CRANIAL NERVES

And Spinal Cord
CRANIAL NERVES

• This section is on every type of board exam.
• The spinal nerves come out of the spine, and the cranial nerves come out of the brain directly.
• There are 12 pairs.
• They are numbered with Roman numerals.
The 12 Pairs of Cranial Nerves
Nerves vs. Tracts

• Outside of the CNS a collection of axons is called a nerve, and inside of the CNS they are called tracts. There is no such thing as a nerve in the CNS.
I. Olfactory Nerves

- Sensory nerves of smell
II. Optic Nerve

- Transmits information from the eye’s retina.
III Occulomotor Nerve

- Innervates four of the six extrinsic eye muscles (that move the eyeball).
- They also have parasympathetic innervation in the iris (pupil dilation) and ciliary muscles (controls the lens).
IV. Trochlear Nerve

- Supplies one extrinsic eye muscle
- (Superior oblique)
VI: Abducens

- Controls one of the eye muscles (lateral rectus).

- Disorder: Horizontal Nystagmus
  - Video
    - http://www.youtube.com/watch?v=phpe_RVGqcA
VI. Abducens Nerve

• Controls one of the eye muscles (lateral rectus). Abducts the eyeball
V. Trigeminal Nerve

This is the main sensory nerve of the face. It has a large branch that passes through the foramen ovale of the skull. It has three parts.

- When a dentist numbs the lower teeth, he injects the mandibular branch. For the upper teeth, he injects the maxillary branch.
- The superior branch is the opthalmic branch.
- Problems with CN-V are called **TRIGEMINAL NEURALGIA**, which is excruciating pain in the face from nerve inflammation.
V. Trigeminal Nerve

- Superior orbital fissure
- Ophthalmic division (V₁)
- Trigeminal (semilunar or gasserian) ganglion
- Maxillary division (V₂)
- Mandibular division (V₃)
- Pons
- Foramen ovale
- Foramen rotundum
- Anterior trunk to chewing muscles
- Infraorbital nerve
- Superior alveolar nerves
- Lingual nerve
- Inferior alveolar nerve
Sneezing

• Sneezes are triggered by the Trigeminal nerve.
• 30% of people are "sun sneezers" who have genetically inherited the photic sneeze reflex. In these people, over-stimulation of the optic nerve by looking at a bright light stimulates the trigeminal nerve to cause a sneeze.
• A sneeze can also be triggered by chewing a strong mint gum or by plucking your eyebrows.
• The eyelid muscles that close your eyes are part of the network of nerves activated during a sneeze. That is why you close your eyes when you sneeze.
VII Facial Nerve

• This innervates the muscles of facial expression.
• A person who cannot blink or smile may have damage to this nerve.
• Even though this is a motor nerve, someone with a damaged facial nerve can not easily taste sweet, sour, or salty substances. The sense of taste runs along with this nerve. The primary gustatory (taste) cortex is located in the temporal lobe in the insula of the cerebrum.
• The Facial nerve also supplies parasympathetic innervation to most salivary glands, causing them to secrete saliva.
• Bell’s Palsy is damage of the facial nerve causing paralysis on one side. The nerves usually swell from infection by herpes simplex virus, but only the motor nerves are involved, not the sensory, so it’s painless. Needs to be distinguished from a stroke and myasthenia gravis.
VII. Facial Nerve

- Innervates muscles of facial expression
VIII. Vestibulocochlear Nerve

- Sensory nerve for balance (vestibule) and hearing (cholea)
IX. Glossopharyngeal Nerve

- Innervates structures of the tongue and pharynx (back of throat).
IX. Glossopharyngeal Nerve

- It has 1 job it does by itself and 2 jobs it shares with CN X.
- Supplies **posterior 1/3 of tongue**
- Supplies **pharynx** (signals the pharynx to constrict during swallowing)
  - (so does CN X)
- Carries information from the **baroreceptors** in the arteries of the neck to the brainstem so your brain knows what your blood pressure is.
  - (so does CN X)
Baroreceptors

- **Baroreceptors** are sensors located in the blood vessels in the aortic arch and carotid artery in the neck. They are stretched when blood goes through them, and that tells the brain if the blood pressure is too high or low. The brain can then cause the blood vessels throughout the body to constrict (increasing peripheral resistance and raising blood pressure) or dilate (decreasing peripheral resistance and lowering blood pressure). The brain can also increase or decrease cardiac output (how hard the heart beats) to adjust blood pressure back to normal.

- Baroreceptors act immediately as part of a negative feedback system (called the baroreflex) as soon as there is a change from the usual blood pressure, returning the pressure to a normal level within a few heart beats.
X. Vagus Nerve

• (vagrant = “wanders”).
• This is the only cranial nerve that travels into the abdomen.
• 90% of all parasympathetic fibers (causing the body to rest and digest) are from this cranial nerve.
• This is the most important cranial nerve because it innervates all of the organs in the thoracic and abdominal cavities: heart, lungs, GI tract, etc, with parasympathetic innervation (rest and digest).
X. Vagus Nerve

• It has 2 jobs it does by itself and 2 jobs it shares with CN IX.
• Makes up most of the parasympathetic nervous system
• Supplies larynx (for speech)
• Supplies pharynx (signals the pharynx to constrict during swallowing)
  – (so does CN IX)
• Carries information from the baroreceptors in the head and neck to the brainstem.
  – (so does CN IX)
X. Vagus Nerve

- A mixed sensory and motor nerve
  The only cranial nerve that “Wanders” into thorax and abdomen
XI: ACCESSORY NERVE

- An accessory part of the vagus nerve
- Enters the skull through foramen magnum and leaves through the jugular foramen.
- It just supplies the shoulder muscles and allows you to shrug your shoulders.
XII. HYPOGLOSSAL NERVE

- Runs inferior to the tongue
- Supplies the anterior 2/3 of the tongue.
- Damage causes impairment of speech.
- Doctor will ask pt to stick out tongue to see if it deviates to one side.
Need to know all of the cranial nerves and their Roman numerals

• Hint: use the first letter of each nerve to make a sentence: “OOOTTAFVGVAH”. OOO, Tommy Turtle Always Finds Vegetable Gardens Very Attractive, Heavenly!
SPINAL CORD

• Really, this is just a continuation of the brain.
• Begins at the **FORAMEN MAGNUM**. It goes to L1-2. In infants, it ends at L4-5, because it doesn’t grow as fast as the rest of the body.
• Beyond the spinal cord, the nerves branch into bundles called the **CAUDA EQUINA** (“Horse’s tail”), which exit through the sacral foramina.
• Spinal nerves are named L1, C5, S2, etc.
Spinal Nerves

• There are 31 pairs of spinal nerves (motor and sensory) that travel down the vertebral canal and exit through the intervertebral foramina and continue out into the body.

• The spinal nerve C1 exits above the C1 vertebrae, and the spinal nerve C2 exits above the C2 vertebrae, and so on. Then the spinal nerve C7 exits above the C7 vertebra, but now there is a surprise….the spinal nerve above the T1 vertebra is called spinal nerve C8, even though there is no C8 vertebra! So that changes the pattern. The spinal nerve T1 exits BELOW the vertebra T1, and that pattern continues the rest of the way.
The Spinal Cord

Figure 13.29a
CROSS SECTION OF THE SPINAL CORD

- CENTRAL CANAL, GREY MATTER, WHITE MATTER, POSTERIOR MEDIAN SULCUS, ANTERIOR MEDIAN FISSURE, DORSAL HORN, VENTRAL HORN, DORSAL ROOT, DORSAL ROOT GANGLION, VENTRAL ROOT, and SPINAL NERVE.
Spinal Cord Cross Section

- Dorsal root ganglion
- Dorsal root
- Dorsal horn
- Ventral horn
- Ventral root
- Posterior median sulcus
- Central canal
- White matter
- Grey matter
- Anterior median fissure
White Matter

- White matter of the nervous system forms conduction pathways called TRACTS.
- The white matter in each half of the spinal cord is organized into three columns:
  - Dorsal (posterior) column
  - Ventral (anterior) column
  - Lateral column
- Each column has ascending tracts, which consist of axons conducting impulses toward the brain and descending tracts, which consist of axons conducting impulses away from the brain.
1. Dorsal (posterior) column
2. Ventral (anterior) column
3. Lateral column
Terms

• **GANGLION** is the term for a group of neuron cell bodies (both sensory and motor). Ganglia are found in the peripheral nervous system only. Inside of the CNS, a group of cell bodies are called nuclei.

• **SENSORY NEURONS** come in (via the spinal nerve) through the dorsal root; their cell body is in the dorsal root ganglion, and its axon goes into the dorsal horn of the grey matter and synapse there.

• It also sends a branch to an area of the white matter called the **DORSAL COLUMN PATHWAY**, which goes into the brain (thalamus).
Neurons Classified by Function

Figure 12.11

Dorsal column pathway

Upper motor neuron

Lower motor neuron
Terms

• **LOWER MOTOR NEURONS** have their cell body in the ventral horn of the grey matter, their axon goes out the ventral root, and synapses in a skeletal muscle. Symptoms of a lower motor neuron disorder is when the patient has weakness or paralysis, including their reflexes.

• **UPPER MOTOR NEURONS** have their cell body in the brain, and they synapse on a lower motor neuron. Symptom of an upper motor neuron disorder is when the patient has weakness or paralysis but reflexes work normally.

• **INTERNEURONS**: These are found in the brain and spinal cord. The ones in the spinal cord have their cell bodies in the dorsal half of the gray matter. They receive signals from the sensory neuron and then synapse on the cell body of the lower motor neuron. In this way, the interneurons (sometimes called association neurons) transmit signals from the sensory pathways to the motor pathways. **The complexity of the CNS can be attributed to the large number of interneurons in the CNS.**
Terms

• Since the interneurons are in the grey matter of the spinal cord, that is the “Integration Area”. They coordinate the afferent and efferent nervous system.

• The correct path a simple spinal reflex travels is from the peripheral receptor, to the afferent neuron, to the integration center, to the efferent neuron, to the effector (the muscle or gland)
Neurons Classified by Function

Figure 12.11

Upper motor neuron

Dorsal column pathway

Lower motor neuron

To effectors (muscles and glands)
Spinal Cord Reflexes

• Stretch Reflex (knee-jerk; patellar reflex)
  – Muscle contracts in response to a sudden stretch force (with a reflex hammer).
  – After a severe spinal cord injury, let’s say all spinal reflexes are lost below the level of the injury for 2 weeks. Then the patellar reflex returns but it is often exaggerated (hyper-reflexic), indicating damage is still present.

• Withdrawal Reflex
  – The body part is quickly removed from a painful stimulus.
  – Sensory neurons carry the information to the spinal cord, and the muscles remove the limb immediately, before the brain receives the pain information.
Simple Reflex Arc

• In the spinal cord, these three neurons together (sensory, lower motor, and interneuron) form the **SIMPLE REFLEX ARC**. They process information without the brain. So if you touch a hot stove, the sensory input comes into the spinal cord, the association neurons send the information to the lower motor neurons, the muscle contracts, and you take your hand off the stove before your brain even knows it. This is an example of a withdrawal reflex.

• Simple reflex behavior involves three neurons, and no brain involvement. Reflexes are automatic events. They involve both motor and sensory neurons, they are rapid, involuntary, and they involve multiple synapses.
Three-Neuron Reflex
Sensory Tracts

• Now the signal has to go to the brain via a TRACT.

• A tract is a collection of axons inside the central nervous system.

• Sensory axons for touch and pressure send a branch to the thalamus portion of the brain.

• SENSORY TOUCH → SPINAL NERVE → POSTERIOR ROOT → (cell body is in the POSTERIOR ROOT GANGLION) → POSTERIOR HORN of grey matter → TRACT (white matter) → THALAMUS (of brain)
Neurons Classified by Function

Upper motor neuron

Dorsal column pathway
To thalamus

Lower motor neuron

To effectors (muscles and glands)
Some tracts are ipsilateral (same side) and some are contralateral (cross over to the other side).
Tracts to the Brain

• These tracts have various names, depending on what types of neurons are traveling within them.
• Some tracts send sensory information to the brain, and some tracts send motor commands from the brain to the muscles.
Sensory Tracts

• **DORSAL COLUMN TRACT** (touch/vibration)
  – Cell bodies are in the dorsal root ganglia, their axons go into the spinal cord and then they go to the thalamus and then up to the cerebral cortex.

• **SPINOTHALAMIC TRACT** (pain/temperature)
  – Cell bodies are in the dorsal root ganglia, their axons go into the spinal cord and then they go to the thalamus and then up to the cerebral cortex.
  – Tens units work by using vibration to override pain sensation

• **SPINOCEREBELLAR TRACT** (balance and position)
  – Cell bodies are in dorsal root ganglia, their axons go into the spinal cord, and then they go to the cerebellum.
Motor Tracts

- CORTICOSPINAL TRACT
  - The cell bodies of the upper motor neurons are in the cerebral cortex, and the axons travel down the spinal cord and synapse on the cell body of a lower motor neuron in the ventral horns of the spinal cord.
SOMATIC MOTOR NEURON

- Sends commands to the skeletal muscle to contract.
- When the neurons leave the spinal cord, they travel together in what is called a plexus. One of these is known as the brachial plexus (in the axilla; innervates the muscles of the upper extremity). You also have cervical, lumbar and sacral plexi as well.
- Starting at the spinal cord and preceding laterally, the subdivisions of a plexus start out in the **ROOTS (RAMI)**, then form a **TRUNK**, which then branches into **DIVISIONS**, which then become **CORDS**, which become the plexus.
The Brachial Plexus

Figure 14.12a

Key:  
- Blue = Roots
- Orange = Trunks
- Yellow = Anterior division
- Green = Posterior division

Roots:
- C4
- C5
- C6
- C7
- C8
- T1

Trunks:
- Upper
- Middle
- Lower

Nerves:
- Dorsal scapular
- Nerve to subclavius
- Suprascapular
- Posterior divisions
- Lateral
- Medial
- Axillary
- Musculocutaneous
- Radial
- Median
- Ulnar

Medial cutaneous nerves of the arm and forearm
Upper subscapular
Lower subscapular
Thoracodorsal
Upper and Lower Motor Neuron Diseases

• Some diseases only effect the UMN, and some only effect the LMN; some diseases affect both UMN and LMN.

• Lower motor neuron disorders:
  – Polio

• Upper motor neuron disorder:
  – Cerebral palsy
  – Multiple Sclerosis

• Upper and Lower motor neuron disease
  – ALS
Amyotrophic Lateral Sclerosis (ALS)

- Also known as Lou Gehrig's disease (baseball player in 1940’s)
- It was more recently called the disease of the ice bucket challenge
- Physicist Stephen Hawking also has this disease.
- A progressive motor neuron disease.
- The disorder causes muscle weakness and atrophy throughout the body as both the upper and lower motor neurons degenerate, ceasing to send messages to muscles.
- The muscles gradually weaken, develop fasciculations (twitches) because of denervation, and eventually atrophy.
- Eye muscles are usually spared.
- Cognitive function is generally spared.
- Death usually occurs in 2-4 years, although Stephen Hawking has had it for the longest period of time, more than 50 years.
ALS in the Brain
(upper motor neurons)
Nervous System Classification

• **Somatic Nervous System**
  – Motor nerves to skeletal muscle (somatic motor neurons)
    • Upper and lower motor neurons
  – Skeletal Muscle Reflexes
    • Sensory, interneurons, lower motor neurons
  – Visceral (organ) Reflexes
  – Sensory nerves (somatosensory neurons)

• **Autonomic Nervous System**
  – Motor nerves to smooth and cardiac muscle (visceral motor neurons)
    • Sympathetic
    • Parasympathetic

• **Peripheral Nervous System**
  – Whatever neurons are outside of CNS

We have covered the red topics
Paralysis
Spinal cord injury (SCI) is a damage to the spinal cord resulting in a change, either temporary or permanent, in its normal motor, sensory, or autonomic function.
NATALIE

- Natalie Video
- http://www.youtube.com/watch?v=vSeEQW5seMU&sns=fb

- Skiing accident in December 2007
- Injury to C5-C6 (chest down paralysis)
- Incomplete SCI
- Latest achievement: elimination of walker, replaced with walking sticks
ANATOMY OF SPINAL CORD

• The spinal cord is the major bundle of nerves that carry nerve impulses to and from the brain to the rest of the body.

• It is surrounded by rings of bone called vertebra.

• The cervical vertebrae are C1 – C7

• The thoracic vertebrae are T1 – T12

• The lumbar vertebrae are L1 – L5
LOCATION OF INJURY

**Tetraplegia**
(replaces the term quadriplegia): Injury to the spinal cord in the cervical region, with associated loss of muscle strength in all 4 extremities

**Paraplegia**: Injury in the spinal cord in the thoracic, lumbar, or sacral segments
Quadriplegia due to Spinal cord injury
TWO TYPES

- A complete injury - no function below the level of the injury; no sensation, no voluntary movement. Both sides of the body are equally affected.

- An incomplete injury - some functioning below the primary level of the injury, may be able to move one limb more than another, may be able to feel parts of the body that cannot be moved, or may have more functioning on one side of the body than the other.

- With the advances in acute treatment of SCI, incomplete injuries are becoming more common.
FACTS

• Approximately 450,000 people live with SCI in the US.
• There are about 10,000 new SCI’s every year; the majority of them (82%) involve males between the ages of 16-30.
• These injuries result from motor vehicle accidents (36%), violence (28.9%), or falls (21.2%).
• Quadriplegia is slightly more common than paraplegia.
SYMPTOMS

• Increased muscle tone (spasticity)
• Loss of normal bowel and bladder control (may include constipation, incontinence, bladder spasms)
• Numbness
• Sensory changes
• Pain
• Weakness, paralysis
• Inability to regulate blood pressure effectively
• Reduced control of body temperature
• Inability to sweat below the level of injury
TESTS AND TREATMENT

- SCI’s must be treated immediately, time between injury and treatment can affect the outcome
- Surgery may be required to:
  - remove fluid or tissue that presses on spinal cord
  - remove bone fragments, disk fragments, or foreign objects
  - fuse broken spinal bones
- CT scan or MRI of the spine
- Myelogram (x-ray of the spine after injecting dye)
- Bed rest-allow bones of spine to heal
PROGNOSIS

- Patients with a complete spinal cord injury (SCI) have a less than 5% chance of recovery. If complete paralysis persists at 72 hours after injury, recovery is essentially zero.

- The prognosis is much better for the incomplete cord syndromes. If some sensory function is preserved, the chance that the patient will eventually be able walk is greater than 50%.
REHABILITATION

• Project Walk® Spinal Cord Injury Recovery Center, an internationally recognized non-profit organization, exists to provide an improved quality of life to people with spinal cord injuries through intense activity-based recovery programs, education, support, and encouragement
• The only center, not attached to a hospital or university, that has published research in peer reviewed journals and has ongoing grant funded research projects.
• Some of the most advanced equipment
• Also, aquatic therapy
“You’re just going to feel a little pinch, then a horrific burning pain, your eyes will roll back into your head, you will drool uncontrollably...”