Somatic nervous system

The somatic nervous system (SNS or voluntary nervous system) is the part of the peripheral nervous system associated with the voluntary control of body movements via skeletal muscles.

The somatic nervous system consists of afferent nerves or sensory nerves, and efferent nerves or motor nerves. Afferent nerves are responsible for relaying sensation from the body to the central nervous system; efferent nerves are responsible for sending out commands from the CNS to the body, stimulating muscle contraction; they include all the non-sensory neurons connected with skeletal muscles and skin.

There are 43 segments of nerves in the human body. With each segment, there is a pair of sensory and motor nerves. In the body, 31 segments of nerves are in the spinal cord and 12 are in the brain stem.

Besides these, thousands of association nerves are also present in the body.

Thus the somatic nervous system consists of two parts:

Spinal nerves: They are peripheral nerves that carry sensory information into and motor commands out of the spinal cord.

Cranial nerves: They are the nerve fibers that carry information into and out of the brain stem. They include smell, vision, eye, eye muscles, mouth, taste, ear, neck, shoulders, and tongue.

Function

The SoNS contains both afferent nerves traveling towards the CNS and efferent nerves responsible for sending signals from the CNS towards the rest of the body. The brain and spinal cord process the input from a variety of sources and integrate them before devising a response. This response determines the location and strength of muscle contraction across different parts of the body. Therefore, the primary function of the somatic nervous

system is to connect the CNS with organs and striated muscles in order to enable complex movements and behavior

Additionally, the SoNS also mediates a subset of involuntary muscle responses called reflex arcs. A reflex arc results in an extremely quick muscle contraction in response to a stimulus, with minimal intervention from the brain. While the impulse for most voluntary muscle contraction originates in the brain or brainstem, a reflex action can be brought about with just a single sensory and motor neuron that synapse in the spinal cord. The knee-jerk response to the stimulation of the patellar ligament in the knee is an example of a reflex response. Other examples include the immediate withdrawal of a hand on touching a hot stove or a quick change in posture when the foot is placed on a sharp stone

Motor Neurons

The neural pathway that results in skeletal muscle contraction can be functionally divided into two main types of neurons – the upper motor neurons in the central nervous system and the lower motor neurons of the somatic nervous system. Lower motor neurons can be a part of cranial or spinal nerves. They innervate muscle fibers and directly cause their contraction.

Upper motor neurons have their cell bodies in the precentral gyrus of the brain. This region is located towards the posterior end of the frontal lobe in the cerebral cortex and is associated with the primary motor cortex. The axons of upper motor neurons related to voluntary muscle movement travel along the CNS in two pathways – the corticospinal and corticobulbar tracts. Neurons whose axons travel along the corticobulbar tract synapse with lower motor neurons in the brain stem. The axons of these lower motor neurons form cranial nerves such as the oculomotor, trochlear or trigeminal nerves that are involved with the contraction of skeletal muscles in the face, neck, jaw and tongue

The axons of other upper motor neurons travel along the corticospinal tract, passing the medulla oblongata and reaching the ventral horns of the spinal cord.

The primary function of these neurons is to connect the brain with the spinal cord. At the spinal cord, upper motor neurons form synapses with lower motor neurons, and release glutamate into the synaptic cleft. The depolymerization of the lower motor neuron results in the transmission of the action potential towards skeletal muscles

There are three types of lower motor neurons – alpha, beta, and gamma. Alpha motor neurons are thick, myelinated, multipolar nerve fibers that are involved in innervating most skeletal muscle fibers and causing their contraction. Gamma motor neurons support the activity of alpha motor neurons by keeping muscle spindles taut. Alpha motor neurons can receive signals from upper motor neurons for voluntary muscle movement. At the same time, they can receive input from sensory and inter neurons as well, in order to initiate reflex actions. The number of alpha motor neurons innervating a single muscle depends on the extent of fine motor control required at the site. Therefore, the muscles of a finger will have substantially more alpha motor neurons associated with them than the muscles of the thigh or upper arm

Neuromuscular Junction

The axon terminus of an alpha motor neuron forms a neuromuscular junction with striated muscle fibers, where acetylcholine is released as the neurotransmitter. When an action potential reaches the axon terminus of the alpha motor neuron, a voltage-gated ion channel allows the entry of calcium ions into the neuron. These ions induce the fusion of synaptic vesicles with the plasma membrane resulting in the release of acetylcholine into the neuromuscular junction. Acetylcholine then binds to the nicotinic receptors on muscle cells. These receptors are ion channels that open upon

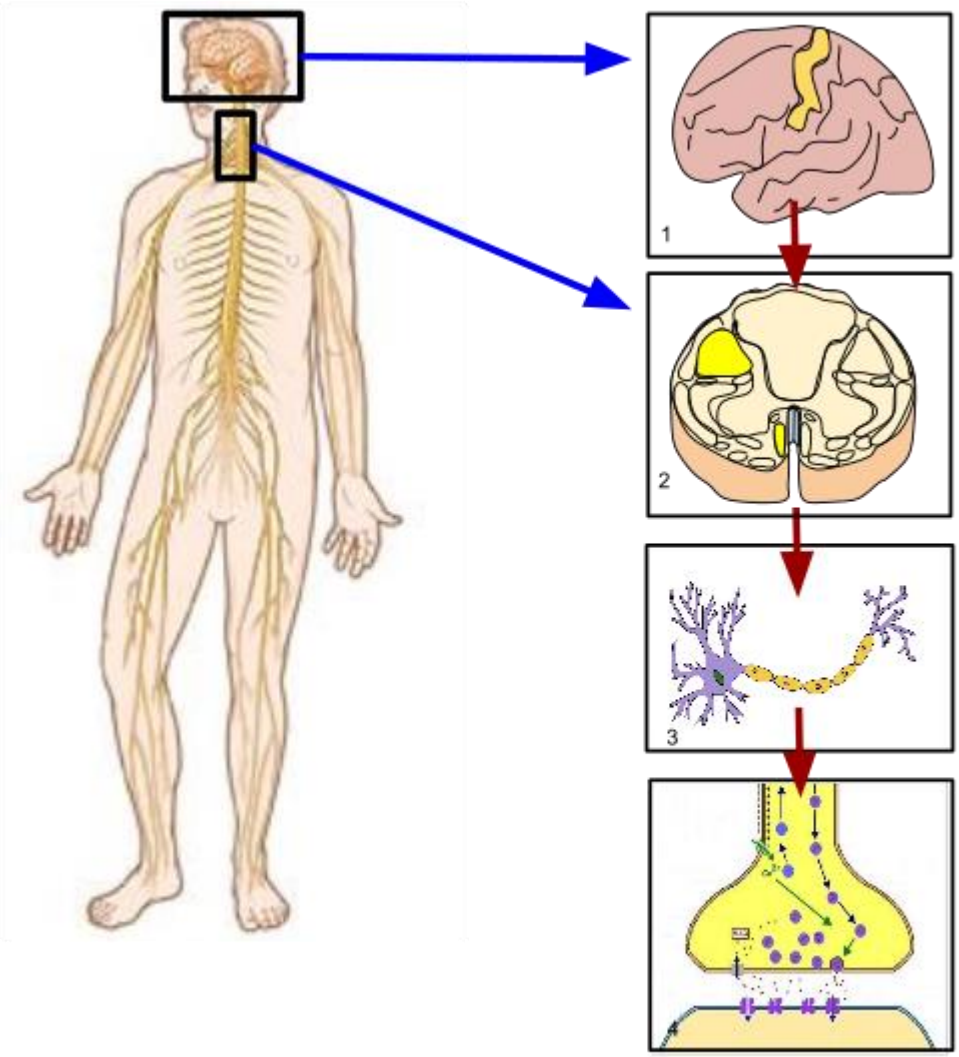
ligand binding, which then leads to a cascade of ions within the muscle fiber, leading to muscle contraction.

Proprioceptors

In addition to the typical extrafusal muscle fibers, the body of a muscle also contains muscle spindles. These small sensory organs contain specialized muscle fibers that have a central non-contractile segment. Afferent neurons of the somatic nervous system have their sensory dendrites in this area. These dendrites contain ion channels that open in response to mechanical forces on the cell. When the muscle spindle is stretched, the opening of ion channels generates an action potential in these sensory neurons. The presence of mechanically gated ion channels allows these neurons to carry detailed information about the condition of the muscle, and its contractile activity.

Nociceptors

Nociceptors are pain receptors found across the body, and are an essential part of injury prevention, especially in muscle fibers. These neurons are activated in response to potentially damaging stimuli, such as heat, cold, or extreme forces. The presence of nociceptors prevents us from hyperextending joints, overstretching muscles and protects us from a wide range of injuries.



1. (Brain) Precentral gyrus: the origin of nerve signals initiating movement.

2. (Cross Section of Spinal Cord) Corticospinal tract: Mediator of message from brain to skeletal muscles.

3. Axon: the messenger cell that carries the command to contract muscles.

4. Neuromuscular junction: the messenger axon cell tells muscle cells to contract at this intersection