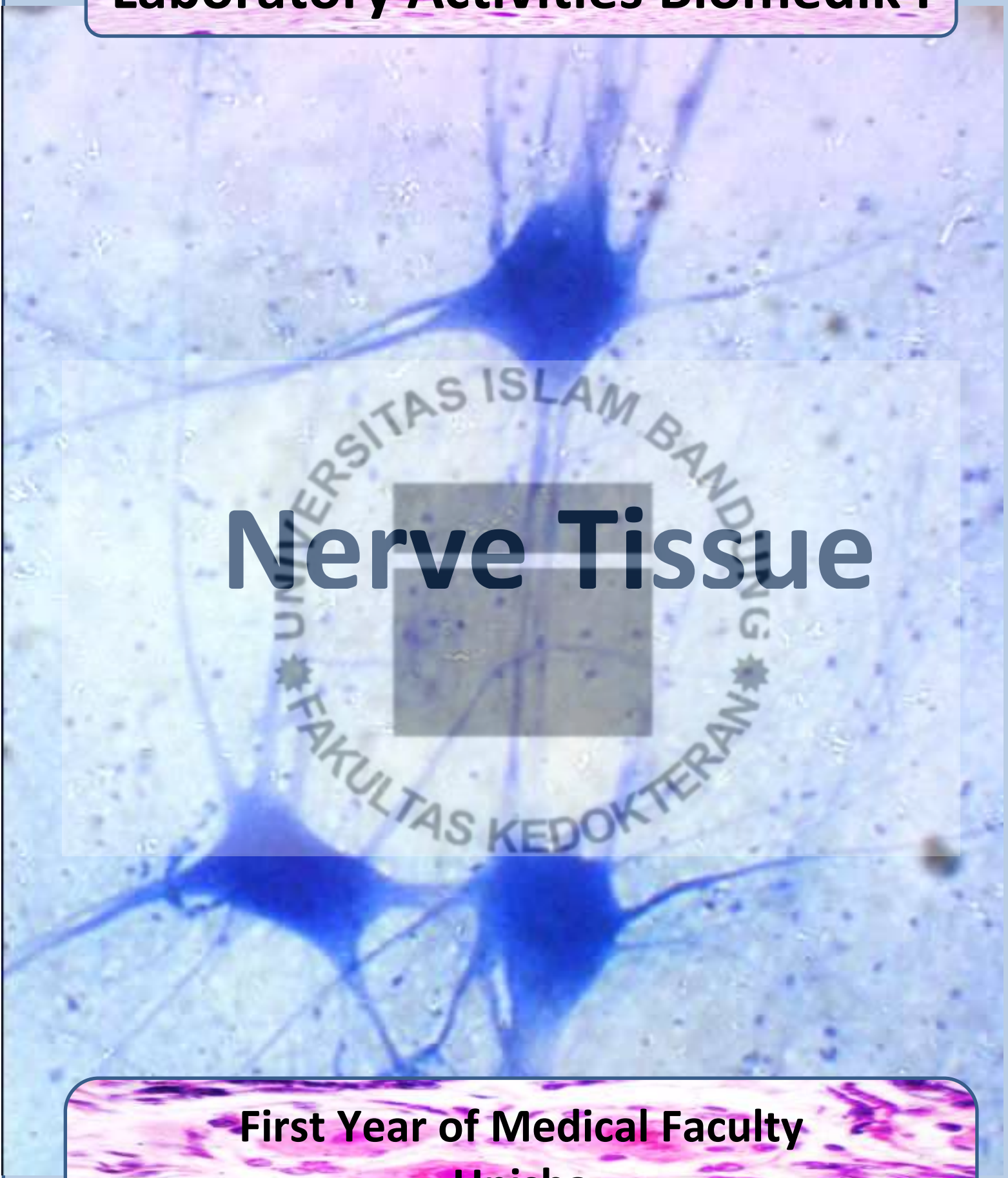
Laboratory Activities Biomedik I



Nerve Tissue

First Year of Medical Faculty
Unisba
2019

Laboratory Activities
Histology: Nerve Tissue

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A Sequence

I. Introduction : 30 min
II. Pre Test : 5 min
III. Activity Lab : 120 min
- Discussion : 30 min
- Identify : 90 min

B Topic

1. General microstructure of nerve tissue
2. General microstructure of the neuron and neuroglia
3. Microstructure of the Ganglion
4. Microstructure of the Meningens

C Venue

Biomedical Laboratory Faculty of Medicine, Bandung Islamic Universtity

D Equipment

1. Light microscopy
2. Stained tissue section:
3. Colouring pencils

	Slide
• Neuron • neuroglia • Meningen	1. Motor Neuron 2. Cerebrum 3. Cerebellum 4. Medulla spinalis
Ganglia: • Sensoric ganglia • Autonomic ganglia	5. Ganglion otonom 6. Ganglion Sensorik

E Pre-requisite

- **Before following the laboratory activity, the students must prepare :**
  1. Mention the types of cells that exist in nerve tissue !
  2. Draw the schematic picture of neuron cell and give explanation
  3. Mention six type of neuroglia and describe their functional (astrocyte, microglia, oligodendrosit, sel schwan, epenymal cell, and satellite cells), then draw the schematic neuroglia and give explanation
  4. Draw the schematic picture of sensoric ganglion microsructure and give explanation
  5. Draw the schematic picture of otonom ganglion microsructure and give explanation

6. Draw the schematic picture of meningens microstructure and give explanation about tissue type

- Content lab in manual book (pre and post test will be taken from the manual, if scorring pre test less than 50, can not allowed thelab activity)

- Bring your text book, reference book e.q atlas of Histology, e-book etc. (minimal one group one atlas).
- Bring colouring pencils for drawing

Introduction

The **nervous system** is separated into two physically and functionally interconnected components, namely

1. the **central nervous system (CNS)**, that is, the **brain** and **spinal cord** and
2. the **peripheral nervous system (PNS)**, that is, **ganglia** and **peripheral nerves**.

The human nervous system, by far the most complex system in the body, is formed by a network of many billion nerve cells (neurons). Neuron is basic functional unit of the nervous system, and these are supported in various manner by cells known as ***neuroglia or*** supporting cells or glial cells.
Each neuron has hundreds of interconnections with other neurons, forming a very complex system for processing information and generating responses. Neurons have processes known as ***dendrites*** which deliver information to the cell body of the neuron and a single **axon** that transmits information from the neuron's cell body, known as ***soma***, to target cells, be they other neurons, various types of muscle cells, and/or secretory cells of glands. Axons can be very long (100 or more cm in length) and frequently are wrapped by myelin sheaths that increase the velocity of impulse transmission.

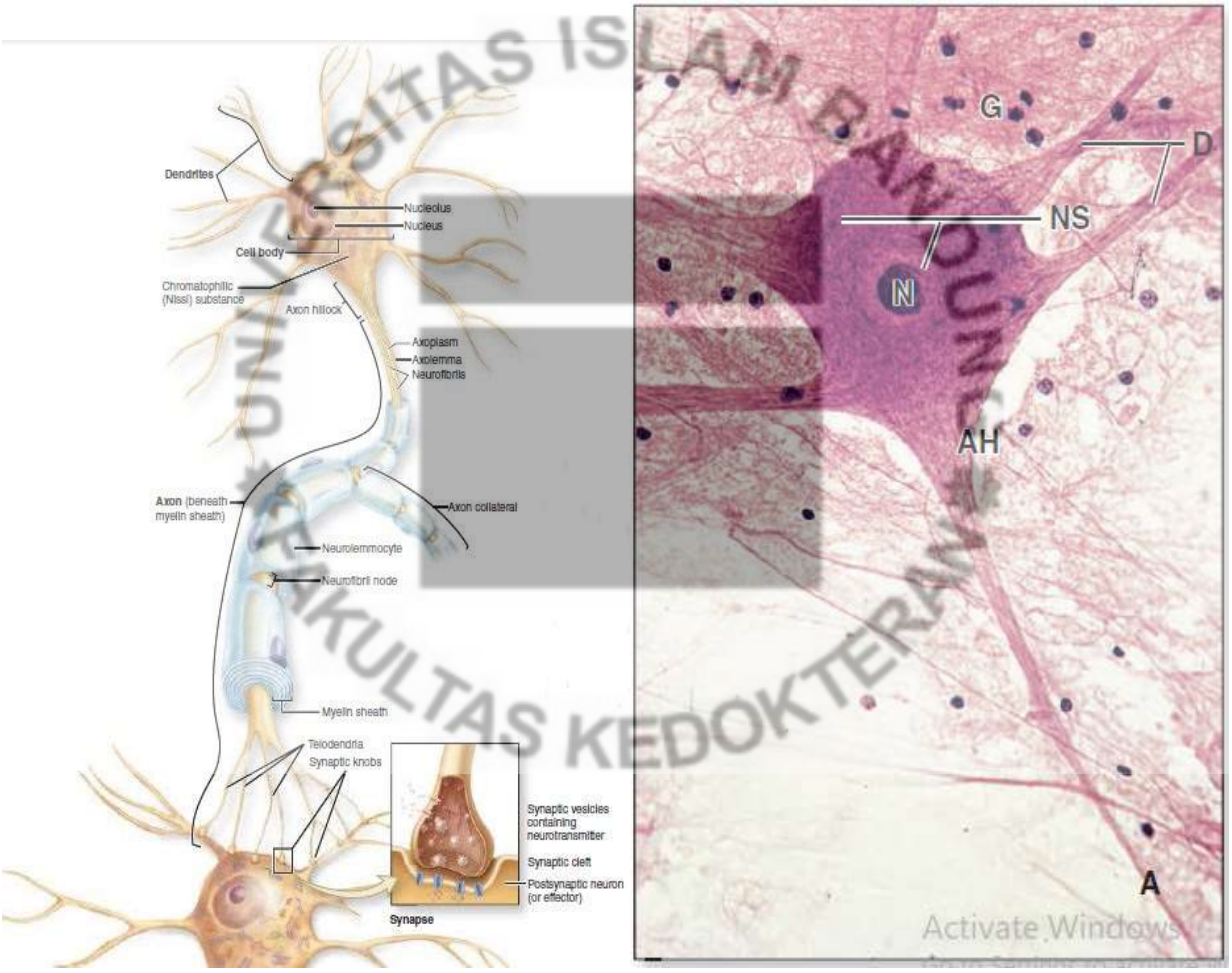


Figure 1. Neurons and their processes are extremely variable in size and shape. Cell bodies can be very large, measuring up to 150 µm in diameter. Other neurons, such as the cerebellar granule cells, are among the body's smallest cells.

Neuron's cells' body (perikaryon)

The cell body is the neuronal region that contains the nucleus and surrounding cytoplasm, exclusive of the cell processes (Figure 1). It acts as a trophic center, producing cytoplasm for movement into the processes, although most cell bodies also receive a great number of nerve endings conveying excitatory or inhibitory stimuli generated in other nerve cells. Most nerve cells have a **generally spherical, unusually large, euchromatic** (**pale-staining) nucleus with a prominent nucleolus**. The chromatin is finely dispersed, reflecting the intense synthetic activity of these cells.

Cytoplasm of perikarya often contains a highly developed RER with many parallel cisternae and neighboring regions with numerous polyribosomes, indicating active production of both cytoskeletal proteins and proteins for transport and secretion. Histologically these regions with concentrated RER and other polysomes appear as clumps of basophilic material called **chromatophilic substance (or Nissl substance, Nissl bodies) (figure 2)**

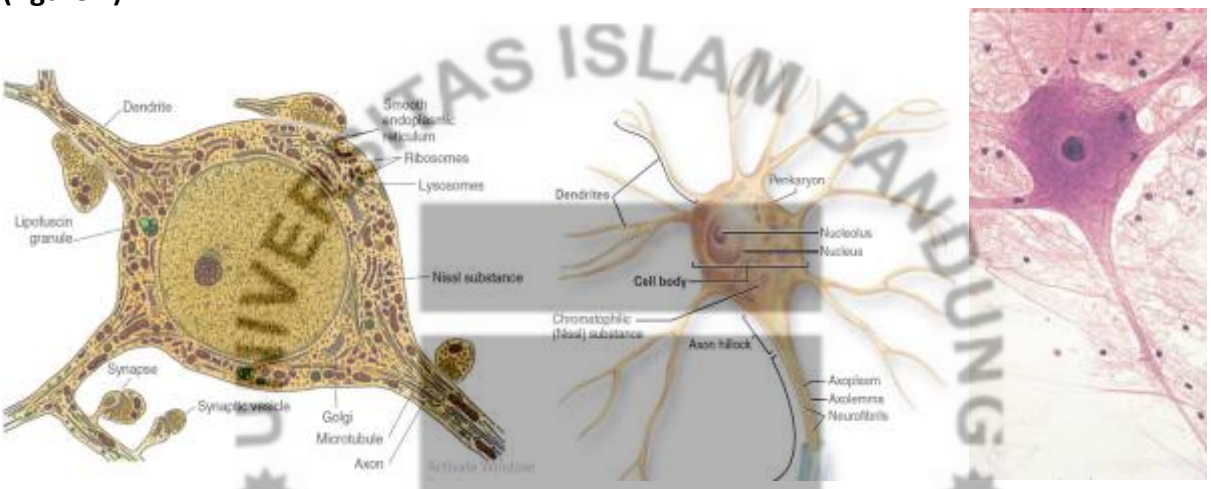


Figure 2

The amount of this basophilic material varies with the type and functional state of the neuron and is particularly abundant in large nerve cells such as motor neurons. The **Golgi apparatus** is located only in the cell body, but mitochondria can be found throughout the cell and are usually abundant in the axon terminals.

Intermediate filaments are abundant both in perikarya and processes and in this cell are often called **neurofilaments**. Neurofilaments become cross-linked with certain fixatives and, when impregnated with silver stains, they form **neurofibrils visible with the light microscope**. Neurons also contain microtubules identical to those found in other cells. Nerve cells occasionally contain inclusions of pigmented material, such as **lipofuscin**, consisting of residual bodies left from lysosomal digestion.

Axon

Most neurons have only one axon, typically longer than its dendrites. Axonal processes vary in length and diameter according to the type of neuron. Axons of the motor neurons that innervate the foot muscles have lengths of nearly a meter; large cell bodies are required to maintain these axons, which contain most of such neurons' cytoplasm. The plasma membrane of the axon is often called the **axolemma** and its contents are known as **axoplasm** (contains mitochondria, microtubules, neurofilaments, and transport vesicles, but very few polyribosomes or cisternae of RER, features that emphasize the dependence of

axoplasm on the perikaryon). Axons originate from a pyramid-shaped region of the perikaryon called the **axon hillock** (Figure 1), just beyond which the axolemma has concentrated ion channels that generate the action potential. At this initial segment of the axon, the various excitatory and inhibitory stimuli impinging on the neuron are algebraically summed, resulting in the decision to propagate—or not to propagate—a nerve impulse.

Axons generally branch less profusely than dendrites, but do undergo terminal arborization (Figure 1). 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. Each small axonal branch ends with a dilation called a terminal **bouton** (Fr. bouton, button) that contacts another neuron or non-nerve cell at a synapse to initiate an impulse in that cell. If an axon is severed from its cell body, its distal part quickly degenerates and undergoes phagocytosis.

Dendrites

Dendrites (Gr. dendron, tree) are typically short, small processes emerging and branching off the soma (Figure 1). Usually covered with many synapses, dendrites are the principal signal reception and processing sites on neurons. The large number and extensive arborization of dendrites allow a single neuron to receive and integrate signals from many other nerve cells. For example, up to **200,000 axonal endings** can make functional contact with the dendrites of a single large **Purkinje cell of the cerebellum**.

Dendrites become much thinner as they branch, with cytoskeletal elements predominating in these distal regions. In the CNS most synapses on dendrites occur on dendritic spines, which are dynamic membrane protrusions along the small dendritic branches, visualized with silver staining (Figure 3) and studied by confocal or electron microscopy.

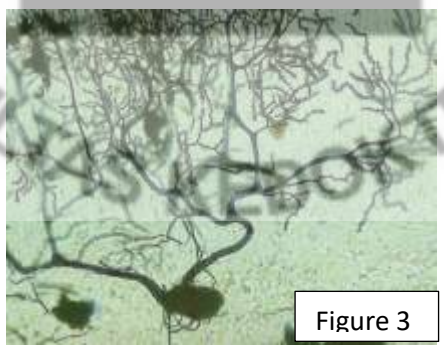


Figure 3

Dendritic spines serve as the initial processing sites for synaptic signals and occur in vast numbers, estimated to be on the order of 1014 for cells of the human cerebral cortex. Dendritic spine morphology depends on actin filaments and changes continuously as synaptic connections on neurons are modified. Changes in dendritic spines are of key importance in the constant changes of the neural plasticity that occurs during embryonic brain development and underlies adaptation, learning, and memory postnatally.

Neurons can be classified according to the number of processes extending from the cell body (Figure 4):

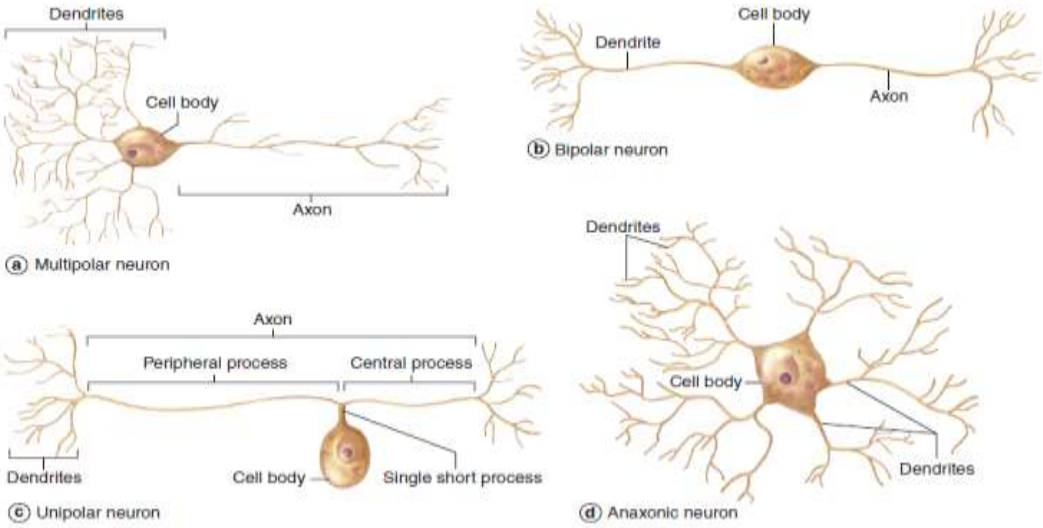


Figure 4

a. Multipolar neurons, which have one axon and two or more dendrites
b. Bipolar neurons, with one dendrite and one axon
c. Unipolar or pseudounipolar neurons, which have a single process that bifurcates close to the perikaryon, with the longer branch extending to a peripheral ending and the other toward the CNS.
d. Anaxonic neurons, with many dendrites but no true axon, do not produce action potentials, but regulate electrical changes of adjacent neurons.

The information is transmitted to and from neurons by chemical signals released at specialized intercellular junctions known as synapses.

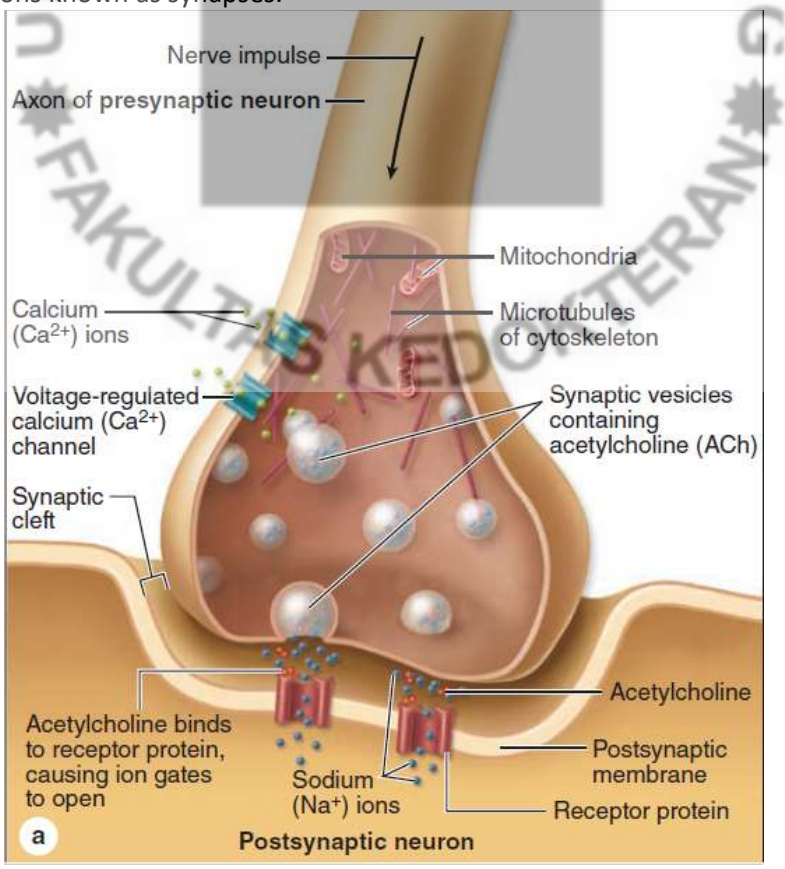


Figure 5

Type of synapses

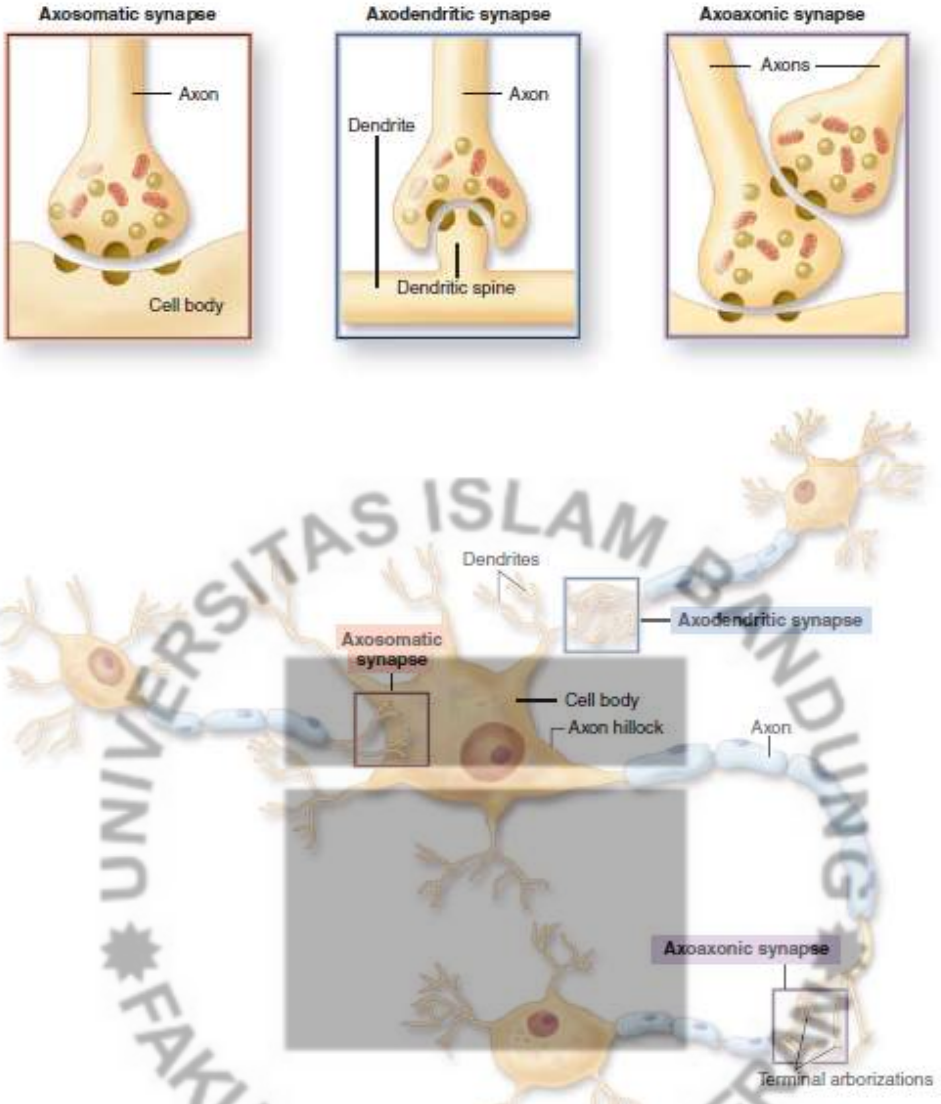


Figure 6

Cytoskeleton is vital for function, especially neurofilaments (architecture) and microtubules (axonal transport). The cytoskeleton of neurons is highly organized to maintain the unique shape of these cells, and particularly axons, which may be up to 1 m long. Neurofilament protein, the intermediate filament of nerve cells, is thought to act as an internal scaffold to maintain the shape of the axon and cell body. In the axon, certain membrane proteins are anchored in place in an organized pattern by attachment to cellular neurofilaments. There is also a highly organized network of microtubules,
which transport substances and organelles up and down the axon.
The metabolic maintenance of the long cell process of the axon requires a transport system for organelles, enzymes and metabolites from the cell body, which is largely directed by the microtubular cytoskeleton. Enzymes and elements of the cytoskeleton are transported down the axon at a speed of 1–5 mm/day by an unknown mechanism (slow axonal transport). Membranebound organelles, such as neurosecretory vesicles, are transported at speeds of 400 mm/day (anterograde fast axonal transport).

Neuroglia/Glial cells

Glial cells support neuronal survival and activities, and are **10 times more abundant** than neurons in the mammalian brain. Like neurons most glial cells develop from progenitor cells of the embryonic neural plate. In the CNS glial cells surround both the neuronal cell bodies, which are often larger than the glial cells, and the processes of axons and dendrites occupying the spaces between neurons. Except around the larger blood vessels, the CNS has only a **very small amount of connective tissue and collagen**. **Glial cells substitute for cells of connective tissue in some respects**, supporting neurons and creating immediately around those cells microenvironments that are optimal for neuronal activity. The fibrous intercellular network of CNS tissue superficially resembles collagen by light microscopy, but is actually the network of fine cellular processes emerging from neurons and glial cells. Such processes are collectively called the **neuropil** (Figure 7)

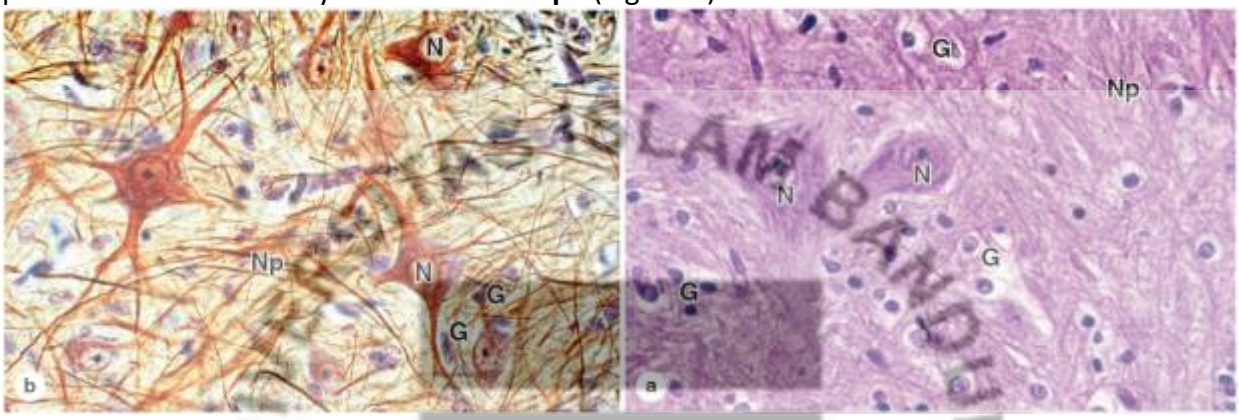


Figure 7

There are six major kinds of glial cells, as shown schematically in Figure 7, four in the CNS and two in the PNS. Their main functions, locations, and origins are summarized in Table 9–2.

TABLE 9–2 Origin, location and principal functions of neuroglial cells.

Glial Cell Type	Origin	Location	Main Functions
Oligodendrocyte	Neural tube	CNS	Myelin production, electrical insulation
Schwann cell (Neurolemmocyte)	Neural crest	Peripheral nerves	Myelin production, electrical insulation
Astrocyte	Neural tube	CNS	Structural and metabolic support of neurons; BBB; repair processes
Satellite cells (of ganglia)	Neural crest	Peripheral ganglia	Structural and metabolic support for neuronal cell bodies
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

FIGURE **9–9** **Glial cells of the CNS and PNS.**

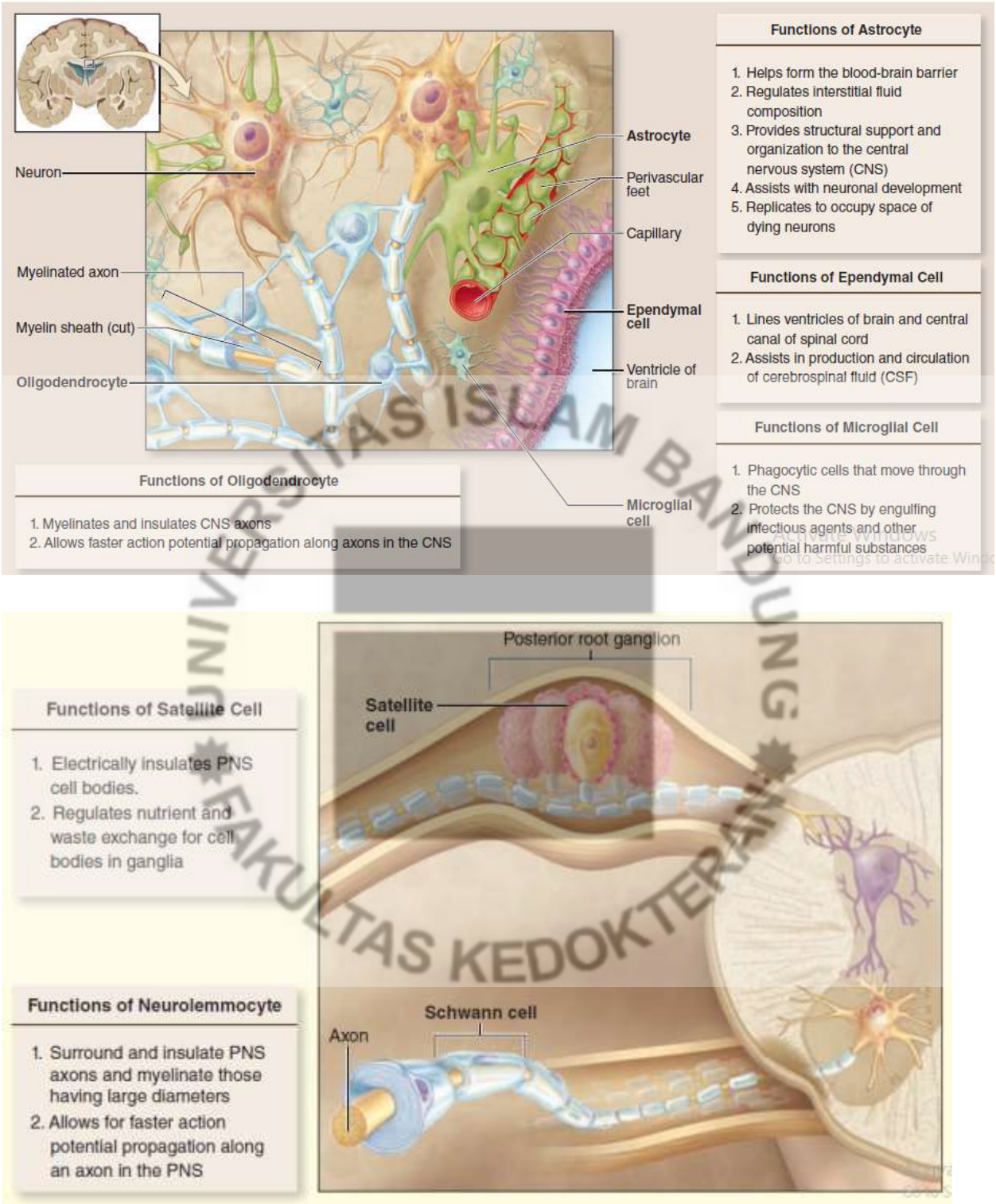


Figure 8

2.1 Oligodendrocytes

Oligodendrocytes (Gr. *oligos*, small, few **+** *dendron*, tree **+** *kytos*, cell) extend many processes, each of which becomes sheetlike and wraps repeatedly around a portion of a nearby CNS axon (Figure 9). During this wrapping most cytoplasm gradually moves out of the growing extension, leaving multiple compacted layers of cell membrane collectively termed **myelin**. An axon's full length is covered by the action of many oligodendrocytes. The resulting **myelin sheath** electrically insulates the axon and facilitates rapid transmission of nerve impulses. Found only in the CNS oligodendrocytes are the predominant glial cells in white matter, which is white because of the lipid concentrated in the wrapped membrane sheaths. The processes and sheaths are not visible by routine light microscope staining, in which oligodendrocytes usually appear as small cells with rounded, condensed nuclei and unstained cytoplasm (Figure 9).[1]

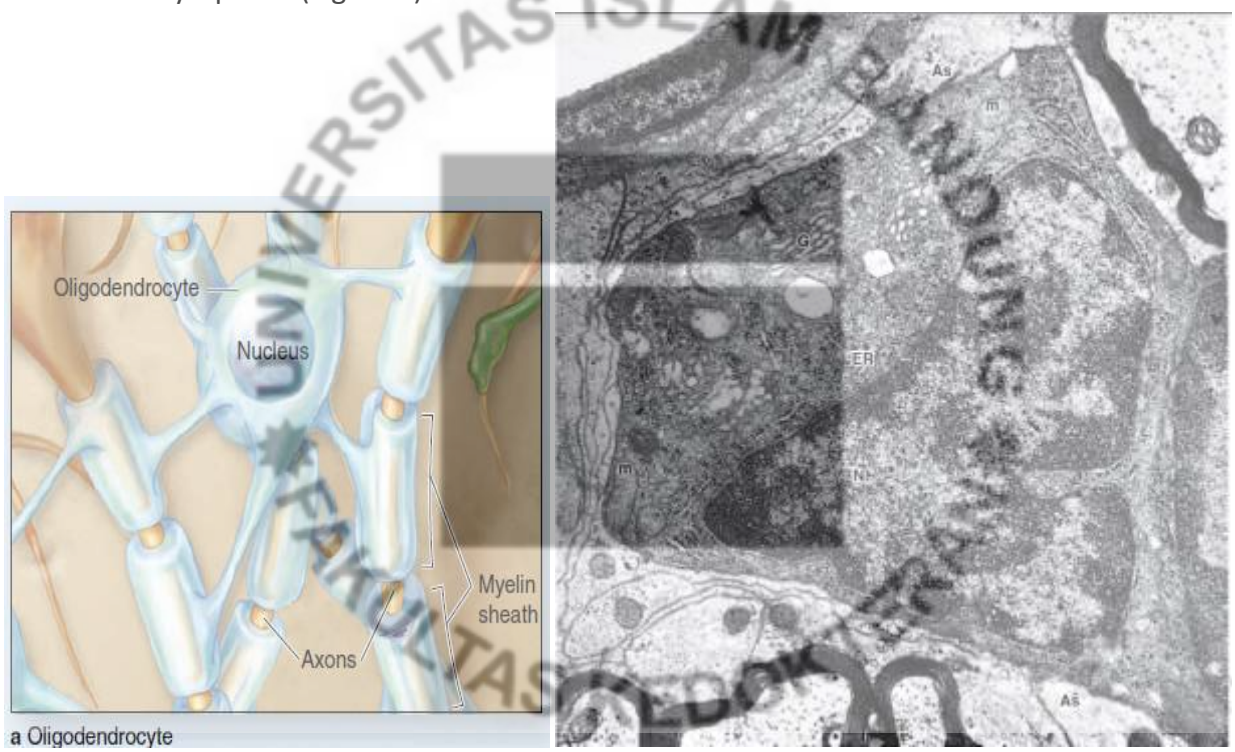


Figure 9 b. Electron micrograph of an oligodendrocyte (×2925). Note the nucleus (N), endoplasmic reticulum (ER), Golgi apparatus (G), and mitochondria (m). Processes of fibrous astrocytes (As) contact the oligodendrocyte. (From Leeson TS, Leeson CR, Paparo AA. *Text/Atlas of Histology*. Philadelphia: WB Saunders; 1988.)

Schematic diagram of the process of myelination in the central nervous system. Unlike the Schwann cell of the peripheral nervous system, each oligodendroglion is capable of myelinating several axons

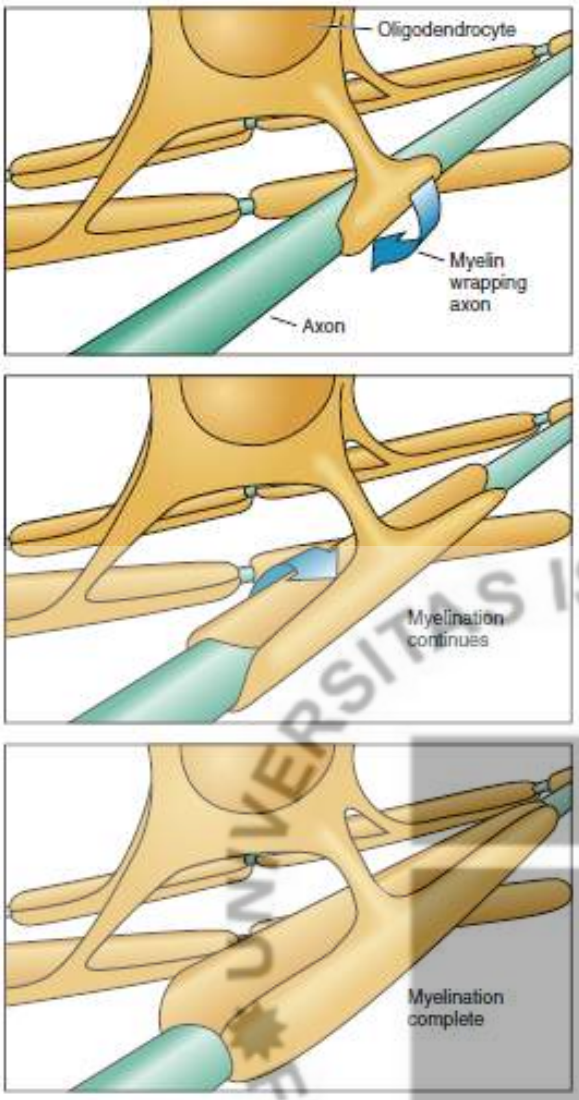


Figure 10. Interfascicular oligodendrocytes, located in rows beside bundles of axons, are responsible for manufacturing and maintaining myelin about the axons of the CNS, serving to insulate them (see Fig. 9–6). In producing myelin, oligodendrocytes function similarly to the Schwann cells of the PNS, except that a single oligodendrocyte may form a number of processes, each of which wraps a small region (internode) of as many as 50 axons with segments of myelin, whereas a single Schwann cell wraps a small region (internode) of only one axon with myelin.

Schwann cells also differ from interfascicular oligodendrocytes in the following ways: Schwann cells possess a basal lamina and retain some cytoplasm within the intracellular domains of the myelin lamellae, and connective tissue invests the myelin sheaths and their surrounding Schwann cells. During active myelin synthesis, interfascicular oligodendrocytes have a very high metabolic rate because they can produce as much as 300% of their weight in myelin synthesis on a daily basis.

Subsequent to completion of myelinization of all of the internodes under their control, these cells must maintain responsibility over the metabolic fate of the myelin that they produced.

Satellite oligodendrocytes are closely applied to cell bodies of large neurons and are present only in gray matter. Their function is not understood completely, but they appear to monitor the extracellular fluid around neuronal cell bodies, and, according to some investigators, they may act in a reserve capacity, and, if the need arises, they may migrate into the white matter to replenish interfascicular oligodendrocytes.

2.2 Astrocytes

Also unique to the CNS **astrocytes** (Gr. *astro-,* star **+** *kytos*) have a large number of long radiating, branching processes (Figures 10). Proximal regions of the astrocytic processes are reinforced with bundles of intermediate filaments made of **glial fibrillary acid protein (GFAP)**, which serves as a unique marker for this glial cell. Distally the processes lack GFAP, are not readily seen by microscopy, and form a vast network of delicate terminals contacting synapses and other structures. Terminal processes of a single astrocyte typically occupy a large volume and associate with over a million synaptic sites.

Astrocytes originate from progenitor cells in the embryonic neural tube and are by far the most numerous glial cells of the brain, as well as the most diverse structurally and functionally. **Fibrous astrocytes**, with long delicate processes, are abundant in white matter; those with many shorter processes are called **protoplasmic astrocytes** and predominate in the gray matter. The highly variable and dynamic processes mediate most of these cells many functions.

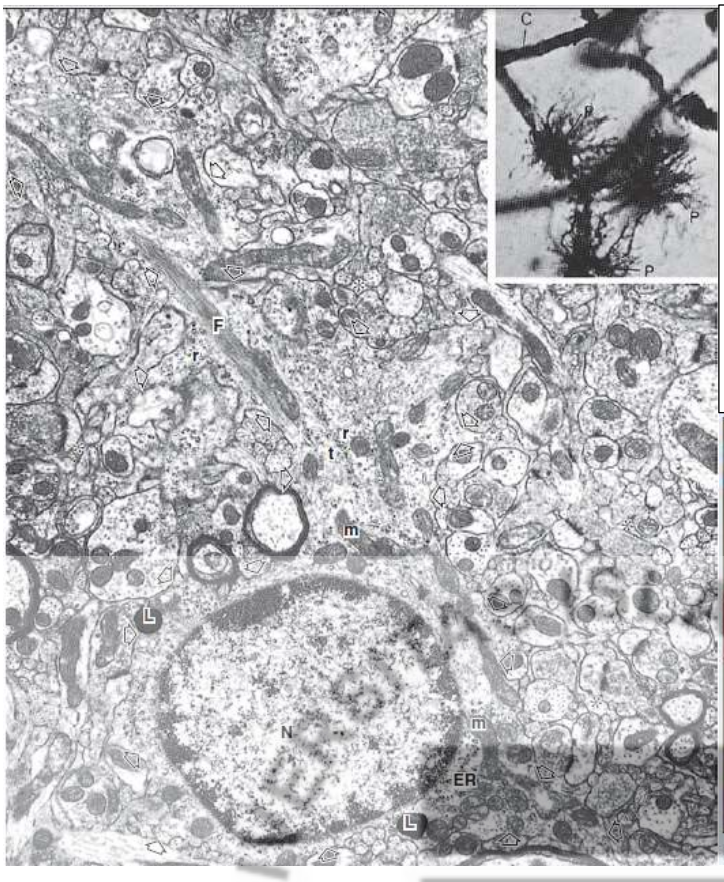
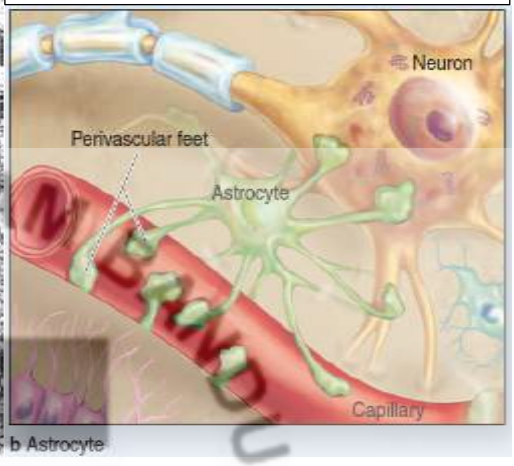


Figure 10. Electron micrograph of protoplasmic astrocyte(×11400). Observe the nucleus(N),filaments(F), mitochondria (m), microtubules (t), free ribosomes (r), and granular reticulum (ER).
Two lysosomes (L) are also identified in the processes of the neuroglia. Note the irregular cell boundary, indicated by *arrowheads. Asterisks* indicate processes of other neuroglial cells of the neuropil. (From Peters A, Palay SL, Webster HF. *The Fine Structure of the Nervous System*.



nset, Light micrograph of three highly branched protoplasmic astrocytes (P) surrounding capillaries (C). (From Leeson TS, Leeson CR, Paparo AA. *Text/Atlas of Histology*. Philadelphia: WB Saunders; 1988.)

Functions attributed to astrocytes of various CNS regions include the following:

1. Extending processes that associate with or cover synapses, affecting the formation, function, and plasticity of these structures.
2. Regulating the extracellular ionic concentrations around neurons, with particular importance in buffering extracellular K+ levels.
3. Guiding and physically supporting movements and locations of differentiating neurons during CNS development.
4. Extending fibrous processes with expanded **perivascular feet** that cover capillary endothelial cells and modulate blood flow and help move nutrients, wastes, and other metabolites between neurons and capillaries (Figure 9–9a).
5. Forming a barrier layer of expanded protoplasmic processes, called the **glial limiting membrane**, which lines the meninges at the external CNS surface.
6. Filling tissue defects after CNS injury by proliferation to form an **astrocytic scar**.

Finally, astrocytes communicate directly with one another via **gap junctions**, forming a very large cellular network for the coordinated regulation of their various activities in different brain regions.

2.3 Ependymal Cells

Ependymal cells are columnar or cuboidal cells that line the fluid-filled ventricles of the brain and the central canal of the spinal cord (Figures 11). In some CNS locations, the apical ends of ependymal cells have cilia, which facilitate the movement of cerebrospinal fluid (CSF), and long microvilli, which are likely involved in absorption.

Ependymal cells are joined apically by apical junctional complexes similar to those of epithelial cells. However, **unlike a true epithelium there is no basal lamina**. Instead, the basal ends of ependymal cells are elongated and extend branching processes into the adjacent neuropil.

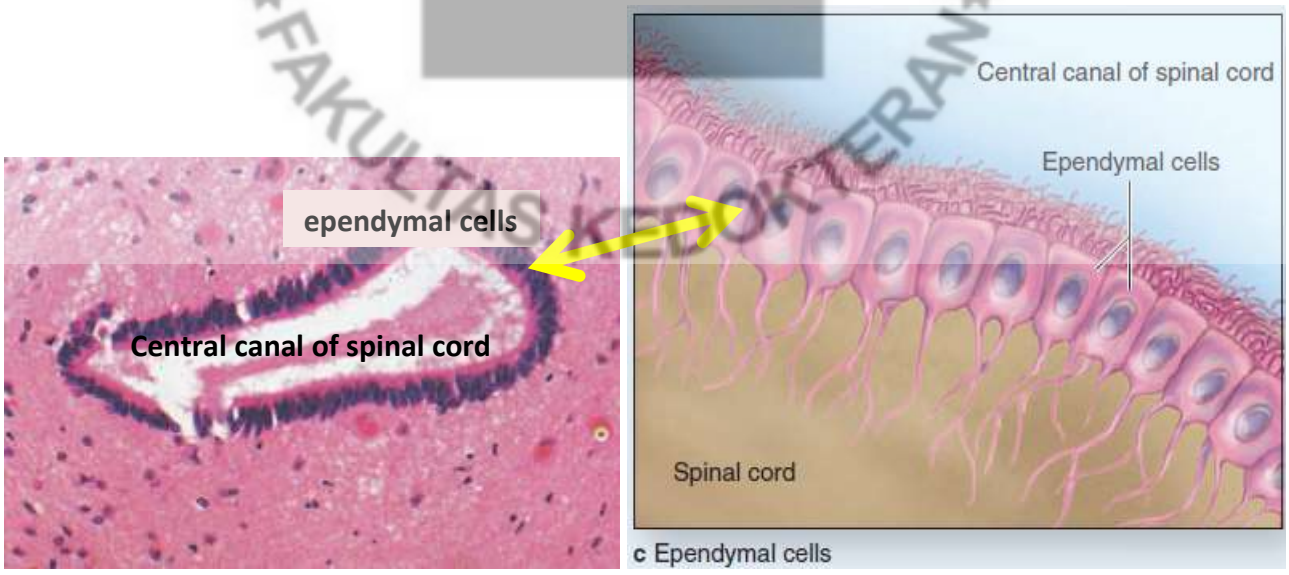


Figure 11. spinal cord

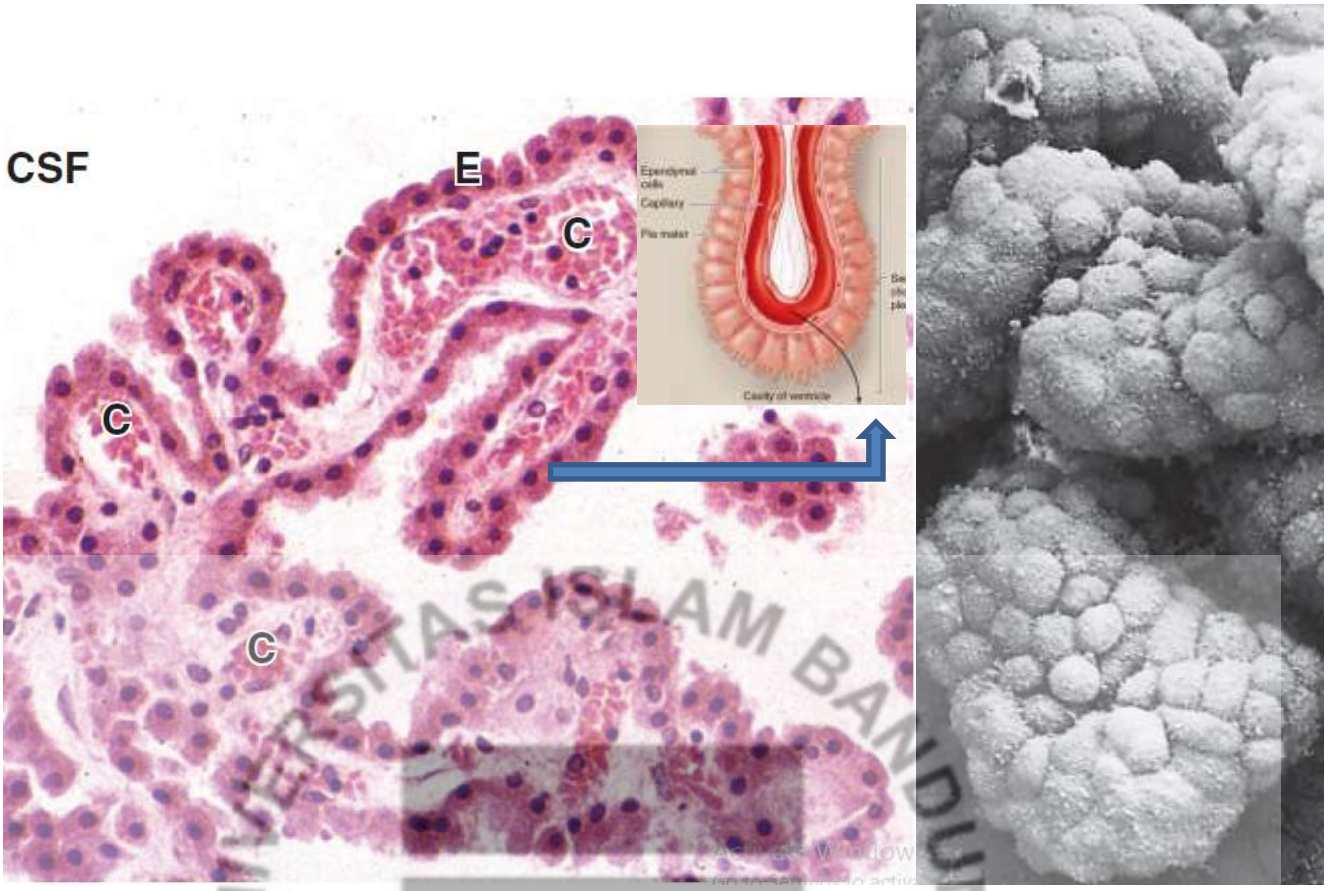


Figure 12. The choroid plexus consists of ependyma and vascularized pia mater and projects many thin folds from certain walls of the ventricles.
(b) At higher magnification each fold of choroid plexus is seen to be well-vasculorized with large capillaries (C) and covered by a continuous layer of **cuboidal ependymal cells** (E). X150. (c) The choroid plexus is specialized for transport of water and ions across the capillary endothelium and ependymal layer and the elaboration of these as CSF.
With high-magnification TEM, the myelin sheath appears as a thick electron-dense axonal covering in which the concentric membrane layers may be visible (Figure 9–22). The prominent electron-dense layers visible ultrastructurally in the sheath, the major dense lines, represent the fused, protein-rich cytoplasmic surfaces of the Schwann cell membrane. Along the myelin sheath, these surfaces periodically separate slightly to allow transient movement of cytoplasm for membrane maintenance; at these myelin clefts (or Schmidt-Lanterman clefts) the major dense lines temporarily disappear (Figure 12)

2.4 Microglia

Less numerous than oligodendrocytes or astrocytes but nearly as common as neurons in some CNS regions, **microglia** are small cells with actively mobile processes evenly distributed throughout gray and white matter (Figures 13). Unlike other glial cells **microglia migrate**, with their processes **scanning the neuropil and removing damaged or effete synapses or other fibrous components**. Microglial cells also constitute the major mechanism of **immune defense in the CNS**, **removing any microbial invaders** and secreting a number of **immunoregulatory cytokines**. Microglia do not originate from neural progenitor cells like

other glia, but from circulating blood monocytes, belonging to the same family as macrophages and other antigen-presenting cells.

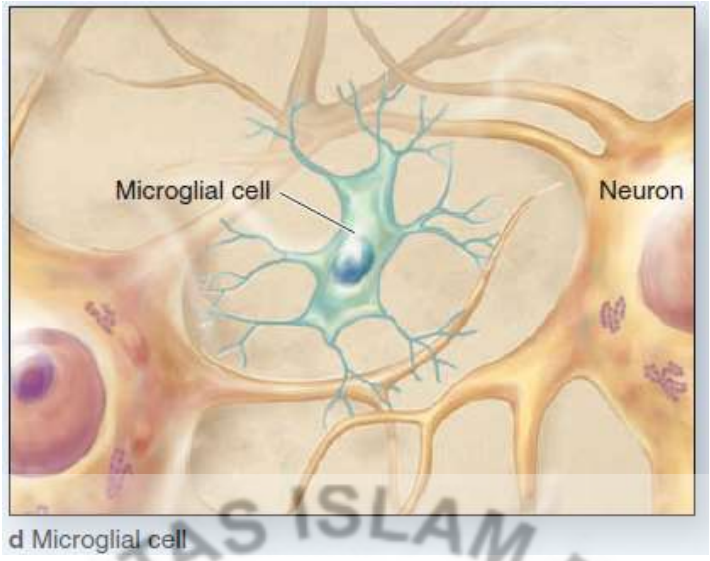
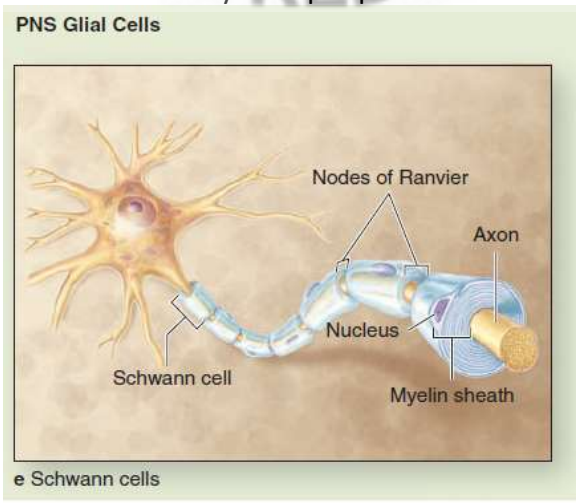


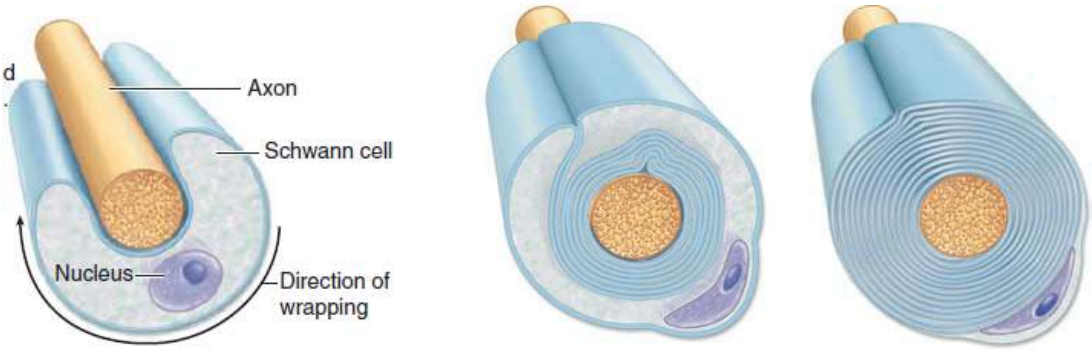
Figure 13

Nuclei of microglial cells can often be recognized in routine hematoxylin and eosin (H&E) preparations by their small, dense, slightly elongated structure, which contrasts with the larger, spherical, more lightly stained nuclei of other glial cells. Immunohistochemistry using antibodies against cell surface antigens of immune cells demonstrates microglial processes. When activated by damage or microorganisms microglia retract their processes, proliferate, and assume the morphologic characteristics and functions of antigen-presenting cells.

2.5 Schwann Cells

Schwann cells (named for 19th century German histologist Theodor Schwann), sometimes called **neurolemmocytes**, are found only in the PNS and differentiate from precursors in the neural crest. Schwann cells are the counterparts to oligodendrocytes of the CNS, having trophic interactions with axons and most importantly forming their **myelin sheathes**. However unlike an oligodendrocyte, a Schwann cell forms myelin around a portion of only one axon. Figure 14 shows a series of Schwann cells sheathing the full length of an axon, a process described more fully with peripheral nerves.





Schwann cell starts to wrap around a portion of an axon.

The overlapping inner layers of the Schwann cell plasma membrane form the myelin sheath.

Eventually, the Schwann cell cytoplasm and nucleus are pushed to the periphery of the cell as the myelin sheath is formed.

Figure 13

2.5 Satellite Cells

Also derived from the **embryonic neural crest**, small satellite cells form an intimate **covering layer over the large neuronal cell bodies in the ganglia** of the PNS (Figures 14). Satellite cells exert a trophic or supportive effect on these neurons, insulating, nourishing, and regulating their microenvironments.

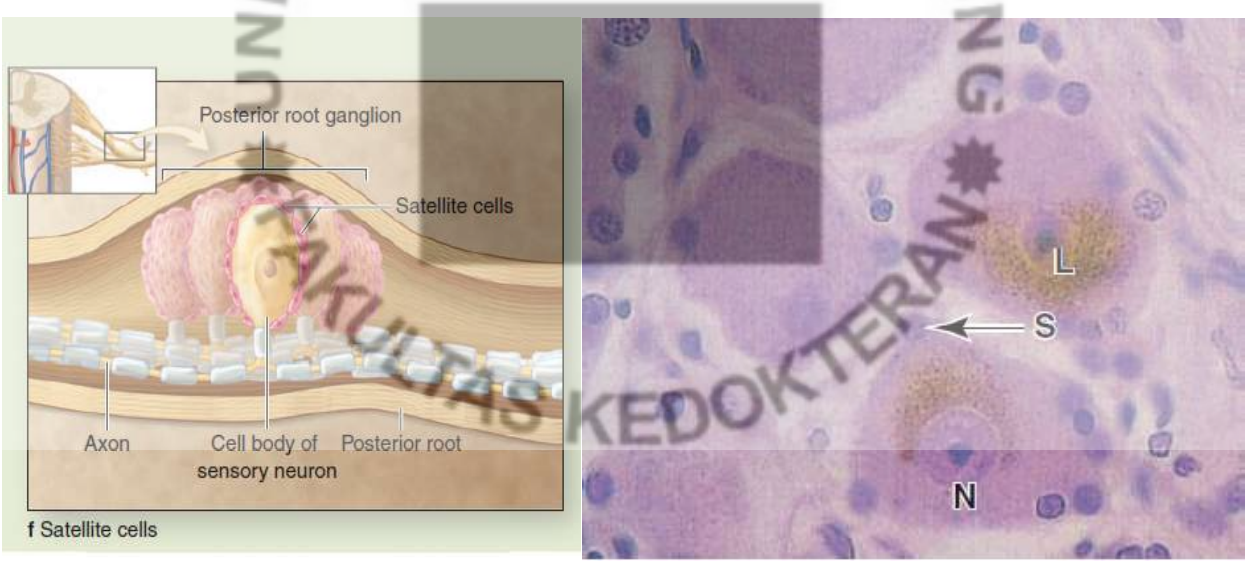


Figure 14

Satellite cells are very closely associated with cell bodies of sensory nerves and support these cells in various ways. Nuclei of the many satellite cells (S) surrounding the perikarya of neurons (N) in a dorsal root ganglion can be seen by light microscopy, but the cytoplasmic extensions from the cells are not visible. These long-lived neurons commonly accumulate brown lipofuscin (L). X560. H&E.

II. Ganglia

Ganglia (figure 15) are typically ovoid structures containing neuronal cell bodies and their surrounding glial satellite cells supported by delicate connective tissue and surrounded by a denser capsule. Because they serve as relay stations to transmit nerve impulses, at least one nerve enters and another exits from each ganglion. The direction of the nerve impulse determines whether the ganglion will be a **sensory** or an **autonomic** ganglion.

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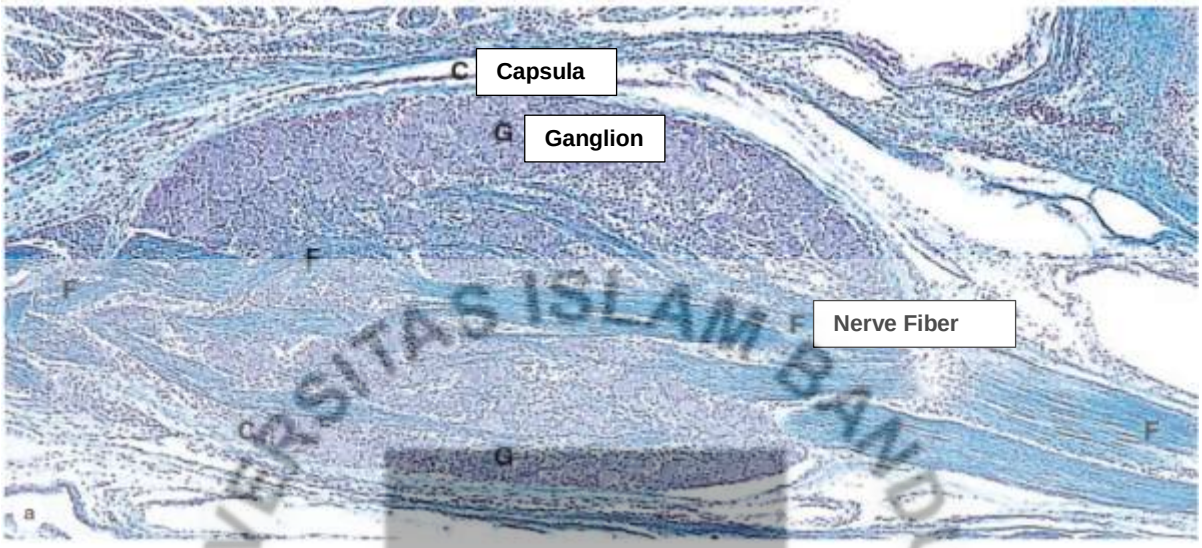


Figure 15. (a) A sensory ganglion (G) has a distinct connective tissue capsule (C) and internal framework continuous with the epineurium and other components of peripheral nerves, except that no perineurium is present and that there is no blood-nerve barrier function. Fascicles of nerve fibers (F) enter and leave these ganglia. X56. Kluver-Barrera stain.

2.a Sensory Ganglia

Sensory ganglia receive afferent impulses that go to the CNS. Sensory ganglia are associated with both cranial nerves (cranial ganglia) and the dorsal roots of the spinal nerves (spinal ganglia). The large neuronal cell bodies of ganglia (Figure 16) are associated with thin, sheetlike extensions of small glial **satellite cells** (Figures 16). Sensory ganglia are supported by a distinct connective tissue capsule and an internal framework continuous with the connective tissue layers of the nerves. The neurons of these ganglia are pseudounipolar and relay information from the ganglion's nerve endings to the gray matter of the spinal cord via synapses with local neurons

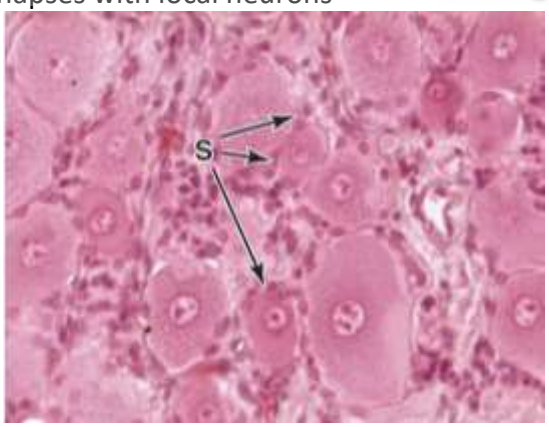


Figure 16. Higher magnification shows the small, rounded nuclei of glia cells called satellite cells (S) that produce thin, sheetlike cytoplasmic extensions that completely envelop each large neuronal perikaryon. X400. H&E.

2.b Autonomic Ganglia

Autonomic (Gr. *autos,* self **+** *nomos,* law) nerves effect the activity of smooth muscle, the secretion of some glands, heart rate, and many other involuntary activities by which the body maintains a constant internal environment (**homeostasis**). Autonomic ganglia are small bulbous dilations in autonomic nerves, usually with multipolar neurons. Sympathetic ganglia are smaller than most sensory ganglia but similar in having large neuronal cell bodies (N), some containing lipofuscin (L). Sheets from satellite cells (S) enclose each neuronal cell body with morphology slightly different from that of sensory ganglia. Autonomic ganglia generally have less well-developed connective tissue capsules (C) than sensory ganglia **(figure 17)**.

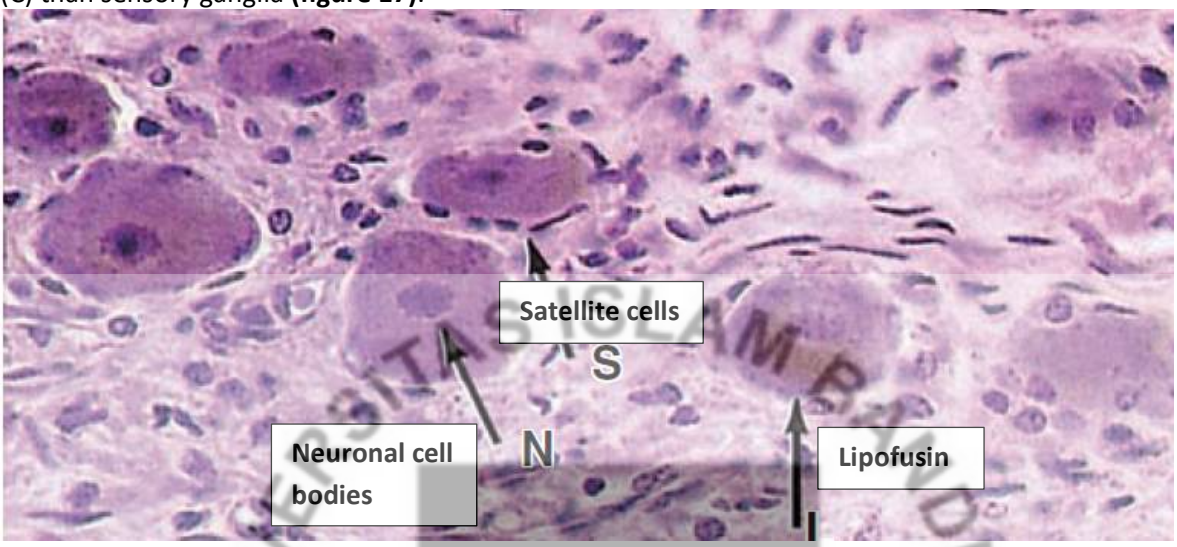


Figure 17. Sympathetic ganglia are smaller than most sensory ganglia but similar in having large neuronal cell bodies (N), some containing lipofuscin (L). Sheets from satellite cells (S) enclose each neuronal cell body with morphology slightly different from that of sensory ganglia. Autonomic ganglia generally have less well-developed connective tissue capsules (C) than sensory ganglia. X400. H&E.

III. Meninges

The skull and the vertebral column protect the CNS, but between the bone and nervous tissue are membranes of connective tissue called the **meninges**. Three meningeal layers are distinguished: the dura, arachnoid, and pia maters (Figures 19).

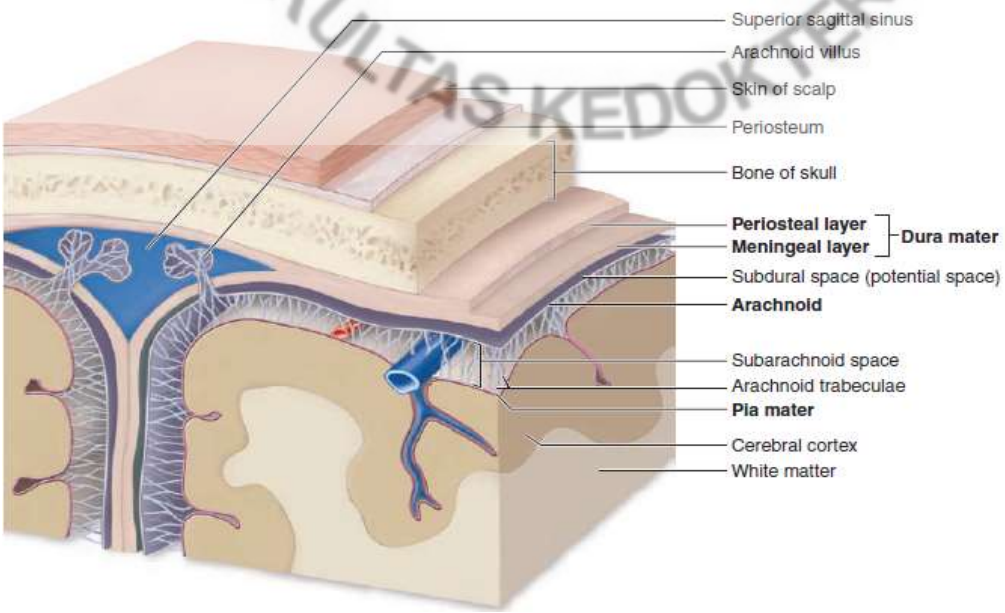


Figure 18.a

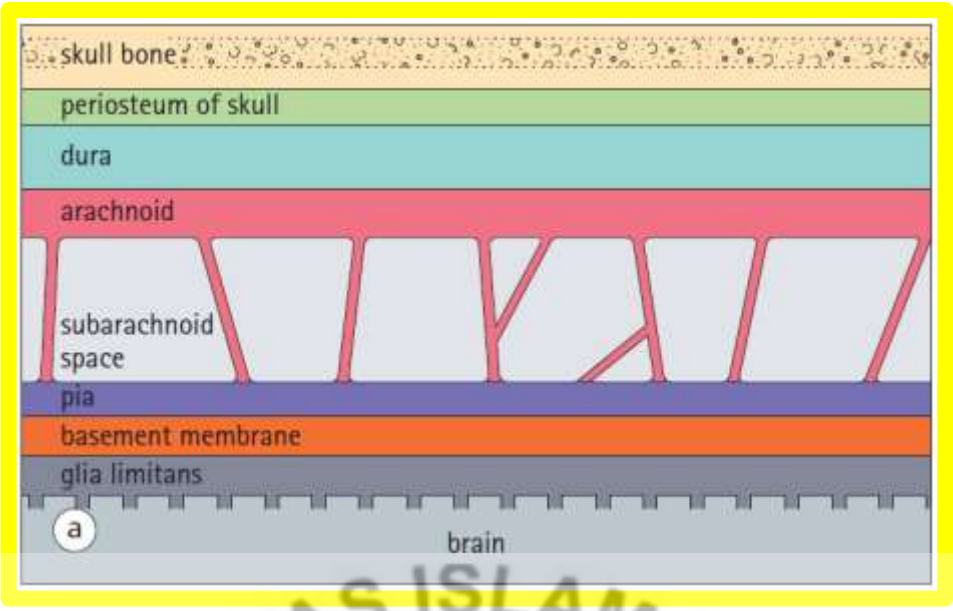


Figure 18.b[2]

3.1 Dura Mater

The thick external **dura mater** (L. *dura mater*, tough mother) consists of **dense irregular connective tissue** organized as an outer periosteal layer continuous with the periosteum of the skull and an inner meningeal layer. These two layers are usually fused, but along the superior sagittal surface and other specific areas around the brain they separate to form the blood-filled **dural venous sinuses** (Figure 18).[1,3]

Around the spinal cord the dura mater is separated from the periosteum of the vertebrae by the **epidural space**, which contains a plexus of thin-walled veins and **loose connective tissue** (Figure 19). The dura mater may be separated from the arachnoid by formation of a thin **subdural space.**

3.2 Arachnoid

The **arachnoid** (Gr. *arachnoeides*, spider web-like) has two components: (1) a sheet of **connective tissue** in contact with the dura mater and (2) a system of loosely arranged **trabeculae composed of collagen and fibroblasts**, continuous with the underlying pia mater layer. Surrounding these trabeculae is a large, sponge-like cavity, the **subarachnoid space**, filled with CSF. This fluid-filled space helps cushion and protect the CNS from minor trauma. The subarachnoid space communicates with the ventricles of the brain where the CSF is produced.

The connective tissue of the arachnoid is said to be **avascular** because it lacks nutritive capillaries, but larger blood vessels run through it (Figures 18). Because the arachnoid has fewer trabeculae in the spinal cord, it can be more clearly distinguished from the pia mater in that area. The arachnoid and the pia mater are intimately associated and are often considered a single membrane called the **pia-arachnoid**.

In some areas, the arachnoid penetrates the dura mater and protrudes into blood-filled dural venous sinuses located there (Figure 18). These CSF-filled protrusions, which are covered by the vascular endothelial cells lining the sinuses, are called arachnoid villi and function as sites for absorption of CSF into the blood of the venous sinuses.

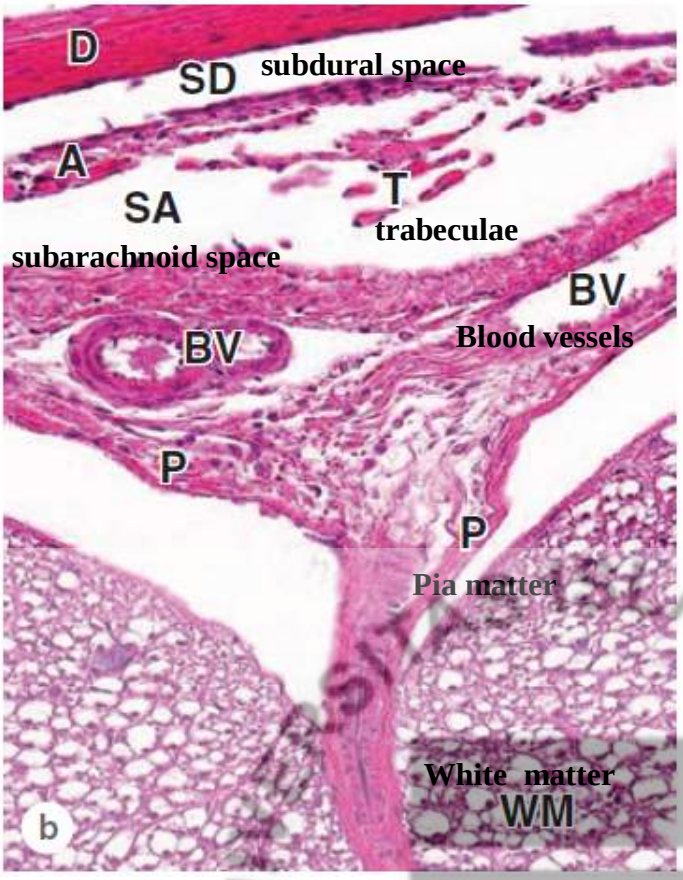


Figure 19

Section of an area near the anterior median fissure showing the tough dura mater (D). Surrounding the dura, the epidural space (not shown) contains cushioning adipose tissue and vascular plexuses. The subdural space (SD) is an artifact created by separation of the dura from underlying tissue. The middle meningeal layer is the thicker weblike arachnoid mater (A) containing the large subarachnoid space (SA) and connective tissue trabeculae (T). The subarachnoid space is filled with CSF and the arachnoid acts as a shock-absorbing pad between the CNS and bone. Fairly large blood vessels (BV) course through the arachnoid. The innermost pia mater (P) is thin and is not clearly separate from the arachnoid; together, they are sometimes referred to as the pia-arachnoid or the leptomeninges. The space between the pia and the white matter (WM) of the spinal cord here is an artifact created during dissection; normally the pia is very closely applied to a layer of astrocytic processes at the surface of the CNS tissue. X100. H&E.

3.3 Pia Mater

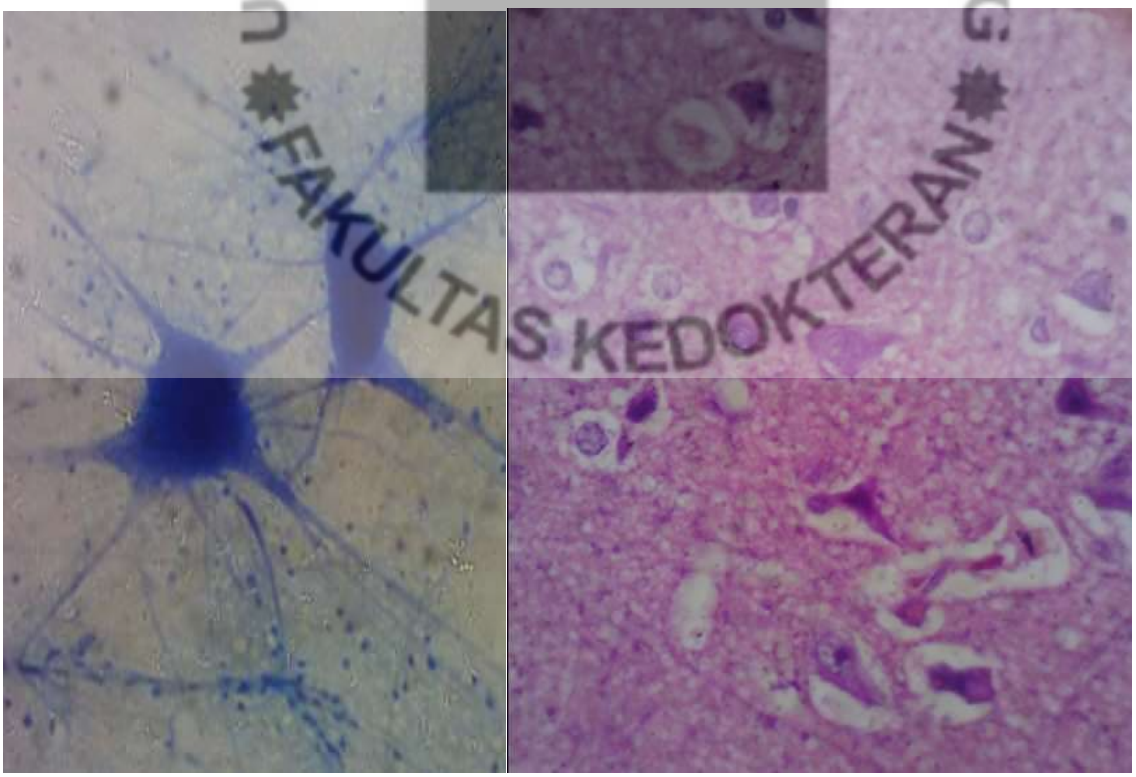
The innermost **pia mater** (L. *pia mater*, tender mother), consists of flattened, **mesenchymally derived cells** closely applied to the entire surface of the CNS tissue. The pia does not directly contact nerve cells or fibers, being separated from the neural elements by the very thin **superficial layer of astrocytic processes** (**the glial limiting membrane, or glia limitans**), which adheres firmly to the pia mater. Together, the pia mater and the layer of astrocytic end feet form a **physical barrier** separating CNS tissue from CSF in the subarachnoid space (Figure 18).

Blood vessels penetrate CNS tissue through long **perivascular spaces** covered by pia mater, although the pia disappears when the blood vessels branch to form the small capillaries. However, these capillaries remain completely covered by the perivascular layer of astrocytic processes (Figures 10).

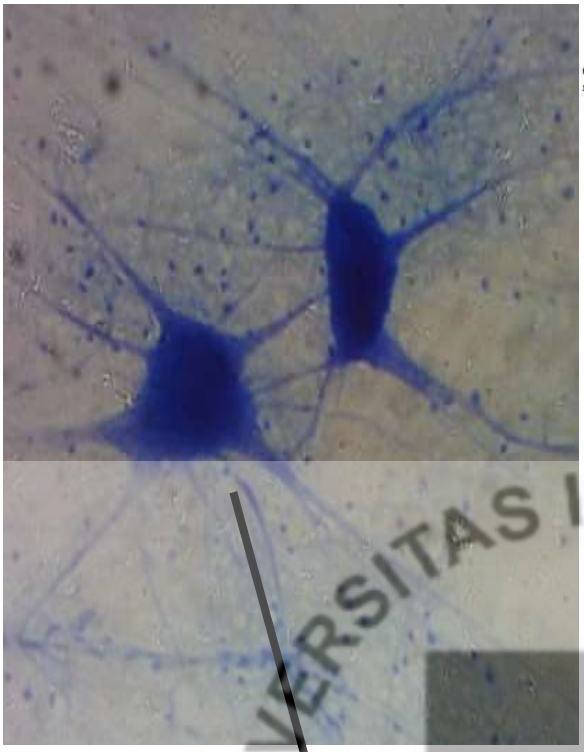
F	Activity Lab

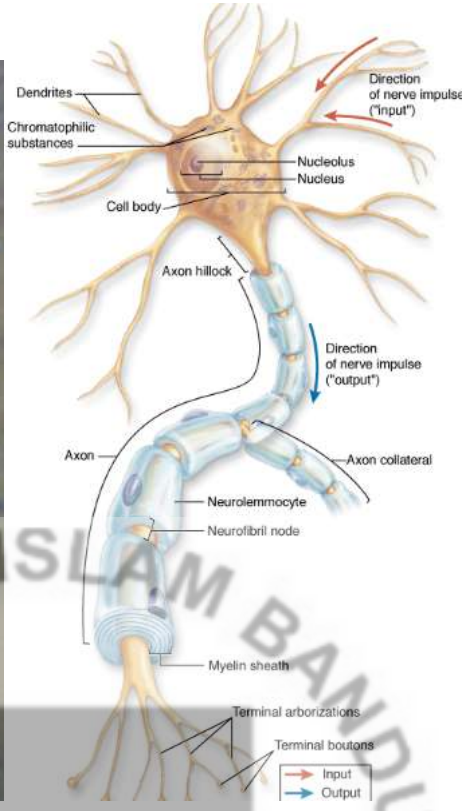
1. Students will be divided into groups
2. Discussion in 30 minute
3. Identify tissue section using light microscopy and draw it , in 90 minute

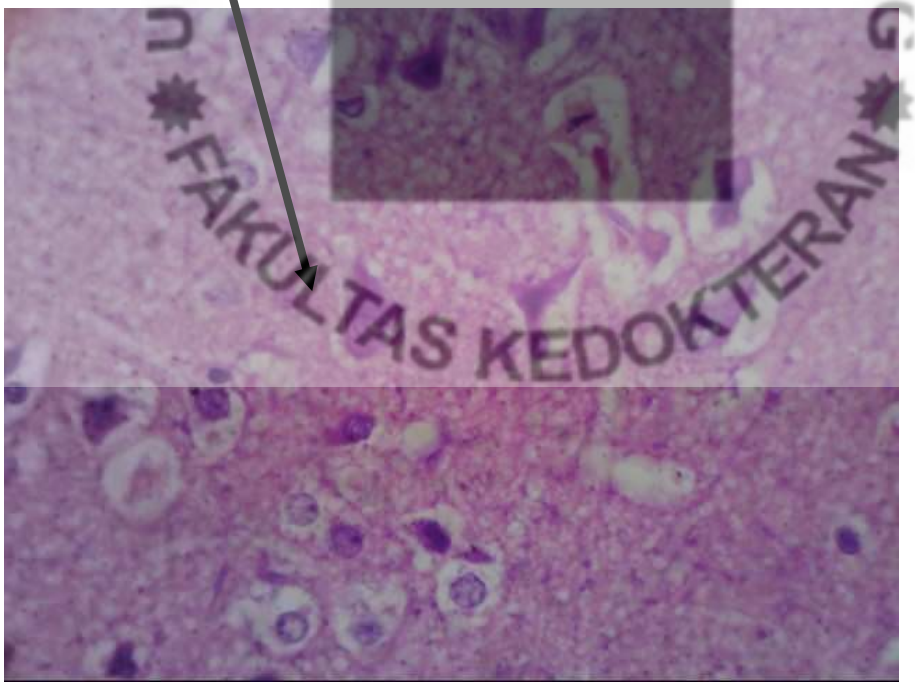
4. **LIST MICROSTRUCTURE IDENTIFY REVIEW (** *give the checklist √ if you have already known*)

I. Neuron and neuroglia	Check list
1. Motor neuron and cerebrum / spinal cord - Identify part of the neuron cell (body, axon/dendrit,) DRAW 1000X 	

Identify the structure below

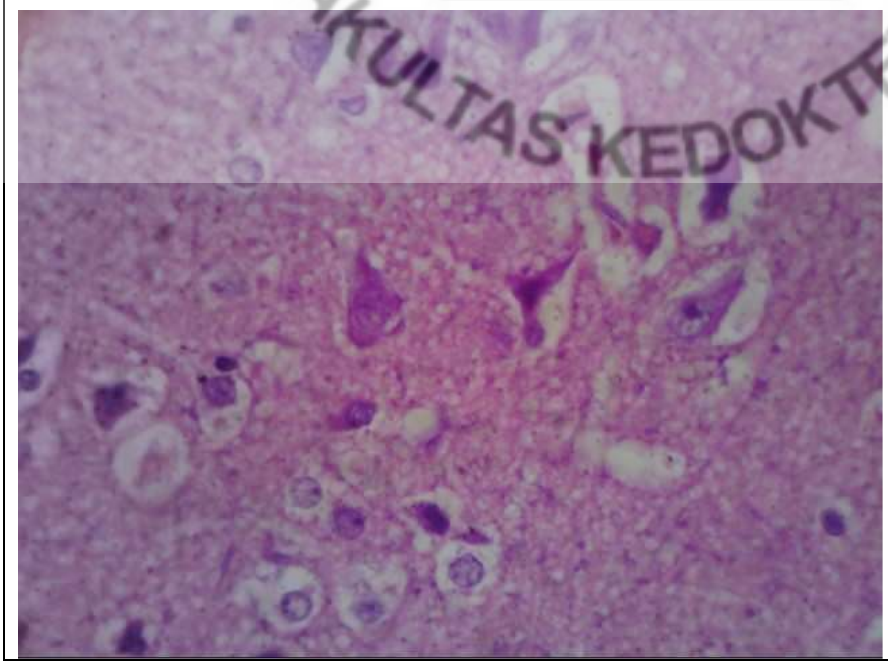




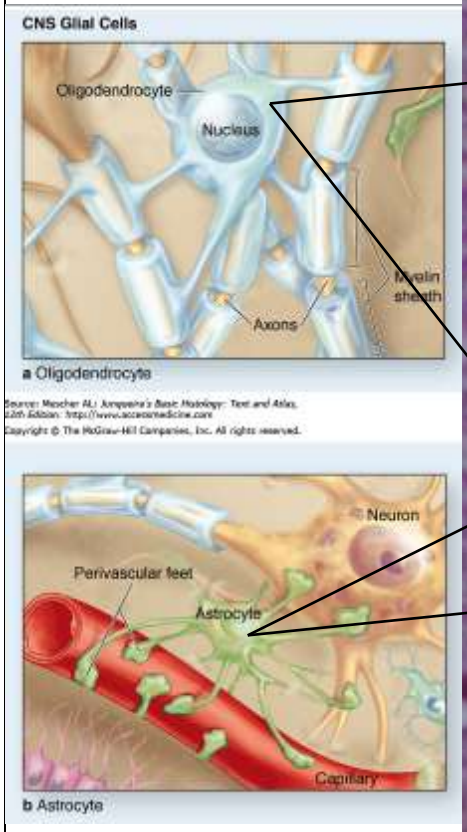


2. Neuroglia (Preparat : Medulla spinalis/cerebrum)
Identify type cell of neuroglia : astrocyte, microglia, oligodendrosit.)

Draw !
1000X



Ada halo


CNS Glial Cells
Oligodendrocyte
Nucleus
Myelin sheath
Axons
a Oligodendrocyte
Source: Mescher AL: Junqueira's Basic Histology: Text and Atlas, 12th Edition: http://www.accessmedicine.com
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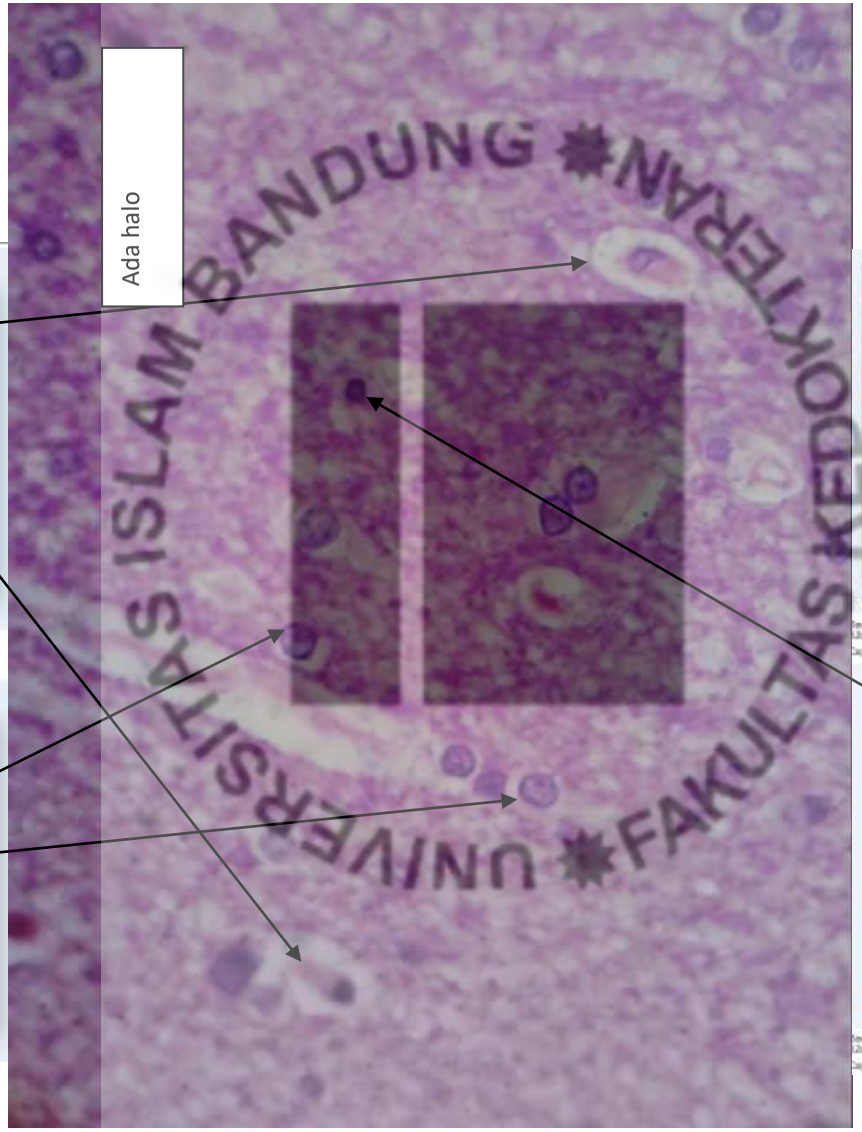
Neuron
Perivascular feet
Astrocyte
Capillary
b Astrocyte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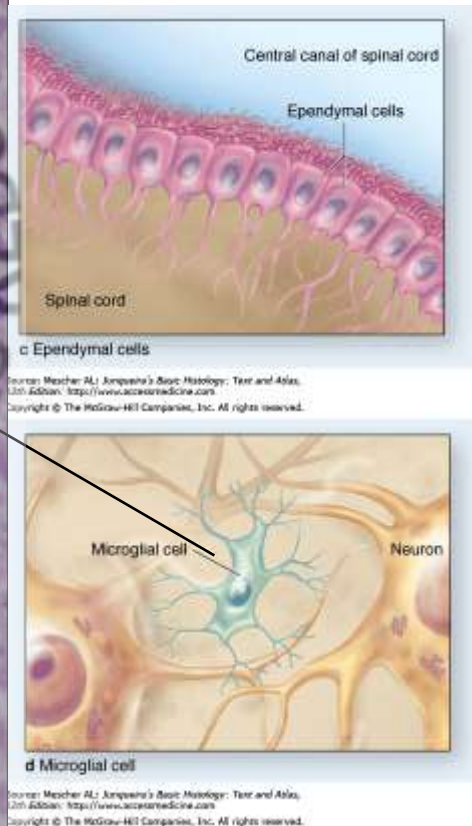
FAKULTAS KEDOKTERAN


Central canal of spinal cord
Ependymal cells
Spinal cord
c Ependymal cells
Source: Mescher AL: Junqueira's Basic Histology: Text and Atlas, 12th Edition: http://www.accessmedicine.com
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Microglial cell
Neuron
d Microglial cell
Source: Mescher AL: Junqueira's Basic Histology: Text and Atlas, 12th Edition: http://www.accessmedicine.com
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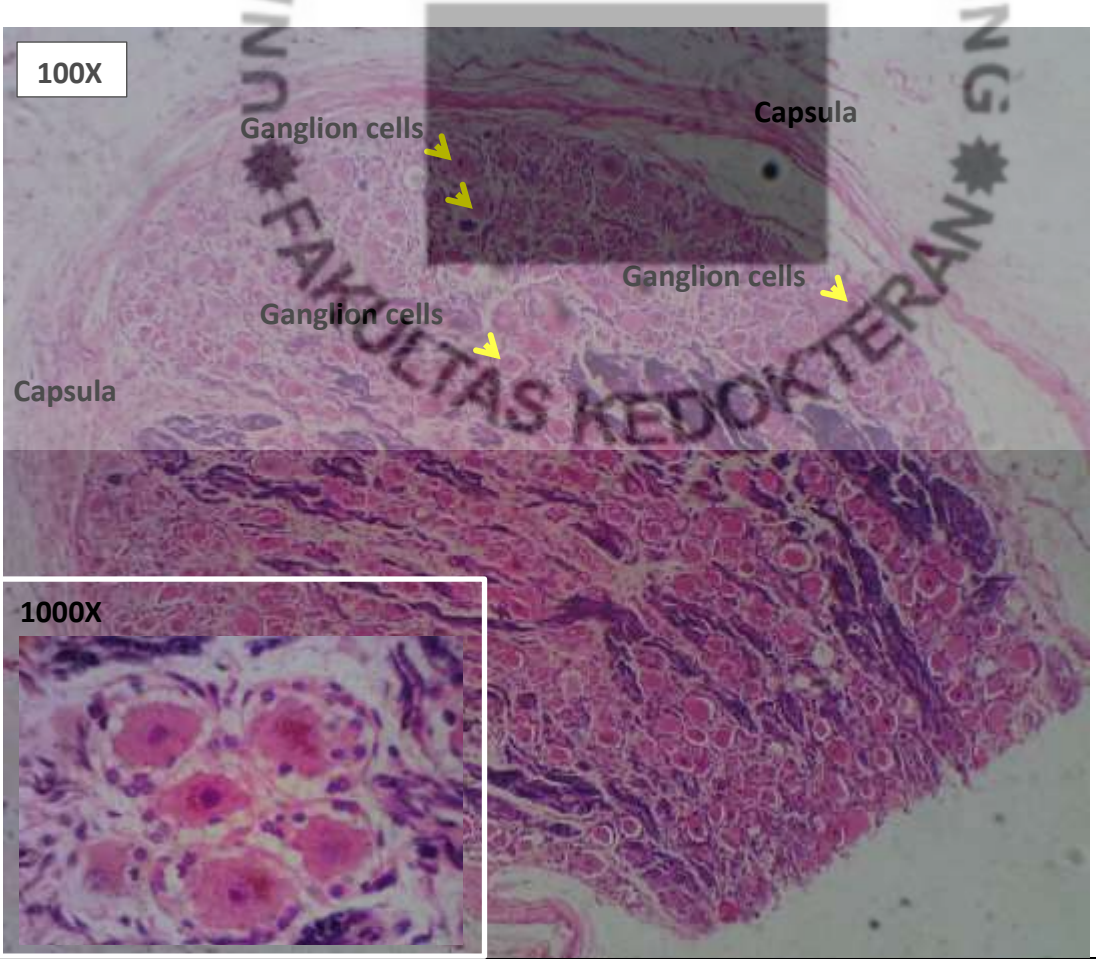
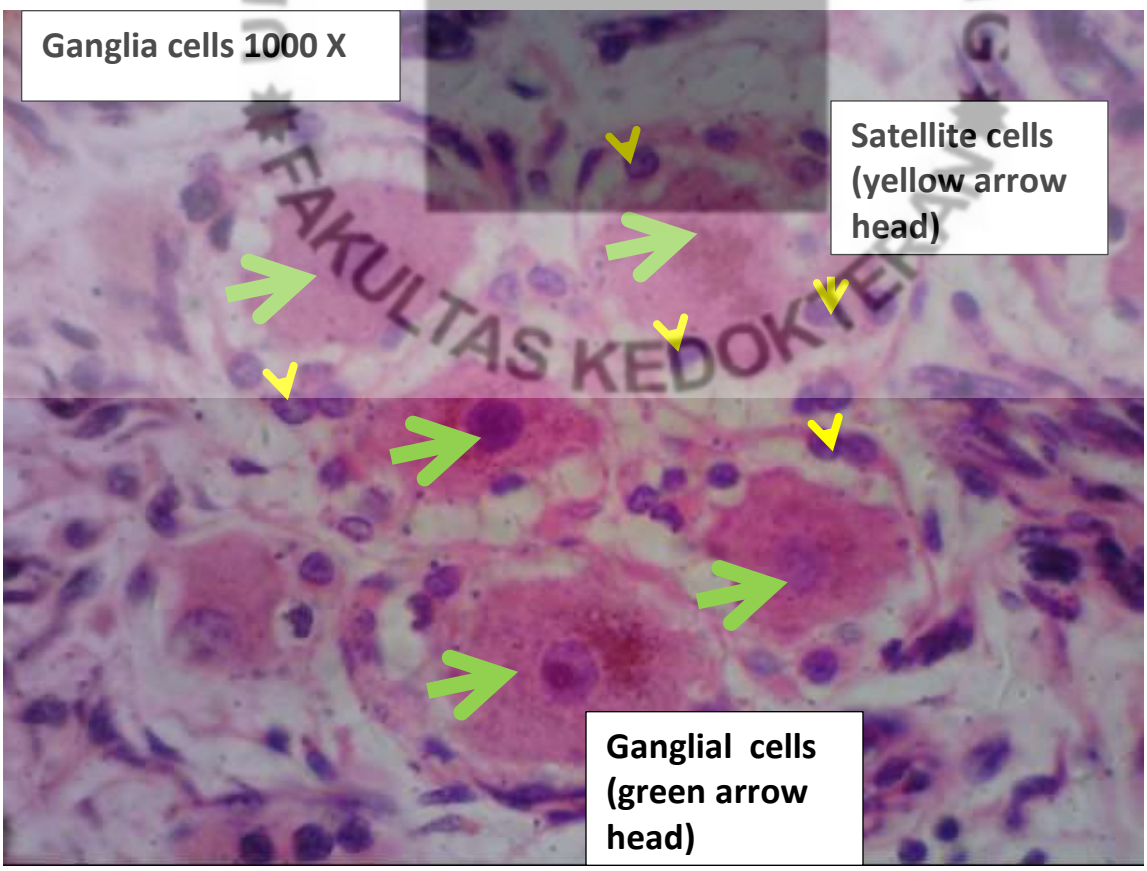
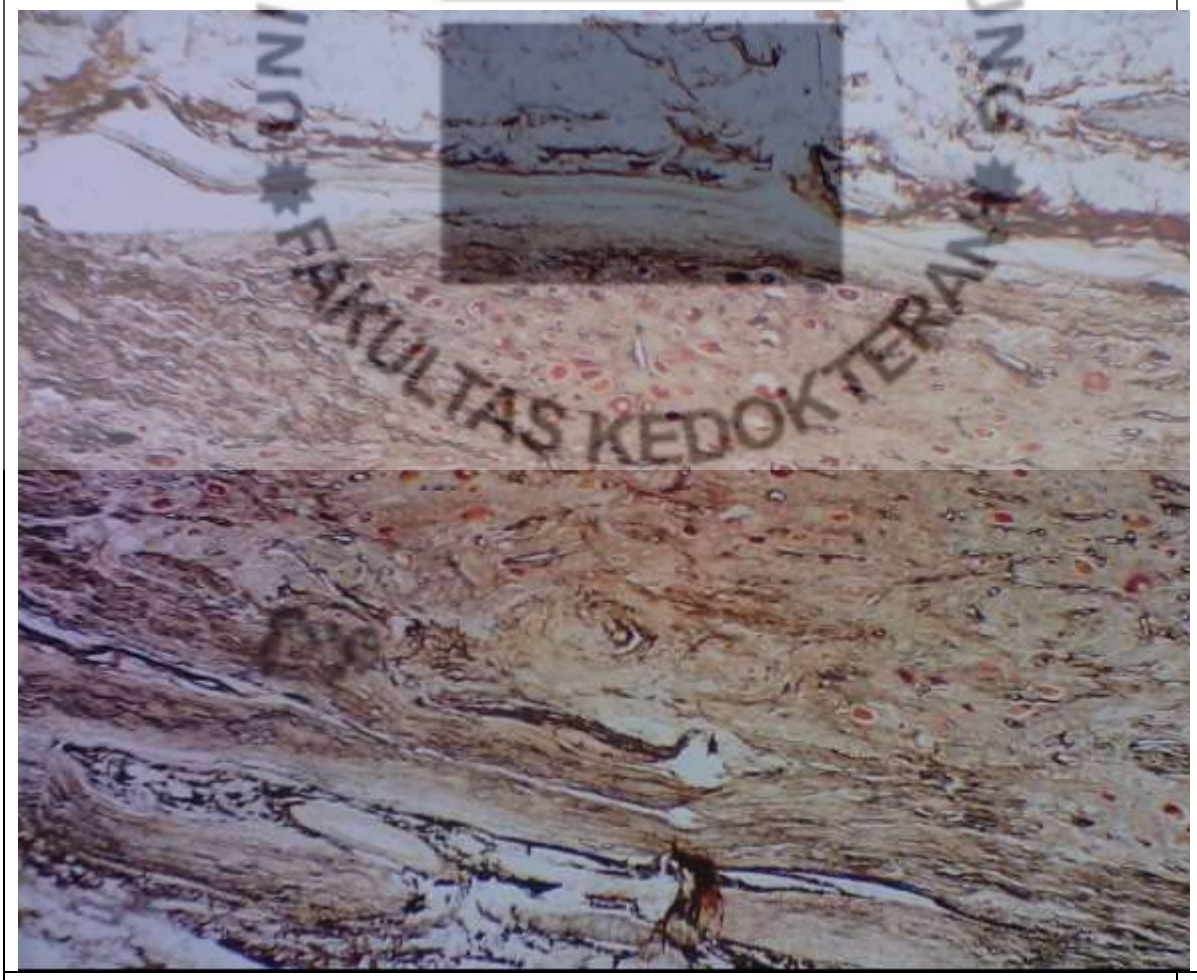
II. Ganglia	
1. Ganglia - Indentify part of sensorik ganglia: ganglia cells (1000X), capsula	



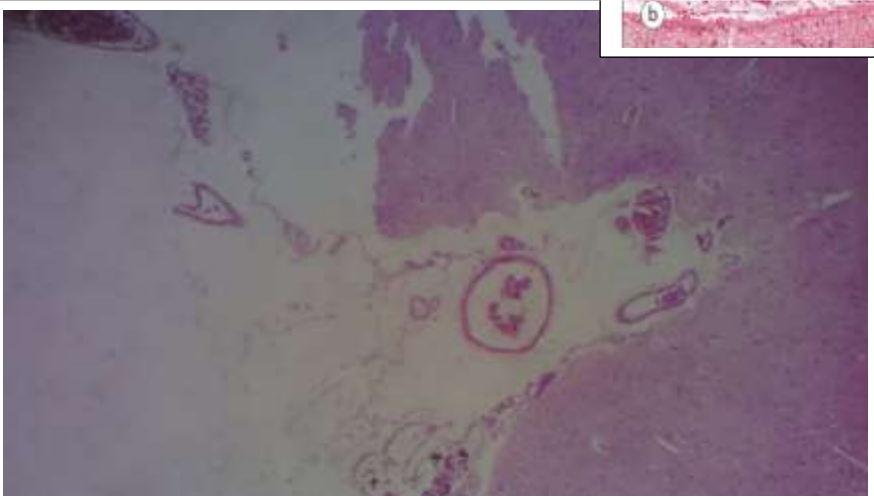
Draw!
1000X



2. Autonomic ganglia

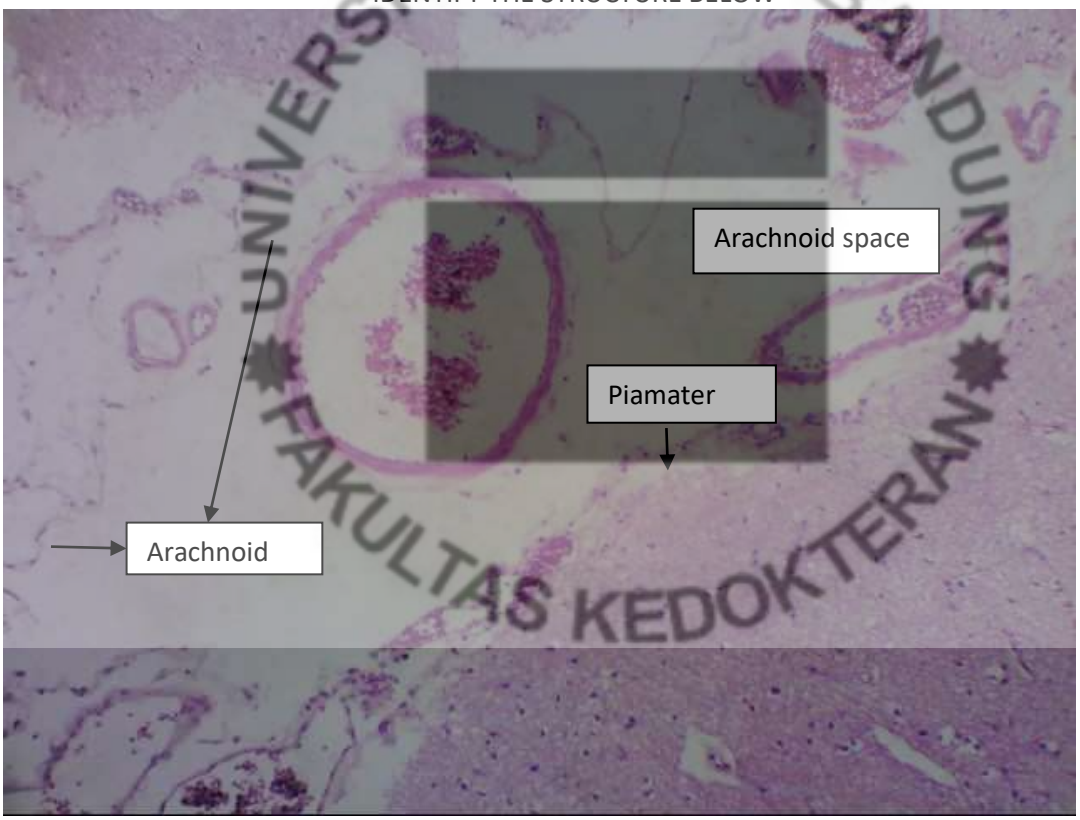


III. Meningens	
Cerebrum slide. - Identify piamater and arachoid at cerebrum surface - Identify arachnoid space DRAW 40X	



Draw 1000X

IDENTIFY THE STRUCTURE BELOW



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