Study Guide for Bio 101 Lecture Final Exam

NERVOUS SYSTEM

Chapter 11, Lecture 18 (Neural Tissue, Neural Physiology)

1. The **Nervous System is a rapidly acting, short-term control system of the body**.

- Neurons communicate with one another through synapses, using chemicals called neurotransmitters, e.g., acetylcholine (ACh), norepinephrine (NE), etc.

- Communication in the nervous system is a ONE-WAY communication:

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                    synapse                          synapse
 Neuron 1 ----------------------->    Neuron 2 ------------------------> ....
(Presynaptic)                    (Postsynaptic)
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- Since communication is one-way, we say that the neuron coming before the synapse is the presynaptic neuron, the one coming after the synapse is the postsynaptic neuron.

- the PREsynaptic neuron sends a chemical message across the synapse and can cause the POSTsynaptic neuron to become excited (depolarized), or inhibited (hyperpolarized), depending on the receptor used on the postsynaptic neuron.

- if the POSTsynaptic neuron is depolarized it may send a signal of its own to the next neuron in the chain of neurons. It it's hyperpolarized, it won't send a signal of its own.

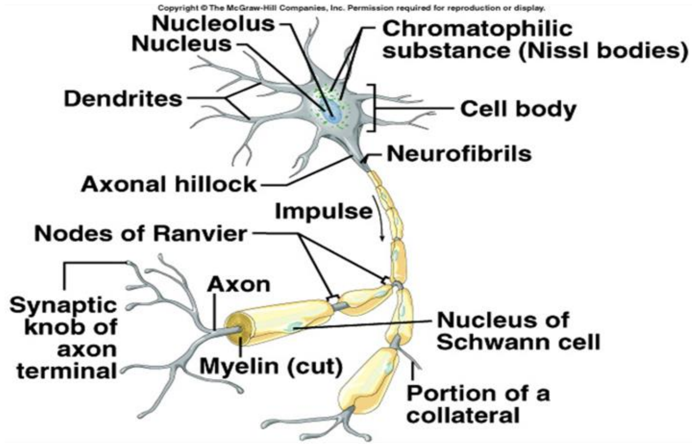
2. **Divisions of the nervous system**

a. The **central nervous system (CNS)** consists of the brain and spinal cord. The **peripheral nervous system (PNS)** consists of all the nerves going into or out of the CNS.

b. The **PNS is divided into a sensory and motor branch**.
- The sensory branch brings information (nerve impulses) TO the CNS, e.g. sensory information from eyes, ears, skin, joints, etc.
- The motor branch brings information FROM the CNS to structures like muscles, glands, blood vessels, etc.

c. The **MOTOR division of the PNS has 2 branches: Somatic and Autonomic.**
- The somatic nervous system sends information from the CNS to Skin, bOnes, Muscles, and Articulations (remember: SOMAtic).
- The autonomic nervous system sends information to the 'squishy' stuff in the body: glands, blood vessels, organs, etc.

3. **Neuron structure and function**



Be able to label structures on left

- Dendrites bring impules TO the soma

- Soma is the 'processing' part of the neuron

- Axon carries impules AWAY from the soma

- Synaptic knobs contain ntx

-- Myelin is found on axons

-- Neurons conduct nerve impulses

***Initial segment – where action potentials (nerve impulses) begin**

4. **Classification of neurons**

a. Classified **structurally** by the number of processes (poles) coming directly from the cell body: one process = UNIpolar; two processes = BIpolar; many processes = MULTIpolar.

b. **Functionally**, neurons, are classified as

- Sensory = afferent or ascending; send info TO CNS
- Motor = efferent or descending; send info AWAY FROM CNS
  - Mnemonic SAME to remember: SensoryAfferent - MotorEfferent
- Interneurons = the neurons 'in between' the sensory and motor neurons that process incoming info from sensory neurons and send outgoing info to motor neurons.

5. **Neuroglia**

Name of Cell	Location	Function(s)
Satellite Cells	PNS	Regulate microenvironment of neurons
Astrocytes	CNS	Regulate microenvironment of neurons; scar tissue in CNS
Schwann Cells	PNS	Myelination of axons; structural support for non-myelinated axons
Oligodendrocytes	CNS	Myelination of axons; structural framework
Microglia	CNS	Phagocytes of the CNS
Ependymal Cells	CNS	Assist in producing and controlling composition of CSF

6. **Membrane channels**

Type of Channel	Subtype	How it's opened
Passive	Leak	Always open
Active	Mechanical	When cell membrane 'deforms', channel opens, e.g., skin receptors
Active	Ligand (chemical)	When a chemical (ligand), e.g., ACh, binds, channel opens
Active	Voltage	When voltage across cell membrane changes, channel opens

7. **Resting (transmembrane) potential of neurons**

a. **Transmembrane potential** is the difference in 'charge' (positive or negative) on either side of the cell membrane. Resting neurons maintain a -70 mV negative charge INSIDE, and a positive charge OUTSIDE their cell membranes when they are RESTING, that is not being stimulated or sending a nerve impulse.

b. Remember: EXTRAcellular fluid has high Na+, low K+ concentration. INTRAcellular fluid is the opposite: low Na+, high K+ concentration.

b. Positively charged **K+ ions** flowing **out** of the neuron through **leak channels**, *create* the negative transmembrane potential of neurons. Each time a K+ ion leaves a neuron, the membrane potential gets more negative. Eventually, this reaches -70 mV.

c. Although it is the outflow of K+ that CREATES the *initial* resting transmembrane potential, Na-K-ATPase pumps are responsible for continually MAINTAINING the minus 70mV resting potential.

- In a resting neuron, they use the energy of ATP to bring K+ that has leaked out of the cell back INTO the cell, and send Na+ that has leaked into the cell back OUT.
- Thus, they maintain the -70mV transmembrane potential whenever it gets disturbed (because of leakage of ions, or after a graded or action potential).

d. In a resting state, a neuron has a -70mV on the inside of the cell membrane relative to the outside. This state of having a different charge on the inside and outside of the cell membrane is called a *polarized* state of the neuron cell membrane.

a. **Depolarization = Excitation** of a postsynaptic neuron, i.e., moving closer to threshold and moving closer to generating a nerve impulse or action potential

i. Depolarization = moving the transmembrane potential toward ZERO, or an non-polarized state. (Thus, DEpolarization = taking the membrane polarization away)

ii. If positive ions/charges, like Na+, move into the cell from outside, the inside of the cell membrane becomes less negative. Thus, Na+ moving into a neuron = depolarization.

b. **Repolarization = returning** the membrane potential toward the resting -70mV level following a depolarization. (Thus, REpolarization = restoring the membrane polarization)

- If positive ions/charges, like K+, move out of the cell from inside, the inside of the cell membrane becomes more negative. Thus,K+ moving out of a neuron causes a previously depolarized neuron to return its membrane potential back toward resting potential.

c. **Hyperpolarization = Inhibition** of a postsynaptic neuron, i.e., moving away from threshold and moving further away from generating a nerve impulse or action potential

i. Hyperpolarization = moving the transmembrane potential away from ZERO, toward a MORE polarized state. (Thus, HYERpolarization = making the polarization greater)

ii. If positive ions/charges, like K+, move out of the cell from inside when the neuron is already at its resting -70mV transmembrane potential, the inside of the cell membrane becomes more negative. Thus, K+ moving out of a resting neuron can cause a hyperpolarization.

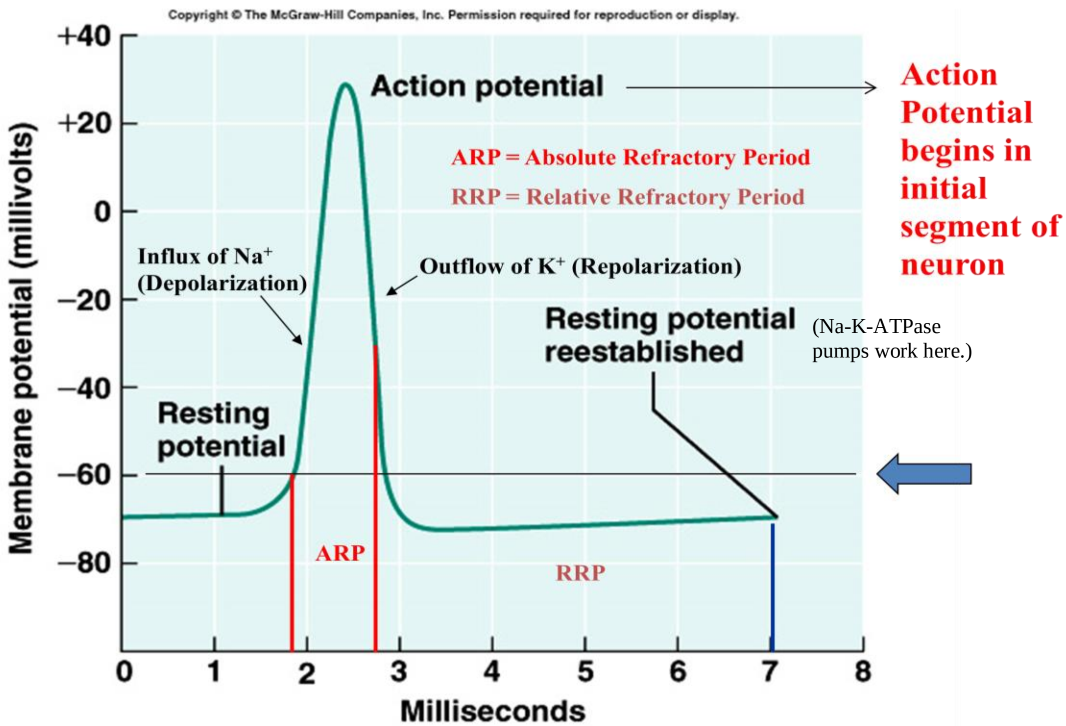
iii. If negative charges, like Cl-, move into the cell from outside, this is another way in which the postsynaptic neuron can become hyperpolarized, or inhibited.

10. **Action potentials**

a. Definition of the terms ***threshold*** **and** ***action potential***.
- Action potential = nerve impulse
- Threshold - A certain membrane potential that MUST be reached before a neuron generates an action potential.

b. An action potential in a neuron begins in the **initial segment of the neuron**, an area located near where the axon connects to the cell body (soma) of the neuron.
- The initial segment of a neuron contains a great number of VOLTAGE-GATED Na+ CHANNELS.
- The voltage gated Na+ are 'set' to open when the membrane potential reaches threshold voltage.
- Once these channels open, Na+ flood into the neuron causing a further, massive depolarization. This is the action potential that progresses toward to the synaptic knob.

c. The following is an absolutely **critical diagram for you to be familiar with**. It sums up much of what has been stated above in one figure. If you *understand* it, you'll have a good, basic understanding of how the neuron works.



d. Definition of the **Absolute Refractory Period (ARP) and the Relative Refractory Period (RRP)**.

- The Absolute Refractory Period (ARP) is the period of time during which the nerve cannot be stimulated to generate another action potential.
- The Relative Refractory Period (RRP) is the period of time during which the nerve can be stimulated to generate another action potential, but ONLY if there is a large than normal stimulus (depolarization).

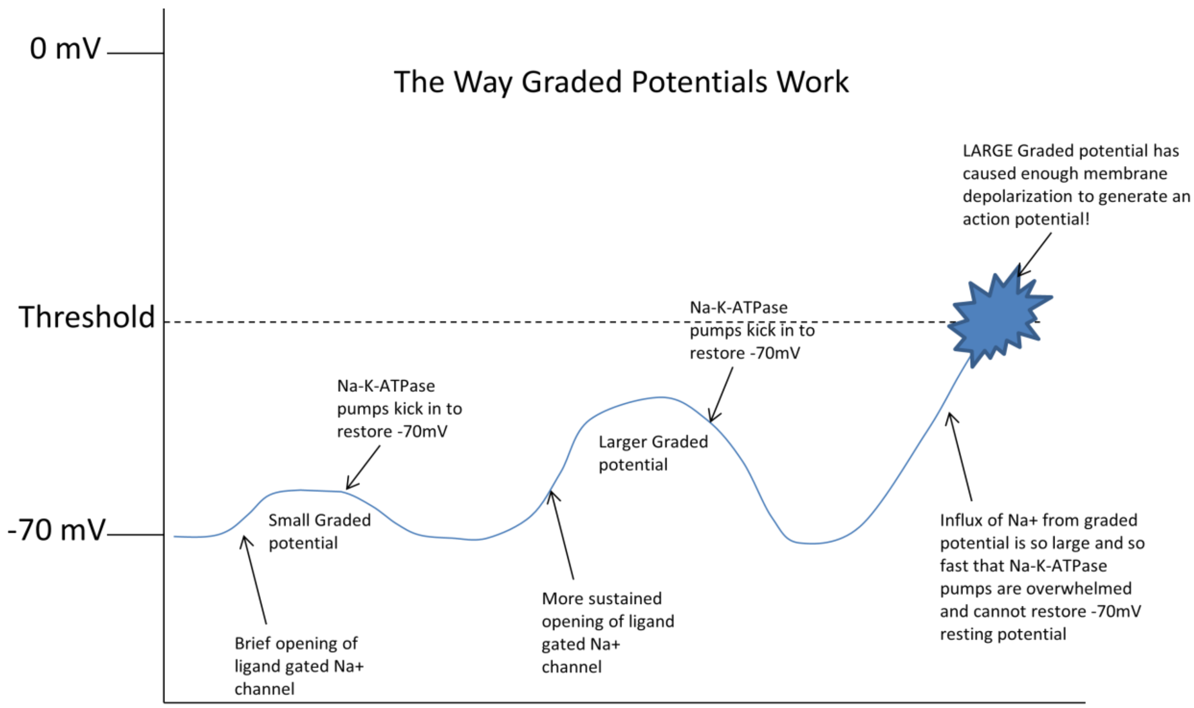
e. The **Absolute Refractory Period is important to the transmission of a nerve impulse** because it keeps the action potential travelling in one direction, i.e., away from the initial segment and toward the synaptic knobs of the axon.

11. **Graded potentials**

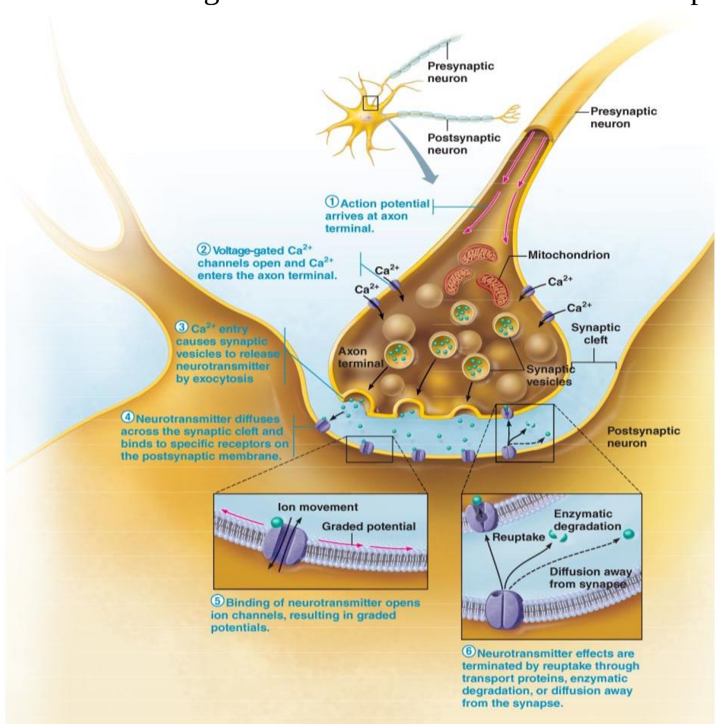
a. A graded potential causes a change in membrane potential in a local area within a neuron. It causes a fluctuation in the neuron's membrane voltage, but may or may not cause the neuron's membrane potential to reach threshold.

b. Brief opening of LIGAND-gated channels on a neuron's dendrites and soma cause graded potentials.

c. If the graded potential causes a large enough rise in the neuron's membrane voltage so it reaches threshold, the neuron will generate an action potential. See the example below:



12. There's a great figure in Marieb's textbook for the steps involved in **chemical synaptic transmission**: Figure 11.17. You should know the steps in this process shown in that figure.



13. **Myelination**

a. The myelin sheath on axons of nerves is a fatty covering that is interrupted periodically by spaces called nodes of Ranvier.

b. In the PNS myelination is accomplished by Schwann cells; in the CNS myelination is carried out by oligodendrocytes. Schwann cells and oligodendrocytes are types of glial cells.

c. Myelination of an axon can greatly increase transmission speed of an action potential down an axon since it causes the action potential to 'jump' from one node of Ranvier to the next. This type of transmission is called **saltatory transmission**.

14. **Excitatory (EPSP) and Inhibitory (IPSP) Post Synaptic Potentials**

a. EPSP's depolarize the postsynaptic neuron; and are excitatory.

b. IPSPs hyperpolarize the postsynaptic neuron and are inhibitory.

15. **Spatial and temporal summation** are related to *graded* potentials.

- Note: Each time a presynaptic neuron 'fires' or sends an action potential, it causes a ligand gated channel on the postsynaptic membrane to open VERY briefly, and allows a small quantity of extracellular ions (Na+, Cl-) to flow into the postsynaptic neuron.
- Spatial summation - increased number of axons in an area fire at once to increase strength of a graded potential
- Temporal summation - increased frequency (speed) of firing of one of more axons to increase the strength of a graded potential

16. Acetylcholine (ACh) - excitatory in both CNS and PNS; Norepinephrine (NE) - excitatory or inhibitory, depending on receptor

Lecture 19 – The Central Nervous System (Chapter 12)

1. The brain is physically protected by the skull bones, meninges, and cerebrospinal fluid (CSF). It is chemically protected by the blood-brain barrier (see below).

2. **Meninges** (sing: meninx)

   a. Dura mater - outer, thick, tough covering that is attached to bone.
   b. Arachnoid mater - webbed meninx between dura and pia mater. CSF flows beneath the arachnoid mater in a space called the subarachnoid space.
   c. Pia mater - inner, thin, delicate membrane that is attached to the nervous tissue it covers.

3. The **blood-brain barrier**

a. Consists of

- Capillaries interconnected by tight junctions
- Astrocytes/ependymal cells control permeability of general capillaries/choroid capillaries

b. Is a very selectively permeable barrier to passage of substances into and out of the CNS.

3. **Cerebrospinal fluid (CSF)**

a. The choroid plexuses located within the ventricles of the brain, along with ependymal (glial) cells, produce and regulate the composition of CSF.

b. After being made in the ventricles of the brain by the choroid plexuses, the CSF circulates:

i. In the subarachnoid space and central canal of the spinal cord
ii. Back up into the subarachnoid space around the brain
iii. Then through arachnoid granulations (villi) into the dural venous sinus to combine with blood returning to the heart (called venous blood).

4. **Cerebrum**

a. **Lobes** of the cerebrum (this is HIGHLY simplified, but a good general rule)

i. Frontal lobe - motor
ii. Parietal, temporal, and occipital lobes and the insula - sensory
iii. All lobes - association (function in interpreting sensory information)

b. The **primary motor cortex**

i. The primary motor cortex is located anterior to the central sulcus. This is also called the precentral gurus.
ii. This is the area where SOMATIC motor nerve impulses begin
iii. This area receives 'directions' from other areas of the brain, especially the rest of the frontal cortex and pre-frontal cortex.

c. The **primary sensory cortex**

i. The primary sensory cortex is located posterior to the central sulcus. This is also called the postcentral gyrus.
ii. The area initially receives sensory impulses of which we are conscious
iii. It communicates with association areas of the brain so that they can determine what the sensory impulses actually mean.

d. The thin, 2-4 mm thick outer layer of the cerebrum is called the **cerebral cortex**. The Motor and Sensory Homunculi are associated with this thin strip of gray (unmyelinated) nerve tissue of the cerebral cortex.

e. **Major functions of the areas of the brain**

Part of Brain	**Major Function**
Motor areas	
Primary motor cortex (Precentral gyrus)	Voluntary control of skeletal muscles
Broca's area (motor speech area)	Controls muscles needed for speech
Frontal eye field	Controls muscles needed for eye movement
Sensory areas	
Cutaneous Sensory Area (postcentral gyrus)	Receives somatic sensations
Visual area (occipital lobe)	Receives visual sensations
Auditory area (temporal lobe)	Receives auditory sensations
Association areas (all lobes)	Analyze and interpret sensory experiences; coordinate motor responses memory, reasoning, verbalization, judgment, emotions
Basal nuclei	Subconscious control certain muscular activities, e.g., learned movement patterns (a nucleus is a collection of neuron cell bodies in the CNS); putamen, globus pallidus, caudate
Limbic system	controls emotions, produces feelings, interprets sensory impulses, facilitates memory storage and retrieval (learning!)
Diencephalon	
Thalamus	gateway for sensory impulses heading to cerebral cortex, receives most sensory impulses
Hypothalamus	Vital functions associated with homeostasis
Brainstem	
Midbrain	Major connecting center between spinal cord and brain and parts of brainstem; contains corpora quadrigemina (visual and auditory reflexes)
Pons	Helps regulate rate and depth of breathing, relays nerve impulses to and from medulla oblongata and cerebellum
Medulla Oblongata	Contains cardiac, vasomotor, and respiratory control centers, contains various nonvital reflex control centers (coughing, sneezing, vomiting)
Reticular formation (system)	Filters incoming sensory information; habituation, modulates pain, arouses cerebral cortex into state of wakefulness (reticular activating system)
Cerebellum	Subconscious coordination of skeletal muscle activity, maintains posture

f. A **'nucleus'** in a collection of nerve cell BODIES (gray matter) located in the CNS. A **'ganglion'** is a collection of nerve cell BODIES (gray matter) located in the PNS, i.e., outside the CNS.

5. **Memory**

a. Is formed when some stimulus causes connections between a pathway of neurons so that when that stimulus is encountered again, that neural pathway can be activated to produce a recall of a specific fact, event, activity, etc.

b. This allows us to 'recall' some specific information at a later time.

c. The more times a particular memory pathway is activated (accessed), the better the memory can be accessed. (Hence repetition as one way to remember something.)

d. The more senses (visual, smell, touch, hearing) involved in the *initial* formation of a memory, the easier it will be to activate that pathway later and recall the memory.

e. **Types of memory** and an example of each

i. Immediate memory lasts a few seconds, e.g., remembering the earliest part of a sentence to make sense of it.

ii. Short-term memory (STM) lasts a few seconds to a few hours

- Working memory is a form of this (repeating a phone number over to yourself just long enough to dial it – and then forget it!)
- Limited to a few 'bits' of information (about 7-9). So, 'chunk up'!

iii. Long-term memory (LTM) can last a lifetime

- Can hold much more information that STM
- Declarative (events and facts); Procedural (motor skills)
- Remembering childhood events as an adult

6. **Spinal cord**

a. The spinal cord

i. Is a conduit for nerve impulses to travel to and from the brain

ii. Functions in reflex pathways

- On their way to/from the brain, nerve impulses usually cross over to the other side of the body either in brainstem or in the spinal cord. This is the reason that if someone has a stroke on the right side of the brain, the LEFT side of their body is the side that shows deficits (abnormalities).

b. The **cauda equina** (horse's tail), located from about L2 to S5, begins where the solid portion of the spinal cord ends. Thus, it's a strand of nerves travelling down the vertebral column - hence, it's name.

c. The cell bodies of somatic *motor* neurons are located in the anterior (ventral) horns of the spinal cord gray matter. The cell bodies of somatic *sensory* neurons are located in the dorsal root ganglia, and send their axons into the posterior (dorsal) horn of the spinal cord gray matter.

d. The lateral horns of the spinal cord are originating points for autonomic (visceral) motor nerve impulses

e. Ascending spinal nerve tracts carry sensory impulses; descending spinal nerve tracts carry motor impulses.

f. **Spinal nerve tracts**

i. A nerve tract is a bundle of axons that have a common point of origin and a common end point.
ii. Nerve tracts are named for their: 1) origin 2) destination - in that order
iii. Examples of sensory tracts (ascending): spinocerebellar, spinothalamic
iv. Examples of motor tracts (descending): cortiospinal, rubrospinal, reeticulospinal

g. **Sensory pathways** typically contain 3 major neurons in a sensory pathway

i. First order neuron: from sensory point (e.g., skin receptor) to spinal cord
ii. Second order neuron: from spinal cord to thalamus
iii. Third order neuron: from thalamus to primary sensory cortex (postcentral gyrus).

h. **Motor pathways** typically contain 2 major neurons in a pathway

i. Upper motor neurons: primary motor cortex (precentral gyrus) to the spinal cord (approximately at the level where the spinal nerve will leave)
ii. Lower motor neuron: spinal cord to effector organ, e.g., muscle

7. **Reflexes**

a. A reflex is a quick, subconscious, automatic, stereotyped (same) response to a sensory stimulus received from either somatic or visceral structures in the body.

b. Thus, reflexes occur in BOTH the somatic division and the autonomic divisions of the nervous system

c. Characteristics of major types of reflexes

i. Knee jerk: Monosynaptic, ipsilateral
ii. Withdrawal: Polysynaptic, ipsilateal
ii. Crossed-extensor: Polysynaptic, contralateral

<u>**Lecture 20 – Peripheral Nervous System and Reflexes (Chapter 13)**</u>

1. **Cranial nerves (see summary table below)**

a. Twelve pairs of nerves (one on each side) that arise from the brain.
b. Number of cranial nerve is usually prefixed with a 'N' or 'CN'
c. Numbered using Roman Numerals (I, II, II, IV, ...)

Numeral	Name	Function	Sensory, Motor, or Both (Mixed Nerve)
I	OLFACTORY (OLD)	OLFACTION/SMELL	SENSORY (SOME) ←
II	OPTIC (OPIE)	VISION	SENSORY (SAY) ←
III	OCULOMOTOR (OCCASIONALLY)	MOVE EYE	MOTOR (MARRY)
IV	TROCHLEAR (TRIES)	MOVE EYE (superior oblique)	MOTOR (MONEY)
V	TRIGEMINAL (TRIGONOMETRY)	CHEWING, MASTICATION AND SENSORY FROM FACE (*MAJOR SENSORY NERVE OF FACE*)	BOTH (BUT)
VI	ABDUCENS (AND)	MOVE EYE	MOTOR (MY)
VII	FACIAL (FEELS)	FACIAL EXPRESSION (*MAJOR MOTOR NERVE OF FACE*)	BOTH (BROTHER)
VIII	VESTIBULOCOCHLEAR (VERY)	HEARING AND EQUILIBRIUM	SENSORY (SAYS) ←
IX	GLOSSOPHARYNGEAL (GLOOMY)	MOVE MUSCLES OF TONGUE AND PHARYNX	BOTH (BIG)
X	VAGUS (VAGUE)	INNERVATE VISCERA/VISCERAL SMOOTH MUSCLE IN THORAX/ABDOMEN; MOTOR FOR SPEECH/SWALLOWING	BOTH (BOOBS)
XI	ACCESSORY (AND)	MOVE NECK MUSCLES	MOTOR (MATTER)
XII	HYPOGLOSSAL (HYPOACTIVE)	MOVE TONGUE	MOTOR (MOST)

2. **Peripheral nerves** - peripheral nerves can be classified as follows:

TABLE 13.2 The Classification of Nerve Fibers

Class	Description
Afferent fibers	Carry sensory signals from receptors to the CNS
Efferent fibers	Carry motor signals from the CNS to effectors
Somatic fibers	Innervate skin, skeletal muscles, bones, and joints
Visceral fibers	Innervate blood vessels, glands, and viscera
General fibers	Innervate widespread organs such as muscles, skin, glands, viscera, and blood vessels
Special fibers	Innervate more localized organs in the head, including the eyes, ears, olfactory and taste receptors, and muscles of chewing, swallowing, and facial expression

c. **Layers of peripheral nerves** (going from smallest to largest)

i. Axon of an individual nerve cell/fiber is the smallest element

ii. Each individual axon is covered by a layer of CT called endoneurium

iii. Axons are collected into bundles called fascicles

iv. Fascicles are surrounded by a layer of CT called perineurium

v. Fascicles are collected into a bundle that makes the peripheral nerve

vi. Each peripheral nerve is surround by a layer of CT called epineurium

3. **Spinal nerves**

a. A spinal nerve is a collection of nerve fibers (axons of nerve cells), all of which arise from approximately the same level in the spinal cord, and exit through the intervertebral foramina to supply all parts of the body.

b. Spinal nerves are called 'mixed' nerves because they contain both motor and sensory nerve fibers.

c. There are 31 pairs of spinal nerves, each named for the level of the vertebral column where it exits the spinal cord, e.g., C1, T4, L5, etc.

d. After exiting through the intervetebral foramina, spinal nerves can supply

i. The anterior and lateral portions of the body via ventral rami (branches)

ii. The posterior portions of the body via dorsal rami

c. **Nerve plexuses**

i. A nerve plexus is commingling of spinal nerves that unite, recombine with other spinal nerves, and then separate to supply various areas of the body.

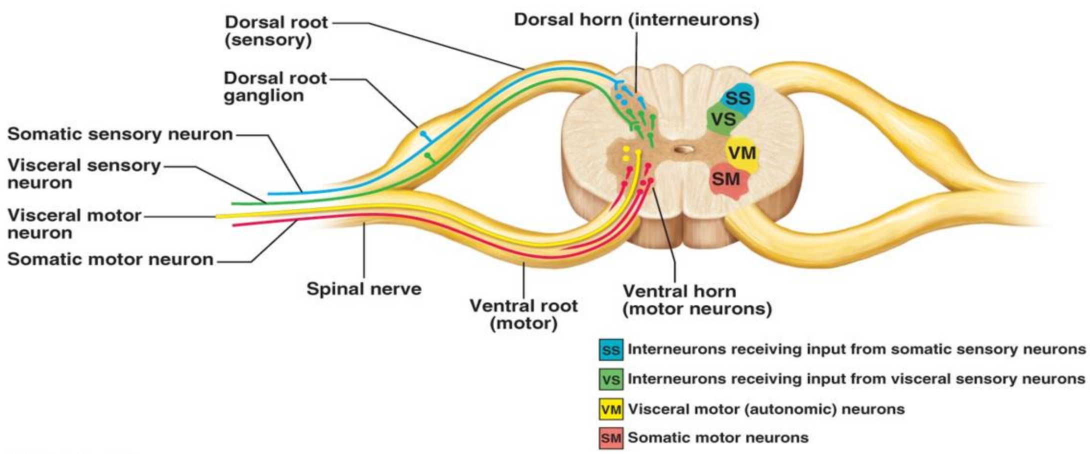
ii. Nerve plexuses are formed by spinal nerves arising from the *ventral* rami.

iii. There are several important nerve plexuses, origins, innervations, and actions you'll need to know - summarized in the table below

Summary Table of Nerve Plexuses

Name of Plexus	Spinal nerves	Major nerves/innervation	Major actions
Cervical	C1 - C4	To muscles/skin of neck	Head movement
		Phrenic nerve	Controls diaphragm
Brachial	C5 - T1	Musculocutaneous Median Ulnar	Flexion forearm/hand
		Radial	Extension forearm/hand
		Axillary	Muscles/skin shoulder
Lumbosacral	L1 - S5	Obturator (Lumbar Plexus) Femoral (Lumbar Plexus) Saphenous (Lumbar Plexus	Muscles/skin of thighs and leg
		Sciatic (Sacral plexus)	Muscles/skin thigh, leg, and foot
		Pudendal (Sacral plexus)	Muscles of perineum

4. The spinal cord and the origins of the spinal nerves



Ventral root - axons of motor neurons whose cell bodies are in spinal cord

Dorsal root - axons of sensory neurons in the dorsal root ganglion

Dorsal root ganglion - cell bodies of sensory neurons

Lecture 21 – Autonomic Nervous System (ANS) - (Chapter 14)

Branch of ANS	PARASYMPATHETIC	SYMPATHETIC
General Function	* "rest and digest" * (SLUDD); Salivation, lacrimation, urination, digestion, defecation * 3 decreses; ↓ heart rate, ↓ pupil size, ↓ airway diameter	* "fight or flight" * E situations: Emergency, exercise, embarassment, excitement
Origin of Preganglionic fiber	cranial region of brain or sacral region of spinal cord (craniosacral outflow)	thoracic or lumbar region of spinal cord (thoracolumbar outflow) Divergence for widespread activation of body
Location of Ganglia	within or near effector organ	alongside or in front of spinal cord (paravertebral ganglia; collateral ganglia)
NTx secreted by postganglionic fiber	acetylcholine	Norepinephrine (some acetylcholine; sweat glands, smooth muscle on blood vessels, brain)

1. **Anatomy/terminology of the Autonomic Nervous System (ANS)**

a. Each pathway in the ANS is composed of two neurons that meet in a ganglion (ganglia - pleural)

i. Preganglionic: closest to the spinal cord

ii. Postganglionic: closest to the organ it innervates

iii. Ganglion: Structure in which pre- and postganglionic neurons synapse (therefore, a ganglion contains axons of preganglionic neurons and cell bodies of postganglionic neurons)

b. Structural elements of the **Sympathetic Nervous System**

i. On each side of the spinal cord are ganglia of the sympathetic NS that have the appearance of 'beads on a string' running parallel to the spinal cord.

ii. Each of these ganglia is called a PARAvertebral ganglion and is typically located close very close to the spinal cord. (Exception: preganglionic nerves to adrenal glads.)

iii. The entire 'beads on a string' structure on either side of the spinal cord is known as the sympathetic trunk.

iv. There are three special ganglia of the sympathetic NS that are not on the side of the spinal cord, but in front of it. These are the PREvertebral (or collateral) ganglia and contain sympathetic nerves that supply abdominal organs.

c. The **Parasympathetic NS** has it ganglia located very near, or sometimes within, the organ that it innervates rather than close to the spinal cord. For that reason, parasympathetic ganglia are called 'terminal' ganglia.

2. Autonomic plexuses are formed by a commingling of sympathetic and parasympathetic postganglionic nerves that unite, recombine with other autonomic fibers, and then separate to supply various organs. The major autonomic plexuses above the diaphragm are the cardiac, pulmonary, and esophageal plexuses. The major autonomic plexuses below the diaphragm are the celiac (solar), inferior mesenteric, and hypogastric plexuses.

3. All neurons of the ANS secrete ACh EXCEPT postganglionic, sympathetic neurons, which use norepinephrine (NE) as a neurotransmitter.

4. ACh is ALWAYS excitatory, i.e., it causes a nerve impulse (action potential) to be generated in a postsynaptic neuron. Norepinephrine can be excitatory or inhibitory, depending upon the postganglionic receptor to which it binds. (More about NE in A&P II...)

5. Receptors that bind ACh are called 'cholinergic'. Receptors that bind NE are called 'adrenergic'.

Lecture 22 - Special Senses (Chapter 12)

1. There are **five major groups of sensory receptors**
   a. Chemoreceptors (general) - respond to changes in chemical concentrations
   b. Pain receptors or nociceptors (general) - respond to stimuli likely to cause tissue damage
   c. Thermoreceptors (general) - respond to changes in temperature
   d. Mechanoreceptors (general, special) - respond to mechanical forces
   e. Photoreceptors (special) - respond to light (these are the rods and cones)
2. The **major classification of mechanoreceptors**, which use mechanically gated ion channels are:
   a. Baroreceptors - detect changes in pressure
   b. Proprioceptors - detect changes in tension in mucles and tendons and are protective

i. Muscle spindles - initiate contraction of muscle (the stretch reflex)
ii. Golgi tendon organs - inhibit contraction of muscle

3. **Sensory adaptation** is a reduction in sensitivity of sensory receptors from continuous stimulation.

a. In order for sensory adaptation to occur, the stimulus must be painless and constant.
b. Pain receptors, or proprioceptors, do not undergo adaptation since they signal damage to tissue (although pain can be modulated within the CNS)

4. **When a stimulus exceeds the capability (too hot or too cold) of a thermoreceptor**, pain receptors are activated instead. This is a protective mechanism since too high or too low a temperature can cause tissue damage.