Chapter 17
Nervous Tissue

Introduction
The nervous system and the endocrine system are the body’s major control and integrating centers.

Neurology is the study of the normal functioning and disorders of the nervous system.

- The nervous system: brain, cranial nerves (and their branches), spinal cord, spinal nerves (and their branches), ganglia, enteric plexuses, and sensory receptors
- A nerve: a bundle of axons (plus associated connective tissue and blood vessels) located outside the brain and spinal cord
- Ganglia: neuron cell bodies, located outside the brain and spinal cord
- Enteric plexuses: networks of neurons in the walls of GI tract organs; they help regulate digestive system activities
- Sensory receptors: monitor changes in the internal and external environment
Components of the nervous system and anatomical organization of the nervous system. Figure 17.1

Organization of the Nervous System

The nervous system consists of two major divisions:
- **Central nervous system (CNS).**
  - Consists of the brain and spinal cord.
- **Peripheral nervous system (PNS).**
  - Cranial nerves that emerge from the brain
  - Spinal nerves that emerge from the spinal cord
  - Contains
    - Sensory or afferent neurons which transmit nerve impulses from sensory receptors to the CNS
    - Motor or efferent neurons which transmit nerve impulses from the CNS to muscles and glands

Functional organization of the nervous system

Figure 17.2
The Function of the Nervous System

- **Sensory function** –
  - sensory receptors detect stimuli in the internal and external environments
  - transmit sensory information by sensory or afferent neurons to the brain or spinal cord
- **Integrative function** –
  - interneurons analyze the sensory information to provide perception, storing some of it, and making decisions regarding appropriate behaviors
- **Motor function** –
  - motor or efferent neurons respond to integration decisions by initiating actions in effectors, including muscle fibers and glandular cells

Somatic Nervous System

- The somatic nervous system (SNS) of the PNS consists of sensory and motor neurons.
- **Somatic sensory neurons** - information from sensory receptors to the CNS
  - skin, skeletal muscles, joints, and for the special senses (vision, hearing, taste, and smell)
- **Somatic motor neurons** - information from the CNS to skeletal muscles only
  - output of information resulting in a muscular contraction.

Autonomic Nervous System

- **Autonomic nervous system** of the PNS has sensory and motor components.
- **Autonomic (Visceral) Sensory neurons** - information from organs (smooth muscle organs in the thorax, abdomen, and pelvis) to the CNS.
- **Autonomic motor neurons** - information from the CNS to smooth muscle, cardiac muscle, and glands
  - cause the muscles to contract and the glands to secrete.
The Motor Branch of the ANA

- The motor part of the ANS consists of two branches, the sympathetic division and the parasympathetic division.
- The sympathetic neurons increase heart rate, support exercise or emergency actions, so-called “fight-or-flight” responses.
- The parasympathetic neurons slow it down and the parasympathetic division takes care of “rest and digest” activities.

Enteric Nervous System

- The enteric nervous system (ENS) of the PNS-
  - the “brain of the gut”
  - over 100 million neurons throughout the length of the gastrointestinal (GI) tract.
- Sensory neurons of the ENS-
  - monitor chemical changes within the GI tract and the stretching of its walls.
- Motor neurons of the ENS-
  - govern contraction of GI tract smooth muscle and secretions from the stomach, and endocrine cells.

Histology

- Nervous tissue - comprised of two types of cells
- Neurons highly specialized cells.
  - Neurons have lost the ability to undergo mitotic divisions.
- Neuroglia are smaller cells but greatly outnumber neurons.
  - Neuroglia support, nourish, and protect neurons, and maintain the interstitial fluid
  - Neuroglia continue to divide throughout an individual’s lifetime.
Neurons

- Neurons possess electrical excitability.
  - A nerve impulse travels rapidly and at a constant strength.
- Motor neurons cause muscles to contract.
- Sensory neurons allow you to feel sensations.
- Nerve impulses travel at speeds ranging from 0.5 to 130 meters per seconds (1 to 280 mi/hr)

Parts of a Neuron
**Parts of a Neuron**

- **Cell body (perikaryon)** contains a nucleus
- **Nissl bodies** are for high levels of protein synthesis
- **Lipofuscin**, a pigment that occurs as clumps of yellowish brown granules in the cytoplasm.
- **Dendrites** are the receiving or input portions.
- **Axon** carries nerve impulses toward another neuron, a muscle fiber, or a gland cell.
- **Axon hillock**, a cylindrical projection that joins the cell body at a cone-shaped elevation.

**Parts of a Axon**

- **Trigger Zone**- junction of axon hillock and the initial segment
  - in most neurons, impulses arises and then travel along the axon.
  - free of Nissl bodies
  - numerous voltage-sensitive channels in the plasma membrane.
- **Axoplasm**- cytoplasm of an axon
- **Axolemma**- plasma membrane
- **Axon terminals (telodendria)**- axon and its collaterals end by dividing into many fine processes

**Synapse**

- **Synapse**- The site of communication between two neurons.
- **Presynaptic neuron**- a nerve cell that carries an impulse toward a synapse.
- **Postsynaptic neuron**- a nerve cell or effector (muscle or gland)
- **Neuromuscular junction**- synapse between a motor neuron and a muscle fiber.
  - synaptic vesicles release the neurotransmitter acetylcholine (ACH)
Neurotransmitters

- About 100 substances are either known or suspected neurotransmitters.
- The presynaptic neuron releases neurotransmitters into the synaptic cleft which act on the postsynaptic cell.
- Neurotransmitters include:
  - acetylcholine (ACh), glutamate, aspartate, GABA, glycine, norepinephrine (NE), dopamine (DA), serotonin, endorphins, nitric oxide (NO), etc.

Structural Diversity in Neurons

- Neurons display great diversity in size and shape.
- Cell bodies range from 5 micrometers (um) to 135 mm.
- The pattern of dendritic branching is varied and distinctive for neurons in different parts.
- A few small neurons lack an axon, and many others have very short axons.

Structural Diversity in Neurons

- **Multipolar neurons** usually have several dendrites and one axon
- **Bipolar neurons** have one main dendrite and one axon
- **Unipolar neurons** are sensory neurons have just one process extending from the cell body
Neuroglia

- Neuroglia (glia):
  - Half the volume of the CNS.
  - Smaller than neurons.
  - Do not generate or propagate nerve impulses.
  - Can multiply and divide in the mature nervous system.

- Six types:
  - Astrocytes, oligodendrocytes, microglia, and ependymal cells—only in the CNS.
  - Schwann cells (neurolemmocytes) and satellite cells—in the PNS.

Neuroglia of the central nervous system

Neuroglia of the central nervous system

Astrocytes

- Star-shaped cells

Protoplasmic astrocytes found in gray matter
Fibrous astrocytes are located mainly in white matter.

The processes of astrocytes make contact with blood capillaries, neurons, and the pia mater.

Functions of Astrocytes

Contain microfilaments that provide strength for structural support of neurons.
Their processes wrapped around blood capillaries secrete chemicals that maintain the unique permeability characteristics of the endothelial cells.
In the embryo, astrocytes secrete chemicals that appear to regulate the growth, migration, and interconnections among neurons in the brain.
Help maintain the appropriate chemical environment for the generation of nerve impulses.
May also play a role in learning and memory by influencing the formation of neural synapses.
**Oligodendrocytes**

- Oligodendrocyte have process that form the **myelin sheath**
  - a lipid and protein covering around some axons
  - insulates the axon and increases the speed of nerve impulse conduction.

**Oligodendrocytes**

- Most common glial cell type
- Analogous to Schwann cells of PNS

**Microglia**

- Microglia originate in red bone marrow and migrate into the CNS as it develops (unlike other neuroglial cells, which develop from the neural tube).
- Microglia function as phagocytes and they remove cellular debris, microbes and damaged nervous tissue.
Microglia

- Small cells found near blood vessels

Ependymal cells

- Ependymal cells line the ventricles of the brain and central canal of the spinal cord
  - produce, possibly monitor, and assist in the circulation of cerebrospinal fluid.
  - form the blood–cerebrospinal fluid barrier.
Neuroglia of the PNS

Completely surround axons and cell bodies.

The two types of glial cells in the PNS:

- **SCHWANN CELLS** – (neurolemmocytes)
  - encircle PNS axons and form the myelin sheath
  - participate in axon regeneration, which is more easily accomplished in the PNS.

- **SATELLITE CELLS** –
  - surround the cell bodies of neurons of PNS ganglia.
  - regulate exchange of materials between neuronal cell bodies and interstitial fluid.

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Myelination

- Axons that are surrounded by a multilayered lipid and protein covering, called the **myelin sheath**, are **myelinated**.
- Axons without such a covering are **unmyelinated**.
- Two types of neuroglia produce myelin sheaths:
  - Schwann cells (in the PNS)
  - Oligodendrocytes (in the CNS).
The white matter is aggregations of myelinated and unmyelinated axons of many neurons.

The gray matter of the nervous system contains neuronal cell bodies, dendrites, unmyelinated axons, axon terminals, and neuroglia.
Neural Circuits

The CNS contains billions of neurons organized into complex networks called neural circuits, each having its own function.

- **Simple series circuit** -
  - a presynaptic neuron transmits a message to a single postsynaptic neuron, which in turn stimulates another neuron.

- **Diverging circuit** -
  - a presynaptic neuron forms synapses with several postsynaptic cells.

- **Converging circuit** -
  - presynaptic neurons form synapses with a single postsynaptic neuron

- **Reverberating circuit** -
  - a presynaptic neuron is stimulated causing the postsynaptic neuron to transmit a series of nerve impulses

- **Parallel after-discharge circuit** -
  - a single presynaptic neuron stimulates a group of neurons, all of which form synapses with a common postsynaptic neuron.
Regeneration and Neurogenesis

- The nervous system exhibits **plasticity**, the ability to change based on experience.

- Mammalian neurons have very limited powers of **regeneration**, the ability to replicate or repair themselves.

- **Neurogenesis** - formation of new neurons from stem cells
  - known to occur in the adult hippocampus
  - has not been shown to occur elsewhere in the brain or spinal cord.

Multiple Sclerosis (MS)

- Autoimmune disorder causing destruction of myelin sheaths in CNS
  - sheaths becomes scars or plaques
  - 1/2 million people in the United States
  - appears between ages 20 and 40
  - females twice as often as males
- Symptoms include muscular weakness, abnormal sensations or double vision
- Remissions & relapses result in progressive, cumulative loss of function

Epilepsy

- The second most common neurological disorder
  - affects 1% of population
- Characterized by short, recurrent attacks initiated by electrical discharges in the brain
  - auras - lights, noise, or smells may be perceived prior
  - skeletal muscles may contract involuntarily
  - loss of consciousness
- Epilepsy has many causes, including:
  - brain damage at birth, metabolic disturbances, infections, toxins, vascular disturbances, head injuries, and tumors
End of Chapter 17

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