

# CHAPTER 16: NERVOUS SYSTEM

*Building a Medical Terminology Foundation 2e* by Kimberlee Carter; Marie Rutherford; and Connie Stevens

- 16.1 – Introduction to the Nervous System
- 16.2 – Anatomy (Structures) of the Nervous System
- 16.3 – Physiology (Function) of the Nervous System
- 16.4 – Nervous System Diseases, Disorders and Diagnostic Testing
- Vocabulary & Check Your Knowledge
- References

Except where otherwise noted, this OER is licensed under CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)

Please visit the web version of *Building a Medical Terminology Foundation 2e* (<https://ecampusontario.pressbooks.pub/medicalterminology2/>) to access the complete book, interactive activities and ancillary resources.

# 16.1 - Introduction to the Nervous System

## Learning Objectives

- Identify the anatomy of the nervous system and describe the main functions of the nervous system
- Analyse, translate, and define medical terms and common abbreviations of the nervous system and use correct abbreviations
- Practice the spelling and pronunciation of nervous system terminology
- Identify the medical specialties associated with the nervous system and explore common diseases, disorders, and procedures related to the nervous system

## Nervous System Word Parts

Click on prefixes, combining forms, and suffixes to reveal a list of word parts to memorize for the nervous system.

### Prefix

- **poly-** (many, much)
- **a-** (absence of, without, no, not)
- **an-** (absence of, without, no, not)
- **pan-** (all, total)
- **post-** (after)
- **para-** (beside, beyond, around, abnormal)
- **pre-** (before)
- **sub-** (below, under)
- **dys-** (painful, abnormal, difficult, laboured)
- **intra-** (within)

- **hemi-** (half)
- **hyper-** (above, excessive)
- **inter-** (between)

### Combining Form

- **cephal/o** (head)
- **cerebell/o** (cerebellum)
- **cerebr/o** (cerebrum)
- **dur/o** (dura mater, hard)
- **encephal/o** (brain)
- **esthesi/o** (sensation, sensitivity, feeling)
- **gangli/o** (ganglion)
- **ganglion/o** (ganglion)
- **gli/o** (glia, gluey substance)
- **mening/o** (meninges)
- **meningi/o** (meninges)
- **ment/o** (mind)
- **mon/o** (one, single)
- **myel/o** (spinal cord)
- **neur/o** (nerve)
- **phas/o** (speech)
- **poli/o** (gray matter)
- **psych/o** (mind)
- **quadr/i** (four)
- **radic/o** (nerve root)
- **radicul/o** (nerve root)
- **rhiz/o** (nerve root)

### Suffix

- **-al** (pertaining to)
- **-algia** (pain)
- **-cele** (hernia, protrusion)
- **-cyte** (cell)
- **-ectomy** (excision, surgical removal, cutting out)
- **-genic** (producing, originating, causing)
- **-gram** (the record, radiographic image)
- **-graph** (instrument used to record)
- **-graphy** (process of recording, radiographic imaging)
- **-ia** (condition of, diseased state or abnormal state)
- **-ic** (pertaining to)
- **-iatrist** (specialist, physician)

- **-atry** (specialty, treatment)
- **-ictal** (seizure, attack)
- **-itis** (inflammation)
- **-logist** (specialist, physician)
- **-logy** (study of)
- **-lysis** (loosening, dissolution, separating)
- **-malacia** (softening)
- **-oid** (resembling)
- **-oma** (tumour)
- **-osis** (abnormal condition)
- **-paresis** (slight paralysis)
- **-pathy** (disease)
- **-plasty** (surgical repair)
- **-plegia** (paralysis)
- **-sclerosis** (hardening)
- **-rrhaphy** (suturing, repairing)
- **-tomy** (incision, cut into)

**Activity source:** Nervous System Word Parts by Kimberlee Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

## Introduction to the Nervous System

The picture you have in your mind of the nervous system probably includes the **brain**, the **nervous tissue** contained within the cranium, and the **spinal cord**, the extension of nervous tissue within the vertebral column. That suggests it is made of two organs—and you may not even think of the spinal cord as an organ—but the nervous system is a very complex structure. Within the brain, many different and separate regions are responsible for many different and separate functions. It is as if the nervous system is composed of many organs that all look similar and can only be differentiated using tools such as the **microscope** or **electrophysiology**.

**Watch The Nervous System, Part 1: Crash Course Anatomy & Physiology #8 (11 min) on YouTube**  
 ([https://youtu.be/qPix\\_X-9t7E](https://youtu.be/qPix_X-9t7E))

## Nervous System Medical Terms

### Nervous System Medical Terms (Text Version)

Practice the following **nervous system** words by breaking into word parts and pronouncing.

1. **quadriplegia**

- quadr/i/plegia
- paralysis of four (limbs)

2. **neurectomy**

- neur/ectomy
- excision of nerves

3. **poliomyelitis**

- poli/o/myel/itis
- inflammation of gray matter of the spinal cord

4. **intracerebral**

- intra/cerebr/al
- pertaining to within the cerebrum

5. **encephalosclerosis**

- encephal/o/sclerosis
- hardening of the brain

6. **interictal**

- inter/ictal
- occurs between seizures or attacks

7. **rhizotomy**

- rhiz/o/tomy
- incision into a nerve root

8. **hyperesthesia**

- hyper/esthesi/a
- excessive sensitivity to stimuli

9. **mental**

- ment/al
  - pertaining to the brain
10. **neuralgia**
- neur/algia
  - pain of the nerves
11. **radiculopathy**
- radicul/o/pathy
  - disease of the nerve roots
12. **panplegia**
- pan/plegia
  - total paralysis
13. **monoparesis**
- mon/o/paresis
  - slight paralysis of one (limb)
14. **duritis**
- dur/itis
  - inflammation of the dura mater
15. **anesthesia**
- an/esthesi/a
  - without (loss of) feeling or sensation
16. **cerebellitis**
- cerebell/itis
  - inflammation of the cerebellum
17. **encephalomalacia**
- encephal/o/malacia
  - softening of the brain
18. **cerebral thrombosis**
- cerebr/al thromb/osis
  - Abnormal condition of blood clot pertaining to the cerebrum (blood clot in a blood vessel in the brain)
19. **craniocerebral**

- crani/o/cerebr/al
  - pertaining to the cranium and cerebrum
20. **glioma**
- gli/oma
  - tumour composed of the glial tissue
21. **psychiatrist**
- psych/iatrist
  - physician who studies and treats disorders of the mind
22. **cephalgia**
- ceph/algia
  - \*rebel does not follow the rules\*
  - Pain in the head (headache)
23. **neuroma**
- neur/oma
  - tumour made up of nerve (cells)
24. **psychogenic**
- psych/o/genic
  - originating in the mind
25. **polyneuropathy**
- poly/neur/o/pathy
  - disease of many nerves
26. **psychosis**
- psych/osis
  - abnormal condition of the mind
27. **mononeuropathy**
- mon/o/neur/o/pathy
  - disease affecting a single nerve
28. **electroencephalograph**
- electr/o/encephal/o/graph
  - instrument used to record electrical activity of the brain
29. **radicotomy**

- radic/o/tomy
  - incision into a nerve root
30. **aphasia**
- a/phas/ia
  - condition of without speaking
31. **poliomyelitis**
- poli/o/myel/itis
  - inflammation of the gray matter of the spinal cord
32. **gangliitis**
- gangli/itis
  - inflammation of the ganglion
33. **hemiplegia**
- hemi/plegia
  - paralysis of half (right or left) side of the body
34. **subdural hematoma**
- sub/dur/al hemat/oma
  - tumour filled with blood pertaining to below the dura mater
35. **dysphasia**
- dys/phas/ia
  - condition of difficulty speaking
36. **encephalitis**
- encephal/itis
  - inflammation of the brain
37. **subdural**
- sub/dur/al
  - pertaining to below the dura mater
38. **neurology**
- neur/o/logy
  - study of nerves
39. **CT myelography**
- CT myel/o/graphy



- process of recording the spinal cord with computed tomography
40. **glioblastoma**
- gli/o/blast/oma
  - tumour composed of developing glial tissue
41. **neuroid**
- neur/oid
  - resembling a nerve
42. **neuroarthropathy**
- neur/o/arthr/o/pathy
  - disease of the nerves and joints
43. **meningitis**
- mening/itis
  - inflammation of the meninges
44. **hemiparesis**
- hemi/paresis
  - slight paralysis of half (right or left) side of the body
45. **neurorrhaphy**
- neur/o/rrhaphy
  - suturing of a nerve
46. **psychology**
- psych/o/logy
  - study of the mind
47. **neurologist**
- neur/o/logist
  - specialist who studies and treats the nervous system
48. **neuroplasty**
- neur/o/plasty
  - surgical repair of a nerve
49. **psychopathy**
- psych/o/pathy
  - disease of the mind

50. **preictal**

- pre/ictal
- occurs before a seizure or attack

51. **radiculitis**

- radicul/itis
- inflammation of the nerve roots

52. **electroencephalography**

- electr/o/encephal/o/graphy
- process of recording the electrical activity of the brain

53. **cerebral angiography**

- cerebr/al angi/o/graphy
- process of recording (blood) vessel pertaining to the cerebrum

54. **psychiatry**

- psych/iatry
- specialty of the mind

55. **psychosomatic**

- psych/o/somat/ic
- pertaining to the mind and body

56. **neurotomy**

- neur/o/tomy
- incision into a nerve

57. **cerebral**

- cerebr/al
- pertaining to the brain

58. **neuropathy**

- neur/o/pathy
- disease of (peripheral) nerves

59. **myelomalacia**

- myel/o/malacia
- softening of the spinal cord

60. **encephalomyeloradiculitis**

- encephal/o/myel/itis
  - inflammation of brain, spinal cord and nerve roots
61. **monoplegia**
- mon/o/plegia
  - paralysis of one (limb)
62. **meningomyelocele**
- mening/o/myel/o/cele
  - protrusion of the meninges and spinal cord
63. **paresthesia**
- par/esthesi/a
  - \* rebel does not follow the rules\*
  - abnormal sensation in the extremities
64. **psychologist**
- psych/o/logist
  - specialist of the mind
65. **postictal**
- post/ictal
  - occurs after a seizure or attack
66. **meningioma**
- meningi/oma
  - tumour of the meninges
67. **neurolysis**
- neur/o/lysis
  - dissolution of nerve (for pain management)
68. **electroencephalogram**
- electr/o/encephal/o/gram
  - the record of electrical activity of the brain
69. **gliocyte**
- gli/o/cyte
  - glial cell
70. **polyneuritis**

- poly/neur/itis
- inflammation of many nerves

71. **neuritis**

- neur/itis
- inflammation of the nerves

72. **ganglionectomy**

- ganglion/ectomy
- excision of a ganglion

73. **meningocele**

- mening/o/cele
- protrusion of the meninges

74. **rhizomeningomyelitis**

- rhiz/o/mening/o/myel/itis
- inflammation of the nerve root, meninges and spinal cord

**Activity source:** Nervous System Medical Terms by Kimberlee Carter, from Building a Medical Terminology Foundation by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

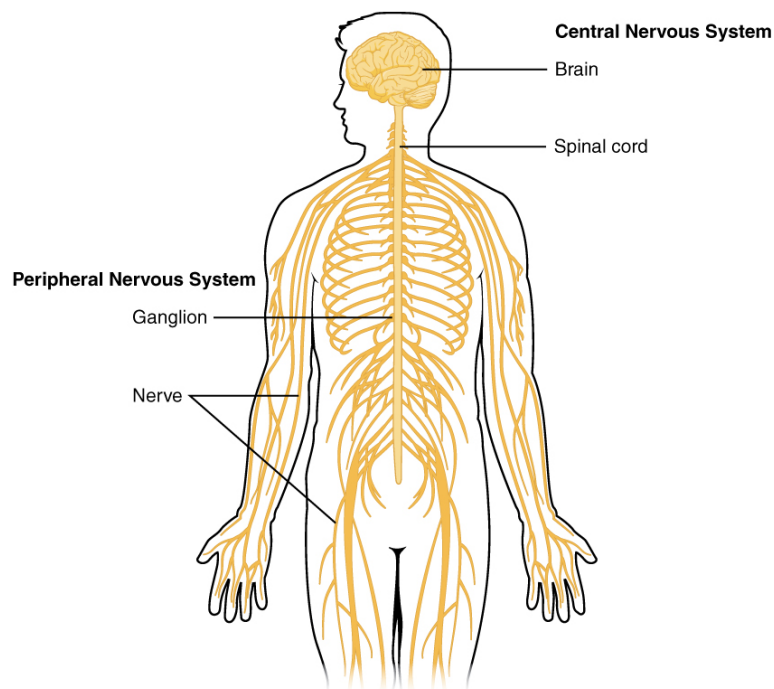
## Attribution

Except where otherwise noted, this chapter is adapted from “Nervous System (<https://ecampusontario.pressbooks.pub/medicalterminology/chapter/nervous-system/>)” in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)* (<https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>). Adaptations: dividing Nervous System chapter content into sub-chapters.

# 16.2 - Anatomy (Structures) of the Nervous System

## The Central and Peripheral Nervous Systems

The nervous system can be divided into two major regions: the central and peripheral nervous systems. The **central nervous system (CNS)** is the brain and spinal cord, and the **peripheral nervous system (PNS)** is everything else (see Figure 16.1). The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column. It is a bit of an oversimplification to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. In actuality, there are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. Depending on different aspects of the nervous system, the dividing line between central and peripheral is not necessarily universal.



**Figure 16.1 Central and Peripheral Nervous System.** The structures of the PNS are referred to as ganglia and nerves, which can be seen as distinct structures. The equivalent structures in the CNS are not obvious from this overall perspective and are best examined in prepared tissue under the microscope. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.1 Image description.]

Nervous tissue, present in both the CNS and PNS, contains two basic types of cells: neurons and glial cells. **Neurons** are the primary type of cell that most anyone associates with the nervous system. They are responsible

for the computation and communication that the nervous system provides. They are electrically active and release chemical signals to target cells. Glial cells, or **glia**, are known to play a supporting role for nervous tissue. Ongoing research pursues an expanded role that glial cells might play in signaling, but neurons are still considered the basis of this function. Neurons are important, but without glial support they would not be able to perform their function. A glial cell is one of a variety of cells that provide a framework of tissue that supports the neurons and their activities. The neuron is the more functionally important of the two, in terms of the communicative function of the nervous system. To describe the functional divisions of the nervous system, it is important to understand the structure of a neuron.

### Did You Know 1?

The brain has over 100 billion neurons.

Neurons are cells and therefore have a **soma**, or cell body, but they also have extensions of the cell; each extension is generally referred to as a process. There is one important process that every neuron has called an **axon**, which is the fiber that connects a neuron with its target. Another type of process that branches off from the soma is the dendrite. **Dendrites** are responsible for receiving most of the input from other neurons.

Looking at nervous tissue, there are regions that predominantly contain cell bodies and regions that are largely composed of just axons. These two regions within nervous system structures are often referred to as **gray matter** (the regions with many cell bodies and dendrites) or **white matter** (the regions with many axons). Figure 16.2 demonstrates the appearance of these regions in the brain and spinal cord. The colours ascribed to these regions are what would be seen in “fresh,” or unstained, nervous tissue. Gray matter is not necessarily gray. It can be pinkish because of blood content, or even slightly tan, depending on how long the tissue has been preserved. White matter is white because axons are insulated by a lipid-rich substance called myelin. Lipids can appear as white (“fatty”) material, much like the fat on a raw piece of chicken or beef. Actually, gray matter may have that colour ascribed to it because next to the white matter, it is just darker—hence, gray.

The distinction between **gray matter** and **white matter** is most often applied to central nervous tissue, which has large regions that can be seen with the unaided eye. When looking at peripheral structures, often a microscope is used and the tissue is stained with artificial colours. That is not to say that central nervous tissue cannot be stained and viewed under a microscope, but unstained tissue is most likely from the CNS—for example, a frontal section of the brain or cross section of the spinal cord.

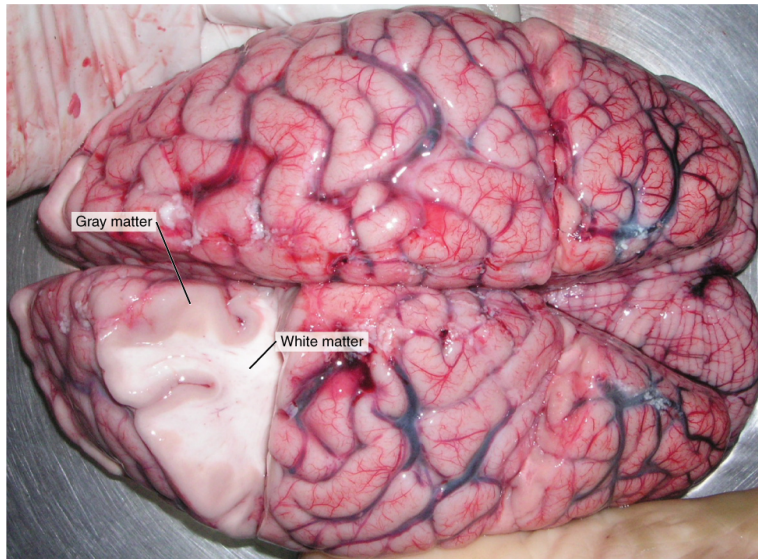


Figure 16.2 Gray Matter and White Matter. A brain removed during an autopsy, with a partial section removed, shows white matter surrounded by gray matter. Gray matter makes up the outer cortex of the brain. (credit: modification of work by "Suseno"/Wikimedia Commons). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.2 Image description.]

## The Adult Brain

The adult brain is separated into four major regions: the cerebrum, the diencephalon, the brain stem, and the cerebellum. The cerebrum is the largest portion and contains the cerebral cortex and subcortical nuclei. It is divided into two halves by the longitudinal fissure.

### *The Cerebrum*

The iconic gray mantle of the human brain, which appears to make up most of the mass of the brain, is the **cerebrum** (see Figure 16.3). The wrinkled portion is the cerebral cortex, and the rest of the structure is beneath that outer covering. There is a large separation between the two sides of the cerebrum called the **longitudinal** fissure. It separates the cerebrum into two distinct halves, a right and left **cerebral hemisphere**. Deep within the cerebrum, the white matter of the corpus callosum provides the major pathway for communication between the two hemispheres of the cerebral cortex.

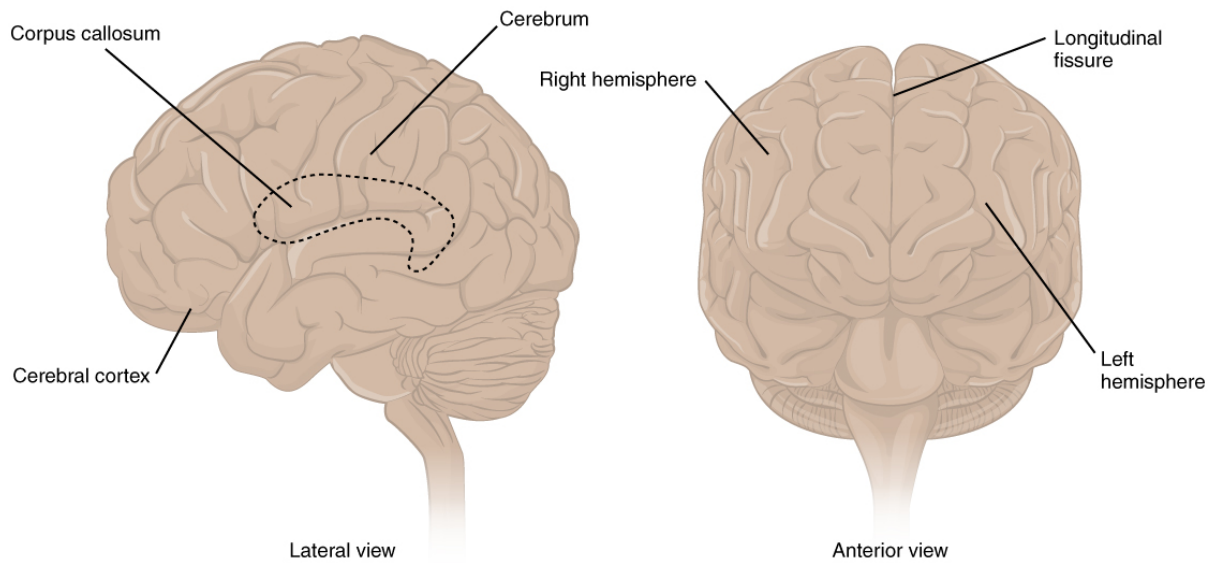


Figure 16.3 The Cerebrum. The cerebrum is a large component of the CNS in humans, and the most obvious aspect of it is the folded surface called the cerebral cortex. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.3 Image description.]

## Did You Know 2?

The brain is about 75% water and is the fattest organ in the body.

Many of the higher neurological functions, such as memory, emotion, and consciousness, are the result of cerebral function. The complexity of the cerebrum is different across vertebrate species. The cerebrum of the most primitive vertebrates is not much more than the connection for the sense of smell. In mammals, the cerebrum comprises the outer gray matter that is the cortex (from the Latin word meaning “bark of a tree”) and several deep nuclei that belong to three important functional groups. The basal nuclei are responsible for cognitive processing, the most important function being that associated with planning movements. The basal forebrain contains nuclei that are important in learning and memory. The limbic cortex is the region of the cerebral cortex that part of the limbic system, a collection of structures involved in emotion, memory, and behavior.

### *Cerebral Cortex*

The cerebrum is covered by a continuous layer of gray matter that wraps around either side of the forebrain—the



**cerebral cortex.** This thin, extensive region of wrinkled gray matter is responsible for the higher functions of the nervous system. A gyrus (plural = gyri) is the ridge of one of those wrinkles, and a sulcus (plural = sulci) is the groove between two gyri. The pattern of these folds of tissue indicates specific regions of the cerebral cortex.

The head is limited by the size of the birth canal, and the brain must fit inside the cranial cavity of the skull. Extensive folding in the cerebral cortex enables more gray matter to fit into this limited space. If the gray matter of the cortex were peeled off of the cerebrum and laid out flat, its surface area would be roughly equal to one square meter.

The folding of the cortex maximizes the amount of gray matter in the cranial cavity. During embryonic development, as the **telencephalon** expands within the skull, the brain goes through a regular course of growth that results in everyone's brain having a similar pattern of folds. The surface of the brain can be mapped on the basis of the locations of large gyri and sulci. Using these landmarks, the cortex can be separated into four major regions, or lobes (see Figure 16.4). The lateral sulcus that separates the temporal lobe from the other regions is one such landmark. Superior to the lateral sulcus are the **parietal lobe** and **frontal lobe**, which are separated from each other by the **central sulcus**. The posterior region of the cortex is the **occipital lobe**, which has no obvious anatomical border between it and the parietal or temporal lobes on the lateral surface of the brain. From the medial surface, an obvious landmark separating the parietal and occipital lobes is called the parieto-occipital sulcus. The fact that there is no obvious anatomical border between these lobes is consistent with the functions of these regions being interrelated.

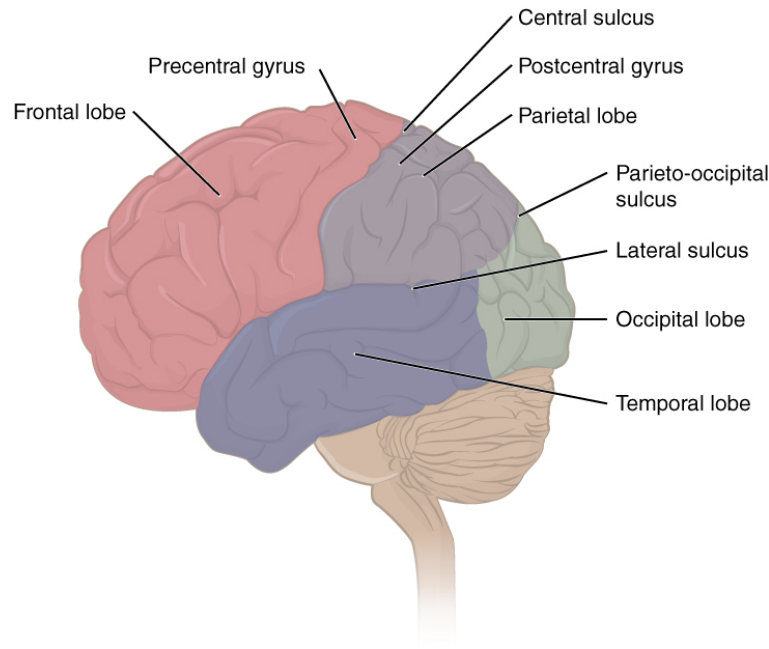


Figure 16.4 Lobes of the Cerebral Cortex. The cerebral cortex is divided into four lobes. Extensive folding increases the surface area available for cerebral functions. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.4 Image description.]

## Concept Check 1

- Identify the two major divisions of the nervous system.
- Describe the **cerebral cortex**.
- What are the halves of the cerebrum known as?

### *The Diencephalon*

The diencephalon is deep beneath the cerebrum and constitutes the walls of the third ventricle. The diencephalon can be described as any region of the brain with “thalamus” in its name. The two major regions of the diencephalon are the thalamus itself and the hypothalamus (see Figure 16.5). There are other structures, such as the epithalamus, which contains the pineal gland, or the subthalamus, which includes the subthalamic nucleus that is part of the basal nuclei.

### *Thalamus*

The **thalamus** is a collection of nuclei that relay information between the cerebral cortex and the periphery, spinal cord, or brain stem. All sensory information, except for the sense of smell, passes through the thalamus before processing by the cortex. For example, the portion of the thalamus that receives visual information will influence what visual stimuli are important, or what receives attention.

The cerebrum also sends information down to the thalamus, which usually communicates motor commands. This involves interactions with the cerebellum and other nuclei in the brain stem. The cerebrum interacts with the basal nuclei, which involves connections with the thalamus. The primary output of the basal nuclei is to the thalamus, which relays that output to the cerebral cortex. The cortex also sends information to the thalamus that will then influence the effects of the basal nuclei.

### *Hypothalamus*

Inferior and slightly anterior to the thalamus is the **hypothalamus**, the other major region of the diencephalon. The hypothalamus is a collection of nuclei that are largely involved in regulating homeostasis. The hypothalamus is the executive region in charge of the **autonomic nervous system** and the endocrine system through its regulation of the anterior pituitary gland. Other parts of the hypothalamus are involved in memory and emotion as part of the limbic system.

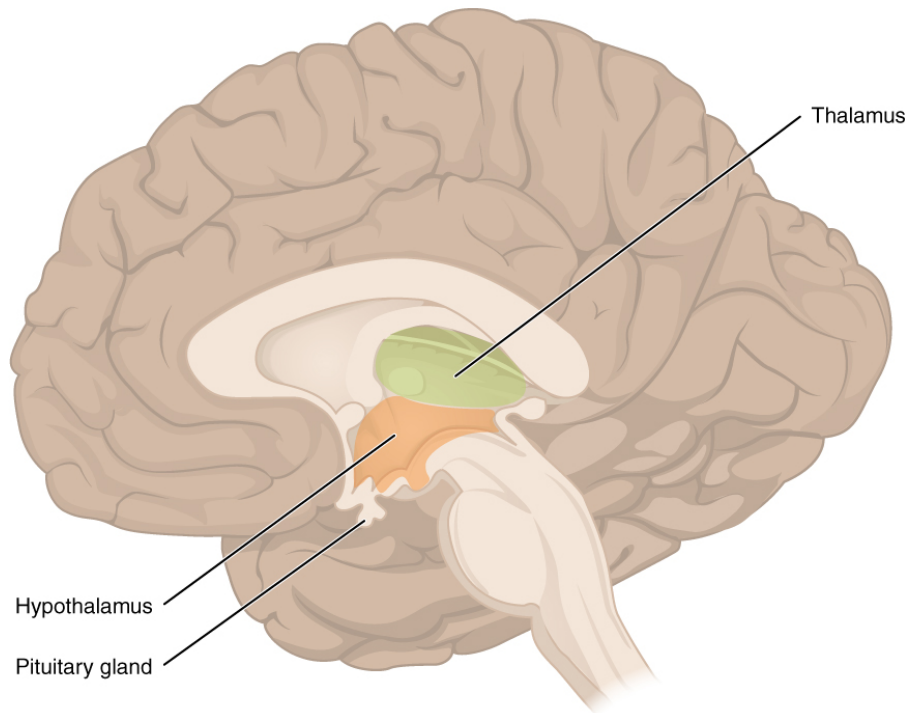


Figure 16.5 The Diencephalon. The diencephalon is composed primarily of the thalamus and hypothalamus, which together define the walls of the third ventricle. The thalami are two elongated, ovoid structures on either side of the midline that make contact in the middle. The hypothalamus is inferior and anterior to the thalamus, culminating in a sharp angle to which the pituitary gland is attached. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.5 Image description.]

### Brain Stem

The midbrain and hindbrain (composed of the **pons** and the **medulla**) are collectively referred to as the brain stem (see Figure 16.6). The structure emerges from the ventral surface of the forebrain as a tapering cone that connects the brain to the spinal cord. Attached to the brain stem, but considered a separate region of the adult brain, is the cerebellum. The midbrain coordinates sensory representations of the visual, auditory, and somatosensory perceptual spaces. The pons is the main connection with the cerebellum. The pons and the medulla regulate several crucial functions, including the cardiovascular and respiratory systems and rates.

The cranial nerves connect through the brain stem and provide the brain with the sensory input and motor output associated with the head and neck, including most of the special senses. The major ascending and descending pathways between the spinal cord and brain, specifically the cerebrum, pass through the brain stem.

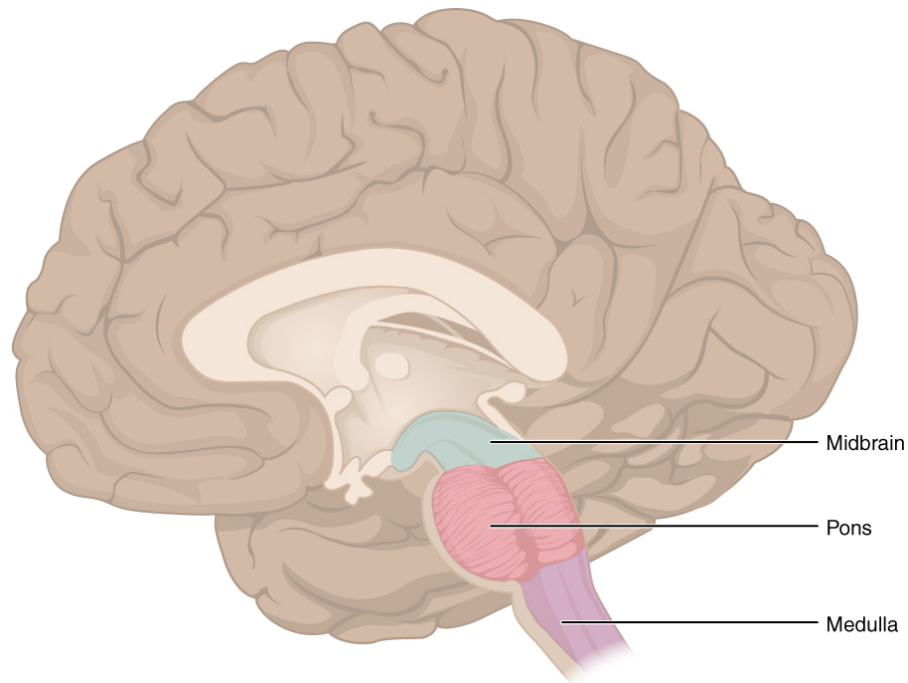


Figure 16.6 The Brain Stem. The brain stem comprises three regions: the midbrain, the pons, and the medulla. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.6 Image description.]

### *Midbrain*

One of the original regions of the embryonic brain, the midbrain is a small region between the thalamus and pons. It is separated into the **tectum** and **tegmentum**, from the Latin words for roof and floor, respectively. The cerebral aqueduct passes through the center of the midbrain, such that these regions are the roof and floor of that canal.

### *Pons*

The word **pons** comes from the Latin word for bridge. It is visible on the anterior surface of the brain stem as the thick bundle of white matter attached to the cerebellum. The pons is the main connection between the cerebellum and the brain stem. The bridge-like white matter is only the anterior surface of the pons; the gray matter beneath that is a continuation of the tegmentum from the midbrain. Gray matter in the tegmentum region of the pons contains neurons receiving descending input from the forebrain that is sent to the cerebellum.

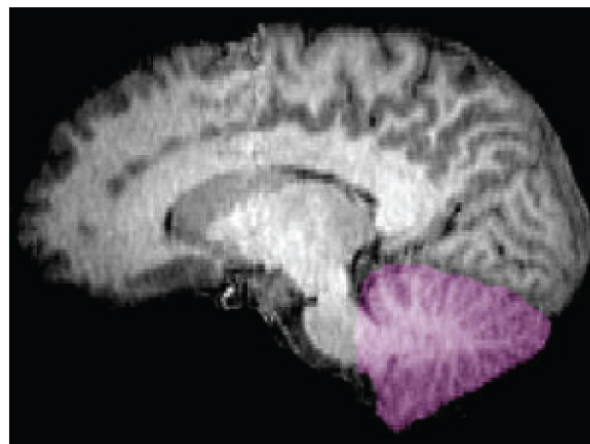
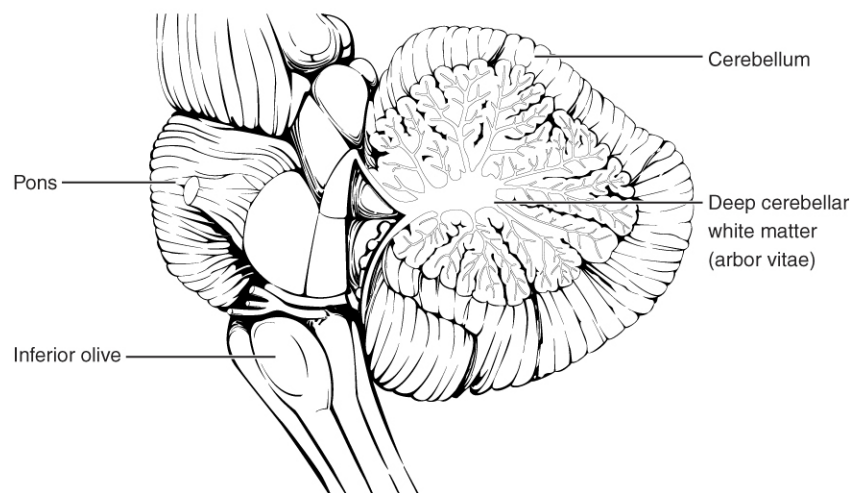
### *Medulla*

The medulla is the region known as the **myelencephalon** in the embryonic brain. The initial portion of the name, “myel,” refers to the significant white matter found in this region—especially on its exterior, which is continuous

with the white matter of the spinal cord. The tegmentum of the midbrain and pons continues into the medulla because this gray matter is responsible for processing cranial nerve information. A diffuse region of gray matter throughout the brain stem, known as the reticular formation, is related to sleep and wakefulness, such as general brain activity and attention.

### *The Cerebellum*

The cerebellum, as the name suggests, is the “little brain.” It is covered in **gyri** and sulci like the cerebrum, and looks like a miniature version of that part of the brain (see Figure 16.7). The cerebellum is largely responsible for comparing information from the cerebrum with sensory feedback from the periphery through the spinal cord. It accounts for approximately 10 percent of the mass of the brain.



*Figure 16.7 The Cerebellum.* The cerebellum is situated on the posterior surface of the brain stem. Descending input from the cerebellum enters through the large white matter structure of the pons. Ascending input from the periphery and spinal cord enters through the fibers of the inferior olive. Output goes to the midbrain, which sends a descending signal to the spinal cord. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.7 Image description.]

## Concept Check 2

- What is the primary processing purpose of the **medulla**?
- Identify the structure in the brain responsible for sensory feedback through the spinal cord. Suggest what may happen if this function failed.

## The Spinal Cord

The description of the CNS is concentrated on the structures of the brain, but the spinal cord is another major organ of the system. Whereas the brain develops out of expansions of the neural tube into primary and then secondary vesicles, the spinal cord maintains the tube structure and is only specialized into certain regions. As the spinal cord continues to develop in the newborn, anatomical features mark its surface. The anterior midline is marked by the anterior median fissure, and the posterior midline is marked by the posterior median sulcus. Axons enter the posterior side through the dorsal (posterior) nerve root, which marks the posterolateral sulcus on either side. The axons emerging from the anterior side do so through the ventral (anterior) nerve root. Note that it is common to see the terms dorsal (dorsal = “back”) and ventral (ventral = “belly”) used interchangeably with posterior and anterior, particularly in reference to nerves and the structures of the spinal cord. You should learn to be comfortable with both.

On the whole, the posterior regions are responsible for sensory functions and the anterior regions are associated with motor functions. This comes from the initial development of the spinal cord, which is divided into the basal plate and the alar plate. The basal plate is closest to the ventral midline of the neural tube, which will become the anterior face of the spinal cord and gives rise to motor neurons. The alar plate is on the dorsal side of the neural tube and gives rise to neurons that will receive sensory input from the periphery.

The length of the spinal cord is divided into regions that correspond to the regions of the vertebral column. The name of a spinal cord region corresponds to the level at which spinal nerves pass through the intervertebral foramina. Immediately adjacent to the brain stem is the following divisions of the spinal cord:

- cervical region
- thoracic region
- lumbar region
- sacral region

## Did You Know 3?

The bundle of nerve fibers making up the spinal cord is no thicker than the human thumb.

The spinal cord is not the full length of the vertebral column because the spinal cord does not grow significantly longer after the first or second year, but the skeleton continues to grow. The nerves that emerge from the spinal cord pass through the intervertebral **foramina** at the respective levels. As the vertebral column grows, these nerves grow with it and result in a long bundle of nerves that resembles a horse's tail and is named the **cauda equina**. The sacral spinal cord is at the level of the upper lumbar vertebral bones. The spinal nerves extend from their various levels to the proper level of the vertebral column.

## Neurons

Neurons are the cells considered to be the basis of nervous tissue. They are responsible for the electrical signals that communicate information about sensations, and that produce movements in response to those stimuli, along with inducing thought processes within the brain. An important part of the function of neurons is in their structure, or shape. The three-dimensional shape of these cells makes the immense numbers of connections within the nervous system possible.

### *Parts of a Neuron*

As you learned in the first section, the main part of a neuron is the **cell body**, which is also known as the soma (soma = “body”). The cell body contains the nucleus and most of the major organelles. But what makes neurons special is that they have many extensions of their cell membranes, which are generally referred to as processes. Neurons are usually described as having one, and only one, axon—a fiber that emerges from the cell body and projects to target cells. That single axon can branch repeatedly to communicate with many **target** cells. It is the axon that **propagates** the nerve impulse, which is communicated to one or more cells. The other processes of the neuron are dendrites, which receive information from other neurons at specialized areas of contact called synapses. The dendrites are usually highly branched processes, providing locations for other neurons to communicate with the cell body. Information flows through a neuron from the dendrites, across the cell body, and down the axon. This gives the neuron a polarity—meaning that information flows in this one direction. Figure 16.8 shows the relationship of these parts to one another.

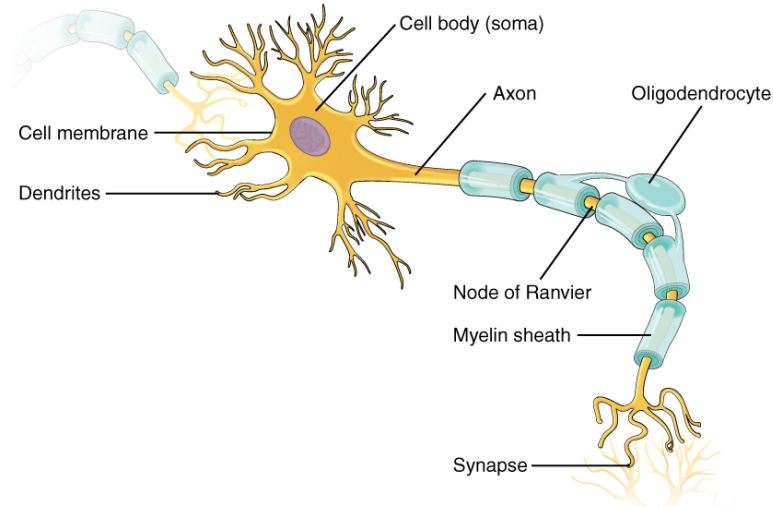


Figure 16.8 Parts of a Neuron. The major parts of the neuron are labeled on a multipolar neuron from the CNS. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.8 Image description.]

Where the axon emerges from the cell body, there is a special region referred to as the **axon hillock**. This is a tapering of the cell body toward the axon fiber. Within the axon hillock, the cytoplasm changes to a solution of limited components called **axoplasm**. Because the axon hillock represents the beginning of the axon, it is also referred to as the initial segment.

Many axons are wrapped by an insulating substance called myelin, which is actually made from glial cells. Myelin acts as insulation much like the plastic or rubber that is used to insulate electrical wires. A key difference between **myelin** and the insulation on a wire is that there are gaps in the myelin covering of an axon. Each gap is called a node of Ranvier and is important to the way that electrical signals travel down the axon. The length of the axon between each gap, which is wrapped in myelin, is referred to as an axon segment. At the end of the axon is the axon terminal, where there are usually several branches extending toward the target cell, each of which ends in an enlargement called a synaptic end bulb. These bulbs are what make the connection with the target cell at the synapse.

### *Types of Neurons*

There are many neurons in the nervous system—a number in the trillions. And there are many different types of neurons. They can be classified by many different criteria. The first way to classify them is by the number of processes attached to the cell body. Using the standard model of neurons, one of these processes is the axon, and the rest are dendrites. Because information flows through the neuron from dendrites or cell bodies toward the axon, these names are based on the neuron's polarity (see Figure 16.9).



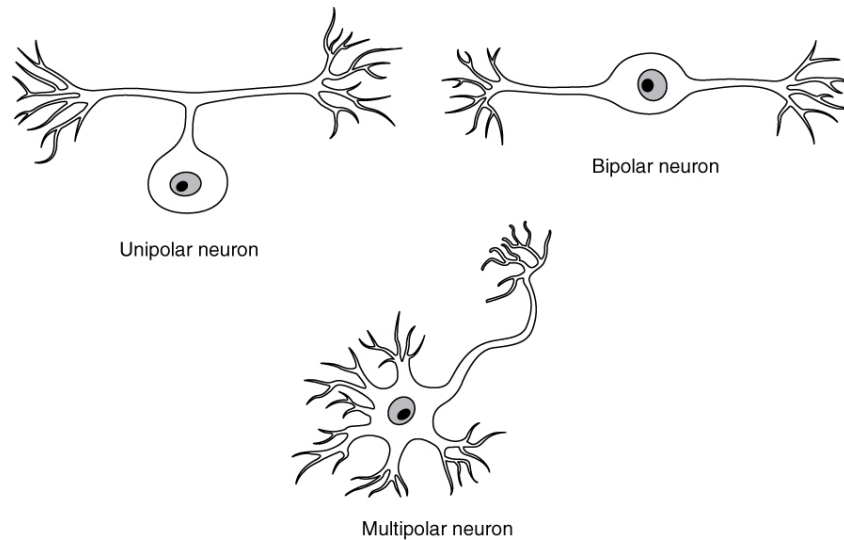


Figure 16.9 Neuron Classification by Shape. Unipolar cells have one process that includes both the axon and dendrite. Bipolar cells have two processes, the axon and a dendrite. Multipolar cells have more than two processes, the axon and two or more dendrites. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.9 Image description.]

**Unipolar** cells have only one process emerging from the cell. True unipolar cells are only found in invertebrate animals, so the unipolar cells in humans are more appropriately called “pseudo-unipolar” cells. Invertebrate unipolar cells do not have dendrites.

**Bipolar** cells have two processes, which extend from each end of the cell body, opposite to each other. One is the axon and one the dendrite. Bipolar cells are not very common. They are found mainly in the olfactory epithelium (where smell stimuli are sensed), and as part of the retina.

**Multipolar** neurons are all of the neurons that are not unipolar or bipolar. They have one axon and two or more dendrites (usually many more). With the exception of the unipolar sensory ganglion cells, and the two specific bipolar cells mentioned above, all other neurons are multipolar.

Neurons can also be classified on the basis of where they are found, who found them, what they do, or even what chemicals they use to communicate with each other. Some neurons referred to in this section on the nervous system are named on the basis of those sorts of classifications (see Figure 16.10). For example, a multipolar neuron that has a very important role to play in a part of the brain called the cerebellum is known as a Purkinje (commonly pronounced per-KIN-gee) cell. It is named after the anatomist who discovered it (Jan Evangelista Purkinje, 1787–1869).

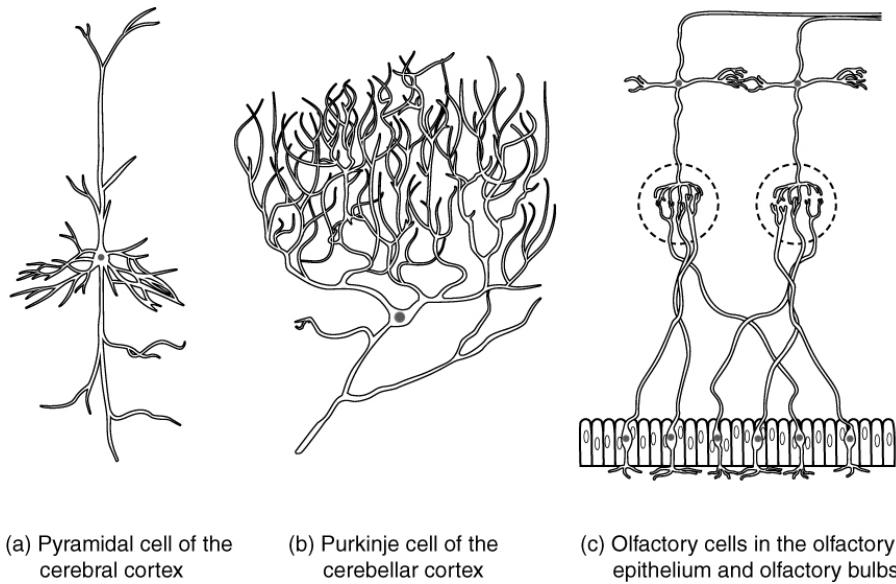


Figure 16.10 Other Neuron Classifications. Three examples of neurons that are classified on the basis of other criteria. (a) The pyramidal cell is a multipolar cell with a cell body that is shaped something like a pyramid. (b) The Purkinje cell in the cerebellum was named after the scientist who originally described it. (c) Olfactory neurons are named for the functional group with which they belong. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.10 Image description.]

## Glial Cells

Glial cells, or neuroglia or simply glia, are the other type of cell found in nervous tissue. They are considered to be supporting cells, and many functions are directed at helping neurons complete their function for communication. The name glia comes from the Greek word that means “glue,” and was coined by the German pathologist Rudolph Virchow, who wrote in 1856: “This connective substance, which is in the brain, the spinal cord, and the special sense nerves, is a kind of glue (neuroglia) in which the nervous elements are planted.” Today, research into nervous tissue has shown that there are many deeper roles that these cells play. And research may find much more about them in the future.

There are six types of glial cells. Four of them are found in the CNS and two are found in the PNS. Table 16.1 outlines some common characteristics and functions.

**Table 16.1: Glial Cell Types by Location and Basic Function. From Betts et al., 2013. Licensed under CC BY 4.0.**

CNS Glia	PNS Glia	Basic Function
Astrocyte	Satellite cell	Support
Oligodendrocyte	Schwann cell	Insulation, myelination
Microglia	–	Immune surveillance and phagocytosis
Ependymal cell	–	Creating CSF

## Glial Cells of the CNS

One cell providing support to neurons of the CNS is the astrocyte, so named because it appears to be star-shaped under the microscope (astro- = “star”). **Astrocytes** have many processes extending from their main cell body (not axons or dendrites like neurons, just cell extensions). Those processes extend to interact with neurons, blood vessels, or the connective tissue covering the CNS that is called the pia mater (see Figure 16.11). Generally, they are supporting cells for the neurons in the central nervous system. Some ways in which they support neurons in the central nervous system are by maintaining the concentration of chemicals in the extracellular space, removing excess signaling molecules, reacting to tissue damage, and contributing to the **blood-brain barrier** (BBB). The blood-brain barrier is a physiological barrier that keeps many substances that circulate in the rest of the body from getting into the central nervous system, restricting what can cross from circulating blood into the CNS. Nutrient molecules, such as glucose or amino acids, can pass through the BBB, but other molecules cannot. This actually causes problems with drug delivery to the CNS. Pharmaceutical companies are challenged to design drugs that can cross the BBB as well as have an effect on the nervous system.

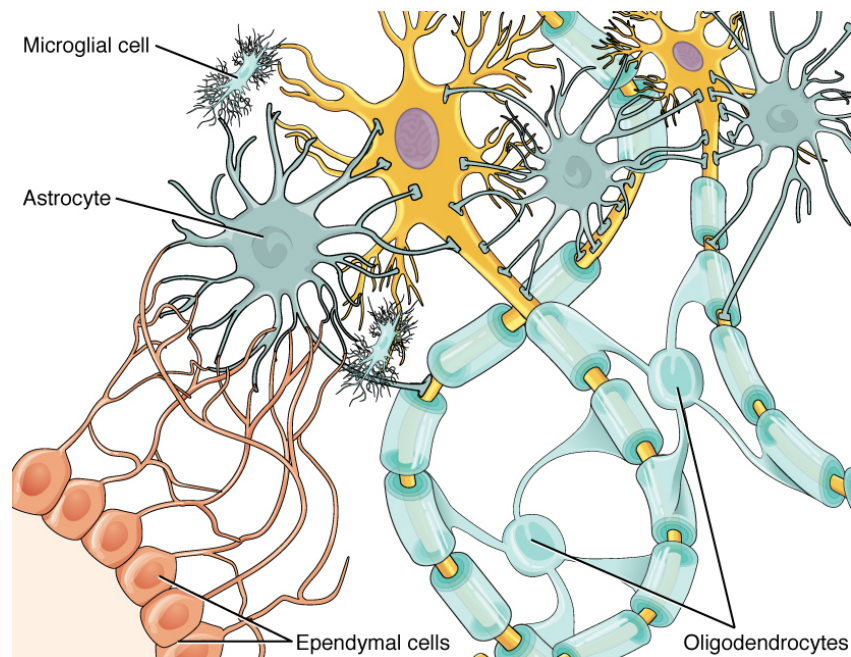


Figure 16.11 Glial Cells of the CNS. The CNS has astrocytes, oligodendrocytes, microglia, and ependymal cells that support the neurons of the CNS in several ways. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.11 Image description.]

Like a few other parts of the body, the brain has a privileged blood supply. Very little can pass through by diffusion. Most substances that cross the wall of a blood vessel into the CNS must do so through an active transport process. Because of this, only specific types of molecules can enter the CNS. Glucose—the primary energy source—is allowed, as are amino acids. Water and some other small particles, like gases and ions, can enter. But most everything else cannot, including white blood cells, which are one of the body’s main lines of defense. While this barrier protects the CNS from exposure to toxic or pathogenic substances, it also keeps out the cells that could protect the brain and spinal cord from disease and damage. The BBB also makes it harder for

pharmaceuticals to be developed that can affect the nervous system. Aside from finding efficacious substances, the means of delivery is also crucial.

**Oligodendrocyte**, sometimes called just “oligo,” which is the glial cell type that insulates axons in the CNS. The name means “cell of a few branches” (oligo- = “few”; dendro- = “branches”; -cyte = “cell”). There are a few processes that extend from the cell body. Each one reaches out and surrounds an axon to insulate it in myelin.

**Microglia** are, as the name implies, smaller than most of the other glial cells. Ongoing research into these cells, although not entirely conclusive, suggests that they may originate as white blood cells, called macrophages, that become part of the CNS during early development. While their origin is not conclusively determined, their function is related to what macrophages do in the rest of the body. When macrophages encounter diseased or damaged cells in the rest of the body, they ingest and digest those cells or the pathogens that cause disease. Microglia are the cells in the CNS that can do this in normal, healthy tissue, and they are therefore also referred to as CNS-resident macrophages.

The **ependymal** cell is a glial cell that filters blood to make cerebrospinal fluid (CSF), the fluid that circulates through the CNS. Because of the privileged blood supply inherent in the BBB, the extracellular space in nervous tissue does not easily exchange components with the blood. Ependymal cells line each ventricle, one of four central cavities that are remnants of the hollow center of the neural tube formed during the embryonic development of the brain. They also have cilia on their apical surface to help move the CSF through the ventricular space. The relationship of these glial cells to the structure of the CNS is seen in Figure 16.11.

### *Glial Cells of the PNS*

One of the two types of glial cells found in the PNS is the **satellite** cell. Satellite cells are found in sensory and autonomic ganglia, where they surround the cell bodies of neurons. This accounts for the name, based on their appearance under the microscope. They provide support, performing similar functions in the periphery as astrocytes do in the CNS—except, of course, for establishing the BBB.

The second type of glial cell is the **Schwann** cell, which insulate axons with myelin in the periphery. Schwann cells are different than oligodendrocytes, in that a Schwann cell wraps around a portion of only one axon segment and no others. Oligodendrocytes have processes that reach out to multiple axon segments, whereas the entire Schwann cell surrounds just one axon segment. The nucleus and cytoplasm of the Schwann cell are on the edge of the myelin sheath. The relationship of these two types of glial cells to ganglia and nerves in the PNS is seen in Figure 16.12.

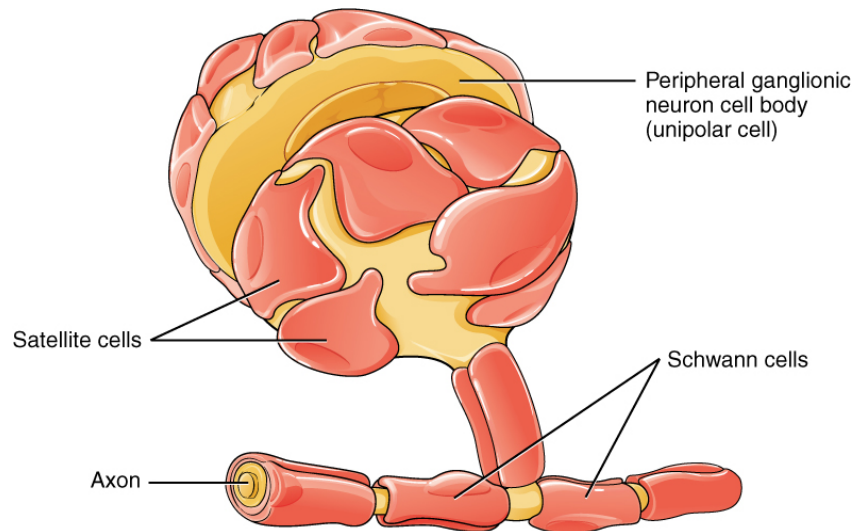


Figure 16.12 Glial Cells of the PNS. The PNS has satellite cells and Schwann cells. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.12 Image description.]

## Myelin

The appearance of the myelin sheath can be thought of as similar to the pastry wrapped around a hot dog for “pigs in a blanket” or a similar food. The glial cell is wrapped around the axon several times with little to no cytoplasm between the glial cell layers. For **oligodendrocytes**, the rest of the cell is separate from the myelin sheath as a cell process extends back toward the cell body. A few other processes provide the same insulation for other axon segments in the area. For Schwann cells, the outermost layer of the cell membrane contains cytoplasm and the nucleus of the cell as a bulge on one side of the myelin sheath. During development, the glial cell is loosely or incompletely wrapped around the axon. The edges of this loose enclosure extend toward each other, and one end tucks under the other. The inner edge wraps around the axon, creating several layers, and the other edge closes around the outside so that the axon is completely enclosed.

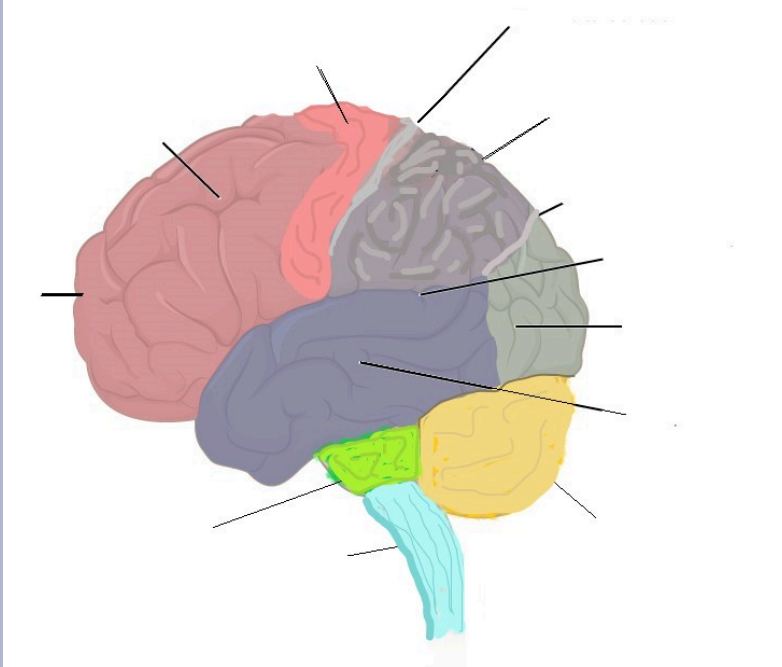
## Check Your Knowledge of the Nervous System Brain Anatomy

### Nervous System Brain Anatomy Labeling Activity

#### Nervous System Brain Anatomy Labeling Activity (Text Version)

Label the diagram with correct words listed below:

- |   |                   |                              |
|---|-------------------|------------------------------|
| 1. Central sulcus, longitudinal fissure | 5. Occipital lobe | 9. Brainstem                 |
| 2. Pons                                 | 6. Cerebrum       | 10. Parietal lobe            |
| 3. Precentral gyrus                     | 7. Cerebellum     | 11. Temporal lobe            |
| 4. Frontal Lobe                         | 8. Lateral Sulcus | 12. Parieto-occipital sulcus |



**Nervous System Brain Anatomy Labeling Activity Diagram (Text Version)**

This diagram shows the lateral view of the brain and the major lobes which are labeled. From the front of the brain (left): \_\_\_\_\_[Blank 1] is responsible for thought processes, followed by a raised surface area known as \_\_\_\_\_[Blank 2], a deep groove known as the \_\_\_\_\_[Blank 3], and another raised area known as \_\_\_\_\_[Blank 4]. The \_\_\_\_\_[Blank 5] is responsible for processes senses such as the sense of touch, followed by the \_\_\_\_\_[Blank 6] which is another deep groove on the surface of the brain. The \_\_\_\_\_[Blank 7] processes visual fields and the \_\_\_\_\_[Blank 8], which is responsible for memory capacity. The \_\_\_\_\_[Blank 9] is responsible for balance, followed by the \_\_\_\_\_[Blank 10], which is often referred to as the medulla oblongata, and finally is the \_\_\_\_\_[Blank 11] which is known as the bridge connecting the cerebrum to the cerebellum. The \_\_\_\_\_ [Blank 12] is a deep groove on the surface of the cerebrum.

**Check your answers <sup>1</sup>**

**Activity source:** Nervous System Brain Anatomy labeling activity by Sheila Bellefeuille from *Building a Medical Terminology Foundation*, illustration from *Anatomy and Physiology (OpenStax)*, licensed under CC BY 4.0./ Text version added.

## Image Descriptions

**Figure 16.1 image description:** This diagram shows a silhouette of a human highlighting the nervous system. The central nervous system is composed of the brain and spinal cord. The brain is a large mass of ridged and striated tissue within the head. The spinal cord extends down from the brain and travels through the torso, ending in the pelvis. Pairs of enlarged nervous tissue, labeled ganglia, flank the spinal cord as it travels through the rib area. The ganglia are part of the peripheral nervous system, along with the many thread-like nerves that radiate from the spinal cord and ganglia through the arms, abdomen and legs. [Return to Figure 16.1].

**Figure 16.2 image description:** This photo shows an enlarged view of the dorsal side of a human brain. The right side of the occipital lobe has been shaved to reveal the white and gray matter beneath the surface blood vessels. The white matter branches through the shaved section like the limbs of a tree. The gray matter branches and curves on outside of the white matter, creating a buffer between the outer edges of the occipital lobe and the internal white matter. [Return to Figure 16.2].

**Figure 16.3 image description:** This figure shows the lateral view on the left panel and anterior view on the right panel of the brain. The major parts including the cerebrum are labeled. Lateral view labels (clockwise from top) read: cerebrum, cerebral cortex, corpus callosum (located on the interior of the brain). Anterior view labels indicate the right and left hemispheres, and the longitudinal fissure between them. [Return to Figure 16.3].

**Figure 16.4 image description:** This figure shows the lateral view of the brain and the major lobes are labeled. From the front of the brain (left) labels read: frontal lobe, precentral gyrus, central sulcus, postcentral gyrus, parietal lobe, lateral sulcus, occipital lobe, temporal lobe. [Return to Figure 16.4].

**Figure 16.5 image description:** This figure shows the location of the thalamus, hypothalamus and pituitary gland in the brain. Each part is labelled respectively. The thalamus is located in the midsection of the brain. The hypothalamus is located below the thalamus, and the pituitary gland below that. [Return to Figure 16.5].

**Figure 16.6 image description:** This figure shows the location of the midbrain, pons and the medulla in the brain that make up the brain stem. The midbrain is located at the top, the pons is located beneath that, and the medulla is the lowest most point of the brain stem. [Return to Figure 16.6].

**Figure 16.7 image description:** This figure shows the location of the cerebellum in the brain which is located on the posterior surface of the brain stem. Labels read (top, left): pons, inferior olive, (top, right) cerebellum, deep cerebellar white matter (arbor vitae). In the top panel, a lateral view labels the location of the cerebellum and the deep cerebellar white matter. In the bottom panel, a photograph of a brain, with the cerebellum in pink is shown. [Return to Figure 16.7].

**Figure 16.8 image description:** This illustration shows the anatomy of a neuron. The neuron has a very irregular cell body (soma) containing a purple nucleus. There are six projections protruding from the top, bottom and left side of the cell body. Each of the projections branches many times, forming small, tree-shaped structures protruding from the cell body. The right side of the cell body tapers into a long cord called the axon. The axon is insulated by segments of myelin sheath, which resemble a semitransparent toilet paper roll wound around the axon. The myelin sheath is not continuous, but is separated into equally spaced segments. The bare axon segments between the sheath segments are called nodes of Ranvier. An oligodendrocyte is reaching its two arm like projections onto two myelin sheath segments. The axon branches many times at its end, where it connects to the dendrites of another neuron. Each connection between an axon branch and a dendrite is called a synapse.

The cell membrane completely surrounds the cell body, dendrites, and its axon. The axon of another nerve is seen in the upper left of the diagram connecting with the dendrites of the central neuron. [Return to Figure 16.8].

**Figure 16.9 image description:** Three illustrations show some of the possible shapes that neurons can take. In the unipolar neuron, the dendrite enters from the left and merges with the axon into a common pathway, which is connected to the cell body. The axon leaves the cell body through the common pathway, the branches off to the right, in the opposite direction as the dendrite. Therefore, this neuron is T shaped. In the bipolar neuron, the dendrite enters into the left side of the cell body while the axon emerges from the opposite (right) side. In a multipolar neuron, multiple dendrites enter into the cell body. The only part of the cell body that does not have dendrites is the part that elongates into the axon. [Return to Figure 16.9].

**Figure 16.10 image description:** This diagram contains three black and white drawings of more specialized nerve cells. Part A shows a pyramidal cell of the cerebral cortex, which has two, long, nerve tracts attached to the top and bottom of the cell body. However, the cell body also has many shorter dendrites projecting out a short distance from the cell body. Part B shows a Purkinje cell of the cerebellar cortex. This cell has a single, long, nerve tract entering the bottom of the cell body. Two large nerve tracts leave the top of the cell body but immediately branch many times to form a large web of nerve fibers. Therefore, the Purkinje cell somewhat resembles a shrub or coral in shape. Part C shows the olfactory cells in the olfactory epithelium and olfactory bulbs. It contains several cell groups linked together. At the bottom, there is a row of olfactory epithelial cells that are tightly packed, side-by-side, somewhat resembling the slats on a fence. There are six neurons embedded in this epithelium. Each neuron connects to the epithelium through branching nerve fibers projecting from the bottom of their cell bodies. A single nerve fiber projects from the top of each neuron and synapses with nerve fibers from the neurons above. These upper neurons are cross shaped, with one nerve fiber projecting from the bottom, top, right and left sides. The upper cells synapse with the epithelial nerve cells using the nerve tract projecting from the bottom of their cell body. The nerve tract projecting from the top continues the pathway, making a ninety degree turn to the right and continuing to the right border of the image. [Return to Figure 16.10].

**Figure 16.11 image description:** This diagram shows several types of nervous system cells associated with two multipolar neurons. Astrocytes are star shaped-cells with many dendrite like projections but no axon. They are connected with the multipolar neurons and other cells in the diagram through their dendrite like projections. Ependymal cells have a teardrop shaped cell body and a long tail that branches several times before connecting with astrocytes and the multipolar neuron. Microglial cells are small cells with rectangular bodies and many dendrite like projections stemming from their shorter sides. The projections are so extensive that they give the microglial cell a fuzzy appearance. The oligodendrocytes have circular cell bodies with four dendrite like projections. Each projection is connected to a segment of myelin sheath on the axons of the multipolar neurons. The oligodendrocytes are the same color as the myelin sheath segment and are adding layers to the sheath using their projections. [Return to Figure 16.11].

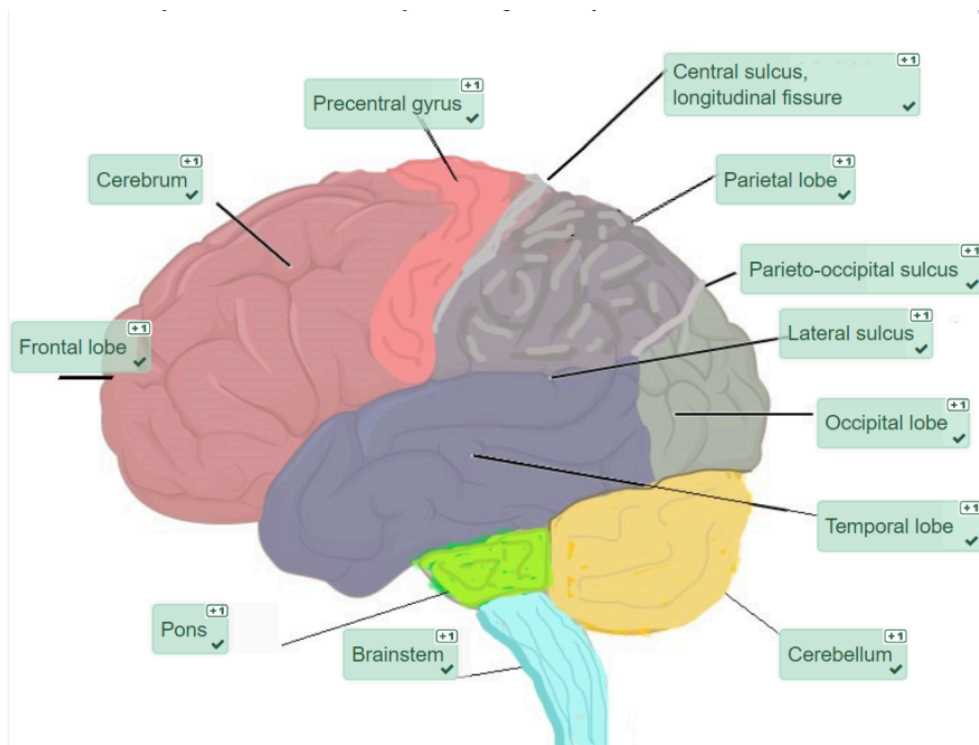
**Figure 16.12 image description:** This diagram shows a collection of PNS glial cells. The largest cell is a unipolar peripheral ganglionic neuron which has a common nerve tract projecting from the bottom of its cell body. The common nerve tract then splits into the axon, going off to the left, and the dendrite, going off to the right. The cell body of the neuron is covered with several satellite cells that are irregular, flattened, and take on the appearance of fried eggs. Schwann cells wrap around each myelin sheath segment on the axon, with their nucleus creating a small bump on each segment. [Return to Figure 16.12].



## Attribution

Except where otherwise noted, this chapter is adapted from “Nervous System (<https://ecampusontario.pressbooks.pub/medicalterminology/chapter/nervous-system/>)” in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)* (<https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>). Adaptations: dividing Nervous System chapter content into sub-chapters.

## Notes



**Check your answers: Nervous System Brain Anatomy labeling activity Diagram (Text Version)** This diagram shows the lateral view of the brain and the major lobes which are labeled. From the front of the brain (left): **frontal lobe** is responsible for thought processes and is part of the **cerebrum**, followed by a raised surface area known as **precentral gyrus**, a deep groove known as the **central sulcus**, and another raised area known as **postcentral gyrus**. The **parietal lobe** is responsible for processes senses such as the sense of touch, followed by the **lateral sulcus** which is another deep groove on the surface of the brain. The **occipital lobe** processes visual fields and the **temporal lobe**, which is responsible for memory capacity. The **cerebellum** is responsible for balance, followed by the **brainstem** which is often referred to as the medulla oblongata, and finally is the **pons**, which is known as the bridge connecting the cerebrum to the cerebellum. The **parieto-occipital sulcus** is a deep groove on the surface of the cerebrum.

# 16.3 - Physiology (Function) of the Nervous System

The nervous system is involved in receiving information about the environment around us (sensation) and generating responses to that information (motor responses). The nervous system can be divided into regions that are responsible for sensation (sensory functions) and for the response (motor functions). But there is a third function that needs to be included. Sensory input needs to be integrated with other sensations, as well as with memories, emotional state, or learning (cognition). Some regions of the nervous system are termed integration or association areas. The process of integration combines sensory perceptions and higher cognitive functions such as memories, learning, and emotion to produce a response.

## Sensation

The first major function of the nervous system is sensation—receiving information about the environment to gain input about what is happening outside the body (or, sometimes, within the body). The sensory functions of the nervous system register the presence of a change from homeostasis or a particular event in the environment, known as a stimulus. The senses we think of most are the “big five”: taste, smell, touch, sight, and hearing. The stimuli for taste and smell are both chemical substances (molecules, compounds, ions, etc.), touch is physical or mechanical stimuli that interact with the skin, sight is light stimuli, and hearing is the perception of sound, which is a physical stimulus similar to some aspects of touch. There are actually more senses than just those, but that list represents the major senses. Those five are all senses that receive stimuli from the outside world, and of which there is conscious perception. Additional sensory stimuli might be from the internal environment (inside the body), such as the stretch of an organ wall or the concentration of certain ions in the blood.

## Response

The nervous system produces a response on the basis of the stimuli perceived by sensory structures. An obvious response would be the movement of muscles, such as withdrawing a hand from a hot stove, but there are broader uses of the term. The nervous system can cause the contraction of all three types of muscle tissue. For example, skeletal muscle contracts to move the skeleton, cardiac muscle is influenced as heart rate increases during exercise, and smooth muscle contracts as the digestive system moves food along the digestive tract. Responses also include the neural control of glands in the body as well, such as the production and secretion of sweat by the eccrine and merocrine sweat glands found in the skin to lower body temperature.

Responses can be divided into those that are voluntary or conscious (contraction of skeletal muscle) and those that are involuntary (contraction of smooth muscles, regulation of cardiac muscle, activation of glands). Voluntary responses are governed by the somatic nervous system and involuntary responses are governed by the autonomic nervous system, which are discussed in the next section.

## Integration

Stimuli that are received by sensory structures are communicated to the nervous system where that information is processed. This is called integration. Stimuli are compared with, or integrated with, other stimuli, memories of previous stimuli, or the state of a person at a particular time. This leads to the specific response that will be generated. Seeing a baseball pitched to a batter will not automatically cause the batter to swing. The trajectory of the ball and its speed will need to be considered. Maybe the count is three balls and one strike, and the batter wants to let this pitch go by in the hope of getting a walk to first base. Or maybe the batter's team is so far ahead, it would be fun to just swing away.

## Controlling the Body

The nervous system can be divided into two parts mostly on the basis of a functional difference in responses. The **somatic nervous system (SNS)** is responsible for conscious perception and voluntary motor responses. Voluntary motor response means the contraction of skeletal muscle, but those contractions are not always voluntary in the sense that you have to want to perform them. Some somatic motor responses are reflexes, and often happen without a conscious decision to perform them. If your friend jumps out from behind a corner and yells “Boo!” you will be startled and you might scream or leap back. You didn't decide to do that, and you may not have wanted to give your friend a reason to laugh at your expense, but it is a reflex involving skeletal muscle contractions. Other motor responses become automatic (in other words, unconscious) as a person learns motor skills (referred to as “habit learning” or “procedural memory”).

The **autonomic nervous system (ANS)** is responsible for involuntary control of the body, usually for the sake of homeostasis (regulation of the internal environment). Sensory input for autonomic functions can be from sensory structures tuned to external or internal environmental stimuli. The motor output extends to smooth and cardiac muscle as well as glandular tissue. The role of the autonomic system is to regulate the organ systems of the body, which usually means to control homeostasis. Sweat glands, for example, are controlled by the autonomic system. When you are hot, sweating helps cool your body down. That is a homeostatic mechanism. But when you are nervous, you might start sweating also. That is not homeostatic, it is the physiological response to an emotional state.

There is another division of the nervous system that describes functional responses. The **enteric nervous system (ENS)** is responsible for controlling the smooth muscle and glandular tissue in your digestive system. It is a large part of the PNS, and is not dependent on the CNS. It is sometimes valid, however, to consider the enteric system to be a part of the autonomic system because the neural structures that make up the enteric system are a component of the autonomic output that regulates digestion. There are some differences between the two, but for our purposes here there will be a good bit of overlap. See Figure 16.13 for examples of where these divisions of the nervous system can be found.

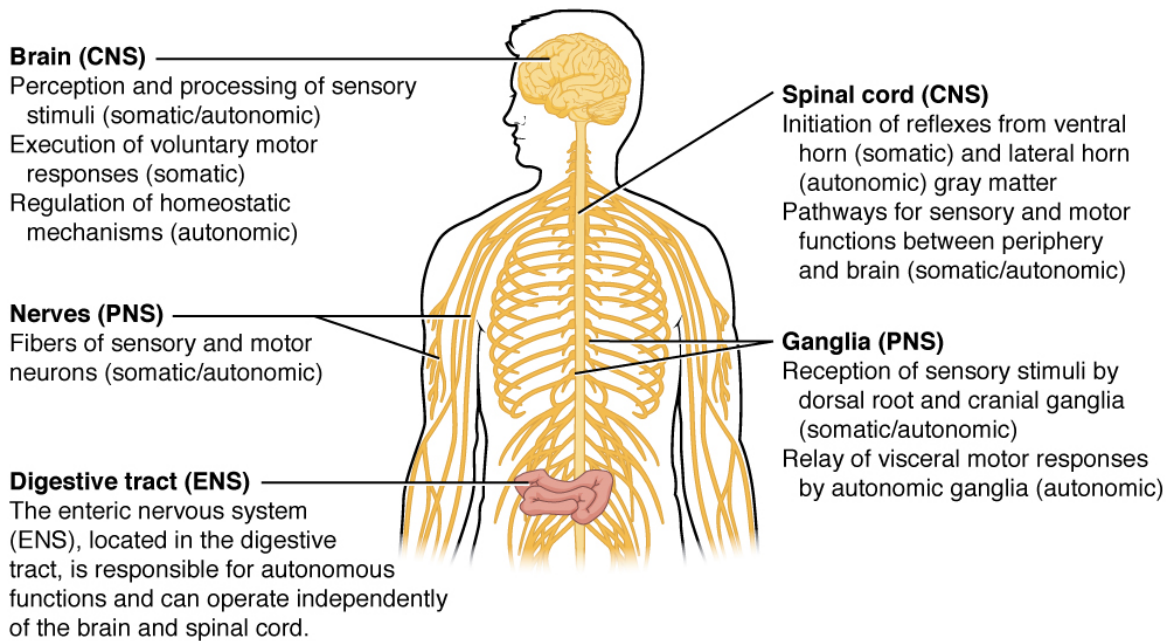


Figure 16.13 Somatic, Autonomic, and Enteric Structures of the Nervous System. Somatic structures include the spinal nerves, both motor and sensory fibers, as well as the sensory ganglia (posterior root ganglia and cranial nerve ganglia). Autonomic structures are found in the nerves also, but include the sympathetic and parasympathetic ganglia. The enteric nervous system includes the nervous tissue within the organs of the digestive tract. From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.13 Image description.]

## Functions of the Cerebral Cortex

The cerebrum is the seat of many of the higher mental functions, such as memory and learning, language, and conscious perception, which are the subjects of subtests of the **mental status** exam. The cerebral cortex is the thin layer of gray matter on the outside of the cerebrum. It is approximately a millimeter thick in most regions and highly folded to fit within the limited space of the cranial vault. These higher functions are distributed across various regions of the cortex, and specific locations can be said to be responsible for particular functions. There is a limited set of regions, for example, that are involved in language function, and they can be subdivided on the basis of the particular part of language function that each governs.

## Cognitive Abilities

Assessment of cerebral functions is directed at cognitive abilities. The abilities assessed through the mental status exam can be separated into four groups: orientation and memory, language and speech, sensorium, and judgment and abstract reasoning.

## Orientation and Memory

Orientation is the patient's awareness of his or her immediate circumstances. It is awareness of time, not in terms of the clock, but of the date and what is occurring around the patient. It is awareness of place, such that a patient should know where he or she is and why. It is also awareness of who the patient is—recognizing personal identity and being able to relate that to the examiner. The initial tests of orientation are based on the questions, “Do you know what the date is?” or “Do you know where you are?” or “What is your name?” Further understanding of a patient's awareness of orientation can come from questions that address remote memory, such as “Who is the President of the United States?”, or asking what happened on a specific date.

Memory is largely a function of the temporal lobe, along with structures beneath the cerebral cortex such as the hippocampus and the amygdala. The storage of memory requires these structures of the medial temporal lobe. A famous case of a man who had both medial temporal lobes removed to treat intractable epilepsy provided insight into the relationship between the structures of the brain and the function of memory.

The prefrontal cortex can also be tested for the ability to organize information. In one subtest of the mental status exam called set generation, the patient is asked to generate a list of words that all start with the same letter, but not to include proper nouns or names. The expectation is that a person can generate such a list of at least 10 words within 1 minute. Many people can likely do this much more quickly, but the standard separates the accepted normal from those with compromised prefrontal cortices.

Read the New York Times Magazine article Forgetting Everything [New Tab] (<https://www.nytimes.com/2007/11/11/magazine/11wwln-diagnosis-t.html>) to learn about a young man who texts his fiancée in a panic as he finds that he is having trouble remembering things. At the hospital, a neurologist administers the mental status exam, which is mostly normal except for the three-word recall test. The young man could not recall them even 30 seconds after hearing them and repeating them back to the doctor. An undiscovered mass in the mediastinum region was found to be Hodgkin's lymphoma, a type of cancer that affects the immune system and likely caused antibodies to attack the nervous system. The patient eventually regained his ability to remember, though the events in the hospital were always elusive. Considering that the effects on memory were temporary, but resulted in the loss of the specific events of the hospital stay, what regions of the brain were likely to have been affected by the antibodies and what type of memory does that represent?

## Language and Speech

Language is, arguably, a very human aspect of neurological function. There are certainly strides being made in understanding communication in other species, but much of what makes the human experience seemingly unique is its basis in language. Any understanding of our species is necessarily reflective, as suggested by the question “What am I?” and the fundamental answer to this question is suggested by the famous quote by René Descartes: “Cogito Ergo Sum” (translated from Latin as “I think, therefore I am”). Formulating an understanding of yourself is largely describing who you are to yourself. It is a confusing topic to delve into, but language is certainly at the core of what it means to be self-aware.

The neurological exam has two specific subtests that address language. One measures the ability of the patient to understand language by asking them to follow a set of instructions to perform an action, such as “touch your right finger to your left elbow and then to your right knee.” Another subtest assesses the fluency and coherency

of language by having the patient generate descriptions of objects or scenes depicted in drawings, and by reciting sentences or explaining a written passage.

An important example of multimodal integrative areas is associated with language function (see Figure 16.14). Adjacent to the auditory association cortex, at the end of the lateral sulcus just anterior to the visual cortex, is **Wernicke's area**. In the lateral aspect of the frontal lobe, just anterior to the region of the motor cortex associated with the head and neck, is Broca's area. Both regions were originally described on the basis of losses of speech and language, which is called **aphasia**. The aphasia associated with Broca's area is known as an **expressive aphasia**, which means that speech production is compromised. This type of aphasia is often described as non-fluency because the ability to say some words leads to broken or halting speech. Grammar can also appear to be lost. The aphasia associated with Wernicke's area is known as a **receptive aphasia**, which is not a loss of speech production, but a loss of understanding of content. Patients, after recovering from acute forms of this aphasia, report not being able to understand what is said to them or what they are saying themselves, but they often cannot keep from talking.

The two regions are connected by white matter tracts that run between the posterior temporal lobe and the lateral aspect of the frontal lobe. **Conduction aphasia** associated with damage to this connection refers to the problem of connecting the understanding of language to the production of speech. This is a very rare condition, but is likely to present as an inability to faithfully repeat spoken language.

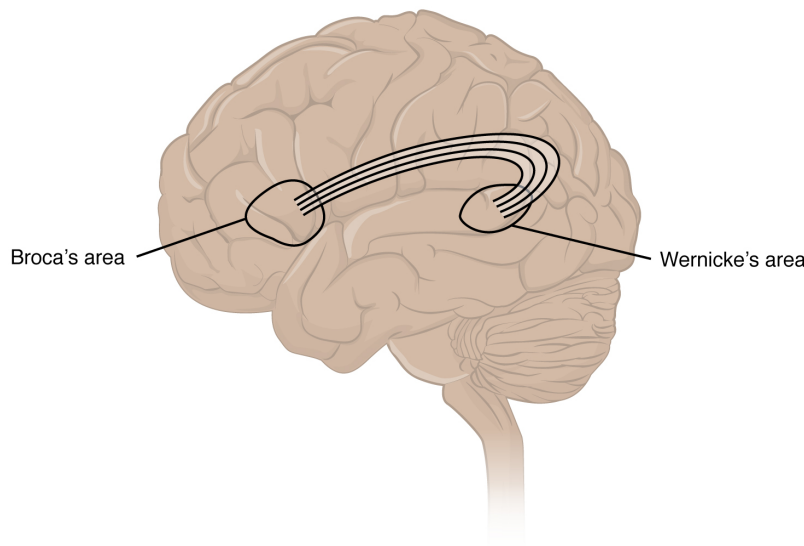


Figure 16.14 Broca's and Wernicke's Areas. Two important integration areas of the cerebral cortex associated with language function are Broca's and Wernicke's areas. The two areas are connected through the deep white matter running from the posterior temporal lobe to the frontal lobe. From Betts et al., 2013. Licensed under CC BY 4.0.

## Sensorium

Those parts of the brain involved in the reception and interpretation of sensory stimuli are referred to collectively as the sensorium. The cerebral cortex has several regions that are necessary for sensory perception.

Several of the subtests can reveal activity associated with these sensory modalities, such as being able to hear a question or see a picture. Two subtests assess specific functions of these cortical areas.

The first is praxis, a practical exercise in which the patient performs a task completely on the basis of verbal description without any demonstration from the examiner. The second subtest for sensory perception is gnosis, which involves two tasks. The first task, known as stereognosis, involves the naming of objects strictly on the basis of the somatosensory information that comes from manipulating them. The patient keeps their eyes closed and is given a common object, such as a coin, that they have to identify. The patient should be able to indicate the particular type of coin, such as a dime versus a penny, or a nickel versus a quarter, on the basis of the sensory cues involved. For example, the size, thickness, or weight of the coin may be an indication, or to differentiate the pairs of coins suggested here, the smooth or corrugated edge of the coin will correspond to the particular denomination. The second task, graphesthesia, is to recognize numbers or letters written on the palm of the hand with a dull pointer, such as a pen cap.

## Judgment and Abstract Reasoning

Planning and producing responses requires an ability to make sense of the world around us. Making judgments and reasoning in the abstract are necessary to produce movements as part of larger responses. For example, when your alarm goes off, do you hit the snooze button or jump out of bed? Is 10 extra minutes in bed worth the extra rush to get ready for your day? Will hitting the snooze button multiple times lead to feeling more rested or result in a panic as you run late? How you mentally process these questions can affect your whole day.

The prefrontal cortex is responsible for the functions responsible for planning and making decisions. In the mental status exam, the subtest that assesses judgment and reasoning is directed at three aspects of frontal lobe function. First, the examiner asks questions about problem solving, such as “if you see a house on fire, what would you do?” The patient is also asked to interpret common proverbs, such as “don’t look a gift horse in the mouth.” Additionally, pairs of words are compared for similarities, such as apple and orange, or lamp and cabinet.

## Everyday Connections

### Left Brain, Right Brain

Popular media often refer to right-brained and left-brained people, as if the brain were two independent halves that work differently for different people. This is a popular misinterpretation of an important neurological phenomenon. As an extreme measure to deal with a debilitating condition, the corpus callosum may be sectioned to overcome intractable epilepsy. When the connections between the two cerebral hemispheres are cut, interesting effects can be observed.

The reason for this is that the language functions of the cerebral cortex are localized to the left hemisphere in 95 percent of the population. Additionally, the left hemisphere is connected to the right side of the body through the corticospinal tract and the ascending tracts of the spinal cord. Motor commands from the precentral gyrus control the opposite side of the body, whereas sensory information processed by the postcentral gyrus is

received from the opposite side of the body. For a verbal command to initiate movement of the right arm and hand, the left side of the brain needs to be connected by the corpus callosum. Language is processed in the left side of the brain and directly influences the left brain and right arm motor functions, but is sent to influence the right brain and left arm motor functions through the corpus callosum. Likewise, the left-handed sensory perception of what is in the left pocket travels across the corpus callosum from the right brain, so no verbal report on those contents would be possible if the hand happened to be in the pocket.

People who have had their corpus callosum cut can perform two independent tasks at the same time because the lines of communication between the right and left sides of his brain have been removed. Whereas a person with an intact corpus callosum cannot overcome the dominance of one hemisphere over the other, this patient can. If the left cerebral hemisphere is dominant in the majority of people, why would right-handedness be most common?

## Common Nervous System Abbreviations

### Common Nervous System Abbreviations

- **AD** (Alzheimer's disease)
- **ADHD** (attention deficit hyperactivity disorder)
- **ALS** (amyotrophic lateral sclerosis)
- **CNS** (central nervous system)
- **CP** (cerebral palsy)
- **CSF** (cerebrospinal fluid)
- **CTE** (chronic traumatic encephalopathy)
- **CVA** (cerebrovascular accident)
- **EEG** (electroencephalogram)
- **EP studies** (evoked potential studies)
- **LP** (lumbar puncture)
- **MRI** (magnetic resonance imaging)
- **MS** (multiple sclerosis)
- **OCD** (obsessive-compulsive disorder)
- **PD** (Parkinson's disease)
- **PET** (positron emission tomography)
- **PNS** (peripheral nervous system)
- **PTSD** (post-traumatic stress disorder)
- **SAH** (subarachnoid hemorrhage)
- **TIA** (transient ischemic attack)

**Activity Source:** Nervous System Abbreviations by Kim Carter, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. /Text version added.



## Image Descriptions

**Figure 16.13 image description:** A silhouette of a human with only the brain, spinal cord, PNS ganglia, nerves and a section of the digestive tract visible. The brain, which is part of the CNS, is the area of perception and processing of sensory stimuli (somatic/autonomic), the execution of voluntary motor responses (somatic), and the regulation of homeostatic mechanisms (autonomic). The spinal cord, which is part of the CNS, is the area where reflexes are initiated. The gray matter of the ventral horn initiates somatic reflexes while the gray matter of the lateral horn initiates autonomic reflexes. The spinal cord is also the somatic and autonomic pathway for sensory and motor functions between the PNS and the brain. The nerves, which are part of the PNS, are the fibers of sensory and motor neurons, which can be either somatic or autonomic. The ganglia, which are part of the PNS, are the areas for the reception of somatic and autonomic sensory stimuli. These are received by the dorsal root ganglia and cranial ganglia. The autonomic ganglia are also the relay for visceral motor responses. The digestive tract is part of the enteric nervous system, the ENS, which is located in the digestive tract and is responsible for autonomous function. The ENS can operate independent of the brain and spinal cord. [Return to Figure 16.13].

## Attribution

Except where otherwise noted, this chapter is adapted from “Nervous System” in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)* (<https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>). Adaptations: dividing Nervous System chapter content into sub-chapters.

# 16.4 - Nervous Systems Diseases, Disorders and Diagnostic Testing

## Neurodegenerative Diseases – Alzheimer’s Disease, Parkinson’s Disease, Amyotrophic Lateral Sclerosis (ALS), Multiple sclerosis (MS)

A class of disorders that affect the nervous system are the neurodegenerative diseases: Alzheimer’s disease, Parkinson’s disease, Huntington’s disease, amyotrophic lateral sclerosis (ALS), Creutzfeld–Jacob disease, multiple sclerosis (MS), and other disorders that are the result of nervous tissue degeneration. In diseases like Alzheimer’s, Parkinson’s, or ALS, neurons die; in diseases like MS, myelin is affected. Some of these disorders affect motor function and others present with dementia. Some are the result of genetics, such as Huntington’s disease, or the result of autoimmunity, such as MS; others are not entirely understood, such as Alzheimer’s and Parkinson’s diseases.

Several diseases can result from the demyelination of axons. The causes of these diseases are not the same; some have genetic causes, some are caused by pathogens, and others are the result of autoimmune disorders. Though the causes are varied, the results are largely similar. The myelin insulation of axons is compromised, making electrical signaling slower (Betts et al., 2013).

**Multiple sclerosis (MS)** is one such disease. It is an example of an autoimmune disease. The antibodies produced by lymphocytes (a type of white blood cell) mark myelin as something that should not be in the body. This causes inflammation and the destruction of the myelin in the central nervous system. As the insulation around the axons is destroyed by the disease, scarring becomes obvious (Betts et al., 2013).

**Guillain-Barre** (pronounced gee-YAN bah-RAY) syndrome is an example of a demyelinating disease of the peripheral nervous system. It is also the result of an autoimmune reaction, but the inflammation is in peripheral nerves. Sensory symptoms or motor deficits are common, and autonomic failures can lead to changes in the heart rhythm or a drop in blood pressure, especially when standing, which causes dizziness (Betts et al., 2013).

## Other Nerve Disorders

Infection, trauma, and congenital disorders can all lead to significant signs, as identified through the neurological exam. It is important to differentiate between an acute event, such as stroke, and a chronic or global condition, such as blunt force trauma. Responses seen in the neurological exam can help. A loss of language function observed in all its aspects is more likely a global event as opposed to a discrete loss of one function, such as not being able to say certain types of words. A concern, however, is that a specific function—such as controlling the muscles of speech—may mask other language functions. The various subtests within the mental status exam can address these finer points and help clarify the underlying cause of the neurological loss (Betts et al., 2013).

## Stroke

Damage to the nervous system can be limited to individual structures or can be distributed across broad areas of the brain and spinal cord. Localized, limited injury to the nervous system is most often the result of circulatory problems. The loss of blood flow to part of the brain is known as a **stroke**, or a cerebrovascular accident (CVA). There are two main types of stroke, depending on how the blood supply is compromised: ischemic and hemorrhagic. An **ischemic stroke** is the loss of blood flow to an area because vessels are blocked or narrowed. This is often caused by an embolus, which may be a blood clot or fat deposit. Ischemia may also be the result of thickening of the blood vessel wall, or a drop in blood volume in the brain known as **hypovolemia**. A **hemorrhagic stroke** is bleeding into the brain because of a damaged blood vessel. Accumulated blood fills a region of the cranial vault and presses against the tissue in the brain (see Figure 16.15) (Betts et al., 2013).

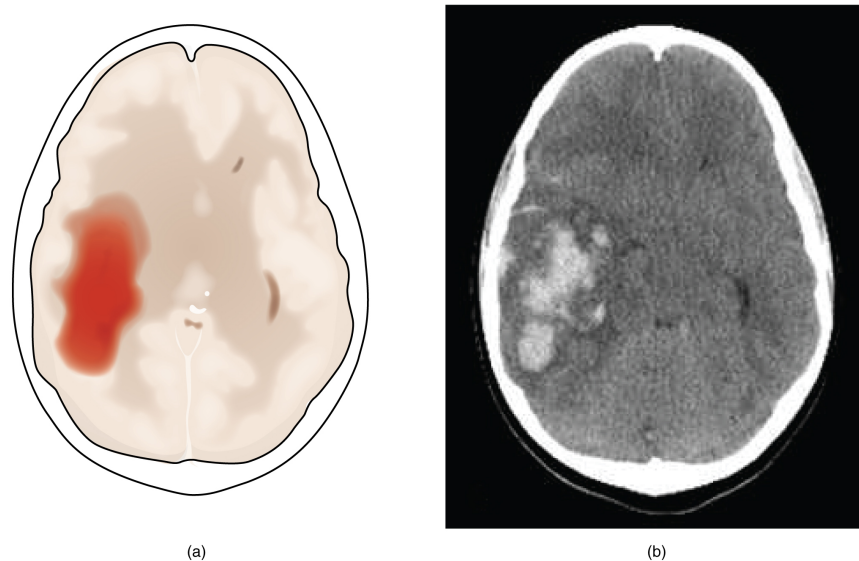


Figure 16.15 Hemorrhagic Stroke. (a) A hemorrhage into the tissue of the cerebrum results in a large accumulation of blood with an additional edema in the adjacent tissue. The hemorrhagic area causes the entire brain to be disfigured as suggested here by the lateral ventricles being squeezed into the opposite hemisphere. (b) A CT scan shows an intraparenchymal hemorrhage within the parietal lobe. (credit b: James Heilman). From Betts et al., 2013. Licensed under CC BY 4.0. [Fig. 16.15 Image description.]

## Cerebral Palsy

Cerebral Palsy (CP) is caused by an interruption to the normal development of a person's brain leading to weakness with muscles. Depending on the area of the brain that is affected, signs and symptoms will vary in the type and severity between individuals. Balance and coordination are often challenging due the inability to control muscles (Centers for Disease Control and Prevention, 2024, Ontario Federation for Cerebral Palsy, 2018). To learn more about cerebral palsy, please visit the Centers for Disease Control and Prevention's web page on cerebral palsy [New Tab] (<https://www.cdc.gov/ncbddd/cp/facts.html>).

## Traumatic Brain Injury (TBI)

According to the Minister of Health, approximately 20,000 people in Canada are hospitalized (each year) for traumatic brain injuries. Brain injuries range from moderate to severe and include concussions. TBI can be caused by falls, automobile accidents, sports, assaults, and strokes. Investment has been made to educate people on how to prevent TBIs with a focus on concussions from sports (Taylor, 2019).

## Neurological System Medical Terms in Use

### Neurological System

#### Neurological System – History and Physical Examination (Text version)

Use the words below to fill in the history and physical examination form:

- festination
- depression
- fatigue
- postural
- rigidity
- cognition
- downgoing
- q.i.d

PATIENT NAME: Susan LOGAN

AGE: 62

SEX: Female

DOB: March 24

DATE OF ASSESSMENT: December 10

ADMITTING PHYSICIAN: Martin Lewis, MD, Neurology

DIAGNOSIS: Parkinson disease

**HISTORY:** This pleasant and co-operative 62-year-old woman has advanced parkinsonism which presents for more than 10 years. It is affecting her daily living to a great degree. She has minor difficulty with ADLs noted in difficulty dressing and meal preparation. She has had frequent falls occasionally related to freezing or to \_\_\_\_\_[Blank 1] but also occurring without any apparent cause. She has marked hesitancy on changing direction and unsteadiness after exertion and develops \_\_\_\_\_[Blank 2]. She has a minor problem with sialorrhea, eating, and swallowing. She can maintain basic personal hygiene without any difficulty. However, showering or bathing requires assistance. She has had some symptoms of anxiety and \_\_\_\_\_[Blank 3] along with her Parkinson disease.

**PHYSICAL EXAMINATION:** On neurologic exam, she did have mild-to-moderate impairment in \_\_\_\_\_[Blank 4] and short-time memory, although she is alert and oriented x3. She has pronounced tremor, worse in the left arm than the right. She has marked \_\_\_\_\_[Blank 5] in the upper left extremity; mild in the right. She has marked reduction of movement with long delays in initiating movement and frequent freezing. She has a moderately-flexed posture and cannot straighten

to command. She has \_\_\_\_\_[Blank 6] instability. Her speech is mildly dysarthric. She has paucity of spontaneous facial expression. She has an unsteady and erratic gait characterized by shuffling strides with festination in propulsion. She can arise from a chair with difficulty only after multiple attempts. Deep tendon reflexes (DTRs) are symmetrical, and toes are \_\_\_\_\_[Blank 7]. Cranial nerves are intact and unremarkable.

TREATMENT AND PLAN: She has been on Sinemet 25/100 t.i.d. for the last 7 years or so. She will be going on vacation soon, and I do not wish to start a second antiparkinsonian medication while she away from medical supervision. However, I have asked her to increase her Sinemet dose to \_\_\_\_\_[Blank 8]. We will see how she does with Sinemet and plan to add bromocriptine 1 mg per day when she returns.

FOLLOW UP: The patient has been scheduled for follow up in 3 weeks, upon her return from vacation. Her treatment regimen will be adjusted at that time.

-----  
Martin Lewis, MD, Neurology

**Note:** Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

**Check your answers:**<sup>1</sup>

**Activity source:** Neurological System – History and Physical Examination by Sheila Bellefeuille and Heather Scudder, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

## Neurological System – Consultation Report

### Neurological System – Consultation Report (Text version)

Use the word below to fill in the consultation report:

- cognition
- dementia
- hypertension
- downgoing
- neurological
- symptomatic
- MRI
- stroke
- blurred

NEUROLOGICAL SYSTEM – CONSULTATION REPORT

PATIENT NAME: Robert BROWN

AGE: 74

SEX: Male

DOB: July 5

DATE OF CONSULTATION: April 15

CONSULTING PHYSICIAN: Martin Lewis, MD, Neurology

REASON FOR CONSULTATION: Assessment of cognitive changes and testing.

HISTORY: The patient presented a few days ago with a marked change in \_\_\_\_\_[Blank 1] identified by his family members and care staff. The reports describe two episodes of the patient presenting a somewhat confused state, instability with a “holding of the temples” and a report of blurring vision. The patient was also observed holding on to walls and furniture to walk around. This seems to have been two transient episodes and has not recurred since. Prior to that, he had maintained excellent cognitive abilities with full lingual ability, no signs of aphasia, \_\_\_\_\_[Blank 2] or loss of consciousness. The cognitive decline noticed was not of gradual onset but rather an acute change within hours to a day. The time span is unclear as the patient lives alone and there was a time lapse between a family visit and the arrival of a personal care assistant.

The patient is a good historian to questioning and does admit to some recent occasional headaches and \_\_\_\_\_[Blank 3] vision. These are new to him as he reports never having “had a headache” in his “whole life”. He reports that the blurring is not constant but only seems to occur when he turns his head to right or left suddenly. There is a “tilting sensation” like he will fall but this clears when he brings his head back to center. He has no history of epilepsy or seizure disorders. No history of TM or ear trauma.

PHYSICAL EXAMINATION: HEENT: Head is normocephalic. EYES: PERRLA. EARS: Auditory exam reveals intact TMs bilaterally. No erythema. The nose and throat exam is unremarkable. NECK: JVD appears normal. VITAL SIGNS: Blood pressure is 132/86 with no previous history of \_\_\_\_\_[Blank 4]. Pulse is 83 and resp. 22 but the patient does admit to feeling anxious during the assessment. Temperature 37C.

NEURO: Orientation and language are normal. Extremity strength testing show some minimal weakness in the right upper. Reflexes are normal. Toes are \_\_\_\_\_[Blank 5] bilaterally. Has difficulty with heel-and toe-walk and is unable to tandem walk. The gait is alternately normal and minimally spastic.

IMPRESSION: What appears to be a transient or acute cognitive change with altered awareness, headache and cephalo-positional blurring of vision. There is some \_\_\_\_\_[Blank 6] change, although minimal and not clinically diagnostic, as evidenced by the slight changes in gait during testing but it does not remain consistently. This is puzzling.

PLAN: It is still not clear to me what these spells are. Some of the neurological possibilities to be considered are TIA, \_\_\_\_\_[Blank 7], brain and spinal cord tumors, inflammation, infection, vascular irregularities, and some neurodegenerative disorders. I have ordered a stat cerebral \_\_\_\_\_[Blank 8], electroencephalogram (EEG) and blood levels for CBC, chem panel. However, I feel we should also rule out the more common possibilities of pseudo-seizure, vertigo, and inner ear anomalies and am in the process of making these appropriate bookings.

I have booked a follow up with this patient in 10 days to review the results. He and his family have been advised to contact me immediately if he has another “spell” or to present to the ER where we can complete testing when the patient is \_\_\_\_\_[Blank 9].

Thank you for this most interesting referral. I will be in touch after I have reviewed the patient.

-----  
Martin Lewis, MD, Neurology

**Note:** Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

**Check your answers:** <sup>2</sup>

**Activity source:** NEUROLOGICAL SYSTEM – CONSULTATION REPORT by Sheila Bellefeuille and Heather Scudder, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

## Neurological System- Follow Up Report

### Neurological System – Follow Up Report (Text version)

Use the words below to fill in the follow-up report:

- electroencephalogram
- balance
- pathology
- vertigo
- coordination
- white matter
- hemorrhagic
- wasting
- calcifications
- mass
- somnolence
- symptomatic

PATIENT NAME: Randy NORTON

AGE: 74

SEX: Male

DOB: October 14

DATE OF ASSESSMENT: January 18

ASSESSING PHYSICIAN: Martin Lewis, MD, Neurology

REASON FOR ASSESSMENT: Follow up assessment of cognitive changes and testing.

HISTORY: This 74-year-old patient was seen in consultation 10 days ago for assessment of cognitive changes. He underwent prescribed testing in the forms of cerebral MRI, \_\_\_\_\_[Blank 1] (EEG) and blood was drawn for CBC and chem panel. The patient was seen by our local ENT for inner ear and \_\_\_\_\_[Blank 2] testing. Test results showed normal hearing. No evidence of an inner ear \_\_\_\_\_[Blank 3] that might have contributed to the \_\_\_\_\_[Blank 4] or lack of balance and \_\_\_\_\_[Blank 5] reported as part of the presenting symptoms.

TEST RESULTS: Cerebral MRI reveals a few T2 hyperintensities in the \_\_\_\_\_[Blank 6] in the

left temporal lobe. The right hemisphere shows some diffuse \_\_\_\_\_[Blank 7] and some occipital wasting. There are multiple, small dark \_\_\_\_\_[Blank 8] areas and a few areas indicative of ischemia.

EEG: This showed some depressive effect indicative of an encephalopathy. The patient did not sleep during the exam but did show some signs of \_\_\_\_\_[Blank 9]. CBC and chem panels were normal.

IMPRESSIONS: This patient present with testing result that may be warning for Alzheimer wasting and also, some localized hemorrhagic events that have since stopped. This type of “leakage” is often not \_\_\_\_\_[Blank 10], and I do not feel that they are connected to his presenting complaints. I see no signs of tumor or \_\_\_\_\_[Blank 11] formation nor infectious process.

On repeat verbal assessment, the patient reports he has not experienced any more of the spells. We will follow him closely in regards to the \_\_\_\_\_[Blank 1]2 with a repeat MRI and perhaps a CT also in 3 months for results comparison to see whether the wasting has advanced or receded.

Thank you for asking me in on this most interesting case.

-----  
Martin Lewis, MD, Neurology

**Note:** Report samples (H5P and Pressbooks) are to encourage learners to identify correct medical terminology and do not represent the Association for Health Documentation Integrity (AHDI) formatting standards.

**Check your answers:** <sup>3</sup>

**Activity source:** Neurological System – Follow Up Report by Sheila Bellefeuille and Heather Scudder, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

## Medical Specialties

### Primary Specialist – Neurologist

Neurologists are medical doctors who complete an additional 5 years of specialized training in the prevention, diagnosis, and treatment of disorders and conditions related to the brain, spinal cord, nerves and muscles (Canadian Medical Association, 2019). For more details, please follow the link to the Canadian Medical Association’s page on Neurology profile [PDF] (<https://www.cma.ca/sites/default/files/2019-01/neurology-e.pdf>).



## Procedures Related to the Nervous System

### Lumbar Puncture

A neurologist may order this procedure to test cerebrospinal fluid (CSF). This procedure is recommended if they believe symptoms are caused by a problem in the nervous system that can be detected in the cerebrospinal fluid. The procedure involves inserting a needle into the spine after numbing it and taking a sample of cerebrospinal fluid (Canadian Cancer Society, n.d.).

### Tensilon Test

This procedure can help a neurologist diagnose myasthenia gravis. In this test, the doctor injects with a medicine called Tensilon, then they observe how it affects muscle movements (Bergen, 2018). For more information, visit Healthline's Tensilon Test web page [New Tab] (<https://www.healthline.com/health/tensilon-test>).

### Electromyography (EMG)

An EMG measures electrical activity between your brain or spinal cord to a peripheral nerve. This nerve is found in your arms and legs, and is responsible for muscle control during times of movement and rest. EMGs can help your neurologist diagnose spinal cord disease as well as general muscle or nerve dysfunction (Moores & Cirino, 2018).

### Electroencephalogram (EEG)

With electrodes applied to your scalp, an EEG measures electrical activity in the brain. It's used to help diagnose conditions of the brain, including inflammation, tumors, and injuries, as well as seizures and psychiatric disorders.

### Image Descriptions

**Figure 16.15 image description:** The left panel of this figure shows an image of the brain with a region in red. This red region indicates a hemorrhage associated with a stroke. The right panel shows a hemorrhage as it might appear on a CT scan. [Return to Figure 16.15].

## Attribution

Except where otherwise noted, this chapter is adapted from “Nervous System (<https://ecampusontario.pressbooks.pub/medicalterminology/chapter/nervous-system/>)” in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)* (<https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>). Adaptations: dividing Nervous System chapter content into sub-chapters.

## Notes

1. festination, 2. fatigue, 3. depression, 4. cognition, 5. rigidity, 6. postural, 7. downgoing, 8. q.i.d,
2. 1.cognition, 2.dementia, 3.blurred, 4.hypertension, 5.downgoing, 6.neurological, 7.stroke, 8.MRI, 9.symptomatic
3. 1.electroencephalogram, 2.balance, 3.pathology, 4.vertigo, 5.coordination, 6.white matter, 7.calcifications, 8.hemorrhagic, 9.somnolence, 10.symptomatic, 11.mass, 12.wasting

# Vocabulary & Check Your Knowledge

## Nervous System Vocabulary

### **Afferent nerves**

Nerves that carry sensory signals (nerve impulses) toward the CNS from the periphery.

### **Aphasia**

Loss of language function.

### **Arachnoid mater**

Middle layer of the meninges named for the spider-web-like trabeculae that extend between it and the pia mater.

### **Astrocyte**

Glial cell type of the CNS that provides support for neurons and maintains the blood-brain barrier.

### **Autonomic nervous system (ANS)**

Functional division of the nervous system that is responsible for homeostatic reflexes that coordinate control of cardiac and smooth muscle, as well as glandular tissue.

### **Axon**

Single process of the neuron that carries an electrical signal (action potential) away from the cell body toward a target cell.

### **Axon hillock**

Tapering of the neuron cell body that gives rise to the axon.

### **Axon segment**

Single stretch of the axon insulated by myelin and bounded by nodes of Ranvier at either end (except for the first, which is after the initial segment, and the last, which is followed by the axon terminal).

### **Axon terminal**

End of the axon, where there are usually several branches extending toward the target cell.

### **Axoplasm**

Cytoplasm of an axon, which is different in composition than the cytoplasm of the neuronal cell body.

### **Babinski Sign**

Dorsiflexion of the foot with extension and splaying of the toes in response to the plantar reflex, normally suppressed by corticospinal input.

### **Bipolar**

Shape of a neuron with two processes extending from the neuron cell body—the axon and one dendrite.

### **Blood-brain Barrier (BBB)**

Physiological barrier between the circulatory system and the central nervous system that establishes a privileged blood supply, restricting the flow of substances into the CNS.

**Brain**

The large organ of the central nervous system composed of white and gray matter, contained within the cranium and continuous with the spinal cord.

**Brain Stem**

Region of the adult brain that includes the midbrain, pons, and medulla oblongata and develops from the mesencephalon, metencephalon, and myelencephalon of the embryonic brain.

**Broca's Area**

Region of the frontal lobe associated with the motor commands necessary for speech production and located only in the cerebral hemisphere responsible for language production, which is the left side in approximately 95 percent of the population

**Brodmann's Areas**

Mapping of regions of the cerebral cortex based on microscopic anatomy that relates specific areas to functional differences, as described by Brodmann in the early 1900s.

**Cauda Equina**

Bundle of spinal nerve roots that descend from the lower spinal cord below the first lumbar vertebra and lie within the vertebral cavity; has the appearance of a horse's tail.

**Caudate**

Nucleus deep in the cerebrum that is part of the basal nuclei; along with the putamen, it is part of the striatum.

**Central nervous system (CNS)**

Anatomical division of the nervous system located within the cranial and vertebral cavities, namely the brain and spinal cord.

**Central Sulcus**

Surface landmark of the cerebral cortex that marks the boundary between the frontal and parietal lobes.

**Cerebellum**

Region of the adult brain connected primarily to the pons that developed from the metencephalon (along with the pons) and is largely responsible for comparing information from the cerebrum with sensory feedback from the periphery through the spinal cord.

**Cerebral Cortex**

Outer gray matter covering the forebrain, marked by wrinkles and folds known as gyri and sulci.

**Cerebrum**

Region of the adult brain that develops from the telencephalon and is responsible for higher neurological functions such as memory, emotion, and consciousness.

**Cerebral Hemisphere**

One half of the bilaterally symmetrical cerebrum.

**Cerebrospinal Fluid (CSF)**

Circulatory medium within the CNS that is produced by ependymal cells in the choroid plexus filtering the blood.

**Choroid Plexus**

Specialized structure containing ependymal cells that line blood capillaries and filter blood to produce CSF in the four ventricles of the brain.

**Corpus callosum**

Large white matter structure that connects the right and left cerebral hemispheres.

**Dendrite**

One of many branchlike processes that extends from the neuron cell body and functions as a contact for incoming signals (synapses) from other neurons or sensory cells.

**Descending tract**

Central nervous system fibers carrying motor commands from the brain to the spinal cord or periphery.

**Diencephalon**

Region of the adult brain that retains its name from embryonic development and includes the thalamus and hypothalamus.

**Direct pathway**

Connections within the basal nuclei from the striatum to the globus pallidus internal segment and substantia nigra pars reticulata that disinhibit the thalamus to increase cortical control of movement.

**Dorsal (posterior) nerve root**

Axons entering the posterior horn of the spinal cord.

**Dura mater**

Tough, fibrous, outer layer of the meninges that is attached to the inner surface of the cranium and vertebral column and surrounds the entire CNS.

**Efferent nerves**

Nerve tissue that carries impulses away from the CNS towards the peripheral that result in motor response (movement).

**Embolus**

Obstruction in a blood vessel such as a blood clot, fatty mass, air bubble, or other foreign matter that interrupts the flow of blood to an organ or some part of the body.

**Enteric nervous system (ENS)**

Neural tissue associated with the digestive system that is responsible for nervous control through autonomic connections.

**Ependymal cell**

Glial cell type in the CNS responsible for producing cerebrospinal fluid.

**Epithalamus**

Region of the diencephalon containing the pineal gland.

**Fissures**

A groove, natural division or elongated cleft, furrow or tear; naturally occurring in the brain, they are also known as sulcus/sulci.

**Foramen magnum**

Large opening in the occipital bone of the skull through which the spinal cord emerges and the vertebral arteries enter the cranium.

**Frontal lobe**

Region of the cerebral cortex directly beneath the frontal bone of the cranium.

**Ganglion**

Localized collection of neuron cell bodies in the peripheral nervous system.

**Glial cell**

One of the various types of neural tissue cells responsible for maintenance of the tissue, and largely responsible for supporting neurons.

**Gray matter**

Regions of the nervous system containing cell bodies of neurons with few or no myelinated axons; actually may be more pink or tan in color, but called gray in contrast to white matter.

**Gyrus/gyri**

Ridge formed by convolutions on the surface of the cerebrum or cerebellum.

**Hemorrhagic stroke**

Disruption of blood flow to the brain caused by bleeding within the cranial vault.

**Hydrocephalus**

An abnormal buildup of cerebrospinal fluid (CSF) in the ventricles of the brain.

**Hypothalamus**

Major region of the diencephalon that is responsible for coordinating autonomic and endocrine control of homeostasis.

**Ischemic stroke**

Disruption of blood flow to the brain because blood cannot flow through blood vessels as a result of a blockage or narrowing of the vessel.

**Integration**

Nervous system function that combines sensory perceptions and higher cognitive functions (memories, learning, emotion, etc.) to produce a response.

**Initial segment**

First part of the axon as it emerges from the axon hillock, where the electrical signals known as action potentials are generated.

**Lumbar puncture**

Procedure used to withdraw CSF from the lower lumbar region of the vertebral column that avoids the risk of damaging CNS tissue because the spinal cord ends at the upper lumbar vertebrae.

**Medulla oblongata**

The continuation of the spinal cord within the skull, forming the lowest part of the brainstem, contains the control centers for heart and lung nerve function.

**Meninges**

Protective outer coverings of the CNS composed of connective tissue.

**Microglia**

Glial cell type in the CNS that serves as the resident component of the immune system.

**Midbrain**

A portion of the brainstem, positioned above the pons, also called mesencephalon, assist in motor reflexes associated with visual and auditory stimuli.

**Motor nerves**

Peripheral, efferent, myelinated nerve tissue that stimulates muscle contraction.

**Multipolar**

Shape of a neuron that has multiple processes—the axon and two or more dendrites.

**Myelin**

Lipid-rich insulating substance surrounding the axons of many neurons, allowing for faster transmission of electrical signals.

**Myelin sheath**

Lipid-rich layer of insulation that surrounds an axon, formed by oligodendrocytes in the CNS and Schwann cells in the PNS; facilitates the transmission of electrical signals.

**Nerve**

Cord-like bundle of axons located in the peripheral nervous system that transmits sensory input and response output to and from the central nervous system.

**Neuron**

Neural tissue cell that is primarily responsible for generating and propagating electrical signals into, within, and out of the nervous system.

**Neuroglia**

Supportive tissue of the nervous system, including the network of branched cells in the central nervous system (astrocytes, microglia, and oligodendrocytes) and the supporting cells of the peripheral nervous system (Schwann cells and satellite cells), also called **glia**.

**Neurotransmitter**

Chemical that is released from a nerve cell, transmits an impulse from a nerve cell to another nerve, muscle, organ, or other tissue.

**Node of Ranvier**

Gap between two myelinated regions of an axon, allowing for strengthening of the electrical signal as it propagates down the axon.

**Nucleus**

In the nervous system, a localized collection of neuron cell bodies that are functionally related; a “center” of neural function.

**Occipital lobe**

Region of the cerebral cortex directly beneath the occipital bone of the cranium.

**Olfaction**

Special sense responsible for smell, which has a unique, direct connection to the cerebrum.

**Oligodendrocyte**

Glial cell type in the CNS that provides the myelin insulation for axons in tracts.

**Paresis**

Partial loss of, or impaired, voluntary muscle control.

**Parietal lobe**

Region of the cerebral cortex directly beneath the parietal bone of the cranium.

**Peripheral nervous system (PNS)**

Anatomical division of the nervous system that is largely outside the cranial and vertebral cavities, namely all parts except the brain and spinal cord.

**Pia mater**

Thin, innermost membrane of the meninges that directly covers the surface of the CNS.

**Pons**

Latin word meaning bridge, essential part of the brain located above the medulla, action in regulation and controls of vital functions primarily sleep, respiration, swallowing, bladder control, hearing, balance (equilibrium), taste, ocular movement, facial expression and sensation.

**Process**

In cells, an extension of a cell body; in the case of neurons, this includes the axon and dendrites.

**Response**

Nervous system function that causes a target tissue (muscle or gland) to produce an event as a consequence to stimuli.

**Satellite cell**

Glial cell type in the PNS that provides support for neurons in the ganglia.

**Schwann cell**

Glial cell type in the PNS that provides the myelin insulation for axons in nerves.

**Sensation**

Nervous system function that receives information from the environment and translates it into the electrical signals of nervous tissue.

**Soma**

In neurons, that portion of the cell that contains the nucleus; the cell body, as opposed to the cell processes (axons and dendrites).

**Somatic nervous system (SNS)**

Functional division of the nervous system that is concerned with conscious perception, voluntary movement, and skeletal muscle reflexes.



**Spinal cord**

Organ of the central nervous system found within the vertebral cavity and connected with the periphery through spinal nerves; mediates reflex behaviours.

**Stimulus**

An event in the external or internal environment that registers as activity in a sensory neuron.

**Stroke**

(also, cerebrovascular accident (CVA)) loss of neurological function caused by an interruption of blood flow to a region of the central nervous system.

**Subarachnoid space**

Space between the arachnoid mater and pia mater that contains CSF and the fibrous connections of the arachnoid trabeculae.

**Sulcus/sulci**

Groove formed by convolutions in the surface of the cerebral cortex; see fissure.

**Synapse**

Narrow junction across which a chemical signal passes from neuron to the next, initiating a new electrical signal in the target cell.

**Synaptic end bulb**

Swelling at the end of an axon where neurotransmitter molecules are released onto a target cell across a synapse.

**Sympathetic nervous system (SNS)**

Part of the nervous system that serves to accelerate heart rate, constrict blood vessels and raise blood pressure in response to stress.

**Temporal lobe**

Region of the cerebral cortex directly beneath the temporal bone of the cranium.

**Thalamus**

Major region of the diencephalon that is responsible for relaying information between the cerebrum and the hindbrain, spinal cord, and periphery.

**Tract**

Bundle of axons in the central nervous system having the same function and point of origin.

**Transient ischemic attack (TIA)**

Temporary disruption of blood flow to the brain in which symptoms occur rapidly but last only a short time.

**Unipolar**

Shape of a neuron which has only one process that includes both the axon and dendrite.

**Ventricle**

Central cavity within the brain where CSF is produced and circulates.

**Wernicke's area**

Region at the posterior end of the lateral sulcus in which speech comprehension is localized.

## White matter

Regions of the nervous system containing mostly myelinated axons, making the tissue appear white because of the high lipid content of myelin.

## Nervous System Glossary Reinforcement Activity

### Nervous System Glossary Reinforcement Activity (Text version)

1. The outer gray matter covering the forebrain, marked by wrinkles and folds known as gyri and sulci is called the \_\_\_\_\_[Blank 1].
  - a. Multipolar
  - b. Cerebral cortex
  - c. Dendrite
2. The single process of the neuron that carries an electrical signal (action potential) away from the cell body toward a target cell is called the \_\_\_\_\_[Blank 2].
  - a. Axon
  - b. Cauda equina
  - c. Cerebrum
3. The large opening in the occipital bone of the skull through which the spinal cord emerges and the vertebral arteries enter the cranium is called the \_\_\_\_\_[Blank 3].
  - a. Foramen magnum
  - b. Corpus callosum
  - c. Dura mater
4. The disruption of blood flow to the brain because blood cannot flow through blood vessels as a result of a blockage or narrowing of the vessel is called \_\_\_\_\_[Blank 4].
  - a. Ischemic stroke
  - b. Embolus
  - c. Initial segment
5. The major region of the diencephalon that is responsible for coordinating autonomic and endocrine control of homeostasis is called the \_\_\_\_\_[Blank 5].
  - a. Hypothalamus
  - b. Myelin
  - c. Neuron

### Check your answers: <sup>1</sup>

**Activity source:** Nervous System Glossary Reinforcement Activity by Gisele Tuzon, from *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY- 4.0. /Text version added.

## Attribution

Except where otherwise noted, this chapter is adapted from "Nervous System" (<https://ecampusontario.pressbooks.pub/medicalterminology/chapter/nervous-system/>) in *Building a Medical Terminology Foundation* by Kimberlee Carter and Marie Rutherford, licensed under CC BY 4.0. / A derivative of Betts et al., which can be accessed for free from *Anatomy and Physiology (OpenStax)* (<https://openstax.org/books/anatomy-and-physiology/pages/1-introduction>). Adaptations: dividing Nervous System chapter content into sub-chapters.

## Notes

1. 1. a) Cerebral cortex, 2.a) Axon, 3. a) Foramen magnum, 4. a) Ischemic stroke, 5. a) Hypothalamus

# References

Bergen, T. (2018, September 3). *Tensilon test*. Healthline. <https://www.healthline.com/health/tensilon-test>

Canadian Cancer Society. (n.d.). *Lumbar puncture*. <https://www.cancer.ca/en/cancer-information/diagnosis-and-treatment/tests-and-procedures/lumbar-puncture/?region=on>

Canadian Medical Association. (2019, December). *Neurology profile*. CMA Specialty Profiles. <https://www.cma.ca/sites/default/files/2019-01/neurology-e.pdf>

Centers for Disease Control and Prevention. (2023, April 20). *Get the facts about TBI*. CDC. [https://www.cdc.gov/traumaticbraininjury/get\\_the\\_facts.html](https://www.cdc.gov/traumaticbraininjury/get_the_facts.html)

Centers for Disease Control and Prevention. (2023, April 25). *Mental health*. CDC. <https://www.cdc.gov/mentalhealth/learn/index.htm>

Centers for Disease Control and Prevention. (2024, February 28). *What is Cerebral Palsy*. CDC. <https://www.cdc.gov/ncbddd/cp/facts.html>

Cherney, K. & De Pietro, M. (2019, May 29). *Neurologist*. Healthline. <https://www.healthline.com/find-care/articles/neurologists/neurologist>

CrashCourse. (2015, February 23). *The Nervous system, part 1: Crash Course anatomy & physiology #8* [Video]. YouTube. [https://www.youtube.com/watch?v=qPix\\_X-9t7E](https://www.youtube.com/watch?v=qPix_X-9t7E)

Merriam-Webster. (n.d.). *Neurologist*. In *Merriam-Webster.com dictionary*. <https://www.merriam-webster.com/dictionary/neurologist>

Moores, D., & Cirino, E. (2018, March 20). *Electromyography (EMG)*. Healthline. <https://www.healthline.com/health/electromyography>

Ontario Federation for Cerebral Palsy. (2018). *About cerebral palsy*. <https://www.ofcp.ca/about-cerebral-palsy>

Taylor, G. (2019, June 3). *Brain injury awareness month – June 2019*. Public Health Agency of Canada. <https://www.canada.ca/en/public-health/news/2019/05/brain-injury-awareness-month-june-2019.html>