NERVOUS TISSUE Part 1

Dr. Larry Johnson
Texas A&M University
Objectives

Part 1

• Describe the components of a neuron.
• Distinguish between neurons and glial cells.
• Identify the components of the meninges, grey and white matter.

Part 2

• Recognize peripheral nerves and identity their structural components (in longitudinal and transverse sections); understand the structural and functional differences between myelinated and unmyelinated fibers with both light microscopy and electron micrographs.

From: Douglas P. Dohrman and TAMHSC Faculty 2012 Structure and Function of Human Organ Systems, Histology Laboratory Manual
Four Basic Types of Tissues in the Body

- **Epithelium** (90% of tumors)
- **Connective Tissue**
- **Muscular Tissue**
Four Basic Types of Tissues in the Body

- **Epithelium** (90% of tumors)
- **Connective Tissue**
- **Muscular Tissue**
- **Nervous Tissue**
Nerve is like Epithelium

Origin of nerve is ectoderm

like epidermis (epithelium) of skin
Nervous Tissue

Functions: specialized for the transmission, reception, and integration of electrical impulses

Distinguishing features: Neurons – very large excitable cells with long processes called axons and dendrites. The axons make contact with other neurons or muscle cells at a specialization called a synapse where the impulses are either electrically or chemically transmitted to other neurons or various target cells (e.g., muscle). Others secrete hormones.
Nervous tissue

**Distribution:** comprise the central nervous system.

Individual peripheral nerves are found throughout the body. Individual neurons and clusters of neurons (called **ganglia**) are found in most organs.
Function of the Nervous System is Communication

Dependent upon special signaling properties of neurons

Long processes of neurons (e.g., 1 meter motor neuraxon)
Function of the Nervous System is Communication

Characteristics of neurons

**Irritability** - protoplasm capable to react to various physical and chemical agents

**Conductivity** - ability to transmit the resulting excitation from one locality to another
Activity of the Nervous System

Information

**Receive**: receptors $\rightarrow$ afferent pathway

**Process**: CNS (centralization is paramount)

**Transmit**: efferent pathways $\rightarrow$ effect

Voluntary (conscious) = **somatic**

Involuntary = **autonomic**

- Sympathetic - fight or flight
- Parasympathetic - vegetative
CNS & PNS divisions

• Central Nervous System (CNS)
  • Brain and spinal cord
    • Grey matter (neuron’s somas and some processes)
    • White matter (myelinated and unmyelinated axons)
      • Myelination is from oligodendrocytes
      • Glial cells:
        • Astrocytes
        • Microglial cells
          Part of the blood-brain barrier (BBB)

• Peripheral Nervous System (PNS)
  • Nerves, sensory ganglia, and autonomic ganglia (or plexus)
  • Schwann cells: myelin producing glial cells of the PNS
Slide 3: Cerebral cortex (Luxol fast blue)

- Grey matter
- White matter
- Neuropil
- Neuron with large nucleus containing a large nucleolus
- Neuroglia support cell
Neuropil = felt-work of a complex and highly ordered meshwork of dendritic, axonal, and glial processes whose entanglements facilitate an ordered activity important in the communications function of the nervous system. The neuropil provides an enormous region for synaptic contact and functional interactions among nerve cell processes.
Cajal staining method
- Used to visualize: the numerous stellate processes of fibrous astrocytes and neurons
INTERMEDIATE FILAMENTS of cells
FIVE CLASSES (not conserved)
KERATIN - INSOLUBLE SUBSTANCE, EPITHELIUM
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DESMIN – CYTOSKELETON IN MUSCLE

VIMENTIN - NUCLEAR ENVELOPE SUPPORT AND STABILITY OF MESENCHYMAL CELL
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DESMIN – CYTOSKELETON IN MUSCLE

VIMENTIN - NUCLEAR ENVELOPE FOR MECHANICAL SUPPORT AND STABILITY OF ITS LOCATION IN CELL, MESENCHYMAL CELL
INTERMEDIATE FILAMENTS
FIVE CLASSES con’t
NEUROFILAMENTS
• DENDRITES AND AXONS OF NERVE CELLS
• INTERNAL SUPPORT - GELATED STATE OF CYTOPLASM
INTERMEDIATE FILAMENTS

FIVE CLASSES con’t

NEUROFILAMENTS

• DENDRITES AND AXONS OF NERVE CELLS
• INTERNAL SUPPORT - GELATED STATE OF CYTOPLASM

GLIAL FILAMENTS - ASTROCYTES
INTERMEDIATE FILAMENTS

IMMUNOFLUORESCENCE DETECTION - TOOL IN DISTINGUISHING CELL TYPE OF ORIGIN OF MALIGNANT TUMORS
Astrocytes

Intermediate filaments of GFAP (glial fibrillary acidic proteins) filament is used clinically to identify astrocytes as in the diagnostic classification of a tumor as an astrocytoma.
Spinal cord

- Posterior median sulcus
- Anterior median fissure
- Pia mater
- Posterior root
- Posterior root ganglion
- Spinal nerve
- Anterior root
- Subarachnoid space
- Arachnoid
- Subdural space
- Dura mater

Anterior view
The ependymal cells have microvilli and can have cilia. Cerebral spinal fluid (CSF) surrounds the brain and spinal cord and acts as a cushion, protecting the brain and spine from injury. The fluid is clear normally, and the pressure in the spinal fluid is important too.
Slide 4, 17, 18: Spinal Cord and Meninges
Nissl bodies = rough endoplasmic reticulum and free ribosomes (polyribosomes or polysomes for short)
Axons surrounded by dissolved myelin sheath

Axonal tracts

Grey matter

White matter

Slide 4, 17, 18: Spinal Cord and Meninges
Slide 4, 17, 18: Spinal Cord and Meninges

Dura mater
Subdural space
Arachnoid matter
Spinal nerve
Subarachnoid space
Pia mater
Slide **4, 17, 18**: Spinal Cord and Meninges

Histo 18

- Dura mater
- Subdural space
- Arachnoid matter
- Spinal nerve
- Subarachnoid space
Dorsal root ganglia
Given pseudounipolar neurons found in the dorsal root ganglia reach from the sensory detection to the spinal cord, there are no synapses of these sensory neurons in the dorsal root ganglia.
THE NERVOUS SYSTEM

CENTRAL NERVOUS SYSTEM (CNS)

• BRAIN AND SPINAL CORD

• NEURONS AND SUPPORT
  NEUROGLIA
NERVOUS TISSUE  Part 2

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THE NERVOUS SYSTEM

PERIPHERAL NERVOUS SYSTEM (PNS)

ALL NERVOUS TISSUE (NEURONS, SUPPORT CELLS, AND AXONS) OUTSIDE THE BRAIN AND SPINAL CORD
Auerbach’s Plexus ("Myenteric Plexus") is sandwiched between the two layers of smooth muscle in the muscularis externa that controls gut peristalsis.

Ganglia - collections of nerve cell bodies in PNS
Ganglia - collections of nerve cell bodies in organs

nerve cell bodies

Human pancreas

Cystic duct of monkey
Peripheral ganglion, monkey

Axons

Satellite cells

Nissl bodies

Neuron
Organization of Peripheral Nerves

Nerve fibers - axons invested by connective tissue

**Epineurum** - surrounding entire nerve

**Perineurum** - surrounding fascicles – constitutes the PNS blood barrier via **tight junctions** between fibroblasts

**Endoneurum** - between individual nerve axons
Organization of Peripheral Nerves

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Slide 6 Nerve (cross section; Bodian’s stain/lissamine red)

Bodian’s stain/lissamine red stain –
- axons and nuclei: black
- myelin: pink-red
- connective tissue: brown to black

Fascicle: group of neurons surrounded by perineurium

endneurium: surrounds each axon’s myelin sheath

Nerve: group of fascicles bound by epineurium
Unmyelinated fibers (axons) do not have a myelin sheath covering, but they are still supported by simple folds of Schwann cells.
EM 54 and 55: Nerve
Function of Myelin

Increase speed of condition
- 1 meter/sec TO 120 meters/sec

High-resistance low capacitance
- Insulator

Protection of axon
Possible nutritional role
Direct regenerating axons
SCHWANN CELL STRUCTURE / FUNCTION

Most peripheral nerves are myelinated

1 Schwann cell/1 axon for location
SCHWANN CELL STRUCTURE / FUNCTION

MOST PERIPHERAL NERVES ARE MYELINATED

1 SCHWANN CELL/1 AXON FOR LOCATION

FORMATION OF MYELIN SHEATH

- NODES OF RANVIER
- SCHMIDT-LANTERMAN CLEFTS
- NEUROKERATIN NETWORK
NODE OF RANVIER

- microtubules
- terminal "loops" of myelin
- axon
- nodal membrane of axon
- Schwann cell cytoplasm
- myelin
Slide 5: Nerve (longitudinal section)

H&E

- Stains axons, Schwann cells (neurolemmocytes), and connective tissue
- Myelin contains lipids, this is not stained and will have dissolved away during tissue preparation

Longitudinal section

Cross section

- Schwann cell nuclei
- Axons
- Neurolemma
- Node of Ranvier
- Fibroblast
Schwann cells, the principle glia of the PNS, wraps around axons of motor and sensory neurons of the PNS to form their myelin sheath.
Nerve (cross section)

- Axons
- Capillaries
- Fibroblasts of perineurium
- Neurolemma of Schwann cell
Slide 7: Myoneural junction (gold chloride/formic acid)

- Skeletal muscle fibers still stain purple to black.
Slide 7: Myoneural junction (gold chloride/formic acid)

- Skeletal muscle fibers still stain purple to black.

Skeletal muscle cells

Axons
Slide 7: Myoneural junction (gold chloride/formic acid)

- Skeletal muscle fibers still stain purple to black.
**Slide 7: Myoneural junction (gold chloride/formic acid)**

- Skeletal muscle fibers still stain purple to black.
Axonal transport

**Anterograde** - toward terminal - kinesin

**Retrograde** - toward cell body - dynein

- Tetanus toxin
- Neurotropic viruses (herpes and rabies) use path to get to cell body in CNS
Summary of the Physiological Events at the Synapse

- Arrival of action potential at axon terminal
- Opening Ca++ channels
- Influx of Ca++ into axon terminal
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- Binding of neurotransmitter to receptors on target cell
Summary of the Physiological Events at the Synapse

• Arrival of action potential at axon terminal
• Opening Ca++ channels
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• Exocytosis of neurotransmitter
• Diffusion of neurotransmitter across synaptic cleft
• Binding of neurotransmitter to receptors on target cell
• Opening of Na+ channels causing depolarization of target cell
• Removal of neurotransmitter
Acetylcholine (ACh) is the neurotransmitter released in the synaptic cleft of the motor end plate innervating muscle.

However, norepinephrine (NE) is the neurotransmitter released from most sympathetic postganglionic nerves.
Clinical Correlation

When a peripheral nerve is injured/severed, the segment of the axon distal to the injury and its myelin sheath completely degenerate and their remnants are removed by macrophages. However, Schwann cells proliferate and form cellular columns that act as guides for the regrowing axon back to the original muscle.
Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

- Douglas P. Dohrman and TAMHSC Faculty 2012 Structure and Function of Human Organ Systems, Histology Laboratory Manual - Slide selections were largely based on this manual for first year medical students at TAMHSC
The End!