The Spinal Cord and Spinal Nerves

General Function
• Reflex reactions (automated responses)
• Limited integration (summation of EPSP & IPSP)
• Transmission of impulse from sensory receptors to brain and from brain to effectors

Protection and Coverings
• Passes through the vertebral foramina of vertebrae
• Enclosed by spinal meninges - three layers
  – Dura mater - dense, irregular connective tissue layer
    • Epidural space contains cushioning fat and other connective tissue
    • Subdural space contains interstitial fluid
  – Arachnoid - thin membrane of collagen and elastic fibers
    • Surround subarachnoid space containing CFS and blood supply
    • Spinal tap - sampling of CFS or for introduction of substances
      (antibiotics, anesthetics, chemotherapy, etc. - done distal to 3rd lumbar vertebrae)
  – Pia mater - thin, vascular, transparent membrane that is attached to spinal cord and brain
  – Suspended within subarachnoid space through denticulate ligaments
• Meningitis - inflammation of meninges

Meninges (graphic)

Cervical Posterior View (graphic)

External Anatomy
• Extends from medulla to 2nd lumbar vertebrae
• Cervical and lumbar enlargements supply nerves to and from limbs
• Cord ends distally as conus medullaris
• Below 2nd lumbar vertebrae - cauda equina
• Organization of afferent and efferent nerves
  – Dorsal (posterior) ganglion and root - sensory
  – Ventral (anterior) root - motor

Regions of Spinal Cord (graphic)

Internal Anatomy
• Cord divided medially by anterior median fissure and posterior median sulcus
• Internal H-shaped gray matter
  – Anterior gray horn - soma & nuclei of somatic motor neurons
  – Lateral gray horn (only in thoracic, upper lumbar & sacral regions) - soma of autonomic motor neurons (smooth & cardiac muscle or glands)
  – Posterior gray horns - somatic and autonomic sensory nuclei
• Central canal containing CFS extends to 4th ventricle in medulla
• White matter surrounding gray matter
  – Anterior, lateral and posterior white columns (funiculi)
  – Consist primarily of tracts (fasciculi)
  – Ascending sensory tracts
  – Descending motor tracts

Cross Section (graphic)

Cross-sectional Structure (graphic)

Spinal Cord Function
• Conveying efferent and afferent information - white matter
• Information integration & reflex action - gray matter

Ascending Tracts
• Spinothalamic (lateral and anterior)
  – Sense of pain, temperature, crude touch and deep pressure
• Posterior column (gracilis & cuneatus)
  – Proprioception, discriminative touch, two-point discrimination, pressure, vibration

Major Spinal Tracts (graphic)

Descending Tracts
• Direct or pyramidal (lateral and anterior corticospinal, corticobulbar)
  – Precise, voluntary movements
• Indirect or extrapyramidal (rubro-, tecto- & vestibulospinal)
  – Automated movement (swinging arms), coordinated movement with vision, posture, muscle tone, body position/equilibrium

Reflexes
• Fast, predictable response to stimulus to maintain homeostasis
• Spinal - integration in spinal cord
• Cranial - integration in brain stem and involve cranial nerves
• Sensory information passed into dorsal root
  – Cell bodies in ganglia
• Motor response passes out of anterior root
  – Somatic cell bodies in anterior horn

Reflex Arc (graphic)

Monosynaptic Reflex
• Stretch reflex - skeletal muscle contracts after stimulation of muscle spindle receptors
  – patellar, ankle, elbow, wrist
• Excitatory ipsilateral arc
• Sensitivity to stretch is controlled by brain and results in muscle tone
• Inhibition of antagonistic muscle is polysynaptic (reciprocal innervation)
• Information also passed to brain


**Stretch Reflex (graphic)**

**Polysynaptic Reflex**

- Tendon reflex - reduces skeletal muscle and tendon tension after stimulation of tendon organs
- Inhibitory ipsilateral arc that involves interneuron
- Excitation of antagonistic muscle is also polysynaptic
- Information also passed to brain

**Tendon Reflex (graphic)**

**Flexor Reflex**

- Also called the withdrawal reflex
- Stepping on object causes contraction of flexor muscle of leg
- Excitatory ipsilateral arc involving interneurons within multiple cord segments (intersegmental reflex arc)

**Flexor Reflex (graphic)**

**Crossed Extensor Reflex**

- Unweighting of one leg due to flexor reflex requires weighting of the other leg
- Excitatory contralateral arc that causes contraction of extensor muscle of opposing leg
- Also may involve multiple segments

**Cross Extensor Reflex (graphic)**

**Reflex Diagnostics**

- Abnormal reflex reaction is a sign of injured nervous tissue
- Patellar reflex
  - Possible damage to sensory, motor or spinal cord from 2nd to 4th lumbar vertebrae
  - Chronic diabetes or neurosyphilis
  - Exaggerated response caused by damage to motor tract in higher centers
- Achilles reflex
  - Possible damage to nerves of posterior leg or lumbosacral cord
  - Diminished by diabetes, neurosyphilis, alcoholism and subarachnoid hemorrhage
  - Exaggerated response caused by damage to cord motor tract in 1st or 2nd sacral region or compression of cervical cord
- Plantar flexion reflex/Babinski sign
  - Stroking of outer sole of foot causes all toes to curl/extension of big toe
  - Damage to corticospinal tract
- Abdominal reflex - stroking of skin of lateral portion of abdomen causes ipsilateral muscle contraction
  - Possible damage to corticospinal tract, thoracic peripheral nerves or cord or multiple sclerosis

**Spinal Nerves**
• Composed of both sensory and motor neurons attaching at both the anterior and posterior roots
• Each nerve branches into rami - posterior, anterior, meningeal (spinal column) and communicantes (ANS)
• 31 pairs of spinal nerves
  — Five regions of nerves
    • Cervical - 8 pairs, thoracic - 12 pairs, lumbar - 5 pairs, sacral - 5 pairs, coccygeal - 1 pair

Branches of Spinal Nerve (graphic)

Nerve Coverings
• Endoneurium - around each axon
• Perineurium - around each fascicle (bundle of neurons)
• Epineurium - around the nerve

Connective Tissue Layers (graphic)

Dermatomes and Myotomes
• Regions of innervation by different sensory or motor nerves respectively
• Overlap from adjacent segments
• Useful as signs of nerve damage or degree and span of anesthesia
• Note dermatomes for S2 and S3

Dermatomes (graphic)