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BIOL 244L HUMAN ANATOMY AND PHYSIOLOGY LABORATORY
NERVOUS SYSTEM I

I. SOME SPINAL REFLEXES

See your textbook chapter 13 on spinal reflexes, and demonstrate among your group three **stretch reflexes**.

Stretch reflexes are mechanisms by which the body maintains balance and posture in the face of various imbalancing forces exerted from outside. For example, consider the process of making a body movement of your arms or legs or just the process of standing still. If some new force were imposed on your limbs or body, your arm or leg will be thrown off target or your body will be thrown off balance unless your muscles immediately counteract that new force. Stretch reflexes help keep muscles in proper position or in smooth movement by acting fast and without you having to think about or plan them.

The simplest (and thus the fastest) pathway is a **monosynaptic reflex arc**. In the stretch reflex, this consists of a sensor in your muscles sensing degree of stretch. A **sensory neuron** (sensory nerve cell) communicates this information to the spinal cord and has a connection (**synapse**) with a **motor neuron**. The synapse is a junction between neurons. An electrical signal called an **action potential** propagates along neurons, and movement of chemicals by diffusion communicates the signal across the synapse. Thus transmission across a synapse takes more time than transmission of a signal along a neuron. The motor neuron runs from the spinal cord back to the muscle and causes it to contract to counteract the force that stretched the muscle. This tends to restore the muscle and joint the muscle crosses to the original position before the imposed stretching force. Overall, this allows you to maintain position or perform smooth movements while counteracting stray forces. The single synapse (monosynaptic reflex) pathway that only involves transmission to and from the spinal cord makes this system fast.

When a tendon is rapped sharply, this causes a sudden stretching force in the attached muscle, and the reflex arc results in the muscle quickly contracting to oppose this sudden stretch. Loss of the stretch reflex or hypersensitivity of the stretch reflex is a symptom of damage to the sensory or motor nerves or to the integrating centers at various levels of the spinal cord. The brain can also influence the sensitivity of the stretch reflex, and higher level (brain level) neurologic injury can affect stretch reflexes.

1. <u>PATELLAR REFLEX</u>: The subject should be seated on a lab work space (but not at the unsupported end of the lab work tables). The person should sit back far enough that the edge of the counter top is just behind the knee joint. The legs should dangle freely.

A. Rap sharply on the tendon just below the kneecap, using the edge of your hand. Repeat just a few times, with time between for recovery of sensitivity. Try having the person look away and count backward from 100 while you deliver the rap. Note how far the lower leg moves after each "rap." What muscle is being stretched when you rap on this tendon and then contracts by the reflex action?

B. Try the same reflex while the person is pressing the palms of their hands together forcefully. Is there a change in the degree of movement of the lower leg?

Why does this change occur?

C. Try the same reflex again after the person jogs once around the courtyard. Is there a change in the degree of movement of the lower leg?
Why does this change occur?

2. ACHILLES REFLEX: The subject should place the front of the shin of the lower leg on a low stool or chair. There should be room for the foot to dangle freely. What happens when you rap sharply on the tendon just above the heel?

3. TRICEPS REFLEX: Provide a clean paper towel for the subject's face. Have the subject bend face own over the counter top, with one arm extending along the counter top out to the inner edge of the elbow joint. The arm, from the elbow down, should dangle freely straight down. Rap sharply on the tendon just above the elbow joint. What happens?

II. HISTOLOGY OF THE NERVOUS SYSTEM

Learn the structures that are in boldface type.

1. NEURONS: Use slide labeled "Neuron, Motor". The slide was prepared by smashing some spinal cord anterior horn material on a slide, then staining it. The many small dark dots on the slide are **neuroglia cell nuclei** (See illustration on neural tissue in Chapter 4). Neuroglia means "nerve glue" and were so named because at the time, no one knew what the function of these cells was. They do have a supportive role for neurons, but it includes supporting metabolism, regulation of nutrient exchange, defense against microorganisms and foreign compounds, and other more specialized roles. Central nervous system cancers are often derived from neuroglia (gliomas). On the other hand, the **neurons** are very large cells, even with the 10X objective lens. They are not very abundant on our slides, so you might have to look around for a while to find some. Identify the **nucleus** and the **neuron processes** (fibers) that are attached to the neuron's **cell body**. See the textbook section on neural tissue in Chapter 4 and the Chapter 12 on neural tissue for photographs of neurons.

2. NERVE FIBERS: Use slide labeled "Nerve fibers". The fibers are neuron processes that conduct the signals away from the cell body to connect with other neurons or muscles. These fibers are called **axons** (the neuron processes that receive signals are called **dendrites**). Hunt for areas that look like the fiber has been pinched. These "pinched" areas are the **nodes of Ranvier or (neurofibril nodes)**. These are between long regions that are covered by the **myelin sheaths**. Areas covered by myelin sheaths are longer than indicated in the diagram in Chapter 12. The myelin acts as electrical insulation on the axon, and the pattern of nodes of Ranvier alternating with segments of myelin acts to increase the propagation speed of the action potential.

3. NERVE: Use the slide labeled "Nerve C.S. & L.S." (C.S. = Cross Section; L.S. = Longitudinal Section) Hold the slide up to the light and note that there are two cross sections (round), and one longitudinal section (elongated). Find one of the cross sections with the 10X objective lens. See Chapter 13 for helpful illustrations.

There are several round structures of various sizes in each nerve cross section, and these round areas are **fascicles** (= "bundles" of individual fibers). Each **fiber** appears like a dot (cross section of an axon), and is surrounded by a circle. The space between the dot and the circle, when alive, was filled with the **myelin sheath**. The illustrations in Chapter 12 show how the space represents the remains of the cell membrane of the **Schwann cell** (neurolemmocyte) that produced the myelin sheath. The circle is a connective tissue layer that surrounds both myelinated and unmyelinated axons, and this connective tissue layer is called the **endoneurium**. The illustrations in your book in Chapter 13 show a myelinated axon covered by endoneurium. The endoneurium connective tissue separates individual axons from each other. At high power, you may see thicker strands of endoneurium staining light blue or purple and binding groups of neurons together but all contained within a fascicle. A **perineurium** covers each fascicle appearing as a wavy band of connective tissue which, like endoneurium, stains blue or purple. Finally, an **epineurium**, staining more densely blue or purple, encloses the whole nerve.

4. <u>SPINAL CORD</u>: Use the slide so labeled. It is stained with silver compounds that cause nerve fibers to show as black. Remember the warnings about skin and clothing stains while handling $AgNO_3$ when we used this reagent to test for chloride ion? Chapter 13 has helpful illustrations. Even without the microscope, one can see the "H" pattern (of "**grey matter**") inside the section of the spinal cord. It is surrounded by the "**white matter**". Grey matter is dark, because it contains lots of neuron cell bodies as well as processes, while white matter is nearly all neuron cell processes with myelin sheaths. Tracts of neurons sticking out to the sides of the section are **dorsal roots** of **spinal nerves**.

With the 4X objective lens, view the specimen to see the overall layout. It is also helpful to look at the slide under still lower power using the dissecting microscope at the front of the room. Note that the **posterior gray horns** (appear as upper side as viewed with the microscope) are slimmer than the **anterior gray horns** (lower side). The anterior horns contain the **cell bodies** of **motor neurons**, and you may use higher power to examine them. These are large cells, stained brown or orange, and are surrounded by hundreds of black-stained **neuron processes** (axons and dendrites). Note that these processes pass out into the white matter. Note also that some of the processes extend from one side of the cord to the other near the **central canal**, forming the **commissures** just above and below the canal. The commissures provide for connections and flow of information between the right and left side of the spinal cord, and the canal is a passage for cerebrospinal fluid. Anterior from the canal (toward the bottom of the microscope field) is the **anterior median fissure**. It appears squeezed together, but the thin brown **pia mater** can be seen in it. Pia mater is the innermost layer of connective tissue enclosing the spinal cord (and also the brain). Where this fissure opens at the bottom, the pia mater separates to cover the bottom edge of the cord. This innermost layer is one of several connective tissue layers covering and protecting the central nervous system and altogether called the **meninges**. Meningitis is an infection of the meninges.

The **white matter** consists mainly of dots, that represent the thousands of nerve fibers that have been cut in cross section. These are seen best at high power. Some of the fibers can be seen to be surrounded by empty circles where the **myelin sheath** had been.

Off to the side of the cord, most slides have at least a portion of the **dorsal root** of a **spinal nerve** cut longitudinally. In it, the nerve fibers are represented by parallel black lines. The **dorsal root ganglion** will contain some groups of rounded **sensory neuron cell bodies**. In general, ganglion is a collection of neuron cell bodies with interconnecting fibers. The cell bodies of the sensory neurons of the reflex arcs studied above lie here.

5. NEUROMUSCULAR JUNCTION: The "Motor Nerve Ending" slide shows the **neuromuscular junctions** where nerve fibers communicate with muscle fibers. The neural portions of these junctions are black on our slides. The muscle fibers are broad bands appearing pink or blackened depending on the intensity of the stain. The nerve fibers are thin black stained threads lying and branching over the muscle fibers. The **axon terminals** are the ends of the branching fibers. These contact the muscle fibers, and the contact, including both the **axon terminal** and the portion of the muscle cell membrane that makes the contact, is the **neuromuscular junction**. See the illustration back in Chapter 10 (Muscle Tissue) of the neuromuscular junction.

6. SYMPATHETIC GANGLION: The slide with this title shows the organization of a ganglion of the sympathetic nervous system. Almost all the sympathetic ganglia lie in a tract like a chain that runs parallel to but outside of the spinal cord (there are a few sympathetic ganglia that are near the abdominal organs). In a sympathetic ganglion, the cell bodies and fibers are all mixed together. This appears differently from a central nervous system ganglion in which the neuron cell bodies are in groups that are distinct from groups of neuron fibers.

With the 10X objective lens, find the thickest end of the reddish strip of tissue on the slide. this thick area is the **ganglion**. Note that it contains rounded **neuron cell bodies**. With the 40X objective lens you should see that many of these cell bodies contain a pale **nucleus** and darker **nucleolus** inside the nucleus. The nucleolus is involved in assembling the ribosome subunits for transfer to the cytoplasm for complete assembly of ribosomes and synthesis of proteins.

Unlike a ganglion associated with the central nervous system (such as the spinal nerve dorsal root ganglion where cell bodies appeared packed together) the cell bodies of the sympathetic ganglia are separated from each other by other material that includes pale streaks which are **nerve fibers**. Small nuclei here and there are in one type of **neuroglia cell**.

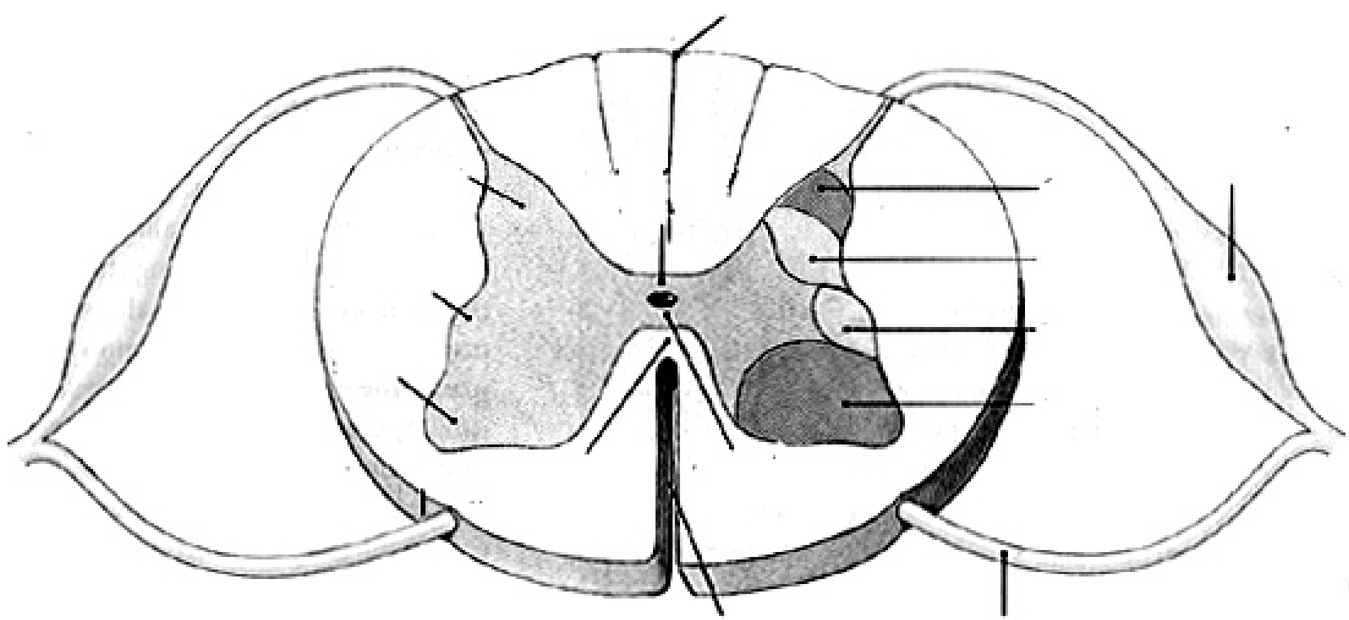
7. NEUROGLIA CELLS: Use the slide labeled "astrocytes." With the 10X objective lens, find the area near the center of the tissue section that has the darkest stain. In that area, there are streaks that extend right and left across the tissue. Look there for small, dark spots that have dark lines radiating away from them. These cells suggested the shape of stars to their discoverer, hence the name "astrocytes." Change to the 40X objective lens for a better view of the **astrocytes**, which are a type of neuroglial cell involved in metabolism of neurotransmitter compounds and regulating passage of compounds into the brain.

III. Spinal Cord Model

Important rule for studying the anatomical models: Do not use a pencil or pen with an inking tip to point out structures on the models. To keep from stain-marking the models, you may use a capped pen or a retracted mechanical pen.

On the model find and know the larger structures studied in the slide for histology above. These include:

grey matter
white matter
dorsal and ventral roots Note that the ventral roots are usually disrupted on the slide but well displayed on the model.
dorsal root ganglion
posterior gray horns
anterior gray horns
central canal
anterior median fissure
pia mater



(a) Sectional view of spinal cord