Laboratory Manual in Animal Histology (Biology 134)

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EXERCISE 5: THE NERVOUS TISSUE

Introduction

The nervous tissue is a group of highly specialized cells for the reception and transmission of information that elicits appropriate responses. This is manifested in their structural and functional organization within our body.

Objectives

At the end of the exercise, the students should be able to:

1. to analyze the parts of a neuron and correlate them with their specific functions; and,
2. differentiate the types of neurons based on their morphology and deduce their functions.

I. The Neuron- cow nerve smear

The neuron is the basic anatomical and physiological unit of the nervous system. Neurons are highly variable in morphology. Use scanner or LPO to scan the entire nerve smear and look for the stellate-shaped cells that are large and stained dark blue in this slide preparation. If you have found this cell, note that it is composed of three main parts:

1. Cell Body (soma or perikaryon)- the large cytoplasm of the neuron that appears to be stellate because of the numerous extensions radiating from it.

2. Nucleus – round and appears vesicular since the chromatin granules are invisible. It has a single prominent dark nucleolus at the center.

3.Cell Processes – the so-called nerve fibers of the neuron. There are two types:

3.1. Axon - long and unbranched cytoplasmic process that is difficult to discern since it has the same length as the other type.

3.2. **Dendrites** - short and branching processes that arise from different sites of the soma. The smaller branches from these processes are again invisible unless a special stain is used to visualize them.

A. Nerve Fiber- longitudinal section

It is the actual axon of a neuron. It is long and cylindrical structure that appears as a thin dark line surrounded by a whitish membrane. Depending upon the preparation of the nerve fiber, the axon may appear black if fixed in osmium or subjected to silver technique, otherwise, it is acidophilic. Take a look at the slide and observe under HPO the following structures:

a.1. Myelin Sheath - the outer white covering of the axon. It is also called the medullary sheath.
a.2. Neurokeratin Network - a mass of fine granular structures within the myelin sheath. It is an artifact resulting from the loss of lipid during the slide preparation of the axon.
a.3. Neurilemma - the thin outermost sheath enclosing the axon. It is cellular sheath of the Schwann cell of the PNS.
a.4. Node of Ranvier - shallow constriction at certain points along the length of the axon. This is the region where the axon is most visible as the sheath and other parts are lost in view.
a.5. Schmidth-Lantermann cleft - an oblique gap on the axon seen as v-shaped lines along the axon. ***What is the importance of this cleft?***

B. Nerve- cross section
The nerve appears as a conglomeration of several nerve fascicles in the peripheral nervous system. Under the scanner objective, this appears as a single large round structure enclosing several round bodies, the nerve fascicles.

b.1. Nerve fascicle – a bundle of many nerve fibers or axons. It is seen as medium-sized round bodies containing small round bodies, the nerve fibers. There are three to five of these rounded bodies inside the nerve.

b.2. Nerve Fiber - the axon or axis cylinder w/c appears round structure inside the nerve fascicle. There are numerous nerve fibers within a single nerve fascicle. Examine one nerve fiber and identify the parts:

- **Axon** – axis cylinder w/c is visible as tiny "dot" at the center of the nerve fiber.
- **Myelin sheath** – whitish area that surround the axon.
- **Neurokeratin network** – a mesh of granules inside the myelin sheath.
- **Epineurium** – a thick layer of loose connective tissue surrounding several nerve fascicles. It is characterize by a great amount of fat cells, blood vessels and nerves. It appears as light or bluish fibers around the nerve fascicles.
- **Perineurium** - densely packed connective tissue sheath that surround the individual nerve fascicles. It is thinner but darker than the epineurium.
- **Endoneurium** - the thin, innermost covering made up of fine collagenous fibers around each nerve fiber. It is actually a continuation of the

II. Central Nervous System- consists of the brain and spinal cord responsible for coordination and integration of bodily activities.

A. Cerebellum-transverse section

It is a small organ lying below the cerebrum known as the center of balance and fine tuning of movements. An overview of the organ shows it to be divided into two main parts:

a.1. White mater- light, inner region containing myelinated nerve fibers.

a.2. Gray Mater - dark, outer region containing the cell bodies and dendrites of the neurons. The cerebellar cortex consists of three layers surrounding the white mater. Focus on this region using an LPO and identify the following layers:

1. **Molecular Layer**- outer layer composed of few cells associated with numerous fibers that extend from the dendrites and axon collaterals of Purkinje fibers, white matter and nuclear layers. This layer is also called *Plexiform layer*.
    - ❖ **Stellate cells** – have irregular dendrites and short axons.
    - ❖ **Basket cells** – have large axons that lie parallel to perpendicular to the long axis of the folium. The axon collaterals of these cells run vertically, thus, form a basket-like network around the bodies of Purkinje cells.
2. **Intermediate Layer –** appears to be an incomplete layer with only a single layer of several large cells called Purkinje cells. They are unevenly spaced apart.
    - ❖ **Purkinje Cells** – have flask-shaped soma with round vesicular nucleus. With H & E prepared slides, only a few primary dendrites are seen arising from it where it subdivides repeatedly forming highly arborized branches. Such elegance, however, fades out upon entry to the molecular layer.

3. Granular or Nuclear Layer – inner layer of highly basophilic cells overlying the white mater. It consists of densely-packed tiny cells called the Granule cells. They are round and small, about the size of the nucleolus of the Purkinje cells. The cell processes are not visible in H and E preparation. Their axons enter the molecular layer and are responsible for their punctuate appearance while the dendrites remain in this layer.

B. Cerebrum- constitutes the great bulk of the brain. It is the center of learning, perception and memory. Its thin surface is highly convoluted, hence, increasing the surface area. Such folds are called sulci. It has also the gray and white matter like the cerebellum. There are six layers in the cerebral cortex but there are no distinct boundaries between the layers. They are simply identified by the predominant cell types present in them.

1. **Molecular or Plexiform Layer**- outermost layer containing just a few cell types, mostly fibers that run in all directions but usually parallel to the surface.
    a. **Granule cells**- have short axons
    b. **Horizontal cells** – their dendrites are disposed parallel to the surface of the cortex.

2. **Outer Granular layer** – predominantly granule cells that appear like dots.
3. **Pyramidal Layer** – composed of cells whose soma are pyramid-like, hence, the name. Other cells like granule cells and Martinotti cells are present but cannot be discerned.
4. **Inner Granular Layer** – consists of numerous stellate cells.
5. **Inner Pyramidal Layer** – similar to the third layer but the cells are quite medium in size.
6. **Polymorphic Layer**- composed of cells with varied shapes and sizes. Aside from the aforementioned cells, spindle cells are also present in this layer.

All the six layers contain neuroglia cells visible as tiny dots which are actually the nuclei of the cells.

C. Spinal Cord- ovoid organ that relay external and internal signals to the CNS. A cross section of the organ shows it to be composed of two regions:

1. **White Mater-** peripheral region composed mainly of myelinated nerve fibers and oligodendrocytes.
2. **Gray Mater** - central region which resembles an H-shaped or paired butterfly "wings".
    - **Dorsal Gray Columns or Posterior Horns**- lateral extensions of the gray mater. These are slender and radiate outwardly from the central part.
    - **Ventral Gray Columns or Anterior Horns** – lateral extensions that are much broader than the posterior horns. These are the sites of the large but relatively few motor neurons. ***What is the shape of the cell?***

    There are a few processes that can be observed but their axons cannot be distinguished from dendrites with certainty. The axons of these motor neurons constitute the ventral roots of the spinal nerves. They are surrounded by a great number of neuroglia.
    - **Central Canal** – vertical slit-like opening at the central horizontal bar of the gray mater. The

lining of this cavity is called *ependymal layer*. ***What kind of cells make up this layer?***

- **Meninges** - connective tissue membrane surrounding the brain & spinal cord. These may not be always seen in the slide. They provide protection and nourishment to the CNS.
- **Dura Mater** – outer layer of thick dense connective tissue fused with the periosteum of the cranium. Its inner surface is composed of thin layer of simple squamous epithelium. It is separated from the next layer by a thin subdural space. It also contains nerves, veins adipose tissue and elastic fibers.
- **Arachnoid layer** – a thin layer of mesothelium inner to the dura mater. Below this is a large space called *subarachnoid space* that contains cerebrospinal fluid. ***What is the function of this fluid?***

- **Pia Mater** – a delicate layer of vascular connective tissue covered by a mesothelium.
- **Perivascular space** - small tunnels containing blood vessels that enter the CNS.

III. Peripheral Nervous System

Ganglia – aggregation of perikarya or soma of neurons outside the CNS. These are located on the posterior roots of the spinal and cranial nerves. These are composed of soma and nerve fibers surrounded by a connective tissue capsule. There are two types of ganglia which differ in the arrangement of these components.

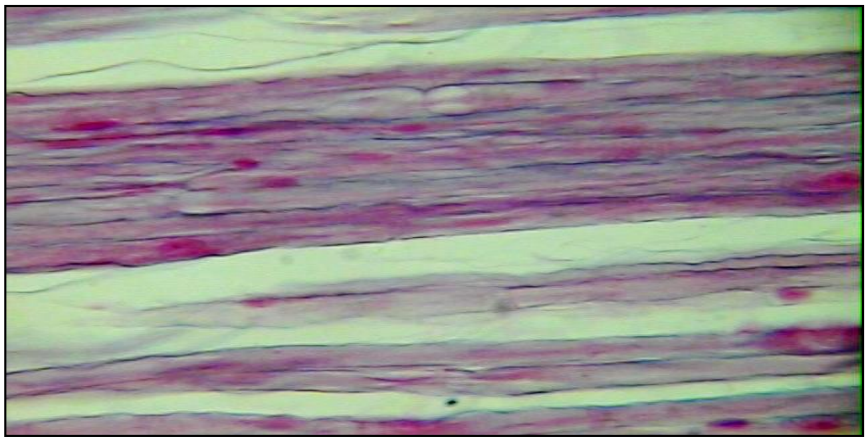
1. **Craniospinal or Sensory Ganglia** – round swellings of the posterior roots of the spinal nerves. Under LPO, look for the following components:
    - **Perlkarya** -large (15-100 um) cells – have round and centrally located nucleoli. They are pseudounipolar with no visible cell processes. Several group of soma are separated from one another by bundles of nerve fibers.
    - **Nerve fibers** - fusiform or elongated bundles of nerve fibers which are located between bundles of soma.
    - **Capsule cells** - also called Amphicytes or Satellite cells. A single layer of small cuboidal cells surrounding each of the ganglion

cells. They appear as a necklace of "pearls" around the ganglion cells.

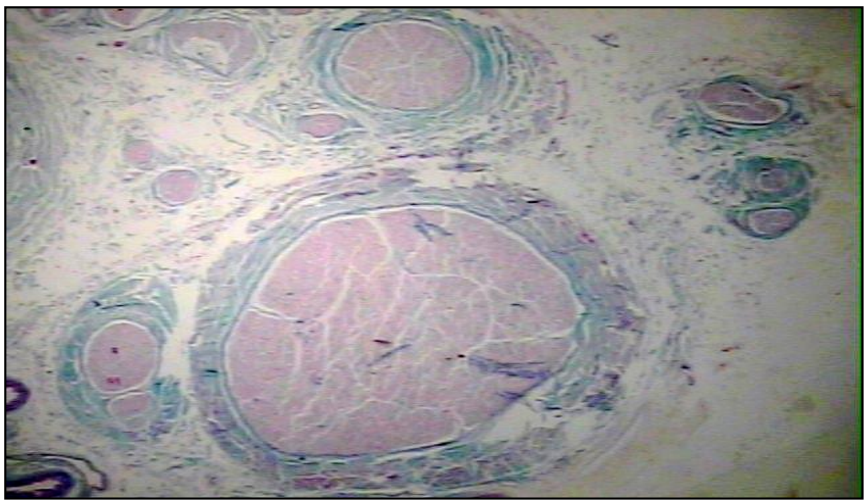
2. **Autonomic or Sympathetic Ganglia** – node-like structures along the sympathetic and parasympathetic trunks of the visceral organs. They are also called intramural ganglia. They have similar components as the sensory ganglia but differ in orientation.
    - **Nerve Fibers** – thread-like structures arranged parallel to one another and form a bundle around a cluster of ganglion cells' perikarya. They are concentrated mainly in the center of the ganglia.
    - **Perikarya** – soma of multipolar cells which appear as angular with large nuclei and nucleoli. The nuclei are often eccentric in position. The cell processes are visible only if stained with silver technique.
    - **Capsula cells** – fewer and smaller than in the sensory ganglia. They form an incomplete layer around the ganglion cells. These cells together with the connective tissue framework provide support to the ganglion cells.

Illustrations

Cow's Nerve smear

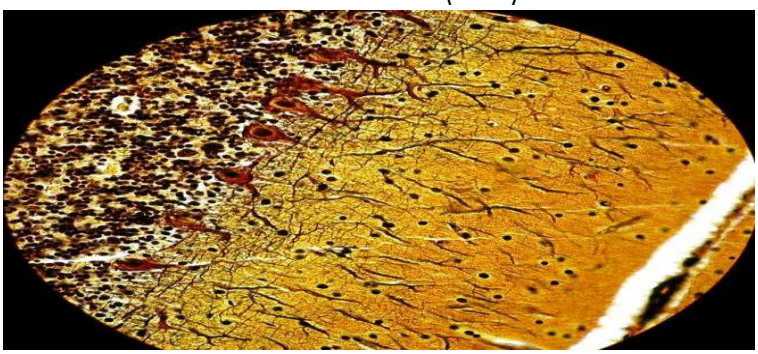


Nerve fiber (l.s.)



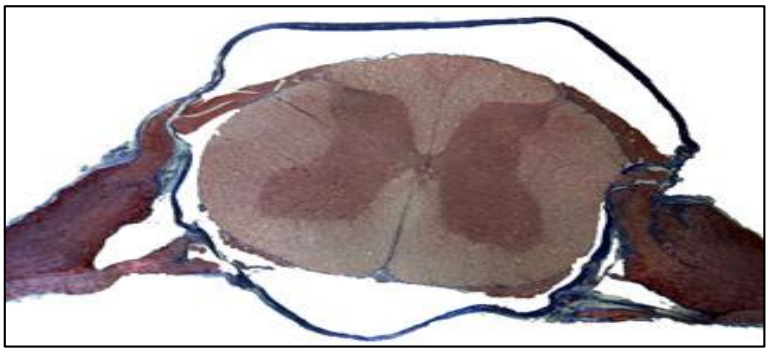
Nerve (c.s.)

Cerebellum (LPO)

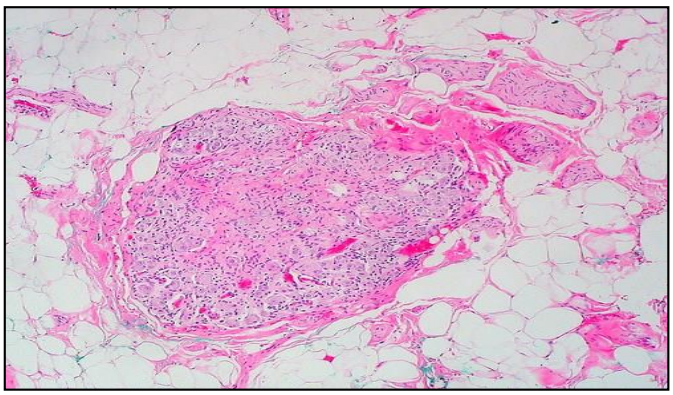


Cerebellar Cortex (HPO)

Cerebrum (LPO)



Spinal Cord (LPO)



Autonomic ganglion

Guide Questions

1. What constitute the blood-brain barrier? Give the significance of this barrier to human.

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   _____
   _____
   _____
   _____

2. Draw the complete parts and label the following:
   a. Purkinje cells
   b. Pyramidal cells
   c. Granule cells
   d. Horizontal cells
   e. Inverted cells of Martinotti