Anatomy CNS

lec. 1

[introduction]

① Functions of CNS:

- ① sensation (input)
  - through external/internal stimuli (changes) → receptors (detection)
  - ↓
  - transfer different energy to signals
- ② integration (brain & spinal cord)
  - reach CNS to process & interpret these signals to determine appropriate response.
- ③ RXN (motor) (output)
  - through signals from CNS to periphery.
  - ⊕ muscle contraction
  - ⊕ glands secretion
  - through the release of neurotransmitters

② Nervous tissue (highly cellular):

Neurons

* functional unit
* signal transduction.
* highly metabolic
* do not regenerate (highly specialized)
* long-lived
* electrically excitable.

⇒ neurodegenerative diseases (due to)

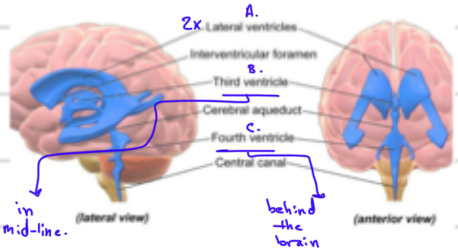
neuroglia

* nourish, protect, support neurons.
* do divide.
* smaller, more numerous.

6 types of neuroglia

CNS				PNS	
oligodendrocytes	Astrocytes ☆	ependymal cells	microglial cells	schwann cells	stellate cells
↓	↓	↓	↓	↓	↓
Forming myelin sheath (↑ velocity)	BBB + buffer (↓ excess neuro-transmitters)	lining ventricles (spaces in brain ⊕ central canal of spinal cord).	immune cells (monocytes).	Forming myelin	support neurons outside CNS. (ganglia).

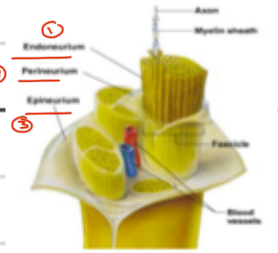
* neurons
  - sensory: cell bodies in dorsal root ganglia (to dorsal root)
  - interneurons: association neuron with CNS.
  - motor: cell bodies in spinal cord. (From ventral root.)



* white × grey matter
  - white: aggregation of axons (only) (un/myelinated) no cell bodies
  - grey: aggregation of cell bodies.

* tracts × nerves × ganglion × nucleus.
  - tracts: bundles of processes in CNS (no CT)
    - ascending (spinal cord → brain) (sensory)
    - descending (brain → spinal cord) (motor)
  - nerves: bundles of processes in PNS (✓ CT)
  - ganglion: cluster of cell bodies in PNS
    * supported by stellate cells
    ⇒ sympathetic chain, dorsal root ganglia, spinal ganglia, trigeminal ganglia
  - nucleus: cluster of cell bodies in CNS
    - surrounded by white matter
    - if not surrounded ↓ cortex.

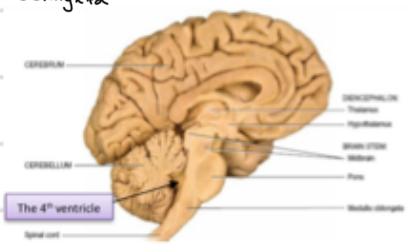
* one axon surrounded by
① endoneurium, a bundle of neurons (fascicle) surrounded by ② perineurium, a bundle of fascicles surrounded by epineurium. ③



* PNS
- 31 spinal nerves (8 x 12 x 5 x 5 x 1)
  - * to & form spinal cord.
  - * occasionally form plexuses.
- 12 cranial nerves
  - * from & to brain

③ brain divisions at the embryonic level:

- fore brain (prosencephalon)
  - cerebrum (telencephalon)
    - * outer part
      - cortex
      - subcortical white matter.
  - diencephalon
    - * thalamus
    - * hypothalamus
    - * epi & subthalamus.
- mid brain (mesencephalon)
- hind brain (rhombencephalon) → it has a cavity (4th ventricle)
  - pons
  - medulla oblongata
  - cerebellum



* brain can also be divided into: cerebrum + cerebellum + brain stem
- pons
- mid brain.
- medulla oblongata

communication between CNS & body.

Peripheral nervous system	
Somatic nervous system	Autonomic nervous system
afferent → **1- Sensory neurons: (somatic sensory neurons)** • Convey information to the CNS from sensory receptors in the skin, skeletal muscles and joints and from the receptors for the special senses. *	**1- Sensory neurons: (autonomic visceral sensory neurons)** • Convey information to the CNS from autonomic sensory receptors, located primarily in the visceral organs (smooth muscle organs in the thorax, abdomen and pelvis). → ex. detection of blood pressure (baroreceptors).
efferent → **2- Motor neurons: (somatic motor neurons)** • Voluntary. • Conduct impulses from the CNS to skeletal muscles.	**2- Motor neurons: (autonomic motor neurons)** • Involuntary (generally). • Conducts impulses from the CNS to smooth muscle, cardiac muscle and glands.

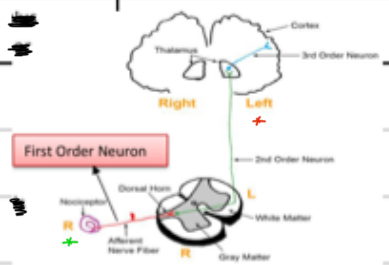
* every area in cerebral cortex represents an area in your body.

④ pathway of neuronal signals (PNS, CNS).

A. sensory pathway (spinothalamic tract):

first order neuron → second order neuron → third order neuron.

stimuli → receptor → nerve → dorsal root ganglia → axon → synapse in spinal cord (dorsal horn) with another neuron → this 2nd neuron ascends up in a tract through brainstem → diencephalon (thalamus) → synapses occurs with another neuron in thalamus → transmits signal to cortex → interpretation/integration.



* signal came from one side (Rt) & along its course it went to opposite side (lt) → decussation.

* >1 neuron for neuromodulation, regulation of these pathways.

* after signal interpreted, response is generated from CNS → periphery.

- spinal nerves (from spinal cord)
  - ventral root (motor)
    - somatic
    - visceral (autonomic)
  - dorsal root (sensory)

B. motor somatic pathways

control/regulate activity of lower.

upper motor neuron → (sometimes no synapse with it.) inter neuron → lower motor neuron.

muscle not in head or neck (spinal nerves) →

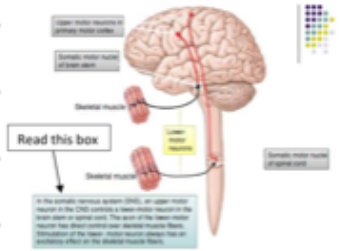
neuron descends through a tract from cortex → specific segment in spinal cord → synapse → with another neuron in ventral horn. → synapses → with lower motor neuron, transmits signal to periphery.

muscle in head/neck (cranial nerves) →

similar pathway but upper motor neuron descends from cortex to brain stem.

→ no ventral horn, so cell bodies of lower motor neurons form nucleus.

* originate from brain stem except I & II
* mixed, motor, sensory
  - some autonomic (parasympathetic) motor fibers → vagus N.



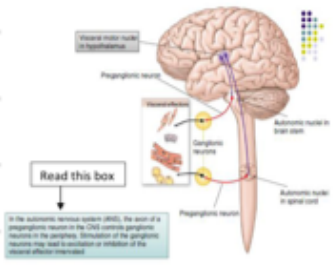
C. motor visceral (autonomic):

* ANS activities are controlled by high centers (hypothalamus).

higher neurons (hypothalamus) → descends to lower compartments (spinal cord/cranial N.) → synapse with preganglionic Neuron. → synapse with post-ganglionic neuron in pre/sympathetic ganglion. → post ganglionic neuron innervates the effectors.

synapse in brain stem/lateral horn of spinal cord.

* lateral horn of grey matter in spinal cord is found only in ANS spinal segments.



ANS spinal segments:
- sympathetic (thoracolumbar) T1 → T12 & L1 & L2
- parasympathetic (craniosacral) S1 → S5
  * cranial part of parasympathetic nervous system are the brainstem nuclei.

* difference between dorsal root ganglia & ANS ganglia is:
  - dorsal root ganglia: no synapses only cell body of sensory neuron → pseudounipolar neuron.
  - ANS ganglia: synapse between pre/post ganglionic neurons → pre → post.

⑤ external anatomy of spinal cord: 42-45 cm (its CT is meninges)

* from foramen magnum (occipital bone of skull) to L1/L2 through vertebral canal.
  - only 2/3 occupied by spinal cord.
    - due to embryogly, bones outside spinal cord. (cervical, lumbar)
* slightly flattened (ant. + post.) ⊕ not uniform in diameter (2 enlargements)
  - to supply upper & lower limbs by forming plexuses.
* spinal cord give rise to (31) spinal segments nerves. (mixed)
  - 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal
* inf. end of spinal cord is tapered (conical shaped) & called conus medullaris. & its extension is lower spinal nerves called cauda equina (horse tail appearance).

* spinal cord is surrounded by 3 layers of CT (meninges):

dura mater
* dense irregular CT.
* outermost layer covering vertebral canal.
* extends from foramen magnum to S2. caudally it continues as filum terminale externum. which continues to attach to coccyx.
* continues with perineurium of spinal N.

Arachnoid mater
* web-like, delicate collagen & elastic fibers.
* adheres to inner surface of dura mater & ends at S2

pia mater
* thin, transparent CT layer that binds tightly to brain & spinal N.
* ends at level L1/L2. & forms filum terminale internum
  - attached to each other caudally & to coccyx.

providing stability & protection to spinal cord within canal

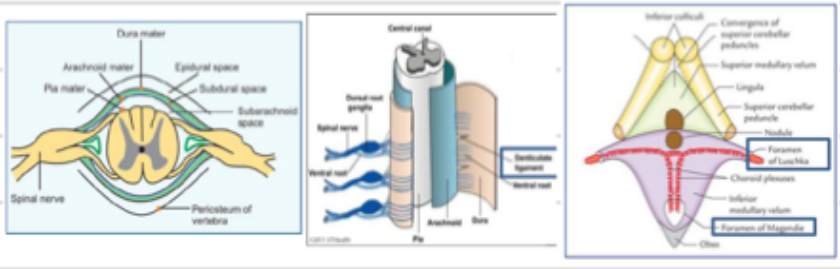
* pia matter forms denticulate ligaments that attach spinal cord to arachnoid mater & inner surface of dura mater.

⑥ spaces:

epidural space
* fat filled.
* for labor anaesthesia.

subdural space
* filled with serous fluid.

subarachnoid space
* most important & true space
* major blood vessels supply CNS pass through it.
* filled with CSF.
* physiological functions.
* CSF circulates through brain ventricles, central canal of spinal cord, subarachnoid space.
* CSF passes through 4th ventricle to arachnoid space through 4 openings:
  1. central canal of spinal cord.
  2. 2 lateral apertures: foramina of luschka.
  3. single median aperture: foramen of magendi.



diagnostic for infx. / CSF pressure changes.

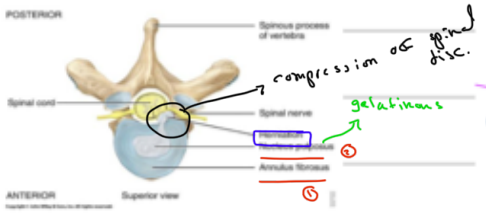
* CSF sample can be taken by lumbar puncture (spinal tap). from L3-L4.

lec. 2 :
spinal cord "1"

* spinal segement : a place from which spinal nerves emerge from (31 spinal nv. = 31 spinal segments)

* spinal cord segement are Not in line with the corresponding vertebrae
  - C1 - C7 → above corresponding vertebrae.
  - C8 → between C7 & T1
  - T1 → S5 → under corresponding vertebrae.
  - } emerge from inter-vertebral foramen.
  - spinal nerve roots ↑ in length as we go downward.

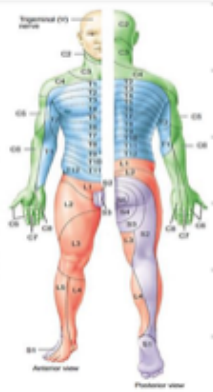
① Herniated/ruptured/slipped disc :



thinnest & weakest point of annulus fibrosis → most likely posteriolateral

* due to heavey weight there will be protrusion (leakage) of nucleus pulposis through annulus fibrosis.
* 95% usually happen in inter-vertebral discs L4/L5 or L5/S1.

* dermatome (K) supplies area of skin. — myotome. supplies group of muscles. — single spinal nerve
  - dermatome → abnormal sensation
  - myotome → weakness
* when spinal N. compressed by herniated disc (motor + sensory)



② common lumbar disc problems :

Common lumbar disc problems

Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris)	Anteromedial leg (saphenous)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsiflexion (EHL) and (TA)	Big toe, Anterolateral leg (CPN)	Hamstring jerk
L5-S1	S1	45-50% (standing on tiptoes)	Foot planter flexion (Gastrocnemius)	Lateral border of foot (sural)	Ankle jerk (Achilles tendon)

EHL: external hallucis longus, TA: tibialis anterior, CPN: common peroneal nerve

→ test used to indicate location of injury.

* major symptom of herniated disc : lower ① back pain, radiating to ② gluteal region, back of ③ thigh & ④ leg.

* spinal N. give rise to meningeal branch (recurrent) gives sensation (sensitive to stretch) to dura mater. when compressed will cause diffused pain due to overlapping dermatomes.

* straight leg raise test (SLR) : flexion of hip, extension of leg, pulling sciatic N. (L4-S3) pulling this N. pressuring nerve root.
  → test for checking disc herniation.

* MRI → for confirming disc herniation.

③ cross-section of spinal cord : divides into columns Ant. + post. + lateral

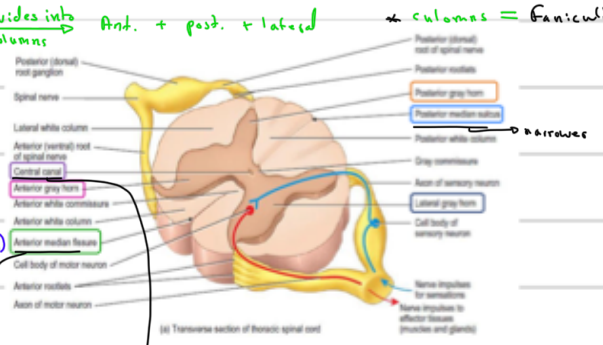
* culomns = fanicwli

* spinal cord → white matter
→ grey matter (collection of cell bodies)
  - ventral (motor)
  - lateral (autonomic)
  - dorsal (sensory)

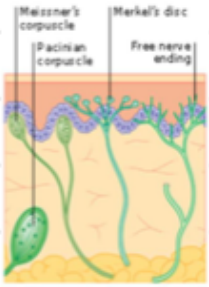
* grey matter is divided into laminae (10 in number).

wider, deeper

contains CSF connected to 4th ventricle.



④ receptors : converting one type of energy to signals (sensation).



- Mechanoreceptors
  - Meissner's corpuscle → touch, pressure, low frequency vibration. → rapidly adapting → signal fades away after stimulus exposure.
  - Pacinian corpuscles → high frequency vibrations → rapidly adapting
  - end organ of Ruffini → sensitive to skin stretch → slowly adapting → signal is transmitted as long as stimulus is present.
  - merkel's disc (tactile disc) → discriminative touch → slowly adapting
- thermoreceptors → TRP channels * detect temperature changes.
- Nociceptors * multimodal * detect damage (pain receptors) ← exaggeration of certain type of energy

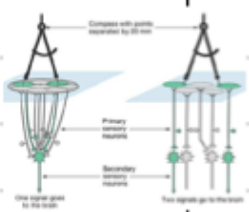
* type of free nerve ending

* seansry fibers type : myelinated: Aα > Aβ > Aδ > C : unmyelinated
(diamtr increases)

* velocity ↑ diameter ↑ (+) myelination

* muscle spindles : stretch receptors detect change in length of muscle.
* golgi tendon organ : receptors detect tension in tendons.

⑤ receptive field. : area of skin supplied by a single fiber (receptor).



* if multiple first order neuron converge into a single 2nd order neuron. brain will consider the 2 receptive fields as (one). ↑ receptive field.

brain can discriminate (A) as (2) seperate points. while at (B) only can detect & feel one point.

↑ number of receptors
↓ area of receptive field
↑ descrimination & recognition by brain.

ex. tips of fingers.

⑥ labelled line theory :

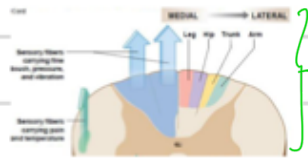
* individual primary afferent fiber carry information from a single type of receptor.

* each fiber is labelled with a certain type of receptor.
ex. pressure cannot stimulate thermoreceptors.

* sensation depends on : ① modality (type) ② locality (homunculus of brain) ③ intensity.

lec. 3

"Spinal cord 2"



* Ascending sensory tracts:

(1) Post. column – medial leminiscal pathway: → high velocity & precise signals (advanced system)

↳ Aα, Aβ sensory fibers.

- Post. tract (column)
  - medial fasciculus (gracilis) — area below T6
  - lateral " (cuneatus) — area above T6

modality (type)

① discriminative touch sensation. (including vibrations)

② conscious proprioception. (muscle joint sensation)

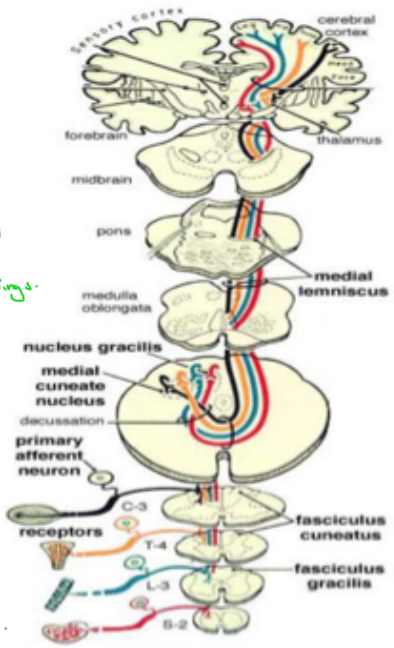
reach cortex.

- conscious realization of (CNS) of position of body in space.
- importance: motor coordination
  - ↳ how to move muscles/joints to achieve desired movement.

receptors

most type of receptors (exc (muscle spindles + golgi tendon organ) except free nerve endings.

*unconscious proprioception reaches only cerebellum.



Pathways

* 1st order neuron: * cell bodies in dorsal root ganglia.
  - (periphery) ↔ (ascending to CNS)
  - (pseudo unipolar neuron)

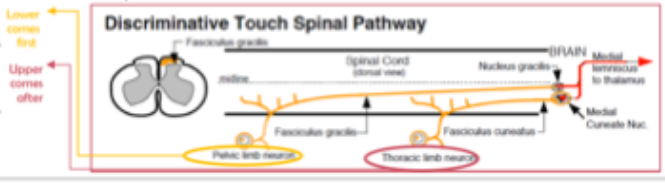
* mechanoreceptors → post. white column → ascends ipsilateral (same side)
  - lower part of medulla oblongata → synapse with 2nd order neuron.

* 2nd order neuron: * cell bodies in 2 nuclei: gracillius (medial) + cuneatus (lateral) → dorsal column nuclei.
  - (lower part of medulla oblongata)
  - internal Arcuate fiber – (leminiscal decussation (crossing over) (primary sensory decussation)) → medial leminiscus (ascends contralaterally).
    - ascends close to midline forming
    - ↓
    - synapse with 3rd order neuron at VPL nucleus ← reach thalamus (consists of: 2 egg-shaped collections of gray matter, & they have multiple nuclei: VPL, VPM, ...)

leminiscus → elongated shape.
fasiculus → circular " .

* 3rd order neuron:
  - thalamus (VPL) → internal capsule → corona radiata → cortex (outer aspect of cerebrum (telencephalon)).
    - (ventral posterior lateral nucleus)
    - narrow critical area located between (① caudate nucleus, ② thalamus, ③ lentiform nucleus)
    - (homunculus of brain) go to area on cortex where localization happens.
  - terminates: parietal lobe of brain, into primary somatosensory area (S1) (somesthetic).

* Somatotopic principle exists in spinal cord as well. like representational order on cortex. (exists here)



gyrus / sulcus

* just like skull, cortex is also divided into: frontal, parietal, temporal, occipital.

* sensory system goes to post-central gyrus of parietal lobe & gets represented as homunculus.

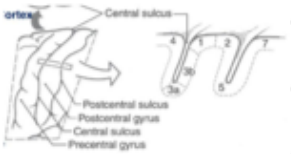
* cortex is divided into functional areas by numbers.

* post-central gyrus is sub divided by types of receptors into 4 areas (ant → post) → 3a, 3b, 1, 2

3a → muscle spindle afferent (mainly)

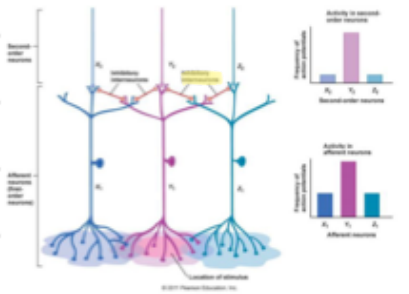
2 → golgi tendon organs & joint afferents (mainly)

3b, 1 → * cutaneous afferents from receptors (meissner corpuscles, merkel's cells)
* also, receive cutaneous input from receptors that transmit → pain + temp.



* lateral inhibition: facilitates localization of site of stimulation.

* the most stimulated receptors, will halt (dim) the signal transmission of other receptors through lateral inhibition of other receptors by [inhibitory inter neurons] → activated by collateral processes of most stimulated neuron.
↳ localization of stimulus becomes more precise.



(2) spinothalamic tract: Ant. + lateral

* lateral spinothalamic tract: → modality: transmits pain + temp.
→ receptors: Free nerve ending receptors.

* pathway:

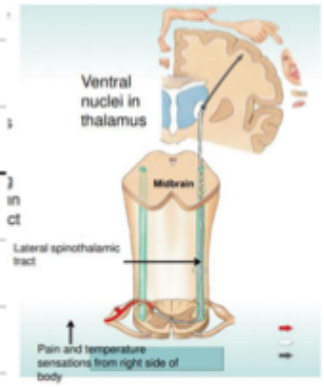
- 1st order neuron: * cell bodies in dorsal root ganglia
* central process of this neuron synapses with 2nd order neuron which cell body exists in dorsal horn (Grey matter) in a place called [substantia gelatinosa.]

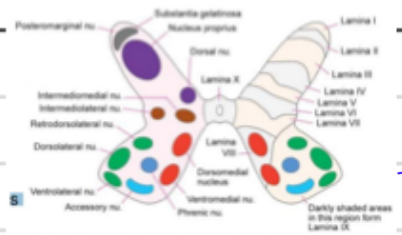
- 2st order neuron:

* their axons cross obliquely to opposite side passing through ant. horn & white commissures & ascending contralateral white column as lateral spinothalamic tract.

axons that connect rt & lt parts of spinal cord.

- 3rd order neuron: thalamus (VPL) → internal capsule → corona radiata.
& they terminate: primary somesthetic cortex (SI), specifically in area number 3b, & in wide spread cortical region.



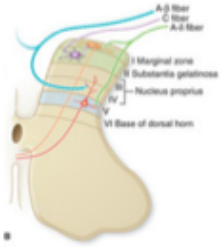


related to the fact that we have 2 types of pain.

* Gray matter of spinal cord is divided into laminae (10 in number)
* dorsal horn are formed by (I → VII).

* lamina (I, II, V) ⇒ related to pain + temperature.
  → form substantia gelatinosa.

* two types of pain
  - Fast: like cut injury → transmitted by Aδ fibers.
  - slow (multiple components + complicated): like chronic pain → autonomic + emotional → transmitted by type C fibers.



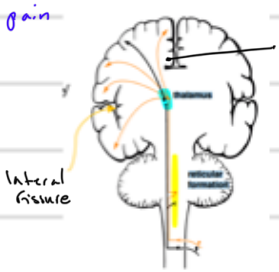
* pain termination signals doesn't stop at the level of cortex, but stimulate other areas too.

* majority of slow pain fibers (I, II) → stimulate (network of fibers) reticular formation in the core of brain stem.
  this formation is door to conscious mind → individual becomes aware of the pain.
* mild sounds while sleeping doesn't wake you up. but with massive sensory input it will stimulate reticular formation & this switches on reflex on cortex which brings you to awareness.

* ① cingulate gyrus.
  - part of limbic system
    - between outside & inside of cortex.
  - responsible for interpretation of emotional aspect of pain.
    - this system helps us avoiding pain.

conditional place preference experiment: ex. rat has been put in 2 boxes, box of pain & box of rest & when it was left for rat to choose box it went to rest box.

② insular gyrus (insula)
- hidden part of cortex in lateral fissure.
- responsible of pain stimuli from internal organs of the body & bringing about autonomic response to pain



* posterolateral tract of lissauer: located between post. & lateral white column.
  - fibers that ascend up or down to synapse with upward or downward spinal segement.

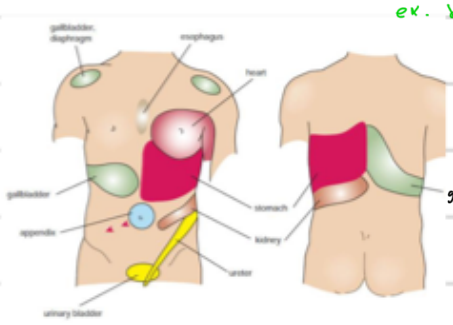
lec. 4
"spinal cord (3)"

* fast pain → well localized → spinothalamic // slow pain → diffuse → spinoreticular → C fibers tend to diverge & synapse with >1 2nd order neuron → ⊕ wider area in cortex.

*pain according to origin → cutaneous: skin.
→ deep somatic: large area (muscles, joints, bones, ligaments) ex. intermittent claudication → accumulation of metabolites ex. lactic acid in muscles. esp. calf muscles due to impaired blood supply. common in uncontrolled diabetic pts.
→ visceral: from internal organs.
→ they might not response to same stimulus. since receptors of visceral organs differ.

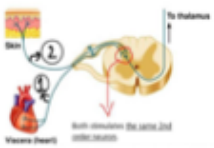
↑ not required but in case.

* visceral pain is often referred. ⇒ pain in one part of the body caused by injury to another part of your body.
ex. heart attack could trigger pain in lt. arm + jaw.



mechanism: convergence theory
↳ we have (2) fibers → from viscera (nociceptor) → may converge into the same 2nd order neuron
→ from skin (another nociceptor) → may converge into the same 2nd order neuron

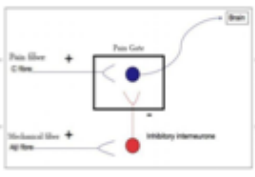
*signals from viscera may be interpreted by CNS as coming from skin where stimulus more frequently originated from.

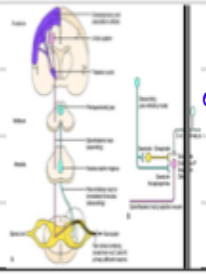


goes to post central gyrus & refers pain to skin since CNS used to pain coming from skin.

* pain control in CNS:

① Gating theory
2 fibers
C fiber → pain
Aβ fiber → non-painful touch + pressure → when activated in inhibits pain transaction.
inhibition of pain by another mechanical stimulus.





② descending control (VIP)
C fiber (pain fiber) → spinoreticular fibers → ⊕
periaqueductal gray (midbrain) → excitatory neurons → nucleus raphe magnus (NRM) (medulla oblongata)
nucleus raphe magnus → production → serotonin → ⊕ inhibitory neurons
inhibitory neurons → secrete → enkephalins + endorphins in substantia gelatinosa
enkephalins + endorphins → termination of pain.

* locus coeruleus (pons) → ⊖ → substantia gelatinosa

(3) **Ant. spinothalamic tract:**

- Modality: crude touch + pressure.
- Receptors: free nerve endings
- Pathway
  - 1st order → dorsal root ganglia
  - 2nd order → post. horn of gray column (nucleus proprius) → lamina 3 + 4
  - 3rd order → VPL (thalamus) → internal capsule → corona radiata → terminates in primary somesthetic area (S1)

(4) **spinotectal tract:** sensory tract from spinal to tectum (roof).

- ascend in anterolateral white column. close to lateral spinothalamic tract.
- terminate: sup. colliculus.
- provide info. → spinovisual reflexes.
  - movement of eyes, head, neck to source of stimulus immediately, like stepping on glass.
  - happens at lvl of spinal cord. No need for higher centers.
- pathway similar to anterolateral spinothalamic tract but termination in sup. colliculus.
- dorsal side of mid brain (corpora quadrigemina) (4 in number)
  - 2 sup. colliculi → visual reflexes
  - 2 inf. colliculi → auditory reflexes

* in medulla: Ant. + lateral spinothalamic tract ⊕ spinotectal tract ⇒ spinal lemniscus ends with VPL.

(5) **Ant. + post. spinocerebellar:** spinal cord → cerebellum // located in: anterolateral columns of white matter.

* peduncle → bundles of white matter.
  - sup. → mid brain
  - mid. → pons
  - inf. → medulla oblongata
  - connects cerebellum to ...

Ant.

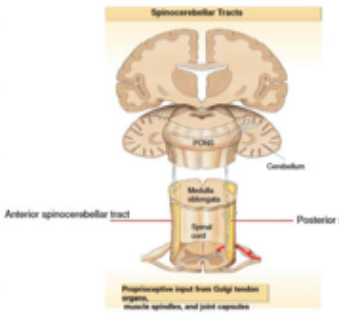
- modality: unconscious proprioception (muscle & joint sensation).
- pathway
  - 1st order neuron: synapse at nucleus dorsalis.
  - 2nd order neuron axons: 2 pathways!
    - majority: cross to opposite side & ascends in contralateral white column. (in spinal cord)
    - minority: ascends in lateral white column of same side.
  - ascend to medulla oblongata & pons.
  - will cross back to ...
  - terminate: cerebellar cortex through (sup. cerebellar peduncle).

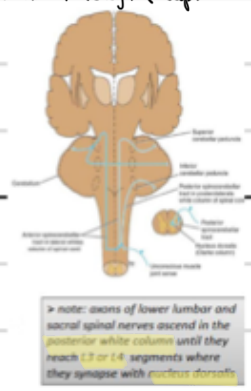
Post.

- modality: * muscle & joint sensation. (unconscious proprioception)
- receptors: like post. spinothalamic tract. (All receptors except free nerve endings)
- pathways
  - 1st order neuron: synapse at base of post. gray column with nucleus dorsalis / clarks nucleus in lamina 7.
    - last place this nucleus exists at its L3/L4 spinal segment. & axons ascend through dorsal column to synapse.
  - 2nd order neuron: ascends ipsilateral on post. lateral side of lateral white matter to medulla oblongata.
  - terminates: cerebellar cortex (inf. cerebellar peduncle).

* Anterolateral + dorsal column system.
  - sensation from rt → lt

* Ant. + post spinocerebellar tract.
  - sensation on same side.



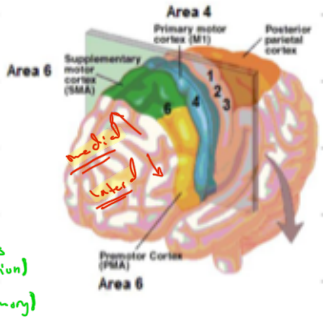


lec. 5

" spinal cord (4) "

* motor (descending) tracts. → pyramidal : conscious control of skeletal muscle movement.
→ extrapyramidal : subconscious " " " " " (regulation of balance, eye/upper limb position, hand, muscle tone).

* motor system starts from cortex (area 4, 6 mainly) & descends downwards.
→ motor cortex exists in frontal lobe (ant. to central sulcus).



* motor cortex →
- Area 4 (pre-central gyrus, primary motor cortex) : pyramidal tracts descend mainly from it.
- Area 6 → mainly extrapyramidal tracts descend from it → premotor area: (external cues hearing + vision); supplementary motor area: (internal cues → memory)
- some motor neurons → Area 321 (sensory area)

→ high overlap between these 2 areas.

* monkey experiment: we put 3 light bulbs infront of monkey, if he clicks on button of the bulb that switched on he gets a treat. (coordination between external cues (vision) + motor activity of hand to switch on). so if premotor area is damaged → X coordination so he won't be able to do the above / no paralysis / no blindness).

* lesion → area (4) : paralysis
→ area (6) : no paralysis / loss of coordination / inability to do fine movements (inserting a thread in needle).

* pyramidal tracts (conscious) — forms pyramids as fibers move through medulla oblongata.
cortex (mainly area 4) → upper motor neuron
↓
synapse with ← spinal cord interneuron (lamina 8)
→ activation of lower motor neuron → skeletal muscles. (cell body in ant horn. lamina 9)

types: Ant. + lateral corticospinal tracts.

X extrapyramidal tracts (subconscious) — fibers don't move through pyramids.

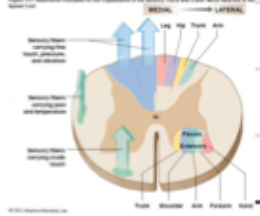
- vestibulospinal tracts → starts → vestibular nuclei in brain stem (below pons & above medulla oblongata)
- reticulospinal tracts → starts → reticular formation. (network of fibers in the core of brain-stem)
- rubrospinal tracts → starts → red nucleus (piece of gray matter highly vascularized & located in mid brain) → has an important role in control of motor system.
- tectospinal tracts → starts → (sup. aspect of mid-brain.

all start from brain stem but under influence of cerebral cortex. (area 6)

* vestibular nuclei → nuclei of sensory nerve of vestibular part of vestibulocochlear cranial nerve VIII. (responsible for sense of balance).

* motor horns: we will talk about ant. horn:

somato-tropic principle exists here:
- medially → medial/axial muscles (All segments) → upright posture / Balance.
- laterally → supply hand/forearm (distal muscles) (only enlargements) → skilled movement
- ventrally → extensor muscles
- dorsally → flexor muscles.



* lamina of motor system:
lamina 8 ⊗ lamina 9 ⊗ lamina 10
- lamina 8 (motor interneurons) (commissural nucleus)
- lamina 9 (cell bodies of LMN). divided into nuclei:
- lamina 10 surrounds central canal. + func. not clear.

- ventromedial → All segments → extensors of vertebral column.
- dorsomedial → T1-L2 → intercostal + abdominal muscles.
- ventrolateral → C5-C8 (arm); L2-S2 (thigh)
- dorsolateral → C6-C8 (forearm); L3-S3 (leg)
- retrodorsolateral → all enlargments (C8-T1), (S1-S2) hand, foot → skilled movement muscles are flexors
- central → phrenic n. (C3-C5)

* pyramidal tract (corticospinal tracts pathway):

* Ant. + lateral corticospinal tracts starts from cerebral cortex (mainly area 4) → fibers descend from corona radiata to internal capsule → to brain stem (midbrain), fibers will pass through middle 3/5th of (crus cerebri (white matter) / basis pedunculi of midbrain) → fibers descend to reach pons & inside it we have pontine nuclei (collection of seperate cell bodies) & here fibers will scatter between pontine nuclei in ant. basilar part. → fibers will descends to medulla oblongata & fibers will recollect again to form ant. aspect of medulla which is the pyramid.

* at the lower part of medulla, fibers will split up :

* in pons, corticospinal tract will interfere with another pathway called middle cerebellar peduncle (cerebrum → pons → cerebellum) this pathway goes horizontally & at the same time cortico-spinal pathway descends vertically.

majority (85%)

will cross over to opposite side (primary motor decussation)

called : lateral corticospinal tract.

will synapse with alpha & gamma motor neurons.

descend in lateral funiculus of spinal cord to lateral part of ant. horn & supply lateral muscles.

responsible for skilled movements.

minority (15%)

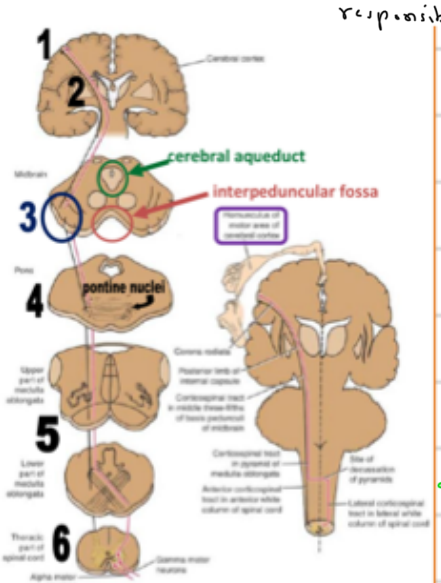
descends ipsilaterally

called: Ant. cortico spinal tract.

will descend to level of spinal cord

cross-over at the level of spinal cord & go to medial part of ant. horn to supply axial muscles.

responsible for posture & balance.



* LCST (lateral cortico-spinal tract) → most sophisticated movements are done by hand. so fibers are distributed as :

55% of fibers will end up in cervical region (hand).
20% " " " " " " thoracic " (trunk)
25% " " " " " " lumbar & sacral region (foot).

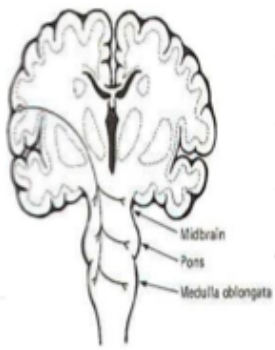
motor neurons originate from area 318. — control of pain

we have 2 theories not important

* LCST synapses mainly by interneurons in lamina 8, but also (4, 5, 6, 7 (dorsal horn)) → not purely sensory.

(↓ synapses = ↑ accurate movement)

* 3% of upper motor neurons synapse directly with lower motor neuron. they originate from giant cells of betz in 5th layer of area (4). & they are responsible of very fine movements.



→ can be considered (pyramidal tracts) although doesn't pass through pyramid.

* cortico nuclear tract (cortico bulbar): cranial nerves & muscles of head & neck.

* in brainstem, no ant. & dorsal horns as in spinal cord. there is nuclei called motor nuclei. (from where cranial nerves arise)

→ collection of cell bodies can do same function as ant. horn.

* fibers descend from cortex (lower 1/4) to a nucleus (motor nucleus) & the descending fibers terminate in the motor nuclei of the following cranial N. in :

midbrain	×	pons	×	pontomedullary junction	×	medulla
3rd + 4th cranial N.		5th cranial N.		6th + 7th cranial N.		9th → 12th cranial N.

ex. trigeminal motor nucles takes fibers from both rt & lt trigeminal N.

* cortico nuclear tract is bilateral. exception : 7th cranial N. supplies lower facial muscles + 12th cranial N. supplies genioglossus muscle (contralateral)

* extrapyramidal tracts (subconscious control):

↳ 4 types & these motor pathways are complex & multisynaptic & regulate:
① axial muscles that maintain balance & posture.
② muscles controlling coarse movements of proximal portions of limbs.
③ head, neck & eye movement.
④ in skilled movement, fine coordination.

① rubrospinal tract (red): * red nucleus located in midbrain at lvl of sup. colliculus.
* synapses with α & γ through interneurons.

↳ recieves input from cerebrum + cerebellum.
↳ has 4 deep cerebellar nuceli: (interposed nuclei) ① dentate nucleus. ② emboliform nucleus ③ Globose nucleus. ④ Fastigial nucleus
Don't Eat Greasy Food

* there is a pathway that emerges from Globose → emboliform → rubral pathway

* rubrospinal tract descend from red nucleus → spinal cord through lateral white column. which is related to activity of lateral corticospinal tract. (exception)

* movement of skilled muscles is mainly flexion.

* lateral motor system = rubrospinal tract (extrapyramidal) + lateral corticospinal tract (pyramidal).

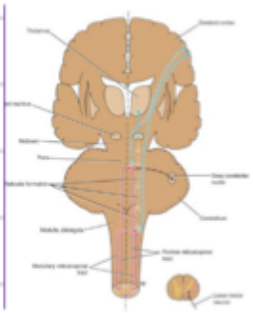
* Function: facilitate activity of flexors (excitatory) & inhibit activity of extensors (inhibitory).
- mainly supplies distal flexor muscles with little effect on proximal muscles.
* very early crossing (at lvl of nucleus).

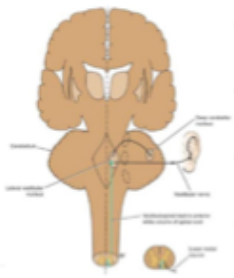
② reticulospinal tracts:

A. pontine reticulospinal tract
* From reticular formation in pons to Ant. white column.
* tonically active (consistent firing) & they remain uncrossed. & the effect of cortex on it is inhibitory (mechanism of disinhibition)
* Function: activate axial + proximal limb extensors. (anti gravity muscles) → so you can stand upright.
↳ knee is fully extended + quadriceps are contracted.
* if we remove inhibitory effect of cortex (decorticate) → overfiring & more activation of reticulospinal tract will occur.

B. medullary reticulospinal tract
* function is opposite to A.
* some fibers cross & some not.
* in lateral white column * not tonically active.
* normally under stimulation.
* lateral reticulospinal tract
* func. → inhibit the axial & proximal limb extensors.

* autonomic motor system is under control of higher centers (hypothalamus) these fibers are thought to pass through medullary reticulospinal tract. so it has descending autonomic fibers so providing pathway by which hypothalamus can control sympathetic & sacral parasympathetic outflow.





③ vestibulospinal tract: (sensory nuclei)
From vestibular nuceli in brainstem (pons + medulla oblongata beneath floor of 4th ventricle)
↳ recieves afferent (sensory) fibers from: ① inner ear (vestibule) → semicircular canals filled with liquid & hair cells → affected by head movement (firing) by vestibular n. → responsible for sense of balance.
② input from deep cerebellar nucleus (fastigial nuclei)
position + gravity.
* descends uncrossed through ant. white column.
* func. → similar to pontine reticulospinal tract.

④ tectospinal tracts: exists in post. aspect of midbrain (2 sup. + 2 inf. colliculi)
* mainly crossed. * descends in Ant. white column close to ant. median fissure.
* Function: reflex movement of head & neck in response to visual stimuli (visiospinal reflex)
* because head & neck area are supplied by upper cervical segments, the majority of fibers of this tract terminate in ant. gray column of upper cervical segment of spinal cord.

lec. 6

" Blood supply of spinal cord & lesions "

Features	Upper motor neuron lesions (UMN)	Lower motor neuron lesions (LMN)
	UMN starts from motor cortex to the cranial nerve nuclei in brain and anterior horn cells in spinal cord	LMN is the motor pathway from anterior horn cell (or Cranial nerve nucleus) via peripheral nerve to the motor end plate
Bulk of muscles	No wasting	Wasting of the affected muscles (atrophy)
Tone of muscles	Tone increases (Hypertonia)	Tone decreases (Hypotonia)
Power of muscles	Paralysis affects movements of group of muscles Spastic/ clasp knife	Individual muscles is paralyzed Flaccid (flaccid paralysis)
Reflexes	Exaggerated (Hyperreflexia)	diminished or absent (Hyporeflexia)
Fasciculation	Absent	Present
Babinski sign	Present	Absent
Clasp-knife reaction	Present	Absent
Clonus	Present	Absent

فتة رجفة العين (alternating contraction & relaxation).

* notes about this table:

* cut/ damage in UMN → exaggerated reflexes because cortex effect on reflexes is inhibitory.

* muscle tone: partial state of contraction in a muscle & it is important in maintaing gesture.

* hyperreflexia + hypertonia → result of increased gamma motor neuron activity.

* clasp knife reaction: when muscle is flexed & you try to extend it, there will be initial resistance, but at certain point/ angle there will be sudden relase & arm will extend rapidly.

explanation of why this happens:

① initial resistance (exaggerated stretch reflex): muscle resists stretching, so when you stretch it it responds by contracting. & because UMN lesions cause exaggerated reflexes the effect is bigger.

② sudden relase (activation of golgi tendon reflex): anti-stretch reflex. → resists excessive contraction of muscle.

* after applying pressure, ↑tension of muscle, will be enought to activate golgi tendon organs. which will cause relaxation.

* ex. contraction in quadriceps → ↑tension in its tendon → firing in golgi tendon organ (sensory receptor organs) → activation of inter neurons in spinal cord.

→ 1st interneuron is inhibitory → reflex is poly synaptic. inhibits LMN & stop it from further contraction.

→ 2nd interneuron is excitatory → activates LMN that is going to antagonist muscle. (Hamstring in this example)

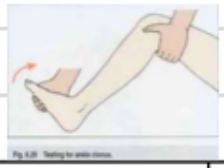
law of reciprocal innervation (one muscle contracted, agonist ↑ is relaxed)

* babinski's sign: present in UMN lesion & not LMN.

* when stimulating sole of foot (laterally mostly) with a blunt object → normally → flexion of toes. → babinski → fanning of toes + dorsiflexion of hallux.

* in babinski, the part of tracts affected is pyramidal rather than both as nuclear or extra pyramidal.

* this sign happens in 1-1.5 years old babies normally, because full development & mylination of pyramidal tracts happens after the age 1-1.5 years, once baby moves on 2 limbs instead of 4.



* clonus (UMN lesion): when dorsiflex foot, we will face resistance, & when we apply enough force → clonus happens: rhythmic contractions & relaxations of muscles, when they are subjected to sudden sustained stretch caused by exaggerated reflexes.

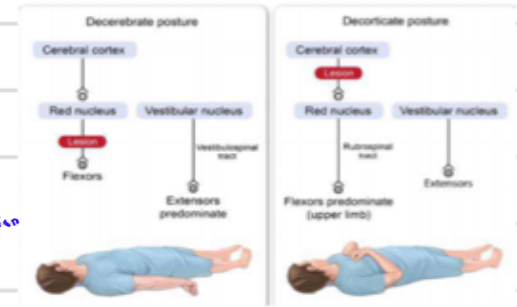
* red nucleus exists at same level of sup. colliculus in midbrain & from it descends rubrospinal tract which is part of lateral motor system.

* decerebrate (→ below red nucleus) & decorticate (→ above red nucleus) rigidity: * UMN lesion.

difference: level of lesion

more fatal because lesion is close to vital systems (respiratory * CVS) in medulla oblongata & pons.

- rigidity in entire body & upper & lower limbs extended.
- rigidity in entire body but lower limbs extended, upper " flexed.



* decorticate → remove cortex which has inhibitory effect on tonically active pontine reticulospinal tract which is responsible for antigravity muscles → extension in lower limbs & flexion in upper limb.

* decerebrate → will affect rubrospinal tract which is part of lateral motor system (loss of flexion in upper limbs → extension in upper limbs + lower limbs.

* clinical significance of lamination of the ascending tracts:

* any external pressure exerted on spinal cord in region of spinothalamic tract → loss of pain + temp. sensation in sacral dermatome.

* if pressure increases → other higher dermatomes will be affected.

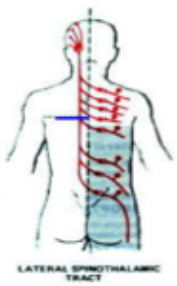
* in spinothalamic tracts: cervical (medial) → sacral (lateral) segments are located medial → lateral.

* intramedullary tumor: affect cervical fibers (medial), extramedullary tumor: affect lower limbs fibers (lateral)

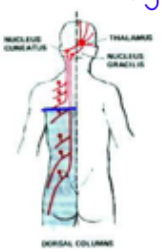
* sacral sparing: occur at intramedullary tumor.

clinical application

① destruction of LSTT (lateral spinothalamic tracts)
→ loss of pain & temp. sensation on contralateral side below lvl of lesion
→ due to decussation which happens on lvl of spinal cord

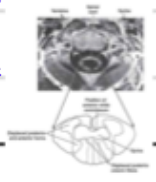


② destruction of post. column (fasciculus gracilis & cuneatus)
→ loss of muscle-joint sense, position sense, vibration sense, & tactile discrimination ipsilaterally below lvl of lesion.
(due to decussation happens above lvl of medulla oblongata, so damage happened before crossing over)



③ syringomyelia
→ cavitation in central canal of spinal cord due to any reason (site of canal) & it will damage fibers crossing in ant. white commissure in both directions.
→ loss of of pain & temp. sensation of both sides.

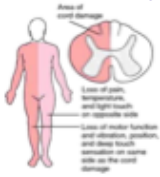
* if syringomyelia extends to involve ant. ventral horn.
- one side → weakness & paralysis of muscles on that side
- both horns → weakness & paralysis of muscles on both sides.



→ cavitation at lvl of C4-C5
→ loss of pain & temp. sensation from shoulders to lvl of nipples.

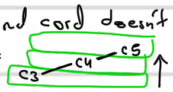
④ Brown-Séquard syndrome
→ functional hemisection of spinal cord (damage to half of spinal cord)
→ damage to corticospinal tract, ALS, post. columns.

- ipsilateral → loss of discriminative tactile, vibratory, position sense below lvl of lesion
- contralateral → paralysis or weakness (hemiparesis, hemiplegia); loss of pain + temp. sensation below lesion.



* it's extremely rare that lesion affect sensory portion only in spinal cord.

* crossing of fibers in spinal cord doesn't happen horizontally instead:



* Arterial blood supply of brain:

* brain is supplied by: ① pairs of internal carotid A. ② vertebral A.
  - ① enters skull through carotid canal (petrous part of temporal bone)
  - ② Enters skull through foramen magnum (in occipital bone).
  - their branches anastomose at inf. surface of brain to form circle of willis.

* in subarachnoid space lies (4) arteries.

* (2) vertebral A. will unite to form basillar A.
  - gives post. cerebral A.
  - recieve post. communicating A.

* Arterial blood supply of spinal cord:

① longitudinal A.
- one ant. spinal A.
  - * arises from vertebral A.
  - * runs in ant. median fissure.
- two post. spinal A.
  - * arises from post. inf. cerebellar A. / branch from vertebral A.
  - * runs in posterolateral sulcus.

② segmental (horizontal) spinal A.
- * enters intervertebral foramen
- * arises in
  - neck: vertebral A. + deep cervical A.
  - thorax: post. intercostal A.
  - abdomen: lumbar A.
- * every segmental A. gives 3 branches
  - post. radical A. → runs with post. (dorsal) root to reach spinal cord
  - ant. radical A. → runs with ant. (ventral) root to reach spinal cord.
  - segmental medullary A. → anastomose with ant. spinal A.

③ Artery of adamkiewicz.
- * usually of left side, from left post. intercostal A. at level of 9th → 12th intercostal A. which branches from aorta & supplies lower 2/3 of spinal cord.
- * reinforce arterial blood supply to lower portion of spinal cord (far from circle of willis)
- * anastomose with Ant. spinal A.

* blood supply of spinal cord (at lvl of segments):

* terminal branches of spinal medullary A. join to form → arterial vasocorona.

- Post. spinal A. ⊕ arterial vasocorona
  - supply post. columns & peripheral parts of ant. + lateral funiculi
- Ant. spinal A.
  - supply most of gray matter & adjacent parts of white matter

* venous drainage of spinal cord:

① 2 pairs of pairs on each side.
② one midline channel passes along post. median sulcus (post. spinal v.)
③ one midline channel that parallels ant. median fissure. (Ant. spinal v.)

extensive internal vertebral plexus in extradural (epidural) space of vertebral canal. → drain into
- segmentally arranged vessels that connect with major systemic veins ← drain into
  - azygos system in thorax
  - intracranial vein.

* central cord syndrome:

occlusion in blood supply of ant. spinal A. happens in case of neck hyperextension.
- bilateral weakness in extremities (mostly upper) → ant. spinal A supplies rt & lt.
- bilateral pain & temp sensation loss → lower extremities supplied by another A. (Artery of adamkiewicz)
- bladder dysfunction.

* compromise of blood flow in post. spinal A.:

ipsilateral loss/reduction → discriminitive, vibratory tactile, positional sensation at & below segmental lvl of injury.