Nervous System:
Spinal Cord and Spinal Nerves
(Chapter 13)

Lecture Materials
for
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Primary Sources for figures and content:
Nervous System Organization:
  CNS = brain and spinal cord
  PNS = all other neural tissue

Structures in the PNS:
  - **Ganglia** = collection of somas together in one place
  - **Nerves** = bundles of axons

Structures in the CNS:
  - **Center** = collection of somas with a common function
  - **Nucleus** = a center with a visible boundary
  - **Neural cortex** = gray matter (somas) covering the brain
  - **Tracts** = bundles of axons with common origins, destinations and functions
  - **Columns/funiculi** = large tracts in the spinal cord
  - **Pathways** = centers and tracts that link the brain with the body

Sensory pathways: receptor \(\rightarrow\) CNS
Motor pathways: CNS \(\rightarrow\) effector
Spinal Cord

- 45cm (18”) from brain to L2
- inside vertebral canal (stacked vertebral foramen)
- surrounded by CT: Spinal Meninges
  - support and protect spinal cord
-three layers
(on handout)
Spinal cord cross sectional anatomy
(on handout)

(a)
-spinal roots exit vertebral canal through intervertebral foramen
-dorsal and ventral roots combine to form spinal nerve
Spinal Nerves
-31 pair
-exit via intervertebral or sacral foramen
-name for location of exit on spine, beginning between skull and C1
Nerves: C₁-C₈, T₁-T₁₂, L₁-L₅, S₁-S₅, C₀
-cord and column grow together until age 4; after column continues but cord does not: roots “stretch” to reach foramen

-adult: cord ends at L₁-L₂

-“stretched” spinal roots after L₂ = cauda equina

Lumbar puncture = “spinal tap”, at L₃-L₄, draw CSF from subarachnoid space
-intervertebral foramen maintained by intervertebral discs between vertebrae

Herniated disc = nucleus pulposus ruptures through anulus fibrosis, compresses nerves in intervertebral foramen and/or spinal cord in vertebral canal
Slipped disc = intervertebral disc distorted or displaced, causes pressure
Nerve structure
(on handout)

- axons repair if cut if follow original path
- severed nerves do not usually repair: axons do not line up correctly
- spinal nerves branch off cord near to what they innervate
- cervical and lumbar enlargements of cord house cell bodies of motor neurons for muscles of appendages
- Dermatome = region of skin surface innervated by one pair spinal nerves
-most spinal nerves do not go directly to target: axons from multiple nerves intermingle in a nerve plexus (on handout)
Trauma and disorders:
- often result from damage or pressure
Paralysis = loss of motor function: disorder of ventral root or anterior gray horn
Paresthesias = sensory loss: disorder of dorsal root or posterior gray horn
-complete transection results in loss of both motor and sensory below injury
Paraplegia = sever between T1 and L4, loss of lower limb function
Quadriplegia = sever in cervical, loss of all limb function (above C5 can kill)

Organization of Neural Pathways
10 million sensory neurons (receptor to CNS)
500 thousand motor neurons (CNS to effector)
20 billion interneurons (coordinate sensory and motor)
Interneurons organized into neuronal pools = functional groups with limited input sources (sensory) and output locations (motor)
- spread of info organized into neural circuits
- 5 neural circuits: (on handout)
Reflexes

= rapid automatic response to specific stimuli
-used to maintain homeostasis
-simple reflex = sensory perception in, motor response out
-simple reflexes can be grouped together for complex actions
Reflex arc = single reflex (on handout)

-reflex arcs = negative feedback: action opposes stimulus as form of defense, fast response, but not always coordinated
Reflex Classification
-four ways to classify (on handout)

**INNATE REFLEXES**
- Genetically determined

**ACQUIRED REFLEXES**
- Learned

**REFLEXES can be classified**

- by development
- by processing site
- by response
- by complexity of circuit

**SCOMATIC REFLEXES**
- Control skeletal muscle contractions
- Include superficial and stretch reflexes

**VICERAL (Autonomic) REFLEXES**
- Control actions of smooth and cardiac muscles, glands

**MONOSYNAPTIC**
- One synapse

**POLYSYNAPTIC**
- Multiple synapses (two to several hundred)

Superficial somatic reflex = stimuli originate at skin or mucous membrane

Stretch reflex = stimuli from overstretched tendon

Response delayed by each synapse but capable of more complex output
Examples of common spinal reflexes

1. Patellar Reflex
   - monosynaptic stretch reflex
   - carried on type A fibers
   - sudden stretch of patellar ligament activates muscle spindles → signal quadriceps group to contract
Muscle spindle = specialized muscle fiber
- constantly signal CNS
- relaxed = signal less
- stretched = signal more → threshold, trigger reflex arc
- prevent overstretching of muscles and tendons
- aid in maintaining upright position
2. Withdrawal reflexes
-complex polysynaptic spinal reflex
-consists of three parts:
   a. Flexor reflex = flex to withdraw
   b. Reciprocal inhibition = inhibit extensors
   c. Crossed extensor reflex = maintain balance

Pain → flexor muscles pull limb away
   → extensors same limb inhibited to prevent opposition to flexion
   → limbs on opposite side extend to provide balance for sudden flexion
Reflexes automatic but can be impacted by higher brain centers:
- fine tune or combine reflexes
- take cues from reflex for coordinated voluntary movements
- facilitate or inhibit reflexes

Reflexes serve as diagnostic tool to assess health and function of spinal cord and brain

*Individual spinal nerves and their innervations and plexus origins will be examined in detail in lab along with select reflexes!