

## Chapter 13 Spinal Cord & PNS

### **THE SPINAL CORD**

The SPINAL CORD extends from the foramen magnum down to about L1, L2. At the distal end is the CONUS MEDULLARIS. This is a blunted conical terminus at L1. The spinal cord has MENINGES that are the same as around the brain, except there is no periosteal layer of the dura mater. The reason for this, is because the vertebral column has to bend and flex. The spinal cord is not fixed to the vertebral canal.

Down from the conus medullaris is the FILUM TERMINALE. It is a continuation of pia mater beyond the conus medullaris and it anchors the spinal cord to the coccyx.

DENTICULATE LIGAMENTS anchor the spinal cord laterally. These are lateral projections of pia mater at each spinal level.

SPINAL ENLARGEMENTS are areas where the spine gets thicker. There are more neurons in these regions because they serve limbs.

There are two of them:

1. Cervical
2. Lumbar

CAUDA EQUINA is a broom-like collection of nerve roots extending inferior to the conus medullaris. It forms because the vertebral column grows faster and longer than the spinal cord. So, the nerves are pulled inferiorly with intervertebral foramina. This area is where spinal taps are done!

### **X-SECTIONAL ANATOMY OF THE SPINAL CORD**

The ANTERIOR MEDIAN FISSURE is a deep longitudinal groove along the anterior surface

The POSTERIOR MEDIAL SULCUS is a shallower groove along the posterior surface

GRAY MATTER is the internal butterfly-shaped region. The wings have horns! The ANTERIOR GRAY HORNS contain somatic motor neurons (go to skeletal muscle). The POSTERIOR GRAY HORNS contain sensory neurons (somatic sensory neurons and visceral sensory neurons). The LATERAL GRAY HORNS contain visceral motor neurons...these are located in the thoraco-lumbar region only (T1-L2)

The GRAY COMMISSURE connects the “wings” of the butterfly...it connects the horns. It surrounds the central canal.

WHITE MATTER surrounds the gray matter in three main areas:

1. Posterior columns
2. Lateral columns
3. Anterior columns

**SPINAL NERVE ROOTS** are divisions of spinal nerve near the cord. They are the **DORSAL ROOT** and the **VENTRAL ROOT**.

- The dorsal root carries sensory fibers into the CNS. The **DORSAL ROOT GANGLION** is a collection of sensory neuron cell bodies (most are unipolar).
- The ventral root carries motor fibers away from the CNS. The cell bodies in anterior and lateral gray horns.

### **THE PNS**

**PERIPHERAL NERVES** are bundles of axons. Most are mixed nerves, meaning they carry sensory AND motor information.

**PERIPHERAL NERVE WRAPPINGS** match the organization of muscle wrappings.

- The whole nerve is wrapped by **EPINURIUM** (fibrous sheath)
- Within each nerve are bundles called fascicles. The bundle is wrapped by **PERINURIUM**
- Each fascicle is a bundle of axons. Each axon is wrapped in **ENDONURIUM**.
- The endonurium is superficial to the myelin sheath

There are 31 **PAIRS OF SPINAL NERVES!**

- 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

All but the cervical exit **BELOW** the vertebra of the same name.

Cervical exit **ABOVE** the vertebrae

CN 8  
exits  
above  
T1

### **PERIPHERAL NERVE STRUCTURE**

#### **ROOTS**

- Dorsal and Ventral Roots
- Laterally they join to form spinal nerve, a short segment where the two roots meet. The spinal nerve is a **MIXED NERVE**.

**SPINAL NERVE** has two major branches.

- The **DORSAL RAMUS** is the smaller one. It supplies medial back muscles and the skin
- The **VENTRAL RAMUS** is the larger one. It supplies the sides and front of the torso as well as entire appendages.
- The **RAMI COMMUNICANTES** is a pair of fibers that connect the spinal nerve to autonomic nervous system.

**PLEXUSES.** The ventral rami in the thoracic region and dorsal rami remain distinct and separate...they innervate skin and body wall musculature. The ventral rami above and below the thoracic region form complex interwoven plexuses. They form because spinal nerves innervate embryologic muscle masses. These muscle masses merge and subdivide

to form mature musculature. The nerves follow the tissue organization. The four plexus that get formed are...

### CERVICAL PLEXUS

- Originates from nerve roots C1-C5
- Innervate skin, musculature of neck and shoulders
- Produces phrenic nerve which contracts diaphragm (hiccups)

### BRACHIAL PLEXUS

- Originates from nerve roots C5-T1
- Innervates shoulder and upper extremity
- Nerve roots merge to form trunks.
- These trunks intertwine to form divisions.
- These divisions blend to form cords.
- The cords intermingle to form nerves.
- Produces 5 major nerves:
  - Ulnar, radial, medial, axillary and muscuocutaneous nerves.

### LUMBAR PLEXUS

- Originates from L1-L4
- Innervates anterior and medial thigh & medial leg
- Forms the femoral nerve and the obturator nerve

### SACRAL PLEXUS

- Originates from L4-S4
- Innervates pelvic region, buttocks and lower extremity (except for regions served by lumbar plexus)
- Major nerve is the sciatic nerve (formed from the tibial nerve and common fibular nerve)

DERMATOMES is a region of skin serviced by a single spinal nerve root. Is often used as the “pin prick” test for nerve function.

CRANIAL NERVES arise from the cerebrum and the brain stem. They primarily serve the head and neck region and there are 12 pairs of them. They are named in two ways, through roman numerals and the descriptive name. We have to know both. Most carry sensory AND motor fibers, while several also carry somatic and visceral information.

Number: CN I  
Name: Olfactory Nerve  
Fxn: Special sensory nerve. *Carries sense of smell only*  
Notes: Exists as tiny nerve bundles entering from **nasal mucosa** (ethmoid bone). Tiny fibers synapse in **olfactory bulbs** and **olfactory tracts** carry signal to the cortex.

Number: CN II  
Name: Optic Nerve  
Fxn: Special sensory nerve. *Vision!*  
Related: The optic nerves meet one another at the **optic chiasm** where they exchange information. The **optic tract** is the pathway from the chiasm to the cortex

Number: CN III  
Name: Oculomotor Nerve  
Fxn: Somatic motor. *It moves 4 of the 6 muscles that move the eye. It also raises eyelid*  
Visceral motor. *Pupillary constriction and lens accommodation (focusing)*

Number: CN IV  
Name: Trochlear Nerve  
Fxn: Somatic motor. *It moves superior oblique eye muscles*

Number: CN V  
Name: Trigeminal Nerve  
Fxn: Somatic sensory. *General sensation over face*  
Somatic motor. *Moves muscles of mastication.*

Number: CN VI  
Name: Abducens Nerve  
Fxn: Somatic motor. *Moves lateral rectus of eye*

Number: CN VII  
Name: Facial Nerve  
Fxn: Somatic sensory. *Proprioception & deep pressure over face*  
Somatic motor (MAIN FXN). *Muscles of facial expression*  
Special sensory. *Taste on anterior 2/3 of tongue*  
Visceral motor. *Lacrimal glands, salivary glands (2 of the 3 pairs)*

Number: CN VIII  
Name: Vestibulocochlear Nerve  
Fxn: Special sensory. *Hearing and equilibrium*

Number: CN IX  
Name: Glossopharyngeal Nerve  
Fxn: Somatic sensory. *General senses from pharynx*  
Special sensory. *Taste on poster 1/3 of tongue*  
Somatic motor. *Pharyngeal muscles (swallowing)*  
Visceral sensory. *From pharynx, carotid, blood vessels (oxygen and CO2 levels in the blood)*  
Visceral motor. *Parotid salivary gland*

Number: CN X  
Name: Vagus Nerve  
Fxn: Somatic sensory. *Proprioception from pharynx, larynx, ear pinna*  
Somatic motor. *Pharyngeal and laryngeal muscles*  
Visceral sensory. *Receives input from thoracoabdominal organs*  
Visceral motor. *To thoracoabdominal organs*

Number: CN XI  
Name: Accessory Nerve  
Fxn: Somatic motor. *Pharyngeal, laryngeal and soft palate muscles. Trapezius. Sternocleidomastoid.*

Number: CN XII  
Name: Hypoglossal Nerve  
Fxn: Somatic motor. *Intrinsic & extrinsic muscles of tongue*

## RECEPTORS

Receptors are skin and muscle that are specialized to detect and respond to stimuli. They carry impulses to the CNS. They are classified by:

- Type of stimulus detected
- Location in body
- Structural complexity

## RECEPTORS CLASSIFIED BY TYPE OF STIMULUS DETECTED

Mechanoreceptor	Response to mechanical distortion <i>Touch, vibration, pressure, itch, stretch</i>
Thermoreceptor	Changes in temperature
Photoreceptor	Responds to light energy
Chemoreceptors	Responds to chemical in solution <i>taste and smell</i>
Nociceptors	Responds to potentially damaging stimuli

## RECEPTORS CLASSIFIED BY WHERE LOCATED IN THE BODY

Exteroceptor	Sense external stimuli. Includes most special senses <i>Touch, pressure, pain, skin temp</i>
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Interoceptor	Responds to internal stimuli <i>Chemical changes, tissue stretch, temperature, pain</i>
Proprioceptor	Sense stretch in skeletal muscles, ligaments, tendons, joints, bones and muscle CT coverings

### RECEPTORS CLASSIFIED BY COMPLEXITY

Simple receptors	Modified dendritic endings provide most of the general senses
Complex receptors	Highly specialized sense organs Provide special senses <i>(vision, hearing, equilibrium, taste, smell)</i>

### MORE DETAIL ABOUT SIMPLE RECEPTORS

Simple receptors are either free nerve endings or encapsulated nerve endings. The **FREE NERVE ENDING RECEPTORS** are typically pain or temperature receptors. They are located especially in epithelium and CT. Some are associated with specific structures. **MERKEL DISCS** detect light touch and are associated with Merkel cells. **HAIR FOLLICLE RECEPTORS** detect light touch through fine hair movement.

**ENCAPSULATED NERVE ENDINGS** are where dendrites are surrounded by a CT capsule. All of these are mechanoreceptors (meaning they respond to mechanical distortion). There are several of these...of course!

- **MEISSNER'S CORPUSCLE** (aka tactile corpuscle) is located in superficial dermis (the dermal papillae) of hairless, thick skin (ex: palm of hands) and it senses light touch.
- **PACINIAN CORPUSCLE** (aka lamellated corpuscle) is located in dermis and hypodermis. It responds to onset of deep pressure and vibration.
- **RUFFINI ENDINGS** are in the dermis, hypodermis and joint capsule. They detect continuous deep pressure
- **MUSCLE SPINDLE** (aka interoceptor). Located in the perimyseum of the skeletal muscle. Responds to muscle stretch
- **GOLGI TENDON ORGAN** located in tendon, closer to the insertion. They sense tendon stretch and muscle contraction
- **JOINT KINESTHETIC RECEPTOR** is located in the articular capsule. It detects joint movement and position. It is a collaboration of pacinian, ruffini, free nerve and golgi tendon organ-like receptors.

### **REFLEXES**

**REFLEXES** are the simplest mode of processing. A reflex is a rapid, predictable response to a particular stimulus.

## METHOD OF ACQUISITION

Many reflexes are innate (inborn). These are unlearned and involuntary. Others are learned (acquired)...such as automatically pressing on the brake of a car. This second type requires practice and repetition. The distinction between the two is not always clear, and inborn reflexes can be changed.

The REFLEX ARC is the specific natural pathway of a reflex. It has several components:

- The RECEPTOR is located at the site of stimulus
- The SENSORY NEURON (sometimes a receptor, sometimes not) carries the signal to the CNS
- The CNS INTEGRATION CENTER is on the spinal cord.
  - MONOSYNAPTIC REFLEX occurs where a sensory neuron synapses directly with a motor neuron going out
  - POLYSYNAPTIC REFLEX has multiple synapses involving at least one interneuron
- The MOTORNEURON transmits the signal to effector organ (muscle or gland)



## SOME SPECIFIC REFLEXES

The STRETCH REFLEX monitors tension on a muscle, and causes an active contraction in response to passive muscle stretch. It excites the muscle spindles in the Golgi tendon organs and signal is sent to the spinal cord. The spinal cord synapses then excite the muscles that counter the stretch and inhibit the muscles that increase the stretch (IPSP). An example is the patellar reflex.

The GOLGI TENDON REFLEX inhibits active contraction of a muscle. It is used to adjust muscle tension during contraction.

The FLEXOR REFLEX (aka “withdrawal reflex”) is a polysynaptic reflex in response to pain. The fact that it is polysynaptic means that it is slower and modifiable. It involves groups of muscles and causes withdrawal of injured body part.

The CROSSED EXTENSOR REFLEX causes flexion on one side of the body and extension on the other side. It is used in maintaining posture/equilibrium.

The SUPERFICIAL REFLEXES are muscular responses to cutaneous sensation. They have clinical importance though their physiological purpose is unclear.

- PLANTAR REFLEX is a curling of the toes in response to stroking the lateral foot. It tests nerves on L4-S2. Babinski’s sign is abnormal in adults...it is dorsiflexion of hallux and fanning of the toes. This response is normal in babies up to 1 year.
- ABDOMINAL REFLEX causes the umbilicus to move toward a stimulus when the skin around that area is stroked. It tests T8-T12

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