1) VERTEBRAE - NORMAL SPINAL CURVATURES: Primary = Concave Anterior - (fetal curvature); preserved in adult Thorax, Sacrum
Secondary = Concave Posterior (develop in childhood) - Cervical (support head), Lumbar (support body)

ABNORMAL CURVATURES - all can cause pain from compression of spinal nerves

<table>
<thead>
<tr>
<th>Curvature</th>
<th>Location (Most common)</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyphosis</td>
<td>Exaggerated Concave Anterior</td>
<td>Osteoporosis, etc. - loss of bone in bodies of vertebrae</td>
</tr>
<tr>
<td>Scoliosis</td>
<td>Exaggerated Lateral</td>
<td>Hemivertebra (half of vertebral body does not form in development), etc.</td>
</tr>
<tr>
<td>Lordosis</td>
<td>Exaggerate Concave Posterior</td>
<td>Obesity, etc.</td>
</tr>
</tbody>
</table>

SUMMARY OF LIGAMENTS OF VERTEBRAE AND DISC HERNIATION

<table>
<thead>
<tr>
<th>Ligament</th>
<th>Connects</th>
<th>Clinical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior Longitudinal Ligament</td>
<td>Anterior side of bodies of vertebrae</td>
<td>Broad band; Prevents disc herniation anteriorly</td>
</tr>
<tr>
<td>Posterior Longitudinal Ligament</td>
<td>Posterior side of bodies of vertebrae (inside canal)</td>
<td>Narrow band; (intervertebral discs herniate in postero-lateral direction, lateral to ligament)</td>
</tr>
<tr>
<td>Ligamenta Flava</td>
<td>Elastic layer connecting Laminae of vertebrae</td>
<td>Last layer penetrated by needle in Epidural anesthesia; (Note: Dura is last in Lumbar Puncture spinal tap)</td>
</tr>
<tr>
<td>Interspinous and Supraspinous ligaments</td>
<td>Spines of vertebrae</td>
<td>Thickened in neck to form Ligamentum nuchae (extends from Ext. Occipital Protuberance to C7)</td>
</tr>
</tbody>
</table>

Note: Herniation of Nucleus pulposus = ‘Slipped Disc’ - Nucleus pulposus bulges out through Annulus fibrosus; usually in a Postero-lateral direction (lateral to the Posterior Longitudinal Ligament); Most common at levels L4-L5 or L5-S1.
Note: Cervical Intervertebral Disc Herniation - Second most common region for disc herniation; Lower cervical disc herniation - Symptoms in Upper Extremity, if below C4 (Brachial Plexus C5-C8, T1)
### SUMMARY OF SOME FEATURES OF VERTEBRAE ON CT, LANDMARKS AND SOME CLINICAL SIGNS

<table>
<thead>
<tr>
<th>Vertebra</th>
<th>ID Features on CT</th>
<th>Clinical, Associated Structures on CT</th>
</tr>
</thead>
</table>
| Cervical    | Foramina Transversaria transmit Vertebral Artery (C1-C6)  
C1 = Atlas - no body  
C2 = Axis - dens  
C7 = Vertebra prominens (long palpable spine)  | 1) Damage to vertebral artery - brainstem symptoms  
2) Upper cervical fracture (C1 or dens of C2) - Quadriplegia;  
3) Disc Herniation in Lower Cervical Vertebrae - symptoms in upper extremity (Brachial plexus) |
| Thoracic    | Ribs abut bodies (head of rib), transverse processes (tubercle of rib)  | Landmark: Thoracic aorta anterolateral to bodies                                                      |
| Lumbar      | Large bodies; No surrounding bones  | Landmarks: Erector spinae posterior; Psoas major lateral; IVC and Abdominal aorta anterior to bodies   |

#### 2) GROSS ANATOMY OF SPINAL CORD AND SPINAL NERVES

<table>
<thead>
<tr>
<th>Syndrome/Procedure</th>
<th>Anatomy</th>
<th>Structures</th>
<th>Clinical, ID Features on CT</th>
</tr>
</thead>
</table>
| Spinal Nerve Compression | Convention: Cervical spinal nerves C1-C7 exit Above corresponding vertebrae; C8 and All other spinal nerves exit Below vertebrae | Dermatomes - area of distribution of single nerve root to skin;  
[V1 - Face (above eyes *)  
V2 - Face (below eyes*)  
V3- Face (below mouth)*]  
C5 - Shoulder  
C6 - Thumb  
C8 - Little finger  
T1 - Armpit  
T4 - Nipple  
T7 - Xiphoid  
T10 - Umbilicus  
L1 - Inguinal lig.  
L4 - Big toe  
S1 - Little toe  
[^ Note: V - also Oral, Nasal Cav., Cranial Dura Mater - headache]  | Symptoms of compression of nerve root - Paresthesia, pain, sensory loss, hyporeflexia, muscle weakness |
| Lumbar Puncture | Inferior end of Spinal Cord = Conus medullaris | Conus medullaris at  
1. In Newborn, vertebral level L3  
2. In Adult, conus at vertebral level L1  | Lumbar Puncture done below Conus Medullaris (region of Cauda Equina); Level:  
1. Children - L4-L5  
2. Adult - L3-L4 or L4-L5 |
| Metastasis to Vertebral Column | Epidural Space (outside Dura) - Dura is separated from inner side of vertebral canal; Note: in Skull, there is no epidural space | Internal Vertebral Venous plexus - inside vertebral canal in Epidural Space; drains to External Venous plexus (outside vertebrae) by Radicular and Intervertebral veins | Disease processes (ex. cancer) can spread to vertebrae and spinal cord via anastomoses of Vertebral venous plexus and intervertebral veins with Lumbar veins (ex. carcinoma of prostate can metastasize to vertebral column) |

Note: overlap of dermatomes in region of trunk: sensory loss in trunk only with Two Thoracic spinal roots
LAYERS PENETRATED IN EPIDURAL ANESTHESIA/LUMBAR PUNCTURE (superficial to deep)

5. Ligamentum Flavum (sudden yield, first ‘pop’) - now inside vertebral canal in Epidural space
6. Epidural Space - STOP HERE FOR EPIDURAL ANESTHESIA
7. Dura Mater (sudden yield, second ‘pop’)
(8. Arachnoid - adherent to inner side of dura mater)
9. Subarachnoid Space (Lumbar Cistern) - STOP HERE FOR LUMBAR PUNCTURE/SAMPLE CSF

3) SPINAL REFLEXES AND DIAGNOSIS OF UPPER AND LOWER MOTOR NEURON LESIONS

<table>
<thead>
<tr>
<th>REFLEX</th>
<th>STIMULUS/SENSE ORGAN(S) EXCITED</th>
<th>RESPONSE</th>
<th>CLINICAL/ABNORMAL RESPONSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretch</td>
<td>Rapid Stretch of muscle (test: tap on muscle tendon) Excites Muscle Spindle Primary (Ia) and Secondary (II) sensory neurons (NOT Golgi Tendon Organ)</td>
<td>Stretched muscle contracts rapidly (monosynaptic connection); also excite synergist and inhibit antagonist Note: Gamma motor neurons can enhance stretch reflexes (Gamma dynamic motor neurons specifically enhance Ia sensitivity; tell patient to relax before test)</td>
<td>Hyporeflexia - decrease in stretch reflexes occurs in Lower Motoneuron Diseases, Muscle atrophy etc. Hyperreflexia - (increase) - characteristic of Upper Motor Neuron lesions (ex. spinal cord injury, damage Corticospinal tract); note: Clonus = hyperreflexia with repetitive contractions to single stimulus</td>
</tr>
<tr>
<td>Autogenic Inhibition</td>
<td>Large force on tendon excites Golgi Tendon Organ lb (test: pull on muscle when resisted)</td>
<td>Muscle tension decreases; Also inhibit synergist muscles; excite antagonist muscles</td>
<td>Clasped Knife Reflex - occurs in Upper Motor Neuron lesions - forceful stretch of muscle is first resisted then collapses</td>
</tr>
<tr>
<td>Flexor Reflex</td>
<td>Sharp, painful stimulus, as in stepping on nail; Excites - Cutaneous and pain receptors</td>
<td>Limb is rapidly withdrawn from stimulus; protective reflex; also inhibit extensors of same limb and excite extensors of opposite limb (Crossed Extensor Reflex)</td>
<td>Babinski sign, toes extend (dorsiflex) to cutaneous stimulus of sole of foot (normally plantar flex); characteristic of Upper Motor Neuron lesion</td>
</tr>
</tbody>
</table>

LOWER AND UPPER MOTOR NEURON LESIONS

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Structure Affected</th>
<th>Symptoms</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Motor Neuron Lesion</td>
<td>Lower Motor Neurons = Alpha Motor neurons with axons that innervate skeletal muscles</td>
<td>Muscle is effectively denervated: 1) Decrease Stretch (Deep Tendon) Reflexes 2) Decreased Muscle Tone 3) Muscle atrophy; Fasciculations (twitches) precede atrophy 4) No Babinski sign</td>
<td>1) Compression of spinal nerve 2) Poliomyelitis - viral infections affecting motor neurons</td>
</tr>
<tr>
<td>Flaccid Paralysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Motor Neuron Lesion</td>
<td>Upper Motor Neurons = All descending neurons that affect Lower Motor Neurons (ex. Corticospinal, Reticulospinal neurons)</td>
<td>Disrupt voluntary control and regulation of reflexes (remove inhibition): 1) Increase Stretch (Deep Tendon) Reflexes 2) Increased Muscle Tone 3) No Fasciculations 4) Babinski sign 5) Clasped Knife Reflex</td>
<td>1) Damage to Corticospinal (corticobulbar) tracts - can occur at all levels from cortex to spinal cord (including brainstem)</td>
</tr>
<tr>
<td>Spastic Paralysis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Some diseases produce both Upper and Lower Motor Neuron Symptoms - (ex. ALS Amyotrophic Lateral Sclerosis)
1- ____ A 28-year-old-women presented to the hospital emergency room with intense lower back spasms in the context of coughing during an upper respiratory infection. Review of her medical records showed that she had experienced progressive lower back problems for the preceding 6 years. She had gained 15 pounds during that period but was not morbidly obese. MRI scan of the vertebral column (image above) showed an exaggerated anterior-posterior curvature. Based upon this image, the radiologist would diagnose this as which of the following conditions?

A. Scoliosis in vertebrae L3-S1
B. Kyphosis in vertebrae T12-L3
C. Increased lordosis in vertebrae L3-S1
D. Increased lordosis in vertebrae T12-L1
E. Scoliosis in vertebrae T12-L3
A 70 year old female with no health insurance was seen at a community based clinic. She complained of stooping of her posture (photo left above). She stated that the condition had been developing over a number of years. However, the deformity had increased to the point that she had difficulty holding her neck upright. She had also begun experiencing chronic back pain. The image (above right) is a lateral view xray of the thoracic spine. Which of the following would be a diagnosis of this condition?

A. Congenital scoliosis
B. Degenerative kyphosis associated with osteoporosis
C. Post-traumatic fracture of bodies of thoracic vertebrae
D. Scoliosis due to the presence of a hemivertebra
E. Degenerative lordosis of thoracic vertebrae
3. A 45 year old man was helping a friend move a piano when he experienced sudden lower back pain. Physical examination showed weakness in dorsiflexion of the foot. The MRI image of the lumbosacral spine (above) shows a structure pressing against the cauda equina. The herniated structure would be immediately adjacent to which of the following spinal ligaments?

A. Anterior longitudinal ligament  
B. Ligamenta flava  
C. Interspinous ligament  
D. Posterior longitudinal ligament  
E. Supraspinous ligament
4. A 2.2 kg girl was born at 34 weeks and showed severe respiratory distress. The neonate had a malformed thorax that limited normal respiration. The skeleton was imaged by CT and showed multiple abnormalities. 3D reconstruction (shown above) of the spine showed a distinct discontinuity in the vertebrae (arrow). Which of the following describes this discontinuity?

A. Lordosis due to the presence of a 'hemivertebra'
B. Scoliosis due to the presence of a 'hemivertebra'
C. Congenital Kyphosis
D. Exaggerated primary curvature
E. Exaggerated secondary curvature in the lumbar region
5. A 25-year-old rugby player injured his neck while tackling another player. He felt numbness over the region of the thumb on the palmar surface that persisted for several days. Physical examination by his physician showed weakness in the biceps muscle. These symptoms could result in herniation of an intervertebral disc located between vertebrae at which of the following levels?

A. C3-C4  
B. C4-C5  
C. C5-C6  
D. C6-C7  
E. C7-T1

6. A newborn baby born at 37 weeks is noted to be unwell, feeding poorly and is jittery, with a temperature of 38°C. A clinical diagnosis of early sepsis is made and a lumbar puncture to sample cerebrospinal fluid (CSF) is suggested on the ward round as a part of sepsis evaluation. To perform the procedure of lumbar puncture (spinal tap) safely in a newborn, the needle must be inserted between which of the following vertebrae?

A. T12-L1  
B. L1-L2  
C. L2-L3  
D. L3-L4  
E. L4-L5

7. A 24-year-old patient is seen for a routine neurological exam. The patient is a medical student who has been studying intensely for Step 1 board (or Final) examinations. Testing of patellar tendon reflexes (deep tendon reflex) shows bilateral, mild hyperreflexia (scored 3). The physician suspects that this is not pathological but due to increased activation of Gamma motor neurons associated with nervousness and anxiety. Which of the following is an action of Gamma motor neurons that could produce the mild hyperreflexia?

A. Increase sensitivity of Golgi tendon organs  
B. Increase sensitivity of Ia fibers in muscle spindles  
C. Directly produce contraction of all muscle cells  
D. Increase sensitivity of free nerve endings in muscles  
E. Produce relaxation of muscle cells in muscle spindles
8. Both Lower motor neuron and Upper motor neuron lesions can cause muscle paralysis. Differential diagnosis is often complex and based upon a number of tests. Which of the following is a characteristic of Lower motor neuron lesions which does not occur in Upper motor neuron lesions?

A. Hyperreflexia  
B. Fasciculations  
C. Increased muscle tonus  
D. Clasped knife reflexes  
E. Babinski sign

9. A patient who was treated for advanced carcinoma of the prostate begins to experience back pain. An MRI image of a lateral view of the vertebral column is shown above. Which of the following could serve as an anatomical pathway by which metastasis could have spread to the structures indicated by the arrow?

A. External Iliac vein  
B. Renal vein  
C. Testicular vein  
D. Lumbar veins  
E. Deep Femoral vein
10. ____ A first year resident in OBGYN, who has been on call for 18 hours, is asked to administer an epidural anesthetic to a patient prior to delivery. As the needle is being inserted, the resident struggles to remember the anatomy of the vertebral column to know when to stop and administer the anesthetic. Which of the following is the last structure the needle should pass through in administering an epidural anesthetic?

A. Anterior Longitudinal Ligament  
B. Posterior Longitudinal Ligament  
C. Supraspinous Ligament  
D. Ligamentum flavum  
E. Nuchal Ligament

11. ____ A patient experiences intermittent numbness of the big toe. The physician suspects that the cause may be due to osteophyte formation at an intervertebral foramen. At which of the following levels would foraminal encroachment by osteophyte formation produce numbness of the big toe?

A. Intervertebral foramen at L1-L2  
B. Intervertebral foramen at L2-L3  
C. Intervertebral foramen at L3-L4  
D. Intervertebral foramen at L4-L5  
E. Intervertebral foramen at T12-L1
Key to Questions on Vertebrae, Spinal Cord, Spinal Nerves

1. C
2. B
3. D
4. B
5. C
6. E
7. B
8. B
9. D
10. D
11. D
REVIEW GROSS ANATOMY OF VERTEBRAE, SPINAL CORD AND SPINAL REFLEXES

1) Vertebrae
   - Spinal Curvatures - normal and abnormal
   - Vertebral Ligaments
   - Herniation of Intervertebral Discs
   - Regional Specializations/Landmarks of Vertebrae on CT

2) Spinal nerves
   - NerveCompression and Dermatome map
   - Epidural Anesthesia and Lumbar Puncture (CSF)
   - Spread of Disease to Vertebrae via Venous System

3) Spinal reflexes
   - diagnosis of Upper and Lower Motor Neuron lesions
1) VERTEBRAE - NORMAL PRIMARY SPINAL CURVATURE

- **Cervical** (C1-C7)
- **Thoracic** (T1-T12)
- **Lumbar** (L1-L5)
- **Sacral** (S1-S5 fused)
- **Coccygeal** (Co1-3 to 5) variable, fused

**Primary Curvature** = Concave Anterior - fetal curvature

Primary Curvature retained in Adult Thorax, Sacrum

NOSE IS ANTERIOR

Thoracic Curvature

Sacral Curvature

Primary Curvature
NORMAL SECONDARY CURVATURES - Develop in early childhood

Cervical curvature - concave posteriorly - helps support head

Lumbar curvature - concave posteriorly - develops with walking - helps support trunk, upper body
Lumbar Curvature - prominent in Sagittal view

Spine of L4

Sacrum - fused, no intervertebral discs

Body of L2

L3-L4 Intervertebral disc

T2 weighted MRI image FLUID (CSF) BRIGHT
ABNORMAL CURVATURES

KYPHOSIS

- 'hump' back -
- EXAGGERATED curvature
- CONCAVE ANTERIORLY IN
  THORAX in elderly - cause
  Osteoporosis, etc.

SCOLIOSIS

- LATERAL
- CURVATURE - can be due to 'presence of
  hemivertebra' - one half of a vertebra fails to develop

LORDOSIS

- EXAGGERATED
- POSTERIOR CURVATURE -
- LUMBAR - cause obesity, etc.; (normal in pregnancy)
LIGAMENTS OF VERTEBRAE

- BODY
- VERTEBRAL CANAL
- PEDICLE
- LAMINA
- SPINE
- INTERVERTEBRAL DISC

POSTERIOR LONGITUDINAL LIGAMENT - posterior to bodies (in canal)

ANTEOR LONGITUDINAL LIGAMENT - anterior to bodies

LIGAMENTA FLAVA - connect laminae

SUPRASPINOUS LIG. - connect spines

INTERSPINOUS LIG. - connect spines
Herniation typically occurs in a Postero-Lateral Direction:
Post. Longitudinal Ligament is narrow, Ant. Longitudinal Ligament is broad; can produce nerve compression at intervertebral foramen.
FEATURES OF CERVICAL VERTEBRA ON CT

Body is small, Vertebral canal is large

FORAMEN TRANSVERSARIUM TRANSMITS VERTEBRAL ARTERY

Damage to Cervical Vertebrae (ex. car accident) can damage Vertebral artery - neurological symptoms of brainstem lesion
HERNIATION OF LOWER CERVICAL DISCS CAN PRODUCE SYMPTOMS IN UPPER EXTREMITY.

UPPER CERVICAL FRACTURE (C1 or C2) - QUADRIPEgia: bilateral sensory loss in extremities.
LANDMARKS, FEATURES OF THORACIC VERTEBRA ON CT

ID: Ribs abut bodies (head of rib), transverse processes (tubercle of rib);

Landmark: Thoracic aorta anterolateral to bodies - extends down from arch of Aorta (located at Sternal Angle - T45 intervertebral disc)
FEATURES OF LUMBAR VERTEBRA ON CT

Landmarks:
- Erector spinae posterior
- Psoas major anterior
- IVC and Abdominal Aorta anterior to body

ID: Large bodies; No surrounding bones
2) GROSS ANATOMY OF SPINAL CORD AND SPINAL NERVES

VERTEBRAE

Cervical (C1-C7)

Thoracic (T1-T12)

Lumbar (L1-L5)

Sacral (S1-S5 fused)

Coccygeal (Co1-3(5))

fused

SPINAL NERVES

Cervical (C1-C8)

Thoracic (T1-T12)

Lumbar (L1-L5)

Sacral (S1-S5)

Coccygeal (Co1)

CONVENTION FOR NAMING LEVELS:

C1 - C7: above vertebra
C8 - all others: below vertebra

Spinal nerves C1-C7 above vertebra
C8 and all others below vertebra
SPINAL NERVE COMPRESSION - SENSORY LOSS - DERMATOME MAP

Clinical: Symptoms of compression of spinal root - Paresthesia (ex. tingling), pain, sensory loss, hyporeflexia, muscle weakness
Note: Overlap of dermatomes in region of trunk: sensory loss in trunk only with compression of two Thoracic spinal roots.
Questions: What is the level of a herniated disc that would produce numbness of Thumb? Little finger? Big Toe?

Answers: Thumb, Disc C5-C6 above vertebra C6; Little Finger, Disc C7-T1 below vertebra C7; Big Toe, Disc L4-L5 below vertebra L4

Recall: C1 - C7: above vertebra; C8 - all others: below vertebra
**CONUS MEDULLARIS**

Conus medullaris -
1. Newborn, Conus medullaris is located at vertebral level L3
2. Adult, Conus Medullaris is located at vertebral level L1

**LUMBAR PUNCTURE - BELOW LEVEL OF CONUS MEDULLARIS**

Superior to Conus Medullaris

**CSF**

Level of Lumbar Puncture

Adult -
between L3-L4 or L4-L5

**CSF**

Children -
MUST be done at L4-L5

**ROOTS OF CAUDA EQUINA**

**CONUS MEDULLARIS**

= INFERIOR END OF SPINAL CORD

**Level of Lumbar Puncture**

**ROOTS OF CAUDA EQUINA**
Spinal cord

Body of L2

Conus medullaris

Cauda equina

CSF in lumbar cistern

CONUS MEDULLARIS

CM

DORSAL ROOT GANGLION

DRG

CAUDA EQUINA

CE

FILUM TERMINALE - EXTENSION OF PIA MATER)

FT

MRI

Spinal cord

Conus medullaris

Body of L2

Cauda equina

CSF in lumbar cistern
SEQUENCE OF STRUCTURES PENETRATED IN EPIDURAL ANESTHESIA, LUMBAR PUNCTURE

5. Ligamentum Flavum (sudden yield, first 'pop') - now inside vertebral canal
6. Epidural space - STOP HERE FOR EPIDURAL ANESTHESIA
7. Dura mater (sudden yield, second 'pop')
8. Arachnoid - adherent to inner side of dura mater
9. Subarachnoid space (Lumbar cistern) - STOP HERE FOR LUMBAR PUNCTURE/SAMPLE CSF
ARTERIES AND VEINS OF SPINAL CORD

Anterior spinal artery - branch of Vertebral A.

Posterior spinal arteries

Radicular arteries

Anterior and Posterior spinal veins

Internal Vertebral Venous Plexus - in Epidural space

Intervertebral veins

DURA
Note: Disease processes can spread to spinal cord and vertebra from other regions of body by Vertebral venous plexus and intervertebral veins (ex. carcinoma of prostate (in pelvis) can metastasize to vertebral column).
3) SPINAL REFLEXES AND DIAGNOSIS OF UPPER AND LOWER MOTOR NEURON LESIONS

DEFINITION OF A REFLEX - SENSORY STIMULUS PRODUCES STEREOTYPED MOTOR RESPONSE

For reflex to occur all elements must be functional; pathways must be intact.
STRETCH (DEEP TENDON) REFLEX : MONOSYNAPTIC CONNECTION

SENSORY STIMULUS

Two methods:
1) Rapidly Stretch muscle (change muscle length)

2) TAP ON MUSCLE TENDON

MOTOR RESPONSE

Stretched muscle contracts rapidly

Activate - Muscle spindle (Group Ia and II); monosynaptically excite Alpha (Lower) motor neuron to same muscle.

Excites Lower (Alpha) motor neuron in Ventral Horn

Note: Response large because also excite motor neurons to muscles with similar action and inhibit muscles with opposite action
MUSCLE TONUS = resting tension in muscle

Tonus reflects firing of alpha motor neurons at rest

TONUS - Tested by physician slowly extending or flexing joints (stretching patient’s muscle)

Activity in muscle spindles at rest is important in determining Tonus because connection is monosynaptic

REFLEXES CHANGED BY GAMMA MOTOR NEURONS - GET PATIENT TO RELAX BEFORE TESTING TONUS OR STRETCH REFLEX

Gamma motor neurons innervate muscle cells in muscle spindles; Gamma motor neurons can heighten stretch reflexes (Gamma dynamic motor neurons specifically effect Ia sensory neurons)

GAMMA MOTOR NEURONS - innervate muscle cells in muscle spindles

ALPHA MOTOR NEURONS - innervate regular skeletal muscle cells
Upper motor neurons can modulate (change) reflexes by:
1) Changing excitability of alpha motor neurons
2) Pre-synaptic Inhibition of Ia terminals; reduces the amount of transmitter release at the synapse upon motor neuron
LOWER MOTOR NEURON DISORDERS

1) Decreased stretch (tendon) reflexes - no activation of muscle
2) Decreased tonus - no tonic alpha motor neuron activity
3) Muscle atrophy - Fasciculations (twitches) precede atrophy - Alpha motor neurons fire spontaneously
4) No Babinski sign - no effect descending control

Flaccid Paralysis - muscle is effectively denervated (can affect single muscles)

Examples:
1) Compression of spinal nerve
2) Poliomyelitis - viral infections affecting motor neurons

UPPER MOTOR NEURONS - descending systems
UPPER MOTOR NEURON DISORDERS

1) Increased stretch (tendon) reflexes - No modulation, remove inhibition of reflex pathways
2) Increased tone - Remove inhibition of reflex pathways
3) No Fasciculations
4) Babinski sign - effect descending control of Flexor reflex
5) Clasped Knife Reflex - high forces activate Golgi tendon organs

Example: Damage to Corticospinal (Corticobulbar) tracts - can occur at all levels from cortex to spinal cord (brainstem)

Spastic Paralysis - affect groups of muscles
1) Increased stretch (tendon) reflexes - No modulation, remove inhibition of reflex pathways
2) Increased tone - Remove inhibition of reflex pathways
3) No Fasciculations
4) Babinski sign - effect descending control of Flexor reflex
5) Clasped Knife Reflex - high forces activate Golgi tendon organs
HYPERREFLEXIA: INCREASED STRETCH REFLEX ON ONE SIDE  [used by permission of Paul D. Larsen, M.D., University of Nebraska Medical Center; http://library.med.utah.edu/neurologicexam]
CLASP-KNIFE PHENOMENON: FORCE ACTIVATES GOLGI TENDON ORGAN

GOLGI TENDON ORGANS SIGNAL MUSCLE FORCE - when force is high, activate Golgi Tendon Organ reflexes (Autogenic inhibition); inhibits alpha motor neurons, DECREASE FORCE

GOLGI TENDON ORGAN (GTO)

SENSORY STIMULUS: FORCE ON MUSCLE TENDON

MOTOR RESPONSE: FORCE DECREASES

Physician applies, gradual forceful stretch of muscle: resistance to stretch builds until it suddenly gives way.
**FLEXOR REFLEX**

**SENSORY STIMULUS** - painful, irritating stimulus to skin

- Cutaneous afferent synapse onto Interneurons

- Interneurons make excitatory synapse onto Flexor motor neurons

- Note: Also excite extensor motor neurons in opposite leg (not fall down)

**MOTOR RESPONSE**

- Lift leg
- Extend opposite leg
- Step on nail
Babinski sign - seen after Upper Motor neuron lesion - direction of movement changes from flexing toes to extending and fanning (abducting) toes.
REFLEXES IN NEONATES: INFANT STEPPING PRODUCED BY PATTERN GENERATORS IN SPINAL CORD

REFLEXES IN NEONATES

PALMAR GRASP

MORO REFLEX - arm extend

STEPPING 'REFLEX' - actually eliciting a motor pattern

Infant Stepping - 'reflexes' are used to check motor function in neonates; holding infant with weight supported can elicit 'stepping' movements in legs

PATTERN GENERATOR - group of interneurons in CNS that are interconnected; produce activities in motor neurons and can generate rhythmic behaviors.

Stepping reflexes probably represents activation of Central Pattern Generator that produces walking movements
GOOD LUCK!