LEARNING OUTCOMES

17.1 Nervous Tissue
1. Describe the basic structure of a neuron, and compare the functions of the three classes of neurons.
2. Illustrate the changes in ion concentrations inside and outside of a neuron that result in an action potential.
3. Explain how a nerve impulse is transmitted across a chemical synapse.

17.2 The Central Nervous System
1. Draw and label the anatomy of the spinal cord.
2. List the four major regions of the brain and the main functions of each region.
3. Describe the functions and locations of these major parts of the brain: hypothalamus, thalamus, medulla oblongata.

17.3 The Limbic System and Higher Mental Functions
1. Describe the anatomical and functional relationship between the limbic system and the cerebrum.
2. Distinguish between short-term, long-term, semantic, episodic, and skill memory.
3. Explain how certain diseases, accidents, and experiments have helped scientists understand some basic components of how memories are made.

17.4 The Peripheral Nervous System
1. Describe the overall anatomy of the peripheral nervous system, including the cranial nerves and spinal nerves.
2. Explain how the somatic system differs from the autonomic system.
3. Contrast the overall functions of the sympathetic and parasympathetic divisions of the autonomic nervous system.

17.5 Drug Abuse
1. List three distinct ways that a drug could increase the effect of a neurotransmitter at a synapse.
2. Compare and contrast the specific mechanisms whereby the most common illicit drugs affect the brain.

17.6 Disorders of the Nervous System
1. Describe two abnormalities seen in the brain of Alzheimer disease patients.
2. Compare the pathogenesis (mechanism causing disease) of Parkinson disease, MS, stroke, meningitis, and prion diseases.
3. Describe the symptoms seen in several disorders of the brain and spinal cord and discuss why it is difficult to find cures for these.

LECTURE OUTLINE

17.1 Nervous Tissue
The nervous system is divided into the central nervous system, consisting of the brain and spinal cord, and the peripheral nervous system, consisting of nerves that carry messages to and from the central nervous system. The nervous system contains two types of cells: neurons and neuroglia.

Types of Neurons and Neuron Structure
There are three classes of neurons: sensory neurons, interneurons, and motor neurons. All neurons have three parts: a cell body, dendrites, and an axon.
Myelin Sheath
Some axons are covered by a protective myelin sheath. The myelin sheath serves as an excellent insulator and plays an important role in nerve regeneration.

The Nerve Impulse
The nature of a nerve impulse can be characterized by voltage changes.

Resting Potential
When the axon is not conducting an impulse, the inside is negatively charged, and the outside is positively charged. There is approximately a –65 mV potential difference across the membrane. This charge difference is due to the action of the sodium-potassium pump that actively transports sodium out of and potassium into the axon.

Action Potential
An action potential is a rapid change in polarity across an axonal membrane as the nerve impulse occurs. It is an all-or-none phenomenon.

Sodium Gates Open
When the action potential begins, the gates of the sodium channels open and sodium flows into the axon. The membrane potential changes from –65 mV to +40 mV.

Potassium Gates Open
Second, the gates of the potassium channels open, and potassium flows outside the axon. This repolarizes the axon.

Conduction of an Action Potential
The action potential travels down an axon one small section at a time.

Transmission Across a Synapse
Every axon branches into many fine endings, each tipped with an axon terminal. Each terminal lies very close to either the dendrite or cell body of another neuron. This is called a chemical synapse. Communication between the two neurons is carried out by molecules called neurotransmitters that are stored in synaptic vesicles in the axon terminals and released when nerve impulses reach the axon terminal.

Synaptic Integration
A neuron is on the receiving end of many excitatory and inhibitory signals. Synaptic integration is the summing up of these signals.

Neurotransmitters
At least 25 different neurotransmitters have been identified. Once a neurotransmitter has been released into a synaptic cleft and initiated a response, it is removed from the cleft.

17.2 The Central Nervous System
The spinal cord and the brain make up the central nervous system (CNS).

The Spinal Cord
The spinal cord extends from the base of the brain through a large opening in the skull and into the vertebral canal.

Structure of the Spinal Cord
The spinal nerves project from the cord between the vertebrae. Fluid-filled intervertebral disks cushion and separate the vertebrae. A cross section of the spinal cord shows a central canal, gray matter, and white matter.

Functions of the Spinal Cord
The spinal cord provides a means of communication between the brain and the peripheral nerves that leave the cord. The spinal cord is also the center for thousands of reflex arcs.
The Brain
The four major parts of the brain are the cerebrum, the diencephalon, the cerebellum, and the brain stem.

The Cerebrum
The cerebrum is the largest portion of the brain. It is the last center to receive sensory input and carry out integration before commanding voluntary motor responses. The cerebrum carries out the higher thought processes required for learning and memory and for language and speech.

The Cerebral Hemispheres
The cerebrum is divided into the left and right cerebral hemispheres. Shallow grooves divide each hemisphere into lobes. The cerebral cortex is a thin but highly convoluted outer layer of gray matter that covers the cerebral hemispheres.

Primary Motor and Sensory Areas of the Cortex
The primary motor area is located in the frontal lobe. The primary somatosensory area is located in the parietal lobe.

Association Areas
Association areas are places where integration occurs.

Processing Centers
Processing centers of the cortex receive information from the other association areas and perform higher-level analytical functions.

Central White Matter
Most of the rest of the cerebrum beneath the cerebral cortex is composed of white matter.

Basal Nuclei
Masses of gray matter located deep within the white matter are called basal nuclei.

The Diencephalon
The hypothalamus and the thalamus are in the diencephalon. The hypothalamus is the integrating center that helps maintain homeostasis by regulating hunger, sleep, thirst, body temperature, and water balance. The thalamus integrates sensory input from the visual, auditory, taste, and somatosensory systems. The pineal gland is located in the diencephalon.

The Cerebellum
The cerebellum receives sensory input from the joints, muscles, and other sensory pathways about the present position of body parts. It also receives motor output from the cerebral cortex about where these parts should be located. The cerebellum maintains balance and posture.

The Brain Stem
The brain stem contains the midbrain, the pons, and the medulla oblongata. The medulla oblongata contains a number of reflex centers for regulating heartbeat, breathing, and blood pressure.

Electroencephalograms
The electrical activity of the brain can be recorded in the form of an electroencephalogram (EEG).

17.3 The Limbic System and Higher Mental Functions
Emotions and higher mental functions are associated with the limbic system in the brain. The limbic system blends primitive emotions and higher mental functions into a united whole.
Anatomy of the Limbic System
The limbic system is a complex network of tracts and nuclei that incorporates portions of the cerebral lobes, the basal nuclei, and the diencephalon. The hippocampus and the amygdala are important for learning and memory and emotions such as anger and fear.

Higher Mental Functions

Memory and Learning
Memory is the ability to hold a thought in mind or to recall events from the past. Learning takes place when we retain and utilize past memories.

Types of Memory
Short-term memories are stored in the prefrontal area. Long-term memory is typically a mixture of semantic and episodic memory. Skill memory is another type of memory.

Long-Term Memory Storage and Retrieval
Our long-term memories are stored in bits and pieces throughout the sensory association areas of the cerebral cortex. Long-term potentiation is an enhanced response at synapses within the hippocampus. Sometimes it causes a postsynaptic neuron to undergo apoptosis.

Language and Speech
Language is dependent upon semantic memory and involves Broca’s and Wernicke’s areas. The left and right hemispheres have different functions in relation to language and speech.

17.4 The Peripheral Nervous System
The peripheral nervous system is composed of nerves and ganglia. Nerves are bundles of axons. Ganglia are collections of cell bodies.

Somatic System
The peripheral nervous system is subdivided into the somatic system and the autonomic system. The somatic system serves the skin, skeletal muscles, and tendons. Some actions in the somatic system are due to reflexes, which are automatic responses to a stimulus.

The Reflex Arc
Reflexes are programmed, built-in circuits that allow for protection and survival. They require no conscious thought. Nerve impulses travel from the sensory neuron to the spinal cord and back to the motor neuron.

Autonomic System
The autonomic system regulates the activity of cardiac and smooth muscle and glands. The system is composed of the sympathetic and parasympathetic divisions. These divisions function automatically and usually in an involuntary manner, innervate all internal organs, and utilize two motor neurons that synapse at a ganglion.

Sympathetic Division
The sympathetic division is especially important during emergency situations.

Parasympathetic Division
The parasympathetic division is sometimes called the housekeeper division because it promotes all the internal responses we associate with “rest and digest.”

17.5 Drug Abuse
In general, drugs either impact the limbic system or affect the action of a particular neurotransmitter at the synapse.

Some Specific Drugs of Abuse
Nicotine
Nicotine causes a release of epinephrine. It induces both physiological and psychological dependence.
Alcohol (Ethanol)
Ethanol influences the action of GABA and glutamate. It damages the liver and is able to cross the placenta and harm the unborn fetus.

Marijuana
Marijuana is rich in tetrahydrocannabinol (THC) that binds to receptors for a neurotransmitter in the brain that is important for short-term memory processing.

Cocaine and Crack
Cocaine prevents the synaptic uptake of dopamine. Cocaine causes extreme physical dependence.

Heroin
Heroin binds to receptors meant for endorphins, natural neurotransmitters that kill pain and produce a feeling of tranquility.

“Club” Drugs
Ecstasy, rohypnol, and ketamine are drugs that are abused by teens and young adults who attend night-long dances called raves or trances.

Methamphetamine
“Meth” or “crank” is a powerful CNS stimulant.

17.6 Disorders of the Nervous System

Disorders of the Brain
Alzheimer disease is the most common cause of dementia. Parkinson disease is characterized by a gradual loss of motor control. Multiple sclerosis is the most common neurological disease that afflicts young adults. MS is an autoimmune disease in which the patient’s own immune system attacks the myelin of the nervous system. A stroke results in disruption of the blood supply to the brain. Meningitis is an infection of the meninges. Several brain diseases are caused by prions including Creutzfeldt-Jakob disease and mad cow disease.

Disorders of the Spinal Cord
Spinal cord injuries may result from trauma. Little or no nerve regeneration is possible in the CNS, so any resulting disability is usually permanent. Amyotrophic lateral sclerosis is a devastating condition that affects the motor nerve cells of the spinal cord.

Disorders of the Peripheral Nerves
Guillain-Barre syndrome is an inflammatory disease that causes demyelination of peripheral nerve axons. Myasthenia gravis is an autoimmune disorder in which the body reacts against the acetylcholine receptor at the neuromuscular junction of the skeletal muscles.