

Histology of Nervous Tissue, Medulla Spinalis and Brain Stem

Assoc.Prof. E.Elif Güzel, M.D.

Nervous Tissue

- 2 cell types:
 - Nerve cells (neurons)
 - receive or transmit impulses
 - interconnections (at least 1000 each)
 - Neuroglial cells
 - more numerous than neurons
 - support neurons in various ways
- Capillaries
- No lymphatics!

Neurons

- **cell body (perikaryon or soma):**
 - large euchromatic nucleus- prominent nucleolus
 - Nissl bodies
 - neurofibrils; microtubules, neurofilaments, microfilaments
- **multiple dendrites:**
 - short processes receive multiple stimuli
 - becomes thinner as they subdivide into branches
- **single axon (varying diameter, up to 1 m in length):**
 - constant diameter
 - axon terminals (end bulbs-terminal boutons) form synapses to transmit the impulse to other neurons or cells

- **Neurons** are variable in size (5-150 μm)- shape (spherical, angular)

- According to the arrangement of their processes

Bipolar neurons; located in the olfactory epithelium, vestibular and cochlear ganglia

Unipolar (or pseudounipolar) neurons; dorsal root (spinal) ganglia

Multipolar neurons; the most numerous

- According to their function

Sensory (afferent) neurons:

convey impulses from receptors *to CNS*

Motor (efferent) neurons:

convey impulses from CNS or ganglia *to muscles, glands and other cells*

Interneurons:

located in CNS, establish networks of neuronal circuits (%99 of all neurons)

- A, typical motor neuron
- B, electron micrograph of a motor neuron

Synapses

- Sites of impulse transmission between the pre- and postsynaptic cells
- According to the way of impulse transmission...
 - Electrical synapses (uncommon in mammals)
 - Chemical synapses (by the release of neurotransmitters)
- According to the neurotransmitter released...
 - Excitatory
 - Inhibitory

Chemical Synapse Transmission

- ***Clinical correlations:*** Tetanus toxin and Clostridium botulinum neurotoxin B selectively block synaptic vesicle exocytosis.

Axonal (or dendritic) transport systems

- Anterograde transport; carries material from perikaryon to periphery.
- Retrograde transport; carries material from periphery to perikaryon.
- Microtubule-associated motor proteins using ATP is involved in the transport.
- Anterograde transport is mediated by kinesin, retrograde transport is mediated by dynein.

Neuroglial Cells

- Functions:
 - physical support for neurons
 - production of myelin
 - repair of neuronal injury
 - metabolic exchange between blood vessels and the neurons

Peripheral neuroglia

Schwann cells

Satellite cells

Enteric neuroglia

Müller's cells

Central neuroglia

Astrocytes

Oligodendrocytes

Microglial cells

Ependymal cells

Schwann cells

- Function:
 - Support myelinated and unmyelinated nerve fibers in the PNS
 - Produce the myelin sheath in the PNS
 - Aid in cleaning up the PNS debris
 - Guide the regrowth of PNS axons.
- Single Schwann cell myelinate only one axon
- Schwann cell can envelope several unmyelinated axons
- Schwann cell is covered by a basal lamina

Satellite cells

- Small cuboidal cells surrounding the neurons in the ganglia.
- Provide a controlled microenvironment around the neuron.

The various types of central neuroglial cells

Astrocytes

- Largest of the neuroglial cells
- Star-shaped cells with multiple processes
- Function;
 - provide structural and metabolic support for neurons
 - maintain the blood-brain barrier
- Contains bundles of intermediate filaments (glial fibrillary acidic protein)
- Exists as two types;
 - Protoplasmic astrocytes in the gray matter
 - Fibrous astrocytes in the white matter

Protoplasmic Astrocytes

- Tips of some processes (vascular feet) come into contact with blood vessels (blood-brain barrier).
- At the surface of brain and medulla spinalis, processes contact the piamater (subpial feet) to form the pia-glial membrane (glia limitans).

Fibrous Astrocytes

- Cells with relatively few, long and straight processes
- Closely associated with blood vessels

Oligodendrocytes

- The darkest staining neuroglial cell
- Produce the myelin sheath in CNS

Microglial cells

- Originate in bone marrow
- Member of the mononuclear phagocyte system
- Function;
 - Clear debris and damaged structures in CNS
 - Antigen-presenting cells

Anatomical Organization of the Nervous System

Central nervous system (CNS)

- brain
- spinal cord

Peripheral nervous system (PNS)

- peripheral nerves
 - cranial nerves (emanate from the brain),
 - spinal nerves (emanate from the spinal cord),
- ganglia (collections of nerve cell bodies outside the CNS)
- receptors

Functional Organization of the Nervous System

- **Sensory (afferent) component;** receives and transmits impulses to the CNS for processing
- **Motor (efferent) component;** originates in the CNS and transmits impulses to the effector organs
 - **Somatic nervous system**
 - voluntary motor innervation (except reflex arcs)
 - **Autonomic nervous system**
 - involuntary motor innervation to viscera
 - afferent sensory innervation from the viscera (pain)

Central Nervous System

- Spinal cord (Medulla Spinalis)
 - Brain
- 
- gray matter
 - white matter
 - no intervening conn. tissue

White matter;

- Myelinated/ few unmyelinated nerve fibers
- Glia
- Capillaries
- White color results from the myelin

Gray matter;

- Neuronal cell bodies
- Dendrites
- Initial unmyelinated portions of axons
- Glia
- Capillaries

Neuropil??

- network of the axons, dendrites and neuroglial processes in the gray matter

Nuclei???

- aggregations of neuron cell bodies embedded in white matter
- counterpart of ganglia

- **Spinal Cord**

- gray matter lies centrally where it forms an H shape in cross-section
- white matter is located in the periphery

- **Brain**

- gray matter
 - periphery (cortex) of the cerebrum and cerebellum
 - basal ganglia
- white matter lies deep to the cortex

Spinal Cord

- Gray matter
 - the butterfly-shaped (H-shaped) area in cross-section
- White matter
- Central canal

- **Dorsal (posterior) horns:**
 - the upper vertical bars of the H
 - receive central processes of the sensory neurons whose cell bodies lie in the dorsal root ganglion
 - contain cell bodies of interneurons
- **Ventral (anterior) horns:**
 - the lower vertical bars of the H
 - house cell bodies of large multipolar somatomotor neurons whose axons make up the ventral roots of the spinal nerves
- **Intermediary column:** visceromotor neurons

- **Multipolar motor neurons**
 - Located in ventral horns
 - Large, basophilic cells
 - Large, spherical, pale staining nucleus
 - Prominent nucleolus

Central canal

- remnant of the lumen of the embryonic neural tube
- lies in the center of the crossbar of the H
- lined by low columnar- cuboidal cells (ependymal cells)

Ependymal cells

- Low columnar- cuboidal cells lining the central canal of the spinal cord and the ventricles of the brain
- Apical surface- microvilli, in some regions ciliated
- Tight junctions
- Lack an external lamina, contact with astrocyte processes

- Spinal cord is divided into 31 segments
- Each segment of the cord is connected to a pair of spinal nerves by dorsal and ventral roots

References

1. Histology: A Text and Atlas by Michael H. Ross, Wojciech Pawlina (2010). 6th ed. Lippincott Williams & Wilkins, Philadelphia. ISBN: 978-0-7817-7200-6
2. Basic Histology: Text & Atlas by Luiz Junqueira, Jose Carneiro (2005). 11th ed. McGraw-Hill, New York. ISBN: 0-07-111888-8
3. Color Textbook of Histology by Leslie P. Gartner, James L. Hiatt (2001). 2nd ed. W.B. Saunders Company, Philadelphia. ISBN: 0-7216-8806-3
4. Histology and Cell Biology: An Introduction to Pathology by Abraham L Kierszenbaum, Laura Tres (2011). 3rd ed. Elsevier Saunders, Philadelphia. ISBN: 978-0-323-07842-9
5. Netter's Essential Histology by William K. Ovalle, Patrick C. Nahirney (2007). 1st ed. Elsevier Saunders, Philadelphia. ISBN: 978-1-929007-86-8