University of the Philippines Manila
COLLEGE OF NURSING

N3-Anatomy and Physiology
1st Semester AY 2022-2023

STUDY GUIDE
Week # 5

THE NERVOUS SYSTEM: STRUCTURE AND FUNCTIONS

Introduction

The nervous system works in regulating life processes by rapidly responding through nerve impulses (or action potentials), as opposed to the endocrine system that also regulates body processes but through the release of hormones. The nervous system is also responsible for our perceptions, behaviors, and memories (Tortora and Derrickson, 2014). In this study guide, we will look closely at the structure of the nervous system and its various functions.

Learning outcomes

After going through this topic, you should be able to:

1. Describe the anatomic and functional divisions of the nervous system
2. Identify the locations and functions of neuroglia and neurons
3. Explain the events that occur at the chemical synapse
4. Identify the major neurotransmitters and their functions
5. Identify the parts of the central nervous system
6. Identify the cranial nerves and their functions
7. Describe the major parts of the peripheral nervous system
8. Distinguish between sympathetic and parasympathetic divisions

Resources that you need to read

Please read the main references below to have a better understanding of the topic.

1. Tortora GJ & Derrickson B. (2014). *Principles of Anatomy and Physiology.* John Wiley & Sons, Inc. 14 edition.

   Specific chapters you need to read:
   - Chapter 12. Nervous Tissue
   - Chapter 13. The Spinal Cord and the Spinal Nerves
   - Chapter 14. The Brain and Cranial Nerve
   - Chapter 15. The Autonomic Nervous System pages
   - Chapter 16. Sensory, Motor, and Integrative Systems

2. Betts JG, Desaix Peter, Johnson E et al (2017). Anatomy and Physiology. OpenStax Rice University.

   Specific chapters you need to read:
   - Chapter 12. The Nervous System and Nervous Tissue pages 503-548

Chapter 13. Anatomy of the Nervous System pages 549-598
Chapter 14. The Somatic Nervous System pages 599-654
Chapter 15. The Autonomic Nervous System pages 655-690

Note: You may access this open education resource in this link: https://openstax.org/details/books/anatomy-and-physiology. You have an option to view the book online or download the PDF file

Topic outline

The specific topics that will be covered in this study guide are as follows:

1. Functions of the Nervous System
2. Organization of the Nervous System
3. Nervous Tissues: Neurons and Neuroglia
4. Action potentials
5. Neurotransmitters
6. The Central Nervous System
7. The Peripheral Nervous System: The Cranial Nerves
8. The Autonomic Nervous System

1. Functions of the Nervous System

The nervous system has three main functions:

1. SENSORY FUNCTION
   The sensory function of the nervous system refers to the ability of sensory receptors to detect internal (i.e., inside the body) and external stimuli. There are *sensory* or *afferent neurons* that detect these stimulations and carry information to the brain and spinal cords through the different cranial and spinal nerves.

2. INTEGRATIVE FUNCTION
   After the sensory receptors detect stimulation from anywhere in the body, this information is then integrated by the nervous system to make decisions for appropriate response. When the nervous system integrates information, this means that the nervous system analyzes the information to inform a possible response, and it also has the ability to store this information (i.e., memory) so that it can inform actions if ever the same stimulation is encountered again the future. The integrative function is facilitated by *interneurons* found in the central nervous system. The integrative function also allows us to perceive (perception) stimuli, that is, we are consciously aware of any sensory stimulation that affects us.

3. MOTOR FUNCTION
   The integration of information at the central nervous system may inform a response to the stimulation. Hence, in the motor function of the nervous system allows for an appropriate motor response to be elicited. Examples of a motor response would include muscle contraction or gland secretion. The motor function is facilitated by *motor* or *efferent neurons* as they carry information from the brain to the spinal cord or to effector organs (i.e., muscles or glands).

Additional Resource:

Additional resource that you can view is the Khan Academy video on the *Functions of the Nervous*

System found in this link https://www.youtube.com/watch?v=qrK-FBdjGk4

2. Organization of the Nervous System

The nervous system is organized into two main subdivisions:

1. CENTRAL NERVOUS SYSTEM
   The central nervous system is primarily composed of the brain and the spinal cord. The main functions of the central nervous system are to:

   a. Process different kinds of incoming sensory information
   b. Source of thoughts, emotions, and memories
   c. Source of stimulation of muscle contraction and gland secretion

2. PERIPHERAL NERVOUS SYSTEM
   The peripheral nervous system is composed of the cranial nerves and their branches, the spinal nerves and their branches, the ganglia, and the sensory receptors. It is further subdivided into three divisions: *somatic nervous system, autonomic nervous system,* and the *enteric nervous system.*

   Somatic Nervous System
   This consists of sensory neurons that convey information from somatic receptors in the head, body wall, limbs, and special senses of vision, hearing, taste, and smell. It also consists of motor neurons that conduct impulses from the central nervous system to skeletal muscles only. The somatic nervous system is voluntarily controlled.

   Autonomic Nervous System
   This consists of sensory neurons that convey information from autonomic sensory receptors from visceral organs, and motor neurons that conduct nerve impulses from the central nervous system to smooth and cardiac muscle, and glands—further subdivided into the *sympathetic* and *parasympathetic nervous systems.* The control of the autonomic nervous system is involuntary.

   Enteric Nervous System
   This consists of sensory neurons that monitor chemical changes within the gastrointestinal tract as well as the stretching the gastrointestinal walls. It also consists of motor neurons that govern contraction of the gastrointestinal tract smooth muscle, secretion of the gastrointestinal organs, and give instructions for endocrine cells in the gastrointestinal tract to produce hormones. The control of the enteric nervous system is involuntary.

Additional Resource:

An additional resource that you can view is the Khan Academy video on the *Structure of the Nervous System* found in this link: https://www.youtube.com/watch?v=jmD0LBdAvlE

Activity 1:

Answer the question below in the discussion forum:

Your alarm clock woke you up early in the morning as a signal that you need to prepare for class. You stretched, yawned, and began to salivate as you smell the brewing coffee. Your stomach also begins to rumble. List the divisions of the nervous system that are involved in each of these responses.

3. Nervous Tissues: Neurons and Neuroglia

There are two main nervous tissue types:

1. NEURONS
   Neurons possess electrical excitability, meaning they can respond to a stimulus. A stimulus is any change in the environment that is strong enough to cause action potentials. We will discuss what action potentials are in a little while.

   A neuron has three main parts:

   a. Dendrites- these are appendages on one end of the neuron that receives stimulus
   b. Soma- or the cell body is responsible for the synthesis of molecules necessary for the functions of the neuron
   c. Axon- this also an appendage from the soma that conducts nerve impulse to another neuron. The axons are the parts of the neurons that have myelin sheath.

   At the end of the axons are spaces called *synapse* where two neurons (or effector cells) communicate.

   The direction of the travel of electrical impulse (or action potential) is from the dendrites to the soma (or cell body) to the axons, then to the synapse to another neuron.

   The neurons are classified based on their functions:

   a. Sensory or afferent neurons- they either contain sensory receptors or located just after sensory receptors. A stimulus activates these sensory or afferent neurons which produced action potential that travels to the central nervous system for integration.
   b. Motor or efferent neurons- they convey action potentials away from the central nervous system to effectors (can be muscles or glands) in the periphery through cranial or spinal nerves.
   c. Interneuron or association neurons- these are in the central nervous system between sensory and motor neurons. They integrate incoming sensory information which will then elicit a motor response.

Additional Resources:

An additional resource that you can view to learn more about the neurons is the Khan Academy video on *Anatomy of a Neuron* found in this link: https://www.youtube.com/watch?v=ob5U8zPbAX4

Additional resource from Anatomyzone on types of neurons by structure is in this link: https://www.youtube.com/watch?v=X4uuCgElLK8

2. NEUROGLIA

Neuroglia are the other type of nervous tissue. Histologically, they are smaller and more numerous. Unlike the neurons, neuroglia do not generate or propagate action potentials, and they can multiply and divide in the mature nervous system. There are different neuroglia that populate the central and peripheral nervous systems.

Neuroglia of the Central Nervous System

The following are the neuroglia found in the central nervous system and their functions:

a. Astrocytes
   - Contain microfilaments that support neurons
   - Protects the central nervous system by wrapping blood capillaries creating the *blood-brain barrier*
   - Helps maintain appropriate chemical environment for nerve impulse
   - It has a role in learning and memory

b. Oligodendrocytes
   - Responsible for forming and maintaining the myelin sheath around the central nervous system

c. Microglia
   - They function as phagocytes as they remove cellular debris and phagocytose microbes and damaged nervous tissues.

d. Ependymal Cells
   - They line the ventricles of the brain and the central canal of the spinal cord
   - Produce, monitor, and assist in the circulation of the *cerebrospinal fluid.*

Neuroglia of the Peripheral Nervous System

The following are the neuroglia of the peripheral nervous system and their functions:

a. Schwann Cells
   - They form the myelin sheath around axons in the peripheral nervous system
   - Participate in myelin regeneration

b. Satellite Cells
   - Provide support to the ganglia
   - Regulate exchanges of materials between neurons and interstitial fluid

The neurons are myelinated. The *myelin sheath* insulates the axon of a neuron and increases the speed of nerve impulse conduction. As you learned earlier, two neuroglia are responsible for the generation of myelin sheath – the Schwann Cells in the peripheral nervous system and the Oligodendrocytes in the central nervous system. The amount of myelin sheath increases from birth to maturity and its presence greatly increases the speed of nerve impulse transmission.

Additional resource:

You may watch the video on *2 minute neuroscience: Myelin* as an additional resource on the topic on myelin sheaths. Here is the link: https://www.youtube.com/watch?v=5V7RZwDpmXE.

4. Action Potentials

A *membrane potential* is the difference in the amount of electrical change on the inside of the plasma membrane as compared to the outside. Cell with membrane potential, like the neurons, are said to be polarized. Polarization happens when ion channels in the cell membrane allow specific ions to diffuse across the plasma membrane. As the ions diffuse across the plasma membrane to equalize differences in charge, the result is a flow of current that can change the membrane potential.

To illustrate further, remember that excitable cells like the neuron, has what we call *resting membrane potential.* Normally, the outside surface of the plasma membrane has a positive (+) charge and the inside surface has a negative (-) change. The resting membrane potential is achieved from the unequal distributions of various ions in the cytosol and the extracellular fluid. The Na+/K+ pump found in the plasma membrane of these cells have important roles in maintaining the resting membrane potential.

From the resting membrane potential, how are action potentials generated then?

The detection of a stimulus by a sensory neuron will cause the voltage gated Na+ channels in the plasma membrane to open allowing for the influx of Na+ ions inside the cell. This then increases the voltage inside the cell to a positive charge (from the resting membrane potential of about -90 mv). The influx of Na+ ions inside makes the cell *depolarized* (or positively charged) and is ready to generate action potential. After the action potential is generated and transmitted, the cells *repolarize* (i.e., goes back to being negatively charged) by the closure of the Na+ and opening of the K+ channels to allow the positively charged ions to exit the cell. The repolarization continues until the resting membrane potential is reached. At this time, the cell is ready to receive another stimulation, and ready to generate another action potential. However, during the *refractory period*, the neuron cannot generate another action potential in response to a normal threshold stimulus.

How fast are nerve impulses conducted?

There are two types of conduction of nerve impulses – (1) continuous conduction happens in cells that are not myelinated and (2) saltatory conduction happens in myelinated cells. In general, saltatory conduction is faster and more efficient compared to continuous conduction. Aside from the presence of myelin sheath, other factors are involved in determine the speed of nerve impulse conduction such as the diameter of the axon and temperature.

Additional resources

You may want to view the video on *Action Potentials* to view an animation on how action potentials are generated. You may view it in this link: https://www.youtube.com/watch?v=FEHNIELPb0s.

You may also watch the video on *Saltatory Conduction* to learn how the myelin sheath helps in speeding the transmission of nerve impulses in the axons. This is a Khan Academy video and you may view from this link: https://www.youtube.com/watch?v=ikFUv-gdNLQ.

5. Neurotransmitters

Now that you know how nerve impulses are generated at the neurons, let us look at how these impulses are communicated between two neurons. How exactly a nerve impulse is transmitted from one neuron to another?

There are basically two types of transmission of nerve impulses:

1. Electrical synapse
   In the presence of an electrical synapse, the nerve impulses are conducted directly between plasma membrane of adjacent neurons through gap junctions. This type of nerve impulse transmission is rapid and coordinated.

2. Chemical synapse
   In a chemical synapse, a nerve impulse in a presynaptic neuron causes the release of *neurotransmitters* into the synaptic cleft producing a nerve impulse in the postsynaptic neuron.

   There are several neurotransmitters that are produced by the neurons to facilitate transmission of nerve impulses in a chemical synapse:

Neurotransmitter	Function
Acetylcholine	- Released by many peripheral nervous system neurons and by some central nervous system neurons - This is an excitatory neurotransmitter at some synapse like the neuromuscular junction - It can also act as an inhibitory neurotransmitter at other synapses like in parasympathetic neurons.
Glutamate and aspartate	- These are excitatory neurotransmitters in the central nervous system
Gamma aminobutyric acid (GABA)	- This is an inhibitory neurotransmitter
Norepinephrine	- Plays a role in arousal, daydreaming, and regulating mood
Dopamine	- Regulates emotional responses, addictive behavior, and pleasurable experiences
Serotonin	- Involved in sensory perception, temperature regulation, control of mood, appetite, and onset of sleep
Endorphins	- These are neuropeptides and are the body's natural painkillers - Linked to improved memory and learning and to feelings of pleasure or euphoria

Nitric Oxide	- A neurotransmitter that is formed on demand and acts immediately - Research suggests it has role in learning and memory

Additional Resource:

Here are additional videos that you can watch to learn more about neurotransmitters and how they function in the transmission of nerve impulses:

1. Synapse structure in this link: https://www.youtube.com/watch?v=iqf3ft0mh1M
2. Types of Neurotransmitters in this link: https://www.youtube.com/watch?v=FXYX_ksRwIk
3. Neurotransmitter release in this link: https://www.youtube.com/watch?v=Ac-Npt3vgCE

6. The Central Nervous System

THE MENINGES

The *meninges* are the three layers of connective tissue coverings around the spinal cord and the brain. The three layers are as follows:

1. Dura Mater- the most superficial of the three. It is made of tough, dense, irregular connective tissue and acts to protect delicate structures of the brain.

2. Arachnoid Mater- the layer in the middle. It is made of collagen and elastic fibers. Below the arachnoid mater is a space where the cerebrospinal fluid flows called *subarachnoid space.*

3. Pia Mater- the deepest of the three. This is made of collagen and elastic fibers and this is a highly vascularized layer.

THE SPINAL CORD

The spinal cord extends from the lowers part of the brain (medulla oblongata) to the upper border of the second lumbar vertebra. *Spinal nerve* facilitate communication between the spinal cord and specific regions of the body.

When viewed externally, the spinal cord has two main enlargements – (1) cervical enlargement which contains the nerves that supply the upper limbs; and (2) lumbar enlargement which contains the nerves that supply the lower limbs. The *cauda equina* is the distal end of the spinal cord from which the spinal nerve from the lumbar, sacral, and coccygeal regions emanate.

Read further on the internal structure of the spinal cord on page 498-500 on Tortora and Derrickson (2011).

Additional resource: Spinal cord: meninges and internal structure by Anatomyzone (anatomyzone.com) at this link: https://www.youtube.com/watch?v=4H_2JRRzha4

From the spinal cord, several *plexuses* emanate. A plexus is a network of nerves supplying the same body part. The plexuses are as follows:

1. Cervical plexus- supplies the skin and muscles of the posterior head, neck, upper shoulders, diaphragm (phrenic nerve)
   - formed from the C1 to C4 spinal roots (first to fourth cervical spinal roots)

2. Brachial plexus- supplies the upper limbs, neck, and shoulder muscles (e.g., radial, ulnar nerves)
   - formed from the spinal roots of C5 to C8 and T1 (fifth to eighth cervical spinal roots and first thoracic spinal root

3. Lumbar plexus- supplies the abdominal walls, external genitals, part of lower limbs (e.g., ilioinguinal, femoral, and obturator nerves)
   - Formed from the spinal roots of T12 (thoracis nerve) and L1 to L4 (lumbar nerves)

4. Sacral plexus- supplies the buttocks, perineum, and lower limbs (e.g., gluteal, sciatic nerves)
   - formed from the spinal roots L4-L5 and S1-S4 (sacral nerves)

The function of the spinal cord is mainly to act as a 'highway' for the transmission of nerve impulse from the periphery to the brain. The *white matter* of the spinal cord consists of tracts that facilitate nerve impulse conduction while the *gray matter* received and integrate incoming and outgoing information and is site for the integration of *reflex.* A *reflex* is a fast, involuntary sequence of actions that occurs in response to a stimulus.

Read further on the rest of the anatomy of the spinal cord on page 493-503 on Tortora and Derrickson (2011).

Read further on spinal cord physiology on pages 512-520.
Additional resources:
Reflex action and reflex arc (Khan Academy) at this link:
https://www.youtube.com/watch?v=Qiv8dUp_I3c

Introduction to how reflexes work - reflex arc, monosynaptic and polysynaptic reflexes (by Armando Hasundungan):
https://www.youtube.com/watch?v=bY0oQnflmog

THE BRAIN

The Blood-Brain Barrier

This consists of tightly sealed blood capillaries assisted by astrocytes. Its functions to protect the brain from harmful substances and pathogens by preventing passage of many substances from blood into the brain. The membrane is lipid soluble and substances like O2 and CO2 can easily cross the barrier.

The Cerebrospinal Fluid (CSF)

This is a clear, colorless liquid that carries O2, glucose, and other needed chemicals from the blood to the brain. This also removes wastes. The CSF circulates through the subarachnoid space, around the brain and

spinal cord, and through the brain cavities, called *ventricles*. The *choroid plexus* in the ventricles are the site of CSF production. The normal volume of the CSF is from 80 to 150 mL.

The Brainstem

The brainstem has three main parts as follows:

1. Medulla Oblongata
    - The white matter of medulla contains all sensory (ascending) and motor (descending) tracts extending between spinal cord and other parts of the brain
    - It has two major nuclei (aggregation of cells):
        - Cardiovascular center- which regulates the rate and force of the heartbeat and diameter of the blood vessels
        - Medullary rhythmicity area- which adjusts the basic rhythm of breathing
    - Other nuclei under the control of the medulla are the following: those that control sensations of touch, pressure, and vibration; proprioception; control of vomiting reflex; control of coughing reflex; control for hiccupping and sneezing; vestibulocochlear nerve (Cranial Nerve VII); glossopharyngeal nerve (Cranial Nerve IX); accessory nerves (Cranial Nerve XI); and the hypoglossal nerves (Cranial Nerve XII).

2. Pons
    - This is located above the medulla and anterior to the cerebellum
    - It is also consisting of tracts and nuclei
    - Some axons in the pons connect the right and left sides of the cerebellum
    - Several nuclei in the pons are where the signals for voluntary movements originate in the cerebral cortex and relayed to cerebellum.
    - Contains nuclei that helps control with breathing
    - Contains nuclei associated with: trigeminal nerve (V), abducens nerve (VI), facial nerve (VII), and vestibulocochlear nerve (VIII).

3. Midbrain
    - Connects the pons and the diencephalon
    - Has the following nuclei:
        - Substantia nigra- large and darkly pigmented nuclei. The loss of neurons in this nuclei is associated with Parkinson's disease.
        - Red nuclei- iron containing pigment in neuronal cells. It functions with the cerebellum to coordinate movement.
        - Superior colliculi- control reflex arcs including movement of eyes and reflexes governing movements of eyes, head, and neck
        - Inferior colliculi- it is a part of the auditory pathway as it relays impulses from the receptors for hearing in the ear to the thalamus.

The *reticular formation* consists of small cluster or neuronal cell bodies (gray matter) intermingled with small bundles of white matter in the brain stem. The *reticular activating system* (RAS) forms part of the ascending part of the reticular formation and stimulation of this part produces consciousness. The descending part of the reticular formation helps regulate muscle tone.

The Diencephalon

The main part of the diencephalon are as follows:

1. Thalamus- this is the major relay station for most of the sensory impulses that reach the cerebral cortex. It regulates motor function by transmitting information from cerebellum and basal nuclei to motor areas of the cerebral cortex.

2. Hypothalamus- it controls the autonomic nervous system as it regulates contraction of smooth and cardiac muscles and the secretion of glands. It also controls the pituitary gland and the production of hormones. It regulates emotional and behavioral patterns, as well as eating and drinking as the 'thirst' center is in this organ. It also controls body temperature and regulates circadian rhythm and states of consciousness.

3. Pineal gland- secretes melatonin which promotes sleepiness and contributes to circadian rhythm.

The Cerebellum

The following are the functions of the cerebellum:
1. Compares intended movements with what is happening
2. Coordinates complex sequences of skeletal muscle contractions
3. Regulates posture and balance

The Limbic System

This part of the brain consists of the amygdala and hippocampus. They have primary role in emotions, including pain, pleasure, docility, affection, and anger. They also have functions with memory.

The Cerebrum

The cerebrum has four main lobes:
1. Frontal lobe
2. Parietal lobe
3. Temporal lobe
4. Occipital lobe

The functional areas of the cerebral cortex are as follows:

Functional Area	Function
SENSORY AREAS	
Primary somatosensory area	- Located posterior the central sulcus - Receives nerve impulses for touch, proprioception, pain, itching, tickle, and temperature, and responsible for the perception of these sensations.
Primary visual area	- Located in the occipital lobe - Receives visual information and involved in visual perception
Primary auditory area	- Located in the temporal lobe - Receives information for sound and involved in auditory perception
Primary gustatory area	- Located in the parietal lobe - Receives impulses for taste and involved in gustatory perception
Primary olfactory area	- Located in the temporal lobe

	- Receives impulses for smell and involved in olfactory perception
MOTOR AREAS	
Primary motor area	- Located anterior to the central sulcus - Control voluntary contractions of specific muscles on the opposite side of the body
Broca's Speech area	- Located in the frontal lobe - Control and coordinates complex activities needed for speaking and understanding language
ASSOCIATION AREAS	
Somatosensory association area	- Located in the parietal lobe - Integrates and interprets somatic sensations such as exact shape and texture or object, and stores memories of past sensory experience.
Visual association area	- Located in the occipital lobe - Relates present and past visual experiences and essential for recognizing and evaluating what is seen.
Auditory association area	- Located in the temporal lobe - Allows recognition of a particular sound such as speech, music, or noise
Wernicke's area	- Interprets meaning of speech by recognizing spoken words
Common integrative area	- Receives and interprets nerve impulses from somatosensory, visual, and auditory association areas, and sensory areas, and parts of the brainstem.
Premotor area	- Generates nerve impulses that cause a specific group of muscles to contract in a specific sequence e.g., to write a word.
Frontal eye field area	- Control voluntary scanning movement of the eyes
Prefrontal cortex	- Concerned with the makeup of person's personality, intellect, complex learning abilities, recall of information, initiative, judgment, foresight, reasoning, conscience, intuition, mood, planning, and abstract ideas.

Additional Resources

Watch the videos in the link below to learn more about the anatomy of the central nervous system:

1. Introduction to the Central Nervous System by *UBC Medicine- Educational Media*: https://www.youtube.com/watch?v=xB7rXw_3gVY
2. Introduction to the Spinal Cord by *UBC Medicine- Educational Media:* https://www.youtube.com/watch?v=IAwk0pshcDE
3. Brain: Cerebrum and Cerebellum (+ Broca's, Wernicke's, and limbic overview) by Sciebert Science https://www.youtube.com/watch?v=9QFHXXEczp0
4. Brain: Diencephalon and Brainstem by Sciebert Science https://www.youtube.com/watch?v=tgdd34PR8Us

7. The Peripheral Nervous System: The Cranial Nerves

There are 12 cranial nerves and the summary are given below:

No.	Name	Sensory/Motor/Mixed	Function
I	Olfactory Nerve	Sensory	Smell
II	Optic Nerve	Sensory	Vision
III	Oculomotor Nerve	Motor	Movement of upper eyelid and eyeball; constricts pupils
IV	Trochlear Nerve	Motor	Movement of the eyeball
V	Trigeminal	Mixed	Sensory: touch, pain, temperature sensations, proprioception Motor: chewing
VI	Abducens Nerve	Motor	Movement of eyeball
VII	Facial Nerve	Mixed	Sensory: taste, proprioception, touch, pain, temperature sensations Motor: facial expression, secretions of tears, saliva
VIII	Vestibulocochlear Nerve	Sensory	Equilibrium and hearing
IX	Glossopharygeal Nerve	Mixed	Sensory: taste, somatic sensations from tongue, proprioception, monitoring BP, O2 and CO2 for regulation of breathing Motor: swallowing, speech, secretion of saliva
X	Vagus Nerve	Mixed	Sensory: taste and somatic sensations from pharynx and epiglottis; monitoring of BP, O2, and CO2 for regulation of breathing; sensations of visceral organs in thorax and abdomen Motor: swallowing, coughing, voice production, slowing of heart rate; secretion of digestive fluids
XI	Accessory Neve	Motor	Movements of head and shoulders
XII	Hypoglossal Nerve	Motor	Movement of tongue during speech and swallowing

Activity 2

Answer the questions below in the discussion forum:

Your patient recently had a viral infection and now she cannot move the muscles on the right side of her face. In addition, she is experiencing a loss of taste and dry mouth and she cannot close her right eye. Which cranial nerves have been affected by the viral infection?

8. The Peripheral Nervous System: Somatic and Autonomic Nervous System

Here we present the difference between the somatic and autonomic nervous system:

Property	Somatic	Autonomic
Effectors	Skeletal muscles	Cardiac muscles, smooth muscles, and glands
Type of control	Mainly voluntary	Mainly involuntary
Neural pathway	One motor neuron extends from the CNS and synapses directly with a skeletal muscle fiber	One motor neuron extends from the CNS and synapses with another motor neuron in a ganglion; the second motor neuron synapses with an autonomic effector
Neurotransmitter	Acetylcholine	Acetylcholine or norepinephrine
Action of neurotransmitter on effector	Always excitatory (i.e., contraction of skeletal muscle)	Maybe excitatory (i.e., contraction of smooth muscle, increased heart rate, increased cardiac contraction) Can be inhibitory (i.e., relaxation of smooth muscle, decreased heart rate, decreased section from glands.

The motor part of the autonomic nervous system is further divided into the (1) sympathetic division and (2) parasympathetic division. Below are the differences in the response depending on which division is stimulated.

Sympathetic Division	Parasympathetic Division
- Dilation of pupils - Increased heart rate, cardiac contraction, and blood pressure - Dilation of airways - Decreased blood supply in non-essential organs such as the kidney and the GI tract	- Salivation - Lacrimation - Urination - Digestion - Defecation - Decreased heart rate - Decreased diameter of airways - Constriction of pupils

- Dilation of blood vessels in organs involved in exercise or fighting off danger - Breakdown of glycogen by liver cells - Release of glucose by liver	

Additional resources:

1. Autonomic Nervous System Introduction by AnatomyZone

https://www.youtube.com/watch?v=eeQ6c5nu-ck

Activity 3

Answer the following questions in the discussion forum:

1. You have been to an 'eat all you can' buffet and have consumed large amounts of food. After returning home, you recline on the couch to watch television. Which division of the nervous system will be handling your body's after-dinner activities? List several organs involved, the major nerve supply to each organ, and the effects of the nervous system on their functions.

2. Your friend is driving home from work, listening to her favorite music, when suddenly a bicycle came out of nowhere. She manages to swerve avoiding hitting the bicycle. She continued to drive home but she noticed that her heart is beating fast, she had goose bumps, and her heads were sweaty. How would you explain these effects?

References:

1. Betts JG, Desaix Peter, Johnson E et al (2017). Chapter 1 An Introduction to the Human Body. *Anatomy and Physiology.* OpenStax Rice University. Pp 7-40.

2. Tortora GJ & Derrickson B. (2014). Chapter 1 An Introduction to the Human Body. *Principles of Anatomy and Physiology.* John Wiley & Sons, Inc. 14 edition. Pp 1-26.