Done by:

H I S T I C S T e a m

Part Four:

Nervous Tissue

Table of Contents

1.Nervous Tissue

- One of the four basic tissues.
- Generates, conducts & transmits impulses.
- Organized anatomically into:
  I. **Central Nervous System** *(CVS)* : Brain and spinal cord.
  II. **Peripheral Nervous System** *(PNS)* : cranial nerves, spinal nerves and ganglia, outside CNS.
  - PNS is divided functionally into:-
    1. **Sensory** component. (afferent, to the CNS) – have ganglia.
    2. **Motor** component (efferent, from CNS to effector organs), further subdivided into:
       a. Somatic system: (directly from CNS to skeletal muscles via a single neuron)
       b. Autonomic system: (CNS → **ganglia** → smooth or cardiac muscle, glands)
- A collection of nerve fibers in PNS: nerve.
- A collection of nerve fibers in CNS: tract.

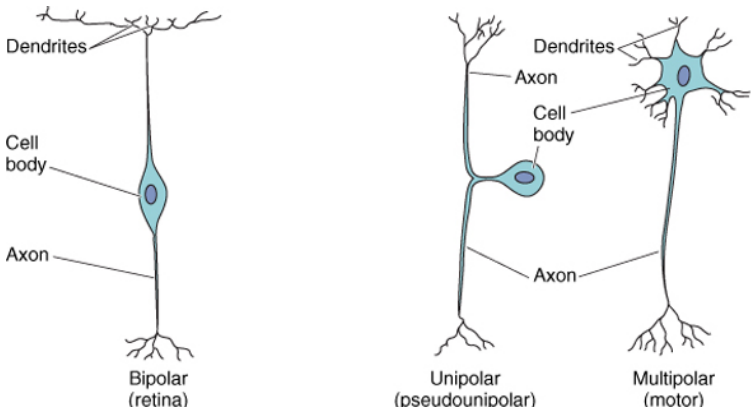
2. Components of Nervous Tissue

- Consists of 10% neurons and 90% neuroglial cells.
- **Neurons:** responsible for the receptive, integrative, and motor functions of the nervous system.
- **Neuroglial cells**: support and protect neurons. (They can divide, in contrast to neurons)

2.1 Neurons

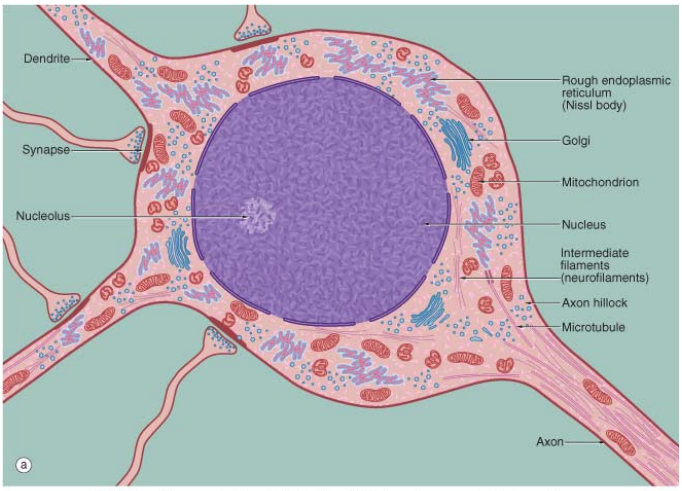
- Consists of:-
  1. Cell body (Perikaryon)
  2. Cytoplasmic processes:-
     - Dendrites
     - Axon

- Divided according to the number of processes arising from the cell body into:-
  1. **Bipolar:** two processes (dendrite + axon). – Spindle (fusiform) shaped.
     - (e.g. specialized sensory cells, like olfactory epithelium)
  2. **Multipolar:** More than two processes (many dendrites, one axon)
     - *Most common form*. Forms most of CNS
     - (e.g. sympathetic ganglia).
     - Can be: - star-shaped *e.g.* sympathetic ganglia, anterior horn cells
       - pyramidal. *e*.g. motor area in cerebrum that controls skeletal muscles
         Largest in soma diameter.
       - pysiform (pear shaped). *e.g.* cerebellum
  3. **Pseudounipolar:** *(unipolar)*: One process dividing into two (e.g. spinal ganglia). – spherical shape.



2.1.1 The Neuron Cell Body (soma, perikaryon)

- **Cell body:** Large, variable according to activity.
- **Cytoplasm:**
  - Basophilic.
  - Abundant RER and polyribosomes (appear as basophilic clumps called **Nissl bodies**)
    - Present in cell body & wide dendrites but absent in axon and axon hillock.
  - Abundant sER that forms **hypolemmal cisternea**.
  - Prominent golgi complex with dilated ends.
  - Lysosomes present.
  - Rich in slender mitochondria with longtidunally arranged cisternea. (abundant in axon terminal).
  - Most have only **one centriole** associated with a basal body of cilium.



  - **Cytoskeleton:** neurofibrils, found in all parts of a neuron. They can be:
    – microtubules (E/M)
    – neurofilaments (intermediate) (L/M, with silver stain, E/M)
    – microfilaments (actin) (E/M)
  - **Cytoplasmic Inclusions:** – lipofuscin pigment granules (aging granules) – few lipid droplets.
    – melanin granules (as a byproduct of neurotransmitter reactions). In substantia negra.
- **Nucleus:** – Large – centrally located – vesicular open-face – with euchromatin – prominent nucleolus.
  - Nucleus can be physiologically eccentric in an exception. *e.g.* sympathetic ganglia.
- Neurons do not divide

2.1.2 Dendrites

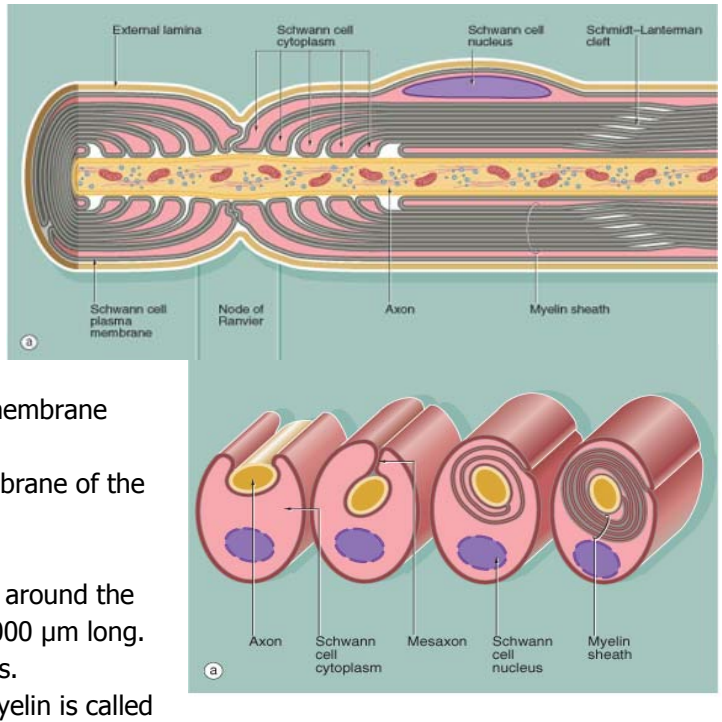
- Each dendrite arises from the neuron cell bodies as a single short elaboration that branches several times (becoming thinner), tapering at the end.
- Contains: RER, SER, neruofibrils, and mitochondria. But does NOT contain golgi complex.
- Can be one or more in a neruron.
- Receive stimuli from sensory cells, axons and other neurons, and transmit impulses into the soma.

2.1.3 Axons

- A single, thin, long process extending from the cell body. (only one in a neuron)
- It carries impulse away from the soma.
- Arises at the **axon hillock**, which is a pyramid-shaped region of the soma with no ribosomes.
- Some axons have collateral branches.
- An axon may branch at the end forming **terminal arbors.**
- It ends by dilations known as **axon terminals** that synapse with other neurons, muscles or glands.
  - Axon terminals are also known as *end pulps* or *terminal boutons*. And contain a lot of mitochondria.
- Axoplasm (cytoplasm of axons) have SER, mitochondria, many microtubules and microfilaments.
  - lacks RER, ribosomes and golgi apparatus.
- They have Schwann cells (are neurolemmated) in PNS, and can be:
  1. Myelinated neurolemmated axon (with myelin sheath) may be sensory or motor.
  2. Unmyelinated neurolemmated axon (without myelin sheath) may be sensory or motor.
     - *E.g.* postganglionic neurons.
- In CNS, they don't have Schwann cells around them (not neurolemmated)
  - Can be myelinated (white matter), or umyelinated (grey matter).

2.2 Schwann cells

- They are located only in PNS, around axons, and form either myelinated or unmyelinated sheath.
- The Schwann cells of myelinated axon in PNS form myelin sheath around the axon.
- In the unmyelinated axon a Schwann cell supports several axons without forming myelin sheath
- Schwann cells have a basal lamina.
- They are flattened cells with flattened nuclei, containing a small Golgi apparatus, and a few mitochondria.
- **Function:** 1- Insulation. 2- Regeneration and synthesis of myelin.



2.2.1 Myelinated Axon

Myelin Sheath

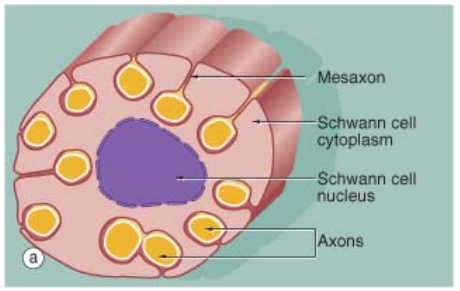
- Myelin sheath is concentric layers of the Schwann cell membrane around the axon
- It contains the phospholipids & proteins of the cell membrane of the Schwann cell

In myelinated axon:

- Each Schwann cell forms one segment of myelin sheath around the axon called **internode**.. Each internode is about 200-1000 µm long. A Schwann cell can wrap several times around the axons.
- Schwann cell cytoplasm trapped within the lamella of myelin is called *cleft of Schmidt-lanterman*.
- Between internodes is a gap called node of Ranvier where there is no myelin sheath (between 2 schwann cells)

2.2.2 Unmyelinated Axon

- Successive Schwann cells surround the axon without forming myelin sheath
- Many axons are found in deep grooves on the surface of a single Schwann cell
- They are smaller than myelinated axons



2.2 Neuroglial cells

- Neuroglia are the supporting cells of the nervous tissue in the CNS.
- They can never transmit impulses.
- Types of neruroglial cells
  1. Schwann cells (in PNS)

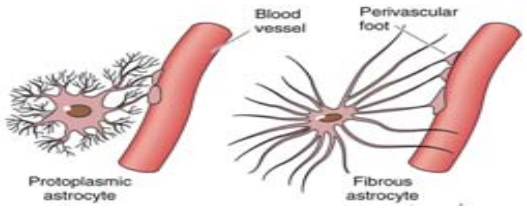
  The rest are in CNS:-

  2. Astrocytes
  3. Oligodendrocytes
  4. Microglia
  5. Ependymal cells

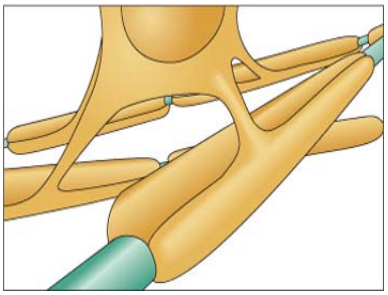
2.2.1 Astrocytes

- The largest of all neuroglia with a star shape and a large nucleus.
- Have cytoplasmic processes which support neurons & the blood vessels
- **Functions:**
  1. The hunt ions, neurotransmitters and other remnants released into the extracellular space.
  2. Form the Blood-brain barrier
  3. Provides neurons with nutrition by releasing glucose from stored glycogen.
  4. Can divide & fill the places of damaged parts of CNS

- ***There are two types of astrocytes***
  1. **Protoplasmic astrocytes**: have many short-branching processes. Found in *gray matter* of CNS supporting the nerve cell bodies, the axons & the blood vessels.
  2. **Fibrous astrocytes**: have long unbranched processes. Found in *white matter* supporting the axons & the blood vessels.



2.2.2 Oligodendrocytes



- Found in gray & white matter of the CNS
- Small cells with few cytoplasmic processes
- Each cytoplasmic process forms a separate myelin segment (internode)
- Darkest neruoglial cell.
- Rich in RER, ribosomes, golgi apparatus and mitochondria.
- Each oligodendrocyte forms myelin sheath for many axons in CNS (similar to Schwann cells in PNS).
- Have no basal lamina.

2.2.3 Microglial cells


Microglia

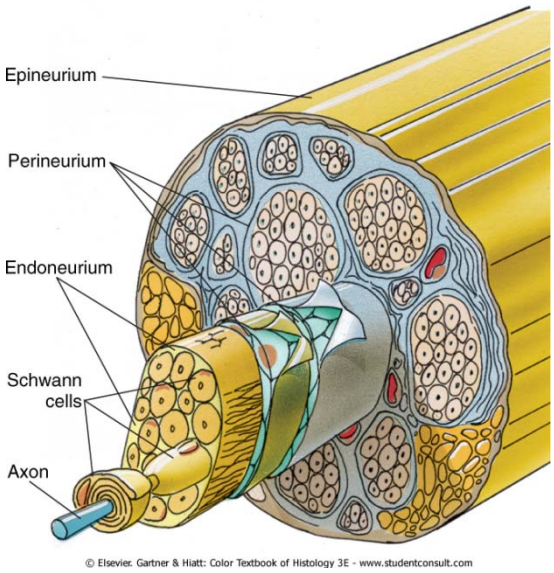
- Found in gray & white matter
- Small cell with oval nucleus
- Show irregular short cytoplasmic processes
- Phagocytic cell (of debris and damaged brain tissue) and act as antigen-presenting cells.
- Originate from monocytes in bone marrow (unlike other neuroglial cells, that originate from nueral tubes

2.2.4 Ependymal cells

- Columnar Ciliated cells (to facilitated CSF movement)
- Lining the ventricles of the brain & central canal of spinal cord
- In the ventricles they secrete the cerebrospinal fluid.
- Derived from neuroepithelium.

3. Peripheral Nerve

- Contains parallel bundles of axons containing both motor & sensory axons.
- Each bundle contains myelinated & umyleinated axons
- No nerve cell bodies
- Covered by connective tissue, which can be divided into:
  1. Epineurium:- external layer of dense fibrous irregular CT covering the nerve.
  2. Perineurium:- dense CT (thinner than epineurium) lined with several epithelioid cells layers of flat cells with tight junctions (zonulae occludentes) & basal lamina. Surrounds each bundle of axons.
  3. Endoneurium:- innermost layer of loose areolar reticular CT around each Schwann cell covering the axon. (usually synthesized by Schwann cells).



3.1 Ganglia

- Ganglia are groups of neuron cell bodies outside the CNS. (*in CNS, called neurons except basal ganglia)*.
- Types of ganglia:-
  1. Dorsal root (spinal) ganglia
  2. Autonomic ganglia (e.g. Sympathetic ganglia)

3.1.1 Dorsal Root Ganglion

(Spinal Ganglion)

- Contains pseudounipolar neurons in groups. (spherical) (so no synapse between cells).
- Each neuron is surrounded by a capsule of supporting cells called satellite (capsule) cells within irregular dense fibrous CT.
- Contains myelinated axons
- Cell body size is variable, shape is spherical with central nucleus.
- Fewer in number than sympathetic ganglia.
- Sensory ganglion

3.1.2 Sympathetic Ganglion

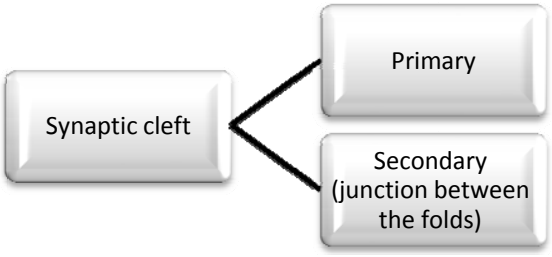
- Contains multipolar neurons separated by spaces containing unmyelinated axons
- Capsule of satellite cells is not thinner than in spinal ganglia, because of dendrites scattering satellite cells
- Cell bodies contain eccentric nuclei
- It is a motor ganglion
- Contains synapses

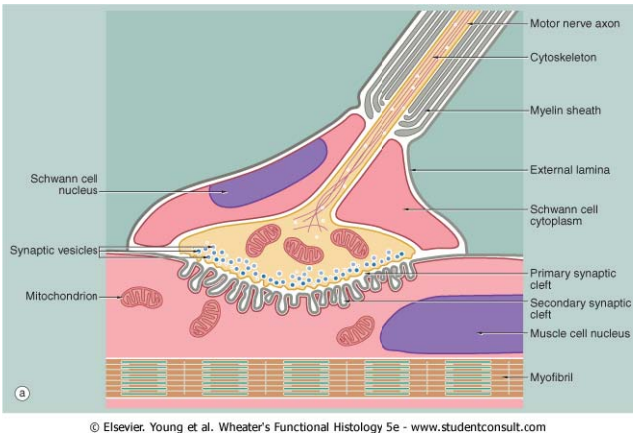
4. Synapse and Nerve Endings

- Synapse is the point of contract between the end of the axon & another neuron, muscle or gland cell.
- Synapse transmits impulses from the axon to another cell
- Types of synapses
  1. Chemical synapse:- (in CNS & PNS) Needs a chemical (neurotransmitter) to transmit impulses
  2. Electrical synapse:- (Only in the CNS) as gap junctions between axon & the other neuron in CNS.

4.1 Chemical Synapse

- The chemical synapse consists of four components:
  1. Presynaptic membrane is the membrane of the end of the axon
  2. Postsynaptic membrane is the membrane of the other cell e.g. Neuron
  3. Synaptic cleft is a space between the two membranes
  4. Synaptic vesicles in the axon secrete the neurotransmitter into the synaptic cleft
- Types of Chemical Synapses
  1. Axosomatic synapse It occurs between axon & cell body.
  2. Axodendritic synapse It occurs between axon & dendrite.
  3. Axoaxonic Synapse It occurs between axon & another axon.





4.2 Nerve Endings

- Terminations of axons in epithelium, CT or muscle
- There are 2 types of nerve endings:-
  1. Motor nerve endings (somatic OR autonomic)
  2. Sensory nerve endings

A) Motor nerve endings

4.2.1 Somatic motor nerve ending

Motor end Plate (Neuromuscular junction)

- Synapse of a motor axon with a skeletal muscle fiber at synaptic cleft.
- The axon of a single neuron divides to supply more than 100 muscle fibers
- The axon terminal is numerous in mitochondria.
- Neuron cell body originates in the CNS (ventral horn of spinal cord).
- Neuron & muscle fibers it supplies is called a motor unit

(*See* 4.2.3.2 Muscle Spindle)

4.2.2 Autonomic motor nerve endings

- Synapses of axons in cardiac muscle, smooth muscle, or gland.
- The cell bodies of these axons are located in autonomic ganglia.

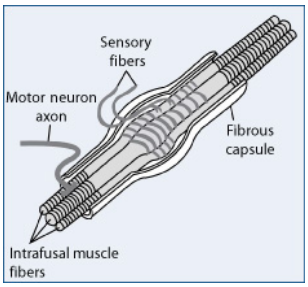
B) 4.2.3 Sensory nerve endings

- Terminations of axons in epithelium , CT or skeletal muscle
- The neuron cell bodies of these axons are located in the spinal & cranial nerve ganglia.
- They are afferent into the CNS.
- **E.g. 1)** Pacinian corpuscle. **2)** Muscle Spindle

4.2.3.1 Pacinian corpuscle

- Pressure receptor found in the skin
- Oval in shape, covered by a CT capsule which is lost along with the neureolemmal sheath and myelin as it enters the corpuscle.
- The end of the axon is umyelinated in the center of the corpuscle
- Many layers of flattened cells surround axon & there is tissue fluid between the layers

4.2.3.2 Muscle spindle



- Spindle-shaped (cylindrical).
- covered by an acidophilic CT capsule
- Supplied by afferent & efferent fibers but acts sensory (receives effectors from CNS)
- Stretch receptor found in skeletal muscle
- Contains small muscle fibers called intrafusal fibers surrounded by sensory axons.
- Central portion of intrafusal fibers contains nuclei, and is of two types:-
  1. Nuclear chain (more numerous fibers) up to 9 or 11.
  2. Nuclear bag (longer fibers)
- Lateral part of intrafusal fibers contains cross striations that are less dominant than that of extrafusal fibers (see below), therefore contractile units are the lateral parts.
- The muscle fibers outside the muscle spindle are called extrafusal muscle fibers supplied by motor axons. They are much larger in diameter than intrafusal fibers. And they are formed from spindle.