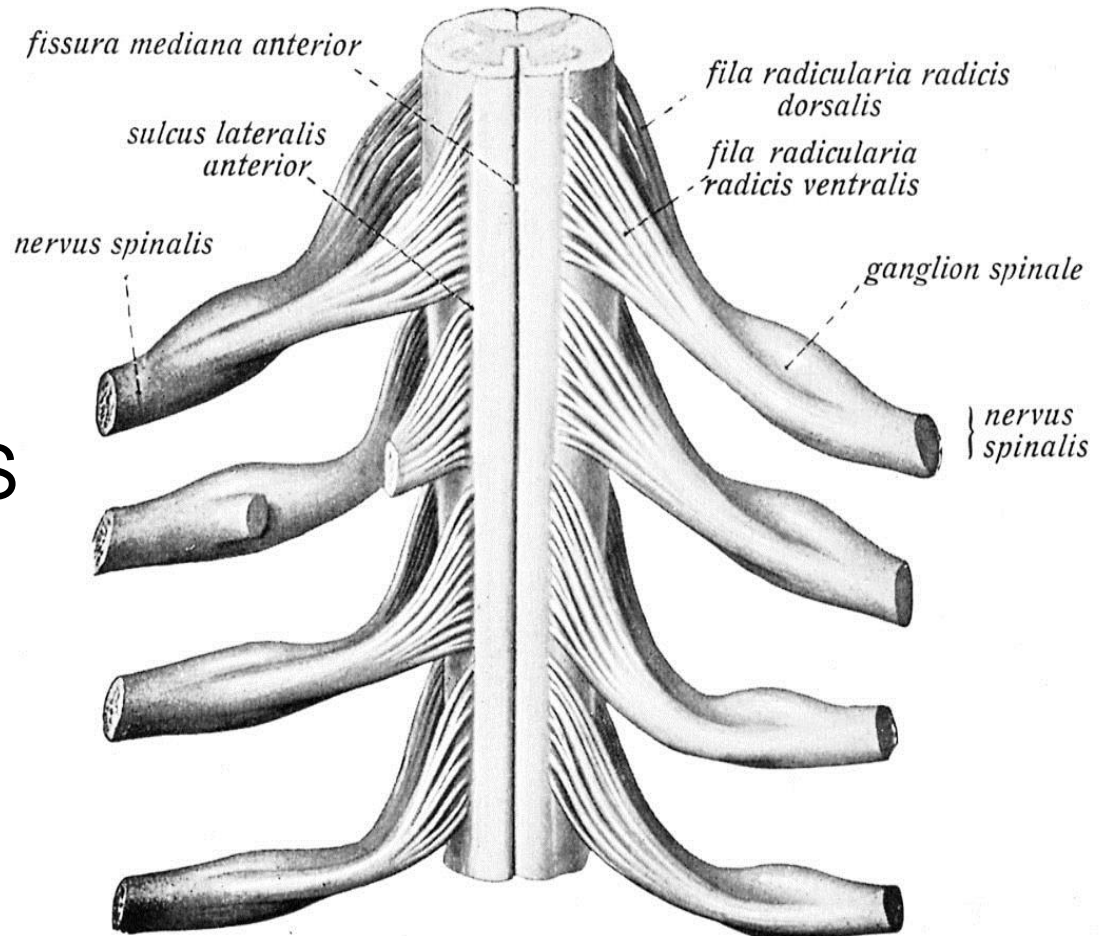


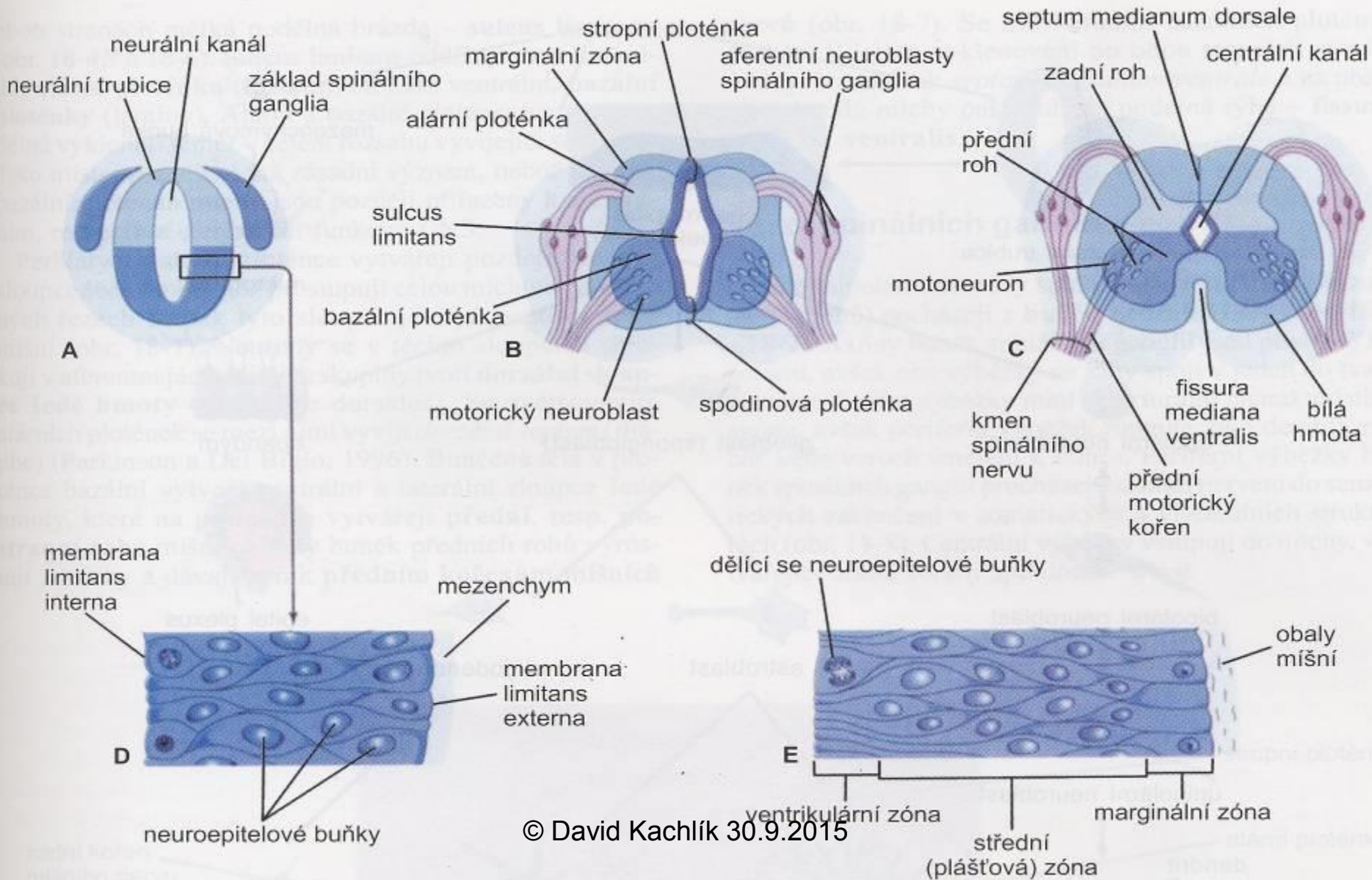
SPINAL CORD

Spinal cord = *Medulla spinalis*

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

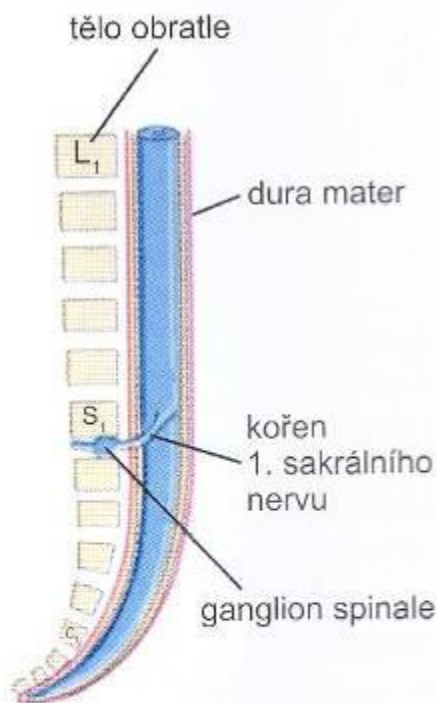


Development of neural tube in the spinal cord region

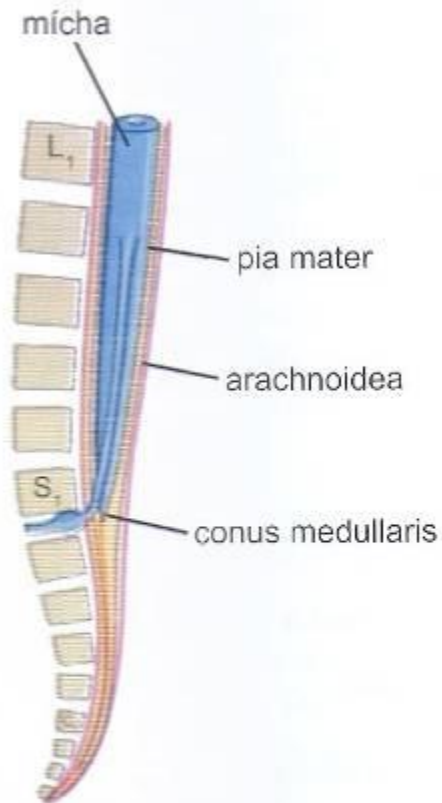


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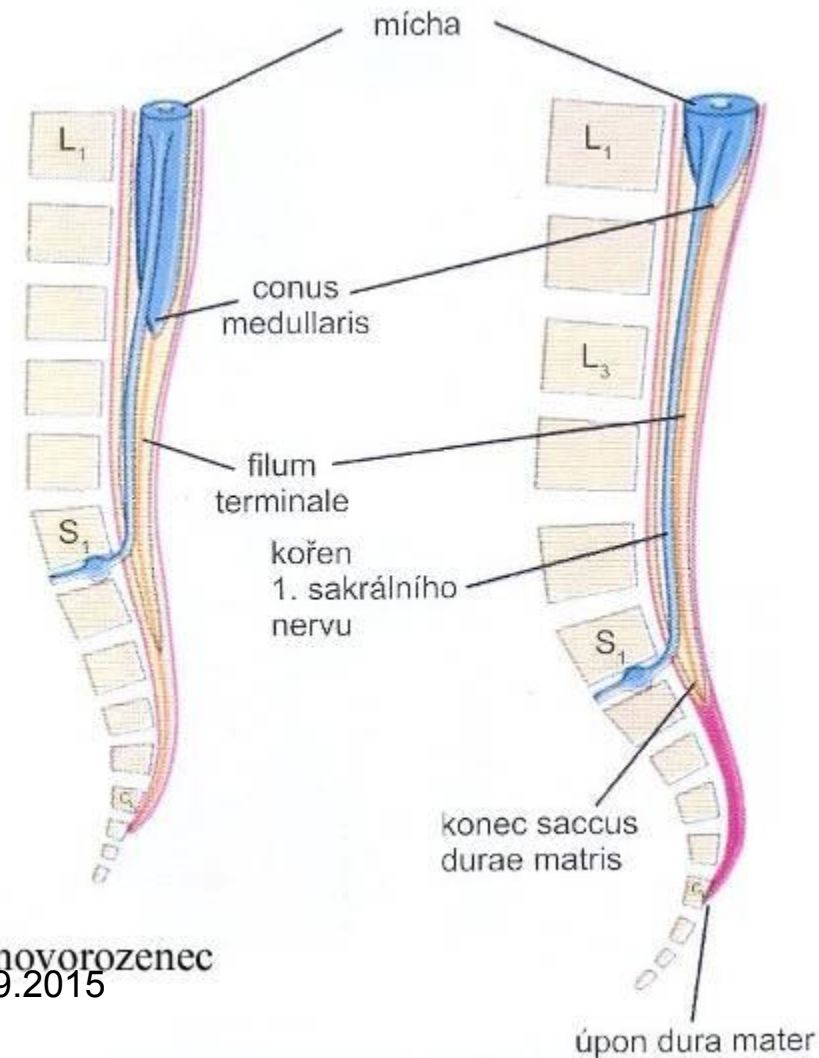
Spinal cord growth



8 týdnů



24 týdnů



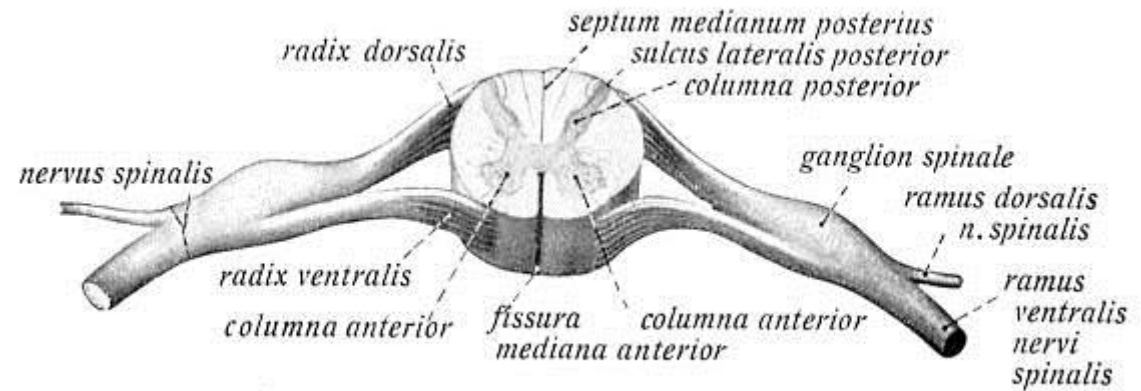
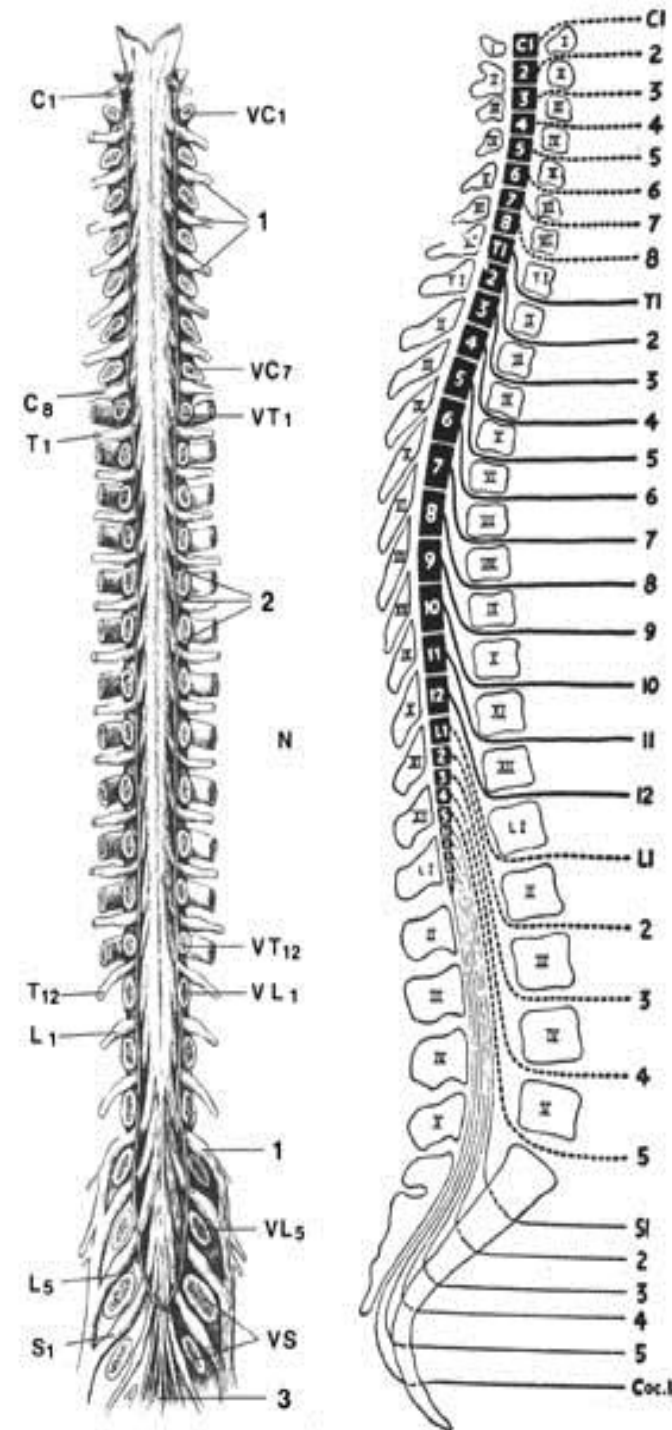
novorozenec

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Spinal cord

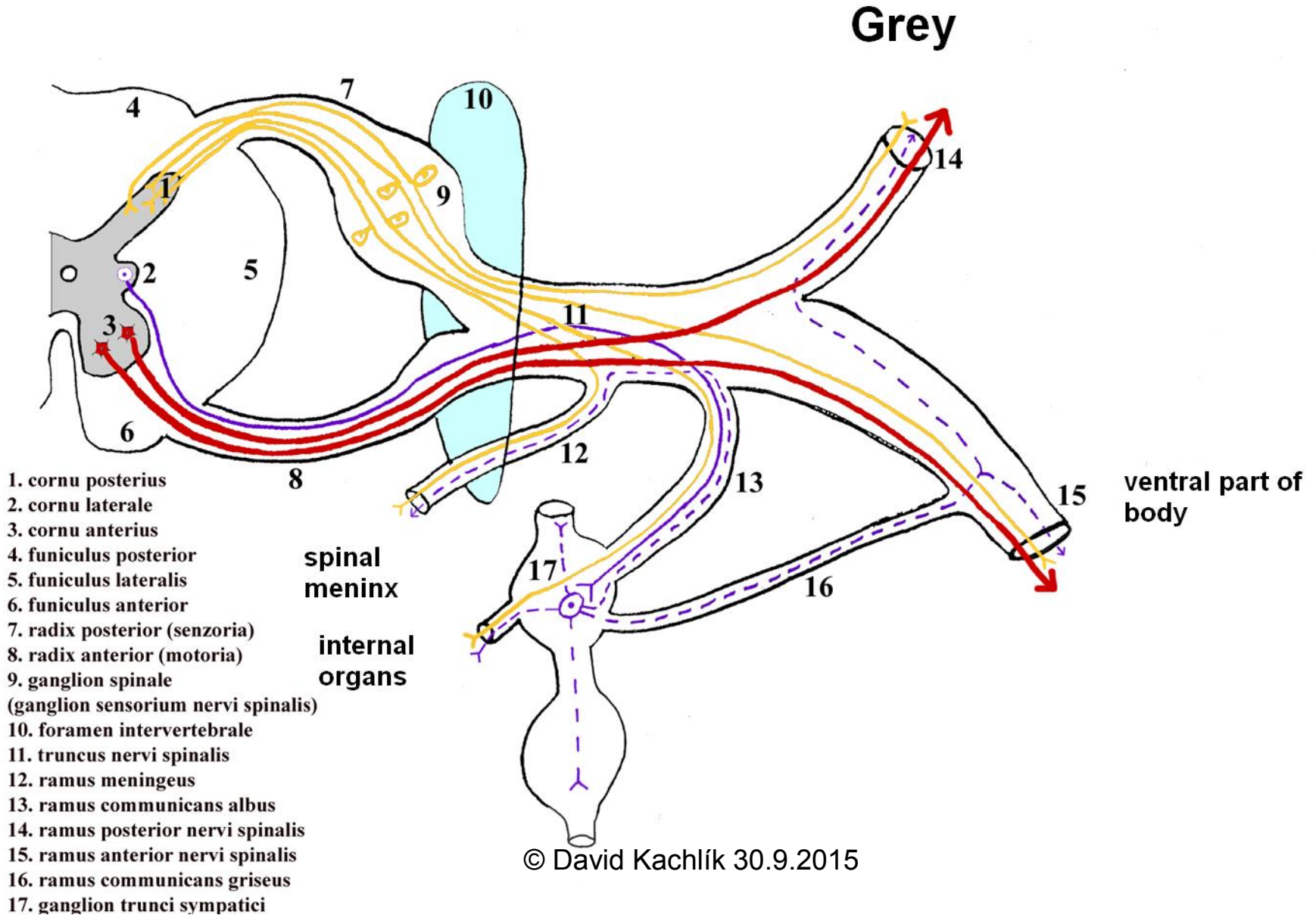
- Segmental organization derived from neural tube and somites
- Spinal segments - 31
- Spinal nerves: C8, T12, L5, S5, Co1
- Comparable to „input-output,, systém of computer
- Seat of reflexes
- Origin of ascending and descending projections

Spinal segments C8, T12, L5, S5, Co1



- Fila radicularia
- Radix anterior (ventral root)
- Radix posterior (dorsal root)
- Ganglion spinale (spinal ganglion)

Spinal nerve branching scheme



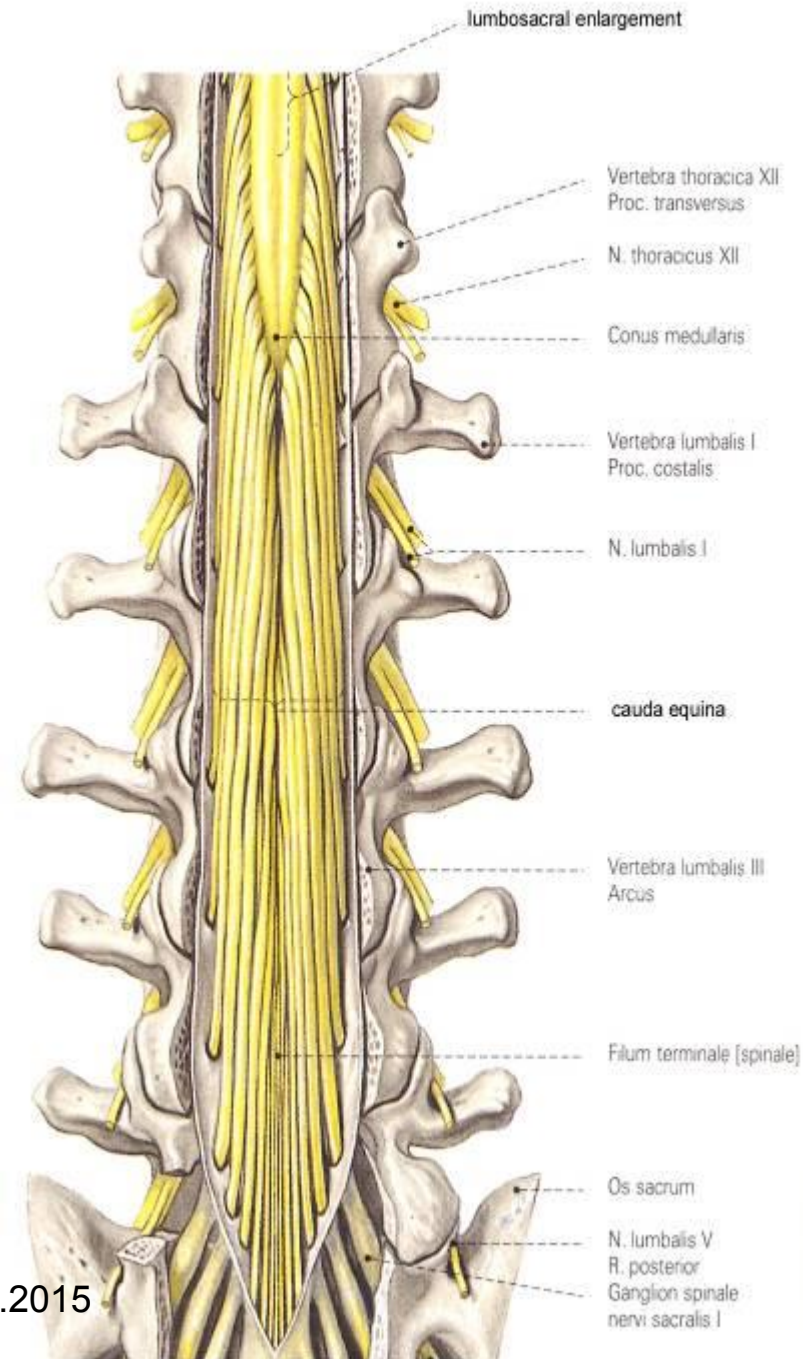
Spinal cord – *external surface*

- arbitrary border between spinal cord and brain stem
 - *foramen magnum*
 - *deccussatio 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 (ventral root)
 - sulcus posterolateralis (dorsal root)
 - sulcus intermedius posterior

Spinal cord

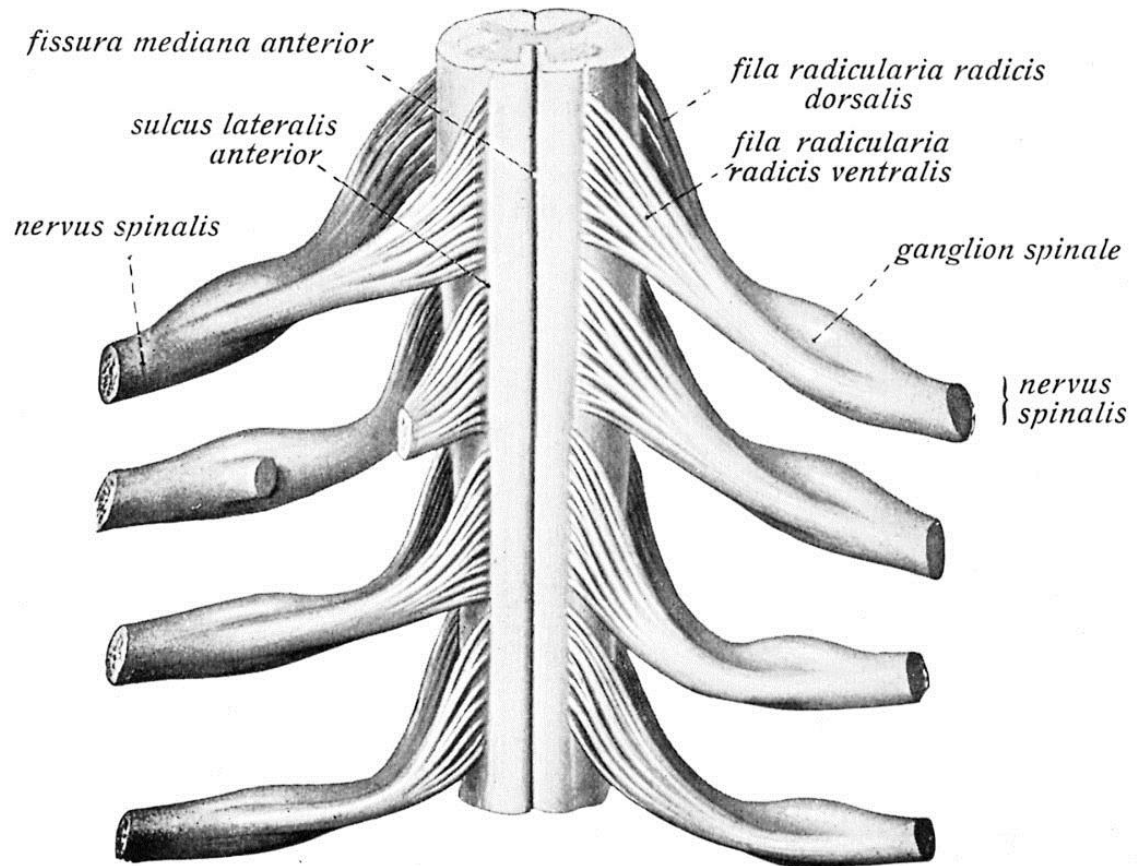
External surface

- *Conus medullaris*
 - vertebrae L1-L2
 - segments S3-S5
- *epiconus*
 - vertebrae T12-L1
 - segments L5-S2
- horse tail = *cauda equina*
(*nerv fibers*)
- pars spinalis filii terminalis



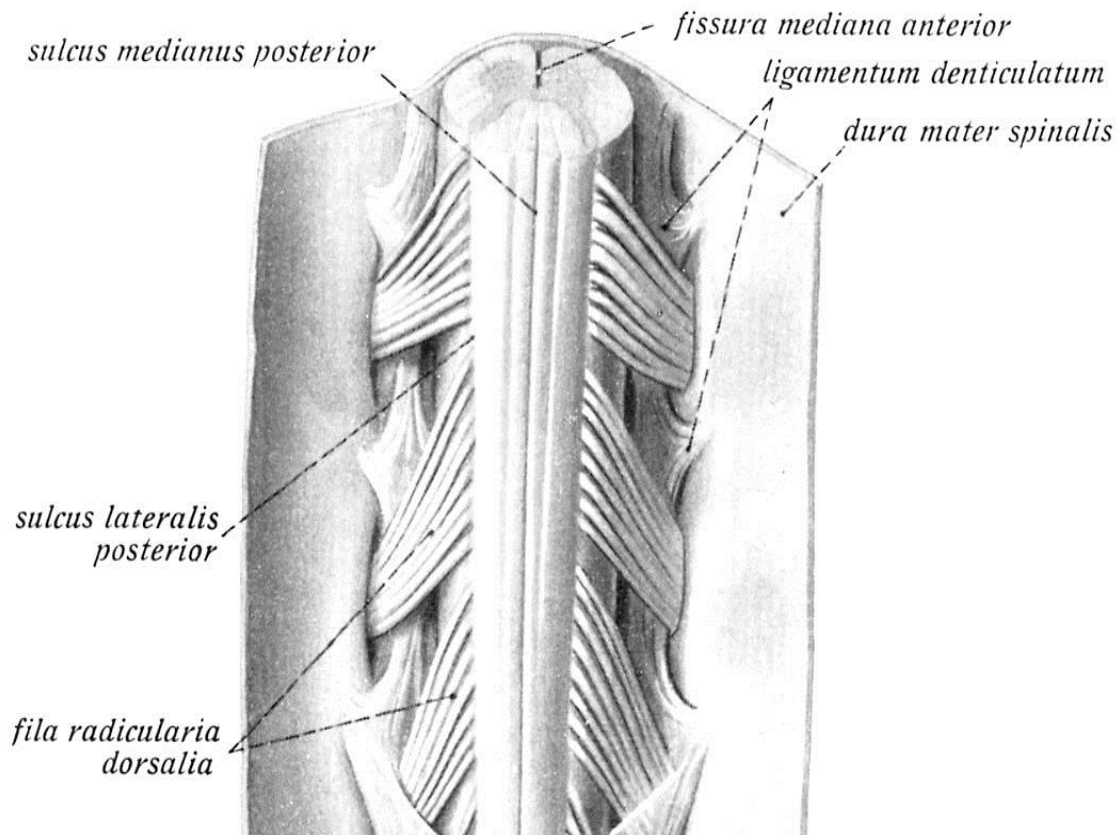
Spinal cord – ventral view

- fissura mediana anterior
- sulcus lateralis anterior



Spinal cord dorsal view

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



Vertebromedullar topography

Chipault rule

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

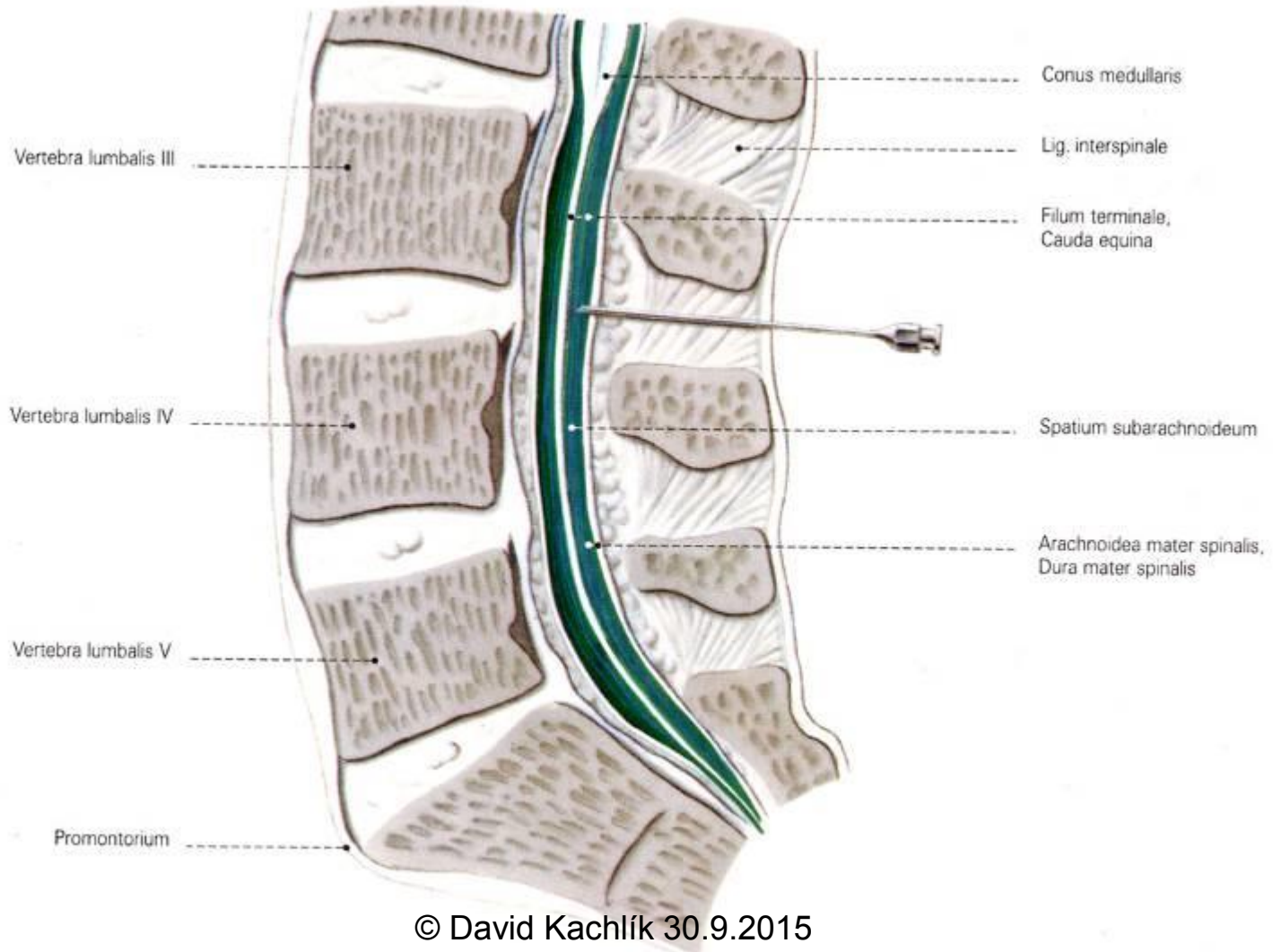
Layers inside vertebral canal

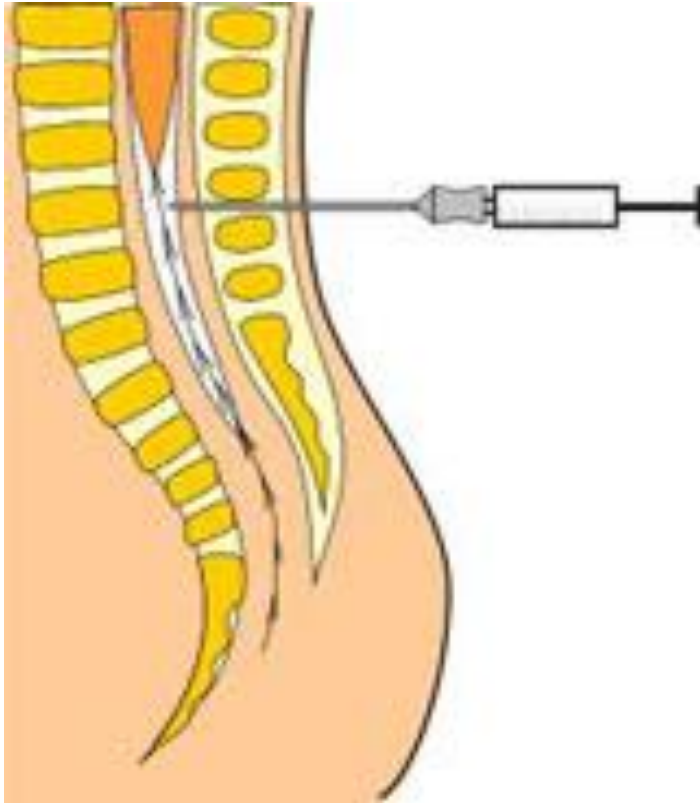
- periosteum = endorhachis
- spatium epidurale
- dura mater spinalis
- arachnoidea mater spinales
- spatium subarachnoideum
 - cisterna lumbalis
- pia mater spinalis
 - lig. denticulatum
- medulla spinalis

Clinical use

- Epidural anesthesia
- Lumbal puncture / spinal anesthesia / application of medicaments
- Electrical stimulation / (chordotomy)

Lumbar puncture

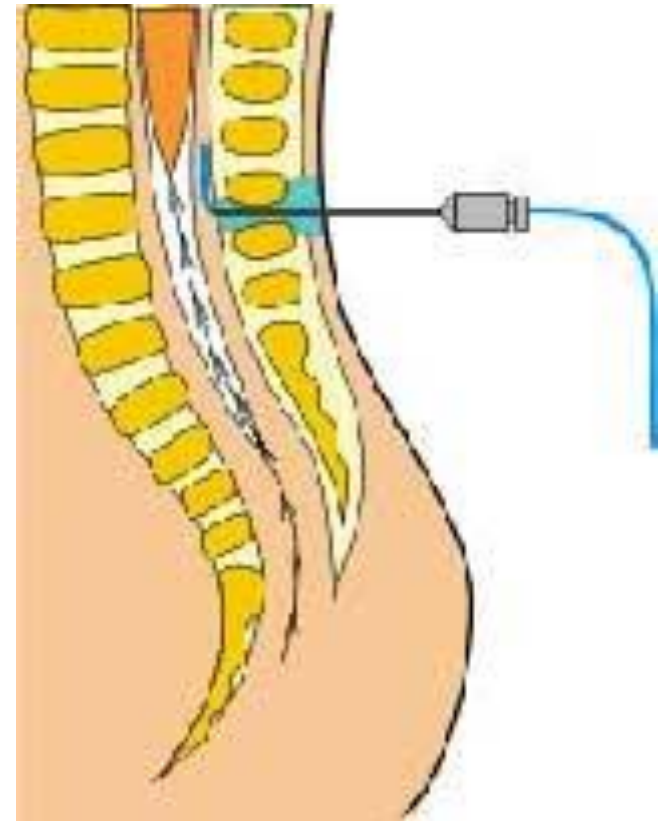




- **subarachnoid anesthesia**

= „spinal“

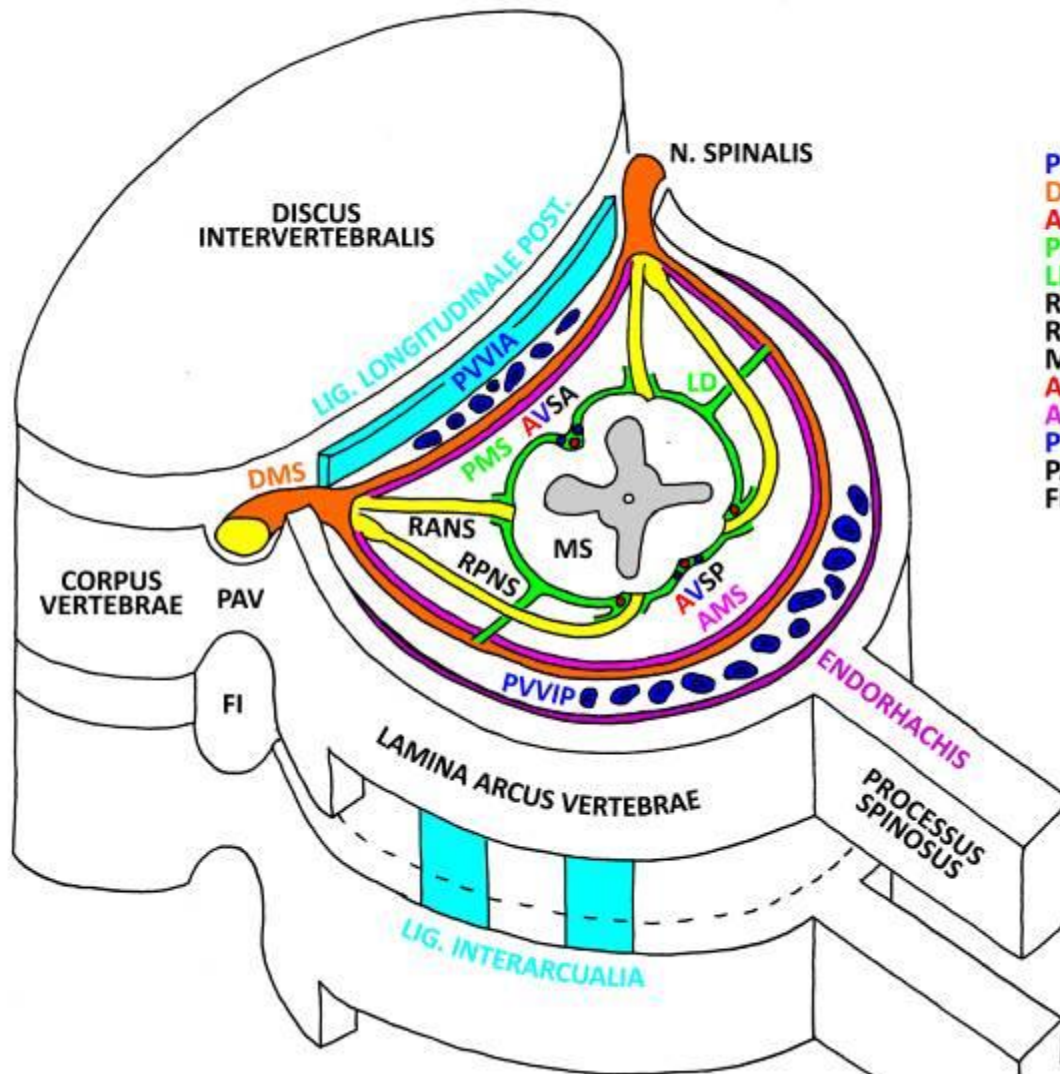
- „lumbal“ – CSF sample !



- **epidural anesthesia**

= „epidural“

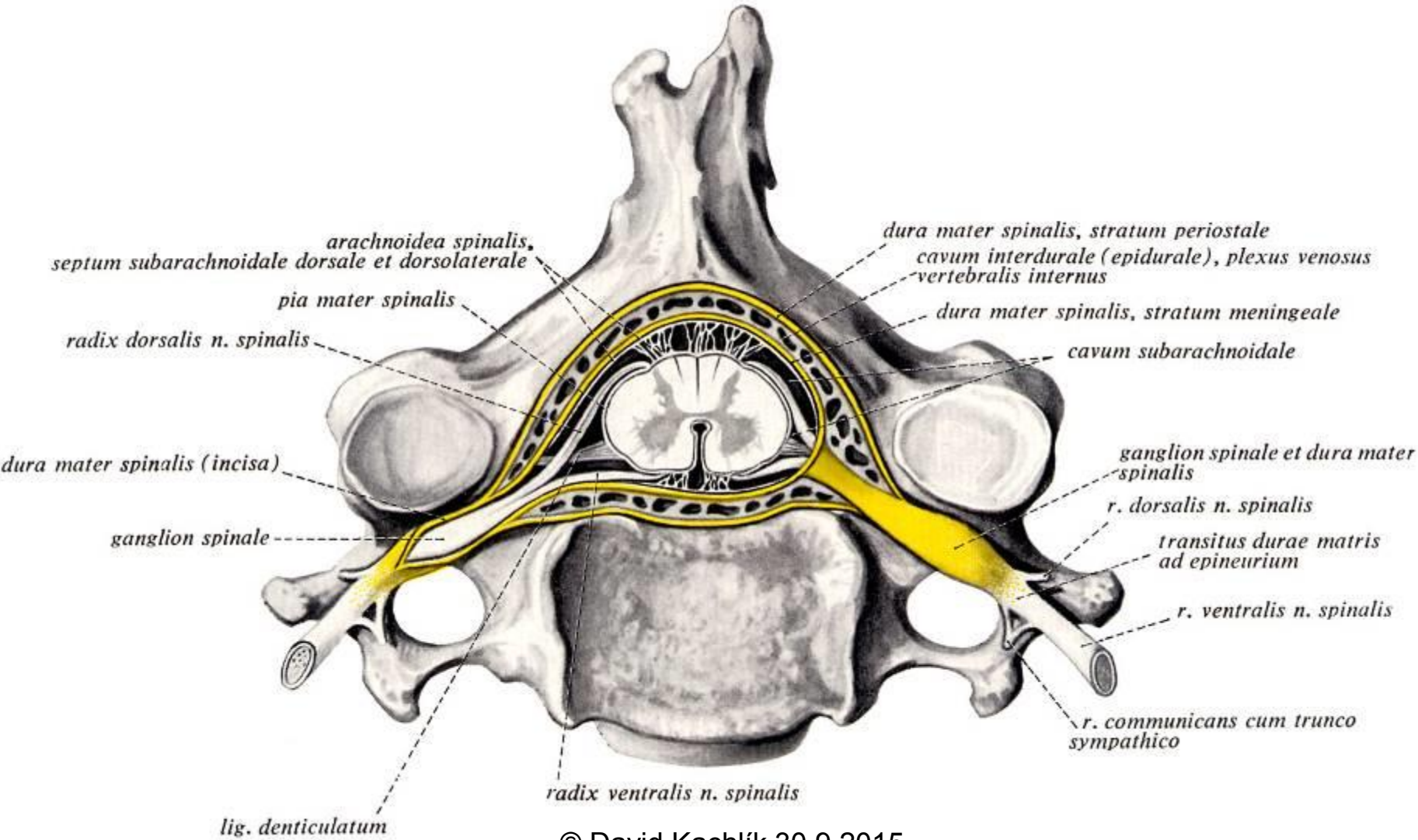
Content of vertebral canal



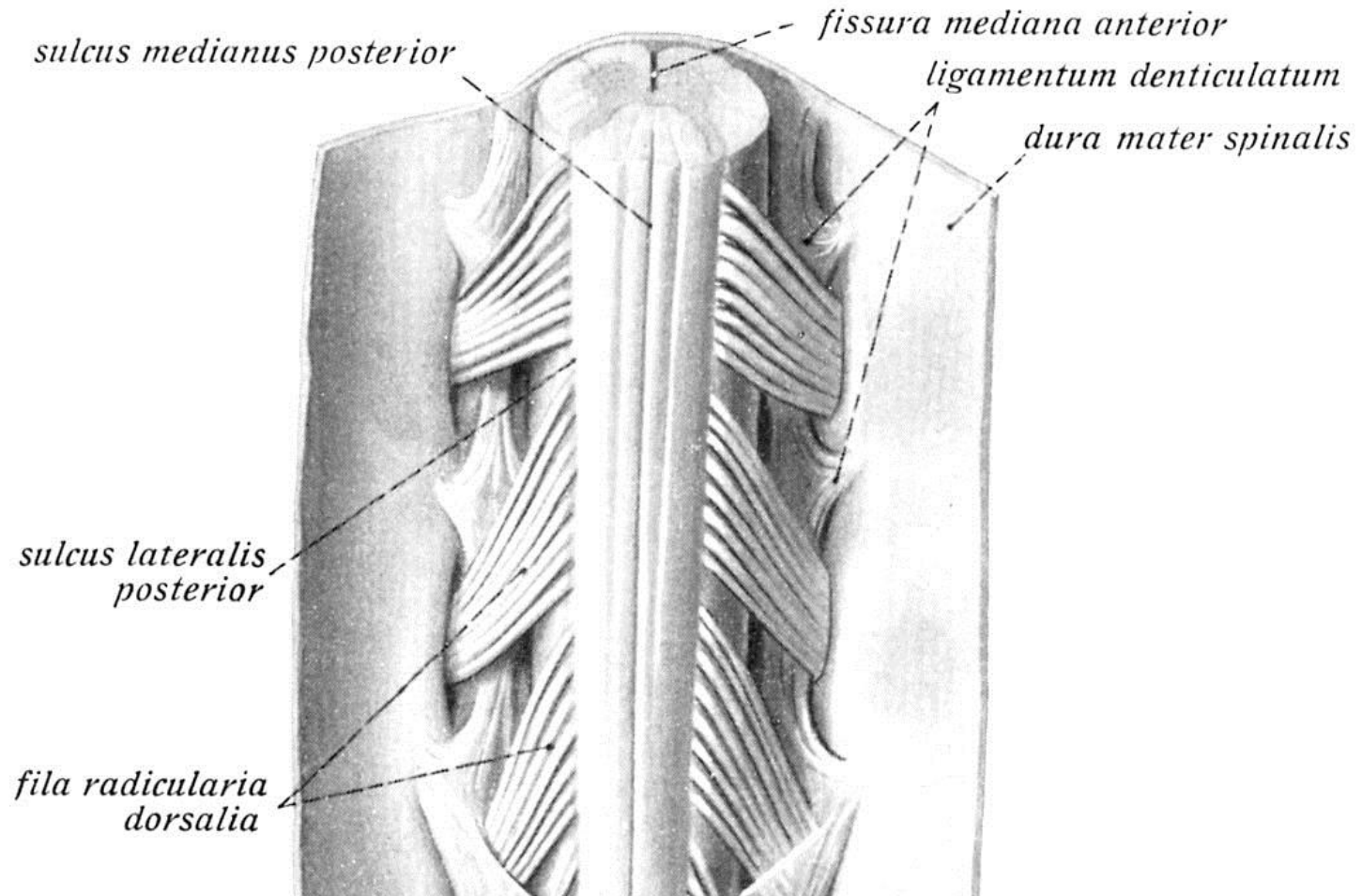
- PVVIA - PLEXUS VENOSUS VERTEBRALIS INTERNUS ANT.
- DMS - DURA MATER SPINALIS
- AVSA - A. ET VV. SPINALES ANT.
- PMS - PIA MATER SPINALIS
- LD - LIG. DENTICULATUM
- RANS - RADIX ANT. N. SPINALIS
- RPNS - RADIX POST. N. SPINALIS
- MS - MEDULLA SPINALIS
- AVSP - AA. ET VV. SPINALES POST.
- AMS - ARACHNOIDEA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

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Content of vertebral canal



Ligamentum denticulatum



Canalis vertebralis

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

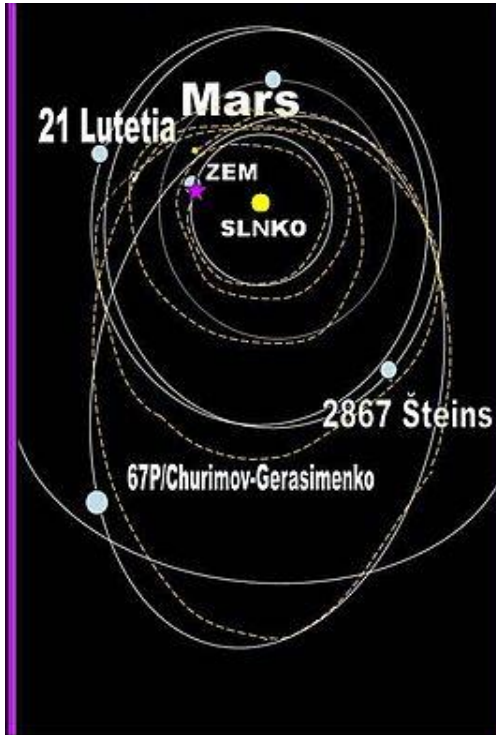
Conten:

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

Sond Rosette (2004)



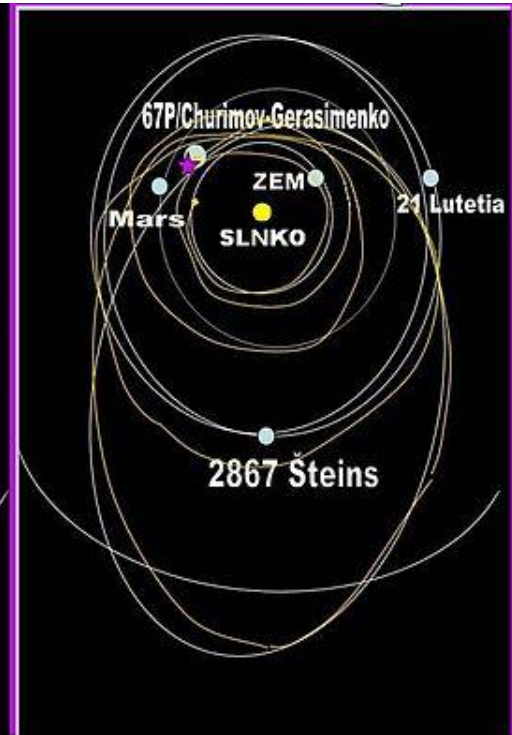
67P Churyumov-Gerasimenko



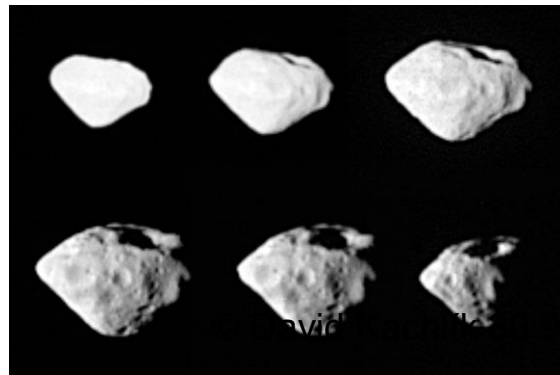
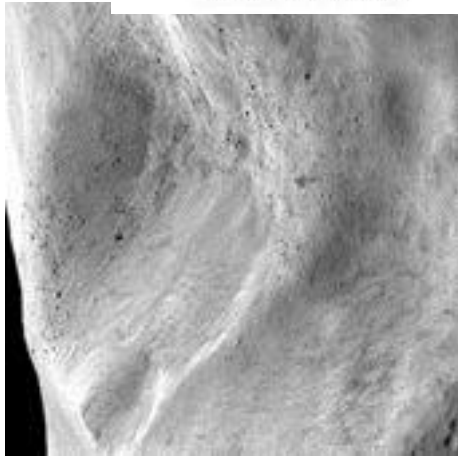
**ŠTART
MAREC 2004**



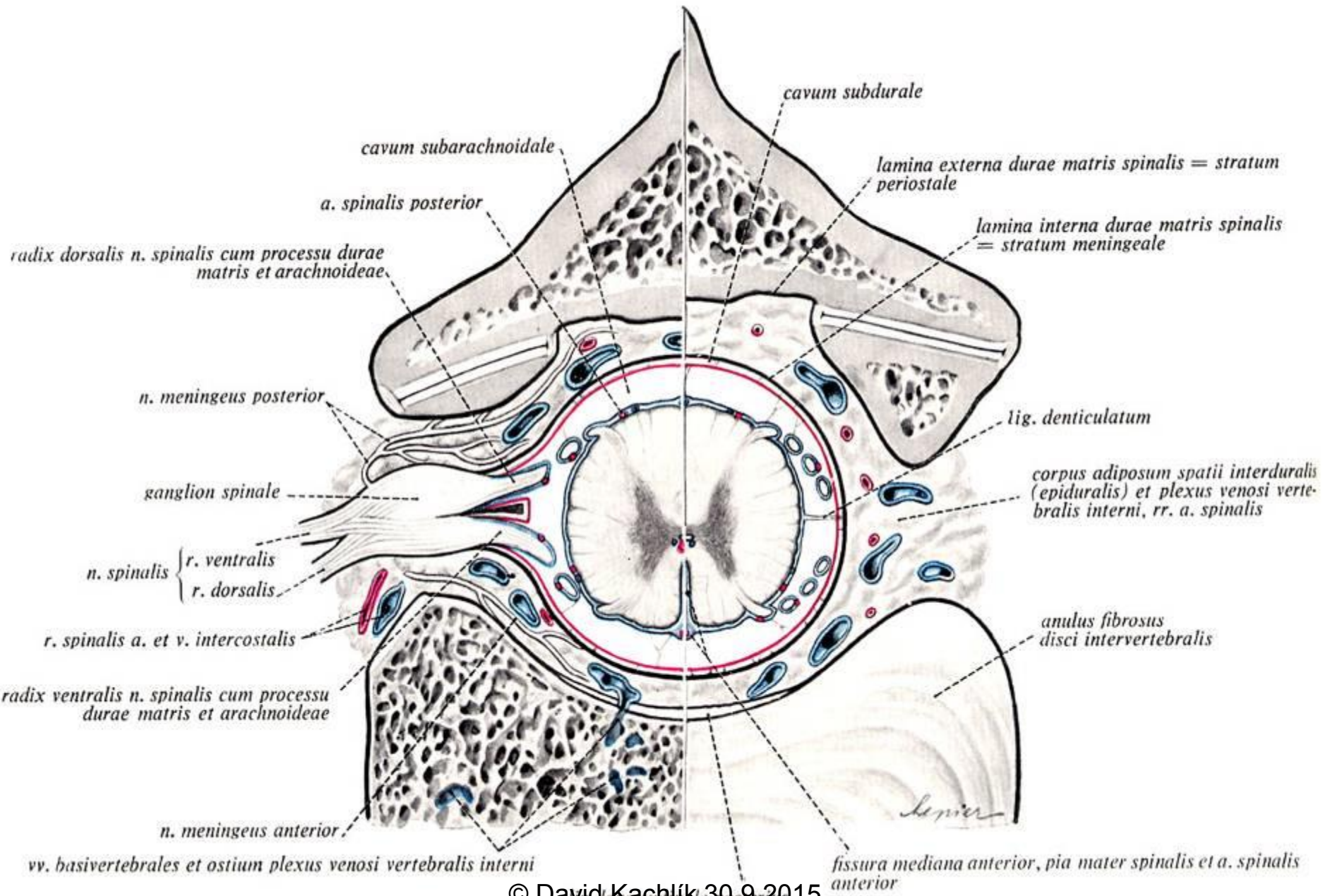
**STRETNUTIE S KOMÉTOU
MÁJ 2014**



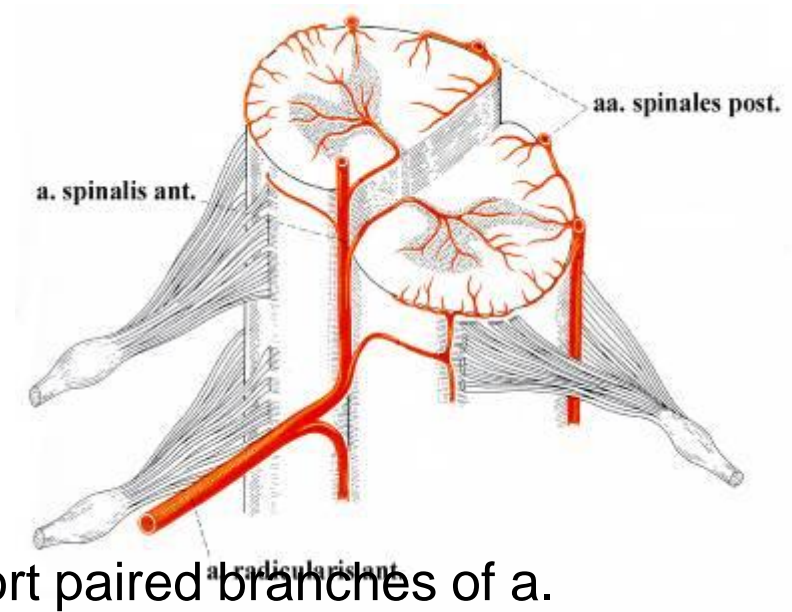
**KONIEC MISIE
DECEMBER 2015**



2015



Arterial supply



Longitudinal vessels

- a. spinalis anterior
 - Non-paired 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 posteriorly (sometimes doubled)
 - Branch from a. basilaris → a. inf. post. cerebelli

Transversal vessels (segmental)

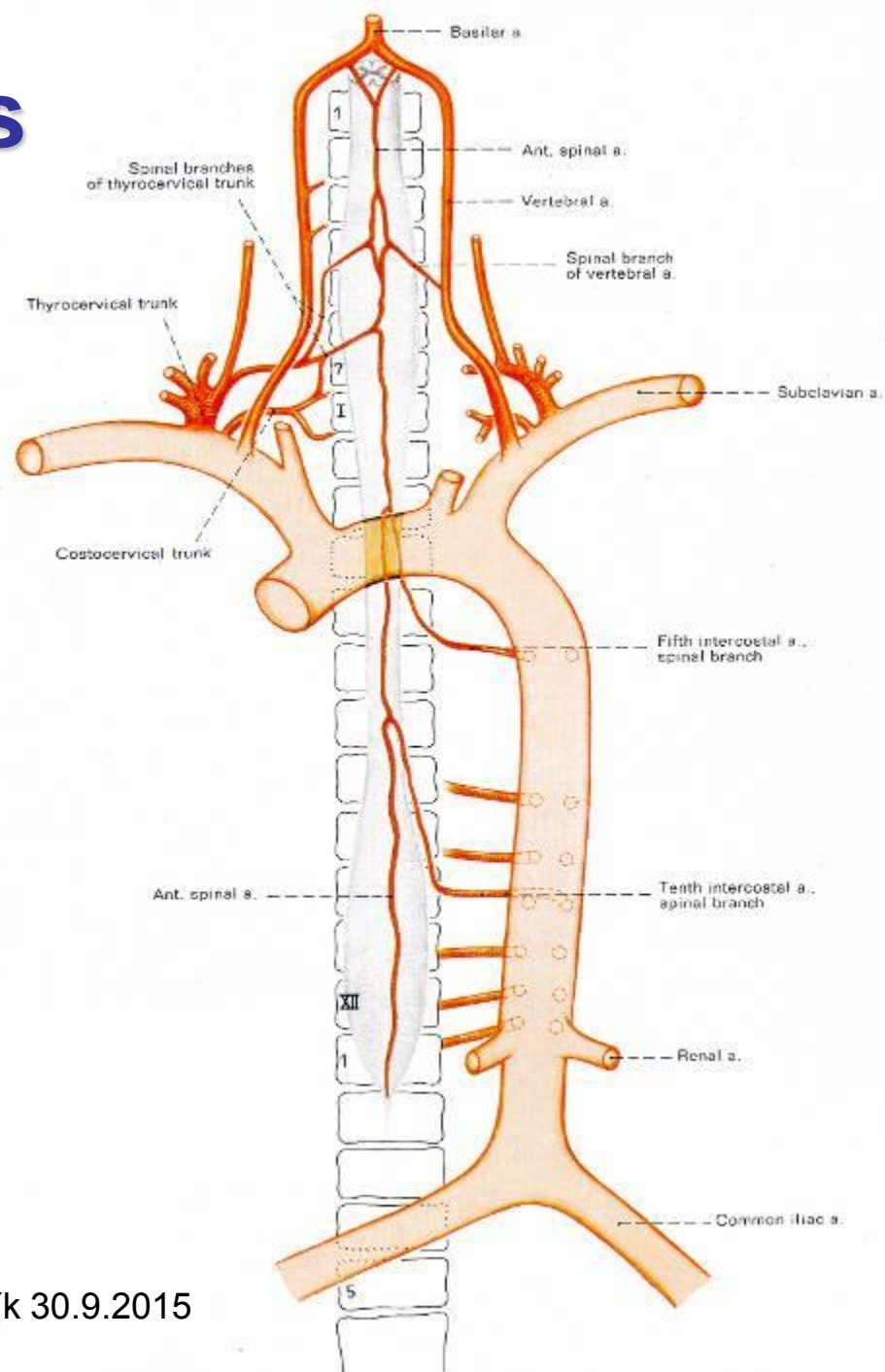
- rr. spinales → a. radicularis anterior et posterior → connects with longitudinal vessels → vasocoronae (around spinal cord)
 - aa. periphericae → white matter

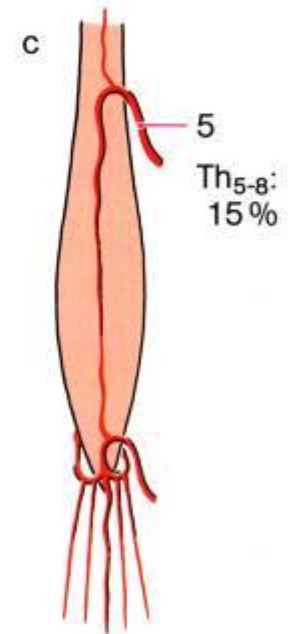
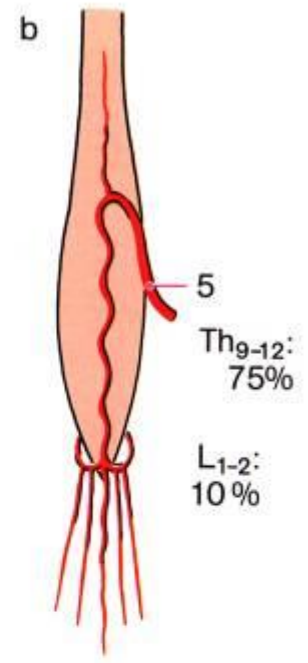
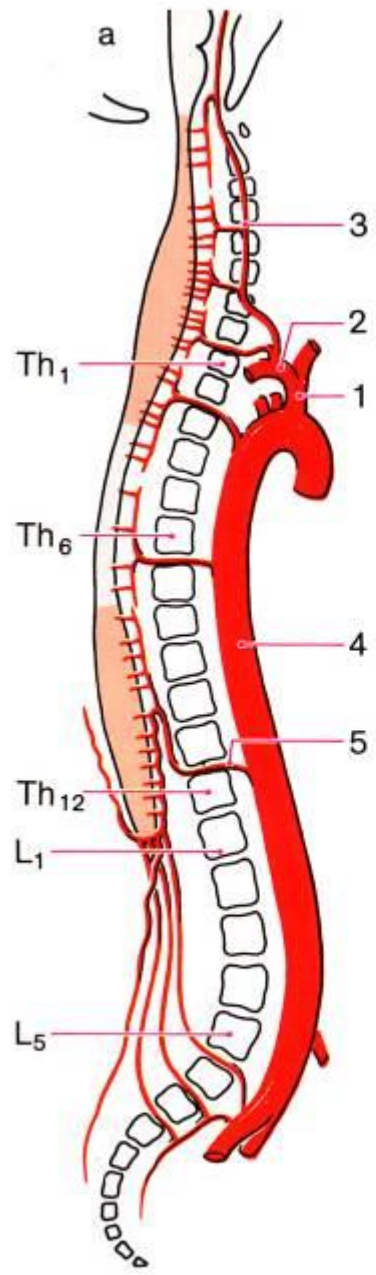
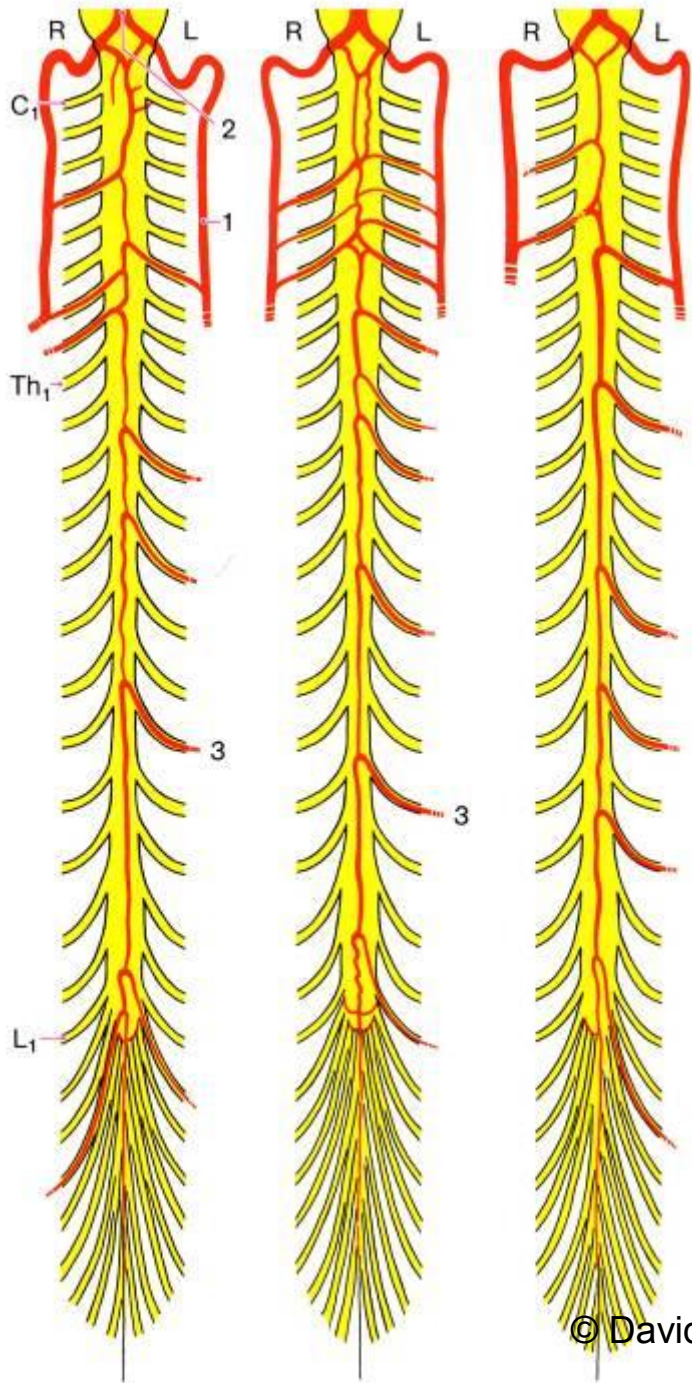
Origins of rr. spinales

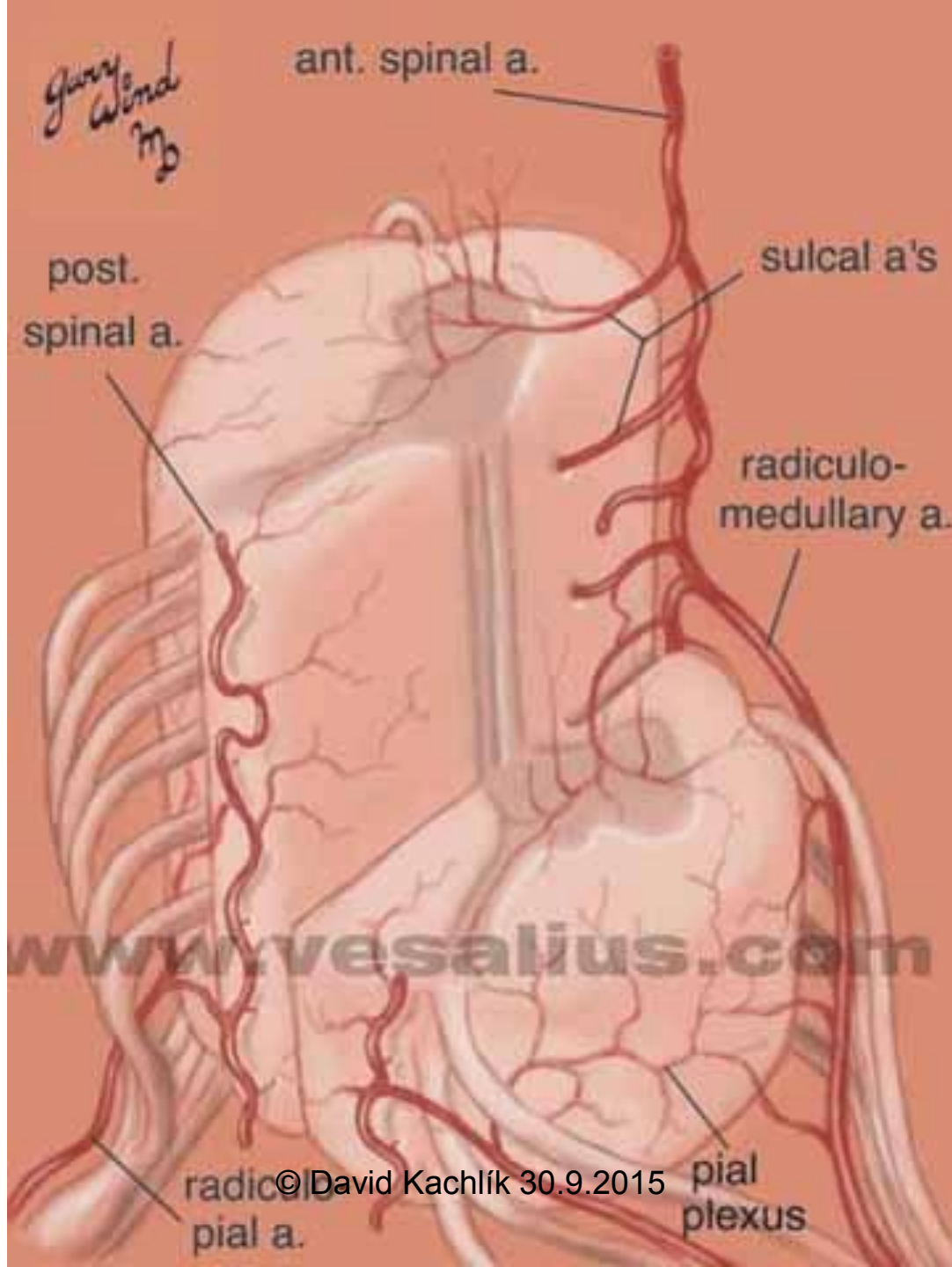
- a. vertebralis
- a. cervicalis ascendens
- a. cervicalis profunda
- aa. intercostales posteriores
- aa. lumbales
- a. iliolumbalis
- aa. sacrales laterales

aa. radicales

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

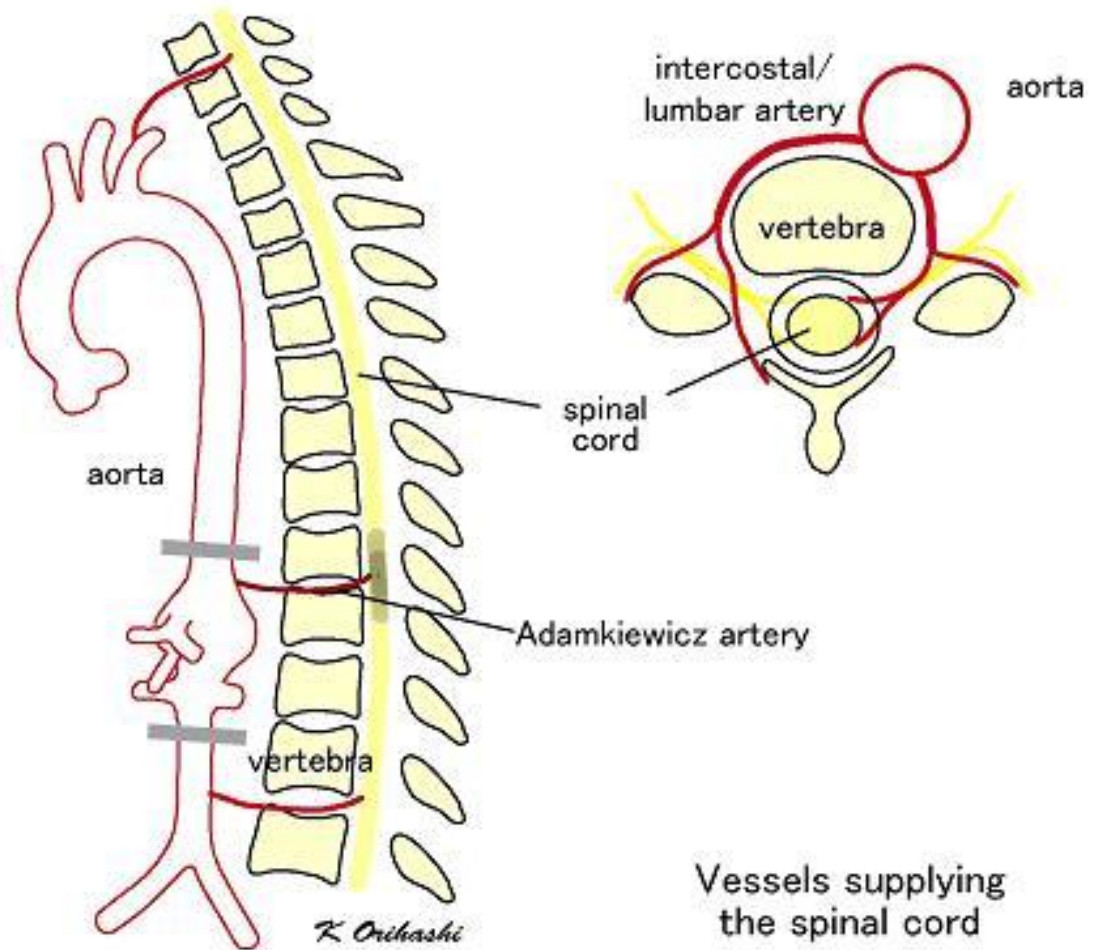






Arteria radicularis magna

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

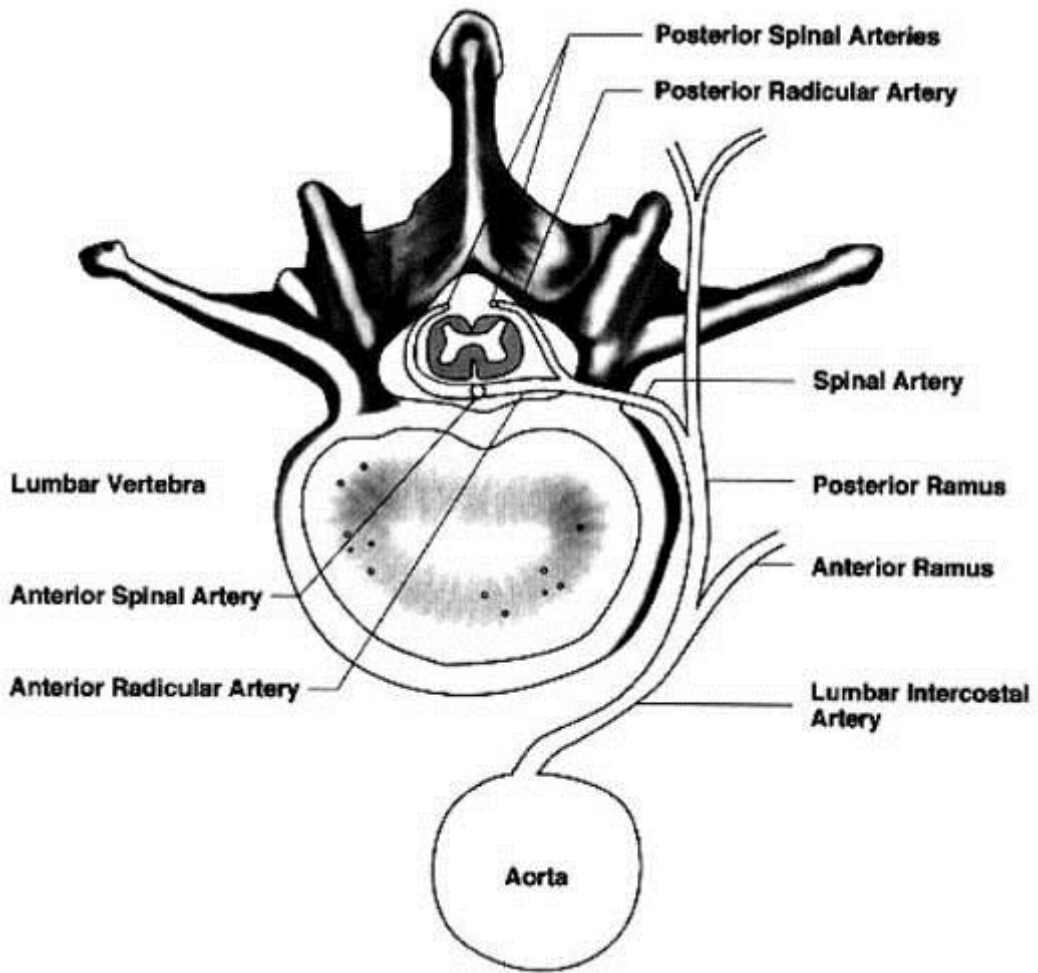


Vessels supplying the spinal cord

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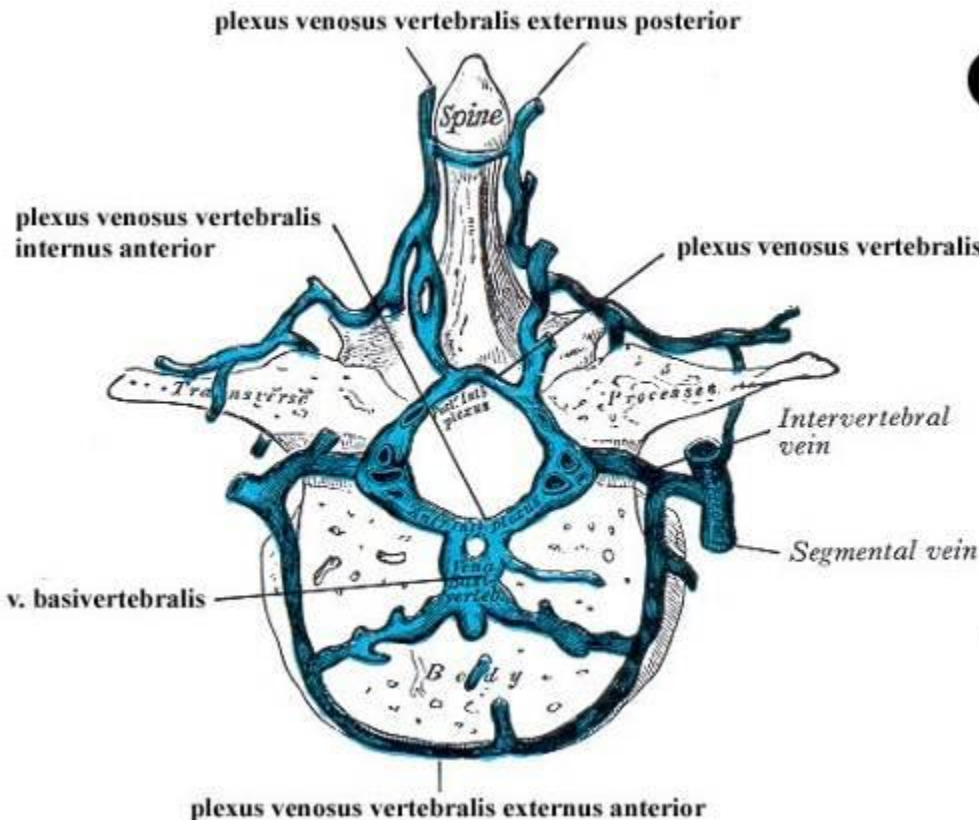
Albert Wojciech Adamkiewicz (1850 - 1921)

Arteria radicularis magna

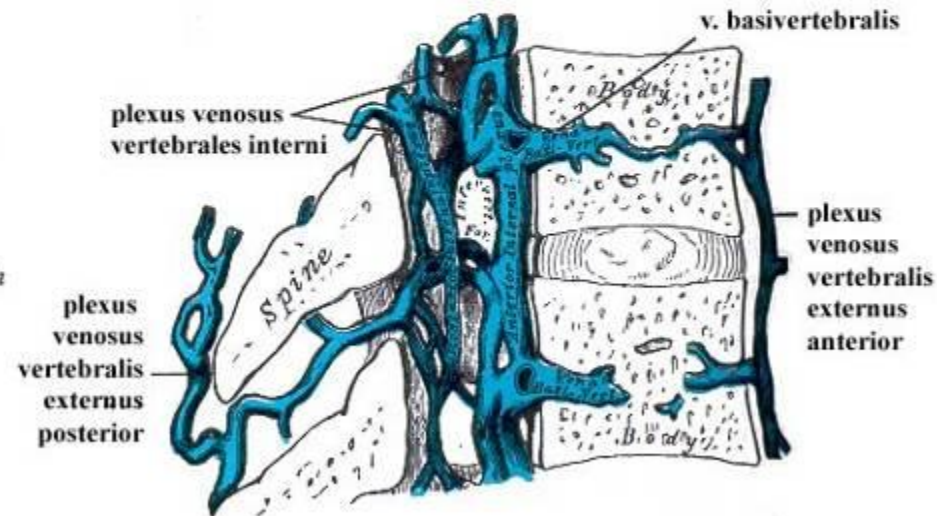


Venous drainage

- Longitudinal veins
- Transversal veins

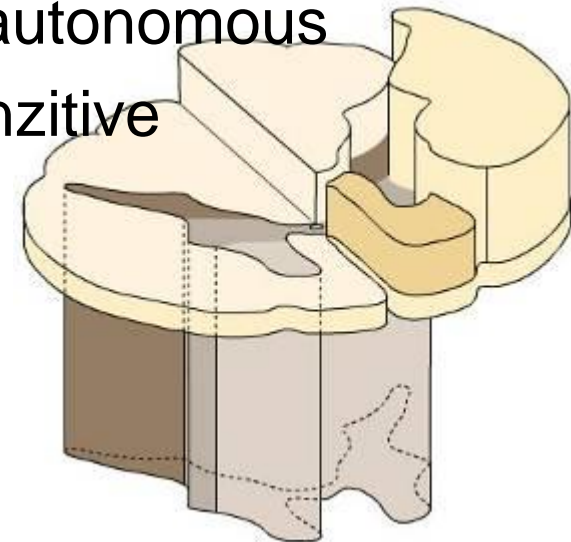


OBRATLOVÉ ŽÍLY



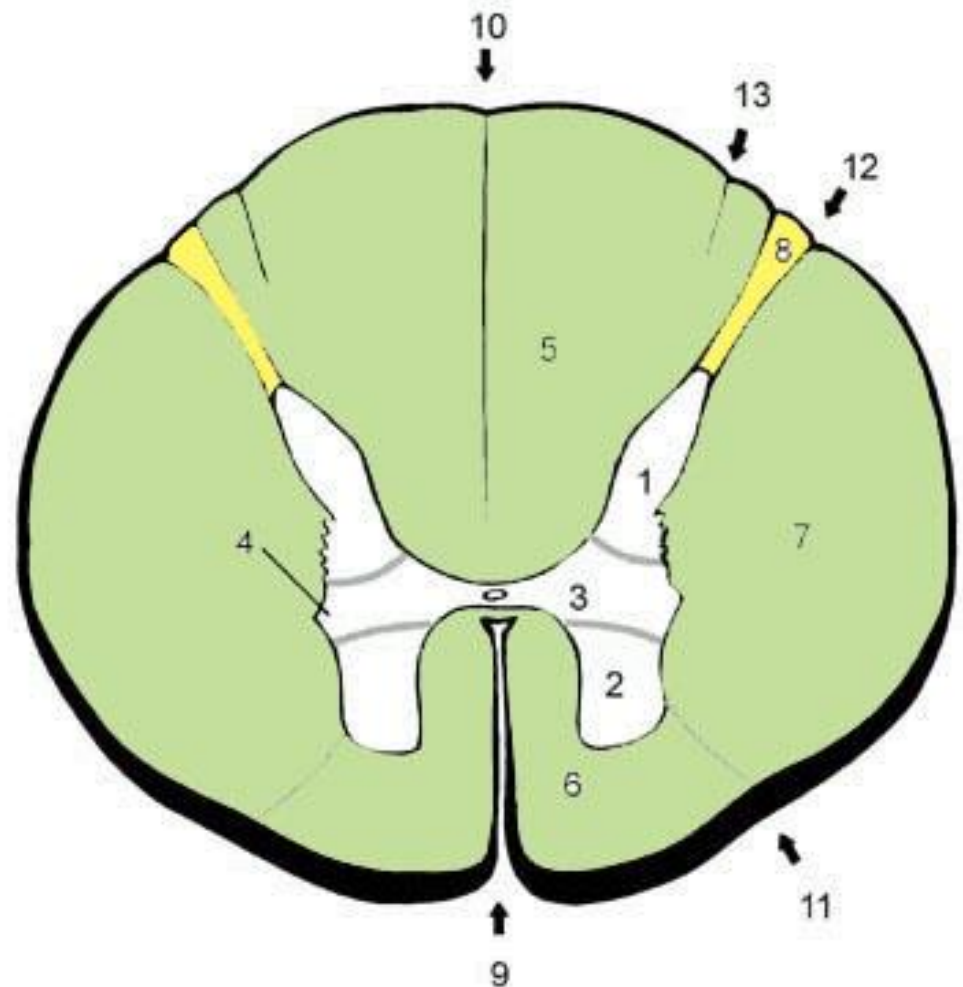
Spinal cord – internal composition

- White matter (*substantia alba*) = funiculi
 - *funiculus anterior (ventral funiculus)*
 - *funiculus lateralis (lateral funiculus)*
 - *funiculus posterior (dorsal funiculus)*
- Grey matter (*substantia grisea*) = columns
 - *columna anterior (ventral horn)* – motor
 - *columna intermedia (medial horn)* - autonomous
 - *columna posterior (dorsal horn)* - sensitive
- *canalis centralis (central canal)*
 - CSF

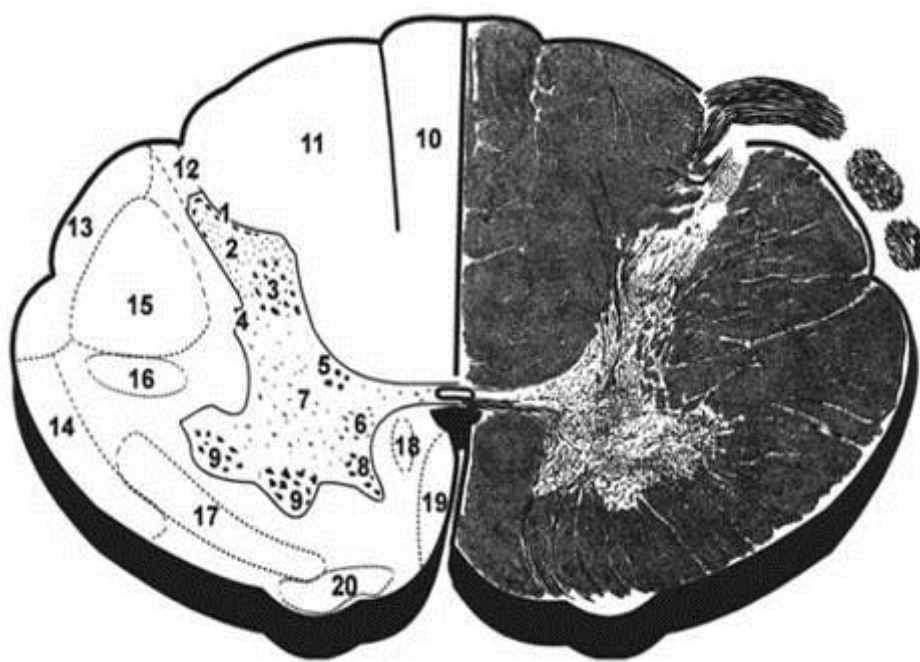


Spinal cord - section

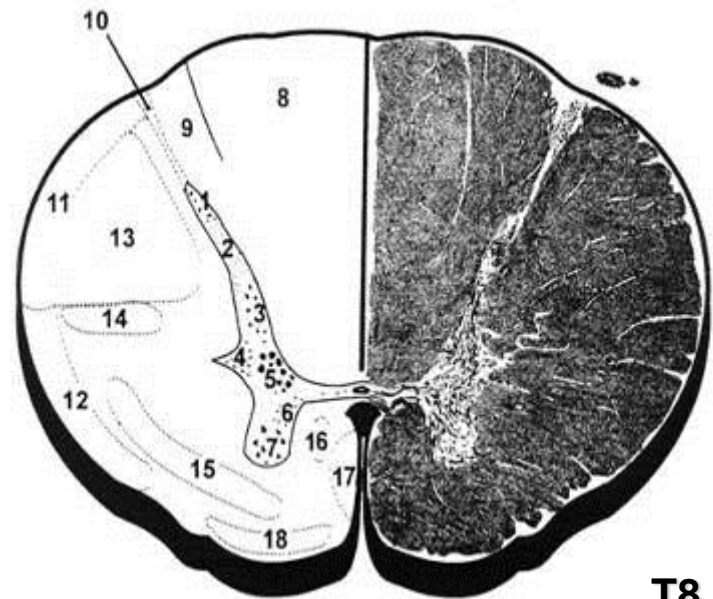
- canalis centralis (central canal)
 - cornu anterius (ventral horn)
 - cornu laterale (lateral horn)
 - cornu posterius (dorsal horn)
 - commissura grisea ant.+ post.
 - funiculus anterior (ventral fascicle)
 - funiculus lateralis (lateral fascicle)
 - funiculus posterior (dorsal fascicle)
 - septum medianum posterius
 - commissura alba ant.+ post.
 - tractus posterolateralis
- Lissaueri*



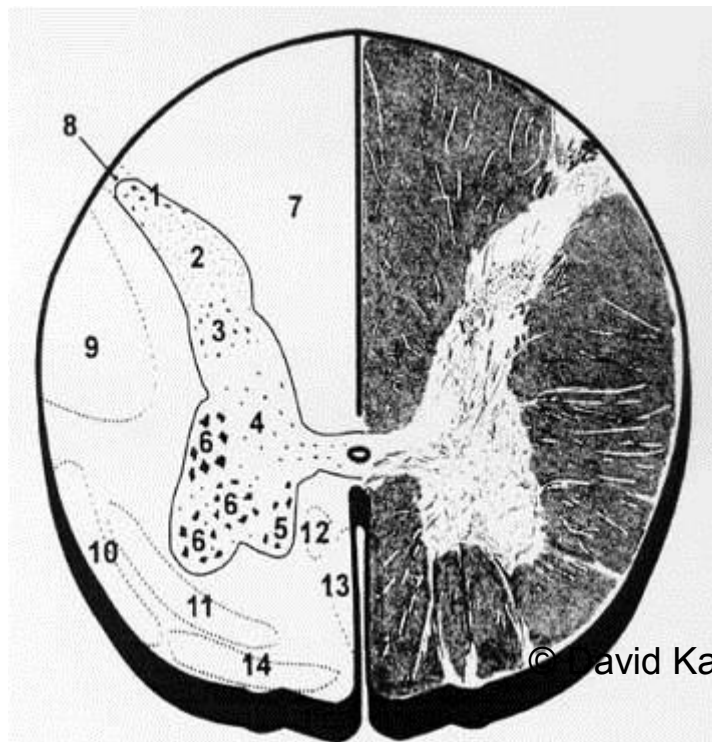
C8



T8

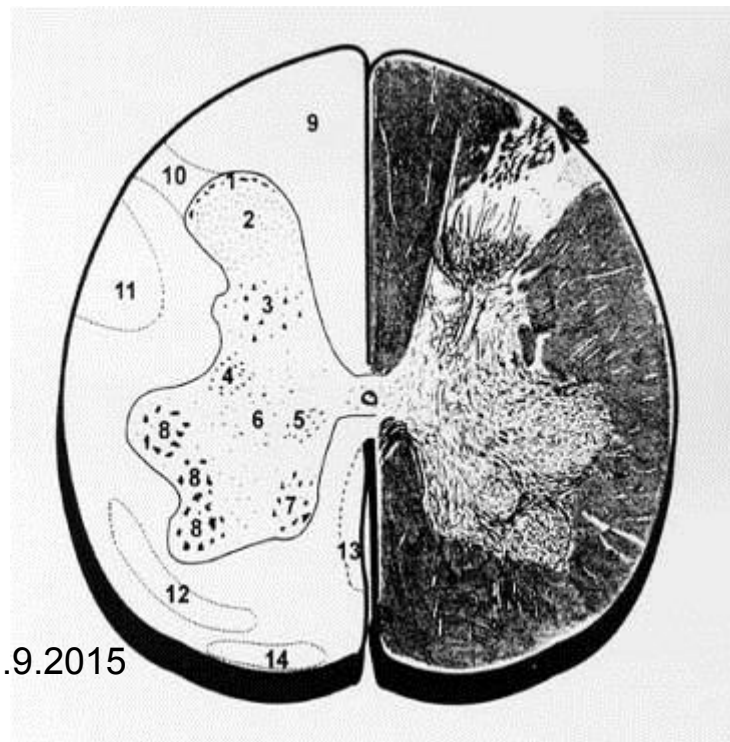


T8



L3

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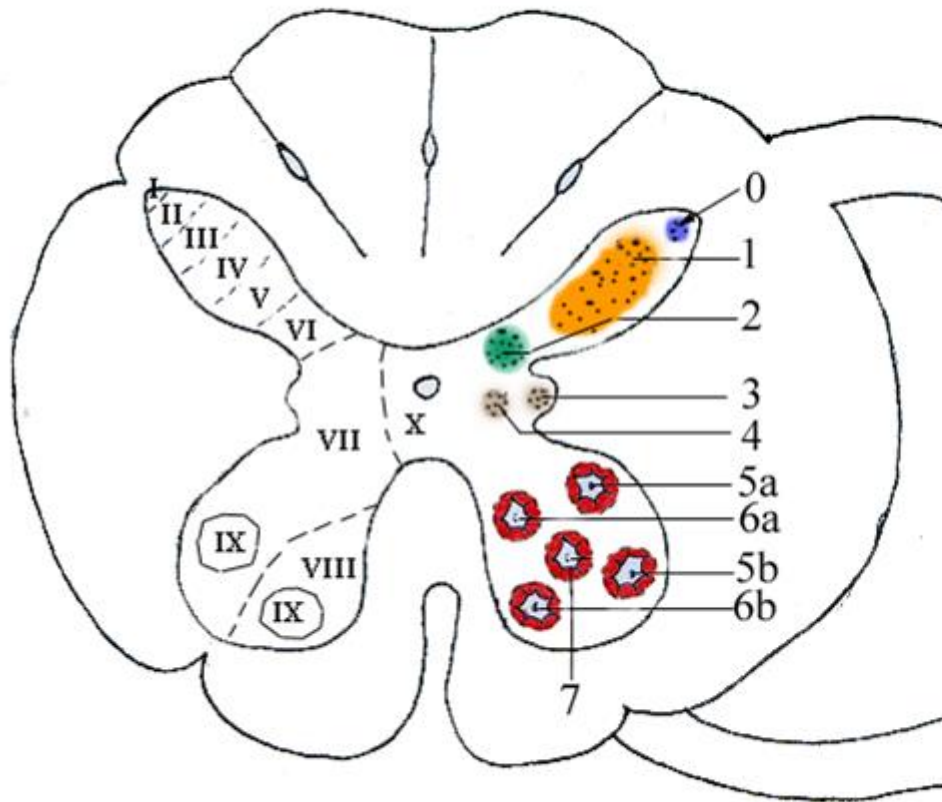


S1

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

Grey matter and its nuclei



- 0 - substantia gelatinosa /Rolandi/
- 1 - nucleus proprius columnae posterioris
(začátek tractus spinothalamicus a spinotectalis)
- 2 - nucleus thoracicus posterior /Stilling-Clark/
(origin of tractus spinocerebellares)
- 3 - nucleus intermediolateralis
- 4 - nucleus intermediomedialis
- 5a - nucleus posterolateralis
(alfa+gama-neurony pro hypaxiální svalstvo)
- 5b - nucleus anterolateralis
(alfa+gama-neurony pro hypaxiální svalstvo)
- 6a - nucleus posteromedialis
(alfa+gama-neurony pro epaxiální svalstvo)
- 6b - nucleus anteromedialis
(alfa+gama-neurony pro epaxiální svalstvo)
- 7 - nucleus centralis

Laminae spinales Rexedi I-X

I = nucleus marginalis (apex cornus posterioris)

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

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

V = cervix c.p.

VI = basis c.p.

VII = **cornu laterale**

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

- ncl. intermediolateralis

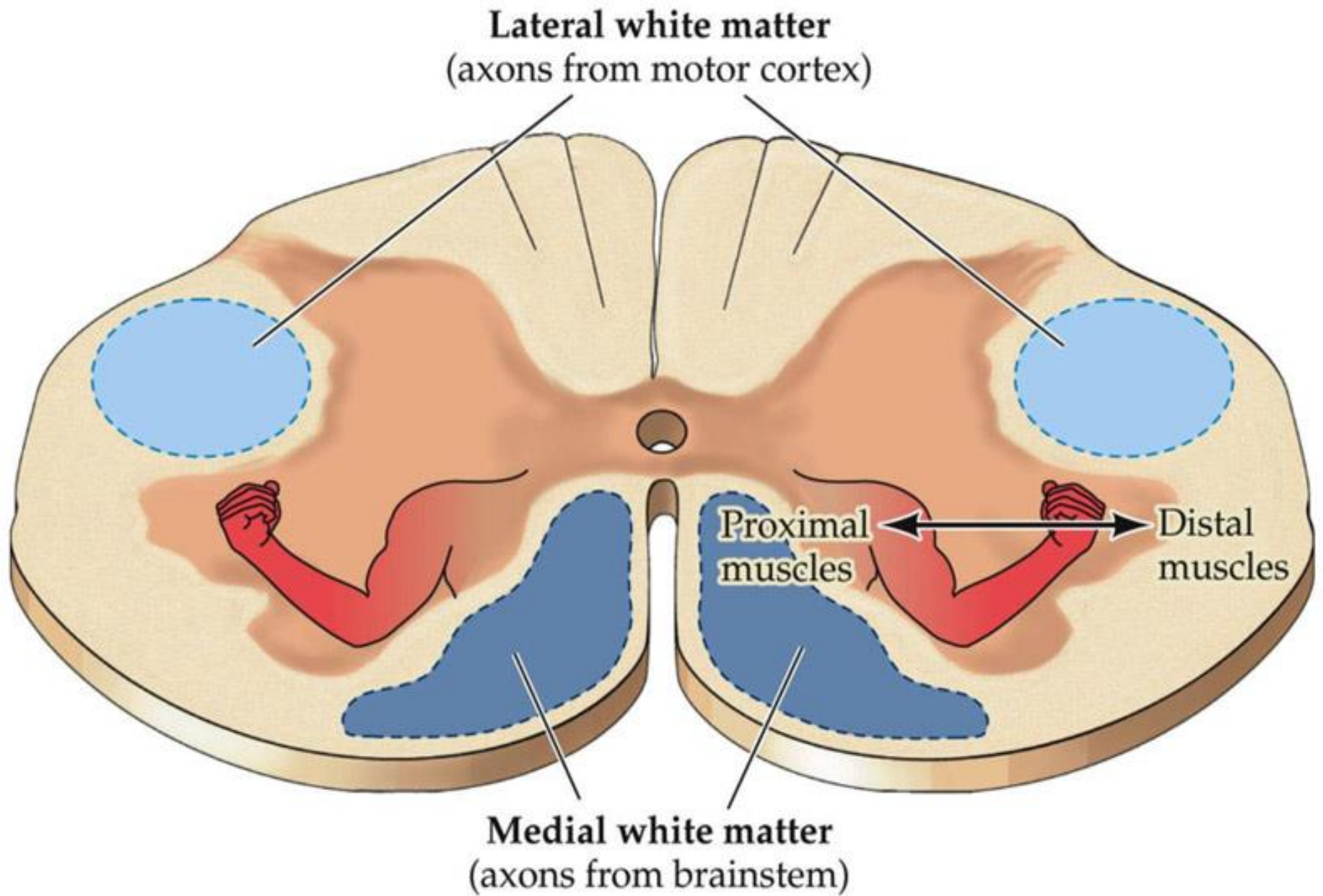
- ncl. intermediomedialis

VIII+IX = cornu anterius

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

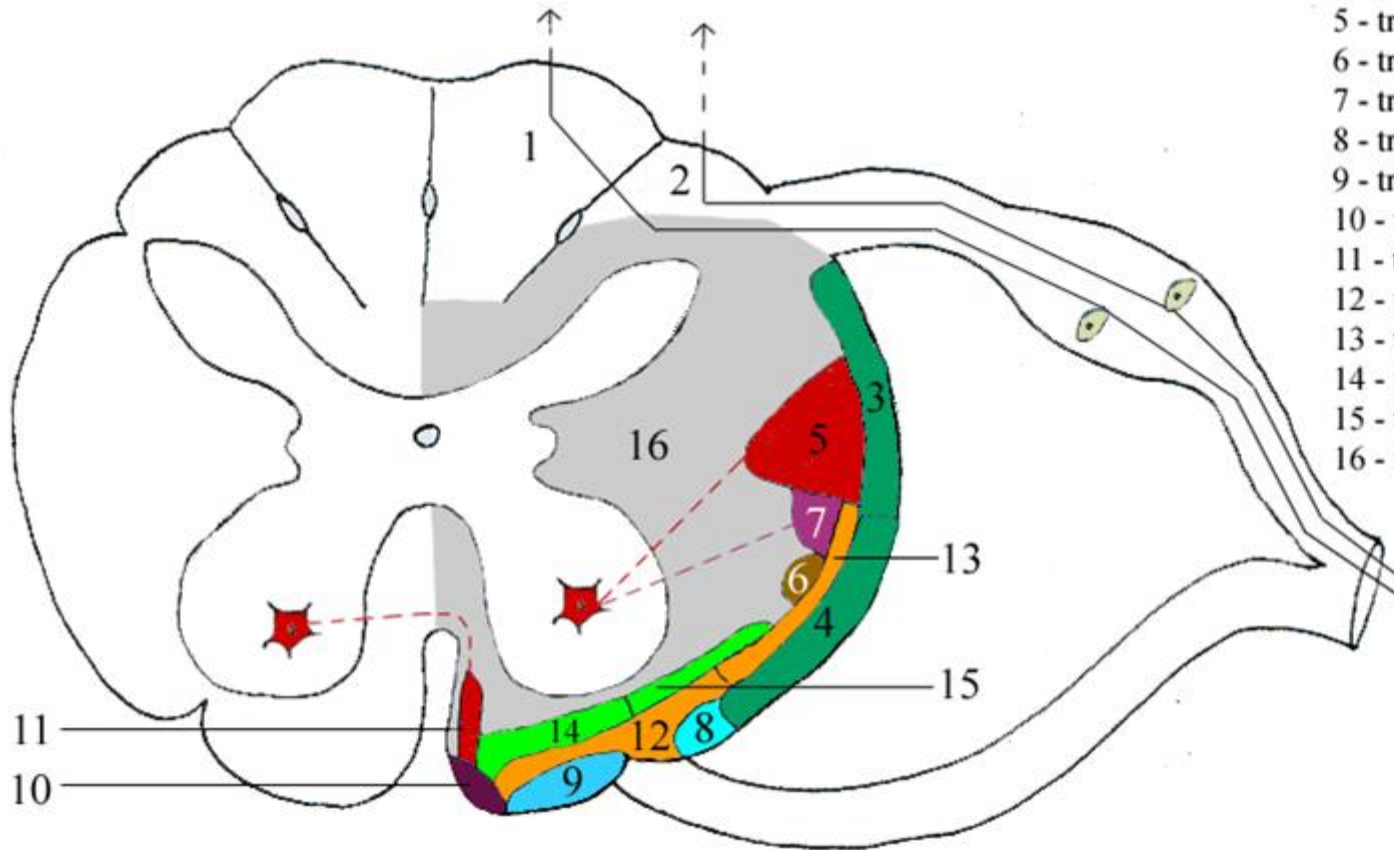
X = commissura grisea ant. + post.



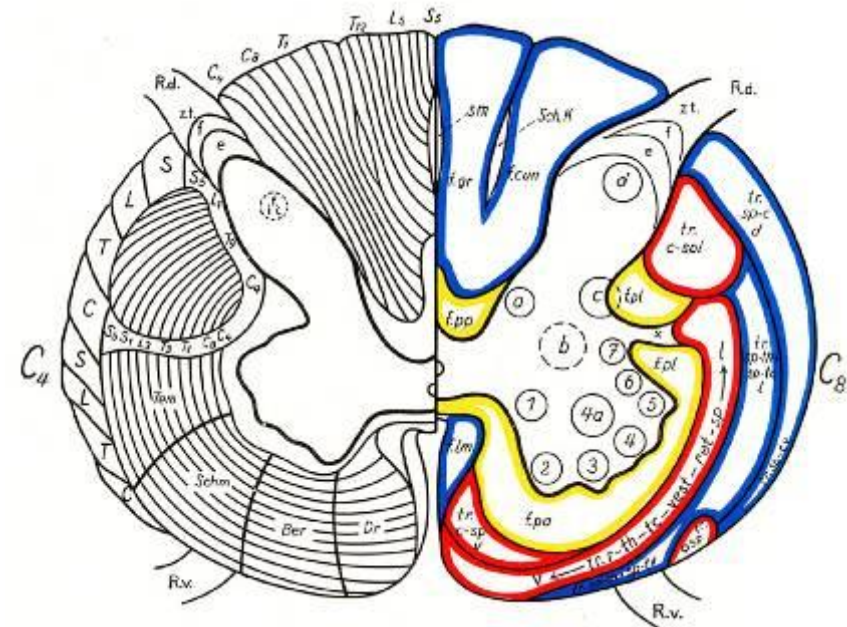
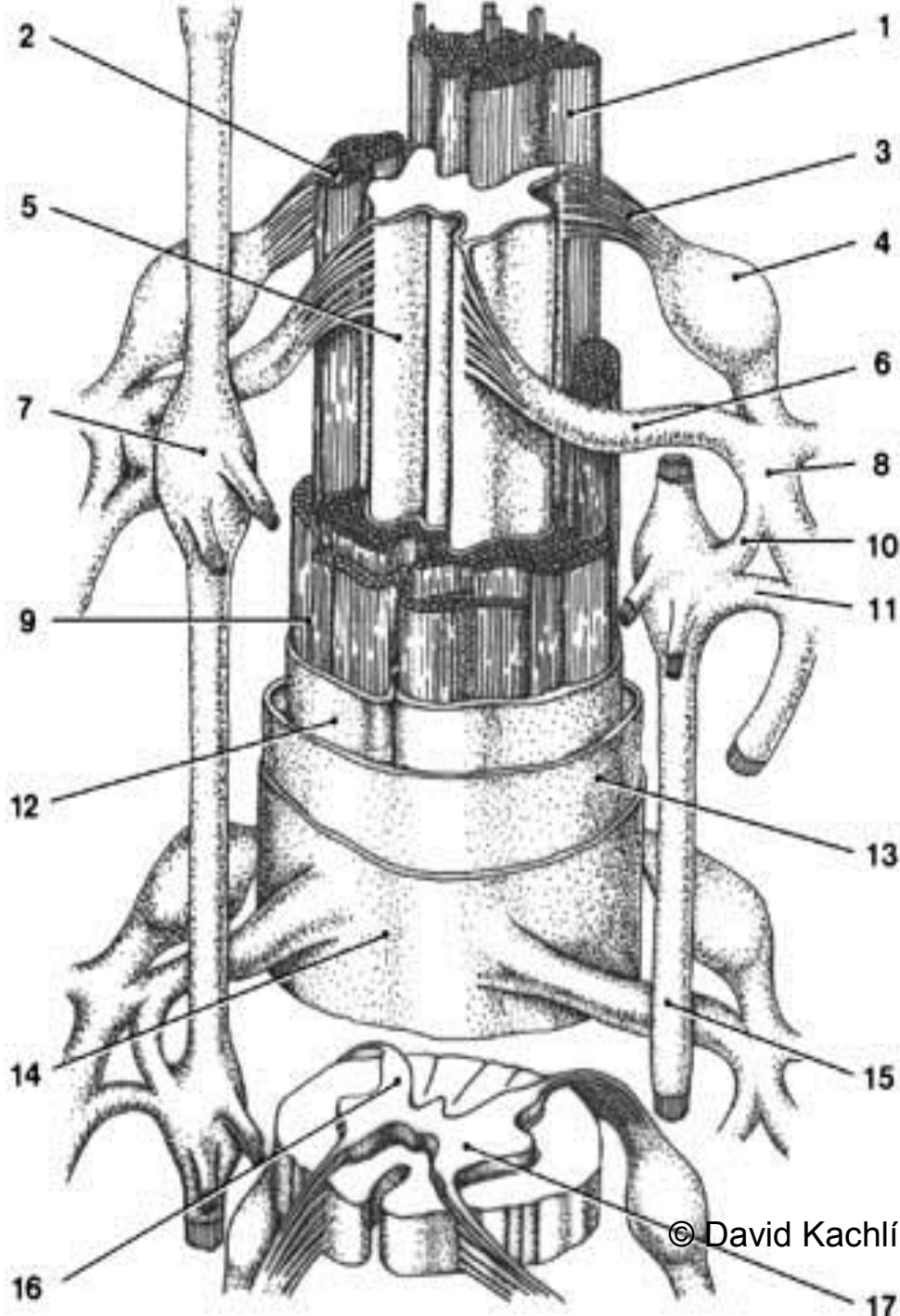


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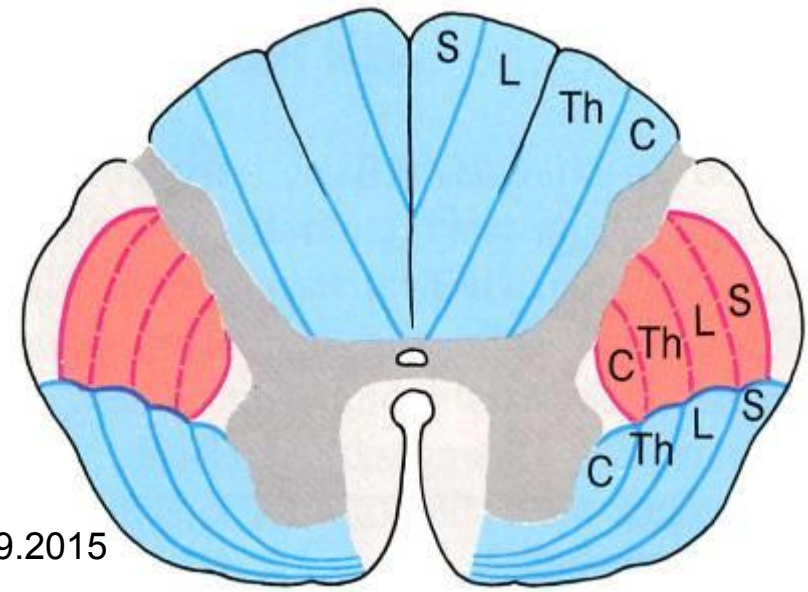
Spinal cord section and its tracts



- 1 - fasciculus gracilis /Golli/
- 2 - fasciculus cuneatus /Burdachi/
only in upper C and Th spinal cord
- 3 - tractus spinocerebellaris posterior
- 4 - tractus spinocerebellaris anterior
- 5 - tractus corticospinalis lateralis
- 6 - tractus spinotectalis
- 7 - tractus rubrospinalis
- 8 - tractus spinoolivaris
- 9 - tractus vestibulospinalis (med. et lat.)
- 10 - tractus tectospinalis
- 11 - tractus corticospinalis anterior
- 12 - tractus spinothalamicus anterior
- 13 - tractus spinothalamicus lateralis
- 14 - fibrae reticulospinales
- 15 - tractus spinoreticularis
- 16 - fasciculi proprii



Somatotopic organization



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 for ncl. intermediolateralis

Spinal cord tracts

- **ascending (afferent, upward)**
 - Somatosensory and viscerosensory
konverging in spinal nerves
- **descending (efferent, downward)**
 - somatomotor
 - visceromotor (autonomous)
- ***Tracts crossing !!!***

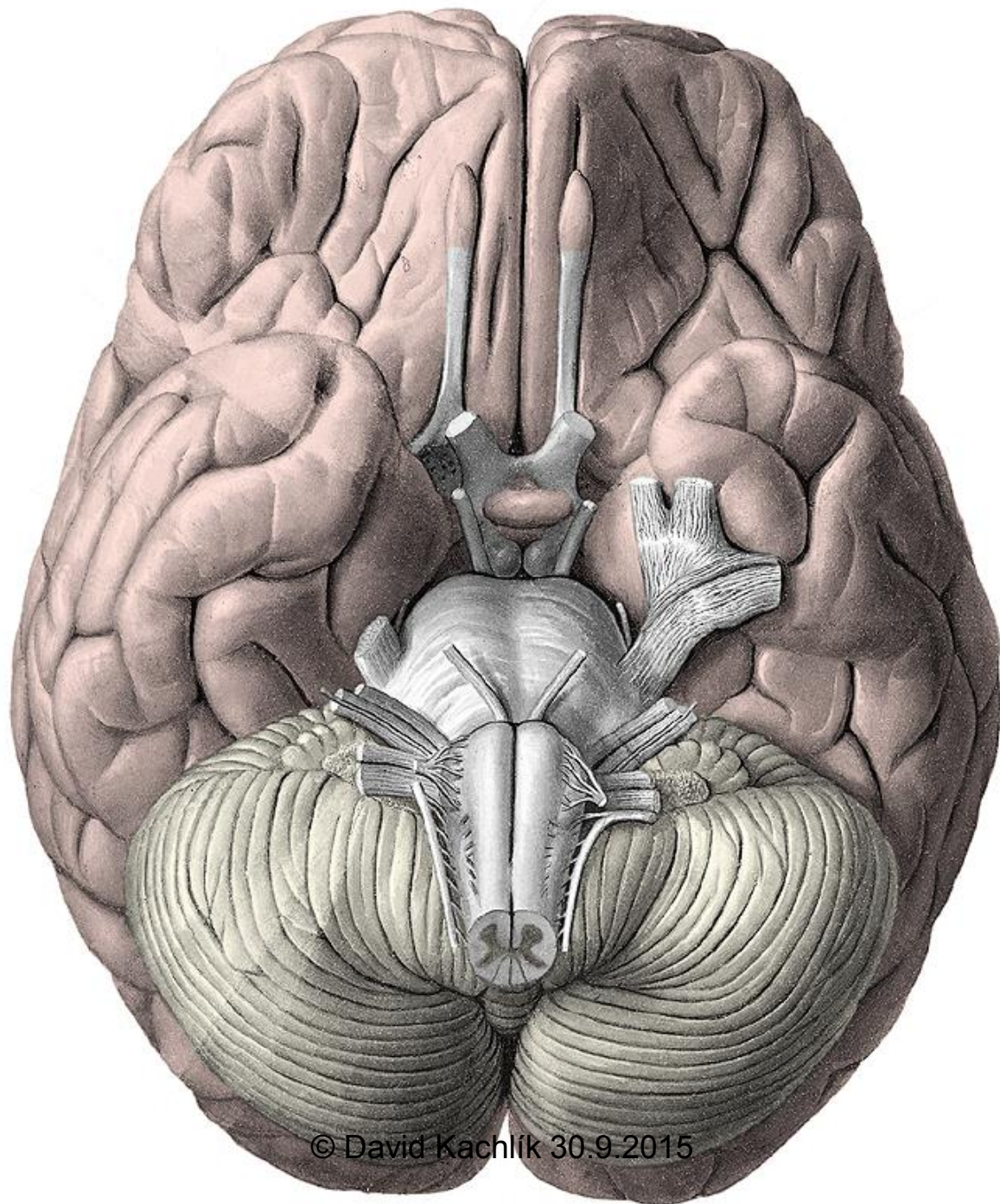
Ascending tracts

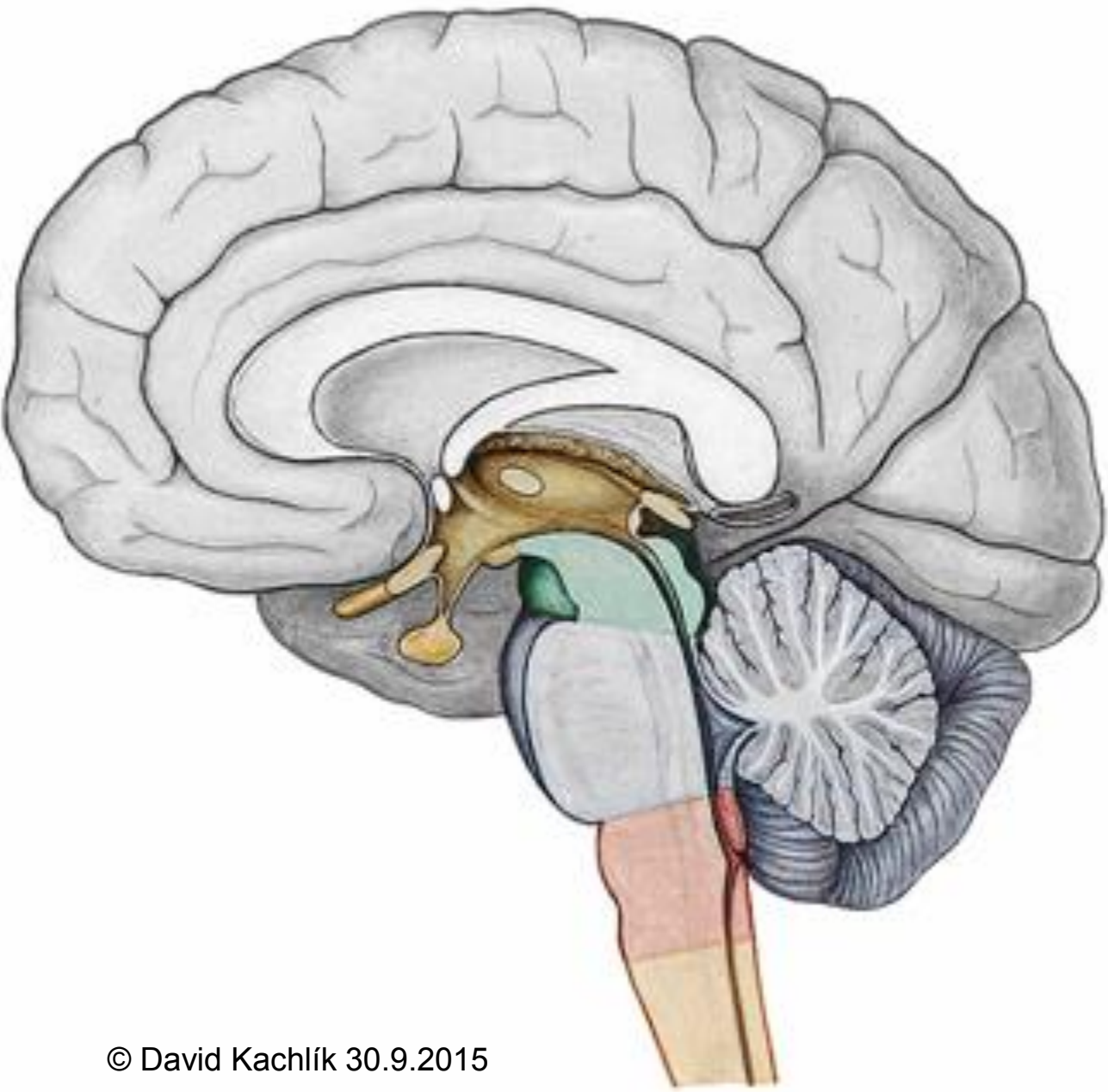
- modality: touch, pain, heat-cold, tactile (proprioception, kinesthesia)
- receptor: exteroceptors, interoceptors, proprioceptors

- 1. neuron: ganglion spinale
- 2. neuron: spinal cord / brain stem
- 3. 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, subtle skin sensitivity, discrimination system, pressure, vibration*
- tractus **spinothalamicus ant.+lat.** = anterolateral system
 - *Fast pain, heat-cold, rough skin sensitivity*
- tractus spinoreticularis
 - *Slow pain*
- tractus spinocerebellares ant.+post.
- *And other...😊*

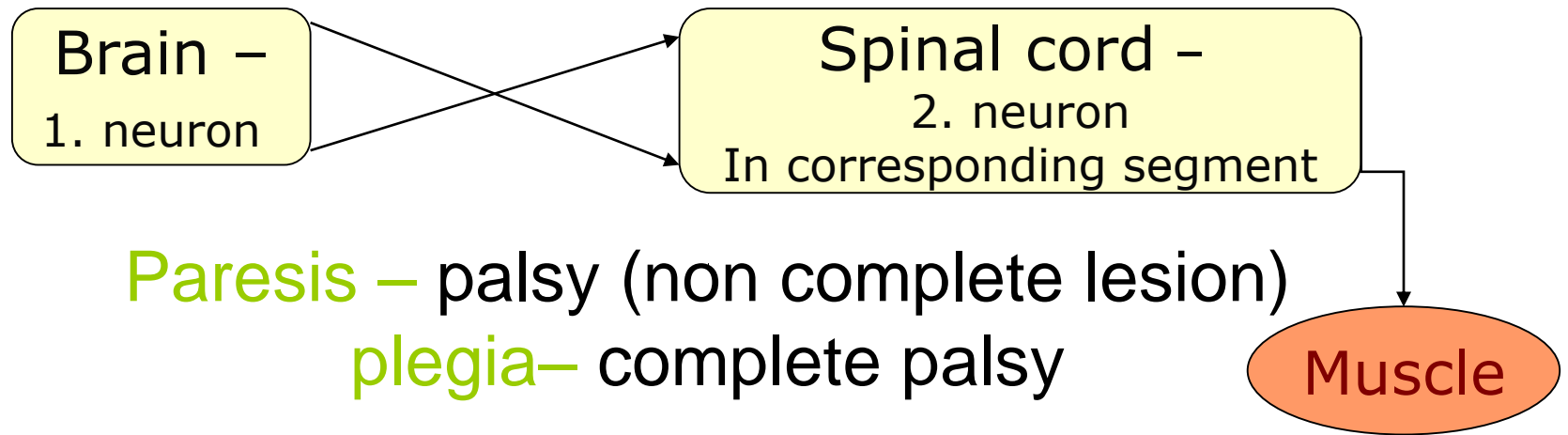




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Descending tracts

- **tractus corticospinalis = pyramidal tract**
 - Principal motor tract – voluntary motoric
 - 1. neuron – cortex (pyramidal cell)
 - 2. neuron – alfa-motoneuron → spinal nerve
- **Extrapyramidal systems**
 - *Non-voluntary motoric*
 - tr. vestibulospinalis – postural muscles
- tr. reticulospinalis – gama moto-neurons
 - tr. rubrospinalis (rudimentary)
 - And other 😊



Paresis – palsy (non complete lesion)

plegia – complete palsy

kvadraparesis – 4 limbs

hemiparesis – half of the body longitudinally (1UL and 1LL)

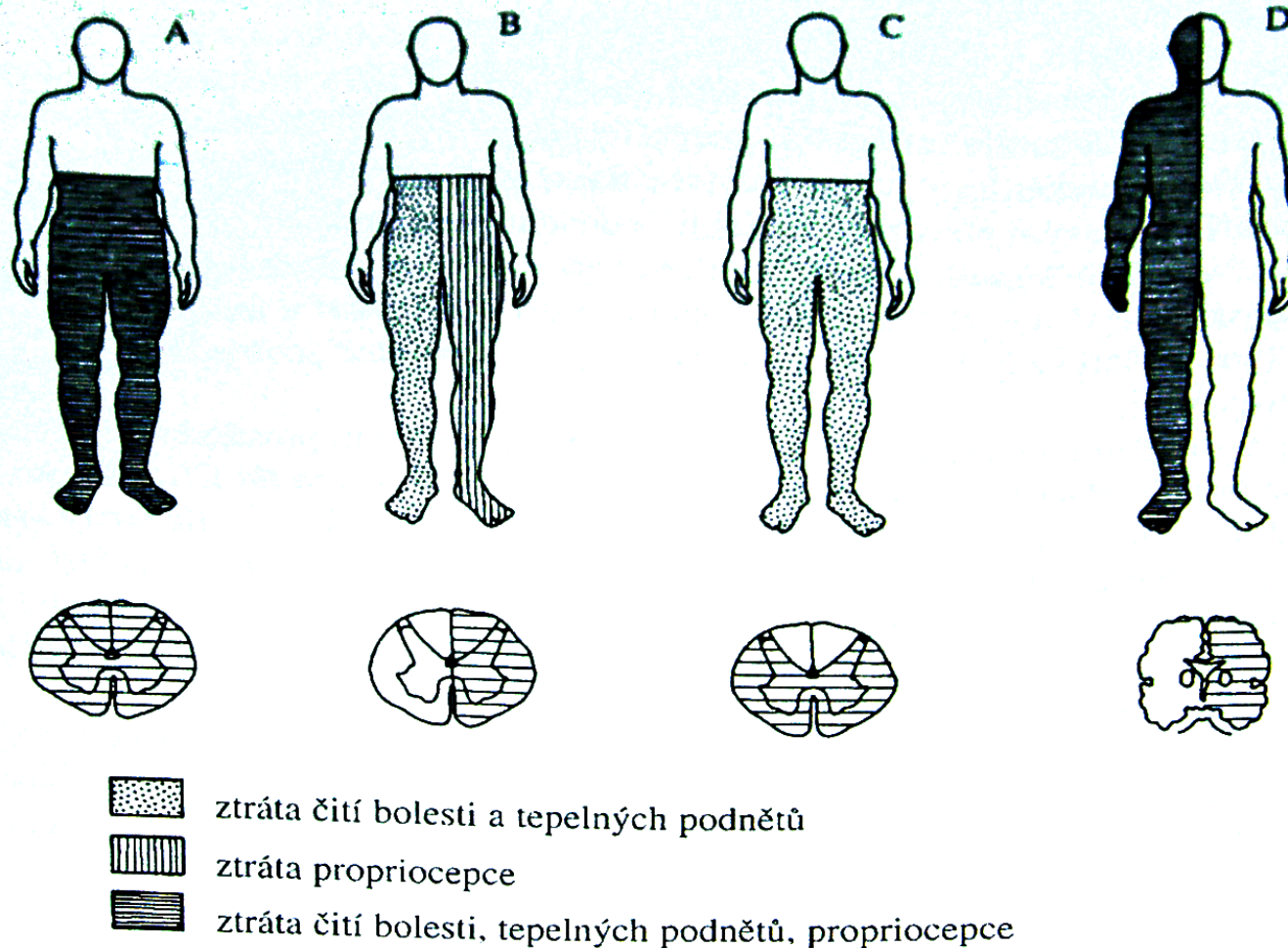
paraparéza – postižení obou DK

central paresis – lesion of 1. motoneuron
= SPASTIC palsy

periferal paresis – lesion of 2. motoneuron

= **WEAK** palsy

Examples of spinal cord lesions



A. transversal spinal cord lesion

B. Brown-Séquard syndrom (spinal cord hemisection)

C. syndrom a. spinalis anterior

D. hemisferic syndrom

Cauda equina – roots L3-S5

- palsy asymmetrical (according to lesioned roots), peripheral = weak (muscular atrophy, areflexia, hypotonia)
- Perception 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 vertebra, most often *discopathia (L4/5, L5/S1...)*

Medullary conus – segments S3-S5

- Is not LL palsy !!
 - Only short flexors of foot fingers and muscles of pelvic diaphragm
- Perception problems – perianal, perigenital, on internal and posterior side of thigh (also S2)
- Pain into perineum and gluteal region
- Sphincter problems:
 - Autonomous urinary bladder (urine retention)
 - Stool incontinency
- Sexual problems (erection and ejaculation)
- visualization – at the level of L1 vertebra
- *Highly suspect expansion process*

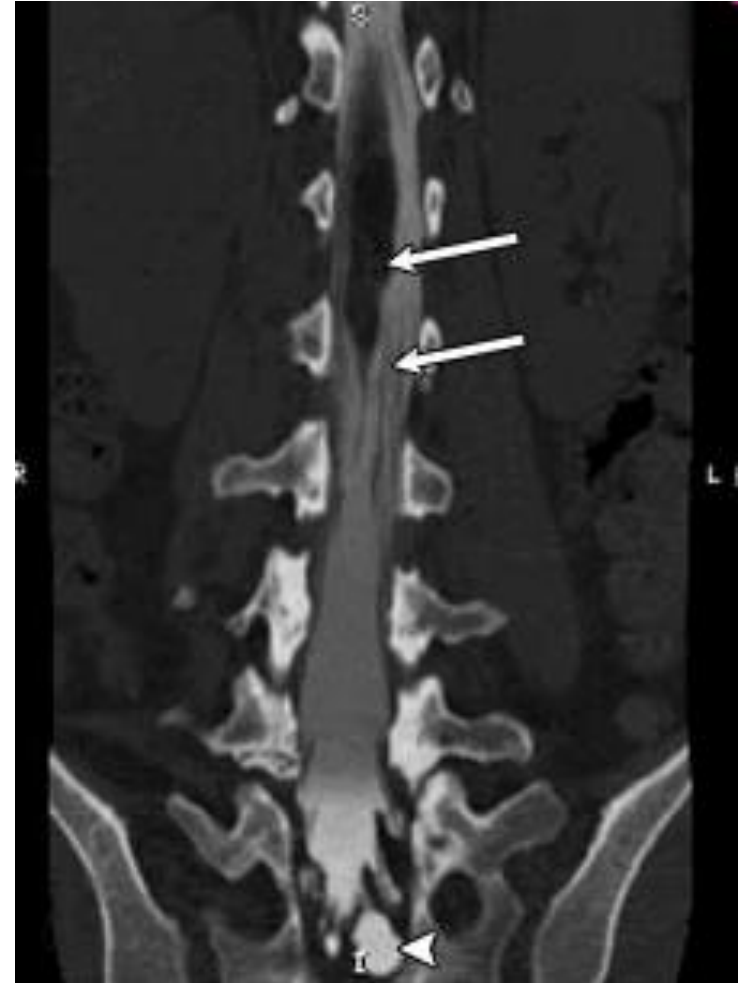
Spinal epiconus, segments L5-S2

- Paresis as in radicular lesion L5 + S1 – *mistakes !!*
paresis of extensors of foot, muscles on the ventral and dorsal side of crus = problems with foot flexion and crus flexion
- Perception problem (posterior side of LL and distally from knees)
- Autonomous urinary bladder
- Sexual problems (erection and ejaculation)
- Visualization is necessary at the level of vertebrae T12/L1!
- *It is not disc prolapse, but suspect expansion process!*

Casuistic 1

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

Examination results



CT myelogram

Arrow points to intramedullary thing, that was identified as tumor from adipous tissue = *lipoma*.

Casuistic 2

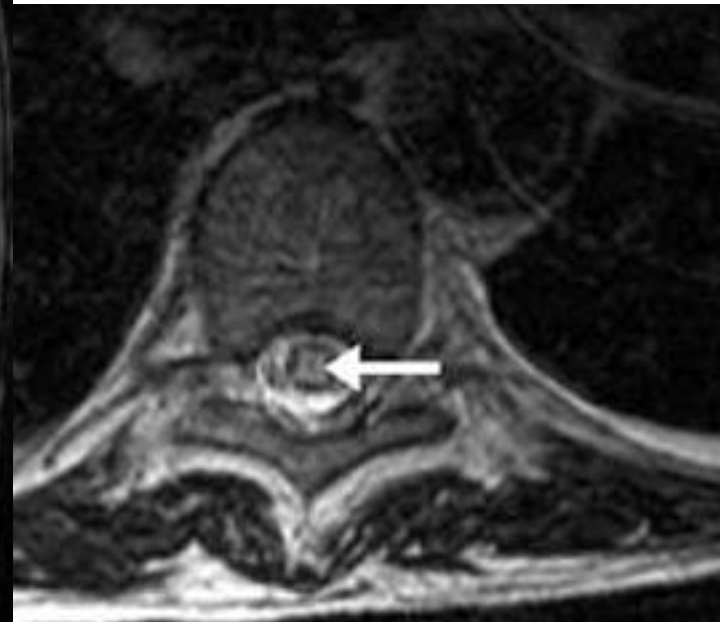
- 60-year female patient with fastly growing paraplegia and complete anesthesia of lower half of the body
- In personal anamnesis there is operation for abdominal aorta aneurysm

Which tracts are impaired?

*How big is spinal cord lesion on „horizontal section“
?*

What could be the cause of sudden paraplegia?

Examination results



MR T-L páteře
ischemia by T5
+ konus



A: abdominal CT –
arrow points to
aortal aneurysma

B: Abdominal CT
– arrow points to
left atrophic
kidney

