Lecture 14
The Nervous System
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The Nervous System

- Highly complex network of neurons and neuroglia
- Communication, coordination, control
- Functions
  - Sensory-afferent
  - Integration
  - Motor-efferent
Organization

Central – Peripheral
  ➤ Sensory – Motor
  • Somatic – Autonomic
  – Sympathetic – Parasympathetic
Central Nervous System

- Consists of brain and spinal cord
- Contains gray matter (neurons and neuroglia) and white matter (myelinated fibers)
- Neurons are the cells that conduct the impulses and neuroglia are the support cells
- Both brain and spinal cord are covered by meninges
31 pairs of spinal nerves
Each pair arise from a spinal segment
8 pairs of cervical nerves
12 pairs of thoracic nerves
5 pairs of lumbar nerves
5 pairs of sacral nerves
1 pair of coccygeal nerves
Spinal Cord Organization
Sensory and Motor Tracts

- Tracts are bundles of neuron fibers
- Sensory tracts take messages up to the brain
  - Ascending tracts
- Motor tracts take messages from the brain down to the segments
  - Descending tracts
Location of Sensory and Motor Tracts

- Central canal
- Posterior median sulcus
- Posterior columns
- Lateral corticospinal tract
- Rubrospinal tract
- Medial reticulospinal tract
- Lateral reticulospinal tract
- Vestibulospinal tract
- Tectospinal tract
- Anterior median fissure
- Anterior corticospinal tract
- Posterior spinocerebellar tract
- Anterior spinocerebellar tract
- Lateral spinothalamic tract
- Spinal nerve
- Anterior spinothalamic tract

Sensory (ascending) tracts
Motor (descending) tracts
A reflex is an immediate sequence of actions in response to a particular stimulus.

Spinal reflexes are integrated through the gray matter of the spinal cord. (patellar reflex)

Cranial reflexes are integrated through the brain stem. (moving eyes to read)

Sensory receptor-sensory neuron-interneuron-motor neuron-effector
Reflex Arc

1. SENSORY RECEPTOR (responds to a stimulus by producing a generator or receptor potential)
2. SENSORY NEURON (axon conducts impulses from receptor to integrating center)
3. INTEGRATING CENTER (one or more regions within the CNS that relay impulses from sensory to motor neurons)
4. MOTOR NEURON (axon conducts impulses from integrating center to effector)
5. EFFECTOR (muscle or gland that responds to motor nerve impulses)
Examples of spinal reflexes include:

- Stretch reflex
- Tendon reflex
- Withdrawal reflex
- Crossed extensor reflex
Stretch Reflex

1. Stretching stimulates SENSORY RECEPTOR (muscle spindle)
2. SENSORY NEURON excited
3. Within INTEGRATING CENTER (spinal cord), sensory neuron activates motor neuron
4. MOTOR NEURON excited
5. EFFECTOR (same muscle) contracts and relieves the stretching

Antagonistic muscles relax
Motor neuron to antagonistic muscles is inhibited

To brain
Spinal Nerve
Inhibitory interneuron
**Flexor (Withdrawal) Reflex**

1. Stepping on a tack stimulates the sensory receptor (dendrites of the pain-sensitive neuron).
2. Within the integrating center (spinal cord), the sensory neuron activates interneurons in several spinal cord segments.
3. Sensory neuron excited.
5. Effectors (flexor muscles) contract and withdraw the leg.
7. Spinal nerve.
8. Ascending interneuron.
**Crossed Extensor Reflex**

1. Stepping on a tack stimulates SENSORY RECEPTOR (dendrites of pain-sensitive neuron) in right foot.
2. SENSORY NEURON excited.
3. Within INTEGRATING CENTER (spinal cord), sensory neuron activates several interneurons.
4. MOTOR NEURONS excited.
5. EFFECTORS (extensor muscles) contract, and extend left leg.

- Spinal nerve
- Ascending interneurons
- Descending interneurons
- Interneurons from other side

Flexor muscles contract and withdraw right leg
Withdrawal of right leg (flexor reflex)
Extension of left leg (crossed extensor reflex)
Spinal Nerves contain sensory and motor neuron fibers from many neurons in a given area.

Nerves are not neurons, they are made up of many neuron fibers, the dendrites of sensory neurons and the axons of motor neurons.

Nerves are highly organized and vascular.
Spinal Nerve

- Spinal nerve
- EPINEURIMUM around entire nerve
- Fascicle
- PERINEURIMUM around individual fascicle
- Blood vessels
- Axon
- ENDONEURIMUM around individual axon
Cranial Nerves

- Cranial nerves originate in the brain
- 12 pairs – Olfactory, optic, oculomotor, trochlear, trigeminal, abducens, facial, vestibulocochlear, glossopharyngeal, vagus, accessory, hypoglossal
- Only 2 (olfactory and optic) are sensory only, most are mixed
Cranial Nerves:
- Cranial nerve I (olfactory)
- Cranial nerve II (optic)
- Cranial nerve III (oculomotor)
- Cranial nerve IV (trochlear)
- Cranial nerve V (trigeminal)
- Cranial nerve VI (abducens)
- Cranial nerve VII (facial)
- Cranial nerve VIII (vestibulocochlear)
- Cranial nerve IX (glossopharyngeal)
- Cranial nerve X (vagus)
- Cranial nerve XI (accessory)
- Cranial nerve XII (hypoglossal)
Organization of the Brain

- Cerebrum
- Diencephalon – thalamus and hypothalamus
- Cerebellum
- Brainstem
BRAIN

DIENCEPHALON:
- Thalamus
- Epithalamus
- Hypothalamus
- Pineal gland

BRAIN STEM:
- Midbrain
- Pons
- Medulla oblongata

CEREBELLMUM

Spinal cord

POSTERIOR

CEREBRUM

Pituitary gland

ANTERIOR
VENTRICLES AND CSF

- Ventricles are cavities in the brain that are filled with cerebrospinal fluid (CSF)
- CSF is produced by the choroid plexus of the third ventricle and reabsorbed in the archnoid villi
- CSF circulates throughout the ventricles and the subarachnoid space
Location of Ventricles

Right lateral view of brain

POSTERIOR

Cerebrum

FOURTH VENTRICLE

Cerebellum

LATERAL APERTURE

MEDIAN APERTURE

CENTRAL CANAL

ANTERIOR

LATERAL VENTRICLES

INTERVENTRICULAR FORAMEN

THIRD VENTRICLE

CEREBRAL AQUEDUCT

Pons

Medulla oblongata

Spinal cord
Circulation of Cerebrospinal Fluid
Cerebrum

- Two hemispheres
- Organized into lobes: frontal, parietal, temporal, occipital, insula
- Sensory areas, association areas, motor areas
R. CEREBRAL HEMISPHERE

Lateral view of right cerebral hemisphere
Sensory areas of the cortex receive information from areas of the body (post central gyrus)

Motor areas of the cortex send messages to specific areas based on the sensory information (precentral gyrus)
SOMATIC SENSORY AND MOTOR MAPS

(a) Frontal section of primary somatosensory area in right cerebral hemisphere

(b) Frontal section of primary motor area in right cerebral hemisphere