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Lori Constantine MSN, RN, C-FNP, the original course author.
Kim Maryniak, RNC-NIC, BN, MSN, PhD(c)

Purpose

The purpose of this neurological anatomy and physiology course is to teach healthcare professionals about the structures and functions of the central and peripheral nervous systems. The anatomical structures of the nervous system work together to control almost all functions, movements, and intellectual tasks.

Understanding the fundamental structures and functions of both the peripheral and central nervous systems, will allow you to provide care for all patients you encounter and intervene effectively for those with alterations in neurological status.

Learning Objectives

After successful completion of this course, the participant will be able to:

- Identify the functions of various anatomical structures within the central and peripheral nervous systems.
- Describe the functions of the central and peripheral nervous systems.
- Describe the basic physiology of how the central and peripheral nervous systems work.

Glossary

Term	Definition
Afferent	Neural information flowing from the periphery to more central areas of the nervous system.
Amygdala	Brain structure that is part of the limbic system. Implicated in emotion.
Arachnoid Mater	Middle layer of the meninges.
Association Fibers	Association fibers transmit impulses between gyri in the same hemisphere.
Astrocyte (astroglia)	A glial cell that supports neurons.
Axon	The part of the neuron that takes information away from the cell body.
Basal Ganglia	Areas of the brain that are important for movement. These areas include the putamen, caudate nucleus, globus pallidus, subthalamic nucleus and substantia nigra.
Bipolar neuron	Neuron with only two processes extending from the cell body.
Blood Brain Barrier	A system of astrocytes and capillaries in the brain that prevents the passage of specific substances.
Brainstem	The central core of the brain.
Cauda equina	The "horse's tail" made up of a bundle of spinal nerves at the base of the spinal cord.
Cell Body	Also called the soma; the part of the cell that contains the nucleus.
Central Nervous System	The brain and spinal cord.
Central Sulcus	Large groove in the brain that separates the frontal and parietal lobes.
Cerebellum	Area of the brain above the pons and medulla that is important for balance and posture.
Cerebral Cortex	Outermost layer (the gray matter) of the cerebral hemisphere.
Cerebrospinal Fluid (CSF)	Clear fluid in the ventricular system of the brain that cushions and protects the brain from injury.
Cerebrum	The cerebrum is the largest portion of the brain. It covers the diencephalon. The surface of the cerebrum is composed of gray matter and is known as the cerebral cortex.
Choroid Plexus	Vascular structures in the ventricular system that produce cerebrospinal fluid.

Term	Definition
Cingulate Cortex	Part of the limbic system, located directly above the corpus callosum. Important for emotional behavior.
Circle of Willis	Blood supply of the brain that unites the anterior and posterior circulation so that the brain has a backup system if one source of blood is interrupted.
Commisural Fibers	Commisural fibers transmit nerve impulses from gyri on one hemisphere with the corresponding gyri in the opposite hemisphere.
Corpus Callosum	Large collection of axons that connect the left and right hemispheres of the brain.
Cranial Nerves	Twelve pairs of nerves that exit from the brain.
Dendrite	Extensions from the neuron cell body that take information to the cell body.
Diencephalon	Second portion of the brain that includes the epithalamus, thalamus, metathalamus, and hypothalamus
Dorsal Root	Bundle of nerve fibers taking information into the spinal cord.
Dura Mater	Outermost layer of the meninges.
Efferent	Neural information flowing from the brain to the periphery.
Endorphin	Neurotransmitter with similar properties as opiates. Important for pain reduction.
Epidural Space	The epidural space is the space above the dura mater, between the dura mater and the skull.
Epithalamus	The uppermost portion of the diencephalon of the brain
Fissures	The deep grooves between the gyri.
Frontal Lobe	This lobe is associated with a variety of functions like consciousness, response to environment, emotional response, word associations, and memory of habits and motor activities.
Glia	Non-neural support cells of the nervous system.
Grey Matter	Greyish nervous tissue containing cell bodies as well as fibers. Forms the cerebral cortex consisting of unmyelinated neurons.
Gyrus (gyri)	"Hills" or "bumps" on the brain that are separated by fissures.
Hippocampus	Area of the limbic system important for memory.
Hypothalamus	Brain structure that monitors internal environment and attempts to maintain balance of these systems. Controls the pituitary.

Term	Definition
Limbic System	Interconnected areas of the brain important for emotional and other behaviors.
Medulla	Part of the brain stem important for breathing, respiration and other behaviors.
Meninges	Three sets of membranes (dura mater, arachnoid mater, pia mater) that cover the brain and spinal cord.
Metathalamus	The posterior part of the thalamus
Myelin Sheath	Fatty substance that surrounds some axons.
Neurotransmitters	Chemicals that transmit information across the synapse to communicate from one neuron to another.
Node of Ranvier	Short unmyelinated segment of an axon.
Occipital Lobe	Area of the brain located behind the parietal lobe and temporal lobe and responsible for vision.
Optic Chiasm	Crossing of the fibers from each retina.
Parietal Lobe	Lobe associated with visual attention, touch perception, goal-directed, voluntary movements, manipulation of objects, and the integration of different senses that allows for understanding a single concept.
Pia Mater	Inner most layer of the meninges. Lines the surface of the brain.
Pituitary	"Master" gland attached to the base of the brain that secretes hormones for regulation of many body functions.
Pons	Area of the brainstem between the medulla and the midbrain.
Precentral gyrus	(Primary motor cortex) - The precentral gyrus is the landmark for the primary motor area of the cerebral cortex.
Postcentral gyrus	(Primary somatosensory cortex) - The postcentral gyrus is the landmark for the primary somatosensory area of the cerebral cortex.
Proprioception	Ability for brain to sense body position in space.
Protection Fibers	Protection fibers transport nerve impulses from parts of the cerebrum to other parts of the brain and spinal cord.
Soma	The neuron cell body. Contains the nucleus.
Subarachnoid space	Space between pia mater and the arachnoid mater that contains CSF; surrounds the entire brain and spinal cord.
Subdural Space	The subdural space is the space below the dura mater, between the dura mater and the arachnoid mater.

Term	Definition
Sulcus (sulci)	Groove located on the surface of the brain.
Synapse	Functional connection between a terminal end of one neuron with a membrane of another neuron.
Temporal Lobe	Associated with hearing ability, memory acquisition, some visual perceptions, and categorization of objects.
Thalamus	Brain structure in which all sensory stimuli, with the exception of olfactory, are received.
Ventricles	Hollow spaces within the brain that are filled with cerebrospinal fluid.
White Matter	White matter is underneath the cerebral cortex consist of nerve fibers.

Introduction

The brain and nervous system play key roles in the normal functioning of our body. Some people might say that without brain function, we are nothing.

It is imperative that nurses caring for patients with brain or nervous system disorders understand the pathophysiology of the disorder or disease. The first step in this process is developing an understanding of the anatomy and physiology of this system.

The anatomy and physiology of the human brain is extremely complex. Although the physical structures of the brain have been mapped out for many years, there is still much to learn about brain physiology. Millions of specialized cells within the brain are equipped to transmit information utilizing a variety of electrical and chemical impulses.

Healthcare professionals will benefit from learning about neurological anatomy and physiology because of the direct impact this knowledge can have when providing direct patient care (Jarvis, 2011).

Basic Unit of the Nervous System: Neurons

Within the brain and nervous system are specialized cells known as neurons. Neurons are responsible for delivering chemical messages to other cells to stimulate a response. This is the basis of how our nervous system works. Within the brain, there are approximately 100 billion neurons. Neurons are typically classified by the direction that they send information. Sensory, or afferent, neurons send impulses from sensory receptors in the periphery or some organ to the central nervous system. Motor, or efferent, neurons send impulses away from the central nervous system to muscles or glands.

Neurons have specialized extensions called dendrites and axons. Dendrites bring information to the cell body (soma) and axons take information away from the cell body. Some neuronal axons are myelinated (have a fatty substance coating them that speeds impulse transmission) and some are not. Nodes of Ranvier are short unmyelinated segments of an axon (Jarvis, 2011).

The Conduction System

Nerve impulses are conducted via neurons. Each neuron receives an impulse and passes on (conducts) the impulse on to the next neuron to continue its path to the final destination. Through a chain of chemical events, the dendrites pick up an impulse that is shuttled through the axon, and transmits it to the next neuron.

Information from one neuron flows to another neuron across synapses. The synapse is a small gap separating neurons. It consists of a pre-synaptic ending that contains neurotransmitters, mitochondria and other cell structures, a postsynaptic ending that contains receptor sites for neurotransmitters, and a synaptic space between the pre-synaptic and postsynaptic endings.

Communication of information between neurons is accomplished by the movement of chemicals across these small synaptic gaps. Neurotransmitters are first released from neurons at the pre-synaptic nerve terminal. They cross the synapse where they may be or may not be accepted by the next neuron's receptor site. The action that follows activation of a receptor site may be either depolarization (excitatory in nature) or hyper-polarization (inhibitory in nature). If the neuron is depolarized, its response is excitatory. If the neuron is hyperpolarized, the response is inhibitory (Jarvis, 2011; Scanlon, 2011).

Test Yourself 1

When a neuron is depolarized, the response will be:

a. Excitatory
b. Inhibitory
c. Neither excitatory or inhibitory

Types of Neurotransmitters

Substances that act as neurotransmitters include amino acids, peptides, monoamines, and acetylcholine. The major neurotransmitters of the brain are glutamic acid and GABA (g – amino butric acid).

The peripheral nervous system has only two neurotransmitters: acetylcholine and norepinephrine.

Neurotransmitters vary greatly in the response they enact upon particular cells or receptor sites. Acetylcholine, for example, can be excitatory or inhibitory depending upon which receptor site it binds to.

Neurotransmitter Functions

This table lists several known and well-studied neurotransmitters (Scanlon, 2011).

Neurotransmitter	Function
Acetylcholine	Mostly excitatory
Dopamine	Excitatory and inhibitory
Epinephrine	Excitatory
Norepinephrine	Excitatory
Serotonin	Excitatory
Glutamate	Excitatory
Glycine	Mostly inhibitory
g - acid (GABA)	Inhibitory

The Nervous System

The nervous system can be divided into two categories:

- the central nervous system (CNS) and
- the peripheral nervous system (PNS)

The central nervous system is composed of the brain and spinal cord. The peripheral nervous system is divided into the somatic and autonomic nervous system.

Functions of the Nervous System

The primary function of the CNS is to receive and process sensory information, and generate appropriate responses to be transmitted to glands and muscles.

The CNS communicates with the PNS via synapses in the cranial nerve ganglia and spinal cord (Scanlon, 2011).

To provide support and protection for the CNS, the body has several layers of defenses, including the bones of the skull and meninges.

Test Yourself 2

The Central Nervous System is:

a. Composed of the brain and spinal cord
b. Divided into the somatic & autonomic nervous systems
c. Composed of cranial nerves and ganglia outside of the spinal cord

Bones of the Skull

The human skull is a hard, unbending container that protects the delicate brain. The bones are very thick in some places, such as the occipital region, and very thin in others, like in the temporal, sinus region.

The bones of the skull are referred to as the cranium. It is the first mechanism in the protection of the brain (Scanlon, 2011).

Meninges

The meninges cover the brain and spinal cord and protect them as well. There are three meningeal layers. They are the dura mater, arachnoid mater, and pia mater.

Dura Mater	The dura mater is the outer, tough layer of the meninges. It lines the inside of the skull. The dura mater also separates specific portions of the brain. The falx cerebri is a portion of the dura mater that separates the right and left hemispheres of the brain. The tentorium cerebelli is a portion of the dura mater that separates the cerebrum from the cerebellum (Scanlon, 2011).
Arachnoid Mater	The arachnoid mater is the middle layer of meninges. It is a web-like structure that allows the passage of blood vessels through it. Between the arachnoid mater and the pia mater, is the subarachnoid space. Cerebral spinal fluid (CSF) flows freely here (Scanlon, 2011).
Pia Mater	The pia mater is the thin, translucent, inner layer of the meninges. It covers the surface of the brain. It is the most vascular layer (Scanlon, 2011).

Potential Spaces

There are potential spaces between the meninges. CSF fluid may accumulate in these potential spaces. The epidural space is the space above the dura, between the dura mater and the skull. The subdural space is the space below the dura, between the dura and the arachnoid mater. The subarachnoid space, as discussed earlier is the space below the arachnoid, between the arachnoid and the pia mater (Scanlon, 2011).

Test Yourself 3

The arachnoid mater:

a. Forms the outer layer of the meninges
b. Forms the inner layer of the meninges
c. Forms the middle layer of the meninges

The Brain

The brain in an adult is one of the body's largest organs. It weighs about three pounds and is divided into four major parts:

1. Cerebrum
2. Diencephalon
3. Brain stem
4. Cerebellum

(Martin, 2012).

The Brain – Cerebrum

The cerebrum is the largest portion of the brain – it actually covers the diencephalon.

The surface is composed of grey matter and is known as the cerebral cortex. Folds of grey matter are convolutions known as gyri. The deep grooves between the folds are known as fissures, while the shallow grooves are known as sulci. The most noticeable fissure, the longitudinal fissure, nearly separates the brain into what is known as the two cerebral hemispheres, right and left.

White Matter
White matter located underneath the **cerebral cortex** consists of three different types of myelinated nerve fibers.

Association Fibers
Association fibers transmit impulses between gyri in the same hemisphere.

Commisural Fibers
Commisural fibers transmit nerve impulses from gyri on one hemisphere with the corresponding gyri in the opposite hemisphere.

Protection Fibers
Protection fibers transport nerve impulses from parts of the cerebrum to other parts of the brain and spinal cord (Jarvis, 2011).

The Brain – Cerebrum – Cerebral Hemispheres

The cerebral hemispheres remain connected by the corpus collosum, a transverse bundle of nerve fibers. Additionally, between the hemispheres is an extension of the dura mater known as the falx cerebri.

Each cerebral hemisphere is subdivided into lobes.

Frontal Lobe
The frontal lobe is located in front of the central sulcus. It is concerned with reasoning, planning, parts of speech and movement (motor cortex), emotions, and problem solving.

Frontal lobe damage has been labeled our emotional control and personality center. The frontal lobe is also involved in spontaneity, memory, language, initiation, judgment, impulse control, and social and sexual behavior. In most people, the left frontal lobe is involved in controlling language related movement, whereas the right frontal lobe plays a role in non-verbal abilities.

Frontal lobe damage seems to have an impact on flexibility and problem solving ability, sexual behaviors, personality changes, motor control, facial expression and Broca's aphasia, or difficulty in speaking (Rughani, 2015; Scanlon, 2011).

Parietal Lobe
The parietal lobe is located behind the central sulcus. It is concerned with perception of stimuli related to touch, pressure, temperature, and pain.

The parietal lobes can be divided into two functional regions, involving sensation and perception. The overall role of the parietal lobe is to integrate sensory information to form a single perception (cognition) (Rughani, 2015; Scanlon, 2011).

Temporal Lobe
The temporal lobe is located below the lateral fissure. It is concerned with sensory perception and recognition of auditory stimuli (hearing) and memory (hippocampus) (Rughani, 2015; Scanlon, 2011).

Individuals with temporal lobes lesions have difficulty placing words or pictures into categories. The temporal lobes are highly associated with memory skills and language.

Temporal lobe damage may result in impaired memory, difficulty recognizing words or speaking, and recall of non-verbal stimuli such as music or drawings (Scanlon, 2011).

Occipital Lobe
The occipital lobe is located at the back of the brain, behind the parietal lobe and temporal lobe. It is concerned with many aspects of vision. Lesions or damage to the occipital lobe typically results in visual changes, even producing visual hallucinations (Scanlon, 2011).

The **central sulcus** separates the **frontal lobe** from the **parietal lobe**. The parietal lobe and the **occipital lobe** are separated by the parieto-occipital sulcus. The frontal and the **temporal lobes** are separated by the **lateral cerebral sulcus**.

The **precentral gyrus** is located immediately anterior to the **central sulcus** and is the major motor area of the brain.

The **post central gyrus** is located immediately posterior to the central sulcus and is the major sensory area of the brain (Jarvis, 2011; Scanlon, 2011).

The Brain – Cerebrum - Limbic System

The limbic (border) system is composed of certain components of the cerebrum and the diencephalon. The components of this system include:

- The limbic lobe
- The hippocampus
- The amygdaloid nucleus
- The mamillary bodies of the hypothalamus
- The anterior nucleus of the thalamus

Basically, the limbic system encircles the brainstem and influences the emotional aspects of behavior that are essential to our survival. It also plays a role in memory, although the exact mechanism is not understood fully.

The limbic system is also thought to play some part in how we sense pleasure, pain, anger, rage, fear, sadness and sexual feelings. Because of its role in these core emotions, it is also known as the visceral or emotional brain (Jarvis, 2011).

Test Yourself 4

Fill in the blank:

__________ encircles the brainstem, and may be involved in sensing pain and pleasure.

a. Frontal lobe
b. Parietal lobe
c. Limbic system

Test Yourself 5

Which structure is concerned with vision?

a. Temporal lobe
b. Occipital lobe
c. Thalamus

The Brain – Diencephalon

The diencephalon is situated between the brain stem and the cerebrum. It houses the thalamus and hypothalamus.

Thalamus
The thalamus constitutes about eighty percent of the diencephalon. The thalamus is composed of two masses of grey matter.

The thalamus serves as a communication station for all sensory impulses that reach the cerebral cortex from the spinal cord, brain stem, cerebellum, and parts of the cerebrum. The thalamus also functions as an understanding center for some sensory impulses such as pain, temperature, light, touch, and pressure (Scanlon, 2011).

Hypothalamus
The primary functions of the hypothalamus are to integrate and control the autonomic nervous system, reception and integration of sensory impulses from the viscera. It coordinates the endocrine response of many hormones within the endocrine system.

The hypothalamus produces and releases hormones that stimulate the pituitary gland. This connection or relationship with the pituitary gland is referred to as the hypothalamic-pituitary axis. When stimulated, the three major hormones released are growth hormone releasing hormone (GRH), thyrotropic releasing hormone (TRH), and corticotropin releasing hormone (CRH). These hormones travel to the pituitary via the hypothalamic pituitary stalk.

Once in the pituitary, they act to produce or release other hormones from the pituitary gland. A negative feedback loop inhibits the hypothalamus to stop stimulating hormone production (Scanlon, 2011).

The hypothalamus is also responsible for the "mind over body" phenomenon. When strong emotions are produced by the cerebral cortex, nerve impulses travel down through the hypothalamus to the body. Likewise, continued psychological stress traveling upward through the hypothalamus may produce long-term, very real systemic illnesses.

The hypothalamus also plays a role in feelings such as rage and aggression and regulates body temperature, hunger, thirst, sleep and wake cycles (Rughani, 2015; Scanlon, 2011).

Test Yourself 6

One of the three major hormones that stimulate the hypothalamus is:

a. Insulin
b. Rennin
c. Aldosterone
d. Growth hormone releasing hormone

The Brain - Brain Stem

The brain stem consists of the medulla oblongata, pons, and mid-brain, or mesencephalon.

Medulla Oblongata

The medulla oblongata, or medulla, is merely a continuation of the upper part of the spinal cord which forms the inferior part of the brain stem. It contains all ascending and descending nerve tracts between the brain and spinal cord. The medulla is also the origin of several cranial nerves. They are cranial nerves VIII, IX, X, XI, and XII (Scanlon, 2011).

Pons

Pons means bridge. The pons is the bridge that connects the spinal cord with the brain and certain parts of the brain with each other. These connections occur via fibers that run in two major directions. The transverse fibers connect with the cerebellum. The longitudinal fibers connect the spinal cord or medulla with the upper parts of the brain stem (Scanlon, 2011).

Mid-Brain (Mesencephalon)

The mid-brain, or mesencephalon, extends from the pons to the lower portion of the diencephalons. The cerebral aqueduct travels through the mid-brain and connects the third and fourth ventricles.

Within the mid-brain, there are nerve fibers that convey nerve impulses from the cerebral cortex to the pons and spinal cord. The mid-brain also has some reflex centers that control eye, head, and neck movements. The mid-brain is also the origin of cranial nerves II and IV (Scanlon, 2011).

The Brain - The Reticular Activating System

The reticular activating system is so named because it resembles the reticular system of a leaf. It is a network of neurons located in the central core of the brainstem that serves to monitor the state of the body in functions such as arousal, sleep, and muscle tone.

The reticular activating system is the attention center in the brain. The reticular activating system is connected at its base to the spinal cord where it receives information projected directly from the ascending sensory tracts. The brain stem reticular formation runs all the way up to the mid-brain. As a result, the reticular activating system serves as a point of union for signals from the outside world to our inner brain. When functioning normally, it provides the neural connections that are needed for the processing and learning of information, and ability to focus on particular tasks.

If the reticular activating system doesn't excite the neurons of the cortex as much as it should, difficulty learning, poor memory, and limited self-control may be expressed. If the reticular activating system failed to activate the cortex at all, unconsciousness and coma would be the result (Rughani, 2015; Scanlon, 2011).

The Brain – Cerebellum

Behind the brain stem, is the cerebellum. It is the second largest area of the brain and is located in the inferior and posterior portion of the brain.

The cerebellum is concerned with the subconscious movements of the skeletal muscles. It is chiefly responsible for maintenance of balance and gait, blending and coordinating the motion of the various muscles involved in voluntary movements.

It helps to maintain equilibrium and control posture. It also functions to predict the future movement of body parts prior to implementation of certain tasks.

The Brain - Cerebrospinal Fluid (CSF)

The cerebral spinal fluid, or CSF, protects and cushions the brain from injury. The CSF acts as a shock absorber from injuries that would normally send the brain crashing up against the inside of the skull. By nature of its circulatory abilities, CSF also delivers nutrients filtered from the blood to the brain and spinal cord and removes wastes and toxic substances produced by the brain and spinal cord (Scanlon, 2011).

CSF circulates in the subarachnoid space, around the brain, the spinal cord and the ventricles of the brain. The ventricles, like the heart's ventricles, are spaces. In the brain, there are two lateral ventricles located in each hemisphere of the brain, just under the corpus collosum. There is a third ventricle just in between and below the thalamus. Finally, there is a fourth ventricle, just below the brain stem and beside the cerebellum. All four ventricles may circulate CSF between them by way of foramen (narrow oval openings), aqueducts (canal-like passages), and apertures (openings).

The CSF is mainly produced by the choroid plexus in the ventricles; a small amount is produced by the blood vessels in the brain and spinal cord. There is approximately 500 mL of CSF produced daily, but only 120-150 mL circulating in the central nervous system at any given time (Scanlon, 2011).

Blood supply is vital to the proper functioning of the brain. Even though the brain is only about two percent of the entire weight of the body, it requires about twenty percent of the total oxygen consumed by the body (Martin, 2012). The principle nutrient in the blood that supplies the brain with fuel to function properly is glucose. Carbohydrate storage in the brain is extremely limited. Therefore, a constant supply of glucose is needed for normal brain functioning.

The Brain - Cerebrovascular Circulation

The internal carotid arteries supply blood to the Circle of Willis, anteriorly. The posterior vertebral arteries provide blood supply to the Circle of Willis, posteriorly. The Circle of Willis unites the anterior and posterior blood supply to the brain. This is a unique mechanism of cerebral circulation that allows the brain to have a backup system if one source of blood is interrupted.

The cerebral arteries arise from the Circle of Willis and supply specific areas of the brain. The posterior cerebral artery (PCA) supplies blood to the occipital lobe, midbrain, thalamus, and part of the temporal lobes. The middle cerebral artery (MCA) supplies blood to parts of the frontal, parietal and temporal lobes. The anterior cerebral artery (ACA) supplies blood to different areas of the frontal, parietal and temporal lobes (Jarvis, 2011).

Test Yourself 6

The mid-brain is also known as the:

a. Mesencephalon
b. Cerebral cortex
c. Medulla Oblongata

Functions of the Brain: Review

Cerebrum

Frontal lobe	**Parietal lobe**	**Temporal lobe**	**Occipital lobe**
Personality Behavior Emotions Intellectual function Ability to write words Speech motor (Broca's area)	Primary center for sensation Ability to recognize body parts Left versus right	Primary auditory reception center Language comprehension (Wernicke's area)	Primary visual reception center Understanding of written material

Diencephalon

Thalamus
Main relay station for the nervous system
Pain threshold

Hypothalamus
Center for temperature control, sleep, pituitary regulation, heart rate, blood pressure, emotional regulation, and autonomic nervous system activity

Brain Stem

Medulla
Continuation of the spinal cord in the brain
Controls quality of respirations and heart rate, swallowing and hiccoughing, and gag and cough reflexes

Pons
Connects medulla oblongata and midbrain, ventral to the cerebellum

Midbrain
The midbrain or mesencephalon, extends from the pons to the lower portion of the diencephalons.

Cerebellum

Second largest area of the brain
Blending and coordinating of motion of the various muscles involved in voluntary movements
Helps to maintain equilibrium and control posture

Interactive Activity: Functions Review

Match the following structures with the correct functions

Temporal lobe	Temperature control
Occipital lobe	Auditory reception
Cerebellum	Visual reception
Hypothalamus	Coordination of voluntary movements

Answers:
Temporal lobe- auditory reception;
occipital lobe- visual reception;
cerebellum- coordination of voluntary movements;
hypothalamus- temperature control

Test Yourself 7

Where does CSF circulate?

a. The subarachnoid space and around the brain
b. Around the spinal cord and between the ventricles of the brain
c. All of the above

The Brain - Cranial Nerves

The cranial nerves arise directly from the brain. Most often, a neurological problem is detected through the assessment of these nerves.

The cranial nerves are composed of twelve pairs of nerves that stem from the nervous tissue of the brain. Some nerves have only a sensory component, some only a motor component, and some both.

The motor components of cranial nerves transmit nerve impulses from the brain to target tissue outside of the brain. Sensory components transmit nerve impulses from sensory organs to the brain.

Cranial Nerve		Major Functions	
Cranial Nerve I:	Olfactory	Sensory	Smell
Cranial Nerve II:	Optic	Sensory	Vision
Cranial Nerve III:	Oculomotor	Sensory and Motor – Primarily Motor	Eyelid and eyeball movement
Cranial Nerve IV:	Trochlear	Sensory and Motor – Primarily Motor	Innervates superior oblique Turns eye downward and laterally
Cranial Nerve V:	Trigeminal	Sensory and Motor	Chewing Face and mouth touch and pain
Cranial Nerve VI:	Abducens	Sensory and Motor – Primarily Motor	Turns eye laterally Proprioception
Cranial Nerve VII:	Facial	Sensory and Motor	Controls most facial expressions Secretion of tears and saliva and taste
Cranial Nerve VIII:	Vestibulocochlear (auditory)	Sensory	Hearing Equilibrium sensation
Cranial Nerve IX:	Glossopharyngeal	Sensory and Motor	Taste Senses carotid blood pressure Muscle sense - proprioception
Cranial Nerve X:	Vagus	Sensory and Motor	Senses aortic blood pressure Slows heart rate Stimulates digestive organs Taste
Cranial Nerve XI:	Spinal Accessory	Sensory and Motor – Primarily Motor	Controls trapezius and sternocleidomastoid Controls swallowing movements Muscle sense - proprioception
Cranial Nerve XII:	Hypoglossal	Sensory and Motor – Primarily Motor	Controls tongue movements Muscle sense - proprioception

Interactive Section: Cranial Nerves

Match the cranial nerve with major function

Cranial nerve VIII (vestibulocochlear)	Smell
Cranial nerve II (optic)	Hearing
Cranial nerve I (olfactory)	Vision
Cranial nerve IX (glossopharyngeal)	Taste

Answers:

VIII- hearing;
II - vision;
I - smell;
IX- taste

The Brain - Spinal Cord

The spinal cord is the primary structure that connects the brain and peripheral nervous system. It is protected by the vertebrae of the spinal column. The spinal cord is located in the vertebral foramen and is made up of 31 segments: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal vertebrae.

While a pair of the spinal nerves exit from each segment of the spinal cord, the spinal cord itself extends down to only the last of the thoracic vertebrae. The spinal nerves that branch from the spinal cord from the lumbar and sacral levels must run in the vertebral canal for a distance before they exit the vertebral column. This collection of nerves in the vertebral canal is called the *cauda equina* (horse's tail) (Scanlon, 2011).

The Brain - Receptors

Receptors in the periphery send impulses to the spinal cord through the spinal nerves. The cell bodies for these nerve fibers are located in the dorsal root ganglion.

These cell bodies are sensory in nature. The cell bodies in the ventral horn are motor in nature and send axons through the ventral root to muscles to control and coordinate how we move.

The nerve fibers enter the spinal cord through the dorsal root. Some fibers make synapses with other neurons in the dorsal horn, while others continue up to the brain (Scanlon, 2011).

The Brain - Reflexes

Reflexes are rapid, involuntary responses to stimuli which are mediated over simple nerve pathways called reflex arcs. Involuntary reflexes are very fast, traveling in milliseconds. Reflexes can be categorized as either autonomic or somatic. Autonomic reflexes are not subject to conscious control, are mediated by the autonomic division of the nervous system, and usually involve the activation of smooth muscle, cardiac muscle, and glands. Somatic reflexes involve stimulation of skeletal muscles by the somatic division of the nervous system.

When peripheral reflexes are intact, a sensory stimulus travels to the spinal cord. That stimulus is then converted to a motor stimulus within the spinal cord. The motor stimulus travels back to the site of sensory input and usually causes muscle contraction. An example is the knee-jerk reflex or placing your hand on a hot stove. The sensory stimulus does not need to travel all the way to the brain to be interpreted and then back to the site of potential injury (Jarvis, 2011).

The Brain – Reflex Testing

Reflex testing is an important diagnostic tool for assessing the condition of the nervous system. Distorted, exaggerated, or absent reflex responses may indicate collapse or pathology of portions of the nervous system.

For example:

- If the spinal cord is damaged, reflex tests can help determine the area of injury
- Motor nerves above an injured area may be unaffected, whereas motor nerves at or below the damaged area may be unable to perform the usual reflex activities

Another example is what occurs in head traumas. Closed head injuries that may produce increased intracranial pressure may be diagnosed by reflex testing. The oculomotor nerve stimulates the muscles in and around the eyes. If increased intracranial pressure is present, such as in some head traumas, then the pressure exerted on cranial nerve III may cause variations in the eye reflex responses (Scanlon, 2011).

Peripheral Nervous System

The peripheral nervous system is subdivided into the somatic nervous system and the autonomic nervous system.

Somatic Nervous System
The somatic nervous system is typically **under voluntary control**. It includes all nerves controlling the muscular system and external sensory receptors.

The somatic nervous system consists of the twelve pairs of cranial nerves and thirty-one pairs of spinal nerves. The somatic nervous system has both motor and sensory divisions.

Motor fibers are efferent fibers which innervate skeletal muscle. They are present in spinal nerves and cranial nerves III, IV, VI and XII and terminate at the skeletal muscles.

Sensory fibers are afferent fibers that relay sensations such as touch, pain and temperature from the skeletal muscles via peripheral, spinal, and cranial nerves V, VII, IX and X to the central nervous system (Martin, 2012; Scanlon, 2011).

Autonomic Nervous System
In contrast, the autonomic nervous system is **not voluntary**.

The autonomic nervous system regulates the activities of the internal organs. It consists of two main parts:

Sympathetic Nervous System The sympathetic nervous system is responsible for the "fight-or-flight" response. This response prepares us for emergency situations.

Parasympathetic Nervous System The parasympathetic nervous system, oppositely, tends to inhibit these reactions. The response of our body depends on the proportionate strength of stimulation supplied by each system at any given instance (Martin, 2012; Scanlon, 2011).

These two "opposite" systems often operate in opposition to each other. Many internal organs are stimulated by both systems. When one stimulates an organ, the other tends to depress the organ.

Autonomic Nervous System – Sympathetic Nervous System

Activation of the sympathetic nervous system increases heart rate, contractility, and conduction velocity of myocardial tissue. Additionally, in blood vessels, sympathetic activation constricts arteries and arterioles. This increases central blood flow and decreases distal blood flow. In other words, blood is shunted away from the periphery to the heart, brain, and skeletal muscles (Jarvis, 2011).

Sympathetic stimulation also dilates the pupils, dilates the trachea and bronchi, stimulates the conversion of glycogen into glucose, inhibits peristalsis in the gastrointestinal tract, and inhibits contraction of the bladder and rectum.

The overall effect of sympathetic activation is to increase cardiac output, systemic vascular resistance (both arteries and veins), and increase arterial blood pressure. Enhanced sympathetic activity is particularly important during exercise, emotional stress, and during hemorrhagic shock (Martin, 2012; Scanlon, 2011).

Autonomic Nervous System - Parasympathetic Nervous System

When the parasympathetic system is activated, it works to decrease heart rate, contractility, and conduction velocity of the myocardial tissue via the vagus nerve (cranial nerve X).

Parasympathetic nerves mainly innervate salivary glands, gastrointestinal glands, and genital erectile tissue where they cause vasodilation (Jarvis, 2008). The parasympathetic system returns the body functions to normal after they have been altered by sympathetic stimulation.

In times of danger, the sympathetic system prepares the body for aggressive activity. The parasympathetic system reverses these changes when the danger is over. Parasympathetic stimulation causes slowing down of the heartbeat, lowering of blood pressure, constriction of the pupils, increased blood flow to the skin and viscera, and decreased peristalsis of the gastrointestinal tract (Martin, 2012; Scanlon, 2011).

Test Yourself 8

The autonomic nervous system is:

a. Under voluntary control.
b. Responsible for the "fight or flight" response.
c. Composed of the somatic and peripheral nervous systems.

Conclusion

The brain and nervous system play key roles in the normal functioning of our body. Some people might say that without brain function, we are nothing.

It is imperative that nurses caring for patients with brain or nervous system disorders understand the pathophysiology of the disorder or disease. The first step in this process is developing an understanding of the anatomy and physiology of this system.

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