

N102
Nervous System Anatomy and Physiology Review
Student Notes

- I. Function of the Nervous System
 - A. Controls and coordinates the body's activities to maintain homeostasis (temp, resp, dig)
 - B. Generation of sensory input to be processed (afferent impulses)
 - C. Processing of incoming data
 - D. Generation of impulses that control various voluntary and involuntary motor functions (efferent impulses)
 - E. Storage of information-sometimes useful into
- II. Cellular A&P
 - A. Two types of cells: neurons and neuroglia cells
 1. Neurons – functional unit of the NS. Purpose is to transmit messages
 - a. Vary in shape and size but all have 3 common characteristics
 - 1) excitability – ability to generate an impulse
 - 2) conductivity – ability to transmit the impulse within its self
 - 3) influence- able to transmit impulse to influence other neurons
 - b. Components of the neuron
 - 1) Cell body – center of the neuron; form the gray matter of the brain
 - 2) Dendrites –projects from the cell body – receives impulses and directs them toward the cell body
 - 3) Axon – carries impulses away from the cell body –
 - i. may be with or without a myelin sheath
 - c. Myelin Sheath
 - 1) Axons that are coated with a myelin sheath are known as myelinated
 - 2) This covering insulates, maintains, and speeds axon transmission
 - 3) It is a lipid substance that gives white color to the white matter in CNS
 - d. Classification of Neurons: structural and functional
 - 1) Structural –defined by the processes/ poles they have
 - i. Multipolar – cell body, 1 axon, several dendrites
 - ii. Bipolar – 1 axon, 1 dendrite
 - iii. Unipolar – only 1 pole or process – close to cell body
 - 2) Functional – defined by the direction an impulse is conducted
 - i. Sensory (afferent) transmit nerve impulses toward CNS from peripheral sensory organs (skin)
 - ii. Motor (efferent) – transmit nerve impulses away from CNS to muscles, glands, organs
 - iii. Interneurons-transmit impulses from afferent (sensory) to efferent (motor) nerves
 2. Neuroglia or glial cells
 - a. Repair, support, and protect the neurons
 - b. 5-10 times more numerous than neurons
 - c. Most common source of primary tumors because they are mitotic-they easily divide and replicate

d. Types of glial cells

- 1) Oligodendrocytes – important to know = produces myelin sheaths on axons-*What does it do?* Speeds transmission
 - 2) Astrocytes – found mostly in gray matter, accumulate in areas where neurons have been damaged and contribute to formation of scar tissue (gliosis), feed neurons, form the BBB, aka star of NS
 - 3) Ependymal cells – aid in secretion and regulation of CSF
3. Nerve Regeneration: all nerves when damaged will try to re-grow
- a. CNS: neurons in the CNS have limited ability to repair themselves and once believed to have no ability to generate new cells
 - b. PNS: nerve regeneration does occur but it is a slow process

B. Nerve Impulse Conduction

1. travels by electrical transmission along axon and chemical transmission between neurons until impulse reaches its destination
 - a. electrical impulse is a result of K⁺ and Na⁺ ions moving in and out of the cells all along the length of the axon
 - 1) resting state-no impulse-high K⁺ in cell
 - 2) depolarization-channels in the cell membrane open and Na⁺ rushes in (deploys) high Na⁺ in cell
 - 3) repolarization-K⁺ channels open and it slowly enters to bring balance back to the cell membrane (returns to resting)
2. Action potentials –electrical impulse that travels along the axon by depolarizing and repolarizing the length of the axon is an action potential-doing the WAVE
3. impulse reaches the end of the nerve fiber then is transmitted across the junction between nerve cells (synapse)
4. chemical interaction generates another action potential in the next neuron
5. this process is repeated until the impulse reaches its destination (muscle, gland, organ)
6. Saltatory conduction
 - a. Type of nerve conduction when the axon is myelinated
 - b. Myelin sheath coats the axon like sausage links
 - c. **Action potential jumps from 1 node of Ranvier to the next** – this hopping makes the impulse increase velocity (travel faster) and conserves energy
 - 1) Nodes of Ranvier – gaps in the myelin on axons that speed impulse along
 - d. with saltatory conduction the Na⁺ and K⁺ ions are only required to move in and out of the cells at the nodes instead of depolarizing and repolarizing the entire length of the axon
7. synapse – junction or space where nerve impulse is transmitted from 1 neuron to another
 - a. neurotransmitter – *chemicals* involved in the transmission of an impulse across the synaptic cleft to the receiving neuron
 - 1) acetylcholine –
 - 2) serotonin –
 - 3) norepinephrine –
 - 4) dopamine

III. Divisions of the nervous system – central and peripheral

A. Central nervous system consists of the

1. brain
 - a. cerebrum
 - b. brainstem – midbrain, pons, medulla
 - c. cerebellum
 2. spinal cord
- B. Peripheral nervous system consists of the
1. 12 pairs cranial nerves
 2. 31 pairs spinal nerves
 3. autonomic nervous system
 - a. sympathetic
 - b. parasympathetic
- C. Nervous System Protective Structures
1. cranium – bony protection for the brain
 - a. 14 facial bones
 - b. 8 cranial bones: 2 each frontal, temporal, parietal, occipital
 - c. skull is rigid and does not allow much extra space –
 - d. frontal – form forehead
 - e. occipital – large bone at base of skull
 - f. temporal – forms sides and base
 - g. parietal – forms sides and top of skull
 - h. Foramen magnum – largest hole in our skull. What comes through here?
brain stem extends to spine foramen means opening and magnum meaning big
 2. Scalp – outermost layer of protection – fibrous and freely movable
 3. Meninges – beneath our rigid skull with all its bones is the meninge layers
 - a. Layers (3) of protective membrane that surround the brain and spinal cord
 - 1) Dura mater – outermost, thickest and toughest
 - 2) Arachnoid – middle layer – thin, delicate, loosely encloses the brain and spinal cord. Pathway for the flowing of CSF in the brain and Spinal Cord
 - 3) Pia Mater – innermost layer covering the surface of the brain and spinal cord, mesh like, vascular
 - b. spaces of the meninges
 - 1) epidural – epi-above so above the dura-potential space between skull and outer dura of the brain
 - 2) subdural – below the dura, between dura and arachnoid layer
 - 3) subarachnoid - between arachnoid and pia mater – where the CSF is contained
 - c. Protective Anatomy
 - 1) Falx cerebri-fold of dura that separates the 2 cerebral hemispheres allows for some expansion without pressure being placed on the opposite cerebral hemisphere
 - 2) Tentorium cerebelli – double dura layer folds between the cerebral hemispheres and the cerebellum to prevent them from pressing on one another
 - i. So the cerebrum can expand some and the thick dura protects it from affecting the cerebellum and brainstem
 - 3) supratentorial – surgery above the tentorium

4) infratentorial – surgery below the tentorium

4. Cerebrospinal fluid

- a. Clear, colorless, odorless
 - 1) On average we have ~135ml
- b. Purpose: “shock absorber” – cushions brain and SC against injury due to movement (like a built in liquid pillow)
- c. Provides nutrients: content similar to plasma (different %’s)
 - 1) no RBC’s
 - 2) water
 - 3) sm amt protein
 - 4) O₂ and CO₂
 - 5) Na, K, Cl, glucose (important nutrient)
- d. Choroids plexus – are cauliflower-like structures located in portions of the ventricles –produces and secretes CSF
 - 1) Choroid plexus consist of many capillaries-blood enters, is filtered, and secreted as CSF (like super ultrafiltrated blood)
 - 2) Continually being formed
- e. CSF flow
 - 1) Termed the 3rd circulation and is a closed system
 - 2) Pools in the ventricles and flows throughout the subarachnoid space and BATHES the brain and SC
- f. CSF is absorbed daily by the arachnoid villi projections

5. Cerebral circulation

- a. Brain does not store nutrients and requires a constant supply of oxygen
Need is met through cerebral circulation
 - 1) Brain receives 750 ml/min of blood or 20% of our total cardiac output
 - 2) Brain requires 25% of body’s total oxygen and glucose requirements
- b. Venous drainage (unique) –how all the blood gets out of the CNS
 - 1) Exit via 2 vascular channels formed by the dural layers called dural sinuses
 - 2) cerebral veins empty into the dural sinuses which empty into the jugular veins for return to the heart
 - 3) Unique feature is absence of valves – gravity is important in maintaining optimal venous outflow
- c. Arterial supply
 - 1) Enters skull thru the largest opening in the skull? Which is the Foramen magnum
 - 2) Anterior circulation supplied by common carotids in the neck which branch into the internal and external carotids
 - 3) Posterior Circulation is supplied by the subclavian artery that branches into 2 vertebral arteries
 - i. These vertebrals unite and become the basilar artery

- 4) Circle of Willis – allows blood to circulate from one hemisphere to the other so it acts as a safety valve to protect from differential pressures or occlusion
 - i. Formed at the junction of the basilar artery (posterior circulation) with the internal carotid arteries (anterior circulation)
 - ii. Has a protective function to shunt blood between anterior and posterior cerebral circulation
- 5) Another protective function of the brain is termed autoregulation-brain can self regulate its blood supply to meet changes in metabolic needs
 1. How? Regulates blood vessel diameters independent of systemic BP –WOW
- 6) Blood brain barrier
 - i. Physiological barrier between blood capillaries and brain tissue. *Made up of tight capillaries and astrocytes. Brain capillaries are more selective with what is allowed to pass to brain tissue*
 - ii. Protects brain from certain potentially damaging agents, organisms, and toxins while allowing nutrients and gases to enter
 - iii. Only certain drugs/medications can pass BBB
 1. Its ability to limit entry into the CNS makes treatments for CNS disorders challenging.

6. Brain

- a. Consists of 3 major divisions – cerebrum, brain stem, cerebellum
- b. anatomical landmarks_
 - 1) gyrus – “convolution” fold on the surface of the brain that increases its surface area
 - 2) fissure – deep predictable separation in cerebral hemispheres
 - i. Great longitudinal fissure – divides cerebral hemispheres into Rt and Lt
- c. cerebrum
 - 1) largest part of the brain
 - 2) nerve centers associated with sensory and motor functions and higher mental functions located here (memory, reasoning)
 - 3) cerebral cortex – outer layer- gray matter What’s in there?– billions of neuron cell bodies and dendrites cover each hemisphere – under this is white matter (myelinated axon tracts)
 - 4) 2 hemispheres
 - i. 2 hemispheres divided by? Great longitudinal fissure
 - ii. Each hemisphere has four lobes
 1. frontal, parietal, temporal, and occipital
 - iii. frontal
 1. right controls left side of body
 2. left controls right side of body (contra-lateral)
 3. voluntary gross motor function
 4. memory

5. higher cognitive function (problem solving)
6. judgment
7. Broca's area – found in frontal lobes = responsible for expressive speech the formation of spoken words (motor). Able to understand well but difficulty saying words. (Ie.. how did you get to the office today? D-d-d-d-drive c-c-c-car) words forced out slow with stuttering.
 - a. damage here in dominant hemisphere = expressive aphasia (no motor integration of lips, mouth, inability to express thoughts) can't form words
 - b. cerebral dominancy for 90% of persons is in the Left frontal lobe – all right handed people and most left handed

iv. Parietal lobes

1. primary sensory area – interpretation of sensory thought
2. sensations of touch, pressure, position
3. body awareness- for example- where is your L buttocks? If you have to turn and look then something is wrong with your parietal lobe.
4. spatial awareness? Ability to comprehend your position in relation to the world around you ie furniture-It is why I don't walk into the podium (usually)

v. Temporal lobes

1. auditory reception – hearing and interpreting sound
 - a. we hear music, have memory of sound, and understanding of language and music (ability to recite lyrics)
2. Wernicke's area – responsible for understanding and interpretation of written and spoken language (reading a book, listening to lecture)
 - a. damage= receptive aphasia
 - i. able to form words but unable to understand others

vi. Occipital lobes

1. primary receptive area for vision and visual association
2. What happens with damage to this lobe?
 - a. Inability to recognize & identify objects

vii. Special structures of the cerebrum

1. Basal Ganglia – basal (base) ganglia (clump of neurons)
2. base of the cerebrum-deep in the center of the cerebral hemispheres (put one finger through your eye and one through your ear and you found it).

- a. initiation, execution, and completion of voluntary movement
- b. automatic motor movements (ie swallow, blink, arm swinging)

3. Diencephalons

- a. area in the brain sits on top of the brainstem includes the thalamus and hypothalamus
- b. Thalamus – relay station for all sensations - grand central. Impulses regarding sensations sent through here
- c. Hypothalamus – Very Busy- regulates the autonomic NS (involuntary body functions) endocrine function (effecting pituitary secretions) and influence is responsible for temp control, fluid balance, reproduction, metabolism, hunger center controlling appetite,
- d. Limbic system- Primal human features. Feeding and sexual behaviors, and emotional responses rage, fear, and depression.

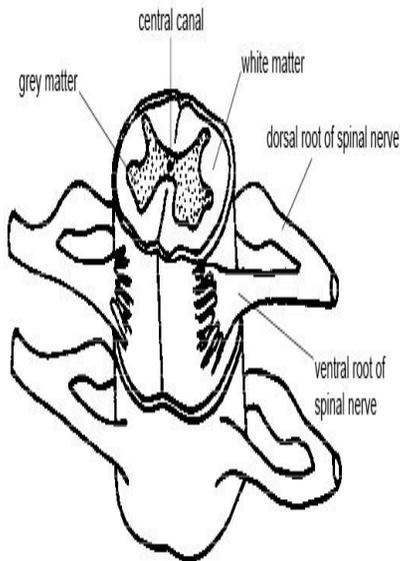
d. Brainstem – second major subdivision of brain

- 1) connects the spinal cord with the cerebrum and cerebellum
- 2) contains ascending and descending pathways for impulses going to and from the brain
- 3) point of attachment for CN III (3) through XII (12)
 - i. 10/12 cranial nerves originate in the brainstem
- 4) contains many reflexes – swallowing, cough, vomiting, hiccup.
- 5) midbrain, pons, medulla oblongata
- 6) Medulla oblongata –primary rhythm center-
 - i. Responsible for respirations, vasomotor (BP), and cardiac function (HR).
- 7) Reticular Formation-specialized system of neurons responsible for controlling the sleep-wakefulness cycle. Known as the RAS- reticular activating system. Involves consciousness and attention span(Why we wake in the middle of the night with a loud noise).

e. Cerebellum – located in posterior (back) fossa, superior to the brain stem, and inferior to the occipital lobe

- 1) Responsible for coordination of motor function and fine, smooth movement, balance, and trunk stability
- 2) Feedback loops correct movements by receiving impulses from the cerebral cortex and influencing motor activity

7. Spinal Cord



- a. Continuous with the brainstem and exits the cranial cavity (thick as a finger)
 - b. Elongated mass of nerve fibers that occupies the upper 2/3 of the vertebral canal
 - 1) Extends from C1 to L1 (first cranial to first lumbar)
 - 2) Protected by: vertebral column and meninges (Dura, arachnoid, pia)
 - c. Spinal Cord Matter-a cross section (bread slice) of the spinal cord shows an H shaped central core of nerve cell bodies (grey) surrounded by white matter ascending and descending tracts (myelinated axons)
 - 1) Gray matter-motor neuron cell bodies, nuclei
 - i. Anterior/ventral – wider arms of the H
 1. here is the primary *motor* neurons through which the spinal tracts carry motor response messages to the periphery (end organs)
 - ii. Posterior (Dorsal)– thinner arms of the H
 1. here are the primary *sensory* neuron through which peripheral nerve messages enter spinal cord and synapse with ascending tracts
 - 2) White matter – myelinated nerve tracts – carry motor messages between the brain and the periphery
 - i. Sensory – afferent – message up, ascending tracts
 - ii. Motor- efferent – message down, descending tracts
8. Ascending tracts – carry specific sensory (afferent) information to the brain from receptors in the peripheral NS
 - a. dorsal column (posterior) – carry impulses of position sense and movement, deep touch, pressure, vibration, kinesthesia (our appreciation of movement, weight, and body parts)
 - b. spinocerebellar tracts – enters spine ends at cerebellum
 - 1) carry subconscious info about muscle tension and body position to cerebellum for coordination of movement
 - 2) impulse enters sc and straight to the cerebellum (no crossing)
 - c. spinothalamic tracts – enters spine ends at thalamus
 - 1) What is the function of the thalamus? Major relay station
 - 2) carry pain and temperature control
 9. Descending Tracts – carry motor impulses that are responsible for muscle movement. Exit the spinal cord via ventral root (wide H)
 - a. Corticospinal
 - 1) Originate – primary motor cortex of frontal lobe
 - 2) Crosses at medulla
 - 3) Responsible for voluntary motor function
 - i. Each side of the brain controls the skeletal muscles on the opposite side of the body- Why? Because cross at medulla
 10. Upper and Lower motor neurons carry efferent messages that influence skeletal muscle
 - a. damage to either can cause weakness and paralysis
 - b. Upper Motor Neurons (UMN)
 - 1) Located in cerebral cortex

2) Lesions generally cause weakness, paralysis, hyperreflexia, and increased muscle tone (spastic)

c. Lower motor neurons-originate in the spinal cord

1) Final step of the nerve impulse before stimulation of skeletal muscle-connect CNS to muscle

2) Lesions/Damage cause weakness, paralysis, decreased muscle tone (flaccid), hyporeflexia (think slower lower Delaware)

11. Reflexes

a. Involuntary response to a stimulus – pathway is a reflex arc

b. receptor organ – has specific sensory fibers that are sensitive to stimulus

c. Monosynaptic Reflex-simplest type-four steps

1) Receptor organ ie.. skin

2) Sensory neuron activated by stimulus (afferent pathway)

3) Information processed in the spinal cord

4) Motor neuron activated (efferent pathway)

d. Example: superficial or cutaneous reflex– skin touches a hot stove, sensory impulse sent to spinal cord, motor message pulls hand away

D. Peripheral Nervous System

1. Includes all nervous system structures that lie outside CNS

2. 12 pairs cranial nerves; 31 pairs spinal nerves and autonomic NS

3. Cranial Nerves

a. Carry sensory fibers or motor fibers or both

b. Come in pairs (one for each eye, ear, etc)

c. CN innervate a specific segment of the brain (remember 10/12 exit at the brainstem)

Cranial Nerve #	Name (s) (m)	Function	How to test
I	<u>Olfactory</u> (s)	smell	ID familiar odors with eyes closed-coffee, vanilla. Test both sides
II	<u>Optic</u> (s)	vision	Visual acuity-use snellen chart Peripheral vision-focus on examiner nose w one eye closed and ID when ex. finger in periphery is first seen or when wiggled
III	<u>Oculomotor</u> (m)	Eye movement Eyelid elevation Pupil constriction	3,4,6 tested together b/c all are involved in eye movement. Follow examiner fingers as moves horiz and vert making an N or wide H
IV	<u>Trochlear</u> (m)	Eye movement	3-evaluate for lid drooping-ptosis 3-pupil constriction- absence can be an early sign of brain herniation
V	<u>Trigeminal</u> (s,m)	face sense chewing	Feel cotton wisp on forehead, cheek, jaw with eyes closed Clench teeth and open jaw with resistance
VI	<u>Abducens</u> (m)	Eye movement	Same testing as CN III
VII	<u>Facial</u> (s,m)	taste facial muscles expressions	Taste-sugar/salt on anterior tongue (both sides) Have pt imitate you-wrinkle forehead, frown, smile-look for symmetry Try to open the pt closed eyes
VIII	<u>Acoustic</u> (s) or Vestibulocochlear	hearing and equilibrium	Hearing tested with a tuning fork, watch ticking, rustling fingers Equilibrium-ask pt to walk in straight line

IX	<u>Glossopharyngeal</u> (s,m)	tongue, pharynx/larynx (taste) superior pharynx muscles (gag-swallow)	9,10 are tested together because control similar functions. Test gag reflex with a tongue depressor to each side of pharynx. Say ahh and check for uvula movement
X	<u>Vagus</u> (s,m)	ph/lar sense smooth muscle of palate, larynx, pharynx (gag-swallow) and Parasymp NS-heart, lungs, digestive system	Observe pt ability to swallow
XI	<u>Spinal Accessory</u> (m)	Muscles: neck, sternocleidomastoid and trapezius	Shrug shoulders and turn head
XII	<u>Hypoglossal</u> (m)	tongue muscle	Stick tongue out and observe for deviation.

4. Spinal Nerves – 31 pairs exiting the SC

- a. Spinal nerves are always combined having both motor and sensory fibers
5. Dorsal root- attachment point to the spinal cord for sensory fibers
6. Ventral root-detachment point from the spinal cord for motor fibers
7. Dermatomes – area of skin innervated by the sensory fibers of a single root
 - a. Interruption of 1 sensory nerve root may result in paresthesia or pain in that dermatome area
 - b. So when a patient reports numbness for example in a certain location it alerts the evaluator to what spinal nerve is involved. Because there are specific nerves connected to specific locations.
8. Myotome– muscle group innervated by primary motor neurons of a single root
9. Cauda equina – latin term meaning “horse’s tail”
 - a. All nerve roots exit horizontally except in the lumbar, sacral, and coccygeal roots which descend down giving the horse tail appearance

E. Autonomic nervous system

1. responsible for involuntary functions of cardiac, smooth muscles, and glands
 - a. Do you tell your heart to pump?
2. 2 major subdivisions = sympathetic and parasympathetic
3. purpose – maintain a relatively stable internal environment for the body
 - a. Through the para and symp NS working together
 - b. Systems often have dual and reciprocal innervation of structures
 - 1) Ie sympathetic increases HR and parasymp dec HR
4. sympathetic-self-preservation instincts
 - a. activated during stress situations (fright, fight, flight)
 - 1) inc HR, B/P, vasoconstriction of peripheral blood vessels
 - 2) cell bodies originate in T1 to L2 thoracic and lumbar regions of the spinal core (thoracolumbar division)
5. parasympathetic-rest and digest
 - a. conserves and restores to body’s energy stores
 - 1) dec HR, bronchi constriction, increased peristalsis
 - 2) originates in brain stem and sacrum (craniosacral division)