Objectives
1. Draw the course of the dorsal column pathway, spinothalamic pathway, spino cerebellar pathways, and corticospinal tract
2. Recognize which receptors are involved in each of the major ascending pathways
3. Recognize the difference between cortical areas 312 and 4
4. Discuss proprioception and its relationship to the Romberg sign
5. Understand the differences between an upper and lower motor neuron lesion
6. Define medial lemniscus, nucleus cuneatus, nucleus gracilis, internal arcuate fibers, VPL, and cerebellar peduncle
7. Appreciate the relationship between the locus ceruleus, raphe, substantia nigra, nucleus basalis, and their corresponding neurotransmitters
Dorsal Column Pathway  

DCP

Information relayed:

- 2 point discrimination (stereognosis)
- Vibration sense (with a tuning fork)
- Proprioception (position sense due to the conscious perception of muscle spindle and golgi tendon receptors)

GSA
DCP

Dorsal Column Pathway, Somatosensory Cortex—312

Central sulcus
Coronal section thru cortex showing basal ganglia and thalami

Lower medulla

Cervical spinal cord

DCP

First order axon from upper limb synapses in nucleus cuneatus

Vibration

2-point discrimination

Conscious proprioception

DCP

Second order axon begins in nucleus cuneatus, crosses the midline, travels in a fiber bundle known as the medial lemniscus, and finally synapses on neurons in the VPL

DCP
Third order axons synapse on the post central gyrus of the sensory cortex of the parietal lobe.

DCP

Area 312 of post central gyrus
VPL nucleus of thalamus
Nucleus cuneatus
Internal arcuate fibers to Medial lemniscus
Fasciculus cuneatus (dorsal columns)
2 point discrimination
Vibration
Proprioception

DCP

Location of key sensory or ascending tracts in the spinal cord
Romberg's sign is positive if the patient requires vision to stand steadily.

The patient is asked to stand with the feet together. If the patient is steady with eyes open but unsteady with eyes closed then there are signs of Rombergism.

Romberg's sign is said to be positive in patients with sensory ataxia and negative in cerebellar ataxia.

DAMAGE TO THE DCP
The Spinothalamic Tract

STT

Classic pain pathway

STT

Primary somatosensory cortex (SI)

FREE NERVE ENDINGS

nucleus proprius

"proper sensory nucleus"

Receive many sensory inputs

Contains many interneurons

Contains "tract cells" that project contralaterally as the spinothalamic tract

All cord levels
Brown- Seward Lesion

- Spinal cord level?
- Pathways transected?
- Symptoms?
Brown- Seuard Lesion

Spinal cord level?
Pathways transacted?
Symptoms?

- Proprioception lost on side of lesion
- Pain and temp lost on side opposite lesion
The Spinocerebellar Tracts
SCT
Unconscious proprioception

SCT
Spinocerebellar Tracts
Dorsal Spinocerebellar Tract (dsct)
Arises from Clark’s Nucleus (C8-L2)
Relays unconscious muscle stretch

Ventral Spinocerebellar Tract (vsct)
From dorsal horn and intermediate gray
Rexed (V-VII)
Relays info of spinal motor centers—
Reflexes, interneurons??

SCT
nucleus dorsalis
*Clark’s nucleus C8,L3
Homologous to the lateral (accessory) cuneate
nucleus in the medulla
Relays muscle spindle information
Projects ipsilaterally to the cerebellum as the
dorsal spinocerebellar tract
The ventral spinocerebellar tract samples interneuronal activity in the intermediate spinal gray. It represents the only afferent pathway in the mainly efferent superior cerebellar peduncle.

Clark’s nucleus only exists from C8—L2. Muscle afferents from below L3 use f. gracilis to reach Clark’s N. The lateral cuneate nucleus picks up the slack in the medulla. Muscle info from upper body reaches the lateral cuneate n. via f. cuneatus. Dorsal spinocerebellar tract relays muscle spindle and golgi tendon organ info to cerebellum via inf cerebellar ped. Ventral spinocerebellar tract relays spinal motor “interneuronal” info via superior cerebellar peduncle. It is double crossed.
Descending Systems:
A Quick Review of the Corticospinal Tract
CST
Objectives

1. Draw the course of the corticospinal pathway
2. Describe the difference between an upper motor neuron and a lower motor neuron
3. Recognize the difference between cortical areas 312 and 4
4. Discuss the cellular anatomy of the pyramidal cell
5. State the signs of a corticospinal lesion
Cst-cells of origin

Cst-cells of origin

Cst-cells of origin

Cst-cells of origin
**Babinski sign**: Rubbing the side of the foot or sole with a blunt object can result in 3 responses:

- **Flexor**: the toes curve inward and the foot everts; this is the response seen in healthy adults (aka a "negative" Babinski).
- **Indifferent**: there is no response.
- **Extensor**: the hallux dorsiflexes and the other toes fan out – the "positive Babinski's sign" indicating damage to the central nervous system – i.e., cat damage – "upper motor neuron".

- Cell injury can lead to spasticity.
- Lower motor neuron injury (anterior horn cell or total nerve lesion).
- Leads to flaccid paralysis.

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**CST**

**Ventral Horn**

Motor neurons (IX) innervate skeletal muscle, are large alpha motor neurons, and are termed **lower motor neurons** and "the final common pathway".

- The phrenic nucleus is found in cervical ventral horn (C3,4,5) keeps the diaphragm alive.
- The spinal accessory nucleus is found at C1-C5.

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**Somatotopy – med/lat divisions of ventral horn**
Pathology correlation

ALS—or polio

Pathology Correlation

ALS
Stroke (MCA)

Link to Utah quizzes

http://library.med.utah.edu/animations/hyperbrain/ pathways/index.html
http://library.med.utah.edu/animations/hyperbrain/ pathways/index.html
Interactive softchalk images of major spinal cord tracts and nuclei

http://www.stritch.luc.edu/lsan/MedEd/softchalk/neurospinaltracts/index.htm

Summary Slide:
DCP relays proprioception, 2 point discrimination, and vibration to 312. Second order neurons cross in the medulla—so—Lesions in the spinal cord produce ipsi deficits.
Lesion in 312 or brainstem above sensory decussation produce contra deficits.

STT relays pain to brain(312). It crosses in the spinal cord so lesions in cord produce contra effects. Unilateral lesions above the cord would also produce contra deficits.

CST starts in area 4, crosses in medullary pyramids, and synapses on anterior horn cells, resulting in fine movements. Lesion in cord produces ipsi deficits. Lesion or strokes above the pyramids produce contra effects.

Muscle spindles have intrafusal fibers, innervated by gamma fibers from the cord, and respond to muscle stretch. GTO's respond to isometric tension increase.
Pacinian corpuscles have capsules, are rapidly adapting, and respond to vibration.

Cerebellar deficits classically result in ipsilateral deficits.
The DSCT shoots up the inferior cerebellar peduncle.
The VSCT crosses in the cord, shoots up the superior cerebellar peduncle and crosses again—thus it is double crossed.

Review of Brainstem Anatomy
The Gross Brainstem

- Superior colliculus
- Inferior colliculus
- Medial cerebellar peduncle
- Superior cerebellar peduncle
- Inferior cerebellar peduncle

Superior peduncle
Cerebral peduncle
Olive
Pyramid
Basal pons

Mid-Sagittal View

- Medulla
- Pons
- Midbrain
- Cerebellum
- Tonsil
- 4th ventricle
- Aqueduct
- 3rd ventricle
- Septum
Caudal medulla (fused baby feet)

- Pyramids
- Internal arcuate fibers
- Nucleus gracilis
- Nucleus cuneatus
- Spinal tract and nucleus of V
- Medial lemniscus

Fibers in the spinal tract of V descend from the face, thru the semilunar ganglion, into the pons, and then down to the spinal cord to synapse with the spinal n. of V.

Rostral Medulla (the "open" medulla)

- Inferior cerebellar peduncle
- Inferior olivary nucleus
- Wide open 4th ventricle
- MLF-medial longitudinal fasciculus

Key Concepts:
- CST, STT
- ML
- IO
- MCP
- SCP
- SCP X's
- RN, SN

The corticospinal and spinohypothalamic tracts have considerable location in the medulla. The fasciculus cuneatus contains the inferior olivary nucleus and part of the fourth ventricle. The corticospinal tract is the spinal tract of the middle cerebellar peduncle. The inferior olivary nucleus receives input from the spinal tract and nucleus of V. The medial longitudinal fasciculus contains the medial lemniscus and substantia nigra.
Caudal Pons—pons is Latin for 'bridge'

Deep cerebellar nuclei, fast guys eat donuts, fastigal, globose, emboliform, dentate

Basal pons

Pontine gray nuclei

Ponto-cerebellar fibers (mosaic fibers)

Huge middle cerebellar peduncle

Rostral pons—cerebellum has gone bye-bye, 4th ventricle is closing

Note large basal pons

Medial lemniscus preparing to enter the thalamus “upside-down” (VPL)

STT entering VPL also

Beginning of PAG (peri aqueductal gray)—pain and autonomic functions

Anterior medullary velum

Also: observe the SCP (mostly efferent) preparing to cross (decussate) on its way to the red nucleus

Caudal Midbrain

Crossing of the SCP

Formation of a true aqueduct

Appearance of the inferior colliculus (pin nut)

It deals with auditory functions via the medial geniculate

Central projection (best of the conductor) replaces the basal pons. CST runs in center

Level of CN IV
Rostral Midbrain—"Mickey Mouse"

Red nucleus—end of SCP, beginning of PNST

Substantia Nigra—dopamine—

CN III

Big fat well defined CP's

Output to cerebrum is termed ARAS—ascending reticular activating system; important in sleep wake cycles.

The blue dot special (Locus Ceruleus) contains noradrenalin

Extensive CNS projections

May adjust background level of sensitivity
Neurons of the substantia nigra (black substance) and the Ventral Tegmental Area contain Dopamine.

Lesion SNc = Parkinson's disease
Lesion VTA = some form of mental illness

Neurons of the Raphe contain Serotonin

Like those of the LC these neurons project all over the place and may adjust levels of attention or arousal

Neurons of the Rostral Brainstem and Basal Forebrain Contain Acetylcholine

Meynert projects to widespread areas of the cerebrum
Septal nuclei project to hippocampus

2 key nuclei in the basal forebrain containing Ach are the basal nucleus of Meynert and the septal nuclei

Destruction of these cholinergic pathways may lead to Alzheimer's
A new monic or 2

Raphe works in a vineyard picking grapes—So:

- SE Raphe's Substantia Dosey blue NE's
- Raphe—Santarin
- Substantia Nigra—dopamine
- Locus ceruleus (blue)—noradrenalin

And,

Uncle Meynert has trouble remembering to move his cholinergics

- Basal nucleus of Meynert contains cholinergic (ach) containing neurons which, when damaged, may cause the memory destroying disease called Alzheimer's
MEMORIZE THE CRANIAL NERVE TABLE!!!!!!!!!