

Topic 6 (Part B): ANATOMY OF THE NERVOUS SYSTEM

Chapter 12: pp. 466-476, 460-463

Chapter 13: pp. 493-513

The Spinal Cord

- from foramen magnum to 1st/2nd lumbar vertebra; below this is ideal spot for **lumbar puncture** (to insert spinal anesthetic or extract spinal fluid)
 - (i) 2-way conduction/traffic system
 - (ii) major reflex centre
 - (iii) initiates complex patterns of motor activity
 - 31 pairs of **spinal nerves** enter and exit via intervertebral foramina
- **cervical & lumbar enlargements** for communication between upper and lower limbs (more communicating pathways)
- spinal cord held in place by:
 - (i) **denticulate ligaments**: pia mater shelving
 - (ii) **filum terminale**: pia mater-covered conus extension

What is the cauda equina?

refers to spinal nerves past conus medullaris, means 'horse's tail' because the nerves do resemble a horse's tail

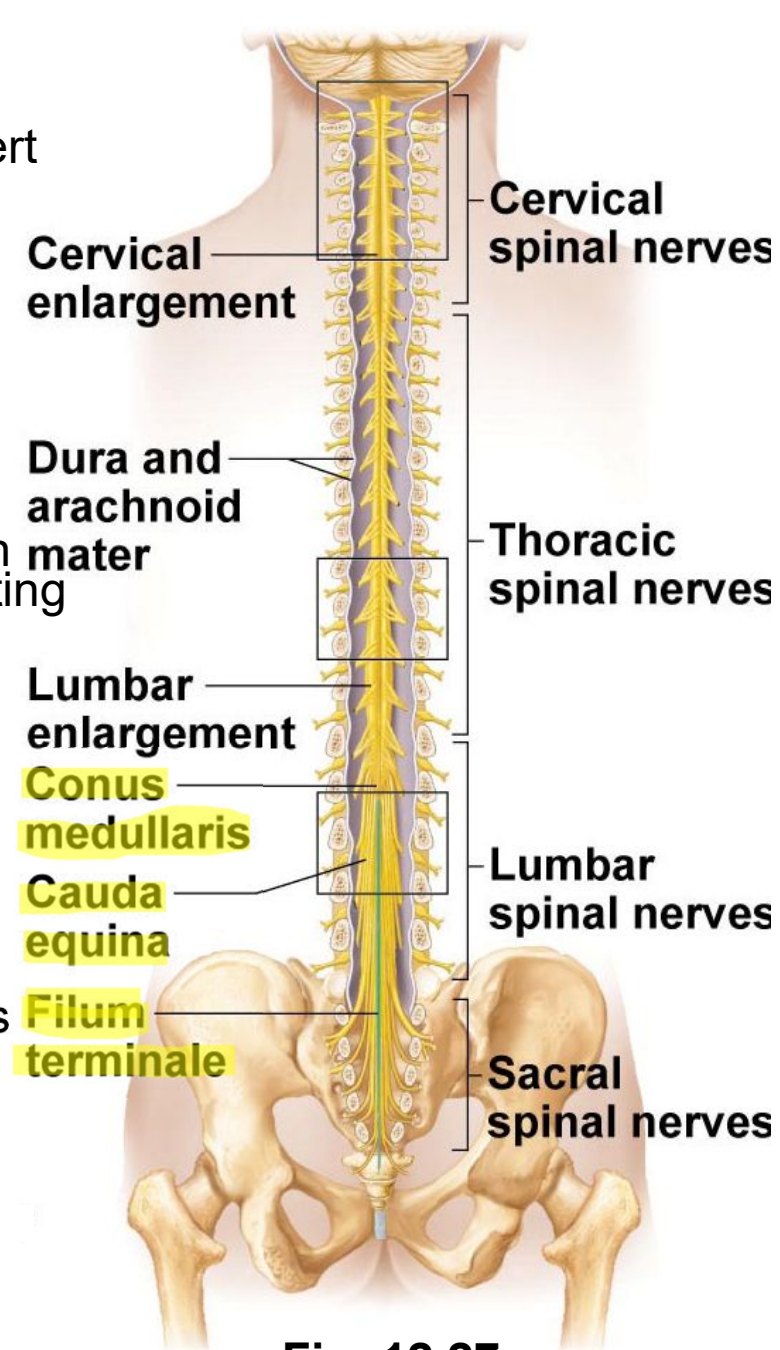
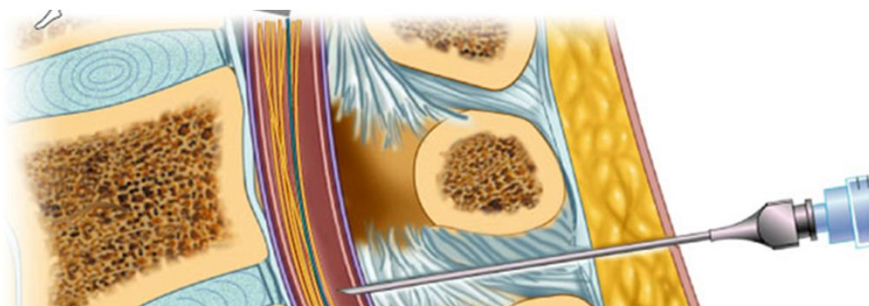
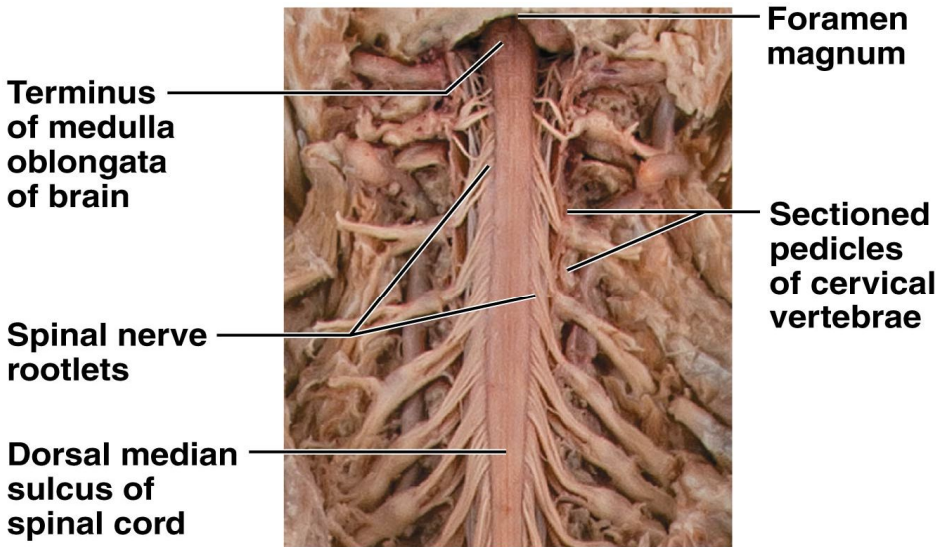


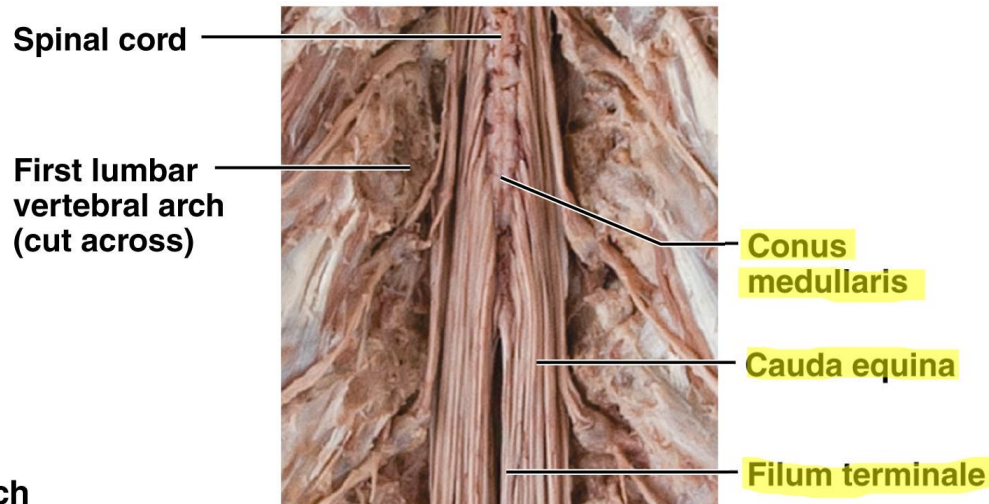
Fig. 12.27



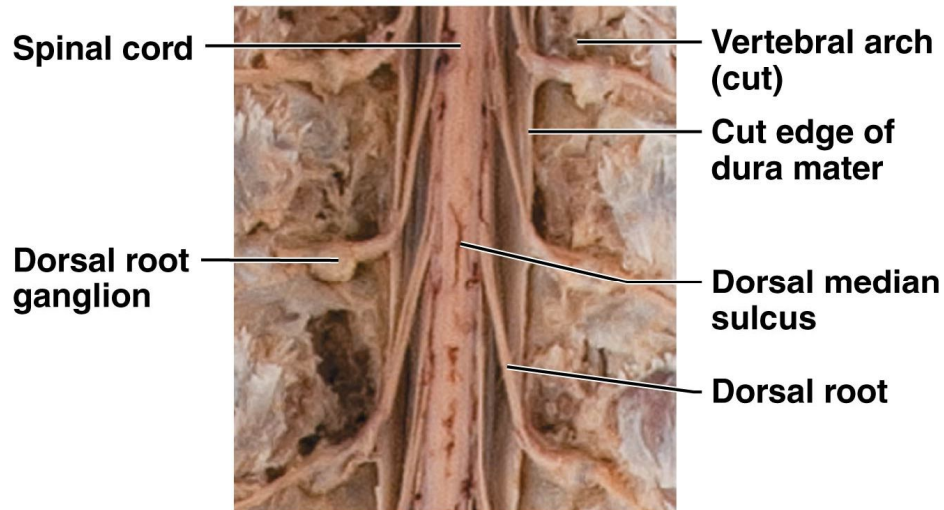


(b) Cervical spinal cord.

Fig. 12.27 b-d



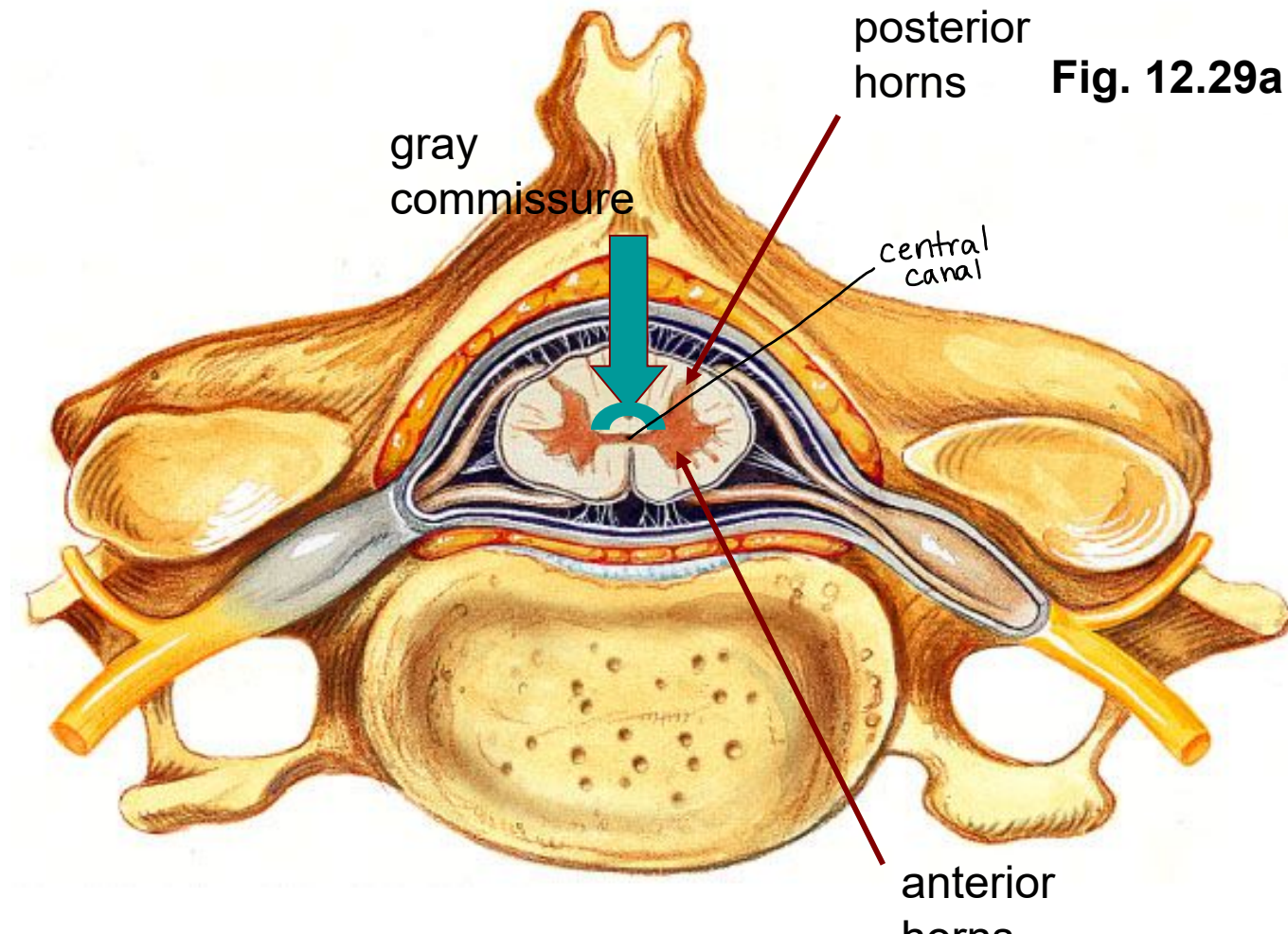
(d) Inferior end of spinal cord, showing conus medullaris, cauda equina, and filum terminale.



(c) Thoracic spinal cord.

Gray Matter & Spinal Roots

- gray matter as for other regions of CNS – but all neurons multipolar
- organized like butterfly wings: paired anterior (ventral) & posterior (dorsal) horns connected by gray commissure (*where is the central canal?*)
- small lateral horns associated with thoracic & superior lumbar regions of cord



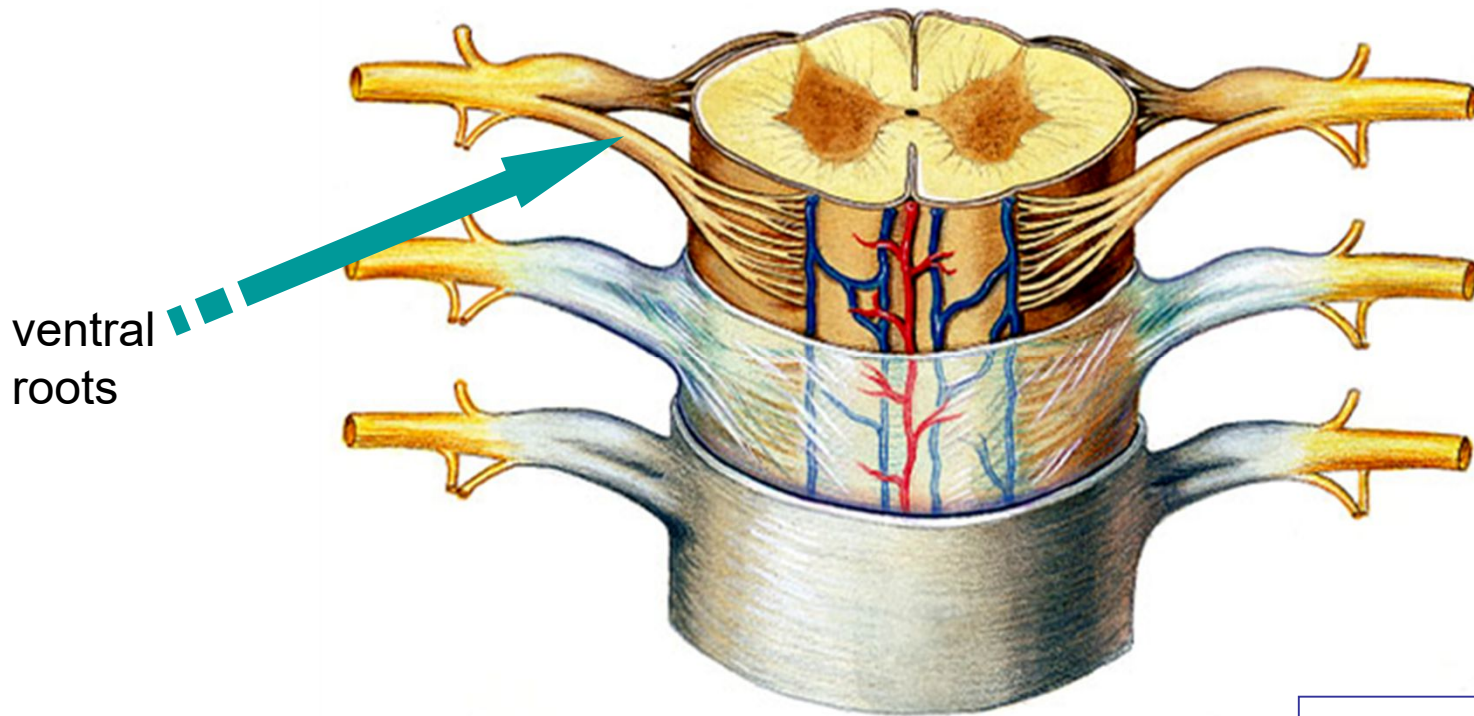


Fig. 12.29b

Anterior horns:

- nerve cell bodies of **somatic motor neurons** – axons **exit** via **ventral roots**
- largest at levels of cervical & lumbar enlargements – *because a lot more communication required between upper and lower limbs*

Lateral horns:

- **autonomic motor neurons** to visceral organs; also **exit** via **ventral roots**

spinal
nerve (2
way
traffic)

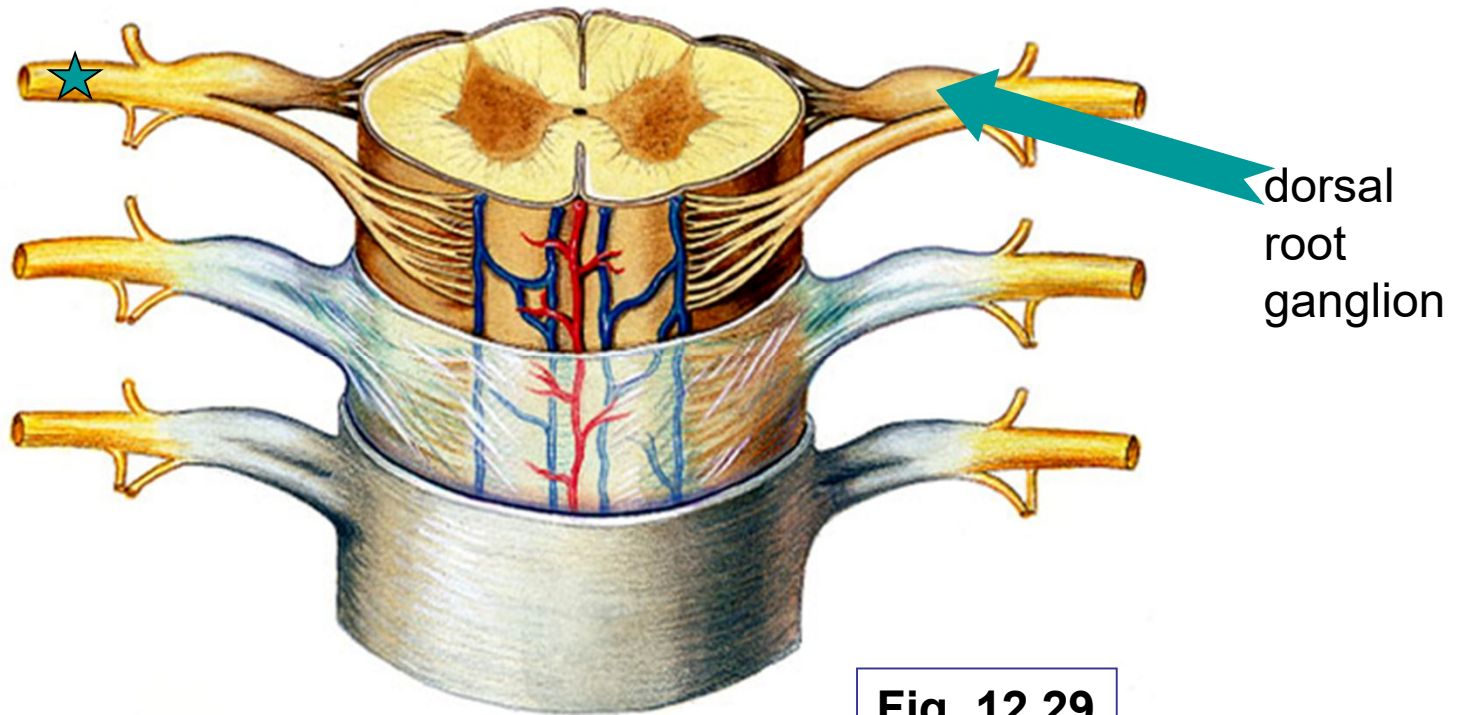


Fig. 12.29

Dorsal root ganglion:

- afferent fibers from peripheral **sensory** receptors form dorsal roots; dorsal root ganglia house cell bodies of associated sensory neurons – their axons **enter** cord to:
 - (i) travel to higher cord/brain centres
 - (ii) synapse with interneurons in posterior horns at level they enter
 - spinal nerve = fused dorsal & ventral roots
- poliomyelitis -> paralysis, losing ability to move ie. issue with outgoing signals*

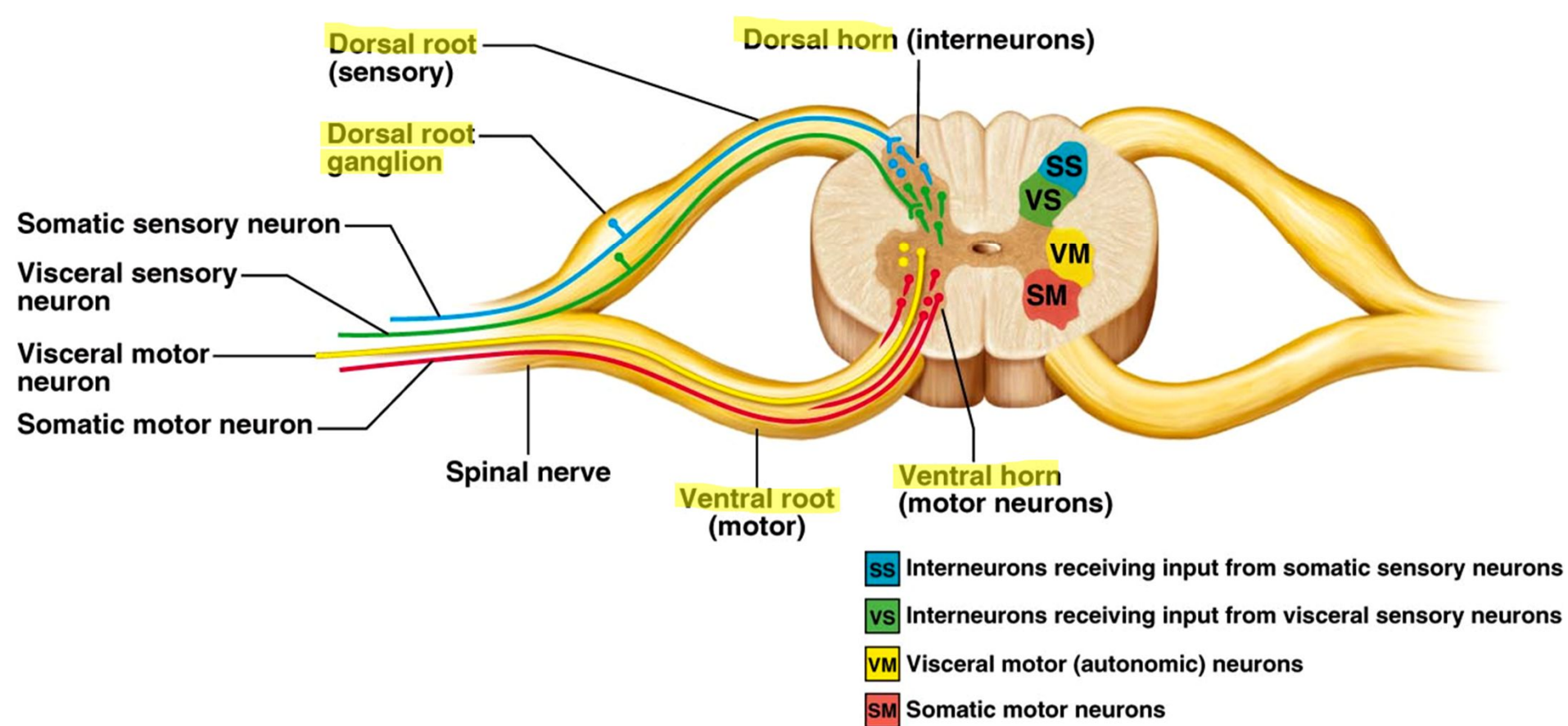


Fig. 12.30: Organization of the Gray Matter of the Spinal Cord

NB: the dorsal and ventral roots are part of the PNS, not the CNS!

Ascending tracts

Dorsal white column

- Fasciculus gracilis
- Fasciculus cuneatus

Spinocerebellar tracts

- Dorsal
- Ventral

Spinothalamic tracts

- Lateral
- Ventral

Descending tracts

Corticospinal tracts (pyramidal tracts)

- Lateral
- Ventral

Rubrospinal tract

Reticulospinal tracts

- Medial
- Lateral

Vestibulospinal tract

Tectospinal tract

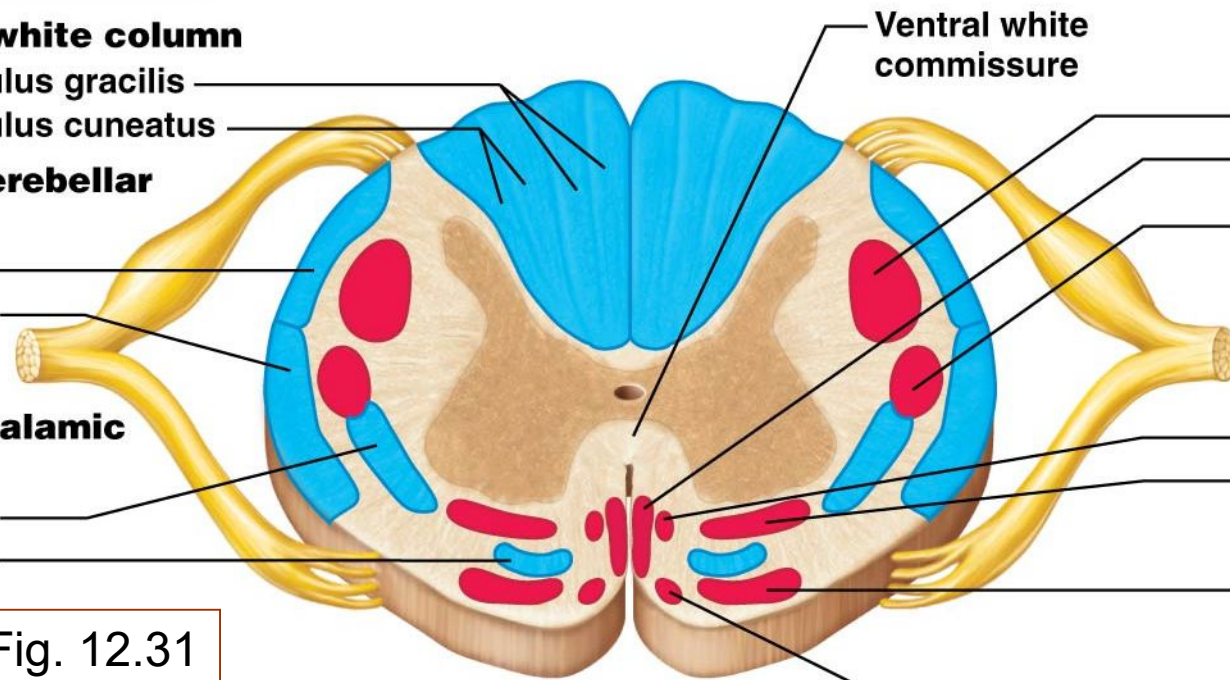


Fig. 12.31

White Matter

- myelinated & unmyelinated fibers – communication between different parts of cord & between cord & brain
- ascending, descending & transverse (commissural) tracts – direction of fibers

Some general properties of spinal tracts:

- (i) Most pathways cross over from one side of CNS to other (decussate)
- (ii) Most consist of a chain of 2 or 3 neurons
- (iii) Most exhibit : **somatotopy** ('mapping' (make sure nerves go to right places)
- (iv) All pathways & tracts are paired

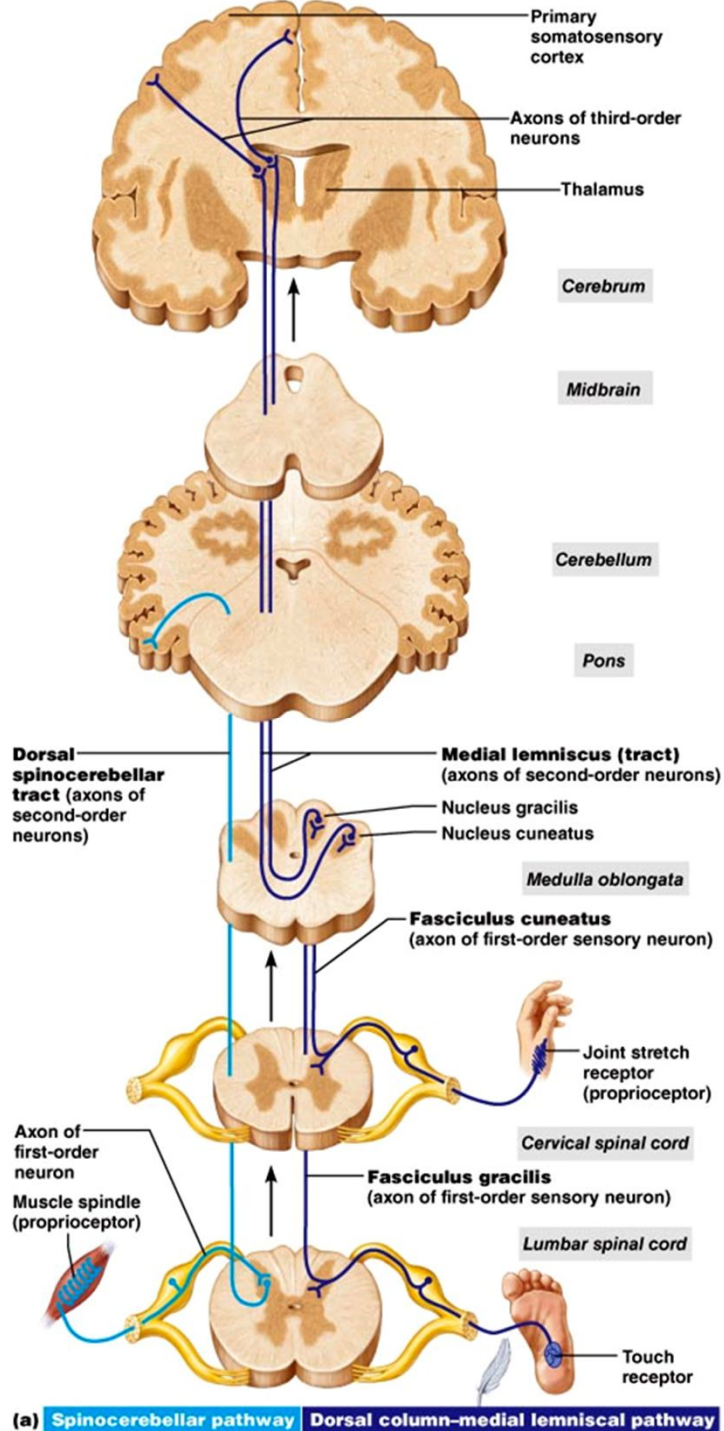
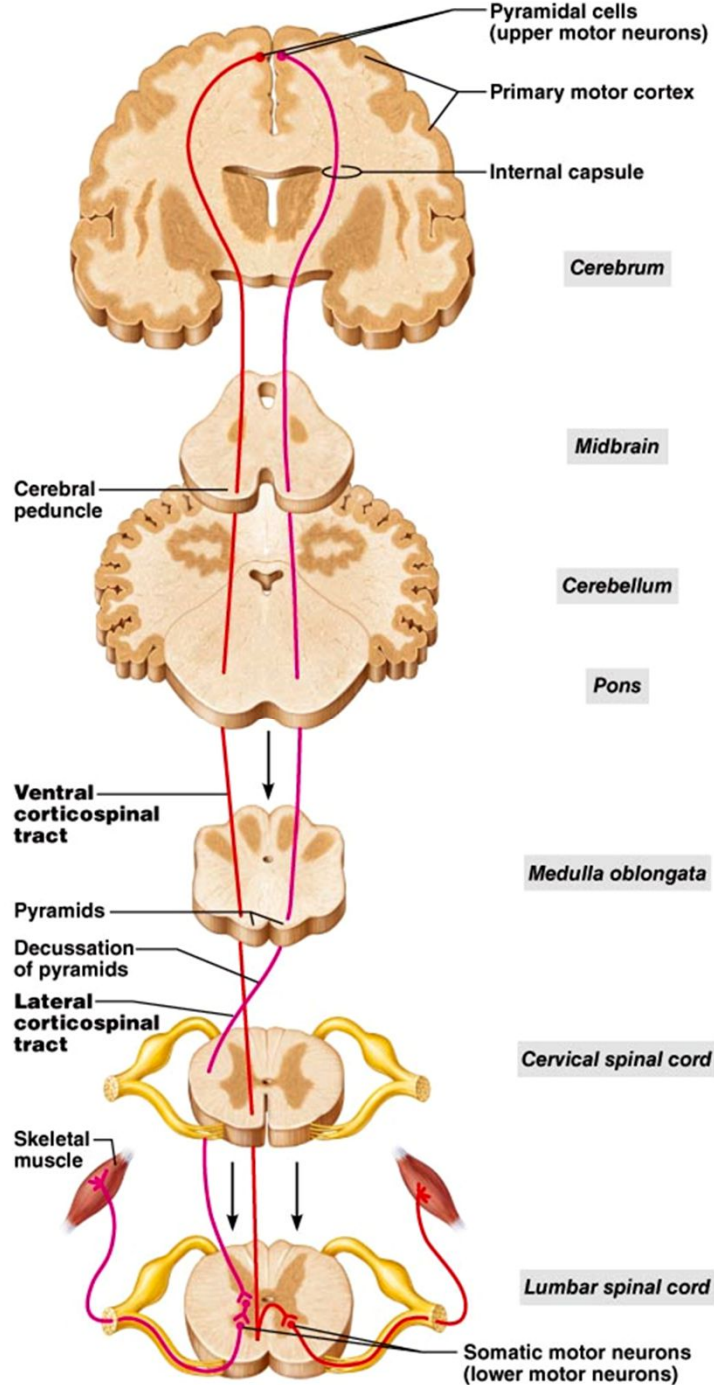


Fig. 12.32a – sample pathway for discriminative touch and conscious proprioception



(a) Pyramidal (lateral and ventral corticospinal) pathways

Fig. 12.33a: Direct pyramidal descending tract to skeletal muscle

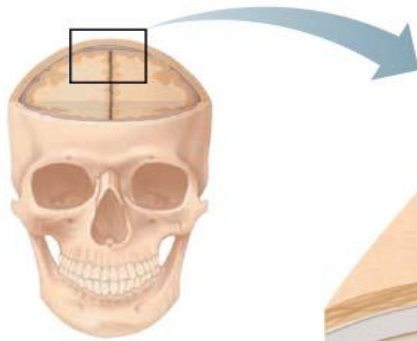
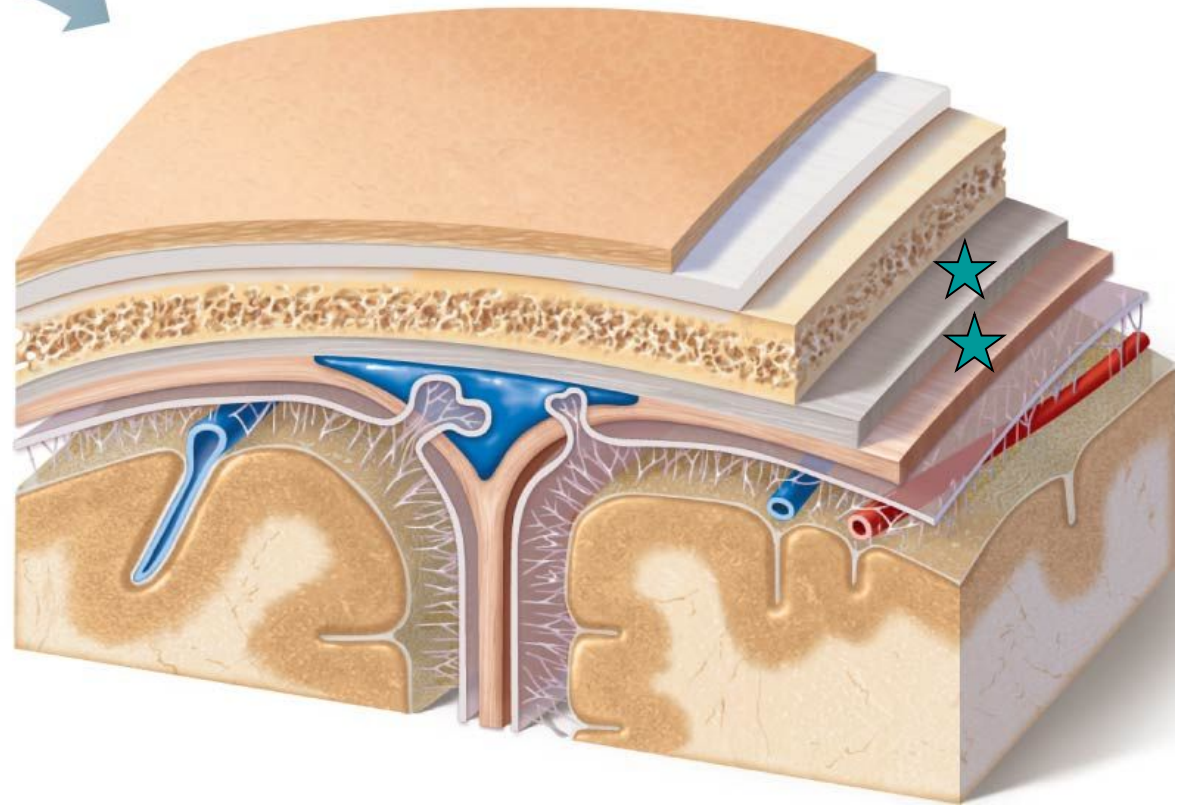


Fig. 12.22



Protection of the CNS

- (i) Bones
- (ii) Meninges
- (iii) Cerebrospinal fluid
- (iv) Blood-brain barrier

Meninges (meninx)

- 3 CT membranes that:
 - (a) cover & protect CNS
 - (b) protect blood vessels & enclose venous sinuses
 - (c) contain cerebrospinal fluid
 - (d) form partitions within skull

Dura mater:

- tough; 2 layers around **brain**: outer **periosteal** layer & inner **meningeal** layer
- **spinal cord** has **only** meningeal layer
- around brain, 2 layers fused except where enclose **dural sinuses**
- **dural septa** to partition and anchor: **falx cerebri**, **falx cerebelli**, **tentorium cerebelli**

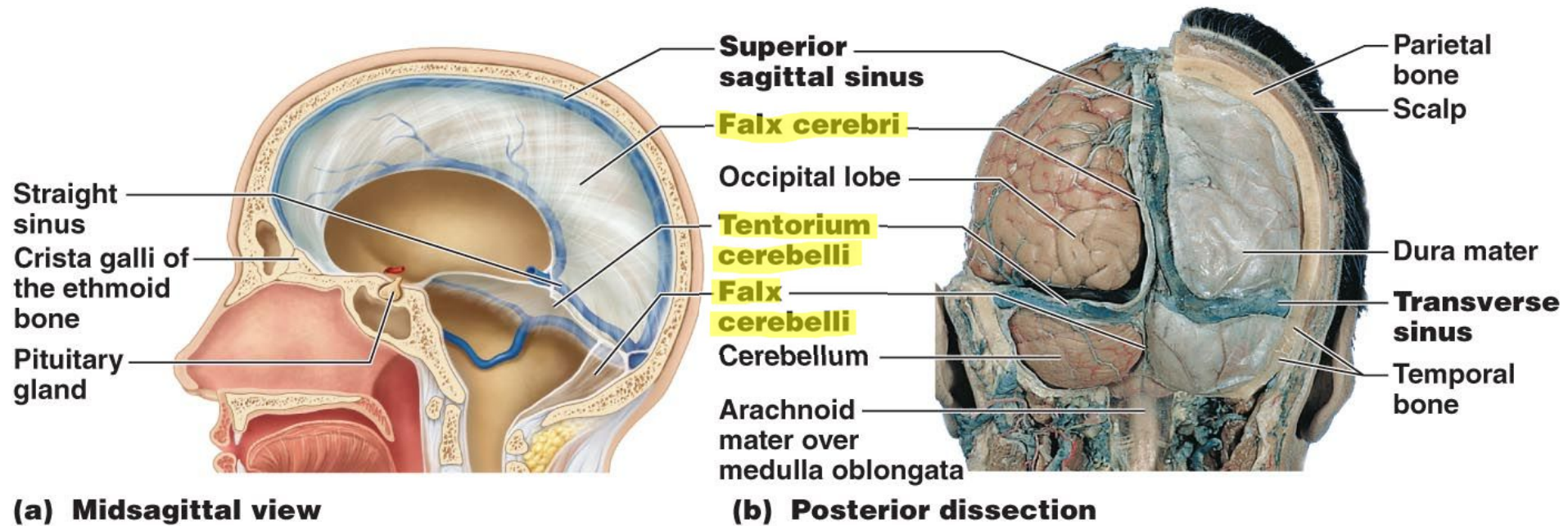
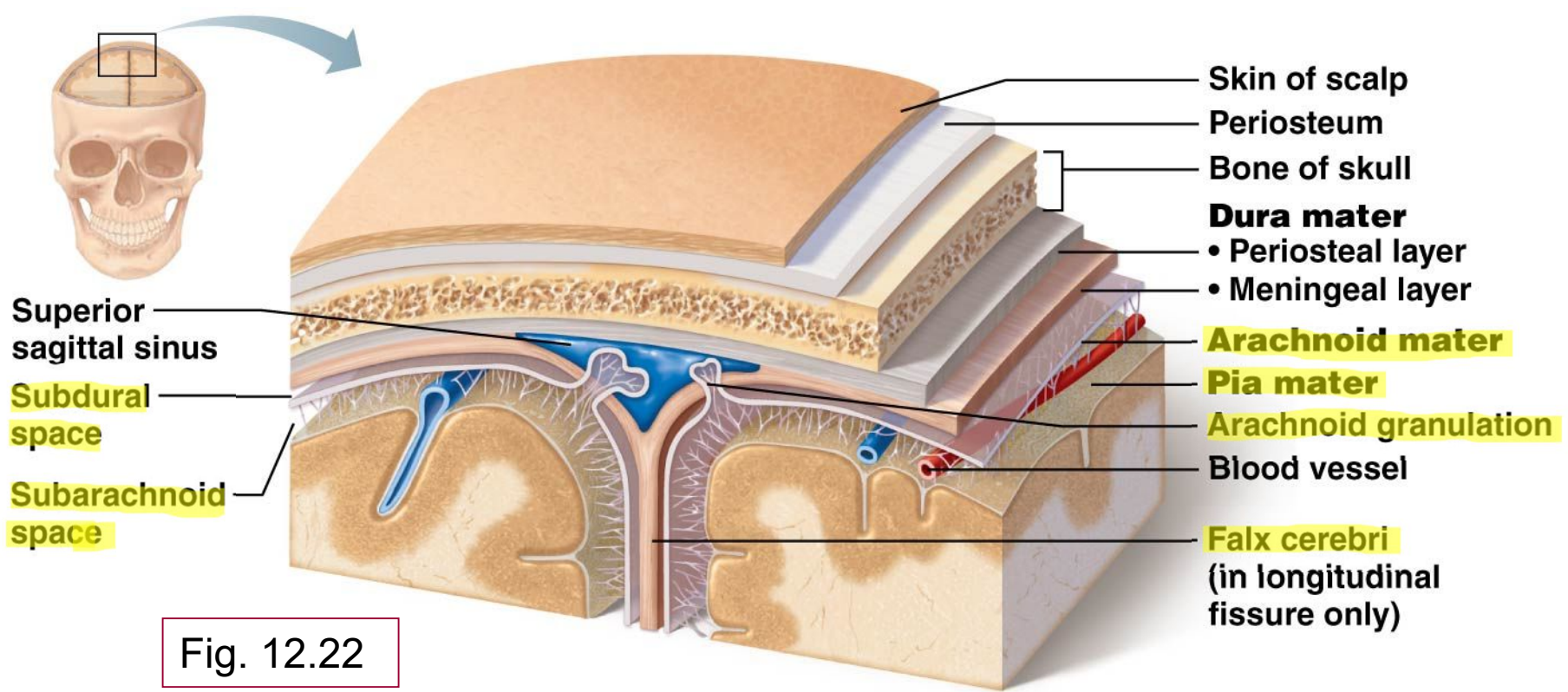


Fig. 12.23: Dural septa and dural venous sinuses



Arachnoid mater:

- loose covering separated from dura mater by **subdural space**
- **subarachnoid space** between arachnoid mater & pia mater – filled with CSF & contains largest blood vessels serving brain
- *role of arachnoid villi (granulations) in accumulation of CSF*

Pia mater: (see also Fig. 12.22)

- delicate CT + tiny blood vessels – clings tightly to brain, follows convolutions

What is meningitis? What is encephalitis?

meningitis → infection of meninges, encephalitis is deeper

Cerebrospinal Fluid

- liquid cushion to give buoyancy to CNS tissue; also protective, nutritive roles
- similar to plasma but less ptn, more vit C, Na^+ , Cl^- , Mg^{++} & H^+ , less Ca^{++} , K^+
- **choroid plexuses** in roof of ventricles form CSF: clusters of permeable capillaries enclosed by layer of ependymal cells (role of these cells?)

total CSF = 150 ml; replaced ~ every 8 hours; choroid plexuses also clean CSF

What is hydrocephalus?

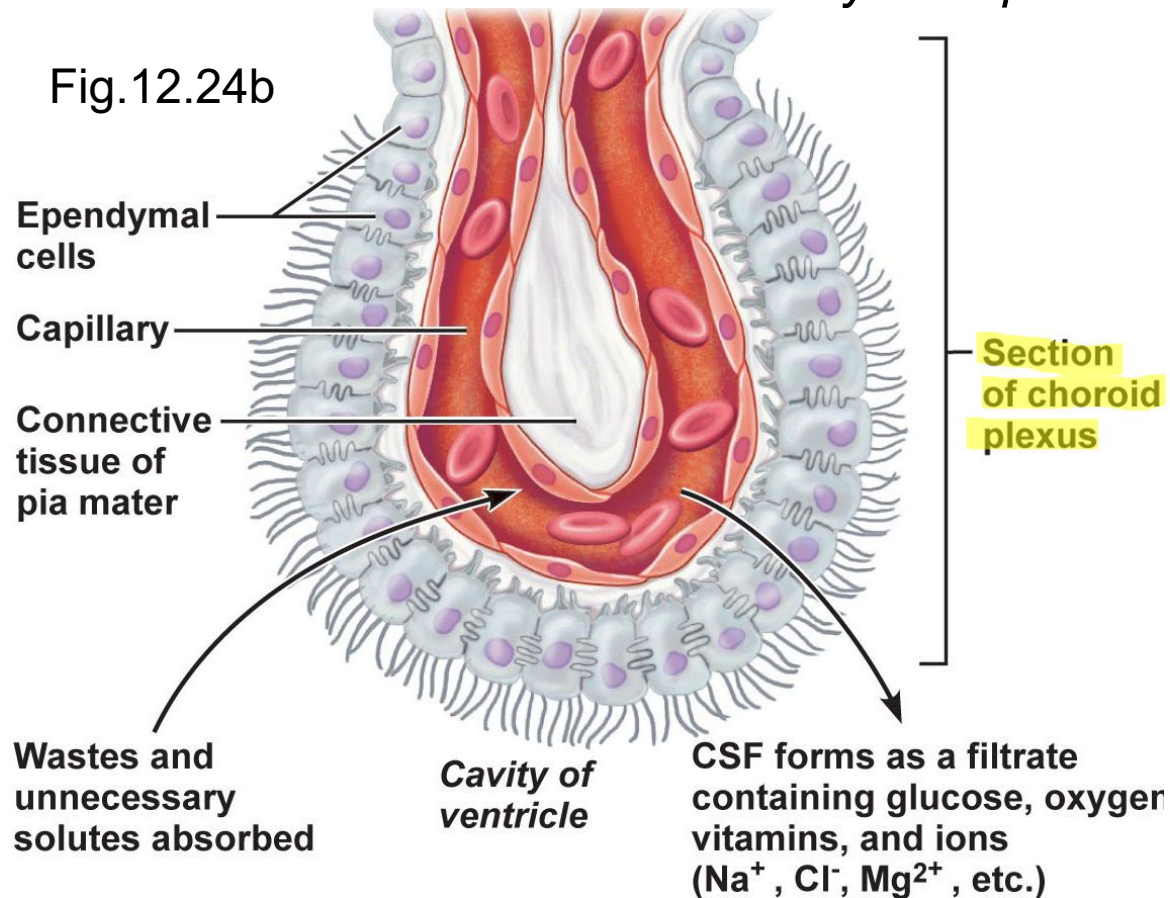


Fig. 12.25

Blood-Brain Barrier

- to control what can get into CNS from blood vessels in CNS, some hormones also act at NTs; ions can increase rate of neuronal firing
- composed of 3 layers:
 - (i) continuous epithelium of capillary wall (sealed by tight junctions)
 - (ii) thick basal lamina surrounding external face of capillary (sturdy basement membrane)
 - (iii) bulbous feet of astrocytes
- *what gets in?* glucose, essential amino acids, some electrolytes; also fats, fatty acids, oxygen, carbon dioxide, any other fat-soluble molecules
- *not completely uniform:*
 - (i) capillaries of choroid plexuses porous but ependymal cells linked by tight junctions
 - (ii) very permeable near vomiting centre, hypothalamus; incomplete in newborns

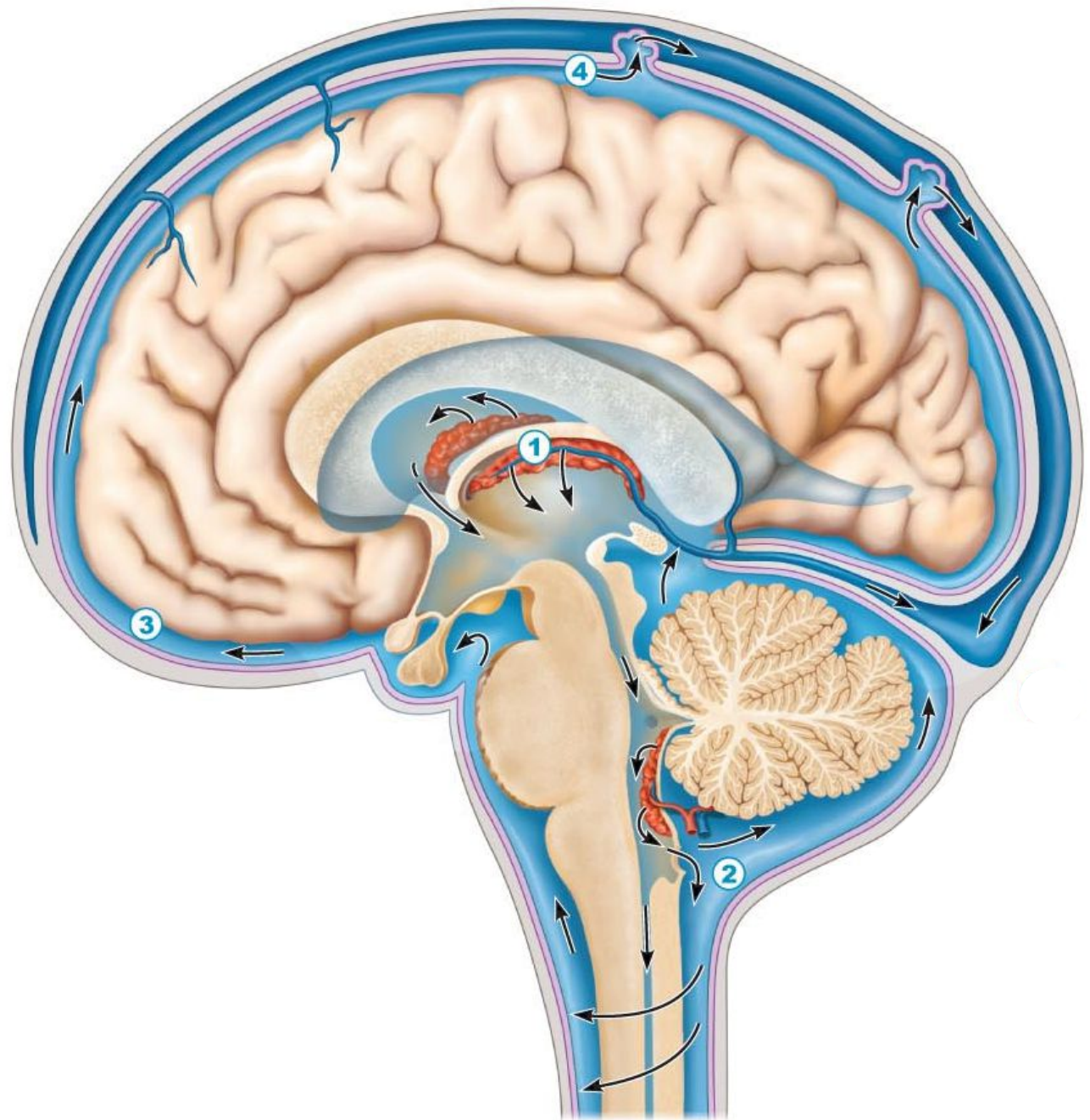


Fig. 12.24a: Formation & Circulation of Cerebrospinal Fluid

Macroscopic Anatomy of the PNS

- 12 pairs of **cranial nerves** pass through various foramina of the skull
- first two pairs attach to forebrain; rest originate from brain stem
- all except vagus nerve serve only head & neck structures
- except those for special sense organs, most cranial nerves are mixed nerves
- **“On occasion, our trusty truck acts funny – very good vehicle anyhow”**

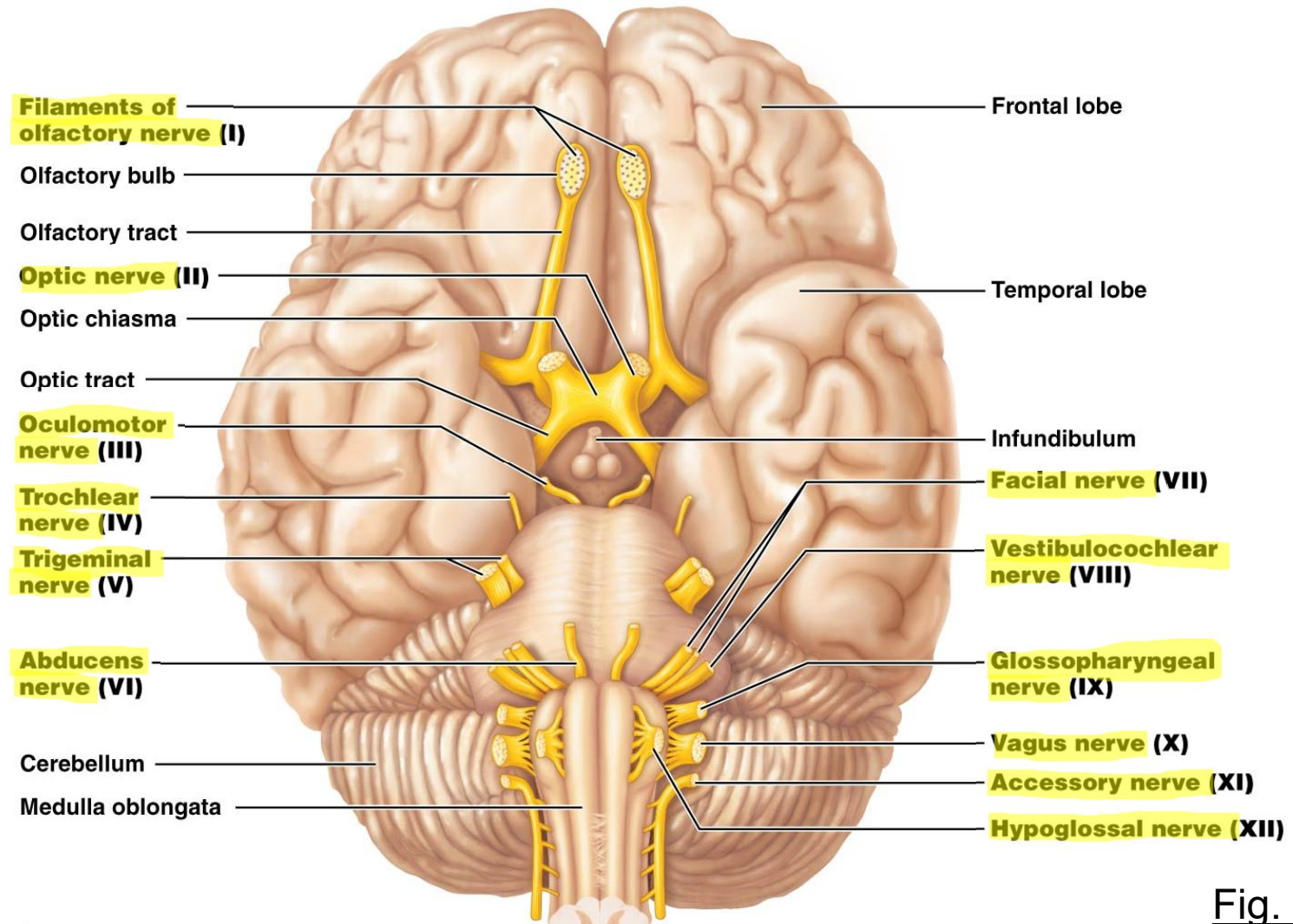


Fig. 13.6 Ventral view

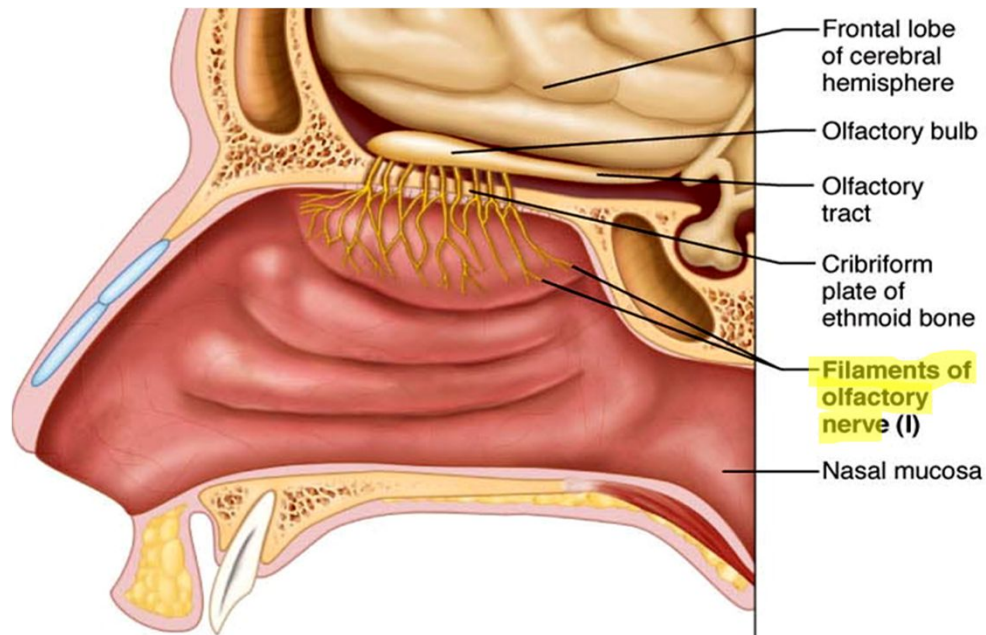
Cranial nerves I - VI	Sensory function	Motor function	PS* fibers
I Olfactory	Yes (smell)	No	No
II Optic	Yes (vision)	No	No
III Oculomotor	No	Yes	Yes
IV Trochlear	No	Yes	No
V Trigeminal	Yes (general sensation)	Yes	No
VI Abducens	No	Yes	No

Some **s**ay **m**arry **m**oney **b**ut **m**y **b**rother **s**ays (it's) **b**ad **b**usiness (to) **m**arry **m**oney (sensory, motor, or both)

Cranial nerves VII - XII	Sensory function	Motor function	PS* fibers
VII Facial	Yes (taste)	Yes	Yes
VIII Vestibulocochlear	Yes (hearing and balance)	Minimal	No
IX Glossopharyngeal	Yes (taste)	Yes	Yes
X Vagus	Yes (taste)	Yes	Yes
XI Accessory	No	Yes	No
XII Hypoglossal	No	Yes	No

Fig. 13.6

*PS = parasympathetic



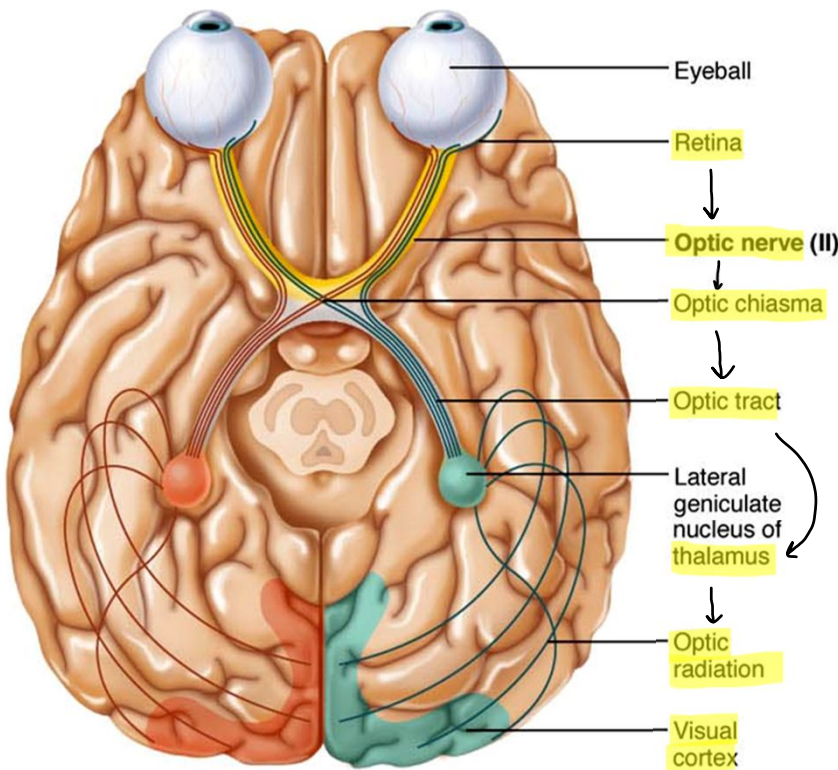
I. Olfactory Nerves:

- from nasal mucosa to olfactory bulbs
- fibers of olfactory bulb neurons extend as olfactory tract to primary olfactory cortex
- afferent sensory fibers for smell

“Some Say”

II. Optic Nerves:

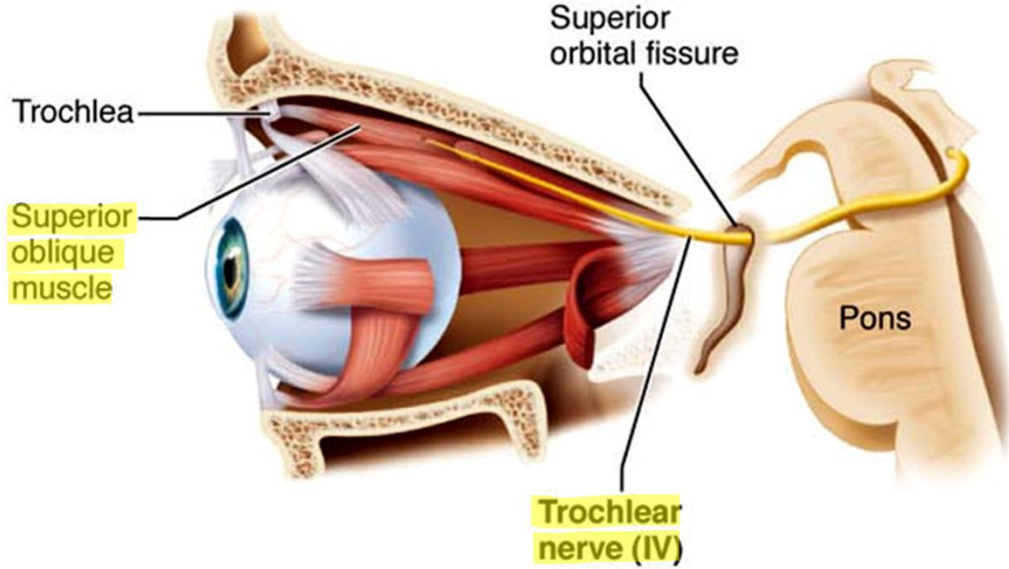
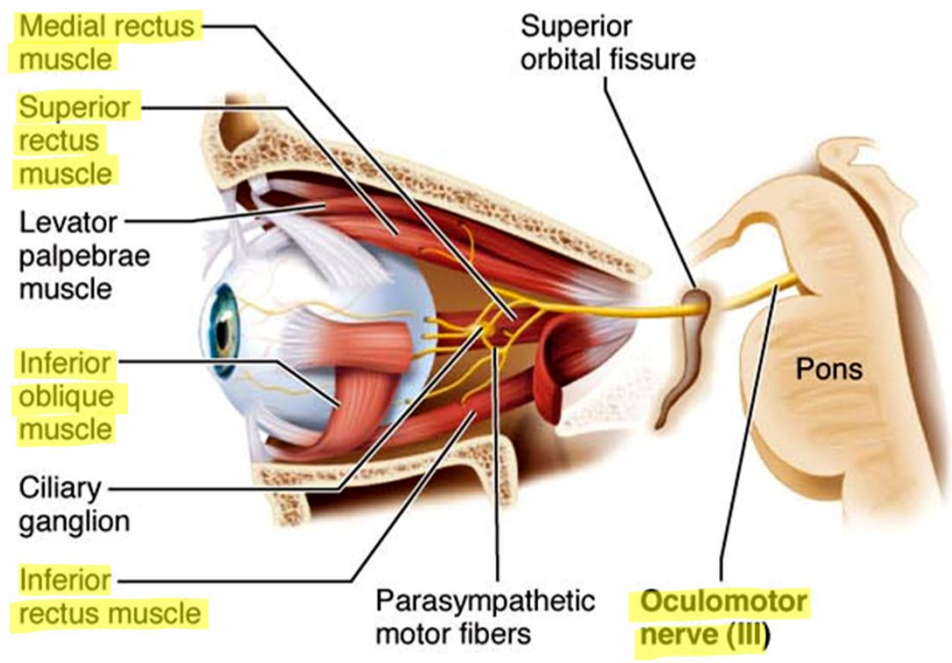
- fibers from retina form optic nerve which passes through optic foramen of orbit
- optic nerves converge to form **optic chiasma** (where some cross over) then as **optic tracts** to **thalamus**, finally as **optical radiation** to **occipital cortex**
- afferent sensory fibers for vision



III. Oculomotor Nerves:

“eye mover”; supplies 4/6 extrinsic muscles of eyeball (3 rectus, 1 oblique – know names)

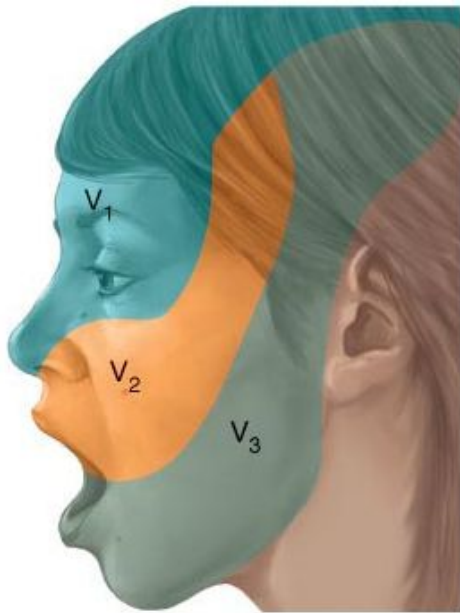
fibers from ventral midbrain (near pons) through bony orbit to eye
mixed **motor** nerves to extrinsic eye muscles, but also parasymp fibers to iris, lens & (sensory afferents from extrinsic eye muscles to midbrain)



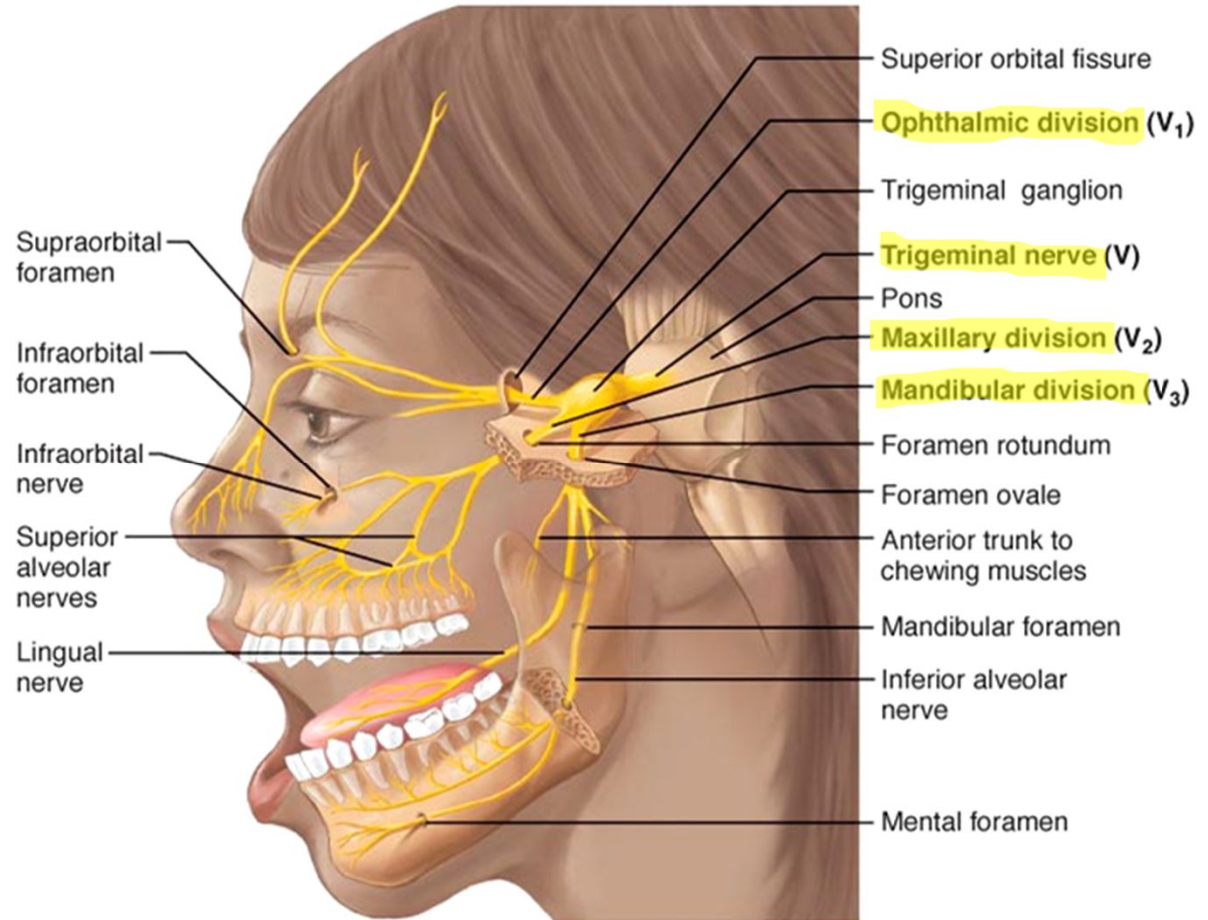
**“Marry Money”
(both motor nerves)**

IV. Trochlear Nerves (pulley):

• innervates ext eye muscle that loops through pulley-shaped ligament in orbit



(b) Distribution of sensory fibers of each division



“But” (both motor and sensory)

V. Trigeminal Nerves:

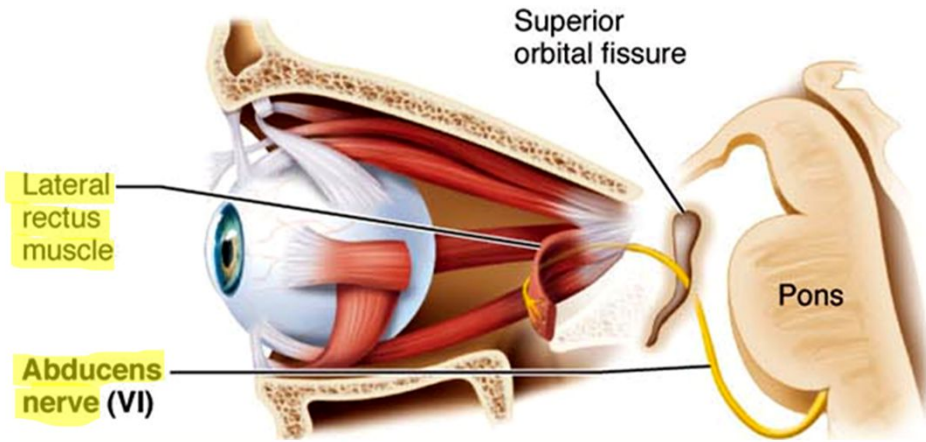
- largest of cranial nerves; 3 branches: **sensory** fibers to face & **motor** fibers for chewing (mandibular division)

Ophthalmic division

Maxillary division

Mandibular division

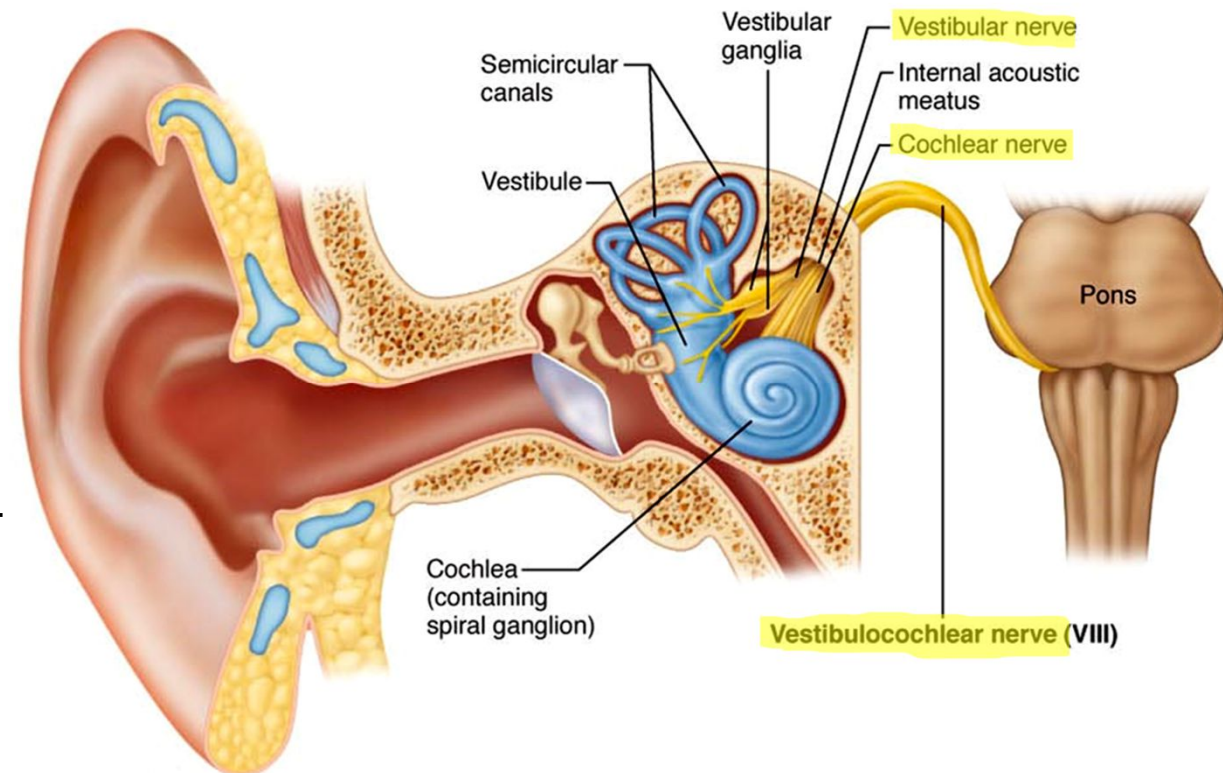
- what nerves are useful to the dentist?? -> maxillary for upper jaw, mandibular for lower jaw



VI. Abducens Nerves:

- controls extrinsic eye muscle that **abducts** eyeball
- mixed nerve; primarily **motor** to lateral rectus muscle

“My Brother **Says**”
motor, sensory



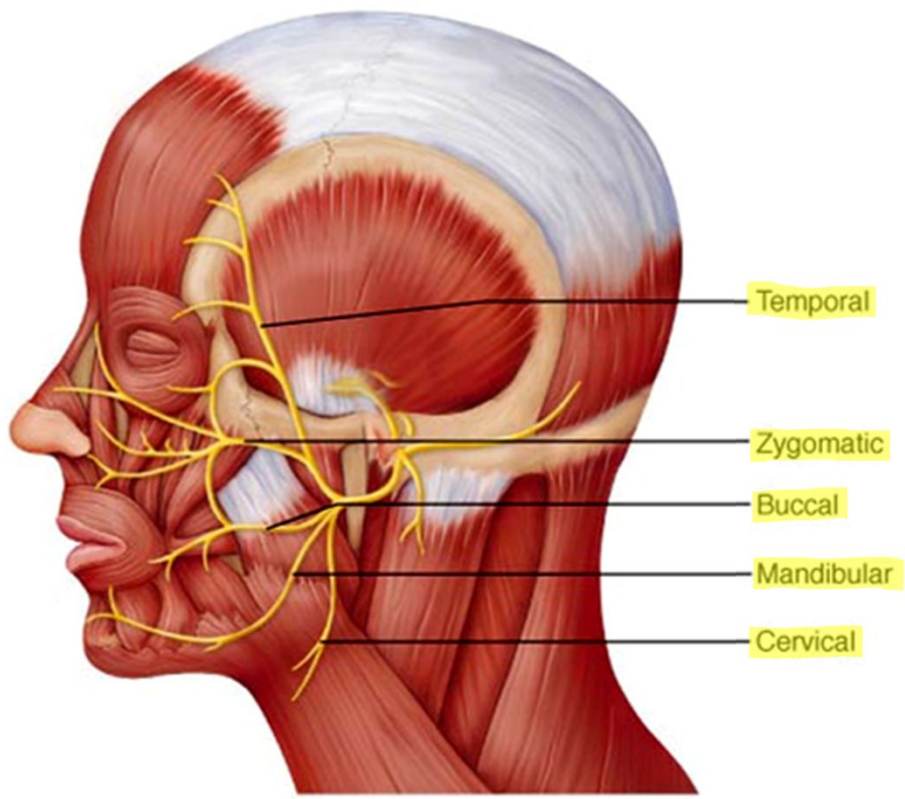
VIII. Vestibulocochlear Nerves:

- **sensory** nerve for hearing & balance
- **cochlear** (hearing) & **vestibular** (balance) branches that fuse

“Brother”
(both)

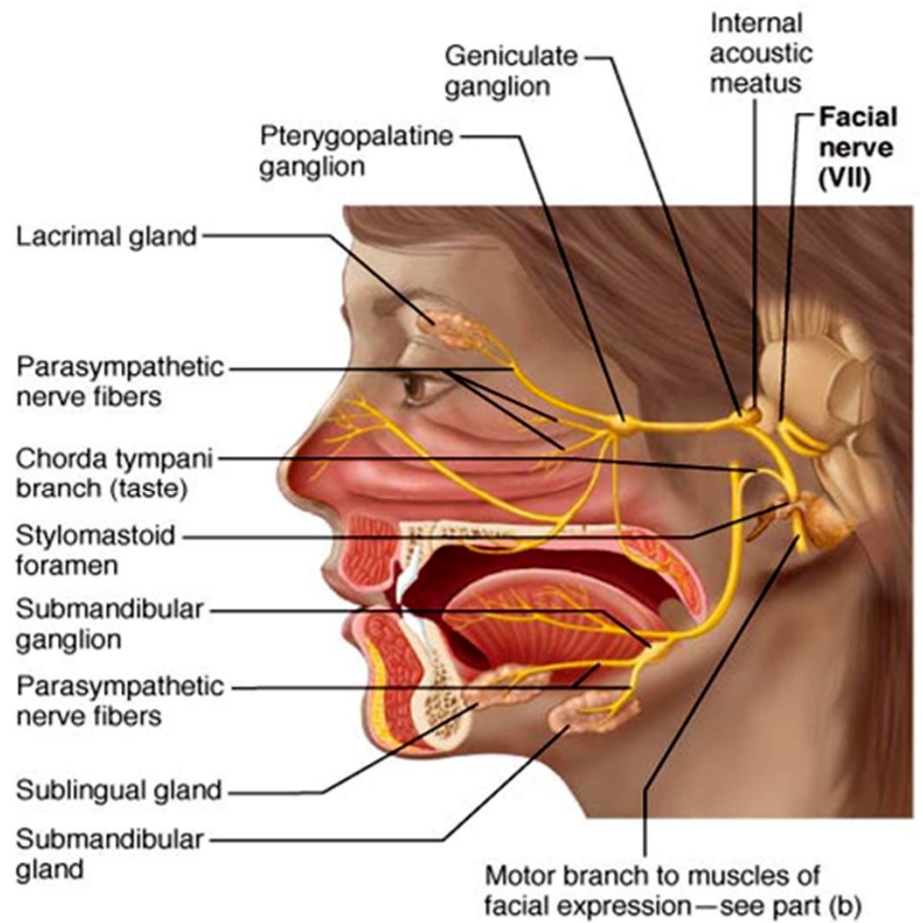
VII. Facial Nerves:

- large nerve; facial expression
- from pons to lateral face
- mixed nerve (primarily motor):



(b) Motor branches to muscles of facial expression and scalp muscles (see pp. 329–331)

also parasympathetic to lacrimal glands & sensory from anterior 2/3 of tongue (sensory and taste info)

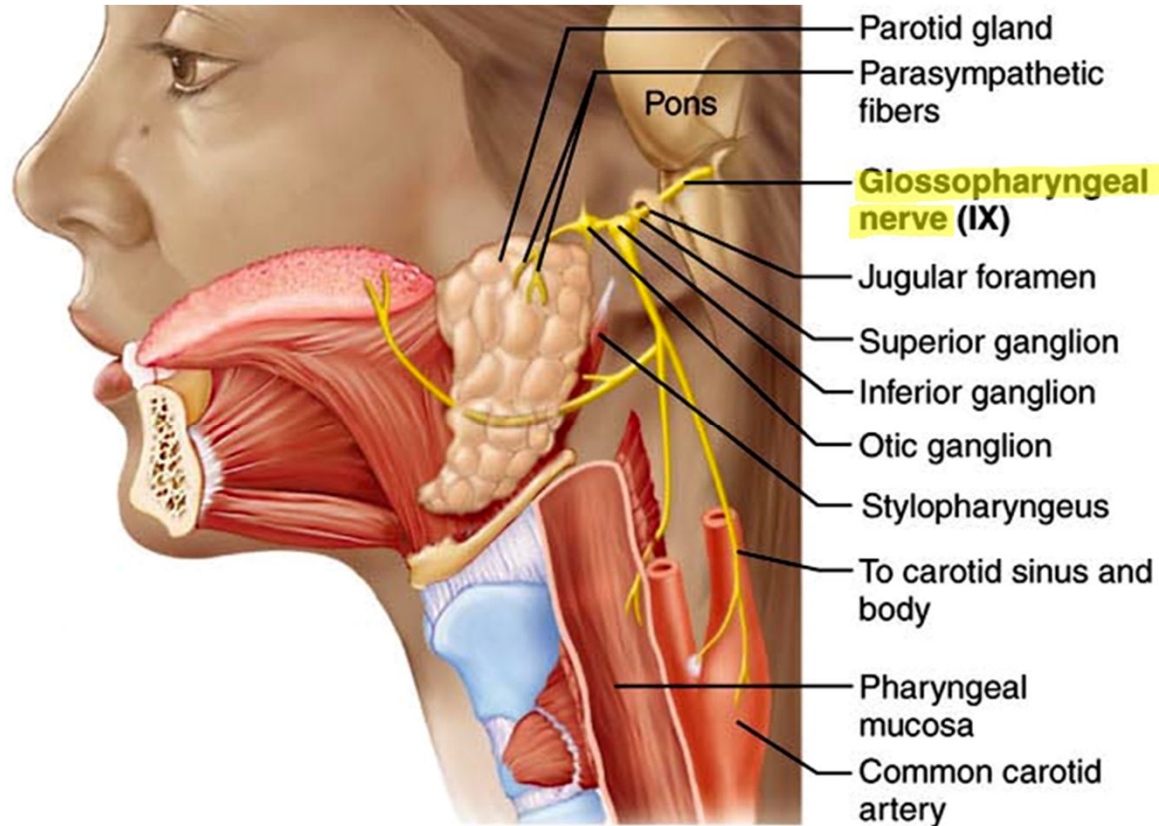


(a) Parasympathetic efferents and sensory afferents

“Bad”
(both)

IX. Glossopharyngeal Nerves (glosso=tongue)

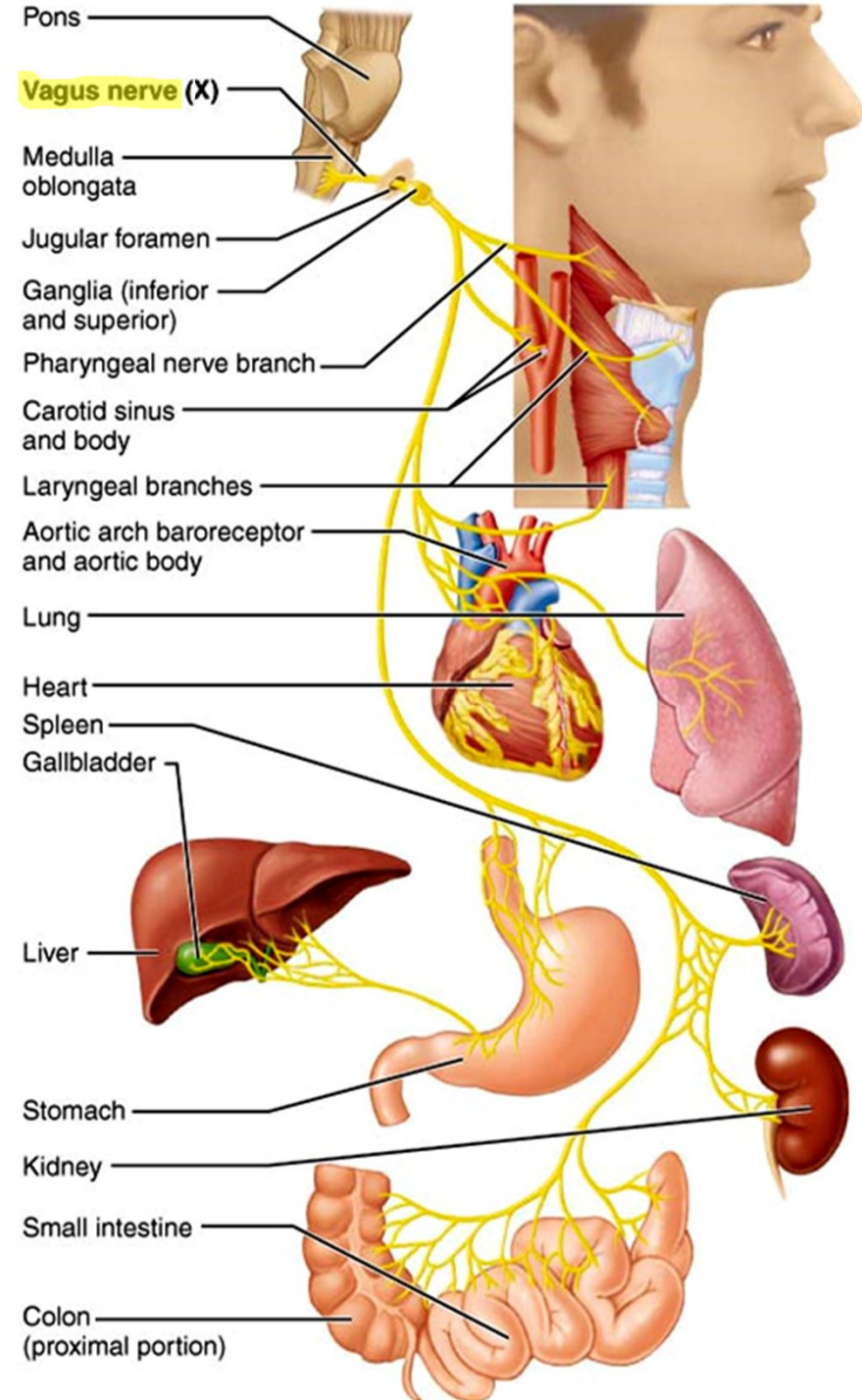
- “tongue & pharynx”; mixed nerves to & from medulla
- swallowing & gag reflex (motor); also parasympathetic fibers to parotid glands (final set of salivary glands, largest)
- sensory (taste, touch, pressure, pain) from pharynx, posterior tongue
- sensory from carotid sinus (chemo, blood pressure)



“Business” (both)

X. Vagus Nerve

- “wanderer”; only cranial nerve to extend beyond head-neck region
- mixed nerves; to & from medulla
- parasympathetic motor to heart, lungs, abdominal viscera; also somatic to pharynx & larynx
- sensory from carotid sinus; also for taste, from proprioceptors in muscles of pharynx, larynx

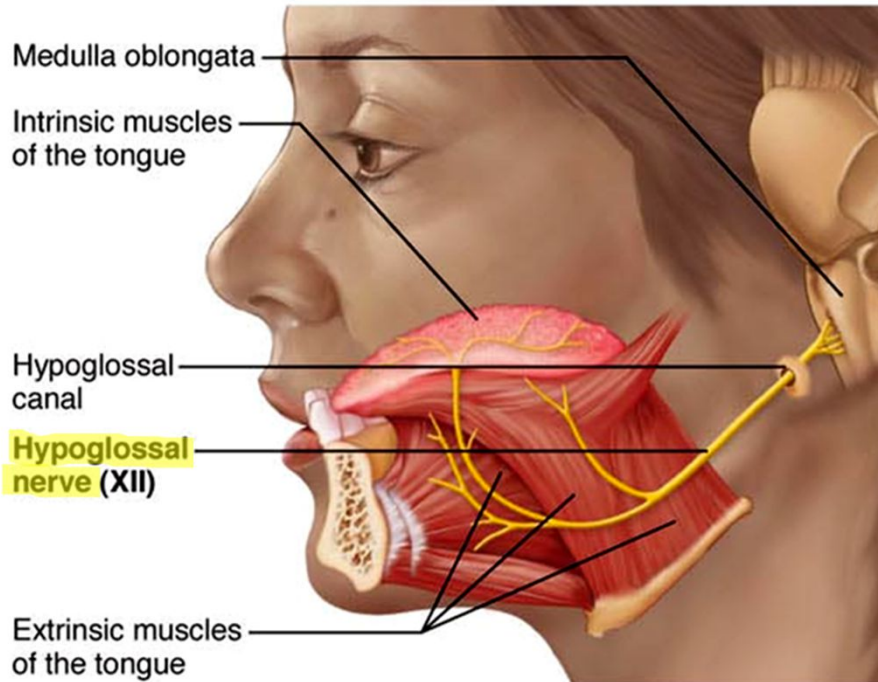
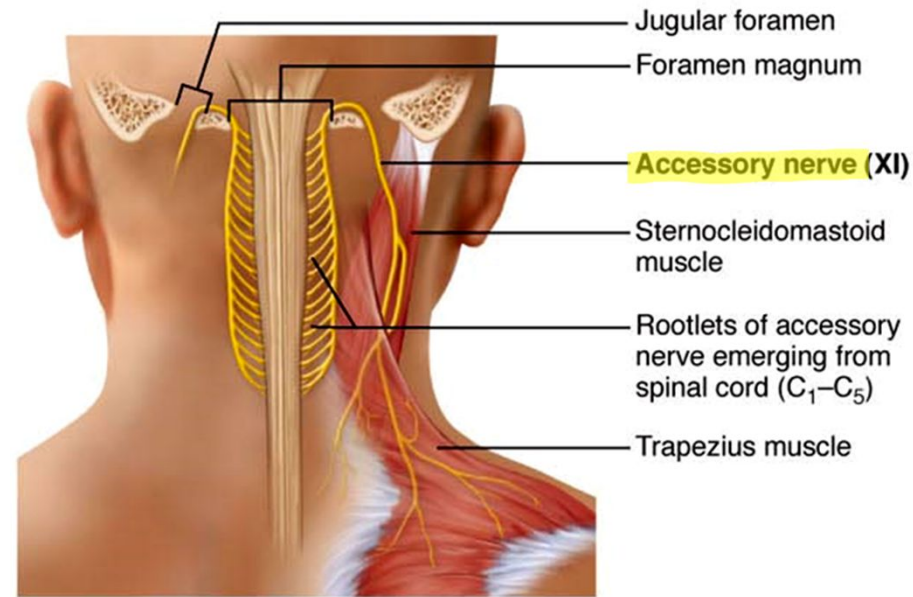


XI. Accessory Nerves:

accessory part of vagus nerve; initially thought to be formed by junction of a cranial root with a spinal root, but really only spinal rootlets

mixed nerves, but **mostly motor** to pharynx, larynx, soft palate; spinal root supplies motor fibers to trapezium & sternocleidomastoid muscles (head & neck movement)

**“Marry Money”
motor nerves**



XII. Hypoglossal Nerves:

- “beneath tongue”, associated with tongue movement; mixed, **primarily motor**
- to tongue for mixing, swallowing and speech

Spinal Nerves

- 31 pairs, all are mixed nerves; named according to point of issue
C₁-C₈; T₁-T₁₂; L₁-L₅; S₁-S₅; C₀, cervical thoracic lumbar sacral, 1 coccyx
- almost immediately after exit from foramen, each spinal nerve branches into a **dorsal ramus** (posterior areas of body) & a **ventral ramus** (anterior areas of body)
- rami carry both **sensory** & **motor** fibers

Understand the difference between a root and a ramus!

roots are one way traffic, while rami have 2 way traffic

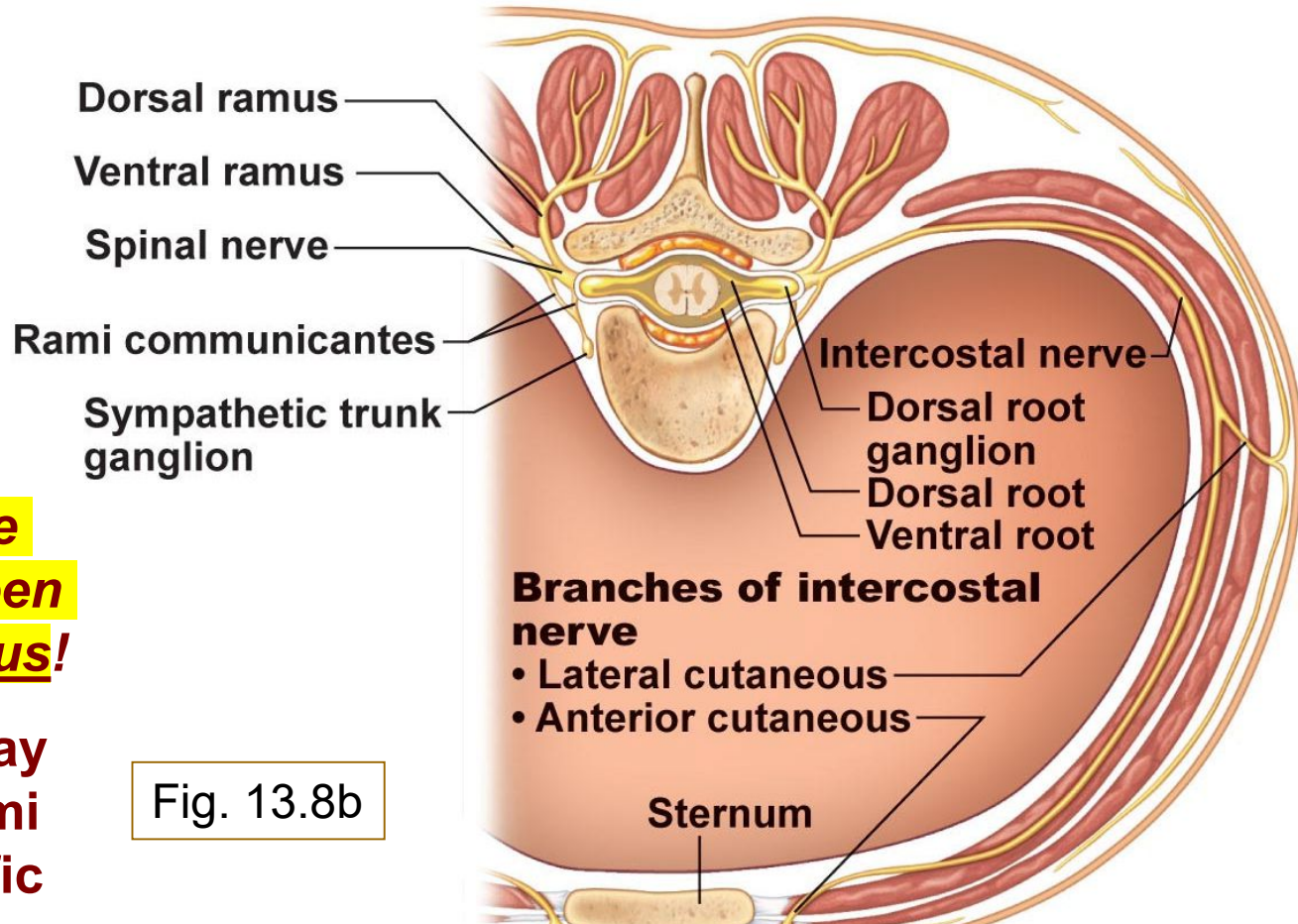


Fig. 13.8b

- except for T₂-T₁₂, all **ventral rami** branch & make lateral connections just outside spinal cord -> **nerve plexuses**
- fibers from different rami crisscross in plexuses:
 - (i) Each branch of a plexus contains fibers from several different spinal nerves
 - (ii) Fibers from each ventral ramus travel to body periphery via several different routes

Result: each muscle in a limb receives nerve supply from more than one spinal nerve • *damage to one spinal segment or root cannot completely paralyze any limb muscle*

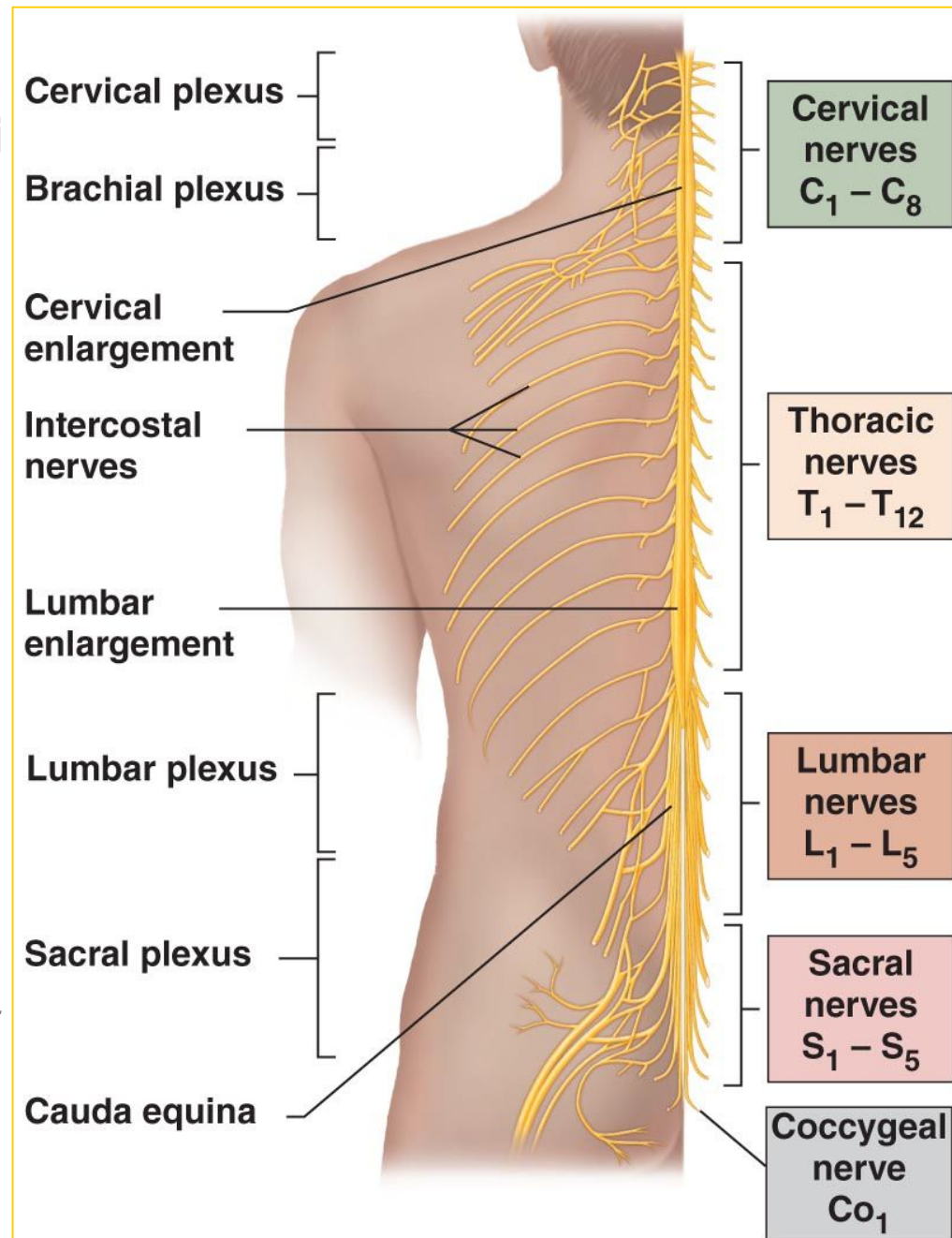


Fig. 13.7

A. Cervical Plexus & the Neck:

- **C₁-C₄**; deep in neck under sternocleidomastoid muscle
- most branches are **cutaneous nerves**
- single most important nerve is **phrenic nerve**: both motor & sensory fibers to diaphragm (important for inspiration)

■ Ventral rami

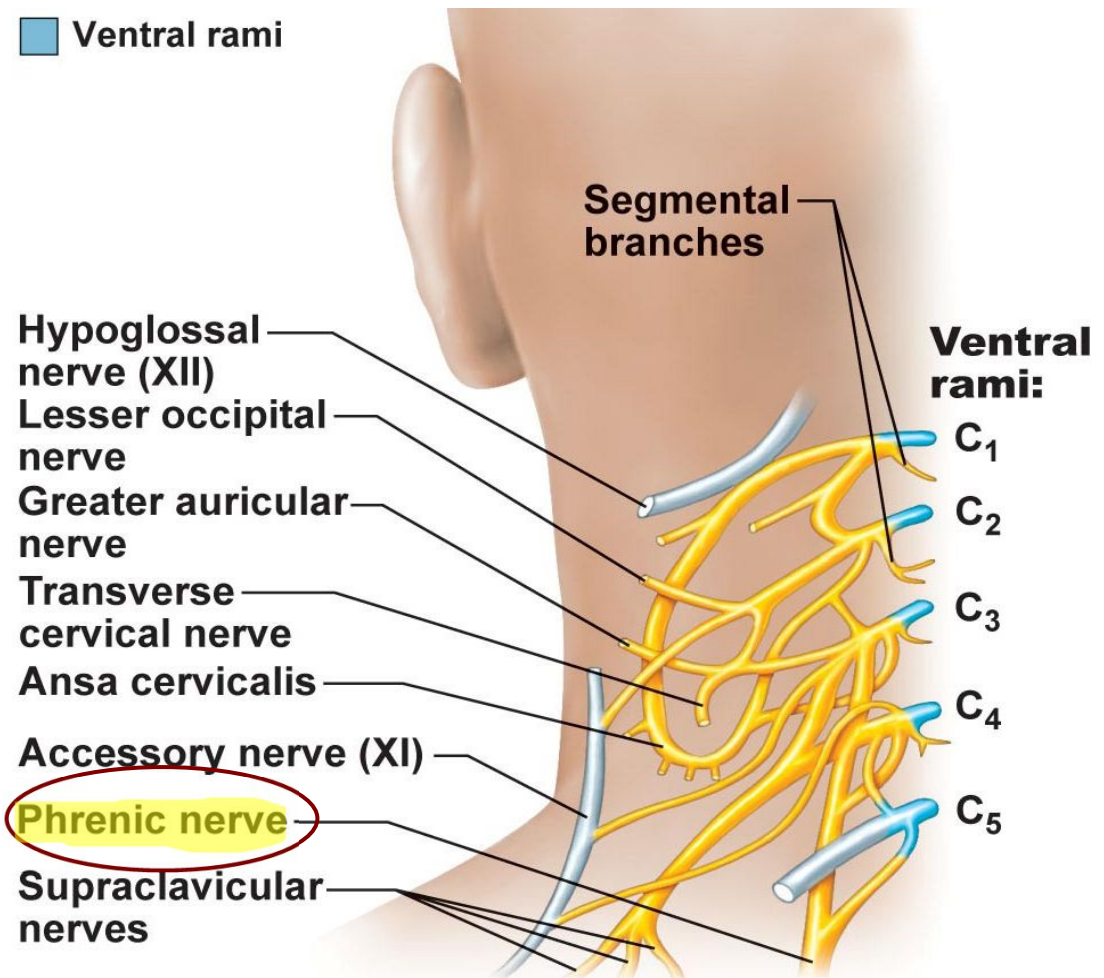


Fig. 13.9

B. Brachial Plexus & Upper Limb:

- C₅-C₈ & most of T₁; partly neck, partly axilla – nerves supplying upper limbs
- (i) **Axillary** nerve to shoulder (esp. deltoid muscle) ‘axilla’ -> armpit area
- (ii) **Musculocutaneous** nerve – to biceps brachii & brachialis to flex arm (‘cutaneous’ -> skin, ie. more lateral)
- (iii) **Median** nerve – flexor muscles in anterior forearm & into palm -> pronate forearm, flex wrist/fingers, oppose thumb

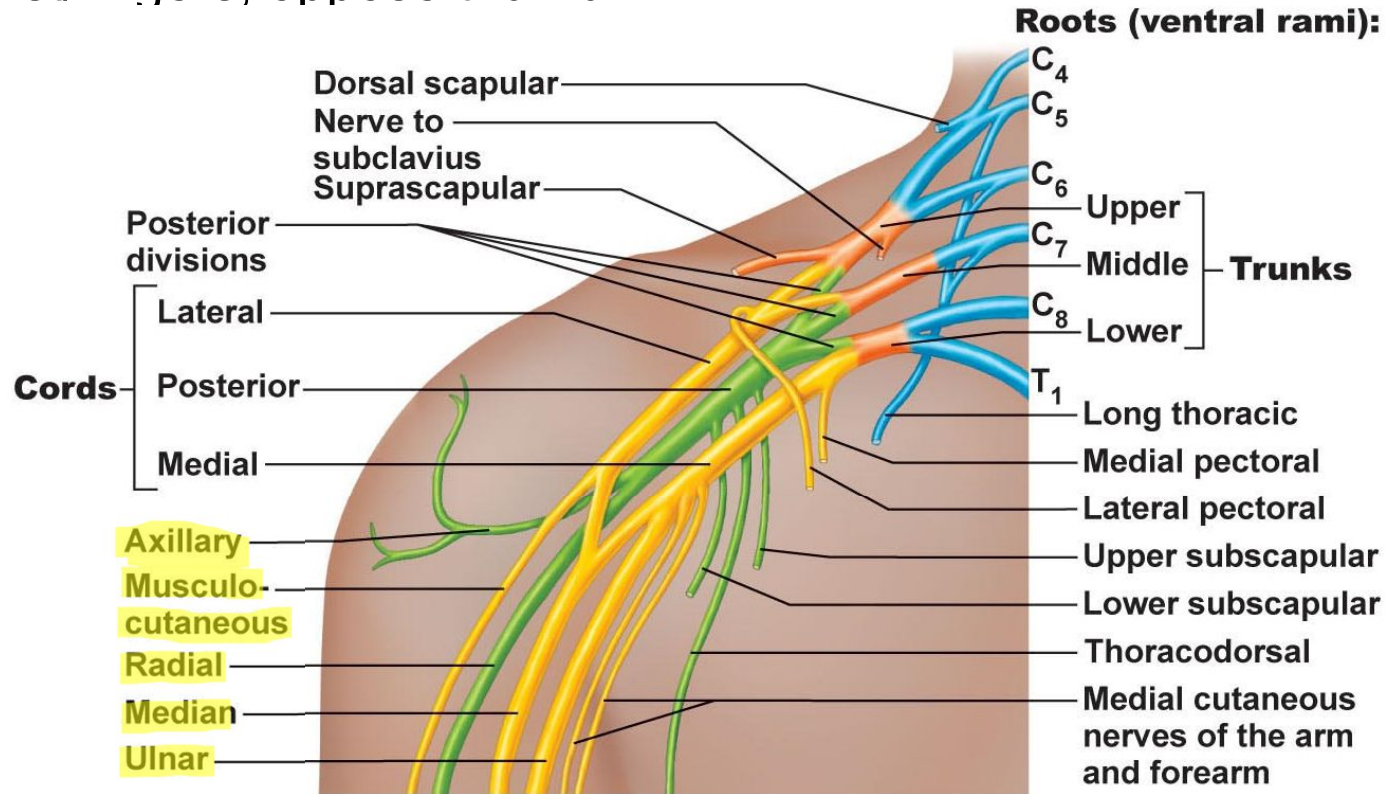
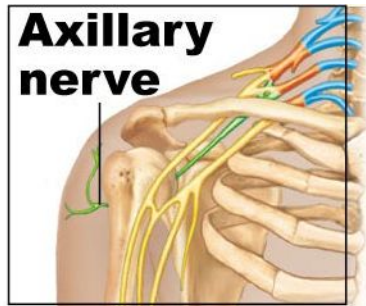


Fig. 13.10a

(a) Roots (rami C₅-T₁), trunks, divisions, and cords

Anterior divisions
 Posterior divisions
 Trunks
 Roots



Anterior divisions
 Posterior divisions

Humerus

Radial nerve

Musculocutaneous nerve

Ulna

Radius

Ulnar nerve

Median nerve

Radial nerve (superficial branch)

Dorsal branch of ulnar nerve

Superficial branch of ulnar nerve

Digital branch of ulnar nerve

Muscular branch

Digital branch

} Median nerve

(c) The major nerves of the upper limb

Fig. 13.10c

(iv) **Ulnar** nerve – medial to elbow (“funny bone”) & follows ulna along medial forearm -> wrist & finger flexion and adduction & abduction of medial fingers

(v) **Radial** nerve – largest – to humerus & dorsal part of hand > elbow extension, supination of forearm, extension of wrist & fingers, abduction of thumb

C. The Back:

- **dorsal rami**; follows segmented plan

D. Anterolateral Thorax:

- T₁-T₁₂; simple & segmented as for innervation of back
- **intercostal nerves**: to intercostal muscles; anterolateral thorax

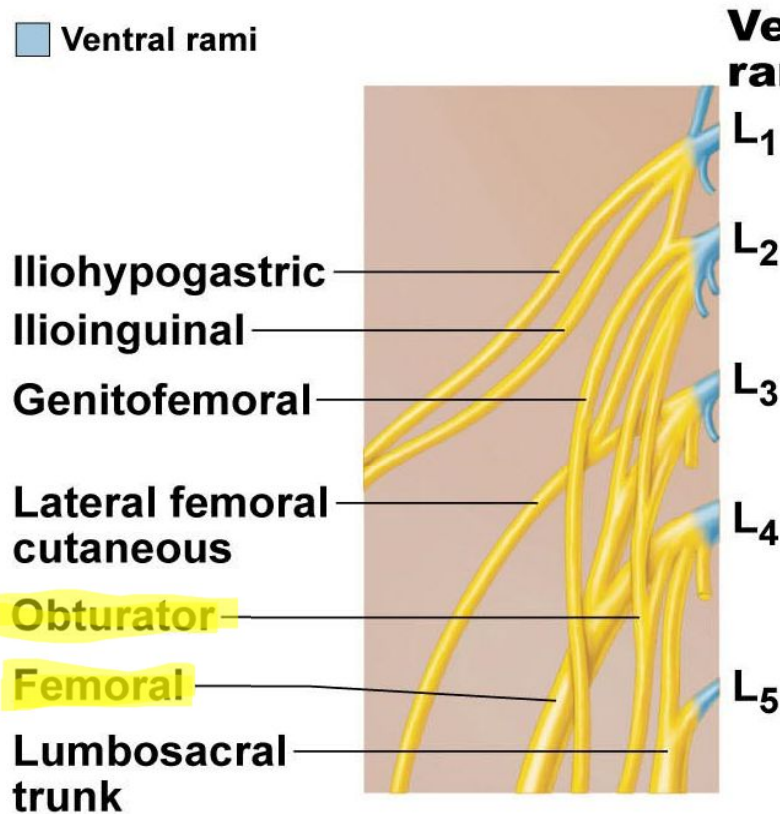
E. Lumbar Plexus:

• L₁-L₄; branches to abdominal wall muscles, also anterior & medial thigh

(i) **Femoral nerve:** anterior thigh muscles -> thigh flexors & knee extensors

(ii) **Obturator nerve:** medial thigh -> thigh adductor muscles

■ Ventral rami



(a) Ventral rami and major branches of the lumbar plexus

Ventral rami:

L₁

L₂

L₃

L₄

L₅

Iliohypogastric

Ilioinguinal

Femoral

Lateral femoral cutaneous

Obturator

Anterior femoral cutaneous

Saphenous

branch of femoral nerve

Fig. 13.11

(b) Distribution of the major nerves from the lumbar plexus to the lower limb

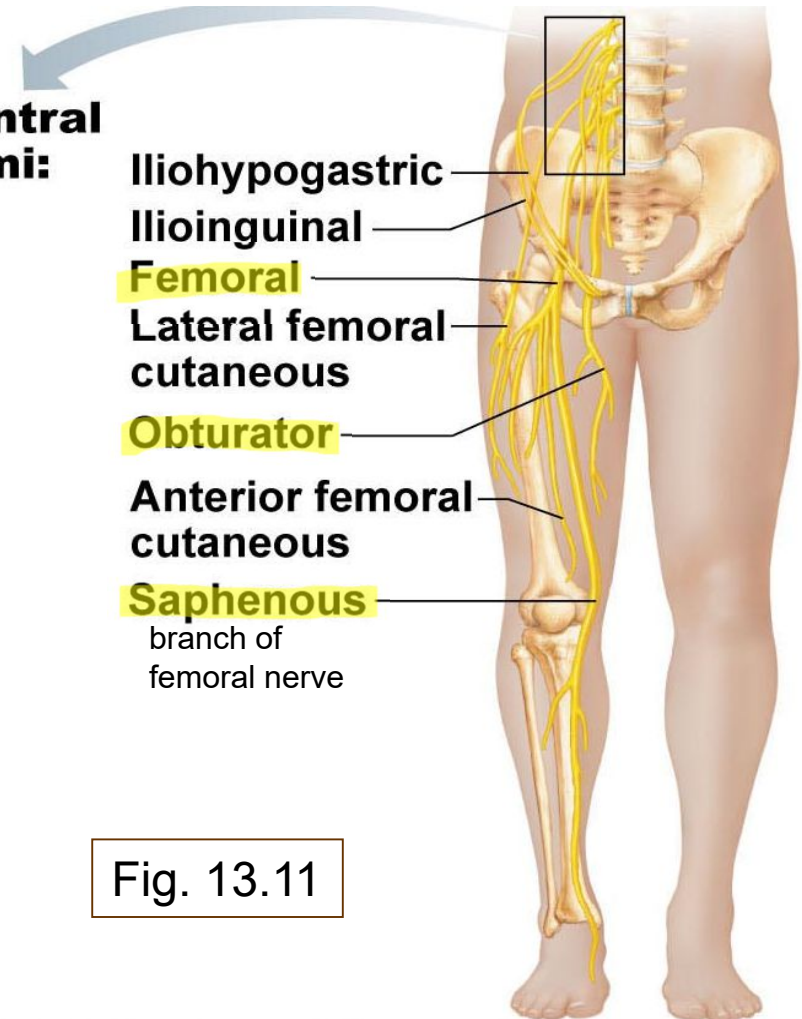
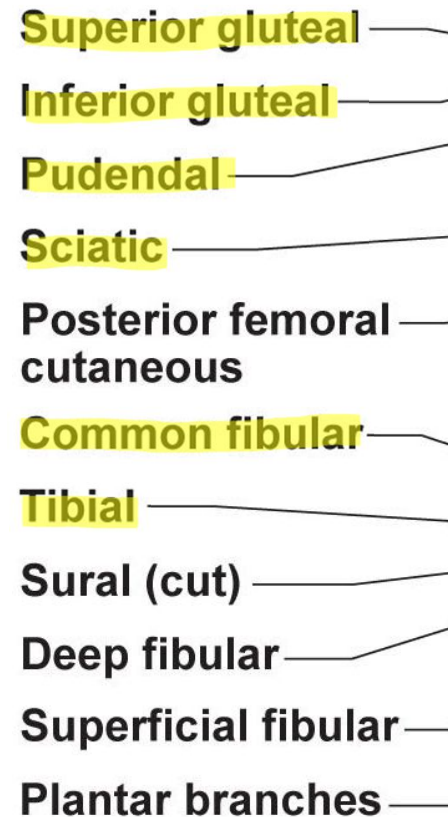
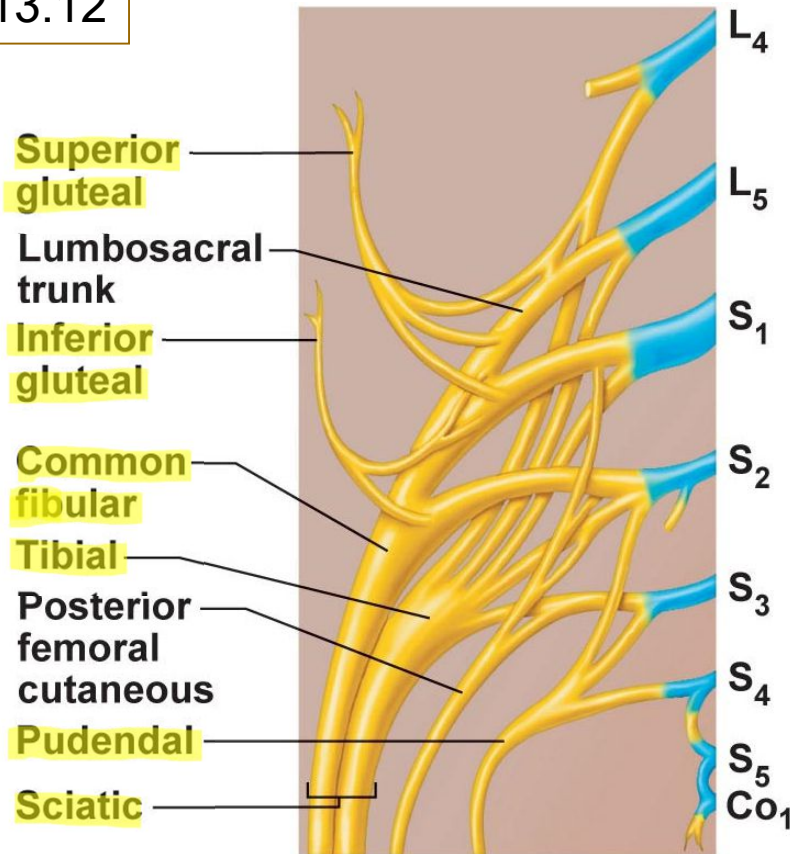


Fig. 13.12



F. Sacral Plexus:

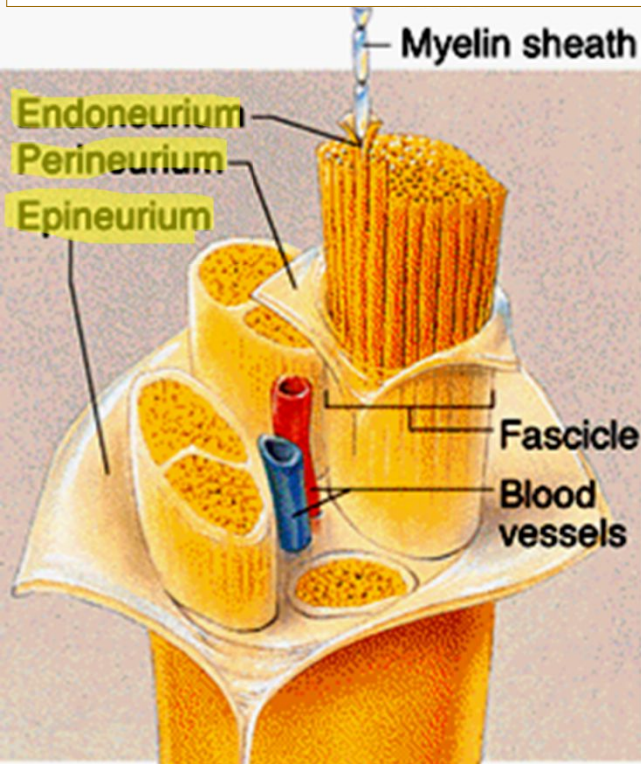
- **L₄-S₄**: immediately caudal (to lumbar plexus – branches to buttocks, lower limbs, pelvis)
 - (i) **Sciatic nerve**: posterior thigh – then diverges into (ii) & (iii):
 - (ii) **Tibial nerve**: behind knee joint to posterior calf & sole of foot
 - (iii) **Common fibular nerve**: to knee joint, calf (anterolateral) & dorsum of foot
 - (iv) **Superior & inferior gluteal nerves**: to buttocks
 - (v) **Pudendal nerve**: muscles & skin of perineum (e.g. erection, voluntary urination)

Dermatome: area of skin innervated by cutaneous branches of a single spinal nerve

Endoneurium: loose CT that encloses nerve fiber + associated myelin or neurilemma sheath (single)

Perineurium: coarser CT wrapping around a group of fibers (fascicle) (bundle)

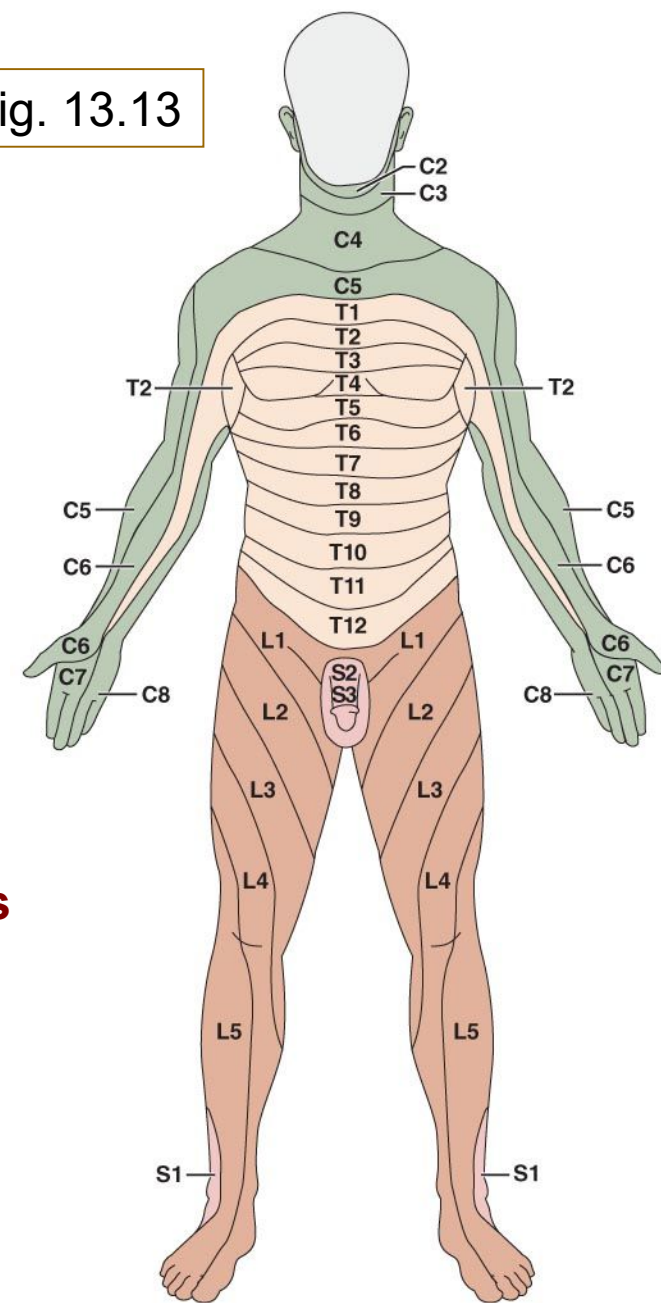
Epineurium: tough fibrous sheath around all the fascicles to make a nerve (entire nerve)



b)

Fig. 13.4: Structure of a Nerve

Fig. 13.13



(a) Anterior view

What do I mean when I say that most nerves are mixed nerves?