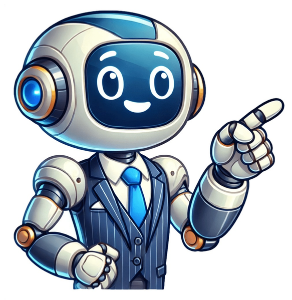

A neurophysiologist is a healthcare provider who has expertise in assessing how your nervous system is functioning, especially its electrical activity. They perform tests and diagnose neurological conditions.Your nervous system (brain, spinal cord and nerves) is your body's command center. It controls everything you think, feel and do — from moving your arm to the beating of your heart.What's the difference between a neurophysiologist and a neurologist?A neurophysiologist is a specialist in the field of neurology.A neurologist is a medical doctor who has training in all aspects of your nervous system, including its general anatomy and function and the conditions that affect it. A neurophysiologist is a neurologist who has specialized knowledge specifically on the function of your nervous system. They perform tests and interpret the results to do so.A neurophysiologist often doesn't recommend treatment for neurological conditions, but a neurologist does.What does a neurophysiologist do?A neurophysiologist assesses and diagnoses conditions that affect the function of your body's nervous system. They mainly do this by performing and analyzing a variety of tests that record your nervous system's electrical activity.There are two main types of neurophysiologists: surgical neurophysiologists and clinical neurophysiologists. They each have specific roles and responsibilities.Some neurophysiologists mainly work in research.Surgical neurophysiologistsA surgical neurophysiologist is part of the surgical team. They work closely with the anesthesiologist or nurse anesthetist, surgeons (like neurosurgeons) and other providers.During surgery, a neurophysiologist tests and monitors your nervous system. Depending on the type of surgery, this monitoring assists your surgeons in avoiding or reducing complications like paralysis, hearing loss or stroke.Surgical neurophysiology is also called intraoperative neurophysiology monitoring (IONM).Some common surgeries that involve a neurophysiologist include:Spinal surgery.Certain types of brain surgery.Certain ear, nose and throat (ENT) procedures.Peripheral nerveVascular surgeries, like carotid endarterectomies and thoracic-abdominal aortic aneurysms (TAAA).Surgical neurophysiologists use several different testing and monitoring systems during surgery, a few of which include:SSEP (somatosensory evoked potentials): This test records the response of your brain, nerves or spinal cord to electrical stimulation of a peripheral nerve. Surgical neurophysiologists commonly use it during spine surgery and in some brain and peripheral nerve surgeries.TCeMEP (transcranial electrical motor evoked potentials): This test records the response of your spinal cord or limb muscles to an electrical stimulus applied to the motor cortex of your brain. Surgical neurophysiologists commonly use it during spine surgery.BSEP (brainstem auditory evoked response): This test records the response of your brainstem to an auditory stimulus — usually a clicking sound delivered through earphones. Surgical neurophysiologists use it to monitor brainstem function and to help preserve hearing in acoustic neuroma and brainstem tumor surgeries.EEG (electroencephalogram): This test records spontaneous brain activity. Surgical neurophysiologists use it to monitor the function and "health" of your cerebral cortex to avoid injuries caused by ischemia (reduced blood flow) during carotid endarterectomies and aneurysm clippings.Clinical neurophysiologistsClinical neurophysiologists work closely with neurologists and neurosurgeons. They perform tests to assess the function of your nervous system and diagnose certain neurological and neuromuscular conditions. They may perform these tests in an outpatient setting or as part of your stay in a hospital, depending on your situation.Tests that clinical neurophysiologists use include:EMG (electromyography): This is a diagnostic test that evaluates the health of your skeletal muscles and the nerves that control them. It can help diagnose several conditions, including peripheral neuropathy, carpal tunnel syndrome, muscular dystrophy and amyotrophic lateral sclerosis (ALS).Nerve conduction study (NCS): This is a diagnostic test that evaluates the function of your peripheral nerves. An NCS can help detect the presence and extent of peripheral nerve damage. Neurophysiologists often perform EMGs and NCSs together.Electroencephalogram (EEG): This test involves sticking electrodes on the surface of your scalp to record electrical activity from your cerebral cortex. Clinical neurophysiologists use it to evaluate seizures and various abnormalities of the central nervous system.Evoked potential test: Evoked potential tests measure the electrical activity in areas of your brain and spinal cord in response to certain stimuli. They record how quickly and completely nerve signals reach your brain. There are several kinds, including brainstem auditory evoked response (BAER), visual evoked potential (VEP) and somatosensory evoked potential (SEP).Sleep study (polysomnography): This is a diagnostic test that tracks and records how multiple body systems work while you're asleep. Clinical neurophysiologists use it to diagnose sleep disorders. THE NEURON The functional unit of the nervous system is the neuron, a term coined by Waldeyer in 1891. Neurons are the excitable cells of nervous tissue which conduct impulses. They arise from the neuroblasts of neural tube and neural crest origin. The complex nervous systems of vertebrates, especially humans, represent remarkably coordinated networks of these fundamental units. Thus it is not surprising to find great diversity in the form and function of individual neurons. Consequently, neurons are classified according to a number of different criteria: (1) morphology or appearance, (2) anatomical location, (3) whether they are sensory or motor, (4) conduction velocity, (5) fiber diameter, and (6) whether they are myelinated or not. Morphological Classification Neurons are single cells composed of a perikaryon or cell body (soma) and a variable number of neurites (processes) extending out from it. Adult neurons are classified as monopolar, bipolar, or multipolar according to whether the perikaryon has one, two, or many neurites (Fig-1). Monopolar Neurons Monopolar neurons have only one prominent neurite extending from the perikaryon, which then branches into two long processes, one central (directed toward the CNS) and one peripheral (directed away from the CNS). Most neurons of this type are sensory and are exclusively located in the peripheral nervous system. The dorsal root ganglion cells of the spinal nerves are monopolar neurons. They relay information from receptors sensitive to touch, pressure, pain, temperature, and stretch, as well as body position and movement. Bipolar Neurons Bipolar neurons have two prominent neurites extending from the perikaryon. One conducts impulses toward and one away from the soma. Bipolar neurons are found in the retina, the cochlear and vestibular ganglia, the olfactory epithelium, and in some parts of the central nervous system. Multipolar Neurons These are by far the most common type of neuron. They populate both the central and peripheral nervous systems and are characterized by several short, highly branched processes called dendrites and a single, long process extending out from the soma called an axon. A slight enlargement at the point where the axon leaves the soma, called the axon hillock, is often observed. Considerable confusion exists regarding the proper use of the terms dendrite and axon. A workable definition is that dendrites are the processes which are specialized to receive stimuli from other cells, while the axon is specialized to conduct impulses. This applies quite adequately to multipolar neurons, but the terms are arbitrary and confusing when applied to monopolar and bipolar neurons. Both the central and peripheral processes of the latter two types conduct impulses. Some neuroscientists refer to both as axons while others call the central process an axon and the peripheral process a dendrite. A system proposed by Bodian describes that portion of the neuron which is specialized to receive stimuli from other neurons or receptors as the dendritic zone. He further describes that portion which is specialized to conduct impulses (essentially the rest of the neuron) as the axon. Accordingly, the soma is included in the dendritic zone of multipolar neuron because a considerable number of synapses (contacts) from other neurons converge on it. However, no synaptic contacts are made with the somas of monopolar and bipolar neurons. In fact, only a very limited part of one of the processes of these latter two types actually receives synaptic contacts from other neurons or receptors. Thus this limited area represents the dendritic zone of monopolar and bipolar neurons. Impulses generated here are then conducted over the rest of the neuron, including the soma. In Bodian's system all of this impulse-conducting portion is the axon. The dendritic zones and axons of the three types of neurons are illustrated in Fig-2. Fig-1 Fig-2 Classification of Nerve Fibers by Group and Type A neuron is afferent to a particular site if it conducts impulses toward it and efferent from that site if it conducts impulses away. For example, a neuron which conducts impulses from the thalamus to the cerebral cortex is efferent from the thalamus and afferent to the cerebral cortex. An efferent neuron which directly innervates a muscle or a gland and causes it to respond in some way is called a motor neuron. An afferent neuron which responds to changes in the external or internal environment and gives rise to conscious sensation is termed a sensory neuron. The latter is a strict definition of the term sensory. Not all afferent neurons give rise to conscious sensation, and thus not all afferent neurons are sensory. Nevertheless, the two terms (sensory and afferent) are often used interchangeably. Historically, mammalian PNS nerve fibers can be classified by group or type because of an observed correlation between conduction velocity and fiber diameter. The group system classifies afferent fibers only, while the type system classifies both. The two systems are codified in Table-1. Table-1 Group and Type Classification of Mammalian Nerve Fibers Group Type Fiber diameter µm Conduction velocity m/s Description Ia A 13-22 70-120 Alpha motor neurons to skeletal muscles A 13-22 70-120 Primary afferents from muscle spindles Ib A 13-22 70-120 Afferents from Golgi tendon organs II A 8-13 40-70 Secondary afferents from muscle spindles, afferents from touch and pressure receptors A 4-8 15-40 Gamma motor neurons to muscle spindles III A 1-5 5-15 Afferents from touch, pressure, pain, and temperature receptors B 0.1-3 0.3-14 Preganglionic autonomic fibers C 0.1-3 0.2-2 Postganglionic autonomic fibers IV C 0.1-3 0.2-2 Afferents from pain and temperature receptors Nerves and Nerve Fiber Tracts The long process which extends out from the soma of the nerve cell is also called a nerve fiber. These fibers are distributed throughout the peripheral nervous system in anatomically distinct structures called nerves. It is important to note that nerves exist only in the peripheral nervous system. There are no nerves within the brain or spinal cord itself. Instead, nerve fibers are distributed throughout the central nervous system in reasonably distinct anatomical groupings called nerve fiber tracts. Thus it is appropriate to speak of a spinal or cranial nerve since it is part of the peripheral nervous system but not to speak of a nerve within the brain or spinal cord. Tract is the appropriate terminology here. An example is the anterior spinothalamic tract, which is composed of a group of fibers which conduct impulses from the spinal cord to the thalamus, a route entirely within the CNS. Schwann Cells The Schwann cells are the nonexcitable cells of the peripheral nervous system. By definition they do not conduct impulses. Recall that Schwann cells are derived from Schwann cell precursors of the primitive neural crests. They develop in close association with all of the neuroblasts of the peripheral nervous system. In some cases this association is so close that the Schwann cells wrap many times around the axon of a developing neuron, laying down layer after layer of myelin and producing a myelinated neuron. In other cases, the association is not characterized by wrapping Schwann cells and the neuron remains non myelinated. Myelinated Neurons In those neurons destined to become myelinated, a Schwann cell begins to wrap around a given length of axon in a spiral fashion. In doing so, the Schwann cell extrudes its cytoplasm as its two membranes press together. In this manner it lays down layer after layer of its own membrane, forming a laminated sheath of highly lipid material called myelin. Several Schwann cells myelinate a single axon in this manner, each on a different section of its length. Because of the tight packing and lamination of the myelin, the small volume of fluid in the periaxonal space immediately surrounding the axon (Figs-3 and 4) is not readily interchangeable with the extracellular fluid of the nerve trunk. The external and internal mesaxons formed by the circling Schwann cell are not free conduits for fluid exchange. The mesaxon is the double membrane formed by the Schwann cell. Thus the axonal membrane is only in contact with a freely interchangeable fluid space at the node of Ranvier, where one Schwann cell meets another. The unique anatomical arrangement of Schwann cells around the axons of myelinated neurons endows them with a special pattern of impulse conduction called saltatory conduction. The entire Schwann cell is surrounded by a basement membrane, which together with the outer Schwann cell membrane comprises the neurilemma. Fig-3 Fig-4 Nonmyelinated Neurons Postganglionic autonomic fibers as well as some of the very narrow diameter nerve fibers from pain and temperature receptors form a rather loose relationship with Schwann cells. These type C nerve fibers are usually found running in long, deep longitudinal depressions in Schwann cells (Fig-4). A single Schwann cell may have depressions for several narrow fibers. In this case, unlike myelinated axons, the extracellular fluid of the nerve trunk is in contact with the axonal membrane via a gap in the mesaxon which is continuous with the periaxonal space. Thus the entire non myelinated axon is in constant contact with a freely interchangeable fluid space and the pattern of impulse conduction is therefore not saltatory as observed in myelinated axons. Even though Schwann cells are in intimate contact with these axons, they are not myelinated because they have not been wrapped by the cells. The characteristics of saltatory and nonsaltatory conduction will be explained in detail elsewhere. As Fig-4 shows, Schwann cells form loose contacts with nonmyelinated axons and several of the cells interdigitate with each other enveloping the axon throughout its length. Neuroglial Cells Neuroglia ("neural glue") is a fine web of tissue which is composed of peculiar branched cells called neuroglial cells. They are located in the central nervous system only and fall into two categories: macroglia and microglia. Macroglial cells are derived from glioblasts of the neural tube and include small starshaped cells called astrocytes as well as oligodendrocytes, which are the CNS equivalent of Schwann cells. Microgliocytes are small nonneural cells, possibly of mesodermal origin. Neuroglial cells playa variety of roles in the CNS. Astrocytes appear to influence the transport of materials to the neurons of the central nervous system as well as to function to maintain an appropriate ionic environment for the neurons. Oligodendrocytes are responsible for myelinating the neurons of the central nervous system. However, unlike a single Schwann cell, which can only myelinate a single axon, each oligodendrocyte can myelinate the axons of several CNS neurons. As previously mentioned, microgliocytes are probably not of CNS origin at all. They are small cells of various forms with slender, branched processes which migrate into the CNS and act as phagocytes scavenging for waste products and breakdown components of CNS neurons. Ependymal Cells Recall that the ependyma is a single layer of epithelial cells lining the ventricles of the brain and the central canal of the spinal cord. They arise from the fixed neuroepithelial cells lining the neural tube. Later they differentiate into the ependymal linings of the central nervous system. Neuroscientists define the central nervous system as the brain and spinal cord. The brain is considered to include the cerebral hemispheres, brainstem, and cerebellum. The brainstem includes the diencephalon, midbrain, pons, and medulla oblongata. The Brain Several surface features of the brain are illustrated in Fig-5. When the meningeal coverings are removed it is apparent that the cerebrum is divided into two equal hemispheres by a deep median, longitudinal fissure. It is also apparent that the surface of each hemisphere is very irregular with many ridges (gyri) separated by shallow grooves (sulci). A particularly deep sulcus is called e fissure. A central sulcus separates each hemisphere into a frontal (anterior) lobe and a parietal (posterior) lobe. A temporal lobe is separated from the frontal lobe in each hemisphere by a lateral fissure. The occipital lobe in each hemisphere is marked off by the parietooccipital fissure and the preoccipital notch. Additional features of the anterior lobe are the superior, middle, and inferior frontal gyri and sulci. Just anterior to the central sulcus is the precentral sulcus and gyrus, while just posterior to it in the parietal lobe is the postcentral gyrus and sulcus. Each temporal lobe is characterized by a superior, middle, and inferior temporal gyrus and sulcus. Several additional brain features can be seen in the median sagittal section illustrated in Fig-6. The cingulate gyrus is a primitive band of cortical tissue circling the corpus callosum. The latter is a thick band of commissural (connecting) fibers between the two cerebral hemispheres. The septum pellucidum is a thin membrane separating the cerebrospinal fluid of the two lateral hemispheres. It can be seen between the fornix and the anterior portion of the corpus callosum. The medial surfaces of the thalamus and hypothalamus form the lateral walls of the third ventricle, which is continuous with the lateral ventricles above through the foramina of Monro and with the fourth ventricle below through the cerebral aqueduct. The anterior and posterior comrnissures, like the corpus callosum, are bands of fibers which connect the two hemispheres. The pineal body and colliculi are prominent features of the posterior brainstem, while the optic chiasm, pituitary gland, and mammillary bodies are prominent anterior features. Fig-5 Fig-6 The Spinal Cord The spinal cord is the caudal extension of the brain stem into the vertebral canal. It is essentially a long, narrow structure with a cervical and lumbar enlargement. The cervical enlargement is due to the great number of afferent and efferent spinal nerve fibers from this region which innervate the arms. The lumbar enlargement represents a similar innervation of the leg musculature. Several prominent sulci are noticeable in a posterior view of the cord (Fig-7). These include a single posterior median sulcus with posterior intermediate and posterior lateral sulci on either side of it. An anterior view shows an anterior median fissure with an anterior lateral sulcus on either side. A long, thin extension of the spinal cord, the filum terminale, extends to the coccyx at the tip of the sacrum. A cross section of the spinal cord at any level will show the characteristic butterfly-shaped pattern of gray matter surrounded by white matter. In Fig-8 notice that the relative amount of gray matter to white matter varies from one level of the cord to another. Spinal Cord White Matter The spinal cord white matter is divided into three large regions called funiculi. The posterior funiculus is bounded by the posterior median and posterior lateral sulci (Fig-9). The lateral funiculus is that region of white matter between the posterior lateral and anterior lateral sulci. The anterior funiculus is bounded by the anterior lateral sulcus and the anterior median fissure. The white matter on both sides of the cord is continuous through the anterior white commissure. Fig-8 Fig-9 Fig-10 Fig-7 Fig-11 Ascending and Descending Tracts in the Spinal Cord White Matter The spinal cord white matter is composed of millions of ascending and descending fibers. The ascending fibers conduct impulses up the cord while descending fibers conduct impulses downward. Most of these fibers have also been myelinated by oligodendrocytes, and it is their resulting myelin sheaths which give the white matter its characteristic color. Most of the spinal cord fibers are grouped together in functional units called tracts. The descending tracts typically become smaller as they pass downward through the cord. This is caused by fibers continually leaving the tracts as they reach their specific destinations. Ascending tracts, with each tract associated with a functional role. The addition of a functional component as well as an examination of the clinical signs associated with selective destruction of the various tracts will make it easier to comprehend the anatomical distribution of the tracts illustrated in Fig-10. Spinal Cord Gray Matter The gray matter in each half of the cord is subdivided into a posterior, intermediolateral, and anterior horn. The gray commissure connects the gray matter on each side of the cord around the central canal (Fig-11). Recognize that Fig-11 is also a composite. Comparison with Fig-8 will help to clarify what a composite is. Because the anterior horn contains the cell bodies of motor neurons to the skeletal muscles, it is considerably larger in the cervical and lumbar enlargements where the cord gives rise to the spinal nerves innervating the arms and legs. Also, because most of the sensory fibers of spinal nerves terminate in the posterior horn, it is not surprising to find a larger horn in the cervical and lumbar regions than in the thoracic cord. An intermediolateral horn, which gives rise to preganglionic sympathetic neurons, is found only in cross sections of the cord between T1 and L2. A similar region giving rise to preganglionic parasympathetic neurons is located in the intermediate gray matter of sacral cord segments 2 to 4. However, unlike segments T1 through L2, it does not extend as a noticeable lateral "horn." Laminar Architecture of the Gray Matter A convenient way to subdivide the gray matter of the spinal cord is according to the general cytoarchitecture found in its various regions. These cell regions, or laminae, are illustrated in Fig-12. It should be noted that this scheme is based on the spinal cord of the cat. Nevertheless, the system is being applied with due caution to humans. Fig-12 Laminae I, II, III, and IV are thought to be the principal sensory receiving areas for afferent input to the cord. Laminae V and VI deal with proprioceptive input (dealing with body position and movement) as well as input from the cerebral cortex and other higher centers. Lamina VII has connections with many higher centers. Lamina VIII receives input from the opposite side of the cord as well as having numerous connections with higher brain centers. Lamina IX is the region of alpha and gamma motor neurons to skeletal muscles. Lamina X is probably a commissural area. It cannot be overstressed that the suspected roles assigned to the laminae above represent a considerable oversimplification. Nevertheless, it gives a basis for understanding synaptic relays as they relate to ascending and descending tracts in the cord and afferent input and efferent output with spinal nerves. PERIPHERAL NERVOUS SYSTEM The peripheral nervous system is composed of 12 pairs of cranial nerves and 31 pairs of spinal nerves. It represents an extension of the central nervous system into the far reaches of the body. Each spinal nerve contains both afferent and efferent fibers while cranial nerves, on the other hand, are more diverse. Some are afferent only, some are efferent only, and some are mixed (both afferent and efferent). Spinal Nerves Each pair of spinal nerves extends laterally from the cord at regular intervals from cervical to coccygeal regions. The spinal nerves leave the vertebral canal via regular openings in the vertebral column called intervertebral foramina (Fig-14). Each spinal nerve is named according to the intervertebral foramina through which it exits. Notice in Fig-13 that there is one spinal nerve pair for each vertebra with the exception of the cervical region, where there are seven cervical vertebrae but eight cervical nerve pairs. Fig-13 Fig-14 Each spinal nerve communicates with the spinal cord via two short roots, one posterior (dorsal) and one anterior (ventral). The anterior and posterior roots of the spinal nerves lie entirely within the vertebral canal. They join and form the spinal nerve just before it exits the vertebral canal through the intervertebral foramen. At the point where spinal nerves T1 through L2 leave their respective foramina, two short arms (rami communicantes) connect the spinal nerve with a sympathetic ganglion lying adjacent to the body of the vertebra (Fig-14). A ganglion is a group of cell bodies located outside of the CNS. These 14 ganglia are connected to each other to form a vertical sympathetic chain. Three additional ganglia, the superior, middle, and inferior cervical, join the chain superiorly while another three to five ganglia in the lumbar region join it inferiorly. Thus 20 to 22 ganglia make up the sympathetic chain on each side of the cord. The three cervical ganglia and the last three to five ganglia in the chain communicate with spinal nerves via only one ramus while the ganglia associated with spinal nerves T1 through L2 communicate through two. Cranial Nerves There are 12 pairs of cranial nerves communicating directly with the brain. They are analogous with the 3 1 pairs of spinal nerves which communicate with the spinal cord. They include the following: I Olfactory VII Facial II Optic VIII Vestibulocochlear III Oculomotor IX Glossopharyngeal IV Trochlear X Vagus V Trigeminal XI Accessory VI AbducCNS XII Hypoglossal Cranial Nerve Emergence and the Brainstem The cranial nerves and their relationship to the brain stem are shown in Fig-15. The olfactory nerves (I) enter through the cribiform plate of the ethmoid bone as 20 to 30 fila (threadlike structures) to contact the olfactory bulb. The optic nerves (II) cross anterior to the pituitary gland in the optic chiasm and continue around the cerebral peduncles of the midbrain as the optic tracts. The oculomotor nerves (III) originate in the midbrain and emerge anteriorly close together at the superior border of the pons. The trochlear nerves (IV) emerge from the posterior surface of the midbrain just below the inferior colliculi. From here they wrap around the cerebral peduncles to appear anteriorly at the superior border of the pons. The trigeminal nerves (V) arise from the anterolateral surface of the pons. The abducens nerves (VI) originate in the pons and emerge close together at the anterior inferior border of the pons. The facial nerves (VII). originating in the pons. and the vestibulocochlear nerves (VIII), which originate in the upper medulla. emerge laterally at the pontomedullary border. Fig-15 Emerging from the lateral medulla posterior to the olive (a rounded elevation lateral to the pyramids in the medulla oblongata) in order from superior to inferior are the glossopharyngeal nerves (IX), vagus nerves (X), and bulbar accessory nerves (XI). Appearing with them but originating in the spinal accessory nuclei of the upper cervical cord are the spinal portions of the accessory nerves. the spinal accessory nerves (XI). Finally, arising from the lateral medulla anterior to the olive are the hypoglossal nerves (XII). CLASSIFICATION OF SPINAL AND CRANIAL NERVE FIBERS Spinal nerve fibers are either afferent or efferent with respect to the spinal cord (Table-2). The spinal efferent fibers are either somatic (innervating skeletal muscles derived from mesodermal somites) or visceral (innervating cardiac muscle, smooth muscle, or glands). Similarly, spinal afferent fibers are also classified as either somatic or visceral. All are called general fibers. Cranial nerve fibers are classified in the same manner as spinal nerve fibers (Table-2). However, there is also a special classification. Nerve fibers classified as special innervate the special sense organs involved in hearing, seeing, smelling, and tasting. In addition, special fibers innervate the vestibular system and those skeletal muscles derived from the mesoderm of the branchial arches (embryonic segments which give rise to structures in the ear and neck). Table-2 Classification of Spinal and Cranial Nerve Fibers I Spinal nerve fiber classification A General afferent fibers. The afferent unipolar neurons of the posterior root of the spinal cord with cell bodies in the posterior root ganglia 1 General somatic afferent (GSA) From exteroceptors responding to touch, pressure, pain, and temperature as well as from the proprioceptors of muscles, tendons, and joints 2 General visceral afferent (GVA) From interoceptors of the viscera B General efferent fibers. The efferent multipolar neurons with cell bodies in the anterior and intermediolateral horns of the spinal cord gray matter 1 General somatic efferent (GSE) The alpha and gamma motor neurons to somatic skeletal muscle and muscle spindles with cell bodies in the anterior horn of the spinal cord gray matter 2 General visceral efferent (GVE) The autonomic fibers to cardiac muscle, smooth muscle, and glands II Cranial nerve fiber classification A General afferent fibers. The afferent unipolar neurons with cell bodies in the craniospinal ganglia 1 General somatic afferent (GSA). From exteroceptors responding to touch, pressure, pain, and temperature as well as from the proprioceptors of muscles, tendons, and joints 2 General visceral afferent (GVA). From interoceptors of the viscera B Special afferent fibers. The afferent neurons from the special sense organs (eye, ear, nose, and tongue) and the vestibular system 1 Special somatic afferent (SSA). Exteroceptors from the eye and ear as well as proprioceptors from the vestibular system 2 Special visceral afferent (SVA). Exteroceptors from the olfactory epithelium and the taste buds C General efferent fibers. The efferent neurons originating in brainstem nuclei innervating somatic skeletal muscle as well as those innervating cardiac muscle, smooth muscle, and glands 1 General somatic efferent (GSE). To somatic skeletal muscles 2 General visceral efferent (GVE). The autonomic fibers to cardiac muscle, smooth muscle, and glands D Special efferent fibers. The efferent neurons originating in brainstem nuclei innervating branchiomeric skeletal muscle 1 Special visceral efferent (SVE). To branchiomeric skeletal muscles Author: Christina Loukopoulou, MSc • Reviewer: Dimitrios Mytilinaios, MD, PhD Last reviewed: September 18, 2024 Reading time: 21 minutes Neurophysiology is the branch of physiology dedicated to understanding the mechanisms and functions of the nervous system, the body's most intricate and vital network. It delves into the dynamic interplay between the brain, spinal cord, and peripheral nerves, unraveling the ways in which these structures work in unison to regulate everything from basic physiological processes to advanced cognitive functions.At its core, neurophysiology examines how neurons, the fundamental units of the nervous system, communicate through electrochemical signals, how they integrate vast amounts of information, and how they generate precise, coordinated responses to both internal and external stimuli. Key facts about neurophysiology Neurophysiology Study of the nervous system, focusing on neuron communication, action potentials, and coordinating the body's responses to stimuli. Central Nervous System (CNS) Comprises the brain and spinal cord; responsible for processing sensory information and generating commands. Peripheral Nervous System (PNS) Includes nerves outside the CNS; divided into the somatic (voluntary movements) and autonomic (involuntary functions) systems. Homeostasis The nervous system maintains stable internal conditions through feedback mechanisms (e.g., temperature regulation). Motor control (efferent division) Involves brain, spinal cord, and peripheral nerves to regulate muscle movement; controlled by the motor cortex, basal ganglia, and cerebellum. Autonomic responses Involuntary actions controlled by the autonomic nervous system, including heart rate and digestion; divided into sympathetic ("fight-or-flight") and parasympathetic ("rest-and-digest"). General senses Includes touch, temperature, pain, pressure, and proprioception; detected by various receptors throughout the body. Special senses - Vision: Light detection by eyes; processed in the occipital lobe.- Hearing: Sound waves detected by the ear; processed in the temporal lobe.- Smell and taste: Chemical detection by olfactory receptors and taste buds.- Vestibular sensations: Balance and spatial orientation via the vestibular system in the inner ear. Neuronal signaling Neurons communicate via action potentials and synaptic transmission involving neurotransmitters. Neurotransmitters Chemical messengers; classified as excitatory (e.g., glutamate) or inhibitory (e.g., GABA), regulating various functions like mood, cognition, and sleep. Neurological disorders Includes Alzheimer's, Parkinson's, epilepsy, multiple sclerosis, stroke, and migraines, affecting different aspects of brain and nervous system functionality. From a structural point of view, the nervous system is divided into two major components: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS includes the brain and spinal cord, serving as the main control center. The brain, housed within the skull, is the most complex organ, containing billions of neurons communicating through trillions of synapses. It is responsible for processing sensory information, generating thoughts, and issuing commands. The spinal cord, protected by the vertebral column, is the primary pathway for transmitting signals between the brain and the rest of the body. The PNS consists of nerves extending from the brain and spinal cord to other body parts, including the limbs and organs. It is divided into the somatic nervous system, which controls voluntary movements and relays sensory information, and the autonomic nervous system (ANS), which regulates involuntary functions like heart rate and digestion. The ANS is further subdivided into the sympathetic and parasympathetic systems, which typically work in opposition. The sympathetic nervous system is primarily responsible for the body's "fight-or-flight" response. Activation of the sympathetic nervous system leads to physiological changes such as an increase in heart rate, dilation of the pupils, and the release of adrenalin/epinephrine. These changes optimize the body for rapid, intense physical activity, enhancing alertness and responsiveness to external stimuli. In contrast, the parasympathetic nervous system governs the "rest-and-digest" functions. It slows the heart rate, reduces blood pressure, and stimulates digestive processes. One of the most crucial functions of the nervous system is homeostasis. Homeostasis is the body's ability to maintain a stable internal environment despite changes in external conditions. This balance is crucial for survival and is tightly regulated by the nervous system. The system monitors physiological variables like temperature, pH, and blood pressure and responds appropriately when these variables deviate from normal ranges. The nervous system uses feedback mechanisms to maintain homeostasis. For instance, in temperature regulation, receptors detect changes in body temperature and send signals to the hypothalamus, the brain's thermoregulatory center. If the body is too hot, the hypothalamus triggers cooling mechanisms like sweating and vasodilation (widening of blood vessels) to release heat. If the body is too cold, it triggers shivering and vasoconstriction (narrowing of blood vessels) to conserve heat. These negative feedback loops are essential for keeping the body functioning within optimal parameters. Motor control refers to the nervous system's ability to regulate and guide muscles and limbs to perform desired movements. It involves the brain, spinal cord, and peripheral nerves. The spinal cord is a key player in motor control, acting as a major conduit for motor information. It transmits signals between the brain and muscles and contains reflex arcs, which are simple neural circuits that control reflex actions. For instance, the knee-jerk reflex is mediated by a reflex arc in the spinal cord, allowing the leg to extend rapidly in response to a tap on the knee without involving the brain. Voluntary movements are primarily controlled by the motor cortex in the frontal lobe. When a person decides to move, the motor cortex sends signals through the corticospinal tract to the spinal cord, which then directs the appropriate muscles. The basal ganglia and cerebellum are crucial for fine-tuning movements. The basal ganglia help initiate movements and regulate their intensity, while the cerebellum monitors ongoing movements, comparing intended actions with actual ones and making adjustments to ensure smooth and accurate motion.Motor learning, the process of acquiring new motor skills, involves the cerebellum and changes in synaptic strength within neural circuits. Autonomic responses are involuntary actions regulated by the autonomic nervous system (ANS), which governs the activity of smooth muscles, cardiac muscles, and glands. Unlike voluntary motor control, autonomic responses manage essential bodily functions such as heart rate, digestion, and respiratory rate. The ANS is divided into two components: The sympathetic nervous system initiates the "fight-or-flight" response, preparing the body for intense physical activity by increasing heart rate, dilating pupils, and redirecting blood to muscles. The parasympathetic nervous system supports the "rest-and-digest" response, slowing heart rate, facilitating digestion, and conserving energy during relaxed states. While the somatic nervous system controls voluntary movements, the autonomic nervous system regulates these involuntary responses, ensuring the body maintains homeostasis during both stressful and restful periods. The sensory systems allow the body to perceive and interpret the environment, enabling appropriate reactions and adaptations. Sensory information is collected by specialized receptors and transmitted to the CNS, where it is processed and integrated to form a coherent picture of the world. General senses include touch, temperature, pain, pressure, and proprioception (the sense of body position). These senses are detected by receptors located throughout the body. For example: Mechanoreceptors respond to mechanical forces like pressure and vibration. Thermoreceptors detect temperature changes. Nociceptors sense painful stimuli, whether from mechanical damage, extreme temperatures, or chemical irritation. Proprioceptors provide information about body position and movement, crucial for balance and coordination. Special senses are more complex and involve specialized organs: Vision is mediated by the eyes, which detect light and convert it into electrical signals. These signals are processed by the visual cortex in the occipital lobe to produce images. Hearing involves the detection of sound waves by the ear, which are converted into electrical signals by hair cells in the cochlea. These signals are then processed by the auditory cortex in the temporal lobe. Smell and taste are chemical senses that detect airborne and soluble chemicals, respectively. The olfactory receptors in the nose and taste buds on the tongue send signals to the brain that are interpreted as specific smells and tastes. Vestibular sensations are crucial for balance and spatial orientation, allowing the body to detect changes in head position and motion. The vestibular system is located within the inner ear and consists of two main components: The semicircular canals, which detect rotational movements of the head. Each of the three canals is oriented in a different plane (horizontal, anterior, and posterior) and is filled with fluid that moves when the head rotates. This movement bends hair cells in the canals, sending signals to the brain to adjust posture and eye movements. The otolith organs (the utricle and saccule), which detect linear accelerations and gravitational forces. These structures contain small crystals that shift in response to head movements, activating hair cells that provide information about changes in head position, such as tilting or moving forward. Signals from the vestibular system are sent to the vestibular nuclei in the brainstem and then integrated with visual and proprioceptive information. This helps maintain balance, coordinate eye movements with head movements (vestibulo-ocular reflex), and adjust posture, making it essential for activities like walking, running, and even standing still. At the core of neurophysiology, lie all the mechanisms that control how neurons communicate with each other and with other cells in the body. This communication which is also known as neuronal signaling occurs through the transmission of electrical impulses, known as action potentials, along the different parts of a neuron. When an action potential reaches the end of an axon, it triggers the release of neurotransmitters, chemical messengers that cross the synapse, the gap between neurons. These neurotransmitters bind to receptors on the adjacent neuron, leading to the generation of a new electrical signal in that neuron. This intricate process allows the nervous system to rapidly process and respond to information, enabling everything from reflex actions to complex thought processes. The resting membrane potential is the electrical potential difference across the neuron's membrane when it is not actively transmitting a signal. It is approximately -70 millivolts (mV) inside the cell relative to the outside. This potential is maintained by the distribution of ions, primarily sodium (Na+), potassium (K+), and chloride (Cl-), and the activity of the sodium-potassium pump (Na+/K+ ATPase), which moves 3 Na+ ions out of the cell and 2 K+ ions into the cell. Action potentials are rapid, transient changes in membrane potential that propagate along the axon. They are essential for nerve signal transmission. Key phases include: Depolarization: Triggered when the membrane potential becomes more positive, typically due to the influx of Na+ ions through voltage-gated channels. Repolarization: Following the peak of the action potential, K+ channels open, allowing K+ ions to exit the cell, restoring the negative membrane potential. Hyperpolarization: The membrane potential temporarily becomes more negative than the resting potential due to prolonged K+ channel activity before returning to the resting state. Synapses are the junctions where neurons communicate with other neurons or effector cells. There are two main types: Chemical synapses: Involve the release of neurotransmitters from the presynaptic neuron into the synaptic cleft, where they bind to receptors on the postsynaptic neuron, leading to changes in its membrane potential. Electrical synapses: Involve direct electrical coupling between neurons through gap junctions, allowing for faster signal transmission. Synaptic transmission is a fundamental process in neuronal communication, involving the release and reception of neurotransmitters across the synapse. When an action potential reaches the presynaptic terminal of a neuron, it triggers the release of neurotransmitters stored in vesicles. These chemical messengers are released into the synaptic cleft and bind to specific receptors on the postsynaptic membrane. This binding causes ion channels to open, leading to changes in the membrane potential of the postsynaptic neuron. Depending on the type of neurotransmitter and receptor involved, this can result in excitatory postsynaptic potentials (EPSPs), which increase the likelihood of the neuron firing an action potential, or inhibitory postsynaptic potentials (IPSPs), which decrease this likelihood. Over time, synaptic plasticity allows these synapses to strengthen or weaken in response to activity, playing a crucial role in learning, memory formation, and the adaptability of the nervous system. Neurotransmitters are the chemical messengers that transmit signals across synapses from one neuron to another. They play a crucial role in regulating a wide range of bodily functions and behaviors, from mood and sleep to heart rate and digestion. Neurotransmitters can be broadly classified into two categories based on their effects on the postsynaptic neuron: Excitatory neurotransmitters, such as glutamate, increase the likelihood that the neuron will fire an action potential. Glutamate is the most abundant excitatory neurotransmitter in the brain and is involved in cognitive functions like learning and memory. Inhibitory neurotransmitters, such as gamma-aminobutyric acid (GABA), decrease the likelihood of an action potential. GABA plays a key role in reducing neuronal excitability and preventing overstimulation, which is crucial for maintaining balance in brain activity. Neurological disorders encompass a wide range of conditions that affect the nervous system, including the brain, spinal cord, and peripheral nerves. These disorders can result from genetic factors, infections, injuries, degenerative processes, or environmental influences. Understanding the neurophysiological basis of these conditions is essential for developing effective treatments and therapies. Alzheimer's disease: A progressive neurodegenerative disorder characterized by the loss of neurons and synapses, particularly in the hippocampus and cerebral cortex. This leads to memory loss, cognitive decline, and personality changes. The accumulation of amyloid plaques and tau tangles in the brain are hallmark features of Alzheimer's disease. Current treatments focus on managing symptoms and slowing disease progression, but research into disease-modifying therapies continues. Epilepsy: A disorder characterized by recurrent, unprovoked seizures caused by abnormal electrical activity in the brain. Epilepsy can result from genetic factors, brain injuries, or developmental issues. Treatment often involves anticonvulsant medications that stabilize neuronal activity and prevent seizures. Multiple sclerosis (MS): An autoimmune disorder where the immune system attacks the myelin sheath, the protective covering of nerve fibers. This leads to disrupted communication between the brain and the rest of the body, causing symptoms like muscle weakness, coordination problems, and fatigue. Treatment focuses on managing symptoms, slowing disease progression, and modifying the immune response. Stroke: A stroke occurs when the blood supply to part of the brain is interrupted or reduced, depriving brain tissue of oxygen and nutrients. This can lead to cell death and loss of function in the affected area. The effects of a stroke depend on its severity and location, ranging from minor speech or movement difficulties to complete paralysis or death. Rehabilitation and medication are key components of stroke recovery and prevention. Parkinson's disease: A neurodegenerative disorder characterized by the progressive loss of dopamine-producing neurons in the basal ganglia, leading to motor symptoms such as tremors, rigidity, bradykinesia (slowness of movement), and postural instability. Treatment typically involves medications that increase dopamine levels or mimic its action, as well as physical therapy to manage symptoms. Migraine: A neurological condition that causes severe, recurring headaches, often accompanied by other symptoms like nausea, vomiting, and sensitivity to light and sound. Migraines are believed to involve abnormal brain activity affecting nerve signals, chemicals, and blood vessels in the brain. Treatment includes medications to relieve symptoms and prevent future attacks. All content published on Kenhub is reviewed by medical and anatomy experts. The information we provide is grounded on academic literature and peer-reviewed research. Kenhub does not provide medical advice. 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Kim Bengochea, Regis University, Denver © Unless stated otherwise, all content, including illustrations are exclusive property of Kenhub GmbH, and are protected by German and international copyright laws. All rights reserved. The entire nervous system is so complex that there are multiple types of practitioners that treat different parts of the system. Any doctor who works primarily with the brain and nervous system is a neurologist. Doctors who work specifically with disorders of the nervous system and the electrical aspects of the brain are known as neurophysiologists. Neurophysiologists are qualified to diagnose and treat a number of conditions related to the nervous system, including:Neurophysiologists often use electricity-based procedures such as electromyography or electroencephalography to diagnose disorders. In many cases, the disorders neurophysiologists treat cannot be reversed, but they can be lessen the effects or slow their progression. These doctors may:Monitor the conditionPrescribe medication to reduce symptomsAssist during neurosurgery to correct problemsManage outpatient deep brain stimulation and similar treatmentsNeurophysiologists are medical doctors who are trained in the field of neurology, with a focus on the nervous system. After completing medical school, a 1-year internship in general medicine is completed, followed by residency training in neurology. Those who want to focus on treating children, may specialize in pediatrics instead.After graduating from medical school, neurophysiologists then complete:A three-year residency period in neurology and neurophysiology specificallyAn exam to become certified by the American Board of Pediatrics or the American Board of Internal MedicineA two-year neurology and neurophysiology fellowship and exam to be certified by the American Board of Psychiatry and Neurology, or one of several other more specialized boardsYou are unlikely to reach out to a neurophysiologist on your own. Instead, your primary care physician will refer you to one. Frequent, Serious HeadachesIf you have painful headaches or migraines with any regularity, your doctor may have a neurophysiologist check for more serious conditions. Numbness or TinglingTingling and numbness are often the result of problems with your nerves. If your hands or feet ever start to go numb or tingle without a clear cause, you may be in the early stages of one of a number of nervous system disorders. Your doctor may send you to a neurophysiologist to help identify the cause of the feeling. SeizuresSeizures are a common sign of epilepsy, but can also be caused by other conditions.. If you have even one seizure, your doctor may refer you to a neurophysiologist for testing to find the cause. Sleeping ProblemsNeurophysiologists can test for a number of sleep disorders, including narcolepsy. They use sleep EEG recordings to check for irregularities in electrical patterns in the brain during sleep. Your first visit to a neurophysiologist is likely to involve a number of tests. These tests generally involve testing and recording the function of your body's nervous system. Many tests done by a neurophysiologist will include the application of electrodes to your skin. The tests are designed to record your body's natural electrical signals, not to affect them. The tests do not hurt. They may include:EEGs: During an EEG, electrodes - small metal discs - are applied to your scalp in a number of places. These electrodes will monitor your brain's electrical signals to check for inconsistencies. EMGs: An EMG test involves the application of electrodes to your skin on your arms, legs, and torso. These electrodes monitor the electrical signals in your nerves, checking to see how your muscles are reacting to these signals. Evoked potential tests: During this test, the doctor checks to see how quickly your nerves send information to your brain. Electrodes will be places on your scalp, then you may either watch a visual pattern on a screen or receive small electrical impulses to your arms or legs. 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