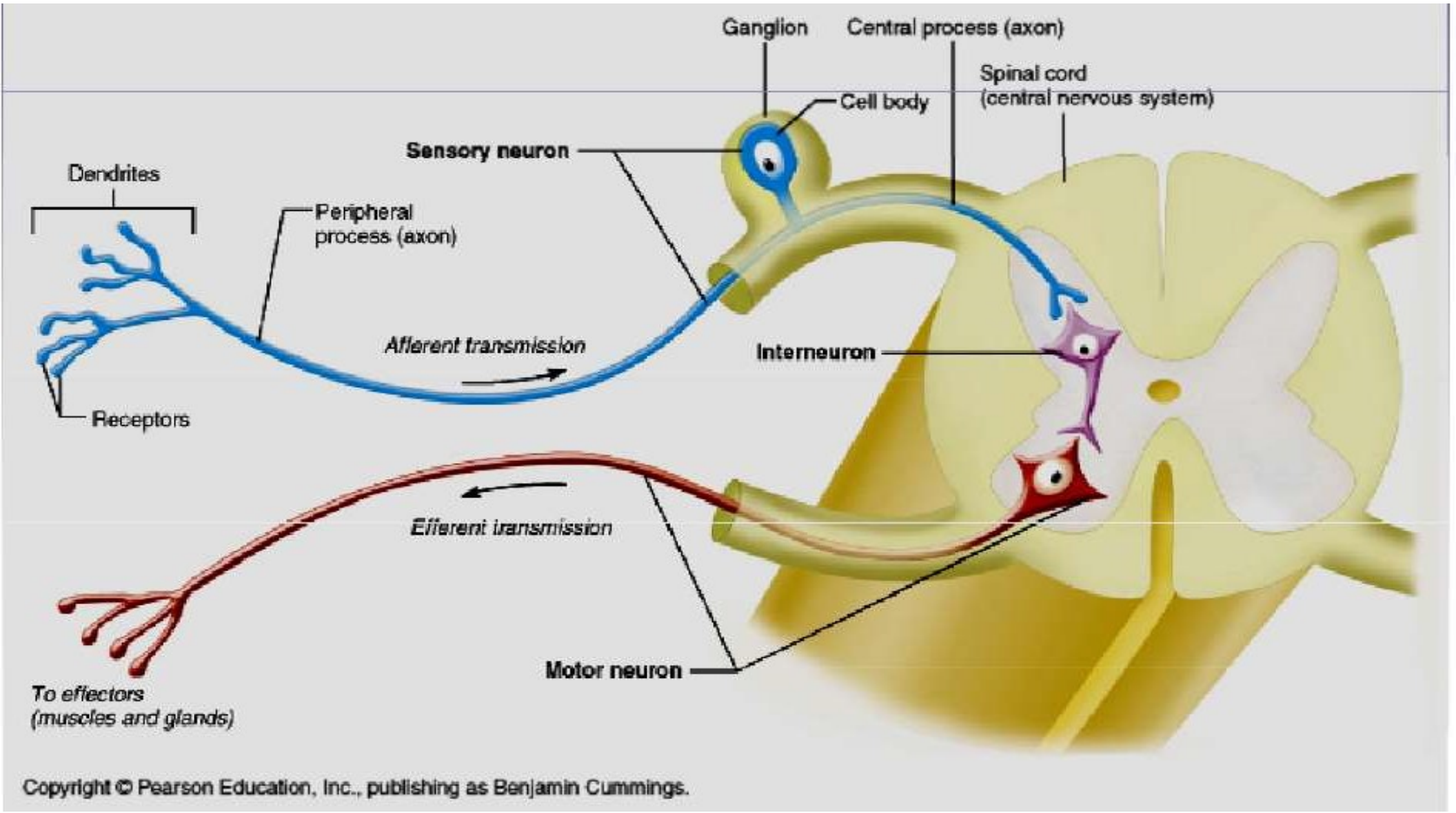


Unipolar neurons

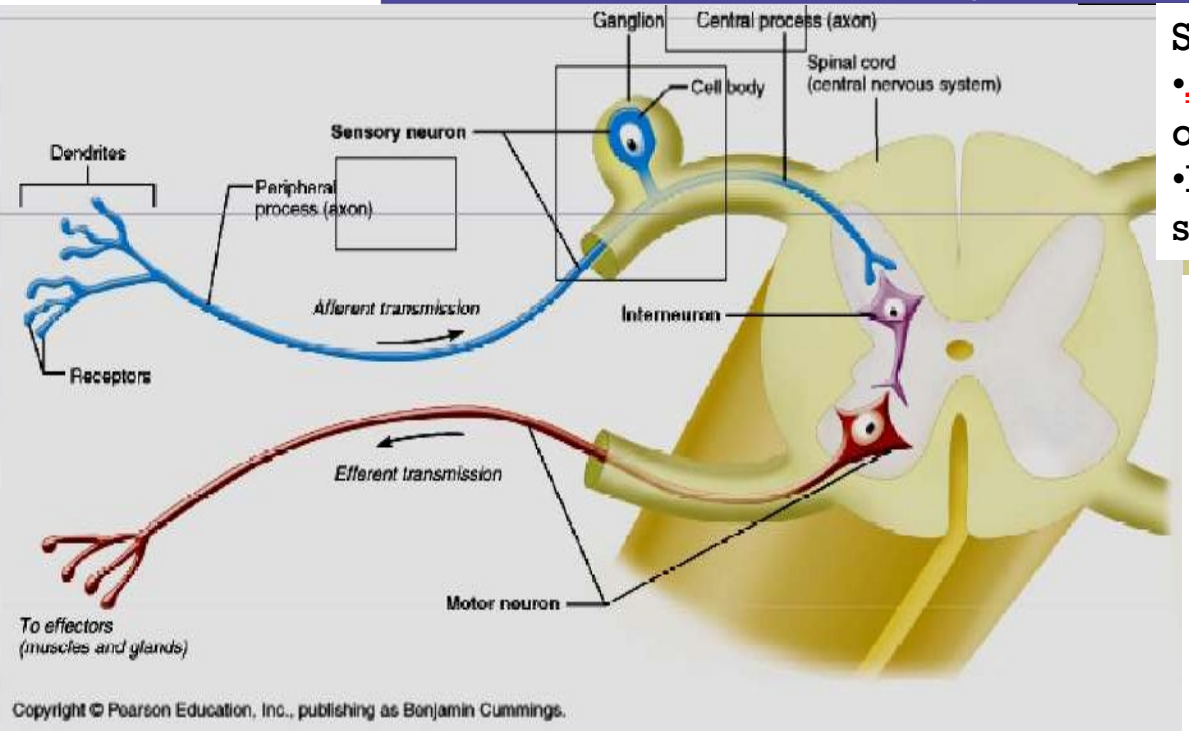
- **Unipolar neurons have a single process that emerges from the cell body**
- **The central process (axon) is more proximal to the CNS and the peripheral is closer to the**
- **Unipolar neurons are chiefly found in the ganglia of the peripheral nervous system**
- **Function as sensory neurons**







Sensory Neurons



- Sensory neurons have their ganglia outside of the CNS
- The single (unipolar) process is divided into the central process and the peripherial process

Sensory Neurone:

•**Afferent Neuron** – Moving away from a central organ or point

•Relays messages from receptors to the brain or spinal cord

These are found exclusively within the spinal cord and brain.

They are stimulated by signals reaching them from

- **sensory neurons**
- **other interneurons or**
- **both.**

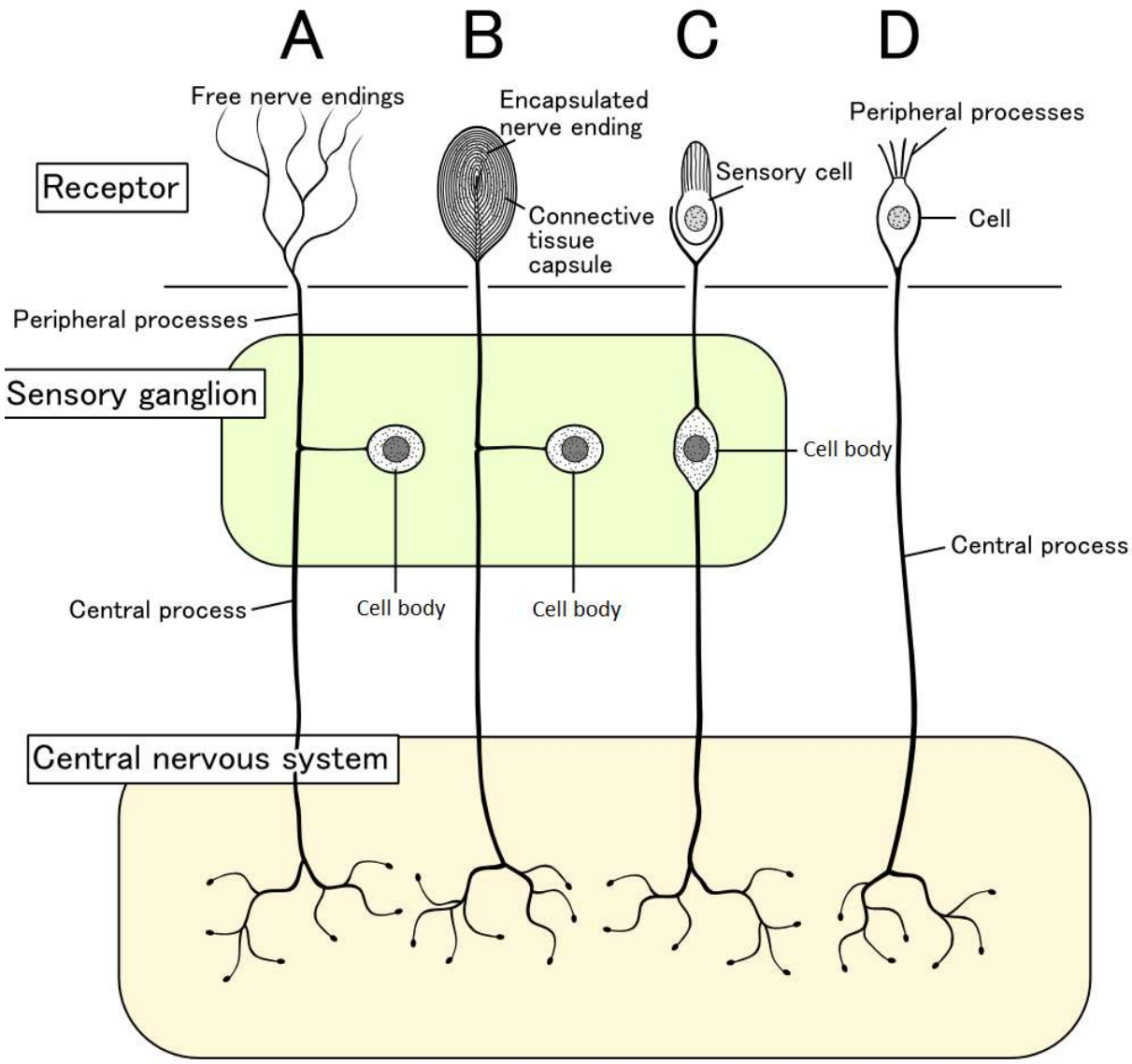
Interneurons are also called association neurons.

Sensory Neuron

- The central process is clearly an axon because it carries a nerve impulse and carries that impulse away from the cell body which meet the criteria which define an axon
- The peripheral by contrast carries nerve impulses toward the cell body which suggests that it is a dendrite
- However, the basic convention is that the central process and the peripheral process are parts of a

SENSORY NEURONS FIBER TYPES

Fiber Type	**Alternate Name**	Fiber Diameter (μm)	Myelinated	**Receptors**	Sensory Modality	**Fiber Tract**
A-α	Ia Ib	13-20	yes	Muscle Spindle Golgi Tendon Organ	Proprioception	Posterior Columns
A-β	II	6-12	yes	Muscle Spindle Meissner Corpuscle Merkel Disk Ruffini Corpuscle Pacinian Corpuscle	Proprioception Touch Touch Touch, Vibration Touch, Vibration	Posterior Columns
A-δ	III	1-5	yes	Hair Follicle Receptor Free Nerve Ending	Touch Pain Temperature	ALSTS
C	IV	0.2-1.5	no	Free Nerve Ending	Pain Temperature	ALSTS



Sensory neurons

These run from the various types of stimulus receptors, e.g.,

- touch
- odor
- taste
- sound
- vision

to the central nervous system (CNS), the brain and spinal cord.

The cell bodies of the sensory neurons leading to the spinal cord are located in clusters, called **ganglia**, next to the spinal cord.

The axons usually terminate at interneurons.

Somatic sensory system

The somatic sensory system includes

- the sensations of touch,
- pressure,
- vibration,
- limb position,
- heat,
- cold,
- pain.

The cell bodies of somatic sensory afferent fibers **lie in ganglia throughout the spine.**

These neurons are responsible for relaying information about the body to the central nervous system.

Neurons residing in ganglia of the head and body supply the central nervous system with information about the aforementioned external stimuli occurring to the body.

Pseudounipolar neurons are located in the dorsal root ganglia (the head)

Human sensory system

The Human sensory system consists of the following sub-systems:

- Visual system consists of the photoreceptor cells, optic nerve, and V1.
- Auditory system
- Somatosensory system consists of the receptors, transmitters (pathways) leading to S1, and S1 that experiences the sensations labelled
  - as touch or pressure,
  - temperature (warm or cold),
  - pain (including itchand tickle),
  - and the sensations of muscle movement and joint position including posture, movement, and facial expression (collectively also called proprioception).
- Gustatory system
- Olfactory system
- Human sensory receptors are:
- Chemosensor
- Mechanoreceptor
- Nociceptor
- Photoreceptor
- Thermoreceptor

Mechanoreceptors

Specialized receptor cells often encapsulate afferent fibers to help tune the afferent fibers to the different types of somatic stimulation.

Mechanoreceptors also help lower thresholds for action otential generation in afferent fibers and thus make them more likely to fire in the presence of sensory stimulation.

Proprioceptors are another type of **mechanoreceptors which literally means "receptors for self**." These receptors provide spatial information about limbs and other body parts.

Nociceptors are **responsible for processing pain and temperature changes**. The burning pain and irritation experienced after eating a chili pepper (due to its main ingredient, capsaicin), the cold sensation experienced after ingesting a chemical such as menthol or icillin, as well as the common sensation of pain are all a result of neurons with these receptors.

Problems with mechanoreceptors lead to disorders such as:

Neuropathic pain - a severe pain condition resulting from a damaged sensory nerve

Hyperalgesia - an increased sensitivity to pain caused by sensory ion
channel, TRPM8, which is typically responds to temperatures between 23 and 26 degrees, and provides the cooling sensation associated with menthol and icillin

Phantom limb syndrome - a sensory system disorder where pain or movement is experienced in a limb that does not exist

Vision

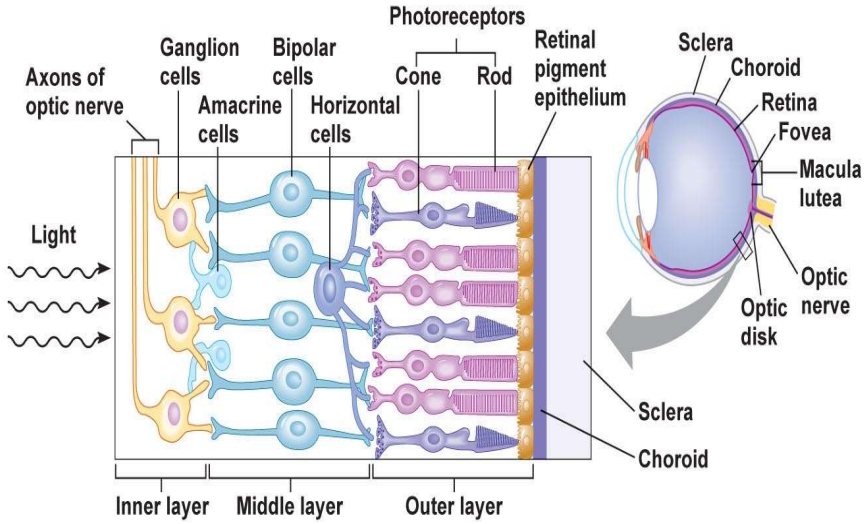
Vision is one of the most complex sensory systems.
The eye has to first "see" via refraction of light. Then, light energy has to be converted to electrical signals by photoreceptor cells and finally these signals have to be refined and controlled by the tic interactions ithin the neurons of the retina.

The five basic classes of neurons within the retina are
- **photoreceptor cells,**
- **bipolar cells,**
- **ganglion cells,**
- **horizontal cells,**
- **amacrine cells.**

The basic circuitry of the retina incorporates a three-neuron chain consisting of

- the photoreceptor (either a rod or cone),
- bipolar cell, and the ganglion cell.
- As the picture shows, the first action potential occurs in the retinal ganglion cell.

This pathway is the most direct way for transmitting visual information to the brain.



Problems and decay of sensory neurons associated with vision lead to disorders such as:

Macular degeneration – degeneration of the central visua field due to either cellular debris or blood vessels accumulating between the retina and the choroid, thereby disturbing and/or destroying the complex interplay of neurons that are present there.

Glaucoma – loss of retinal ganglion cells which causes some loss of vision to blindness.

Diabetic retinopathy – poor blood sugar control due to diabetes damages the tiny blood vessels in the retina

Auditory

- **The auditory system is responsible for converting pressure waves generated by vibrating air molecules or sound into signals that can be interpreted by the brain.**

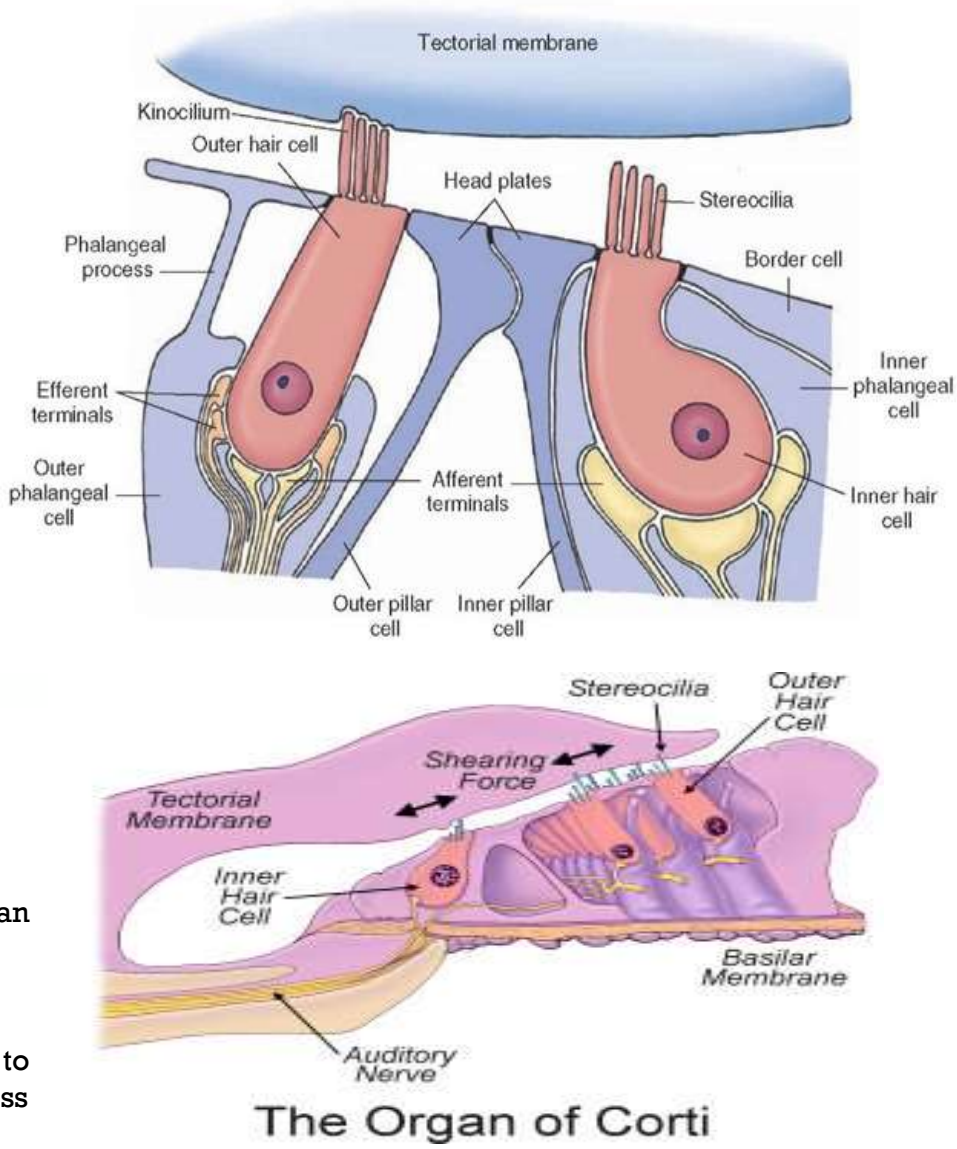
- This mechanoelectrical transduction is mediated with hair cells within the ear.
- depending on the movement, the hair cell can either hyperpolarize or depolarize. When the movement is towards the tallest stereocilia, the K+ cation channels open allowing K+ to flow into cell and the resulting depolarization causes the Ca2+ channels to open, thus releasing its neurotransmitter into the afferent auditory nerve.

- There are two types of hair cells: inner and outer.
- The inner hair cells are the sensory receptors while the outer hair cells are usually from efferent axons originating from cells in the superior olivary complex

Problems with sensory neurons associated with the auditory system leads to disorders such as:

Auditory Processing Disorder – auditory information in the brain is processed in an abnormal way. Patients with auditory processing disorder can usually gain the information Normally, but their brain cannot process it properly, leading to hearing disability.

Auditory verbal agnosia – comprehension of speech is lost but hearing, speaking, reading, and writing ability is retained. This is caused by damage to the posterior superior temporal lobes, again not allowing the brain to process auditory input correctly



The Organ of Corti

	Sensory neuron	Interneuron	Motor Neuron
Length of Fibers	Long dendrites and short axon	Short dendrites and short or long anxon	Short dendrites and long axons
Location	Cell body and dendrite are outside of the spinal cord; the cell body is located in a dorsal root ganglion	Entirely within the spinal cord or CNS	Dendrites and the cell body are located in the spinal cord; the axon is outside of the spinal cord
Function	Conduct impulse to the spinal cord	Interconnect the sensory neuron with appropriate motor neuron	Conduct impulse to an effector (muscle or gland)