Nervous System Module

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Motor Tracts

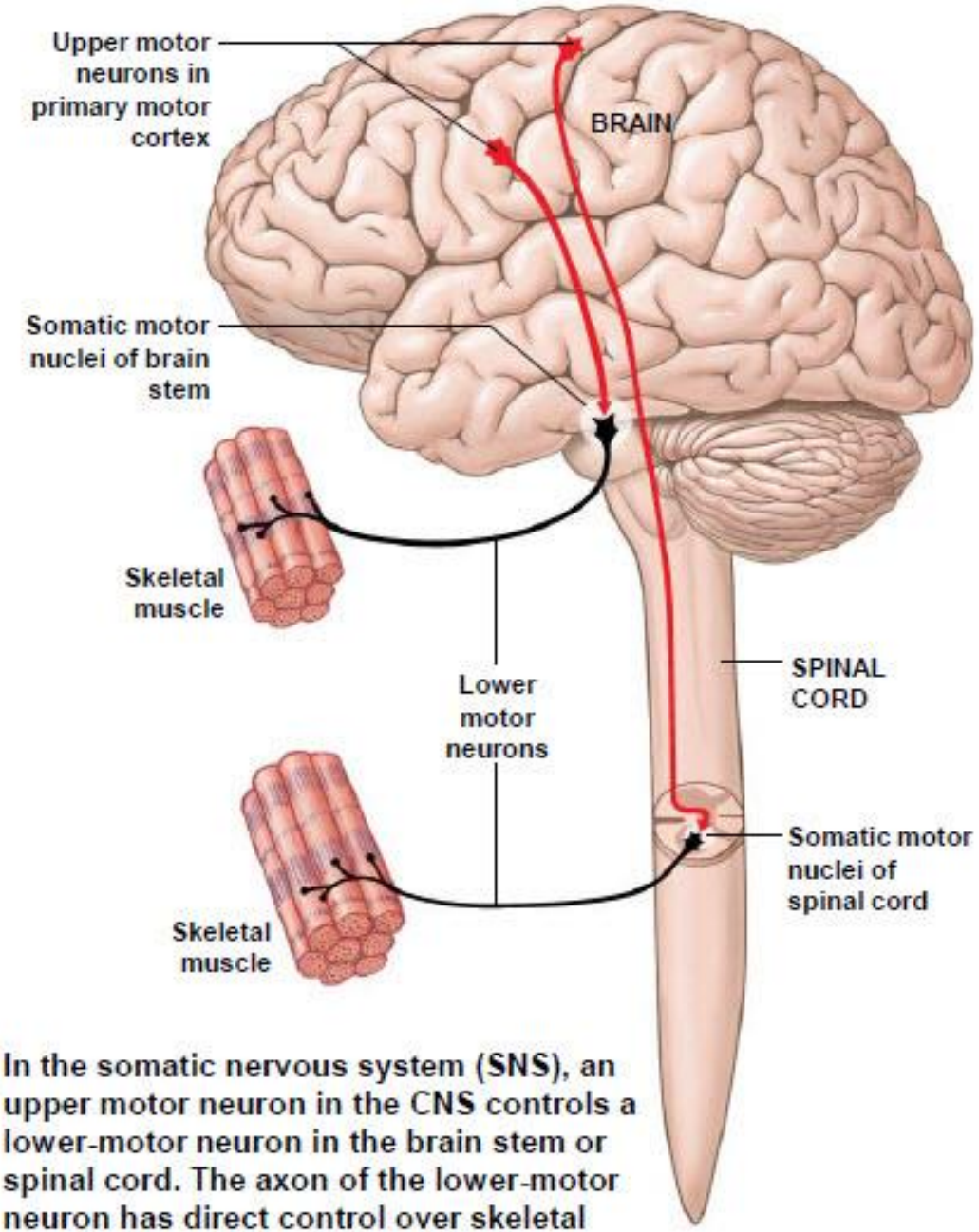
Motor Pathways

- Descending pathways in the brain and spinal cord that control the activities of skeletal muscle.

- Regulate the activities of skeletal muscle.

Motor tracts

- **CNS transmits motor commands in response to sensory information**
- Motor commands are delivered by the:
- ***Somatic nervous system*** (**SNS**): directs contraction of skeletal muscles
- ***Autonomic nervous system*** (**ANS**): directs the activity of glands, smooth muscles, and cardiac muscle



a In the somatic nervous system (SNS), an upper motor neuron in the CNS controls a lower-motor neuron in the brain stem or spinal cord. The axon of the lower-motor neuron has direct control over skeletal muscle fibers. Stimulation of the lower-motor neuron always has an excitatory effect on the skeletal muscle fibers.

Motor Tracts

- ***There are two major descending tracts***
- ***Pyramidal/Corticospinal tract:*** Conscious control of skeletal muscles
- ***Extrapyramidal/ Subconscious tract:*** Subconscious regulation of balance, muscle tone, eye, hand, and upper limb position (*i.e. subconscious integrative coordination of muscular activity*)

Motor Tracts

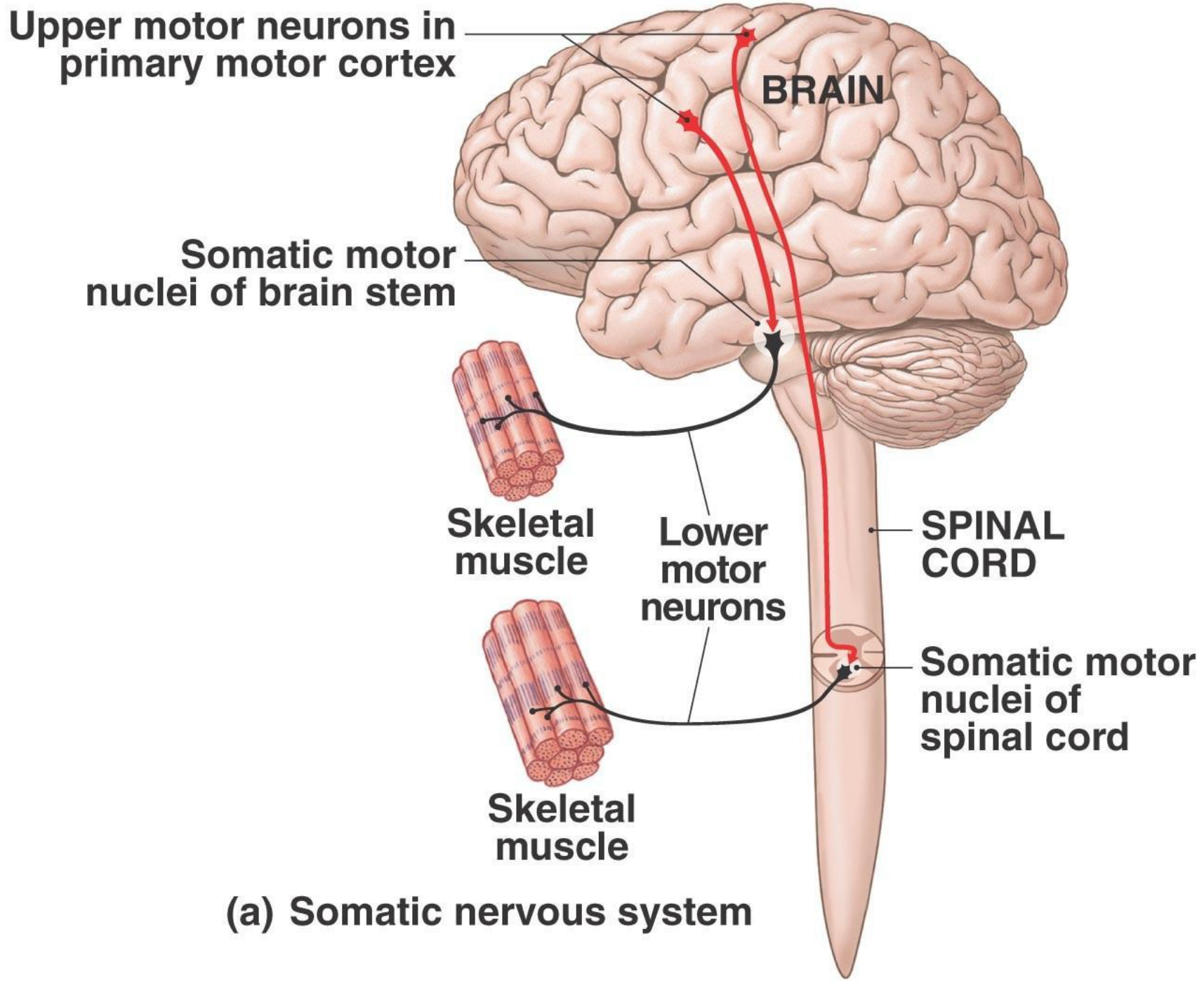
Upper Motor Neurons

Are entirely within the CNS. Originates in: Cerebral cortex – Brainstem forming the **descending tracts** regulating the LMN activity

Lower Motor Neurons

Begins in CNS: From *anterior horns of spinal cord* and from brainstem *cranial nerve nuclei.*

Makes up **spinal and cranial nerves** that innervate skeletal muscles



Motor Tracts

- **The Pyramidal Tract (*conscious tracts*),** three pairs of descending tracts ending directly on lower motor neurons in the brainstem or spinal cord.

1. ***Corticobulbar (nuclear) tracts:*** conscious control over eye, jaw, and face muscles (**Cranial Nerves**)

2. ***Anterior and Lateral corticospinal tracts:*** conscious control over skeletal muscles of trunk and limbs

Motor Tracts

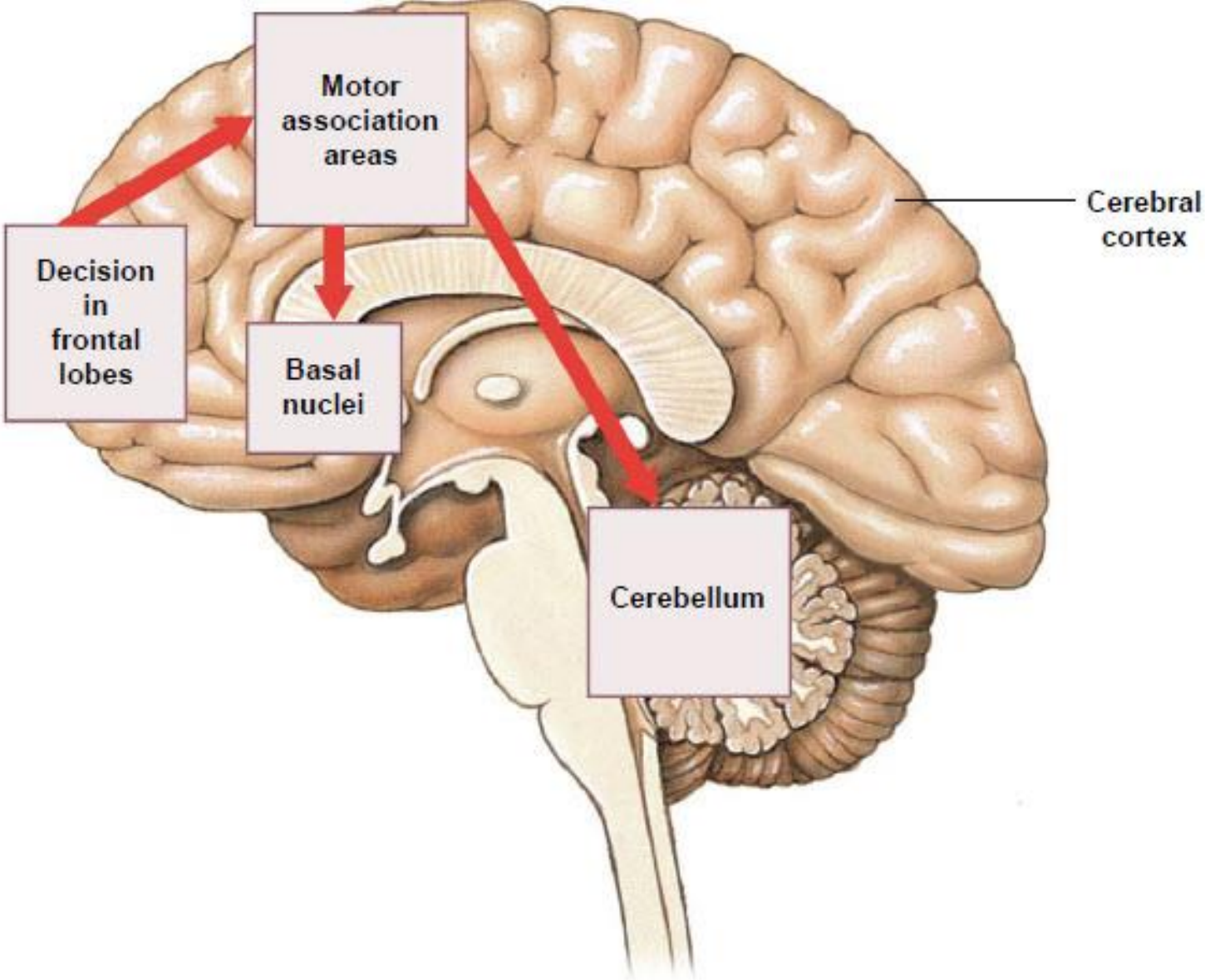
- ***The Subconscious Motor Tracts***

- Consists of four tracts involved in monitoring the subconscious motor control

1. **Vestibulospinal tracts**
2. **Tectospinal tracts**
3. **Reticulospinal tracts**
4. **Rubrospinal tracts**

Execution

- Cerebral cortex initiates voluntary movement.
- Information goes to the **basal nuclei** and **cerebellum**
- These structures modify and coordinate the movements, so they are performed in a smooth manner
- Information goes from the basal nuclei and cerebellum back to the cerebral cortex to constantly monitor position and muscle tone



b The planning stage: When a conscious decision is made to perform a specific movement, information is relayed from the frontal lobes to motor association areas. These areas in turn relay the information to the cerebellum and basal nuclei.

Motor Pathways

Origin of Motor Signal

- The corticospinal tracts begin in the cerebral cortex, from which they receive a range of inputs:

1. **Primary motor cortex (area 4)**
2. **Premotor cortex (area 6)**
3. **Supplementary motor area**

- They also receive nerve fibers from the **somatosensory area**, which play a role in regulating the activity of the ascending tracts.

Pyramidal and Extrapyramidal Systems

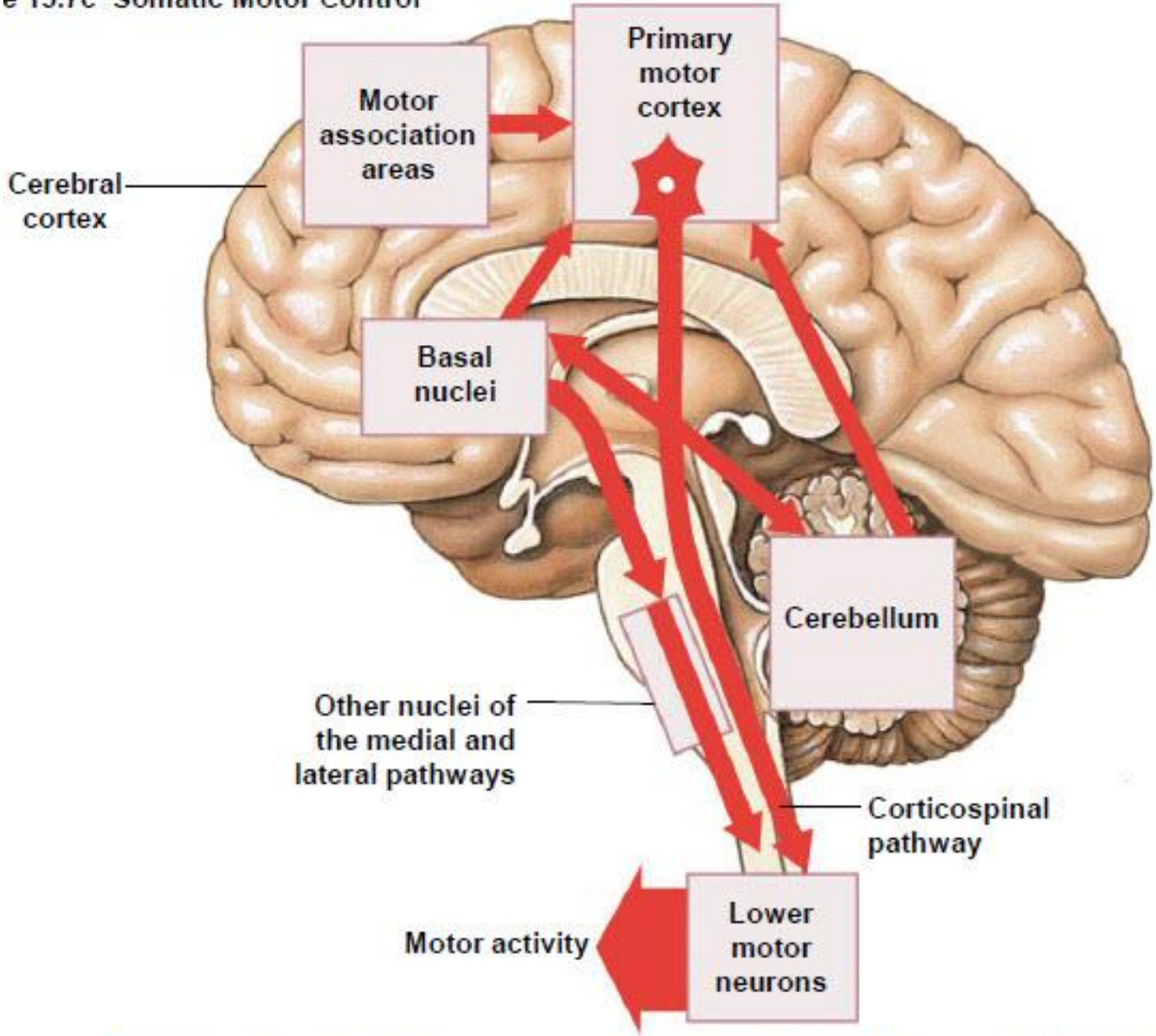
- Pyramidal and extrapyramidal systems can only be separated anatomically but not functionally!

- None of the two systems can work properly alone, they constitute one motor system together!!!

Pyramidal and Extrapyramidal Systems

- Pyramidal system is the chief organizer and executor of voluntary movements.

- Extrapyramidal system includes all the motor centres and pathways that lie outside the pyramidal system and are beyond voluntary control.

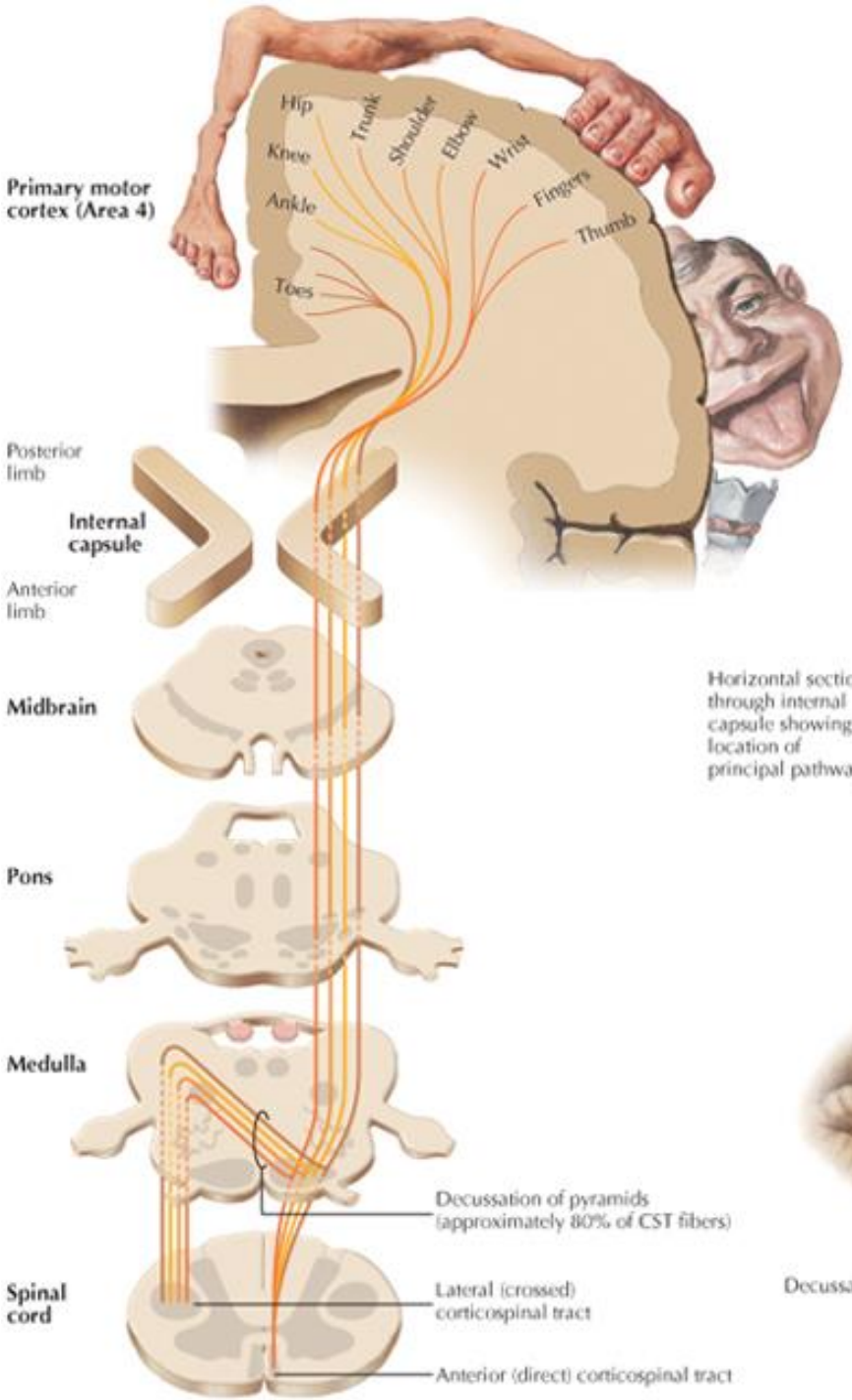


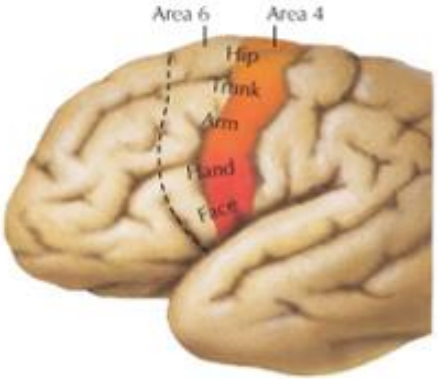
c Movement: As the movement begins, the motor association areas send instructions to the primary motor cortex. Feedback from the basal nuclei and cerebellum modifies those commands, and output along the conscious and subconscious pathways directs involuntary adjustments in position and muscle tone.

Pyramidal Tract

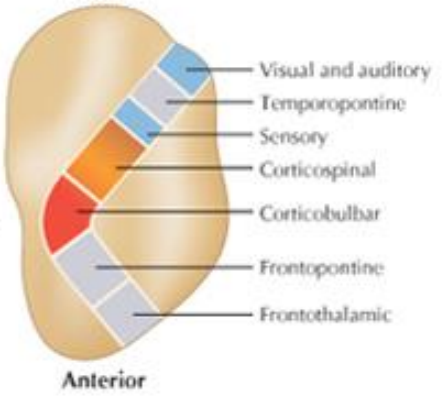
- Starts in upper motor neurons in cerebral motor cortex (approx. 1 million in number)
- Axons form internal capsule in cerebrum and pyramids in the medulla oblongata
- Descending axons of upper motor neurons that terminate in the motor nuclei of cranial nerves and in the spinal cord constitute the **corticonuclear and corticospinal tracts**, respectively.

CORTICOSPINAL TRACT

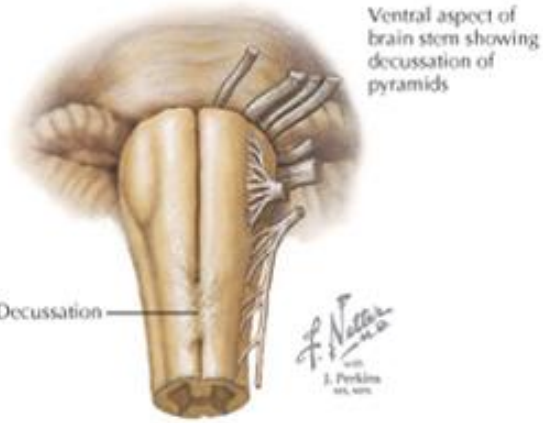




Lateral aspect of cerebral cortex showing topographic localization of motor centers on precentral gyrus and premotor and supplemental motor cortex



Horizontal section through internal capsule showing location of principal pathways



Ventral aspect of brain stem showing decussation of pyramids

Pyramidal Tract

- The ***corticonuclear*** tract reaches the lower motor neurons of both sides (***bilateral innervation***)

- While ***corticospinal*** fibres target the lower motor neurons of the ***opposite side only*** (crossed pathway).

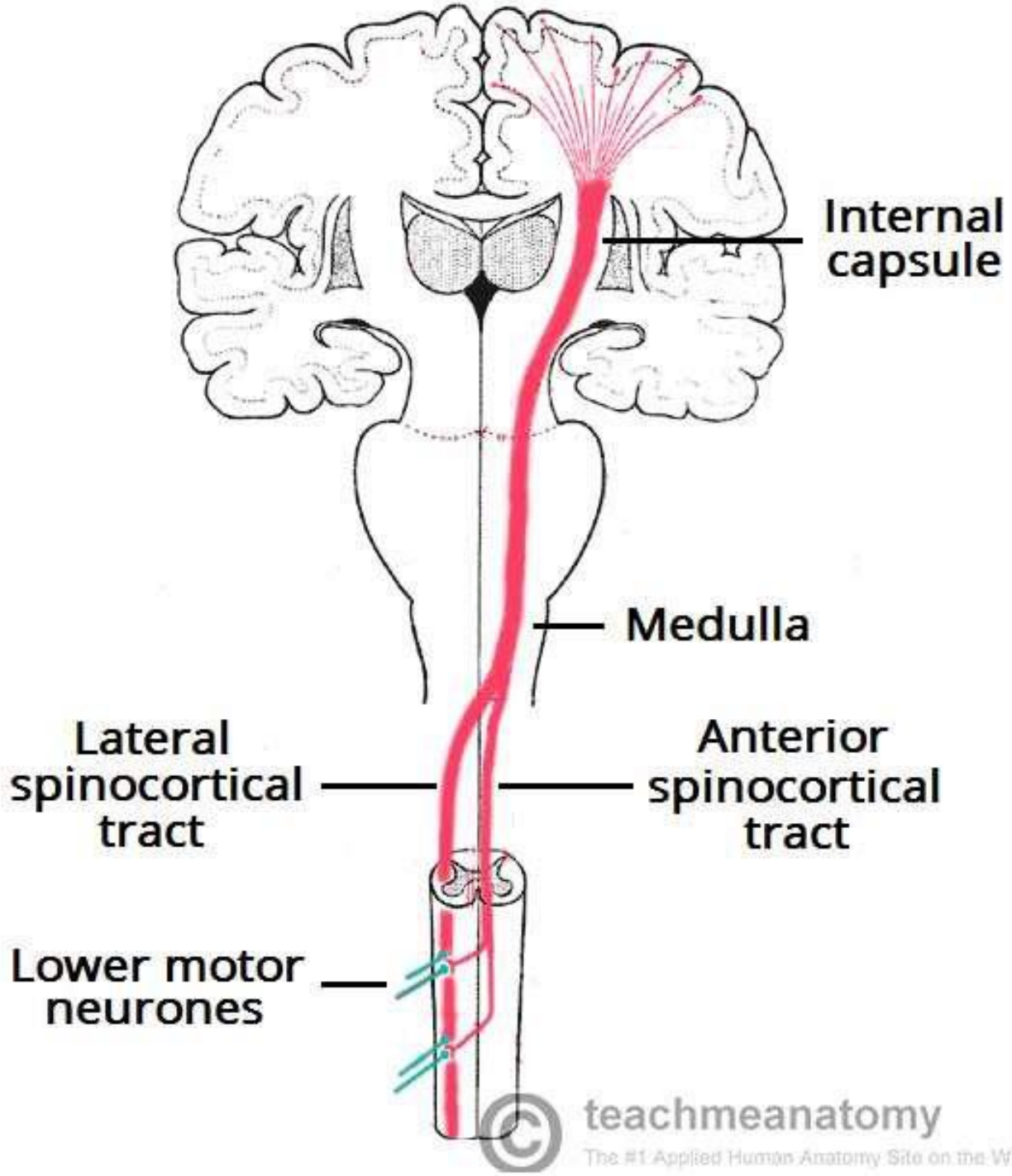
Pyramidal Tract

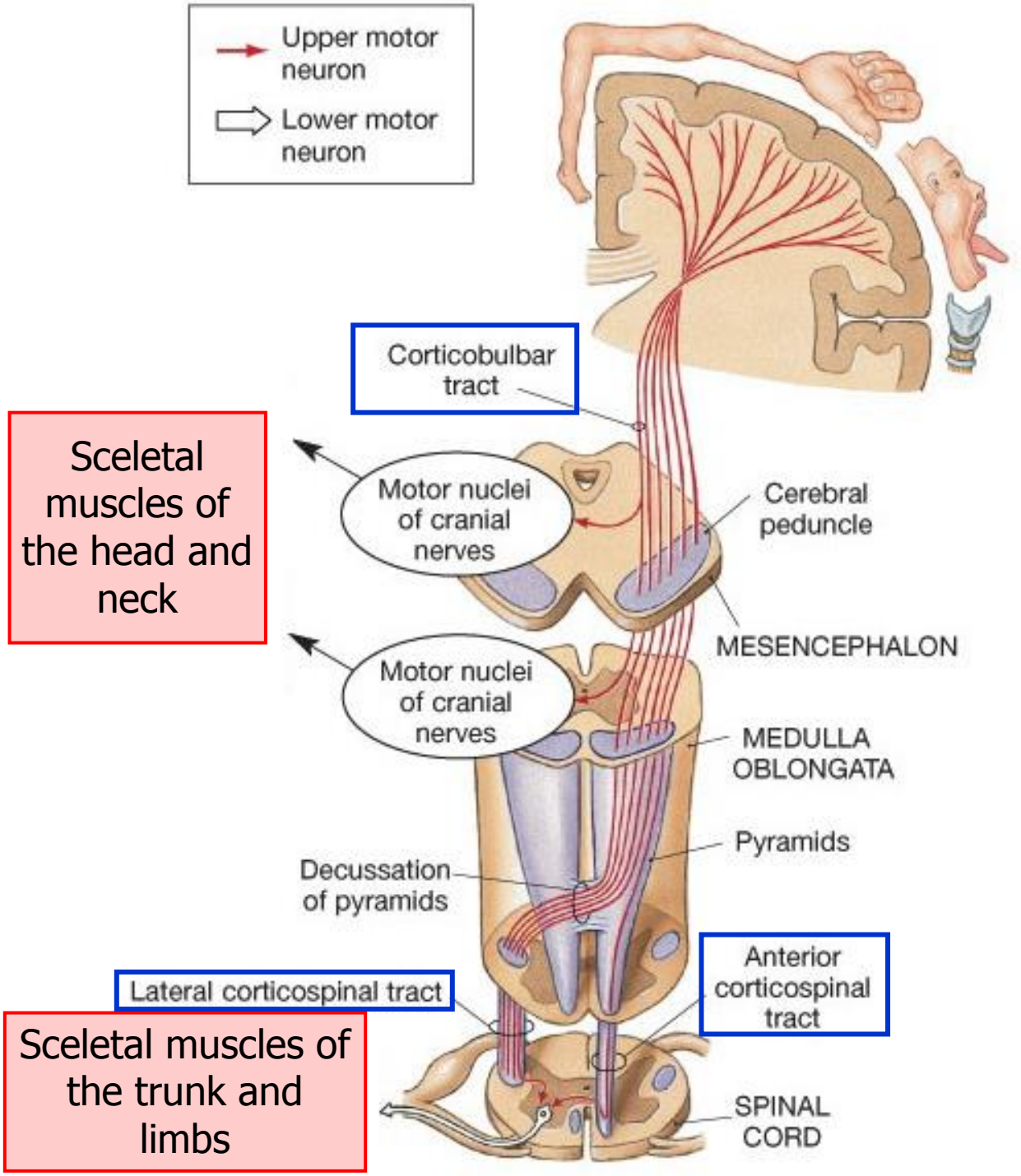
- Most of the fibers ***90 % cross*** the midline (***motor decussation***) descend in the lateral column as ***LCST terminate*** on ***LMN*** of ***anterior gray*** column at ***all spinal level***

- Remaining ***uncrossed*** fibers descend as ***ACST*** ***eventually*** fibers ***cross*** the midline and ***terminate*** on ***LMN*** of ***anterior gray*** column of respective spinal cord segments in cervical and upper thoracic segmental levels.

Pyramidal Tract

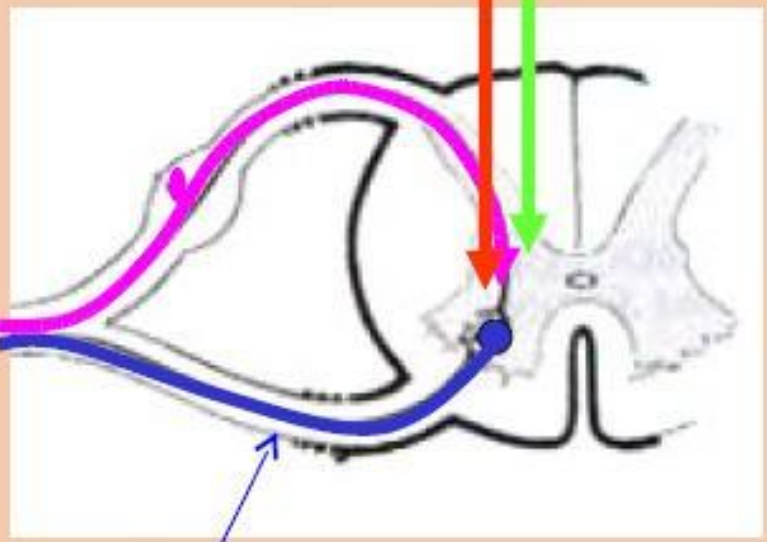
- ***Lateral corticospinal*** tracts
  - Skilled movements (***hands*** & ***feet***)
- ***Anterior corticospinal*** tracts
  - Controls ***neck*** & ***trunk*** muscles
- ***Corticobulbar tracts***
  - Cortex to nuclei of CNs
    - 3,4,5,6,7,9,10,11&12
  - For movements of eyes, tongue, chewing, expressions & speech


Internal capsule
Medulla
Lateral spinocortical tract
Anterior spinocortical tract
Lower motor neurones
teachmeanatomy
The #1 Applied Human Anatomy Site on the Web


Upper motor neuron
Lower motor neuron
Corticobulbar tract
Motor nuclei of cranial nerves
Cerebral peduncle
MESENCEPHALON
Motor nuclei of cranial nerves
MEDULLA OBLONGATA
Pyramids
Decussation of pyramids
Anterior corticospinal tract
Lateral corticospinal tract
SPINAL CORD
Sceletal muscles of the head and neck
Sceletal muscles of the trunk and limbs

cerebral cortex – midbrain - pons - medulla oblongata

descending tracts



sensory inputs

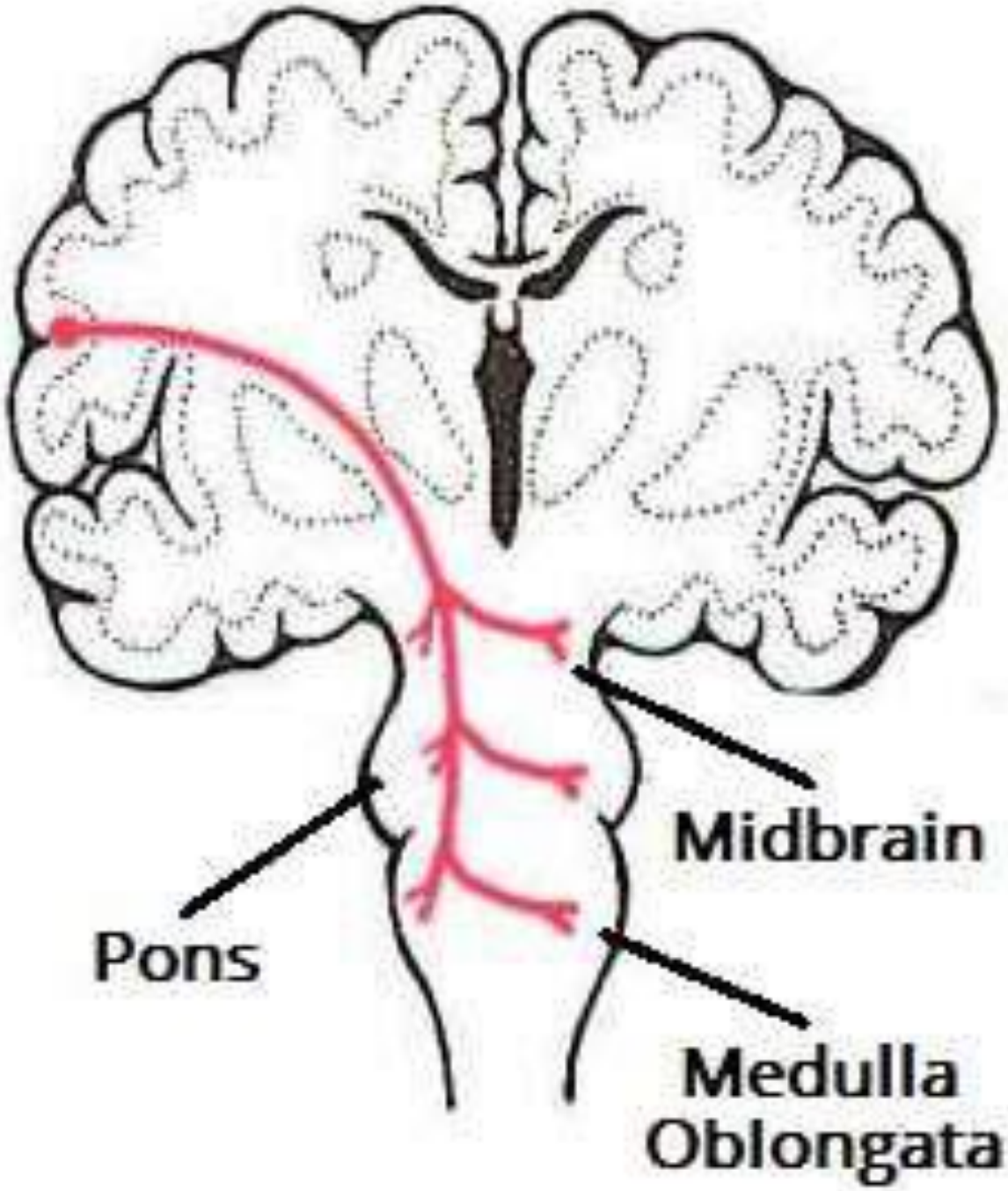
LMN

Corticobulbar Tracts

- The corticobulbar tracts arise from the lateral aspect of the primary motor cortex. They receive the same inputs as the corticospinal tracts.

- The fibers converge and pass through the internal capsule to the brainstem.

- The neurons terminate on the motor nuclei of the cranial nerves. Here, they synapse with lower motor neurons, which carry the motor signals to the ***muscles of the face and neck***.


Midbrain
Pons
Medulla
Oblongata

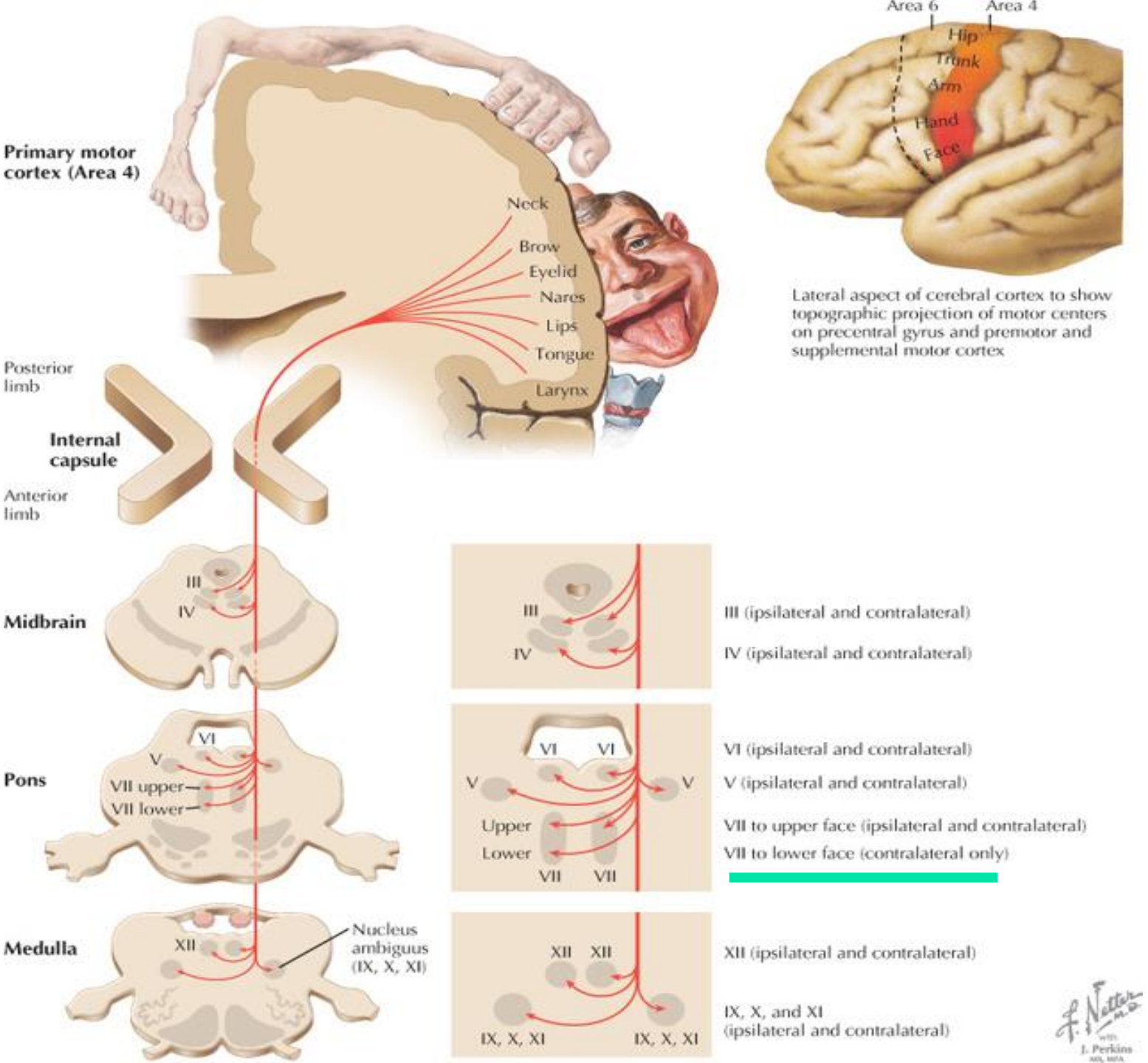
Corticobulbar Tracts

- The fibers terminate in several locations in the ***midbrain*** (***corticomesencephalic tract***), ***pons*** (***Corticopontine tract***), and ***medulla oblongata*** (***corticobulbar tract***).

- The nerves within the corticobulbar tract are involved in movement in muscles of the head.

- They are involved in swallowing, phonation, and movements of the tongue.

CORTICONUCLEAR TRACT



Clinical Significance

- Fibers of the ***corticospinal tracts*** are ***damaged*** anywhere along their course from the cerebral cortex to the lower end of the spinal cord, this will give rise to an ***upper motor neuron syndrome***

Extrapyramidal Systems

- Coordinates movements of various groups of muscles both in space and time
- Regulates job and sport-specific automatic movements consisting of periodic elements (e.g. walking, running, riding a bike, dancing, driving a car, handwriting or typing, etc.)
- Controls emotional movements
- Helps to control posture and balance
- Regulates muscle tone.

Extrapyramidal Tracts

- The extrapyramidal tracts originate in the brainstem, carrying motor fibers to the spinal cord.
- ***There are four tracts in total:***
- The ***vestibulospinal*** and ***reticulospinal*** tracts **do not decussate**, providing ipsilateral innervation.
- The ***rubrospinal*** and ***tectospinal*** tracts **do decussate**, and therefore provide contralateral innervation.

Vestibulospinal Tract

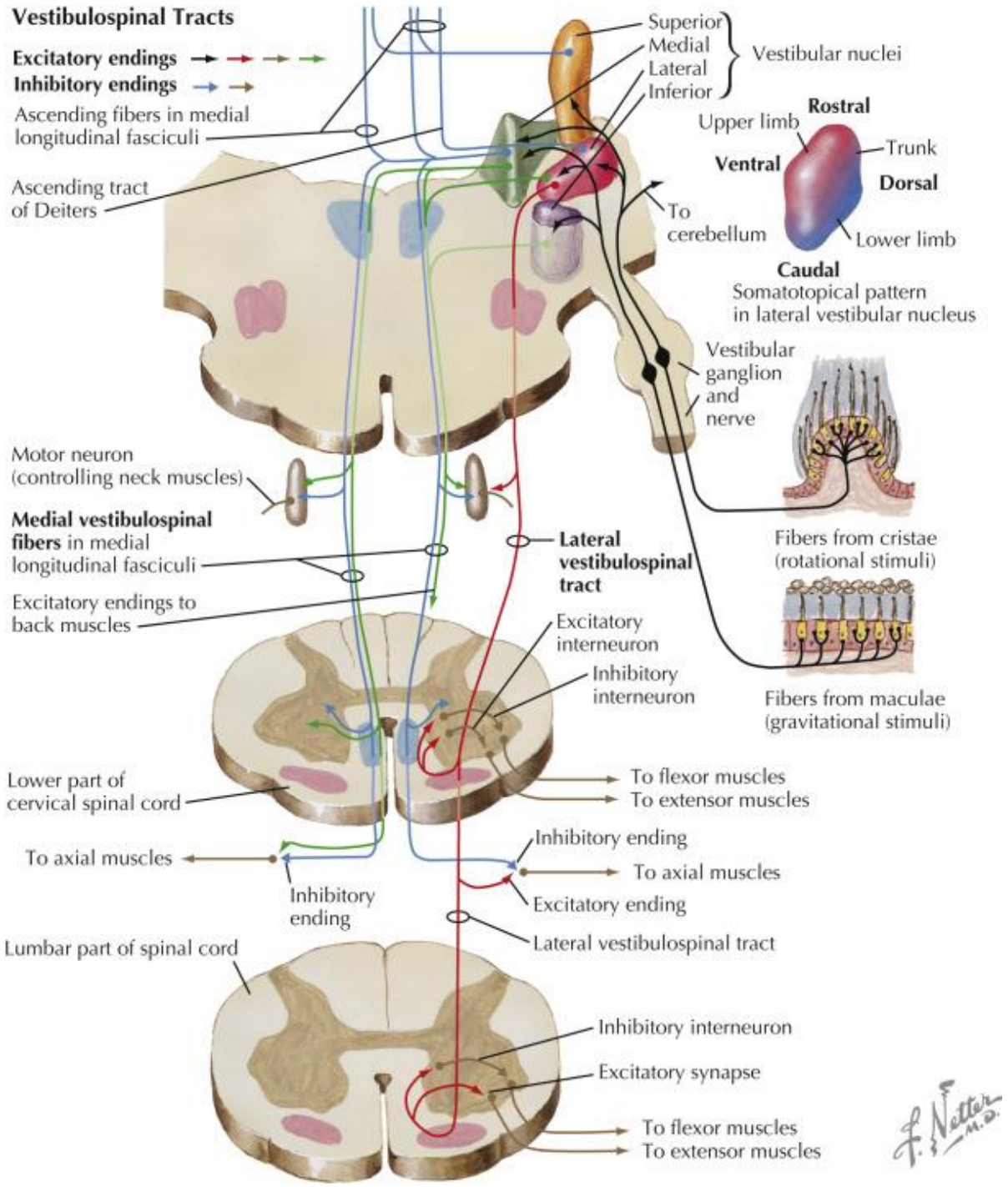
- There are ***two*** vestibulospinal pathways; ***medial*** and ***lateral***.
- They arise from the vestibular nuclei (***medial and lateral nuclei***), which receive input from the organs of balance.
- The tracts convey this balance information to the spinal cord, where it ***remains ipsilateral***.
- Fibers in this pathway ***control balance*** and ***posture*** by innervating the '**anti-gravity**' muscles (flexors of the arm, and extensors of the leg), via lower motor neurons.

Vestibulospinal Tract

- ***Function (Medial Vestibulospinal):*** head-righting reflex to keep the head and vision horizontal when the body is tilted.

- ***Function (Lateral Vestibulospinal):*** This tract mediates excitatory influences upon extensor motor neurons to maintain posture.

A loss of these tracts can produce disorientation and postural instability.


Vestibulospinal Tracts
Excitatory endings
Inhibitory endings
Ascending fibers in medial longitudinal fasciculi
Ascending tract of Deiters
Superior
Medial
Lateral
Inferior
Vestibular nuclei
Rostral
Upper limb
Trunk
Ventral
Dorsal
Lower limb
Caudal
Somatotopical pattern in lateral vestibular nucleus
To cerebellum
Vestibular ganglion and nerve
Motor neuron (controlling neck muscles)
Medial vestibulospinal fibers in medial longitudinal fasciculi
Excitatory endings to back muscles
Lateral vestibulospinal tract
Fibers from cristae (rotational stimuli)
Excitatory interneuron
Inhibitory interneuron
Fibers from maculae (gravitational stimuli)
Lower part of cervical spinal cord
To flexor muscles
To extensor muscles
To axial muscles
Inhibitory ending
Inhibitory ending
To axial muscles
Excitatory ending
Lateral vestibulospinal tract
Lumbar part of spinal cord
Inhibitory interneuron
Excitatory synapse
To flexor muscles
To extensor muscles
F. Netter M.D.

Reticulospinal Tracts

- **Nerve cells start in reticular formation**
- Fibers pass through **midbrain, pons, and medulla oblongata**
- **End** at the **anterior gray column** of spinal cord control activity of motor neurons
- They are important that they results in **refining of voluntary movement** by preventing unnecessary contractions that would result with shaking

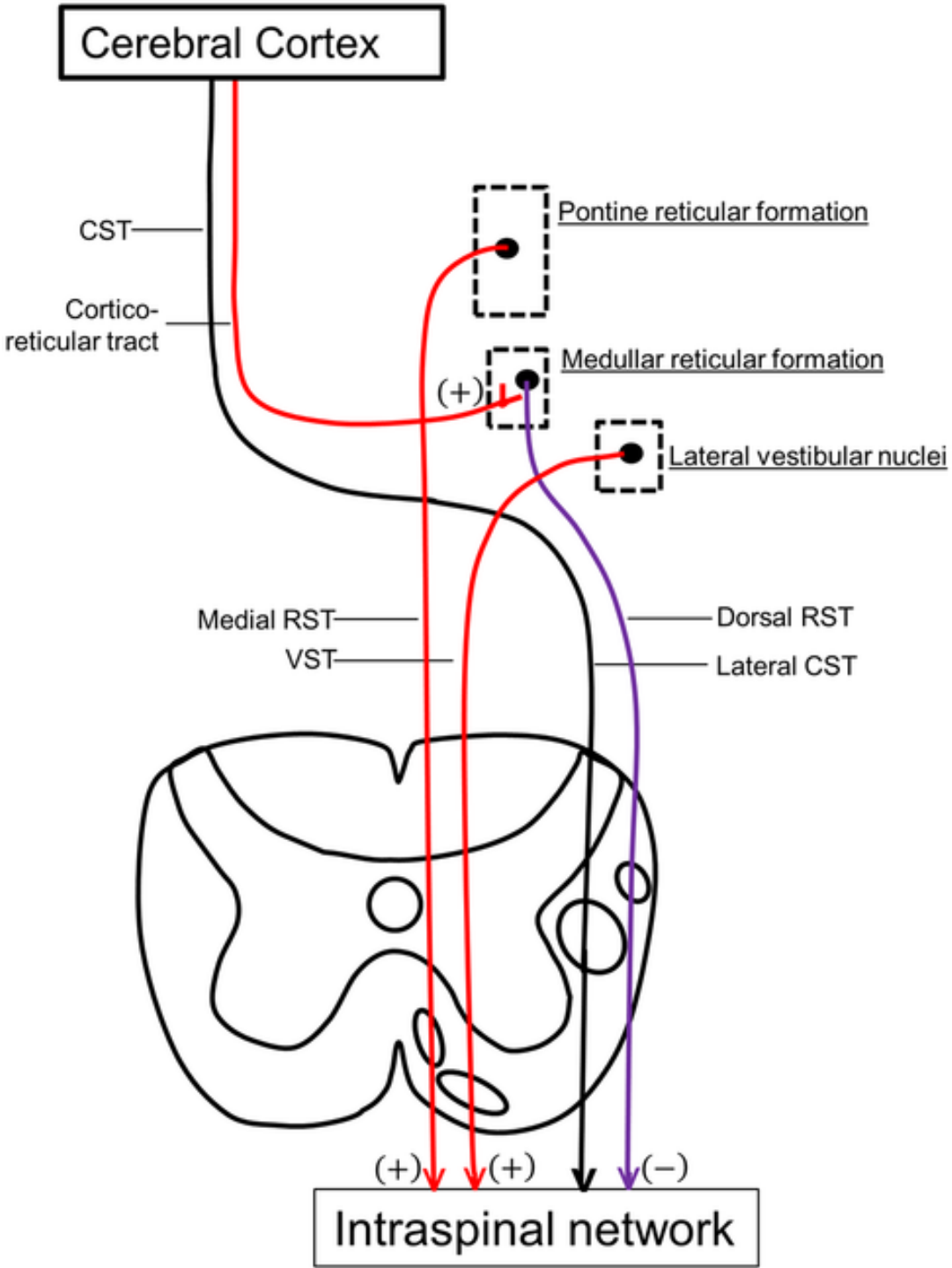


Illustration of supraspinal control of spinal stretch reflex. CST: cortical spinal tract; RST: reticulospinal tract; VST: vestibular spinal tract; (+): facilitation; (-): inhibition. NOTE: other descending pathways, such as rubrospinal tract, tectospinal tract, medial CST are not shown here.

Reticulospinal Tracts

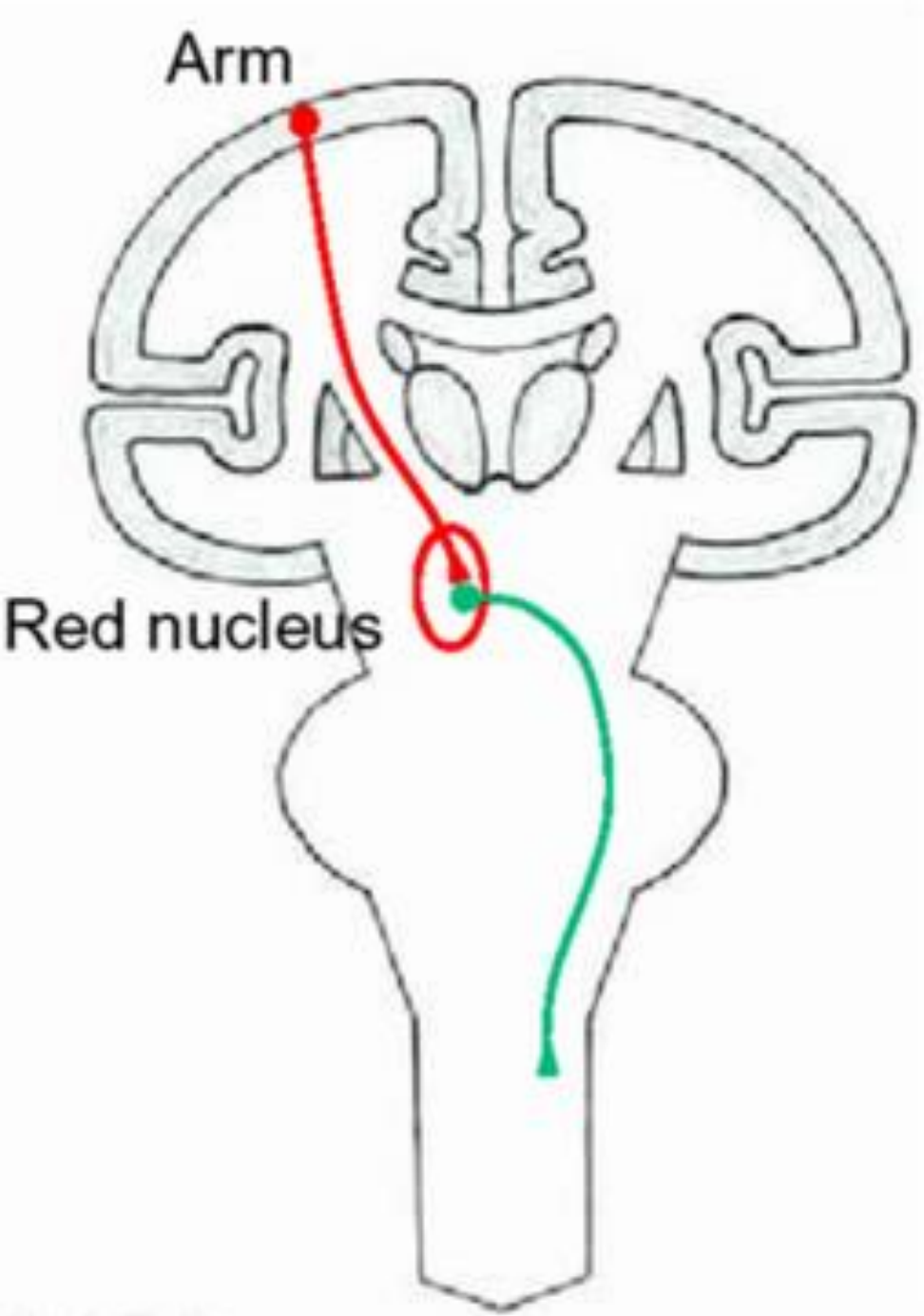
- ***The two reticulospinal tracts have differing functions (Both uncrossed):***

- The ***medial (Pontine) reticulospinal*** tract arises from the pons. It facilitates voluntary movements, and ***increases muscle tone*** to axial and limb antigravity muscles

- The ***lateral (Medullary) reticulospinal*** tract arises from the medulla. It inhibits voluntary movements, and ***reduces muscle tone*** to axial and limb antigravity muscles

Rubrospinal Tract

- Nerve cells in red nucleus (***tegmentum of midbrain at the level of superior colliculus***)
- Nerve fibers / axons ***cross*** the **midline** descend as rubrospinal tract through pons and medulla oblongata
- Terminate in anterior gray column of spinal cord (***facilitate the activity of flexor muscles***) primarily in the cervical spinal cord
- **Function:** ***This tract is excitatory for flexors and inhibitory for extensors in distal limb*** (like corticospinal tract)

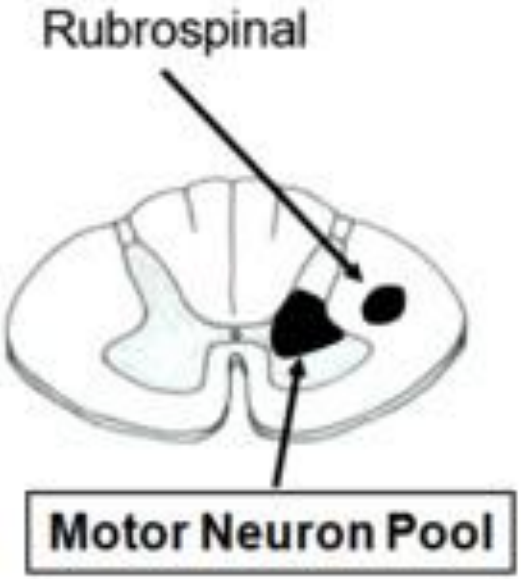


Rubrospinal Tract

Receives input from cortex (corticorubral tract) and from cerebellum.

Contralateral innervation of both α and γ motoneurones, directly and indirectly, mainly to cervical region.

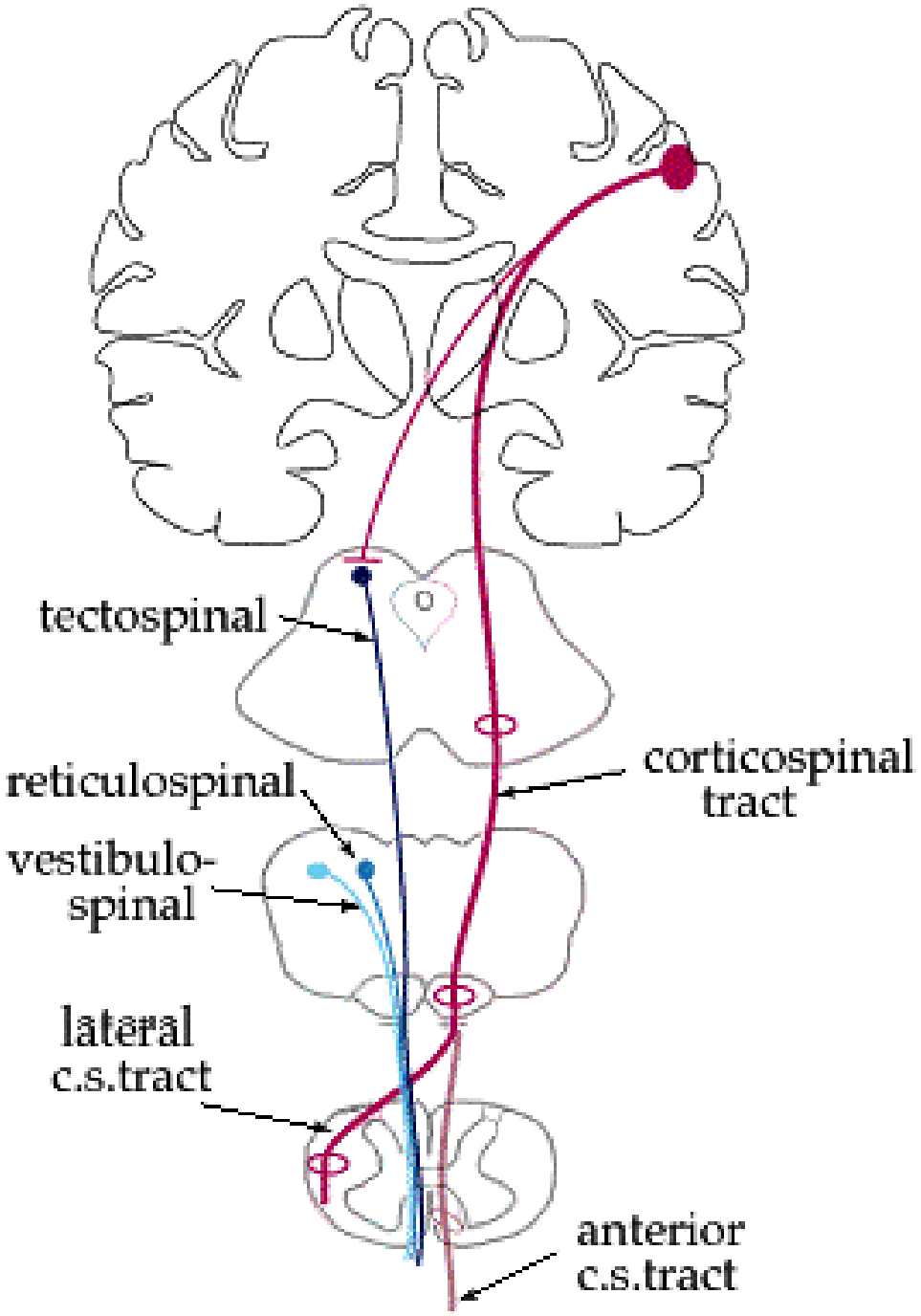
Biased to proximal flexor muscles.
Facilitation of voluntary activity.



Tectospinal Tracts

- This pathway begins at the ***superior colliculus*** of the midbrain. The superior colliculus is a structure that receives input from the **optic nerves.**

- The neurons then quickly ***decussate***, and enter the spinal cord. They terminate at the cervical levels of the spinal cord.


tectospinal
reticulospinal
vestibulo-
spinal
lateral
c.s.tract
corticospinal
tract
anterior
c.s.tract

Tectospinal Tracts

- It is responsible for ***motor impulses that arise from one side of the midbrain to muscles on the opposite side of the body***.

- The function of the tectospinal tract is to ***mediate reflex postural movements of the head in response to visual and auditory stimuli***.

- The tract descends to the cervical spinal cord to terminate in ***Rexed laminae VI, VII, and VIII to coordinate head, neck, and eye movements, primarily in response to visual stimuli***

Lower Motor Neurons (LMN)

- Motor neurons that innervate the voluntary muscles and skeletal muscles

1. ***In anterior gray column of spinal cord.***

2. ***Motor nuclei of brainstem***

3. ***Or their peripheral nerves***

Lower Motor Neurons (LMN)

- Form final common pathway
- Lower motor neuron are constantly bombarded by nerve impulses (*excitatory or inhibitory*) that descend from cerebral cortex, pons, midbrain and medulla.
- Sensory inputs are carried through the posterior root.

UMNL Paralysis

- ***Injury any where from the cortex till AHC***

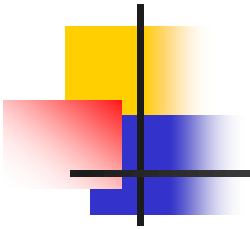
Damage upper motor neurons = <u>Spastic paralysis</u>

1. Paralysis (spastic) on ***<u>opposite side</u>*** from injury
2. Loss of fine skilled movements
3. Increased muscle tone
4. Exaggerated reflexes

LMNL Paralysis

- ***Injury any where following the AHC***
- ***Damage lower motor neurons = Flaccid paralysis***

1. No voluntary movement (paralysis) on ***same side*** as damage
2. No reflex actions
3. Muscle limp & flaccid
4. Decreased muscle tone



Common Spinal Cord Lesions

Spinal Cord Lesions

Complete transverse section (transection) of the spinal cord:

Above C5 → death (due to paralysis of diaphragm and intercostal muscles).

Between C5 –T1 → Quadriplegia.

Below T1 → Paraplegia.

Central Gray Matter - Central Cord Syndrome

- Seen in ***syringomyelia*** (***progressive cavitation around or near the central canal of spinal cord especially in cervical segments***)

- ***Interrupt*** fibers of ***lateral spinothalamic*** tract that passes ***in front*** of the ***central canal***.

- ***Loss*** of ***pain*** and ***temperature*** sensibility on ***both sides*** proprioception and light touch is spared (***sensory dissociation***).

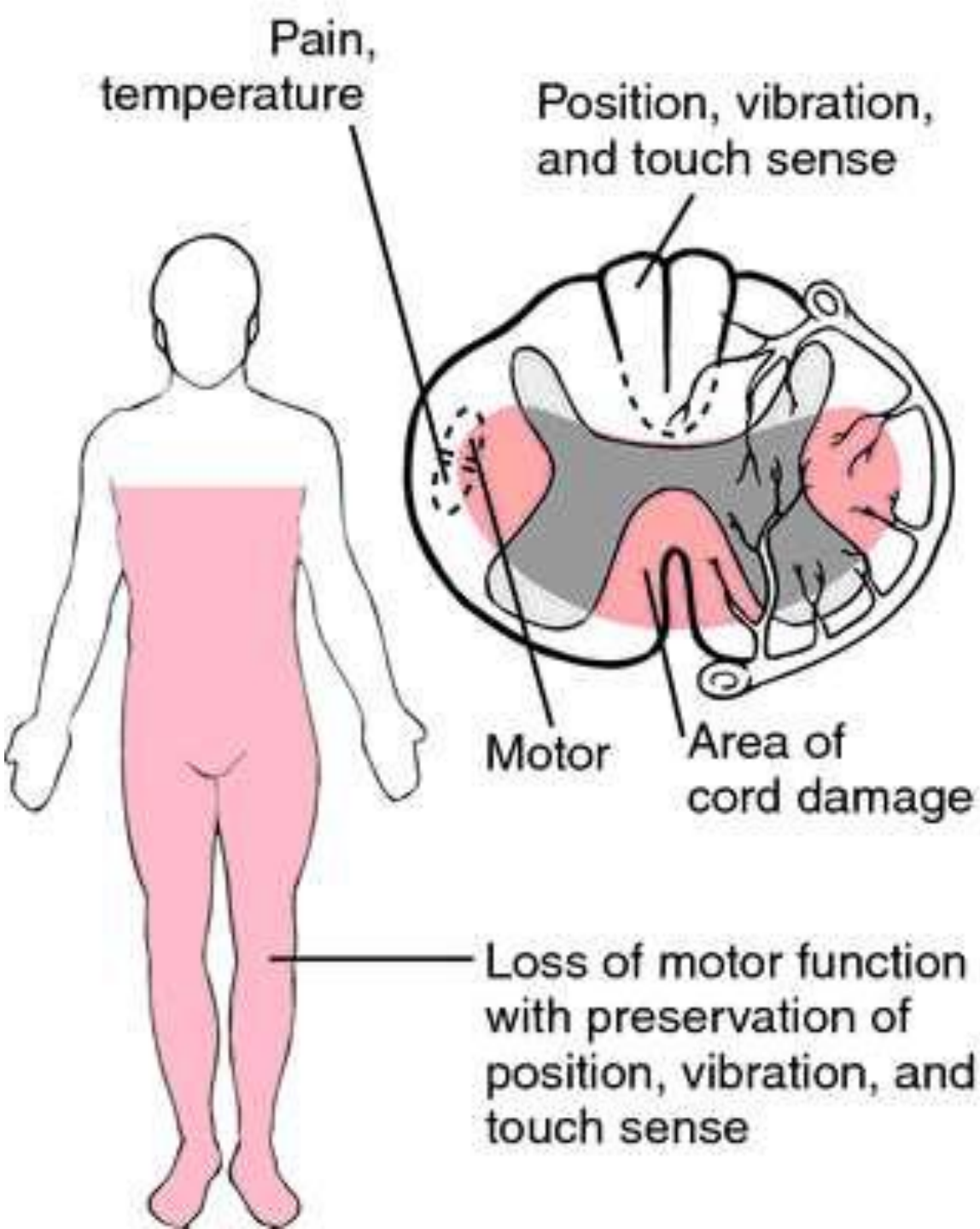

8
W 1295 : L 647

Colored area defines syringeoma, a malformation where a section of the spinal cord is filled with spinal fluid.

Anterior Cord Syndrome

- Anterior spinal artery syndrome the primary blood supply to the anterior portion of the spinal cord, is interrupted, causing ischemia or ***infarction*** of the spinal cord in the ***anterior two-thirds*** of the ***spinal cord*** and ***medulla*** oblongata.

- It is characterized by ***loss*** of ***motor*** function ***below*** the level of ***injury***, ***loss*** of ***sensations carried*** by the ***anterior columns*** of the spinal cord (***pain, temperature*** and ***touch***) sparing posterior column sensations


Pain,
temperature
Position, vibration,
and touch sense
Motor
Area of
cord damage
Loss of motor function
with preservation of
position, vibration, and
touch sense

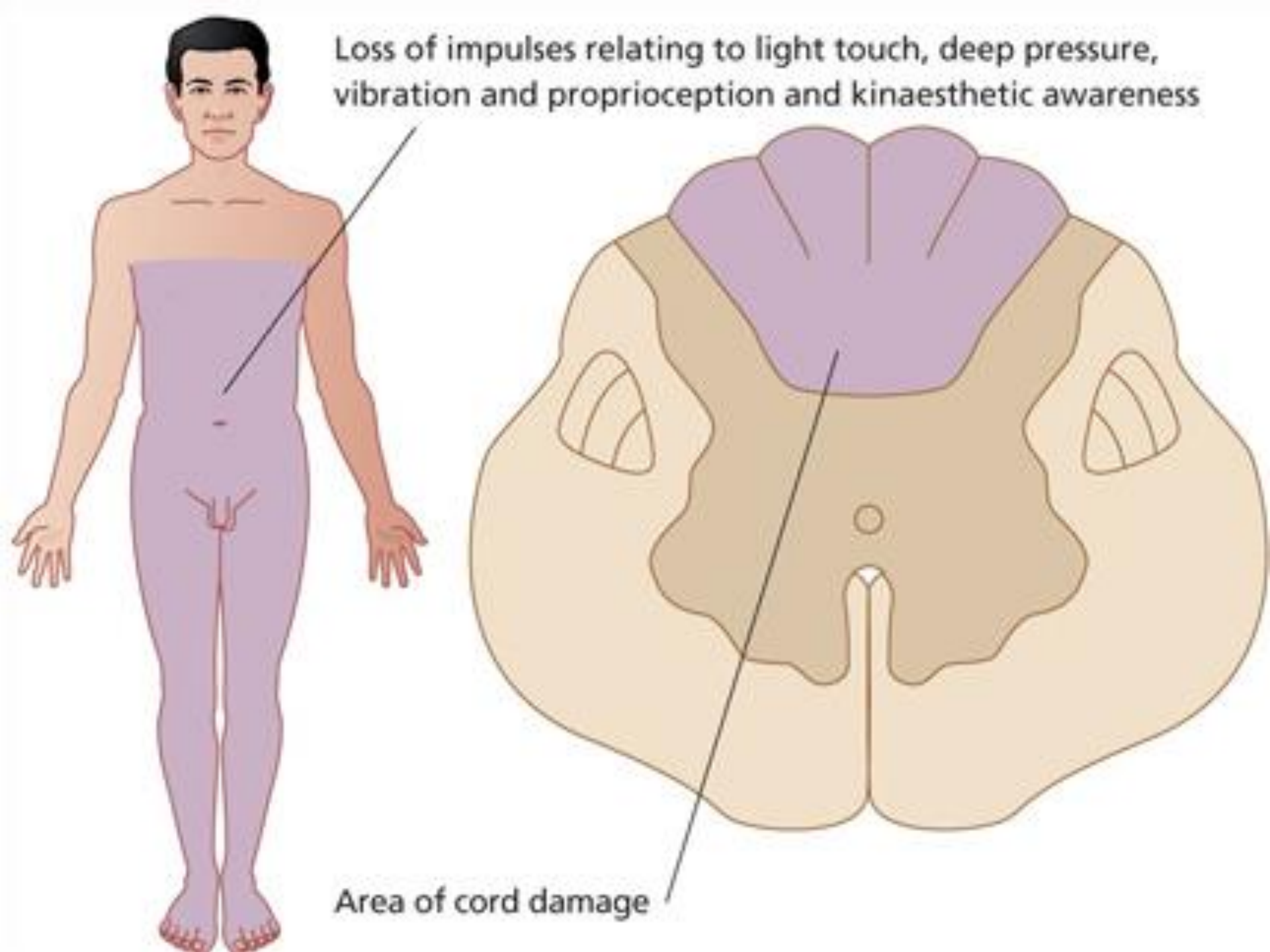
Posterior Cord Syndrome

- Is a condition caused by lesion of the posterior portion of the spinal cord caused by an interruption to the posterior spinal artery.

- Unlike anterior cord syndrome, it is a very rare condition.

Clinical presentation:

- Loss of proprioception + vibration sensation + loss of two point discrimination +loss of light touch


Loss of impulses relating to light touch, deep pressure, vibration and proprioception and kinaesthetic awareness
Area of cord damage

Brown-Sequard syndrome

Hemi-section of the spinal cord

1. Dorsal column damage
2. Lateral column damage
3. Anterolateral column damage
4. Damage to local cord segment and nerve roots

Brown-Sequard syndrome

- ***Same level of lesion***

Loss of all sensation, hypotonic paralysis and loss of all reflexes related to the affected side

Brown-Sequard syndrome

- ***Below the level of lesion***

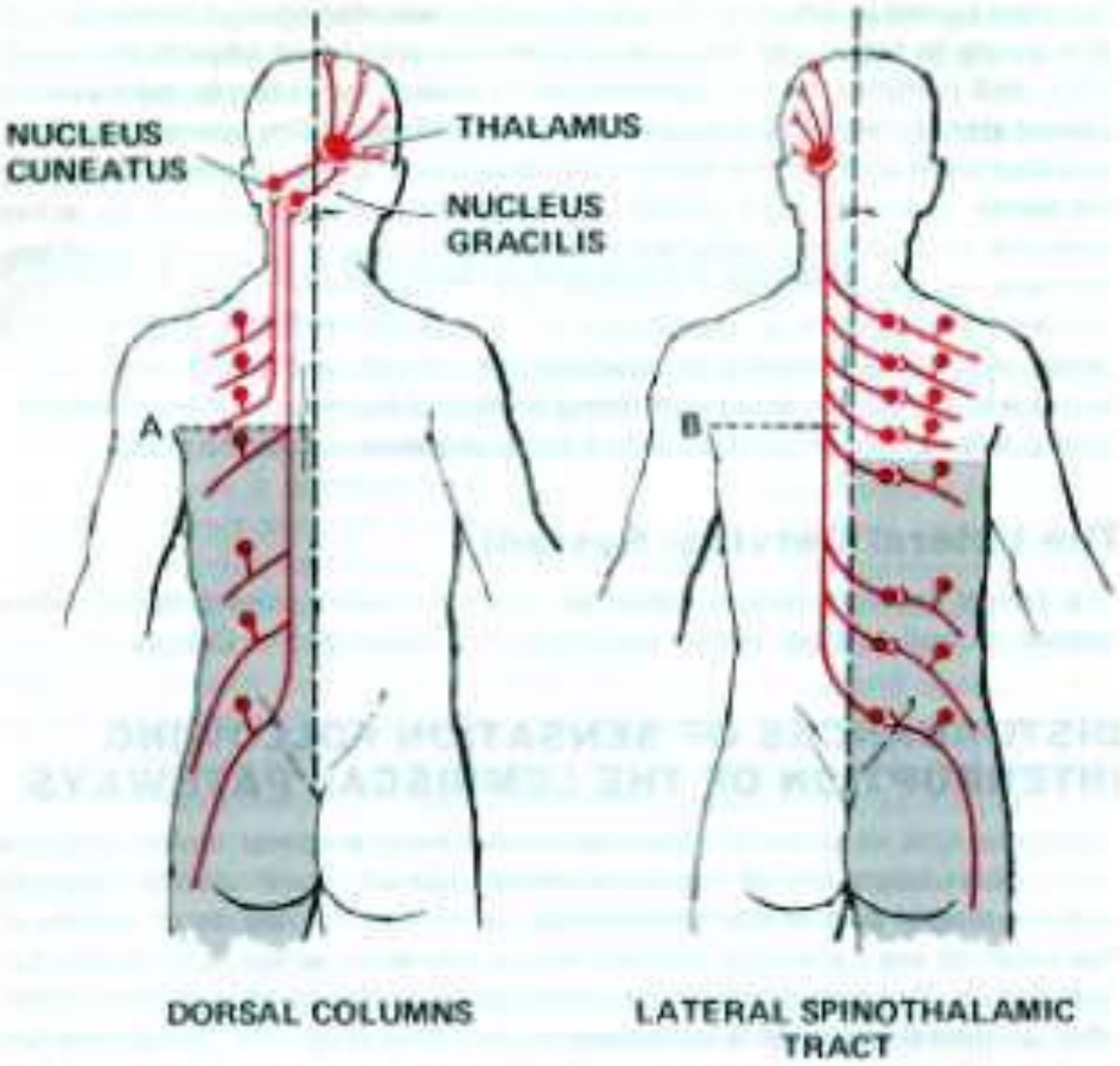
- On the side of lesion, ***dorsal column damage***

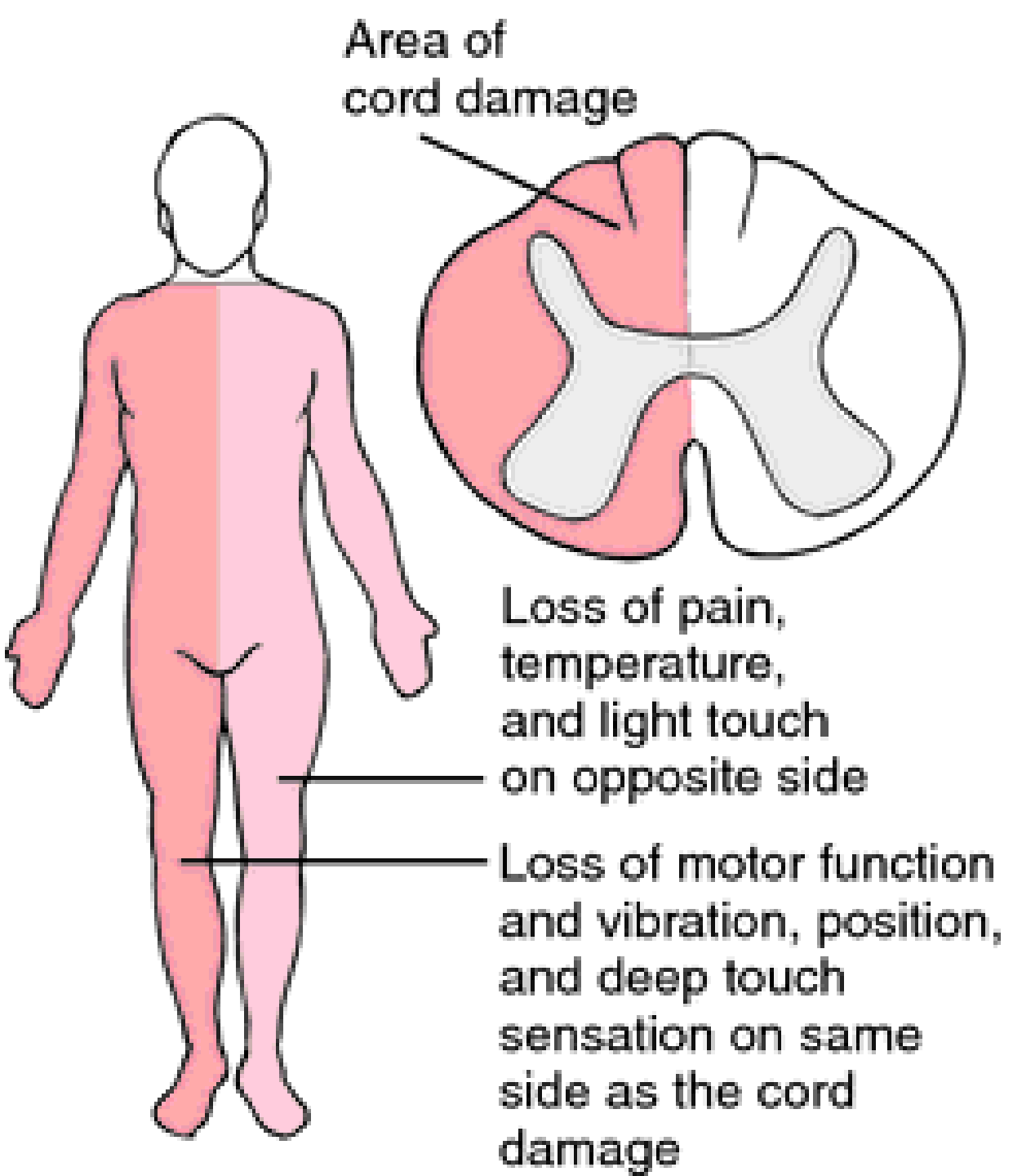
1. Loss of position sense
2. Loss of vibratory sense
3. Loss of tactile discrimination

- ***Anterolateral system damage***

1. Loss of sensation of pain, temperature and touch on the side opposite the lesion

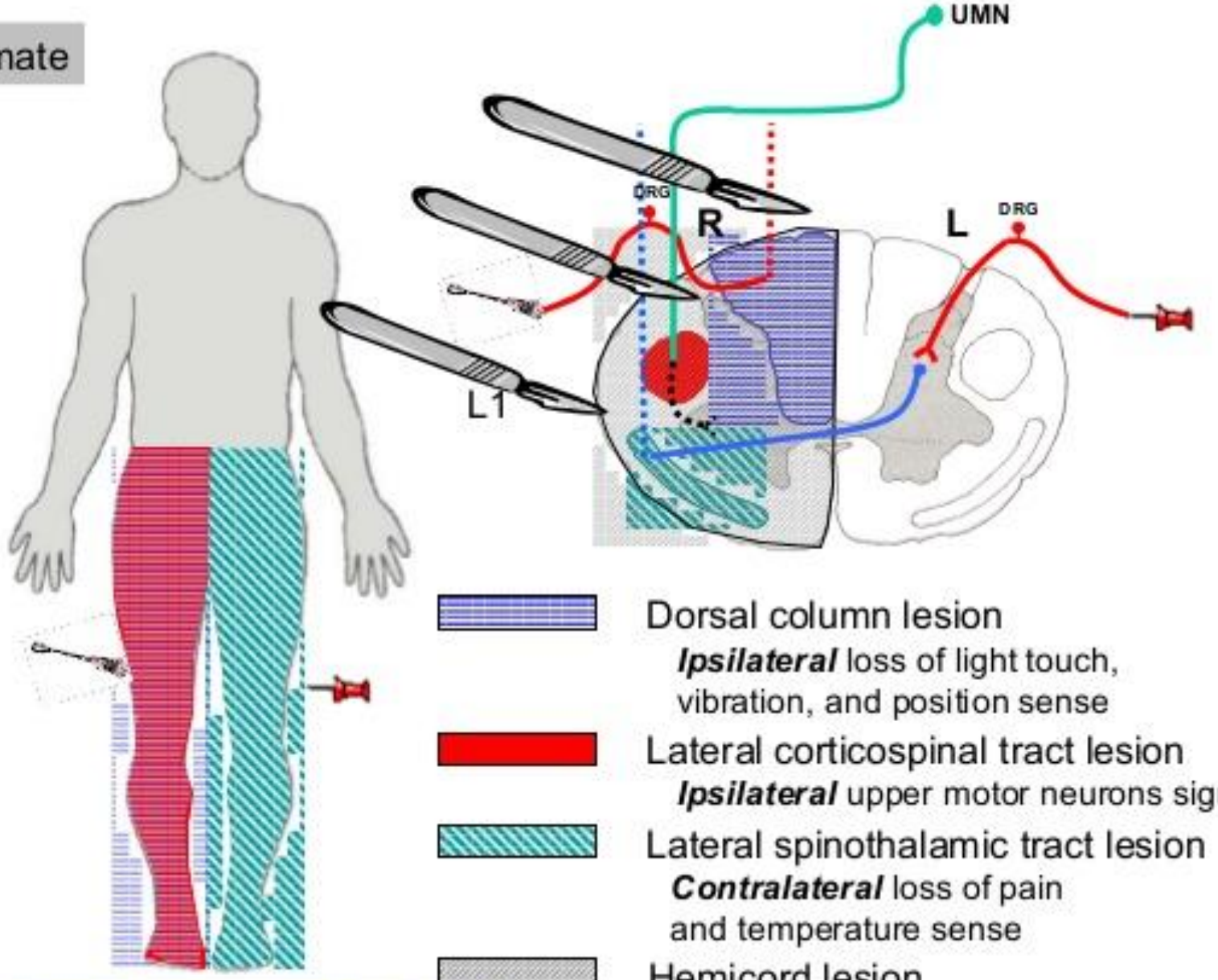
- ***Motor affection:*** UMNL, with spastic paralysis and exaggerated reflexes


NUCLEUS
CUNEATUS
THALAMUS
NUCLEUS
GRACILIS
A
B
DORSAL COLUMNS
LATERAL SPINOTHALAMIC
TRACT


Area of
cord damage
Loss of pain,
temperature,
and light touch
on opposite side
Loss of motor function
and vibration, position,
and deep touch
sensation on same
side as the cord
damage

Hemicord Lesion (Brown-Sequard Syndrome)

Click to animate



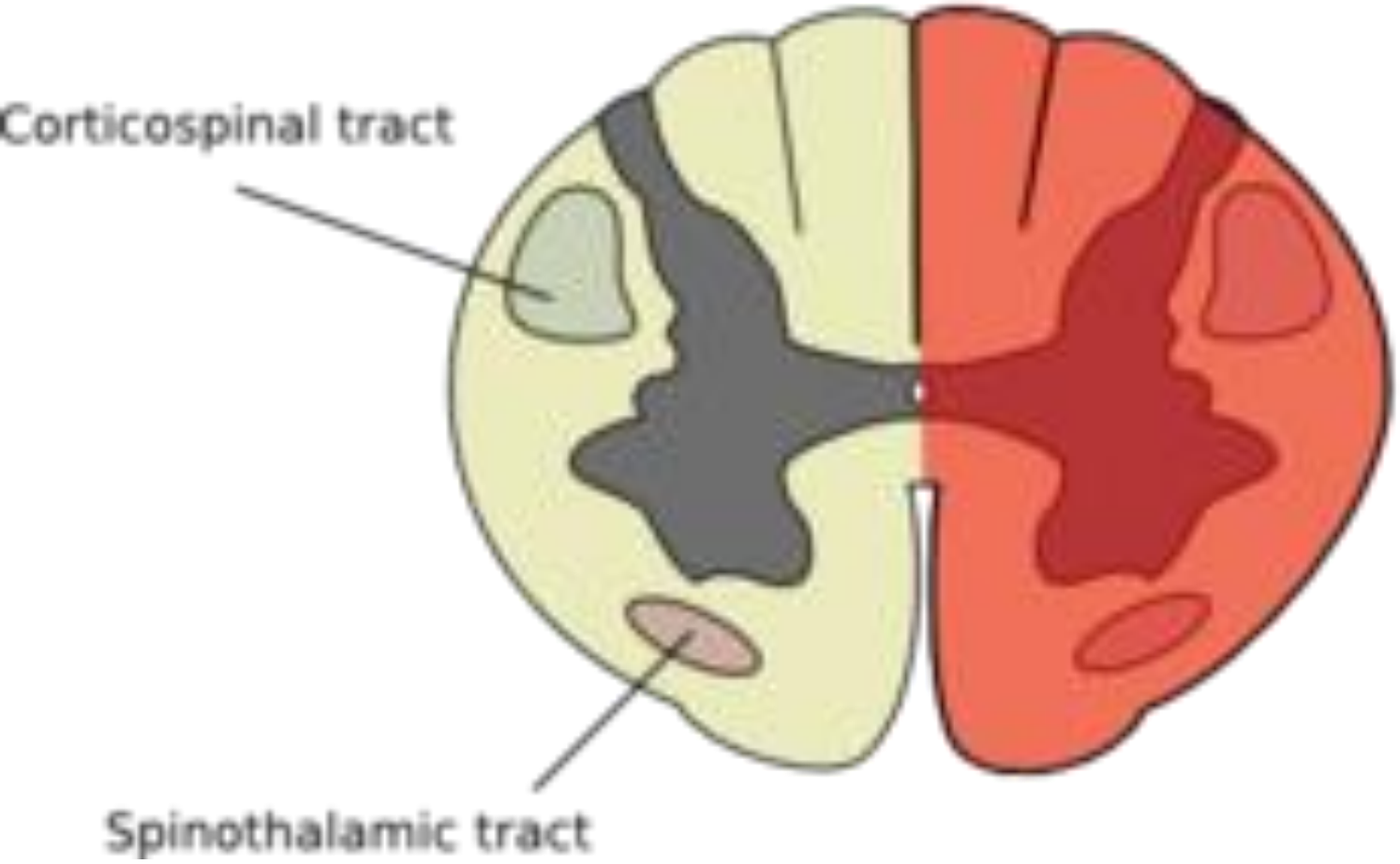
Dorsal column lesion
Ipsilateral loss of light touch, vibration, and position sense

Lateral corticospinal tract lesion
Ipsilateral upper motor neurons signs

Lateral spinothalamic tract lesion
Contralateral loss of pain and temperature sense

Hemicord lesion

Brown-Séquard Syndrome



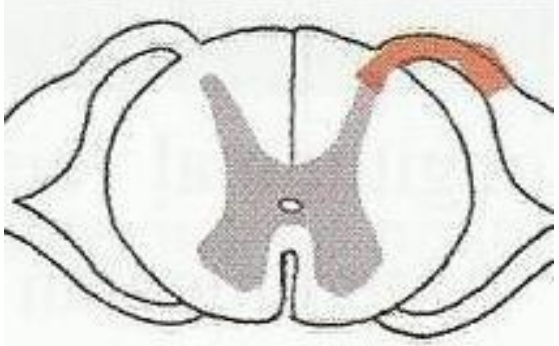
Tabes Dorsalis

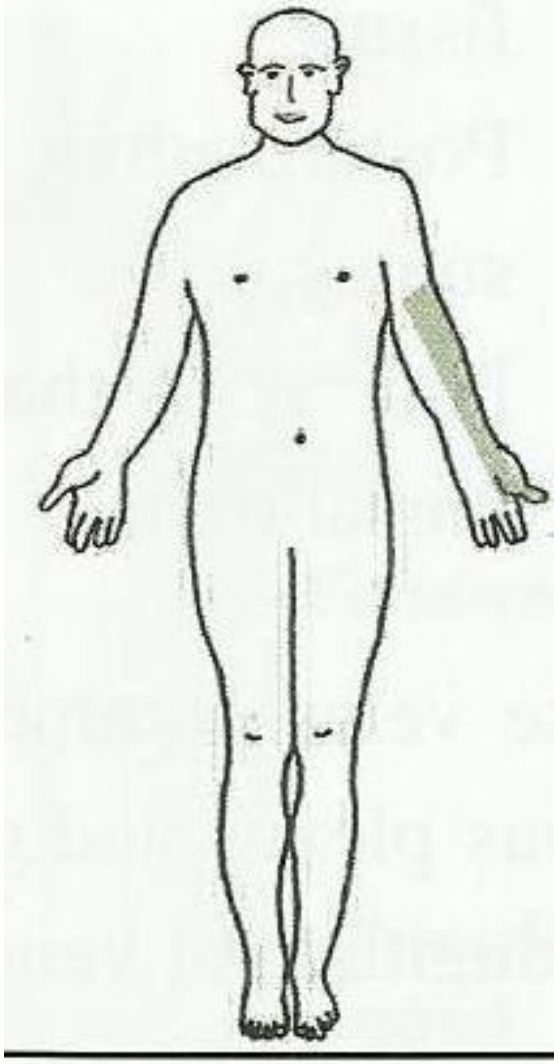
This is caused by **syphilis - destruction of nerve fibers of the** dorsal root of spinal nerves.

Initially, irritation of the pain fibers: **severe pain in the dermatomes supplied by the affected dorsal roots**.

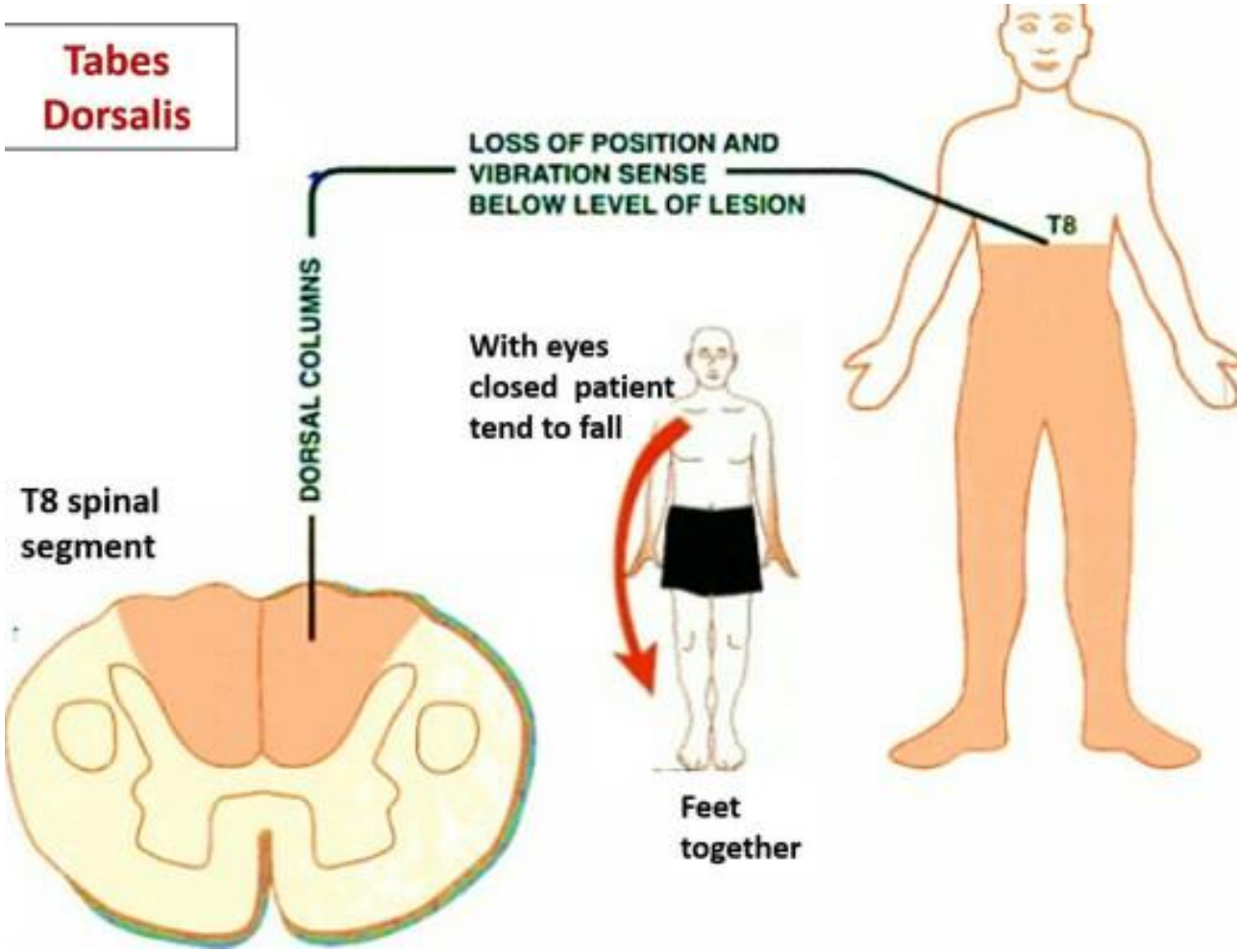
Later on, degeneration of nerve fibers leads to:

1. Loss of deep sensations (e.g. squeezing tendocalcaneus).
2. Loss of proprioception → sensory ataxia.
3. Loss of tendon reflexes.
4. Hypotonia of muscles.





Tabes Dorsalis



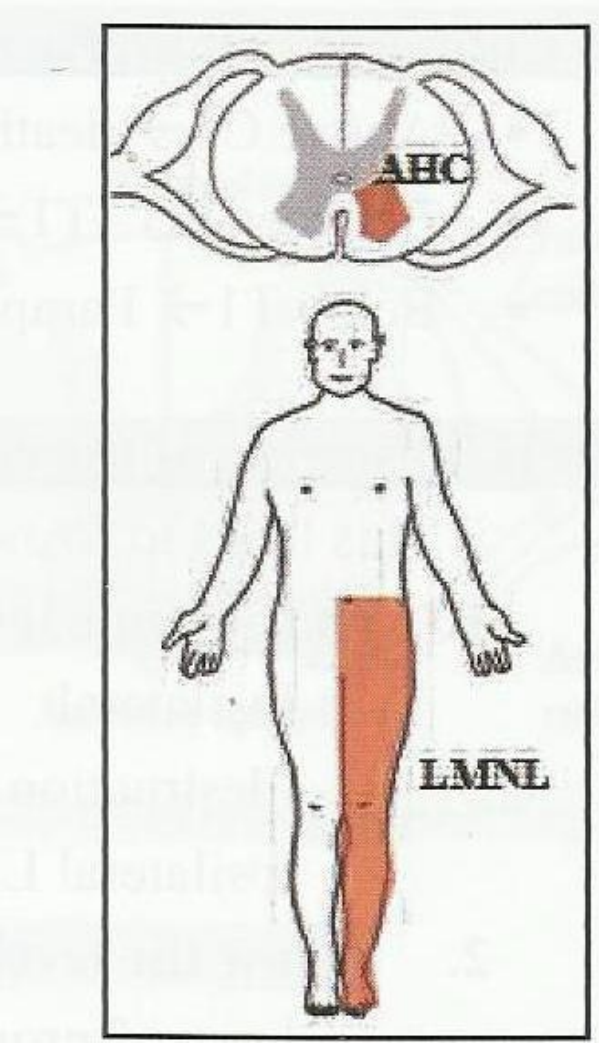
Poliomyelitis

It is caused by virus affecting lower motor neurons.

It is of two types:

Spinal type: affecting anterior horn cells → LMNL.

Bulbar type: affecting motor nuclei of the cranial nerves →LMNL.



Conus Syndrome

- Its not a disease in its own right, but rather the product of a spinal trauma. In most cases, a blow to the back—such as from a car accident or gunshot—is to blame. Caused by ***S3 and S5 lesions***. Lumbar stenosis (multilevel), spinal trauma including fractures and herniated nucleus pulposus are all causes of the condition

1. Saddle anesthesia (S3-S5)

2. Urinary retention with overflow incontinence (due to detrusor areflexia)

Conus Syndrome

3. Fecal incontinence.
4. Impotence.
5. Loss of anal reflexes (S4-S5).
6. Preserved motor function of lower limbs.


A


B

Cauda Equina Syndrome

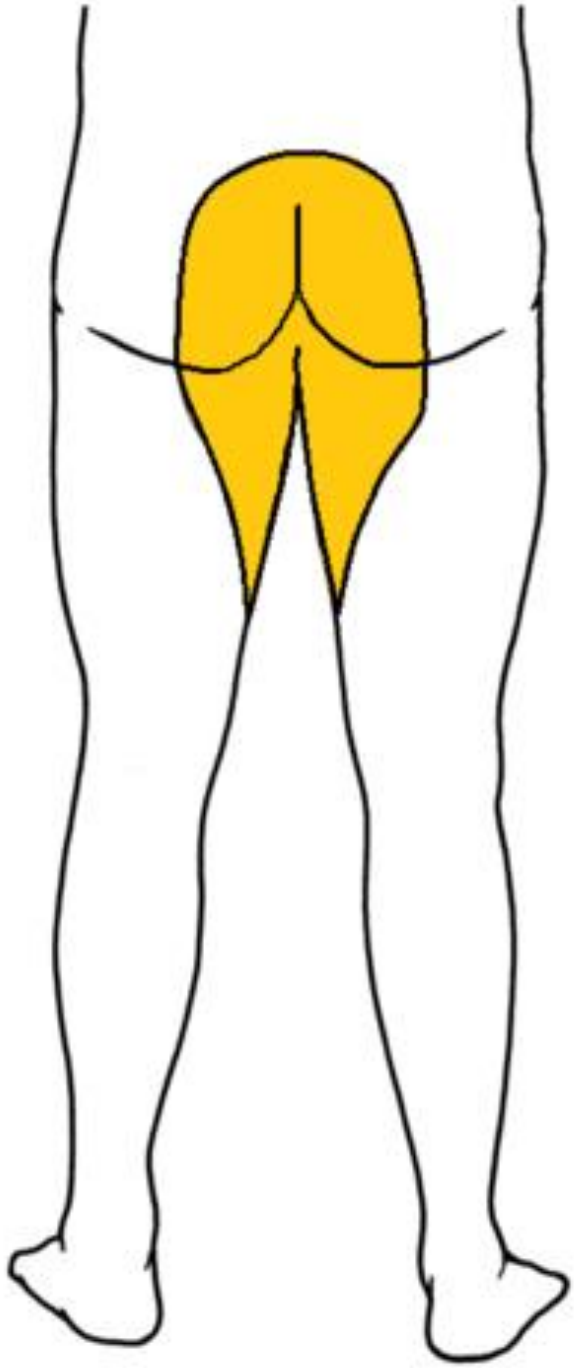
- Cauda equine is composed of lumbar, sacral, and coccygeal nerve roots.

- Lesions of the cauda equine below L1 vertebral level result in cauda equina syndrome.

Cauda Equina Syndrome

- Lesions affecting the lower portion of cauda equine may have ***lower limb weakness*** but sensory loss only in saddle area along with involvement of urination, defecation and sexual dysfunction.

Saddle Numbness



Cauda Equina Syndrome Symptom Chart

Bladder disturbances

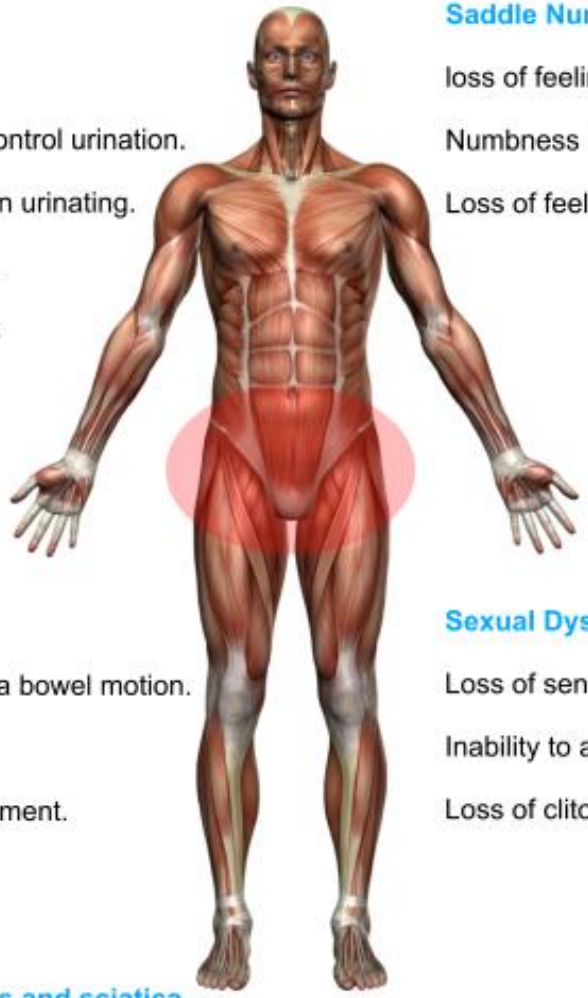
Urination different to normal.

Inability to start, stop and/or control urination.

Loss of normal sensation when urinating.

Loss of full bladder sensation.

Inability to empty bladder fully.



Saddle Numbness

loss of feeling between the legs.

Numbness in and around the genitals/anus.

Loss of feeling of toilet paper when wiping.

Bowel function affected

Loss of feeling when passing a bowel motion.

Constipation.

Loss of control of bowel movement.

Sexual Dysfunction

Loss of sensation during sexual intercourse.

Inability to achieve an erection or ejaculate.

Loss of clitoral sensation.

Low Back pain/leg weakness and sciatica

A combination of these problems may be present. Keep a look out for bilateral toe extensor/flexor weakness, this can occur before other muscle weakness. Marked inability to bend forward with back pain/sciatica and leg weakness may indicate a large disc prolapse. Anal sphincter reflex maybe affected. Look out for bilateral achilles reflex absence.

- For further inquiries ***PLZ*** feel free to contact at any time through email

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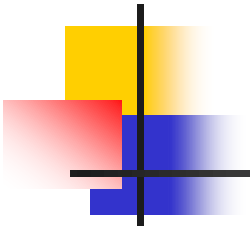

Thank You