Chapter 28
NERVOUS SYSTEM
Functions of Nervous Tissue

1. Sensory Input: Conduction of signals from sensory organs (eyes, ears, nose, skin, etc.) to information processing centers (brain and spinal cord).

2. Integration: Interpretation of sensory signals and development of a response. Occurs in brain and spinal cord.

3. Motor Output: Conduction of signals from brain or spinal cord to effector organs (muscles or glands). Controls the activity of muscles and glands, and allows the animal to respond to its environment.
Nervous System Processes and Responds to Sensory Input

Sensory receptor

Effector

Peripheral nervous system (PNS)

Central nervous system (CNS)

Brain and spinal cord

Sensory input

Motor output

Integration
1. **Neuron**: Nerve cell. Structural and functional unit of nervous tissue.
   - Carry signals from one part of the body to another.

2. **Supporting cells**: Nourish, protect, and insulate neurons.
   - There are roughly 50 supporting cells for every neuron.
   - In humans, **Schwann cells** wrap around the axons of neurons, forming a **myelin sheath** that is essential for transmission of nerve impulses.
Neuron Structure

- **Cell body**: Contains nucleus and most organelles.
- **Dendrites**: Extensions that convey signals towards the cell body.
  - Short, numerous, and highly branched
- **Axon**: Extension that transmits signals away from the cell body to another neuron or effector cell.
  - Usually a long single fiber.
  - Axon is covered by a **myelin sheath** made up of many **Schwann cells** that are separated by small spaces (Nodes of Ranvier).
Structure of the Neuron

- Dendrites
- Cell body
- Nucleus
- Axon hillock
- Axon
- Schwann cell
- Myelin sheath
- Nodes of Ranvier
- Synaptic terminal
- Terminal branches
- Node of Ranvier
- Layers of myelin produced by Schwann cell
- Schwann cell
- Nucleus of Schwann cell
Neuron Structure

- Myelin sheath and nodes of Ranvier greatly speed up nerve impulses, which jump down axon from node to node.

  **Speed of signal**

  - Myelinated axon: 100 meters/second
  - Unmyelinated axon: 5 meters/second

- **Multiple sclerosis**: A disease in which a person’s immune system destroys the myelin sheaths on their neurons.
  - Loss of muscle control
  - Impaired brain function
  - Death
Central vs. Peripheral Nervous System

Central Nervous System (CNS): Brain & spinal cord. Processing centers of nervous system.

Peripheral Nervous System (PNS): Nerves that carry signals in and out of the nervous system.
Three Types of Neurons

1. Sensory Neurons: Carry information from the stimulation of sensory organs (eyes, ears, etc.) to the central nervous system (CNS).

2. Interneurons: Found only in CNS. Integrate and process data from sensory neurons and send commands to motor neurons.

3. Motor Neurons: Receive information or commands from the CNS, and relay them to effector cells (muscles or glands) to elicit a response.
Central Nervous System

◆ **Brain**: Master control center. Over 100 billion neurons and many more supporting cells.
  - Emotion
  - Intellect
  - Controls some muscles and spinal cord
  - Homeostatic centers

◆ **Brain**: Protected by:
  - Skull
  - **Meninges**: Three layers of tissue covering brain.
  - **Cerebrospinal Fluid**: Liquid surrounding brain.
  - **Blood-brain barrier**: Maintains stable environment and protects brain from infection and many harmful chemicals.
Central Nervous System

◆ **Cerebral Cortex:**
  - Less than 5 mm thick
  - Highly folded, occupies over 80% of total brain mass.
  - Contains 10 billion neurons and billions of synapses.
  - Left and right hemispheres are divided into 4 lobes
  - Intricate neural circuitry is responsible for many unique human traits:
    - Reasoning
    - Mathematical ability
    - Language skills
    - Imagination
    - Personality traits
    - Artistic talent
    - Sensory perception
    - Motor function
Cerebral Cortex is the Most Complex and Largest Part of Human Brain
Cerebral Cortex Controls Sensory and Motor Functions
Central vs. Peripheral Nervous System

Central Nervous System (CNS):

- **Spinal Cord**: Lies inside vertebral column.
  - Receives sensory information from skin and muscles.
  - Sends out motor commands for movement.
  - **Reflexes**: Unconscious responses to a stimulus. Only sensory and motor neurons are involved.
Knee-Jerk Reflex Involves Spinal Cord, not Brain
What is a Nerve Impulse?

An electrical signal that depends on the flow of ions across the neuron plasma membrane.

- **Resting Potential**: A neuron at rest has a net negative charge (-70 mV, equivalent to 5% of the voltage in an AA battery).

The net negative charge is due to different ion concentrations across the neuron membrane.
Resting Potential is Caused by Differences in Ion Concentrations Across Neuron Membrane
What is a Nerve Impulse?

An electrical signal that depends on the flow of ions across the neuron plasma membrane.

- **Action Potential**: When a neuron is stimulated above a certain threshold, this causes:

1. **Depolarization**: An influx of positive ions ($Na^+$) into the cell, caused by the opening of sodium channels. The inside of the cell becomes **positively charged** for a brief moment (1-2 milliseconds).

2. **Repolarization**: After a few milliseconds, the neuron allows other positive ions ($K^+$) to **leave the cell** so the inside of the cell becomes negatively charged once again.
Action Potential Requires Stimulus Above a Certain Threshold

(a) Graded potential: hyperpolarization
(b) Graded potential: depolarization
(c) Action potential
Nerve Impulses are Caused by Action Potentials
Neurons Communicate at Synapses

Synapse: Junction between two neurons or a neuron and an effector cell (muscle or gland).

There are two types of synapses:

1. **Electrical Synapse:**
   - Found in heart and digestive tract of human body.
   - Action potentials pass directly from one neuron to another.

2. **Chemical Synapse:**
   - Found in CNS, muscles, and most other organs.
   - Require **neurotransmitters:** Chemicals that convey messages from one neuron to another.
   - *Transmitting neuron* releases neurotransmitters which cross synapse and cause an action potential in the *receiving neuron.*
Chemical Synapses Use Neurotransmitters
Important Neurotransmitters

Dopamine:
- High levels are associated with schizophrenia.
- Low levels are associated with Parkinson’s disease.

Serotonin and Norepinephrine:
- Affect mood, sleep, attention, and learning.
- Low levels are associated with depression.
- Prozac increases the amount of serotonin at synapses.

Endorphins:
- Small peptides that decrease pain perception by CNS.
- Natural painkillers produced in times of stress (childbirth).
- Also decrease urine output, depress respiration, and cause euphoria and other emotional effects on brain.
- Heroin and morphine mimic action of endorphin.
Neurotropic Drugs

Stimulants:

- Include caffeine, cocaine, and amphetamines.
- Increase the activity of the CNS by altering effect of neurotransmitters at chemical synapses.

Depressants:

- Include alcohol and Valium.
- Decrease the activity of the CNS by altering effect of neurotransmitters at chemical synapses.
Diseases of the Nervous System
I. Alzheimer’s Disease

◆ Most common form of dementia in U.S.
◆ Unknown cause, probably both genetic and environmental factors are important.
◆ No effective treatment
◆ Certain diagnosis is usually only possible through discovery of typical brain lesions during autopsy.
◆ Usually affects elderly: Over 4 million cases in U.S.
  - 10% of those over 65
  - Almost half of those over 85
◆ Symptoms progress over time. Three stages:
  - **Mild Stage**: Forgetfulness, minor disorientation, mild personality changes, depression, difficulty in finding right words during conversation, and performing arithmetic calculations (e.g.: balancing checkbook).
Stages of Alzheimer’s Disease:

**Moderate Stage:** Noticeable memory loss, difficulty performing everyday tasks (bathing, dressing, cooking, driving, operating appliances), may wander off, confuse day and night, fails to recognize acquaintances and distant relatives.

**Severe Stage:** Very limited speech (less than 12 words), eventually becomes mute and uncomprehending, loses all self-care ability, can’t recognize closest relatives, friends, or caregivers, becomes incontinent, progressively loses ability to walk, stand, sit up, smile, and hold head up. Many patients die from complications like pneumonia.
Definite diagnosis of Alzheimer’s usually requires post-mortem brain examination. Notice pronounced atrophy with wide sulci (grooves) in frontal and parietal regions. Source: www-medlib.med.utah.edu/WebPath/CNSHTML
II. Autism

◆ Severe developmental brain disorder, starts in childhood.

◆ Symptoms vary from child to child, but may include:
  
  - Speech abnormalities or lack of speech
  - Lack of attachment to parents or caretakers
  - Lack of eye contact, interest in people, and toys
  - Repetitive behaviors (e.g.: rocking, counting fingers repeatedly)
  - Self-injurious behaviors (e.g.: head banging, screaming fits, arm flapping)
  - Rigid adherence to specific rituals, patterns, or routines
  - Extreme dislike of being touched, sounds, and/or certain foods
  - Walking on tiptoes and balancing on feet.
  - Low IQ (May be due to lack of cooperation) and poor social skills
  - Savants: May have areas of normal or advanced competence: Math skills, memory, musical talent, drawing, etc.

◆ Unknown cause, probably both genetic and environmental factors are important (See L.A. Times article 5/4/2000).
II. Autism

- Usually affects children before the age of 3.
  - Males are more susceptible: 4 males for every female.
  - Occurs in 1 in 1000 births, but epidemic (6 to 7% of children) in certain areas.
  - Occurs in all racial, ethnic, and social backgrounds.
  - Does not appear to be caused by psychological environment.

- No cure, but some treatments may improve symptoms in some individuals.