Continuing Education Independent Study Series

The Nervous System

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Preface

"The Nervous System" is part of the AST Continuing Education Independent Study (CEIS) Series. The series has been specifically designed for surgical technologists to provide independent study opportunities that are relevant to the field and support the educational goals of the profession and the Association.

Acknowledgments

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INTRODUCTION

Purpose

The purpose of this module is to acquaint the learner with the structure and function of the nervous system. Upon completing this module, the learner will receive 2 continuing education (CE) credits in category 1G.

Objectives

Upon completing this module, the learner will be able to do the following:

1. Describe the histology of neuroglia and neurons.
2. Describe the function of neuroglia and neurons.
3. Describe the nerve impulse transmission.
4. Explain the anatomic features of the spinal cord and brain.
5. Discuss the functions of the divisions of the brain.
6. Discuss the formation and circulation of cerebrospinal fluid.
7. Identify the 12 cranial nerves.
8. Describe the function of the sympathetic and parasympathetic nervous systems.

Using the Module

1. Read the information provided, referring to the appropriate figures.
2. Complete the enclosed exam without referring back to the text. The questions are in a multiple-choice format. Select the best answer from the alternatives given.
3. Mail the completed exam to AST, CEIS Series, 7108-C S. Alton Way, Englewood, CO 80112-2106. Please keep a copy of your answers before mailing the exam. You must return the original copy of the answer sheet; this exam may not be copied and distributed to others.
4. Your exam will be graded, and you will be awarded continuing education credit upon achieving a minimum passing score of 70%. If you are an AST member, your credits will be automatically recorded and you do not need to submit the credits with your yearly CE report form.
5. You will be sent the correct answers to the exam. Compare your answers with the correct answers to evaluate your level of knowledge and determine what areas you need to review.

Studying Technical Material

To study technical material, find a quiet place where you can work uninterrupted. Sitting at a desk or work table will be most conducive to studying.

Having a medical dictionary available as you study is very helpful so you can look up any words with which you are unfamiliar. Make notes in the margins of any new definitions so that you can review them.

The ultimate test of how well you learn this material is your ability to relate your knowledge to what is happening in the surgical field. As you concentrate on the surgical field, identify the structures you are seeing and their position within the body.

Additional Resource

Core Curriculum for Surgical Technology. 3rd ed. Englewood, CO: Association of Surgical Technologists; 1990.

Gray H. *Gray's Anatomy.* New York: Bounty Books, 1978.

Tortora G, Anagnostakos N. *Principles of Anatomy and Physiology.* 7th ed. New York: Harper & Row; 1993.

THE NERVOUS SYSTEM

Organization

The nervous system is divided into two divisions: the central nervous system and the peripheral nervous system.

The central nervous system (CNS) consists of the brain and spinal cord. All sensations and corresponding movement or reaction must be relayed through the CNS.

The peripheral nervous system (PNS) consists of the nerves that connect the entire body to the spinal cord and brain. This system is further divided into an afferent system (nerve cells that conduct impulses toward the CNS) and an efferent system (nerve cells that conduct impulses away from the CNS).

The efferent system is further divided into the autonomic system and the somatic system. The autonomic system relays messages to involuntary tissues such as smooth muscle tissue, cardiac muscle tissue, and glands. The autonomic system consists of the sympathetic division and the parasympathetic division.

The somatic system, which is voluntary, conveys impulses to skeletal muscle tissue and produces movement.

Histology

The nervous system consists of two types of cells: neuroglia and neurons.

Neuroglia

Neuroglia (glial cells) are cells that provide support and protection (most tumors arise from this tissue). These cells are derived from the ectoderm. They are smaller than neurons and are much more plentiful. Neuroglia can be divided into four types:

1. Astrocytes: Star-shaped cells, largest and most numerous of glial cells. They twine themselves around neurons to form a supporting network. They also attach neurons to their blood vessels and participate in the blood-brain barrier.
2. Oligodendrocytes: Similar to astrocytes but have fewer processes and are smaller. These cells form semirigid connections between neurons. They also produce the myelin sheath that forms around nerve fibers.
3. Microglia: Small cells derived from monocytes. These cells are stationary except when needed to engulf and destroy microbes or other debris.
4. Ependyma: These cells are epithelial cells that form a continuous lining of the ventricles and the central canal of the spinal cord. It is thought that they assist in the circulation of cerebrospinal fluid.

Neurons

Neurons are cells that conduct impulses within the body and process all information. They are the functional units of the nervous system.

Structure. Each neuron consists of a cell body; dendrites, which are cytoplasmic processes that conduct impulses toward the cell body; and an axon, which is a cytoplasmic process that conducts impulses away from the cell body (Figure 1).

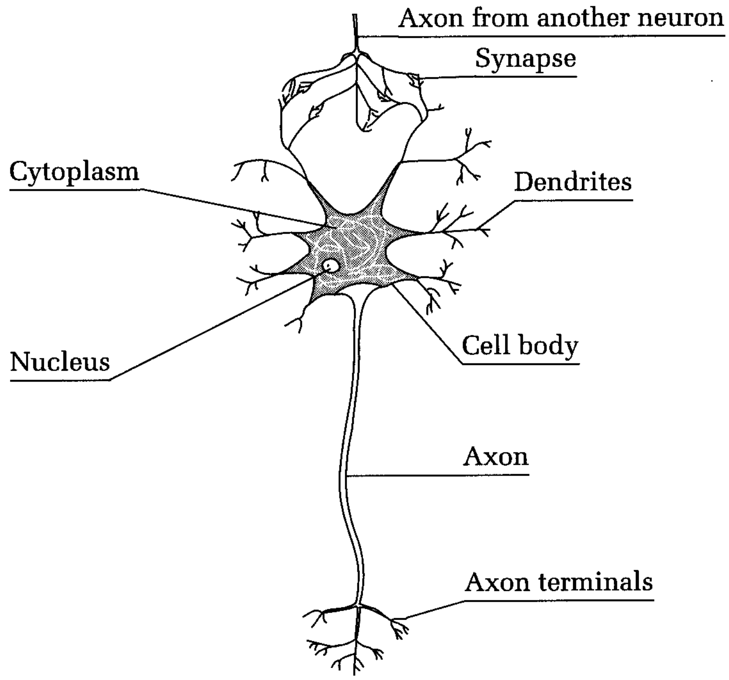

Figure 1.
Structure of a neuron.

The cell body of a neuron consists of a nucleus surrounded by granular cytoplasm that contains the usual organelles found in other cells. Neuron cell bodies are gray in color and may be referred to as gray matter. Clusters of neuron cell bodies within the CNS are called nuclei; within the PNS they are referred to as ganglia.

Dendrites are thick extensions of the cell body cytoplasm. The distal ends of the dendrites are receptors that receive impulses. They conduct impulses (signals) towards the cell body.

An axon is a single process of cytoplasm that extends from the cell body. The function of the axon is to conduct impulses away from the cell body. The distal end of the axon is expanded and referred to as the synaptic end bulb. These bulbs contain synaptic vesicles that store neurotransmitters that influence the conduction of impulses.

Any process that extends from the cell body may be referred to as a nerve fiber. Many of these fibers outside of the CNS are clothed in a multilayered, white covering called a myelin sheath. The myelin sheath is produced by neurolemmocytes (Schwann cells) that lie along the fiber.

These cells wrap themselves around the fiber many times, producing a covering called the neurolemma. Neurolemma is found only on fibers within the PNS. It functions in the regeneration of injured cells. The oligodendrocytes function as the neurolemmocytes in the CNS; however, they do not produce neurolemma and therefore cannot regenerate.

Types. Neurons can be classified either structurally, which is based on the number of cell processes, or functionally, which is based on the direction they transmit impulses.

The structural classification of neurons is as follows.

1. Multipolar neuron: Several processes, one axon, and many dendrites. Located in the brain and spinal cord.
2. Bipolar neuron: One axon and one dendrite. Located in the retina, inner ear, and olfactory areas.

The functional classification is as follows:

1. Sensory neuron: Transmits impulses toward CNS.
2. Motor neuron: Transmits impulses away from CNS.
3. Association neuron: Transmit impulses from one cell to another. Approximately 90% of neurons are association neurons.

Physiology. Impulses are conducted from one neuron to another via an electrical impulse (Figure 2). The electrical impulse is generated by a stimulus that causes movement of ions along the outside of the neuron. The impulse is conducted across neural junctions (synapses) with the help of chemicals called neurotransmitters. Examples of neurotransmitters are acetylcholine, glutamic acid, asparticacid, norepinephrine, dopamine, serotonin, gamma aminobutyric acid, and glycine.

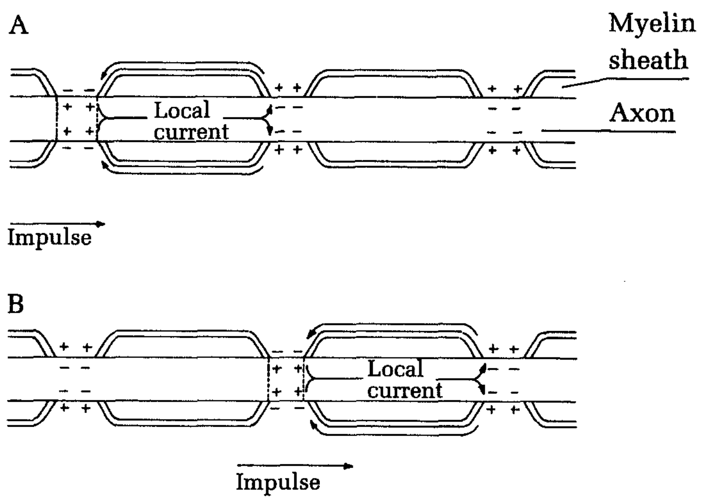

Figure 2.

Neuron conduction. A, The nerve impulse at the first node generates a local current that passes to the second node. B, At the second node, the local current generates a nerve impulse. Then, the nerve impulse from the second node generates a local current that passes to the third node, and so on. After the nerve impulse jumps from node to node, each node becomes repolarized. ((Adapted from Tortora and Anagnostakos. Copyright 1990 by Biological Sciences Textbooks, Inc., A&P Textbooks, Inc., and Elia-Sparta, Inc. Reprinted by permission of HarperCollins Publishers, Inc.)

Neural Tissue

Neural tissue is arranged in different types of groupings.

1. White matter: Group of myelinated axons.
2. Gray matter: Group of unmyelinated axons or cell bodies and dendrites.
3. Nerve: Group of fibers outside of the CNS, usually white.
4. Ganglion: Group of nerve cell bodies outside of the CNS.
5. Tract: Group of nerve fibers within the CNS. The chief tracts in the spinal cord are the ascending tracts, which relay sensory impulses, and the descending tracts, which relay motor impulses. These tracts are myelinated white matter.
6. Nucleus: Group of unmyelinated (gray matter) cells within the CNS. The major areas of gray matter in the spinal cord are referred to as horns.

Spinal Cord

Gross Anatomy

The spinal cord is a cylindrical structure that lies within the spinal cavity (Figure 3). It extends from the foramen magnum to the second lumbar vertebra.

The spinal cord tapers downward with two enlargements, cervical and lumbar.

The final conical portion of the cord is known as the conus medullaris. Extending from the conus medullaris are wisps of nerves referred to as the cauda equina.

A cross-section of the cord reveals an H-shaped area of gray matter surrounded by white matter. The cross-bar of the H is the gray commissure; in the center of the gray commissure is a small hole, the central canal, which runs the length of the cord and is continuous with the fourth ventricle of the brain. The upright bars of the H are called horns. The white matter is divided into columns by the H gray matter. These columns contain ascending (sensory) tracts of fibers and descending (motor) tracts.

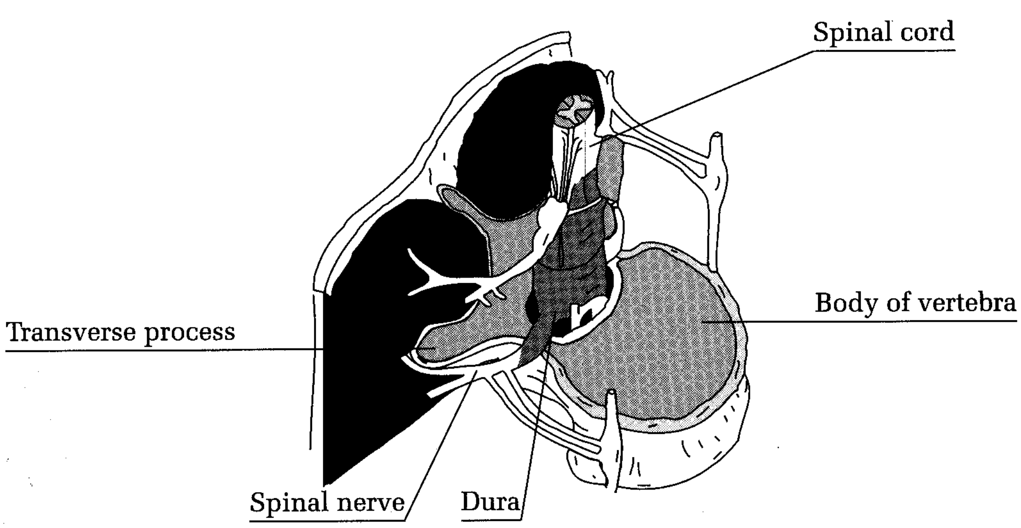

Figure 3.
The spinal cord and a vertebra.

Coverings

The three coverings of the cord are known as the spinal meninges.

1. Dura mater: Outer tough covering that extends from the level of the second sacral vertebrae and is continuous with dura matter of brain.
2. Arachnoid: Middle layer or covering that is spider web-like in structure. The space between the arachnoid and dura is the subdural space, which contains serous fluid.
3. Pia mater: Inner layer or covering that adheres to the cord. Cerebrospinal fluid circulates between the arachnoid and the pia mater.

Functions

The spinal cord conveys sensory and motor impulses within spinal tracts and serves as the center of reflex actions that can be used for diagnosing functional problems of the nervous system. Reflex arcs are pathways consisting of a sensory neuron, association neuron, and motor neuron, that allow for fast responses to stimuli. Reflexes tested frequently include the patellar reflex, the Achilles reflex (ankle jerk), Babinski sign (stimulation of the outer sole of the foot with extension of the great toe and fanning of the others), and the abdominal reflex.

Spinal Nerves

A spinal nerve consists of a posterior and an anterior nerve root that leaves the cord and unites to form a spinal nerve. Sensory areas of the body are controlled by specific spinal nerves at each vertebral location. This can be schematically represented by dermatome graphs (Figure 4).

There are 31 pairs of spinal nerves identified by the level of the vertebral column from which they emerge.

A network of spinal nerves is called a plexus. Examples are as follows:

1. Cervical plexus: Formed by first four cervical nerves (Figure 5). It supplies the skin and muscles of head and neck, and upper shoulders. The phrenic nerves that arise from the cervical plexus supply the diaphragm.
2. Brachial plexus: Formed by C5-8 and T1 spinal nerves. The radial, median, and ulnar nerves arise from the brachial plexus, which supplies the shoulder and upper limb (Figure 6).
3. Lumbar plexus: Formed by L1 -L4 nerves. It supplies the abdominal wall, genitals, and lower extremity (Figure 7). The femoral nerve arises from lumbar plexus.
4. Sacral plexus: Formed by L4-5 and S1-S4 nerves (Figure 8). The sciatic nerve (the largest nerve in the body) arises from sacral plexus. The sacral plexus supplies the buttocks, perineum, and lower extremities.

Brain

The brain is covered with the same three layers as the spinal cord: the dura mater, arachnoid, and pia mater.

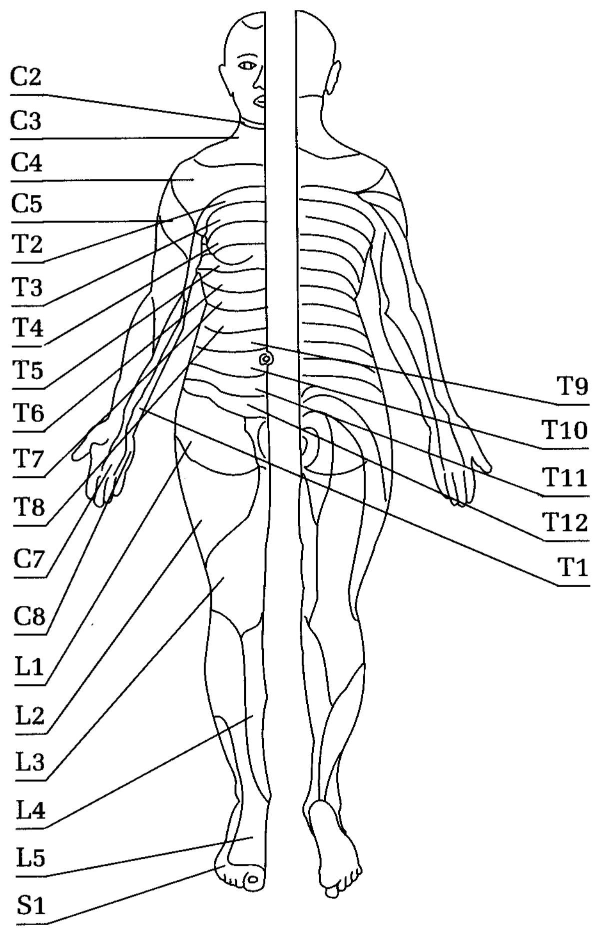

Figure 4.
Dermatome graphs showing the sensory areas controlled by each specific spinal nerve.

Division and Functions

The brain is divided into four parts: the brain stem, consisting of the medulla oblongata, pons, and midbrain; the diencephalon, consisting of the thalamus and hypothalamus; the cerebrum; and the cerebellum (Figure 9).

Medulla. The medulla oblongata forms the inferior portion of the brain. It serves as a conduction center for motor and sensory nervous impulses from the spinal cord and the brain, controls the heart beat and force of contraction, controls the rhythm of breathing, and also controls the dilatation and contraction of blood vessels. Several cranial nerves also originate in the medulla (VIII, IX, X, XI, and XII).

Pons. The pons functions as a bridge between the spinal cord and the brain relaying impulses. The V, VI, VII, and VIII cranial nerves originate in the pons. The pons also assists in controlling breathing.

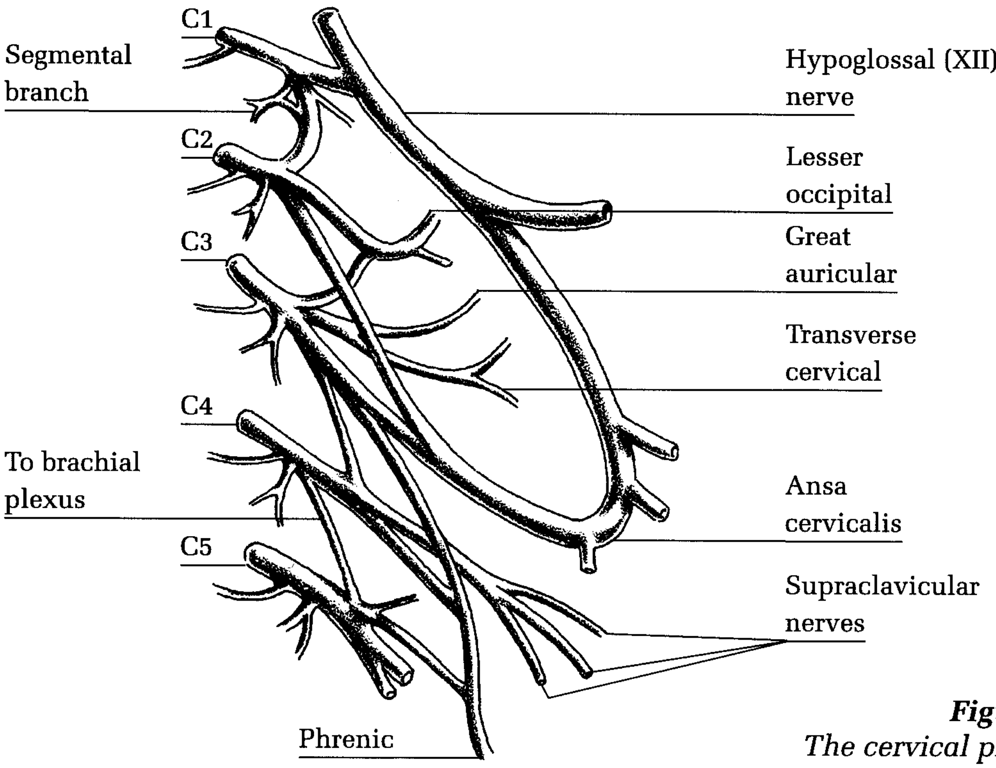

Figure 5.
The cervical plexus.

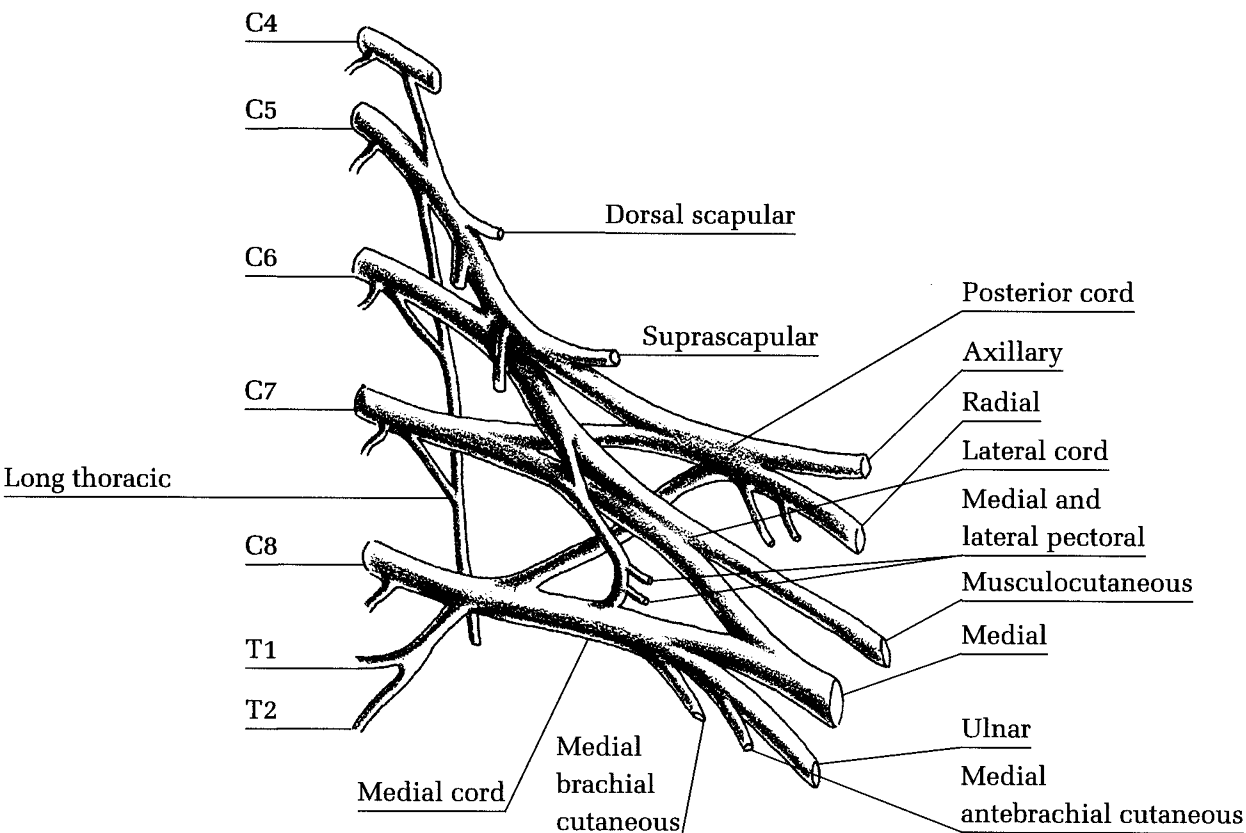

Figure 6.
The brachial plexus.

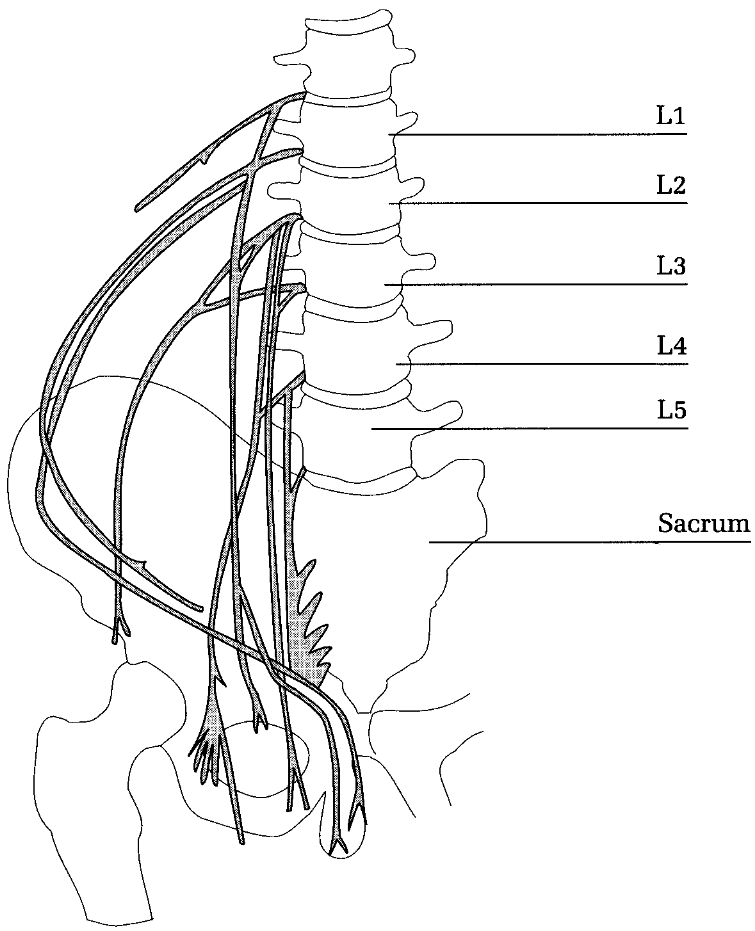

Figure 7.
The lumbar plexus.

Midbrain. Within the midbrain, various fibers and/or nuclei perform several functions such as conveying impulses from the cerebrum to the spinal cord; serving as reflex centers for eye, head, and trunk movement in response to auditory stimuli; and conveying impulses for fine touch. The midbrain serves as the origin of cranial nerves III and IV.

Thalamus. The thalamus consists of two small, oval masses joined by a bridge of tissue. The thalamus serves as a relay station for most of the sensory input from the cord and other parts of the brain. It also interprets pain, temperature, light touch, and pressure and plays a part in emotions and memory.

Hypothalamus. The hypothalamus is a small area of the brain lying just behind the sella turcica of the sphenoid bone, forming the floor and parts of the lateral walls of the third ventricle. The primary functions of the hypothalamus include the control of the autonomic nervous system, body temperature, food intake, thirst, waking state and sleep patterns, and feelings of rage and aggression. It serves as the relay between the nervous system and the pituitary gland.

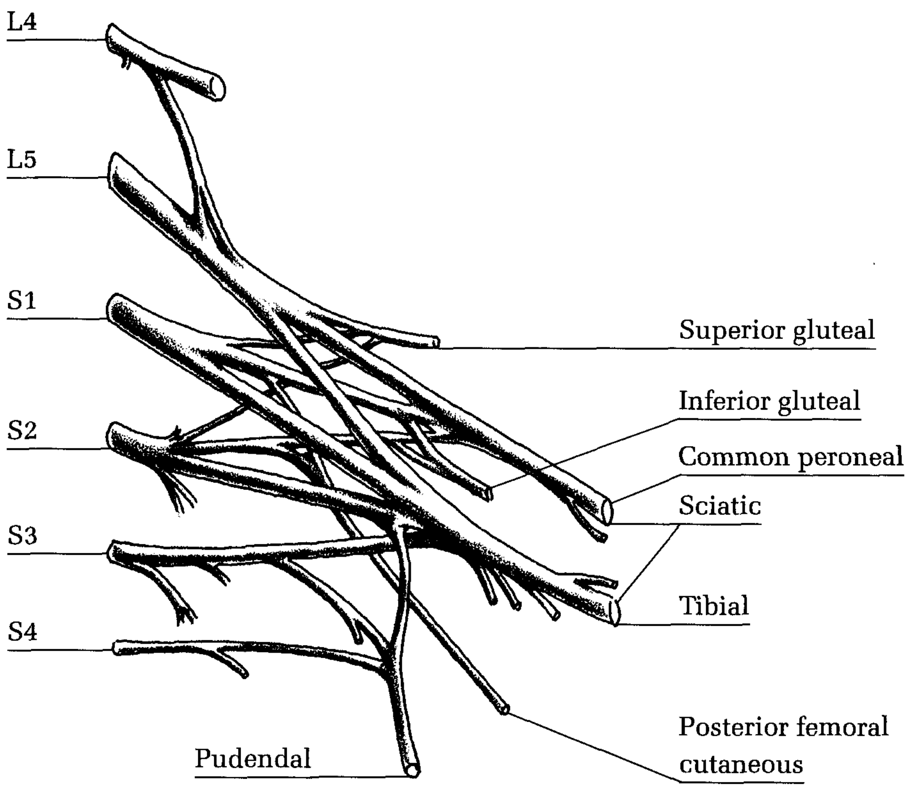

Figure 8.
The sacral plexus.

Cerebrum. The cerebrum is composed of an outer layer of gray matter called the cerebral cortex and an inner layer of white matter. The cortex is arranged in folds called gyri; the deep grooves between the folds are fissures and the shallower grooves are sulci. The largest fissure, the longitudinal fissure, separates the cerebrum into hemispheres. Internally, transverse fibers of white matter join the two hemispheres. The cerebrum is divided into lobes named for the bones under which they lie: frontal lobe (one), parietal lobes (two), temporal lobes (two), and occipital lobe (one). The insula, which lies deep within the lateral cerebral fissure, is the fifth division of the cerebrum. Also within the cerebrum are masses of gray matter referred to as basal ganglia. These include the corpus striatum, substantia nigra, subthalamic nucleus, and the red nucleus. These basal ganglia control many of the gross motor movements. The cerebrum controls the sensory input to the brain, the muscles for movement, and emotional and intellectual processes.

Cerebellum. The cerebellum is butterfly shaped and is located at the back lower portion of the head (Figure 11). The cerebellum is composed of two hemispheres joined by an area known as the vermis. The cerebellum controls coordinated muscular movements and maintains equilibrium and posture.

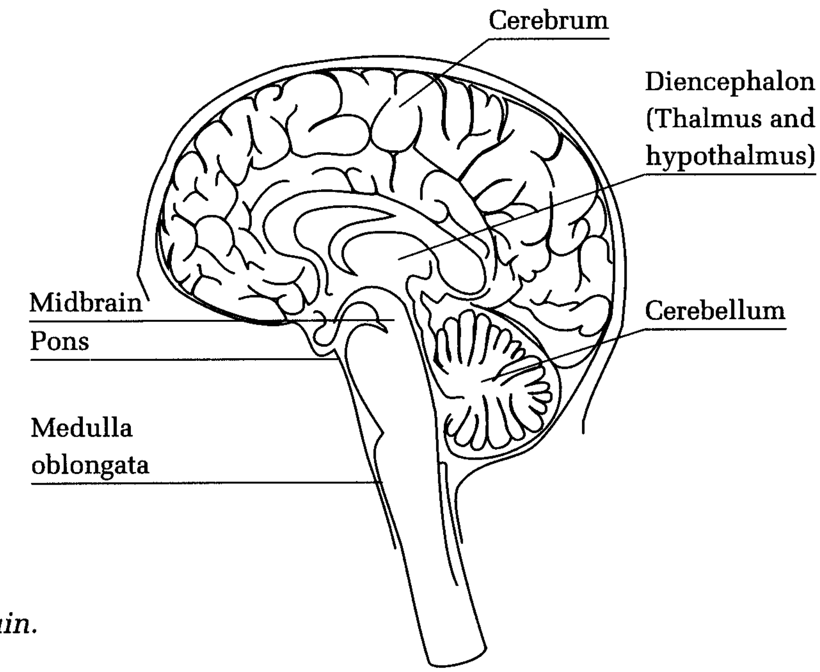

Figure 9.
Divisions of the brain.

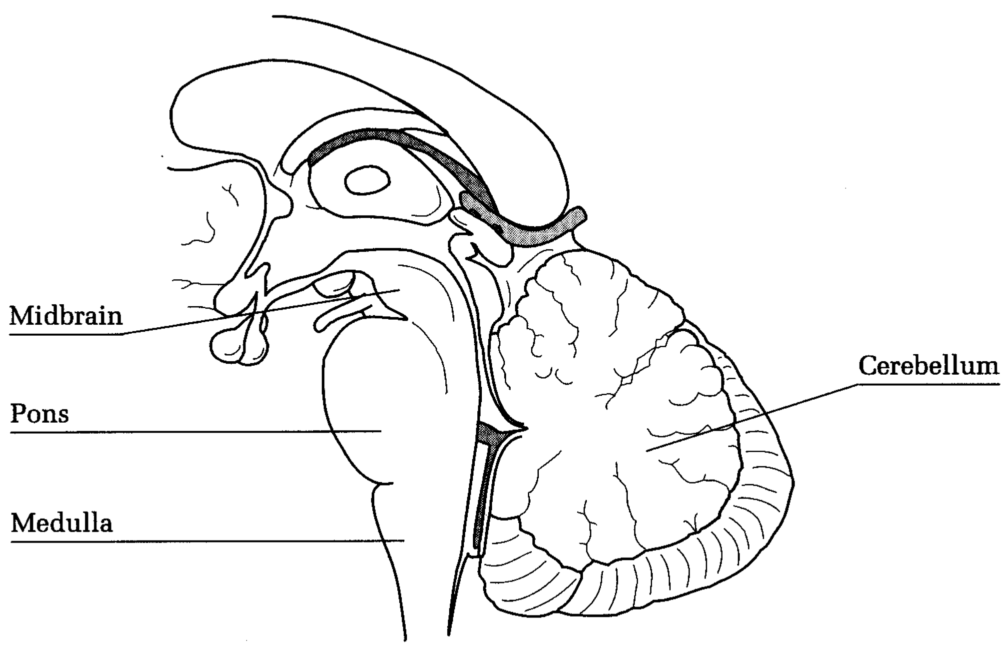

Figure 10.
Divisions of the brain stem.

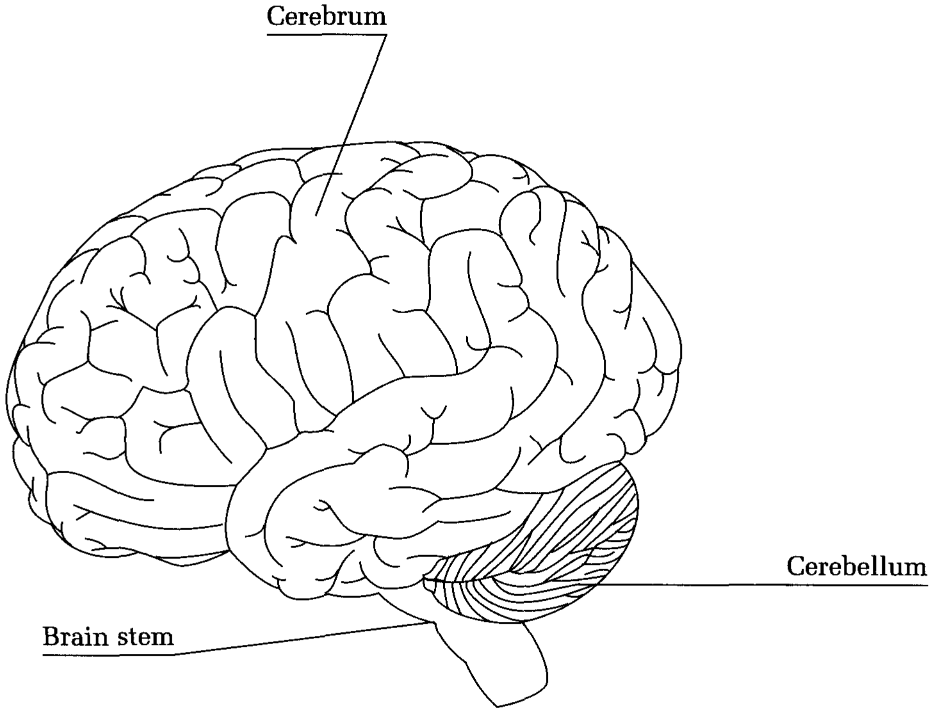

Figure 11.
The cerebrum.

Cerebrospinal Fluid

Cerebrospinal fluid (CSF) is a clear liquid that contains protein, glucose, urea, and salts. Its function is one of protection and circulation. It cushions the brain and spinal cord, brings nutrients, and removes waste and toxins. The normal amount of CSF is between 80 and 150 ml.

CSF is formed by the choroid plexuses in the ventricles. The circulation of CSF is as follows: lateral ventricles through interventricular foramen to the third ventricle; through the cerebral aqueduct to the fourth ventricle; to the subarachnoid space of the posterior brain downward to the posterior surface of the spinal cord; upward along the anterior surface of the cord; around the anterior portion of the brain; and finally absorbed by cerebral veins (superior sagittal sinus) through the arachnoid villi that project into the sinus.

Blood Supply

The brain is supplied with blood by the carotids (Figure 12).

1. External carotid: Supplies the scalp and dura mater.
2. Internal carotid: Supplies the brain.
3. Left and right internal carotids: Join with the basilar artery to form the circle of Willis, which supplies the brain through branching arteries.

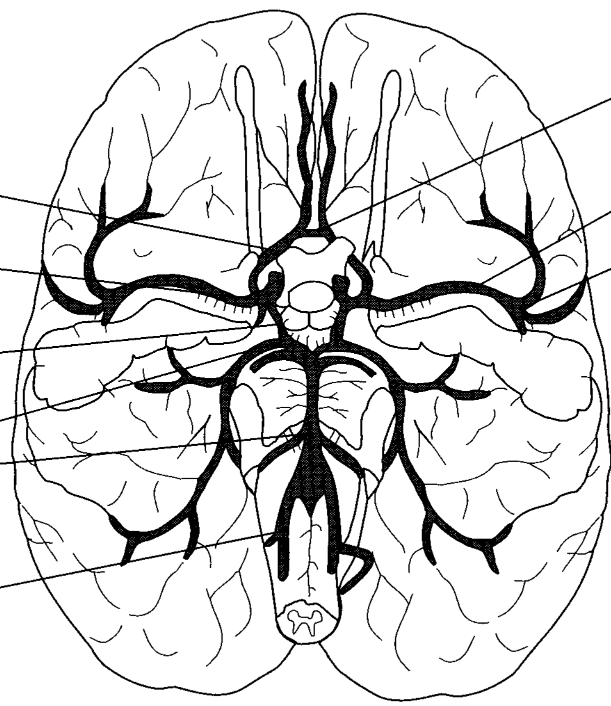

Figure 12.
Blood supply to the brain, showing the circle of Willis and the principal arteries of the base of the brain.

Venous return is accomplished via the sigmoid sinus, superior sagittal sinus, inferior sagittal sinus, straight sinus,and transverse sinuses. These sinuses empty into the internal jugular veins.

Blood-Brain Barrier

The capillaries of the brain are constructed of densely packed cells that are surrounded by numerous astrocytes. It is thought that the astrocytes produce substances that allow the capillaries to be selective about allowing substances to pass through their walls. Substances such as glucose, oxygen, sodium, amino acids, nicotine, alcohol, heroin, and others similar to proteins can pass through; most antibiotics do not pass. The blood-brain barrier functions as a protective barrier to toxic substances.

Cranial Nerves

There are 12 pairs of cranial nerves originating from the brain. Their number, names, and functions are summarized in Table 1.

Table 1. Cranial Nerves

Number	Name	Function
I	Olfactory	Controls smell
II	Optic	Controls vision
III	Oculomotor	Controls movement of the eye, accommodation of the lens, constriction of the pupil
IV	Trochlear	Controls movement of the eye
V	Trigeminal	Controls chewing, touch, pain and temperature of the scalp and face
VI	Abducens	Controls movement of the eye
VII	Facial	Controls the facial muscles, controls saliva, tears, and taste
VIII	Vestibulocochlear	Controls hearing impulses and equilibrium
IX	Glossopharyngeal	Controls swallowing, saliva, taste, regulation of blood pressure via carotid sinus
X	Vagus	Controls visceral muscles including the heart
XI	Accessory	Controls swallowing and head movements
XII	Hypoglossal	Controls movement of the tongue

Autonomic Nervous System

The autonomic nervous system is responsible for the unconscious regulation of cardiac and smooth muscles and glands. The autonomic nervous system is regulated by the cerebral cortex, hypothalamus, and medulla.

Divisions

The sympathetic division controls energy use and thoracic and abdominal viscera. The cells are located in the T1 through L3 area of the spinal cord. The sympathetic ganglions lie next to the vertebral column.

Sympathetic fibers release norepinephrine and are therefore referred to as the "fight or flight" system, which helps the body deal with stressful situations.

The parasympathetic division controls energy conservation. The first nerves of the parasympathetic system are located in cranial nerves (vagus). The others are located in the sacral region of the spinal cord.

Parasympathetic fibers release acetylcholine. This system keeps viscera working and maintains the status quo.