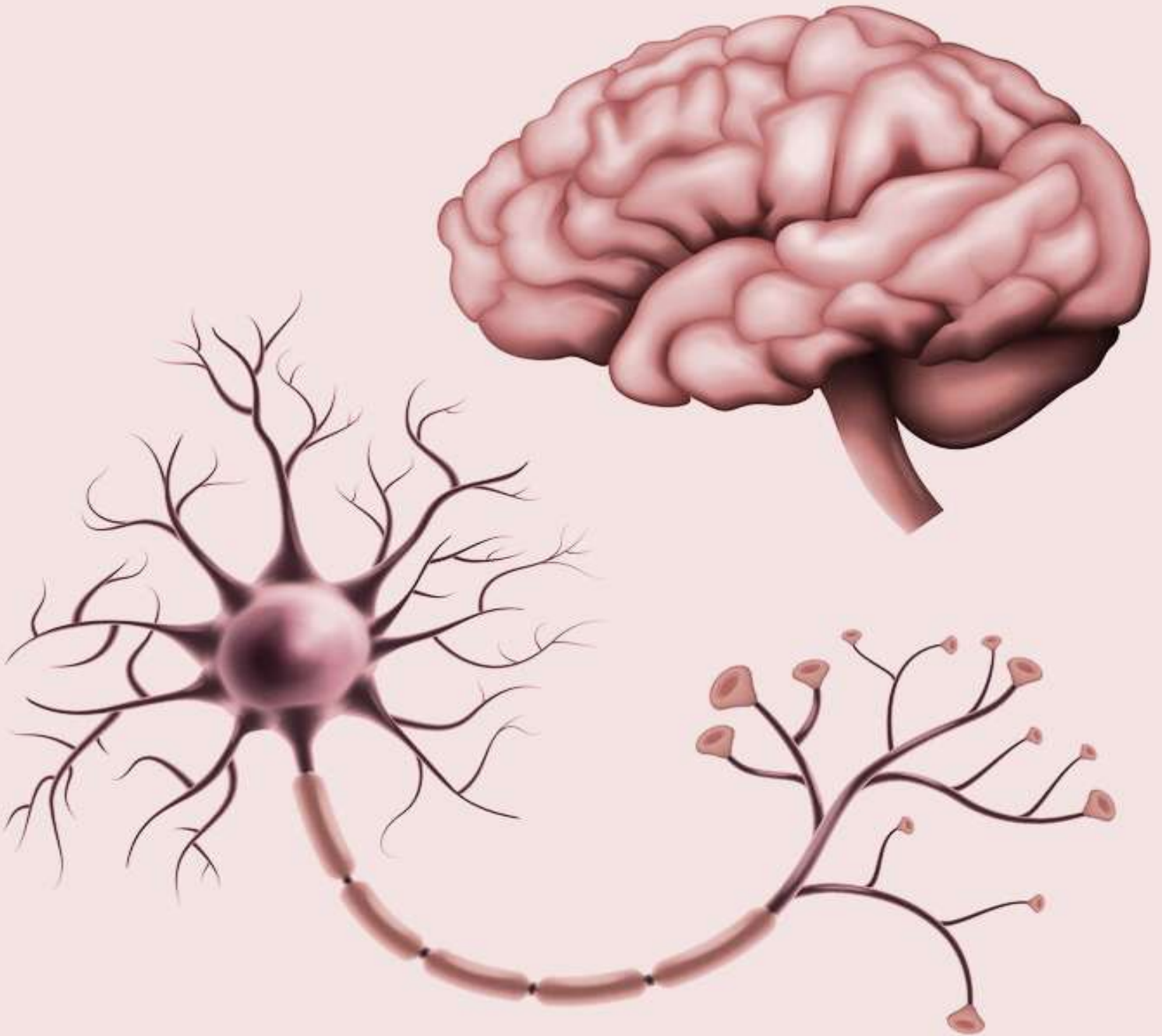


NERVOUS SYSTEM



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Contents

Neurons and their Functions.....	1
Types of Neurons.....	2
The Flow of Information in the Nervous System.....	3
Nerve and Nerve Tracts.....	3
The Nerve Impulse and Transmission	4
Synapse	8
Neurotransmitters	9
Types of the Nervous System.....	13
Reflex Action	21
Conditioned Reflex.....	25
Drug Abuse	25
The social effects of drug abuse on individuals, families and communities	36

HUMAN BODY SYSTEM

The Nervous System

- Responsible for the reception and processing of sensory information.
- It has two main divisions: The Central Nervous System (**CNS**) and the Peripheral Nervous System (**PNS**).
- Its three functions are:
 1. Receives sensory input
 2. Information processing and integration
 3. Generates motor output

Neurons and their Functions

- The nervous system is composed of **neurons** and **glial** cells.

a) Neurons

- The basic structural and functional units.
 - The basic unit of communication
- Specialized to respond to stimuli, conduct impulses, and release chemical regulators
- Enable the perception of stimuli, learning, memory, and the control of muscles and glands
- They consist of a cell body, dendrites and axons.
 - Dendrites and axons are processes or extensions from the cell body.

i. Cell body (Soma)

- It contains the cell organelles.
- It is the neuron's core and contains the nucleus
- Most are located inside the CNS and form the grey matter.
- Cell bodies located in the PNS are called **ganglia**.

ii. Axon

- It conducts information away from the cell body.
- It delivers impulse to another neuron, a gland or a muscle.
- It branches into many axon terminals at its end.
- Individual axons (nerve fibers) form a nerve.
- Many are insulated with myelin sheath.
 - It is a protective covering made up of specialized cells called **Schwann cells** in the PNS.
 - It provides insulation that enhances the speed and efficiency of nerve impulse transmission.
 - The small gaps between the myelin sheath segments are called **Nodes of Ranvier**.

iii. Dendrites

- Short extensions that receive signals from sensory receptors or other neurons.
- Neurons can have more than one set of dendrites, known as dendritic trees.

b) Glial cells (Neuroglia, Greek *glia* - glue)

- Supporting cells that are about five times more abundant than neurons.
- Provide nourishment to the neurons

Types of Neurons

a) Sensory (afferent) Neurons

- Carry messages from receptors to the CNS.
- Triggered by physical and chemical inputs
- Have a long dendrite and short axon

b) Motor (efferent) Neurons

- Transmit messages from the CNS to effectors and allow the CNS to communicate with effectors
- Play a role in voluntary and involuntary movements
- Have a long axon and short dendrites

c) Interneurons (Association neurons)

- Found entirely within the CNS
- Form connections between sensory and motor neurons
- Pass signals from sensory to motor neurons, integrate these functions.

The Flow of Information in the Nervous System

- Receptors detect stimuli (sensory input).
- Sensory neurons transmit information to the CNS.
- CNS (interneurons) processes and interprets sensory input.
- Signals sent from CNS to effectors (muscles, glands).
- Effectors carry out motor responses (movement, secretion etc).

Nerve and Nerve Tracts

a) Nerve

- A group of neurons (bundle of neurons) with blood vessels and connective tissue.
- Nerves can vary in size and function.

b) Sensory (afferent) nerves

- Made only of sensory neurons
- Carry sensory information from the PNS to the CNS
- Optic nerve and olfactory nerve are examples

c) Motor (efferent) nerves

- Made only of motor neurons
- Transmit motor commands from the CNS to muscles and glands
- Autonomic nerves are motor nerves

d) Mixed Nerves

- Contain both sensory and motor neurons
- They are involved in bidirectional communication.
- Most peripheral nerves (e.g. the sciatic nerves) are mixed nerves

e) Nerve tract

- Groups of neurons within the central nervous system
- All the neurons are concerned with either sensory or motor activity.
- They are composed of white matter (composed primarily of myelinated nerve fibers)

Checkpoint 1

1. What are the two main divisions of the nervous system?

A. Sensory and Motor	C. CNS and PNS
B. Sympathetic and Parasympathetic	D. Somatic and Autonomic
2. Which part of a neuron conducts information away from the cell body?

A. Dendrites	C. Nucleus
B. Axon	D. Soma
3. What is the role of glial cells in the nervous system?

A. Conducting electrical impulses	C. Providing nourishment to neurons
B. Generating motor output	D. Receiving sensory input
4. What is the protective covering of many axons called?

A. Nucleus	C. Myelin sheath
B. Axon terminal	D. Dendrite
5. Where are cell bodies of neurons located if they are inside the Peripheral Nervous System?

A. Nucleus	C. Ganglia
B. Axon terminal	D. Dendrite

6. Which type of neuron carries messages from receptors to the CNS?
- A. Afferent neurons
 - B. Interneurons
 - C. Efferent neurons
 - D. Mixed neurons
7. Which type of neuron is found entirely within the CNS?
- A. Afferent neurons
 - B. Interneurons
 - C. Efferent neurons
 - D. Mixed neurons
8. What is the function of motor (effector/efferent) nerves?
- A. Carry sensory information from the PNS to the CNS
 - B. Transmit motor commands from the CNS to effectors
 - C. Form connections between sensory and motor neurons
 - D. Involved in bidirectional communication
9. Which nerve is an example of a sensory (afferent) nerve?
- A. Facial nerve
 - B. Mixed nerve
 - C. Sciatic nerve
 - D. Olfactory nerve
10. What are mixed nerves composed of?
- A. Both sensory and motor neurons
 - B. Both sensory and association neurons
 - C. Only sensory neurons
 - D. Only motor neurons

The Nerve Impulse and Transmission

- Nerve impulse is a minute electrical event that works as a result of charge differences across the membrane of the axon.
- The three stages of impulse conduction are resting potential, depolarization, and repolarization.

a) Resting potential

- It is the membrane potential when an axon is not conducting an impulse.
- When an axon is resting, the outside is positive compared to the inside (polarized).
 - The inside of the membrane is more negative.
- The resting membrane potential is equal to about -65mV (-40mV – -90mV).
- Na^+ is about 16 times higher outside and K^+ is about 25 times higher inside.
 - It is this concentration gradient that contributes to the negative resting membrane potential of the axon.
 - Potassium leak channels are always open and allow K^+ ions to flow freely across the membrane according to their electrochemical gradient.
- At rest, the neuron is relatively impermeable to ions.
 - Ion channels can be opened by a variety of stimuli.

b) Depolarization

- The neuron receives a stimulus either from other neurons or through sensory inputs.
- In response to the stimulus, voltage-gated sodium channels open and allow sodium ions (Na^+) to flow into the neuron.
- The inside of the axon becomes positive compared to the outside.
 - The entry of sodium ions reduces the negativity inside the cell.
- The membrane potential changes from its resting state (-65mV) towards a less negative value (closer to zero or even positive). This change in membrane potential is called **depolarization**.

- Depolarization causes adjacent locations to similarly depolarize.
- Depolarization leads to the generation of action potentials.
 - Action potential is the wave of positive charge inside the axon when the neuron is stimulated

c) Repolarization

- As soon as depolarization takes place, the membrane becomes very permeable to K^+ ions.
- Potassium channels opened and K^+ ions diffuse out of the cell along concentration gradient.
- The inside charge becomes more negative
- The restoration of positive charge outside the cell and negative charge inside the cell occurs.
- The process in which the membrane potential of a cell returns to its resting state after depolarization is called **repolarization**.
 - A change in the membrane potential where the inside of the cell becomes more negative than its resting membrane potential is called **hyperpolarization**.
 - ✓ Hyperpolarization results from the flowing out of K^+ ions from the cell.
 - ✓ The extent of hyperpolarization can reach -90 mV.
 - ✓ It makes the cell less excitable by increasing the threshold required to generate an action potential.
- Na-K pump starts and normal concentration of Na^+ and K^+ is reestablished.
 - Na and K pumps return sodium ions outside and potassium ions inside
 - Each pump actively transports two K^+ ions into the cell to every three Na^+ ions transported out.
- The membrane is once again at its resting membrane potential and ready to respond to another stimulus.
- A neuron can transmit hundreds of impulses each second.

Synapse

- A synapse is a specialized junction between neurons or between a neuron and an effector cell.
- It allows neurons to transmit electrical or chemical signals to other neurons or target cells.
- A synapse typically consists of three main components:
 - a. The presynaptic terminal:** It contains synaptic vesicles filled with neurotransmitters.
Synaptic vesicles are found within the synaptic knobs of neurons.
 - b. The synaptic cleft:** A narrow gap between the presynaptic and postsynaptic membranes.
It typically ranges from about 20 to 40 nm in width.
 - c. The postsynaptic membrane:** It contains neurotransmitter receptors.
- There are 3 main types of synapses based on the neuronal structures participating in the connection.
 - a. Axodendritic Synapse:** The axon terminal of one neuron forms a synaptic connection with the dendrites of another neuron. This type of synapse is common in the nervous.
 - b. Axosomatic Synapse:** The axon terminal of one neuron forms a synaptic connection directly with the cell body (soma) of another neuron.
 - c. Axoaxonic Synapse:** The axon terminal of one neuron forms a synaptic connection with the axon of another neuron.

Signal transmission through a synapse

1. Action potential reaches presynaptic terminal.
2. Voltage-gated Ca^{2+} channels open when an action potential reaches the axon terminal and depolarizes the membrane
3. Calcium enters axon terminal from the extracellular space surrounding the neuron.
4. Neurotransmitter (e.g., acetylcholine) is released and diffuses into the cleft.
5. Neurotransmitter binds to the postsynaptic receptors
6. Neurotransmitter binding leads to the opening of ion channels in the postsynaptic membrane.

7. Neurotransmitter is removed from synaptic cleft through reuptake by transporter proteins, enzymatic degradation, diffusion, and uptake by glial cells.

Checkpoint 2

1. During which stage of impulse conduction do voltage-gated sodium channels open?
 - A. Resting potential
 - B. Depolarization
 - C. Repolarization
 - D. Hyperpolarization
2. What is the change in membrane potential called when the inside of the axon becomes more positive during depolarization?
 - A. Repolarization
 - B. Action potential
 - C. Hyperpolarization
 - D. Resting potential
3. What is the primary function of the Na-K pump during repolarization?
 - A. Initiating the action potential
 - B. Transporting sodium ions into the cell
 - C. Restoring the resting membrane potential
 - D. Transporting potassium ions out of the cell
4. How many K^+ ions are transported into the cell by the Na-K pump for every three Na^+ ions transported out?
 - A. One
 - B. Three
 - C. Two
 - D. Four
5. Which stage of impulse conduction involves the restoration of the membrane potential to its resting state?
 - A. Resting potential
 - B. Repolarization
 - C. Depolarization
 - D. Hyperpolarization

6. Which ion flows into the neuron during depolarization?
- A. Sodium (Na^+)
 - B. Chloride (Cl^-)
 - C. Potassium (K^+)
 - D. Calcium (Ca^{2+})
7. Which stage of impulse conduction involves the neuron being relatively impermeable to ions?
- A. Resting potential
 - B. Repolarization
 - C. Depolarization
 - D. Hyperpolarization
8. Which component of the synapse contains synaptic vesicles filled with neurotransmitters?
- A. Presynaptic terminal
 - B. Postsynaptic membrane
 - C. Synaptic cleft
 - D. Axon terminal
9. What is the narrow gap between the presynaptic and postsynaptic membranes called?
- A. Presynaptic terminal
 - B. Postsynaptic membrane
 - C. Synaptic cleft
 - D. Synaptic vesicle
10. In which type of synapse does the axon terminal form a synaptic connection with the dendrites of another neuron?
- A. Axodendritic synapse
 - B. Axoaxonic synapse
 - C. Axosomatic synapse
 - D. Axon terminal synapse

Neurotransmitters

- They are chemical messengers released by neurons to transmit signals across synapses.
- They facilitate communication between neurons, as well as between neurons and other cells, such as muscle cells or gland cells.
- They are synthesized within the neuron's cell body (soma) or axon terminal.
- Neurotransmitters are packaged into synaptic vesicles after synthesis.
- Synaptic vesicles serve as storage depots for neurotransmitters until they are released.
- There are two types of neurotransmitters based on their effects on postsynaptic neurons.
 - Excitatory neurotransmitters: Exciting neural activity
 - Inhibitory neurotransmitters: Inhibiting neural activity
- Examples of neurotransmitters include acetylcholine, dopamine, serotonin, glutamate, gamma-aminobutyric acid (GABA), and norepinephrine.

a. Acetylcholine.

- One of the most common chemical transmitters found in synapses.
- It is widely distributed throughout the nervous system (CNS and PNS).
- It can have excitatory effects at neuromuscular junctions but inhibitory effects in certain regions of the brain.
- It is the primary neurotransmitter released by motor neurons at the neuromuscular junction.
- A number of well-known poisons work by affecting synapses with acetylcholine.
 - Certain toxins, such as botulinum toxin, inhibit the release of acetylcholine and lead to muscle paralysis.
 - Strychnine and organophosphorus compounds prevent the normal degradation of acetylcholine in the synaptic cleft causing rigid paralysis.

- Curare (arrow poison) binds competitively to the acetylcholine receptors and blocks the transmission of nerve impulses from motor neurons to muscle cells.

b. Dopamine

- It is a neurotransmitter in the brain.
- It plays essential roles in movement, motivation, reward, and cognition.
- Dopamine can have excitatory or inhibitory effects depending on the specific receptors they activate and the brain regions they act upon.

c. Serotonin

- Involved in mood disorders (e.g., depression, anxiety), sleep-wake cycles, appetite regulation, and cognitive processes such as learning and memory.
- It primarily acts as an inhibitory neurotransmitter in the central nervous system (CNS). It can also exert excitatory effects in certain brain regions or under specific conditions.

d. Glutamate

- It acts as the primary excitatory neurotransmitter in the brain.
- It mediates synaptic transmission involved in learning, memory, cognition, and various sensory processes.
- It is essential for synaptic plasticity and neuronal development.

e. Gamma-Aminobutyric Acid (GABA)

- It acts as the primary inhibitory neurotransmitter in the brain.
- It modulates neuronal excitability, preventing excessive neural firing and promoting relaxation.
- It plays a crucial role in regulating anxiety, stress responses, and sleep.

f. Norepinephrine

- It acts as both a neurotransmitter and hormone, regulating arousal, attention, stress responses, and mood.

- It Involves in the body's fight-or-flight response, regulating attention and vigilance, modulating mood states, and regulating autonomic functions such as heart rate and blood pressure.
- It can have excitatory or inhibitory effects depending on the specific receptors they activate and the brain regions they act upon.

Checkpoint 3

1. What is the primary function of neurotransmitters?
 - A. To generate electrical impulses in neurons
 - B. To integrate incoming signals from dendrites
 - C. To facilitate communication between neurons
 - D. To maintain the electrolyte balance of neurons
2. What is the role of synaptic vesicles in neurotransmission?
 - A. They amplify the electrical signals in neurons
 - B. They store neurotransmitters until they are released
 - C. They produce neurotransmitters in the synaptic cleft
 - D. They degrade neurotransmitters after they are released
3. Which of the below is the part of a neuron that produces neurotransmitters?

A. Dendrites	C. Presynaptic terminals
B. Schwann cells	D. Synaptic vesicles
4. Which of the following is **NOT** a neurotransmitter?

A. Serotonin	C. Dopamine
B. Acetylcholine	D. Insulin
5. Which of the following is a common symptom of poisons affecting acetylcholine?

A. Memory loss	C. Increased heart rate
B. Muscle paralysis	D. Visual hallucinations

6. Which of the following statements about acetylcholine is false?
- A. It is widely distributed throughout the nervous system.
 - B. It can have excitatory effects at neuromuscular junctions.
 - C. It is the primary neurotransmitter released by sensory neurons.
 - D. Certain toxins can inhibit its release, leading to muscle paralysis.
7. Which toxin binds competitively to acetylcholine receptors, blocking the transmission of nerve impulses from motor neurons to muscle cells?
- A. Botulinum toxin
 - B. Organophosphorus compounds
 - C. Strychnine
 - D. Curare (arrow poison)
8. Which neurotransmitter acts as both a neurotransmitter and hormone?
- A. Dopamine
 - B. Norepinephrine
 - C. Serotonin
 - D. Glutamate
9. What neurotransmitter is commonly associated with pleasure or reward?
- A. GABA
 - B. Dopamine
 - C. Serotonin
 - D. Glutamate
10. What neurotransmitter is primarily involved in regulating the sleep-wake cycle?
- A. Serotonin
 - B. Acetylcholine
 - C. Dopamine
 - D. Glutamate

Types of the Nervous System

- The human nervous system can be broadly divided into two main groups: Central Nervous System (CNS) and Peripheral Nervous System (PNS).

1. Central Nervous System (CNS)

- The CNS consists of the brain and spinal cord.
- It plays a role in integrating and processing sensory information, coordinating motor responses, and regulating higher cognitive functions.

a) The Brain

- The brain is located within the cranial cavity of the skull.
- The average adult human brain weighs about 1.4 kg and has a volume of approximately 1,300 to 1,400 cc.
- The human brain has a roughly oval shape.
- The brain requires protection because it is a delicate and vital organ.
- Four major features help protect the brain from injury:

i. Skull: Protects the brain with hard bones.

ii. Meninges: three membranes that protect and nourish the brain.

➤ The layers of the meninges, from outer to inner, are Dura mater, Arachnoid mater and Pia mater.

- **Dura mater:** The tough, outermost layer that lines the inside of the skull.
- **Arachnoid mater:** A delicate, web-like membrane located beneath the dura mater, with a subarachnoid space containing cerebrospinal fluid.
- **Pia mater:** The innermost layer that directly adheres to the surface of the brain, providing nourishment and support to neural tissue.

iii. Cerebrospinal fluid: Cushions and regulates brain's environment, supports the weight of the brain, and helps to maintain uniform pressure around the brain.

iv. Blood-brain barrier: Selectively allows nutrients, prevents toxins.

- Brain is a complex and vital organ that serves as the command center of the nervous system.
- It is divided into distinct regions, including the cerebrum, cerebellum, and brainstem.
- The brain is classified into forebrain, midbrain, and hindbrain based on developmental and anatomical features.
 - i. Forebrain:** It is the most anterior (front) portion of the brain and includes the cerebrum, thalamus, hypothalamus, and limbic system.
 - ii. Midbrain:** It is located between the forebrain and hindbrain and plays a role in relaying sensory information to higher brain regions.
 - iii. The hindbrain:** It is the most posterior (rear) portion of the brain and includes the cerebellum, pons, and medulla oblongata.
- Different regions of the brain are specialized for specific functions.

Cerebrum (Telencephalon)

- Cerebrum is the largest part of the brain, occupying the uppermost portion.
- It is divided into two cerebral hemispheres, connected by the corpus callosum.
- The outer layer called cerebral cortex contains billions of neurons and is involved in processing sensory information and initiating motor responses.
- It is responsible for higher cognitive functions such as thinking, memory, and perception.
- It consists of four lobes: frontal, parietal, temporal, and occipital, each with distinct functions.

Cerebellum

- Cerebellum is located beneath the cerebrum, at the back of the brain.
- It is responsible for coordinating voluntary movements, balance, and posture.

- Receives input from sensory systems and the cerebral cortex to fine-tune motor control and coordination.

Medulla oblongata

- Medulla oblongata is the lowest part of the brainstem.
- It connects the spinal cord to the brain.
- It acts as a relay station for sensory and motor signals traveling between the brain and spinal cord.
- It plays a vital role in controlling heartbeat, breathing, and blood pressure.
- It is responsible for regulating reflexes like swallowing, coughing, and sneezing.

Thalamus

- Thalamus serves as a relay station for sensory information traveling to the cerebral cortex.
- Located above the brainstem, beneath the cerebral hemispheres.
- Receives sensory signals from various sensory pathways (except olfaction) and relays them to the appropriate regions of the cerebral cortex for further processing.
- Also involved in regulating consciousness, sleep, and alertness.
- Plays a crucial role in integrating and modulating sensory input before it reaches the cortex.

Hypothalamus

- The hypothalamus is a small, pea-sized structure located beneath the thalamus, within the brain.
- It serves as a crucial link between the nervous system and the endocrine system, regulating many bodily functions and maintaining homeostasis.
- Controls various autonomic functions such as body temperature, hunger, thirst, and sleep-wake cycles.
- Regulates hormone secretion from the pituitary gland, influencing processes such as growth, reproduction, and stress response.

- Also involved in emotional regulation and the expression of behaviors related to survival and reproduction.

Pons

- The pons is a prominent structure located in the brainstem, above the medulla oblongata and below the midbrain.
- It serves as a relay center, transmitting signals between the cerebrum, cerebellum, and spinal cord.
- Involved in regulating vital functions such as breathing, sleep, and arousal.
- Contains nuclei responsible for controlling facial movements, sensation, and certain reflexes.
- Plays a role in coordinating voluntary movements and posture, working closely with the cerebellum.

b) The Spinal Cord

- It is located within the spinal canal and links the CNS to sensory and motor neurons of the PNS.
- It has much simpler structure than the brain.
- It is a long, thin, tubular structure that runs out from the brain down to the lower back.
 - It begins as a continuation of the medulla oblongata.
 - In adults, it is 42 – 45 cm long and weighs between 30 and 35 grams.
- In the spinal cord, white matter forms the outer layer and the grey matter is located in the middle.
- It has entrance and exit points at regular intervals.
 - The entrance and exit points correspond to the locations where spinal nerves emerge from the spinal cord.
 - The nerves that emerge from the spinal cord and extend outwards to various parts of the body are called spinal nerves.
- It is protected by the vertebrae, the spinal meninges and the CSF.

- The vertebrae are stacked bony segments that provide structural support and protection to the spinal cord.
- The meninges provide structural support, protection from injury, and help to maintain the internal environment of the spinal cord.
 - ✓ Dura mater (outermost), arachnoid mater (middle layer) and pia mater (inner most) are the three layers of the spinal meninges.
- Cerebrospinal fluid (CSF) is a clear, colorless fluid that surrounds the spinal cord and serves several important functions including cushioning, buoyancy, nutrient and waste transport, and protection from chemical imbalance.

2. Peripheral Nervous System (PNS)

- The PNS consists of all the nerves located outside of the brain and spinal cord.
- It connects the CNS to the body's organs, muscles, and sensory receptors.
- It facilitates communication between different parts of the body and the CNS.
- It can be further subdivided into two main functional components:

A. Afferent Division

- It includes all the sensory neurons that carry information from receptors to the CNS.
- It is responsible for transmitting sensory information from sensory receptors to the CNS.

B. Efferent Division

- It is responsible for carrying motor commands from the CNS to muscles, glands, and other effector organs.
- It enables voluntary and involuntary movements, as well as the regulation of glandular secretion.
- The efferent division can be further subdivided into SNS and ANS.

i. Somatic Nervous System (SNS)

- It carries sensory and motor information to and from the CNS.
- It controls voluntary movements of skeletal muscles.

ii. Autonomic Nervous System (ANS)

- It regulates involuntary bodily functions, such as heart rate, digestion, respiration, and glandular secretion.
- It is further divided into the sympathetic and parasympathetic divisions.
 - The two divisions of the ANS often work in opposition to each other.

Sympathetic System

- It prepares the body for rapid, vigorous action in response to stress or danger.
- It is often referred to as the "fight or flight" system.
- Some of the effects of sympathetic activation include:
 - Increased heart rate and force of contraction.
 - Dilation of airways to increase oxygen intake.
 - Dilation of pupils to enhance visual acuity.
 - Inhibition of digestive activity and reduction of blood flow to the digestive organs.
 - Release of glucose into the bloodstream to provide energy.
 - Dilation of blood vessels in skeletal muscles to increase blood flow.

Parasympathetic System

- It conserves energy and promotes relaxation, digestion, and other non-emergency functions.
- It is often called the "rest and digest" system.
- Some of the effects of parasympathetic activation include:
 - Slowing of heart rate.
 - Constriction of airways.

- Constriction of pupils.
- Stimulation of digestive activity and increased blood flow to the digestive organs.
- Promotion of urination and defecation.

Checkpoint 4

1. Which of the following correctly identifies the two parts of the Central Nervous System?

A. ANS and SNS	C. Neuron and Neuroglia
B. Spinal cord and Brain	D. Sympathetic and parasympathetic
2. Which statement accurately describes the brain?
 - A. The human brain is rectangular in shape.
 - B. It is enclosed and protected by the vertebral column.
 - C. The average adult human brain weighs about 1.4 kg.
 - D. The brain does not require protection due to its resilience.
3. Which of the following correctly describes the meninges?
 - A. Specialized cells responsible for producing cerebrospinal fluid.
 - B. A network of blood vessels supplying nutrients to the brain tissue.
 - C. Three membranes that protect and nourish the brain and spinal cord.
 - D. The outermost layer of the brain responsible for processing information.
4. Which sequence represents the correct order of layers of the meninges from outer to inner?
 - A. Arachnoid mater, Dura mater, Pia mater
 - B. Dura mater, Pia mater, Arachnoid mater
 - C. Pia mater, Arachnoid mater, Dura mater
 - D. Dura mater, Arachnoid mater, Pia mater
5. Which of the following structures is part of the forebrain?

A. Pons	C. Cerebrum
B. Cerebellum	D. Medulla oblongata

6. What is the primary function of the cerebral cortex?
- A. Coordinating voluntary movements, balance, and posture
 - B. Controlling vital functions such as breathing and heartbeat
 - C. Regulating reflexes like swallowing, coughing, and sneezing
 - D. Processing sensory information and initiating motor responses
7. Which part of the brain is primarily responsible for symptoms such as staggering, slurred speech, and difficulty walking as a result of alcohol consumption?
- A. Thalamus
 - B. Cerebellum
 - C. Cerebrum
 - D. Hypothalamus
8. Which part of the brain is primarily responsible for controlling vital functions such as heartbeat, breathing, and blood pressure?
- A. Cerebrum
 - B. Thalamus
 - C. Hypothalamus
 - D. Medulla oblongata
9. Which of the below is the function of the thalamus?
- A. Processing visual and auditory information
 - B. Regulating heartbeat, blood pressure and breathing
 - C. Relaying sensory information to the cerebral cortex
 - D. Linking the nervous system and the endocrine system
10. How does the hypothalamus contribute to maintaining homeostasis?
- A. By controlling voluntary muscle movements
 - B. By regulating body temperature, hunger, and thirst
 - C. By regulating waste products of respiration in the body
 - D. By transmitting signal between the brain and spinal cord

11. Which one serves as a relay center, transmitting signals between the cerebrum, cerebellum, and spinal cord?
- A. Pons
 - B. Thalamus
 - C. Hypothalamus
 - D. Corpus callosum
12. Which of the following best describes the location of the spinal cord?
- A. It is situated within the thoracic cavity.
 - B. It is located within the abdominal cavity.
 - C. It runs through the vertebral canal.
 - D. It is found within the cranial cavity.
13. In the spinal cord, which matter forms the outer layer?
- A. Pia mater
 - B. Dura mater
 - C. Grey matter
 - D. White matter
14. Which of the following does NOT protect the spinal cord?
- A. Skull
 - B. Vertebrae
 - C. Spinal meninges
 - D. Cerebrospinal fluid
15. What does the Peripheral Nervous System (PNS) primarily consist of?
- A. Nerves within the brain and spinal cord
 - B. The brain, the spinal cord and visceral organs
 - C. Sensory nerves that carry impulse from receptors
 - D. Nerves located outside of the brain and spinal cord
16. Which division of the Peripheral Nervous System (PNS) is responsible for carrying sensory information from sensory receptors to the Central Nervous System (CNS)?
- A. Somatic Nervous System
 - B. Autonomic Nervous System
 - C. Afferent Division
 - D. Efferent Division

17. Which component of the efferent division of the PNS controls voluntary movements of skeletal muscles?
- A. Sympathetic System
 - B. Parasympathetic System
 - C. Somatic Nervous System
 - D. Autonomic Nervous System
18. Which division of the Autonomic Nervous System (ANS) prepares the body for rapid, vigorous action in response to stress or danger?
- A. Parasympathetic System
 - B. Somatic Nervous System
 - C. Afferent Division
 - D. Sympathetic System
19. What are the two main subdivisions of the Autonomic Nervous System (ANS)?
- A. Sensory and Motor Divisions
 - B. Afferent and Efferent Divisions
 - C. Central and Peripheral Divisions
 - D. Sympathetic and Parasympathetic Divisions
20. Which of the following is an effect of sympathetic activation?
- A. Decreased heart rate and force of contraction
 - B. Constriction of pupils to enhance visual acuity
 - C. Reduction of blood flow to the digestive organs
 - D. Narrowing of airways to decrease oxygen intake

Reflex Action

- A sudden, automatic and uncontrolled response of the body or body parts.
 - Innate reflexes are present at birth and do not require prior learning or experience to occur.
- In reflex actions, the messages do not reach a conscious area of the brain.
- It usually helps as to avoid danger or damage.
- Some examples are knee-jerk reflex, pupillary reflex, blink reflex, withdrawal reflex, and sneeze reflex.
- The pathway of neurons involved in a reflex action is known as **reflex arc**.
- The five essential parts of the reflex arc are: Receptors, Sensory neurons, CNS, Motor neurons and Effectors.
- Many reflexes involve the spinal cord.

Conditioned Reflex

- It occurs when an organism learns to associate a neutral stimulus (such as the sound of a bell) with a meaningful stimulus (such as food).
- It involves the modification of behavior based on past experiences and associations between stimuli.
- Conditioned reflexes are a result of experience or learning.
- Ivan Pavlov investigated conditioned reflex action using a dog.

Pavlov's experiment

1. Initially, dogs salivated at the sight of food (innate reflex).
 2. He rang a bell before presenting food, creating an association.
 3. Eventually, dogs salivated at the sound of the bell alone (conditioned reflex).
- Pavlov's experiments provided valuable insights into the mechanisms of learning and behavior.

Checkpoint 5

1. Which term refers to reflexes that are present at birth and do not require prior learning?
 - A. Innate reflexes
 - B. Learned reflexes
 - C. Acquired reflexes
 - D. Adaptive reflexes
2. What best defines a reflex action?
 - A. A voluntary action requiring prior learning.
 - B. A slow and conscious response of the body.
 - C. A response involving only the conscious brain.
 - D. An automatic and uncontrolled response of the body.
3. What is the primary purpose of reflex actions?
 - A. To improve motor skills
 - B. To avoid danger or damage
 - C. To engage the conscious brain
 - D. To test the body's response capabilities
4. What is the nerve path in the body that leads from stimulus to reflex action called?
 - A. Synapse
 - B. Reflex arc
 - C. Neural circuit
 - D. Motor pathway
5. Which is the correct sequence of components of a reflex arc?
 - A. Receptors, Sensory neurons, CNS, Motor neurons, Effectors
 - B. Sensory neurons, Receptors, CNS, Motor neurons, Effectors
 - C. Effectors, Motor neurons, CNS, Sensory neurons, Receptors
 - D. Receptors, CNS, Sensory neurons, Motor neurons, Effectors
6. In a reflex action, why is the spinal cord often involved?
 - A. To consciously interpret the stimulus
 - B. To provide a rapid, automatic response
 - C. To coordinate complex movements
 - D. To initiate the motor response

7. In the withdrawal reflex, what type of response occurs in the muscles of the affected limb?
- A. Contraction
 - B. Extension
 - C. Relaxation
 - D. Constriction
8. What is the primary function of the sneeze reflex?
- A. To stimulate the sense of smell
 - B. To expel excess mucus from the lungs
 - C. To regulate airflow in the respiratory system
 - D. To clear foreign particles from the nasal passages
9. Who is credited with the investigation of conditioned reflex action using dogs?
- A. Ivan Pavlov
 - B. Charles Darwin
 - C. Louis Pasteur
 - D. Aleksandr Oparin
10. In a classic experiment on conditioned reflexes, what stimulus was used to condition dogs?
- A. A gust of wind
 - B. A tap on the nose
 - C. A flash of light
 - D. A ringing bell

Drug Abuse

- A **drug** is a substance which alters the way in which your mind, or body, or both, works.
- Drugs have the following features in common:
 - They are addictive.
 - They affect brain function and alter behaviour.
 - They damage health, resulting in lower productivity and absence from school/work.
 - They adversely affect the individual, families, community and country.
- In Ethiopia caffeine, nicotine, khat and alcohol are the legal recreational drugs.
 - Legal drugs are used for the mild pleasure they bring, to be sociable and because using them becomes a habit.
- Drugs such as LSD, ecstasy, cannabis, cocaine and heroin are illegal but rarely used in Ethiopia.
 - Lifestyle associated with illegal drug use has major impact on health.
 - Illegal drug use can lead to addiction, mental health disorders, and increased risk of contracting HIV and hepatitis C.
- **Drug (or substance) use** is when you choose to take a substance to the extent that affects your brain and/or body function and mental activity.
- **Drug (or substance) abuse** is when you use a substance to the point of excess and/or dependence.
 - Drug abuse is becoming more of a public health problem in Ethiopia.
- **Drug dependence** is when you use a drug again and again and become addicted.
 - Addiction leads to an inability to manage or function properly without the drug.
 - ✓ It can manifest psychologically as a craving or compulsion to keep using.
 - ✓ Physical dependence occurs when the body requires the drug to function normally.
 - ✓ Increasing amounts of the drug are needed to maintain the desired effect.

- Addiction is marked by a change in behaviour caused by the biochemical changes in the brain after continued substance abuse.
- Drug addiction (substance use disorder) is a disease that negatively affects a person's brain and behaviour.
- **Withdrawal symptoms** are a set of unpleasant effects upon the body caused by a sudden stopping of using a drug.
 - Withdrawal symptoms include aches, shaking, sweating, headaches, cravings, and fevers.

Most Abused Drugs in Ethiopia

- The most commonly abused drugs in Ethiopia are cigarette, alcohol, khat, cannabis, and solvents.

a. Smoking

- The addictive drug in cigarette smoke is **nicotine**.
 - Nicotine causes the release of dopamine in the brain, which gives people a good feeling.
 - Nicotine affects the brain and produces a sensation of calm, well-being and being able to cope with.
 - ✓ Over time, the brain begins to crave those feelings from nicotine.
 - Nicotine leads to addiction primarily through its effects on the brain's reward system, particularly the release of dopamine.
- Cigarette smoke also contains many very harmful chemicals such as tar and carcinogens.
- Smoking increases the risk of coronary heart disease, strokes, lung diseases (e.g. Chronic Obstructive Pulmonary Disease (COPD), and lung cancer), and cancer of the lip, mouth, throat, pancreas, bladder and kidney.
 - Quitting smoking can significantly reduce the risk of developing these diseases and improve overall health and well-being.
- Smoking doesn't only harm the person who smokes; it also affects those around them.

- Passive smoking, which involves inhaling smoke from others, can pose significant health risks.
- Smoking during pregnancy has adverse effects on the unborn child.
- Nicotine addiction makes quitting smoking difficult.
- Several methods can help individuals quit smoking:
 - Quitting smoking abruptly or gradual reduction
 - Nicotine replacement therapies like patches or gum.
- Will power and determination are needed whichever method you chose. Ultimately, it's easier not to start smoking in the first place.

b. Alcohol

- Alcohol is most commonly used by people of all ages in Ethiopia.
 - Ethiopians drink far less than many other countries.
 - For many people alcohol is part of their social life.
 - In small amounts, alcohol makes people feel relaxed and cheerful.
 - It also makes you less inhibited and feel more confident.
- Alcohol has been around for thousands of years and it is accepted all over the world.
 - Its cultural and historical significance has contributed to its widespread acceptance and legalization.
- Alcohol has a powerful effect on the brain. It produces pleasurable feelings and blunts negative feelings.
 - This is why some people drink alcohol again and again.
- Alcohol is very addictive and poisonous.
 - The poison in alcohol is ethanol.
- When you drink alcohol, it goes into your liver and the liver works to break down this poison.

- The liver gets rid of the alcohol before it causes permanent damage and death. But drinking too much alcohol can hurt your liver.
- Over time, too much alcohol can cause serious health issues like liver disease.
- Alcohol affects neurotransmitters in the brain, particularly gamma-aminobutyric acid (GABA) and glutamate.
 - Alcohol enhances the effects of GABA and inhibits glutamate, resulting in a depressant effect on the central nervous system.
 - ✓ GABA is an inhibitory neurotransmitter that slows down brain activity, leading to relaxation and sedation.
 - ✓ Glutamate is an excitatory neurotransmitter that stimulates brain activity.
- With repeated alcohol consumption, your body develops a tolerance to its effects.
 - Over time, you may need to drink more alcohol to achieve the same level of desired effects.

Effects of Alcohol

- It dilates blood capillaries near the skin surface, creating a sense of warmth and well-being.
 - Increased blood flow to the skin reduces blood flow to internal organs.
 - Skin capillary dilation can cause heat loss from the body.
 - Alcohol's effects on blood vessels may alter heart rate and blood pressure.
- It increases heart rate and hunger.
 - It contributes to an increase in hunger and food intake due to its effects on blood sugar levels and appetite-regulating hormones.
- It affects the nervous system, slowing down reactions and impairing self-control.
- It causes poor muscular coordination which leads to slurred speech and lack of balance.
- It acts as a diuretic which means it causes increased urination and dehydration, resulting in headaches and nausea as its effects wear off.

- The unpleasant physical and mental symptoms that occur after consuming excessive amounts of alcohol is called **hangover**.
- Excessive alcohol consumption leads to impaired judgment, increasing the likelihood of engaging in risky behaviors such as unprotected sex.
- Binge drinking, especially among young people, can lead to violent behavior, property damage, and increased risk of HIV/AIDS through unprotected sex. They are also more likely to become pregnant.
- Alcohol impairs behavior, increasing the risk of accidents, particularly dangerous when driving.
- Alcohol abuse contributes to domestic violence and various crimes, often in combination with other drugs.
- Chronic heavy drinking can lead to addiction, liver damage, including cirrhosis and liver cancer, brain damage, and ultimately death.
- Alcohol addiction is a chronic relapsing disorder associated with compulsive alcohol drinking, the loss of control over intake, and the emergence of a negative emotional state when alcohol is no longer available.
- Alcohol use disorder (AUD) is a condition characterized by an impaired ability to stop or control alcohol use despite adverse social, occupational, or health consequences.

c. Khat (*Catha edulis*)

- Khat is a shrub grown commonly in the horn of Africa.
- In Ethiopia, it is often used in social situations and its use is growing fast among young people.
 - It is a legal drug in Ethiopia and over 30% of our population use khat regularly.
- The most common method of consuming khat is by chewing fresh khat leaves and young buds.
 - It can also be made into a tea.

- It has a stimulant effect similar to amphetamine, cocaine or very strong coffee depending on how much it is consumed.
- Khat affects neurotransmitters in the brain, particularly dopamine, norepinephrine, and serotonin.
- It contains psychoactive compounds, including cathinone and cathine, which produce stimulant effects when consumed.
 - It makes people feel happy (euphoria) and also reduces your appetite.
 - It can induce feelings of increased energy, excitement, and wakefulness (khat high).
 - It can improve concentration and focus.

Effects of khat

- People can become addicted to khat. When they cannot get the drug, feel depressed, tired and unable to concentrate.
- Prolonged use of khat can lead to the discoloration of teeth and increases the risk of tooth decay and cavities.
- Khat use is linked to unprotected sex, putting young people at risk of pregnancy and HIV/AIDS infection.
- Young men who use khat have been shown to be more likely to use a sex worker, and more likely to have many different sexual partners.
- It makes people more likely to be injured in accidents, more likely to be involved in crime.
- It makes people less likely to have a job and more likely to have problems in their family lives.
- People spend hours chewing and dreaming when they could be working.

d. Cannabis(marijuana)

- Cannabis is a plant that contains 400 known chemicals, 60 of which, called the cannabinoids, are unique to the plant.

- The most potent is delta-9-tetrahydrocannabinoid (THC).
- THC is known to affect the brain cells responsible for memory, emotion and motivation.
- Cannabis is usually smoked but it can also be eaten. Many people mix cannabis with tobacco.
- It can make you feel a great sense of wellbeing and relaxation, happy and euphoric – and this is why people use it.
- It is a mild hallucinogenic drug.
 - Hallucinogens are drugs that produce vivid waking dreams, where the user sees or hears things that are not really there, or has a distorted view of the world.
 - Many people find the effect of the drug a very unpleasant and disturbing experience.
- It affects different people in different ways, and even the same person can react very differently depending on how it is used.
- Cannabis is illegal in Ethiopia, but in spite of this there is a long tradition of using it.
- Because cannabis is illegal, people have to buy their supplies from illegal drug dealers.
- It seems to be very effective in pain relief for diseases such as multiple sclerosis.

The health risks of using cannabis

- Heavy and prolonged cannabis use has been associated with an increased risk of schizophrenia and mental illness.
- It can increase the risk of becoming infected with HIV/AIDS and other sexually transmitted diseases through unprotected sex.
- Cannabis use can impair memory, attention, and decision-making skills.
 - It impairs motor coordination and judgment.
 - They make people less able to work.
- Smoking cannabis leads to respiratory symptoms like coughing and bronchitis.
- Temporary increase in heart rate and blood pressure.

- Increases the likelihood of accidents when driving under its influence.
- There are many other illegal drugs but they are not widely used in Ethiopia, although in some places they are becoming more common. They include:

LSD (Lysergic Acid Diethylamide)

- LSD is a potent hallucinogenic drug synthesized in laboratories.
- It has profound effects on the brain, altering perception, mood, and thought processes.
- The drug is known for inducing vivid hallucinations and altering one's sense of reality.
- Prolonged use of LSD, and even first-time use in some cases, can lead to severe mental illness.
- The powerful effects of LSD on the brain can trigger conditions such as psychosis, schizophrenia, and other psychotic disorders.
- The hallucinations induced by LSD can be so intense that users may engage in extremely risky behaviors.
- There have been numerous cases of individuals experiencing LSD-induced hallucinations believing they can fly, leading to tragic incidents of people leaping from buildings and suffering fatal injuries.

Cocaine

- Cocaine is derived from the leaves of the coca plant (*Erythroxylum coca*).
- It provides a rush of energy and powerful high.
- It can lead to feelings of paranoia and depression afterward.
 - Paranoia is a state of extreme distrust and suspicion of others or one's surroundings.
- It is highly addictive; body quickly craves more.
 - Addiction develops rapidly, leading to dangerous behaviors and consequences.
- It is expensive and leads to financial strain.
- It raises blood pressure and heart rate.

- It causes irregular heartbeat and increased body temperature.
- It can result in sudden heart failure, even with first-time use.
- Cocaine puts mental and physical health at risk with each use.

Heroin

- Heroin is an opioid derived from the opium poppy (*Papaver somniferum*).
 - Opioids are a class of drugs that act on the nervous system to relieve pain.
- Opiates have been used for centuries as painkillers and recreational drugs.
- Heroin typically appears as a white or brown powder.
- It can be injected, snorted, smoked, eaten, or used as a suppository.
- It interacts with brain receptors to produce pleasure and block pain.
- Users experience reduced hunger, pain, and sexual sensations.
- Heroin addicts often share needles, increasing the risk of HIV/AIDS.
- Other risks include abscesses, hepatitis, and damage to the heart and brain.
- High doses of heroin can be lethal.

The social effects of drug abuse on individuals, families and communities

- The excessive use of drugs significantly affects the individual user, the family and the wider community.

a. Effects on individuals

- Drugs affect the nervous system, causing relaxation or increased energy.
- They can lead to aggressive behavior and impaired cognitive function.
- They often result in insomnia, anxiety, depression, and paranoia.
- Changes in appetite and weight impact work, social, and family life.
- Drug users may turn to crime, including prostitution, to support their habit.
 - This increases the risk of HIV/AIDS and other diseases.

- Neglect of personal hygiene and poor nutrition can lead to ill health.
- Injection drug use increases the risk of blood-borne diseases like hepatitis and HIV/AIDS.
- Some drugs can trigger mental illness and have direct lethal or brain-damaging effects.

b. Effects on family and friends

- Drug abuse damages relationships at home and with friends.
- Job loss due to poor performance or absence worsens financial strain.
- Drugs impair sexual function and often lead to promiscuous behavior.
 - This can strain relationships and lead to divorce.
- Some use drugs to cope with family problems, but drug use often causes family breakdown.
- Long-term drug use isolates individuals from family and community support.
- Families of drug users experience a range of negative emotions.
 - They may feel defeated, helpless, angry, depressed, and lonely.
 - Uncertainty about the drug user's whereabouts causes emotional distress.
- Conflicts arise within the family on how to address the problem.
- Drug users may steal and sell items from home to support their habit.
- Children in these families may feel lonely, confused, and depressed.
 - Some may turn to drug use themselves to cope with pain, perpetuating the cycle.

c. Effects on the community

- Drug abuse leads to theft, burglary, car theft, mugging, and violent crimes.
- Communities with high drug usage experience violence, sexual abuse, assault, and property damage.
- Drug use impairs vision, coordination, and timing, contributing to accidents.
- Communities often face fear, anxiety, and grief due to accidents caused by drug use.

- Drug abuse disrupts work, breaks up families, and has a significant economic impact on communities.
- Communities bear the cost of healthcare for addicts, education programs, and supporting affected families.
- The cost of drug abuse is high, both economically and personally.
 - It includes healthcare expenses, support programs, and the social consequences of addiction.
- Overcoming drug abuse requires individual commitment to avoid drugs and help others do the same.
- Communities can become stronger by promoting sensible alcohol use and preventing the use of illegal substances like khat and cannabis.

Checkpoint 6

1. What best defines a drug??
 - A. A substance that alters brain function only
 - B. A substance that is legal for recreational use
 - C. A substance that is addictive but does not affect behavior
 - D. A substance that alters the way the mind or body functions
2. Which of the following is a common feature of drugs?
 - A. They are legally prescribed by doctors
 - B. They have no impact on mental health
 - C. They adversely affect health and behavior
 - D. They enhance productivity and school attendance

3. Which substances are legal recreational drugs in Ethiopia?
- A. LSD, ecstasy, cannabis, cocaine
 - B. Caffeine, nicotine, khat, alcohol
 - C. Heroin, cannabis, cocaine, LSD
 - D. Methamphetamine, ecstasy, khat, alcohol
4. What is the distinction between drug use and drug abuse?
- A. Drug use is for recreational purposes, while drug abuse is for medicinal purposes.
 - B. Drug use involves using illegal substances, while drug abuse involves legal substances.
 - C. Drug use is occasional and moderate, while drug abuse involves excess or dependence.
 - D. Drug use is when a substance alters brain function, while drug abuse is when it affects body function.
5. What characterizes drug dependence?
- A. Using a drug once and becoming addicted
 - B. Using a drug occasionally without any effects
 - C. Using a drug repeatedly and becoming addicted
 - D. Using a drug without any adverse health effects
6. What are withdrawal symptoms?
- A. Symptoms that occur only when a person is addicted to a drug
 - B. Pleasant effects upon the body caused by using a drug everyday
 - C. A set of symptoms that occur as a consequence of using too much drug
 - D. Unpleasant effects upon the body caused by stopping the use of a drug suddenly
7. Which of the following is the addictive drug in cigarette smoke?
- A. Tar
 - B. Nicotine
 - C. Caffeine
 - D. Cathinone

8. What psychoactive compounds are found in khat?
- A. Caffeine and nicotine
 - B. Cathinone and cathine
 - C. Morphine and THC
 - D. Heroin and LSD
9. What effect does alcohol have on the central nervous system?
- A. It stimulates brain activity
 - B. It increases anxiety and stress levels
 - C. It enhances memory and cognitive functions
 - D. It inhibits brain activity and promotes relaxation
10. Which compound in cannabis is the most potent?
- A. Delta-9-tetrahydrocannabinoid (THC)
 - B. Tetrahydrocannabivarin (THCV)
 - C. Cannabidiol (CBD)
 - D. Cannabinol (CBN)
11. What term describes drugs that produce vivid waking dreams and distorted perceptions?
- A. Opioids
 - B. Stimulants
 - C. Depressants
 - D. Hallucinogens
12. What is one potential consequence of driving under the influence of cannabis?
- A. Increased likelihood of accidents
 - B. Enhanced decision-making skills
 - C. Improved reaction time
 - D. Decreased risk of accidents
13. What is LSD primarily known for?
- A. Inducing relaxation and sleep
 - B. Enhancing memory and cognitive function
 - C. Suppressing appetite and increasing energy
 - D. Altering perception and inducing vivid hallucinations
14. From which plant is cocaine derived?
- A. Cannabis
 - B. Coca plant
 - C. Opium poppy
 - D. Khat plant

15. What class of drugs does heroin belong to?

- A. Opioids
- B. Stimulants
- C. Sedatives
- D. Hallucinogens

16. What mental health issues can result from drug abuse?

- A. Increased self-esteem
- B. Enhanced cognitive abilities
- C. Reduced anxiety
- D. Insomnia and paranoia

17. How does drug abuse affect relationships at home and with friends?

- A. It strengthens relationships
- B. It has no impact on relationships
- C. It damages relationships
- D. It improves communication

18. What effect can drug abuse have on sexual function?

- A. It enhances sexual function
- B. It has no effect on sexual function
- C. It impairs sexual function
- D. It improves libido

19. What might children in families affected by drug abuse experience?

- A. Increased self-esteem
- B. Improved academic performance
- C. Enhanced social skills
- D. Loneliness and depression

20. How does drug use contribute to accidents in communities?

- A. It enhances timing and reflexes
- B. It has no effect on accident rates
- C. It improves vision and coordination
- D. It impairs vision, coordination, and timing

Answers

Checkpoint 1

- | | | | |
|------|------|------|-------|
| 1. C | 4. C | 7. B | 10. A |
| 2. B | 5. C | 8. B | |
| 3. C | 6. A | 9. D | |

Checkpoint 2

- | | | | |
|------|------|------|-------|
| 1. B | 4. C | 7. A | 10. A |
| 2. B | 5. B | 8. A | |
| 3. C | 6. A | 9. C | |

Checkpoint 3

- | | | | |
|------|------|------|-------|
| 1. C | 4. D | 7. D | 10. A |
| 2. B | 5. B | 8. B | |
| 3. C | 6. C | 9. B | |

Checkpoint 4

- | | | | | |
|------|------|-------|-------|-------|
| 1. B | 5. C | 9. C | 13. D | 17. C |
| 2. C | 6. D | 10. B | 14. A | 18. D |
| 3. C | 7. B | 11. A | 15. D | 19. D |
| 4. D | 8. D | 12. C | 16. C | 20. C |

Checkpoint 5

- | | | | |
|------|------|------|-------|
| 1. A | 4. B | 7. A | 10. D |
| 2. D | 5. D | 8. D | |
| 3. B | 6. B | 9. A | |

Checkpoint 6

- | | | | |
|------|-------|-------|-------|
| 1. D | 6. D | 11. D | 16. D |
| 2. C | 7. B | 12. A | 17. C |
| 3. B | 8. B | 13. D | 18. C |
| 4. C | 9. D | 14. B | 19. D |
| 5. C | 10. A | 15. A | 20. D |