Histology of the Peripheral Nervous System

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• Peripheral nervous system (PNS)
  – peripheral nerves
  – ganglia
  – receptors
Peripheral Nerves

- Bundles of nerve fibers surrounded by connective tissue
  - cranial nerves
  - spinal nerves
- A bundle has both sensory and motor components, myelinated and unmyelinated fibers together
Connective Tissue Investments of Peripheral Nerves

- epineurium
- perineurium
- endoneurium
Epineurium

- Covers the entire peripheral nerve
- Dense, irregular, collagenous connective tissue
- Contains blood vessels, may contain some fat cells
- Continuous with the dura mater
Perineurium

- Covers each bundle (fascicle) within the nerve
- A unique connective tissue thinner than epineurium
- Perineurial cells
  - several layers of squamous cells joined by tight junctions
  - constitutes blood-nerve barrier
  - external lamina on both surfaces
  - contractile (actin filaments)
- Blood-nerve barrier isolates the neural environment
- Longitudinally oriented collagen fibers between the layers of cells
Endoneurium

- Surrounds individual nerve fibers
- Is in contact with and surrounds the basal lamina of the Schwann cells
- A loose connective tissue
  - thin layer of reticular fibers, fibroblasts, macrophages, capillaries
Classification of Nerves

• Functionally, the PNS is divided into
  1) Sensory (afferent) component; receives-transmits impulses from skin-viscera to the CNS
  2) Motor (efferent) component; CNS to effector organs.
• According to the myelination, nerve fibers are classified into
  1) Myelinated
  2) Unmyelinated
Myelinated fibers

- Myelin is a whitish lipoprotein complex
- Formed by the wrapping of the plasmalemma of the Schwann cell around the axon in PNS.
Myelination in PNS

• Function:
  – provides the electrical insulation of neurons
  – ensures the rapid conduction of impulses

• The outer mesaxon; connection of the outer plasmalemma with the myelin sheath

• The inner mesaxon; connection of the inner plasmalemma (adjacent the axon) to the myelin sheath

• Myelin sheath express myelin specific proteins (MSP); Protein 0, peripheral myelin protein, myelin basic protein
• **Nodes of Ranvier**: gaps in the myelin sheath between two neighbouring Schwann cells along the length of the axon.

• **Clefts of Schmidt-Lanterman**: are the oblique interruptions of the myelin sheath because of Schwann cell cytoplasm trapped within the lamellae of myelin.
Myelination in CNS

• Oligodendrocytes produce the myelin sheath in the CNS

• Different from PNS in several ways:

1. Single oligodendrocyte wrap segments of several axons

2. Oligodendrocytes express different myelin-specific proteins
   - proteolipid protein (PLP),
   - myelin oligodendrocyte glycoprotein,
   - oligodendrocyte myelin glycoprotein

3. Oligodendrocytes don’t have an external lamina

4. Nodes of Ranvier in the CNS are larger than those in the PNS
Unmyelinated fibers

- axons of small diameter are usually unmyelinated
- in CNS; not embedded in oligodendrocytes
- in PNS; enveloped within simple grooves of the Schwann cells
- A single axon or a group of axons may be enclosed in a single invagination of the Schwann cell surface.
• In myelinated fibers action potential “jumps” from node to node, a process called **saltatory conduction**
• Unmyelinated fibers; continuous conduction of the impulse (slower and requires more energy than the saltatory conduction)
• **According to the extent of myelination,** peripheral nerve fibers are classified into three major groups
PNS is further subdivided as:

- **Somatic system;**
  - impulses are transmitted via a single neuron

- **Autonomic system;**
  - impulses are first transmitted to an autonomic ganglion
  - a second neuron originating in the ganglion transmits the impulses to organs
Somatic Nervous System (SNS)

- The multipolar cell bodies are located in the
  - motor nuclei of the cranial nerves embedded within the brain
  - ventral horn of the spinal cord
- Axons travel via the peripheral nerves to the skeletal muscle
Autonomic Nervous System (ANS)

- Provides motor impulses to organs and glands
- Possesses two neurons
  - Preganglionic neurons;
    - cell bodies are located in the CNS
    - axons are myelinated
  - Postganglionic neurons;
    - cell bodies are located in autonomic ganglia
    - axons are unmyelinated
- ANS is composed of 2 parts
  - Sympathetic nervous system
  - Parasympathetic nervous system
Sympathetic nervous system

- Preganglionic fibers are short, postganglionic fibers are long
- Cell bodies of the preganglionic neurons are located in the lateral column of T and L segments of the spinal cord

- Axons exit via the ventral roots
- Spinal nerve
- White rami connectors
- Sympathetic ganglia (multipolar cell bodies of the postganglionic nerves)
- Gray rami connectors
- Spinal nerve
- Effector organs
Parasympathetic nervous system

• Preganglionic fibers are long, postganglionic fibers are short

• Originates in the brain stem and the sacral segments of the spinal cord (S2-S4) (craniosacral division of ANS)

• Cell bodies of preganglionic parasympathetic neurons originating in the brain lie in the visceromotor nuclei of the cranial nerves III, VII, IX, X.

• Cell bodies of preganglionic parasympathetic neurons originating in the sacral spinal cord are located in the lateral column of ventral horn

• Axons project to terminal ganglia (Meissner’s and Auerbach’s plexuses) to synapse with the postganglionic neurons.
Receptors

- Specialized structures located at the distal tips of the sensory neurons.
- Initiate an impulse in response to a stimulus.
- Classified as:
  - **Exteroceptors** react to stimuli from the external environment (touch, temperature, smell, sound and vision)
  - **Interoceptors** react to stimuli from within the body (the degree of filling of the alimentary canal, urinary bladder)
  - **Proprioceptors** react to stimuli from within the body, provide sensation of body position and muscle tone
• Free nerve endings
  (mostly found in epithelium)
• Encapsulated nerve endings with connective tissue sheaths are located mostly in the skin (Krause’s end bulb, Ruffini’s corpuscles, Meissner’s corpuscles, Pacinian corpuscles) and skeletal muscle.
Ganglia

• Aggregations of the neuronal cell bodies in PNS
• Ovoid structures surrounded by a capsule
• 2 types:
  – Sensory ganglia
  – Autonomic ganglia
• Consists of
  – neuronal cell bodies
  – the nerve fibers leading to and from them
  – satellite cells
  – connective tissue
Sensory Ganglion

- Two types;
  - Cranial ganglia (associated with cranial nerves)
  - Spinal ganglia (dorsal root ganglia)

- **Spinal ganglia**
  - A capsule and a connective tissue framework support the ganglion cells
  - House unipolar (pseudounipolar) cell bodies of sensory neurons
  - Satellite cells
    - small cuboidal cells surrounding the neuronal cell bodies in the ganglia
    - form a complete layer around the cell body

- No synapse in sensory ganglia!
Autonomic (Visceral) Ganglion

- House multipolar cell bodies of postganglionic nerves
- When compared with spinal ganglia
  - The capsule is thinner
  - Contains more connective tissue among the cells
  - Less ganglion cells
  - Few and irregularly arranged satellite cells
Degeneration and Regeneration of a Nerve

• What happens if a peripheral nerve fiber is cut???
• Cut ends should remain near each other for regeneration to be successful!!
• A: Normal
• B: When the fiber is injured,
  ➢ Macrophage infiltration
  ➢ Chromatolysis
  ➢ Wallerian degeneration
• C: Schwann cells proliferate, forming a compact tube which guides the growth of the axon
• D: Muscle fiber gets the nerve stimuli and regenerates as well.
• E: When the axon does not penetrate the tube of Schwann cells, its growth is not organized.
• Neuronal damage in the CNS is irreparable;
  – injured cells within the CNS are phagocytosed by microglial cells
  – glial scar occupies the liberated space
References


