11.6: Peripheral Nervous System

One Piano, Four Hands

Did you ever see two people play the same piano? How do they coordinate all the movements of their own fingers, let alone synchronize them with those of their partner? The peripheral nervous system plays an important part in this challenge.
What Is the Peripheral Nervous System?

The peripheral nervous system (PNS) consists of all the nervous tissue that lies outside of the central nervous system (CNS). The main function of the PNS is to connect the CNS to the rest of the organism. It serves as a communication relay, going back and forth between the CNS and muscles, organs, and glands throughout the body.
Tissues of the Peripheral Nervous System

The tissues that make up the PNS are nerves and ganglia. Ganglia are nervous tissues that act as relay points for messages transmitted through nerves of the PNS. Nerves are cable-like bundles of axons that make up the majority of PNS tissues. Nerves are generally classified on the basis of the direction in which they carry nerve impulses as sensory, motor, or mixed nerves.

- **Sensory nerves** transmit information from sensory receptors in the body to the CNS. Sensory nerves are also called afferent nerves. You can see an example in the figure below.

- **Motor nerves** transmit information from the CNS to muscles, organs, and glands. Motor nerves are also called efferent nerves. You can see one in the figure below.

- **Mixed nerves** contain both sensory and motor neurons, so they can transmit information in both directions. They have both afferent and efferent functions.
Figure \(\PageIndex{3}\): An afferent nerve is a sensory nerve. The one pictured here sends nerve impulses from sensory cells in the skin to the CNS. An efferent nerve is a motor nerve. This one sends nerve impulses from the CNS to a muscle. (Public domain; Pearson Scott Foresman via Wikimedia Commons).

**Divisions of the Peripheral Nervous System**

The PNS is divided into two major systems, called the autonomic nervous system and the somatic (or sensory-somatic) nervous system. Both systems of the PNS interact with the CNS and include sensory and motor neurons, but they use different circuits of nerves and ganglia.

**Somatic Nervous System**

The **somatic nervous system** primarily senses the external environment and controls voluntary activities in which decisions and commands come from the cerebral cortex of the brain. For example, when you feel too warm, decide to turn on the air conditioner, and walk across the room to the thermostat, you are using your somatic nervous system. In general, the somatic nervous system is responsible for all of your conscious perceptions of the outside world and all of the voluntary motor activities you perform in response. Whether it’s playing a piano, driving a car, or playing basketball, you can thank your somatic nervous system for making it possible.

Structurally, the somatic nervous system consists of 12 pairs of cranial nerves and 31 pairs of spinal nerves. Cranial nerves are in the head and neck and connect directly to the brain. Sensory cranial nerves sense smells, tastes, light, sounds, and body position. Motor cranial nerves control muscles of the face, tongue, eyeballs, throat, head, and shoulders. The motor nerves also control the salivary glands and swallowing. Four of the 12 cranial nerves participate in both sensory and motor functions as mixed nerves, having both sensory and motor neurons.

Spinal nerves of the somatic nervous system emanate from the spinal column between vertebrae. All of the spinal nerves are mixed nerves, containing both sensory and motor neurons. The areas of skin innervated by the 31 pairs of spinal nerves are shown in the figure below. These include sensory nerves in the skin that sense pressure, temperature, vibrations, and pain. Other sensory nerves are in the muscles, and they sense stretching and tension. Spinal nerves also include motor nerves that stimulate skeletal muscles contract, allowing for voluntary body movements.
Autonomic Nervous System

The autonomic nervous system primarily senses the internal environment and controls involuntary activities. It is responsible for monitoring conditions in the internal environment and bringing about appropriate changes in them. In general, the autonomic nervous system is responsible for all the activities that go on inside your body without your conscious awareness or voluntary participation.

Structurally, the autonomic nervous system consists of sensory and motor nerves that run between the CNS (especially the hypothalamus in the brain) and internal organs (such as the heart, lungs, and digestive organs) and glands (such as the pancreas and sweat glands). Sensory neurons in the autonomic system detect internal body conditions and send messages to the brain. Motor nerves in the autonomic system function by controlling the contractions of smooth or cardiac muscle or glandular tissue. For example, when sensory nerves of the autonomic system detect a rise in body temperature, motor nerves signal smooth muscles in blood vessels near the body surface to undergo vasodilation and the sweat glands in the skin to secrete more sweat to cool the body.
The autonomic nervous system, in turn, has three subdivisions: the sympathetic division and parasympathetic division. The two subdivisions of the autonomic system are summarized in the figure below. Both affect the same organs and glands, but they generally do so in opposite ways.

- **The sympathetic division** controls the fight-or-flight response. Changes occur in organs and glands throughout the body that prepare the body to fight or flee in response to a perceived danger. For example, the heart rate speeds up, air passages in the lungs become wider, more blood flows to the skeletal muscles, and the digestive system temporarily shuts down.

- **The parasympathetic division** returns the body to normal after the fight-or-flight response has occurred. For example, it slows down the heart rate, narrows air passages in the lungs, reduces blood flow to the skeletal muscles, and stimulates the digestive system to start working again. The parasympathetic division also maintains internal homeostasis of the body at other times.

## Disorders of the Peripheral Nervous System

Unlike the CNS, which is protected by bones, meninges, and cerebrospinal fluid, the PNS has no such protections. The PNS also has no blood-brain barrier to protect it from toxins and pathogens in the blood. Therefore, the PNS is more subject to injury and disease than is the CNS. Causes of nerve injury include diabetes, infectious diseases such as shingles, and poisoning by toxins such as heavy metals. Disorders of the PNS often have symptoms such as loss of feeling, tingling, burning sensations, or muscle weakness. If a traumatic injury results in a nerve being transected (cut all the way through), it may regenerate, but this is a very slow process and may take many months.

Two other diseases of the PNS are Guillain-Barre syndrome and Charcot-Marie-Tooth disease.

- Guillain-Barre syndrome is a rare disease in which the immune system attacks nerves of the PNS, leading to muscle
weakness and even paralysis. The exact cause of Guillain-Barre syndrome is unknown, but it often occurs after a viral or bacterial infection. There is no known cure for the syndrome, but most people eventually make a full recovery. Recovery can be slow, however, lasting anywhere from several weeks to several years.

- Charcot-Marie-Tooth disease is a hereditary disorder of the nerves and one of the most common inherited neurological disorders. It affects predominantly the nerves in the feet and legs but often also in the hands and arms. The disease is characterized by loss of muscle tissue and sense of touch. It is presently incurable.

Summary

- The peripheral nervous system (PNS) consists of all the nervous tissue that lies outside of the central nervous system (CNS). Its main function is to connect the CNS to the rest of the organism.
- The tissues that make up the PNS are nerves and ganglia. Ganglia act as relay points for messages that are transmitted through nerves. Nerves are classified as sensory, motor, or a mix of the two.
- The PNS is divided into the somatic and autonomic nervous systems. The somatic system controls voluntary activities, whereas the autonomic system controls involuntary activities.
- The autonomic nervous system is further divided into sympathetic, parasympathetic, and enteric divisions. The sympathetic division controls fight-or-flight responses during emergencies, the parasympathetic system controls routine body functions the rest of the time, and the enteric division provides local control over the digestive system.
- The PNS is not as well protected physically or chemically as the CNS, so it is more prone to injury and disease. PNS problems include injury from diabetes, shingles, and heavy metal poisoning. Two disorders of the PNS are Guillain-Barre syndrome and Charcot-Marie-Tooth disease.

Review

1. Describe the general structure of the peripheral nervous system, and state its primary function.
2. What are ganglia?
3. Identify three types of nerves based on the direction in which they carry nerve impulses.
4. Outline all of the divisions of the peripheral nervous system.
5. Compare and contrast the somatic and autonomic nervous systems.
6. When and how does the sympathetic division of the autonomic nervous system affect the body?
7. What is the function of the parasympathetic division of the autonomic nervous system? What specific effects does it have on the body?
8. Name and describe two disorders of the peripheral nervous system.
9. Give one example of how the CNS interacts with the PNS to control a function in the body.
10. For each of the following types of information, identify whether the neuron carrying it is sensory or motor and whether it is most likely in the somatic or autonomic nervous system.

a. Visual information
b. Blood pressure information
c. Information that causes muscle contraction in digestive organs after eating
d. Information that causes muscle contraction in skeletal muscles based on the person’s decision to make a movement

11. The cranial nerves:

A. Carry sensory information
B. Carry motor information
C. Are part of the somatic nervous system
D. All of the above

12. True or False. All of the spinal nerves carry both sensory and motor information.

13. True or False. The sympathetic nervous system enhances digestion to provide more energy for the body.

Explore More

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The autonomic nervous system is considered to be involuntary because it doesn't require conscious input. However, it is possible to exert some voluntary control over it. For example, people who practice yoga or other so-called mind-body techniques are able to reduce their heart rate and certain other autonomic functions. Slowing down these otherwise involuntary responses is a good way to relieve stress and reduce the wear-and-tear that stress can place on the body. Such techniques may also be useful for controlling post-traumatic stress disorder and chronic pain. Three types of integrative practices for these purposes include breathing exercises, body-based tension modulation exercises, and mindfulness techniques.

Breathing exercises can help control the rapid, shallow breathing that often occurs when you are anxious or under stress. Breathing exercises can be learned quickly, and they provide immediate feelings of relief. Specific breathing exercises include paced breath, diaphragmatic breathing, and Breathe2Relax, which is a computerized breathing practice program. You can access the Breathe2Relax program with this online video:
Body-based tension modulation exercises include yoga postures also known as “asanas” and tension manipulation exercises. The latter include the Trauma/Tension Release Exercise (TRE) and the Trauma Resiliency Model (TRM). Watch this video for a brief but informative introduction to the TRE program:
Mindfulness techniques have been shown to reduce symptoms of depression as well as those of anxiety and stress. They have also been shown to be useful for pain management and performance enhancement. Specific mindfulness programs include Mindfulness-Based Stress Reduction (MBSR) and Mindfulness Mind-Fitness Training (MMFT). You can learn more about MBSR by watching the video below.
Phantom limbs are the sensations of feeling body parts, like arms or hands that aren't on your body (either amputated or missing). Phantom Limbs are explained here:
Ever wonder why "hot" peppers are perceived as hot? Check out this link: