Chp. 13   The Nervous System

• Nervous system – Allows for communication between cells through sensory input, integration of data and motor output

• 2 cell types: neurons and neuroglia

Expanding on neurons

• 3 types of neurons:
  • Sensory – takes impulses from sensory receptor to CNS
  • Interneurons – receive information in the CNS and send it to a motor neuron
  • Motor – takes impulses from the CNS to an effector (i.e. gland or muscle fiber)

• Neuron structure (Ch. 4 review):
  • Cell body – main cell where organelles and nuclei reside
  • Dendrite – many, short extensions that carry impulses to a cell body
  • Axon (nerve fiber) – single, long extension that carries impulses away from the cell body

Types of neurons
The myelin sheath

• A lipid covering on long axons that acts to increase the speed of nerve impulse conduction, insulation and regeneration in the PNS

• Schwann cells – neuroglia that make up the myelin sheath in the PNS

• Nodes of Ranvier – gaps between myelination on the axons

• Saltatory conduction – conduction of the nerve impulse from node to node

Neuron structure

The nerve impulse: resting potential (RP)

• Resting potential – when the axon is not conducting a nerve impulse
  • More positive ions outside than inside the membrane
  • There is a negative charge of -65mV inside the axon
  • More Na⁺ outside than inside
  • More K⁺ inside than outside
The nerve impulse: action potential

• Action potential – rapid change in the axon membrane that allows a nerve impulse to occur
  • Sodium gates open letting Na⁺ in
    • Depolarization occurs
    • Interior of axon loses negative charge (+40mV)
  • Potassium gates open letting K⁺ out
    • Repolarization occurs
    • Interior of axon regains negative charge (-65mV)
    • Wave of depolarization/repolarization travels down the axon
  • Resting potential is restored by moving potassium inside and sodium outside

The synapse

• A small gap between the sending neuron (presynaptic membrane) and the receiving neuron (postsynaptic membrane)
  • Transmission is accomplished across this gap by a neurotransmitter (e.g. ACh, dopamine and serotonin)
  • Neurotransmitters are stored in synaptic vesicles in the axon terminals
A synapse and how it functions

13.1 Overview of the nervous system

Synaptic integration

• Integration is the summation of the inhibitory and excitatory signals received by a postsynaptic neuron

• This occurs because a neuron receives many signals

The nervous divisions

• 2 divisions:
  – Central nervous system (CNS): Brain and spinal cord
  – Peripheral nervous system (PNS): Nerves and ganglia (cell bodies)
The central nervous system

• Consists of the brain and spinal cord

• Both are protected by:
  • Bones – skull and vertebral column
  • Meninges – 3 protective membranes that wrap around CNS
  • Cerebral spinal fluid (CSF) – space between meninges is filled with this fluid that cushions and protects the CNS

• Both made up of 2 types of nervous tissue:
  • Gray matter – contains cell bodies and nonmyelinated fibers
  • White matter – contains myelinated axons

What does the spinal cord look like?

The CNS: Overview of the brain
1. The brain: Cerebrum – the lobes

- Cerebrum – largest portion of the brain

- Divided into 4 lobes/hemispheres:
  - Frontal lobe: primary motor area and conscious thought
  - Temporal lobe: primary auditory, smell and speech area
  - Parietal lobe: primary somatosensory and taste area
  - Occipital lobe – primary visual area

13.2 The central nervous system

1. The brain: Cerebrum – the cerebral hemispheres

1. The brain: Cerebrum – the cerebral cortex
2. The brain: Diencephalon

3. The brain: Cerebellum

- Receives and integrates sensory input from the eyes, ears, joints and muscles about the current position of the body
- Functions to:
  - Maintains posture
  - Coordinates voluntary movement
  - Allows learning of new motor skills (i.e. playing the piano or hitting a baseball)

4. The brain: The brain stem

- Includes:
  - Midbrain – relay station between the cerebrum and spinal cord or cerebellum; reflex center
  - Pons – a bridge between cerebellum and the CNS; regulate breathing rate; reflex center for head movements
  - Medulla oblongata – reflex centers for regulating breathing, heartbeat and blood pressure
  - Reticular formation – major component of the reticular activating system (RAS) that regulates alertness
13.3 The limbic system and higher mental functions

Higher mental functions

- Learning – what happens when we recall and use past memories
- Memory – ability to hold a thought or to recall past events
- Short-term memory – retention of information for only a few minutes
- Long-term memory – retention of information for more than a few minutes and include the following:
  - Episodic memory – persons and events
  - Semantic memory – number and words
- Skill memory – performing skilled motor activities (i.e. riding a bike)
- Language – depends on semantic memory

What parts of the brain are active in reading and speaking?
The peripheral nervous system

The PNS: Somatic division

- Serves the skin, skeletal muscles and tendons
- Automatic responses are called reflexes

The PNS: Autonomic division

- Regulates the activity of involuntary muscles (cardiac and smooth) and glands
- Divided into 2 divisions:
  - Sympathetic: coordinates the body for the "fight or flight" response by speeding up metabolism, heart rate and breathing while down regulating other functions
  - Parasympathetic: counters the sympathetic system by bringing up a relaxed state by slowing down metabolism, heart rate and breathing and returning other functions to normal
13.4 The peripheral nervous system

Health focus: Degenerative brain disorders

• Alzheimer disease
  – Usually seen in people after 65 yrs. old
  – Starts with memory loss
  – Abnormal neurons with plaques of beta amyloid and neurofibrillary tangles
  – Difficult to treat

• Parkinson disease
  – Usually begins between the ages of 50-60
  – Characterized by loss of motor control
  – Due to degeneration of dopamine-releasing (inhibitory effect) neurons in the brain

13.5 Drug abuse

Drugs and drug abuse

• Drugs have two general effects on the nervous system: affect the limbic system or promote the action of a certain neurotransmitter

• Most drug abusers take drugs that affect dopamine and thus artificially affect this reward circuit to the point they ignore basic physical needs in favor of the drug

• Drug abusers tend to show a physiological and psychological effect

• Once a person is physically dependent they usually need more of the drug for the same effect because their body has become tolerant
13.5 Drug abuse

Drug abuse: Alcohol

- Alcohol – a depressant directly absorbed from the stomach and small intestine
- Most socially accepted form of drug use
- About 80% of college-aged people drink
- Alcohol denatures proteins, causes damage to tissues such as the brain and liver; chronic consumption can damage the frontal lobe
- High blood alcohol levels can lead poor judgment, loss of coordination or even coma and death

Drug abuse: Nicotine and Cocaine

- Nicotine – stimulant derived from tobacco plant
  - Causes neurons to release dopamine that helps lead to dependence
  - Adversely affects a developing embryo or fetus
  - Increases heart rate and blood pressure
  - Psychological and physiological dependency
- Cocaine – stimulant derived from a plant
  - Results in a rush sensation (5-30 minutes) and an increased sex drive
  - Results in hyperactivity and little desire for food and sleep
  - Extreme physical dependence with this drug
  - “Crack” is a street name for cocaine that is processed to a free base for smoking

Drug abuse and its use: Marijuana

- Marijuana: psychoactive drug derived from a hemp plant called Cannabis
- Most often smoked as a “joint”
- Mild euphoria and brain damage
- Alterations to vision and judgment as well as impaired motor coordination with slurred speech
- Heavy users may experience depression, anxiety, hallucinations, paranoia and psychotic symptoms
- Banned in the US in 1937 but recently has been legalized in a few states for medical use in seriously ill patients
  - Should marijuana be available to more patients?
  - Should people in states where it is legal for medical purposes to be prosecuted? How should this be regulated?