The Nervous System

Mr. Bania

NHS Human Anatomy and Physiology
II. Organs and Divisions of the Nervous System

A. Two Divisions of the Nervous System:
   1. Central Nervous System (CNS) – brain and spinal cord
   2. Peripheral Nervous System (PNS) – peripheral nerves
      a. Autonomic Nervous System (ANS)
      b. somatic nervous system
III. Cells of the Nervous System

A. Neuron

1. Cell body (main part) - function is to receive and send messages
2. Dendrites – processes or projections that transmit impulses to the neuron cell bodies or axons
3. Axon – one elongated projection - processes that transmit impulses away from the neuron cell bodies or dendrites.
4. Microstructure
   a. All organelles
   b. Neurofibrils – series of protein tubes
   c. Nissil bodies (chromatophilic substance) – similar to rough ER
5. Classification of neurons

a. Bipolar two nerve fibers – special sense organs

b. Unipolar – one nerve fiber – cells of PNS

c. Multipolar – many nerve fibers (only one axon - CNS)
6. Types of Neurons

a. Afferent/sensory – carry impulse from sense organ to CNS

b. Efferent/motor – carry impulse from CNS to Effector

c. Interneurons – connect afferent and efferent – found in CNS
A Reflex Arc Shows How Neuron Types Work Together.

The afferent and efferent fibers often pass in the same nerve.
B. Schwann cells

1. Work with neurons of PNS to produce myelin
2. Area of myelin – neurilemma
3. Between schwann cells – nodes of ranvier
4. Neuroglia cell “helper cell” “glue cell”
C. Microglial cells

1. Cells help phagocytize invaders
2. Small until nerve tissue inflamed
D. Oligodendrocytes

1. Occur in brain and spinal cord
2. Form in rows and make myelin sheath on CNS
E. Astrocyte

1. Found between capillary and neuron
2. Forms BBB
3. Fill space following injury
IV. Nerves

A. Bundle of PNS axons
B. Have Myelin (Schwann) in PNS – White Matter
C. In CNS, bundle called tracts (white matter)
D. Cell bodies and dendrites – grey matter
E. Epineurium, Endoneurium, perineurium, fasicles

Cross-section of myelin sheath
V. Electric Potential (RESTING)

A. Resting Potential (nonstimulated) – when a neuron is not sending an impulse

B. Electric Potential (relative polarization) builds in neuron by Na+/K+ pump moving 3Na+ ions out of cell, while only allowing 2K+ ions in – setting up outside of the cell to be more positive (relative)

C. The cytoplasm of neurons also contains many anions (PO$_4^-$, SO$_4^-$) and proteins
VI. Nerve Impulses

A. When the changes in the neuron’s cell membrane reach a threshold (all or none), an action potential is created.

B. When nerve is stimulated (action potential), it forces Na+ gated channels on the membrane to open, thus allowing an influx of Na+ ions – changing the polarity from more – inside to + (depolarization).
   1. Negative inside draws ions in quickly
   2. K+ ions move outside neuron

C. Myelin provides only certain areas for Na+ to enter (Node of Ranvier), thus the impulse “jumps” – more efficient
   1. Saltatary conduction – 120 meters/sec
   2. Unmyleinated sensory neurons - .5 meters/sec
VII. The Synapse

A. Place where impulses are transmitted between neurons
B. Presynaptic neuron, postsynaptic neuron
C. Synaptic knob – tiny bulge on presynaptic
D. Neurotransmitters – chemicals that move messages across the synaptic cleft
E. At the end of the axon $\text{Ca}^{2+}$ diffuse instead of $\text{Na}^+$ and this causes the synaptic vesicles (neurotransmitters) to go to membrane (cleft)
F. Neurotransmitters

1. Can be:
   a. Excitatory – increase sensitivity to Na+
   b. Inhibitory – decrease sensitivity to Na+
   c. 50 different ones have been identified
   d. Axon knob can release more than 1

2. Acetylcholine – (most common) elicits a muscle response

3. Endorphins/Enkaphalins – released to relieve pain/stress – sometimes through exercise

4. Catecholamines – mood, motor function, sleep
   a. Norepinephrine (equivalent to adrenaline)
   b. Dopamine (morphine) – cocaine elevates
   c. Seratonin (good mood)
VIII. Impulse Processing

A. The way nerves are organized and neurons respond to impulses

1. Neural pools – found in brain and process information
2. Facilitation – when a neuron, due to neurotransmitters are more excitable to a stimulus
3. Convergence – When a single neuron can receive impulses from more than one
4. Divergence – One neuron stimulates more than one
IX. Reflex Arcs

A. A simple type of neuron pathway (carries action potential)

B. Usually does not involve brain

C. Impulse Conduction
   1. Receptor (tendon, skin)
   2. Dorsal root ganglion (group of cell bodies)
   3. Synapse (space between neurons)
   4. Efferent Neuron
   5. Effector

A. Types
   1. Three neuron (sensory, interneuron, and motor neuron)
      a. Withdrawal Reflex
   2. Two neuron (sensory + motor neuron)
      a. Patellar Reflex
Figure 9.15
The knee-jerk reflex involves two neurons—a sensory neuron and a motor neuron. Note the single synapse within the spinal cord.

Figure 9.16
A withdrawal reflex involves a sensory neuron, an interneuron, and a motor neuron. Note the synapses within the spinal cord.
X. Meninges

A. Located between the bones (skull, vertebrate) and nerve tissue – protection and cushioning

B. Types
1. Pia mater – directly around brain and spinal cord
2. Dura mater – lines the bone
3. Arachnoid membranous layer between pia mater and dura mater
4. Cerebral Spinal Fluid (CSF)
   a. Fills arachnoid space adds cushioning and protection
   b. Also fills spaces called ventricles
FIGURE 7-13  Spinal Cord. The meninges, spinal nerves, and sympathetic trunk are visible.
XI. Spinal Cord

A. Begins in foramen magnum and ends at lumbar vertebrate

B. 31 spinal nerves
   1. Cervical enlargement – gives rise to neck and upper limbs
   2. Lumbar enlargement – lower limbs
1. Has grey matter (cell bodies – motor neurons) “H”
   a. Anterior horn – efferent motor fibers
   b. Posterior horn – afferent sensory fibers
   c. Gray commissure (central bar) with central canal runs longitudinally
2. White matter has nerve tracts – major nerve pathways
   1. Anterior white, posterior white, lateral white, columns both sides
   2. Columns contain fascicles or tracts of fibers
   3. Ascending tracts – sensory to brain
   4. Descending tracts – brain to motor
   5. Names by where they are coming from to where they are going
XII. Brain – 1 billion multipolar neurons

A. Parts
1. Brain Stem – most inferior
   a. Medullar oblongata – most upward portion of spinal cord, cardiac center
      i. Controls vital centers – cardiac center (heartbeat), respiratory (respirations) and vasomotor (blood vessel thickness)
   b. Pons- located above medualla oblongata – regulates rate and depth of breathing
   c. Midbrain – located above pons, reflex centers for eye and turning head
   d. Function
      i. Act as a two way path for neurons
      ii. Reticular formation – tiny islands of grey matter that awakens cerebrum when stimulus is presented
2. Diencephalon

a. Portion between above midbrain and below the cerebrum
b. Optic chiasma – optic nerve cross – stereoptic vision
c. Pineal gland – melatonin; pituitary gland – master gland
d. Thalamus
   i. Helps produce sensation by relaying sense organ messages to cerebrum
   ii. The arrival of sensory stimulation is paired with emotion here (arousal and alerting)
e. Hypothalamus
   i. Below the thalamus
   ii. Extends into the third ventricle to the pituitary gland
   iii. Links nervous system and endocrine system
   iv. Plays an important role in water balance, balance, sleep cycles temperature regulation, appetite, emotions
   v. Comprises the limbic system – system that controls emotional experiences and expression
3. Cerebellum

A. Structure
1. Second largest part of brain lies posterior to the pons and medulla, beneath occipital bone
2. Consists of two lateral hemispheres, separated by a layer of dura mater, and connected by a structure called the vermis
   a. Composed mostly of white matter, with a layer of grey matter (cortex) on the outside
   b. Peduncles – nerve tracts that move info to and from the cerebellum
      i. Inferior – pair-brings sensory information in about body parts
      ii. Middle – brings in information concerning desired positioning
      iii. Superior – transmits correcting impulses to midbrain for descending motor tracts

B. Function
   a. Production of coordinated movement, and balance
4. Cerebrum

a. Structure

1. Most superficial (peripheral) part of brain. Made of 5 lobes.
   - i. Frontal (bone)
   - ii. Parietal (bone)
   - iii. Occipital (bone)
   - iv. Temporal (bone)
   - v. Insula (deep)

2. Cerebral cortex – grey matter (75% of all neurons of NS) – provide specific sensory, motor, and association functions (conscious thought)

3. Divided into right/left hemispheres by longitudinal fissure (deep groove), and is separated from cerebellum by transverse fissure

4. Has ridges (gyri) and grooves (sulci). Sulci separate lobes.
   - i. Central sulcus separates frontal/parietal lobe
   - ii. Lateral sulcus separates temporal/frontal+parietal

5. Corpus callosum – white matter tracts that connect right/left side
b. Function – conscious thought, higher level thinking

i. Frontal lobe
   a. primary motor area (in front of central sulcus), pyramid shaped cells (pyramidal) begin corticospinal tracts, and most cross over in brain stem
   b. Motor speech (Broca’s area) coordinates speech organs
   c. Concentration, planning

ii. Parietal Lobe
   a. somatic sensory area (posterior to central sulcus),
   b. Understanding speech using words
   c. taste area,
   d. sensory association

i. Occipital Lobe – Visual cortex and visual association

ii. Temporal Lobe – Auditory, auditory association, memory of visual and auditory patterns.
c. Right Side vs. Left Side

1. Each side of the brain has its own unique and special abilities. The right side of the brain is intuitive, while the left side of the brain is logical.
   
   i. **Left side processes:**
      a. Speech, Analysis, Time, Sequence
   
   ii. **Right side processes:**
      a. Creativity, Patterns, Spatial Awareness, Context

   iii. 90% of the population is left brain.
      a. left brain people – tend to be more verbal, analytical, and problem solvers
      b. right brain people - tend to be artsy, good with math, and are more visual in nature

**Myths**

- **Handedness** - No correlation between hemispheric dominance and being right handed vs. left handed.
- **Intelligence** - No evidence to support right-sided hemispheric dominance is superior to left side hemispheric dominance and vice versa. There is no correlation to intelligence.
- **Genetics** - No evidence that dominance is hereditary.
- **Gender** - Females tend to be more left hemispheric dominant and males tend to be more right hemispheric dominant.
XIII. Peripheral Nervous System

A. Somatic Nervous System - cranial and spinal nerves - connect brain and spinal cord to skin and structures

B. Autonomic Nervous System - part of PNS that controls instinctive behavior
C. Cranial Nerves

1. Twelve pairs are attached to underside of brain
2. Expressed in Roman Numerals
3. Important ones
   a. I Olfactory (smell)
   b. II Optic (vision)
   c. VII facial (taste buds)
   d. VIII Vestibulocochlear
<table>
<thead>
<tr>
<th>NERVE*</th>
<th>CONDUCT IMPULSES</th>
<th>FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Olfactory</td>
<td>From nose to brain</td>
<td>Sense of smell</td>
</tr>
<tr>
<td>II Optic</td>
<td>From eye to brain</td>
<td>Vision</td>
</tr>
<tr>
<td>III Oculomotor</td>
<td>From brain to eye muscles</td>
<td>Eye movements</td>
</tr>
<tr>
<td>IV Trochlear</td>
<td>From brain to external eye muscles</td>
<td>Eye movements</td>
</tr>
<tr>
<td>V Trigeminal</td>
<td>From skin and mucous membrane of head and from teeth to brain; also from brain to chewing muscles</td>
<td>Sensations of face, scalp, and teeth, chewing movements</td>
</tr>
<tr>
<td>VI Abducens</td>
<td>From brain to external eye muscles</td>
<td>Turning eyes outward</td>
</tr>
<tr>
<td>VII Facial</td>
<td>From taste buds of tongue to brain; from brain to face muscles</td>
<td>Sense of taste; contraction of muscles of facial expression</td>
</tr>
<tr>
<td>VIII Vestibulocochlear</td>
<td>From ear to brain</td>
<td>Hearing; sense of balance</td>
</tr>
<tr>
<td>IX Glossopharyngeal</td>
<td>From throat and taste buds of tongue to brain; also from brain to throat muscles and salivary glands</td>
<td>Sensations of throat, taste, swallowing movements, secretion of saliva</td>
</tr>
<tr>
<td>X Vagus</td>
<td>From throat, larynx, and organs in thoracic and abdominal cavities to brain; also from brain to muscles of throat and to organs in thoracic and abdominal cavities</td>
<td>Sensations of throat and larynx and of thoracic and abdominal organs; swallowing, voice production, slowing of heartbeat, acceleration of peristalsis (gut movements)</td>
</tr>
<tr>
<td>XI Accessory</td>
<td>From brain to certain shoulder and neck muscles</td>
<td>Shoulder movements; turning movements of head</td>
</tr>
<tr>
<td>XII Hypoglossal</td>
<td>From brain to muscles of tongue</td>
<td>Tongue movements</td>
</tr>
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FIGURE 7-16 Cranial Nerves. View of the undersurface of the brain shows attachments of the cranial nerves.
D. Spinal Nerves

1. Afferent – posterior horn of spinal cord; efferent anterior horn of spinal cord
   a. posterior root ganglion has cell bodies of sensory neurons
   b. Motor neuron cell bodies in grey matter of spinal cord
   c. Most spinal nerves form a plexus – a complex network of nerves

2. 31 pairs of Spinal Nerves attached to the spinal cord
   a. 8 pairs attached to cervical segment
   b. 12 pairs to the thoracic segment
   c. 5 pairs to lumbar region
   d. 5 pairs to the sacrospinal segment
   e. 1 pair to coccygeal segment

3. Spinal Nerves have no special name – identified by a letter and number
   a. C1 – indicated spinal nerves attached to 1st segment of cervical part of cord
   c. T8 – attached to 8th segment of thoracic part of cord
   d. Sciatica – lower vertebrate
E. Dermatome - surface area maps of nerves