

Bio 103 Nervous System

Lecture Outline: **NERVOUS SYSTEM**
[Chapters 10, 11, 12]

Introduction

Neural Tissue Types:

Neurons –

Neuroglial Cells -

Divisions

1. Central Nervous System (CNS)

Parts:

Functions: analyze, evaluate, integrate →

2. Peripheral Nervous System (PNS)

Nerves:

A. Divisions of PNS

1. Sensory Division (afferent)

Receptors –

2. Motor Division (efferent)

Effectors –

Motor Division consists of:

Somatic –

Autonomic –

B. Nervous System Functions

Sensory Function:

-
-

Integrative Function

-
-

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Motor Function

-
-

The Neuron

Neurons are specialized to react to chemical and physical changes in their surrounds and conduct impulses in response to these changes

A. Structures of the Neuron

1. Cell body (soma)

-
- perikaryon
- Nissl bodies
- *

2. Dendrites

-
-

3. Axon

- ends at synaptic terminal
- initial segment:
- axon hillock:

Myelination of Axons

White matter

-

Gray matter

-
-

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B. Classification of Neurons

1. Structure

- based on number of cytoplasmic extensions

a. Bipolar neurons

-
-

b. Unipolar neurons

-
-

c. Multipolar neurons

-
-

2. Function

- based on function

a. Sensory neurons

- afferent
- carry impulses to CNS
-
-

b. Interneurons

- link neurons
-
-

c. Motor neurons

-

- carry impulses away from CNS
- carry impulses to effectors

-

Neuroglial Cells

A. PNS neuroglia

1. Schwann Cells

- produce myelin found on peripheral myelinated neurons
-

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2. Satellite Cells

- support clusters of neurons cell bodies (ganglia)
-

B. CNS neuroglia

1. Astrocytes

-
- regulates ion concentration
- connect neurons to blood vessels
-

2. Oligodendrocytes

-
- provides myelin for many axons

3. Microglia

-
- proliferate where brain or spinal cord is injured to diseased

4. Ependyma

- ciliated
- line central canal of spinal cord
-
-

C. Neural Response to Injury

*

1. Macrophages remove fragments of myelin and other cellular debris
2. Neuroglial cells secrete _____
3. Axon is stimulated to develop a sprout which may grow into a tube formed by connective tissue
4. Schwann cells proliferate and _____

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The Synapse:

* nerve impulses pass from neuron to another cell at the synapse

- presynaptic cell
- postsynaptic cell

neuro-neuronal junction:

NMJ:

neuroglandular junction:

Synaptic transmission:

-

Neurophysiology

A. Transmembrane potential

-

1. Passive forces:

Chemical gradients:

ECF

ICF

Electrical gradients:

Positive charge

Negative charge

Resting membrane potential = -70 mV

- due to

2. Active forces:

Sodium-Potassium exchange pump

- exchange of 3 Na⁺ for every 2 K⁺

[moves 3 Na⁺ out of the cell; moves 2 K⁺ into the cell;
uses ATP as energy source to move these ions]

- used to maintain the resting potential (_____)

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B. Local Potential Changes

Caused by:

-
-
-

* environmental changes affect the membrane potential by opening a gated ion channel

Graded (or local) Potentials

- do not spread far from site of stimulus

Threshold stimulus

- a local potential that is strong enough to start an action potential

Depolarization -

Hyperpolarization -

Repolarization -

C. Action Potentials

1. At rest the membrane is _____
2. Threshold stimulus is reached
3. Sodium channels _____ and membrane _____
4. Potassium leaves cytoplasm and membrane _____

D. All-or-None Response

If a neuron responds at all, it responds completely

A nerve impulse is conducted whenever a stimulus of threshold Intensity or above is applied to an axon

All impulses carried on an axon are the _____

E. Refractory Period

1. Absolute –
2. Relative -

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F. Na⁺/ K⁺ exchange pump

Over time this pump will return ions to their prestimulation levels on appropriate side of membrane

Na⁺ → _____ are pumped _____ of the cell

K⁺ → _____ are pumped _____ the cell

G. Propagation (or conduction) of AP

1. Continuous propagation:

- chain reaction that spread AP along every part of the cell membrane

- occurs on _____

- 1m/sec

2. Saltatory propagation:

- jumping of AP from _____ to _____ in myelinated fibers

H. Axon Diameter

1. Type A fibers

-

-

2. Type B fibers

-

-

3. Type C fibers

-

-

Neurotransmitters

Synaptic transmission: Chemical Synapses

presynaptic neuron ---> synaptic cleft ---> postsynaptic neuron

Neurotransmitters can be excitatory or inhibitory

E →

I →

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Acetylcholine (ACh)

-

-

Norepinephrine (NE)

- adrenergic synapses
- released at most SNS post-ganglionic fibers

Dopamine

-

Serotonin

- not enough may cause depression
- SSRI

GABA (gamma aminobutyric acid)

- inhibitory
-

Neuromodulators:

Endorphins -

Impulse Processing

The way the nervous system processes impulses and acts upon them

Neural Pools

- groups of interneurons that make synaptic connections with each other
- interneurons work together to perform a common function
- each pool receives input from other neurons
- each pool generates output to other neurons

Convergence

- neuron receives input from _____
- incoming impulses represent information from different types of sensory receptors
- allows nervous system to collect, process, and respond to info
- makes it possible for a neuron to sum impulses from different sources

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Divergence

- one neuron sends impulses to _____
- can amplify an impulse
- impulse from a single neuron in CNS may be amplified to activate enough motor units needed for muscle contraction

Nervous System Structure

1. PNS =

Nerves -

Ganglia -

2. CNS =

Tract (column) -

Nucleus (center) -

A. Meninges

- Membranes surrounding _____

-

- 3 Layers:

1. Dura mater

2. Arachnoid mater

3. Pia mater

Organization of the spinal meninges:

Epidural space

Dura mater

Arachnoid

Subarachnoid space

Pia mater

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B. Ventricles

1. Interconnected cavities within cerebral hemispheres and brain stem
2. Continuous with central canal of spinal cord
- 3.

Lateral ventricles

Third ventricle

Fourth ventricle

Cerebral aqueduct

C. Cerebrospinal Fluid

- Secreted by choroid plexus (_____)
- Circulates in ventricles, central canal of the spinal column, and subarachnoid space
-
- clear liquid that provides _____ and _____
- helps maintain stable ion concentrations in CNS

Hydrocephalus:

- blocked _____
- excess production of CSF
- treatment: hydrocephalic shunt

D. Spinal Cord

1. Slender column of nervous tissue continuous with the brain
2. Extends downward through vertebral canal
- 3.

Functions:

- center for spinal reflexes
- conduit for nerve impulses to and from the brain

Tracts:

- ascending tracts –
- descending tracts –

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Reflex arcs:

Reflexes – automatic, subconscious responses to stimuli within or outside the body

Pathway:

Receptor

Afferent (sensory) neuron

CNS

Efferent (motor) neuron

Effector

Reflex Behavior:

Patellar reflex

-

-

Withdrawal reflex

-

-

Brain

Functions:

- interprets sensations
- determines perception
- stores memory
- reasoning
- make decisions
- coordinates muscular movements
- regulates visceral activities
- determines personality

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Major Parts of the brain:

-
-
-
-
-

A. Structure of Cerebrum

1. corpus callosum connects cerebral hemispheres (left and right)
- 2.
- 3.
4. longitudinal fissure –
5. transverse fissure separates cerebrum from cerebellum

B. Functions of the Cerebrum

- interpreting impulses
- initiating voluntary movements
- storing information as memory
- retrieving stored information
- reasoning
- seat of intelligence and personality

C. / D. Lobes of Cerebral Hemispheres and Functions

1. Frontal
- 2.
3. Temporal
- 4.

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E. Functional Regions of Cerebral Cortex

Cerebral cortex – thin layer of gray matter that constitutes the outermost portion of cerebrum

-

1. Sensory Areas

Cutaneous Area

-
-

Visual Area

-
-

Auditory Area

-
-

Area for Taste

-

Area for Smell

-

2. Association Areas

- regions that are not primary motor or sensory areas
- widespread throughout the cerebral cortex
- analyze and interpret sensory experiences
-

Frontal Lobe Association Areas:

-
-
-

Parietal Lobe Association Areas:

-
-

Temporal Lobe Association Areas:

-
-

Occipital Lobe Association Areas:

-

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Memory (association area)

Short Term

- working memory
- closed neuronal circuit
- circuit is stimulated over and over
-

Long Term

- changes structure of function of neurons
- enhances synaptic transmission

3. Motor Areas

Primary Motor Areas:

-
-

Broca's Area:

-
-
-

Frontal Eye Field

-
-

F. Basal Nuclei

- masses of gray matter
- deep within cerebral hemispheres
- produce _____
- control certain muscular activities primarily by inhibiting motor functions

G. Diencephalon

- Area between cerebral hemispheres and above the brainstem
- Surrounds third ventricle
- Includes: thalamus, hypothalamus, _____, optic chiasma, Infundibulum, posterior pituitary, Mammillary bodies, and _____

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Thalamus

- gateway for sensory impulses heading to cerebral cortex
-
- channels impulses to appropriate part of cerebral cortex for interpretation

Hypothalamus

- maintains homeostasis by regulating visceral activities
-

H. Brain Stem

3 Parts:

1.
 -
 - contains bundles of fibers that join lower parts of brainstem and spinal cord with higher part of brain
 - cerebral aqueduct
 - corpora quadrigemina –
2.
 - rounded bulge on underside of brainstem
 -
 -
 - relays nerve impulses to and from medulla oblongata and cerebellum
3.
 -
 - conducts ascending and descending impulses between brain and spinal cord
 - contains cardiac, vasomotor, and respiratory control centers
 - contains various non-vital reflex control centers

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I. Cerebellum

- inferior to occipital lobes, posterior to pons and medulla oblongata
- cerebellar cortex –
- arbor vitae –
- integrates sensory information concerning position of body parts
-
-

A. Peripheral Nervous System (PNS)

1.

- somatic fibers connecting to the skin and skeletal muscles
- autonomic fibers connecting to viscera

2.

- somatic fibers connecting to the skin and skeletal muscles
- autonomic fibers connecting to viscera

B. Structure of Peripheral Nerve

Connective tissue coverings:

Epineurium –

Perineurium –

Endoneurium –

C. Nerve Fiber Classification

1. _____ (afferent) conduct impulses into brain or spinal cord

General visceral afferent fibers – carry sensory impulses to CNS from blood vessels and internal organs

General somatic afferent fibers – carry sensory impulses to CNS from skin and skeletal muscles

2. _____ (efferent) conduct impulses to muscles or glands

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General somatic efferent fibers – carry motor impulses from CNS to skeletal muscles

General visceral efferent fibers – carry motor impulses away from CNS to smooth muscles and glands

3. Mixed Nerves – contain both _____ nerve fibers and _____ nerve fibers

Special somatic efferent fibers

- carry motor impulses from brain to muscles used in chewing, swallowing, speaking, and forming facial expressions

Special visceral afferent fibers

- carry sensory impulses to brain from olfactory and taste receptors

Special somatic afferent fibers

- carry sensory impulses to brain from receptors of sight, hearing, and equilibrium

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D. Cranial Nerves - 12 Pair

<u>Name</u>	<u>Major Function</u>
I. OLFACTORY	S only: Smell
II. OPTIC	S only: Sight
III. OCULOMOTOR	S : Receptors that influence pupil size M : Muscles that move eye (<i>except</i> sup. oblique, lat. rectus)
IV. TROCHLEAR	S : Muscle sense (eye muscles) M : Superior oblique eye muscle
V. TRIGEMINAL	S : Sensations of head, face M : Muscles of mastication
VI. ABDUCENS	S : Muscle sense (eye muscles) M : Lateral rectus eye muscle
VII. FACIAL	S : Tastebuds (anterior 2/3 tongue) M : Muscles for facial expressions
VIII. VESTIBULOCOCHLEAR (or AUDITORY)	S only: Sense of balance, hearing
IX. GLOSSOPHARYNGEAL	S : Tastebuds (posterior 1/3 tongue) M : Muscles for swallowing
X. VAGUS	S : Pharynx, thoracic & abdominal viscera M : Major PSN nerve to thoracic & abdominal viscera
XI. ACCESSORY (SPINAL)	S : Proprioception from head, neck, shoulder muscles M : Head and shoulder movements
XII. HYPOGLOSSAL	S : Proprioception from tongue M : Tongue movement and swallowing

S = sensory function

M = motor function

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E. Spinal nerves

* Mixed nerves

31 pairs exit through intervertebral foramina

8 pr. cervical nerves
 12 pr. thoracic nerves
 5 pr. lumbar nerves
 5 pr. sacral nerves
 1 pr. coccygeal nerves

31 pair spinal nerves

Dorsal Root (posterior or sensory root)

- axons of sensory neurons

Dorsal root ganglion

- cell bodies of sensory neurons whose axons conduct impulses inward from peripheral body parts

Ventral root (anterior or motor root)

- axons of motor neurons whose cell bodies are in spinal cord

Spinal Nerve – union of ventral and dorsal roots

Nerve Plexus – complex networks formed by anterior branches of spinal nerves

- fibers of various spinal nerves are sorted and recombined

1. Cervical Plexuses

(C1 - C5)

C1 – C4 lies deep in the neck

- supplies muscles and skin of the _____

C3 – C5 contribute to the _____

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2. Brachial Plexuses

C5 - T1 - innervates shoulder / upper arm

Musculocutaneous nerve – muscles of the anterior arms and skin of forearms

Ulnar and Median nerves – supply muscles of forearms and hands

-

Radial nerve – supply posterior muscles of arms and skin of forearms and hands

Axillary nerve – supply muscles and skin of anterior, lateral, and posterior arms

3. Lumbosacral Plexuses

T12 – S5

- extends from lumbar region into pelvic cavity

Obturator nerve – supply motor impulses to adductors of thighs

Femoral nerve – supply motor impulses to muscles of anterior thigh and sensory impulses from skin of thigh and legs

Sciatic nerve – supply muscles and kin of thighs, legs, feet

A. Autonomic Nervous System (ANS)

- functions without conscious effort
- controls visceral activities
- regulates –

Two Divisions:

1. Sympathetic (SNS) -
 - strongly stimulated by stress →
2. Parasympathetic (PSN) -
 - Rest and repose
 -

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SNS Stimulation Responses:

- Dilates pupils
- Contracts arrector pili muscles
- VC vessels in skin and viscera
- Dilates vessels in skeletal and cardiac muscles
-
-
- Secretion of epinephrine
- Glucose is released from liver into blood
- Dilation of bronchioles
-

PSN Stimulation Responses:

- Elimination of waste
- Increases digestive activity
-
- Relaxation of bladder sphincters
-
- Dilates vessels to external genitalia

Control of Autonomic Activity

- Controlled largely by CNS
- Medulla oblongata regulates –
- Hypothalamus regulates –
- Limbic system and cerebral cortex control emotional responses

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Life Span Changes

- Brain cells begin to die before birth
- Over average lifetime, brain shrinks 10%
-
- By age 90, frontal cortex has lost half its neurons
- Number of dendritic branches decreases
- Decreased levels of neurotransmitters
-
- Slowed responses and reflexes
-
- Changes in sleep patterns that result in fewer sleeping hours

Clinical Applications: Cerebral Injuries and Abnormalities

Concussion

Cerebrovascular Accident

Cerebral Palsy

Parkinson's Disease