



ISSN Print: 2664-7222
ISSN Online: 2664-7230
IJPPS 2025; 7(2): 328-334
www.pharmacyjournal.org
Received: 04-07-2025
Accepted: 06-08-2025

C Anusha
Associate Professor,
Department of Pharmaceutics,
Dr. KV Subba Reddy Institute
of Pharmacy, Kurnool City,
Andhra Pradesh, India

Yelakapentla Shravani
Student, Dr. KV Subba Reddy
Institute of Pharmacy,
Kurnool City, Andhra Pradesh
India

Corresponding Author:
C Anusha
Associate Professor,
Department of Pharmaceutics,
Dr. KV Subba Reddy Institute
of Pharmacy, Kurnool City,
Andhra Pradesh, India

Descriptive study of neural control and co-ordination

C Anusha and Yelakapentla Shravani

DOI: <https://doi.org/10.33545/26647222.2025.v7.i2d.226>

Abstract

Receptors in the body constantly monitor changes both inside and outside the body. From the external environment, they detect stimuli such as temperature, light, and sound, while within the internal environment, they sense variations in pressure, pH levels, carbon dioxide concentration, and electrolyte balance. All this gathered information is known as sensory input. The sensory input is then converted into electrical signals called nerve impulses, which are transmitted to the brain. In the brain, these signals are processed and combined to create sensations, produce thoughts, or store memories. The process of interpreting and organizing this information to make decisions is called integration. Based on the sensory input and the integration process, the nervous system generates a response by sending signals through motor neurons to effectors such as muscles and glands. Muscles respond by contracting, leading to movement, while glands respond by secreting hormones or other substances. These actions are collectively known as motor output or motor function. Effectors are so named because they bring about an effect in response to the nervous system's directions, allowing the body to react to changes and maintain proper function and balance.

Keywords: Brain, spinal cord, brain stem, cerebrum, cerebellum, hypothalamus.

1. Introduction

The nervous system is a complex and highly organized network that controls and coordinates all body activities, integrates information, and responds to internal and external stimuli. It is composed of specialized cells known as neurons and includes the brain, spinal cord, and nerves. As the body's major controlling, regulatory, and communicating system, it serves as the center of all mental activity, including thought, learning, and memory. Working closely with the endocrine system, the nervous system helps maintain homeostasis the stable internal balance necessary for survival. In this way, the nervous system acts as the body's communication and control center, ensuring that every organ and tissue works together efficiently and responds appropriately to both internal and external changes, thereby maintaining balance and enabling the body to function effectively ^[1, 2].

2. Nervous System

Definitions

- The nervous system is a complex network that co-ordinates actions and sensory information by transmitting signals throughout the body.
- The nervous system is described as the body's control and communication centre responsible for detecting and responding to changes both internally and externally. It works with the endocrine system to regulate vital body functions and maintain homeostasis. The nervous system is composed of the brain, spinal cord, and peripheral nerves, facilitating rapid communication between different body parts ^[3, 4].
- The organised network of nerve tissue in the body. It includes the central nervous system [the brain in the spinal cord], the peripheral nervous system [nerves that extend from the spinal cord to the rest of the body], and other nerve tissue ^[5, 6].
- Fuel wood refers to the woody material collected from trees, The nervous system is the body's control centre, responsible for co-ordinating and regulating all body activities, including both voluntary and involuntary functions ^[7, 8].

- e) The nervous system is a complex network of nerves and specialised cells called neurons that transmit signals between different parts of the body ^[9, 10, 11].

3. Classification of Nervous System:

The nervous system detects and responds to changes inside and outside the body. Together with the endocrine system, it controls many vital aspects of body function and maintains homeostasis. To this end the nervous system provides an immediate response while endocrine activity is, in the main, slower and more prolonged. The nervous system consists of the brain, the spinal cord and peripheral nerves.

For descriptive purposes the parts of the nervous system are grouped as follows:

- The central nervous system (CNS), consisting of the brain and the spinal cord
- The peripheral nervous system (PNS) consists of all the nerves outside the brain and spinal cord.

The nervous system can be classified in several ways, but the most common classification is based on structure and function.

1. Structural Classification

- **Central Nervous System (CNS):** The organ of the central nervous system that is likely most familiar to you, yet still holds the greatest mysteries for physiologists, is the brain. Enclosed completely by the skull, the brain is composed primarily of nervous tissue.
 - a) **Components:** Brain and spinal cord
 - b) **Function:** Integration and command center; processes information and coordinates responses.
- **Peripheral Nervous System (PNS):** The peripheral nervous system is made up of the most numerous organs of the nervous system, the nerves, which carry signals to and from the central nervous system.
 - a) **Components:** All nerves outside the CNS, including:
 - b) Cranial nerves (from brain)
 - c) Spinal nerves (from spinal cord)
 - d) **Function:** Connects the CNS to the limbs and organs.

2. Functional Classification

A. Somatic Nervous System (SNS)

- a) Voluntary control
- b) **Function:** Controls skeletal muscles
- c) **Sensory Input:** From skin, muscles, joints

1. Sympathetic Nervous System

“Fight or flight” response. Increases heart rate, dilates pupils, etc.

2. Parasympathetic Nervous System

“Rest and digest” response. Slows heart rate, increases digestion, etc.

3. Enteric Nervous System (sometimes considered part of ANS)

Controls gastrointestinal functions independently to some extent ^[12, 13].

Mechanism of nervous system

The mechanism of the nervous system refers to how it works to receive, process, and respond to information. This involves a sequence of events that allow the body to detect stimuli, interpret them, and generate appropriate responses.

1. Sensory Input (Detection of Stimuli)

- **Function:** Detect changes (stimuli) in the internal or external environment.
- **Carried out by:** Sensory receptors

2. Integration (Processing of Information)

- **Function:** The brain and spinal cord analyze the incoming sensory information and decide on a response.
- **Carried out by:** Interneurons in the central nervous system (CNS)

Neural Pathway Summary

Stimulus → Receptor → Sensory neuron → CNS (Integration) → Motor neuron → Effector → Response

Types of Responses

- **Voluntary:** Controlled consciously (e.g., moving your arm)
- **Involuntary:** Automatic/reflex actions (e.g., blinking, heartbeat)
Example: Reflex Arc (Simplest Nervous System Mechanism)

Reflexes bypass the brain for faster responses. ^(14,15)

3. Procedure For Generation and Conduction of Nerve Impulses

Part 1: Generation of Nerve Impulse (Action Potential)

1. Resting Membrane Potential

- At rest, the neuron's membrane is polarized.
- Inside the neuron: more negative (≈ -70 mV).

2. Stimulus

A stimulus (e.g., mechanical, chemical, or electrical) causes a small depolarization.

3. Depolarization

- Voltage-gated Na^+ channels open.
- Na^+ rushes into the neuron.
- Membrane potential becomes less negative, then positive (up to $+30$ to $+40$ mV) ^[16, 17].

Part 2: Conduction of Nerve Impulse

1. Local Current Flow

- Depolarization at one segment of the axon causes adjacent regions to reach a threshold.
- This triggers an action potential in the next section like a domino effect.

2. Saltatory Conduction (in Myelinated Neurons)

- In myelinated axons (covered by Schwann cells or oligodendrocytes), the impulse jumps from node to node:
- Nodes of Ranvier: gaps in myelin where voltage-gated channels are concentrated.
- This makes conduction faster and more energy-efficient ^[18, 19].

3. Structure of Brain & Spinal Cord

Structure of the Brain

The brain and spinal cord together form the central nervous system (CNS), which is responsible for processing and coordinating sensory data and motor commands. Below is a structured overview of their anatomy and key components:

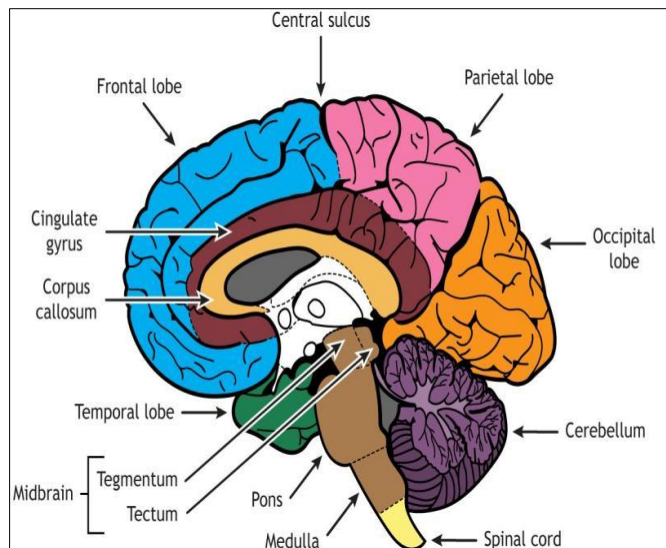


Fig 1: Structure of Brain

Structure of the Brain

The brain is divided into four main parts

1. Cerebrum

- Largest part of the brain
- Divided into two hemispheres (left and right), each controlling the opposite side of the body
- Surface is made up of gyri (ridges) and sulci (grooves)

2. Cerebellum

- Located under the cerebrum at the back of the skull
- Coordinates voluntary movements, balance, and posture

3. Diencephalon

- **Includes:**

- **Thalamus:** relays sensory information to the cerebrum
- **Hypothalamus:** controls autonomic functions like hunger, thirst, body temperature, and the endocrine system via the pituitary gland

4. Brainstem

- Connects the brain to the spinal cord
- Divided into three parts:
- **Midbrain:** controls eye movements and auditory/visual processing
- **Pons:** regulates breathing, connects cerebellum with cerebrum
- **Medulla oblongata:** controls heart rate, breathing, blood pressure

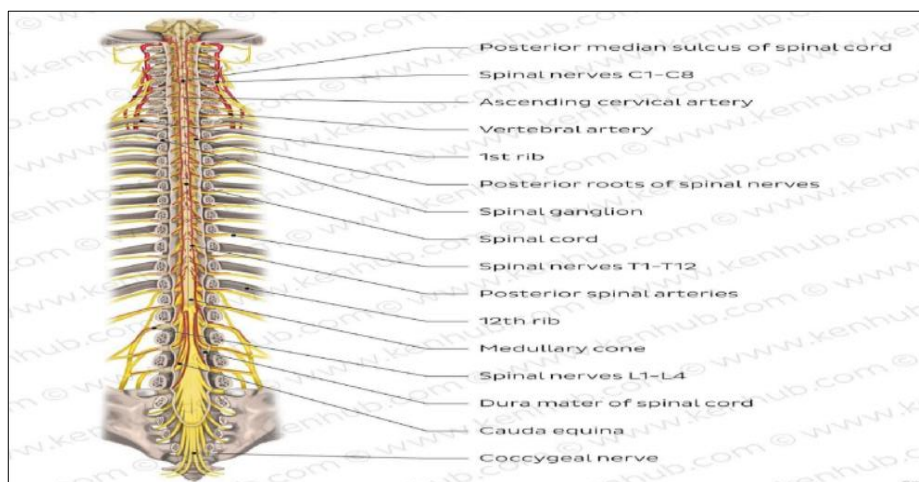


Fig 2: Structure of Spinal Cord

The spinal cord is a long, cylindrical structure extending from the medulla oblongata to the lower back, protected by the vertebral column.

Main features

Segments

- 31 spinal cord segments:
- 8 cervical
- 12 thoracic
- 5 lumbar

- 5 sacral
- Coccygeal

Gray matter (inner region shaped like an “H”):

- Contains neuronal cell bodies
- Divided into:
 - a) Dorsal (posterior) horns:** sensory neurons
 - b) Ventral (anterior) horns:** motor neurons
- **White matter** (outer region): Central canal:

Runs through the spinal cord and contains cerebrospinal fluid (CSF)

Protective Structures for Both Brain & Spinal Cord

- **Meninges** (three protective layers):
 - a) **Dura mater** - tough outer layer
 - b) **Arachnoid mater** - web-like middle layer
 - c) **Pia mater** - delicate inner layer adhering to the surface

- **Cerebrospinal Fluid (CSF)**

Cushions the brain and spinal cord 2. Provides nutrients and removes waste

- **Blood-Brain Barrier (BBB)**

Protects the brain from harmful substances in the blood [20, 21].

6. Functions of cerebrum

The cerebrum is the largest part of the human brain and is responsible for a wide range of vital functions. It is divided into two hemispheres (left and right) and is further divided into four lobes: frontal, parietal, temporal, and occipital.

Main Functions of the Cerebrum:

1. Sensory Processing

- Receives and interprets sensory information from various parts of the body (e.g., touch, temperature, pain, vision, hearing, taste, and smell).
- Each type of sensation is processed in specific regions of the cerebrum.

2. Motor Function

- a) Controls voluntary muscle movements.
- b) The primary motor cortex (in the frontal lobe) sends signals to muscles to produce movement [22, 23].

Functions of cerebellum

The cerebellum is a part of the brain located at the back of the head, beneath the occipital lobes and behind the brainstem. Although it only makes up about 10% of the brain's volume, it contains more than 50% of the brain's neurons. The cerebellum plays a key role in motor control, but it also contributes to other functions.

Main Functions of the Cerebellum:

1. Coordination of Voluntary Movements

- Ensures smooth, balanced, and precise body movements.
- Helps in tasks that require fine motor skills, like writing or playing an instrument.

2. Balance and Posture

- Integrates information from the inner ear (vestibular system), eyes (visual system), and muscles/joints (proprioceptive system) to maintain balance.
- Helps adjust posture automatically during movement.

3. Motor Learning

- Involved in learning and refining new motor skills (e.g., riding a bike, typing).
- Adjusts and fine-tunes movement patterns based on practice and feedback [24, 25].

Functions of hypothalamus

The hypothalamus is a small but crucial part of the brain located below the thalamus and just above the brainstem. It

plays a central role in maintaining homeostasis; the body's internal balance by regulating many vital physiological processes.

Main Functions of the Hypothalamus

1. Regulation of the Autonomic Nervous System

- Controls involuntary body functions like:
 - Heart rate
 - Blood pressure

2. Endocrine System Control

- Links the nervous system to the endocrine system via the pituitary gland.
- Produces oxytocin and vasopressin (ADH), which are stored and released by the posterior pituitary.

3. Temperature Regulation

- Acts as the body's thermostat.
- Detects changes in body temperature and initiates responses.

The medulla oblongata is a vital part of the brainstem that connects the brain to the spinal cord. It plays a crucial role in regulating many involuntary (autonomic) functions necessary for survival.

1. Regulation of Autonomic Functions

- Respiratory center controls the rate and depth of breathing.
- Cardiac center regulates heart rate and force of contraction.

2. Reflex Centers

- Controls reflexes like:
 - Coughing
 - Sneezing
 - Hiccupping

Drugs involved to treat the diseases related to the nervous system

Diseases related to the nervous system, which includes the brain, spinal cord, and nerves can be complex and varied. The treatment often involves drugs targeting neurotransmitters, ion channels, inflammation, or degenerative processes.

1. Neurodegenerative Diseases

Alzheimer's disease

- **Donepezil (Aricept):** Acetylcholinesterase inhibitor
- **Rivastigmine, Galantamine:** Similar action

Parkinson's disease: Parkinson's disease is a chronic and progressive neurological disorder that affects movement. It occurs due to the degeneration of dopamine-producing neurons in a part of the brain called the substantia nigra, which is responsible for controlling smooth and coordinated muscle movements.

Key Features of Parkinson's Disease

Caused by loss of dopamine, a neurotransmitter

- **Entacapone, Tolcapone:** COMT inhibitors
- **Amantadine:** Increases dopamine release

Symptoms of Parkinson disease

A. Motor Symptoms (affect movement)

1. Tremor

- Shaking, often in the hands or fingers
- Usually starts on one side (called "resting tremor")
- Bradykinesia Slowness of movement
- Makes daily tasks difficult and time-consuming
- Muscle Rigidity
- Stiffness in arms, legs, or neck. Can cause pain and limit range of motion

B. Non-Motor Symptoms (affects other body systems)

- Depression and Anxiety
- Sleep Disturbances o Insomnia, vivid dreams, REM sleep behavior disorder

2. Seizure Disorders (Epilepsy)

A seizure disorder (also known as epilepsy) is a neurological condition in which a person experiences repeated, unprovoked seizures. A seizure is a sudden burst of abnormal electrical activity in the brain that can cause changes in behavior, movement, feelings, or consciousness.

Phenytoin

- Carbamazepine
- Valproic acid

Symptoms

The symptoms of a seizure disorder (epilepsy) depend on the type of seizure and the part of the brain affected. They can range from brief staring to full-body convulsions.

1. General Symptoms of Seizure Disorders

These may occur before, during, or after a seizure:

- Sudden confusion or disorientation
- Uncontrolled jerking or shaking of limbs

2. Symptoms by Type of Seizure

A. Focal (Partial) Seizures - Affect one area of the brain

i. Focal Aware Seizures (Simple Partial)

- Person remains conscious
- Symptoms: unusual sensations (smells, tastes, sounds), twitching, visual changes

ii. Focal Impaired Awareness Seizures (Complex Partial)

- Altered awareness or confusion
- Symptoms: blank stare, repeated movements (e.g. hand rubbing, chewing)

B. Generalized Seizures - Affect both sides of the brain

i. Tonic-Clonic Seizures (Grand Mal)

- Loss of consciousness
- Body stiffens (tonic), then jerks (clonic)
- May involve tongue biting, loss of bladder control

ii. Absence Seizures (Petit Mal)

- Sudden staring and unresponsiveness (few seconds)
- Common in children

iii. Myoclonic Seizures

Sudden brief muscle jerks (like being shocked)

3. After the Seizure (Postictal Phase)

- Confusion
- Memory loss
- Difficulty speaking

3. Anxiety Disorders

Anxiety disorder is a type of mental health condition characterized by excessive, persistent, and irrational feelings of fear, worry, or nervousness that interfere with daily life and activities.

Benzodiazepines - e.g., Diazepam, Lorazepam

- **SSRIs** - e.g., Sertraline, Paroxetine
- **SNRIs** - e.g., Venlafaxine, Duloxetine
- **Bupirone** - non-benzodiazepine anxiolytic

Depression

Depression is a common and serious mental health disorder that negatively affects how a person feels, thinks, and acts. It is characterized by persistent sadness, loss of interest or pleasure in activities, and a range of emotional and physical problems.

- **SSRIs:** Fluoxetine, Citalopram
- **SNRIs:** Venlafaxine, Duloxetine
- **TCAs:** Amitriptyline, Nortriptyline
- **MAOIs:** Phenelzine, Tranylcypromine
- **Atypical antidepressants:** Bupropion, Mirtazapine

Schizophrenia & Psychosis

Schizophrenia is a chronic and severe mental disorder that affects how a person thinks, feels, and behaves. People with schizophrenia often appear to have lost touch with reality.

- **Typical antipsychotics:** Haloperidol, Chlorpromazine
- **Atypical antipsychotics:** Risperidone, Olanzapine, Clozapine, Aripiprazol

4. Multiple Sclerosis (MS)

Multiple Sclerosis (MS) is a chronic autoimmune disease that affects the central nervous system (CNS) specifically the brain and spinal cord. It occurs when the body's immune system mistakenly attacks the myelin sheath, the protective covering of nerve fibers, leading to inflammation and damage.

- Interferon-beta
- Glatiramer acetate
- Fingolimod sphingosine-1-phosphate receptor modulator
- Natalizumab, Ocrelizumab monoclonal antibodies
- Steroids - for acute attacks

Neuropathic Pain

Neuropathic pain is a type of chronic pain that occurs when there is damage or dysfunction in the nerves, spinal cord, or brain. It is caused by a problem within the nervous system itself, rather than by an external injury like a cut or inflammation.

- Gabapentin, Pregabalin
- Amitriptyline (a TCA)
- Duloxetine (an SNRI)
- Carbamazepine - especially in trigeminal neuralgia
- Migraine

A migraine is a type of neurological headache disorder characterized by recurrent episodes of moderate to severe headaches, often accompanied by other symptoms such as nausea, vomiting, and sensitivity to light or sound.

Acute attacks**Triptans:** Sumatriptan, Rizatriptan

- NSAIDs, Ergotamine
- Prophylaxis
- **Beta-blockers:** Propranolol

5. **Sleep Disorders:** Sleep disorders are a group of conditions that affect the ability to sleep well regularly. Whether due to health problems, lifestyle choices, or other issues, these disorders can cause problems falling asleep, staying asleep, or staying awake during the day.

- **Insomnia:** Zolpidem, Eszopiclone, Melatonin
- **Narcolepsy:** Modafinil, Sodium oxybate

8. Recent Advancements in the Nervous System (2023-2025)**1. Brain-Computer Interfaces (BCIs)**

- **Example:** Neuralink (Elon Musk's company) received FDA approval for human trials in 2023.
- **Impact:** Enables direct communication between the brain and external devices. Promising applications in paralysis, stroke recovery, and neurodegenerative diseases.

2. Gene Editing & CRISPR Therapies

- **Advancement:** Use of CRISPR-Cas9 and newer base-editing tools to target neurological genetic disorders.
- Applications
 - a) Huntington's disease
 - b) ALS (Amyotrophic Lateral Sclerosis)
 - c) Spinal muscular atrophy (SMA)

3. AI in Neuroscience

- AI models now predict neural activity and decode thoughts or visual images from brain scans (like fMRI).
- Used in diagnosing Alzheimer's and predicting outcomes for brain injuries or tumor

9. Conclusion

Here is a detailed conclusion of the nervous system, covering its structure, function, and importance in maintaining life and homeostasis:

Conclusion of the Nervous System (Detailed)

The nervous system is a highly complex and vital system that plays a central role in regulating and coordinating bodily functions. It enables humans and animals to perceive their environment, respond to internal and external stimuli, and maintain homeostasis. The nervous system is divided into two main parts: the central nervous system (CNS) and the peripheral nervous system (PNS).

1. Integration and Control Center

The CNS, consisting of the brain and spinal cord, acts as the control center. It processes sensory information, interprets it, and initiates appropriate responses.

2. Communication Pathways

The PNS comprises nerves and ganglia outside the CNS. It connects the brain and spinal cord to the rest of the body, allowing bidirectional communication. It is further divided into:

- The somatic nervous system: controls voluntary muscles and sensory information.

- The autonomic nervous system (ANS): regulates involuntary functions (heart rate, digestion, respiration) and includes the sympathetic and parasympathetic divisions.

3. Fast and Efficient Signaling

The nervous system uses electrical impulses (action potentials) and chemical messengers (neurotransmitters) to transmit signals rapidly and precisely. This allows instantaneous reactions, making it crucial for survival, especially in dangerous or rapidly changing environments.

Key Takeaways

- The nervous system is essential for all body activities, from simple reflexes to complex thinking.
- It provides rapid communication, coordination, and control through electrical and chemical signaling.

References

1. Asan AS, McIntosh JR, Carmel JB. Targeting sensory and motor integration for recovery of movement after CNS injury. *Front Neurosci.* 2022 Jan 21;15:791824. DOI: 10.3389/fnins.2021.791824. PMID: 35126040; PMCID: PMC8813971.
2. Katz-Sidlow RJ. The formulation of the neuron doctrine: the island of Cajal. *Arch Neurol.* 1998 Feb;55(2):237-240. DOI: 10.1001/archneur.55.2.237. PMID: 9482368.
3. Ludwig PE, Reddy V, Varacallo MA. Neuroanatomy, central nervous system (CNS). *Treasure Island (FL): StatPearls Publishing;* 2025 Jan-. 2022 Oct 10. PMID: 28723039.
4. Zabłocka A, Janusz M. Struktura i funkcjonowanie ośrodkowego układu nerwowego [Structure and function of the central nervous system]. *Postepy Hig Med Dosw (Online).* 2007 Jul 30;61:454-460. Polish. PMID: 17679915.
5. Murtazina A, Adameyko I. The peripheral nervous system. *Development.* 2023 May 1;150(9):dev201164. DOI: 10.1242/dev.201164. Epub 2023 May 12. PMID: 37170957.
6. Kennard MA. Autonomic interrelations with somatic nervous system. *Psychosom Med.* 1947 Jan-Feb;9(1):29-36. DOI: 10.1097/00006842-194701000-00003. PMID: 20284394.
7. Sasaki M, Suzuki H. [The autonomic and somatic nervous systems]. *No To Shinkei.* 1985 Jan;37(1):43-52. Japanese. PMID: 3978002.
8. Bianco V, Borgatti R, Berchicci M. Behavioral and neural mechanisms underlying sensory-motor integration. *Brain Sci.* 2024 Aug 14;14(8):812. DOI: 10.3390/brainsci14080812. PMID: 39199503; PMCID: PMC11352412.
9. Moreno-López Y, Olivares-Moreno R, Cordero-Erausquin M, Rojas-Piloni G. Sensorimotor integration by corticospinal system. *Front Neuroanat.* 2016 Mar 9;10:24. DOI: 10.3389/fnana.2016.00024. PMID: 27013985; PMCID: PMC4783411.
10. Schieber MH. Mechanisms of reflex and voluntary control of movements. *Prog Brain Res.* 2000;129:289-297. DOI: 10.1016/s0079-6123(00)29031-3.
11. Pierrot-Deseilligny E, Burke D. The circuitry of the human spinal cord: its role in motor control and

- movement disorders. Cambridge: Cambridge University Press; 2005.
12. Hammond C. Functional neuroanatomy of reflexes. *J Clin Neurophysiol.* 2007;24(2):134-149. DOI: 10.1097/WNP.0b013e31804c53a7.
 13. Hille B. Ion channels of excitable membranes. 3rd ed. Sunderland (MA): Sinauer Associates; 2001.
 14. Bean BP. The action potential in mammalian central neurons. *Nat Rev Neurosci.* 2007 Jun;8(6):451-465. DOI: 10.1038/nrn2148.
 15. Hartline DK. Saltatory conduction and the molecular mechanism of myelination. *Nature.* 2008 Mar 6;453(7194):932-939. DOI: 10.1038/nature07075.
 16. Waxman SG. Conduction in myelinated, unmyelinated, and demyelinated fibers. *Arch Neurol.* 1977 Sep;34(9):585-589. PMID: 894487.
 17. Karageorgi S, McGrath M, Lee IM, Buring J, Kraft P, De Vivo I. Polymorphisms in genes hydroxysteroid-dehydrogenase-17b type 2 and type 4 and endometrial cancer risk. *Gynecol Oncol.* 2011 Apr;121(1):54-58. DOI: 10.1016/j.ygyno.2010.11.014. Epub 2010 Dec 3. PMID: 21129770; PMCID: PMC3062639.
 18. Kuntsche J, Koch MH, Fahr A, Bunjes H. Supercooled smectic nanoparticles: influence of the matrix composition and *in vitro* cytotoxicity. *Eur J Pharm Sci.* 2009 Oct 8;38(3):238-248. DOI: 10.1016/j.ejps.2009.07.012. Epub 2009 Aug 5. PMID: 19664705.
 19. Thinnes FP. Plasmalemmal VDAC-1 corroborated as amyloid A β -receptor. *Front Aging Neurosci.* 2015 Sep 30;7:188. DOI: 10.3389/fnagi.2015.00188. PMID: 26483684; PMCID: PMC4588700.
 20. Parsons LM, Fox PT. Sensory and cognitive functions. *Int Rev Neurobiol.* 1997;41:255-271. DOI: 10.1016/s0074-7742(08)60355-4. PMID: 9378591.
 21. Daum I, Ackermann H. Cerebellar contributions to cognition. *Behav Brain Res.* 1995 Mar;67(2):201-210. DOI: 10.1016/0166-4328(94)00144-5. PMID: 7779291.
 22. Strick PL, Dum RP, Fiez JA. Cerebellum and nonmotor function. *Annu Rev Neurosci.* 2009;32:413-434. DOI: 10.1146/annurev.neuro.31.060407.125606. PMID: 19555291.