5 The Nerve Structure and Function

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Abstract

In this chapter, information is given about the anatomical structure of the nervous system and nerve cells. The nervous system is discussed under two main headings as the central and peripheral nervous system. Under the heading of the central nervous system, information is given about the brain, medulla spinalis, meninges, and the vessels that feed the central nervous system. The peripheral nervous system is investigated separately in terms of anatomical and functional aspects. In addition, the anatomical structure of the nerve cell and other cells of the nervous system are also mentioned.

5.1 Nervous System

The nervous system monitors the changes that occur inside and outside the body, carries the obtained information from one part of the body to another, and creates appropriate responses. It is responsible for perception, behavior, and memory, plans, initiates, and terminates movements. It is divided into the central nervous system (CNS) and the peripheral nervous system (PNS). While the brain and its extension, the medulla spinalis, form the CNS, all nerve structures outside of this system form the PNS. The structures that form the nervous system are given in Fig. 5.1.

5.1.1 Central Nervous System

The main task of the CNS is to integrate all the information that comes to it, to perceive the events that take place, and to conclude with adaptive behavior to all kinds of changes. Information from the peripheral nervous system is transmitted to the coded areas that are associated with them; all obtained information is combined. The final information obtained is transmitted to the appropriate central nervous system area for a response. Finally, from here, a stimulus is sent to the target organ for the formation of the appropriate response, and the most appropriate response is provided against the information obtained.

5.1.1.1 Brain

An adult human brain consists of more than 100 billion nerve cells and neurons. 90% of these cells make up of glial cells. The brain is the common name for six anatomical structures in CNS. These anatomical structures are the medulla oblongata, pons, midbrain, cerebellum, diencephalon, and cerebrum (Fig. 5.2).

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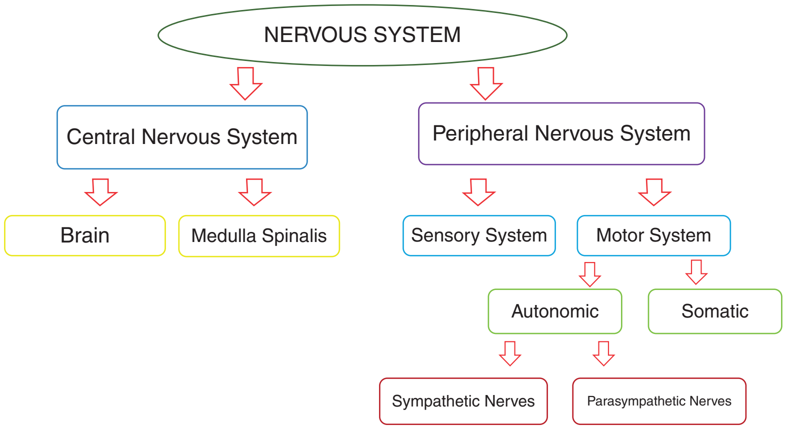


Fig. 5.1 Central nervous system and parts

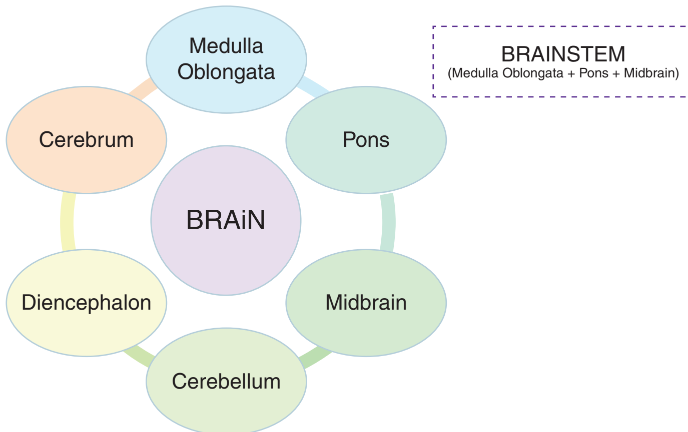


Fig. 5.2 Anatomical structures that make up the brain

Cerebrum

It is the largest structure among that form the brain. It consists of two parts, gray and white matter. The grey matter is formed by neuronal cell bodies while the white matter is formed by the axons. The cerebral cortex is divided into two hemispheres. There are recesses (sulcus) and protrusions (gyrus) formed to expand the surface area in both hemispheres. The hemispheres communicate with each other through the corpus callosum, which is composed of axons (Fig. 5.3). The central sulcus, which is one of the important anatomical structures in the brain, is an important and decisive recess. The lobe in the front of this sulcus is the frontal lobe, and it performs the motor function, which is the main output of the brain. The parietal, temporal, and occipital lobes located behind this sulcus are the structures responsible for the sensory function of the brain. These lobes receive incoming sensory information, process it, and transmit it to the frontal lobe.

Diencephalon

It is the name given to all of the thalamus, hypothalamus, epithalamus, and subthalamus structures located between the cerebrum and midbrain (Fig. 5.3). The thalamus consists of nearly 80% of the diencephalon. The thalamus is the center of call for all senses that go to the cerebrum, except for the sense of smell. The thalamus, which consists of gray matter, is responsible for transmitting sensations to the relevant cerebral areas. The hypothalamus is the structure just anterior–inferior to the thalamus and just above the hypophysis (pituitary gland). The hypothalamus controls body temperature, hunger, thirst, circadian rhythm, and strong emotional responses by

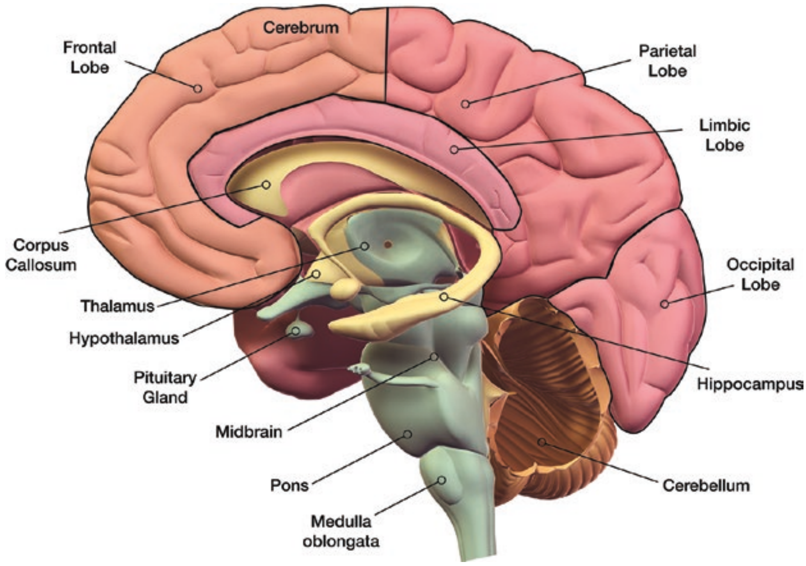


Fig. 5.3 Side view of the structures that make up the central nervous system (Hank Grebe/ Shutterstock.com)

affecting the autonomic nervous system and endocrine system.

Brainstem

The medulla oblongata, pons, and midbrain together are defined as the brainstem. They are responsible for the control of emotional responses given in situations such as circulation, respiration and fear–anxiety, modulation of pain, formation of voice, and regulation of consciousness and sleep cycle. It is directly connected to the cerebrum, basal ganglia, diencephalon, cerebellum, and spinal cord. It is an important structure where the third and 12th cranial nerves (except for a part of the accessory cranial nerve) are located (Fig. 5.3).

Cerebellum

Cerebellum means small brain in Latin. Through the connections it has at different levels, it controls the functions of other anatomical structures of the CNS. The most important function is to control and coordinate the movement by comparing it with purpose. It provides precise control of movement within milliseconds. The cerebellum controls and regulates by making a copy of all motor impulses given from the cerebrum and comparing it with proprioceptive information from the periphery (Fig. 5.3).

Clinical Information

Not all sensations that pass through the thalamus are transmitted to the sensory cortex. Some of these senses are transmitted to the motor cortex. In this way, it is possible to obtain a motor response from sensory stimulation. The central gyrus is also called the sensorimotor cortex since the motor response can be obtained with the senses.

Clinical Information

When the control of motor movement is considered at the hierarchical level, the upper centers have inhibition characteristics in order to control the lower centers. After the damage that removes the control of the upper centers, increased excessive activation is seen in the lower centers. The lower centers, which are freed from the control of the upper centers, have a nonfunctional and increasing uncontrolled activity.

5.1.1.2 Medulla Spinalis

The medulla spinalis (MS) is an extension of the brain. It is responsible for the emergence of rapid and reflexive responses and the continuation of stability in the face of warnings. It also takes part in the transmission of sensory stimuli from the environment to the upper centers and the motor responses from the upper centers to the target organ. While MS has the same length as the spinal canal until the 12th week of intrauterine life, it ends at the level of the third lumbar vertebra at birth and at the level of the first lumbar vertebra in adults. There are several important lines that define MS externally. These are the anteromedian fissure, posteromedian sulcus, anterolateral sulcus, posterior median sulcus, and posterolateral sulcus (from anterior to posterior).

In the cervical region, the transverse diameter of MS is larger than the anteroposterior diameter. Due to this size, it is oval in shape. In the thoracic and lumbar regions, it is round in shape.

The cross-sectional area of MS in the cervical region is greatest due to the density of ascending and descending tracts, while it is smallest in the thoracic region. Ventral and dorsal nerve roots are occurred by the combination of six to eight small nerve fibers. Small nerve fibers that appear from the posterolateral sulcus create the dorsal nerve root. Small nerve fibers that appear from the anterolateral sulcus create the ventral nerve root (Fig. 5.4).

MS is divided into two areas, the white and the gray zone. The white region is an area where the axons of the descending, ascending, and proprioceptive pathways are located. Anatomically, it is divided into three funicles anterior, lateral, and posterior, and functionally, it is divided into three main pathways descending, ascending, and proprioceptive. Axons of the propriospinal tracts originate from nerve cells located in the gray area of the spinal cord. The gray area is an "H" or butterfly-shaped area where the nerve cell bodies are located. It is roughly divided into anterior and posterior horns. There is also a small lateral horn located between T12–L2. The gray area is divided into 10 subregions called the lamina. Laminas and their properties are given in Table 5.1.

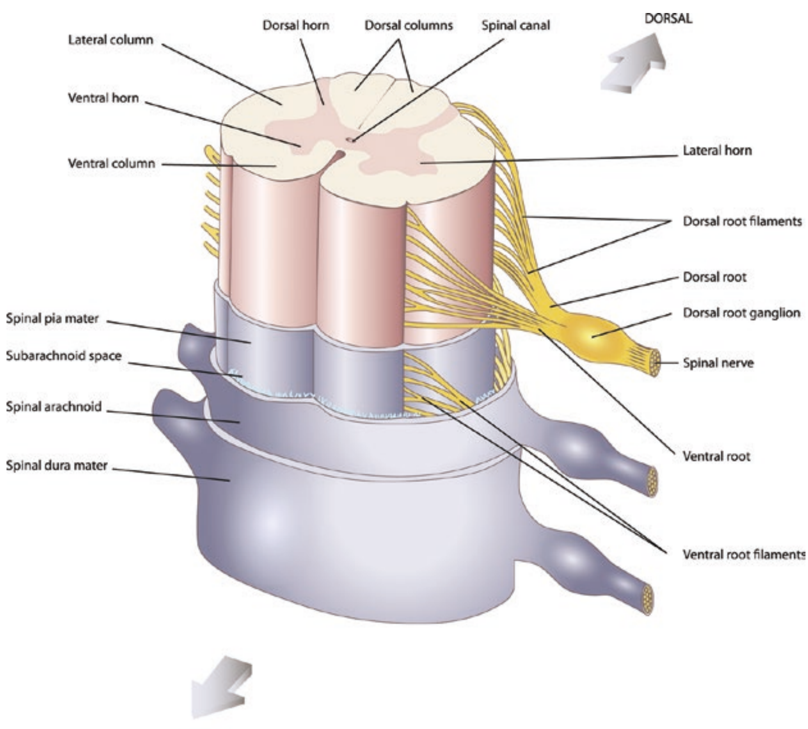


Fig. 5.4 Medulla spinalis (Vasilisa Tsoy/Shutterstock.com)

Table 5.1 Laminas in the gray area of the spinal cord and its features

Lamina area	Features
Lamina I	Pain and heat
Lamina II	Substantia gelatinosa, responsible for all stimuli, sends information to lamina III–IV
Lamina III–IV	Vibration and pressure
Lamina V	Stimuli from the skin, muscle, and skin mechanoreceptors and visceral nociceptors
Lamina VI	Flexor response to painful stimulus
Lamina VII	Numerous interneurons and propriospinal neurons are involved in the movement, reflexes, and autonomic functions
Lamina VIII	Proprioceptive and interneurons, regulation of motor movement
Lamina IX	Motor neurons that excite skeletal muscle
Lamina X	Consists of cells located around the central canal. Axons cross from one side to the other

Clinical Information

While the frontal lobe, located in front of the central sulcus in the cerebrum, is responsible for motor output, the parietal, temporal, and occipital lobes located behind it are nervous system structures that receive and process sensory input and send it to the frontal lobe for motor output. The anterior horn cells in the medulla spinalis have motor character, while the posterior horn has sensory. Similarly, the anterior part of the thalamus is related to motor functions, while the posterior part is related to sensory functions.

While the structures in the anterior part of the central nervous system are responsible for motor movement in general, the structures in the posterior part show a topographic location related to the senses.

5.1.1.3 Meninges

Meninges are the outermost membrane layer that surrounds and protects the central nervous system. The meninges consist of three layers, from the outside to the inside, the dura mater, the arachnoid mater, and the pia mater (Fig. 5.5). The dura mater is the outermost layer of the meninges. There are two layers in the cerebral region, and the outermost layer covers the inner surface of the skull bones and acts as a periosteum. Its inner layer covers the entire CNS, including the spinal cord. The inner layer of the dura mater also forms dense folds that prevent and support the mobility of the brain between both hemispheres (falx cerebri) and between the hemispheres and the cerebellum (tentorium cerebelli). In addition, there are spaces called venous sinuses that provide venous blood flow to the brain within the dura mater. The arachnoid mater is thin and transparent, similar to a spider web. It fuses with the dura mater at the level of the second sacral spine. Between the arachnoid and the pia mater, there is the subarachnoid space that has cerebrospinal fluid. The pia mater is the innermost delicate and thin structure that adheres to the brain and spinal cord structures. It contains many small blood vessels. At the level the spinal cord ends, it forms the filum terminale. The filum terminale extends to the level of the sacral second vertebra.

There are three important gaps between the meninges and the bone tissue. These are (I) the epidural space between the bone tissue and the dura mater, (II) the subdural space between the dura mater and the arachnoid mater, and (III) the subarachnoid space between the arachnoid mater and the pia mater. The subarachnoid space contains cerebrospinal fluid (CSF) and major blood vessels. Anatomical spaces between the meninges are shown in Fig. 5.6.

To Learn Easily

In order to learn the order of the membranes surrounding the CNS, the initials can be combined and coded as DAP, from outside to inside.

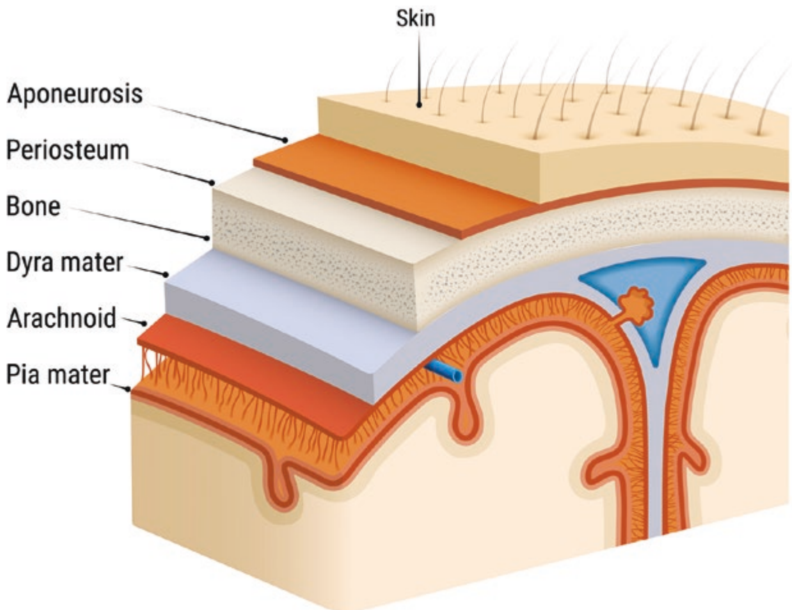


Fig. 5.5 Meninges (Danilina Olga/ Shutterstock.com)

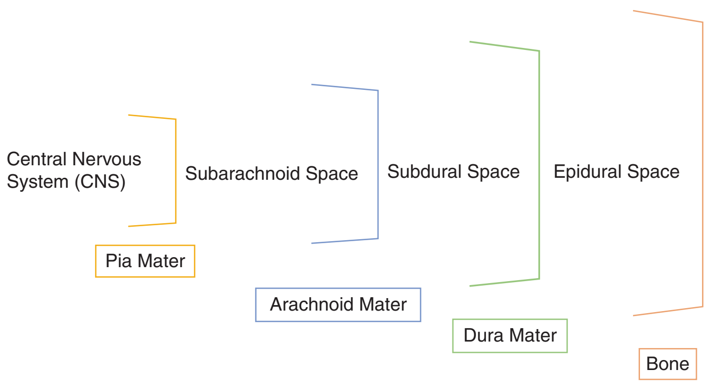


Fig. 5.6 Meninges and spaces between the meninges

5.1.1.4 Vessels Feeding the Central Nervous System

The spinal cord is supplied by branches from the vertebral and segmental arteries. The vertebral artery gives off the anterior and sometimes posterior spinal artery branches. The anterior spinal artery supplies the anterior 2/3 of the spinal cord, including the anterior and lateral funiculus. The remaining 1/3 of the spinal cord (the posterior funiculus) is supplied by the posterior spinal artery. Segmental arteries are the main arteries that provide nutrition in the thoracic and lumbar regions where the spinal arteries begin to become insufficient.

CNS structures other than the medulla spinalis are supplied by the right and left internal carotid and vertebral arteries coming from both sides. Both vertebral arteries join to form the basilar artery. While the posterior cerebral artery is the most important branch of the basilar artery, the anterior and middle cerebral arteries and the anterior and posterior communicating arteries are the most important branches of the internal carotid artery.

The anterior–posterior communicating, anterior–posterior cerebral, and internal carotid arteries anastomose with each other to form Willis Polygon. Willis Polygon gives branches that feed the lower surface of the diencephalon and mesencephalon (Fig. 5.7).

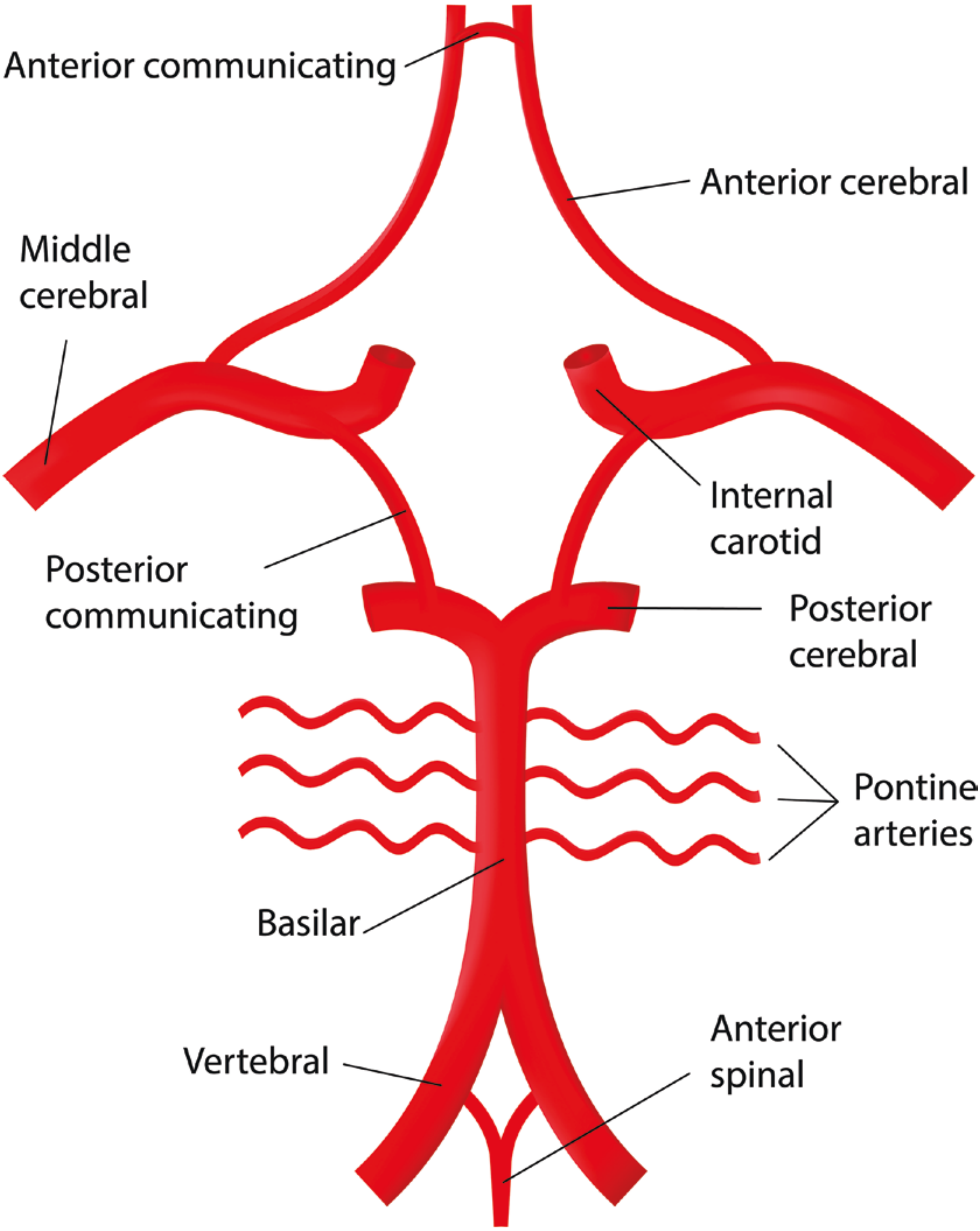


Fig. 5.7 Willis Polygon (joshya/Shutterstock.com)

5.1.2 Peripheral Nervous System

While the PNS consists of three different structures anatomically, cranial nerves, spinal nerves, and autonomic nervous system, it consists of sensory (afferent) and motor (efferent) nerve fibers functionally (Fig. 5.8). While the sensory nerve fibers transmit the impulses from the organs to the CNS, the motor nerve fibers transmit the impulses occurring in the CNS to the skeletal muscle, internal organs, and tissues. Sensory nerve fibers constitute the majority of nerves in the PNS. Motor nerve fibers are divided into somatic and autonomic nerve fibers. Somatic nerve fibers provide contraction of skeletal system muscles, while autonomic nerve fibers provide contraction of cardiac and smooth muscle fibers.

5.1.2.1 Anatomical Peripheral Nervous System

Cranial Nerves

Although it is generally accepted that there are 12 pairs of cranial nerves in the human body, there are also studies that define the terminal cranial nerve as the “0th” or “13th” cranial nerve. This cranial nerve has been described since 1914, especially in the late 1980s called the 0th cranial nerve. It is associated with the gonadotropin-releasing hormone and is thought to play a role in reproductive and behavioral control.

Cranial nerves are named according to their distribution or function. They are located on the inferior surface of the brain and are numbered from top to bottom in the order of attachment to the brain (Fig. 5.9). The names of the cranial nerves, their classification according to their functions, and their functions are given in Table 5.2.

To Learn Easily

The trochlear nerve (4th) is responsible for the motor stimulation of the oblique superior muscle (SO), the abducens nerve (6th) is responsible for the motor stimulation of the rectus lateralis (RL) muscle, and the oculomotor nerve (3rd) is responsible for the motor stimulation of the remaining eye muscles. It can be formulated as (SO_4-RL_6) $Other_3$.

Clinical Information

In the cranial nerve examination, it should be noted that while the afferent stimulation of the face is provided by the trigeminal nerve (5th), the efferent stimulation is provided by the facial nerve (7th).

Clinical Information

The light reflex is evaluated by means of a light source held in the eye. The optic nerve (2nd) is responsible for the afferent stimulation of the light reflex, and the oculomotor nerve (3rd) is responsible for the efferent stimulation. Even if the light is applied to only one eye, constriction occurs in both pupils due to bilateral stimulation.

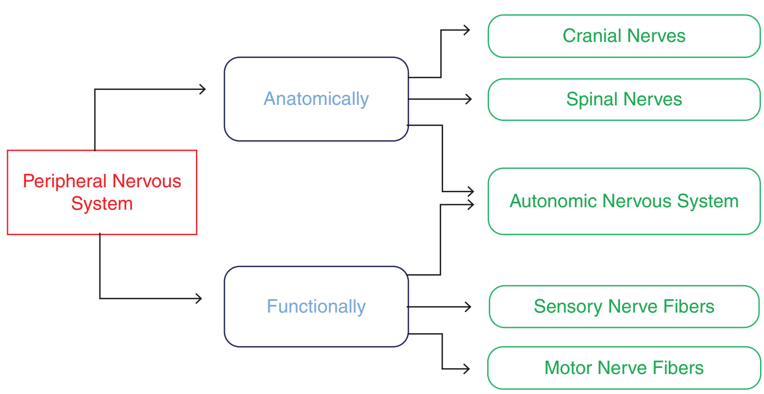


Fig. 5.8 Structures constituting the peripheral nervous system

Clinical Information
Corneal reflex, the eye is closed when the lateral cornea is touched with the cotton ball while the patient is looking outward and upward. The trigeminal nerve (5th) is responsible for the afferent stimulation of this reflex, and the facial nerve (7th) is responsible for the efferent stimulation.

Clinical Information
The gag reflex is a motor movement that occurs when the base of the tongue or the pharynx is touched by an abeslang (abaisse langue)-like object. Afferent stimulation is provided by the glossopharyngeal nerve (9th), while the vagus nerve (10th) is responsible for efferent stimulation (motor response). It should be considered that this reflex, which is important in the evaluation of the cranial nerves responsible for swallowing function, may not be present in approximately 40% of even healthy individuals.

Spinal Nerves

They are the nerves that provide communication between the CNS and receptors, muscles, and glands. There are 31 pairs of spinal nerves in the human body, these are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal. Both ventral and dorsal nerve roots are presented at all levels, with the exception of the first spinal nerve located in the cervical region. In the first spinal nerve, the ventral nerve root is found in everyone, while the dorsal nerve root is found in only 46% of people. Only 28% of individuals with a first dorsal nerve root have a spinal ganglion.

Ventral (motor) and dorsal (sensory) roots emerging from the medulla spinalis unite in the intervertebral canal to form spinal nerves. After the spinal nerves emerge from the intervertebral foramen, they divide into three branches: anterior, posterior, and communicans rami. The posterior branch is responsible for the stimulation of the muscles and skin at the back of the trunk. The anterior branch is responsible for the stimulation of the muscles and skin of the extremities, the anterior-lateral parts of the neck, and the back by forming plexuses. Communicans rami take charge as a part of the autonomic nervous system (Fig. 5.10). The anterior branches of the spinal nerves, with the exception of the thoracic region, expand bilaterally in five regions and mix with each other, and form structures called plexuses. These are cervical (C1–4), brachial (C5–T1), lumbar (T12–L4), sacral (L4–S4), and coccygeal (S3–5) plexuses, from top to bottom.

Autonomic Nervous System

The autonomic nervous system is responsible for body regulatory activities such as blood pressure, heart rate, body temperature, and glandular function. The autonomic nervous system is divided into two subgroups, the sympathetic and parasympathetic nervous systems. While the sympathetic nervous system regulates body functions in a stressful mood, the parasympathetic nervous system regulates body functions in a relaxed mood. The parasympathetic nervous system is the “rest and recovery” system and is distributed throughout the body by the vagus nerve, which is the tenth cranial nerve. The sympathetic nervous system, on the other hand, is described as the “flight, fear, war” system as it distributes to the body from the ganglia located in the antero-lateral part of the thoracolumbar spine. The structural differences between the sympathetic and parasympathetic nervous systems are shown in Table 5.3 and their functions are shown in Fig. 5.11. A third autonomic nervous system called the enteric nervous system has been also described to emphasize the strong brain and gut

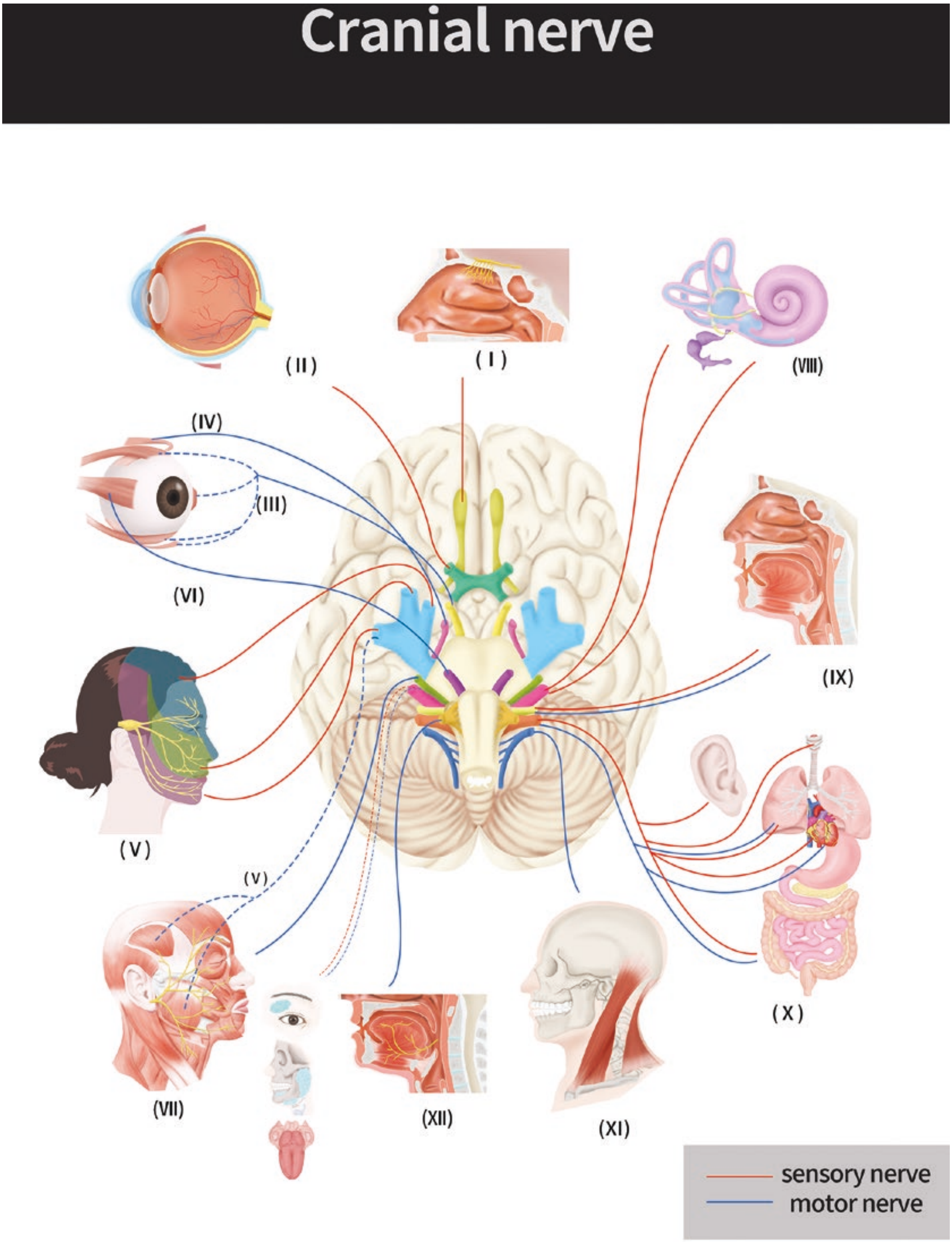


Fig. 5.9 Cranial nerves and target organs (Chu KyungMin/Shutterstock.com)

Table 5.2 Classification and functions of cranial nerves

Cranial nerve	Classification according to function	Responsible function
0. Terminal (Nulla) nerve	Sense + Autonomous	• Smell • Transmission of the sense of smell to the limbic areas (amygdala, hypothalamic nuclei) • Secretion of gonadotropin hormones from the hypothalamus
1. Olfactory nerve	Sense	• Smell
2. Optical nerve	Sense	• Vision • Forms the afferent pathway of the pupillary light reflex
3. Oculomotor nerve	Motor + Autonomous	• It stimulates four of the six muscles that move the eyeball (m. rectus medialis, superior, inferior, and obliquus inferior) and the levator palpebrae superior muscle, which lifts the upper eyelid • Parasympathetic fibers form the efferent pathway of the light reflex, constricting the pupil
4. Trochlear nerve	Motor	• Stimulation of the obliquus superior muscle
5. Trigeminal nerve	Sense + Motor	• Stimulation of chewing muscles • Sensory stimulation of the face, anterior scalp, and paranasal sinuses • All sensory stimulation of the anterior two-thirds of the tongue except taste • Afferent innervation of the corneal reflex
6. Abducens nerve	Motor	• Stimulation of the rectus lateralis muscle
7. Facial nerve	Sense + Autonomous + Motor	• Stimulation of all facial muscles • Sense of taste from the anterior two-thirds of the tongue • Motor stimulation of the corneal reflex • Stimulation of parasympathetic fibers, submandibular and sublingual salivary glands from the major salivary glands
8. Vestibulocochlear nerve	Sense	• Responsible for hearing and balance
9. Glossopharyngeal nerve	Sense + Autonomous + Motor	• Sense of taste from the posterior one-third of the tongue • Motor innervation of the stylopharyngeus muscle • Parasympathetic stimulation of the parotid, the largest salivary gland
10. Vagus nerve	Sense + Autonomous + Motor	• Sensory innervation of the supraglottic region • Innervation of the muscles that provide the function of all pharyngeal and vocal cords except the stylopharyngeus muscle • Parasympathetic innervation of all thoracic and abdominal cavity organs
11. Accessory nerve	Motor	• Innervation of the sternocleidomastoid and trapezius muscles
12. Hypoglossal nerve	Motor	• Innervation of tongue muscles

relationship. The ganglia in this nervous system are also called "small brains" because they have a large number and complex organization.

Clinical Information

When autonomic nerve fibers are injured, the nutritional and metabolic activities of the tissues are disrupted. This disorder is more prominent in the distal tissues (hand and foot). The skin is pale, thin, dry, and shiny. In addition, the nails are brittle and sweating is not observed.

5.1.2.2 Functionally Peripheral Nervous System

Sensory (Afferent) Nerve Fibers

They are responsible for the continuous transmission of the information collected about the current situation to the CNS, both from the environment in which the body is located and through the receptors in the body. Sensory fibers enter the spinal cord from the posterior root and are carried to the upper centers (Fig. 5.12). Receptors are divided into special (photoreceptors on the retina, taste receptors on the tongue,

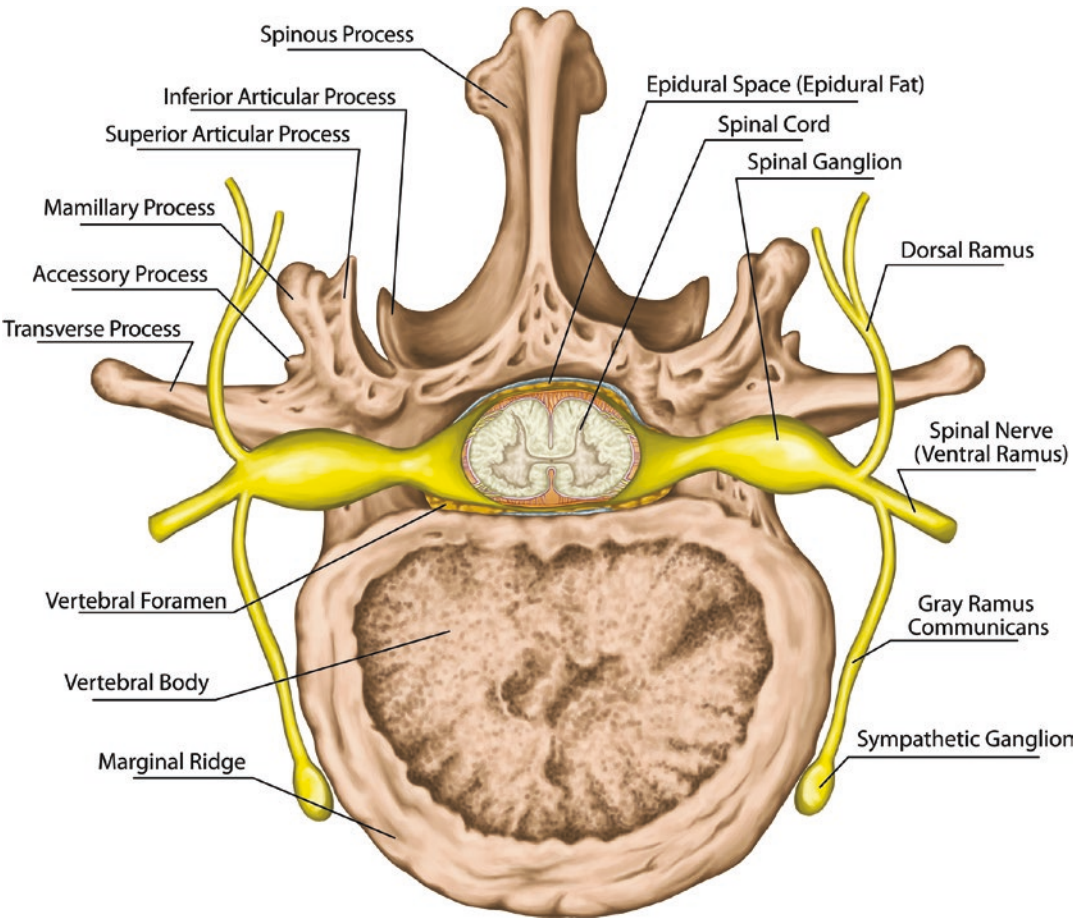


Fig. 5.10 Spinal nerve and related structures (stihii/Shutterstock.com)

Table 5.3 Structural differences between the sympathetic and parasympathetic nervous systems

	Sympathetic nervous system	Parasympathetic nervous system
Exit zones from the CNS	Thoracolumbar region	Craniosacral region
Active state	In stressful situations	In the absence of stress
Neurotransmitter	Acetylcholine norepinephrine	Acetylcholine
Where the ganglia are located	Outside of the CNS but in a nearby area	Near or in the target organ
Length of nerve fibers	Short preganglionic fibers Long postganglionic fibers	Long preganglionic fibers Short postganglionic fibers

etc.) and general receptors scattered throughout the body. The overall receptor density varies according to body regions. For example, cutaneous receptors are more concentrated on the soles of the feet and toes. Since the damage to the receptors will cause a decrease in sensory information, it may also cause a decrease in motor performance. Because the CNS sends appropriate engine commands to the target, thanks to the notification it receives.

Motor (Efferent) Nerve Fibers

Motor nerve fibers are divided into somatic and autonomic nerve fibers. While somatic nerve fibers provide contraction of skeletal system muscles, autonomic nerve fibers provide contrac-

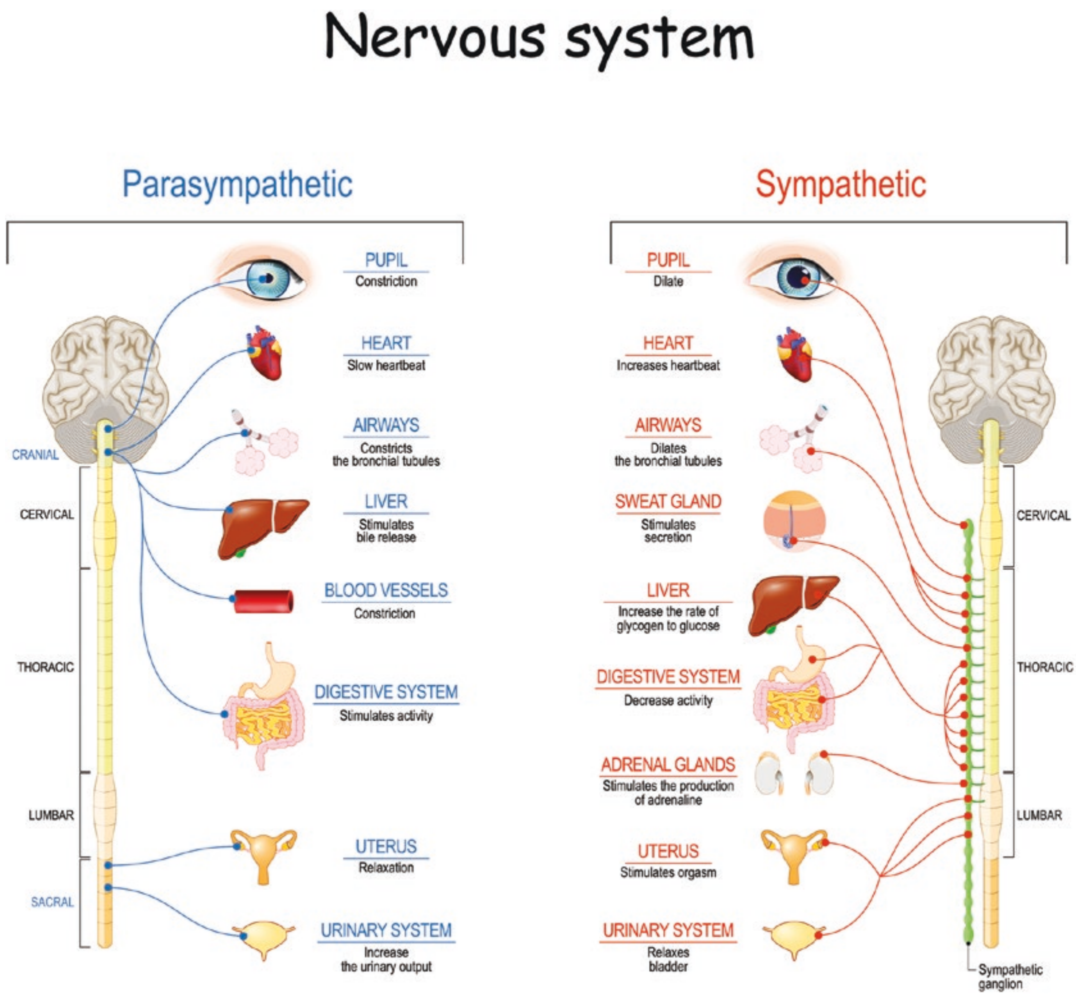
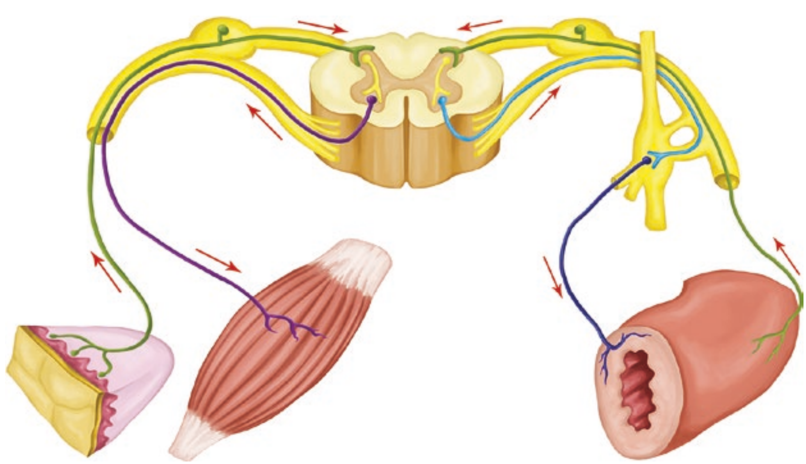


Fig. 5.11 Autonomic nervous system and its functions (Designua/Shutterstock.com)

Fig. 5.12 Sensory (afferent), motor (efferent), and autonomic nerve fibers (stihii/Shutterstock.com)



tion of cardiac and smooth muscle fibers. The CNS, by evaluating the feedback it received, transmits the appropriate motor commands it creates to the muscles via the cranial and spinal nerves that form the somatic nerve fibers, thus ensuring that appropriate responses are revealed (Fig. 5.12).

Autonomic Nerve Fibers

Above is mentioned under the title of "***Anatomically Peripheral Nervous System***" (Fig. 5.12).

> **Clinical Information**
> In peripheral nerve injuries, atrophy occurs especially after the first 3 months. Muscle fibers are replaced by fibrous connective tissue. If the nerve is not healed, the fibrous connective tissue covers all the muscle fibers, and the function is irreversibly lost.

> **Clinical Information**
> It contains afferent–efferent, myelinated–unmyelinated, and autonomic–somatic nerve fibers in a peripheral nerve. Autonomic fibers are both afferent and efferent, stimulating organs, blood vessels, and glands. All these structures are mixed in the nerve fiber.

> **Clinical Information**
> The nerve fiber starting from the anterior horn motor cell and the muscle fibers stimulated by this nerve fiber are called motor units. While each muscle fiber is stimulated by one motor neuron, a motor neuron can stimulate more than one muscle fiber. Small motor neurons and a few muscles fiber that are stimulated by these small motor neurons are called *small motor units*. Large motor neurons and a large number of muscle fibers that are stimulated by these large motor neurons are called *large motor units*.
>
> Anterior horn motor cells responsible for fine motor movements stimulate 5–20 muscle fibers, while anterior horn motor cells responsible for gross motor movements, stimulate 100–500 muscle fibers. Not all motor units in a muscle are the same size. In this way, it is possible to gradually increase muscle strength. When a muscle starts to contract with increasing force, small motor units are activated first, and as the stimulation increases, the muscle's contraction force increases by activating large motor units. This situation continues until all the motor units in the muscle are stimulated, and the muscle reaches the highest strength value. Since movements that require fine dexterity require little force–high control, the onset of contraction from the small motor units allows this control to occur correctly.

5.2 Anatomical Structure of Nerve Cell

Nerve cell (neuron) is the smallest functional structure of the nervous system and consists of three parts: cell body, dendrite, and axon. Each nerve cell receives input from another nerve cell or cells and sends output to the other nerve cell or cells. The only exception to this rule is nerve cells that are connected to sensory receptors and muscle fibers.

Dendrites and axons together are called nerve fibers. The cell body consists of the cell nucleus and the cytoplasm. It provides protein synthesis and the healthy functioning of the cell. It is especially concentrated in the gray matter of the CNS. It is responsible for the analysis, consolidation, and storage of information. Dendrites have many branches and have most of the surface area of the nerve. It is responsible for collecting and transmitting information to the cell body. The axon may be less than 1 mm in length or more than 1 m in length and may have many terminal branches. It is responsible for transmitting information directly to the cell body. Axons have different names and conduction rates according to their functions (Table 5.4). Dendrites and axons appear white from myelin and form white matter in the CNS.

Spinal nerves are surrounded by three layers of protective connective tissue. These layers are named as endoneurium, perineurium, and epineurium from the inside out (Fig. 5.13).

Table 5.4 Classification of axons according to their functions

Functionally axon type	Axon type	Transmission speed (m/s)	Function
Sensory (afferent) nerve fibers	Ia	70–120	Deep sense from muscle spindles
	Ib	70–120	Deep sense from the Golgi tendon organ
	II	30–70	Touch, pressure, vibration
	III	12–30	Temperature, touch, pressure, and rapidly transmitted pain
	IV	0.5–2	Slow transmitted pain
Motor (efferent) nerve fibers	Alpha	15–120	Extrafusal muscle fiber
	Gamma	10–45	Intrafusal muscle fiber
	Preganglionic autonomic nerve fiber	3–15	Myelinated preganglionic autonomic nerve fibers, autonomic ganglion
	Postganglionic autonomic nerve fiber	2	Unmyelinated postganglionic autonomic nerve fibers, target organ (organs, blood vessels, glands)

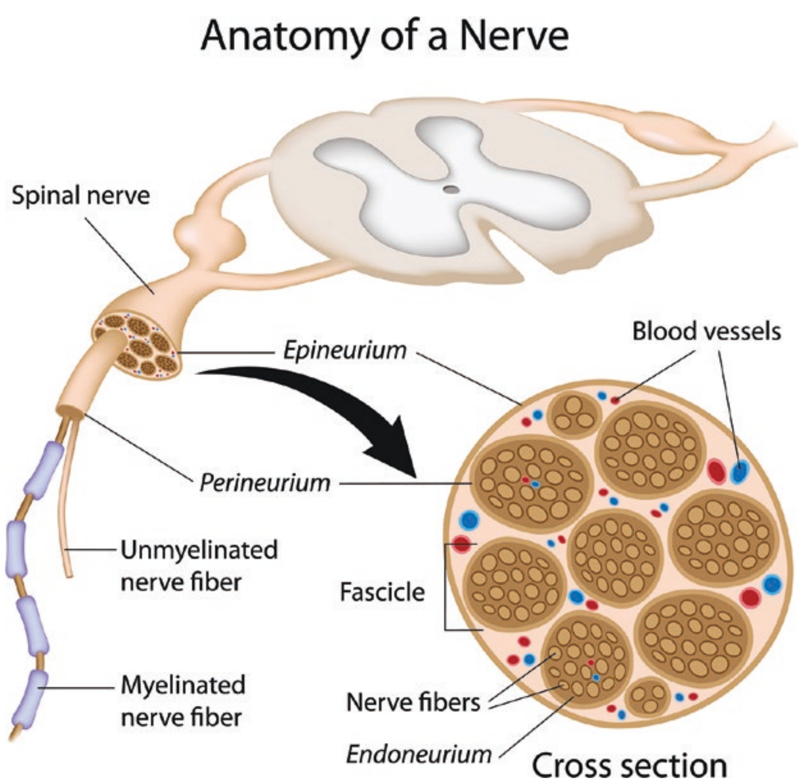


Fig. 5.13 The structure of the spinal nerve fiber (Alila Medical Media/Shutterstock.com)

5.3 Other Cells in the Nervous System

Apart from nerve cells, glia cells are another main cell type found in the CNS. The quantity of glia cells is more than three times the quantity of neuron. There are three types of glia cells: astrocytes, microglia, and oligodendrocytes (Fig. 5.14).

Astrocytes are the most various and numerous cell types in the CNS. They are cells that maintain brain homeostasis, provide physical and metabolic support to the nervous system, and regulate the extracellular space. One of its most important tasks is to regulate synaptic transmission. Microglia cells are the main phagocytic cells of the CNS. Together with astrocytes, they regulate inflammatory processes in the neuroimmune system and undertake a defense function against pathological conditions. Oligodendrocytes, on the other hand, synthesize and form the myelin sheath surrounding axons and increase nerve conduction velocity 10–100 times.

The myelin sheath is produced by Schwann cells in the peripheral nervous system. The myelin sheath surrounds the axon in layers. The greater the thickness of the myelin sheath, the greater the nerve conduction velocity. The myelin sheath is interrupted by structures called the node of Ranvier in every 1–2 mm. In this way, the transmission allows to be transmitted faster by

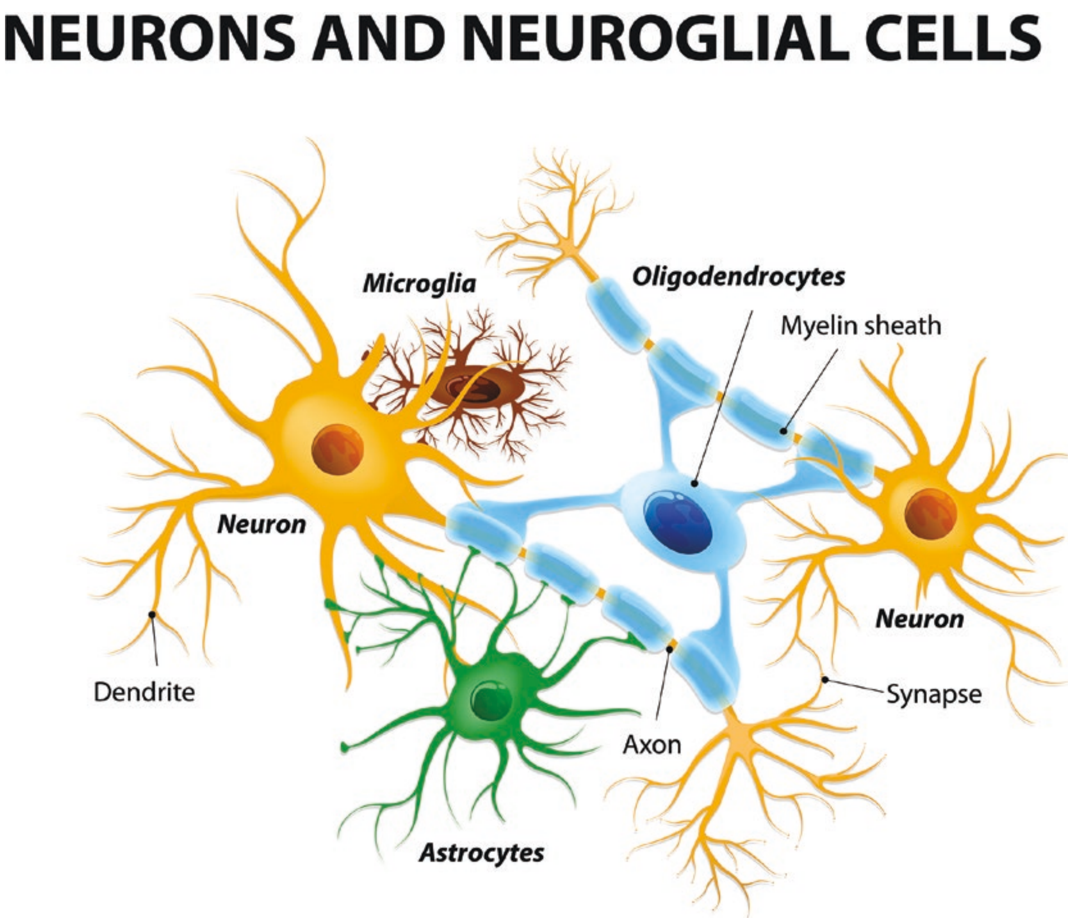


Fig. 5.14 Other cells forming the nervous system (Designua/Shutterstock.com)

jumping. The cells between the two nodes of Ranvier are surrounded with only one Schwann cell. These cells are also surrounded by the endoneurium.

5.4 Hierarchical Structure of Anatomical Structures Responsible for Motor Response in the Nervous System

The upper centers in the nervous system try to keep it under control by inhibiting the lower centers. There are alpha and gamma motor neurons, afferent nerves that carry information from the muscles, and the spinal reflex system at the bottom of the hierarchy in the motor system. These structures can reveal primitive movements independent of the upper centers.

The brainstem is found just above the spinal reflex system. It is essential to regulate the posture in accordance with the changing conditions independently. Posture is kept by spinal and vestibular afferent inputs. In sudden changes in environmental conditions, adaptation to the new situation is achieved with sudden body movements. Here, the main task of the upper centers is to regulate the postural responses of the system in conscious movements and to ensure that the responses given to the suddenly changing environmental conditions emerge in a more controlled manner. If the control of the cerebrum is completely lost, responses such as decortication and decerebration rigidity occur.

The structures that come after the brain stem in the motor hierarchy are the primary motor and sensory cortex. These areas are responsible for basic movements that occur without thought. Above these areas are the premotor, supplementary, and sensory areas located behind the primary sensory cortex. These areas are responsible for the emergence of complex movements that are not as simple as those controlled by the primary motor and sensory cortex but do not require thinking.

The top of the motor hierarchy is consisting of the prefrontal cortex and the parietal, occipital, and temporal association areas. This is the area where the cause–effect relationship is established, which requires reflection before the emergence of the movement. It controls all simple or complex movements made with short or long-term thinking before the motor movement is revealed. The priority is the act of thought to reveal the cause-and-effect relationship (Fig. 5.15).

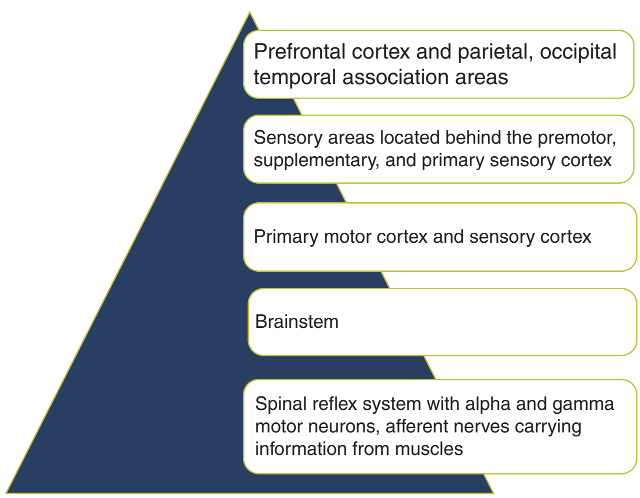


Fig. 5.15 Nervous system structures responsible for the motor hierarchy

5.5 Conclusion

The nervous system differs anatomically and physiologically due to the important functions it undertakes in the human body. The main purpose of all these differences is to perform all the tasks undertaken by the nervous system quickly and completely. In order for the function to occur flawlessly, the entire nervous system must be healthy both anatomically and physiologically. In this chapter, the anatomy of the nervous system has been tried to be organized functionally for physiotherapists.

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