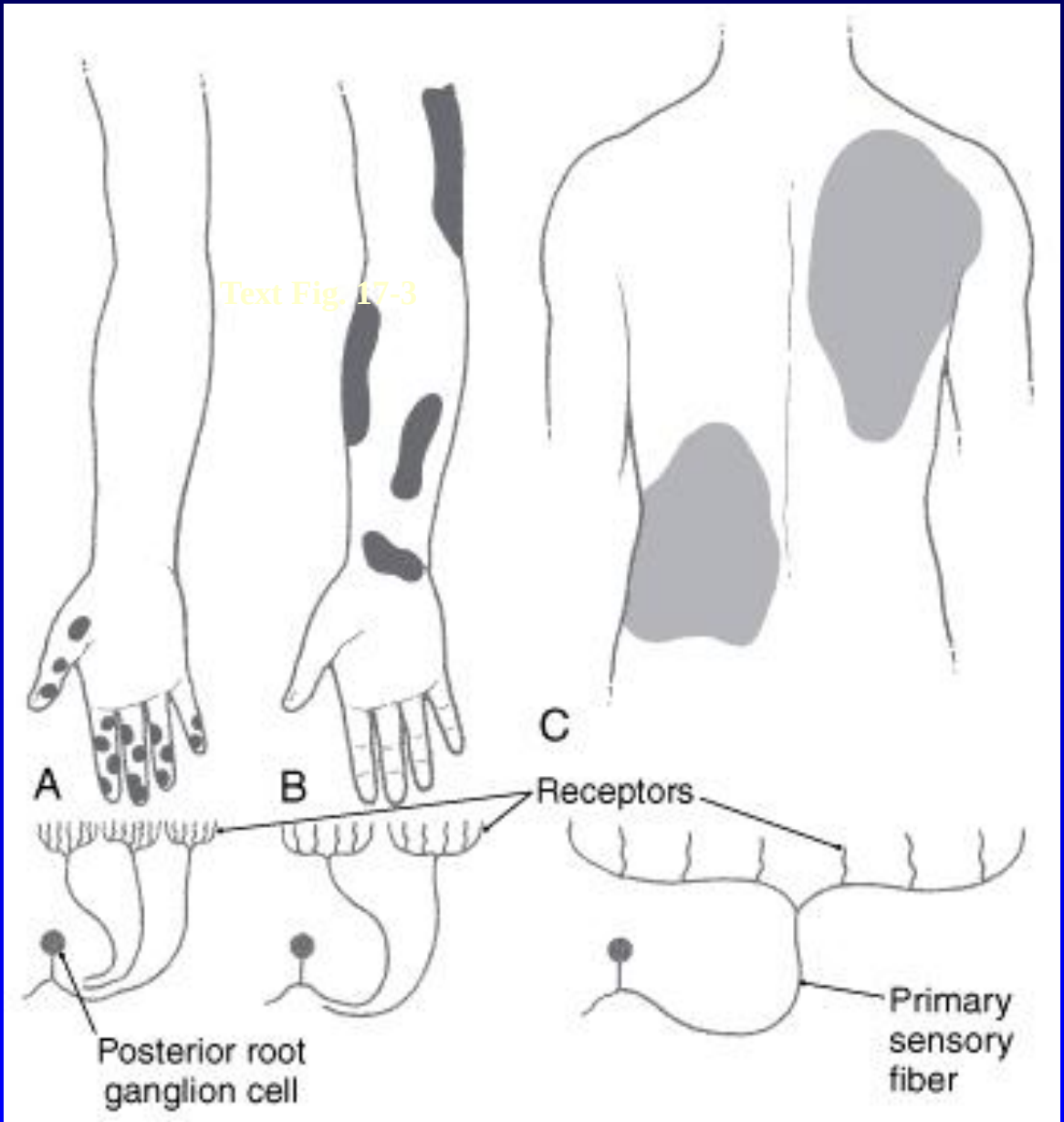
Physiology of the sensory system

Two-point discrimination

- **Number receptors / area**

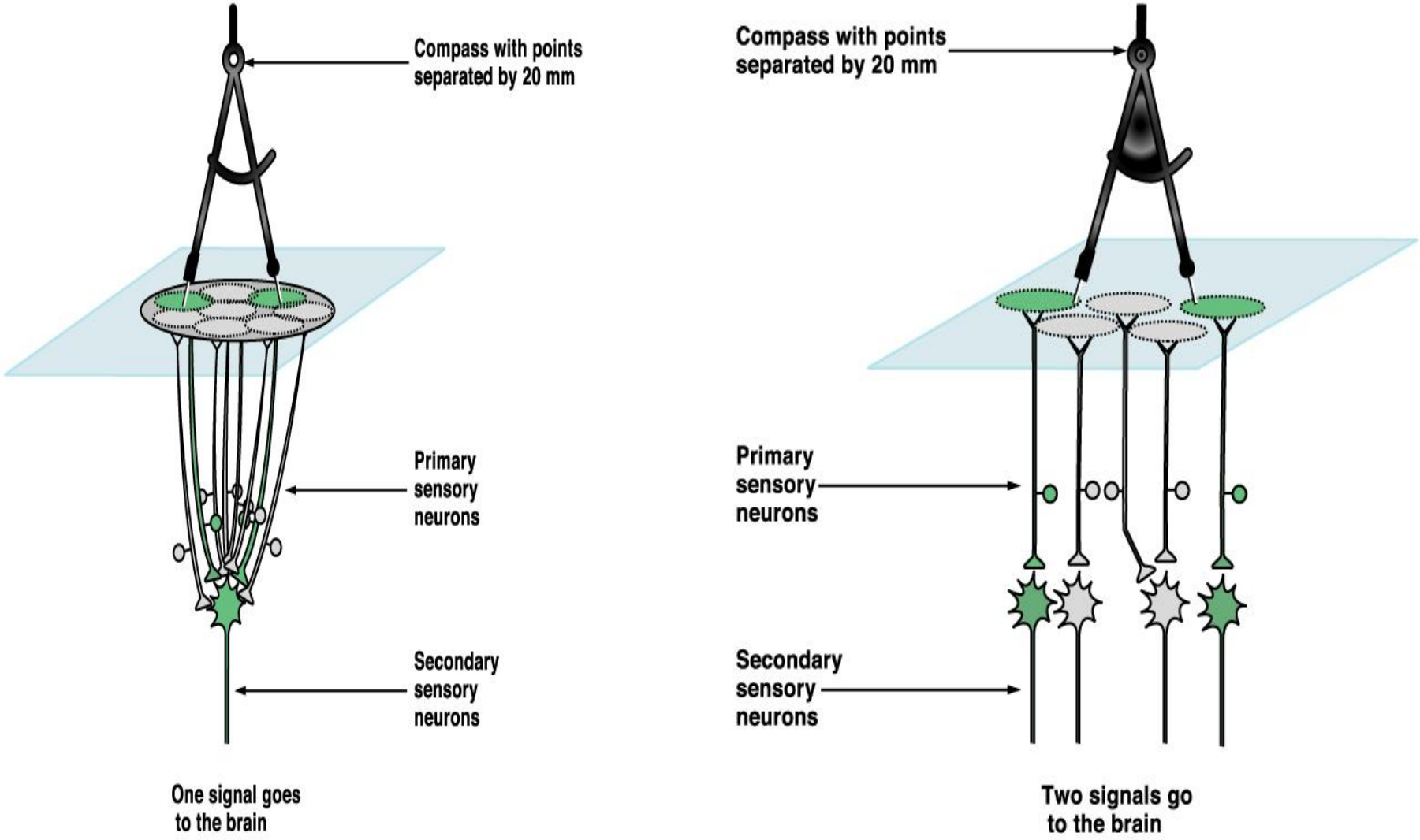
(receptive field of the receptor)



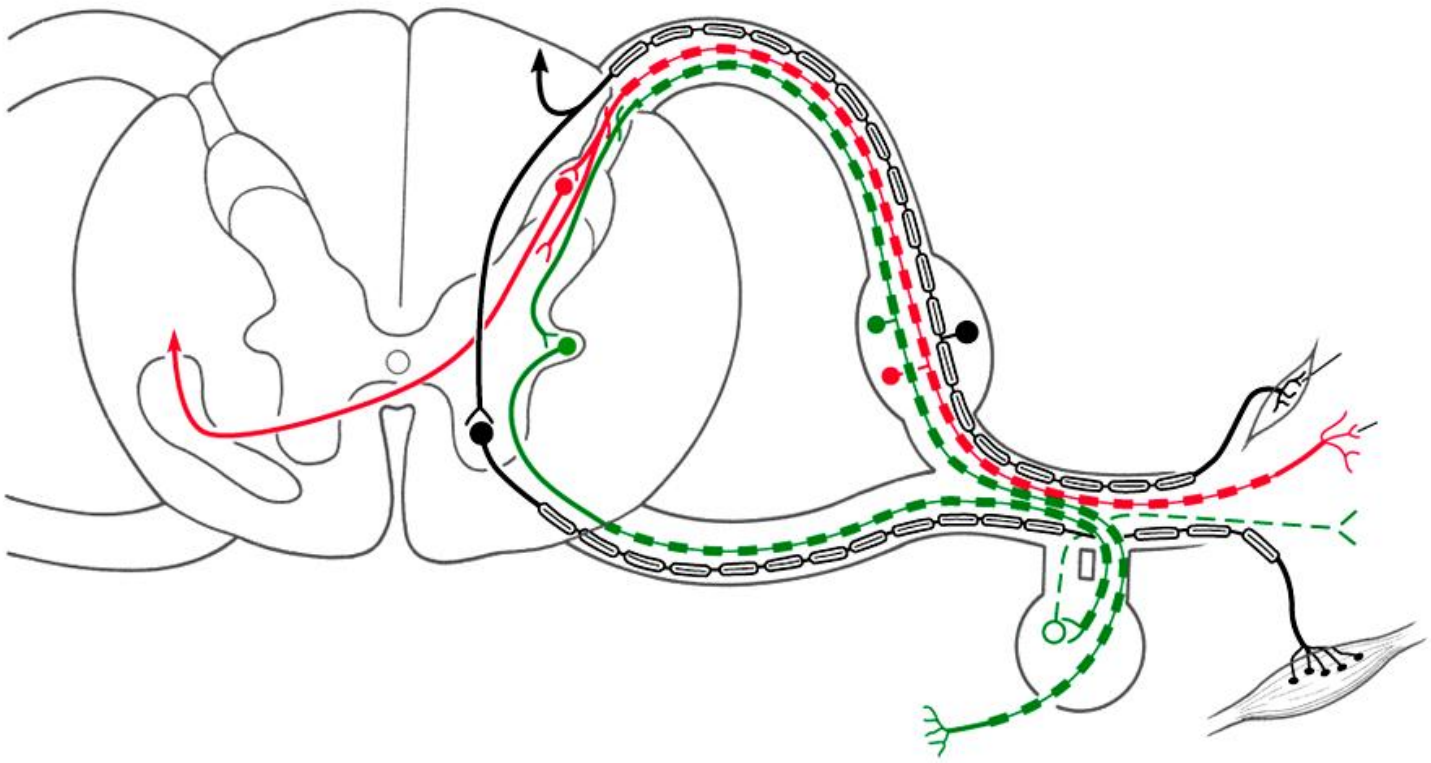
Smaller the receptive fields, greater the density of receptors.
This relationship allows for greater discrimination in sensory inputs.

Two-point discrimination

- **Number receptors / area**
- **Pathway arrangement**


Compass with points separated by 20 mm
Primary sensory neurons
Secondary sensory neurons
One signal goes to the brain
Compass with points separated by 20 mm
Primary sensory neurons
Secondary sensory neurons
Two signals go to the brain

The Spinal Nerve



Text Fig. 9-6, Anatomical Orientation

Sensations modalities

Fast

- 2-point discrimination
- Vibration
- Prorioception

Posterior Column-Medial lemniscus Pathway (PCML)

Slow

- Crud touch (itch & rub)
- Temperature
- Pain

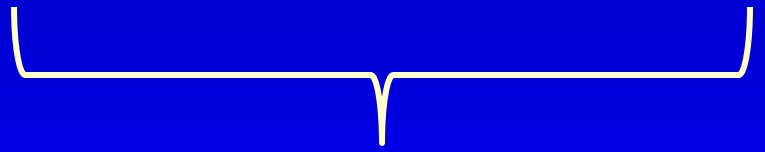
Sensations modalities

Fast

- 2-point discrimination
- Vibration
- Prorioception

Slow

- Temperature
- Crud touch (itch & rub)
- Pain



Antero-lateral system (ALS)
Other name: Spinothalamic pathway

Sensations modalities

Fast

- 2-point discrimination
- Vibration
- Prorioception

Posterior Column-Medial lemniscus Pathway (PCML)

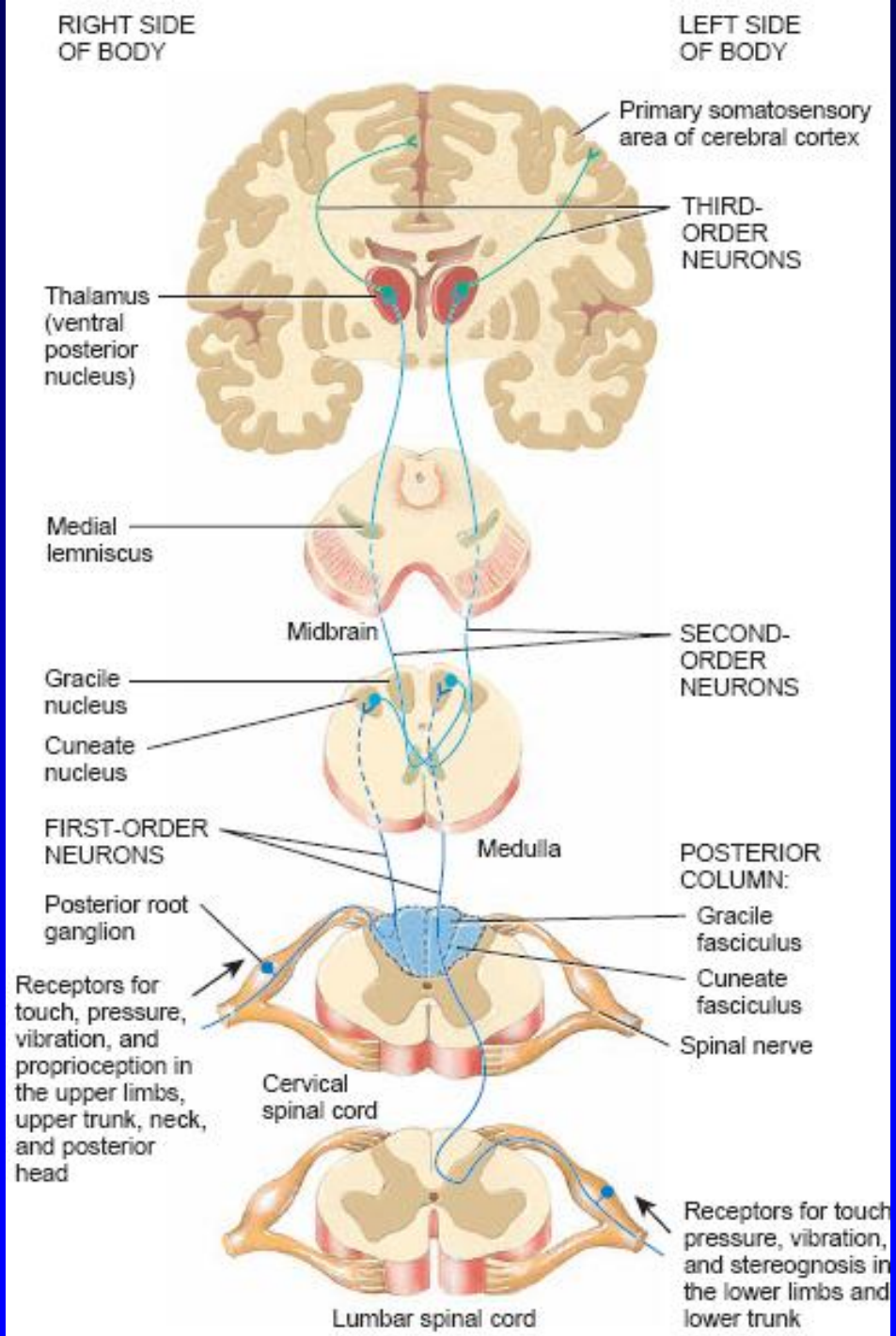
Slow

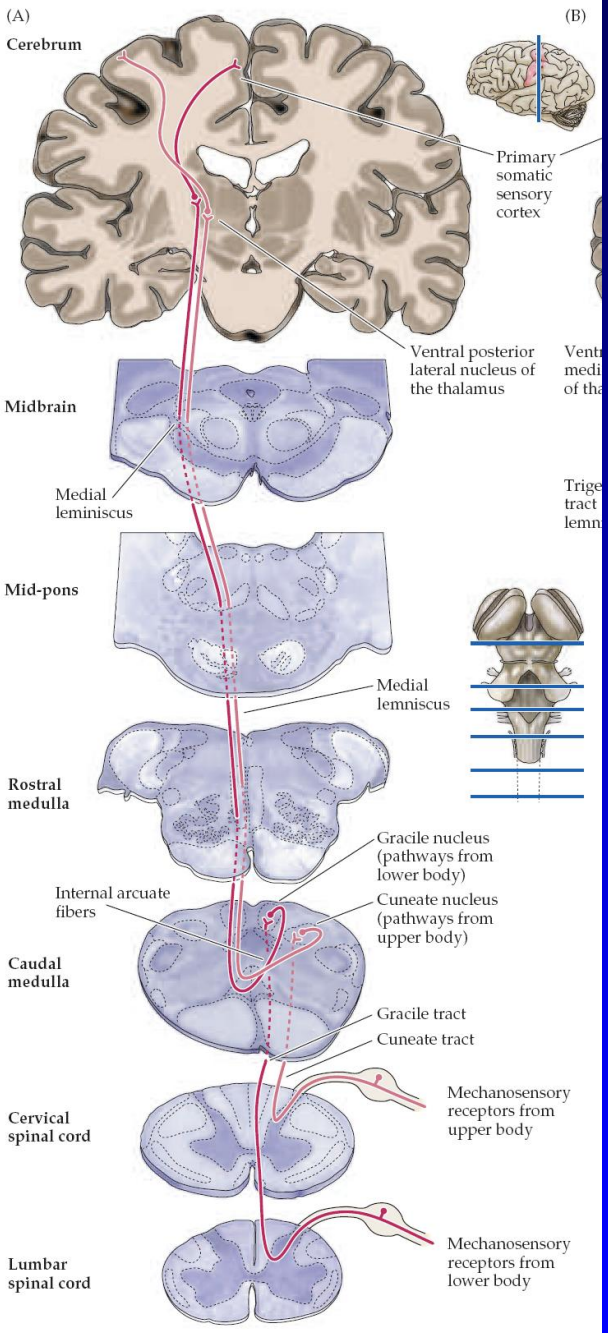
- Temperature
- Crud touch (itch & rub)
- Pain

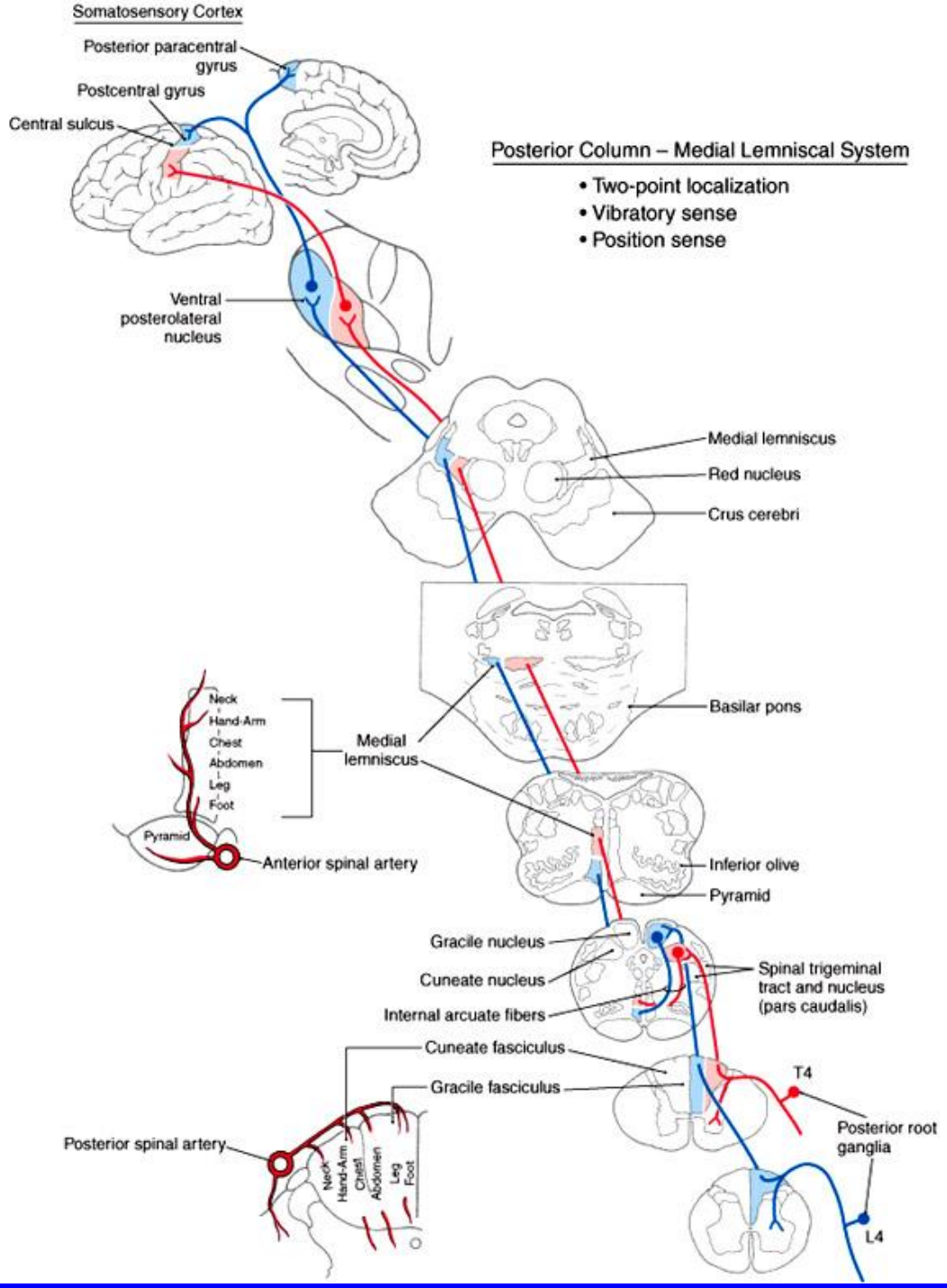
Antero-lateral system (ALS)
Other name: Spinothalamic pathway

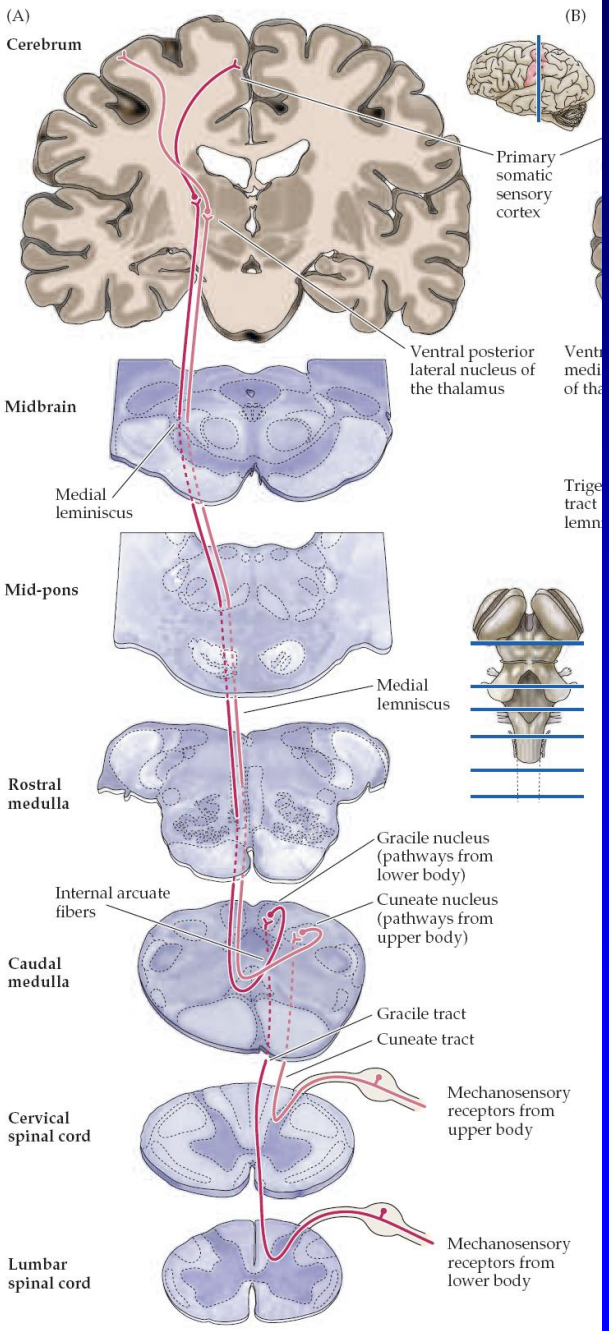
Pressure ??????

Posterior Column-Medial lemniscus Pathway (PCML)

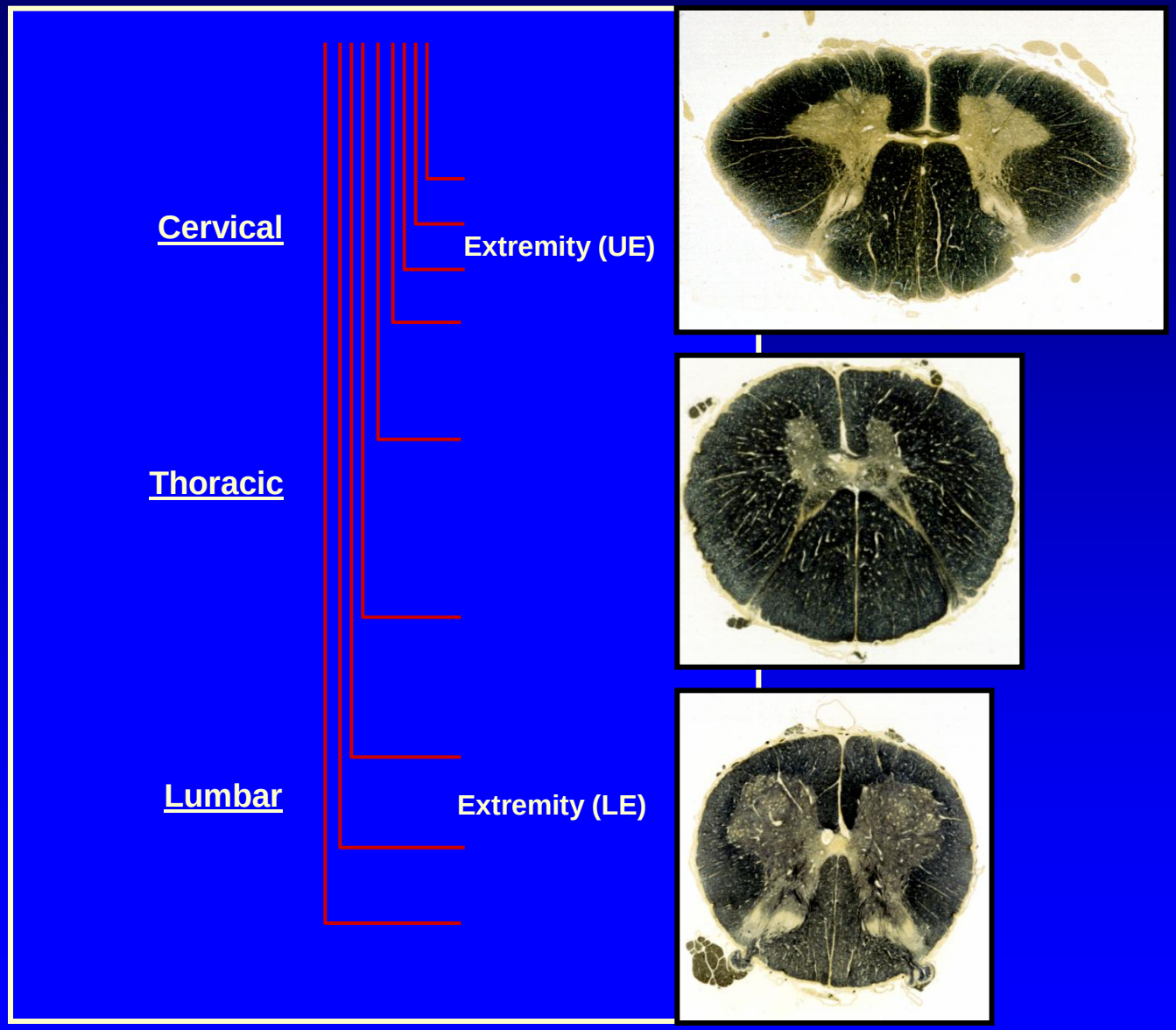

RIGHT SIDE OF BODY
LEFT SIDE OF BODY
Primary somatosensory area of cerebral cortex
THIRD-ORDER NEURONS
Thalamus (ventral posterior nucleus)
Medial lemniscus
Midbrain
SECOND-ORDER NEURONS
Gracile nucleus
Cuneate nucleus
FIRST-ORDER NEURONS
Medulla
POSTERIOR COLUMN:
Posterior root ganglion
Gracile fasciculus
Cuneate fasciculus
Receptors for touch, pressure, vibration, and proprioception in the upper limbs, upper trunk, neck, and posterior head
Spinal nerve
Cervical spinal cord
Receptors for touch pressure, vibration, and stereognosis in the lower limbs and lower trunk
Lumbar spinal cord


(A)
(B)
Cerebrum
Primary somatic sensory cortex
Ventral posterior lateral nucleus of the thalamus
Midbrain
Medial leminiscus
Mid-pons
Medial lemniscus
Rostral medulla
Gracile nucleus (pathways from lower body)
Internal arcuate fibers
Cuneate nucleus (pathways from upper body)
Caudal medulla
Gracile tract
Cuneate tract
Mechanosensory receptors from upper body
Cervical spinal cord
Mechanosensory receptors from lower body
Lumbar spinal cord

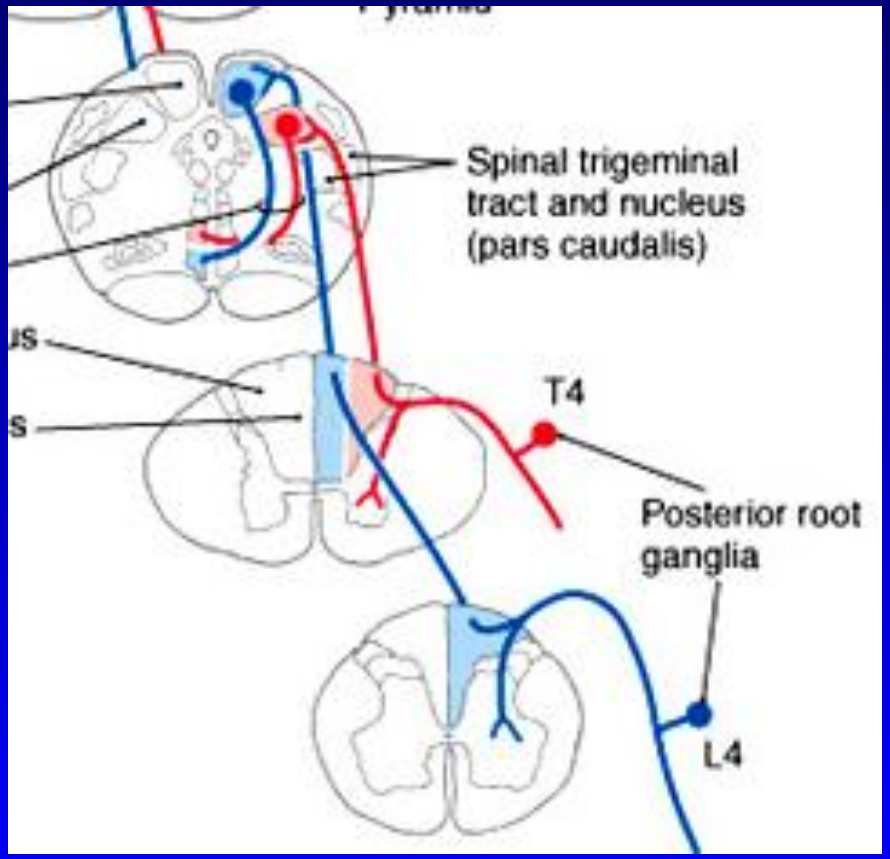

Somatosensory Cortex
Posterior paracentral gyrus
Postcentral gyrus
Central sulcus
Posterior Column – Medial Lemniscal System
• Two-point localization
• Vibratory sense
• Position sense
Ventral posterolateral nucleus
Medial lemniscus
Red nucleus
Crus cerebri
Basilar pons
Neck
Hand-Arm
Chest
Abdomen
Leg
Foot
Pyramid
Medial lemniscus
Anterior spinal artery
Inferior olive
Pyramid
Gracile nucleus
Cuneate nucleus
Internal arcuate fibers
Spinal trigeminal tract and nucleus (pars caudalis)
Cuneate fasciculus
Gracile fasciculus
T4
Posterior root ganglia
Posterior spinal artery
L4

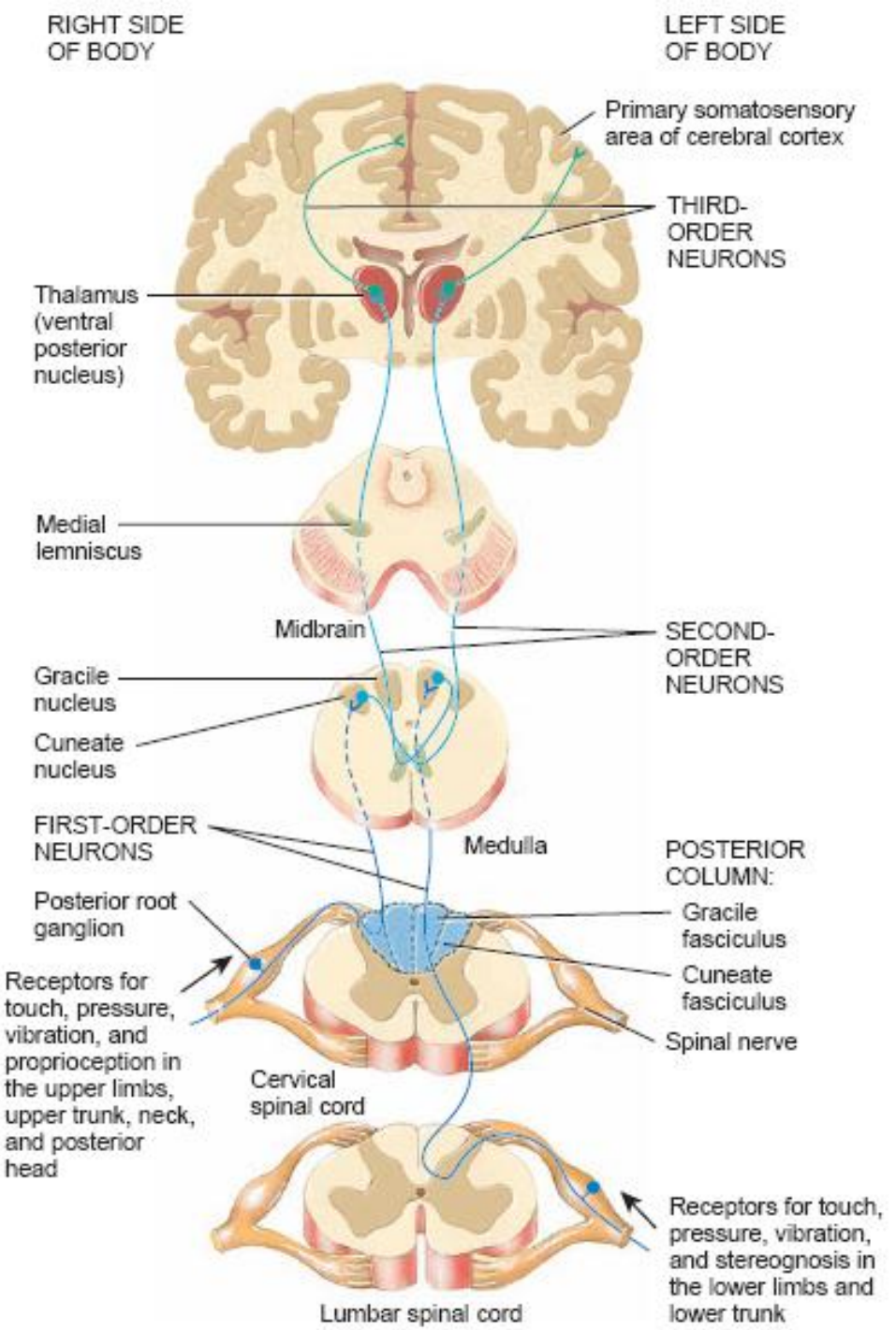

(A)
(B)
Cerebrum
Primary somatic sensory cortex
Ventral posterior lateral nucleus of the thalamus
Midbrain
Medial leminiscus
Mid-pons
Medial lemniscus
Rostral medulla
Gracile nucleus (pathways from lower body)
Internal arcuate fibers
Cuneate nucleus (pathways from upper body)
Caudal medulla
Gracile tract
Cuneate tract
Cervical spinal cord
Mechanosensory receptors from upper body
Lumbar spinal cord
Mechanosensory receptors from lower body

Ascending and Descending Tracts of the Spinal Cord

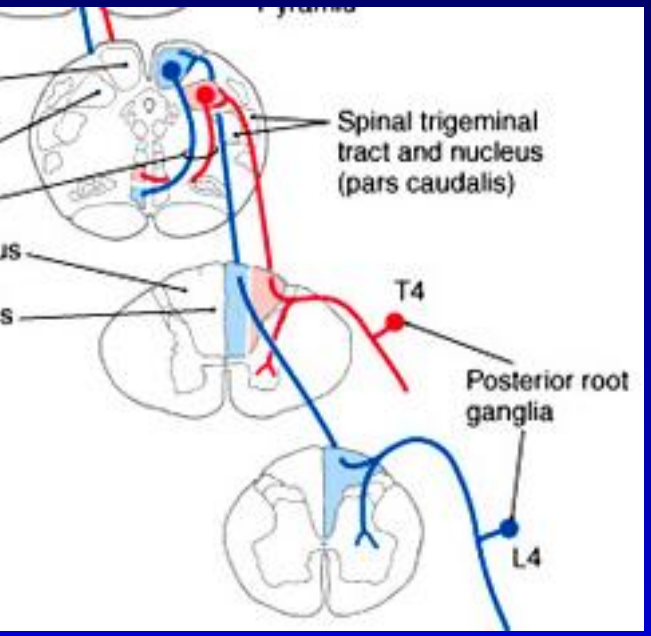


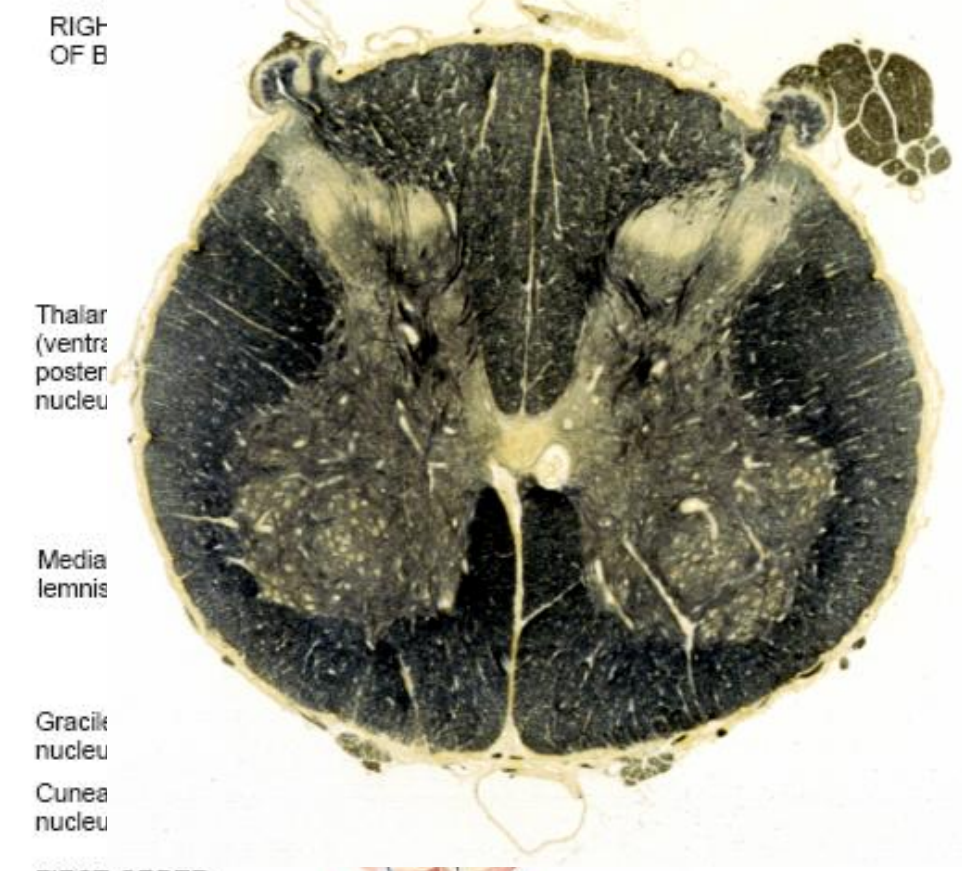
PCML Pathway

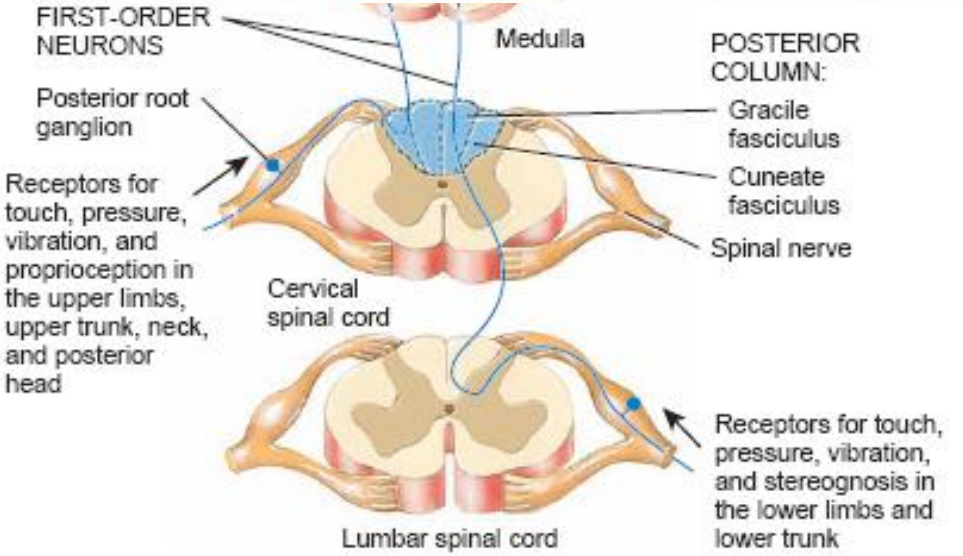




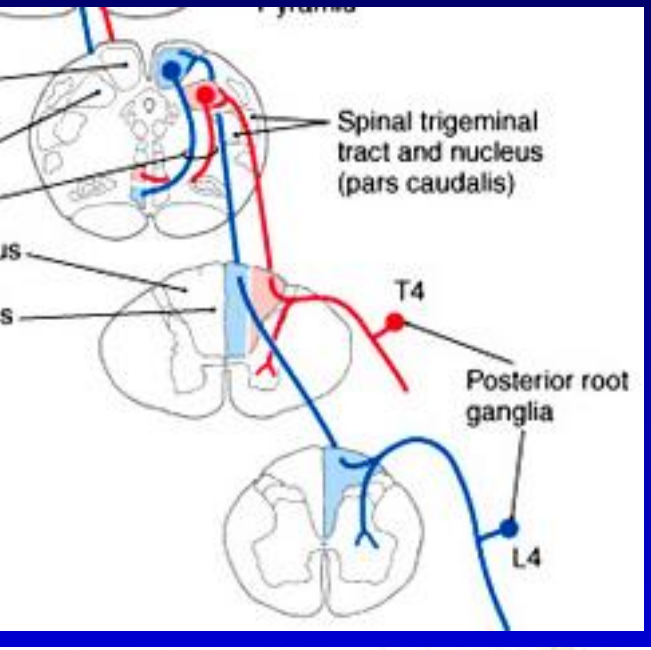
PCML Pathway

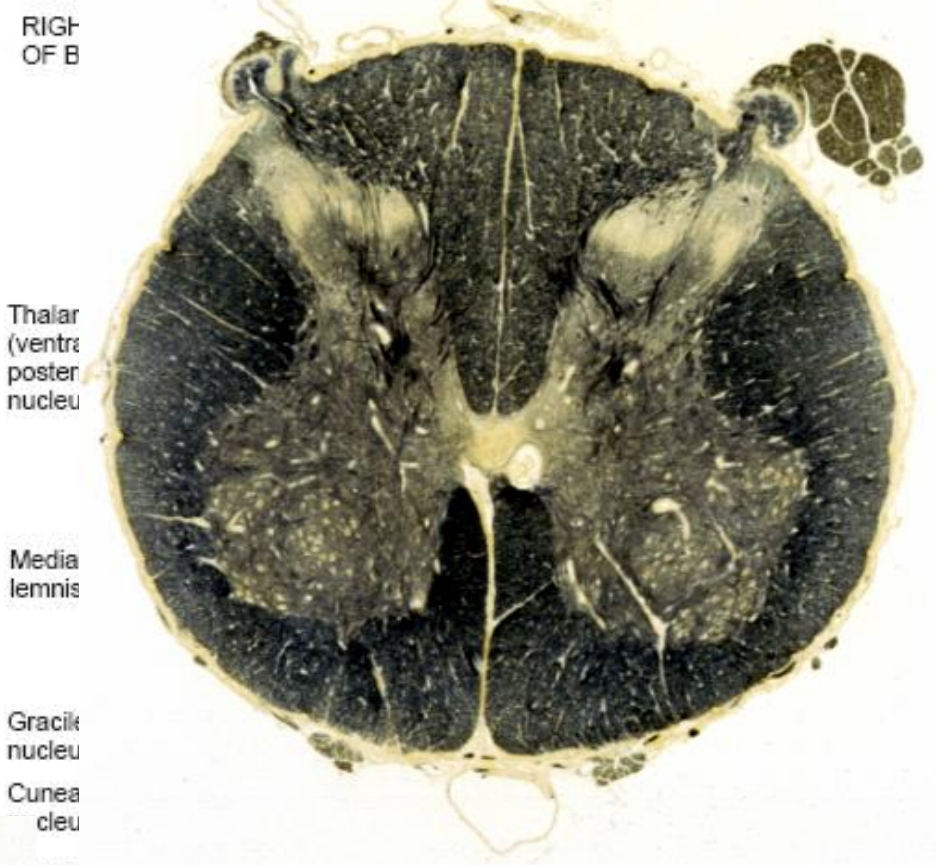


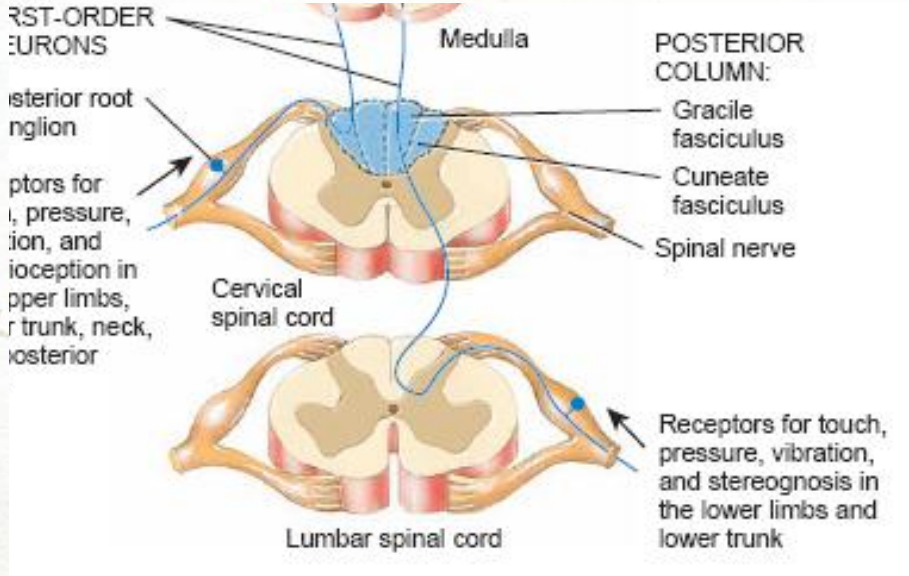




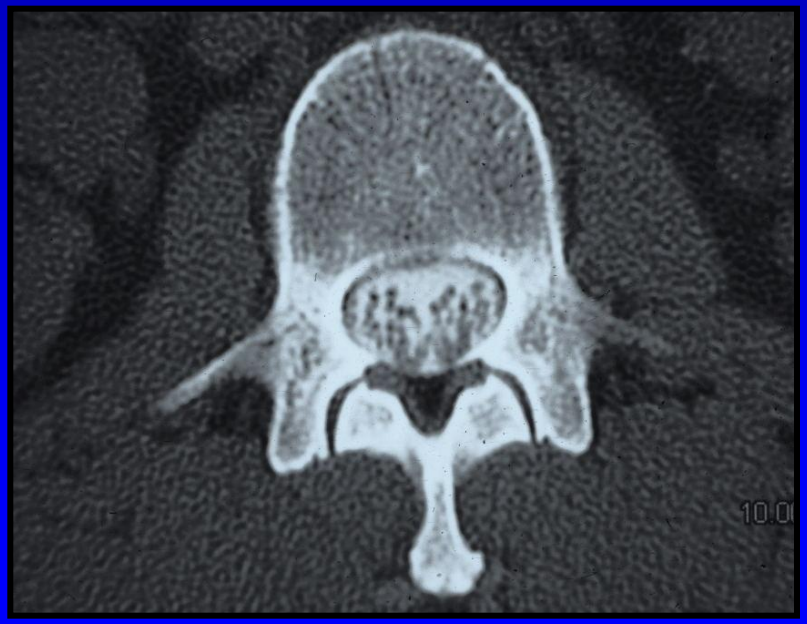
PCML Pathway



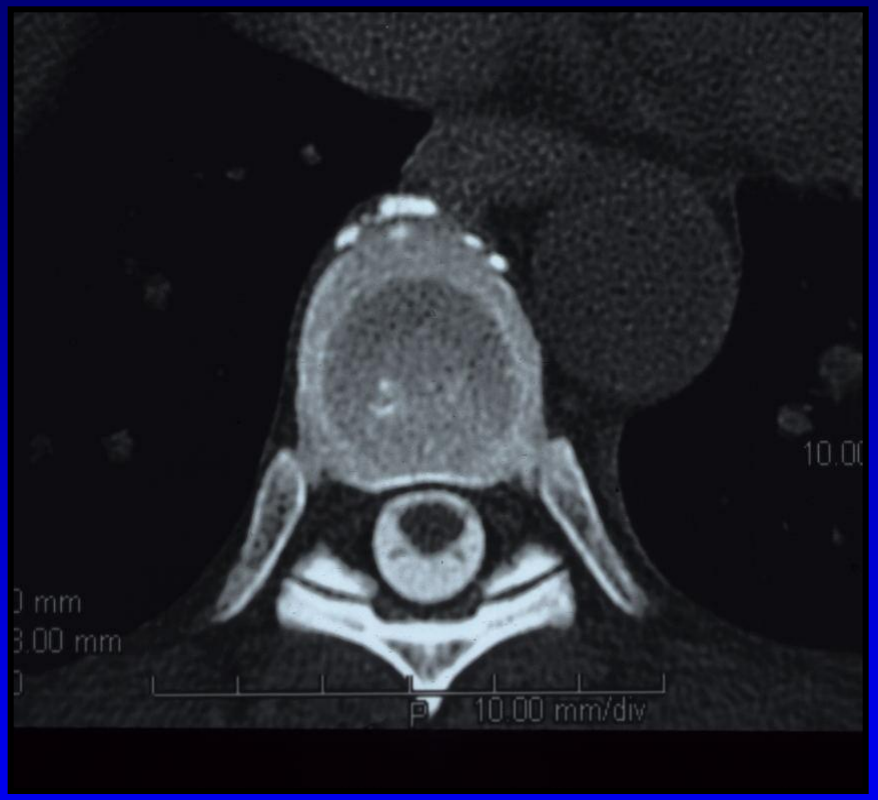




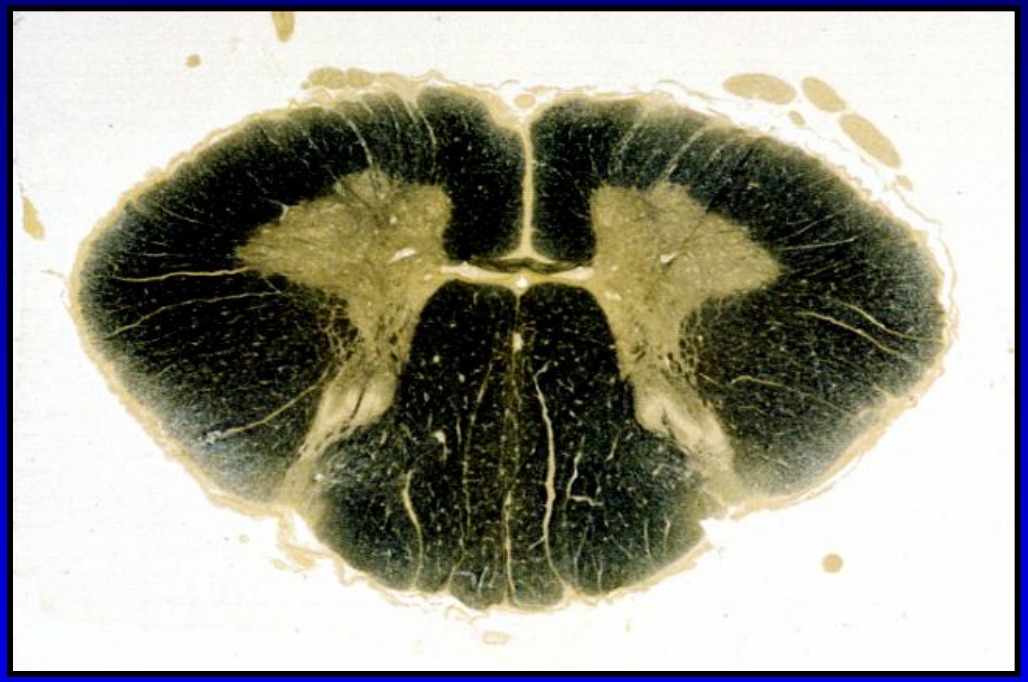
Lumbar Levels

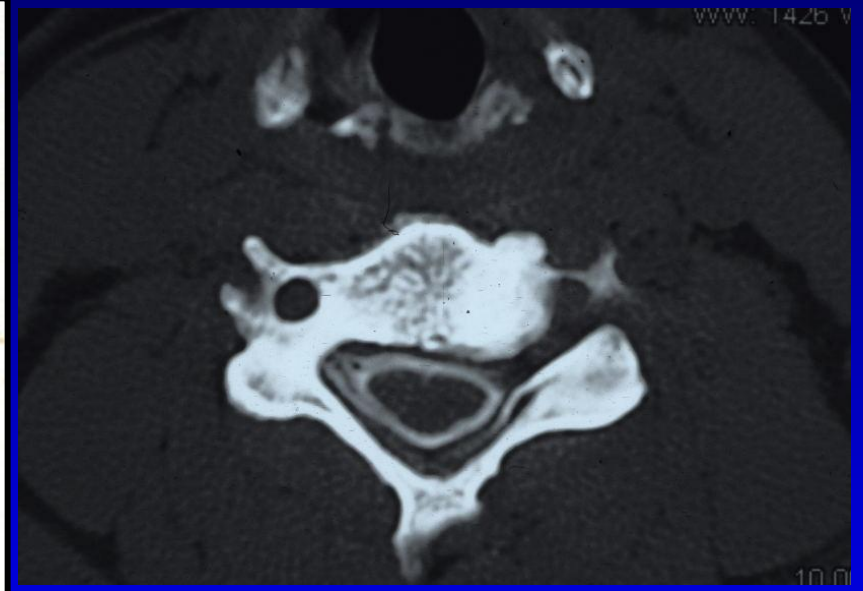


Thoracic Levels

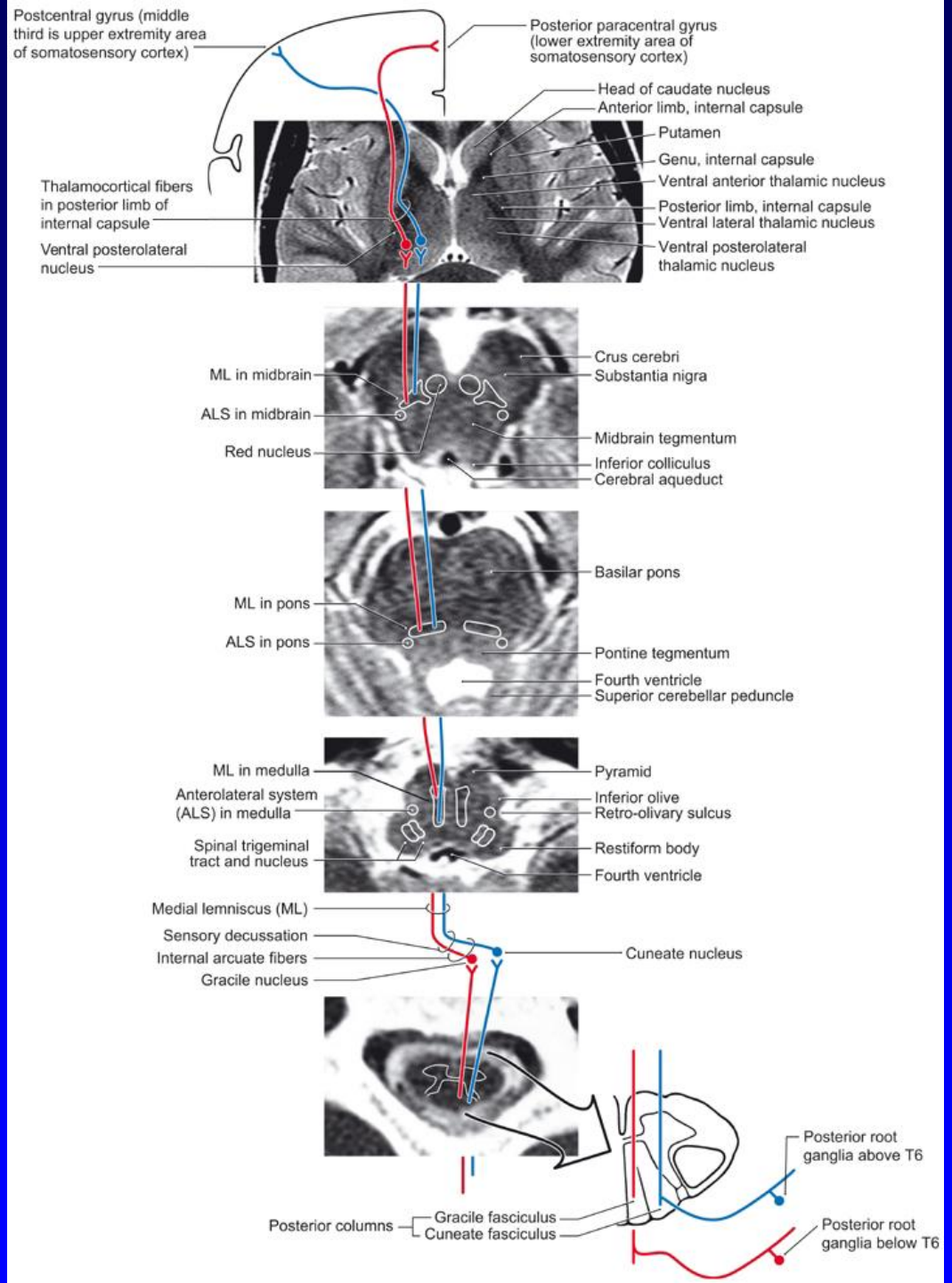


Cervical Levels

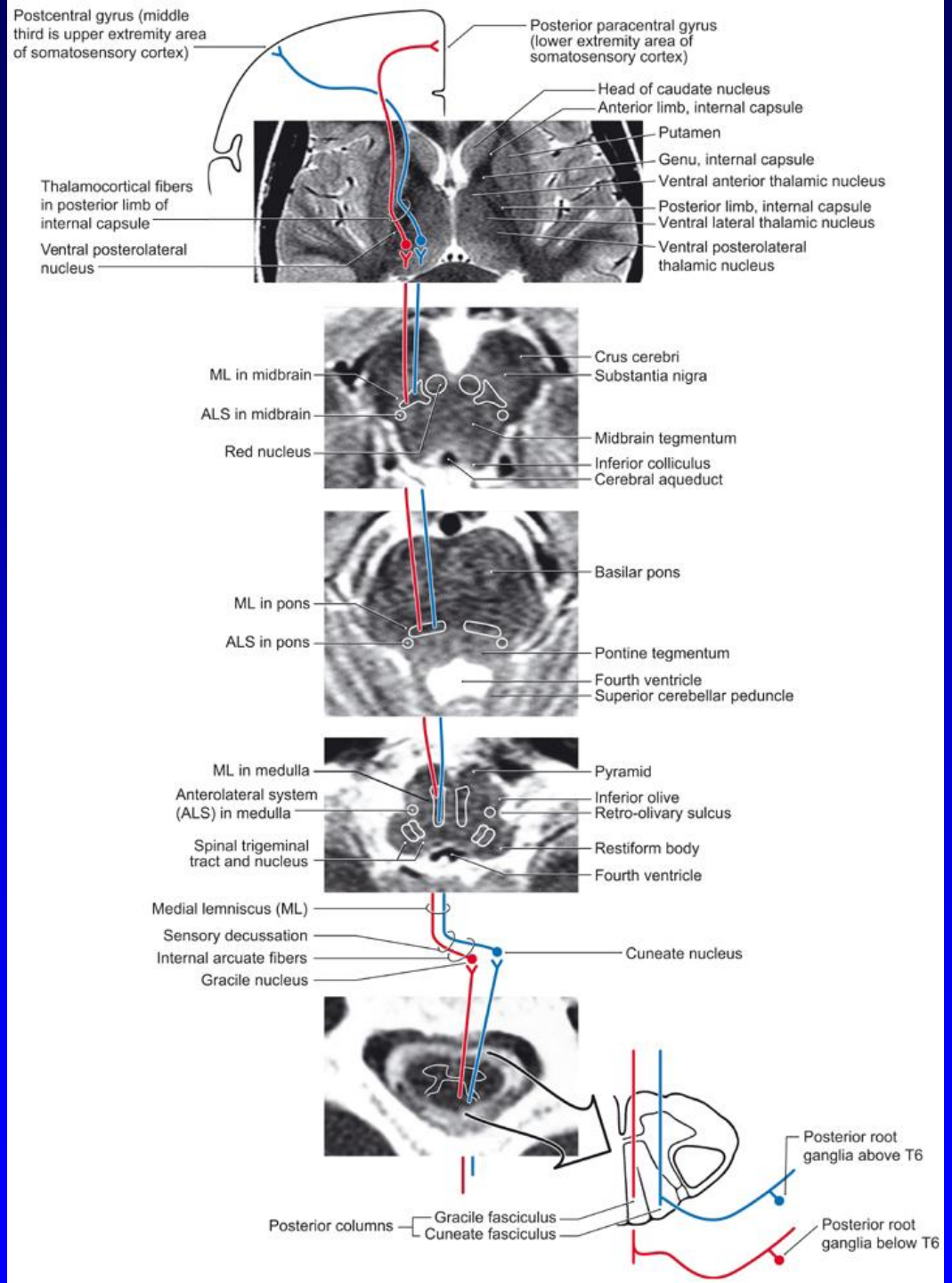




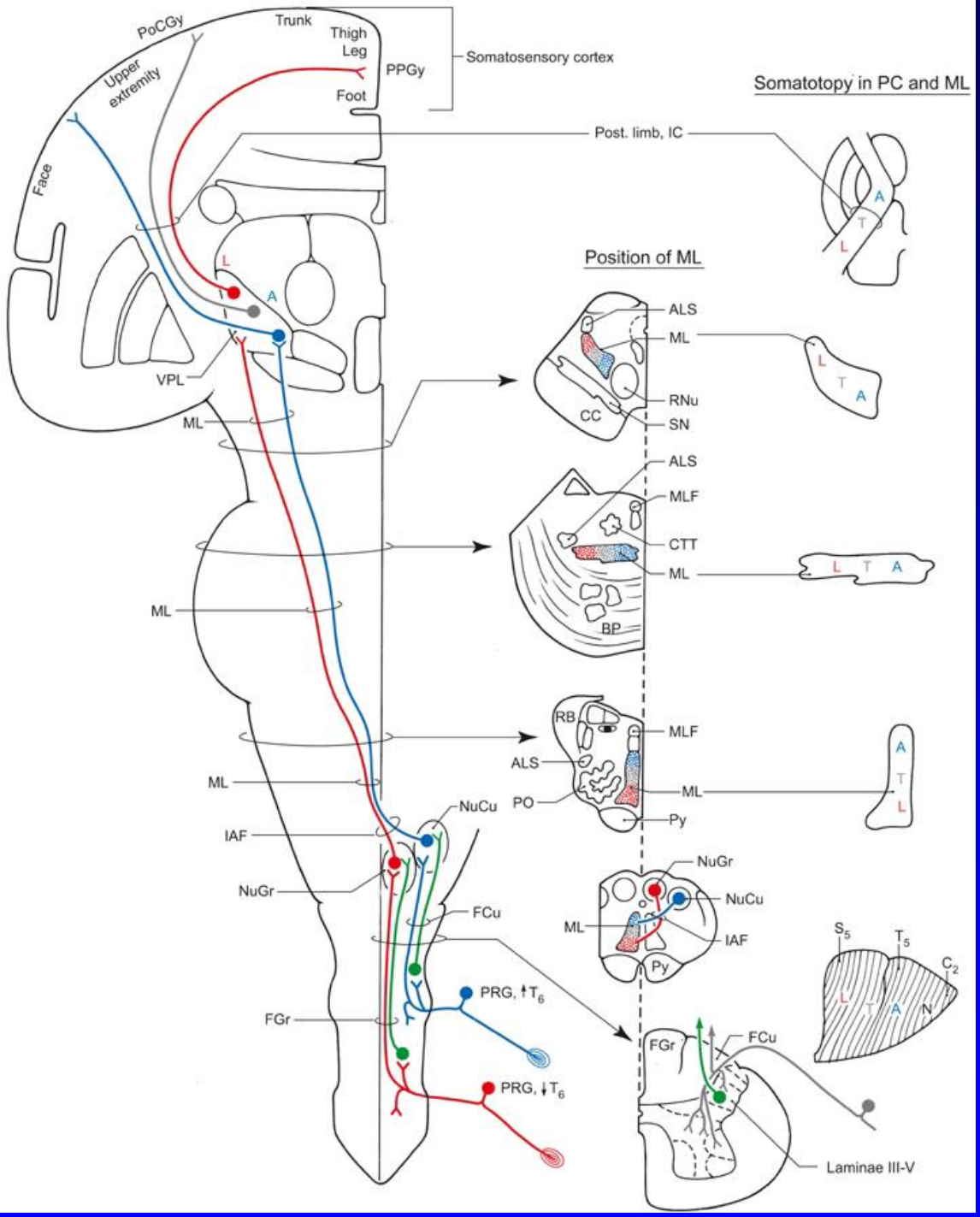
MRI of PCML

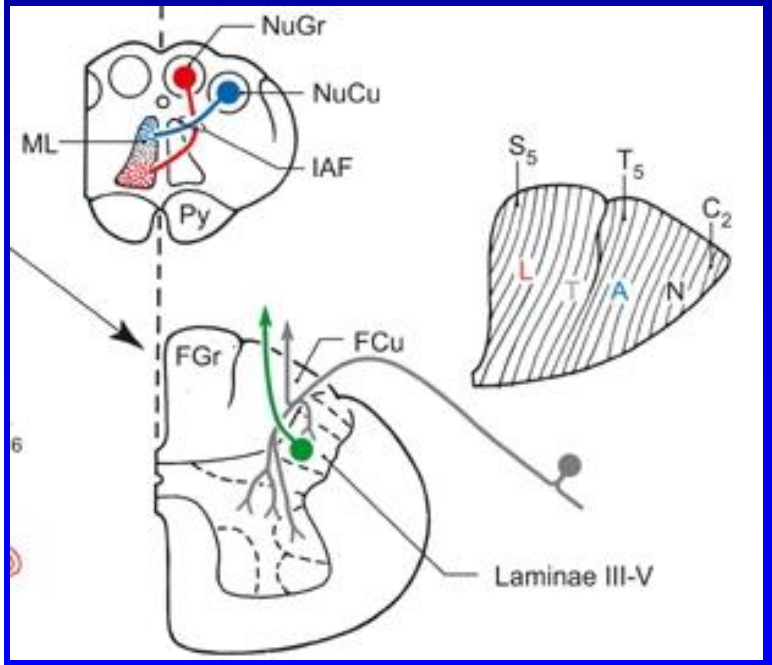

Postcentral gyrus (middle third is upper extremity area of somatosensory cortex)
Posterior paracentral gyrus (lower extremity area of somatosensory cortex)
Head of caudate nucleus
Anterior limb, internal capsule
Putamen
Genu, internal capsule
Ventral anterior thalamic nucleus
Posterior limb, internal capsule
Ventral lateral thalamic nucleus
Ventral posterolateral thalamic nucleus
Thalamocortical fibers in posterior limb of internal capsule
Ventral posterolateral nucleus
ML in midbrain
ALS in midbrain
Red nucleus
Crus cerebri
Substantia nigra
Midbrain tegmentum
Inferior colliculus
Cerebral aqueduct
ML in pons
ALS in pons
Basilar pons
Pontine tegmentum
Fourth ventricle
Superior cerebellar peduncle
ML in medulla
Anterolateral system (ALS) in medulla
Spinal trigeminal tract and nucleus
Pyramid
Inferior olive
Retro-olivary sulcus
Restiform body
Fourth ventricle
Medial lemniscus (ML)
Sensory decussation
Internal arcuate fibers
Gracile nucleus
Cuneate nucleus
Posterior root ganglia above T6
Posterior columns
Gracile fasciculus
Cuneate fasciculus
Posterior root ganglia below T6

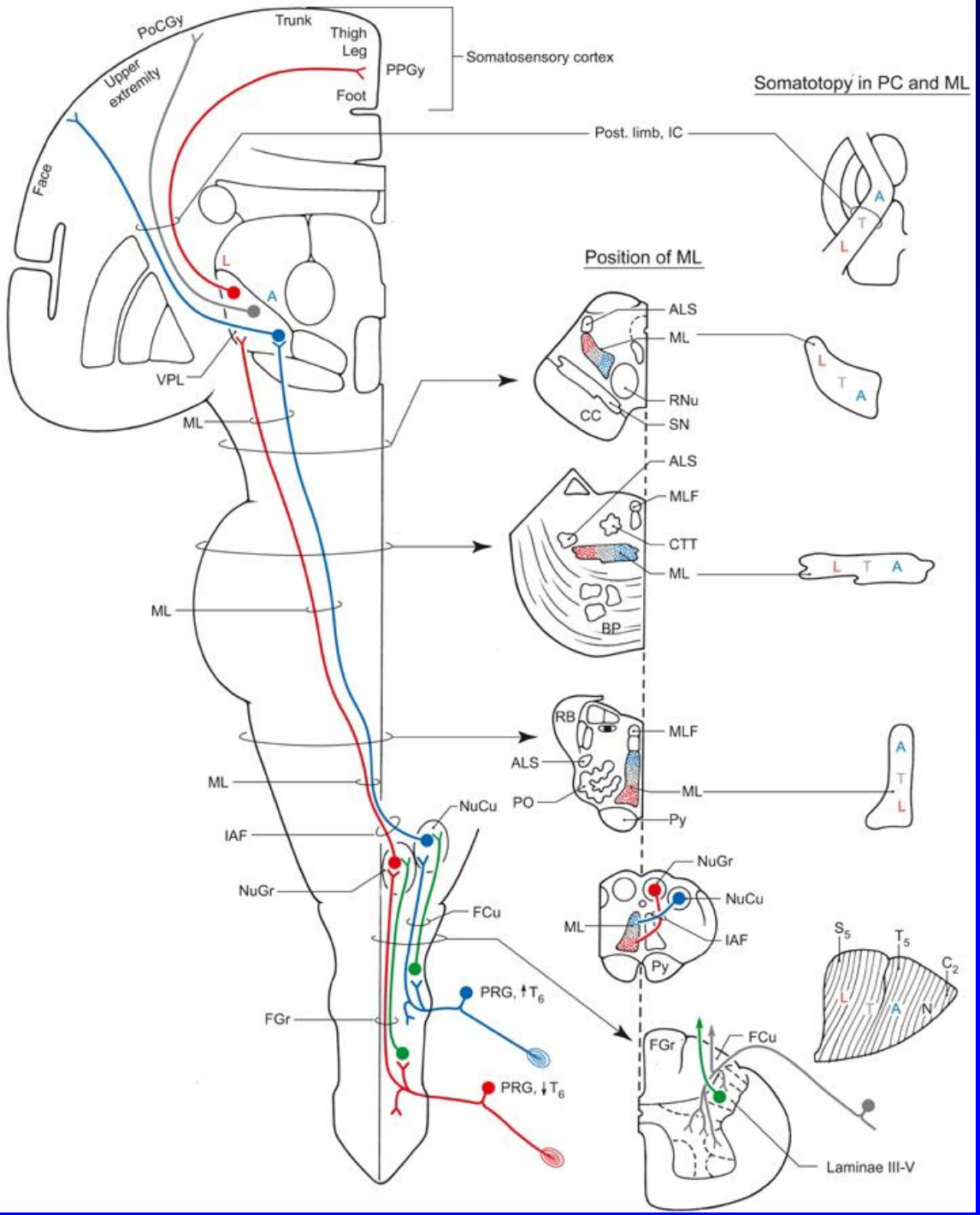
MRI of PCML

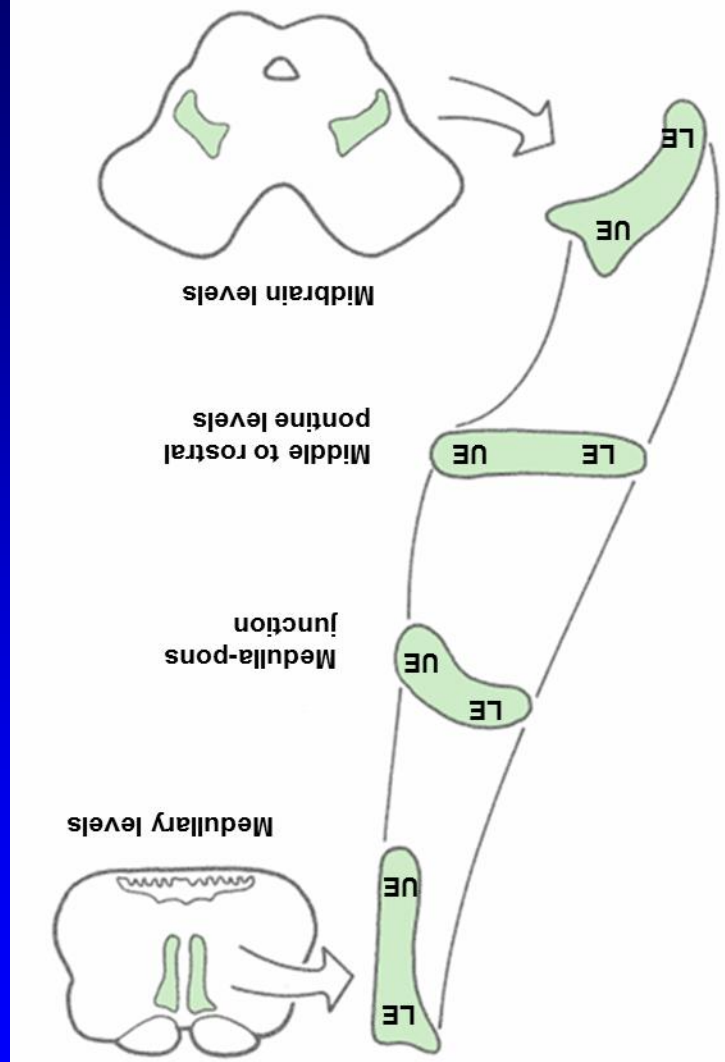

Postcentral gyrus (middle third is upper extremity area of somatosensory cortex)
Posterior paracentral gyrus (lower extremity area of somatosensory cortex)
Head of caudate nucleus
Anterior limb, internal capsule
Putamen
Genu, internal capsule
Ventral anterior thalamic nucleus
Posterior limb, internal capsule
Ventral lateral thalamic nucleus
Ventral posterolateral thalamic nucleus
Thalamocortical fibers in posterior limb of internal capsule
Ventral posterolateral nucleus
ML in midbrain
ALS in midbrain
Red nucleus
Crus cerebri
Substantia nigra
Midbrain tegmentum
Inferior colliculus
Cerebral aqueduct
ML in pons
ALS in pons
Basilar pons
Pontine tegmentum
Fourth ventricle
Superior cerebellar peduncle
ML in medulla
Anterolateral system (ALS) in medulla
Spinal trigeminal tract and nucleus
Pyramid
Inferior olive
Retro-olivary sulcus
Restiform body
Fourth ventricle
Medial lemniscus (ML)
Sensory decussation
Internal arcuate fibers
Gracile nucleus
Cuneate nucleus
Posterior root ganglia above T6
Posterior columns
Gracile fasciculus
Cuneate fasciculus
Posterior root ganglia below T6

Somatotopic organization of (PCML)


PoCGy
Trunk
Thigh
Leg
PPGy
Somatosensory cortex
Upper extremity
Foot
Face
Somatotopy in PC and ML
Post. limb, IC
A
T
L
Position of ML
L
A
VPL
ML
ALS
ML
RNu
CC
SN
L
T
A
ALS
MLF
CTT
ML
BP
L T A
ML
RB
MLF
ALS
ML
PO
Py
A
T
L
ML
NuCu
IAF
NuGr
FCu
NuGr
NuCu
ML
IAF
Py
S5
T5
C2
L
T
A
N
PRG, ↓T6
FGr
PRG, ↓T6
FGr
FCu
Laminae III-V


NuGr
NuCu
ML
IAF
Py
S5
T5
C2
L
T
A
N
FGr
FCu
Laminae III-V


PoCGy
Trunk
Thigh
Leg
PPGy
Foot
Upper extremity
Face
Somatosensory cortex
Somatotopy in PC and ML
Post. limb, IC
Position of ML
VPL
ML
ALS
MLF
CTT
RB
BP
CC
RNu
SN
PO
Py
NuCu
IAF
NuGr
FCu
FGr
PRG, ↓T6
Laminae III-V
S5
T5
C2


Midbrain levels
Middle to rostral pontine levels
Medulla-pons junction
Medullary levels
UE
LE

PCML Function

- 2-point discrimination
- Vibration
- Prorioception

PCML Function

- 2-point discrimination
- Vibration
- Prorioception

❖ **STEREOGNOSIS**

PCML Function

- 2-point discrimination
- Vibration
- Prorioception

❖ **STEREOGNOSIS**

❖ **GRAPHESTHESIA**

PCML Function

- 2-point discrimination
- Vibration
- Prorioception

❖ **STEREOGNOSIS**

❖ **GRAPHESTHESIA**

❖ **Help in movement and Wight recognition**

PCML lesion associated symptoms

- Loss of 2-point discrimination sensation
- loss of Vibration sensation
- Loss Prorioception sensation

PCML lesion associated symptoms

- Loss of 2-point discrimination sensation
- loss of Vibration sensation
- Loss Prorioception sensation

❖ **ASTEREOGNOSIS / STEREOGNOSIA**

PCML lesion associated symptoms

- Loss of 2-point discrimination sensation
- loss of Vibration sensation
- Loss Prorioception sensation

  - **ASTEREOGNOSIS / STEREOGNOSIA**
  - **AGRAPHESTHESIA**
  - **ABAROGNOSIS**
  - **SENSORY ATAXIA**

PCML lesion associated symptoms

- Loss of 2-point discrimination sensation
- loss of Vibration sensation
- Loss Prorioception sensation

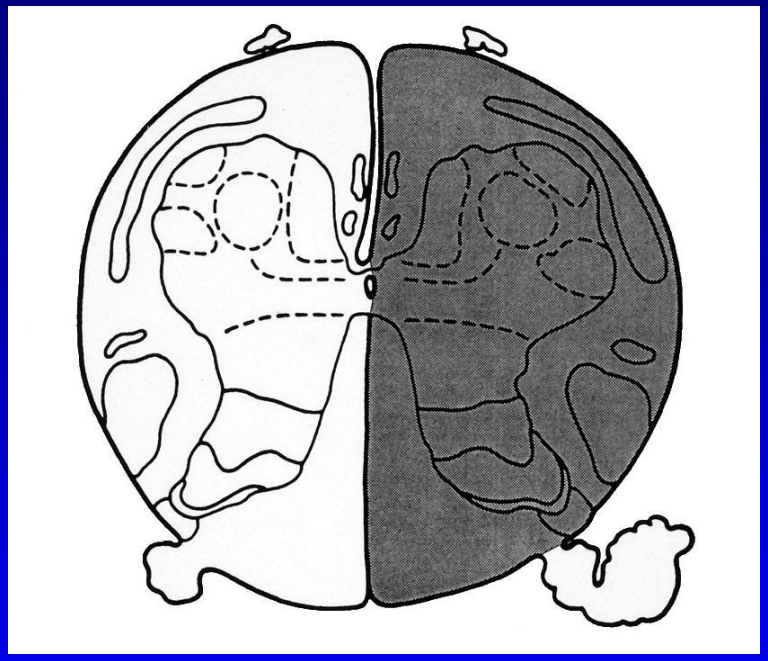
  - **ASTEREOGNOSIS / STEREOGNOSIA**
  - **AGRAPHESTHESIA**
  - **ABAROGNOSIS**
  - **SENSORY ATAXIA**

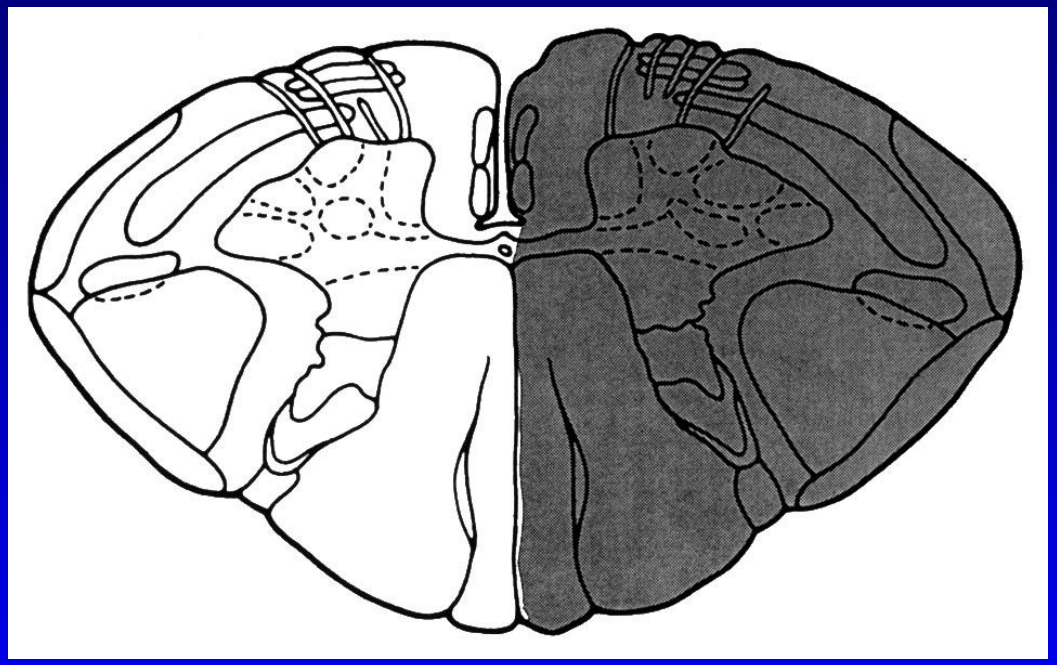
PCML lesion associated symptoms

- Loss of 2-point discrimination sensation
- loss of Vibration sensation
- Loss Prorioception sensation

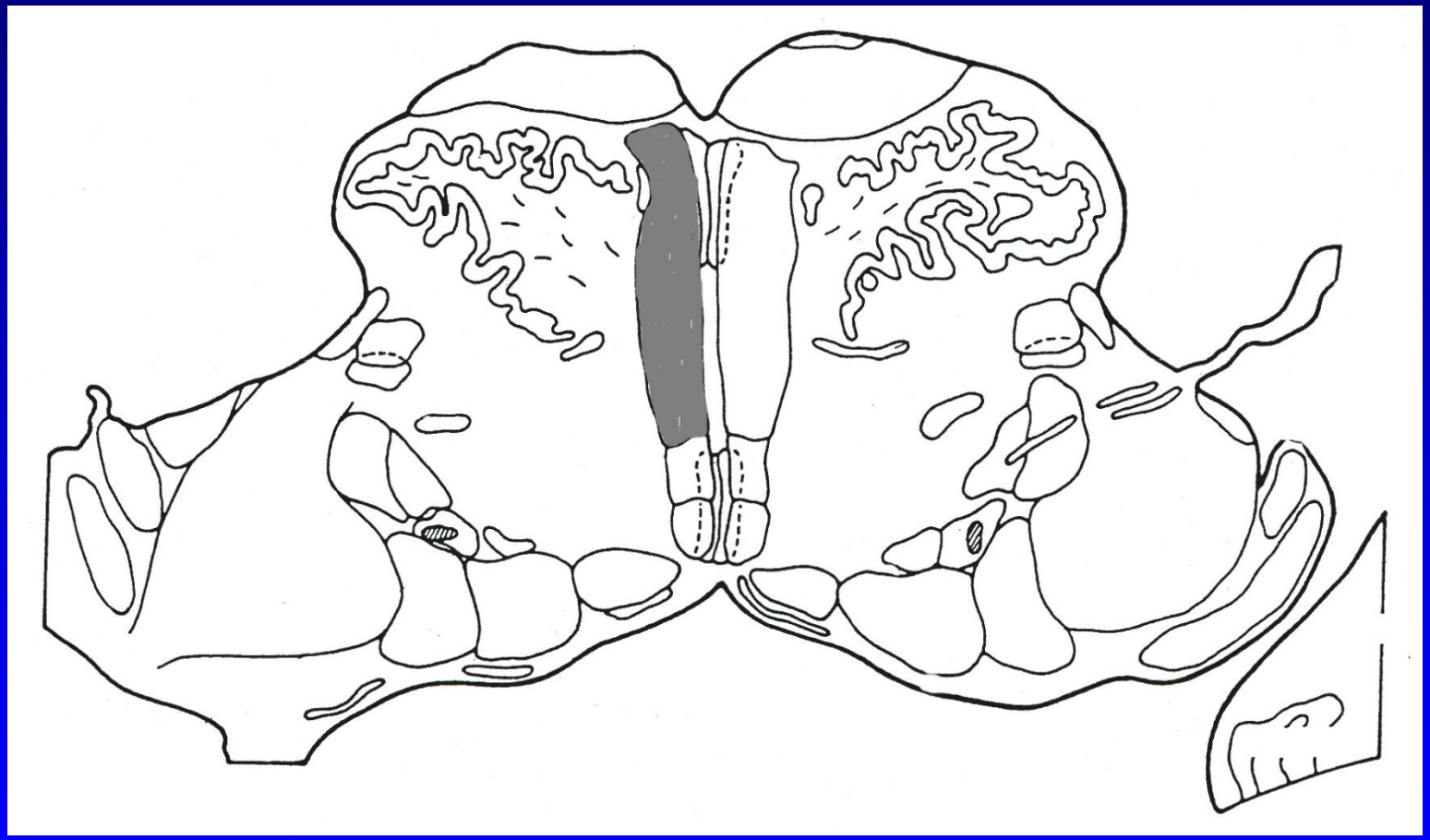
  - **ASTEREOGNOSIS / STEREOGNOSIA**
  - **AGRAPHESTHESIA**
  - **ABAROGNOSIS**
  - **SENSORY ATAXIA**

Case Study





Case Study



Antero-lateral system (ALS)

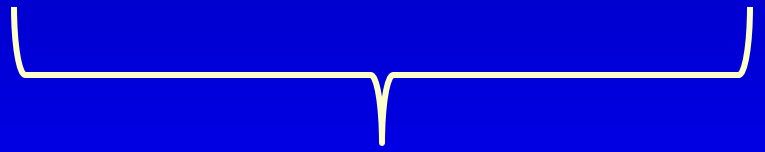
Sensations modalities

Fast

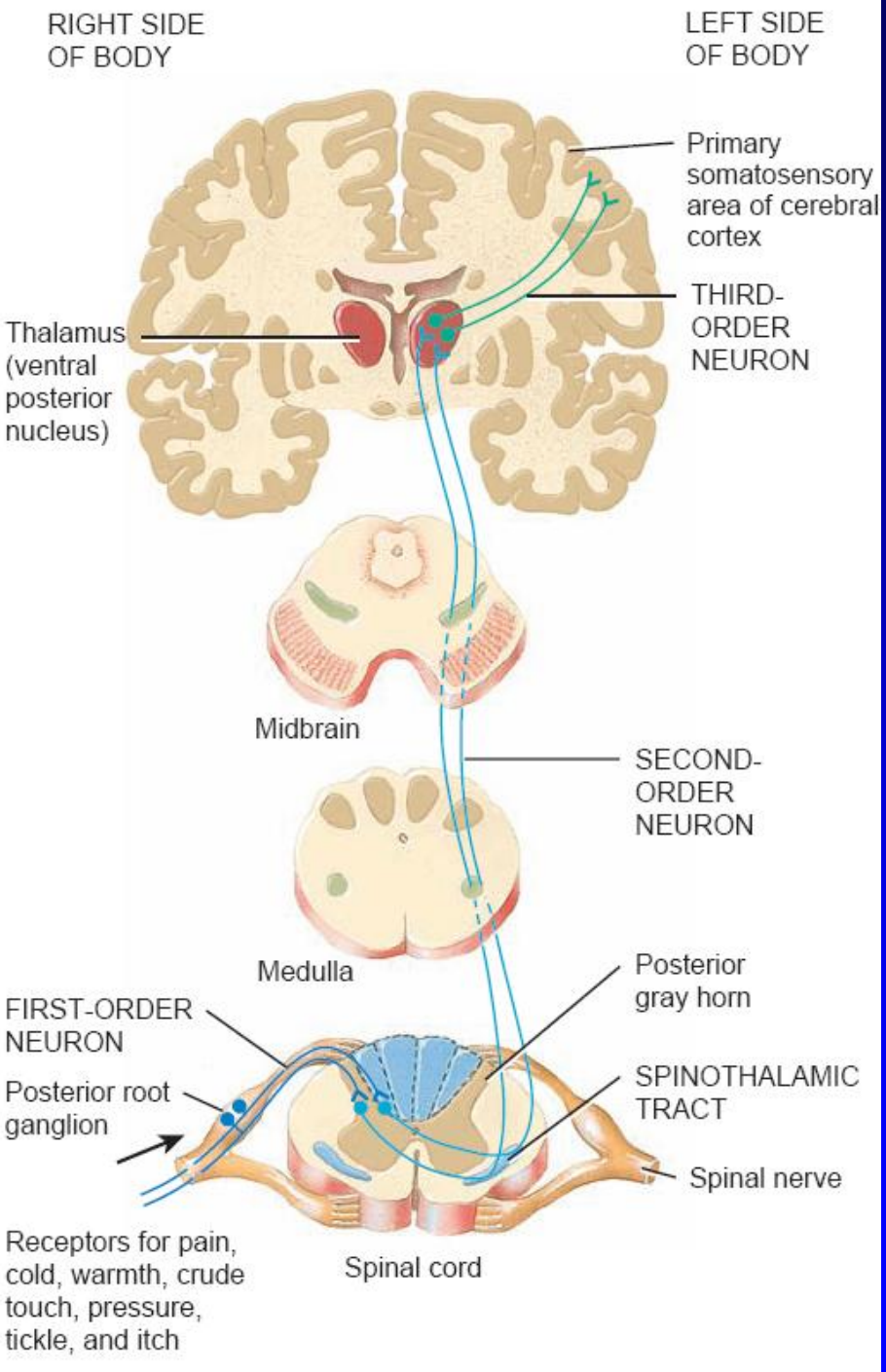
- 2-point discrimination
- Vibration
- Prorioception

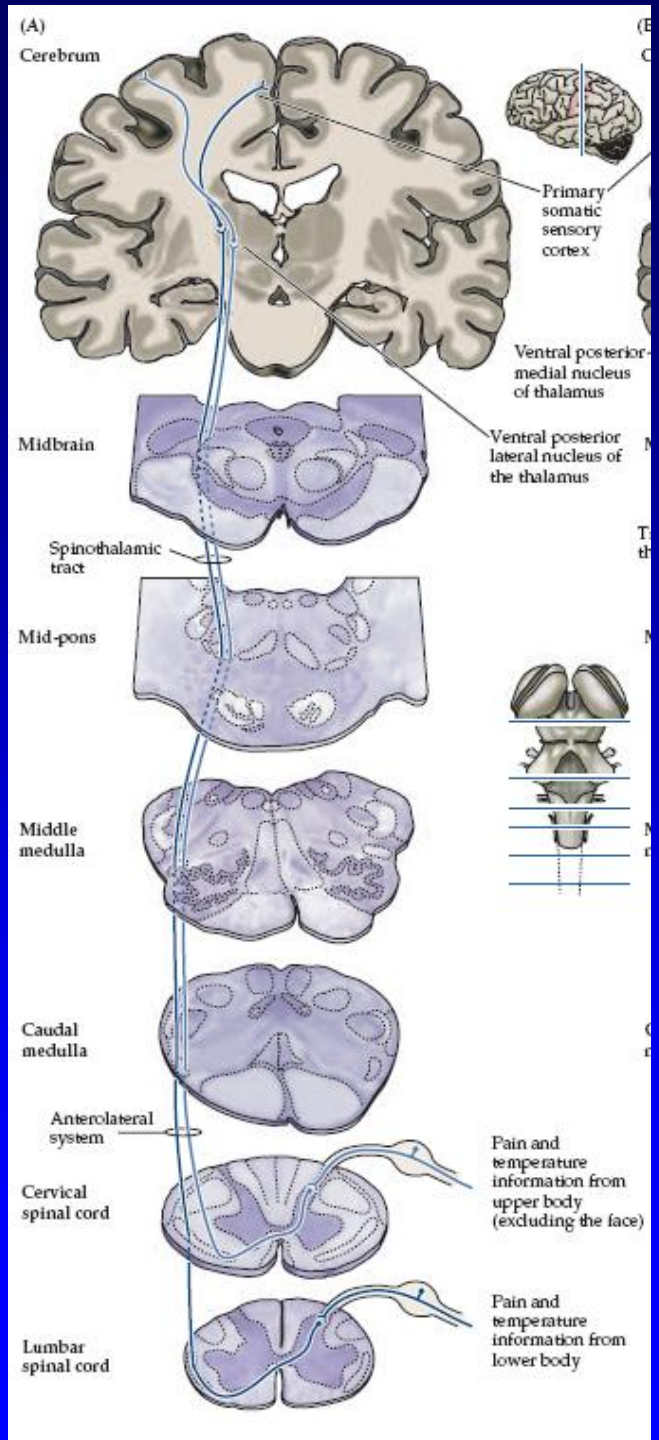
Slow

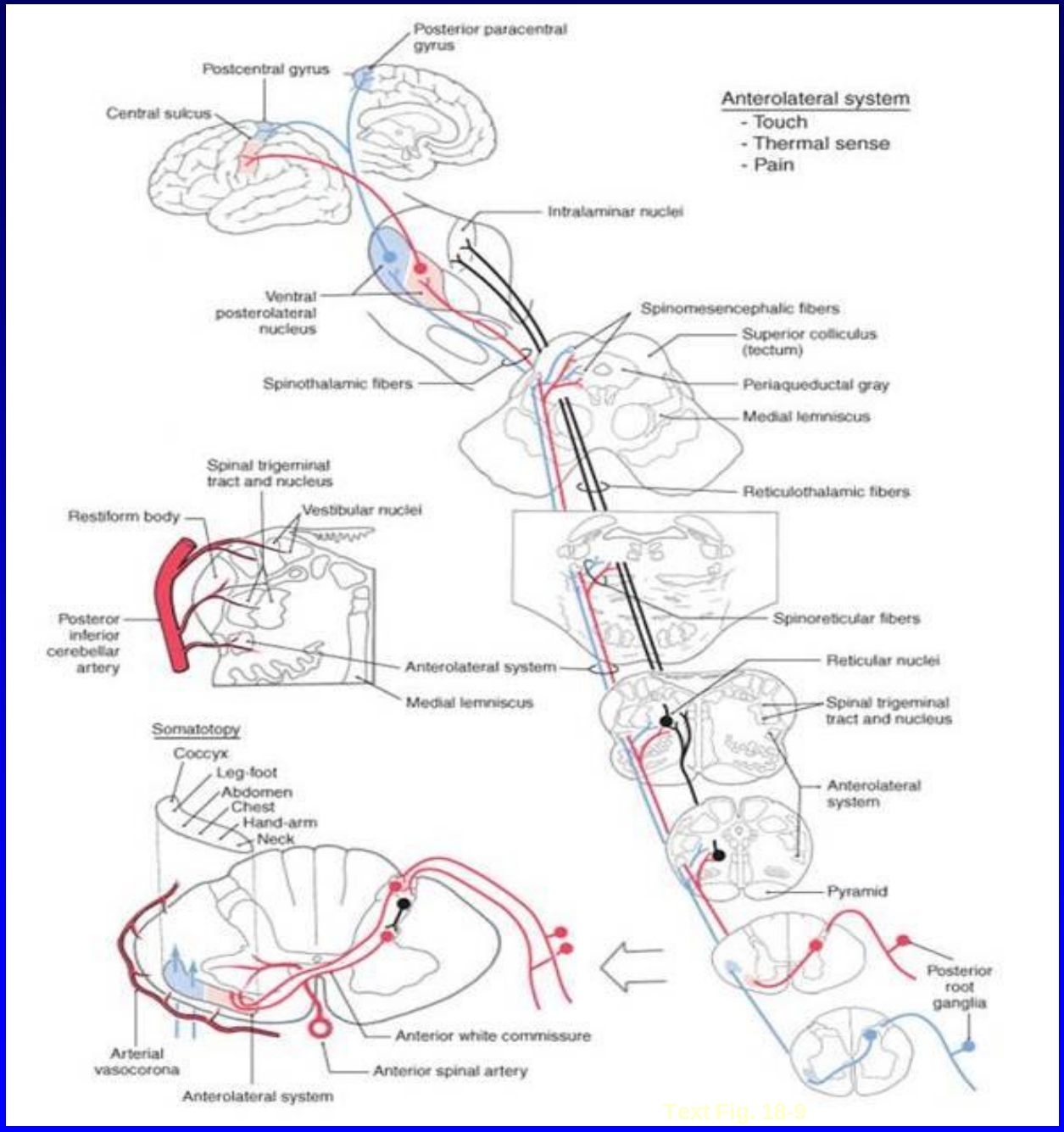
- Temperature
- Crud touch (itch & rub)
- Pain



Antero-lateral system (ALS)
Other name: Spinothalamic pathway

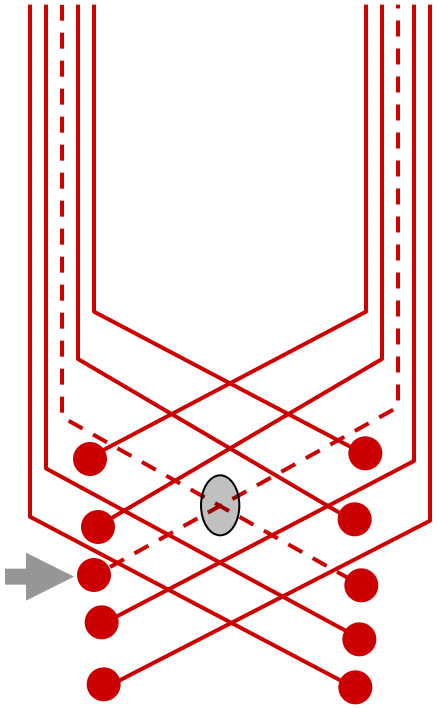

RIGHT SIDE OF BODY
LEFT SIDE OF BODY
Primary somatosensory area of cerebral cortex
THIRD-ORDER NEURON
Thalamus (ventral posterior nucleus)
Midbrain
SECOND-ORDER NEURON
Medulla
Posterior gray horn
FIRST-ORDER NEURON
SPINOTHALAMIC TRACT
Posterior root ganglion
Spinal nerve
Receptors for pain, cold, warmth, crude touch, pressure, tickle, and itch
Spinal cord


(A)
Cerebrum
Primary somatic sensory cortex
Ventral posterior medial nucleus of thalamus
Ventral posterior lateral nucleus of the thalamus
Midbrain
Spinothalamic tract
Mid-pons
Middle medulla
Caudal medulla
Anterolateral system
Cervical spinal cord
Pain and temperature information from upper body (excluding the face)
Lumbar spinal cord
Pain and temperature information from lower body

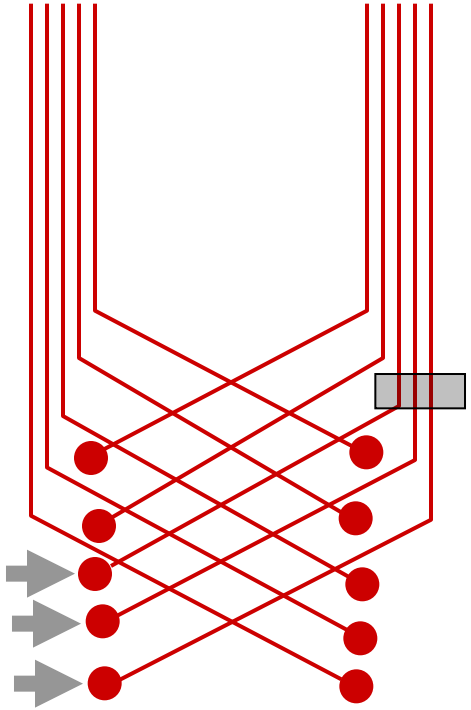

Posterior paracentral gyrus
Postcentral gyrus
Central sulcus
Anterolateral system
- Touch
- Thermal sense
- Pain
Intralaminar nuclei
Ventral posterolateral nucleus
Spinothalamic fibers
Spinomesencephalic fibers
Superior colliculus (tectum)
Periaqueductal gray
Medial lemniscus
Reticulothalamic fibers
Spinal trigeminal tract and nucleus
Restiform body
Vestibular nuclei
Posterior inferior cerebellar artery
Anterolateral system
Medial lemniscus
Spinoreticular fibers
Reticular nuclei
Spinal trigeminal tract and nucleus
Anterolateral system
Pyramid
Posterior root ganglia
Somatotopy
Coccyx
Leg-foot
Abdomen
Chest
Hand-arm
Neck
Anterior white commissure
Anterior spinal artery
Arterial vasocorona
Anterolateral system

Text Fig. 18-9

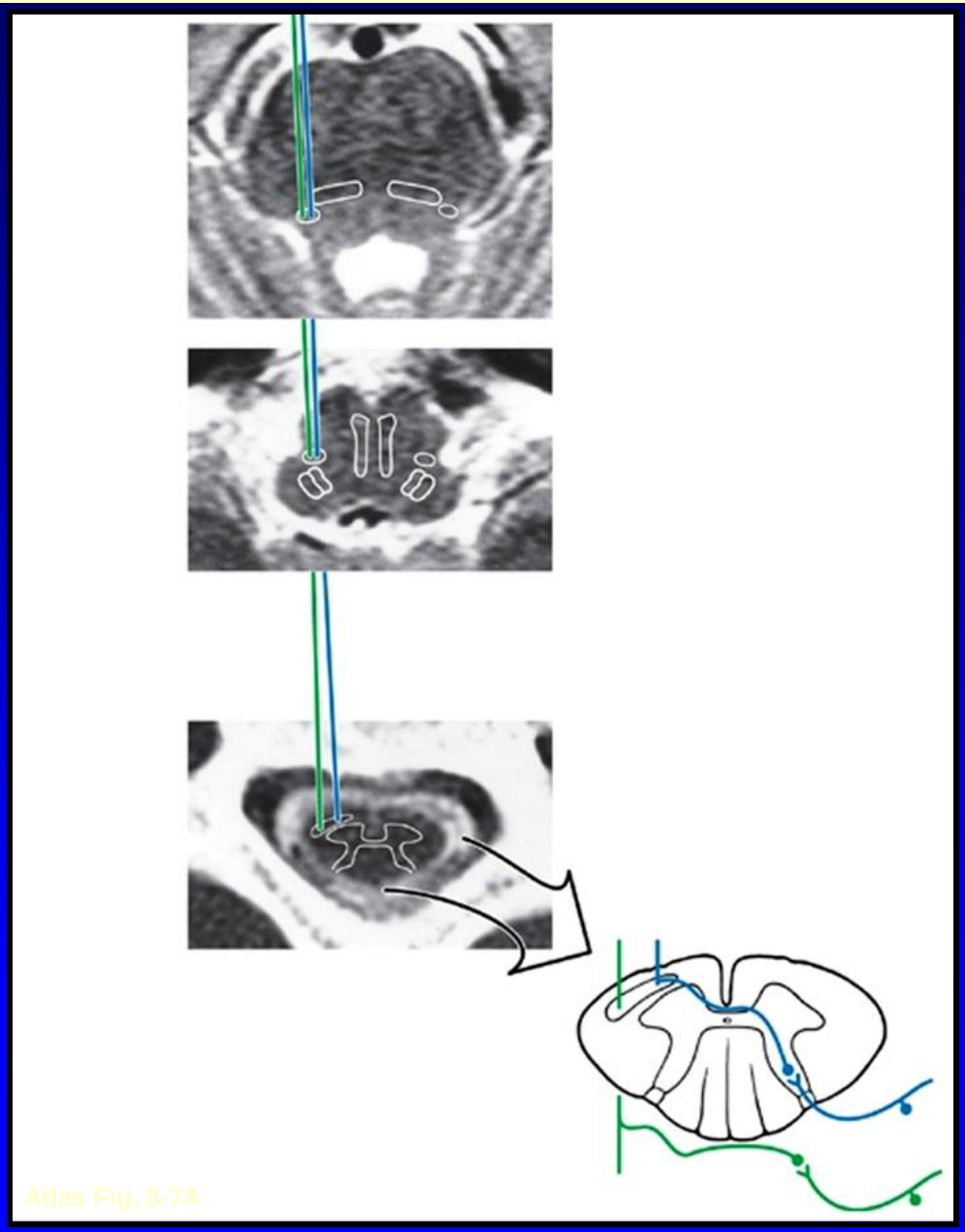
Syringomyelia and the ALS



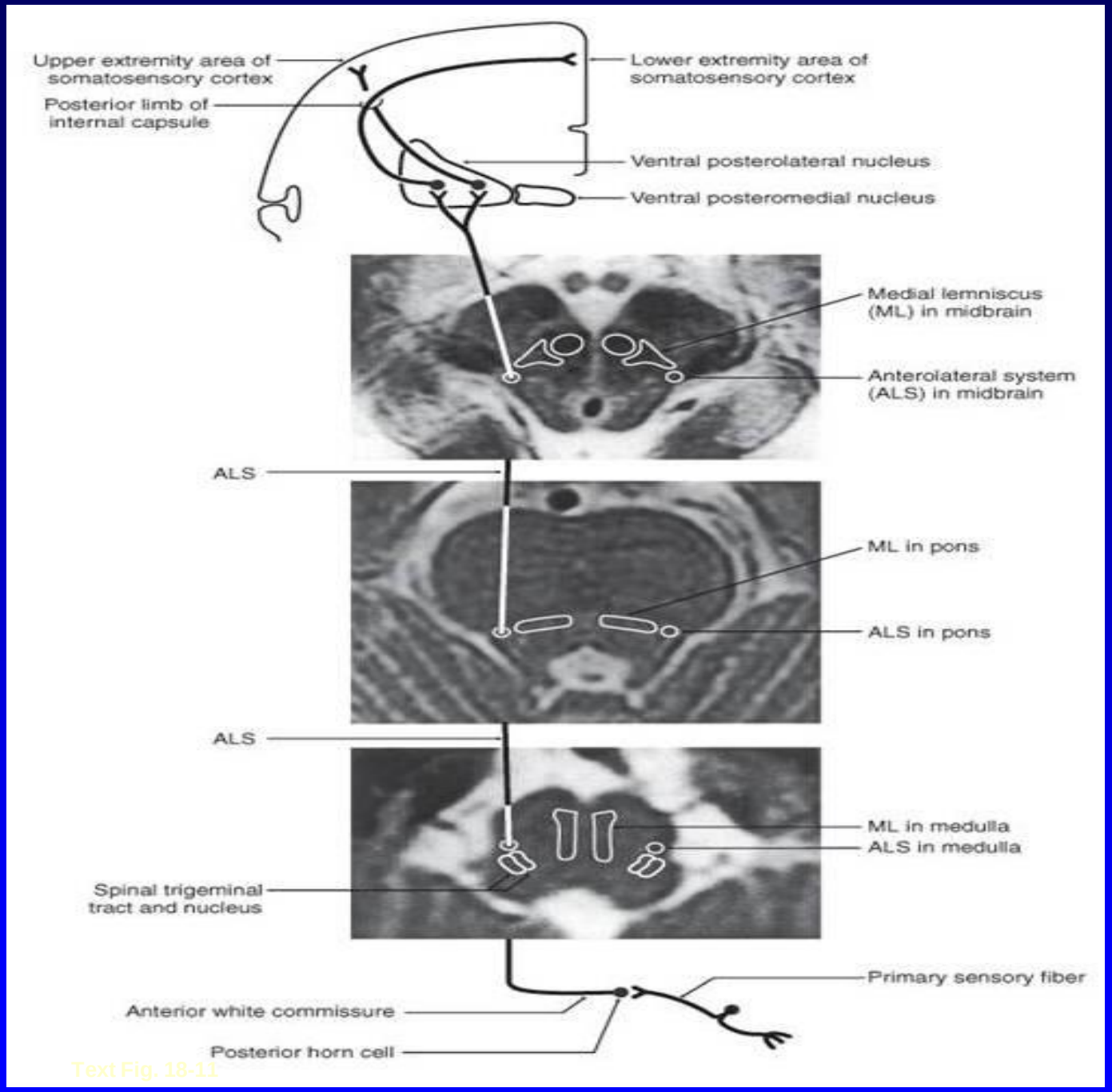
Spinal cord Hemisection and the ALS



The ALS in the Spinal Cord, Medulla and Pons

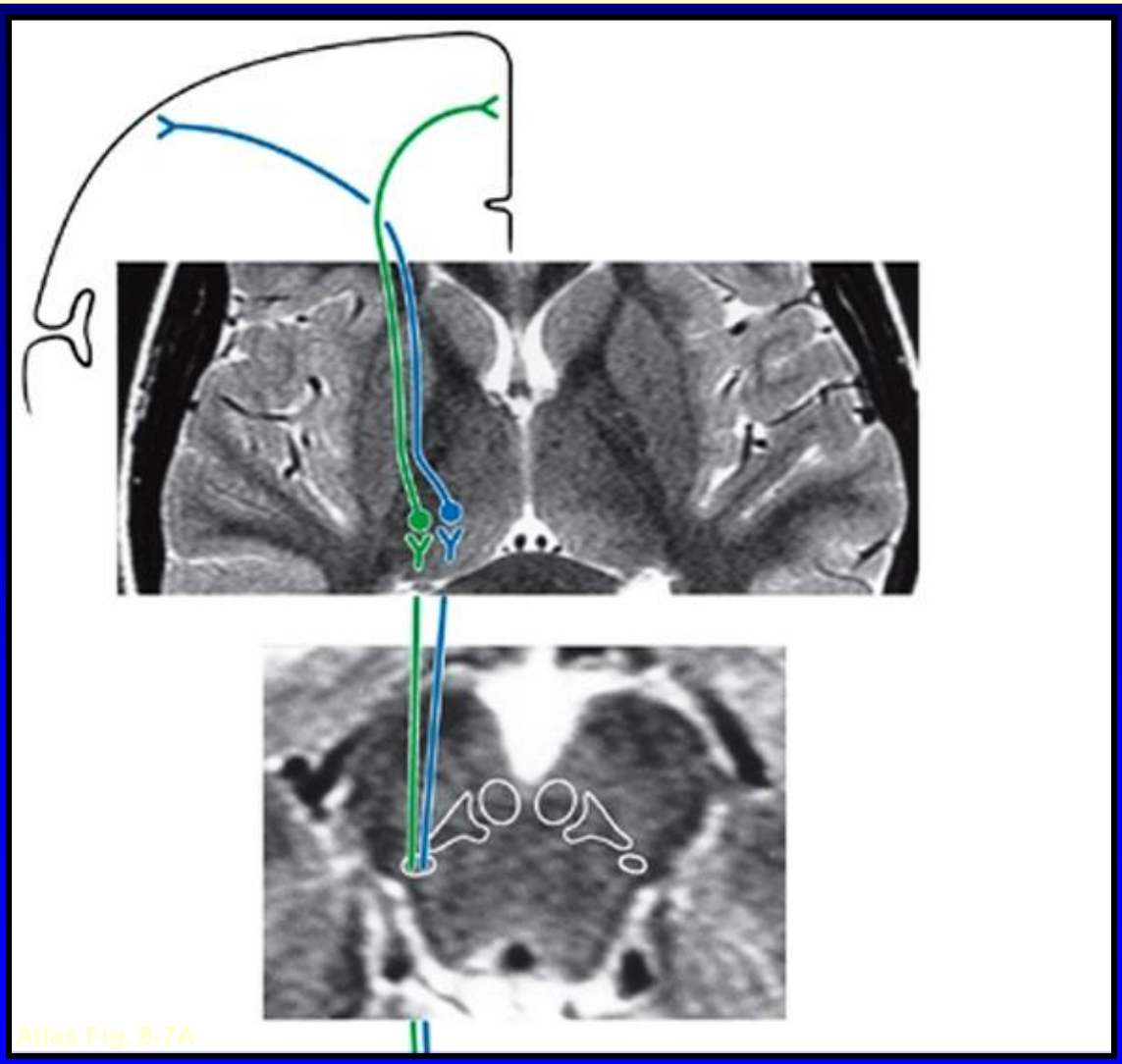


Atlas Fig. 8-7A



Text Fig. 18-11

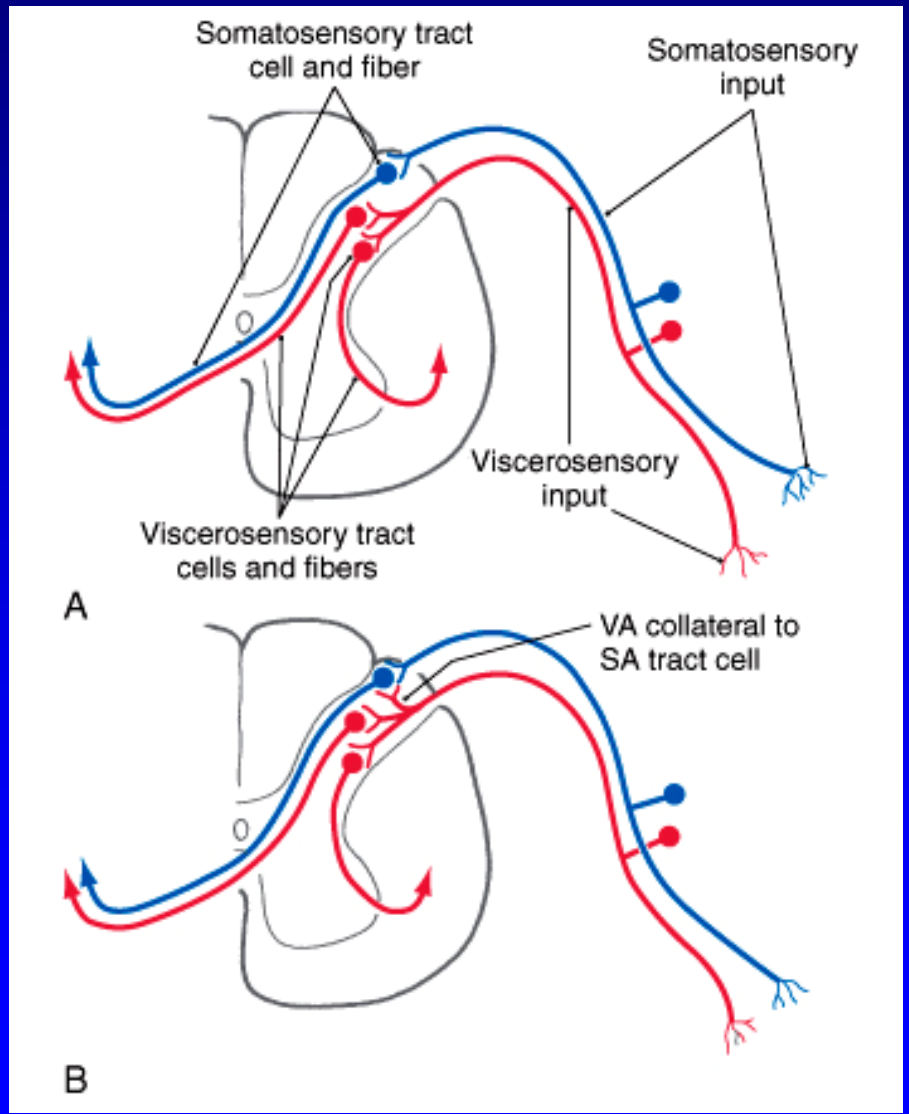
The ALS in the Midbrain, Thalamus and Cerebral Hemisphere

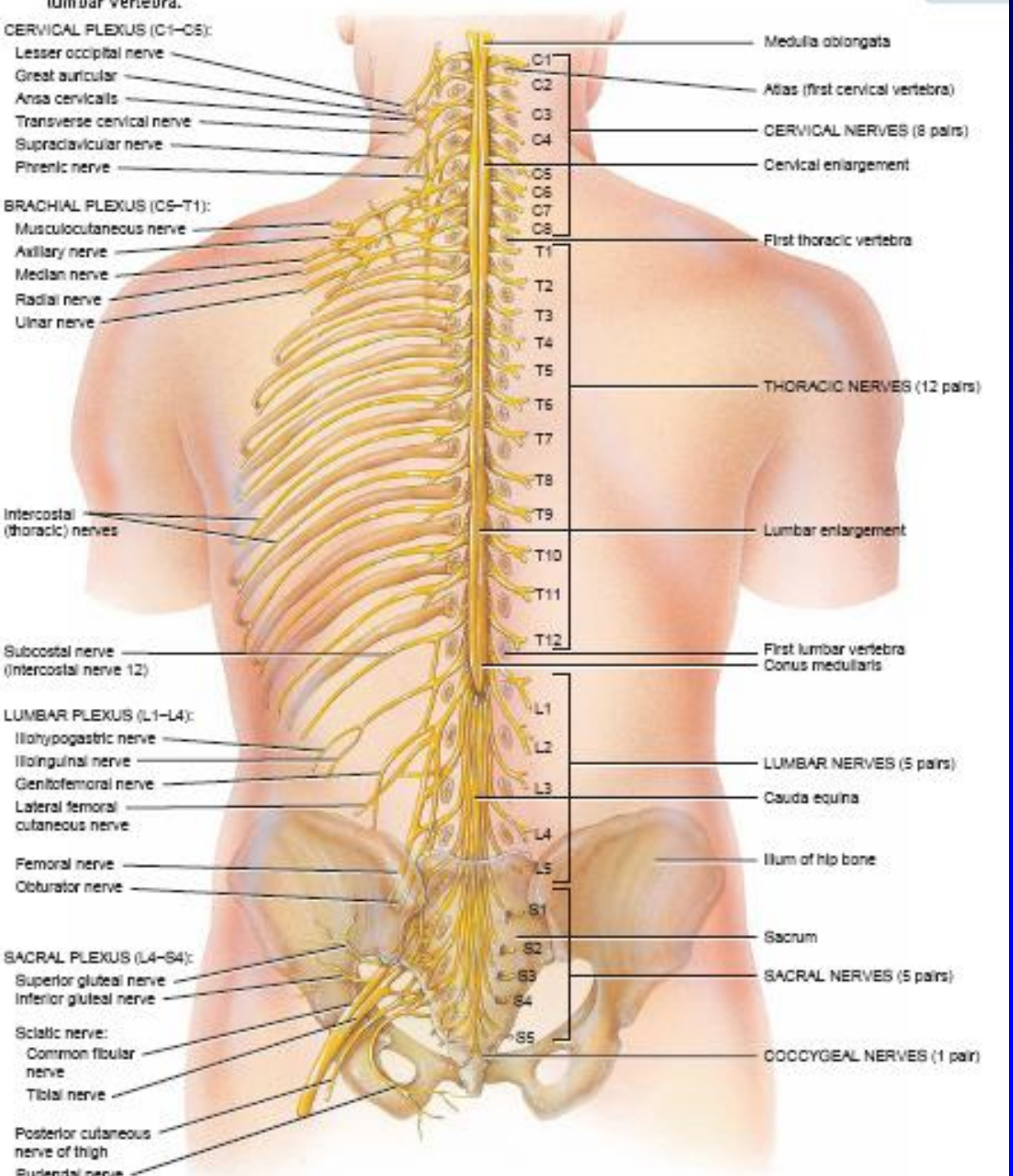


Atlas Fig. 8-7A

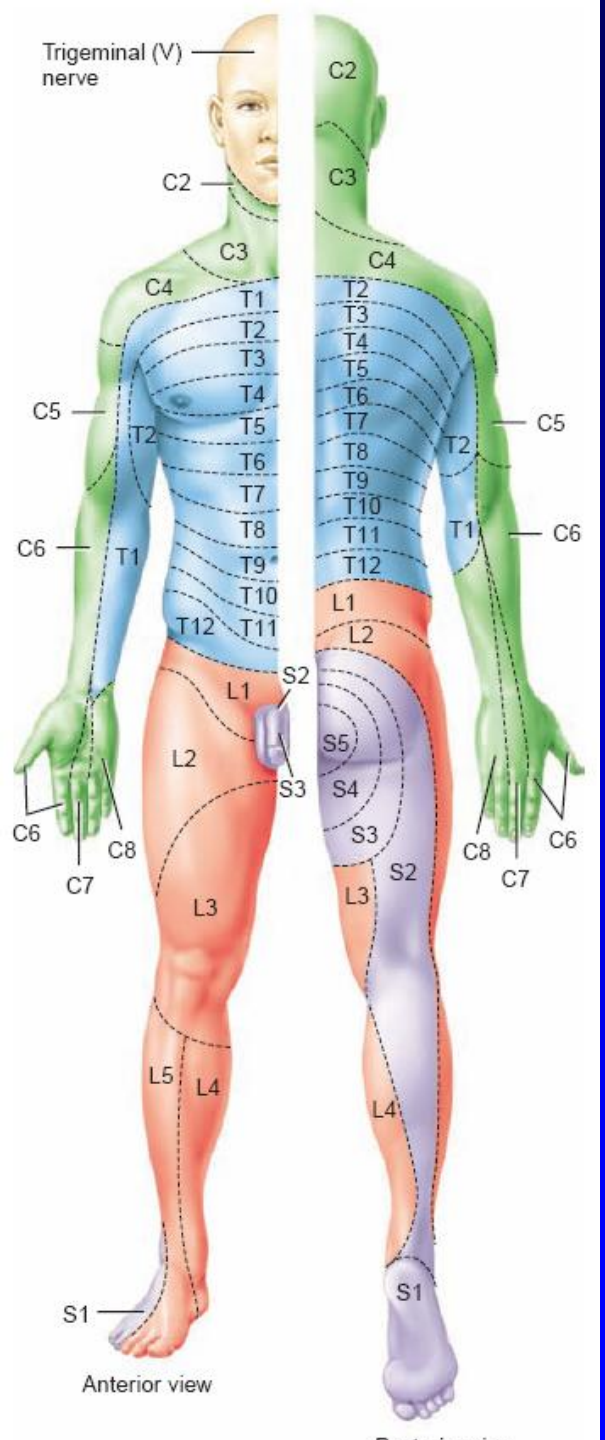
Dermatomes

Dermatomes

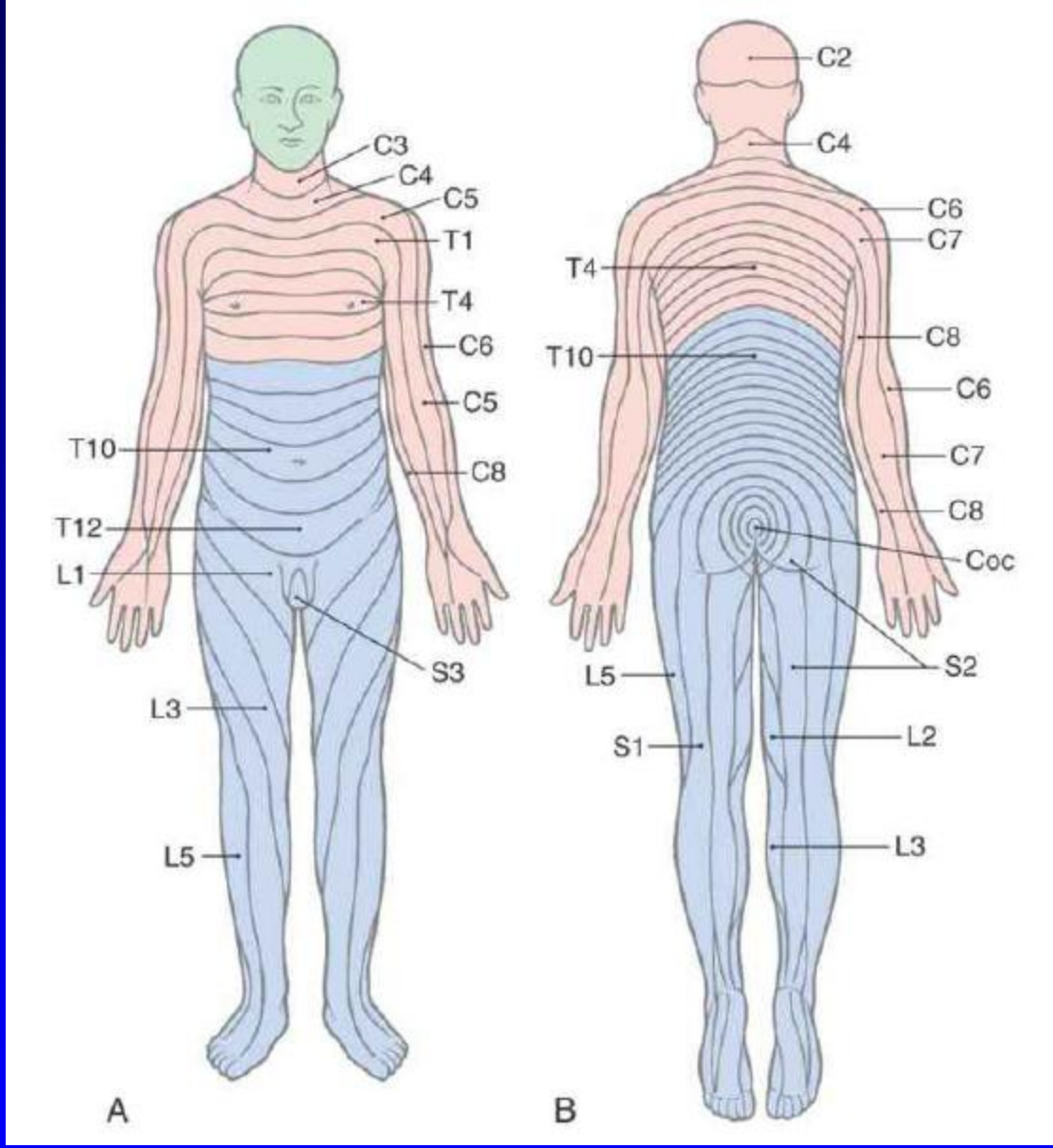

Somatosensory tract cell and fiber
Somatosensory input
Viscerosensory input
Viscerosensory tract cells and fibers
A
VA collateral to SA tract cell
B


lumbar vertebra.
CERVICAL PLEXUS (C1–C5):
Lesser occipital nerve
Great auricular
Ansa cervicalis
Transverse cervical nerve
Supraclavicular nerve
Phrenic nerve
BRACHIAL PLEXUS (C5–T1):
Musculocutaneous nerve
Axillary nerve
Median nerve
Radial nerve
Ulnar nerve
Intercostal (thoracic) nerves
Subcostal nerve (intercostal nerve 12)
LUMBAR PLEXUS (L1–L4):
Iliohypogastric nerve
Ilioinguinal nerve
Genitofemoral nerve
Lateral femoral cutaneous nerve
Femoral nerve
Obturator nerve
SACRAL PLEXUS (L4–S4):
Superior gluteal nerve
Inferior gluteal nerve
Sciatic nerve:
Common fibular nerve
Tibial nerve
Posterior cutaneous nerve of thigh
Medulla oblongata
C1
C2
C3
C4
C5
C6
C7
C8
Atlas (first cervical vertebra)
CERVICAL NERVES (8 pairs)
Cervical enlargement
First thoracic vertebra
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
THORACIC NERVES (12 pairs)
Lumbar enlargement
First lumbar vertebra
Conus medullaris
L1
L2
L3
L4
L5
LUMBAR NERVES (5 pairs)
Cauda equina
Ilium of hip bone
S1
S2
S3
S4
S5
Sacrum
SACRAL NERVES (5 pairs)
COCCYGEAL NERVES (1 pair)

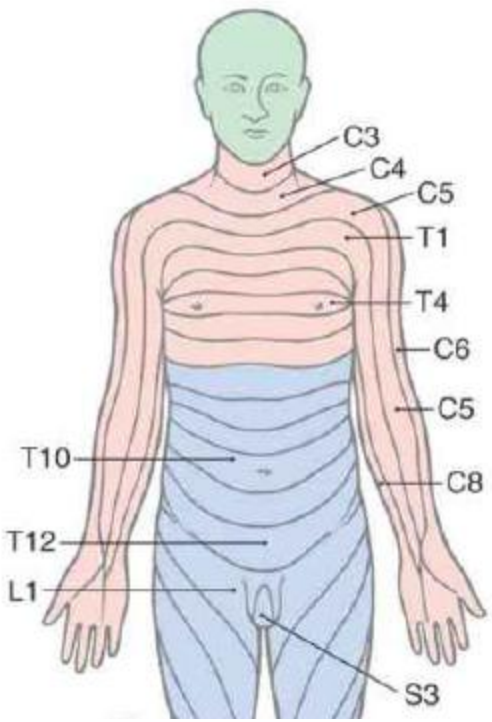
Dermatomes

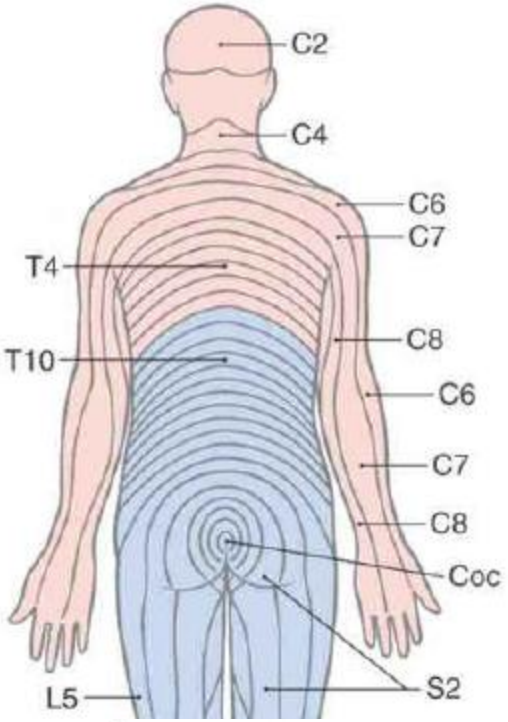

Trigeminal (V) nerve
C2
C3
C4
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
C5
C6
C7
C8
Anterior view

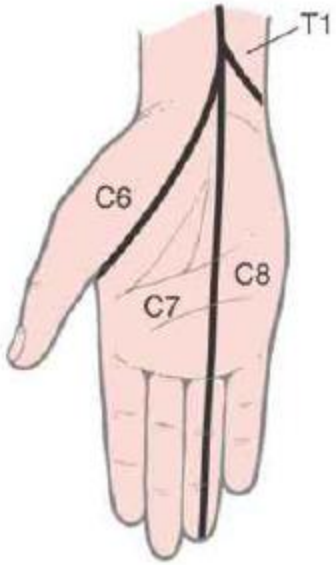
Dermatomes

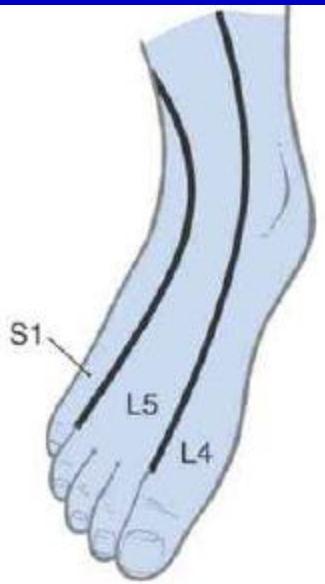

C3
C4
C5
T1
T4
C6
C5
T10
C8
T12
L1
S3
L3
L5
A
C2
C4
C6
C7
T4
C8
T10
C6
C7
C8
Coc
S2
L5
S1
L2
L3
B

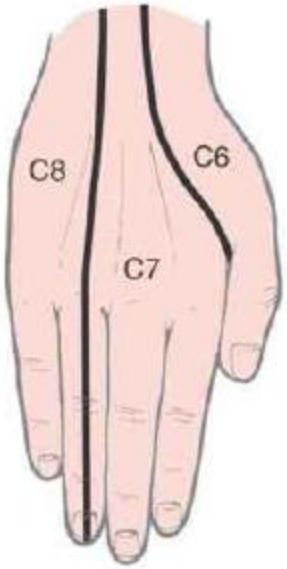
Dermatomes

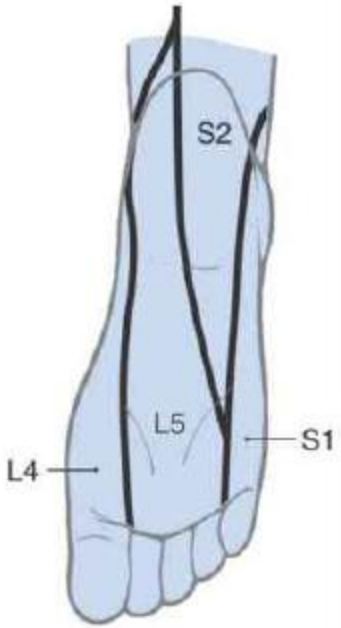












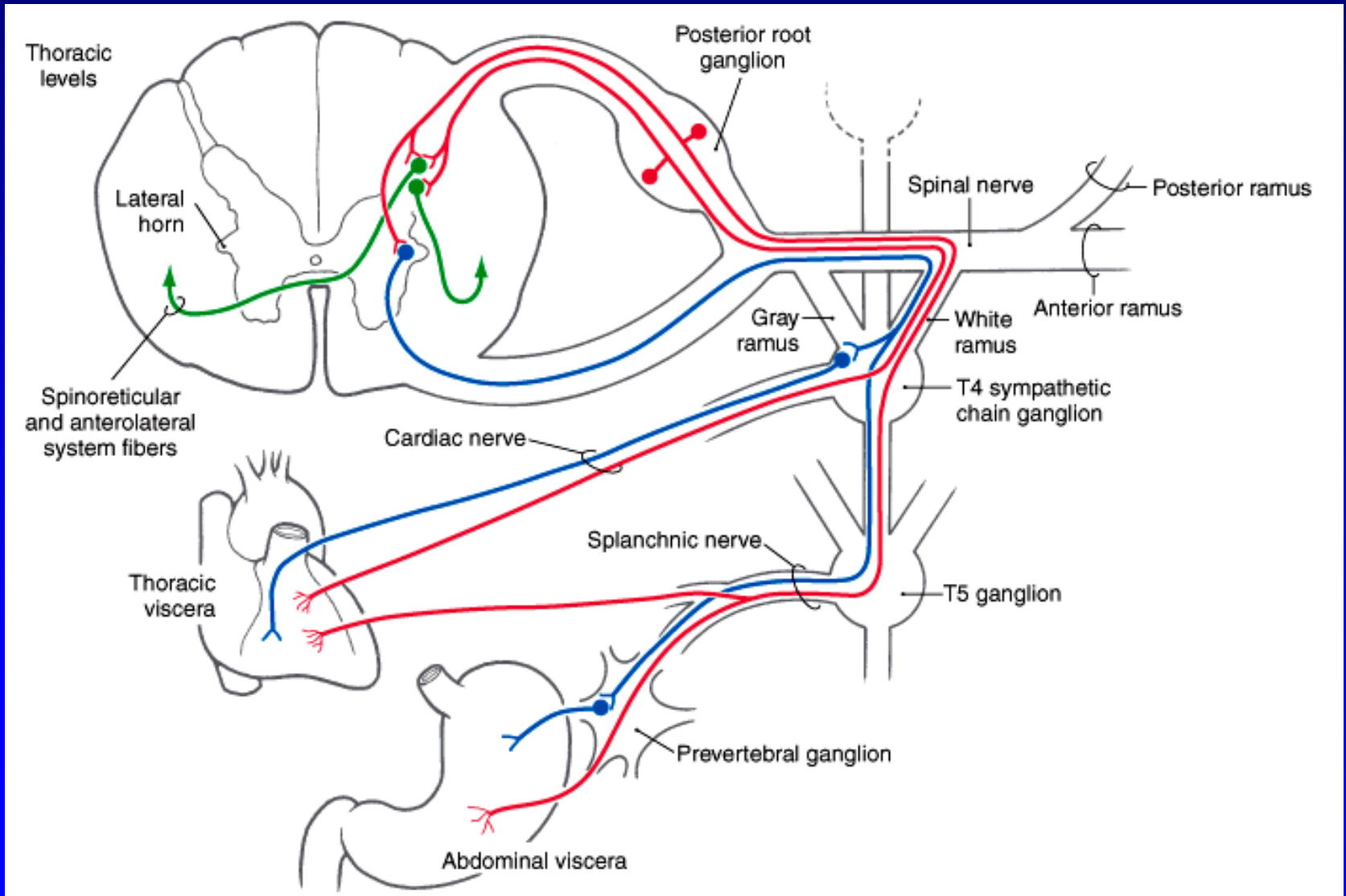
D

Dermatomes

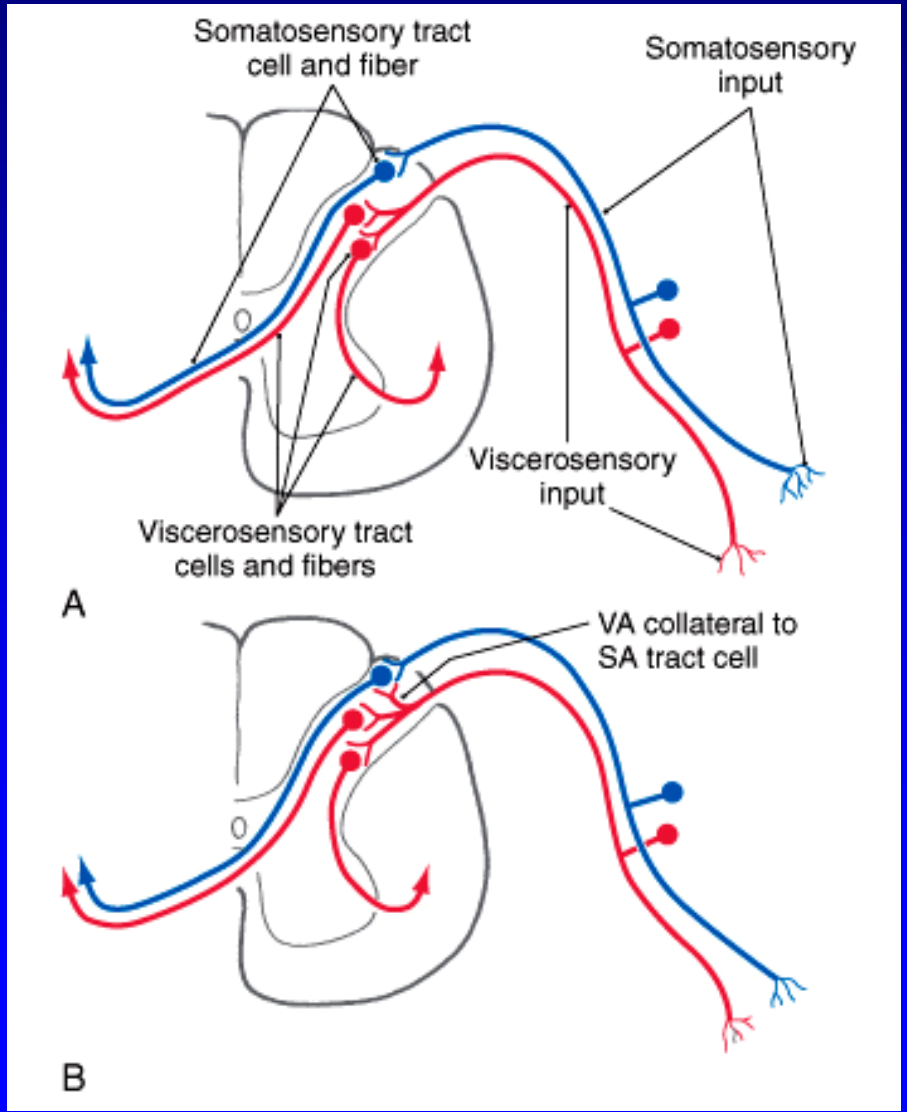
- Shoulder (C5-C6)
- Hand (C6-C8): 6= thumb the, 7= index finger, 8= small finger
- Nipple (T4),
- Umbilicus (T10),
- Inguinal region (T12-L1),
- Along the pelvic rim L1
- knee (L3, L4),
- The big toe (L4-L5)
- The genitalia and anus (S4 and S5)

Visceral sensory & referred pain

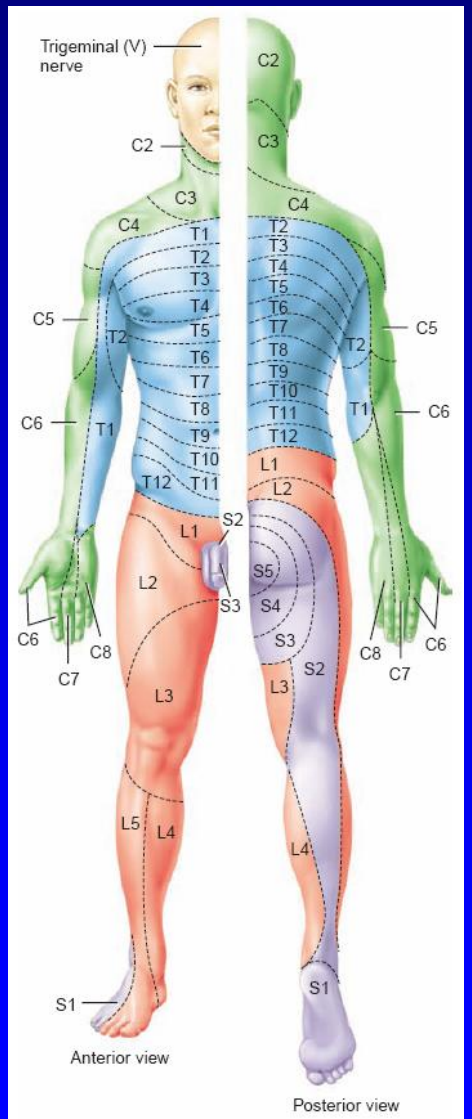
Visceral sensory & referred pain

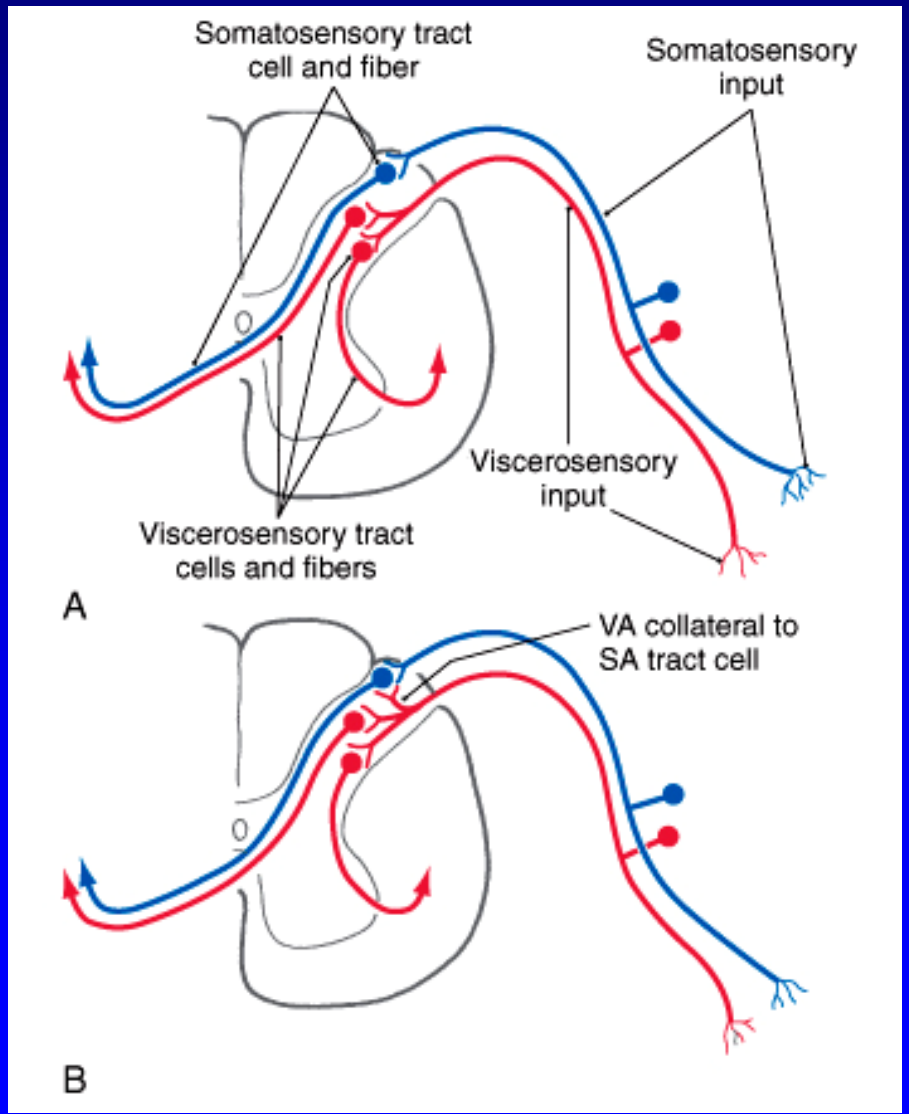


Visceral sensory & referred pain

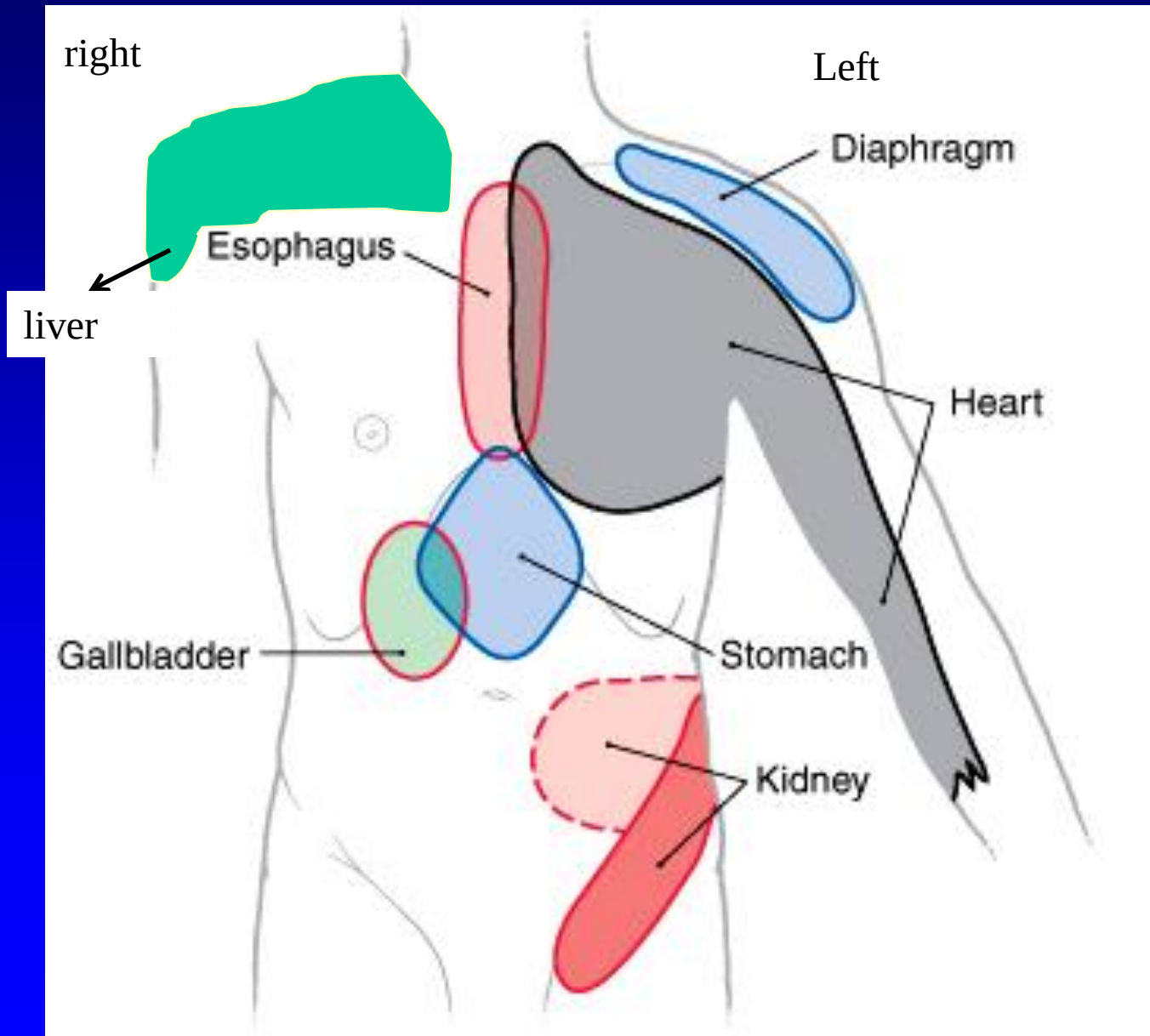


Visceral sensory & referred pain

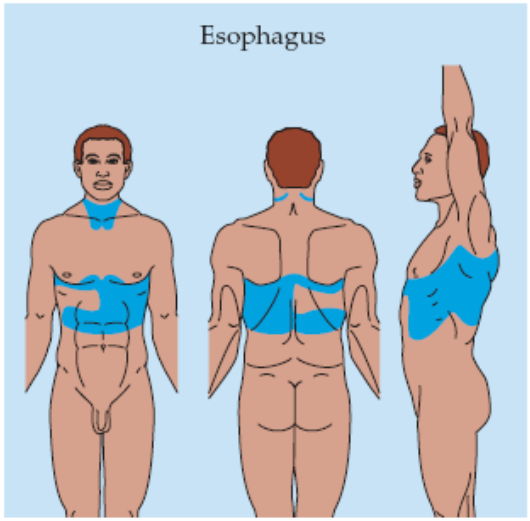


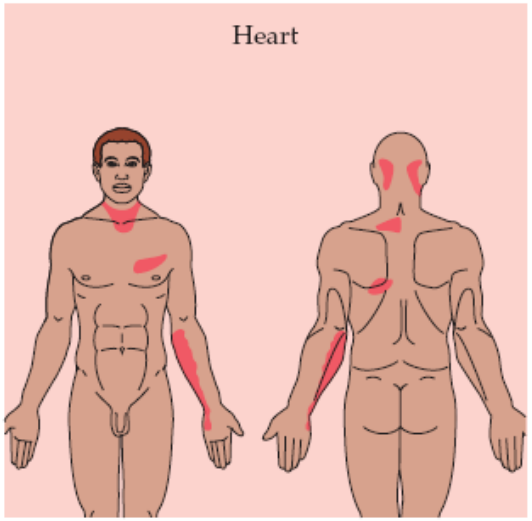


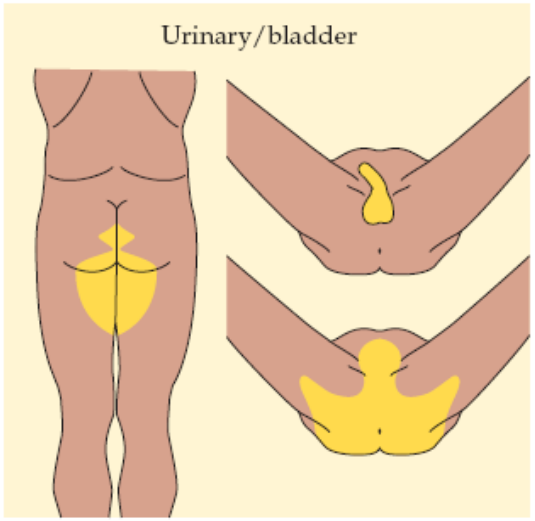
Referred pain

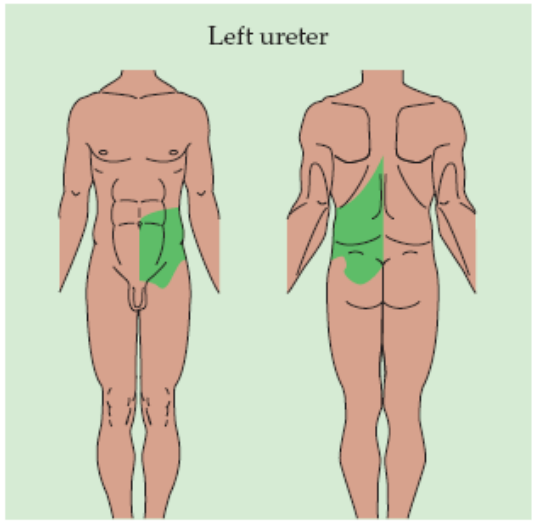


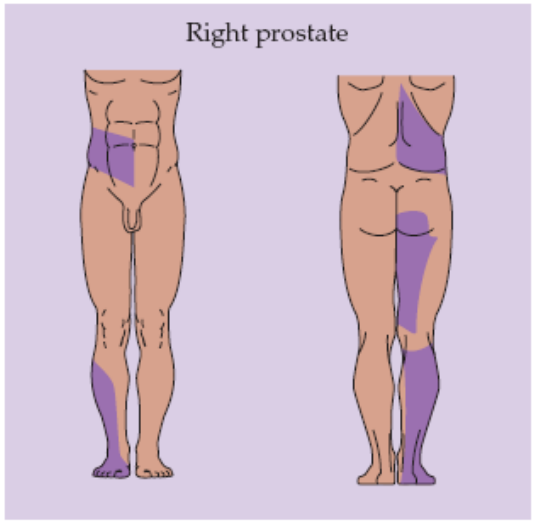
Visceral sensory & referred pain



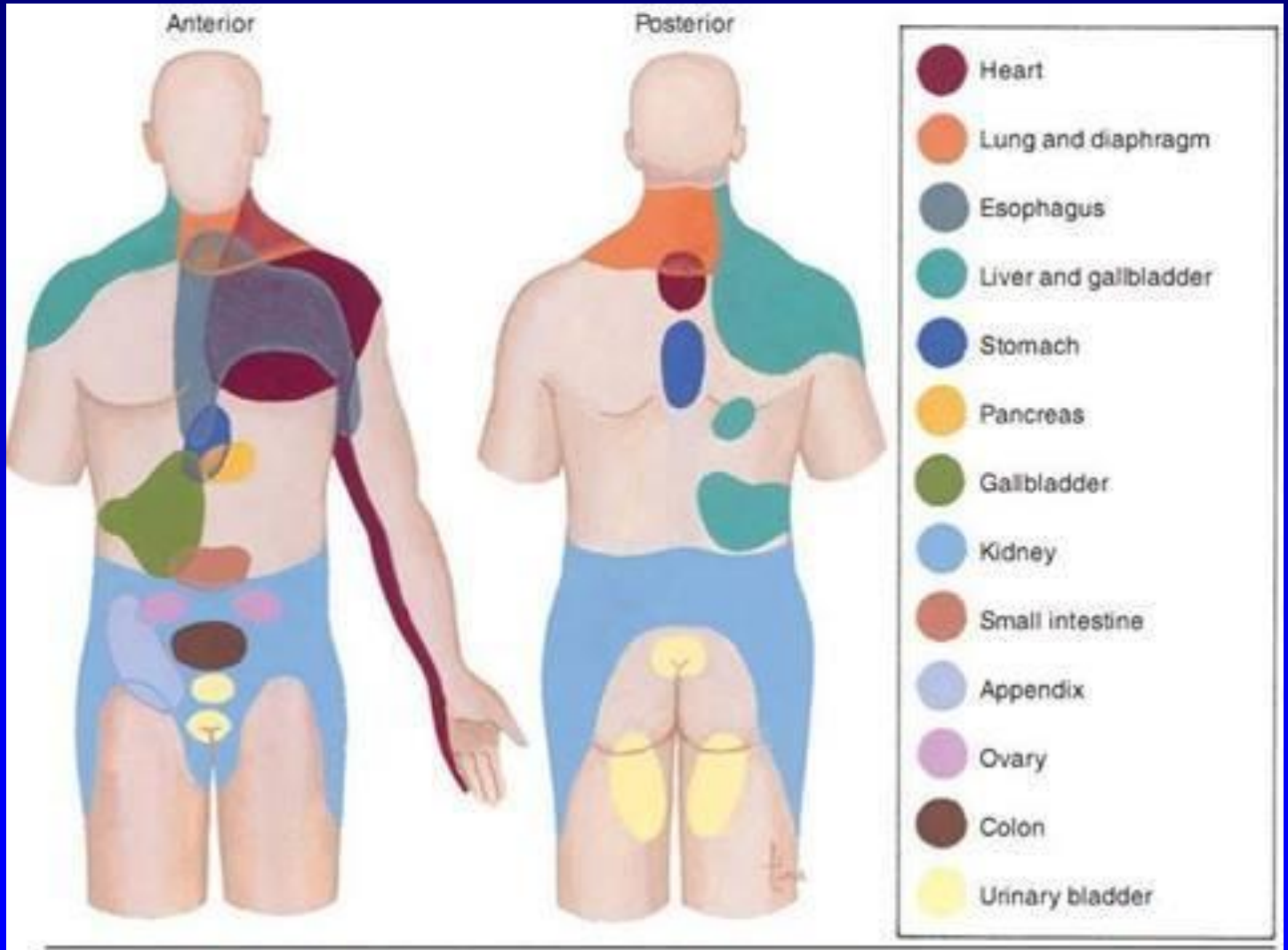








Visceral sensory & referred pain



Referred pain. The sites for referred pain from various organs are shown.