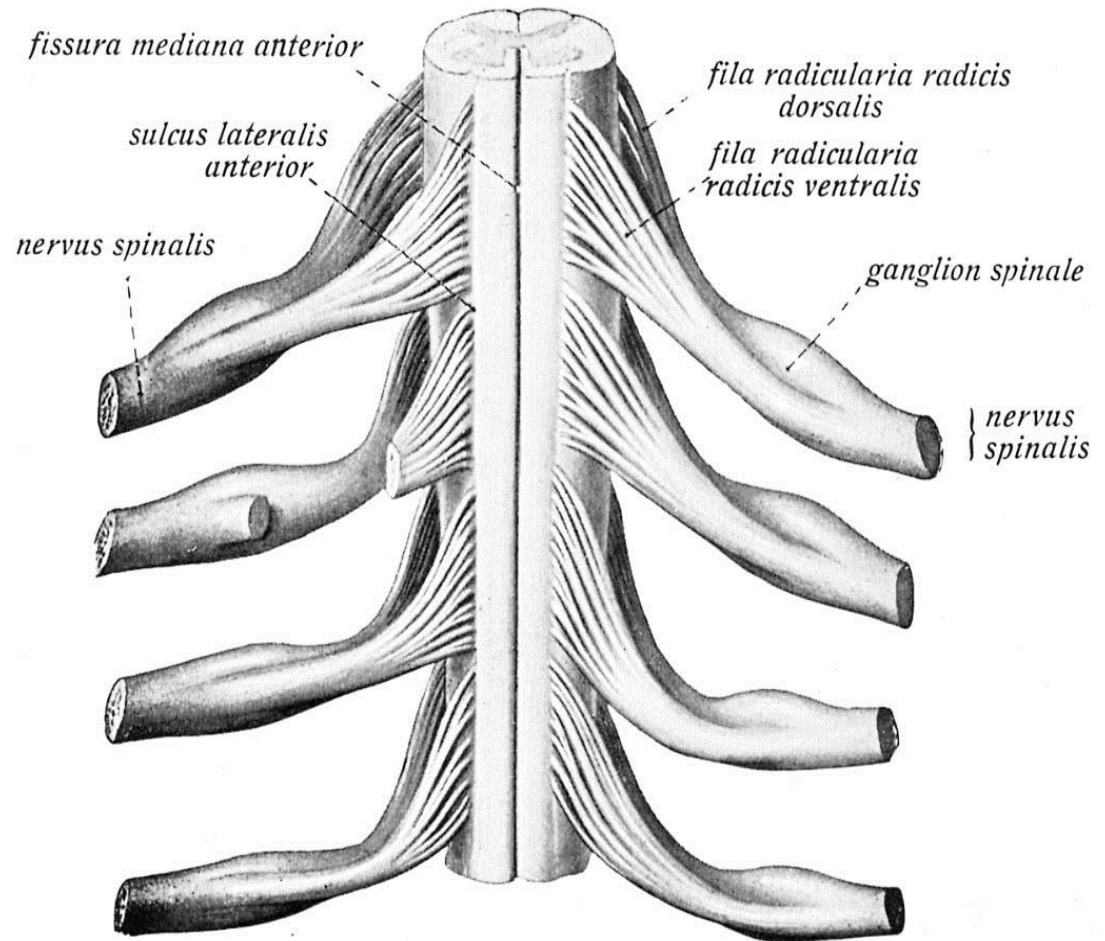


SPINAL CORD

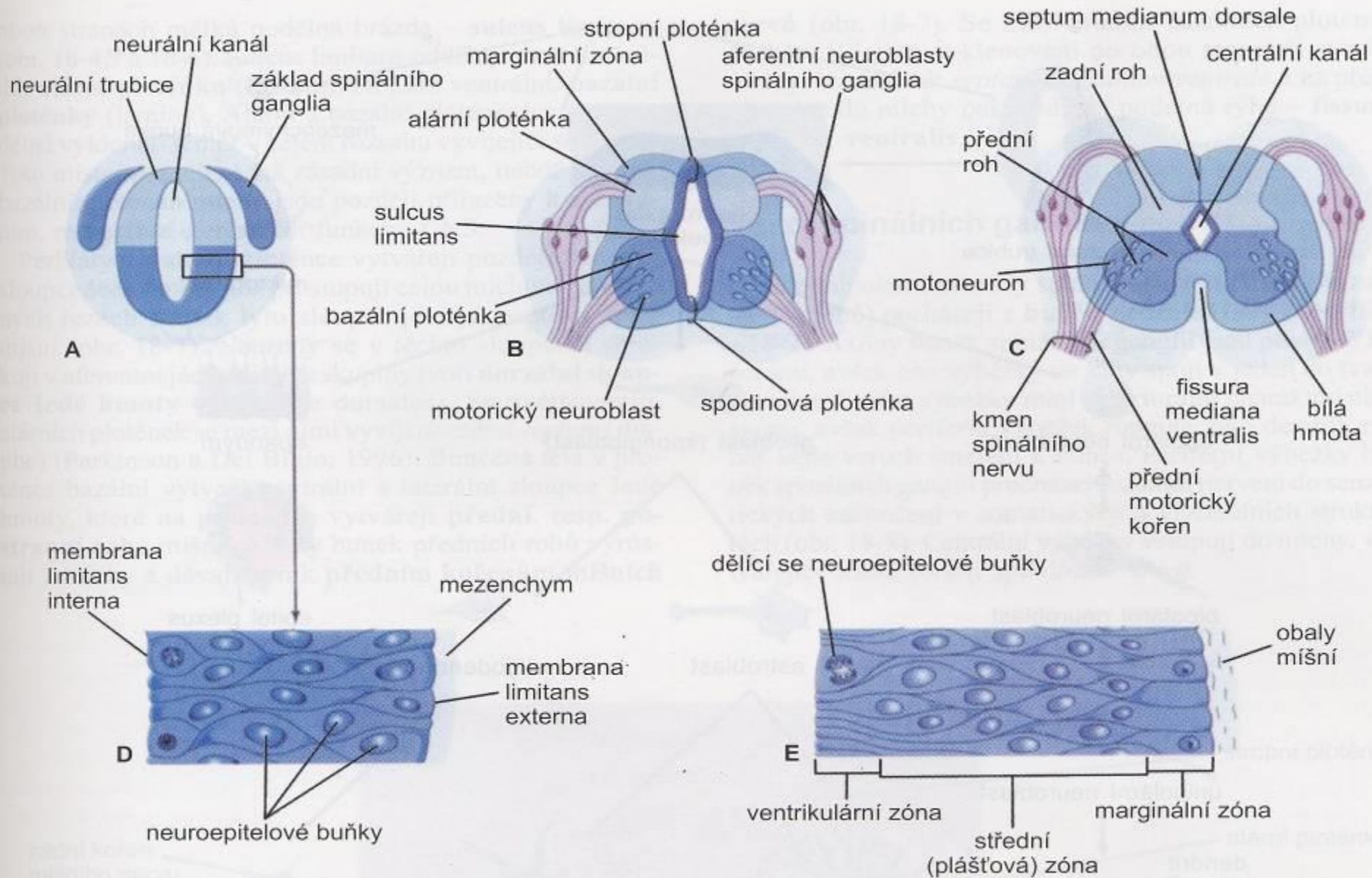
David Kachlík

Spinal cord = Medulla spinalis

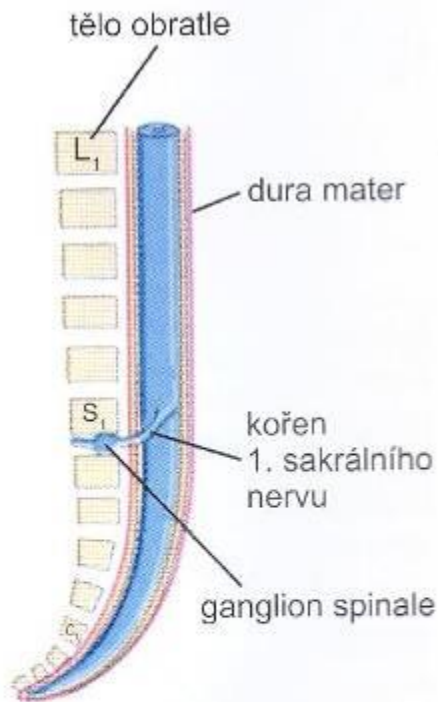
- myelon
- inside canalis vertebralis
- 1st level of CNS



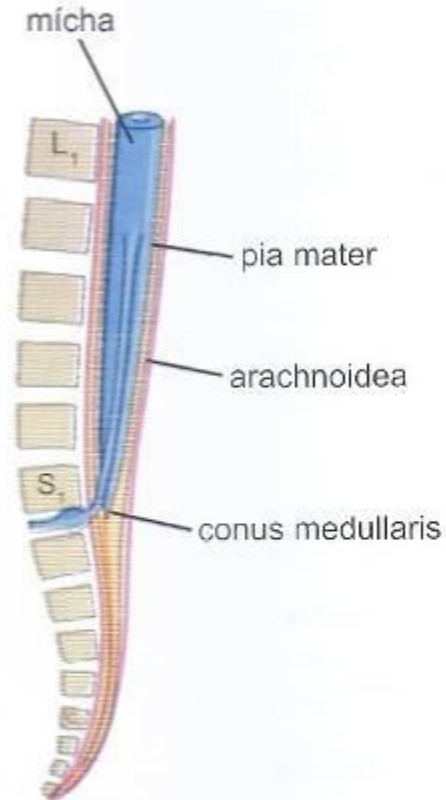
Development of neural tube in the spinal cord region



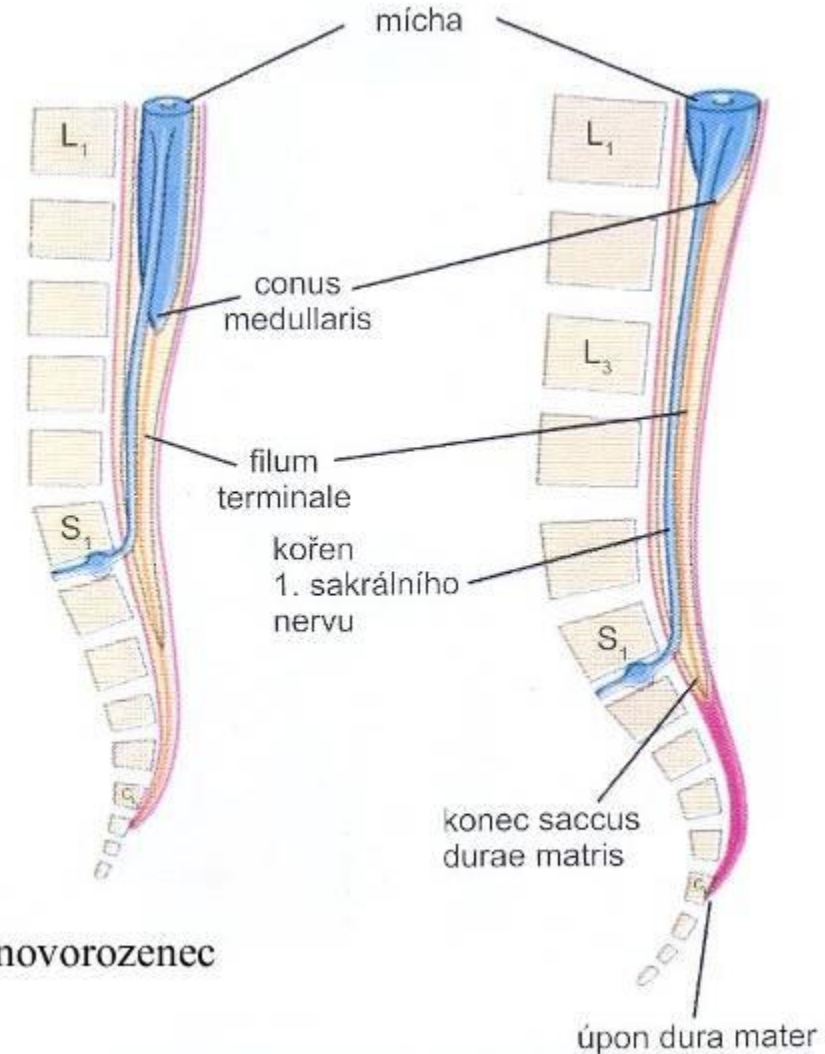
Spinal cord growth



8 týdnů



24 týdnů



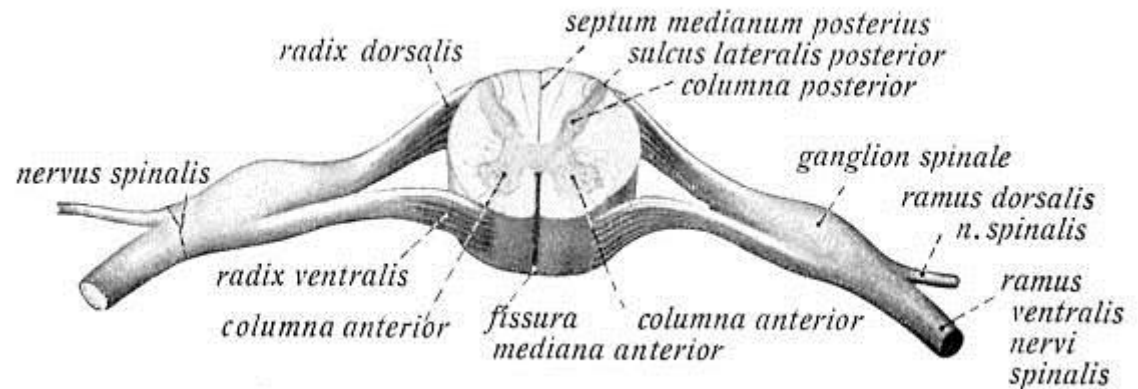
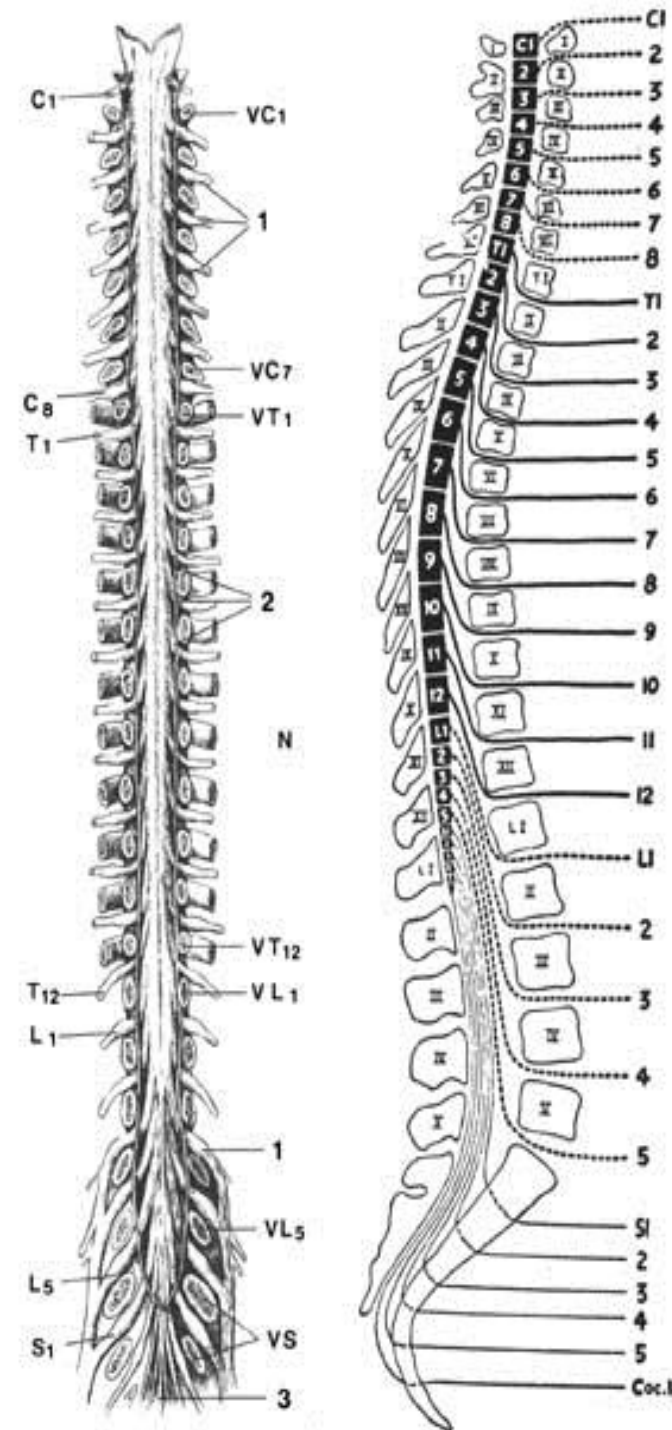
novorozenec

Spinal cord

- segmental organization derived from neural tube and somites
- spinal segments - 31
- spinal nerves: C8, T12, L5, S5, Co1
- comparable to „input-output,, system of computer
- seat of reflexes
- origin of ascending and descending projections (tracts)

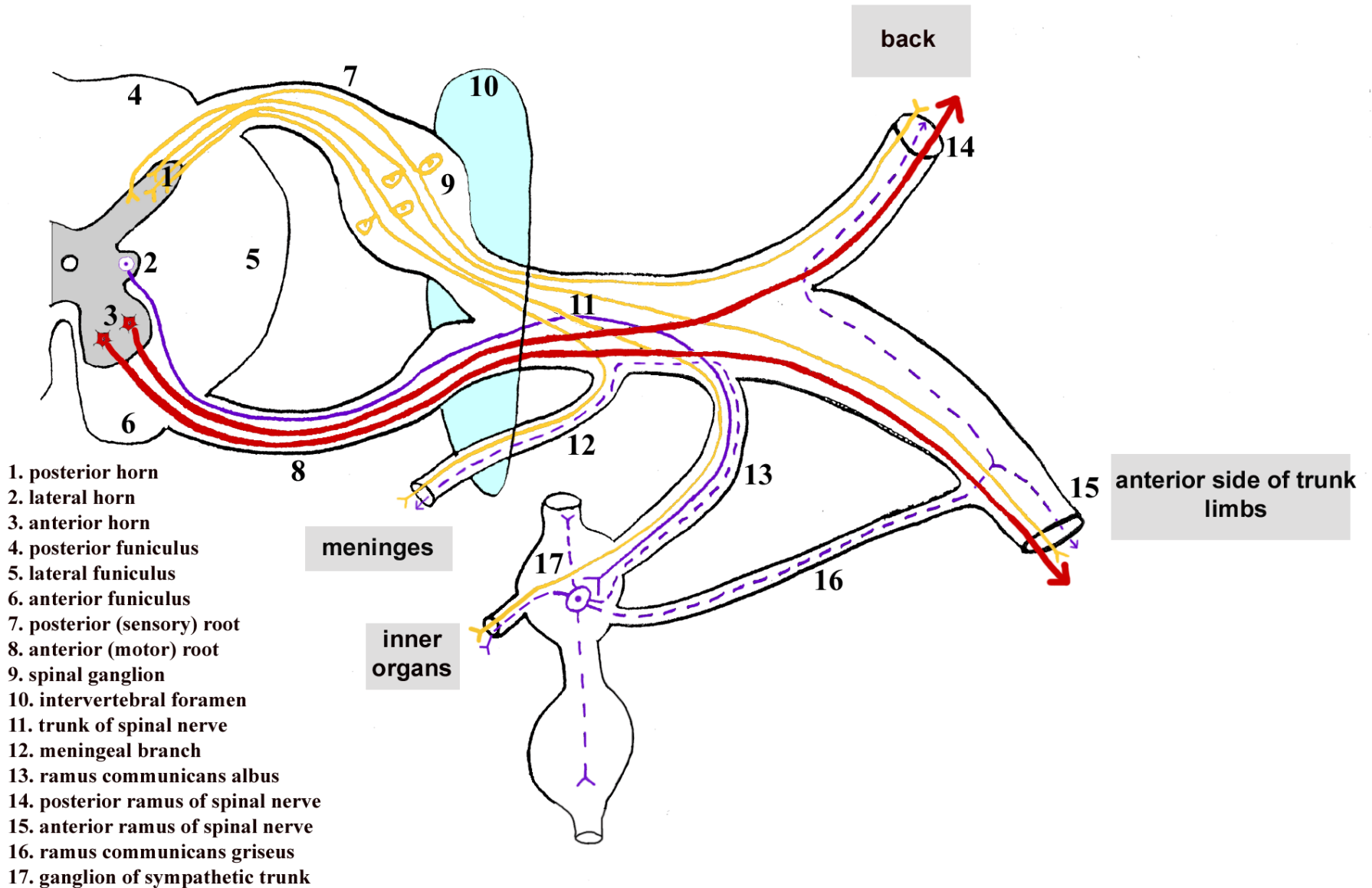
Spinal segments

C8, T12, L5, S5, Co1



- fila radicularia
- radix anterior („ventralis“) = ant. root
- radix posterior („dorsalis“) = post. root
 - ganglion spinale

SCHEME OF SPINAL NERVE BRANCHING



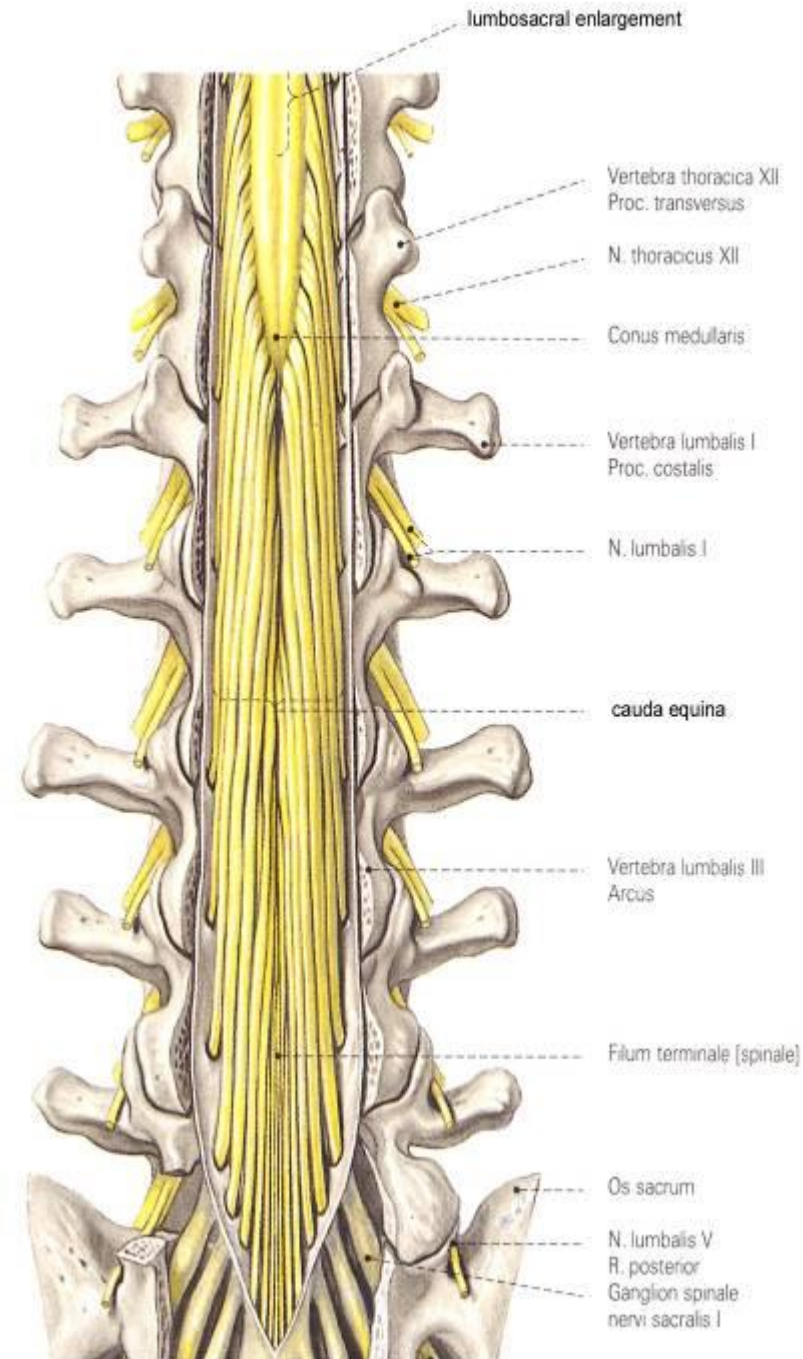
Spinal cord – *external surface*

- arbitrary border between spinal cord and brain stem
 - *foramen magnum*
 - *decussatio pyramidum* (*pyramid decussation*)
 - exit of nervus spinalis C1 (*n. cervicalis primus*)
- intumescentia (plexus origin)
 - cervicalis (C3-T1)
 - lumbosacralis (T12-L4)
- longitudinal sulcus
 - fissura mediana anterior (deep, contains pia mater)
 - sulcus medianus posterior
 - septum medianum posterius (from pia mater)
 - sulcus anterolateralis (anterior root)
 - sulcus posterolateralis (posterior root)
 - sulcus intermedius posterior

Spinal cord

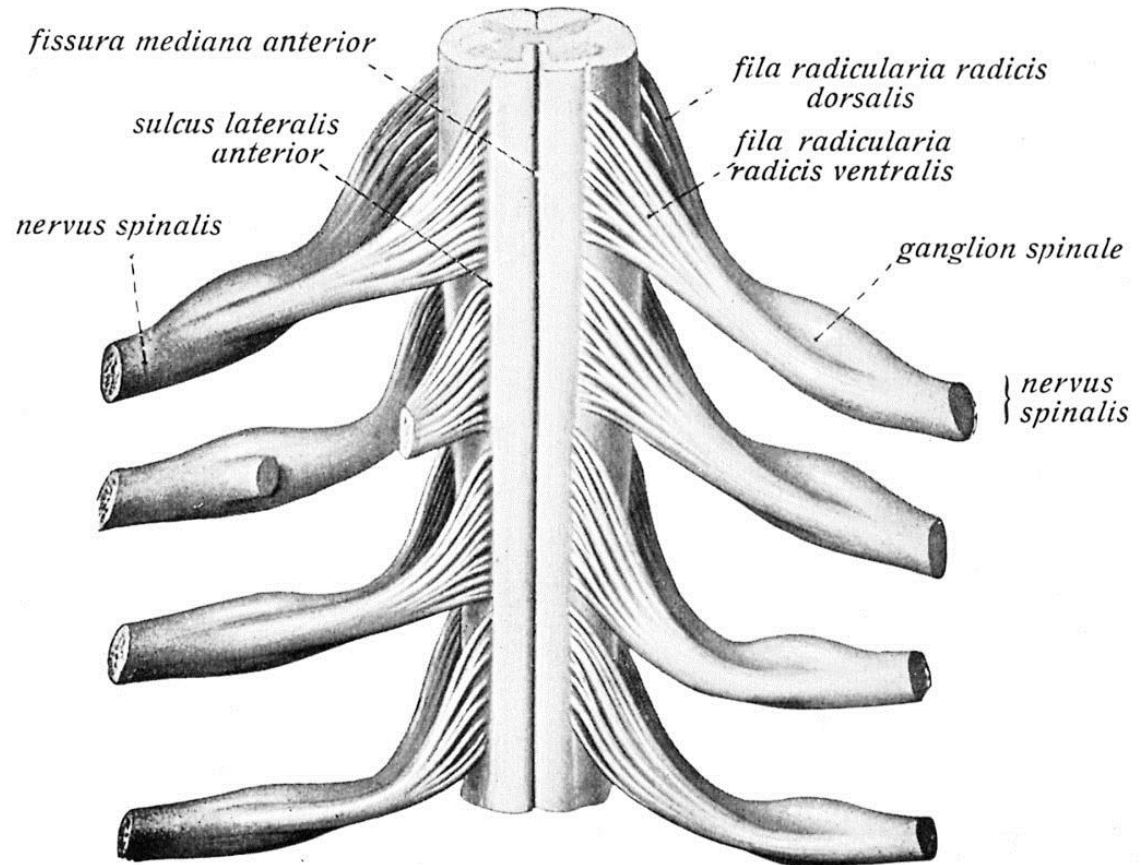
External surface

- **conus medullaris**
 - vertebrae L1-L2
 - segments S3-S5
- **epiconus**
 - vertebrae T12-L1
 - segments L5-S2
- **cauda equina**
 - nerve fibers below vertebra L1
- **pars spinalis filii terminalis**



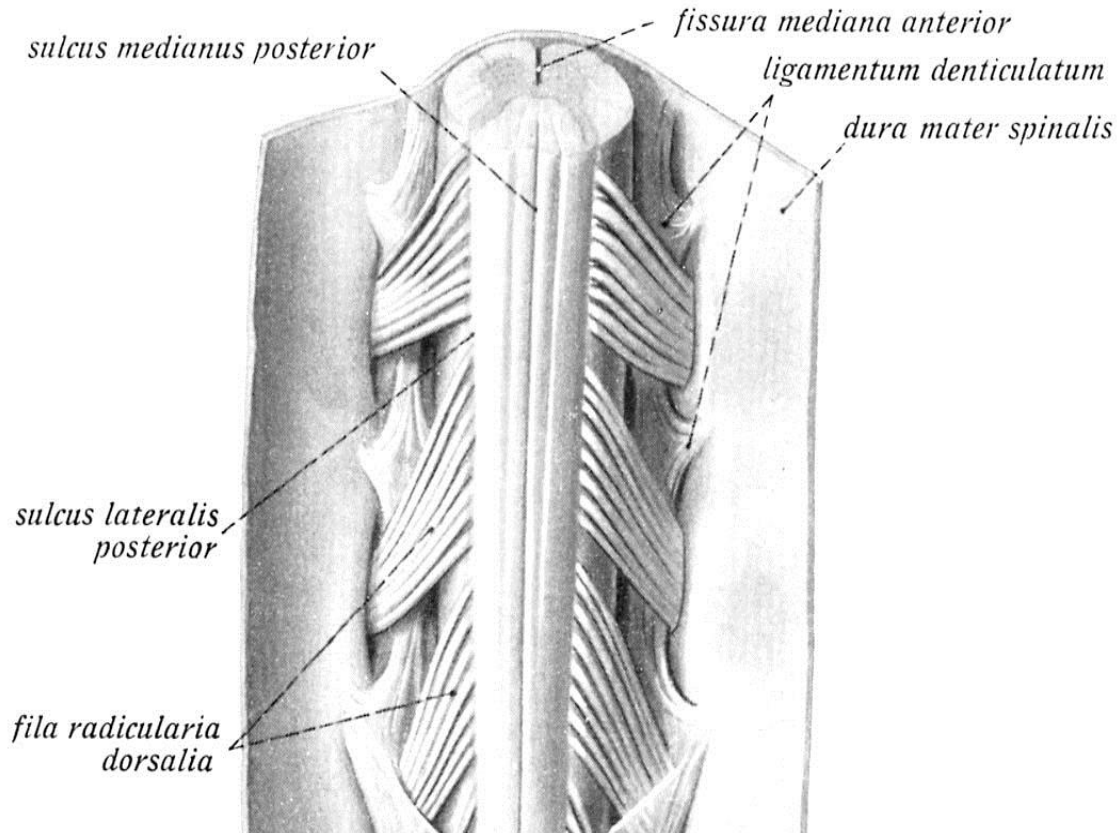
Spinal cord – ventral view

- fissura mediana anterior
- sulcus lateralis anterior
- nervus spinalis
- sulcus anterolateralis



Spinal cord dorsal view

- sulcus medianus posterior
- *fasciculus gracilis*
Golli
- sulcus intermedius posterior
- *fasciculus cuneatus*
Burdachi
 - sulcus posterolateralis



Vertebromedullary topography

Chipault's rule

- proc. spinosi of upper C column = same spinal segments
- proc. spinosi of lower C column = spinal segment + 1
- proc. spinosi of upper T column = s.s. + 2
- proc. spinosi of lower T column = s.s. + 3
- vertebrae T10-12 = lumbar segments
- transition T12-L1 = **epiconus**
- vertebra L1 = **conus**

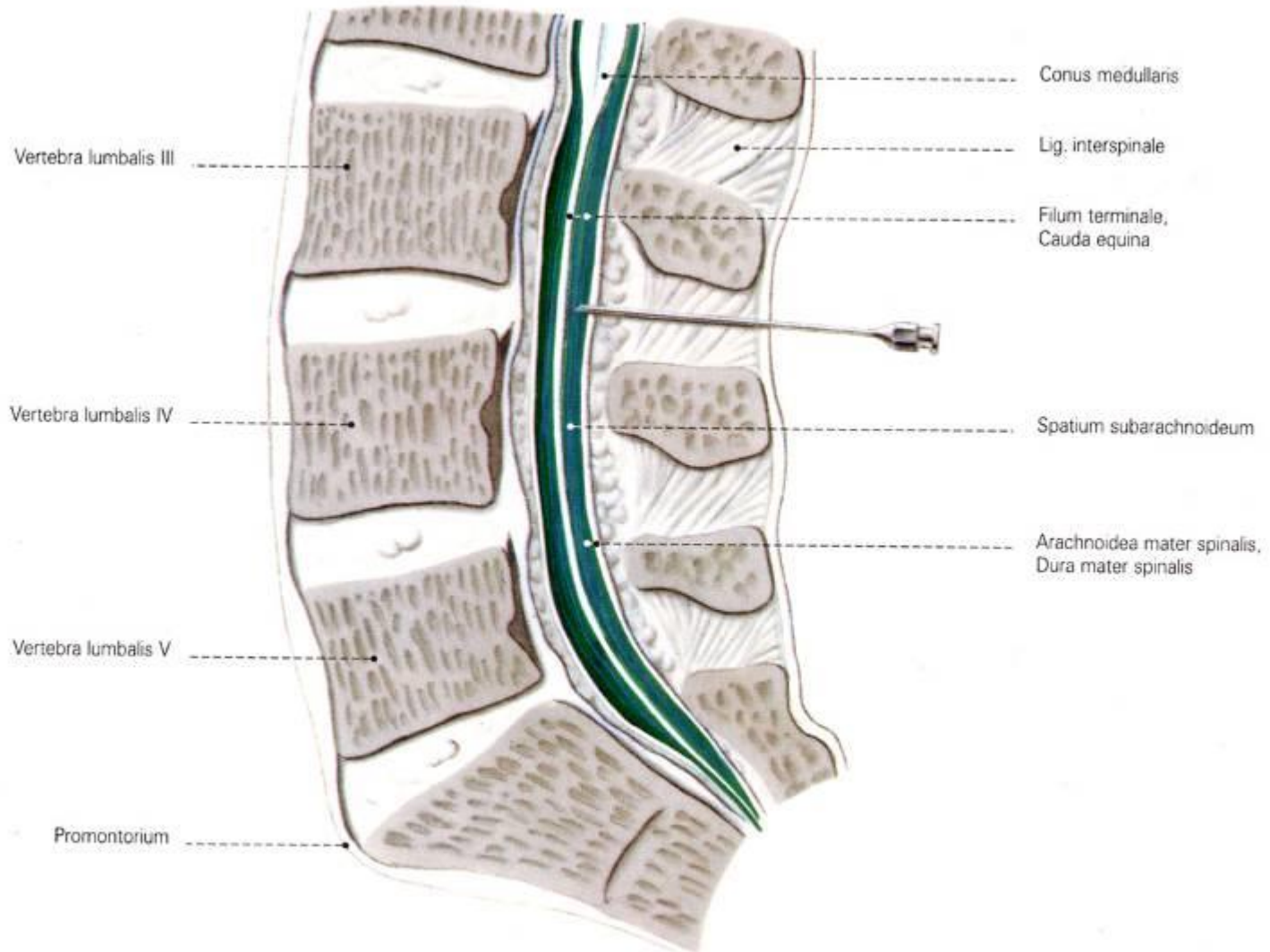
Layers inside vertebral canal

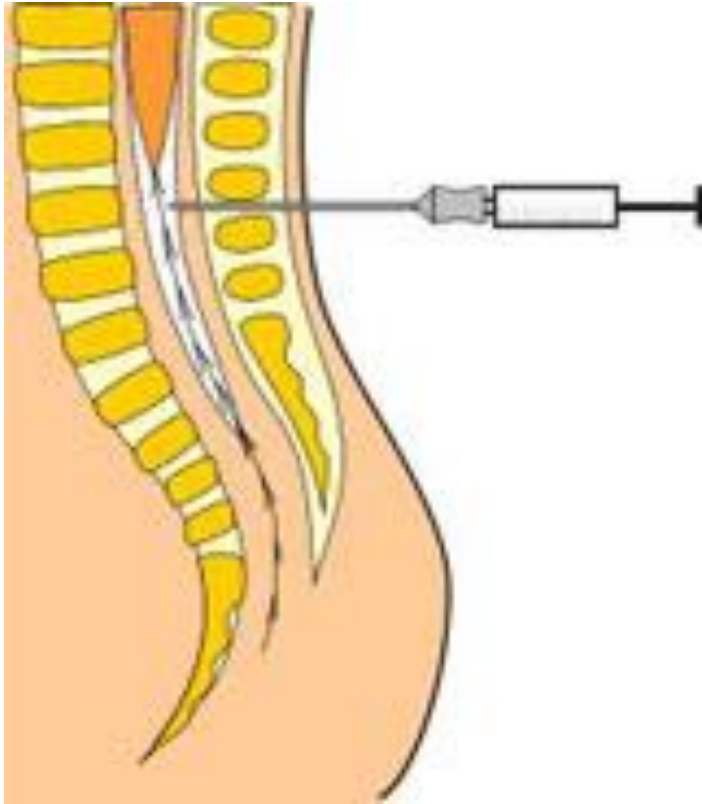
- periosteum = endorhachis
- spatium epidurale
- dura mater spinalis
- arachnoidea mater spinales
- spatium subarachnoideum
 - cisterna lumbalis
- pia mater spinalis
 - lig. denticulatum
- medulla spinalis

Clinical use

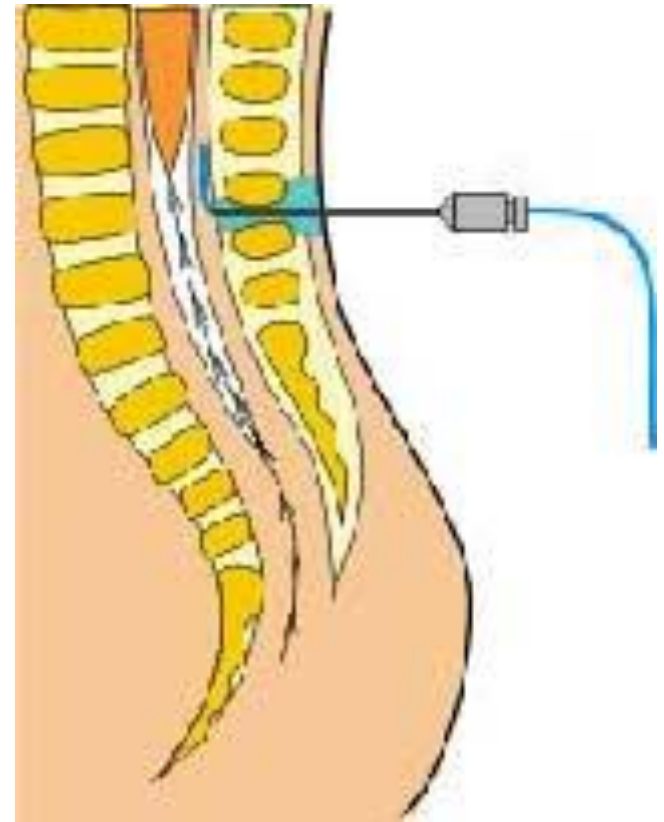
- epidural anesthesia
- lumbar puncture / spinal anesthesia / application of medicaments
- electrical stimulation / (chordotomy)

Lumbar puncture



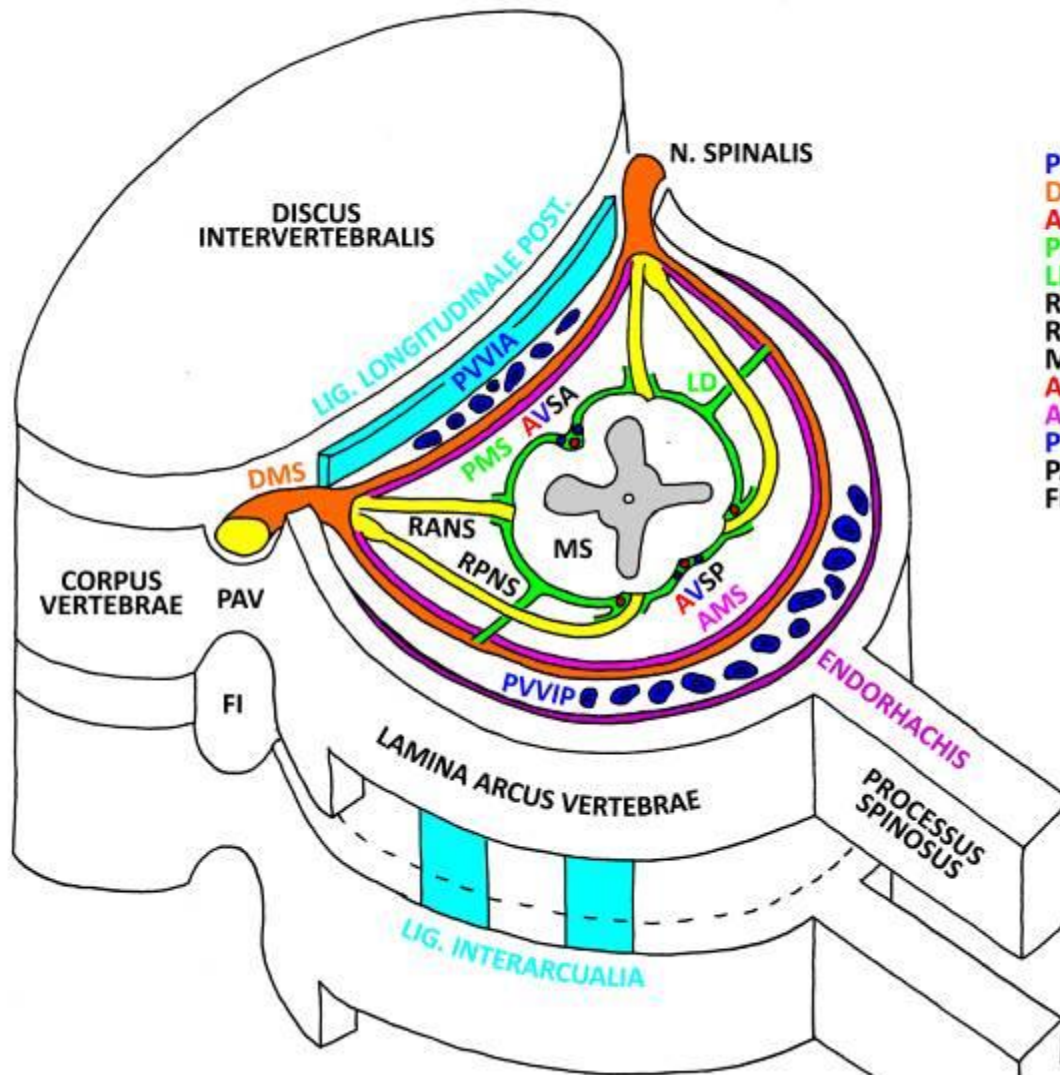


- subarachnoid anesthesia
= „spinal“
- „lumbar“ – CSF sample !



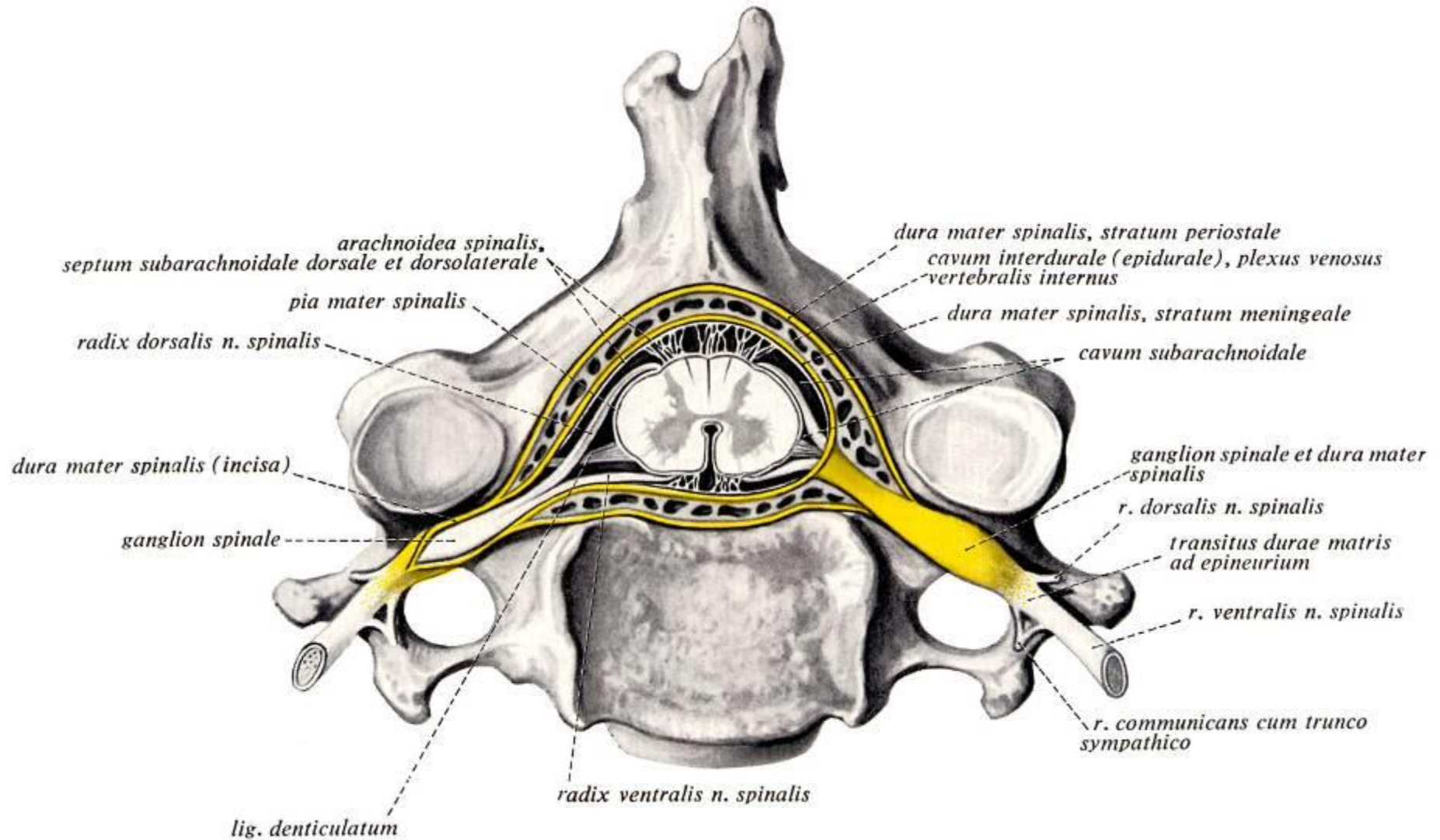
- epidural anesthesia
= „epidural“

Contents of vertebral canal

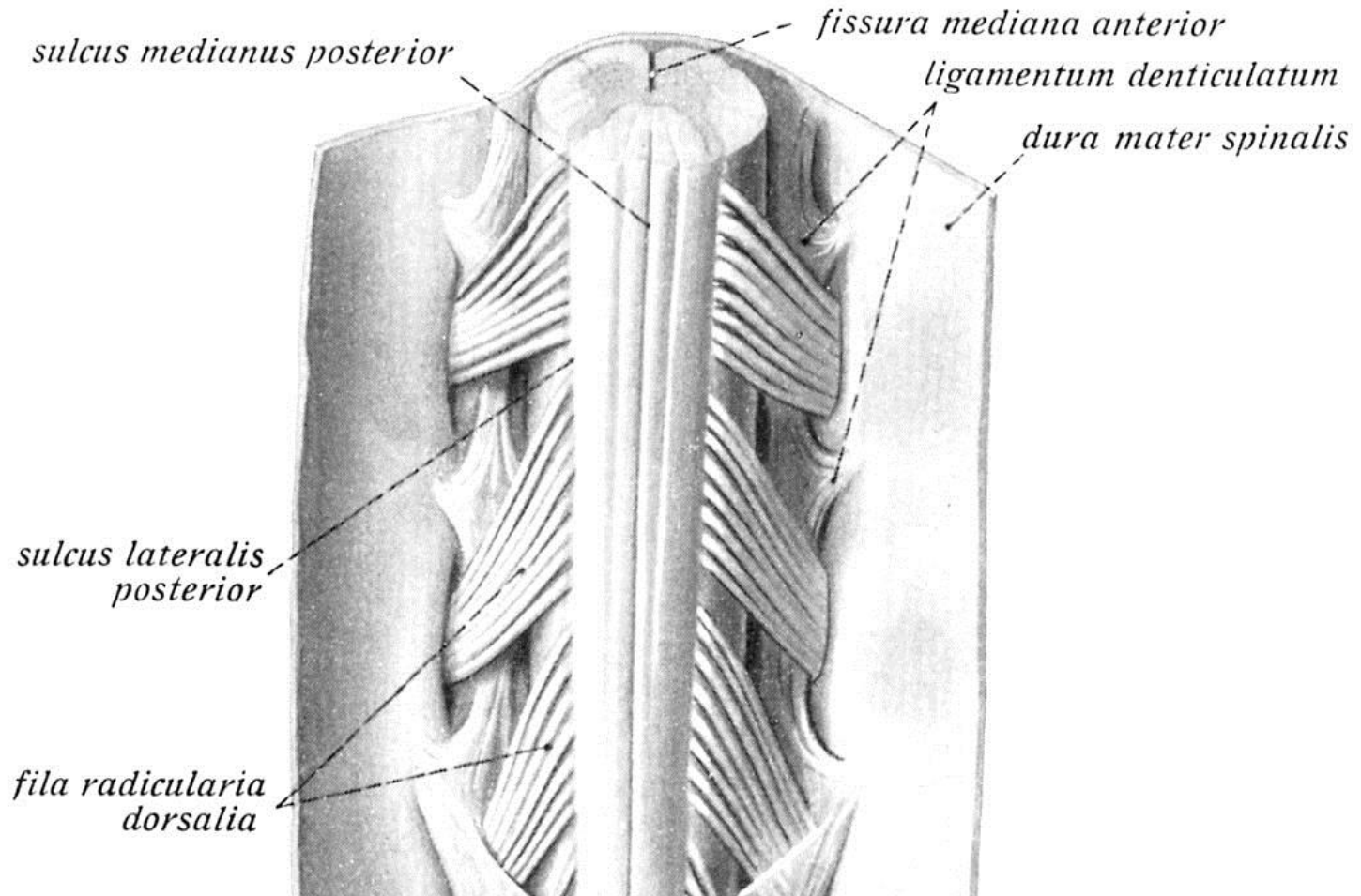


- PVVIA - PLEXUS VENOSUS VERTEBRALIS INTERNUS ANT.
- DMS - DURA MATER SPINALIS
- AVSA - A. ET VV. SPINALES ANT.
- PMS - PIA MATER SPINALIS
- LD - LIG. DENTICULATUM
- RANS - RADIX ANT. N. SPINALIS
- RPNS - RADIX POST. N. SPINALIS
- MS - MEDULLA SPINALIS
- AVSP - AA. ET VV. SPINALES POST.
- AMS - ARACHNOIDEA MATER SPINALIS
- PVVIP - PLEXUS VENOSUS VERTEBRALIS INTERNUS POST.
- PAV - PEDICULUS ARCUS VERTEBRAE
- FI - FORAMEN INTERVERTEBRALE

Contents of vertebral canal



Ligamentum denticulatum



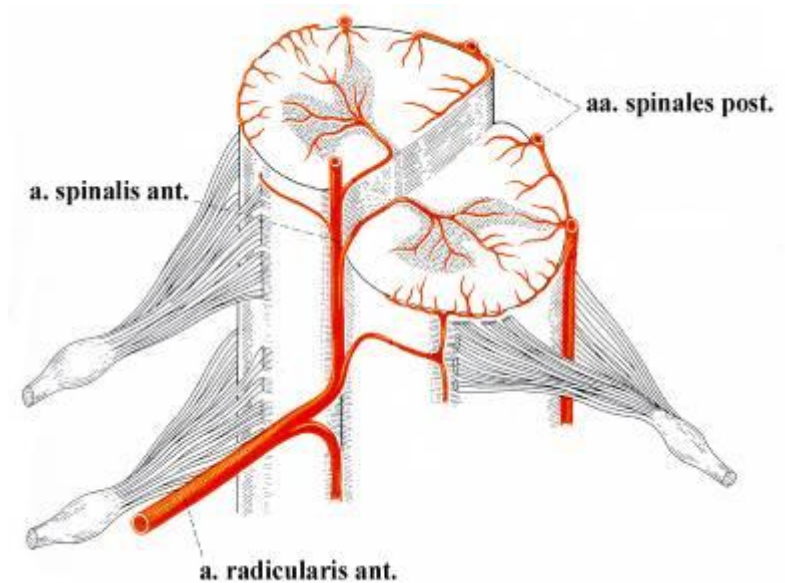
Canalis vertebralis

- *ventrally*: lig. longitudinale posterius
- *dorsally*: arcus vertebrarum, ligg. flava
- *laterally*: pediculi arcus vertebrae, foramina intervertebralia

Contens:

- medulla spinalis + fila radicularia
- dura mater spinalis, arachnoidea mater spinalis, pia mater spinalis, lig. denticulatum
- a. spinalis ant., aa. spinales post.
- plexus venosi vertebrales interni (ant. et post.), vv. spinales ant. et post.

Arterial supply



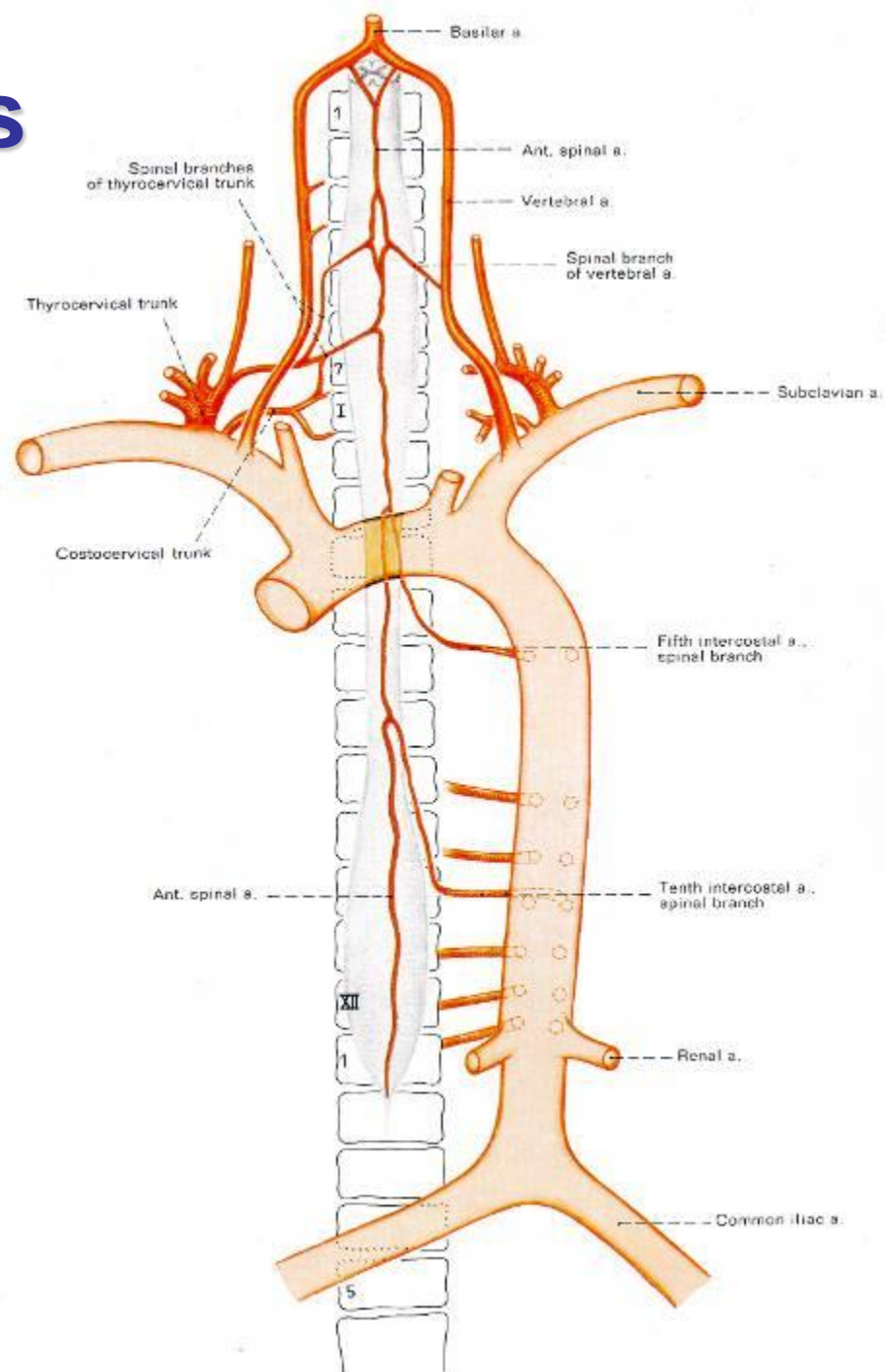
- longitudinal vessels
 - a. spinalis anterior
 - unpaired, ventrally
 - originates from connection of short paired branches of a. vertebralis
 - ventral 2/3 of spinal cord
 - aa. sulcocommissurales → grey matter
 - aa. spinales posteriores
 - paired, dorsally, sometimes doubled
 - branch from a. basilaris → a. inf. post. cerebelli
- transverse vessels (segmental)
 - rr. spinales → a. radicularis anterior et posterior → connects with longitudinal vessels → vasocorona (around spinal cord)
 - aa. periphericae → white matter

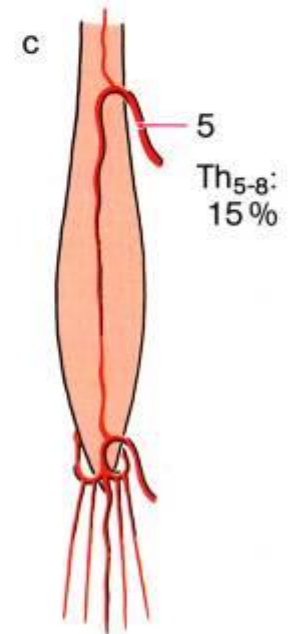
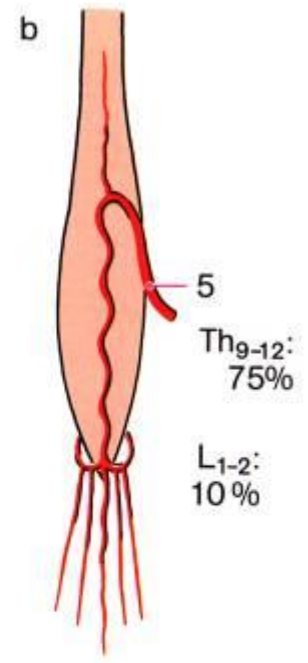
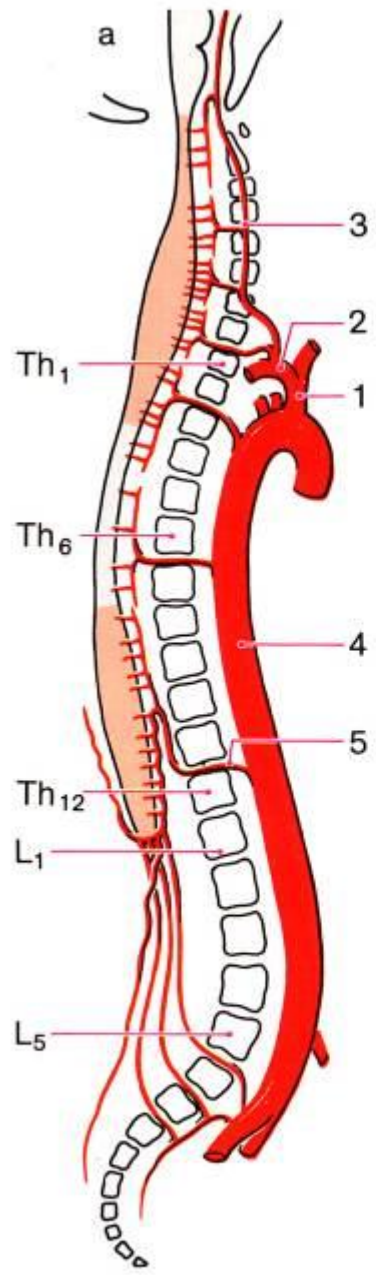
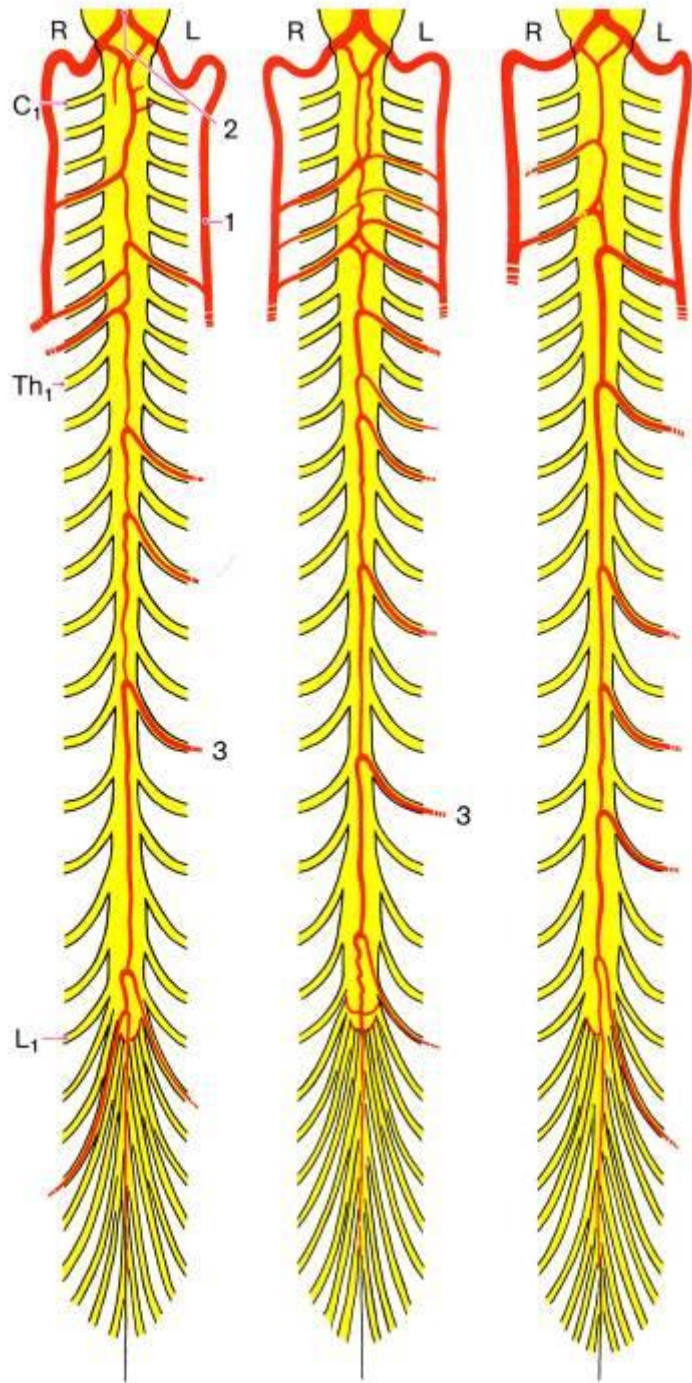
Origins of rr. spinales

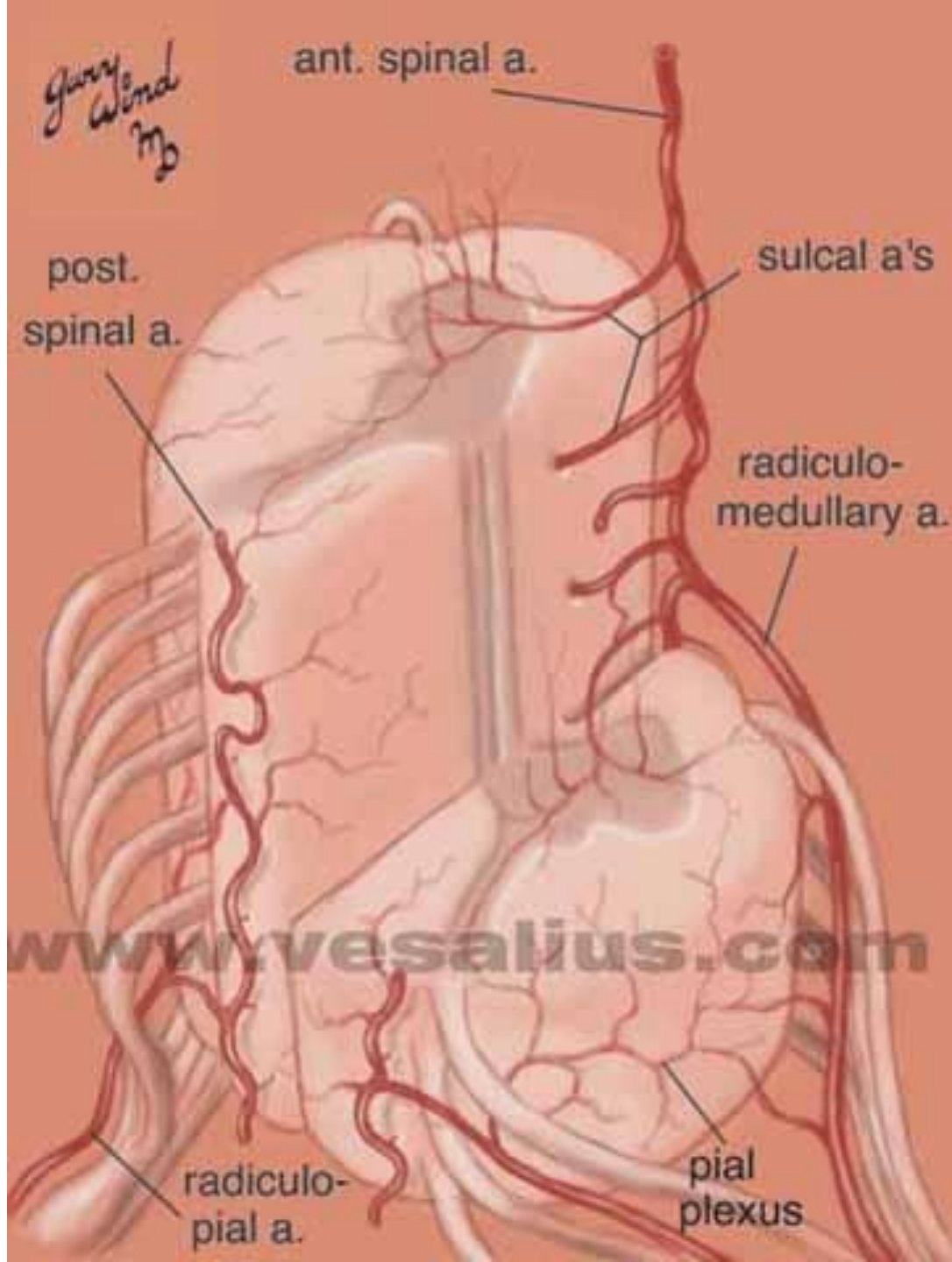
- a. vertebralis
- a. cervicalis ascendens
- a. cervicalis profunda
- aa. intercostales posteriores
- aa. lumbales
- a. iliolumbalis
- aa. sacrales laterales

aa. radicales

- irregular
- 5-9
- **a. radicularis magna**
Adamkiewiczi

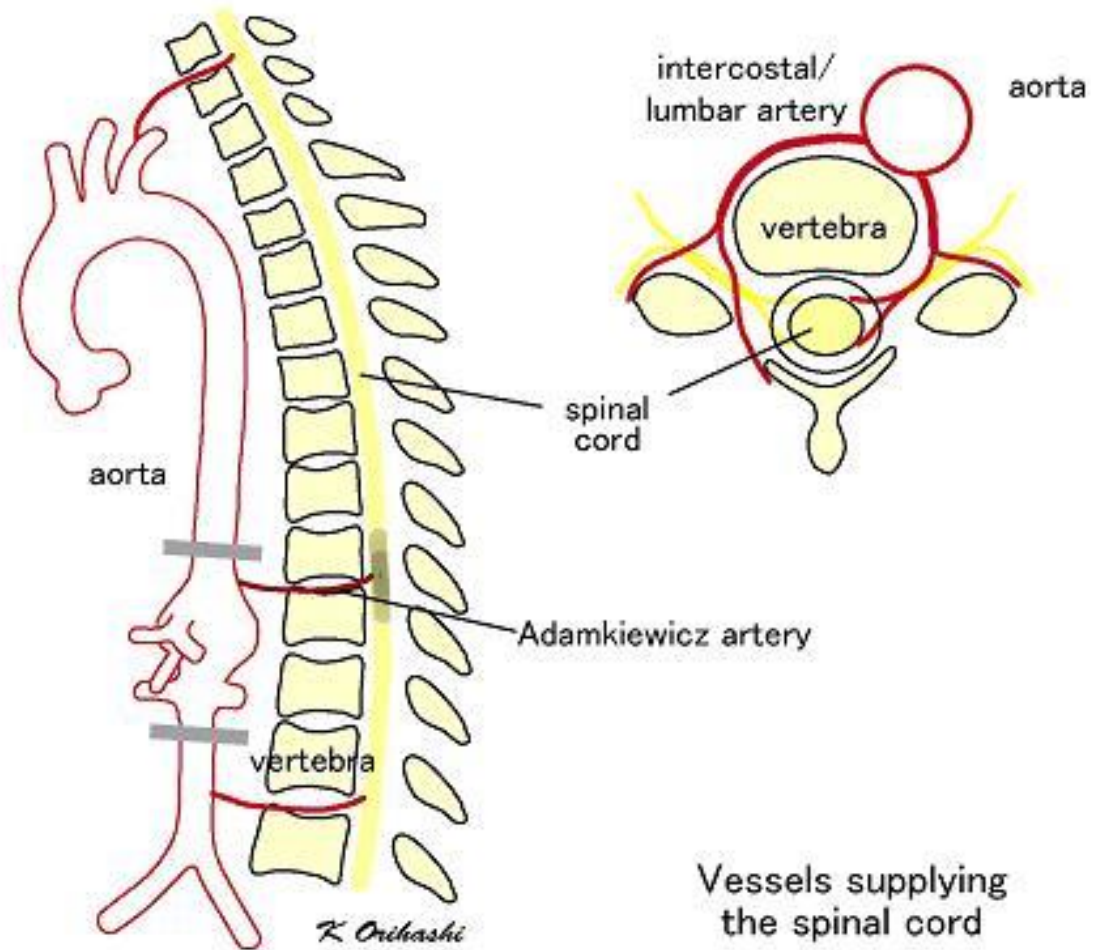






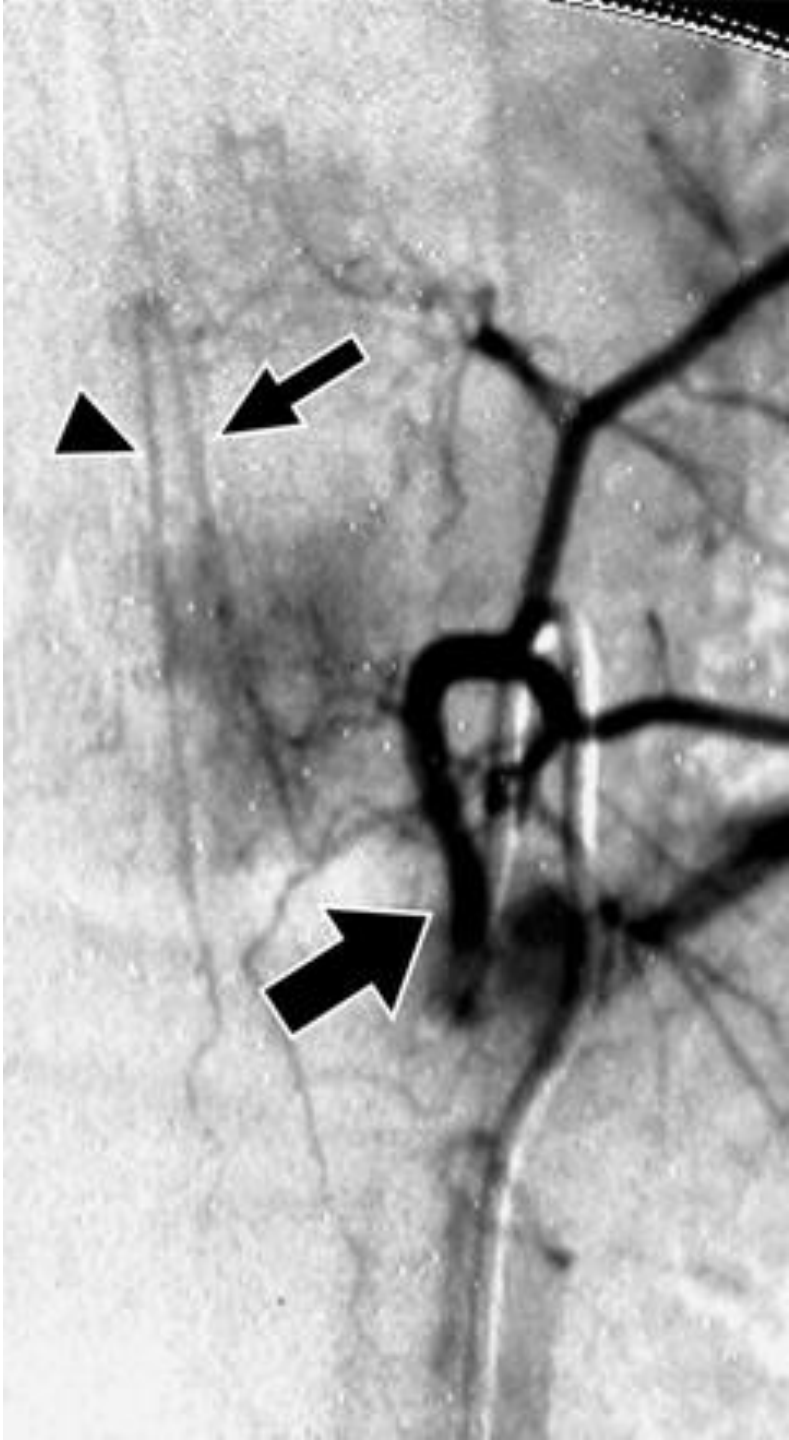
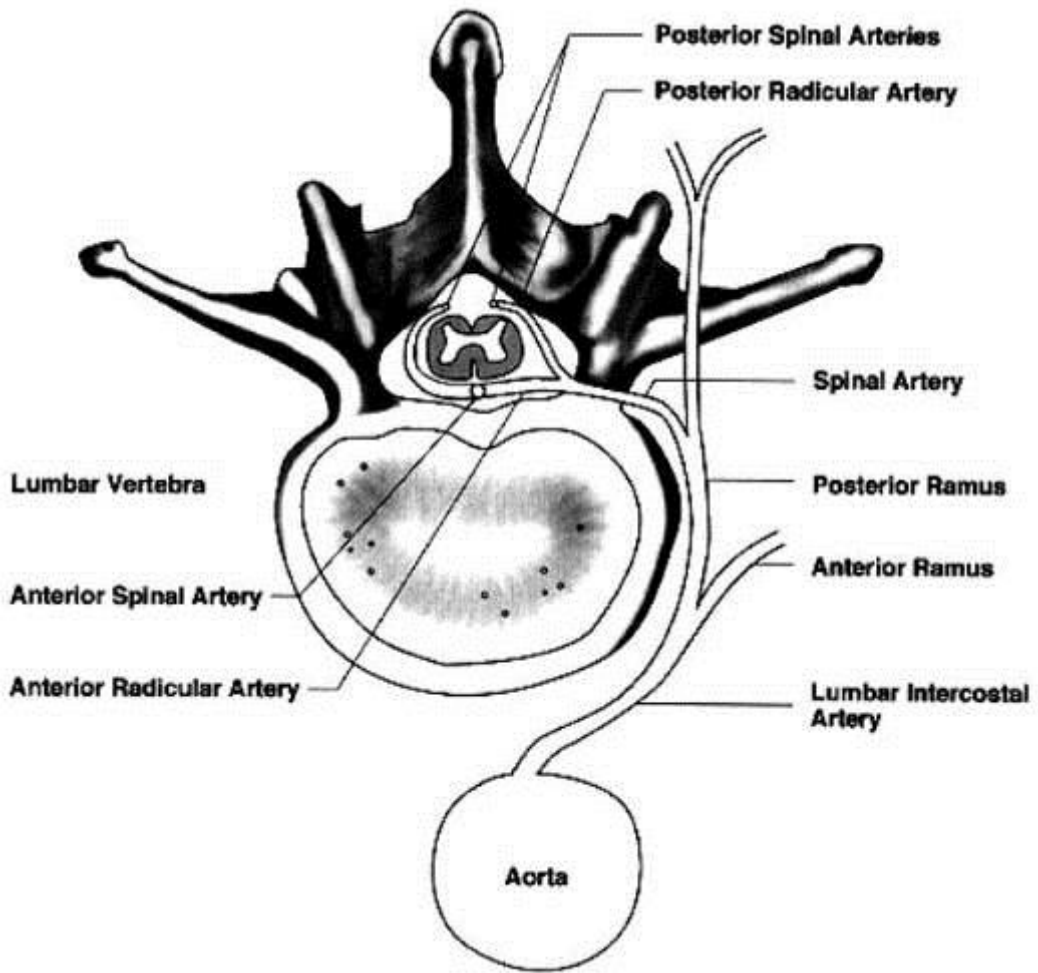
Arteria radicularis magna

- T9–T11
- more often left (65 %)
- supplies
intumescentia
lumbosacralis
and caudal 2/3 of
spinal cord



Albert Wojciech Adamkiewicz (1850 - 1921)

Arteria radicularis magna



Venous drainage

- longitudinal veins
- transverse veins
 - vv. basivertebrales
 - course within corpus vertebrae
 - connects internal and external venous plexuses

spinal cord → plexus venosus vertebralis internus
anterior + posterior (in *spatium epidurale*)

→ vv. radicales

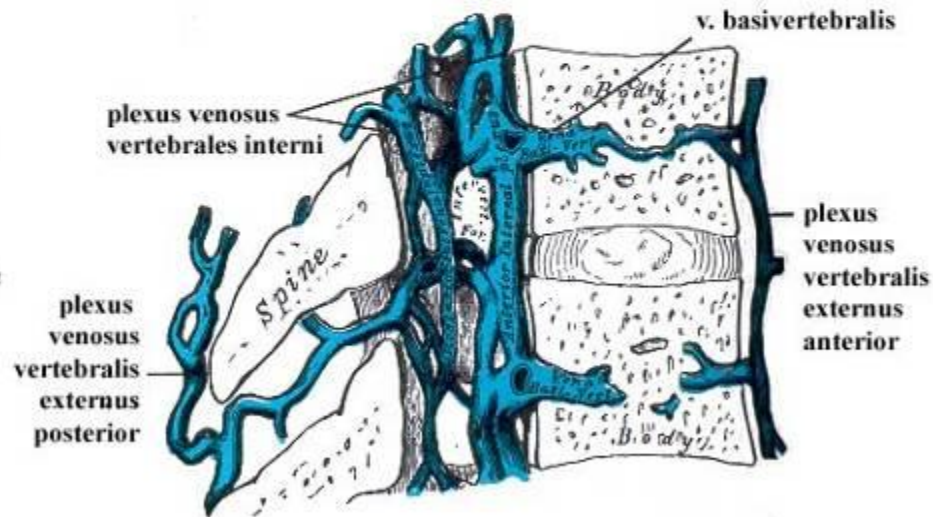
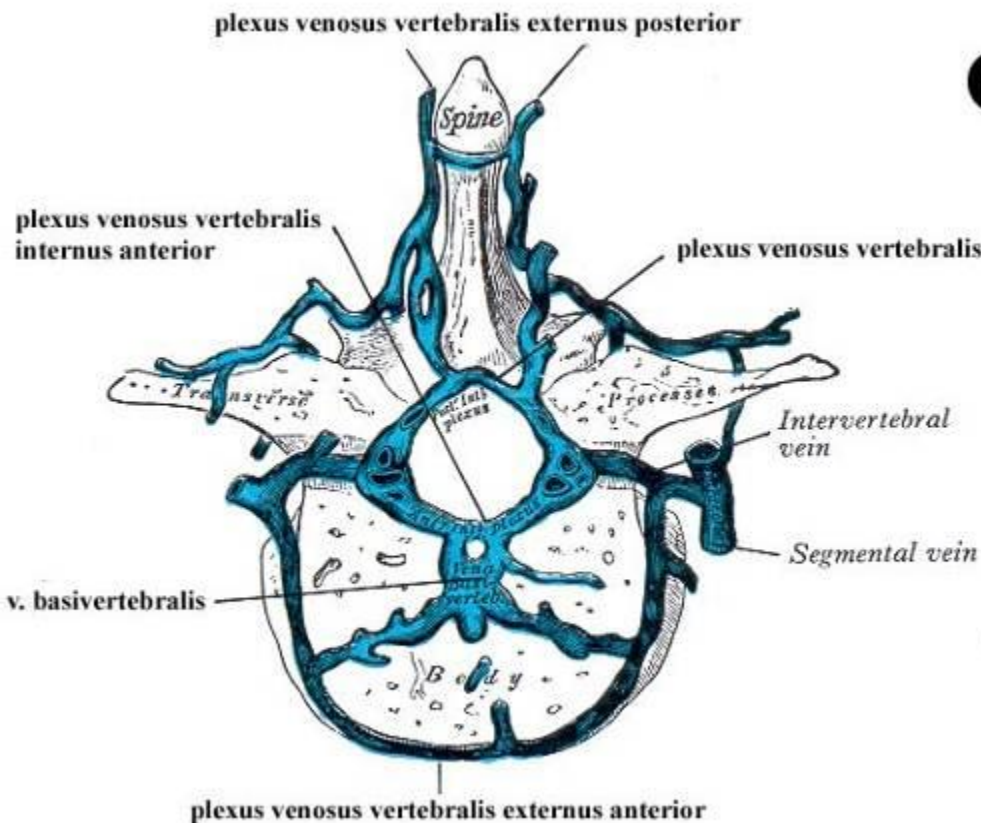
→ vv. intervertebrales

→ plexus venosus vertebralis externus anterior

→ closest regional veins (correspond to arteries)

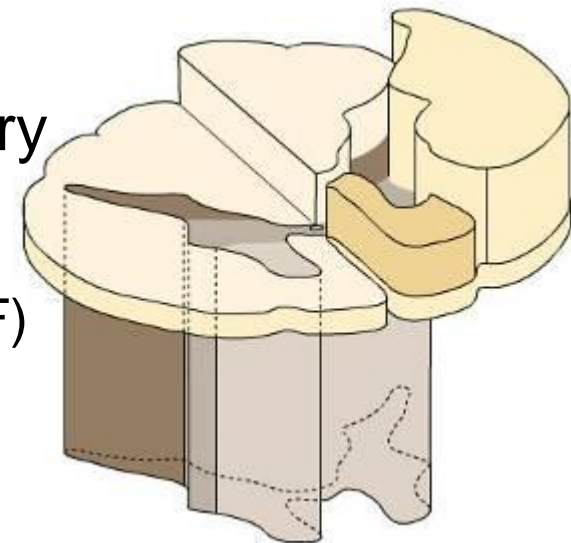
Venous drainage

OBRATLOVÉ ŽÍLY



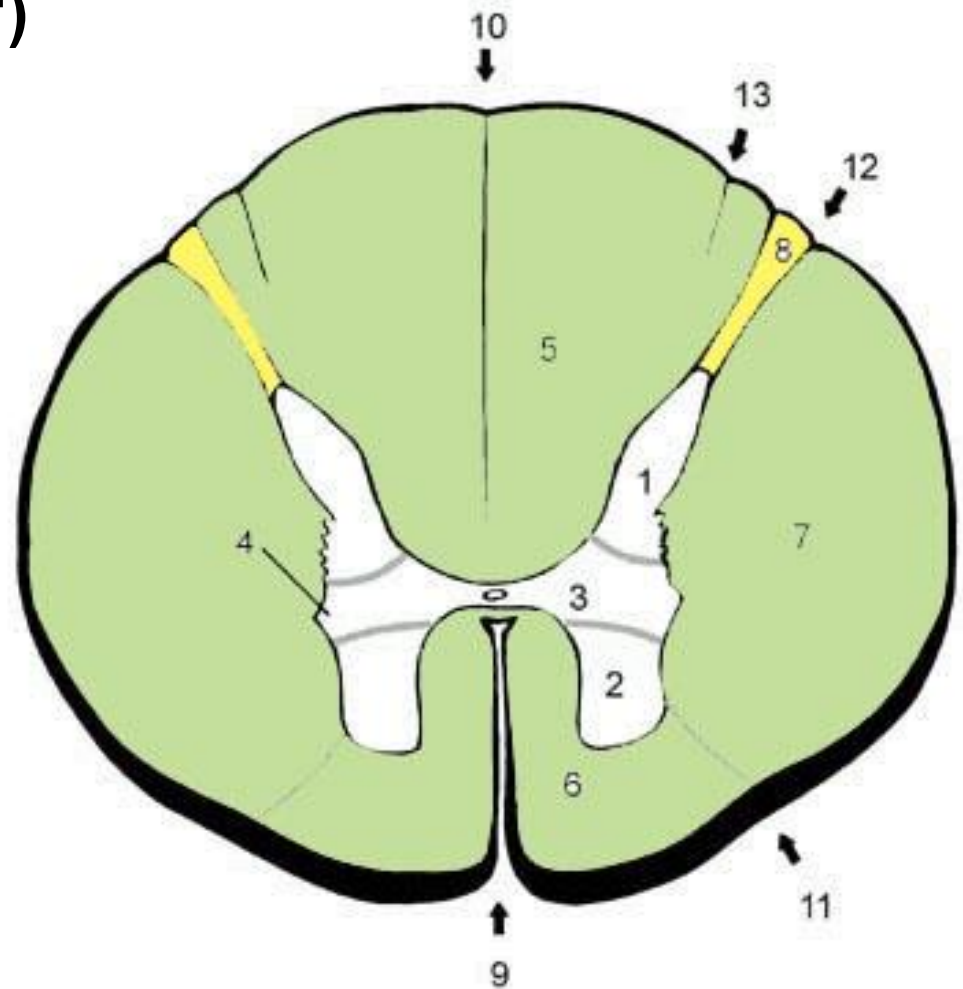
Spinal cord – internal composition

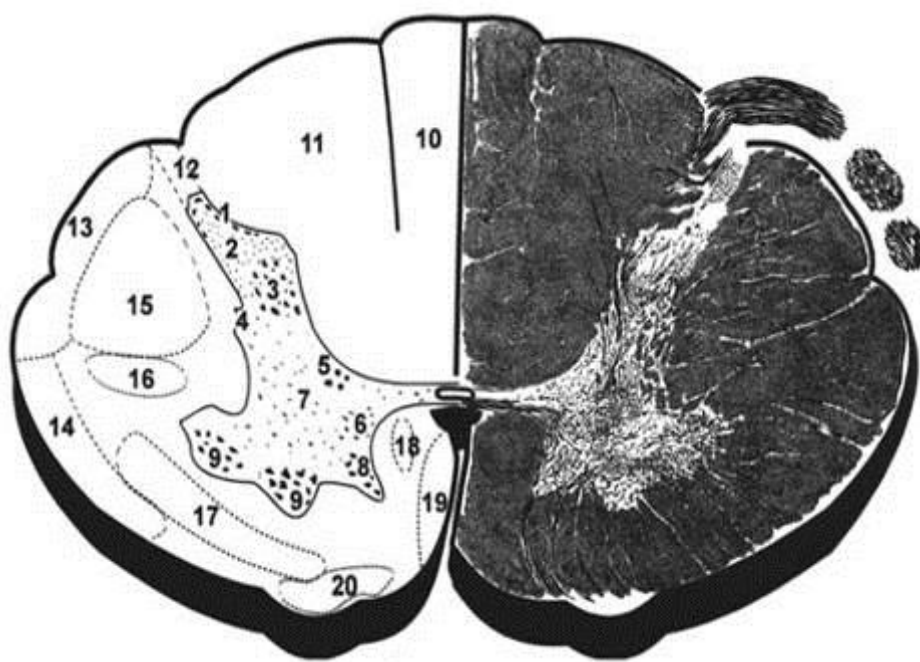
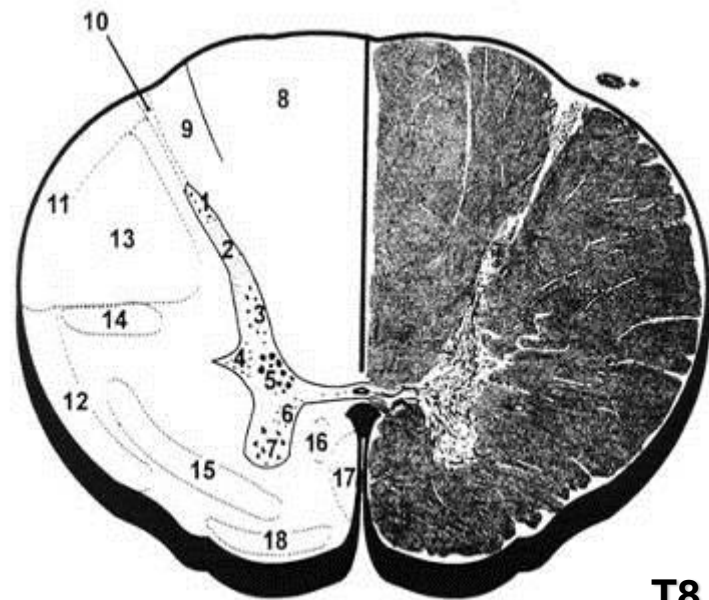
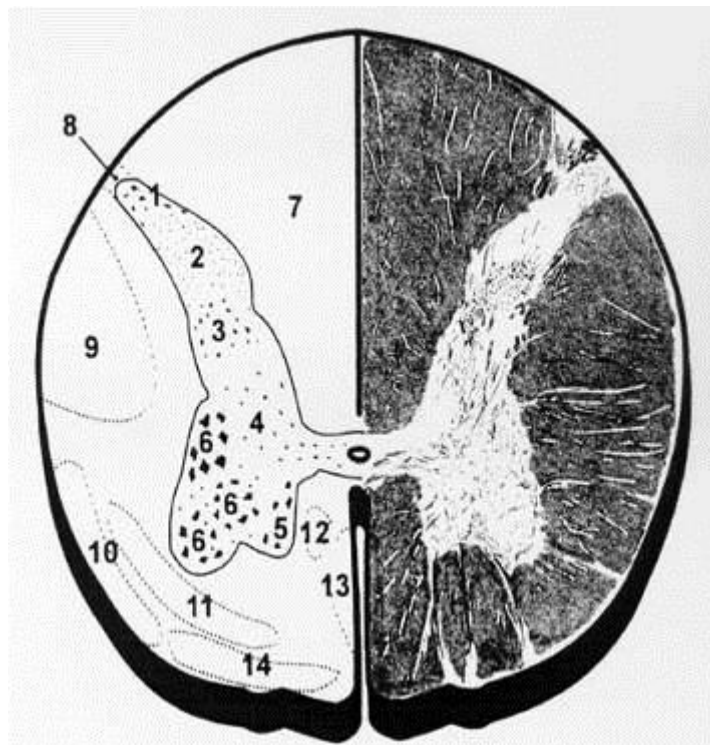
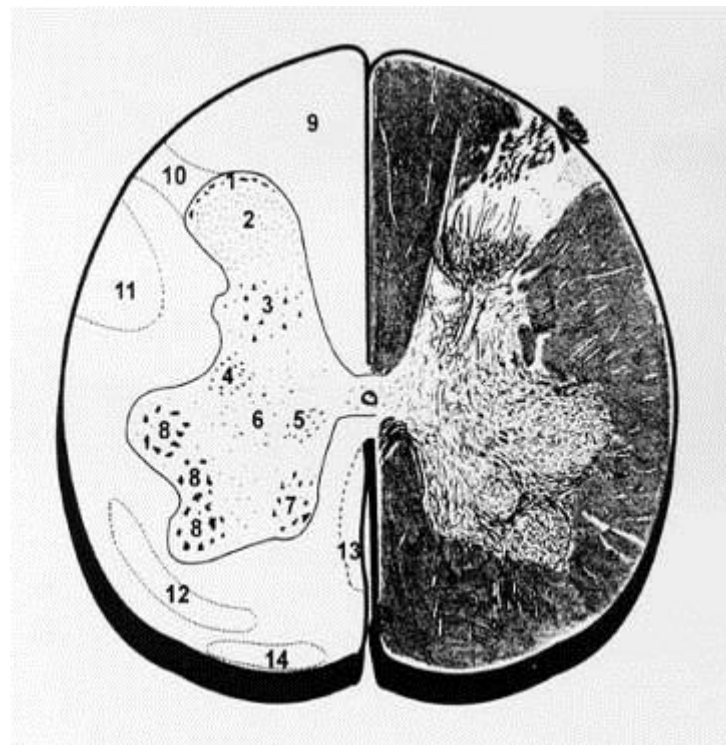
- white matter (*substantia alba*) = funiculi
 - *funiculus anterior* („ventralis“)
 - *funiculus lateralis*
 - *funiculus posterior* („dorsalis“)
- grey matter (*substantia grisea*) = columns
 - *columna anterior* („ventralis“) – motor
 - *columna intermedia* – autonomic
 - *columna posterior* („dorsalis“) – sensory
- canalis centralis
 - liquor cerebrospinalis (cerebrospinal fluid CSF)



Spinal cord - section

- canalis centralis
- **cornu anterius („ventrale“)**
= anterior horn
- **cornu laterale** = lateral horn
- **cornu posterius („dorsale“)**
= posterior horn
- commissura grisea ant.+ post.
- **funiculus anterior („ventralis“)**
- **funiculus lateralis**
- **funiculus posterior („dorsalis“)**
 - septum medianum posterius
- commissura alba ant.+ post.
- tractus posterolateralis
Lissaueri

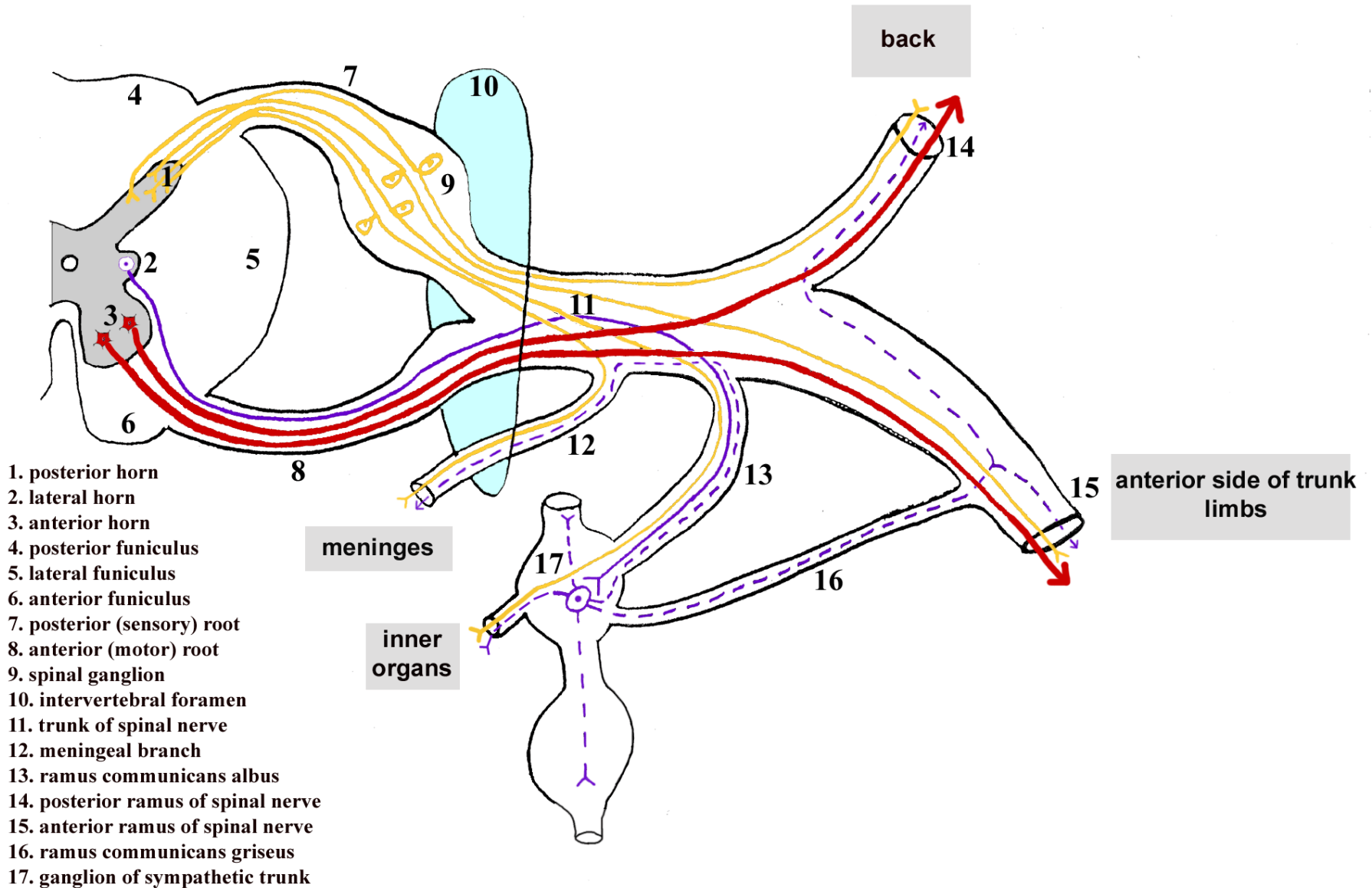


C8**T8****T8****L3****S1**

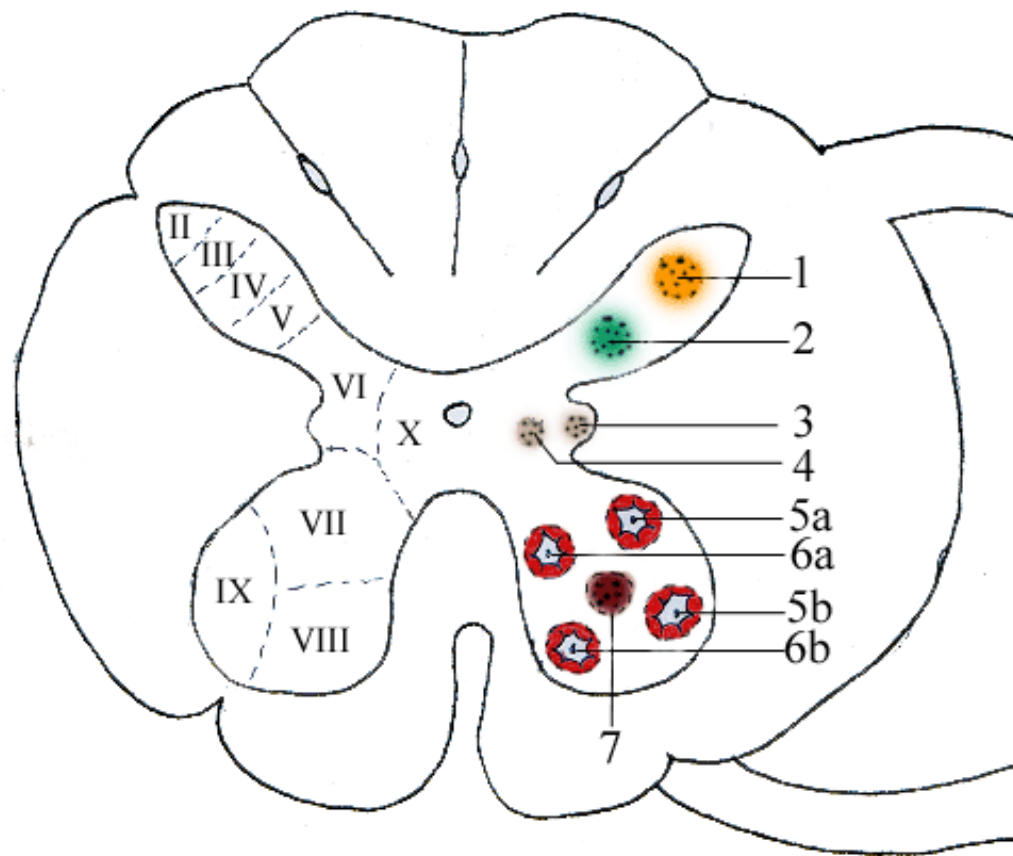
Spinal cord – internal composition, general rules

- longitudinal organization
 - fibers = funiculi = white matter
 - Nerve cells aggregates = nuclei = grey matter
- horizontal organization
 - afferent & efferent fibers
 - crossing
 - commissural (different side)
 - decussation (crossed)
- somatotopic organization

SCHEME OF SPINAL NERVE BRANCHING



SECTION OF SPINAL CORD - GREY COLUMNS AND THEIR NUCLEI



- 1 - nucleus proprius of posterior column
(beginning of spinothalamic and spinotectal tracts)
- 2 - posterior thoracic nucleus /*Stilling-Clark*/
(beginning of spinocerebellar tracts)
- 3 - intermediolateral nucleus
- 4 - intermediomedial nucleus
- 5a - posterolateral nucleus
(alfa motor neurons for hypoaxial muscles)
- 5b - anterolateral nucleus
(alfa motor neurons for hypoaxial muscles)
- 6a - posteromedial nucleus
(alfa motor neurons for epaxial muscles)
- 6b - anteromedial nucleus
(alfa motor neurons for epaxial muscles)
- 7 - gamma motor neurons (for muscle spindles)

Laminae spinales of Rexed I-X

I = zona marginalis (apex cornus posterioris)

II = **substantia gelatinosa *Rolandi*** (caput c.p.)

III+IV = **nucleus proprius** (cervix c.p.)

V = cervix c.p. – in tumescentiae only

VI = basis c.p – in tumescentiae only

VII = **cornu laterale**

- ncl. thoracicus posterior ***Stilling-Clarke***

- ncl. intermediolateralis

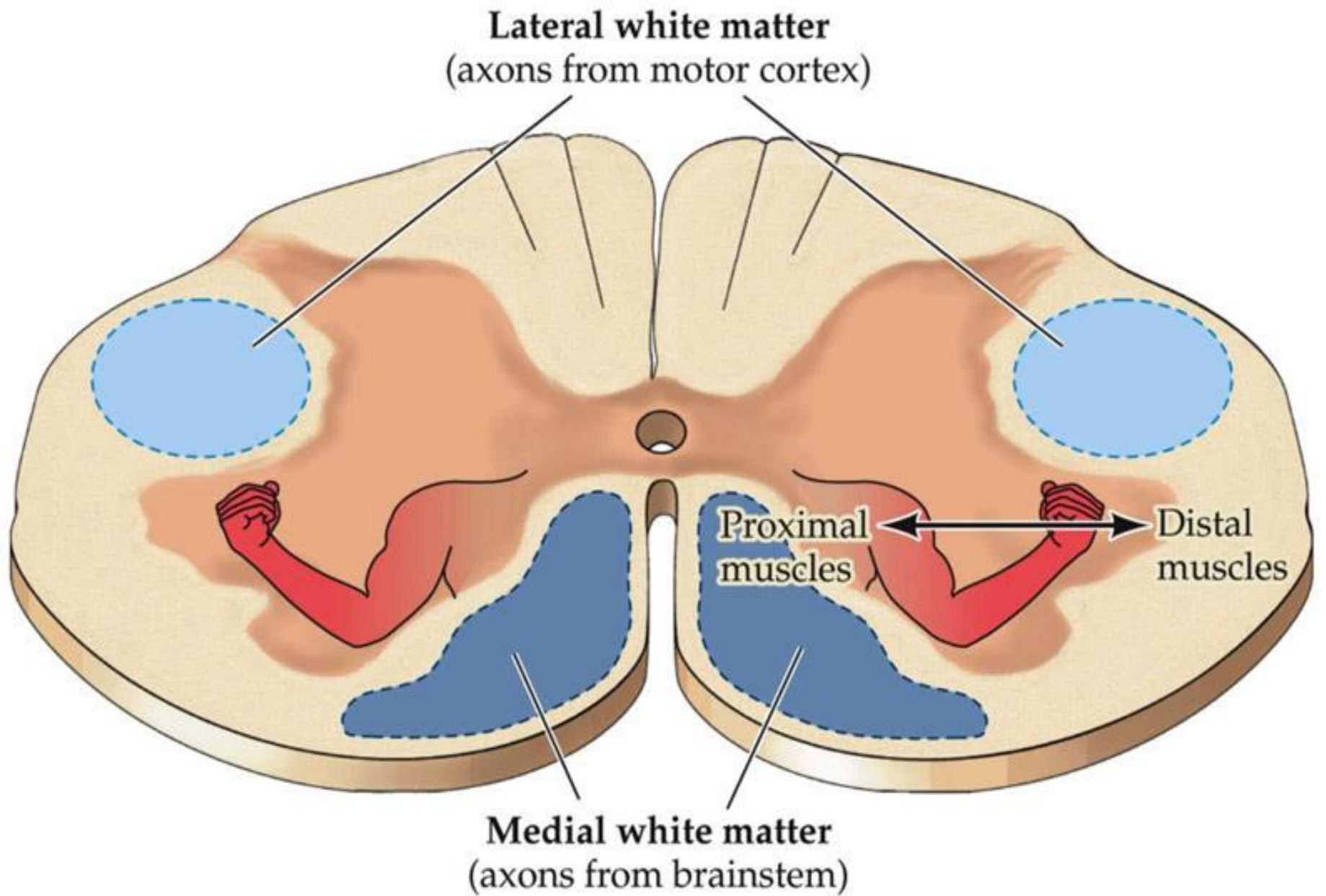
- ncl. intermediomedialis

VIII+IX = cornu anterius

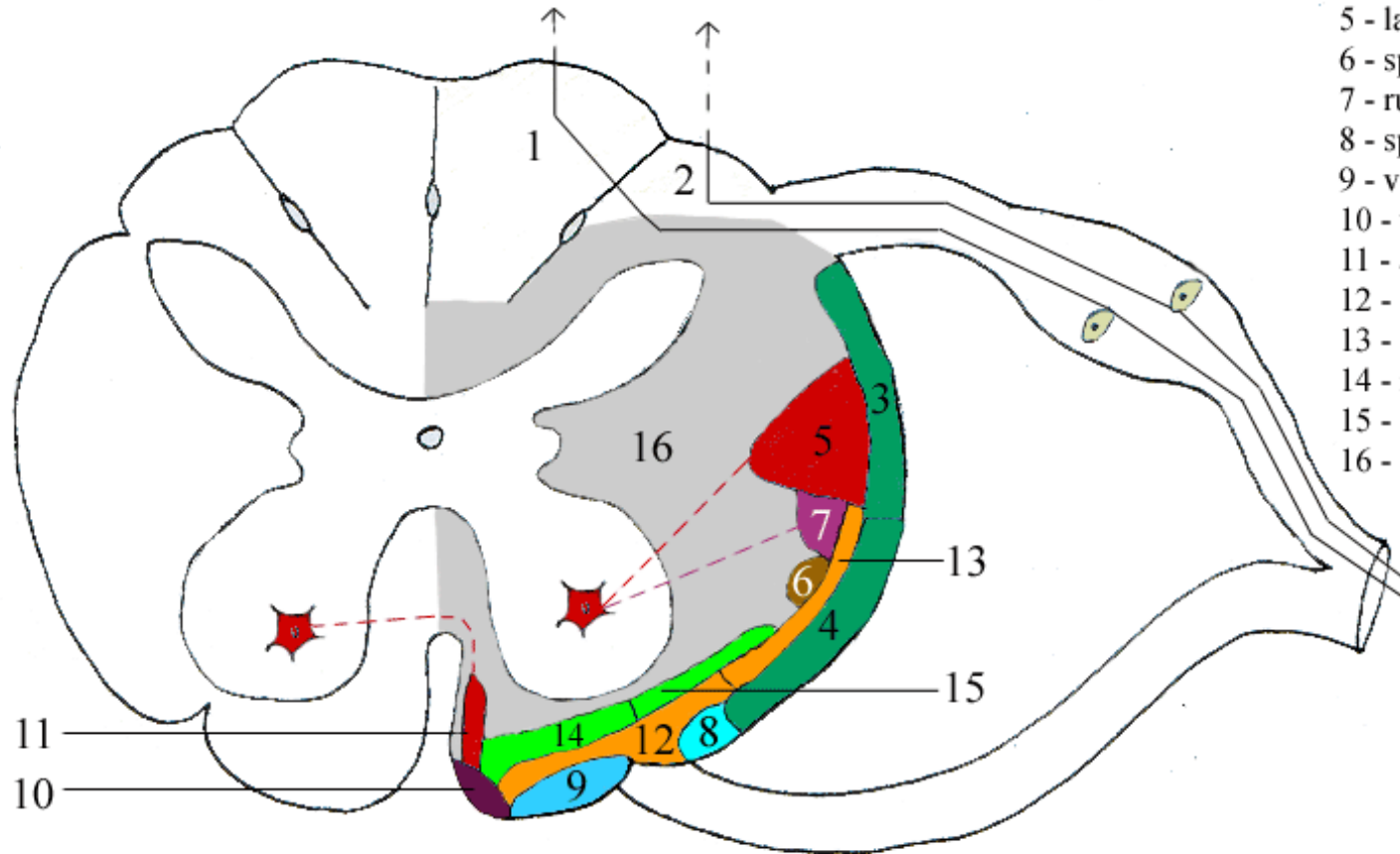
- ncl. anterolateralis, anteromedialis, posteromedialis, posterolateralis, centralis

X = commissura grisea ant. + post.





SECTION OF SPINAL CORD WHITE SUBSTANCE AND ITS TRACTS



- 1 - gracile fasciculus /Golli/
- 2 - cuneate fasciculus /Burdachi/
(in the areas of upper Th a C segments)
- 3 - posterior spinocerebellar tract
- 4 - anterior spinocerebellar tract
- 5 - lateral corticospinal tract
- 6 - spino-tectal tract
- 7 - rubrospinal tract
- 8 - spino-olivary tract
- 9 - vestibulospinal tract (med. and lat.)
- 10 - tectospinal tract
- 11 - anterior corticospinal tract
- 12 - anterior spinothalamic tract
- 13 - lateral spinothalamic tract
- 14 - reticulospinal fibres
- 15 - spinoreticular tract
- 16 - fasciculi proprii

Regional differences in spinal cord

- cervical spinal cord
 - ncl. nervi phrenici (C3-5)
 - ncl. nervi accessorii (C1-6)
 - ncl. spinalis nervi trigemini (C1-2)
 - RF replaces ncl. intermediolateralis
 - (ncl. lateralis cervicalis)
 - (ncl. spinalis lateralis)

Spinal cord tracts

- **ascending (afferent, upward, centripetal)**
 - somatosensory and viscerosensory converging in spinal nerves
- **descending (efferent, downward, centrifugal)**
 - somatomotor
 - visceromotor (autonomic)
- ***tracts decussations!!!***

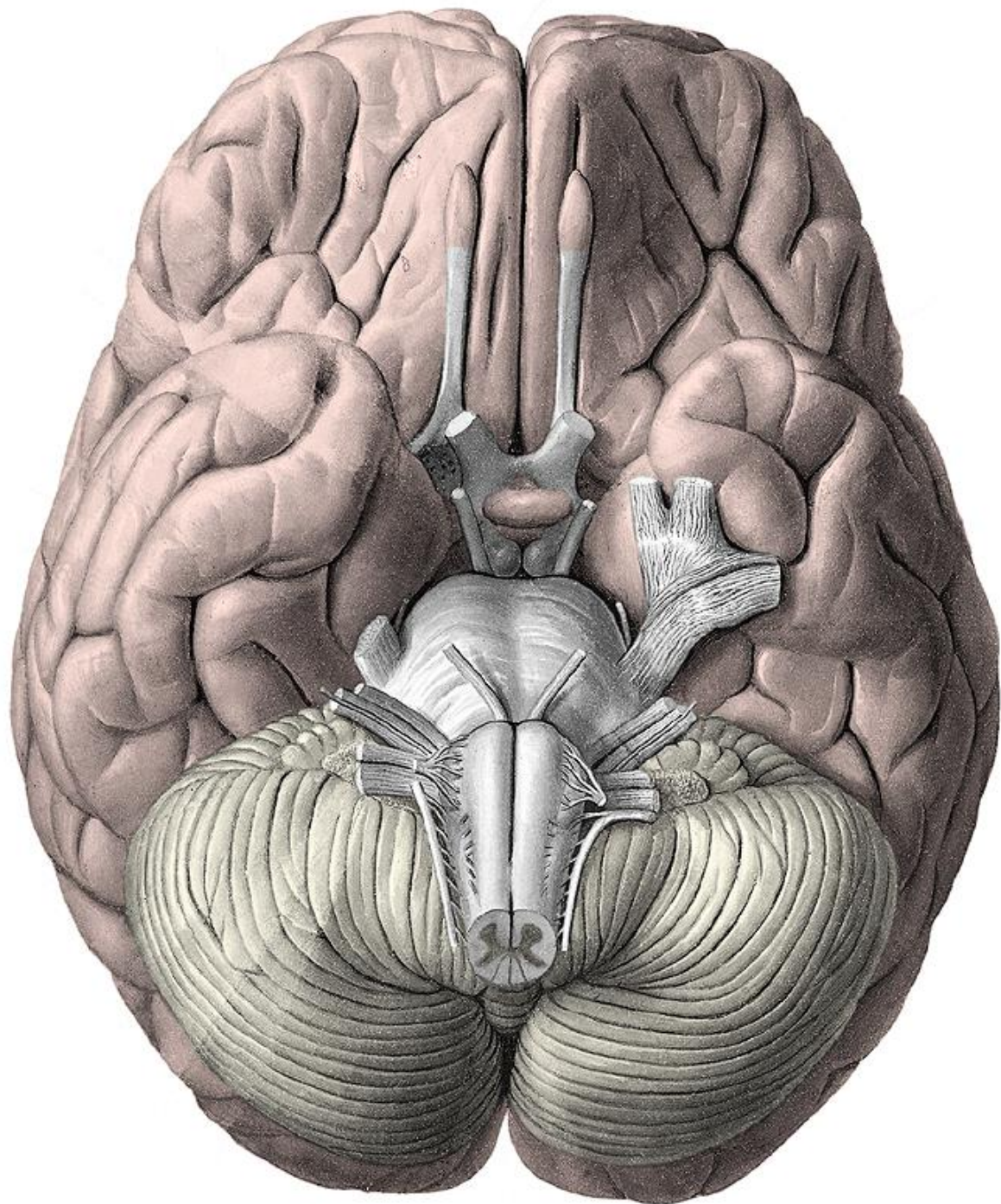
Ascending tracts

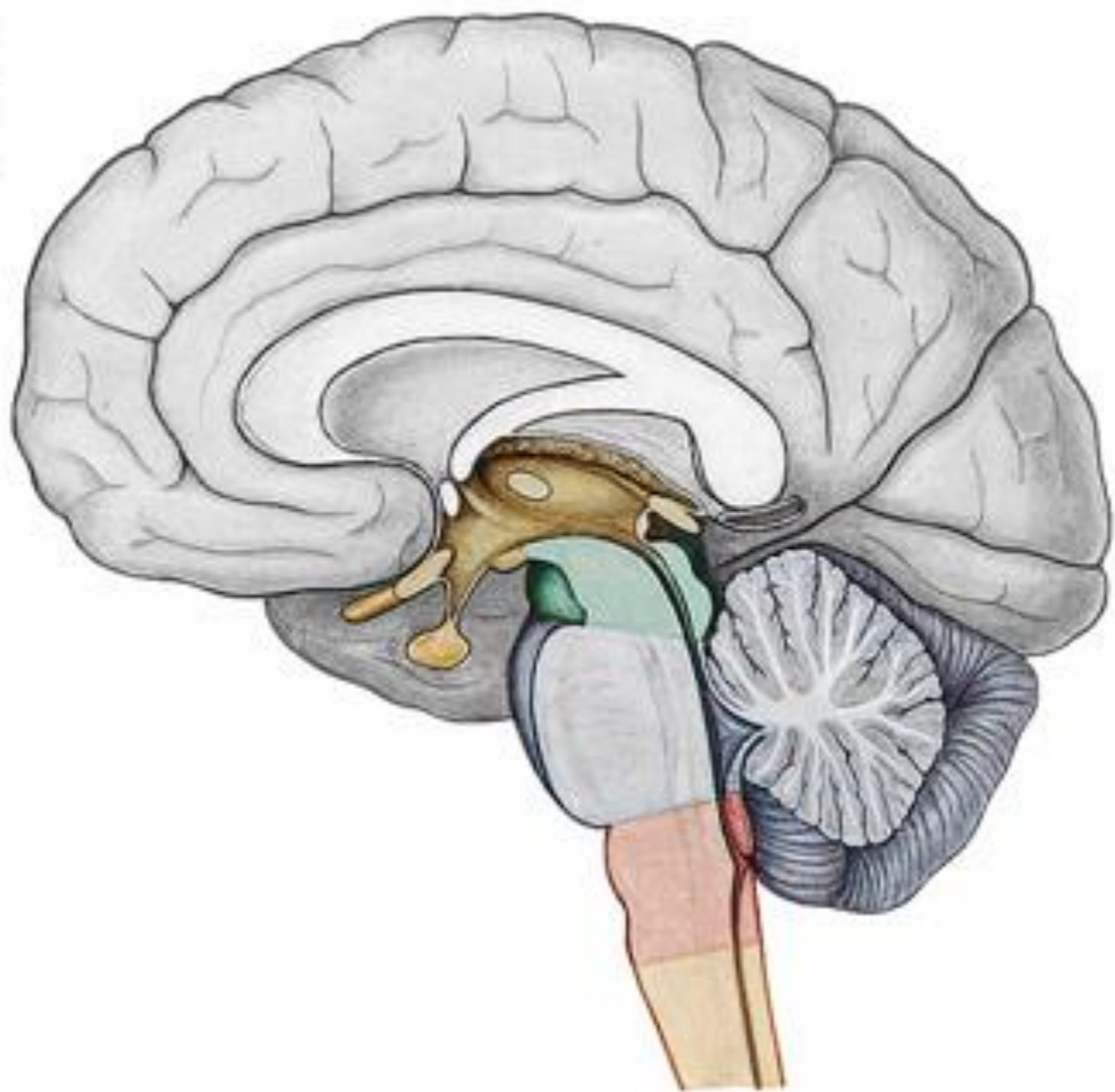
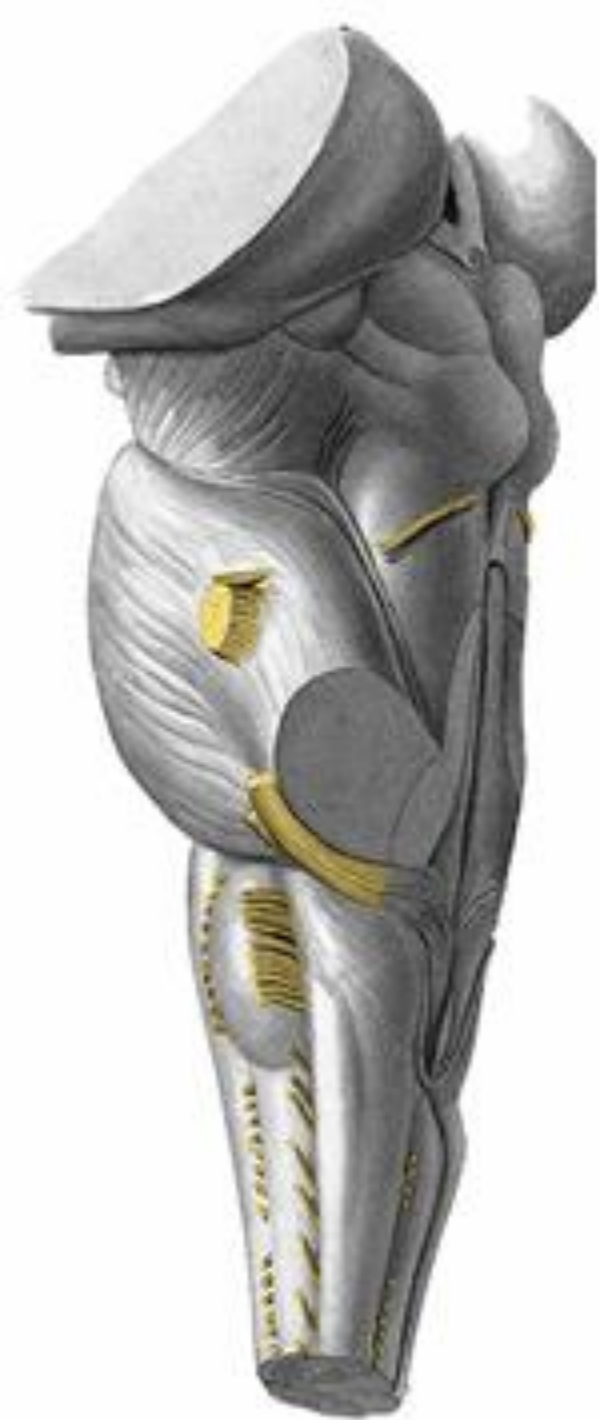
- modality: touch, pain, heat-cold, tactile (proprioception, kinesthesia)
- receptor: exteroceptors, interoceptors, proprioceptors

- 1st order neuron: ganglion spinale
- 2nd order neuron: spinal cord / brain stem
- 3rd order neuron: thalamus (nuclei ventrobasales)
- termination: cortex, cerebellar cortex, brain stem

Ascending tracts

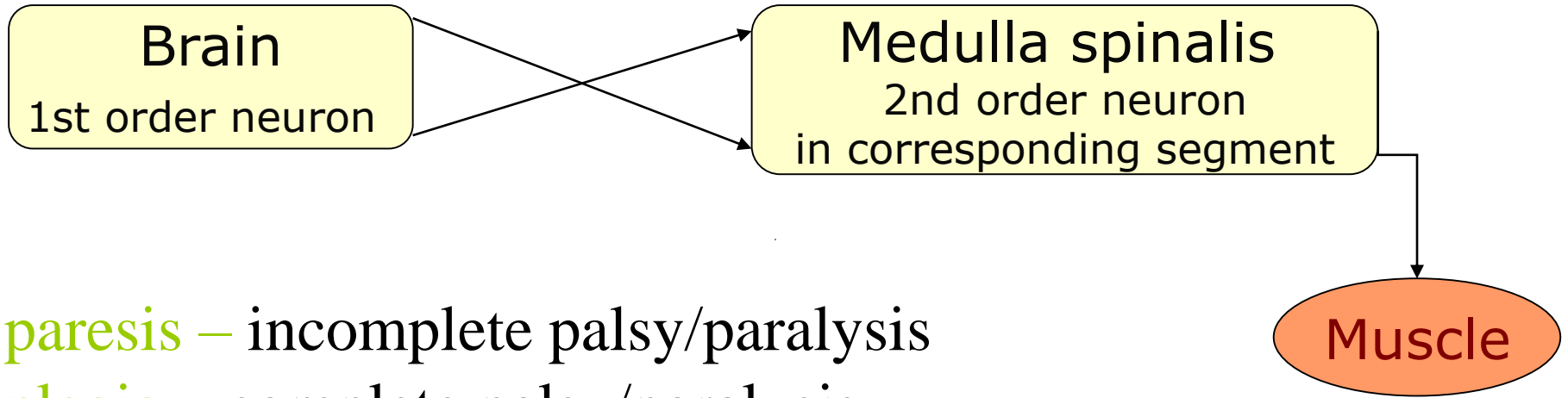
- tractus **spino-bulbo-thalamo-corticalis**
= posterior fascicle tract = lemniscal system = fasciculus gracilis + cuneatus
 - *tactile, fine skin sensation, discrimination, pressure, vibration*
- tractus **spinothalamicus ant.+lat.** = anterolateral system
 - *fast pain, heat-cold, rough skin sensation*
- tractus spinoreticularis
 - *slow pain*
- tractus spinocerebellares ant.+post.
- *and others...😊*





Descending tracts

- **tractus corticospinalis = pyramidal tract**
 - principal motor tract – voluntary movements
 - 1st order neuron – cerebral cortex (pyramidal cell)
 - 2nd order neuron – alpha-motoneuron → spinal nerve
- **extrapyramidal system**
 - *involuntary movements*
 - tr. vestibulospinalis – postural muscles
 - tr. reticulospinalis – gamma-motoneurons
 - tr. rubrospinalis (rudimentary!)
 - and others... 😊

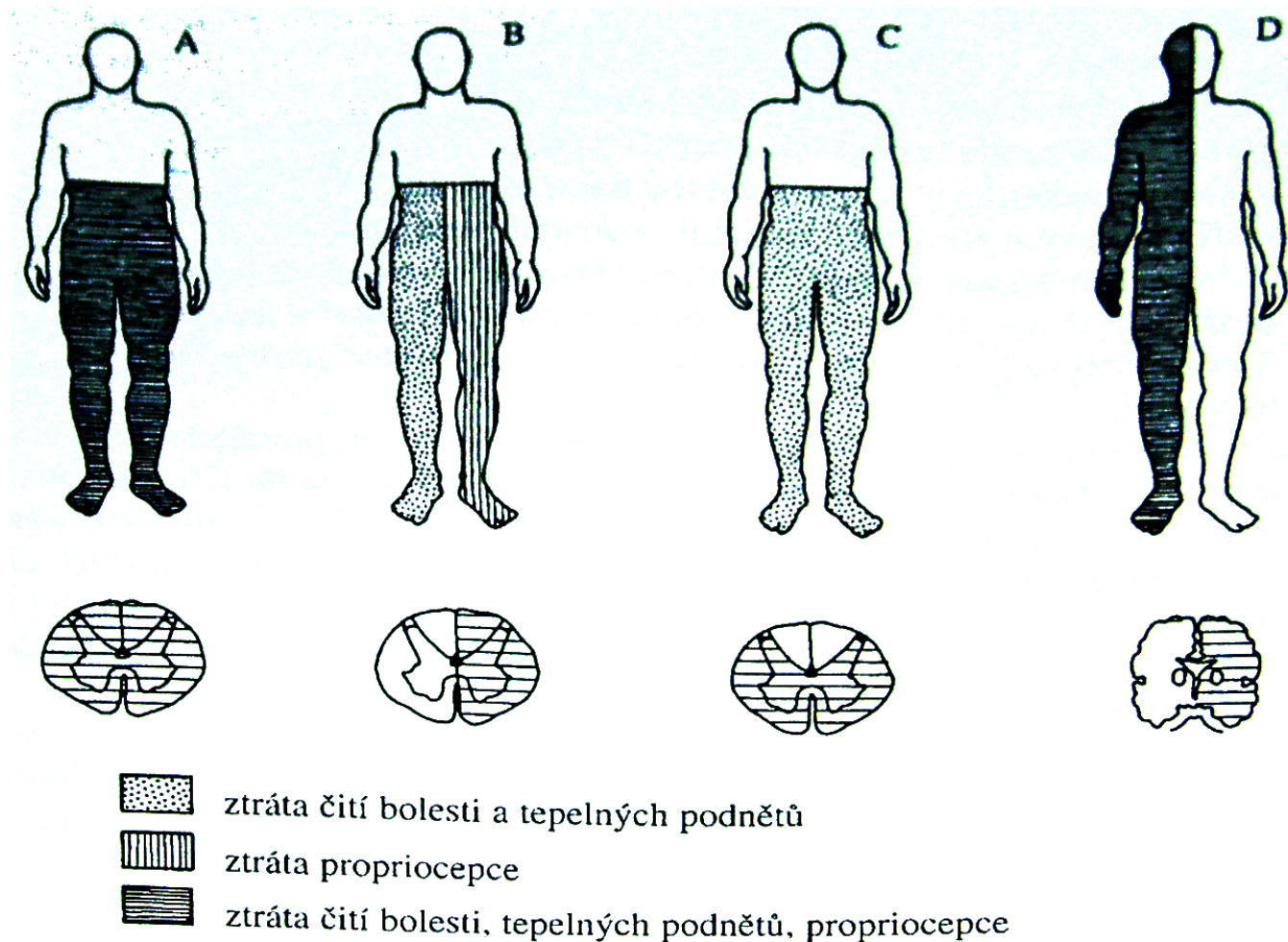


- paresis – incomplete palsy/paralysis
- plegia – complete palsy/paralysis

- quadraparesis – 4 limbs
- hemiparesis – ½ of body longitudinally (1UE+1LE)
- paraparesis – both LE

- central palsy – afflicted 1st order motoneuron
= SPASTIC paralysis (bleeding, ischaemia..)
- peripheral palsy – afflicted 2nd order motoneuron
= FLACCID paralysis (poliomyelitis, Guillan-Barré sy, injury)

Examples of spinal cord lesions



- A. Transversal spinal cord lesioní
B. Brown-Séquard syndrome (spinal hemisyndrome)
C. Syndrome of a. spinalis anterior
D. Hemispheric syndrome

Cauda equina – roots L3-S5

- asymmetrical palsy (according to lesioned roots), peripheral = flaccid (muscular atrophy, areflexia, hypotonia)
- perception (sensation) problems
- radicular – asymmetrical hypesthesia + pain
 - perianal, perigenital (also hemi-, smaller extent)
- problems with sphincters
 - acute urine retention
 - stool retention
- sexual dysfunctions
- *cause*: caudally from L2 v, most often *discopathia (L4/5, L5/S1)*

Conus medullaris – segments S3-S5

- not palsy of lower limb !!
 - only short flexors of toes and muscles of pelvic diaphragm
- perception problems – perianal, perigenital, on internal and posterior side of thigh (also S2)
- pain irradiation into perineal and gluteal regions
- sphincter problems:
 - autonomic urinary bladder (urine retention)
 - stool incontinency
- sexual problems (erection and ejaculation)
- visualization – at the level of L1 vertebra
- *cause: highly suspect expansion process*

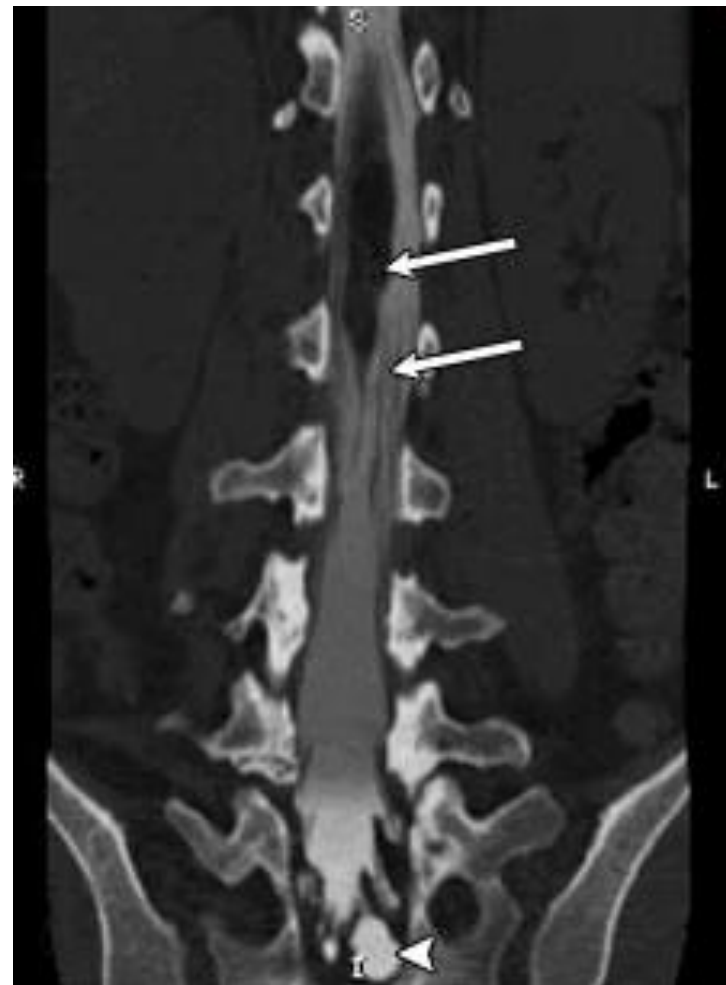
Spinal epiconus, segments L5-S2

- palsy identical to the radicular lesion L5 + S1 – *mistakes !!*
paresis of extensors of foot, muscles on the ventral and dorsal side of leg = problems with flexion and extension of foot and flexion of leg
- perception problem (posterior side of LL and distally to knees)
- autonomic urinary bladder
- sexual problems (erection and ejaculation)
- visualization is necessary at the level of vertebrae T12/L1!
- *cause: It is not disc prolapse, but suspect expansion process!*

Case report 1

- 33-year old female patient comes with severe back pain, radiculopathy (lesion of radices) on the left LL and worsening urine incontinence
- *Which part of the vertebral column would you examine using visualization techniques (X-ray, CT, MR)?*

Examination results



CT myelogram

Arrow points to intramedullary structure, that was identified as tumor from adipose tissue – *lipoma*.

Case report 2

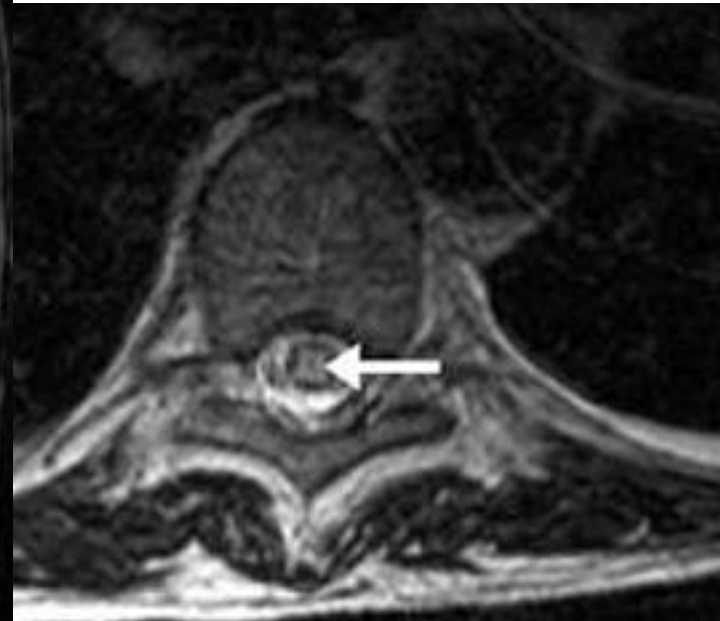
- 60-year female patient with fastly growing paraplegia and complete anesthesia of lower half of the body
- In personal anamnesis there is operation for abdominal aorta aneurysm

Which tracts are impaired?

How large is spinal cord lesion on „horizontal section“ ?

What could be the cause of sudden paraplegia?

Examination results



MR of T-L
transition
*ischemia at T5 +
at conus*



A: abdominal CT –
arrow points to
aortic aneurysma

B: Abdominal CT
– arrow points to
left atrophic
kidney

