Neuro Exam 2 Study Guide

Please use this to help direct your studying. Note that this guide is not exhaustive. Rather, it aims to help you focus on the central concepts from this unit of the course.

Exam Details

- 60 questions
- MPL=0.552 (33.1/60) – this might drop slightly by exam day
- The following table describes major content areas based on the number of questions in which they are prominently featured. Note that some questions synthesize content from different parts of the unit (e.g., clinical cases that report on sensory findings, motor findings, cranial nerve findings, spinal reflexes, and/or blood supply), so the numbers here sum up to more than 60. This table does not tell you how many times a given topic is referenced (e.g., spinal reflexes are referenced more often than they’re featured).

<table>
<thead>
<tr>
<th>Content area</th>
<th>Featured Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebral Cortex</td>
<td>2</td>
</tr>
<tr>
<td>Meninges/Ventricles</td>
<td>2</td>
</tr>
<tr>
<td>Neurovascular Emergencies</td>
<td>2</td>
</tr>
<tr>
<td>Cerebrovasculature</td>
<td>7</td>
</tr>
<tr>
<td>Molecular/Cellular Neuro</td>
<td>4</td>
</tr>
<tr>
<td>Neuroembryology</td>
<td>2</td>
</tr>
<tr>
<td>Peripheral Somatosensation</td>
<td>2</td>
</tr>
<tr>
<td>DCML/STT/Pain</td>
<td>15</td>
</tr>
<tr>
<td>CST &amp; Motor Systems</td>
<td>13</td>
</tr>
<tr>
<td>Spinal Reflexes</td>
<td>3</td>
</tr>
<tr>
<td>Basal Ganglia</td>
<td>5</td>
</tr>
<tr>
<td>Cerebellum</td>
<td>4</td>
</tr>
<tr>
<td>Eye Movement (CNs III, IV, &amp; VI)</td>
<td>6</td>
</tr>
<tr>
<td>CNs V, VII, IX-XII</td>
<td>6</td>
</tr>
<tr>
<td>Vision</td>
<td>6</td>
</tr>
<tr>
<td>Peripheral Neuropathies</td>
<td>5</td>
</tr>
<tr>
<td>Movement Disorders</td>
<td>5</td>
</tr>
<tr>
<td>Qs. w/ CT/MRI/Angiogram</td>
<td>15</td>
</tr>
</tbody>
</table>

- While it may be helpful to review Parts 1-9 of the lab manual, nothing present in Labs 1 & 2 that wasn't discussed in the learning sessions or TBLs will appear on Exam 2.

The following is a list of study suggestions/strategies organized by content area in Unit 2 (refer to Exam 1 study guide for Unit 1-related suggestions). Not everything listed here will ultimately appear on Exam 2, but these are concepts you should know moving forward in the course, for Step 1, and for your general knowledge as physicians-in-training. Remember that while the "high-yield" slides in the learning session and TBL Powerpoints have been
highlighted for a reason, do not neglect the more foundational information often contained on other slides.

General advice

- In any exam question involving a neurological deficit, look for
  - Time component (acute vs. chronic)
  - Key words (e.g., Romberg, fasciculations, clonus, Babinski, astereognosis, resting tremor, etc.)
  - Lateralization (lesion on which side? Ipsi or contra findings? Is a decussation involved?)
  - Localization (lesion at which level? What are the consequences above and below the lesion?)

Intro to spinal cord, somatosensation in the PNS, and stimulus properties

- Be able to render a sketch of the spinal cord in cross-section. Understand what is found in the ventral (anterior) and dorsal (posterior) horns, three funiculi, ventral and dorsal roots, and where the three major tracts (CST, DCML, and STT) are found. Be aware that you may see some terminological variants in the questions (posterior in lieu of dorsal, anterior in lieu of ventral).

- **Lesions to grey matter of spinal cord or the PNS** (e.g., spinal nerves/roots, DRG, dorsal or ventral horns): *only* the lesioned spinal level (+/- 1 or 2 for STT)
  - Note that **polyneuropathies** may affect multiple spinal nerves/roots → look for other indications of peripheral neuropathy (e.g., “stocking and glove” distribution of sensorimotor deficits, abnormal NCV, F-wave, H-reflex results, etc.)

- **Lesions to the white matter of spinal cord** (e.g., funiculi, dorsal columns): potentially all levels *below and including* the lesioned spinal level; look for contralateral STT-related deficits mixed with *ipsilateral* DCML and/or CST-related deficits (exception: anterior white commissure)
  - Know the blood supply of the spinal cord.
  - Understand the concept of dermatomes. Know approximately which levels of the spinal cord correspond to the arms/hands, trunk, and legs/feet.
  - Understand how nerve fibers are classified and which sensory receptors and LMNs are associated with which fibers. (Understand the functional significance of these assignments as well.)
  - Know the different kinds of cutaneous mechanoreceptors, thermoreceptors, and nociceptors.
  - Understand the four major attributes of stimuli and how each is encoded by the nervous system.
  - Be comfortable with terminology describing somatosensory deficits (e.g., hypesthesia, analgesia, allodynia).

The three major tracts: DCML, STT, and CST

- Know the full pathways of the three major tracts. This means understanding where they are and what’s happening to them in the PNS, spinal cord, brainstem, thalamus (if applicable), internal capsule, and cortex.
• Know where 1°, 2°, and 3° somata and fibers of the DCML and STT are located. Know where UMNs and LMNs (somata and fibers) of the CST are located.
• Know where each of the tracts decussates (DCML, CST in the caudal medulla; STT in the spinal cord). Be able to predict the laterality of signs based on lesions rostral, caudal, or at the level of tract decussation.
• Understand the blood supply to the tracts. This is particularly important in the spinal cord and brainstem.
• Know how the integrity of the DCML and STT is clinically tested (DCML examples: Romberg test, two-point discrimination, stereognosis tests; STT examples: pin pricks, vials with water of different temperatures).
• Understand major pathologies involving somatosensory loss in relation to the DCML and/or STT (e.g., tabes dorsalis, subacute combined degeneration/Friedrich’s ataxia, syringomyelia, Brown-Séquard, MS, Guillain-Barré, Charcot-Marie-Tooth, diabetic neuropathy, disc herniation, cauda equina syndrome).
• For all three major tracts, expect
  o **Ipsilateral** signs if a lesion is *below* (caudal to) decussation (spinal cord/PNS for DCML*/CST, dorsal horn/PNS for STT)
    - *Ipsilateral* DCML-related signs if nuclei gracilis or cuneatus lesioned
  o **Contralateral** signs if lesion is *above* (rostral to) decussation (spinal cord for STT, brain for all 3)

**Pain and Pain Perception**

• Understand the difference between acute and chronic pain and between nociceptive and neuropathic pain. Be able to explain the concept of referred pain.
• Know the chemicals in the PNS that participate in nociceptive transduction and sensitization. Know that substance P, glutamate, and CGRP are the neurotransmitters secreted by the 1° STT axon terminals to excite the 2° STT neurons (occurring in the dorsal horn).
• Understand neuropathic pain disorders such as neuralgia, phantom limb pain, and thalamic pain syndrome.
• Appreciate the difference between primary and secondary headaches.
  o Be able to distinguish between major varieties of headaches, including tension, migraine, and cluster headaches and headaches secondary to some underlying pathology.
• Recognize those thalamic and cortical structures involved in the cognitive-emotional interpretation of pain.
• Understand the descending pain modulation pathway and the roles played by the PAG and various neurotransmitters (5-HT, NE, and endorphins like enkephalin and dynorphin)

**Motor systems**

• Understand the functional differences between UMNs and LMNs (UMNs=command cells located in the motor cortex belonging to the CST/CBT and in the brainstem if belonging to the “indirect”/extrapyramidal motor tracts; LMNs=the neurons directly activating muscles, which receive their commands from the UMNs, found in the brainstem cranial motor nuclei for muscles of the face/tongue/throat/neck and the
ventral horn of spinal cord for muscles of the neck/body). Please note that neither the basal ganglia nor cerebellum contains UMs or LMNs, even though they participate in motor function.

- Know the four indirect (extrapyramidal) motor tracts, particularly with respect to their roles in decorticate and decerebrate posturing. Know where each originates, but don't worry about their precise trajectories through the brainstem and spinal cord.
- Understand the different roles served by alpha and gamma LMNs and how LMNs are somatotopically arranged in the spinal cord. Distinguish between extrafusal and intrafusal muscle fibers.
- Appreciate the nature of LMN signs, including fasciculations, fibrillations, and neurogenic atrophy.
- Review the electrophysiology of the neuromuscular junction and understand disorders/select drugs that can affect the NMJ pre- and postsynaptically (myasthenia gravis, LEMS, alpha-latrotoxin, tetanus and botulinum toxins, organophosphates, edrophonium, and nicotinic ACh antagonists).

- Be able to identify and distinguish between major UMN and LMN signs. Understand the role that timing plays with respect to UMN signs (acute vs. chronic).

**Spinal reflexes**
- Be able to define what a reflex is, and explain what testing spinal reflexes tells you clinically.
- Know which 1° afferent neurons (1° spinocerebellar neurons) innervate muscle spindles and Golgi tendon organs; know the histological classification of their fibers. Define the roles played by muscle spindles and Golgi tendon organs in the myotactic (stretch/DTR) and autogenic (inverse myotactic) reflexes, respectively. Distinguish between the functional significance of these two reflexes, and understand the sensorimotor arcs underlying them. Define homonymous, synergistic, and antagonist muscles in the context of spinal reflexes. Appreciate the role played by gamma motor neurons with respect to the intrafusal fibers found in muscle spindles.
- Know the common deep tendon reflexes tested clinically and which spinal levels they assess. Know how DTRs are graded.
- Be certain you understand the nature and significance of a Babinski sign, clonus, clasp-knife rigidity, and pronator drift (all chronic UMN signs).

**Basal ganglia**
- Review how to identify the basal ganglia (especially the caudate, putamen, and globus pallidus) in horizontal and coronal sections/scans. Know where the subthalamic nucleus and substantia nigra are located relative to other structures in the brain.
- Understand the significance of the direct and indirect motor loops (without memorizing them) in motor planning and action selection. Identify the input and output BG nuclei of the loops, and be able to articulate the roles played by the thalamus and cortex.
- Understand the modulatory role of the SN pars compacta and dopamine.
• Be able to explain the general etiologies of hypo- vs. hyperkinetic signs, and distinguish between these signs.
• Understand the lesions underlying Parkinson’s, Huntington’s, and hemiballismus with respect to the direct and indirect pathways. Know that a unilateral lesion of any of the basal ganglia (e.g., as in hemiballismus) results in contralateral signs.

Cerebellum
• Be familiar with basic cerebellar anatomy. Know the blood supply (SCA, AICA, and PICA—piece of cake)!
• Understand what information is relayed by the dorsal spinocerebellar and cuneocerebellar tracts. Without memorizing these pathways, recognize those spinal and brainstem structures with which they're associated.
• Be familiar with the basic somatotopy of the cerebellum.
• Understand the basic histology of the cerebellum. Know the inputs: climbing and mossy fibers, where they carry input from, what they carry input to, and their neurotransmitters. Understand the roles played by granule and Purkinje cells and their neurotransmitters. Recognize the names of the four deep cerebellar nuclei if you see them and the fact that they collectively serve as the sole outputs of the cerebellum to the rest of the nervous system. Know where they receive input from.

Cranial nerves/Brainstem
• General principles
  o Lesions of the cranial nerves always give rise to ipsilateral signs.
  o Lesions of the cranial nuclei give rise to ipsilateral signs except in the case of the trochlear nucleus.
  o Most cranial motor nuclei receive bilateral UMN input, such that if there’s a unilateral UMN lesion, motor function remains largely unaffected. The UMN fibers innervating all cranial motor nuclei are found in the corticobulbar tract (CBT). Know that the CBT originates in the lateral aspect of the primary motor cortex (precentral gyrus) and passes through the genu of the internal capsule. Depending on which cranial motor nuclei CBT fibers are synapsing on, they may pass through the same ventral structures the CST UMN fibers pass through, including the crus cerebri (midbrain), basilar pons, and medullary pyramids. Excluding the three extraocular nuclei (of CNs III, IV, and VI), which don’t receive CBT input, know that there are two major exceptions to bilateral CBT UMN innervation: the lower part of the facial motor nucleus (of CN VII, supplying the lower facial muscles of expression), which receives only contralateral UMN innervation, and the hypoglossal nucleus (of CN XII), which receives only contralateral UMN innervation. Understand the consequences of these exceptions relative to unilateral UMN lesions.
  o Unilateral lesions of decussated 2° fibers from cranial sensory nuclei (CN V) result in contralateral deficits. (In practice, vascular lesions of the trigeminothalamic and trigeminal lemniscus fibers are seldom seen). Appreciate, however, that a unilateral lesion of either VPM nucleus or primary motor cortex (e.g., an MCA stroke) could result in full loss of somatosensation in the contralateral face.
Most cranial nerves emerge ventrally from the brainstem
Most cranial nuclei are found in the dorsal brainstem
Four rules of four the brainstem:
1. 4 structures in the medial brainstem that begin with M: motor nuclei that are medial (those of CNs III, IV, VI and VII), medial longitudinal fasciculus, medial lemniscus (DCML), motor pathways (CST/CBT)
2. 4 structures in the side (lateral) of the brainstem that begin with S: spinocerebellar tracts, spinal trigeminal nucleus of CN V, sympathetic pathway to face/eyes, spinothalamic tract (STT)
3. There are...
   - 4 CNs in or above the midbrain: CNs I-IV
   - 4 CNs in the pons: CNs V-VIII
   - 4 CNs in the medulla: CNs IX-XII
4. For nerves with an associated somatic motor function, there are
   - 4 motor nuclei in the medial brainstem, all of which divide evenly into 12: those of CNs III, IV, VI, and XII (these nerves all emerge medially)
   - The other 4 motor nuclei are in the lateral brainstem: those of CNs V, VII, IX/X (nucleus ambiguus), and IX (these nerves all emerge laterally)

Midbrain structures whose approximate anatomy you should know: DCML & STT (very close to each other, “hug” the red nuclei dorsolaterally), CST/CBT (crus cerebri), CN III (nerve and nuclei), substantia nigra
   - From a vascular standpoint, the distinction between medial and lateral in the midbrain isn’t that important.
   - Know that CN IV emerges from the dorsal caudal brainstem, immediately caudal to the inferior colliculi.

Pontine structures whose approximate anatomy you should appreciate with respect to medial vs. lateral:
   - Medial: CN VI (motor nerve/nucleus /12), DCML (medial lemniscus), CST/CBT (motor pathway), MLF
   - Lateral: Spinal trigeminal nucleus (of CN V)*, CN VII (nerve/facial nucleus), CN VIII (nerve/nuclei), STT, spinocerebellar tracts, sympathetics to face

Rostral medullary structures whose approximate anatomy you should appreciate with respect to medial vs. lateral:
   - Medial: CN XII (motor nerve/nucleus /12), DCML (medial lemniscus), CST (motor pathway), MLF
   - Lateral: spinal trigeminal nucleus (of CN V), CNs IX/X (nerve + nucleus ambiguus), STT, spinocerebellar tracts, sympathetics to face

The only caudal medullary structures you should particularly care about are the nuclei gracilis and cuneatus of the DCML.
Appreciate the blood supply to the cranial nerves, major cranial nuclei, and tracts at the levels of the midbrain, pons, and rostral medulla. With only five major arteries at work in the brainstem (six if you count the AICAs), this isn’t as bad as it might seem!
Be able to recognize the midbrain, pons, and medulla in axial MRIs.
Be able to identify the compromised artery(ies) or level/location of the lesion based on the signs.
  - Hone in on what signs you recognize the best (don’t worry about recognizing all of them)!
  - Look for signs that would rule out certain arteries or lesion sites.
Be able to predict the signs based on the compromised artery(ies) or level/location of the lesion.
  - Hone in on those tracts, nuclei, and nerves with which you’re most familiar (don’t worry about knowing exactly where everything is)!
  - Remember which nuclei are medial and which are lateral
Tracts: motor (CST, CBT) are ventral; sensory (DCML, STT) are more dorsal
Please do not waste time memorizing the following syndromes! Rather, confirm that the signs & symptoms are consistent with your predictions based on the strategies we have developed.

- Olfactory (CN I)
  o Not on Exam 2. We’ll hit it again when we get to the limbic system. Olfaction is generally of limited clinical importance.

- Optic (CN II)
  o See visual system (no pun intended).

- Oculomotor (CN III), trochlear (CN IV), and abducens (CN VI)
  o Know the muscles innervated by each. Understand abduction, adduction, elevation, depression, intorsion, and extorsion in the context of the eyes.
  o Understand the autonomic functions of CN III (pupillary reflex, accommodation). Know that the Edinger-Westphal nucleus is the (proverbial) brains of the operation here. Understand what is occurring in Argyll-Robertson pupil and what may cause it.
    - Trace the general arc of the pupillary reflex and be able to predict lesion locations (ipsi CN II vs. ipsi CN III vs. contra CN III) based on testing.
  o Know the presentations of palsies for each nerve.
    - Presentations of CN IV palsy are varied, but know that it generally makes it impossible to intort the affected eye. This makes activities like reading and descending stairs difficult.
  o Appreciate the roles played by the frontal eye fields (FEFs), paramedian pontine reticular formation (PPRF), and medial longitudinal fasciculi (MLFs) in the initiation and coordination of horizontal conjugate eye movements. Predict the consequences of lesioning at various points along the horizontal conjugate gaze pathway, and infer the nature of the lesion based on conjugate gaze abnormalities.
  o Be familiar with vertical conjugate gaze in the context of Parinaud syndrome.

- Trigeminal (CN V)
  o Know the three divisions (ophthalmic, maxillary, and mandibular) and which parts of the face they correspond to.
  o Know the four nuclei, their functions, and their approximate locations (all dorsolateral, centered around the middle pons).
Don't worry about the precise trajectories of the tracts associated with the trigeminal nuclei; rather understand the function significance of lesions along these pathways. Lesions of the spinal trigeminal nucleus are more common, given its length.

- Review trigeminal neuralgia, trigeminal strength tests, and the jaw jerk reflex; what does testing the latter two reveal?
- Know the two nerves associated with the corneal blink reflex (sensory: CN V; motor: CN VII) and what an absent blink reflex might indicate.

**Facial (CN VII)**
- Know that CN VII wraps around the abducens nucleus (of CN VI) at the facial colliculus in the caudal pons (pontomedullary junction). What might compress the facial colliculus?
- Appreciate the gustatory and autonomic roles of CN VII, and recognize that gustatory input is routed through the NTS.
- Understand the differences between CN VII innervation of the upper facial muscles (bilateral UMN innervation to facial motor nucleus) and the lower facial muscles (contralateral UMN innervation to facial motor nucleus). Be able to make clinical predictions accordingly. Contrast UMN lesions with Bell’s palsy (lesion to CN VII itself).

**Vestibulocochlear (CN VIII)**
- Not on Exam 2.

**Glossopharyngeal (CN IX) + Vagus (CN X)**
- Appreciate the gustatory and visceral roles of these two nerves. Know that the solitary nucleus (NTS) receives gustatory and visceral sensory information from CNs VII, IX, and X, but don’t worry about the pathway details. Know the important autonomic role played by the dorsal motor nucleus (CN X). Don’t worry too much about the somatosensory roles played by these nerves.
- Know the motor roles of the nucleus ambiguus. Hoarseness, difficulty speaking (dysarthria/dysphonia), swallowing (dysphagia), or airway patency and often trace back to lesions of this nucleus or of CNs IX and X.
  - Appreciate the gag reflex and what it tests.

**Spinal accessory (CN XI)**
- Not on Exam 2.

**Hypoglossal (CN XII)**
- Be able to distinguish between UMN and LMN lesions associated with CN XII. Know that in either case, the tongue deviates to the side of the compromised CN XII (i.e., the left CN XII is compromised if its associated UMNs on the right are lesioned or if the left hypoglossal nucleus or CN XII is lesioned).

**Visual system**
- Be familiar with the basic anatomy of the eye. You won’t be tested on this, but it may help contextualize other aspects of the visual system.
- Know that the lens inverts the visual field 180° (left → right, superior → inferior). Understand what funduscropy can reveal and understand the etiologies and presentation of papilledema.
• Look over the steps of phototransduction, but don’t worry about this appearing on the exam (and in all likelihood, Step 1).
• Know that photoreceptors relay information to bipolar cells, which in turn relay information to retinal ganglion cells. Know that the axons of retinal ganglion cells comprise the fibers of the optic nerve.
• Look over mechanisms of retinal processing, but don’t worry about this appearing on the exam (and in all likelihood, Step 1). Understand that at the end of the day, retinal ganglion cells (and the visual system more broadly) are best at detecting contrasts (whether in light levels, color, shape, texture, topology, or position; contrasts in position=movement).
• Know how the visual field maps to the retinal fields in each eye (temporal vs. nasal hemiretinae). Understand the special role of the macula (and fovea).
• Be able to diagram the visual pathway between the retina and primary visual cortex. Know how left vs. right and superior information is segregated. Be very clear on what sort of visual deficits arise from lesions at different points along this pathway. Inversely, be able to predict the location of the lesion based on specific visual field deficits.
• Appreciate that on this exam and Step 1, macular sparing = infarcts of the primary visual cortex (cuneate or lingual gyri, full unilateral V1 lesions of a vascular nature).

Peripheral neuropathies
• Differentiate between mononeuropathy, mononeuropathy multiplex, and polyneuropathy. Know which major peripheral neuropathies typically fall into each class.
• Be able to distinguish between diabetic neuropathy, Guillain-Barré syndrome, Charcot-Marie-Tooth disease, and mechanical neuropathies (e.g., carpal tunnel syndrome, disc herniation, cauda equina syndrome) on the basis of etiology, presentation, and where applicable, epidemiology.
  o Appreciate that many of these display the characteristic “stocking and glove” distribution of sensorimotor deficits early on.
  o Appreciate that all may involve areflexia or hyporeflexia due to lesions of either or both the dorsal or ventral roots of spinal nerves.
  o Recognize that if the dorsal roots are lesioned at multiple levels in either or both legs, you could see a Romberg sign (loss of DCML-related info to the brain).
• Distinguish between myasthenia gravis and Lambert-Eaton myasthenic syndrome on the basis of etiology, mechanism at the NMJ, and presentation.
• Understand the basic utility in NCV and EMG testing, and be able to interpret at a very basic level the meanings of an abnormal or absent F-wave or H-reflex response.

Movement disorders
• Know how and where major motor disorders (e.g., ALS, MS, polio/spinal muscular atrophy, subacute combined degeneration, anterior spinal artery syndrome, syringomyelia, Brown-Séquard) occur along the CST. Be able to distinguish them based on their presentations, including on MRIs and sections of the spinal cord.
- Distinguish Parkinson’s from Huntington’s disease on the basis of which basal ganglia degenerate and the unique presentation of each. Be familiar with key words associated with each disease:
  - **Parkinson’s disease**: resting tremor, cogwheel or lead-pipe rigidity, bradykinesia, masked facies, festinating or shuffling gate, micrographia (small handwriting)
  - **Huntington’s disease**: writhing or purposeless limb movements (athetoid movements or athetosis), facial grimacing or tongue darting (choreiform movements or chorea), early dementia
- Be familiar with common signs of cerebellar damage, including ataxia (gait vs. limb), intention tremor, pendular reflexes, dysmetria, dysarthria (scanning speech), and hypotonia. **Know that cerebellar lesions result in ipsilateral signs.** Understand common causes of cerebellar dysfunction, particularly chronic alcoholism—know it lesions the superior vermis.