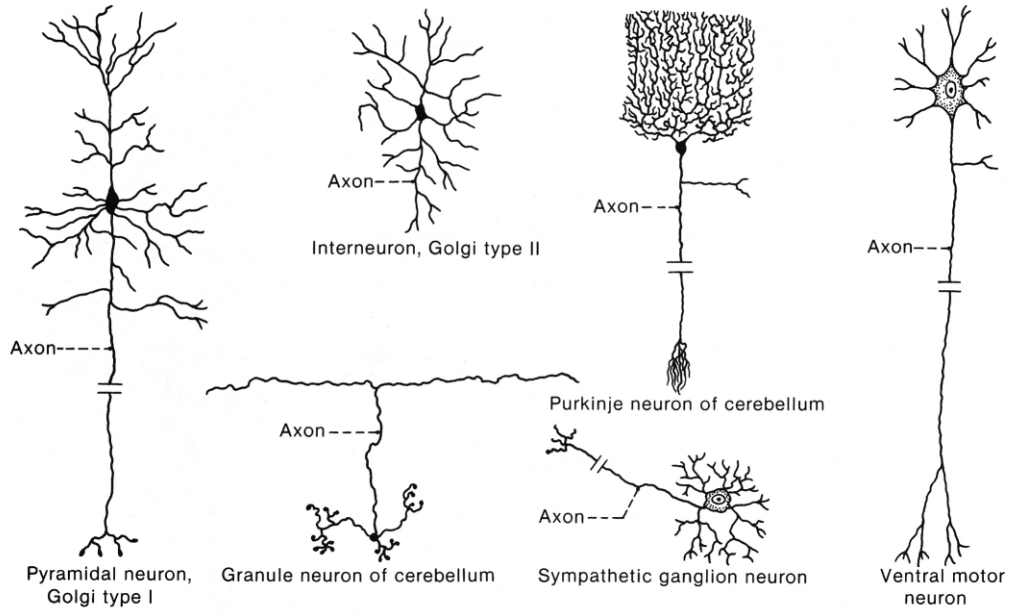
ANATOMY, HISTOLOGY, PHYSIOLOGY (GENERAL)

- ≈ 100 billion (10^{11}) neurons.

Nissl substance (s. tigroid substance) = **stack of rER cisternae** + **polyribosomes**



amacrine neurons – **neturi** aksono

AXONAL TRANSPORT:

a) **slow transport** (AXOPLASMIC FLOW) 0,01-1 cm/d - only *antegrade*;
b) **fast transport** (AXOPLASMIC TRANSPORT) 20-40 cm/d - vyksta *vezikulėse* microtubule motor proteins pagalba *abiem kryptim*

- ramybės būsenoje neurono membrana esti poliarizuota (–70 ÷ –80 mV), i.e. inside negative relative to outside.
- **Na^+/K^+-ATPase actively transports** – 3 Na^+ out, 2 K^+ into cells.
- 70% of nerve energy requirement is used to maintain membrane polarization (by Na^+-K^+ ATPase).
- during maximal activity, metabolic rate of nerve doubles (vs. metabolic rate of skeletal muscle increases 100-fold).

N.B. stimulation normally* occurs at CATHODE!

*hyperpolarizing ANODAL currents inhibit impulse formation.

Extracellular ion concentrations

- ↓***external Na^+ concentration*** decreases ACTION potential size (vs. resting potential).
- ↓***external K^+ concentration*** increases RESTING potential (due to K^+ gradient↑).
- ↓***external Ca^{2+} concentration*** increases EXCITABILITY (of nerve and muscle cells - tetany) by decreasing RESTING potential;
  ↑extracellular Ca^{2+} concentration "stabilizes membrane" (by decreasing excitability).

- action potential (reaching presynaptic terminal) opens **voltage-gated Ca^{2+} channels** → Ca^{2+} **influx** → vesicle exocytosis.
- **LAMBERT-EATON myasthenic syndrome** = antibodies to Ca^{2+} channels → ↓neurotransmitter release. **Aminoglycoside antibiotics** also impair Ca^{2+} channel function.

- *minimal synaptic delay* is 0.5 ms

INTRACRANIAL PRESSURE, BLOOD FLOW

only vasopressor which reduces CSF production (→ ICP↓)	NOREPINEPHRINE

Each 1° C drop → cerebral metabolic rate of oxygen ($CMRO_2$) drops by	7%
$PaCO_2$↓ 1 mmHg:	diameter of cerebral vessels↓ 2-3% CBF↓ ≈ 1.1 ml/100 g/min.
How much of cardiac output is distributed to brain	15-20%
Bone density declines with bedrest	2% per week
Muscle strength declines with bedrest	1–3% per day or 10-15% per week
Intracranial space has a fixed volume made up of	100-130 ml blood (15% arterial, 40% venous, 45% microcirculation), ~75 ml of CSF, and brain tissue.

- smegenys išekstrahuoja iš pratekančio kraujo: ≈ 50% **O_2** ir tik ≈ 10% **gliukozės** (ratio 5 : 1).
  N.B. *with focal cortical activity*, local **CBF** increases ≈ 30% while **O_2 consumption** increases only 5% (luxurious oxygen supply) – venous blood has more oxygen = foundation of fMRI.

Nors smegenys sudaro tik 2% kūno svorio (≈ 1400-1500 g) ir neatlieka jokio mechaninio darbo, bet *elektrofiziologiniam aktyvumui* palaikyti tenka didelės sąnaudos:

– gauna 14-20% **CARDIAC OUTPUT** (i.e. 700-1000 ml/min);
  1) **kidney** – 420 ml /100 g /min
  2) **myocardium** – 84 ml /100 g /min
  3) **liver** – 58 ml /100 g /min
  4) **brain** – 53 (50-60) ml /100 g /min.

- > 50% human genome codes for genes that are nervous system specific.
- 1% human genome codes for genes that are olfaction specific.
- cerebellum has more neurons than cerebrum.
- CNS has 400 miles of vasculature associated with BBB (overall exchange surface area ≥ 12 m^2).
- smegenys praktiškai neturi „degalų“ atsargų - turi pastoviai gauti O_2 ir gliukozę (brain relies on sizable and well-regulated blood flow to satisfy its immediate needs for energy).
- nutrūkus kraujotakai, sąmonės netenkama po 8-10 sekundžių, neuronai žūti pradeda jau po 5 minučių! *glikogeno atsargos (≈ 1.6 mg/g) sunaudojamos per 2 minutes*

Pressure AUTOREGULATION - brain arterioles maintain relatively constant CBF over range of systemic blood pressures;

– CBF remains constant when CPP is 50-160 mmHg (outside this range, CBF varies linearly with MAP):

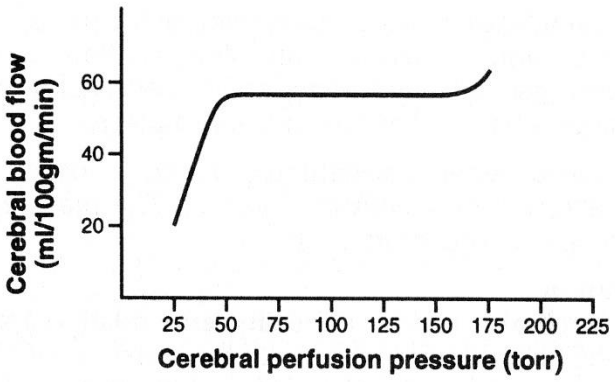
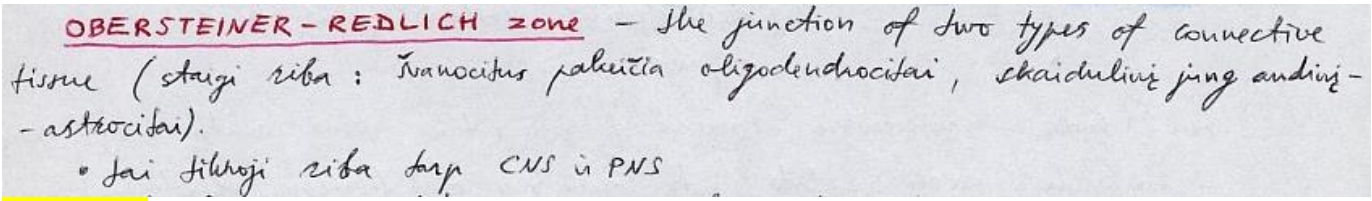


FIGURE 27-2. Cerebral blood flow versus cerebral perfusion pressure. Note that normal autoregulation that occurs for cerebral perfusion pressure is 50–150 mm Hg.

MYELIN



< 35 weeks - no myelination is detected.
After age 2 yrs, pattern of myelination is grossly that of adult brain.

- mielinizuota ≈ 20% visų PNS aksonų

SYNAPSE

Ephapse ("artificial synapse") - place where two or more nerve cell processes (axons, dendrites) touch without forming typical synaptic contact; some form of neural transmission may occur at such contact sites (esp. important in neuropathic pain genesis).

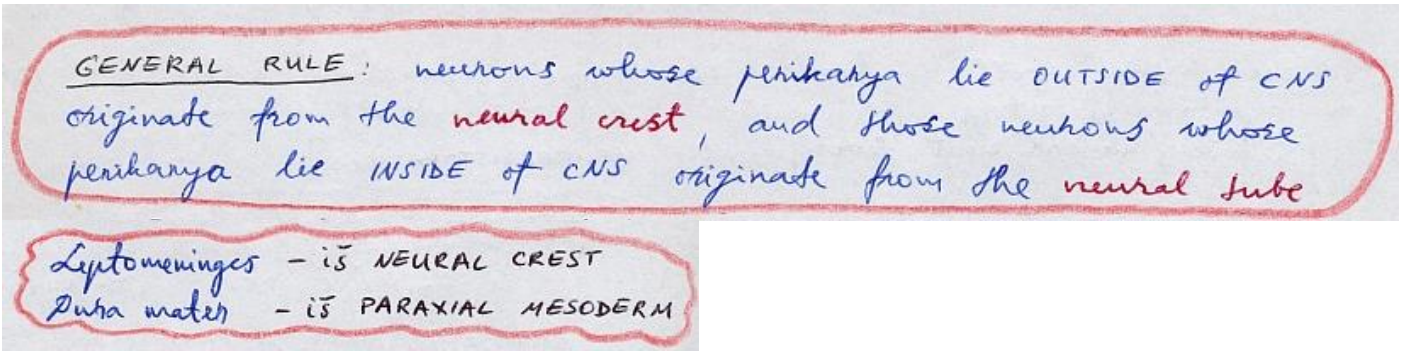
In **LAMBERT-EATON myasthenic syndrome,** antibodies to Ca^{2+} channels inhibit Ca^{2+} entry into nerve terminal and reduce neurotransmitter release.

Aminoglycoside antibiotics also impair Ca^{2+} channel function → similar syndrome.

BBB

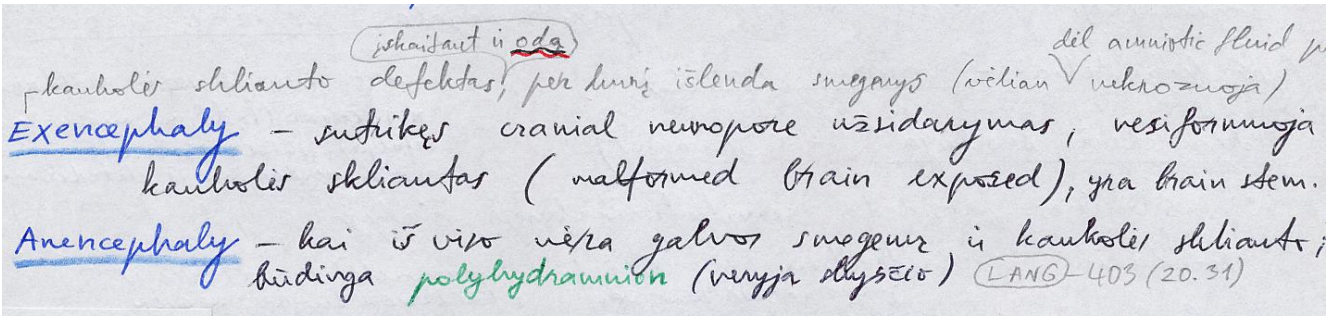
- BBB is **unidirectional**; movement of substances from brain to blood is almost unrestricted (due to bulk flow of CSF to venous system).
- BBB is ***not absolute*** – in **circumventricular organs** (neurohypophysis, area postrema, etc) BBB is less effective.

DEVELOPMENT



Distal spinal cord development (secondary neurulation) from **CAUDAL CELL MASS**
Disorders of secondary neurulation (e.g. tethered filum) → **occult dysraphic states** (abnormalities of sacrococcygeal segments beneath intact dermal elements; no exposed neural tissue).

- these anomalies (sacral agenesis, conus hypoplasia) may be associated with other abnormalities (imperforate anus, malformed genitalia, renal dysplasias, etc) - as part of broader ***caudal regression syndrome***.



N.B. only sites in adult brain where neurons still being produced – **olfactory bulb** and **hippocampus**!

MOTOR SYSTEM

- motor innervation of intrafusal fibers (muscle spindle) – **γ-motoneurons** (their Aγ axons constitute 30% of fibers in ventral roots! - **small motor nerve system**)
- in addition, larger **β-motoneurons** innervate both INTRAFUSAL and EXTRAFUSAL fibers.

  N.B. CNS can contract muscle:
  directly (used practically) – via stimulation of **α-motoneurons**
  indirectly (only theoretically) – via stimulation of **γ-motoneurons** (via stretch reflex)*

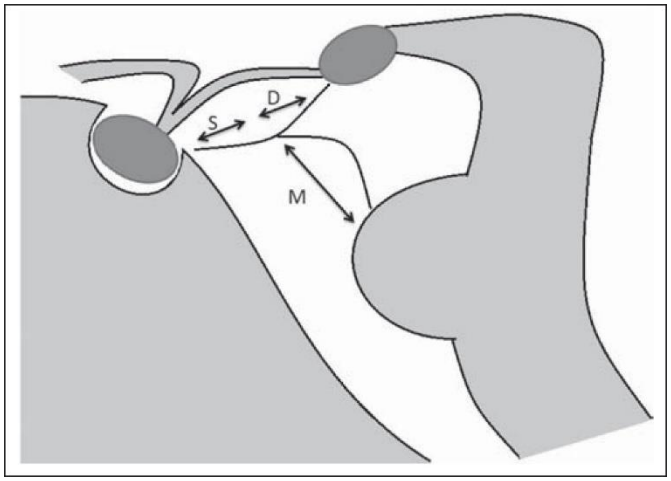
  *muscle spindles provide **α-motoneuron** with excitatory input in addition to that coming from *higher CNS centers*
- *afferent Ia fibers* from spindles pass directly to spinal **α-motoneurons** supplying **the same muscle**; at the same time, *collaterals of afferent Ia fibers* end on **Golgi bottle neurons** (inhibitory interneurons) that secrete **GLYCINE** → inhibition in **α-motoneurons** supplying **antagonistic muscles**.

  N.B. antagonist muscle inhibition reflex is ***disynaptic***!
- small type I red muscle fibers are fatigue resistant.
- **Renshaw cell** - inhibitory interneuron - receives ***recurrent collateral*** from α-motoneuron axon (before it leaves ventral horn); Renshaw cell axon releases GLYCINE → postsynaptic inhibition:
  a) the same alpha motor neuron
  b) other alpha motor neurons that innervate agonists.
  c) inhibitory interneuron mediating reciprocal inhibition.
- **withdrawal** reflex - POLYSYNAPTIC reflex

LILIEQUIST MEMBRANE

- arachnoid membrane.

- attachments: from diaphragma sellae to anterior edge of mammillary body and laterally attached to CN III.
- separates three cisterns:
  1) chiasmatic cistern – LM forms floor for this cistern
  2) perimesencephalic (interpeduncular) cistern – LM forms “curtain” for this cistern
  3) prepontine cistern – LM forms roof for this cistern
- LM separates supratentorial and infratentorial CSF compartments.
- very thin - not routinely visualized in imaging studies (can be visualized on MRI CISS heavily T2 weighted 3D sequences).



D - diencephalic segment, M - mesencephalic segment, S - sellar segment.

NEUROCHEMISTRY

- sweat glands are innervated by **noradrenergic** sympathetic fibers (emotional sweating) and **cholinergic** sympathetic fibers (thermal sweating).
- reformulated **Dale-Feldberg law**: single neuron makes use of ***the same combination of chemical messengers*** at all of its synapses.

Serotonin, GABA*, glycine** – **INHIBITORY neurotransmitters**

*presynaptic inhibition in brain
**postsynaptic inhibition in spinal cord

STRYCHNINE – glycine antagonist
TETANUS TOXIN – glycine and GABA antagonist

Acetylcholine (mainly PNS), glutamate and aspartate (mainly CNS) – **EXCITATORY neurotransmitters**

- cholinergic synapse is unique – transmitter is inactivated by **enzymatic destruction**

GABA

$GABA_A$ agonists: **benzodiazepines**, **barbiturates**, newer **anticonvulsants** (e.g. LAMOTRIGINE, TOPIRAMATE).

$GABA_B$ agonist - BACLOFEN.

GABA receptor blockers: TETANUS TOXIN

- GABA - transmitter to produce presynaptic inhibition. BACLOFEN - $GABA_B$ agonist.
- output neurons in ***basal ganglia*** and ***cerebellum*** use GABA.

ACCH

Receptor Type	Agonists	Antagonists
N_1 (neuronal type + adrenal medulla)		**ganglioblockers**

N_2 (muscle type)	NICOTINE (initially stimulates but then blocks)	α-BUNGAROTOXIN (snake venom), CURARE
M_1 (brain, gastric parietal cells)	MUSCARINE (alkaloid in toadstools, Amanita muscaria)	ATROPINE, SCOPOLAMINE, selective M_3 antagonists (TOLTERODINE, DARIFENACIN, SOLIFENACIN)
M_2 (cardiac cells, smooth muscle)		
M_3 (salivary glands, smooth muscle*, iris)		
M_4 (glands, smooth muscle)		
M_5		

*GI, urinary bladder

M receptors affinities: MUSCARINE > Acch > nicotine
N receptors affinities: NICOTINE > Acch > muscarine

Acetylcholine↓:
- *Acch sekrecijos inhibicija* mioneuralinėje sinapsėje:
  1) BOTULINUM TOXINS
  2) **LAMBERT-EATON MYASTHENIC SYNDROME** (antibodies to presynaptic Ca^{2+} channels)
  3) AMINOGLYCOSIDES (inhibited presynaptic Ca^{2+} channels);
- MYASTHENIA GRAVIS – *Acch receptorių autoimuninė inaktyvacija*;
- CURARE – *Acch receptorių blokada* mioneuralinėje sinapsėje.

Acetylcholine↑:
- BLACK WIDOW SPIDER VENOM – masyvi Acch sekrecija.
- ORGANOPHOSPHATES, *Amanita muscaria* – acetilcholinesterazės inhibitoriai.
- *Inocybe, Clitocybe* mushrooms (toadstools) – contain muscarine.

CATECHOLAMINES

ADENOSINE (CNS depressant, coronarodilator) and CAFFEINE are antagonists!; *stimulatory effects of caffeine and theophylline* are due to adenosine receptors blockade.

- katecholaminerginių neuronų taisyklė:
  DOPAMINERGINIAI – in midbrain
  NORADRENERGINIAI – in pons
  ADRENERGINIAI – in medulla

NA ir A sintezuojami iš **Tyrosine** ir katabolizuojami į **VMA (vanillylmandelic acid)**; dopamine katabolizuojamas į **homovanillic acid**.

N.B. ***neuronuose*** katabolizmą vykdo MONOAMINE OXIDASE (MAO)! ***ekstraceliulinius*** katecholaminus ardo CATECHOL-O-METHYLTRANSFERASE (COMT)

Release of NA is modulated by NA itself (acting on presynaptic α2-autoreceptors),

SEROTONIN (5-HT) sintezuojamas iš **Tryptophan** ir su **MAO** (primarily MAO-A) katabolizuojamas į **5-hydroxyindoleacetic acid (5-HIAA)**

Adreno-receptor	Agonist activity
α_1	NA > A > isoproterenol
α_2	A > NA > isoproterenol
β_1	isoproterenol > A = NA
β_2	isoproterenol > A >> NA

- NA has greater affinity to **α receptors**; A – to **β receptors**.
- **α receptors** are sensitive to both NA and A; **β receptors** are sensitive to A but relatively insensitive to NA.
- ISOPROTERENOL is strongest **β receptor** agonist.
  N.B. EPINEPHRINE is single most active endogenous amine on both **α** and **β receptors**!

Receptor	DIRECT AGONISTS	
	Selective	**Nonselective**

α_1	phenylephrine, midodrine	NA > A > ISP
α_2	clonidine, guanfacine, guanabenz, α-methyldopa	A > NA > ISP
β_1	dobutamine	ISP > A = NA
β_2	albuterol, terbutaline, salbutamol, pirbuterol, ritodrine	ISP > A >> NA

ISP - isoproterenol

Receptor	ANTAGONISTS		
	Selective	**Nonselective**	
α_1	prazosin, terazosin	phenoxybenzamine, phentolamine	labetalol, carvedilol
α_2	yohimbine		
β_1	metoprolol, atenolol, esmolol, bisoprolol, nebivolol	propranolol, nadolol, labetalol	
β_2			

DOPAMINE

1-3 µg/kg/min – stimulation of **D receptors**: VASODILATION (renal & splanchnic) → natriuresis.
3-10 µg/kg/min – stimulation of **β_1 receptors**: CARDIOSTIMULATION (ino & chrono) → systolic BP↑.
>10 µg/kg/min – stimulation of **α_1 receptors**: VASOCONSTRICTION (incl. renal) → diastolic BP↑.

MODULATION OF DOPAMINE ACTIVITY see >>!!!!!!!!!

EPHEDRINE - stimulates **NA release** into synaptic cleft + directly stimulates **adrenergic receptors**.
AMPHETAMINES, TYRAMINE cause release of **catecholamines** into synapses.
COCAINE, ANTIDEPRESSANTS (TRICYCLIC, SSRI) block **catecholamine** reuptake.

- **CNS** symptoms – due to DOPAMINE; **peripheral** symptoms – due to NA.
- treatment of **acute intoxication**: **DIAZEPAM** is drug of choice; **HALOPERIDOL** (for psychotic symptoms).

  N.B. β-blockers are contraindicated (unopposed α effects would produce severe hypertension and coronary vasoconstriction); so for c/v **PHENTOLAMINE** (α blocker) is recommended!

ADDICTION

- all known addictive substances affect brain in different ways, but all increase *amount of dopamine available to act on D_3 receptors in* **nucleus accumbens**.

GLUTAMATE, ASPARTATE

Receptors:
METABOTROPIC - **G protein-coupled** receptors
IONOTROPIC receptors (AMPA, kainate, NMDA) are **ligand-gated ion channels**

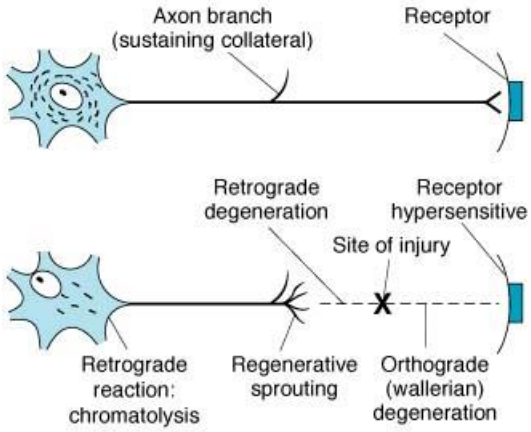
PATHOLOGY BASICS

ROSENTHAL fibers – "junk" in cytoplasm of astrocytes.

WALLERIAN DEGENERATION – **dissolution of distal part of axon and (!) its myelin sheath**
(following transection and separation of axon from its perikaryon)

CHROMATOLYSIS – follows axonal injury; it is preparation for regeneration → perikaryon swelling → pallor of Nissl bodies, nuclear eccentricity

Axon regeneration is slow process, vs. **remyelination** – quite rapid!



GLIOSIS - most important histopathologic indicator of CNS injury (regardless of etiology).
- *ASTROCYTES* participate by hypertrophy & hyperplasia (reactive, s. gemistocytic astrocytes).

IMMUNOHISTOCHEMICAL MARKERS

Epithelial: CK, EMA

For neurons:
1) neuron-specific enolase (NSE)
2) synaptophysin
3) neurofilament protein

Supporting cells (glia of CNS and Schwann cells & satellite cells of PNS): S-100

INTRACELLULAR INCLUSIONS, BODIES

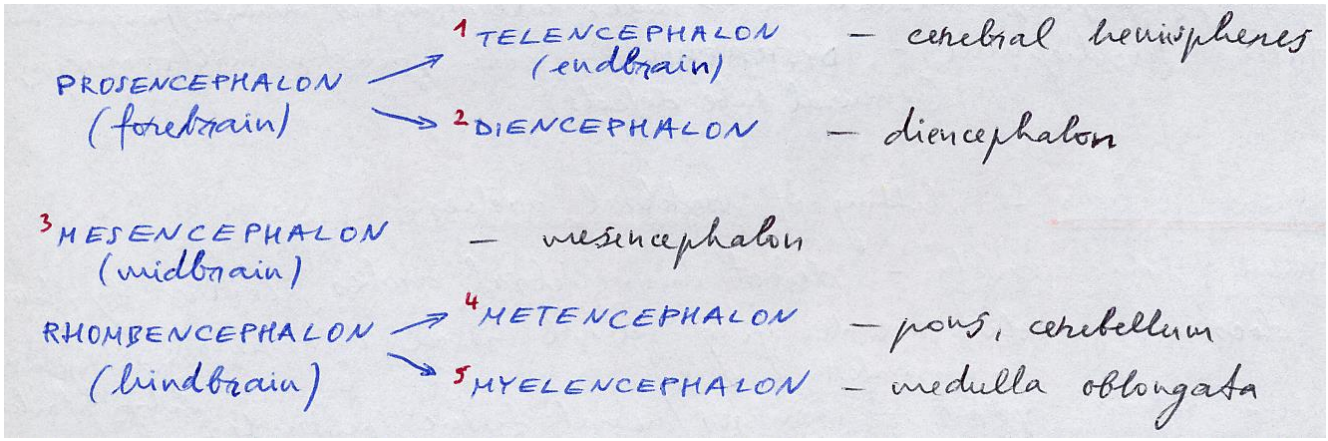
see p. D34 >>

SELECTIVE VULNERABILITY

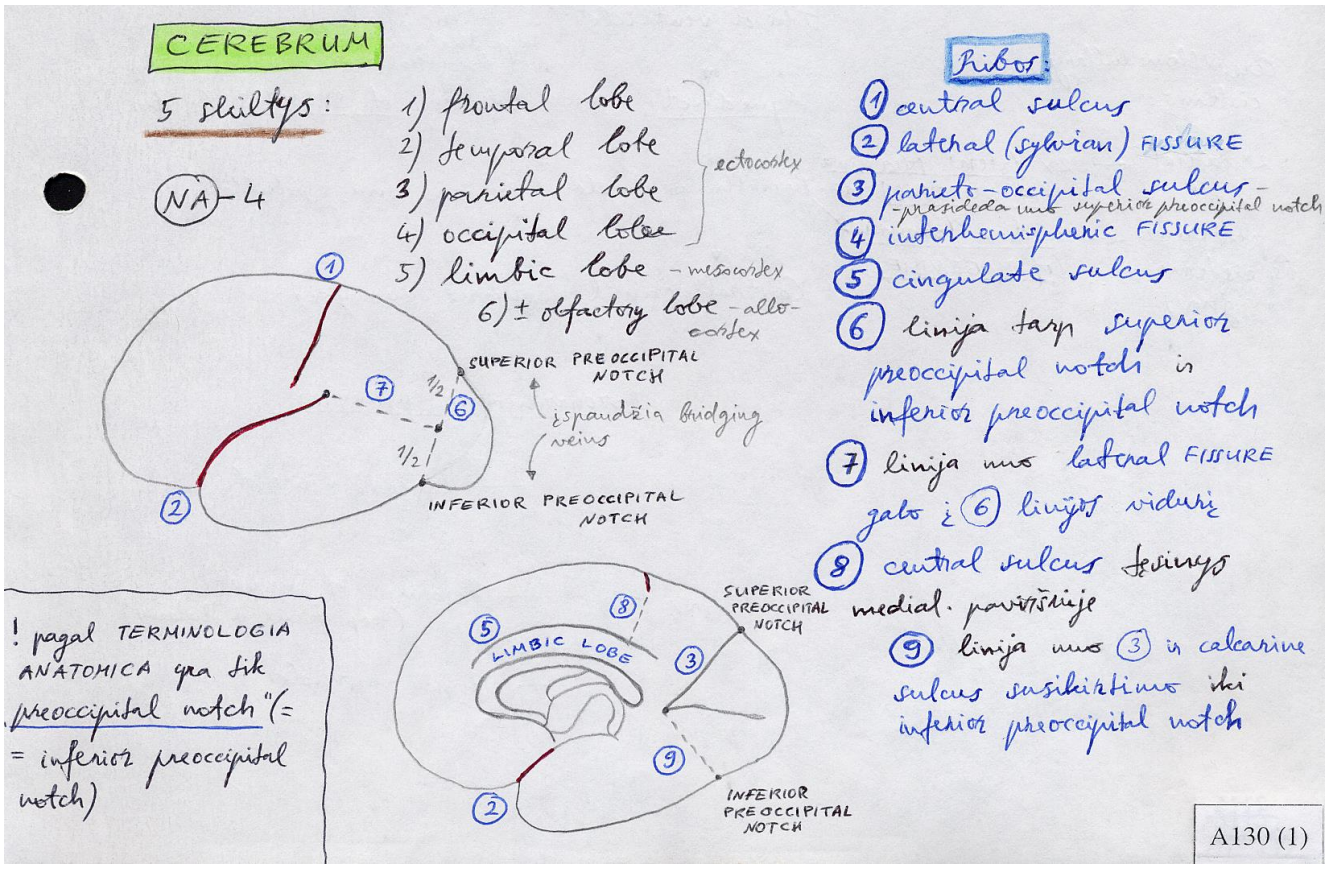
Ischemia – hippocampus (esp. CA1)
Hyperthermia – cerebellar Purkinje cells
Mercury – cerebellar granule cells

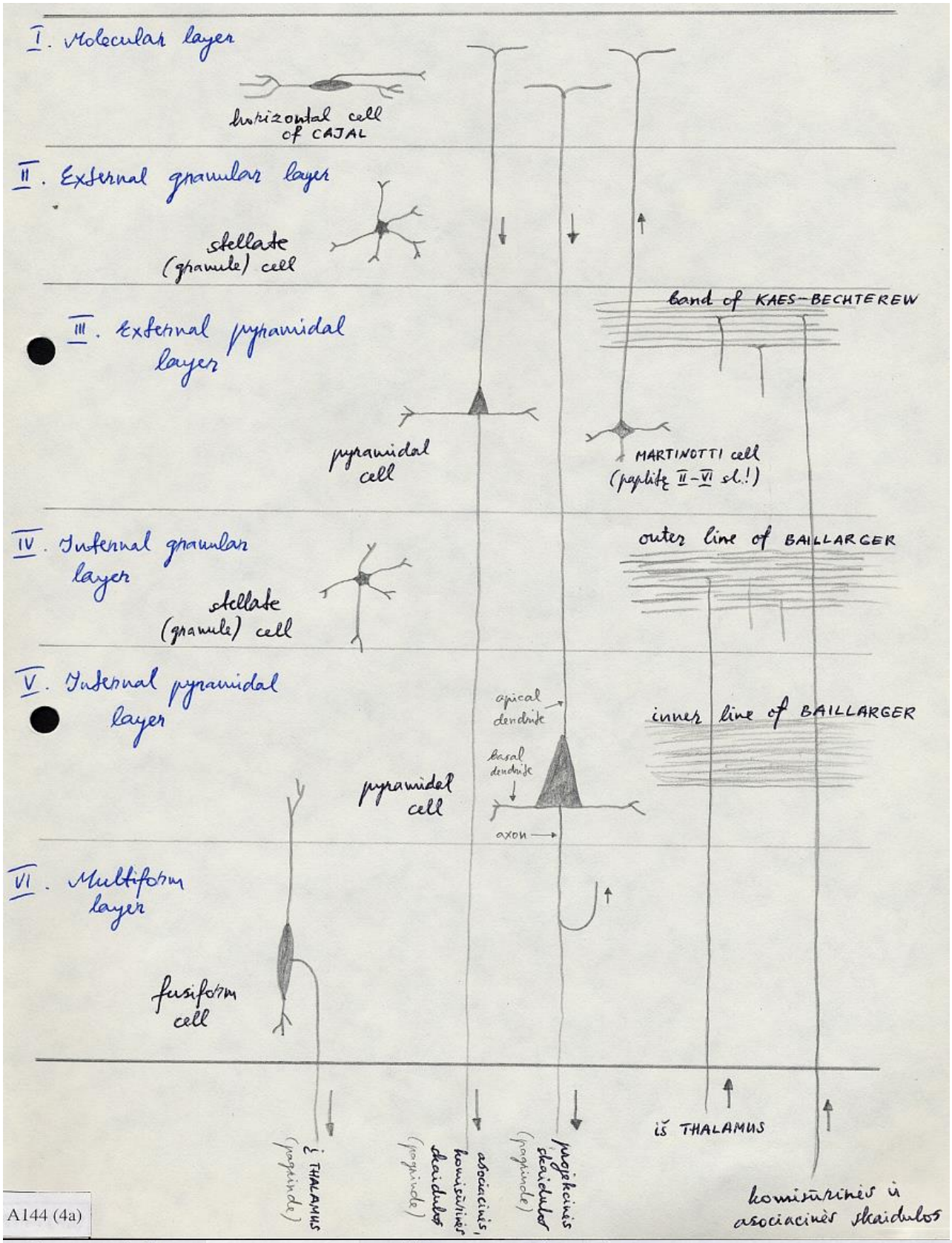
BRAIN

Brain ≈ 2% body weight.



Pros- → Tel- (mainly Cerebral Hemispheres + Corpus Striatum)
Pros- → Di- (mainly Thalamus + Hypothalamus)
Mes- → (or Midbrain)
Rhomb- → Met- (or Pons + Cerebellum)
Rhomb- → Myel- (or Medulla)

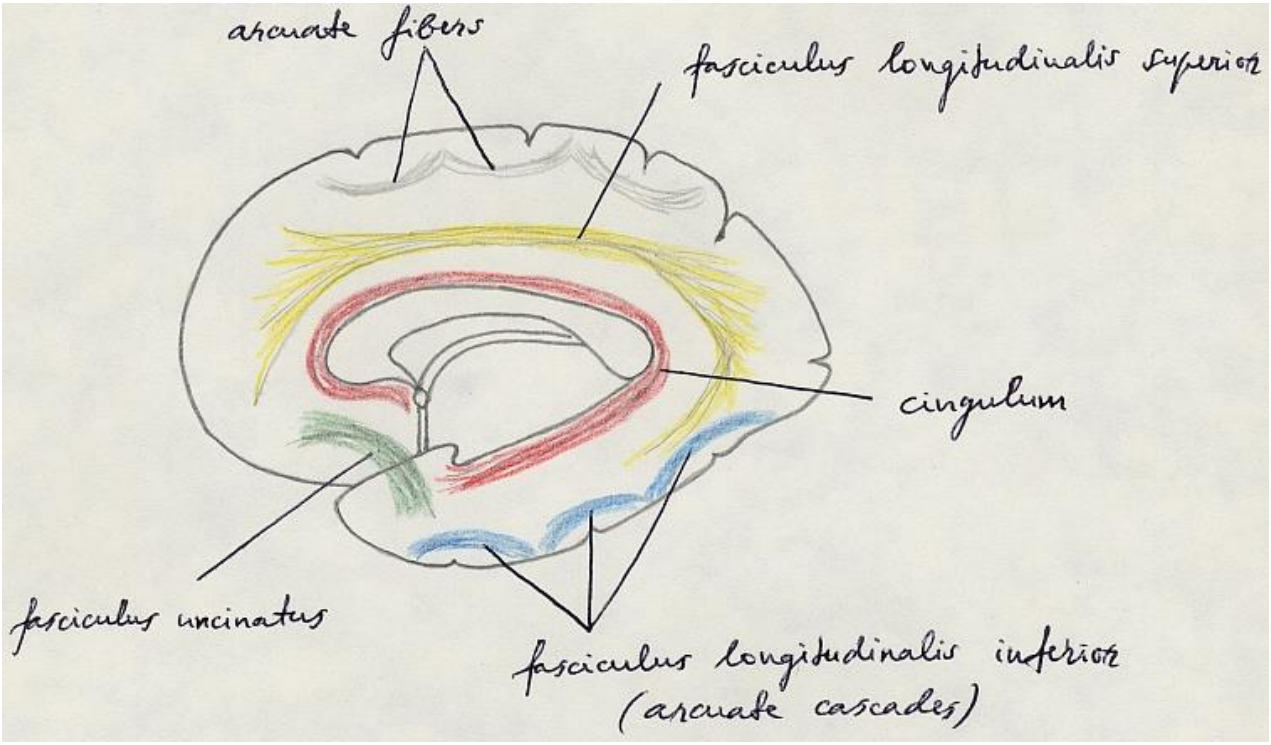


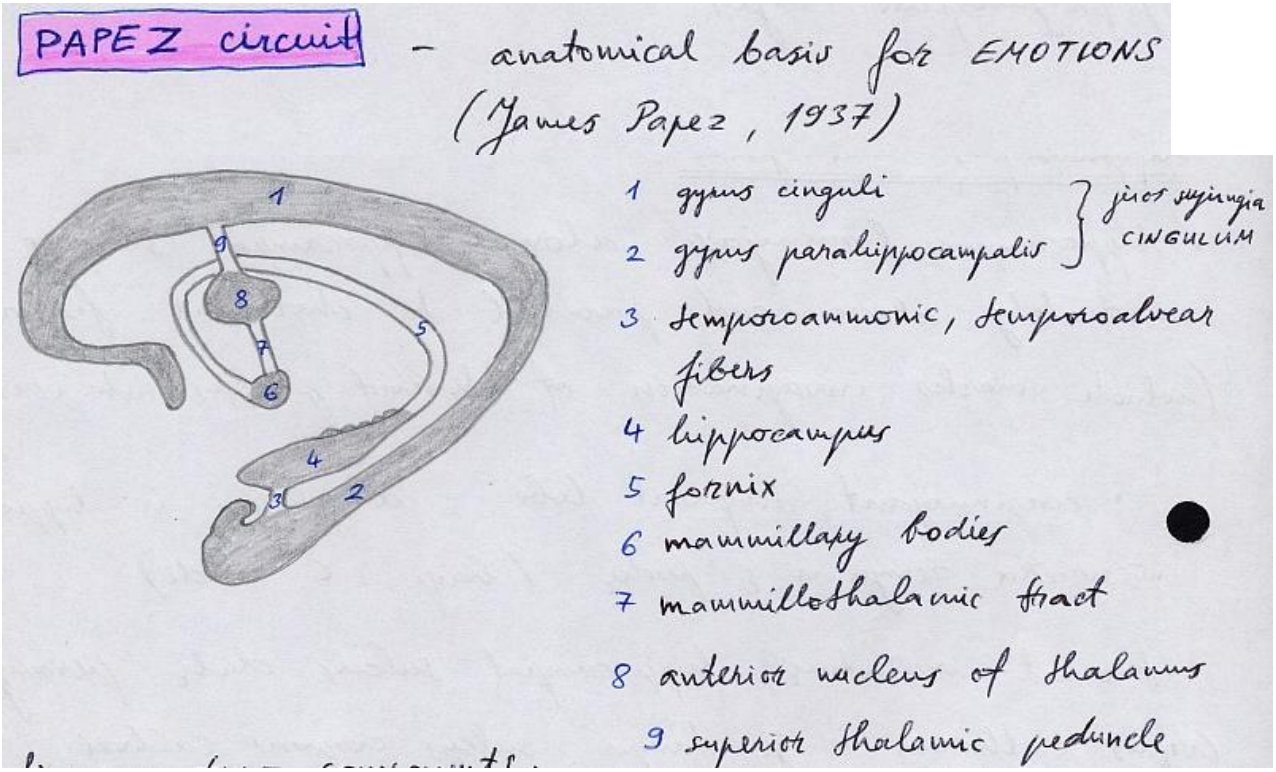


Pyramidal ir fusiform cells – eferentiniai neuronai

Stellate, horizontal of Cajal, Martinotti cells – interneuronai

(axons remain in cortex !)

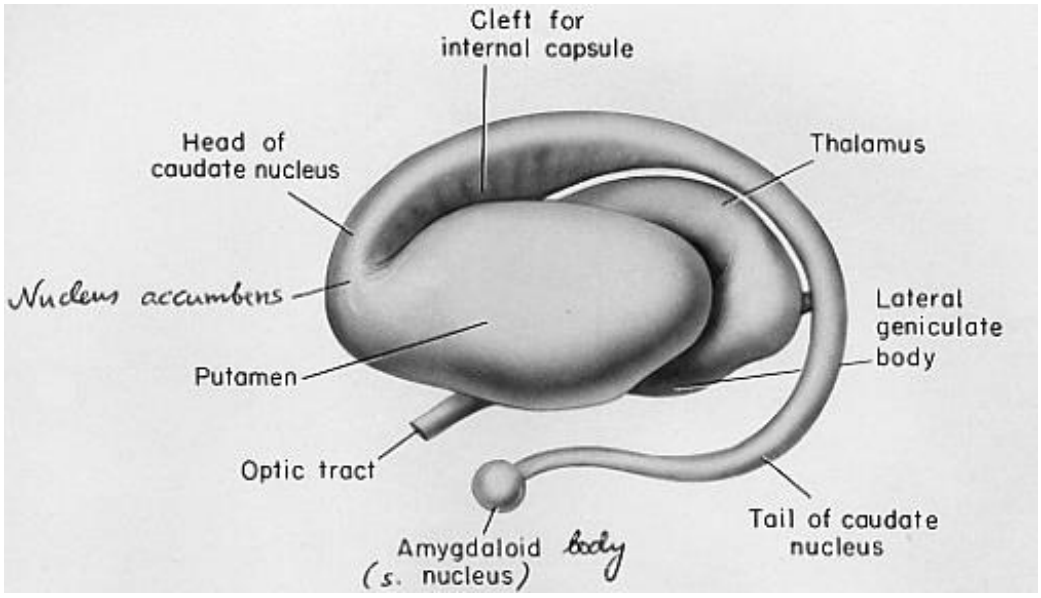


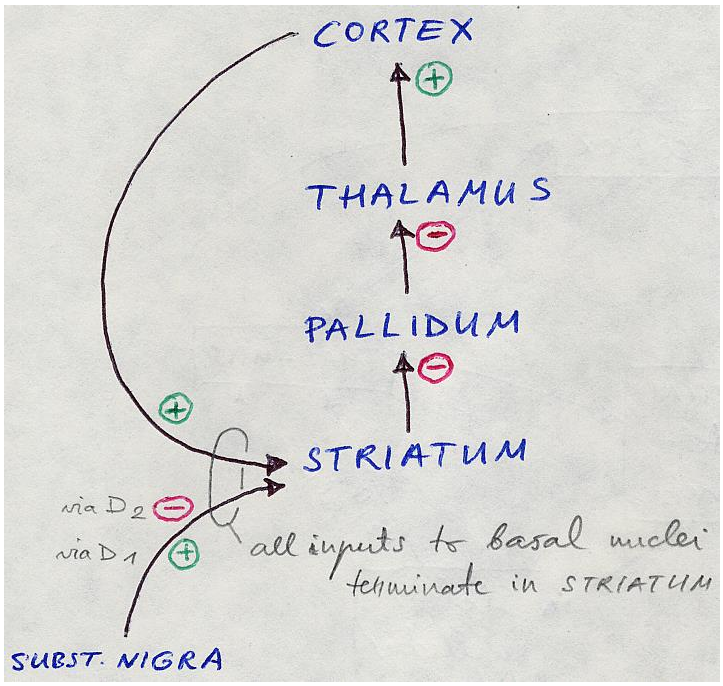


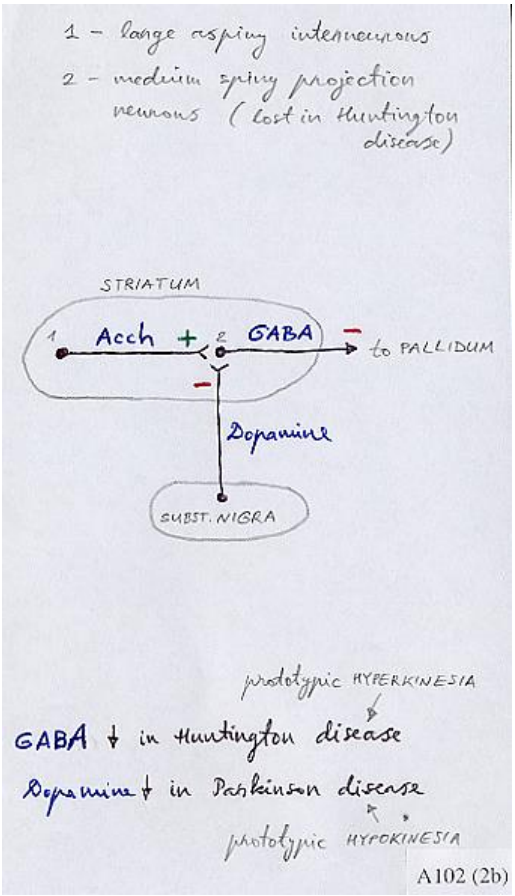
- limbic system connects cortex to hypothalamus.

• Nucl. accumbens jungia caput of caudate nucleus su putamen (around inferior aspect of anterior limb of internal capsule)

BASAL NUCLEI

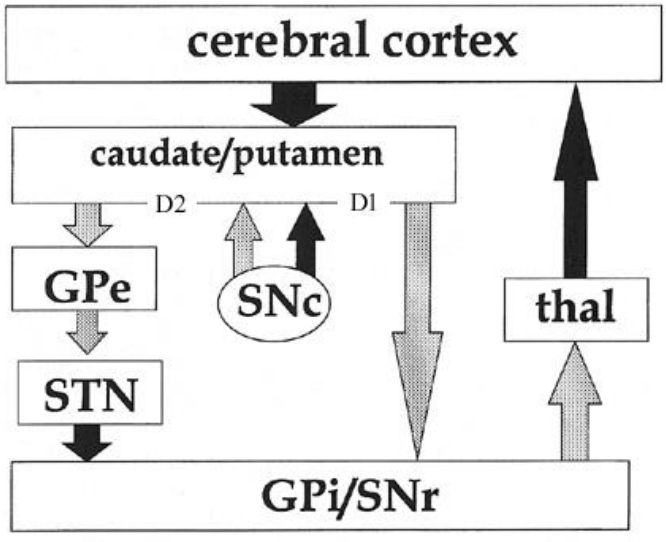

Cleft for internal capsule
Head of caudate nucleus
Thalamus
Nucleus accumbens
Lateral geniculate body
Putamen
Optic tract
Tail of caudate nucleus
Amygdaloid body (s. nucleus)


CORTEX
THALAMUS
PALLIDUM
STRIATUM
via D2
via D1
all inputs to basal nuclei terminate in STRIATUM
SUBST. NIGRA



black arrows – ***excitation***;
speckled arrows - ***inhibition***.

GP_i = globus pallidus internal segment;
GP_e = globus pallidus external segment;
STN = subthalamic nucleus;
SNr = pars reticularis of substantia nigra;
SNc = pars compacta of substantia nigra;
thal = thalamus.



Note two primary pathways from STRIATUM to INTERNAL PALLIDUS + SUBST. NIGRA RETICULATA:

"direct" pathway (***inhibitory***) - flows monosynaptically to GP_i

"indirect" pathway (in sum ***excitatory***) - has intermediate synapses in GP_e and subthalamic nucleus.

N.B. subthalamic nucleus regulates output of basal ganglia to thalamus!

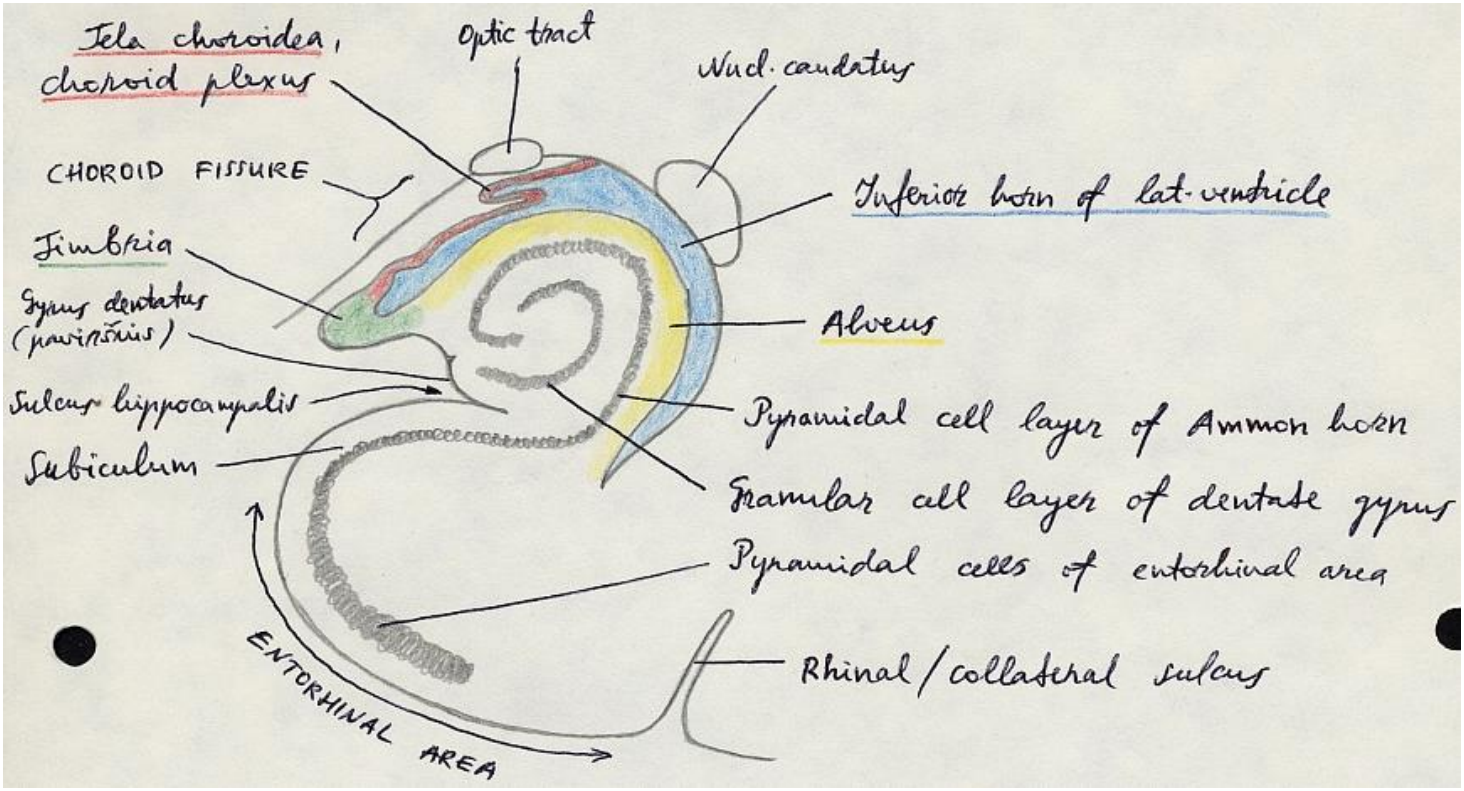
- direct and indirect pathways balance one another physiologically.
- tonic dopaminergic input (from SUBST. NIGRA COMPACTA on striatum) *activates* **direct pathway** neurons that express **D_1 receptors** and *inhibits* **indirect pathway** neurons that express **D_2 receptors**.

LIMBIC SYSTEM, HIPPOCAMPUS

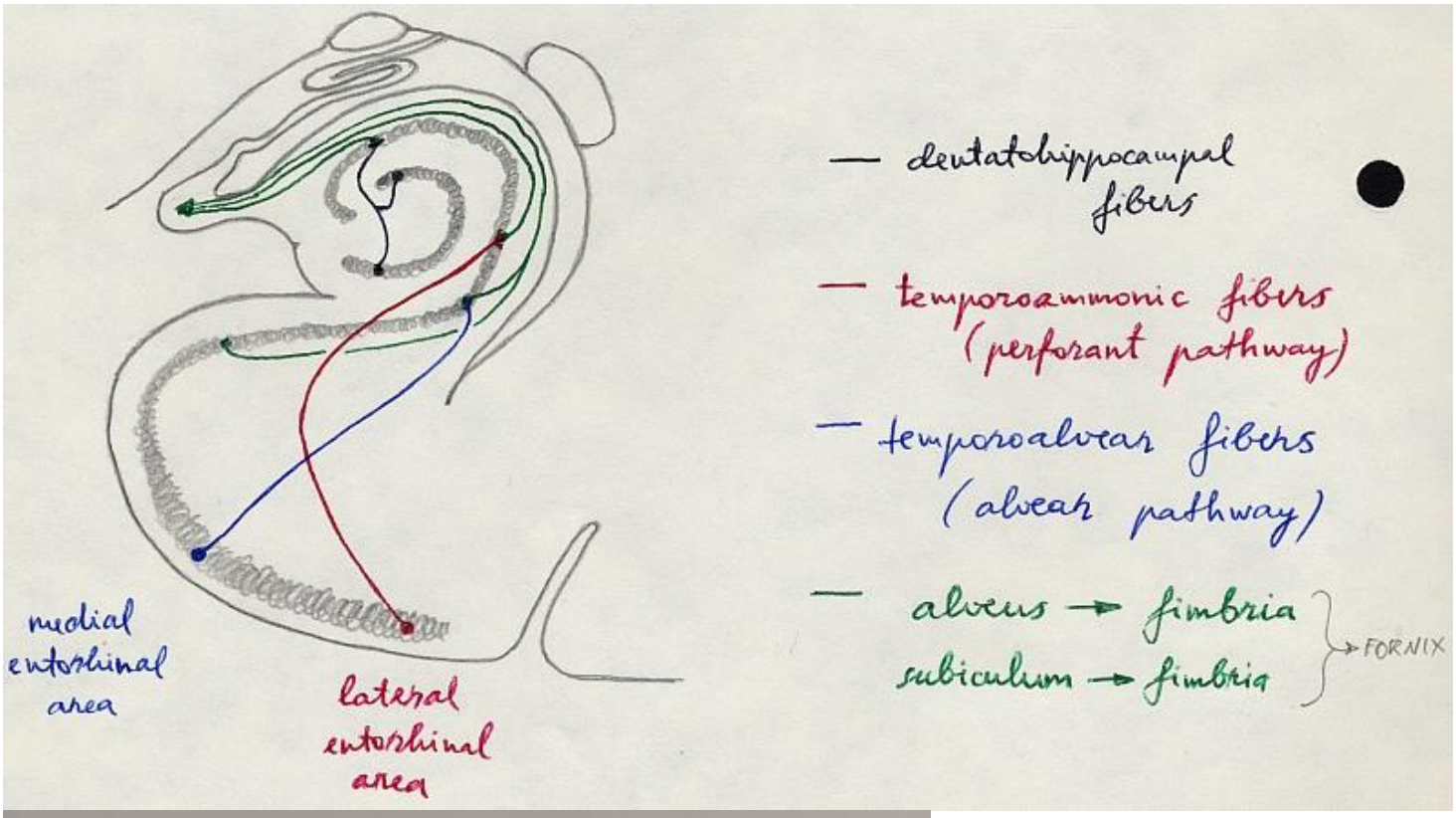
N.B. only sites in adult brain where neurons still being produced – **olfactory bulb** and **hippocampus**!

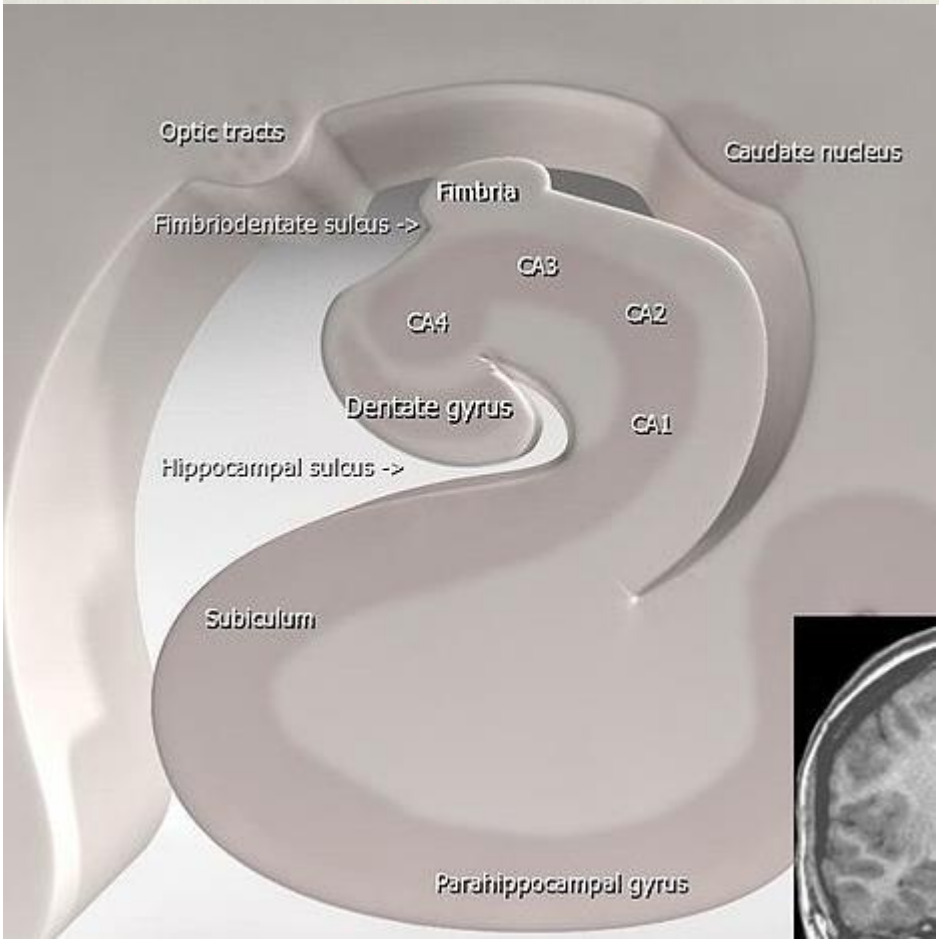
- Bilateral temporal lobe ablation → KLÜVER-BUCY syndrome:

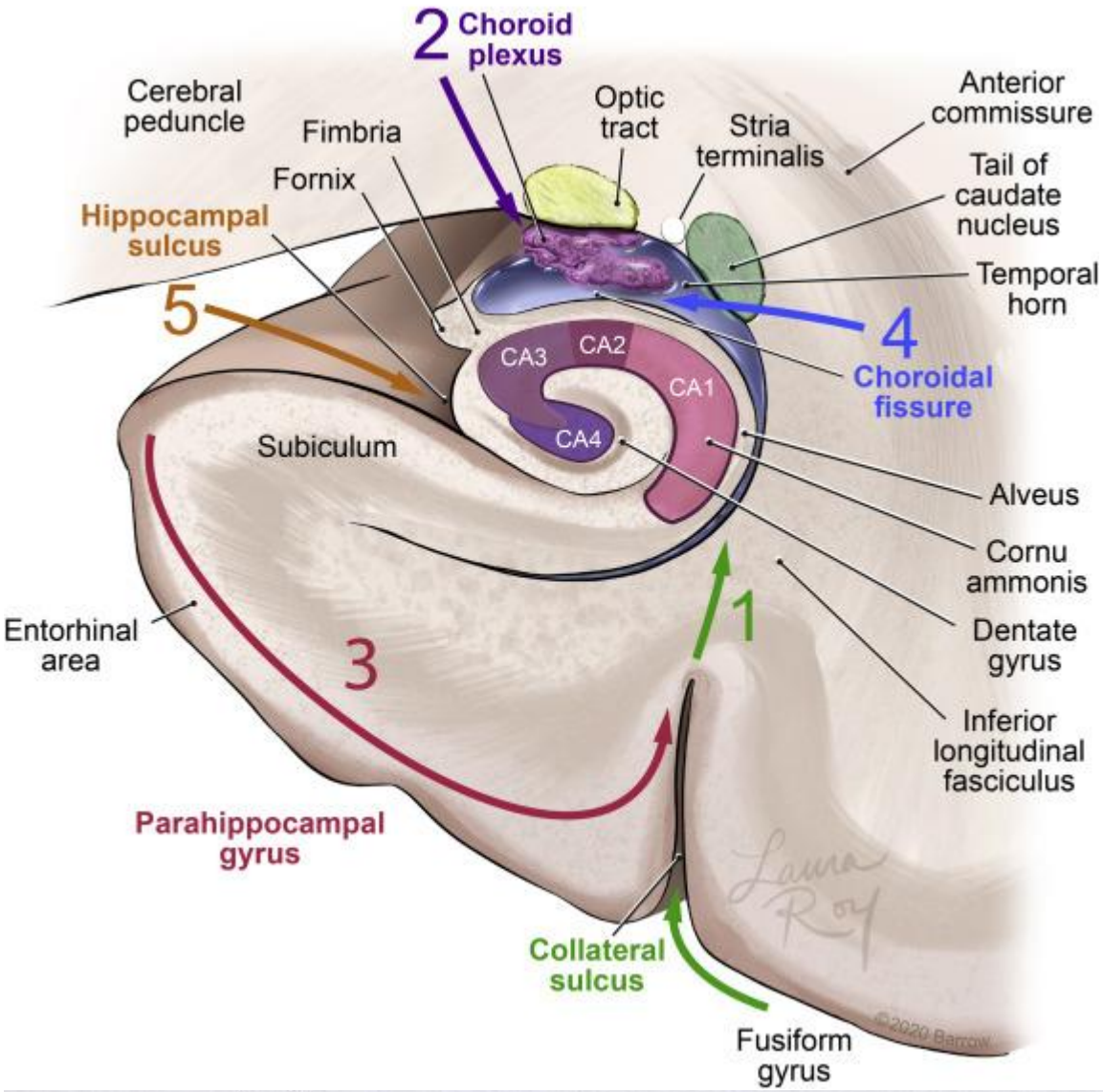
1) drive ↓, emotional reactions ↓ – Papez circuit *
2) hipersekusalumas (only in males) – amygdala *
3) psychic blindness – objects are seen, but not identified –
   – compulsions to examine objects visually, tactually and orally (increased oral activity – viską deda į burną) – temporal visual association cortex * (VISUAL AGNOSIA) ± AUDITORY AGNOSIA

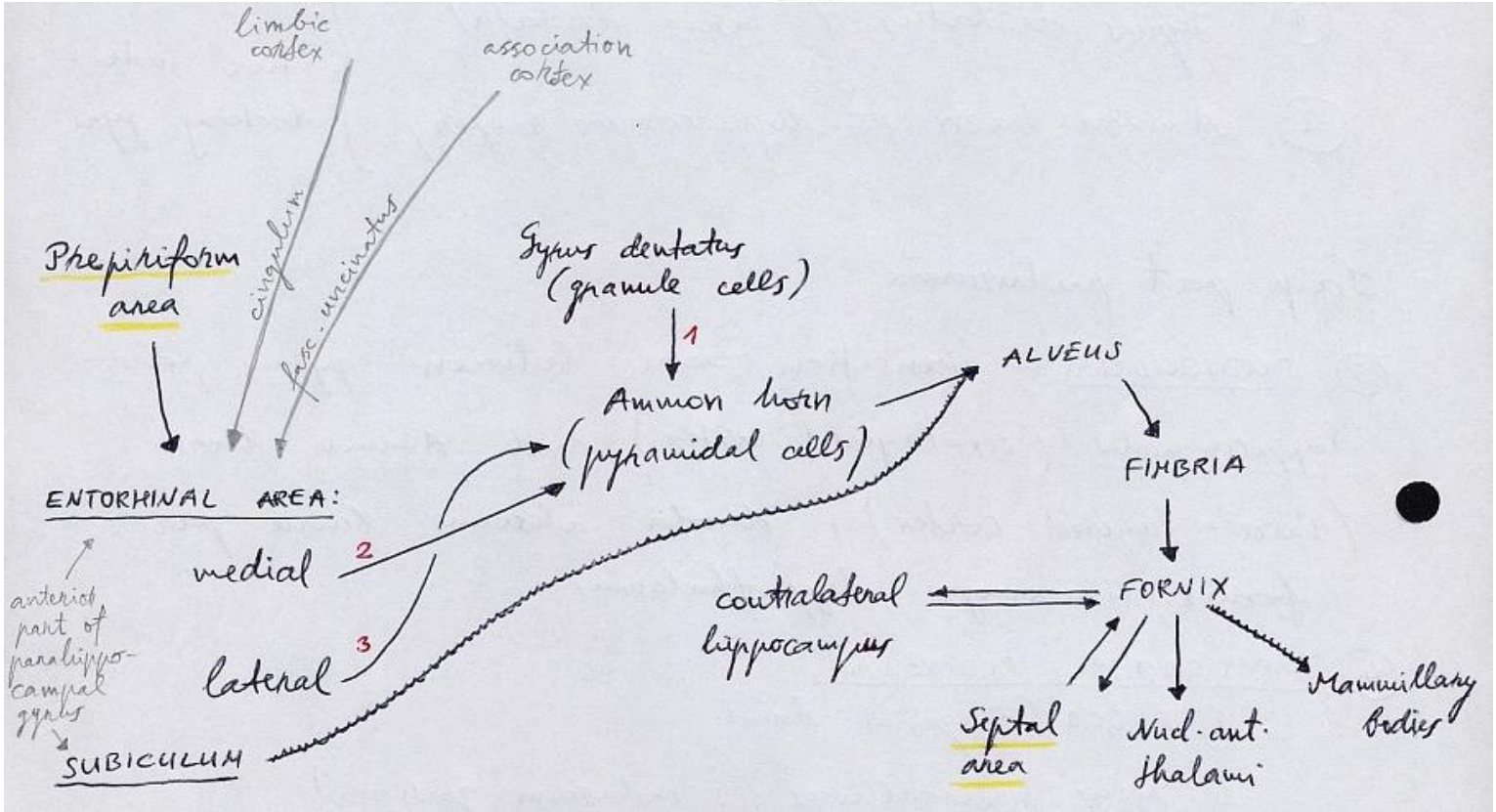


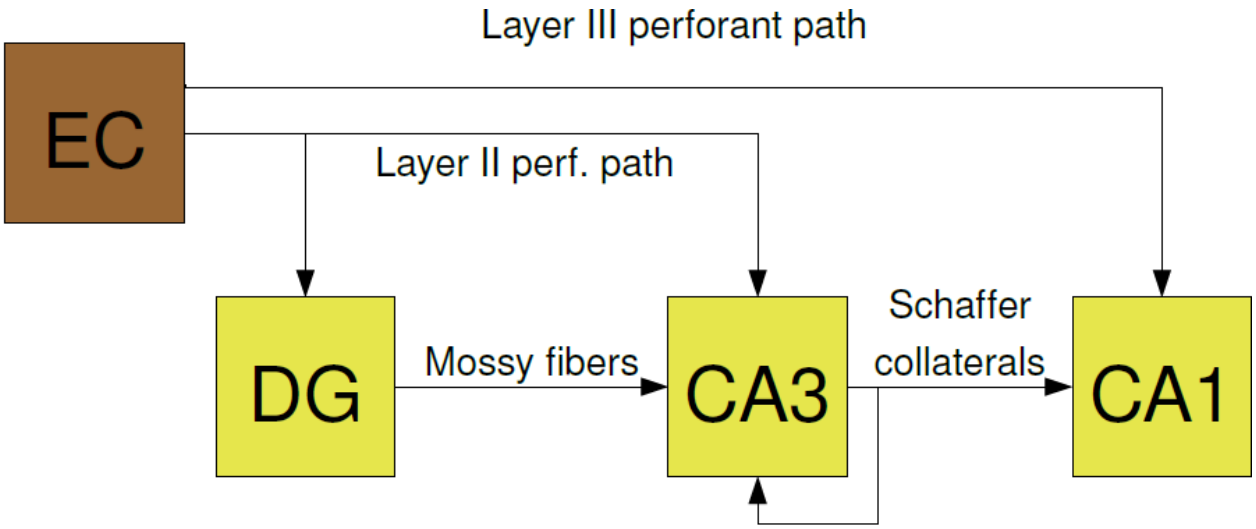
- pyramidal neurons – final common pathway from hippocampus
- hippocampus – memory + emotions (Papez circuit)


— dentatohippocampal fibers
— temporoammonic fibers (perforant pathway)
— temporoalvear fibers (alvear pathway)
— alveus → fimbria
subiculum → fimbria
FORNIX
medial entorhinal area
lateral entorhinal area


Optic tracts
Caudate nucleus
Fimbria
Fimbriodentate sulcus ->
CA3
CA4
CA2
Dentate gyrus
CA1
Hippocampal sulcus ->
Subiculum
Parahippocampal gyrus

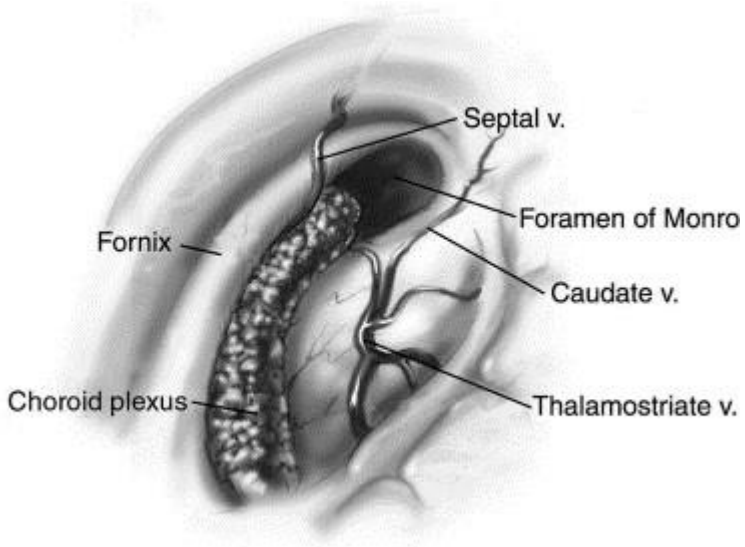

2 Choroid plexus
Cerebral peduncle
Fimbria
Fornix
Optic tract
Stria terminalis
Anterior commissure
Tail of caudate nucleus
Hippocampal sulcus
Temporal horn
5
4
Choroidal fissure
CA3
CA2
CA1
CA4
Subiculum
Alveus
Cornu ammonis
Dentate gyrus
Entorhinal area
1
3
Inferior longitudinal fasciculus
Parahippocampal gyrus
Collateral sulcus
Fusiform gyrus
©2020 Barrow


limbic cortex
association cortex
cingulum
fasc. uncinatus
Prepiriform area
Gyrus dentatus (granule cells)
1
Ammon horn (pyramidal cells)
ALVEUS
FIMBRIA
ENTORHINAL AREA:
medial
2
3
lateral
anterior part of parahippo-campal gyrus
SUBICULUM
contralateral hippocampus
FORNIX
Septal area
Nucl. ant. thalami
Mammillary bodies

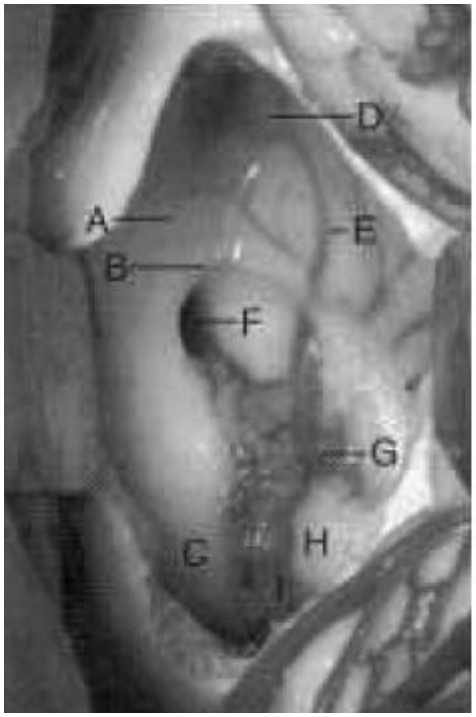


The mossy fiber synapse is one of the largest and most powerful synapses in the brain.

VENTRICLES



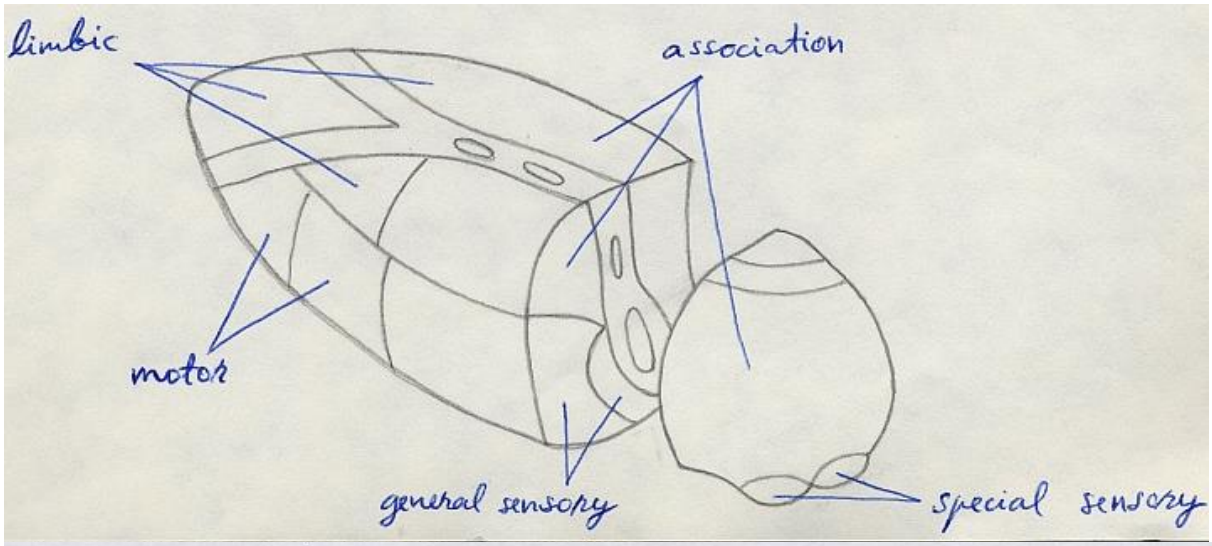
Thalamostriate (s. terminal) vein– at thalamus and caudate interface; travels together with stria terminalis.



A. Septum pellucidum
B. Column of fornix
C. Body of fornix
D. Caudate nucleus
E. Anterior caudate vein
F. Foramen of Monro
G. Thalamostriate vein
H. Thalamus
I. Choroid plexus

DIENCEPHALON

A110 >>

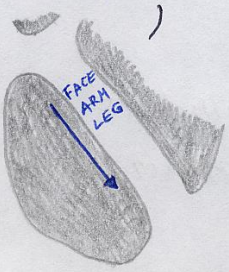


THALAMIC (s. DEJERINE-ROUSSY) SYNDROME – pažeidus n. ventralis posterior (dzn. dėl infarkto):

general sensory

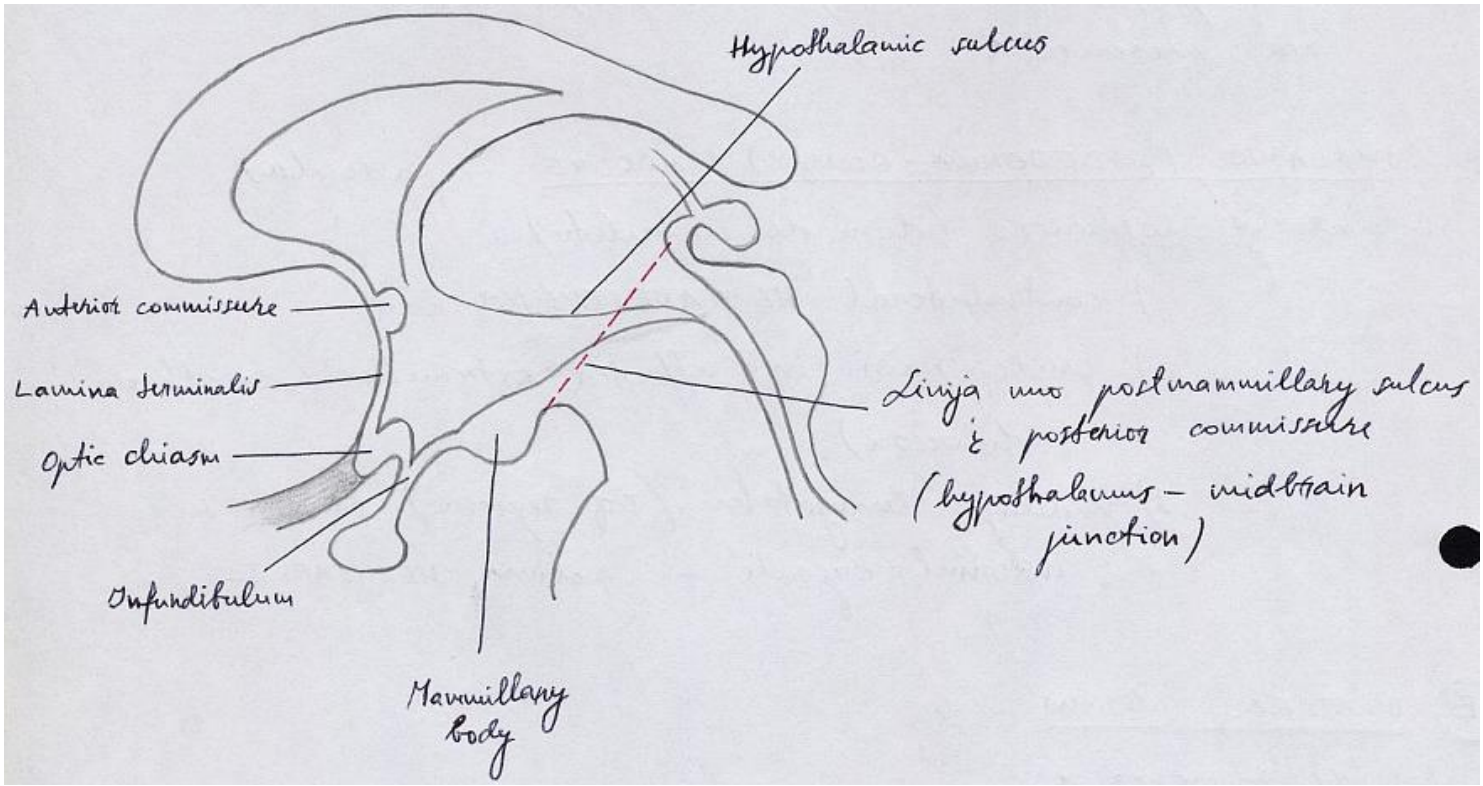
1) contralateral HEMIANESTHESIA
2) crude pain in affected extremities (anesthesia dolorosa)
3) kadangi kraujotaka (šio regiono) bendra su internal capsule – galima HEMIPAREZĖ

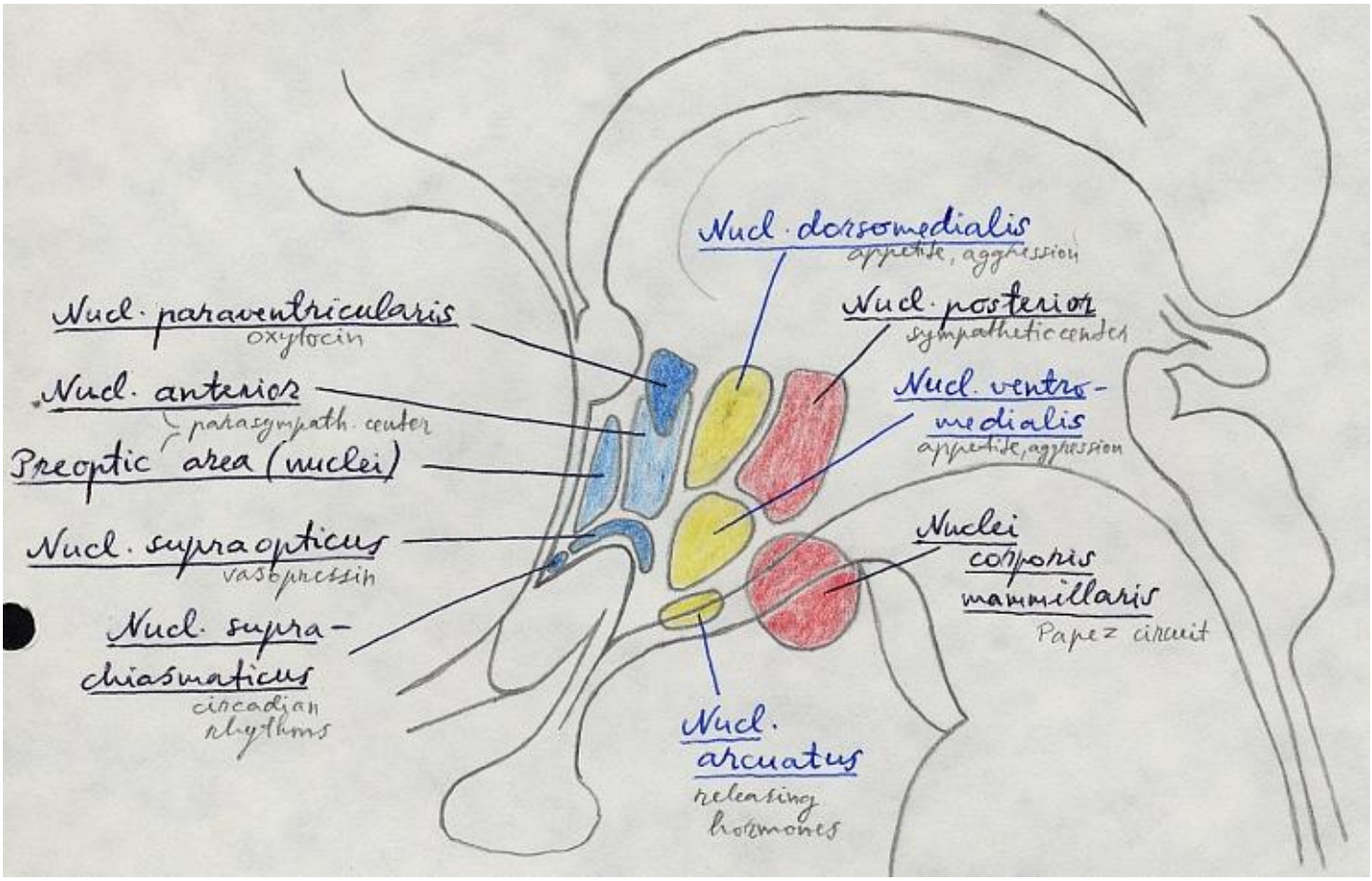
TR. CORTICOBULBARIS eina in genu
TR. CORTICOSPINALIS eina in posterior limb (kuo leidžiasi žemiau, tuo skaidulos slenkasi arčiau posterior limb užpakalinio kraštо:)



in cerebral peduncle (midbrain) FACE skaidulos guli medialiausiai, LEG - lateraliausiai

HYPOTHALAMUS





GYRI AND SULCI

A131 (1-3) >>

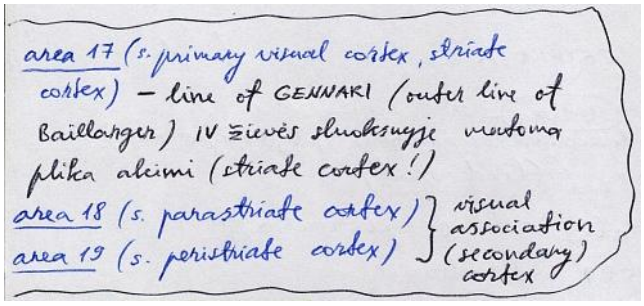
BRODMANN

47-52 areas:

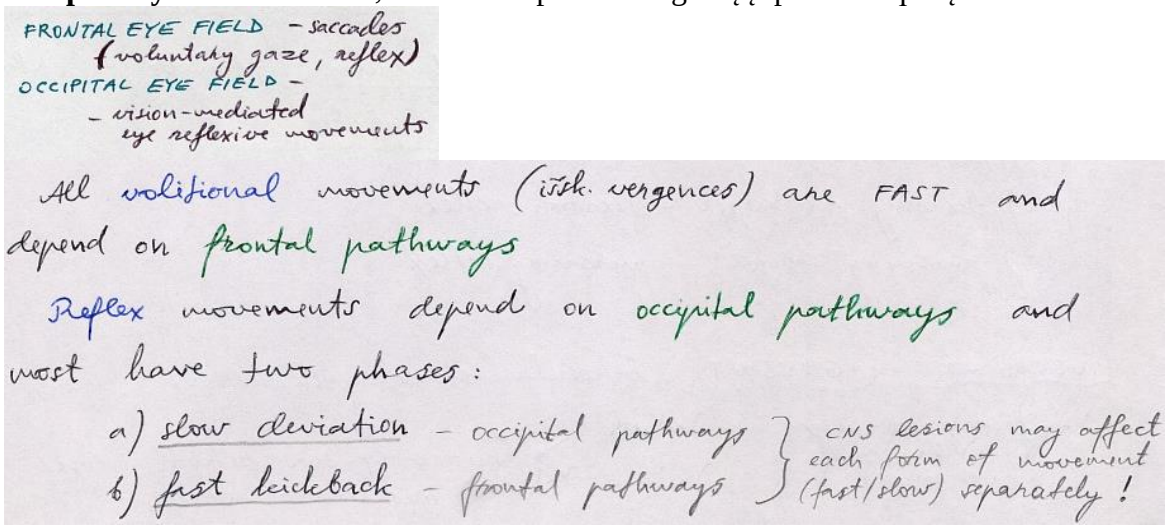
Pagal citoarchitektūrą neocortex galima suskirstyti į tris rūšis
1) motor cortex – agranular
2) sensory cortex – hypergranular
3) association cortex – tarpinė (eugranular)

PRIMARY (TONOTOPIC) AUDITORY CORTEX – receives CORE projections –
– middle part of ANTERIOR TRANSVERSE GYRUS and part of POSTERIOR TRANSVERSE GYRUS (of temporal lobe) – areas 41, 42

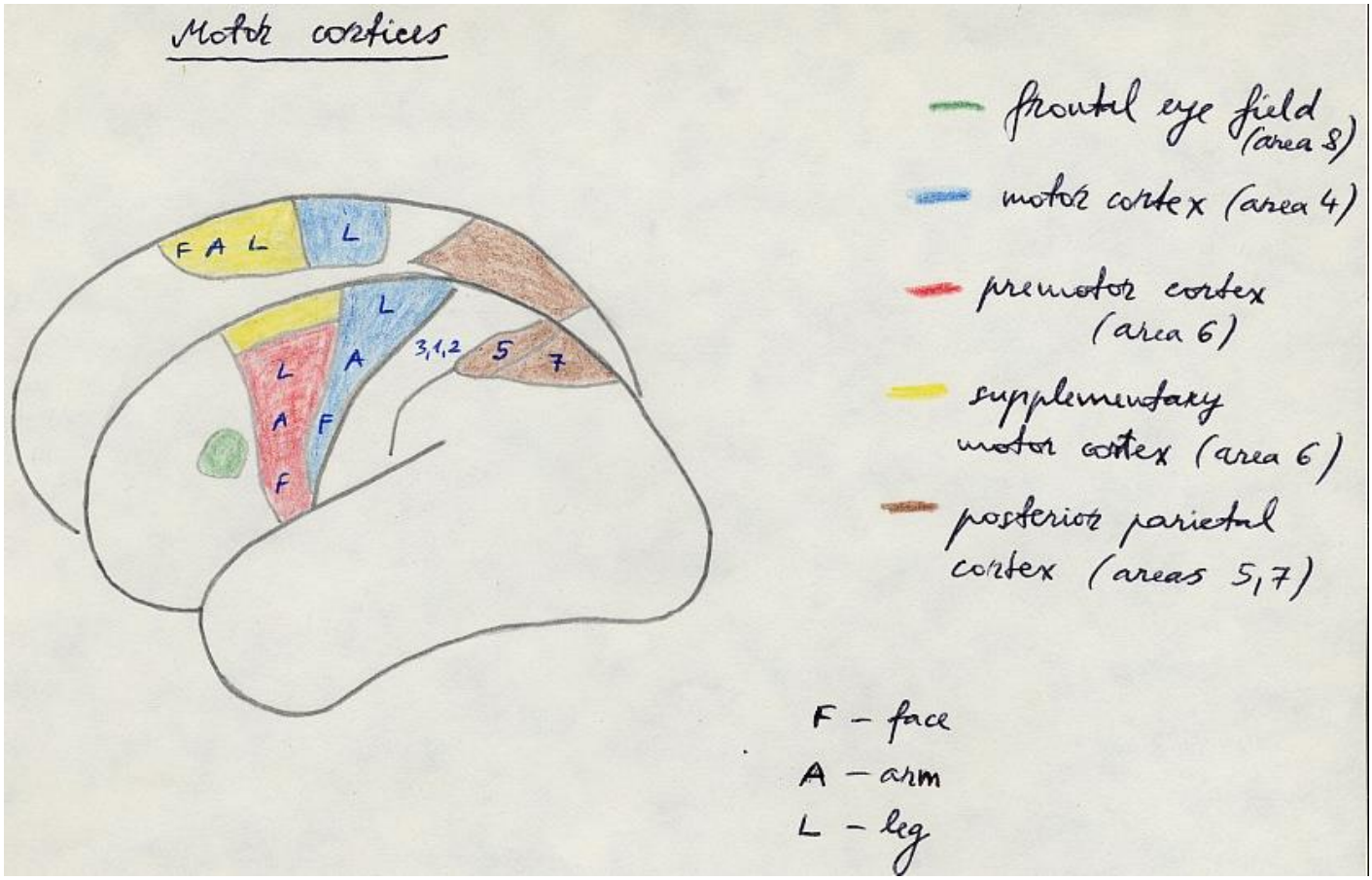
SECONDARY AUDITORY CORTEX – surrounds primary cortex and receives BELT projections – auditory association area –
– remaining parts of of POSTERIOR TRANSVERSE GYRUS and adjacent portions of SUPERIOR TEMPORAL GYRUS – area 22

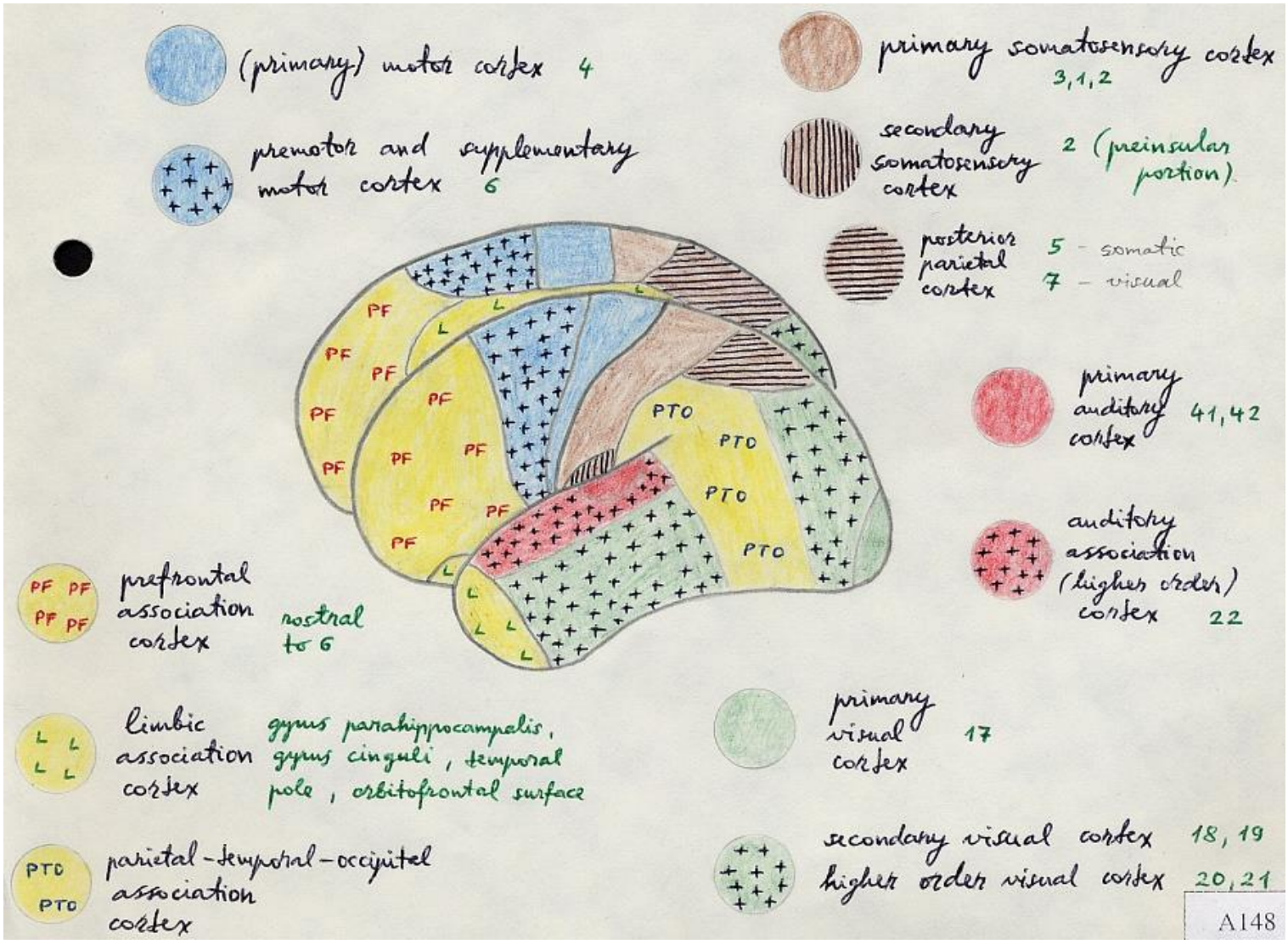


Calcarine cortex – PCA (macula area sudaro 50% ir plius gauna krauja is MCA).
Frontal eye field – area 8, ± 6 (posterior part of middle frontal gyrus) – nukreipia akis ir galvą į priešingą pusę.
Occipital eye field – area 18, 19 – nukreipia akis ir galvą į ipsilateral pusę.

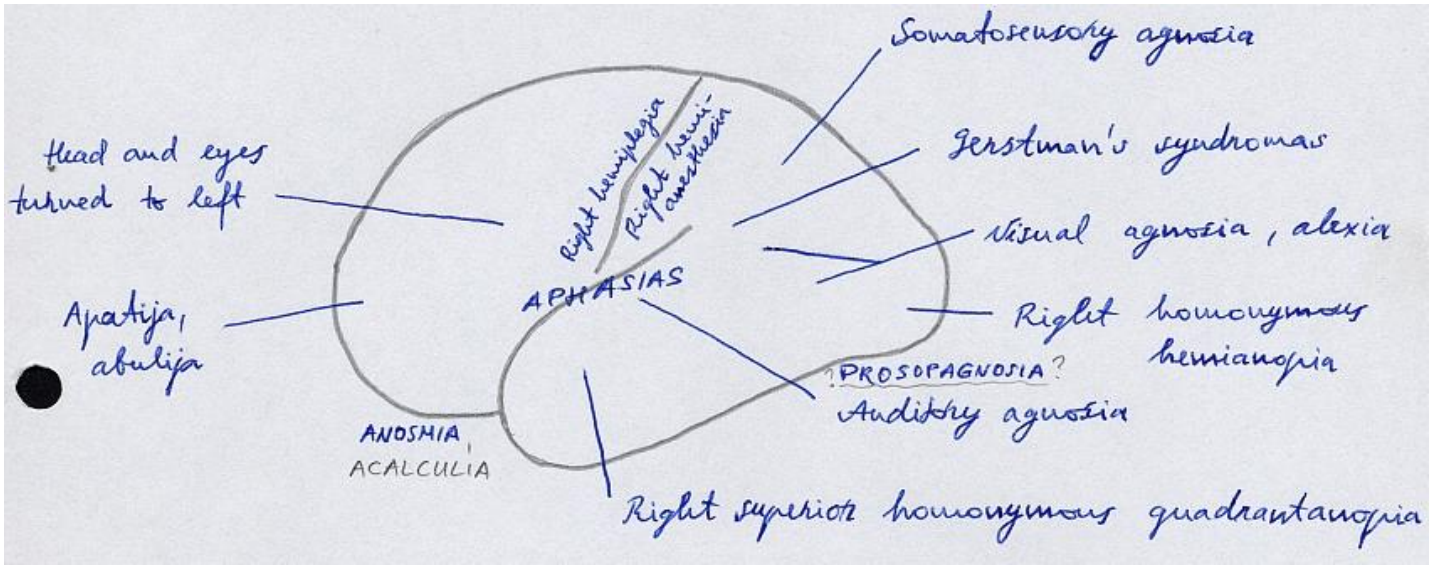


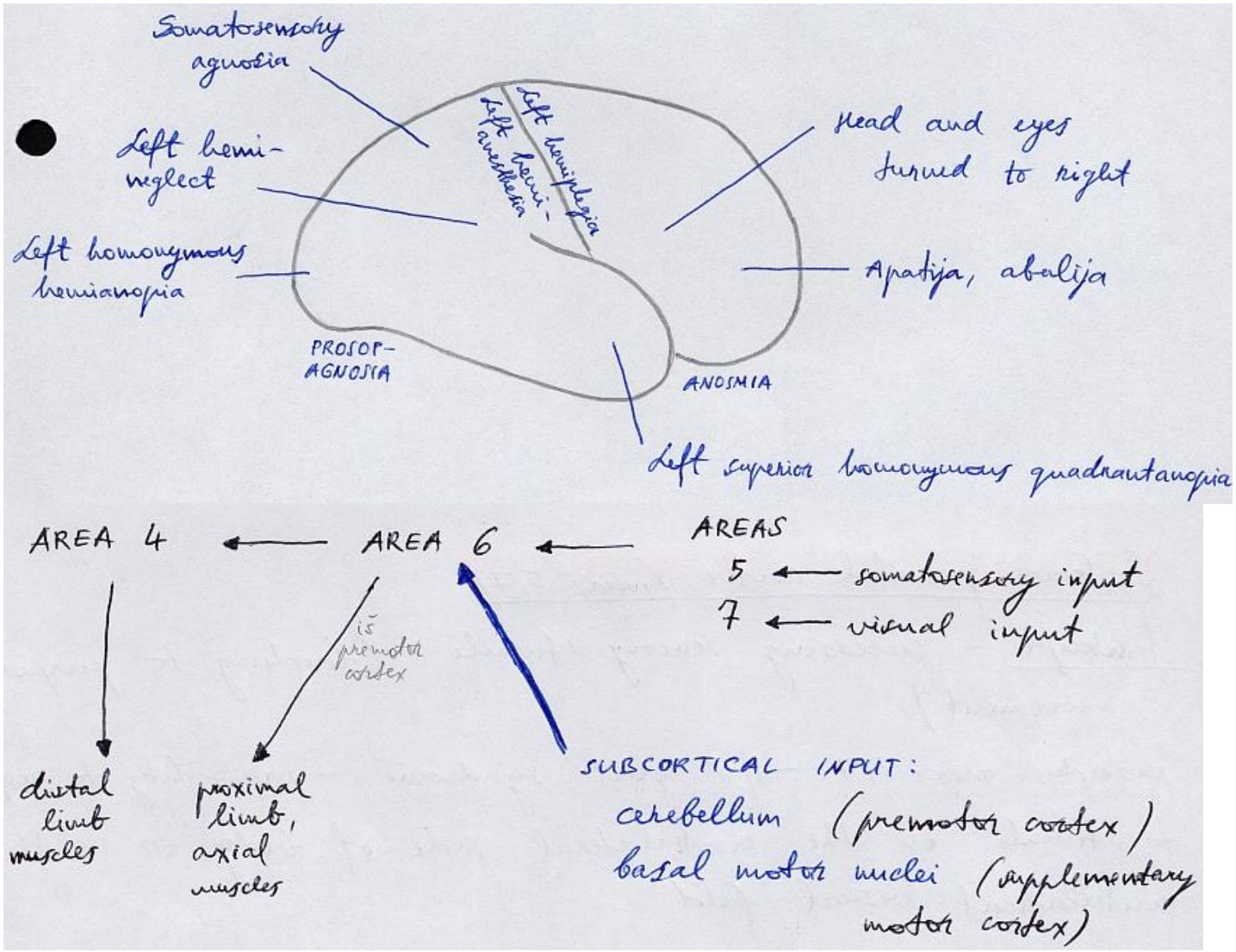
Broca speech – area 44
Motor (gyrus precentralis) – area 4
Premotor, supplementary motor – area 6
Sensory (gyrus postcentralis) – areas 1, 2, 3
Taste does not have separate cortical projection area and is represented in face area.


Motor cortices
frontal eye field (area 8)
motor cortex (area 4)
premotor cortex (area 6)
supplementary motor cortex (area 6)
posterior parietal cortex (areas 5,7)
F A L
L
L
A
F
L
A
F
3,1,2
5
7
F – face
A – arm
L – leg



CEREBRUM INJURY





Linguistic dominance and handedness:

Handedness	Dominant hemisphere (%)		
	LEFT	RIGHT	BOTH
Left or mixed	70	15	15
Right (91%)	96	4	0

SUPRATENTORIAL

Frontal lobe

1. Seizures
2. Intellectual impairment (esp. with bilateral tumors, e.g. butterfly glioma)
3. Impairment of initiative and spontaneity: abulia → akinetic mutism.
4. Personality changes: see also p. Psy5 >>
   a) dorsolateral prefrontal lesions → apathetic & indifferent (pseudodepressed)
   b) orbital prefrontal lesions → loss of inhibition & euphoric (pseudopsychopathic).
5. Motor disturbances – hemiparesis, precipitate urination (tumor of medial surfaces of frontal lobe).
6. Motor aphasia.
7. Anosmia (e.g. meningioma of olfactory groove).
8. "eyes look to stroke side / away from seizure focus" - frontal eye field

Temporal lobe

1. Seizures - complex partial (psychomotor).
2. Personality change (bizarre thinking, trance-like states, mood symptoms, immature emotional behavior; bilateral amygdaloid lesions → Klüver-Bucy syndrome).
3. Sensory aphasia, anomia.
4. Contralateral hemianopia (or at least superior quadrantanopia).
5. Impairment of recent memory (bilateral hippocampal lesions → Korsakoff amnesia)

N.B. lesions in nondominant hemisphere are often relatively "silent"!

Parietal lobe

1. Seizures - generalized or sensory focal seizures.
2. Impaired contralateral cortical sensory modalities (position sense, two-point discrimination, stereognosis)
3. Contralateral homonymous hemianopia (or at least inferior quadrantanopia).
4. Mixed expressive-receptive aphasia, anosognosia.
5. Left angular gyrus: alexia & agraphia
6. Supramarginal gyrus:

   Dominant hemisphere – Gerstmann's syndrome (agraphia, acalculia, finger agnosia, left-right confusion).

   Nondominant hemisphere – **apraxia**, contralateral **hemineglect**.

Occipital lobe

- contralateral quadrantanopia or hemianopia with sparing of macula; visual misperceptions & hallucinations; bilateral lesions – cortical blindness.

Thalamus

1. Hydrocephalus.
2. Contralateral sensory abnormality, neuropathic pain, intermittent paresthesias.
3. Involvement of ***basal ganglia*** → contralateral intention tremor, hemiballistic movement.
4. Involvement of ***hypothalamus*** → eating disorders, precocious puberty.

POSTERIOR FOSSA

- limited space + vital brain stem nuclei

1) early CSF flow obstruction → hydrocephalus (agitation with rapidly worsening mental status)
2) projectile vomiting
3) cranial nerve dysfunction (CN6, CN7)
4) nystagmus, ataxia
5) long tract signs.

BRAINSTEM

Neuronal arrangement in tegmentum:

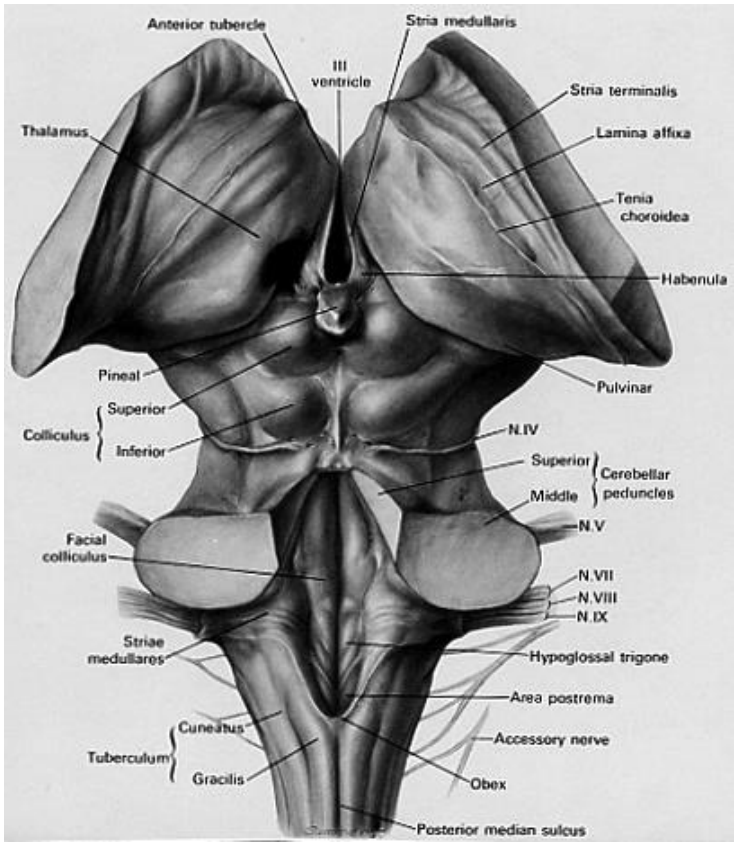
a) nuclei of CN III–XII (išsk. XI) – general (GSA, GSE, GVA, GVE) nuclei esti dorsaliausiai, special nuclei esti ventraliau
b) RF – užpildo tarpus
c) supplementary motor nuclei – esti ventraliausiai:
midbrain – red nucleus, subst. nigra
pons – nuclei basis (!) pontis
medulla – inferior olivary nuclei

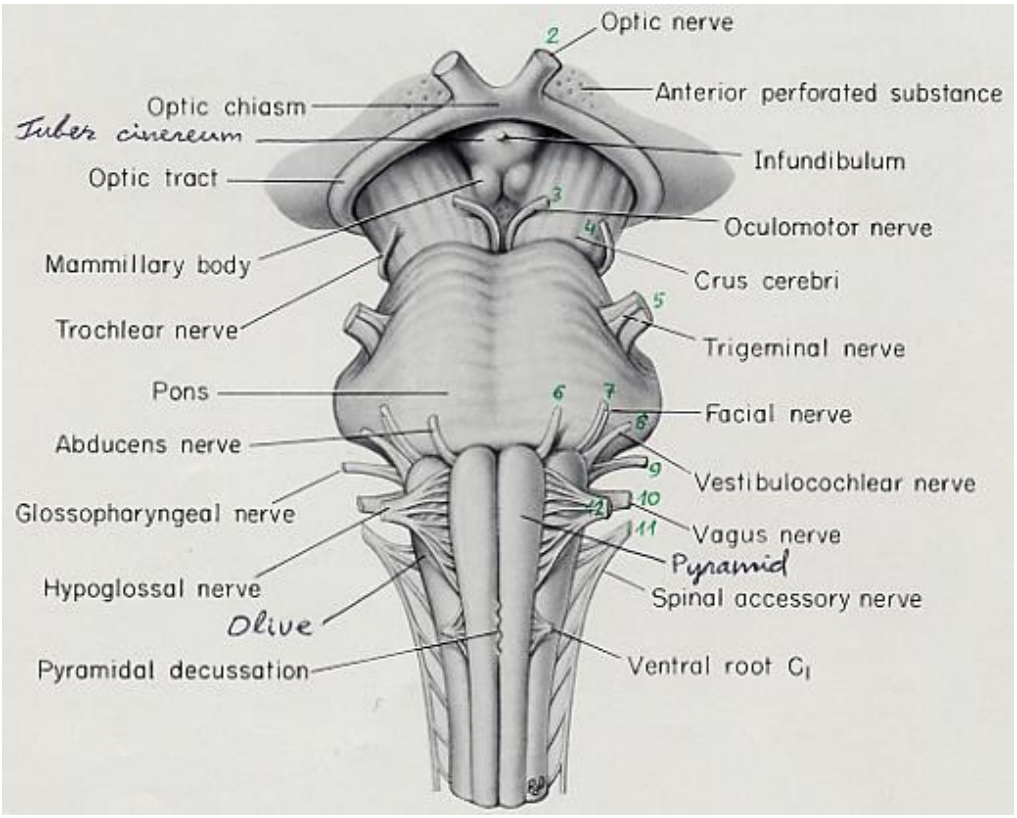
visi trys lemnisci (medial, spinal, trigeminal) baigiasi in THALAMUS – – nucl. ventralis post.

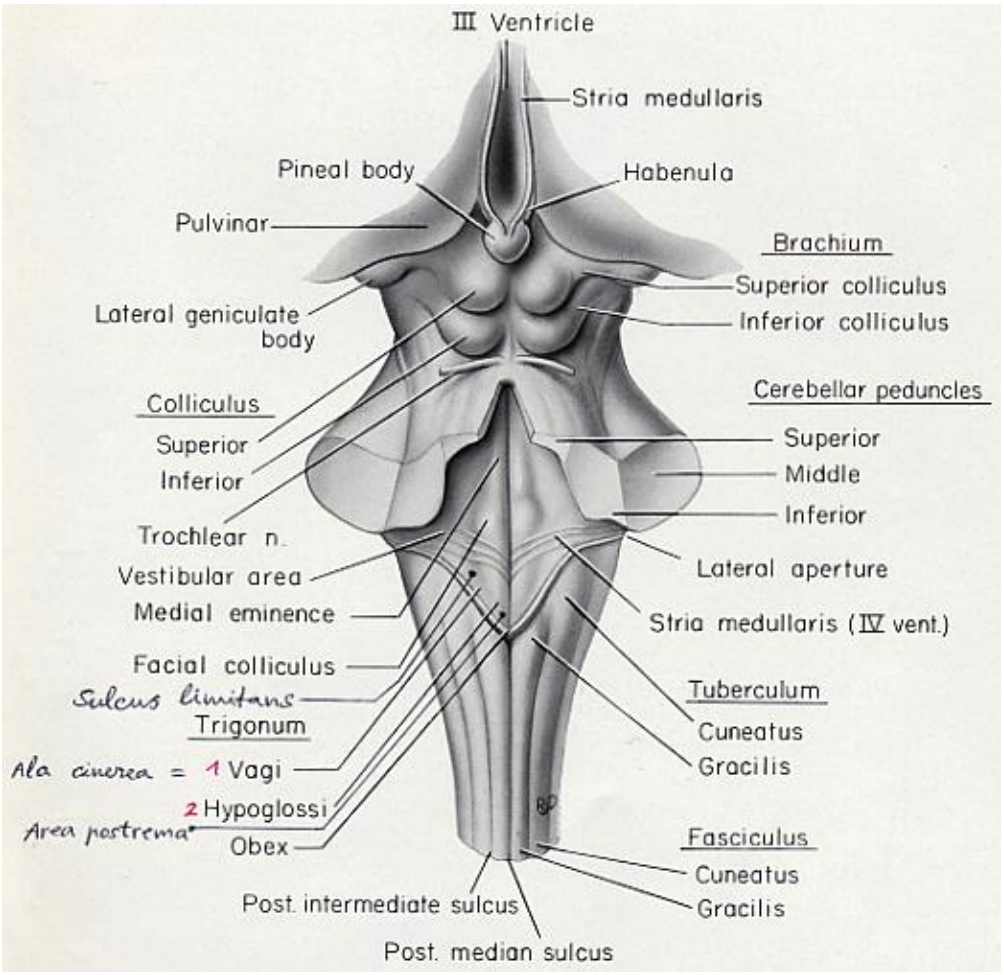
No cranial nerve nuclei occupy tectum or basis!

Brachium pontis = middle cerebellar peduncle
Brachium conjunctivum = superior cerebellar peduncle

Ala cinerea = trigonum vagi
Tuber cinereum – ten kur iseina pituitary infundibulum
Locus cinereus – rostral rhomboid fossa corner (noradrenergic neurons)







Rostral reticular formation → ARAS
Caudal reticular formation → tr. reticulospinalis

See p. A59 >>

	LATERAL			MEDIAL		
	Long tracts		**Cranial nerves**	**Long tracts**		**Cranial nerves**
Pons	TrSpinthal TrRetspin VestConn LatLem	Hiccup	CN5 (touch) CN7 (motor) CN8	TrPyr MedLem CerebellConn	Palatal myoclonus, etc	CN6 + pontine gaze center, MLF
Medulla	TrSpinthal TrRetspin VestConn CerebellConn		CN5 (pain + t-re) CN7 (taste) CN9 CN10	TrPyr MedLem		CN12

Bulbar Palsy – *peripheral* paralysis of CN9, CN10, CN12.

Pseudobulbar Palsy – *central* paralysis of CN7, CN9, CN10, CN12.

Locked-in Syndrome – complete lesion of basis pontis.

Drop Attacks – TIA in bilateral pontine / medullary PYRAMIDAL tract.

MEDIAL syndromes of medulla and pons

- paramedian branches of A. VERTEBRALIS / A. BASILARIS.

Long tracts:

1. **Tr. pyramidalis** → (contralateral) hemiplegia
2. **Medial lemniscus** → (contralateral) loss of tactile (?), position and vibratory sensation.
3. **Cerebellar connections** (superior / middle cerebellar peduncle; in pons only) → (ipsilateral) limb ataxia or nystagmus.

Pažeidimo aukštį nurodo įtraukti nervai:

Medial MEDULLARY (s. **Dejerine**) syndrome:
CN12 → (ipsilateral) tongue hemiparalysis.

Medial PONTINE syndrome:
1. **CN6 nucleus**, **pontine gaze center** → paralysis of horizontal gaze to side of lesion.
2. **MLF** → internuclear ophthalmoplegia (failure of adduction in horizontal gaze but preservation of convergence). see Eye64 p.
3. **Central tegmental tract** → palatal myoclonus accompanied by rhythmic movements of pharynx, larynx, face, eyes, or respiratory muscles.

- gaze-evoked nystagmus – due to vestibular connections, cerebellar connections, MLF.

FOVILLE syndrome (variant of alternating hemiplegia) – ipsilateral CN6, contralateral hemiplegia.

MILLARD-GUBLER syndrome (variant of alternating hemiplegia) – ipsilateral CN7, contralateral hemiplegia.

LATERAL syndromes of medulla and pons

- specific clinical features due to lateral structures:

1. **Tr. spinothalamicus** → (contralateral)* loss of pain-temperature sensation in ***trunk*** and ***extremities***.
2. **Nucl. sensorii of CN5** (descend from midpons to C_3) → (ipsilateral)* loss of cutaneous sensation in ***face***:

*i.e. crossed sensory loss

nucl. pontinus (pons) – touch;
nucl. spinalis (medulla) – pain and temperature (hypalgesia, thermoanesthesia, corneal hypesthesia).

3. **Tr. reticulospinalis** (descending sympathetic fibers from hypothalamus) → (ipsilateral) Horner's syndrome.
4. ***Vestibular connections*** → vertigo, nystagmus, nausea, vomiting.
5. ***Cerebellar connections*** (inferior / middle / superior cerebellar peduncles) → (ipsilateral) limb ataxia, asynergia, intention tremor.
6. Hiccup – unclear cause.

No plegia, no loss of touch-proprioception!

The only CONTRALATERAL sign - loss of pain-temperature sensation in ***trunk*** and ***extremities***.

Pažeidimo aukštį nurodo įtraukti nervai:

Lateral SUPERIOR PONTINE syndrome – SUPERIOR CEREBELLAR ARTERY (SCA):

Lateral lemniscus → partial hearing loss.

- vertigo is less common.
- in lesions at and above superior pons (lesion of **trigeminal lemniscus**) – sensory loss in face becomes contralateral (as in rest of body), i.e. sensory loss is no longer crossed.

Lateral INFERIOR PONTINE (s. **Marie-Foix**) syndrome – ANTERIOR INFERIOR CEREBELLAR ARTERY (AICA):

1. **Pontine gaze center** → paralysis of horizontal gaze to side of lesion.
2. **CN7** → (ipsilateral) facial paralysis
3. **CN8** → (ipsilateral) tinnitus, deafness

+ crossed hypesthesia (ipsilateral face loss of touch / contralateral body hypalgesia-thermoanesthesia)

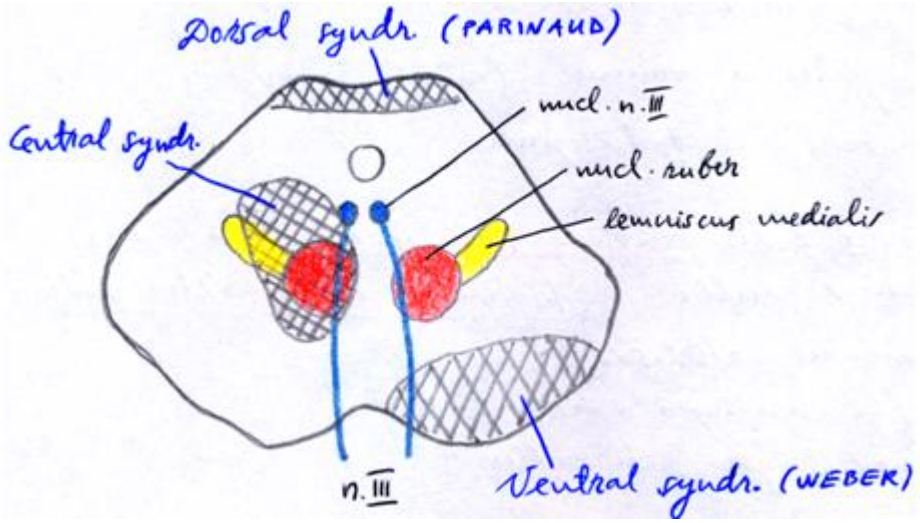
Lateral MEDULLARY (s. **Wallenberg**) syndrome – POSTERIOR INFERIOR CEREBELLAR ARTERY (PICA) (or VERTEBRAL ARTERY):

1. **Nucl. tractus solitarii** (CN7) → (ipsilateral) loss of taste.
2. **CN9**, **CN10** → dysphagia, dysarthria, etc.

+ crossed hypalgesia-thermoanesthesia (ipsilateral face / contralateral body)

Absence of pyramidal tract findings + no change in mental status

MIDBRAIN syndromes



DORSAL midbrain (s. midbrain pretectal, collicular, **Parinaud**) syndrome – lesion of **pretectal area**, **superior colliculi** (e.g. compression from above by pineal mass; PCA infarct) → supranuclear paralysis of conjugate upward gaze → downward eye deviation (rarely, if unilateral → skew deviation).

VENTRAL midbrain (s. **Weber**) syndrome - PARAMEDIAN PCA BRANCHES TO MIDBRAIN - variant of alternating hemiplegia:

1. **Tr. pyramidalis** → (contralateral) hemiplegia, incl. supranuclear CN7 palsy.
2. Ipsilateral emerging **CN3** fibers.

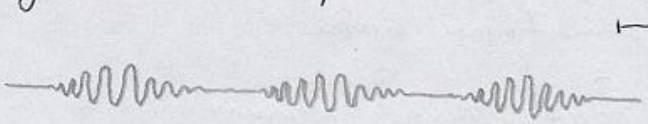
CENTRAL (s. tegmental) midbrain syndrome:

1. **CN3** nucleus
2. **Medial lemniscus**, **tr. spinothalamicus** → (contralateral) hemianesthesia
3. **Nucl. ruber**, **subst. nigra** → (contralateral) hemichorea, hemiparkinsonism.

- if bilateral (**rostral RF** – ARAS) → coma.

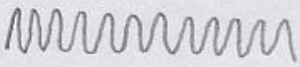
in bilateral lesions of tegmentum (RF) of:

DIENCEPHALON – Cheyne-Stokes respiration:



MIDBRAIN – central neurogenic hyperventilation:

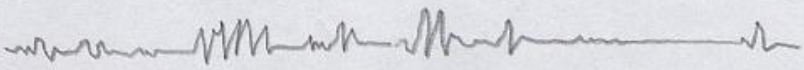
leads to severe ALKALOSIS



iš esmės, pažeidimai rostralian pons palieka pakankamą ventiliaciją

Caudal PONS – apneustic or cluster breathing:

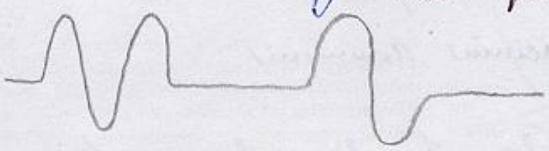
MEDULLA – ataxic breathing or apnea:
(gasping)



pagal STEDMAN:
BIOT = ATAXIC Breathing

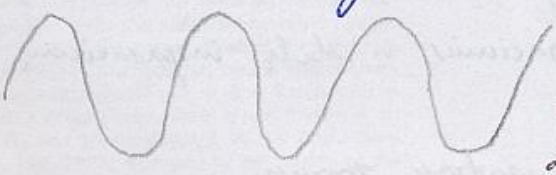
Kiti patologiniai kvėpavimo tipai:

BIOT's breathing – irregular rhythm, rate and depth



– sukelia ICP↑ (e.g. meningitis)

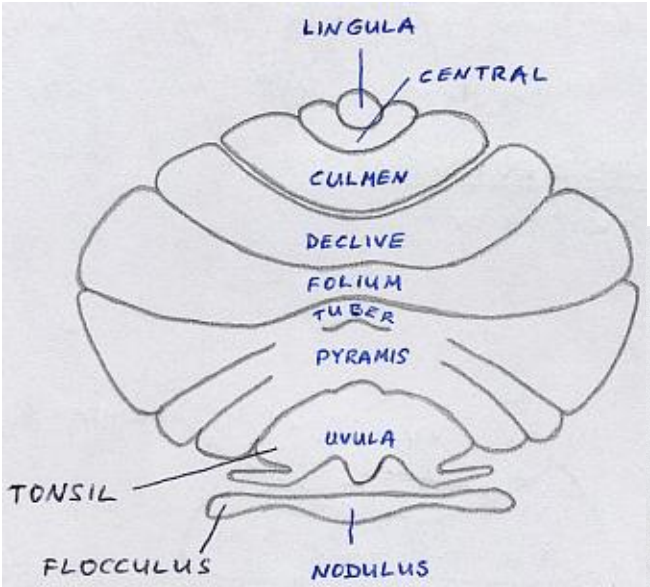
KUSSMAUL's breathing

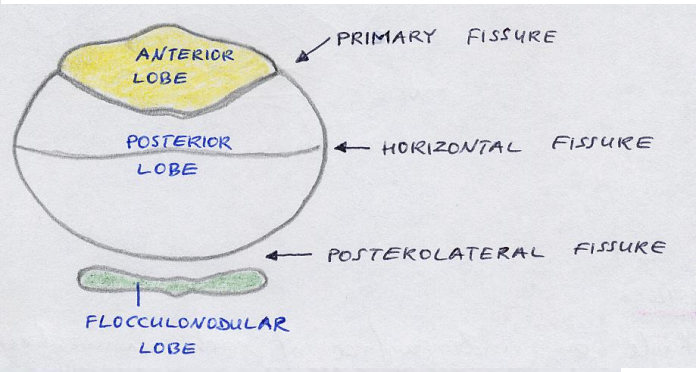


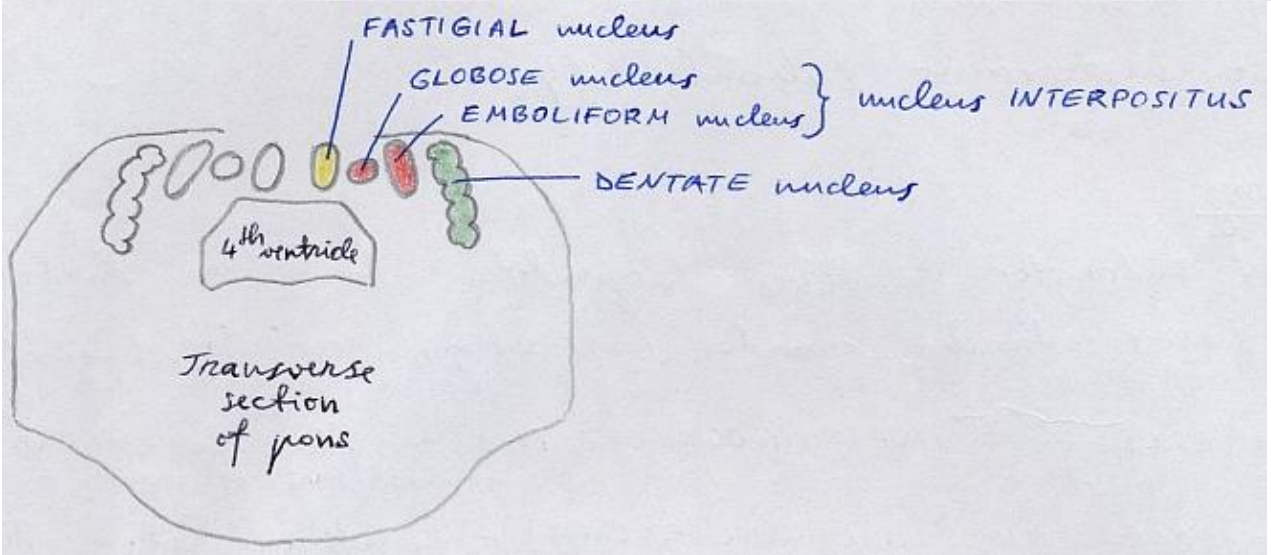
– organizmas stengiasi kompensuoti metabol. acidozę (pvz.: diabetic ketoacidosis)

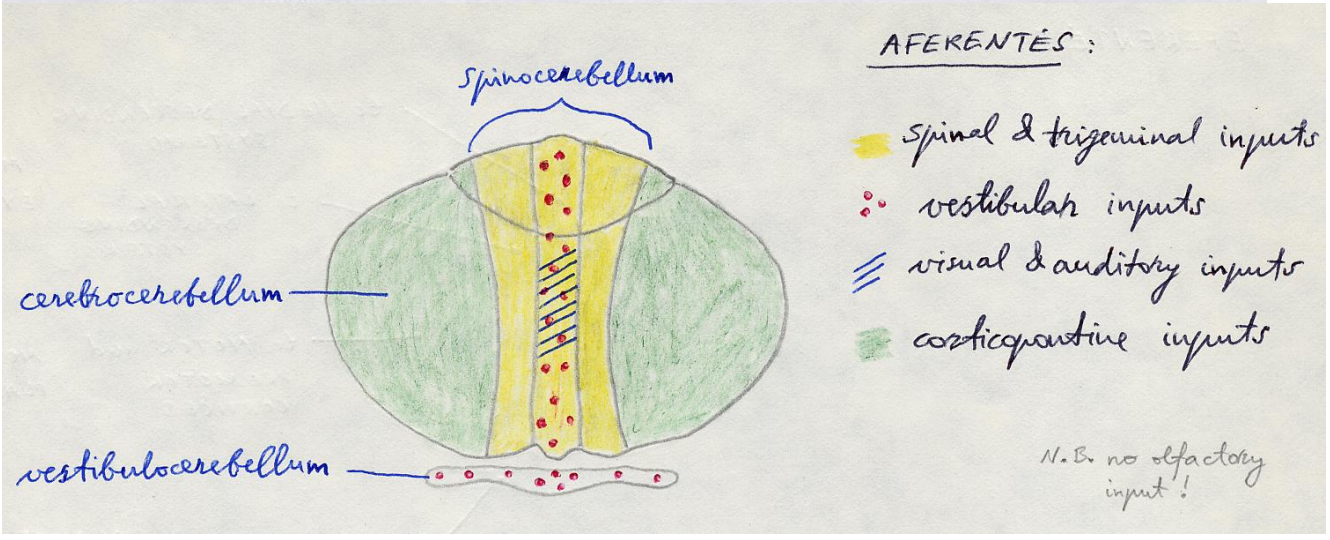
• tai gilus atsarimas (hyperpnea), o dažnis gali būti lėtas ÷ greitas

CEREBELLUM

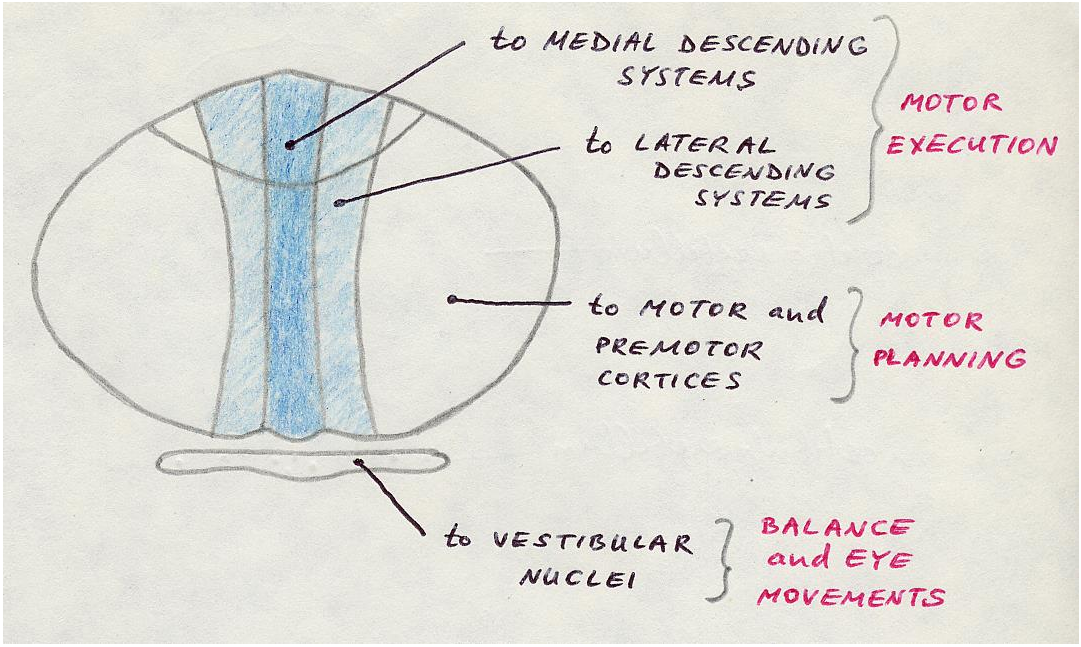

LINGULA
CENTRAL
CULMEN
DECLIVE
FOLIUM
TUBER
PYRAMIS
UVULA
TONSIL
FLOCCULUS
NODULUS


ANTERIOR LOBE
PRIMARY FISSURE
POSTERIOR LOBE
HORIZONTAL FISSURE
POSTEROLATERAL FISSURE
FLOCCULONODULAR LOBE

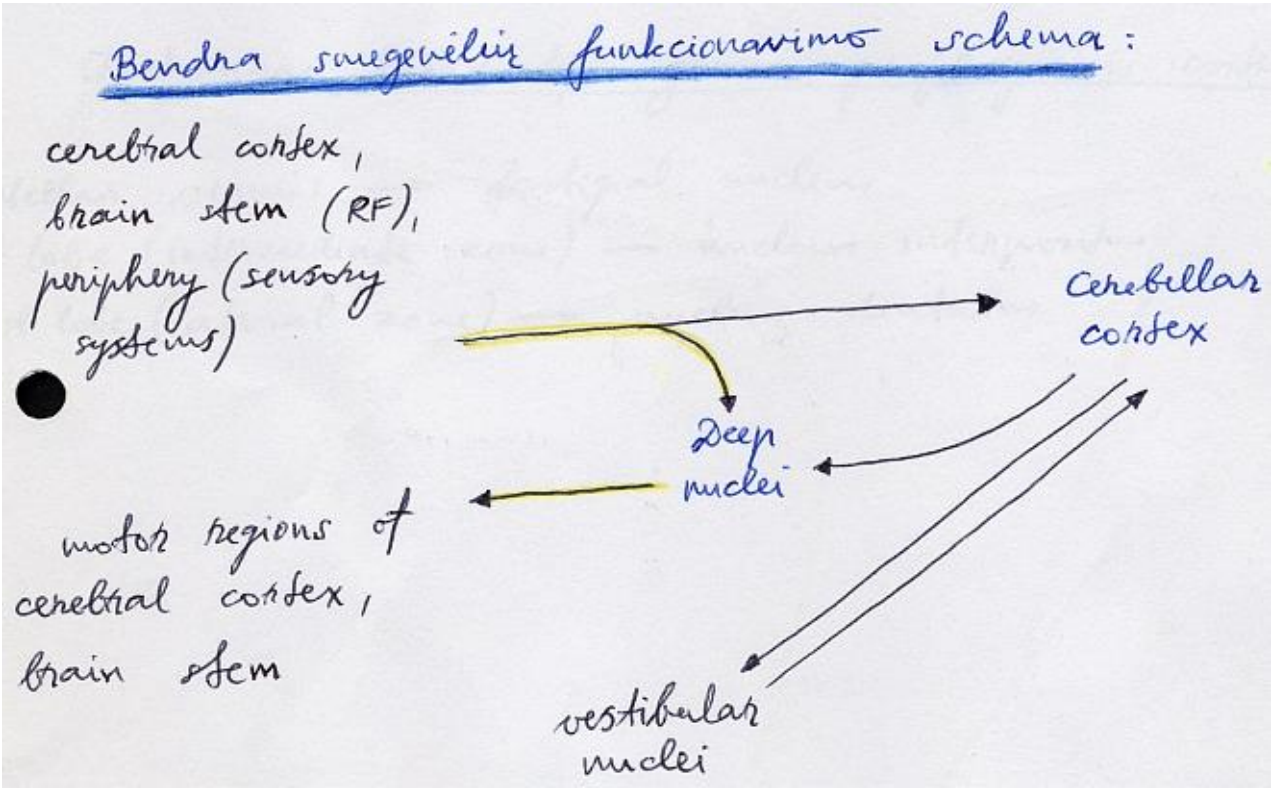

FASTIGIAL nucleus
GLOBOSE nucleus
EMBOLIFORM nucleus
nucleus INTERPOSITUS
DENTATE nucleus
4th ventricle
Transverse section of pons


Spinocerebellum
cerebrocerebellum
vestibulocerebellum
AFERENTÉS :
spinal & trigeminal inputs
vestibular inputs
visual & auditory inputs
corticopontine inputs
N.B. no olfactory input !

Efferents:



Purkinje cells (largest neurons in the body) – final common output pathways for cerebellum.



Pagal afferent input:

① ARCHICEREBELLUM (VESTIBULOCEREBELLUM) – flocculonodular lobe, ventral parts of uvula and lingula

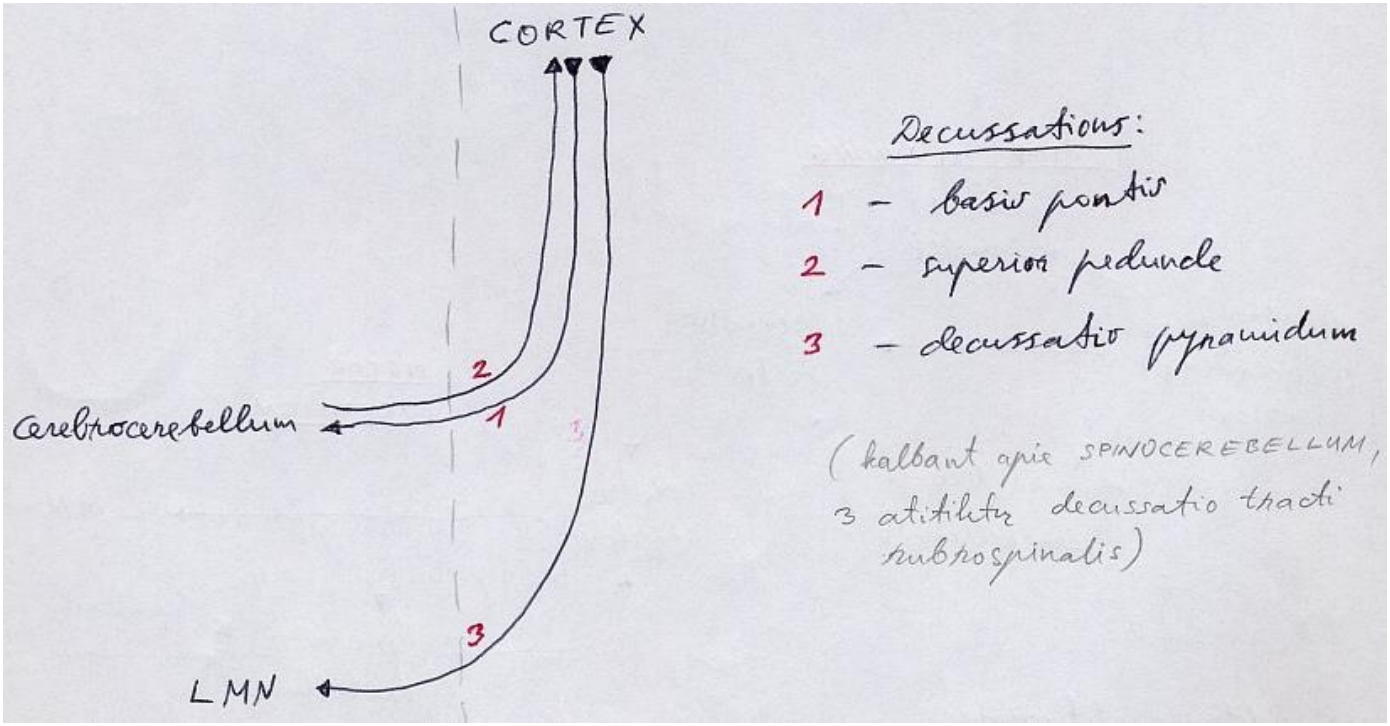
- ***inferior*** cerebellar peduncle; connections bypass deep nuclei.

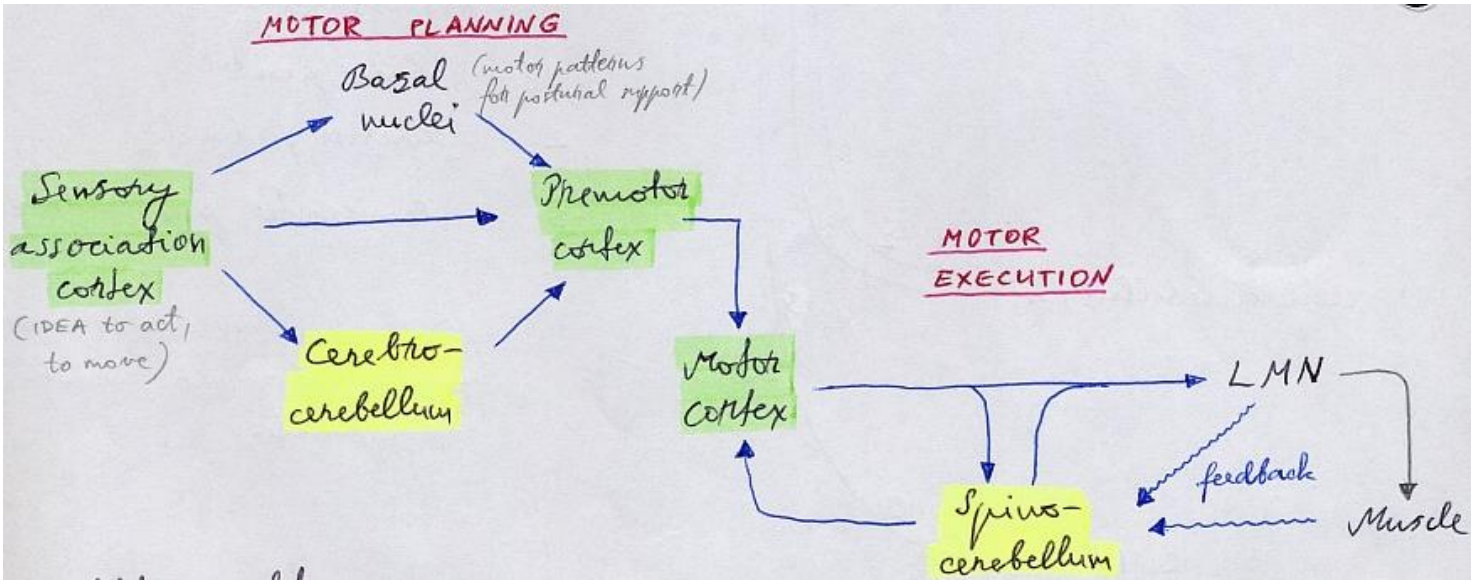
② PALEOCEREBELLUM (SPINOCEREBELLUM) – anterior lobe (intermediate zone and vermis)

③ NEOCEREBELLUM (CEREBROCEREBELLUM s. PONTOCEREBELLUM) – lateral zone

- input from cerebrum via pontine nuclei (no input from periphery)

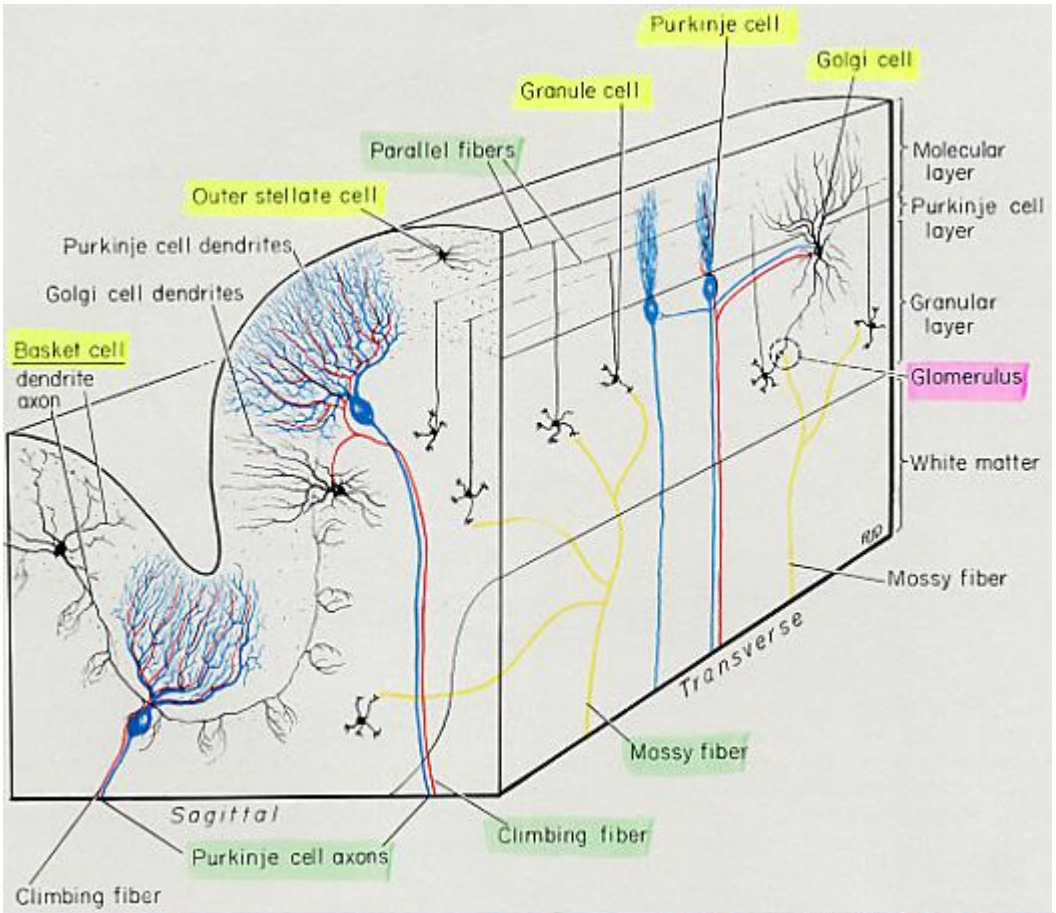
- output via ***superior*** cerebellar peduncle → dentate nucleus (not tr. rubrospinalis!) → cortex





Cerebellar peduncles:
Superior – efferent
Middle – afferent
Inferior:
restiform body – afferent
juxtarestiform body – bidirectional (with vestibular nuclei)

CORTEX

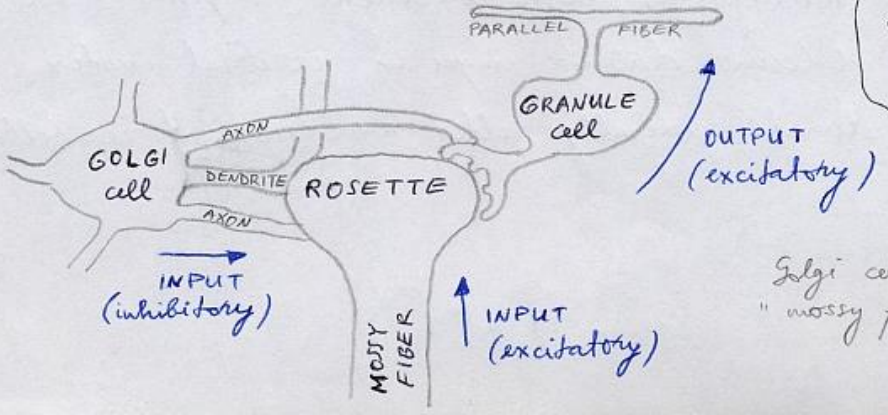


GRANULE cells – afferent neurons → PARALLEL fibers
GOLGI, BASKET, STELLATE cells – inhibitory interneurons
PURKINJE cells – efferent neurons

Inferior olivary nucleus → climbing fibers → Purkinje dendritic synapses
All other inputs → mossy fibers → glomerulus core

Cerebellar glomerulus – synaptic complex, surrounded by glial capsule in granular layer

- core – mossy fiber ending (rosette)
- ant core daugybė sinapsių:
  1) axons and dendrites of Golgi cells
  2) dendrites of granule cells
- in light microscopy appear as clear spaces in dark granular layer
- schema:



Golgi cell slopina transmisiją "mossy fiber → granule cell"

A91 (3)

1. All extrinsic incoming fibers (climbing & mossy) are EXCITATORY

2. Iš žievės neuronų – tik granule cells (parallel fibers) are EXCITATORY (GLUTAMATE); visi kiti žievės neuronai – ± INHIBITORY (GABA) !

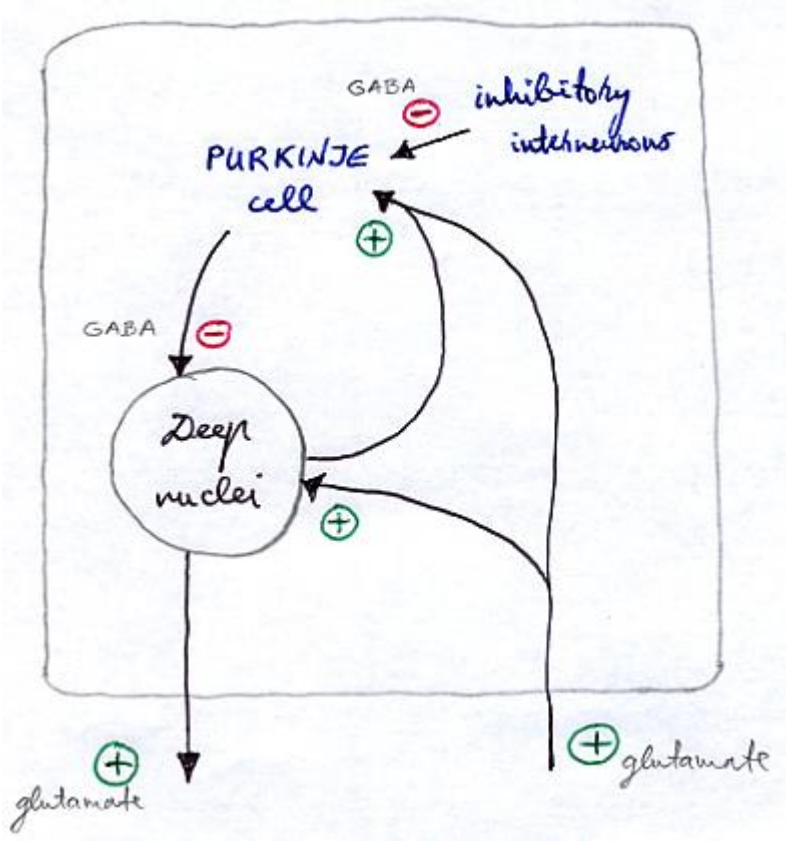
3. Taigi, deep nuclei gauna inhibicijos iš Purkinje fibers ir excitation iš climbing & mossy fibers kolateralių. Patys deep nuclei duoda excitatory fibers

4. Ir glomerulus: Golgi cell inhibuoja, mossy fiber excituoja granule cell

5. Purkinje cells excitacijos gauna iš climbing fibers ir mossy → parallel fibers

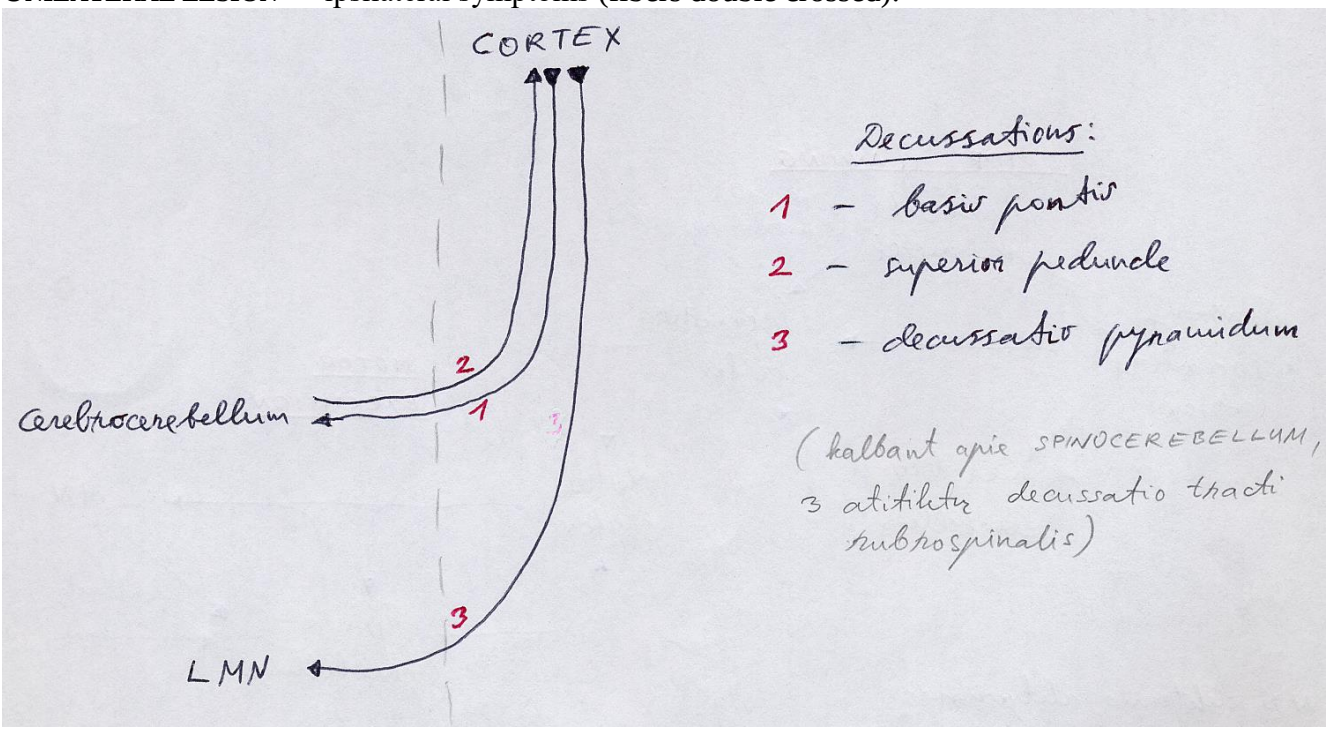
⊖ inhibicijos gauna iš interneuronų:
a) Golgi cells
b) stellate cells
c) basket cells

Rezume: vienintelės INHIBICINĖS smulkiosios smegenėlėse yra 4 CORTEX neuronų tipai (Purkinje + Golgi, stellate + basket)



LESIONS

UNILATERAL LESION → ipsilateral symptoms (fibers double crossed):



CEREBELLAR MUTISM, S. **POSTERIOR FOSSA SYNDROME** (anatomic origin - *deep cerebellar nuclei*): apathy, minimal-to-absent speech, pseudobulbar emotional lability, refusal to initiate movement, cerebellar dysfunction, hemiparesis, swallowing apraxia

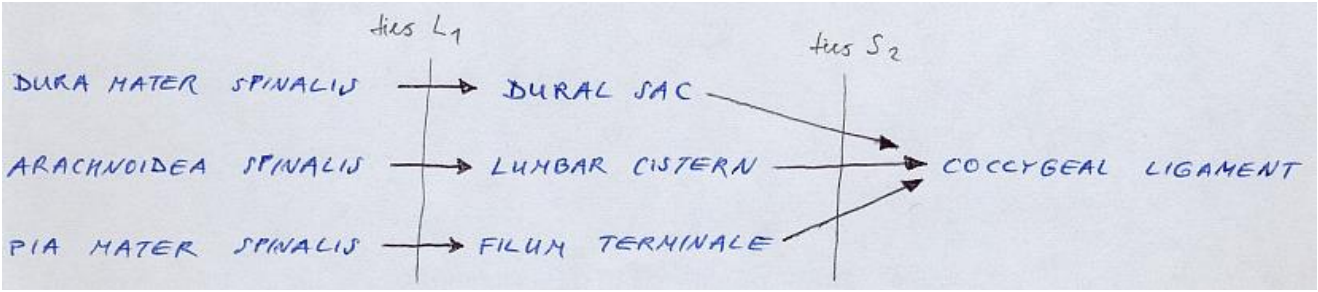
- becomes apparent 12-48 hours after posterior fossa surgery.

SPINAL CORD

Law of BELL and MAGENDIE

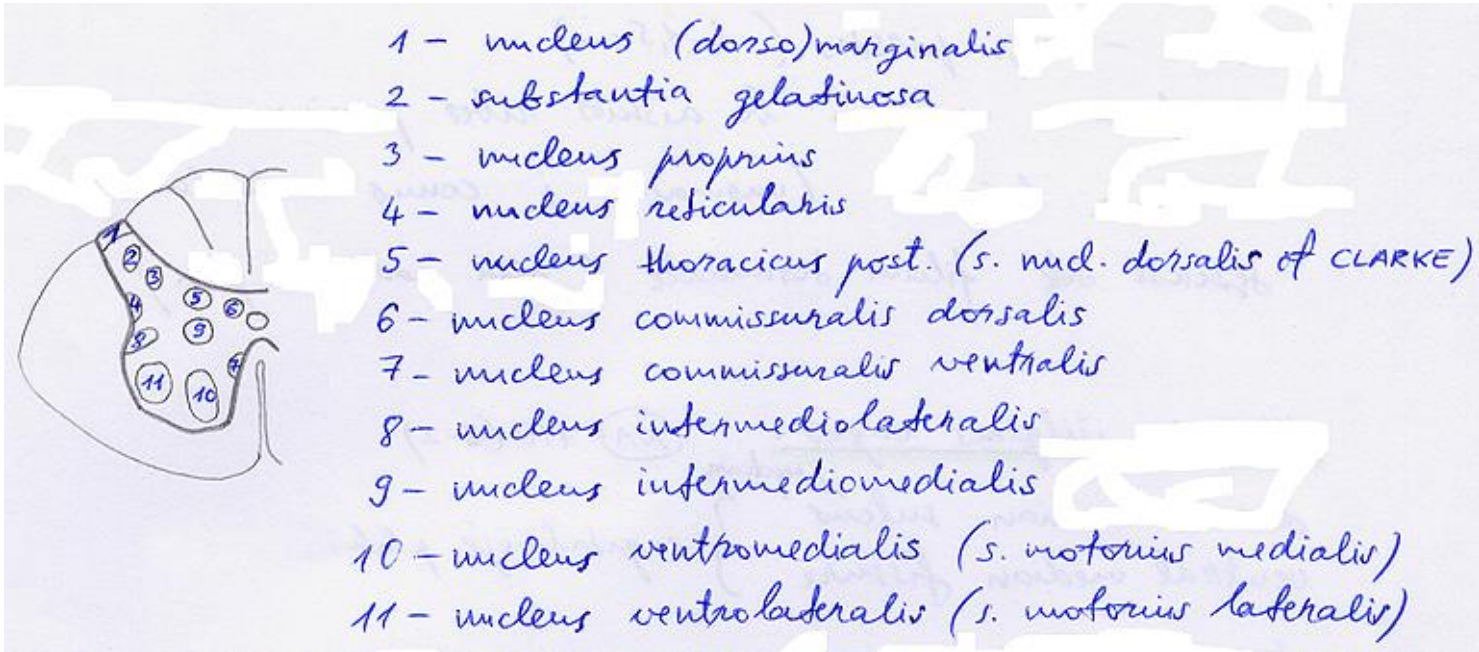
Ventral spinal roots – motor (efferent)

Dorsal spinal roots – sensory (afferent)



N.B. 1% žmonių (ypač žemiems) ingaras sm. baigiasi ties L_{2-3} disku – lumbalinė punkcija abs. kontraindikuotina aukščiau L_3 !

C1 dermatome does not exist!



nucl. proprius → tr. spinothalamicus

nucl. Clarke → tr. spinocerebellaris post.

nucl. of ONUFROWICZ IX (S_2) – innervates external vesical and anal SPHINCTERS

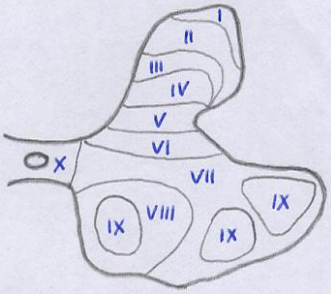
REXED divided the perikaryal columns into LAMINAE I – X :

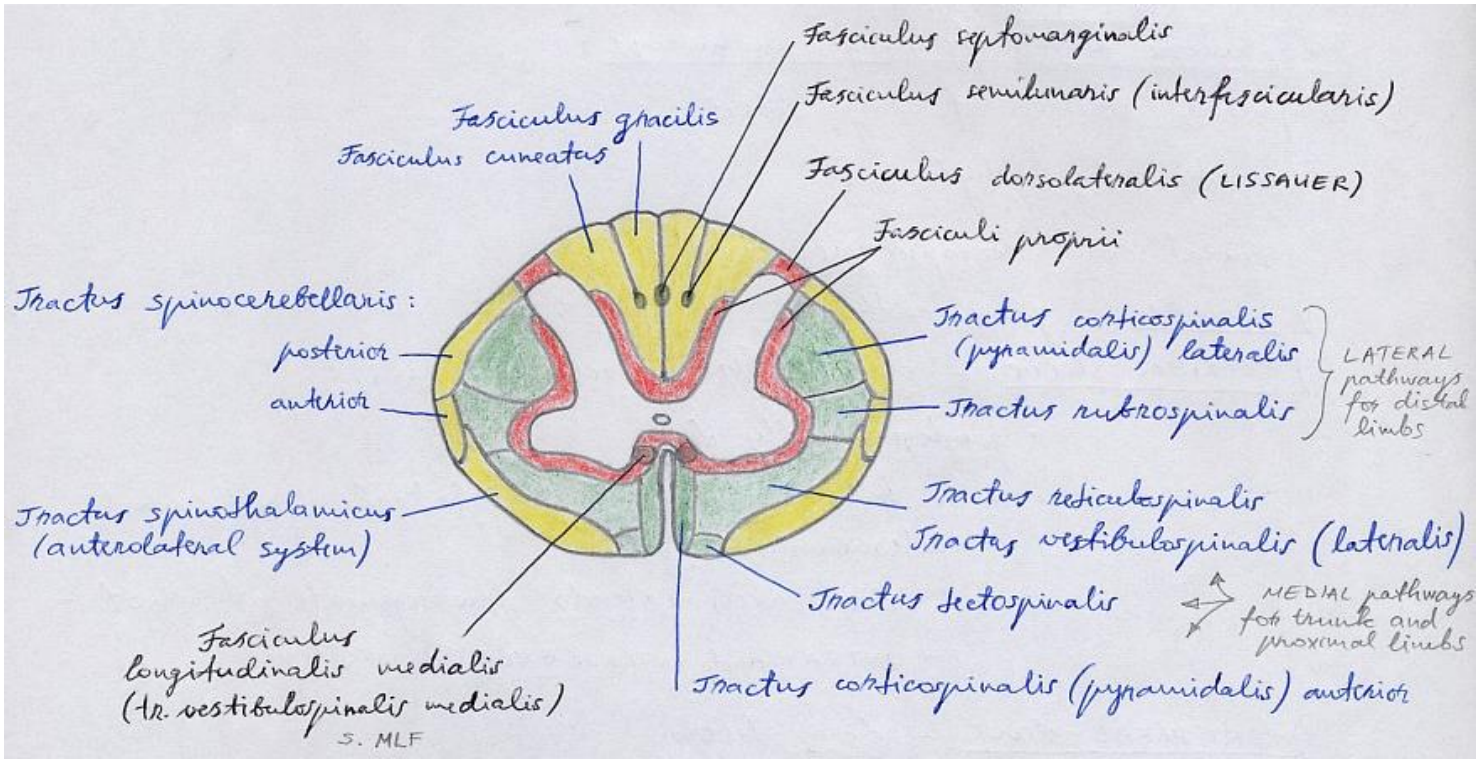
I – VI laminae sudaro DORSAL horn
(II – III – substantia gelatinosa)

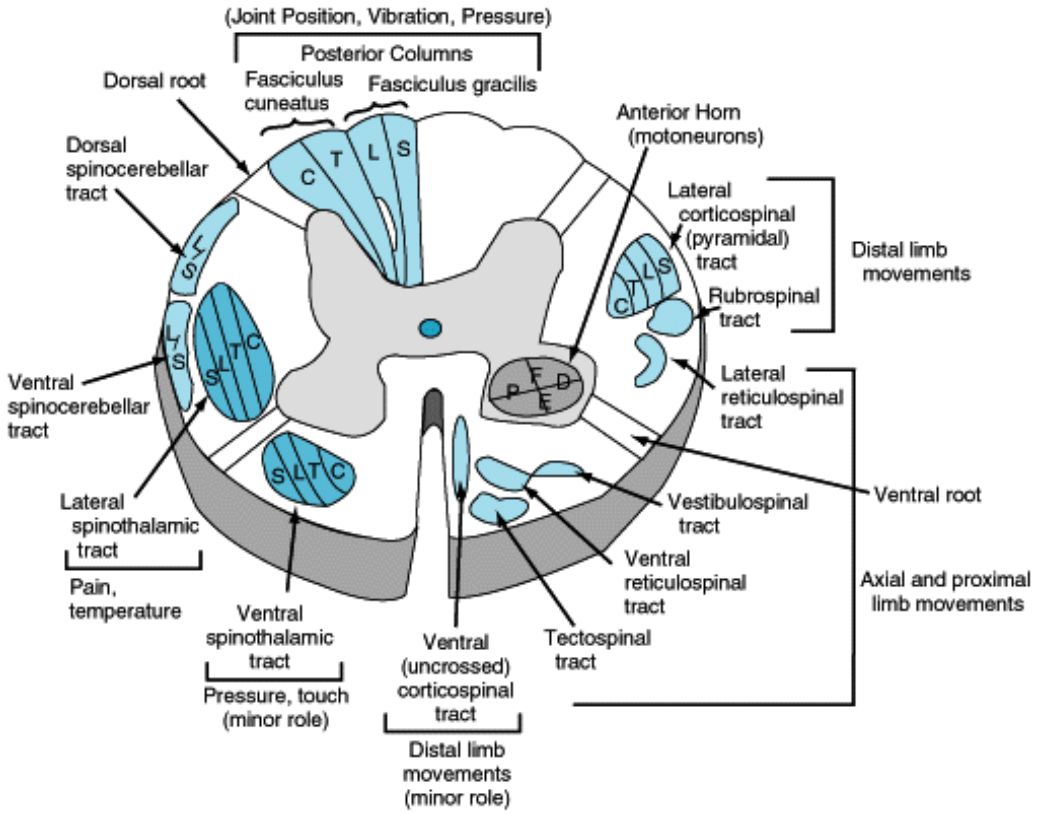
VIII – IX laminae sudaro VENTRAL horn
(izidetpia u VII)

VII lamina – INTERMEDIATE column (zone)

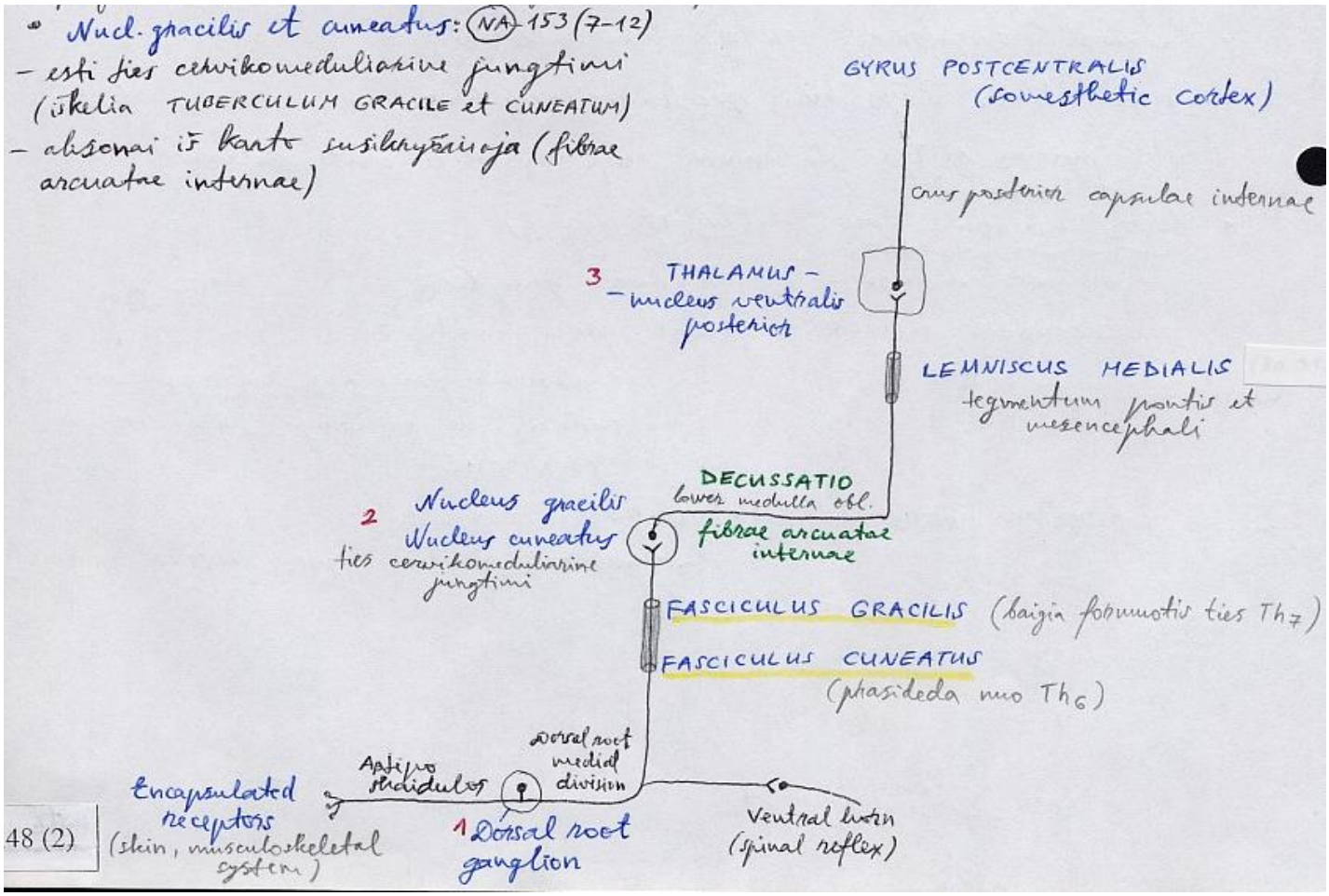
X lamina – area around central canal







DORSAL FUNICULI / COLUMNS



ANTEROLATERAL SYSTEM (LEMNISCUS SPINALIS)

(dl cheltaspinalinių tumorų pirmiausiai nukenčia salutiniai pain & t-re jautimai)

N.B. po decusacijos skaidulos šliejasi prie thalito iš medialinės pusės

GYRUS POSTCENTRALIS (somesthetic cortex)

crus post. capsulae internae

3 THALAMUS:
1) nucl. ventralis post.
2) nuclei intralaminares

pasisiekia iš lateralinės pusės prie LEMNISCUS MEDIALIS (kartu su LEMNISCUS TRIGEMINALIS)

TR. SPINORETICULARIS, SPINOMESENCEPHALICUS, etc. (input to ARAS)

TR. SPINOTHALAMICUS (LEMNISCUS SPINALIS)

Gali fasciculus dorsolateralis (LISSAUER) sudėtyje pakilti/nusileisti per 1-2 segmentus, tačiau didžioji dalis persijungia šėjimo lygyje

Receptoriai

Dorsal root
Lateral division

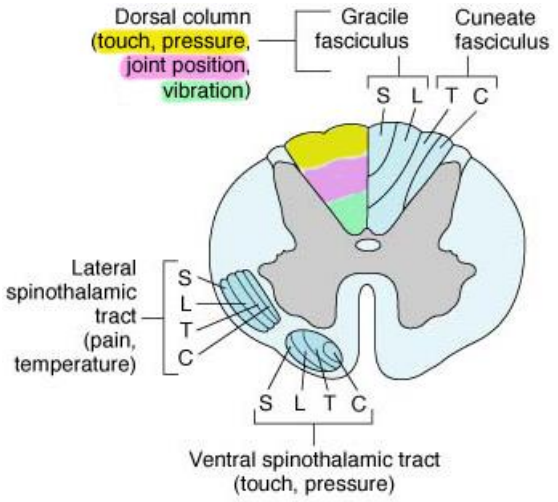
decussate in anterior (ventral) white commissure

C in plonos AŠ tipo skaidulos (somatiniai ir visceraliniai nervai)

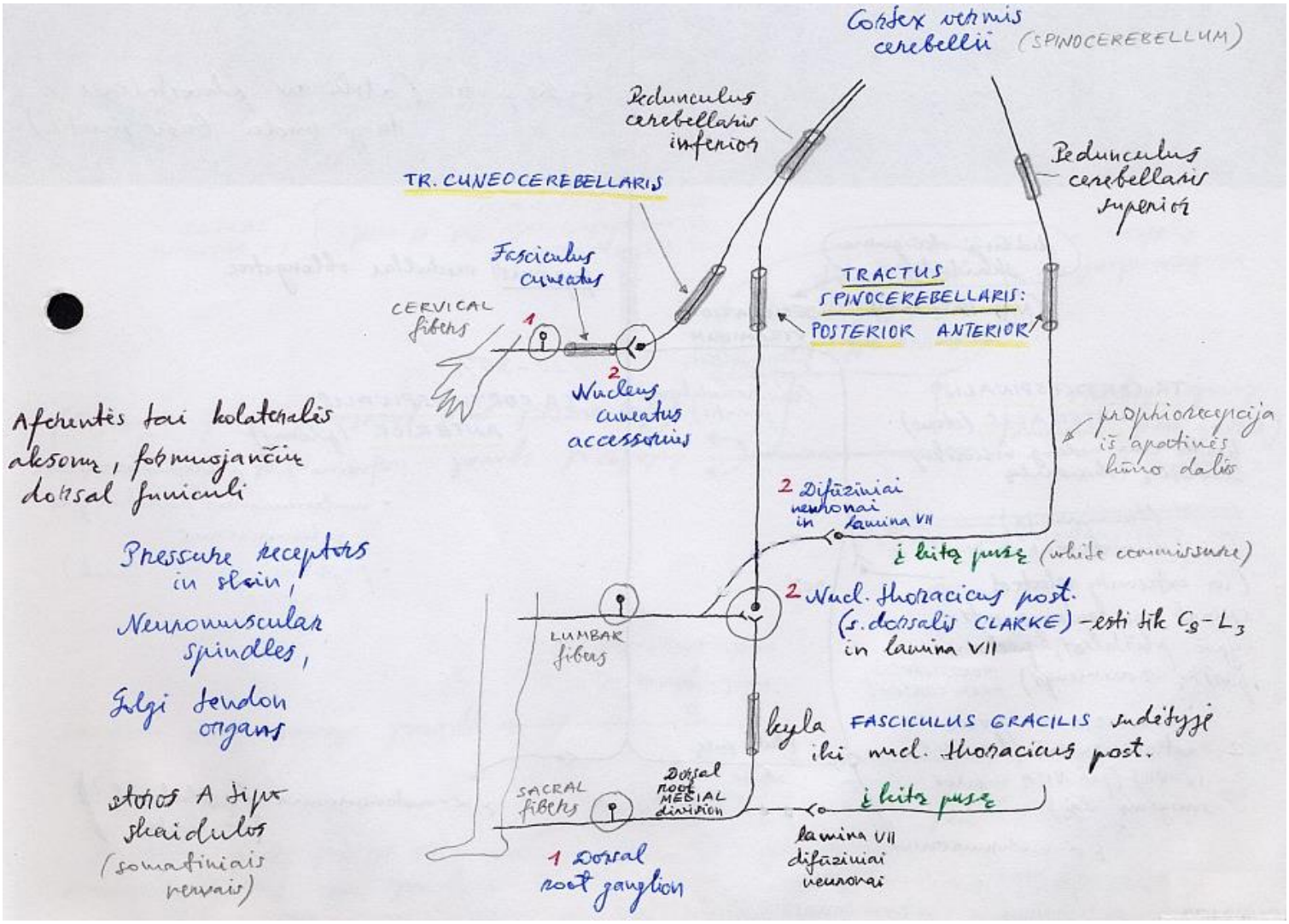
1 Dorsal root ganglion

2 Posterior horn (branduoliai): nucl. posteromarginalis (lamina I), subst. gelatinosa (II), nucl. proprius (III–V)

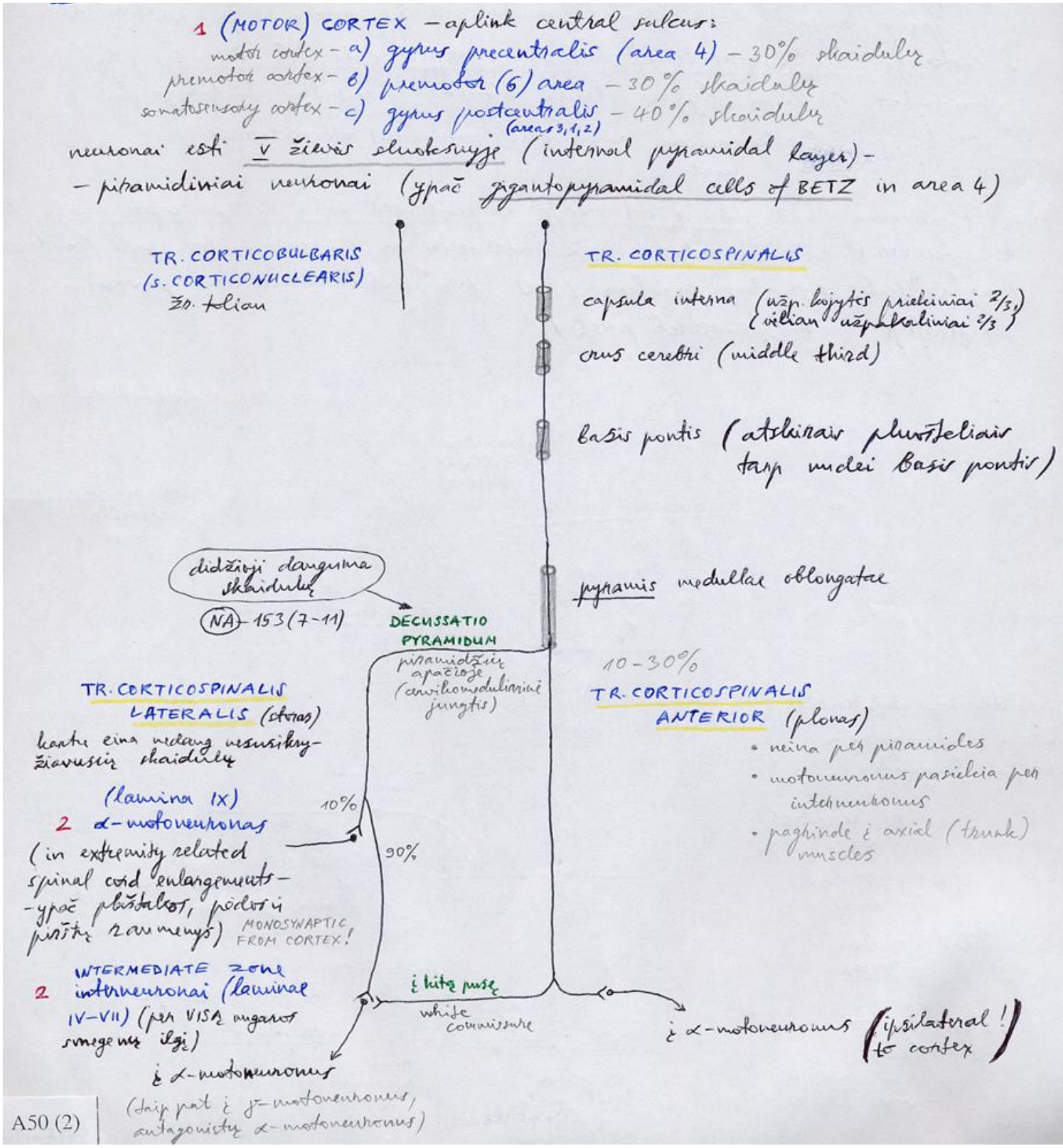
A49 (1)



SPINOCEREBELLAR


Cortex vermis cerebellii (SPINOCEREBELLUM)
Pedunculus cerebellaris inferior
Pedunculus cerebellaris superior
TR. CUNEOCEREBELLARIS
Fasciculus cuneatus
TRACTUS SPINOCEREBELLARIS: POSTERIOR ANTERIOR
CERVICAL fibers
1
2
Nucleus cuneatus accessorius
Aferentės tai kolateralės aksonų, formuojančių dorsal funiculi
Pressure receptors in skin,
Neuromuscular spindles,
Golgi tendon organs
storos A tipo skaidulos (somatiniais nervais)
proprioreceptija iš apatinės kūno dalies
2 Difūziniai neuronai in lamina VII
į kitą pusę (white commissure)
2 Nucl. thoracicus post. (s. dorsalis CLARKE) - esti tik $C_8 - L_3$ in lamina VII
LUMBAR fibers
kyla FASCICULUS GRACILIS sudėtyje iki nucl. thoracicus post.
SACRAL fibers
Dorsal root MEDIAL division
į kitą pusę
lamina VII difūziniai neuronai
1 Dorsal root ganglion

PYRAMIDAL



RUBROSPINALIS

- contralateral **flexor** tone.

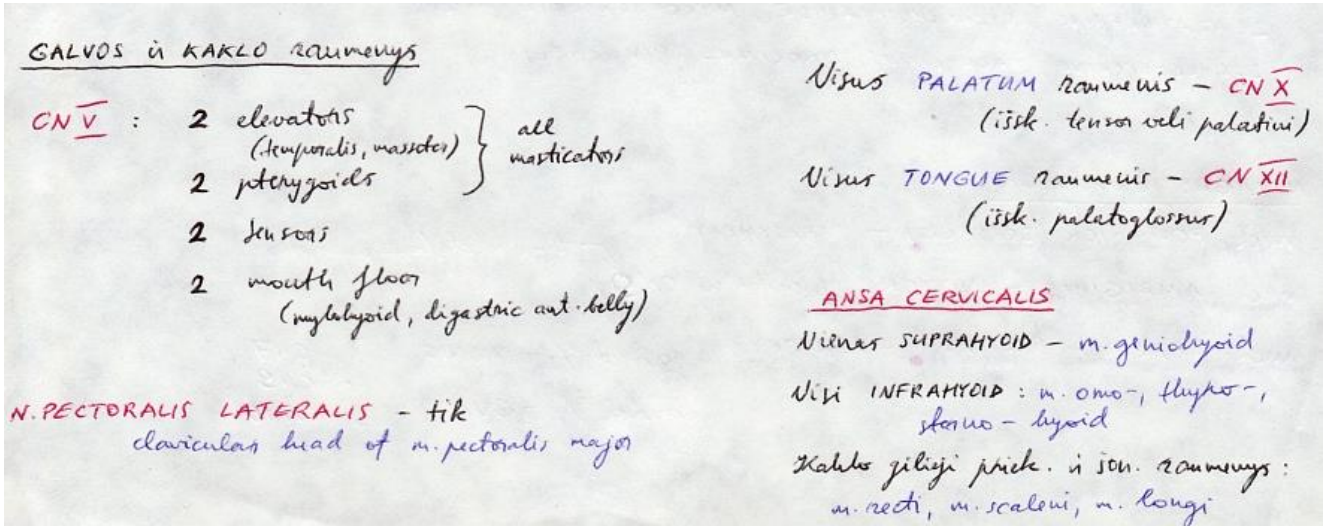
Lesions rostral to red nuclei remove cortical inhibition of rubrospinal neurons → ***flexor*** (decorticate posturing)

VESTIBULOSPINAL

- maintenance of **extensor** tone; origin – lateral vestibular nucleus.

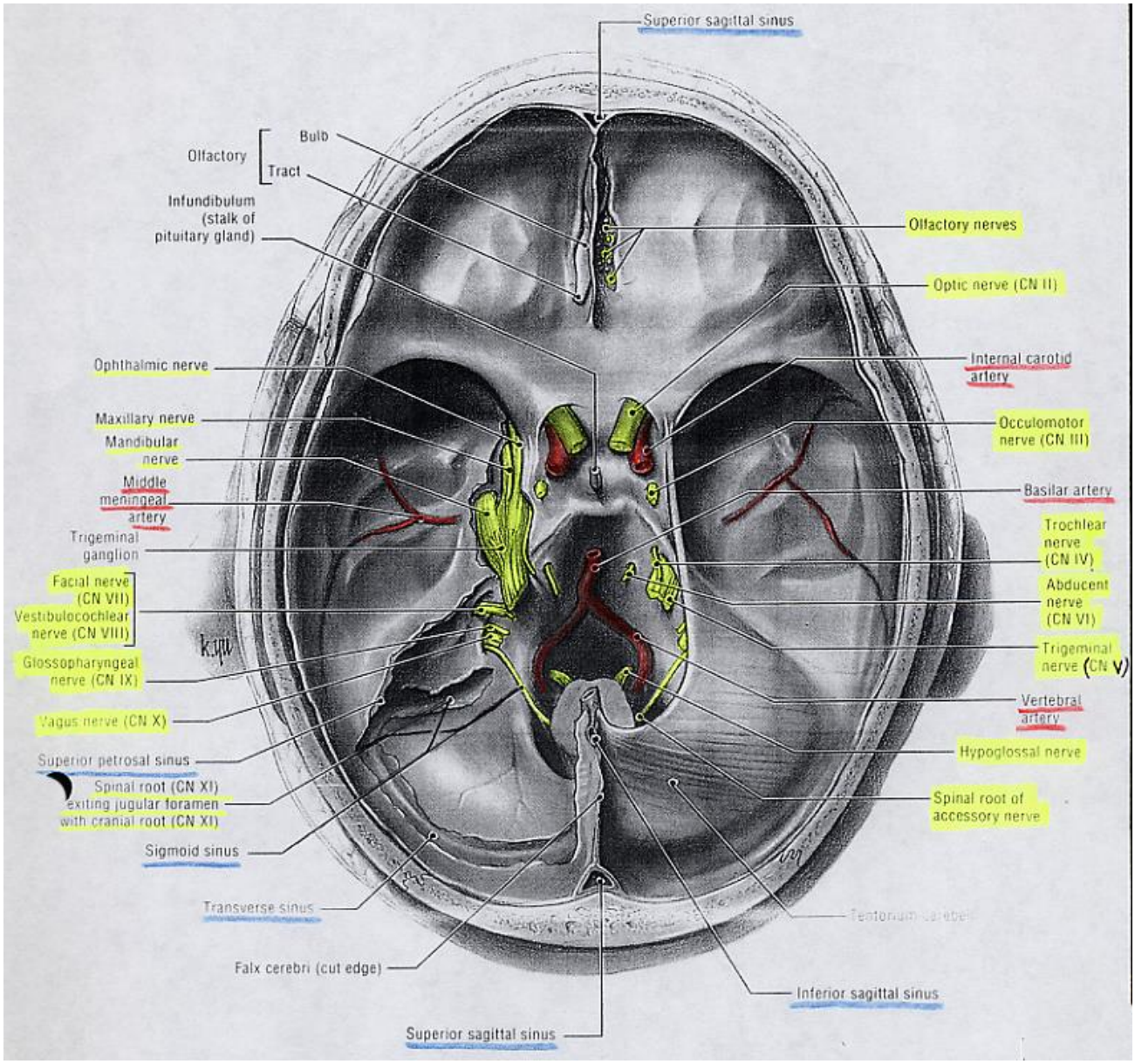
Lesions between inferior and superior colliculi (above vestibular nuclei and below red nuclei) → ***extensor*** (decerebrate) posturing.

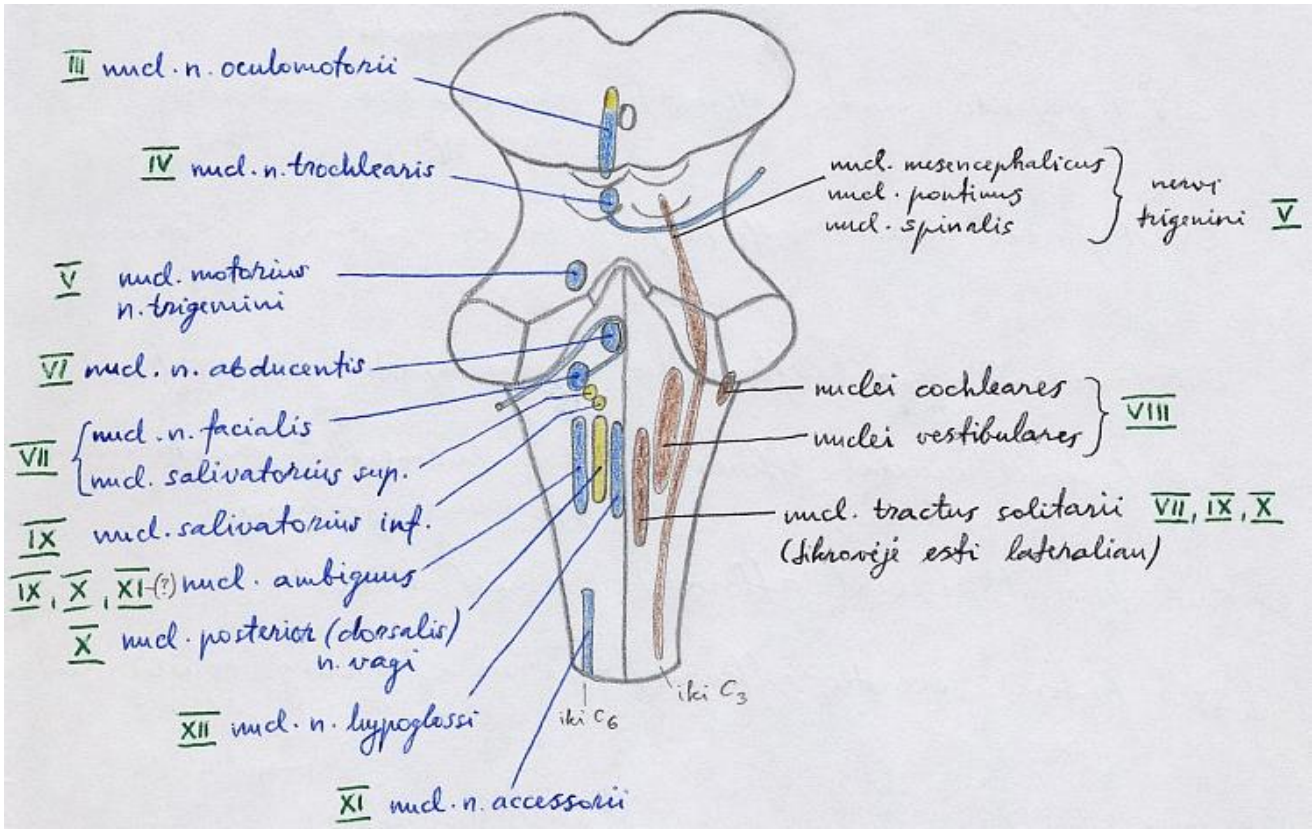
CRANIAL NERVES



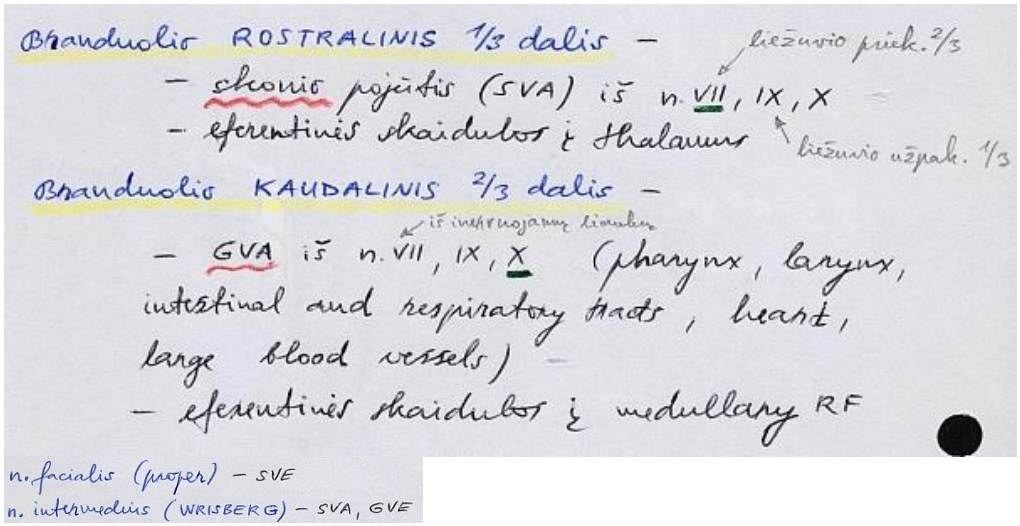
uvula, palatoglossus – CN X

pterygopalatine ganglion = **sphenopalatine** ganglion


Superior sagittal sinus
Olfactory
Bulb
Tract
Infundibulum (stalk of pituitary gland)
Olfactory nerves
Optic nerve (CN II)
Internal carotid artery
Ophthalmic nerve
Maxillary nerve
Mandibular nerve
Occulomotor nerve (CN III)
Middle meningeal artery
Basilar artery
Trigeminal ganglion
Trochlear nerve (CN IV)
Facial nerve (CN VII)
Vestibulocochlear nerve (CN VIII)
Abducent nerve (CN VI)
Trigeminal nerve (CN V)
Glossopharyngeal nerve (CN IX)
Vagus nerve (CN X)
Vertebral artery
Superior petrosal sinus
Hypoglossal nerve
Spinal root (CN XI) exiting jugular foramen with cranial root (CN XI)
Spinal root of accessory nerve
Sigmoid sinus
Transverse sinus
Tentorium cerebelli
Falx cerebri (cut edge)
Inferior sagittal sinus
Superior sagittal sinus



Nucl. tractus solitarii:



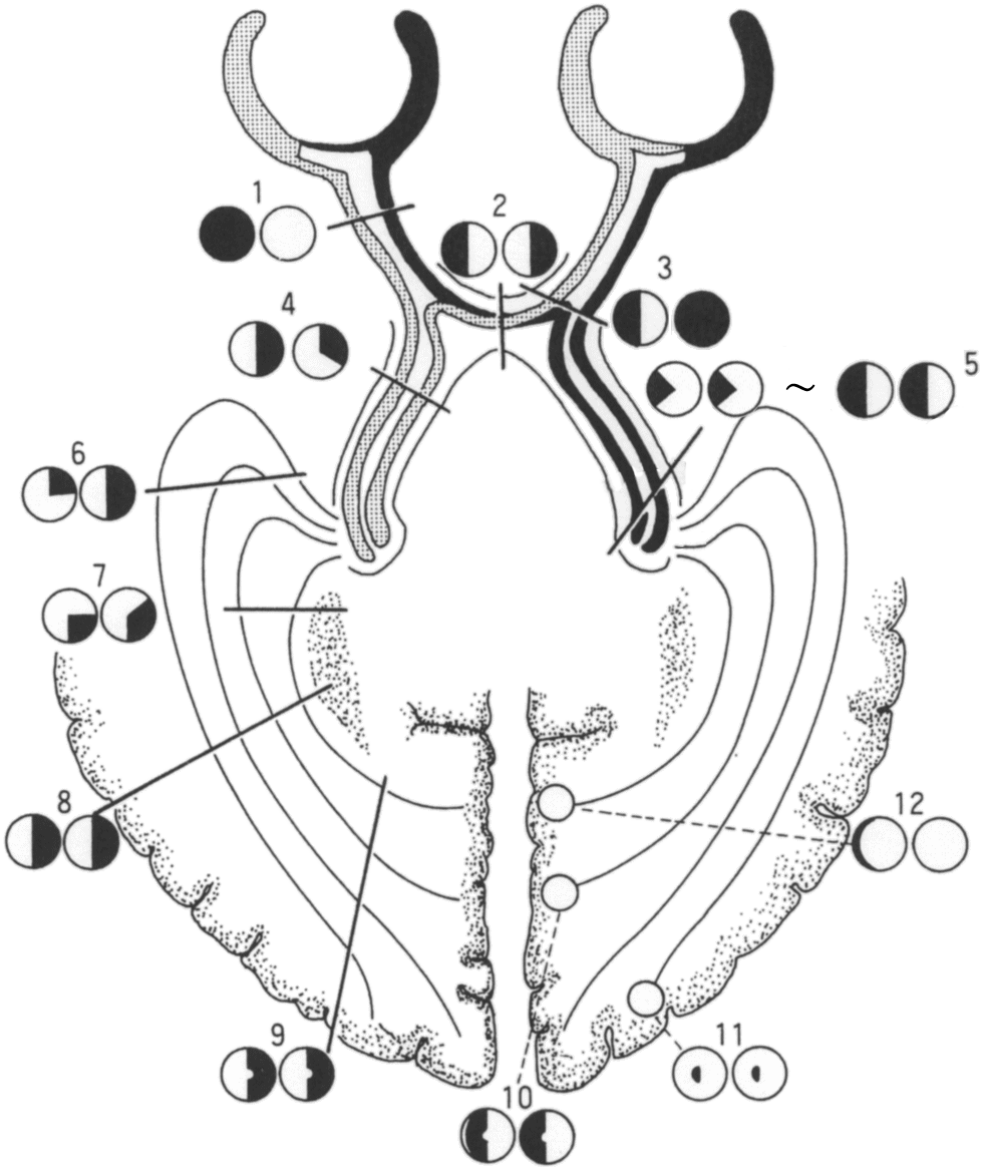
Ganglion geniculi – sensory ganglion for taste.
A72 (4) >>

N.B. fibers to motor neurons of **CN7 (lower face)** and **CN12** are primarily crossed!
N.B. fibers to motor neurons of **CN11** (for sternocleido, not trapezius) are primarily ipsilateral!
vs. fibers to other motor neurons are equally distributed bilaterally

CN2, VISUAL PATHWAYS

- *dvejinimasis didžiausias žiūrint pakenkto raumens veikimo kryptimi*: CN4 - į vidų ir žemyn (m. obliquus superior), CN6 - į išorę, CN3 - likusiomis kryptimis;
- ***papilledema*** does not develop up to age 3 years (because open sutures & fontanelles accommodate ICP↑).

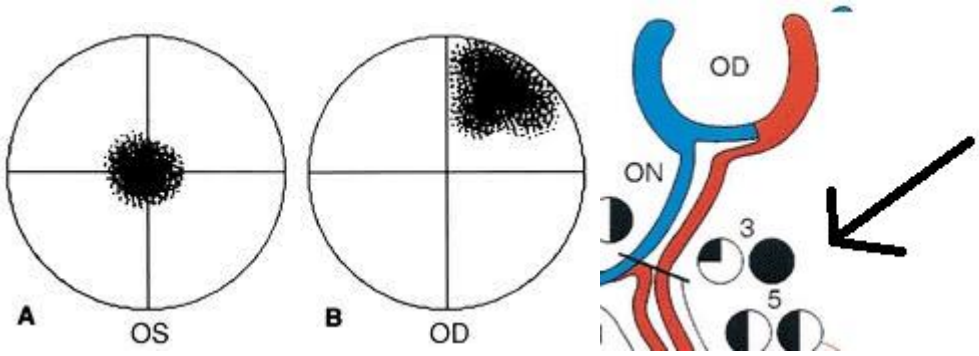
- **retrochiasmal (optic tract ÷ primary visual cortex)** - visual field defects (without acuity abnormalities
- color vision deficit is more sensitive indicator of **optic nerve** injury than loss of visual acuity!
- **chiasm** (53% fibers crossed) – *only location* where lesions may cause nonhomonymous visual field deficits.
- **retina** – lots of transmitters; ***amacrine cells*** are the only cells that secrete ***acetylcholine***.



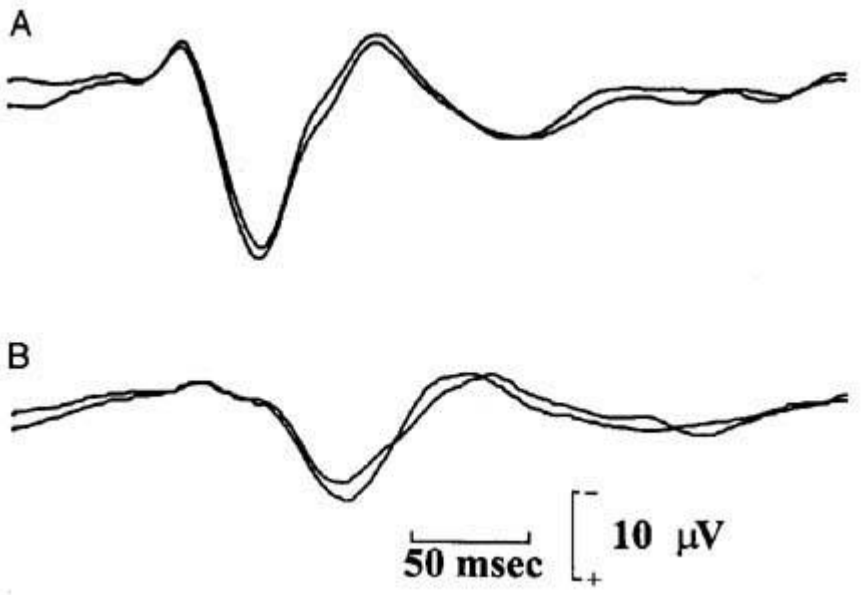
ANTERIOR CHIASMAL SYNDROME

(lesion at junction of optic nerve and chiasm) - affects optic nerve fibers and contralateral inferonasal fibers (**Wilbrand's knee**) → ipsilateral optic neuropathy (central scotoma) + contralateral superotemporal field defect (junctional scotoma)

Central scotoma: Junctional scotoma:



VEP



A - *normal* subject;

B - patient with past history of *optic neuritis* (P100 response is prolonged to 146 msec).

- VEP - most conspicuous and consistent peak at 100 msec (therefore called **P100 response**).
- VEPs are useful in evaluating **anterior visual pathways**;
  N.B. VEPs are *not useful in evaluating lesions posterior to optic chiasm*! (e.g. in cortical blindness, VEP may be normal!!!); retrochiasmatic lesions can be evaluated using *MONOCULAR HEMIFIELD STIMULATION*.
- can suggest ***lesion of anterior visual pathway***; examples:
  a) ***optic neuritis***: P100 absence → prolonged P100 latency (persists indefinitely) + normal shape.
  b) ***compressive lesions of optic nerve***: markedly abnormal VEPs shape + delayed latency
  c) ***ischemic / toxic optic neuropathies***: markedly attenuated P100 amplitude + normal latency.

LEGAL BLINDNESS

a) acuity in better eye < 20/400
b) acuity in better eye > 20/400 with substantial visual field loss (widest vision diameter ≤ 10°).

PAPILLITIS

- ***engorged pulsating veins*** (vs. **PAPILLEDEMA** - ***engorged nonpulsating retinal veins***)

Drugs that may precipitate GLAUCOMA:

1) mydriatics
2) steroids

3) anticholinergics

STEROIDS contraindicated:

1) herpetic corneal pathology
2) glaucoma

MYDRIATICS

- **short acting**:
  2.5% **PHENYLEPHRINE**
  0.5-1% **TROPICAMIDE** (lasts 3 hours)
- **longer action / wider dilation** - 10% **PHENYLEPHRINE**, 1% **CYCLOPENTOLATE** (lasts 24 hours).

MIOTICS

PILOCARPINE 1-4%

CYCLOPLEGICS

CYCLOPENTOLATE 1% (lasts 24 hours)
ATROPINE 1% (lasts 7 days)
HOMATROPINE 5%

CN3, 4, 6

Edinger-Westphal – only parasympathetic.
Sympathetic innervation – from INTERNAL carotid plexus.

ARGYLL-ROBERTSON pupil – pupil unreactive to light.

Inverse ARGYLL ROBERTSON pupil – unreactive to accommodation, reacts to light - due to *damage to PERLIA nucleus*.

MARCUS GUNN pupil - decreased direct pupillary light reflex, i.e. **relative afferent pupillary defect**.

FOSTER KENNEDY syndrome - combination of **optic disc atrophy** and contralateral **papilledema**.

HORNER syndrome – important:

- sympathetic fibers to **pupil** travel with *internal carotid plexus* – damaged during carotid endarterectomy / dissection.
- sympathetic fibers to **(lower) face** skin travel with branches of *external carotid artery* – spared in carotid violations.
- Localizing Tests – eye drops of drugs that affect sympathetic neurotransmission in pupil:

  5-10% COCAINE test
  - cocaine *blocks norepinephrine reuptake*.
  - abnormal miotic pupil will not dilate (lack of normal sympathetic fibers).
  - positive test indicates lesion **ANYWHERE** in sympathetic pathway.

  1% HYDROXYAMPHETAMINE test
  - causes *release of norepinephrine stores* in postganglionic nerve terminals.
  - pupil will not dilate (to extent of normal eye) in **POSTGANGLIONIC** lesion.
  - in **PREGANGLIONIC** lesion, drug will dilate abnormal pupil as well as normal side.

  1% PHENYLEPHRINE test

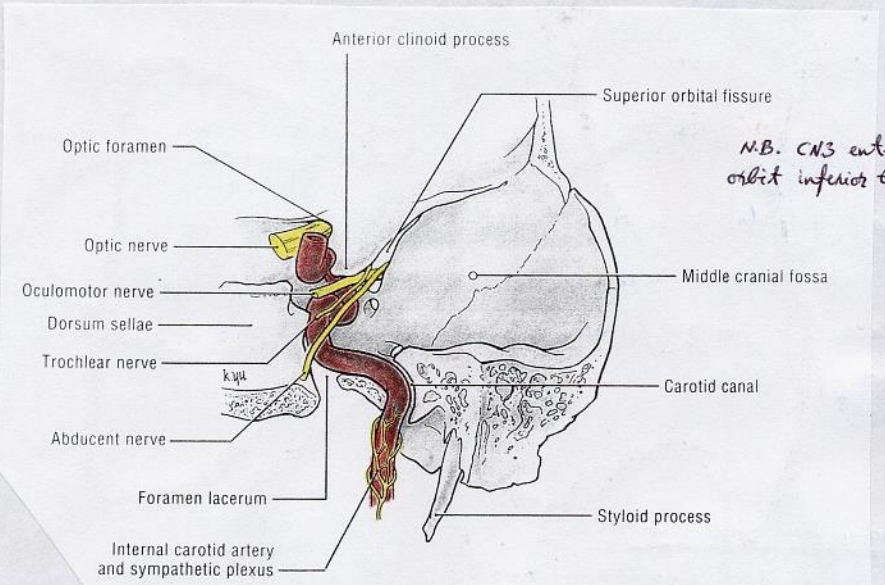
– *direct α-agonist* that in low concentration (1%) dilates pupil only in **POSTGANGLIONIC** lesion (denervation hypersensitivity of pupil).

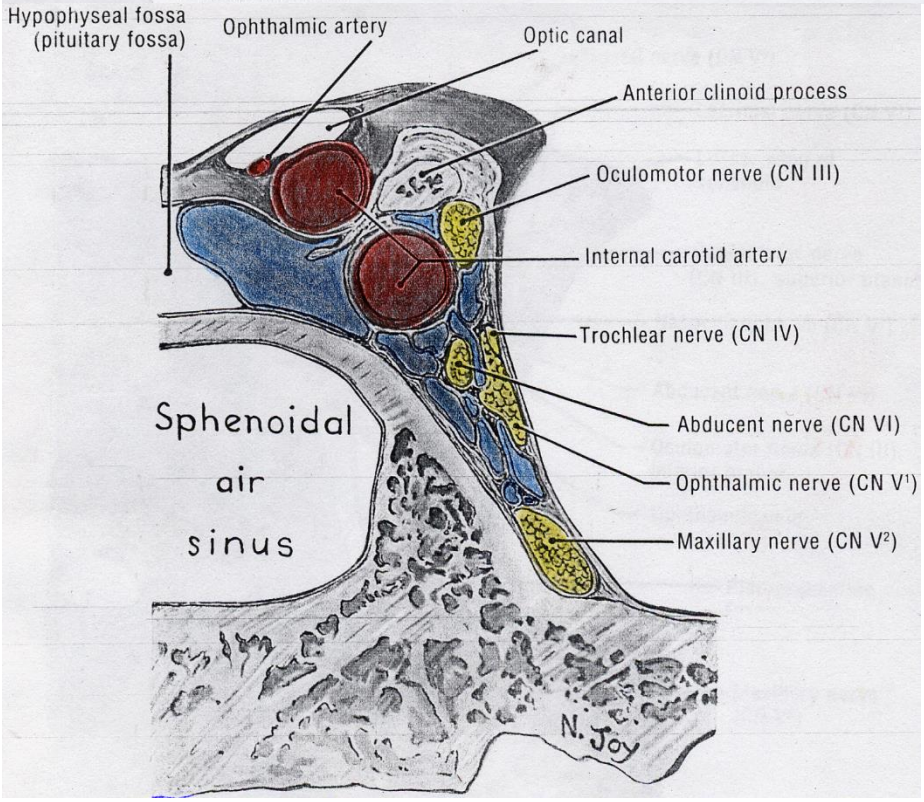
CN3:

• išeina iš interpeduncular fossa near midline, tarp a. cerebri post. ir a. cerebellaris sup. (NA – 229

parasimpat. skaidulos eina dorsomedialiai – nukenčia pirmiausiai iš: a) transtentorial herniation
b) PCA aneurysmos

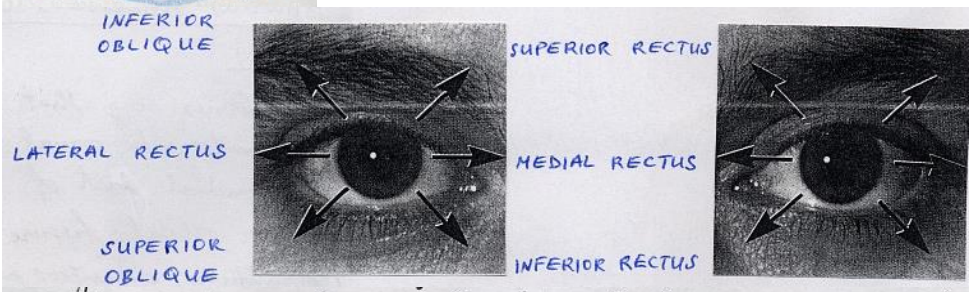
• veria SINUS CAVERNOSUS lateralinę sienelę (dura mater) ir eina sinuso lateralinėje pusėje virtuje



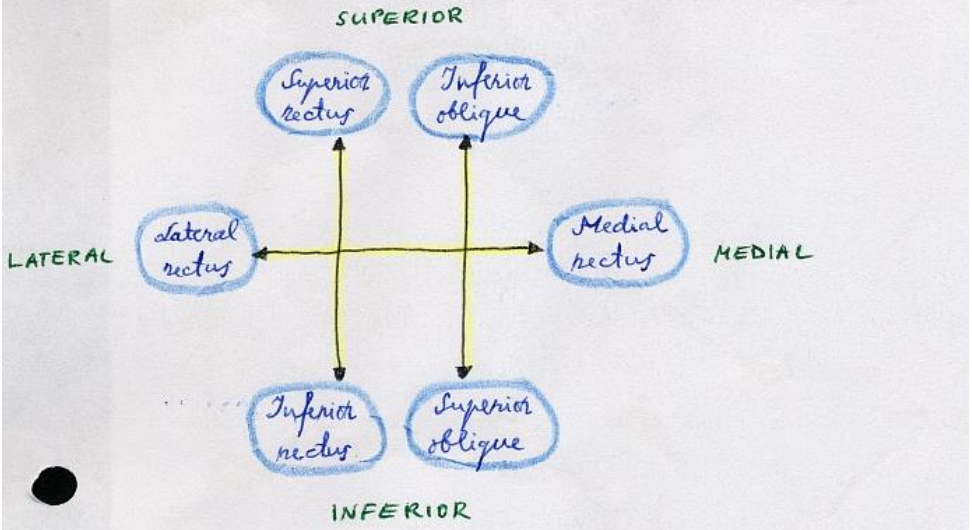


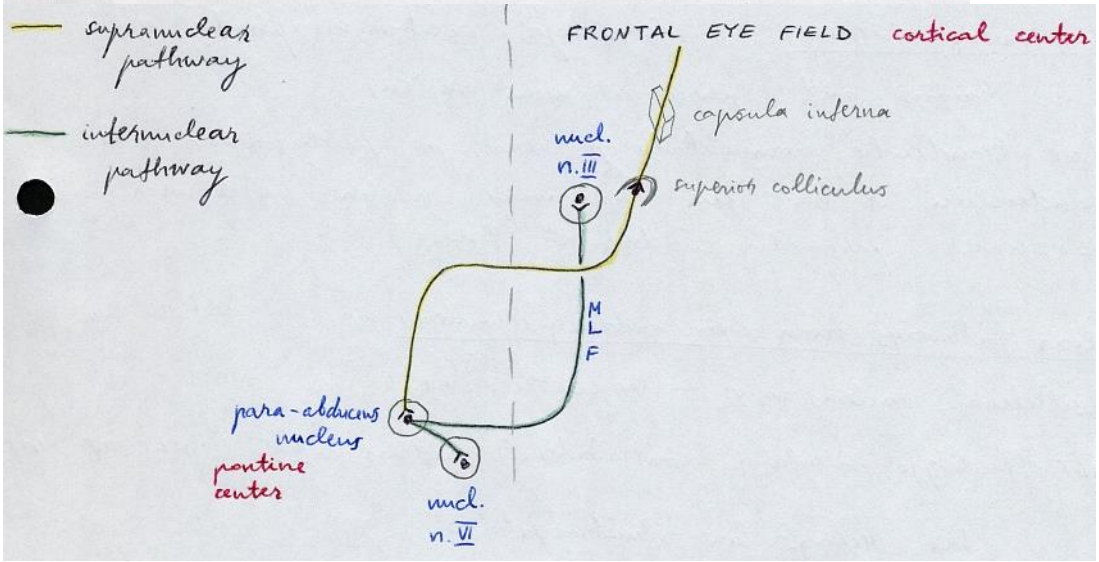
CN6 eina sinus cavernosus centru (visi kiti – pakrasciu).

PERLIA nucleus – – išskirtas tarp submuclei for left & right medial recti – – integrator for convergence



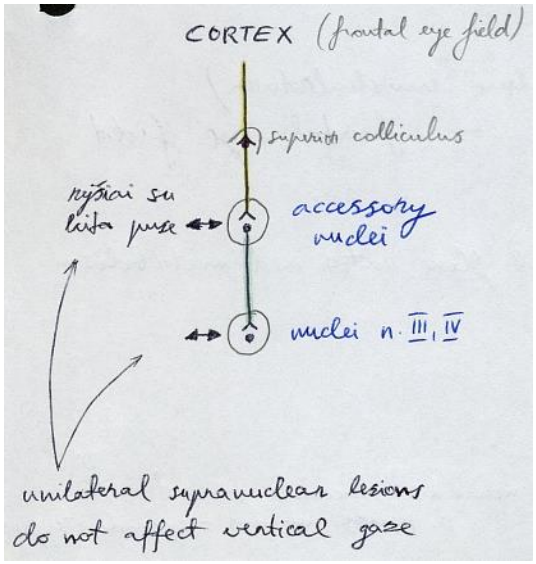
kaip testuoti izoliuotai kiekvieną raumenį



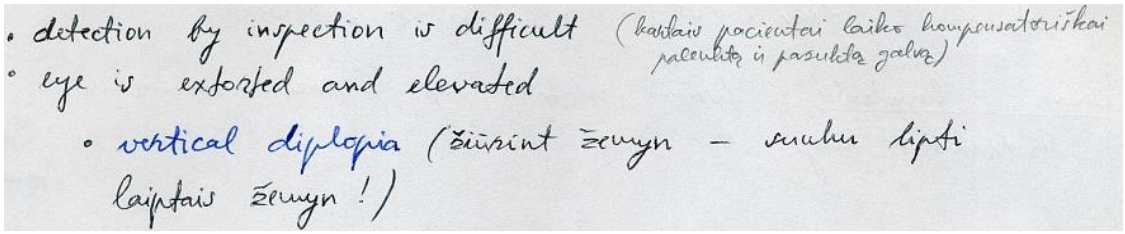


MLF:

Ši liulpa išaliuja locked-in syndr. simptomatiką – pažeidus pontine basis, šalia tetraplegijos esti ir horizontalaus žvilgsnio paralyžius



Nucl. CN4 – iseina i dorsalini pavirsiu ir inervuoja kontralateralini raumeni.
CN4 lesion:



Isolated left **CN4 palsy**
(primary gaze showing left hypertropia):

(right gaze with left inferior oblique overaction):

Isolated right **CN3 palsy**
(knock**down** and knock**out**):


(horizontal EOM testing - inability to adduct right eye, but normal abduction):


Isolated right **CN6 palsy**:


Left **internuclear ophthalmoplegia**:

Left gaze showing full abduction.

Right gaze with severe adduction deficit.

Bilateral MLF lesions → eye component of **locked-in syndrome**.

1½ (one-and-half) syndrome - unilateral large pontine lesion that involves:

1) CN6 nucleus, PPRF → ipsilateral lateral rectus paralysis, contralateral medial rectus paralysis
2) MLF carrying impulses from *contralateral* PPRF → ipsilateral medial rectus paralysis

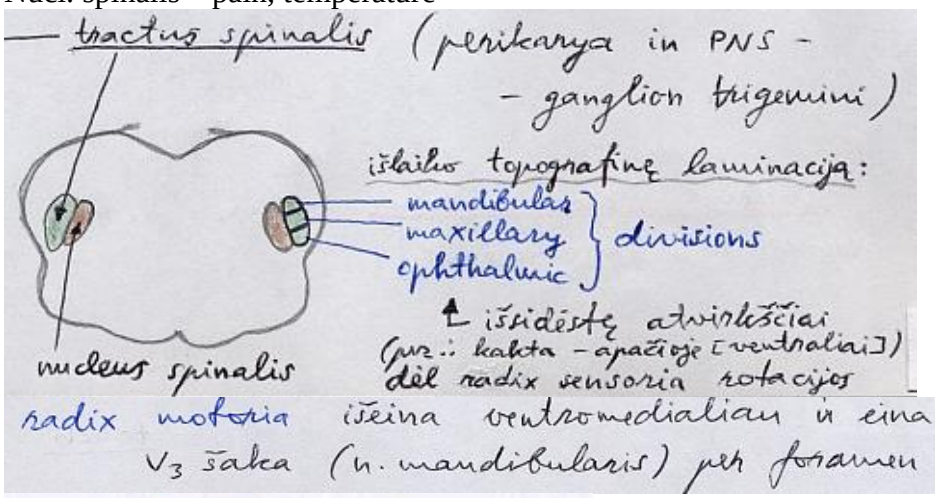
Clinically – loss of medial and lateral voluntary eye movement on lesion side ("one") and loss of medial horizontal eye movement on contralateral side ("half"); the only remaining horizontal movement is abduction of contralateral eye.

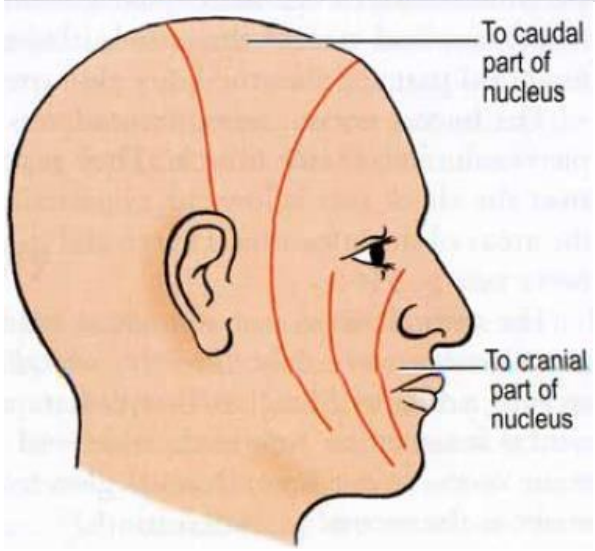
PARINAUD syndrome - compression from above by pineal mass; PCA infarction → **paralysis of conjugate UPWARD gaze** (upward gaze traktas eina dorsaliau negu downward gaze traktas) → downward eye deviation (rarely, if unilateral, skew deviation).

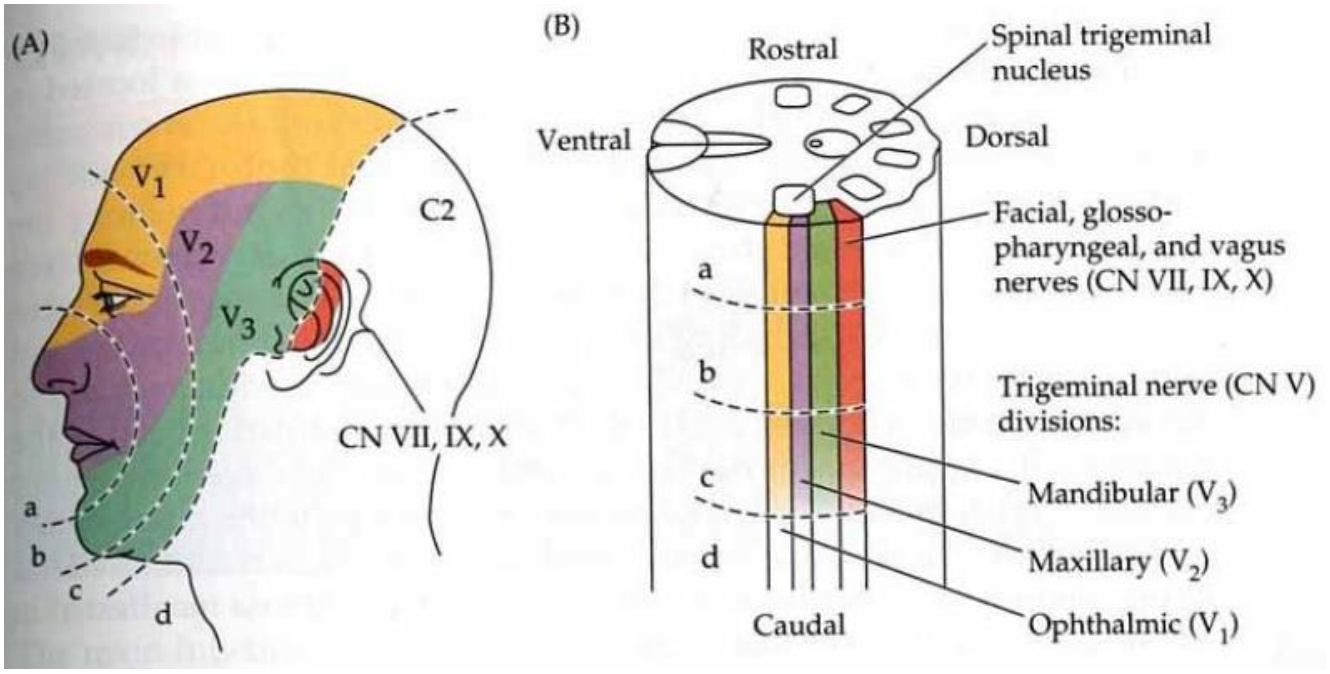
- additional *COLLIER sign* (pathological lid retraction) with *BELL phenomenon* (bandant užsimerkti, akys pakyla į viršų).

CN5

Nucl. mesencephalicus – proprioreception (neurons in CNS!)
Nucl. pontinus – touch
Nucl. spinalis – pain, temperature

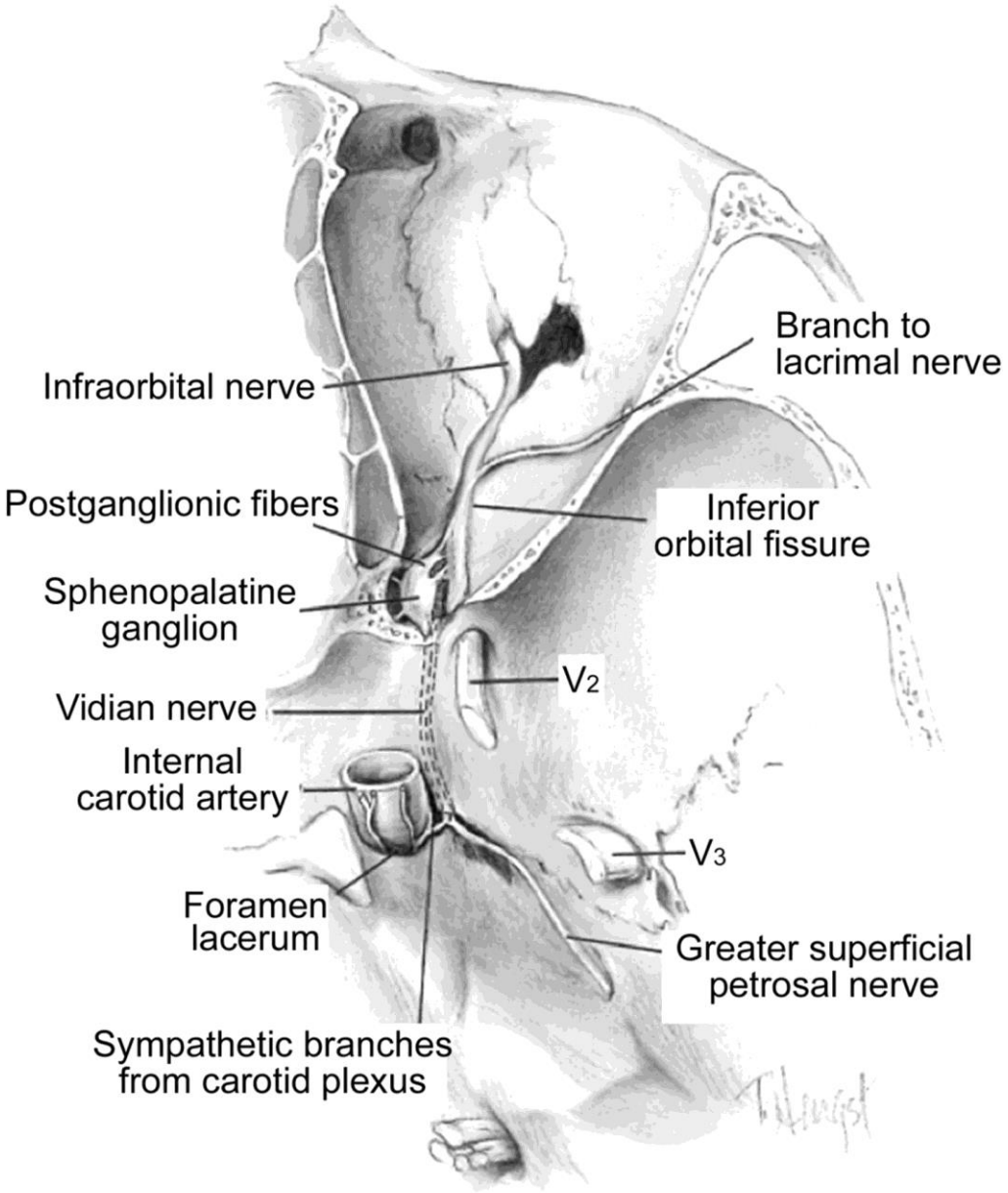


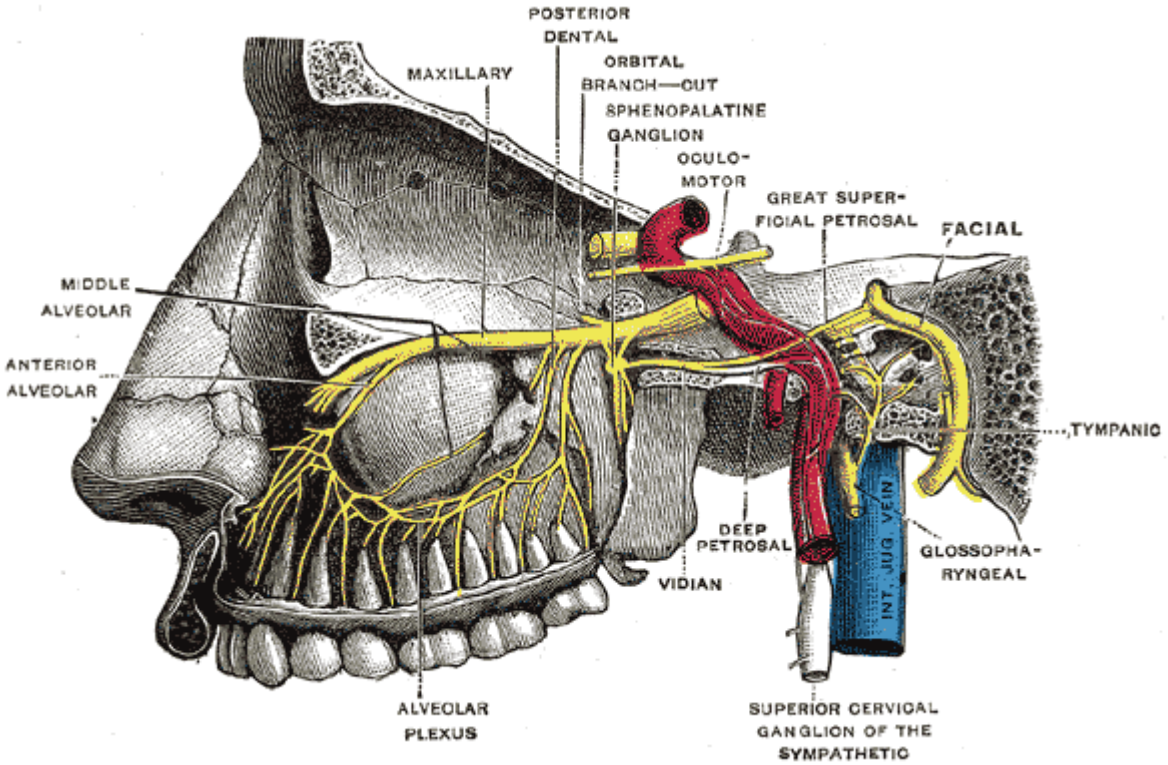




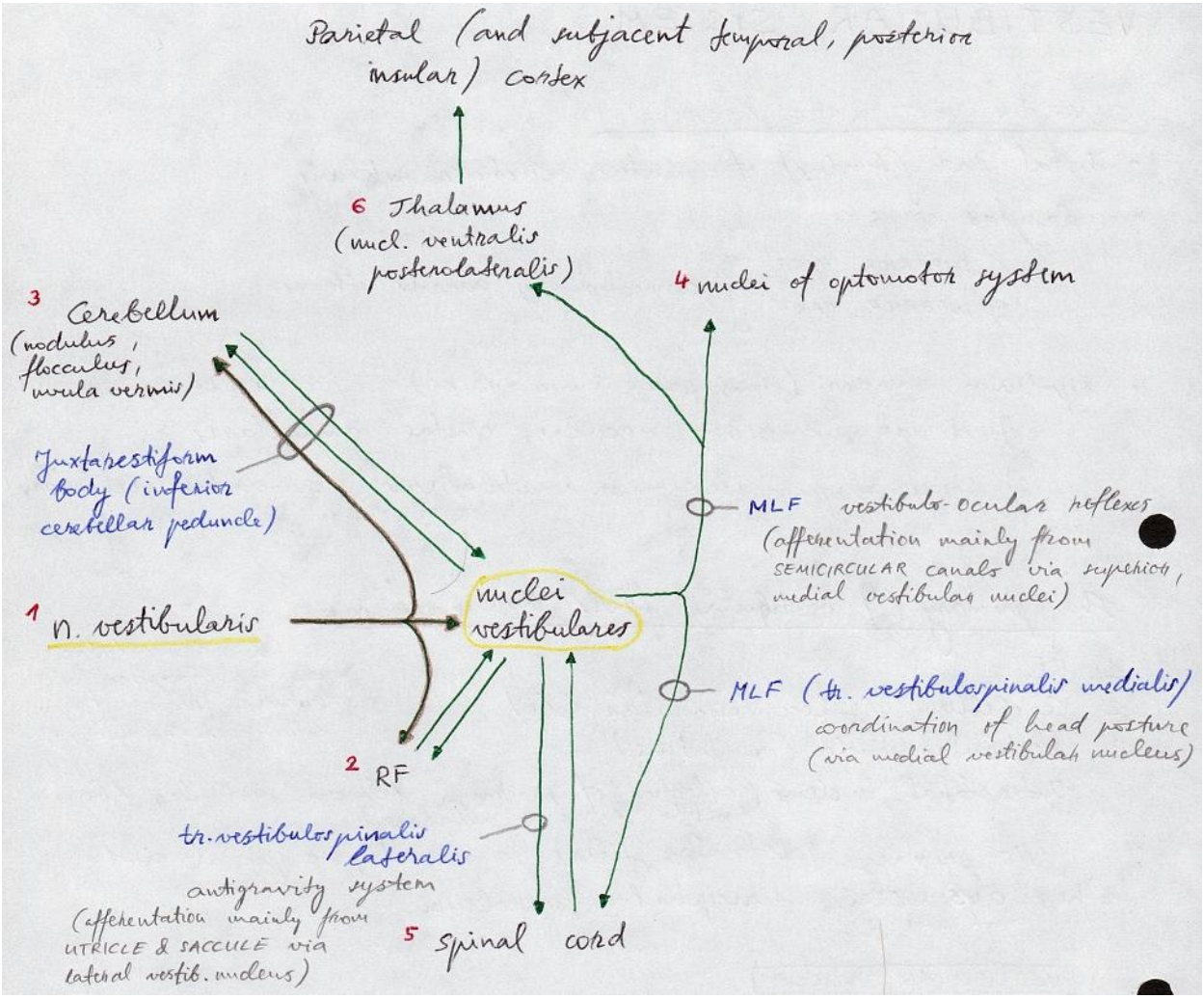
CN7

1) mimikos rameus (izkaidaut m. buccinator, mm. auriculares, m. occipitofrontalis, m. platysma)
2) m. digastricus (post. belly), m. stylohyoideus
3) m. stapedius


Infraorbital nerve
Branch to lacrimal nerve
Postganglionic fibers
Inferior orbital fissure
Sphenopalatine ganglion
V2
Vidian nerve
Internal carotid artery
V3
Foramen lacerum
Greater superficial petrosal nerve
Sympathetic branches from carotid plexus


POSTERIOR DENTAL
MAXILLARY
ORBITAL BRANCH—CUT
SPHENOPALATINE GANGLION
OCULO-MOTOR
GREAT SUPER-FICIAL PETROSAL
FACIAL
MIDDLE ALVEOLAR
ANTERIOR ALVEOLAR
TYMPANIC
DEEP PETROSAL
INT. JUG. VEIN
GLOSSOPHA-RYNGEAL
VIDIAN
ALVEOLAR PLEXUS
SUPERIOR CERVICAL GANGLION OF THE SYMPATHETIC

CN8 - VESTIBULAR

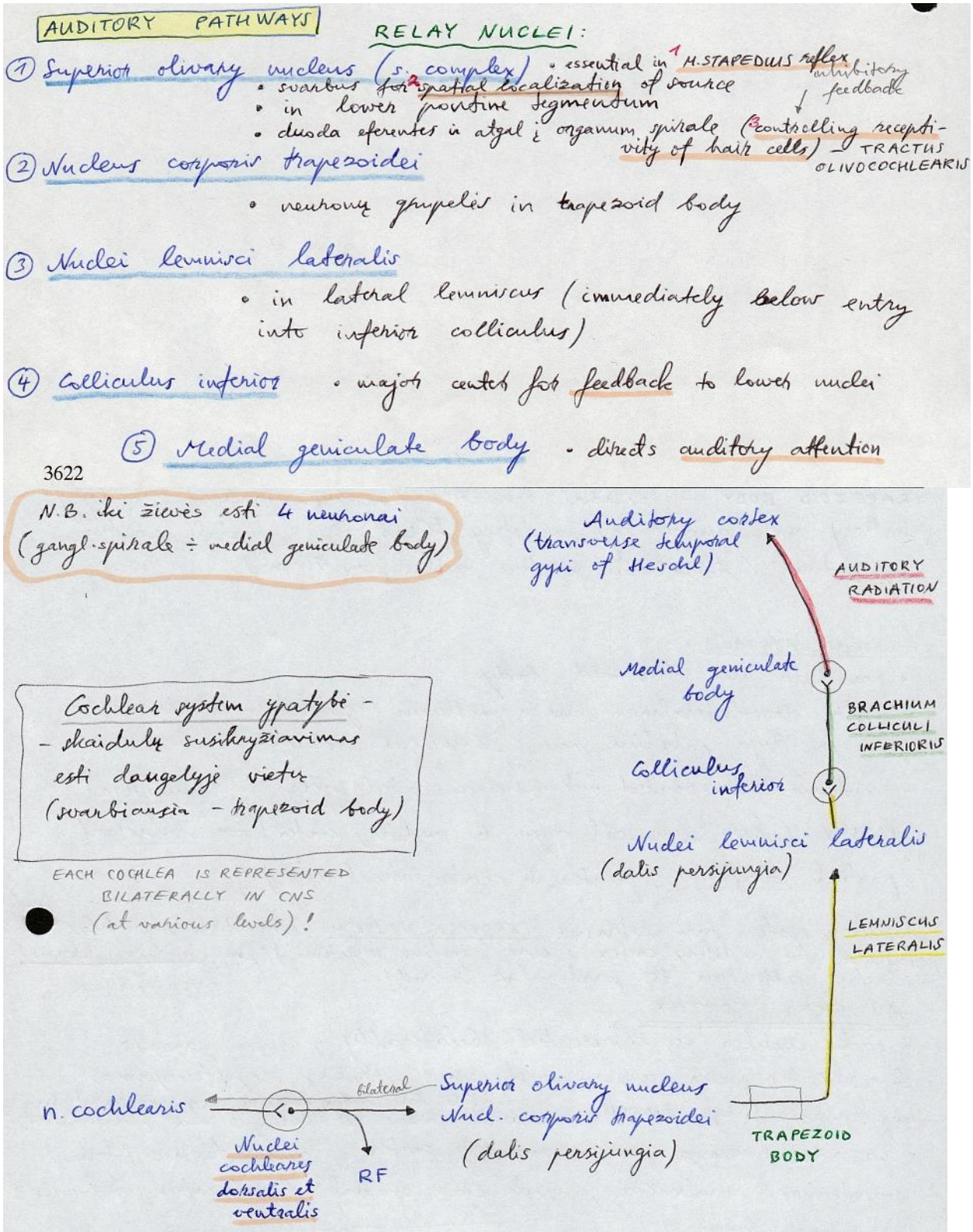


a) TR. VESTIBULOSPINALIS (LATERALIS) – iš nucl. lateralis, į visus spinal cord lygius: contraction of extensors – support of body against collapse by pull of gravity

Overactivity of system → decerebrate rigidity

b) TR. VESTIBULOSPINALIS MEDIALIS (MLF sudėtyje) – baigiasi in cervical spinal cord: coordination of head posture in response to vestibular stimuli

CN8 - COCHLEAR



CN9

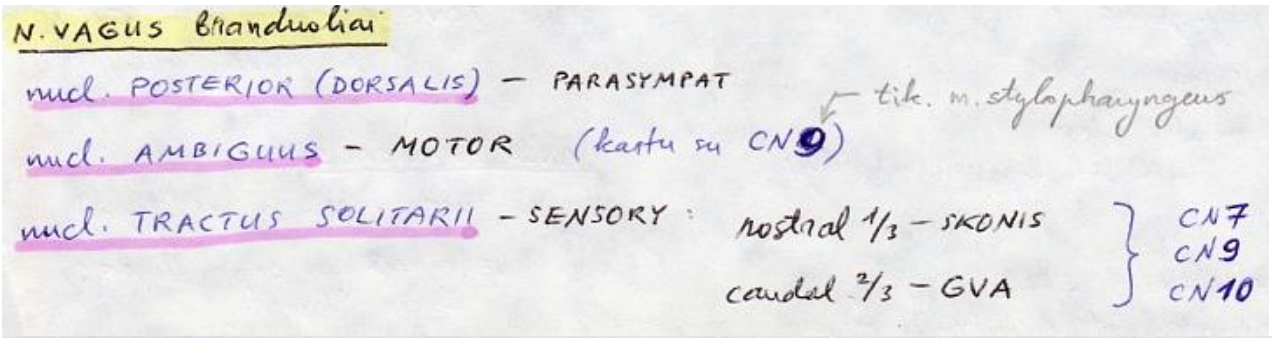
Only muscle – stylopharyngeus

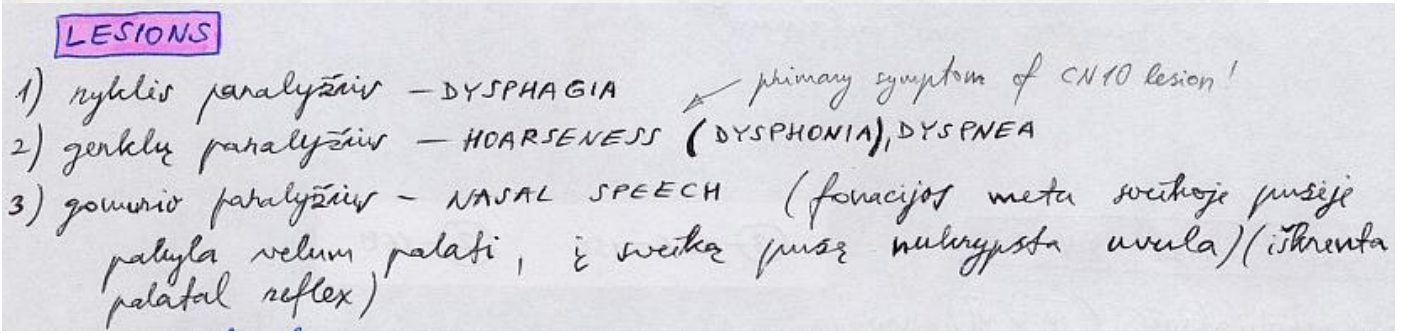
LESIONS

išnyksta GAG reflex → DYSPHAGIA, CHOKING

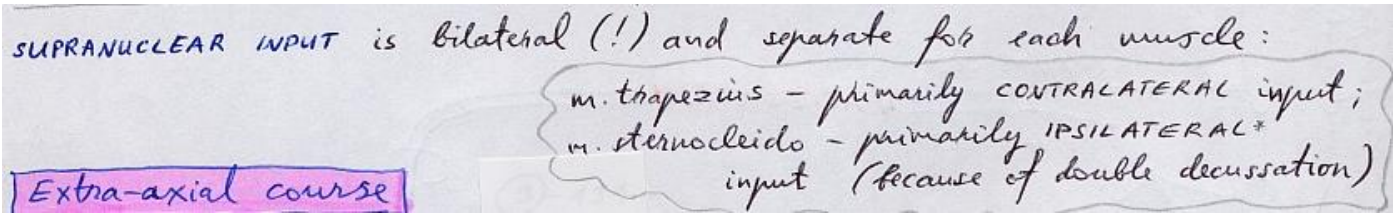
išnyksta CAROTID SINUS reflex

CN10





CN11

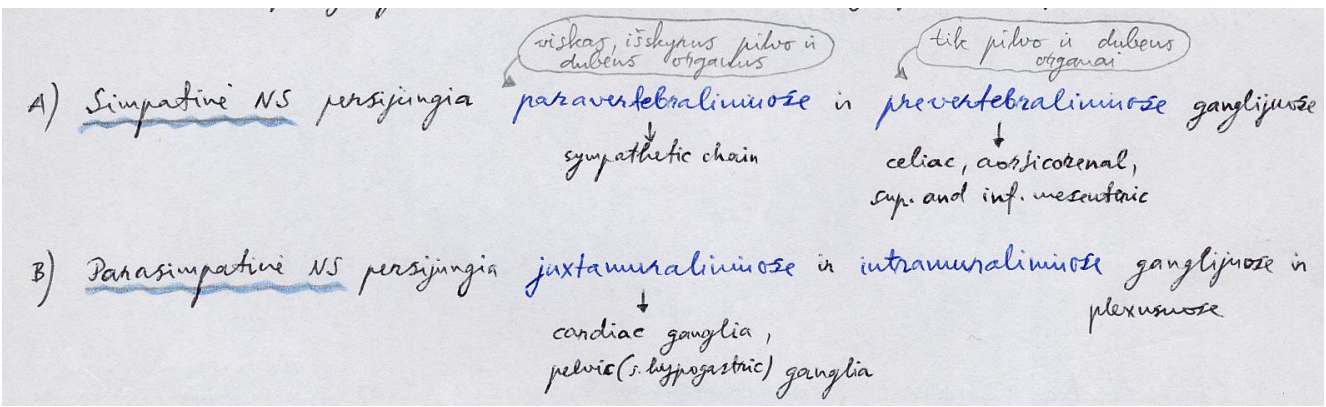


PNS

See p. "Intro (nerves, muscles)" >>

AUTONOMIC NS

SYMPATHETIC



Abiejų sistemų poveikiai antagonistiški, tačiau simpatinė sistema turi ir nepriklausomų efektų:
1) splenic capsule contraction 2) sweating and pilorection
3) m. tarsalis sup.

Organs receiving only SYMPATHETIC innervation: 1) adrenal medulla 2) kidney 5) blood vessels 3) sweat glands 4) pilomotor muscles

Sympathetic chain (PARAvertebral ganglia)

skirsta viskam, išskyrus pilvo ir dubens organus

White rami — Gray rami

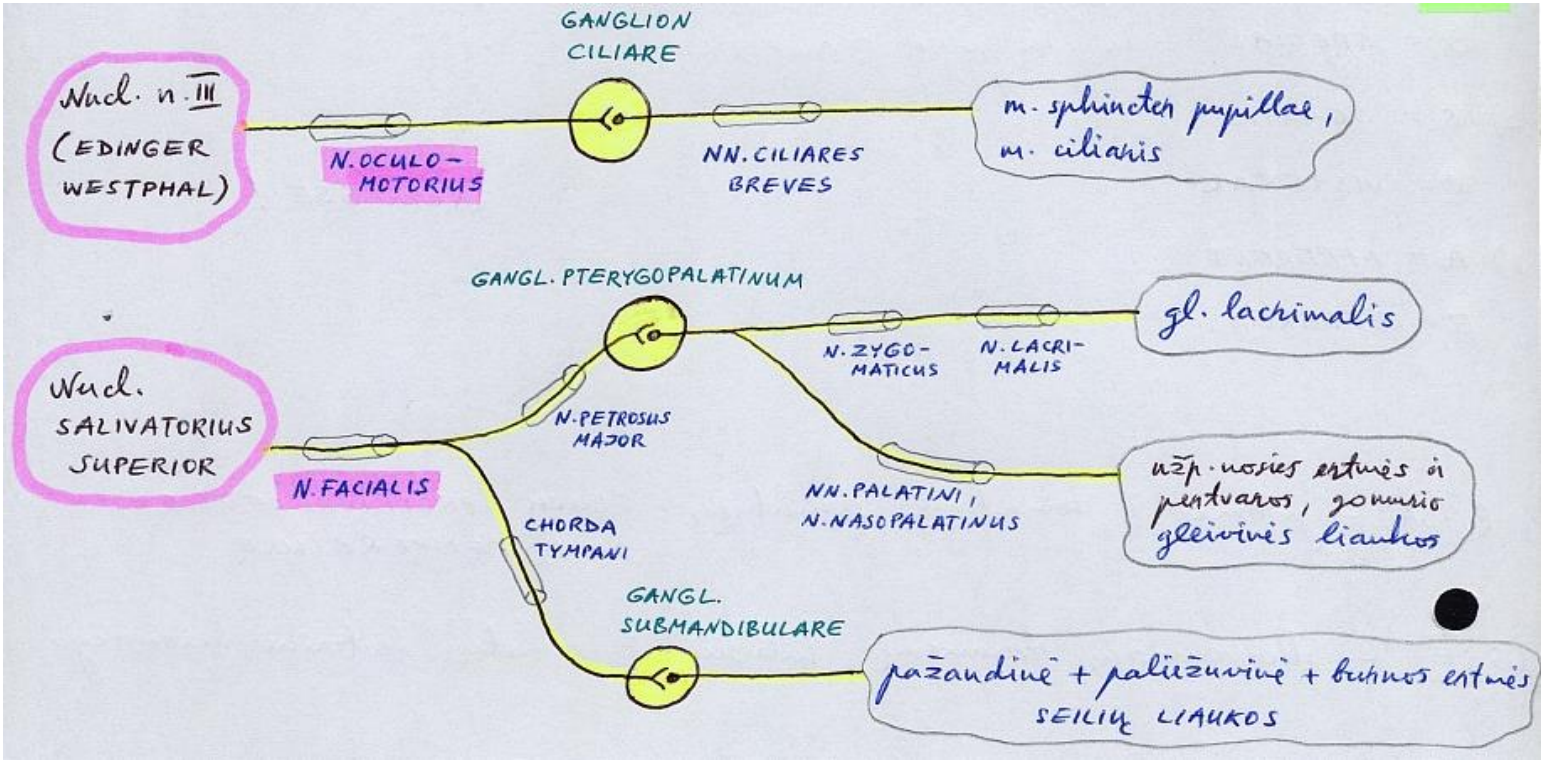
- Kaklinė dalis (3 mazgai)
- Krūtininė dalis (10–12 mazgų)
- Juosmeninė dalis (4–5 mazgai)
- Kryžmeninė dalis (4 ½ mazgo)

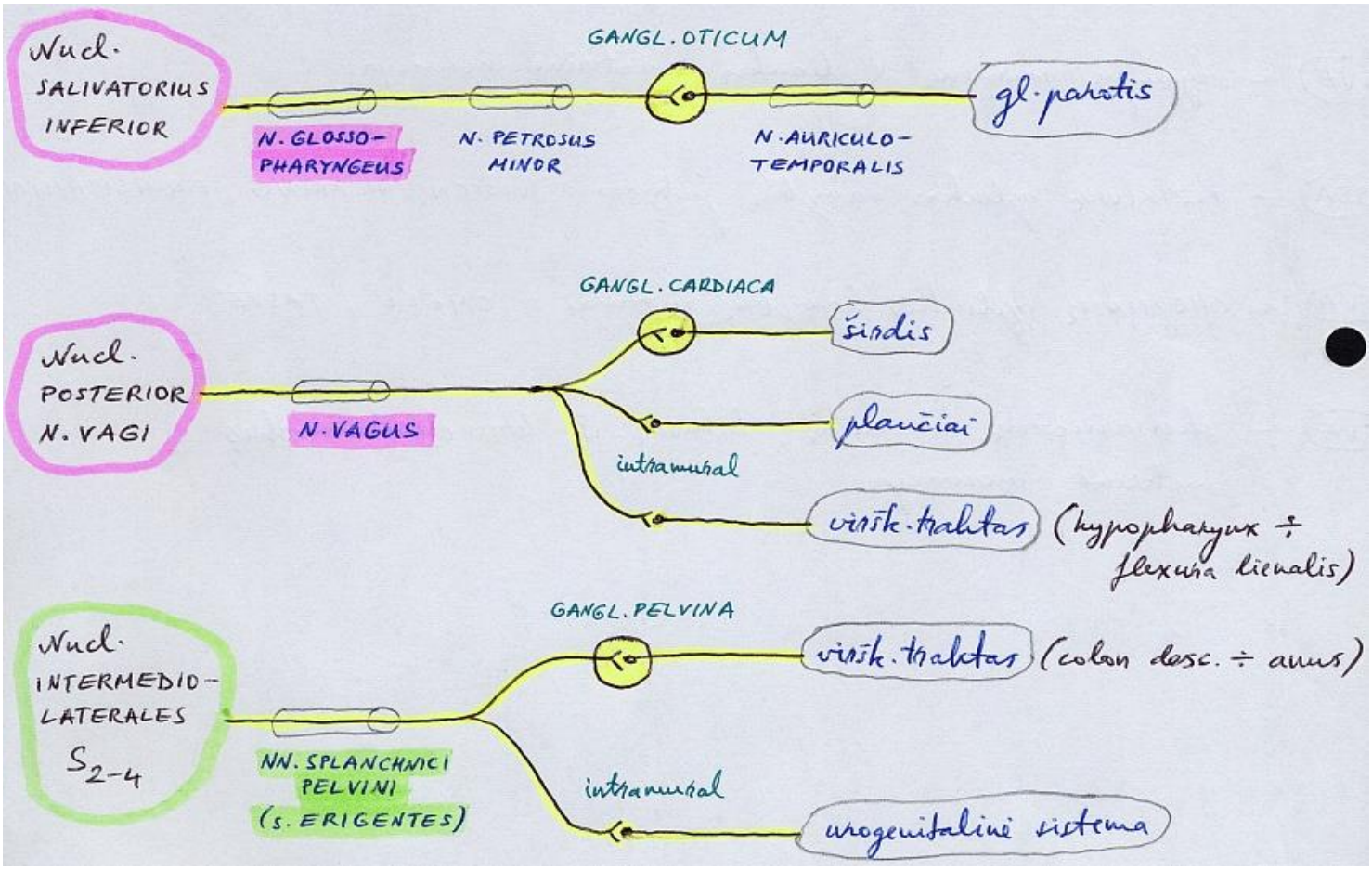
• ganglion cervicothoracicum (s. stellatum) – tai susijungę gangl. cervicale inf. ir gangl. thoracicum I

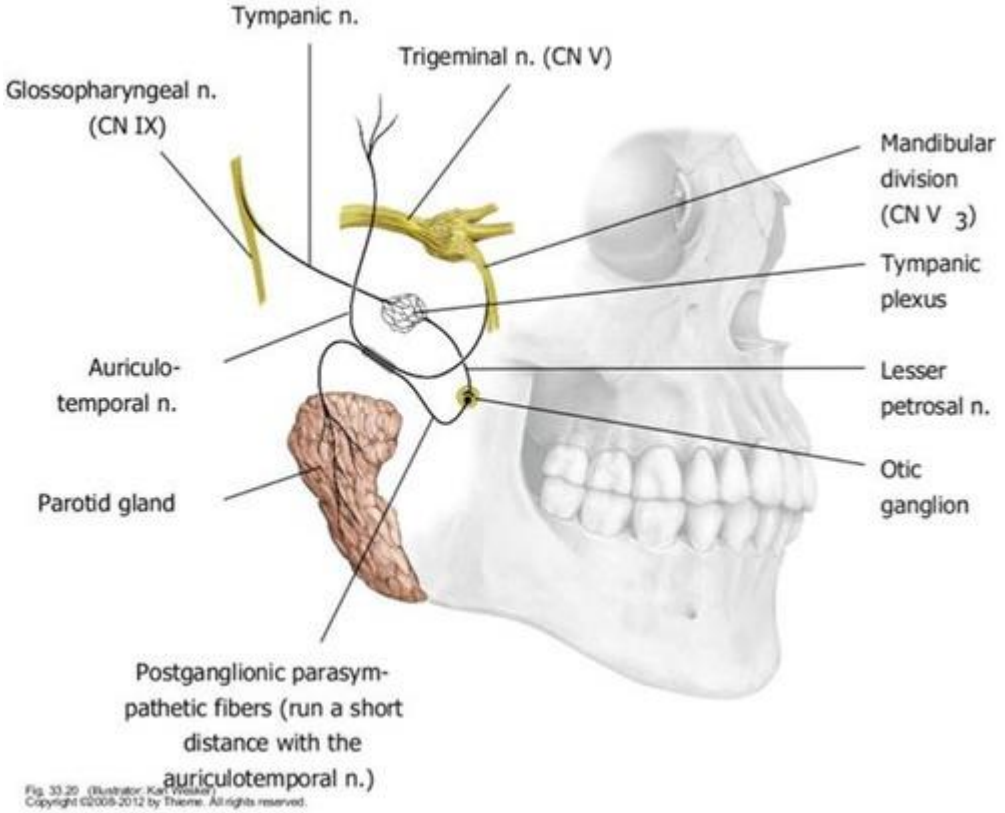
White ramus – esti tik Th_1–L_2
1) simpat. eferentinės (pregangl.) skaidulos
2) visceralinės aferentinės skaidulos
(jei tame lygyje [> Th_1 ar < L_2] nėra white ramus, skaidula keliauja per sympathetic chain, kol pasiekia Th_1–L_2 → white ramus)

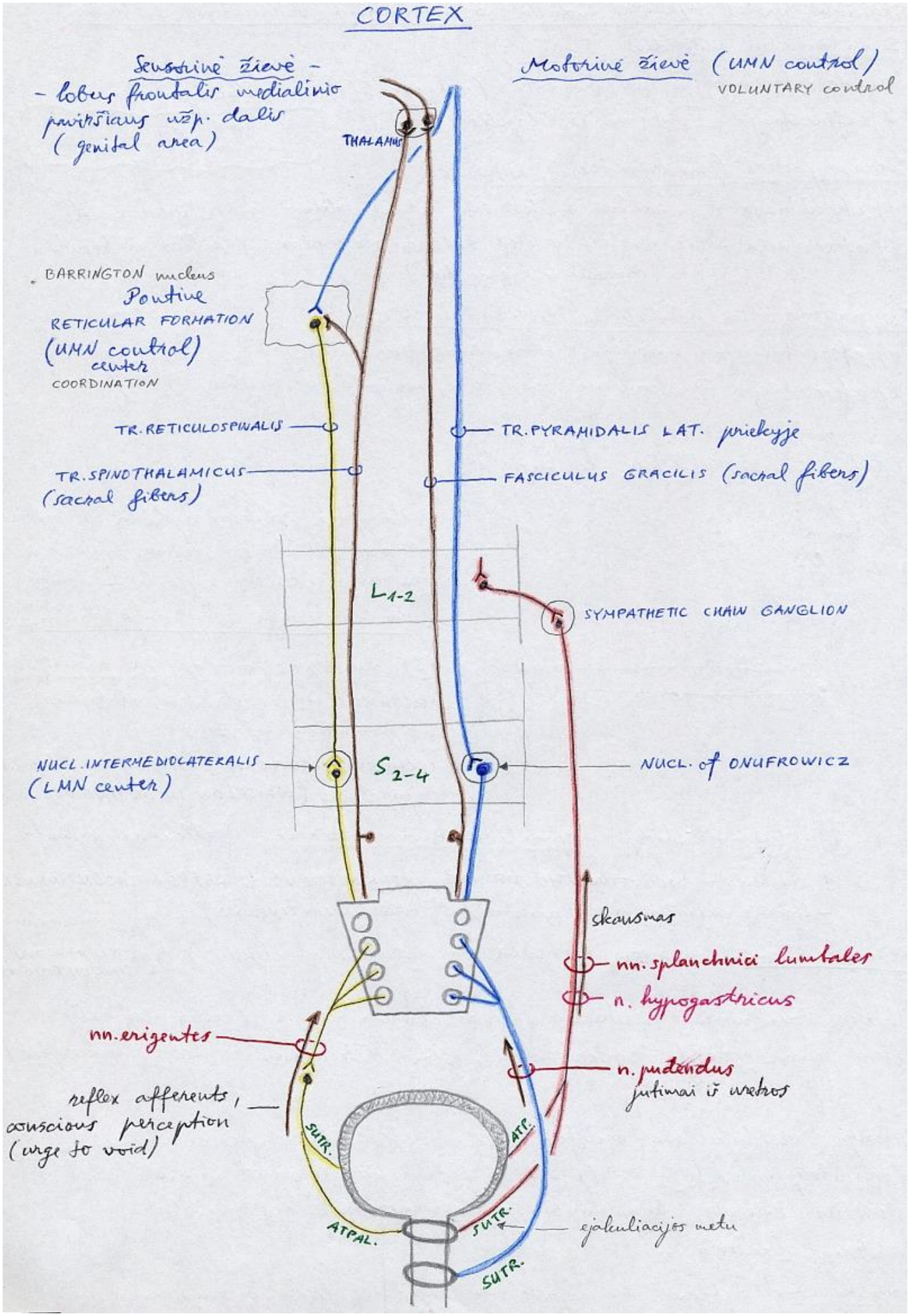
Gray ramus – turi visi spinaliniai nervai
simpat. eferentinės (postgangl.) skaidulos

PARASYMPATHETIC



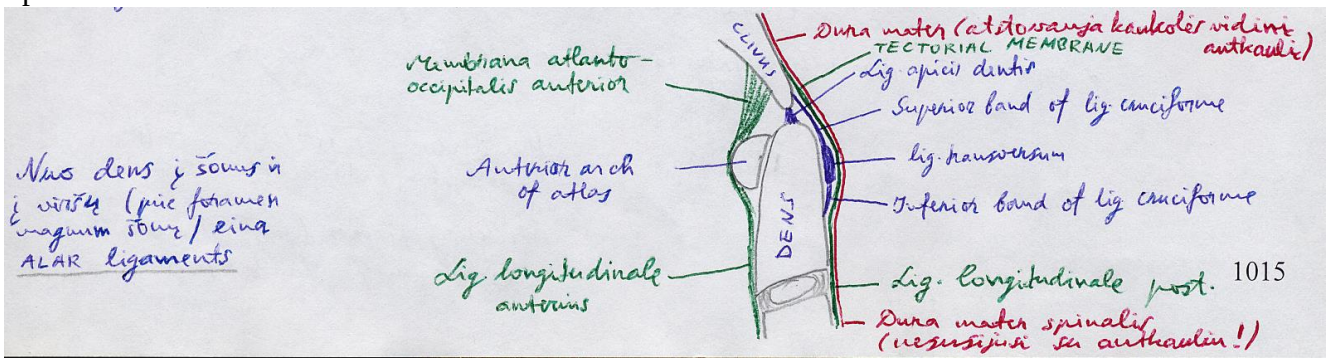


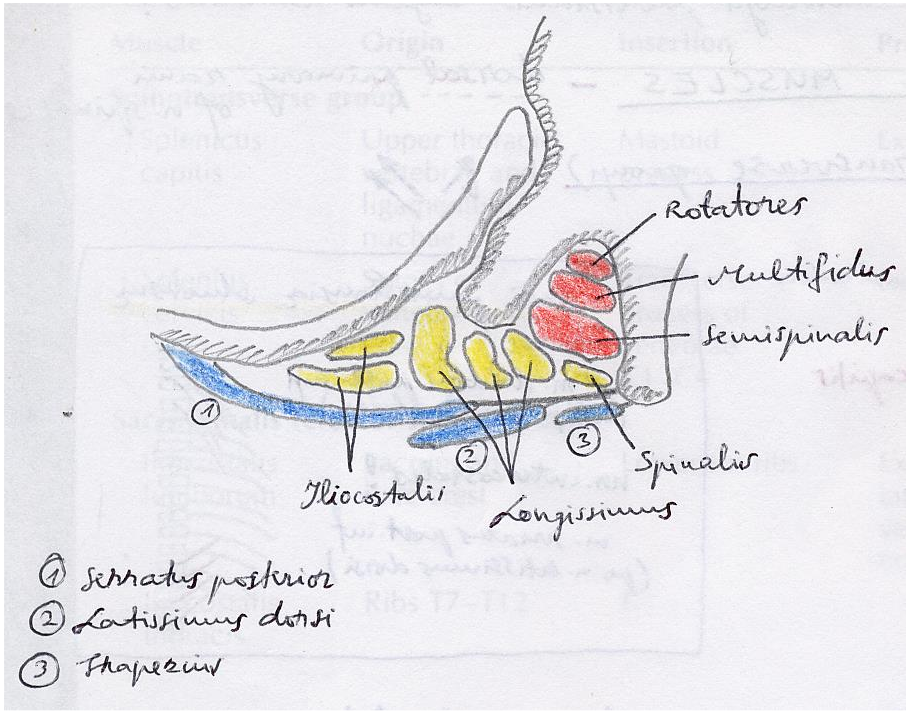


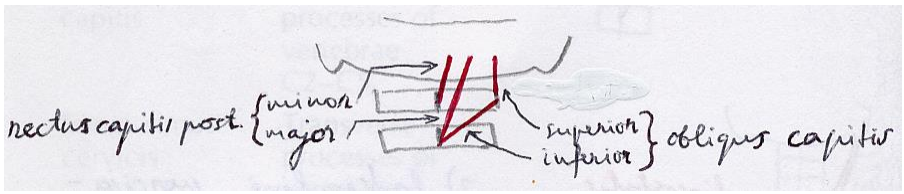

CORTEX
Sensorinė žievė -
- lobus frontalis medialinio paviršiaus užp. dalis
(genital area)
Motorinė žievė (UMN control)
VOLUNTARY control
THALAMUS
BARRINGTON nucleus
Pontine
RETICULAR FORMATION
(UMN control)
center
COORDINATION
TR. RETICULOSPINALIS
TR. PYRAMIDALIS LAT. priekyje
TR. SPINOTHALAMICUS
(sacral fibers)
FASCICULUS GRACILIS (sacral fibers)
L1-2
SYMPATHETIC CHAIN GANGLION
NUCL. INTERMEDIOLATERALIS
(LMN center)
S2-4
NUCL. of ONUFROWICZ
skausmas
nn. splanchnici lumbales
n. hypogastricus
nn. erigentes
n. pudendus
jutimai iš uretros
reflex afferents,
conscious perception
(urge to void)
SUTR.
ATP.
ATPAL.
SUTR.
ejakuliacijos metu
SUTR.

SPINE

Spine: 1013-1015 >>

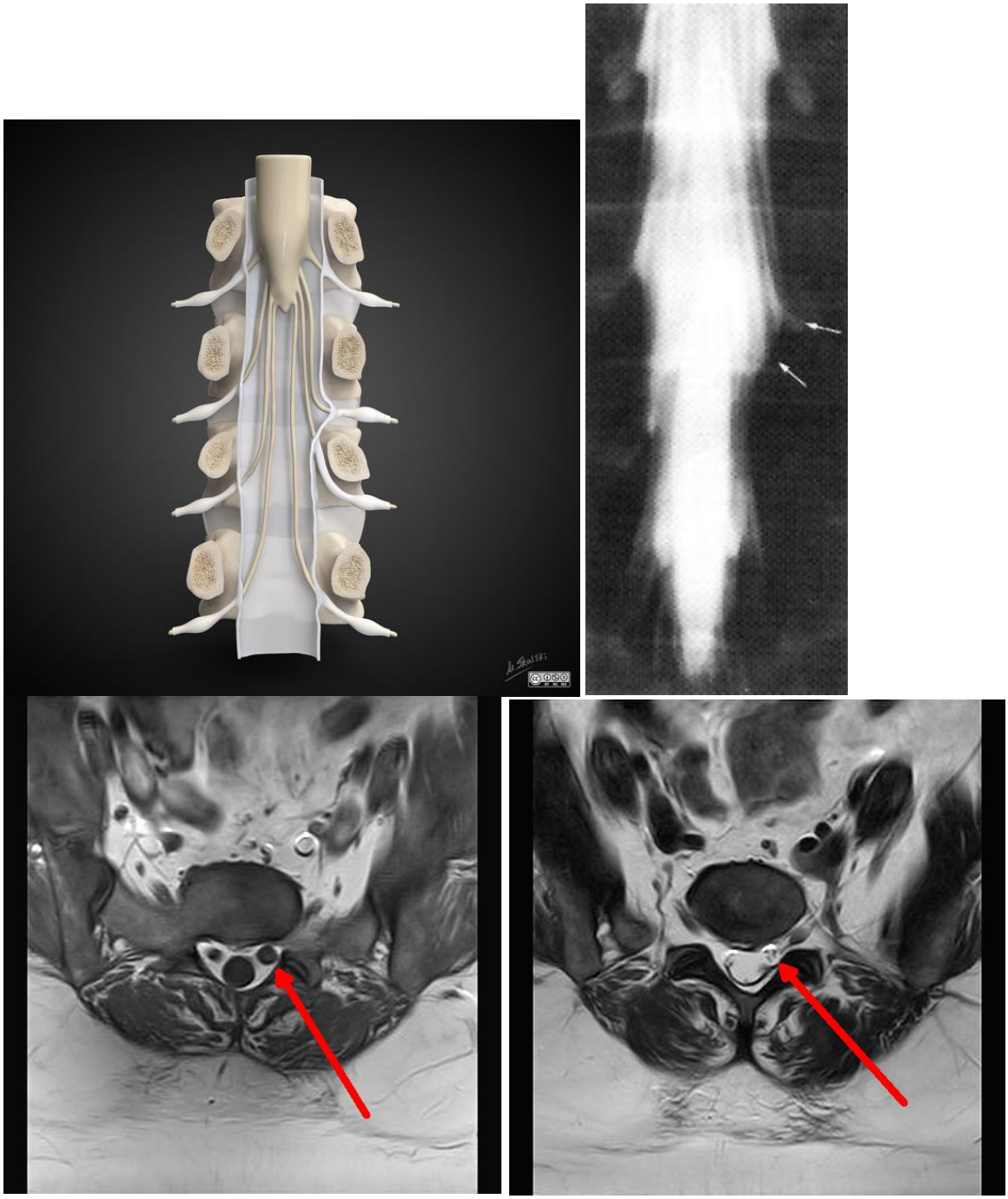






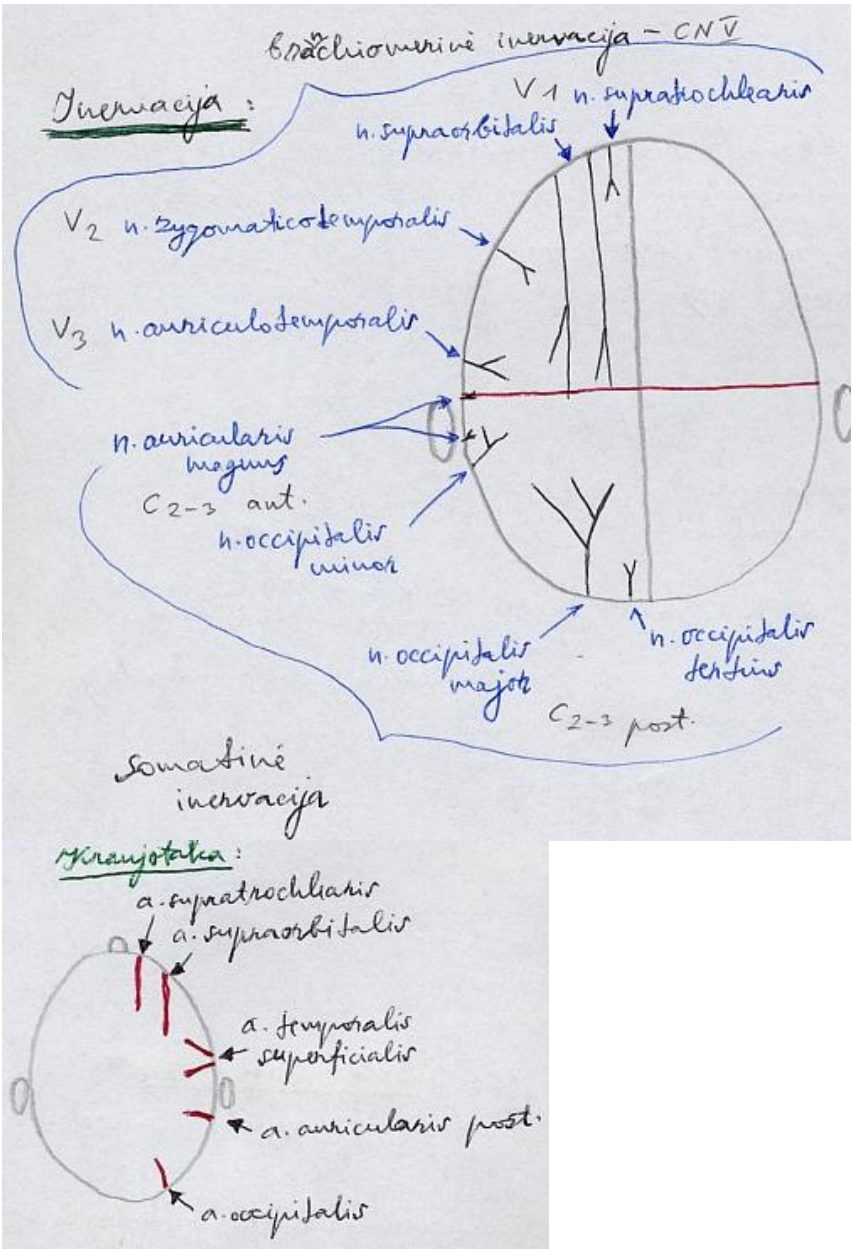
Conjoined root sleeves (normal anatomical variant – present in 1-3% of general population) - two nerve roots at adjacent levels share common sheath as they exit thecal sac (thus giving asymmetrical AP appearance), i.e. they penetrate dura at single intervertebral level (conjoined roots) → *one root sheath is missing at adjacent intervertebral level*.

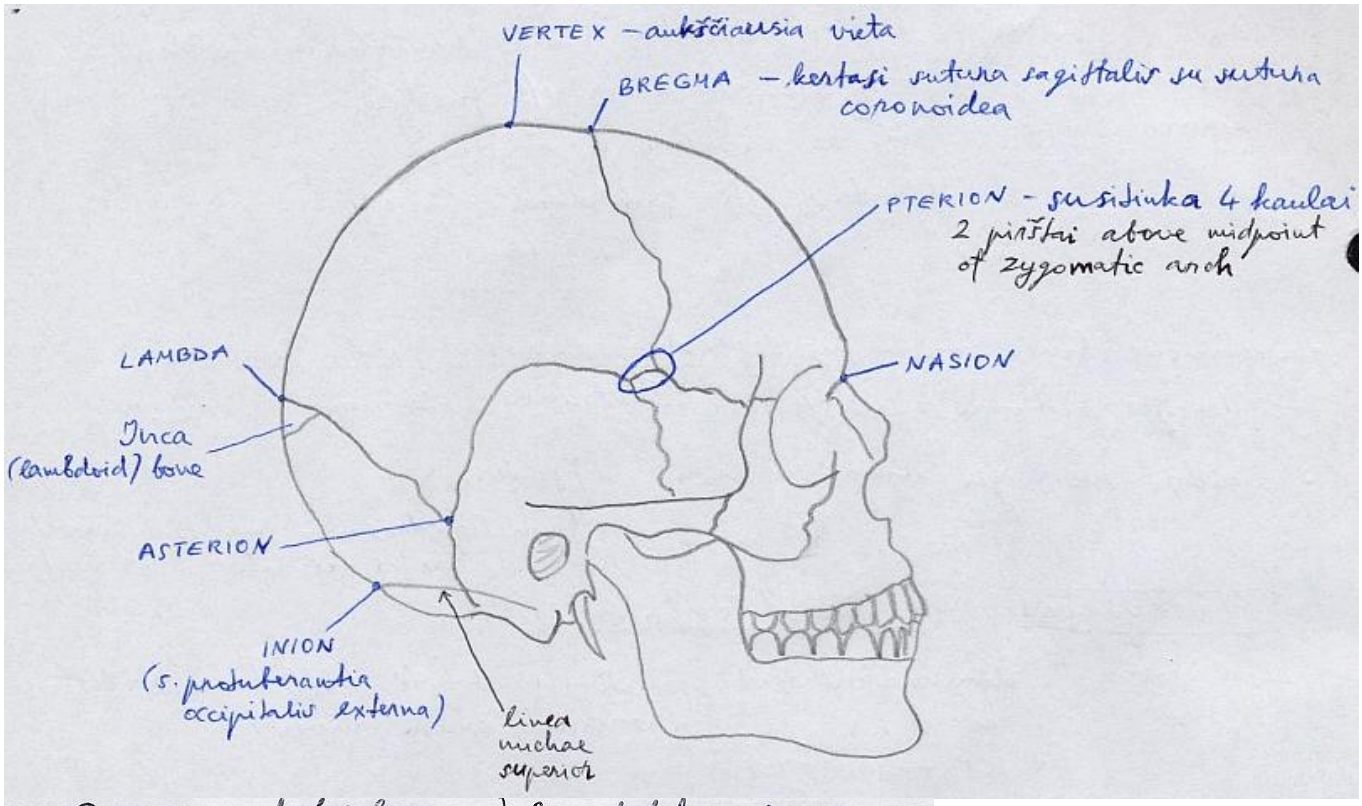
- **conjoined root sleeves** are large, and composite roots are usually clearly visible.
- commonest at L_5 and S_1 roots.



SKULL

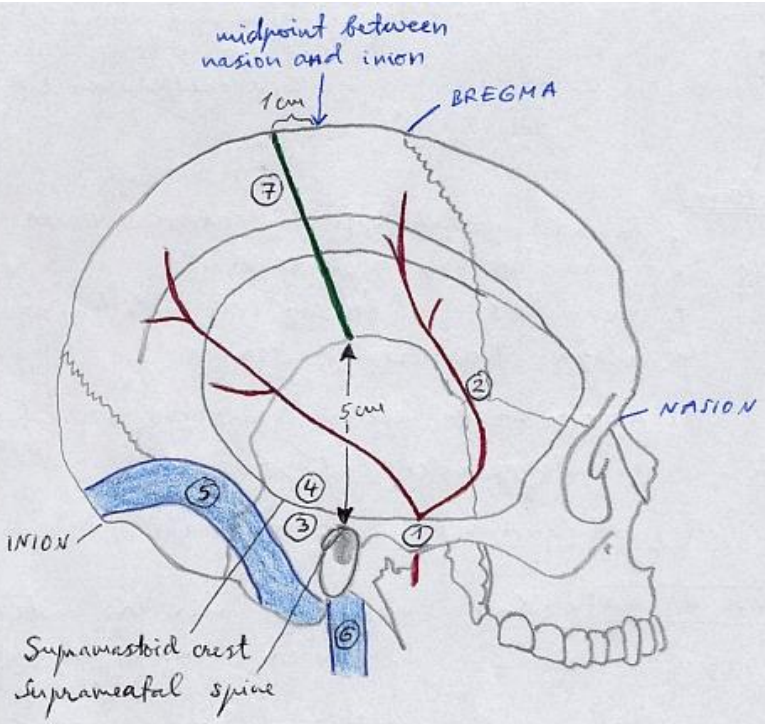
Skull: 1066-1075 >>


Brachiomerinė inervacija – CN V
Inervacija:
V1 n. supratrochlearis
n. supraorbitalis
V2 n. zygomaticotemporalis
V3 n. auriculotemporalis
n. auricularis magnus
C2-3 ant.
n. occipitalis minor
n. occipitalis major
n. occipitalis tertius
C2-3 post.
Somatinė inervacija
Kraujotaka:
a. supratrochlearis
a. supraorbitalis
a. temporalis superficialis
a. auricularis post.
a. occipitalis



Processus styloideus: 1) lig. stylohyoideum
2) lig. stylomandibulare
3) m. styloglossus (n. XII)
4) m. stylohyoideus (n. VII)
5) m. stylopharyngeus (n. IX)

↑ remnant of 2nd branchial arch



① A. meningea media kamuinas už articular tubercle (projekcijoje)

② R. anterior a. meningeae med. eina per PTERION

③ TRIGONUM SUPRAMEATALE (tarp suprameatal spine ir supramastoid crest) - - pateikimas į MASTOID ANTRUM

④ pateikimas į MIDDLE CRANIAL FOSSA (virš supramastoid crest)

⑤ TRANSVERSE + SIGMOID sinus - eina nuo inion iki ≤2cm už external meatus - pereina į ⑥ v. jugularis int. (deep and anterior to mastoid process)

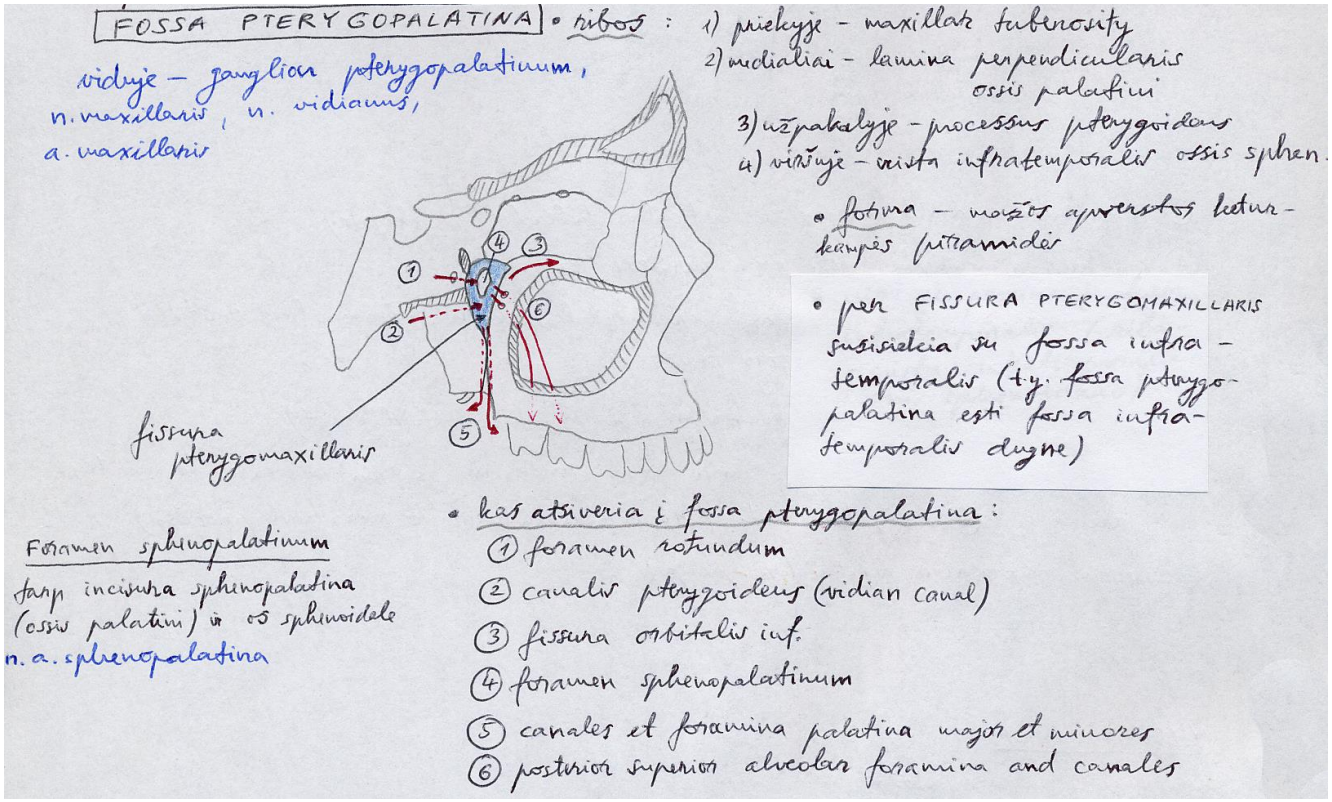
⑦ SULCUS CENTRALIS cerebri (projekcija)

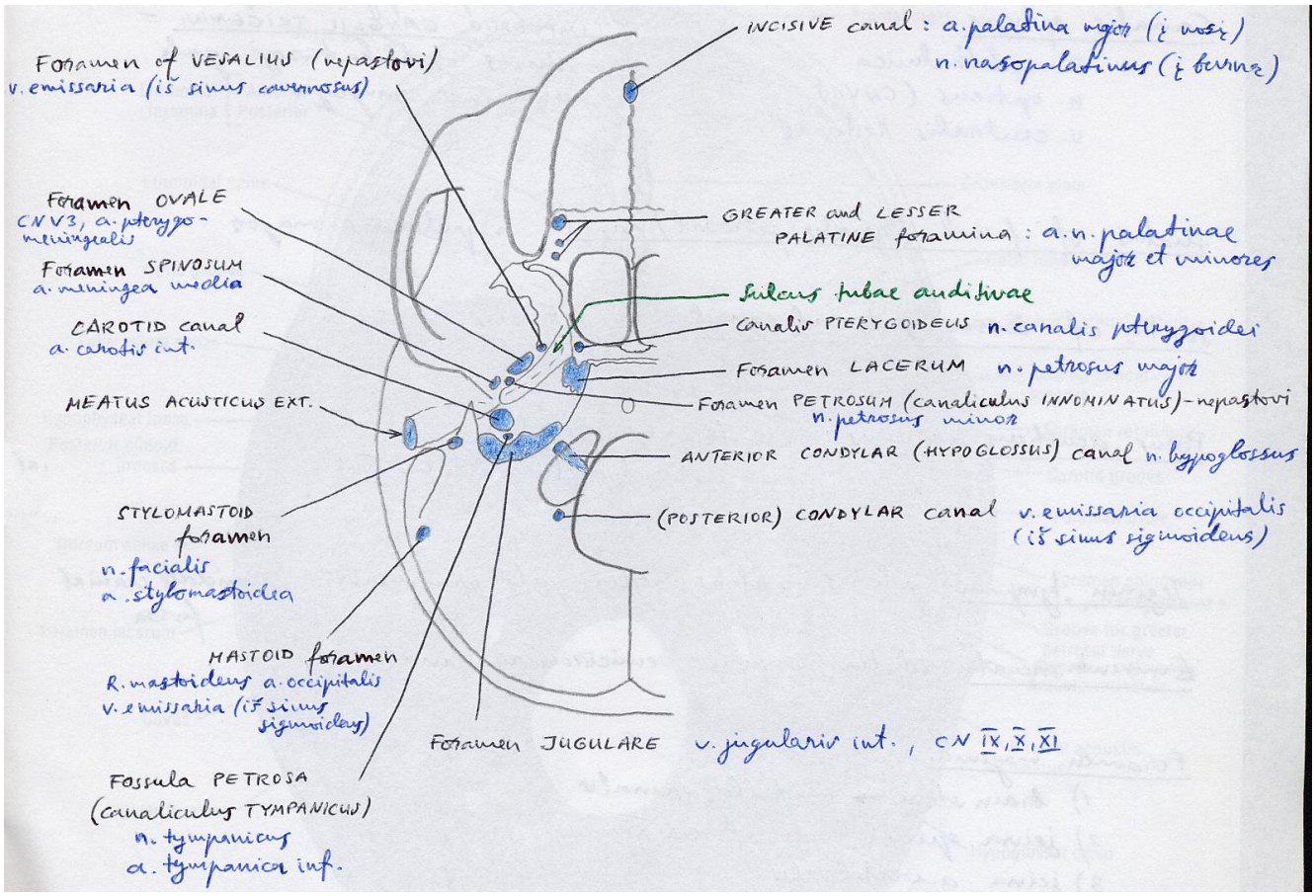
Canalis opticus

- a. ophthalmica
- n. opticus (CN II)
- v. centralis retinae

SPHENOID
- lesser wing ← FISSURA ORBITALIS SUP.:
  1) n. ophthalmicus (CN V1)
  2) CN III, IV, VI
  3) vv. ophthalmicae sup.
- greater wing ← FISSURA ORBITALIS INF.:
  1) n. infraorbitalis (CN V2)
  2) a. infraorbitalis (a. maxillaris)
  3) v. ophthalmica inf.

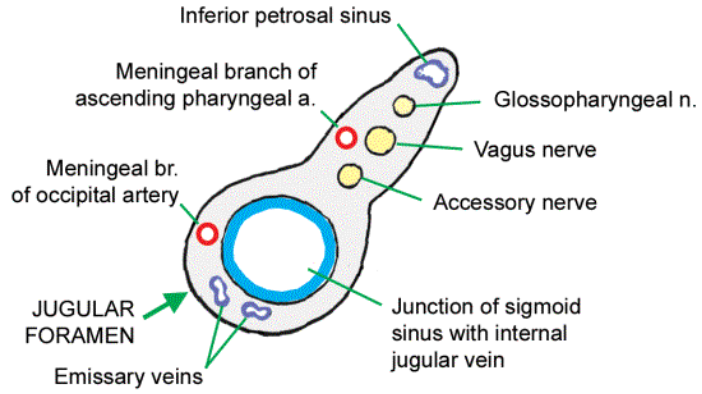
MAXILLA





Foramen/canal [location]	From → To	Contents	Notes
OPTIC CANAL [basisphenoid]	orbital apex → middle fossa	CN2 and sheath; ophthalmic artery	1 mm difference in size suspicious; keyhole and figure of eight variants
SUPERIOR ORBITAL FISSURE [between greater and lesser sphenoid wings]	orbital apex → middle fossa	CN3, 4, 5_1, 6; superior ophthalmic vein; middle meningeal artery branch	

FORAMEN ROTUNDUM [greater sphenoid wing]	middle fossa → pterygopalatine fossa	$CN5_2$, artery of foramen rotundum	may be surrounded by extensive sphenoid sinus
PTERYGOID (VIDIAN) CANAL [body of sphenoid]	foramen lacerum → pterygopalatine fossa	vidian nerve and artery	
FORAMEN OVALE [greater sphenoid wing]	middle fossa → infratemporal fossa	$CN5_3$, accessory meningeal artery; veins	
FORAMEN SPINOSUM [greater sphenoid wing]	middle fossa → infratemporal fossa	middle meningeal artery	may be double
CAROTID CANAL [petrous temporal]	skull base → middle fossa	ICA and sympathetic plexus	runs posteromedial to eustachian tube; rarely passes through middle ear
INTERNAL AUDITORY MEATUS [petrous temporal]	posterior fossa → inner ear	CN7-8 and dural sheath; internal auditory artery	
JUGULAR FORAMEN [between petrous temporal and basiocciput]	posterior fossa → extracranial jugular fossa	pars nervosa: CN9, inferior petrosal sinus. pars vascularis: CN10-11, internal jugular vein, ascending pharyngeal and occipital artery branches	pars nervosa and vascularis may be separate
FORAMEN MAGNUM [basiocciput]	posterior fossa → cervical spinal canal	medulla oblongata, meninges and ligaments; CN11 (spinal root); vertebral and spinal arteries and veins	
HYPOGLOSSAL (ANTERIOR CONDYLAR) CANAL [occipital condyle]	foramen magnum → medial to jugular fossa	CN12; branch of ascending pharyngeal artery	



VASCULAR

PHSYIOLOGY

- blood flow

  kidney – 420 ml /100 g /min
  myocardium – 84 ml /100 g /min
  liver – 58 ml /100 g /min
  brain – 50-60 ml /100 g /min.

cerebral perfusion pressure (CPP) < 40 mmHg → impaired cerebral blood flow (in clinical practice, all patients with **ICP > 40 mmHg** have significantly diminished CBF).

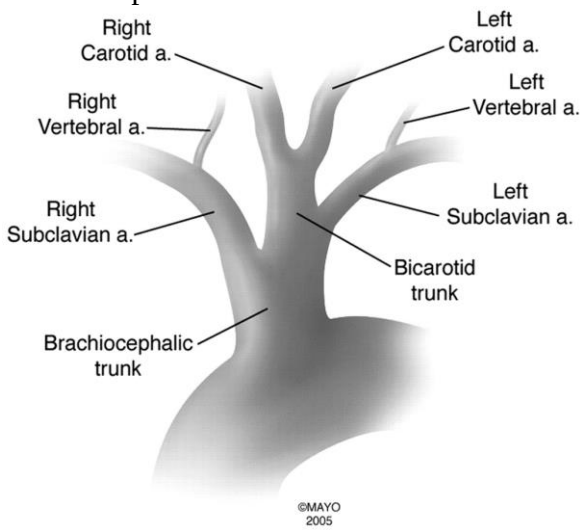
maintain CPP > 60 mmHg (bring ICP < 15-20 mmHg)

- smegenys išekstrahuoja iš pratekančio kraujo: ≈ 50% **O_2** ir tik ≈ 10% **gliukozės** (i.e. ratio 5 : 1).
  N.B. brain is highly aerobic tissue, with oxygen rather than metabolic substrate serving as limiting substance!
  N.B. *with focal cortical activity*, local **CBF** increases ≈ 30% while **O_2 consumption** increases only 5% (luxurious oxygen supply)

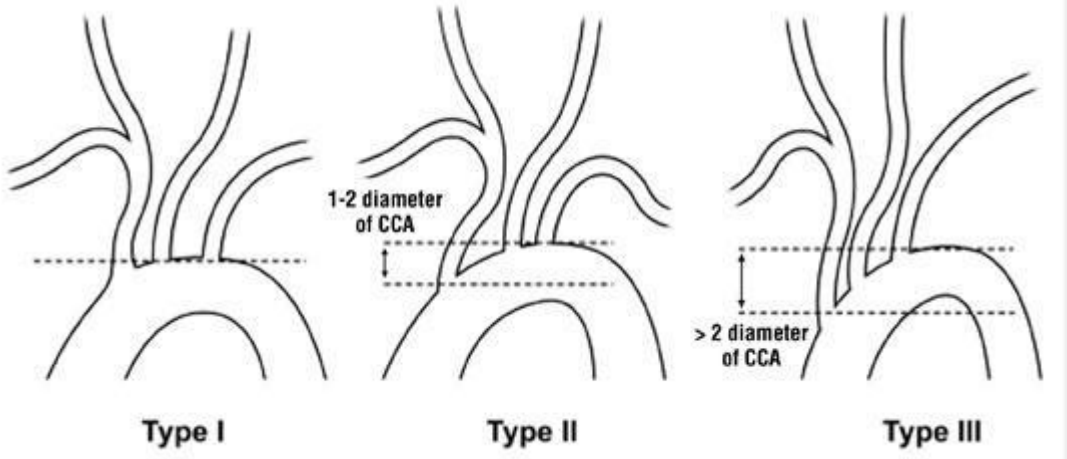
- brain uses glucose as exclusive fuel (badaujant prisitaiko naudoti ir ketone bodies)
- brain veins unique - have no muscular layers or valves – can dilate and reverse blood flow direction if sinus gets occluded.

AORTIC ARCH

True bovine arch found in cattle - single great vessel (brachiocephalic trunk) originates from aortic arch and splits into bilateral subclavian arteries and bicarotid trunk:



Aortic arch types



For type II-III arches, one needs angled Sims catheter to cannulate innominate artery due to acute angle.
brachiocephalic artery = brachiocephalic trunk = innominate artery

SUBCLAVIAN ARTERY

Branches (in order):

1. Vertebral
2. Thyrocervical trunk
3. Internal thoracic (mammary)
4. Costocervical trunk
5. Descending scapular

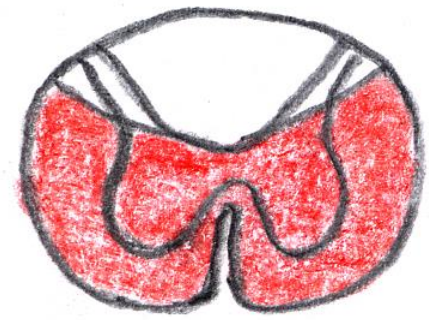
SPINAL CORD

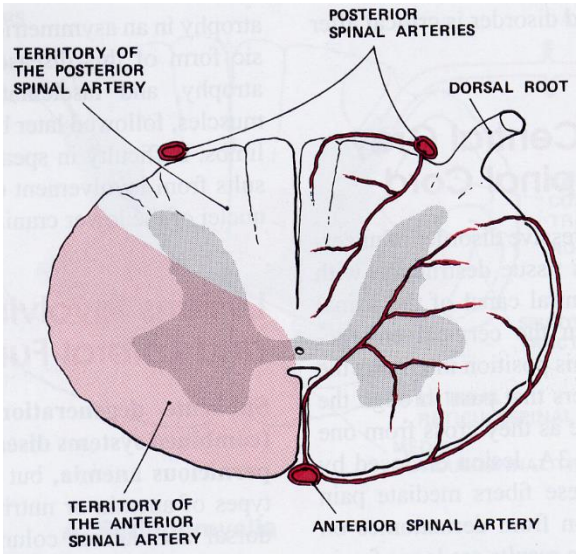
Segmental arteries = posterior intercostal arteries, lumbar arteries
Segmental arteries (catheterized during DSA):

1) branches of vertebral arteries, deep and ascending cervical arteries and to a lesser degree from the ascending pharyngeal and occipital arteries – for cervical cord
2) superior intercostal artery (branch of costocervical trunk) – for T1-2
3) **posterior intercostal arteries** (9 pairs) – for T3-11
4) subcostal arteries (1 pair)
5) **lumbar arteries** (4 pairs)
6) branches of internal iliac artery (mainly the iliolumbar and lateral sacral arteries) and median sacral artery (branch of the aorta at the level of the bifurcation*) – for L5 and sacrum.

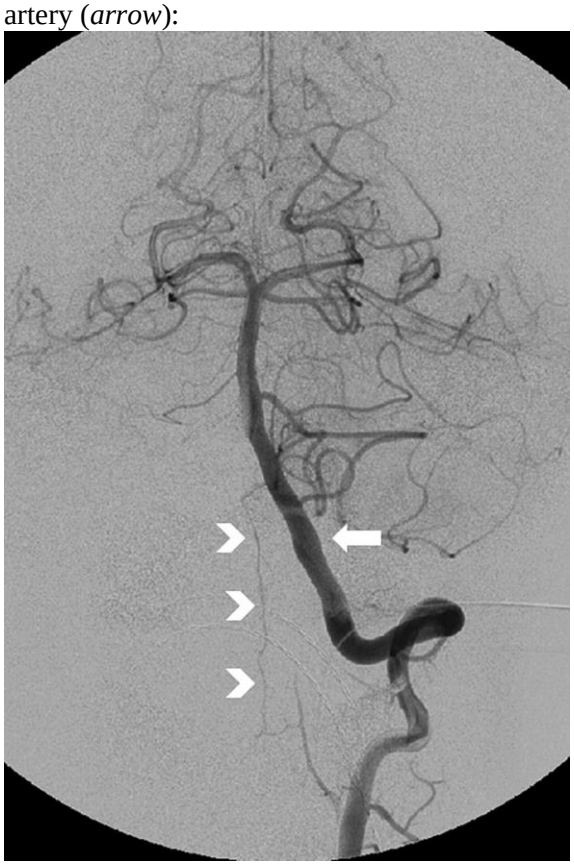
*aorta bifurcates at lower level of L4

A. spinalis ant. territory – anterior 2/3 of spinal cord:





Left vertebral artery DSA (frontal view): anterior spinal artery (*arrowheads*) originating from left vertebral artery (*arrow*):



Poorest in midthoracic region!

MIDTHORACIC REGION (T6-8) is most susceptible to ischemia!

Infarctions in A. SPINALIS ANT. territory are much more common than in AA. SPINALES POST. territory!

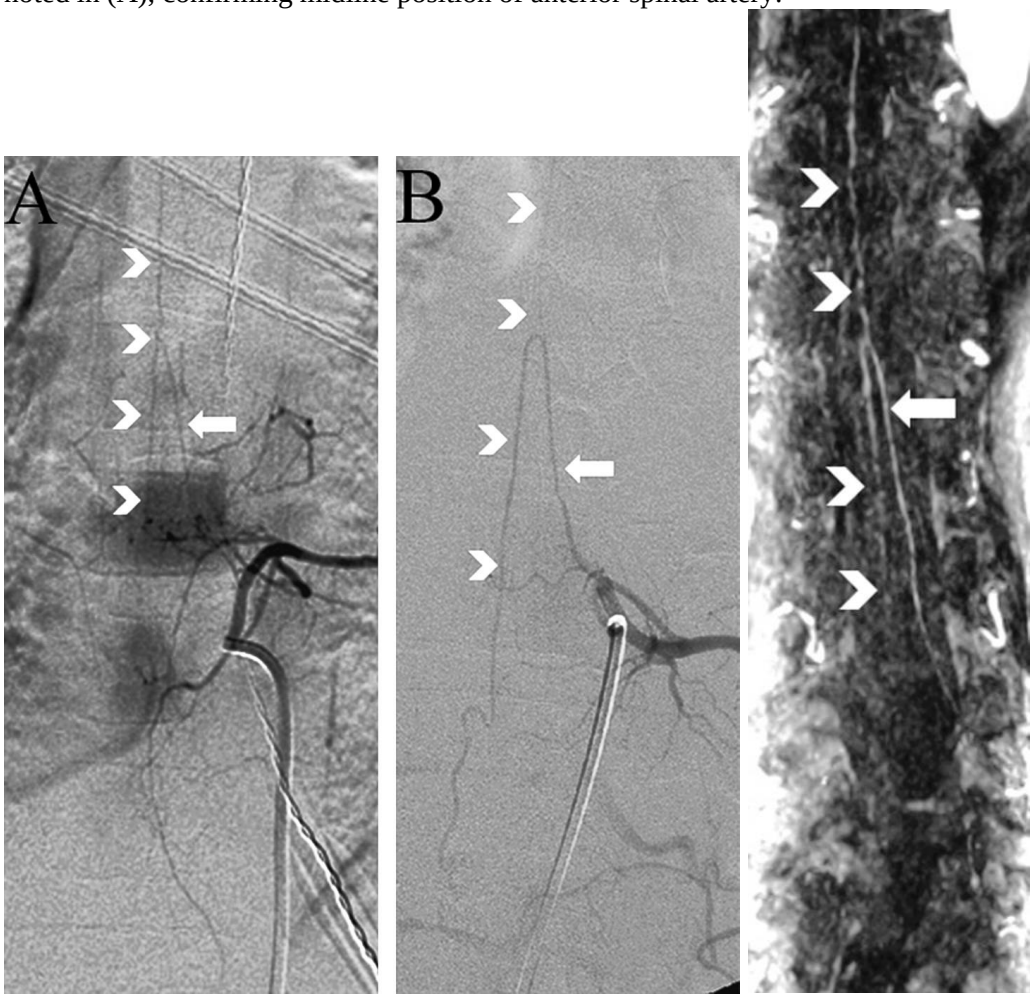
GREAT SEGMENTAL MEDULLARY ARTERY (s. artery of ADAMKIEWICZ, arteria RADICULARIS MAGNA, artery of LUMBAR ENLARGEMENT)

- neporinė, stambiausia ir pastoviausia iš AA. MEDULLARES SEGMENTALES.
- atsišakoja nuo apatinių AA. INTERCOSTALES POST. arba viršutinių AA. LUMBALES (i.e. T_8-L_2); džn. L_2 iš kairės pusės.
- typical ***angiographic appearance*** – loops up then down ("**shepherd's hook**").
- may reach T4 level; anastomozuoja su A. SPINALIS ANT. at the top of hook.

ARTERY OF ADAMKIEWICZ – pagrindinis kraujo tiekėjas *A. SPINALIS ANT. apatiniams* 2/3

DSA (A, B) on the left; MRA on the right

Artery of Adamkiewicz (*arrow*) which supplies anterior spinal artery (*arrowheads*); hemivertebral blush is noted in (A), confirming midline position of anterior spinal artery:



- **great anterior radiculomedullary vein** (GARV, diameter 1.5-2.0 mm) is easily mistaken for Adamkiewicz due its spatial course and location; H: junction of GARV with a median vein (anterior or posterior) is described as a **'coathook'** configuration with more obtuse angulation cf. more acute 'hairpin' configuration of Adamkiewicz.

UPPER THORACIC ANTERIOR SEGMENTAL MEDULLARY ARTERY (s. artery of ALBRECHT VON HALLER)

- constant significant upper thoracic anterior radiculomedullary artery distinct from artery of Adamkiewicz.

BRAIN - arteries

- CCA bifurcates at C3-4 or C4-5 level (upper level of thyroid cartilage).

EXTERNAL CAROTID ARTERY (ECA)

ICA lies usually posterior and lateral to ECA

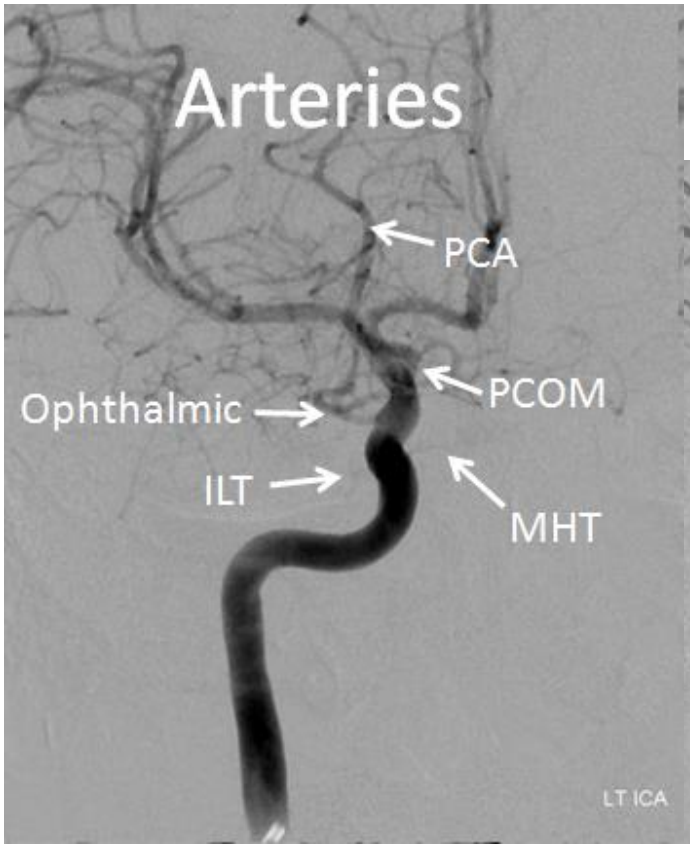
Branches (in order) – SAL FOP MS:

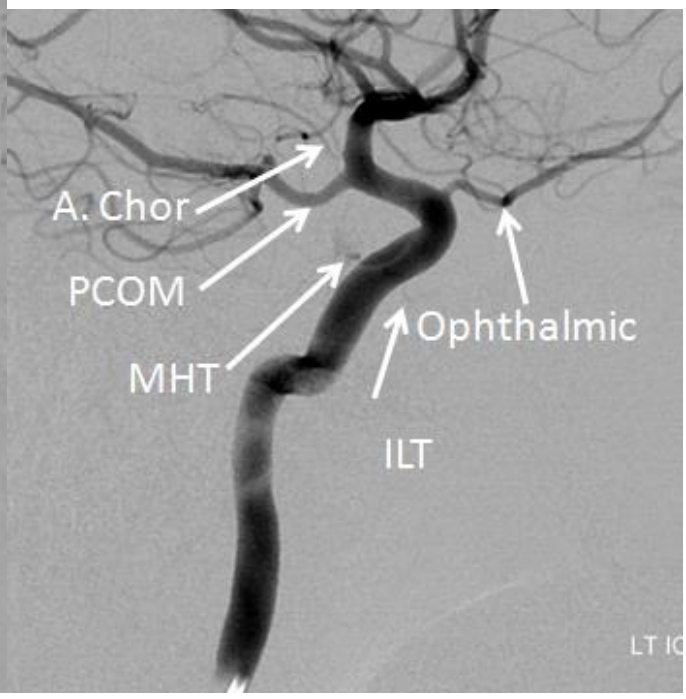
1. Superior thyroid
2. Ascending pharyngeal
3. Lingual
4. Facial
5. Occipital
6. Posterior auricular
7. Maxillary
8. Superficial temporal

Middle Meningeal Artery (MMA)

- origin - proximal Internal Maxillary Artery (IMAX)
- multiple connections to other key vessels (ophthalmic, internal carotid, MHT, ILT, ascending pharyngeal, occipital) - these can be either useful treatment routes or "dangerous anastomoses" (e.g. feeding orbit and central retinal artery)

ICA





ILT – inferolateral trunk

CIRCLE OF WILLIS

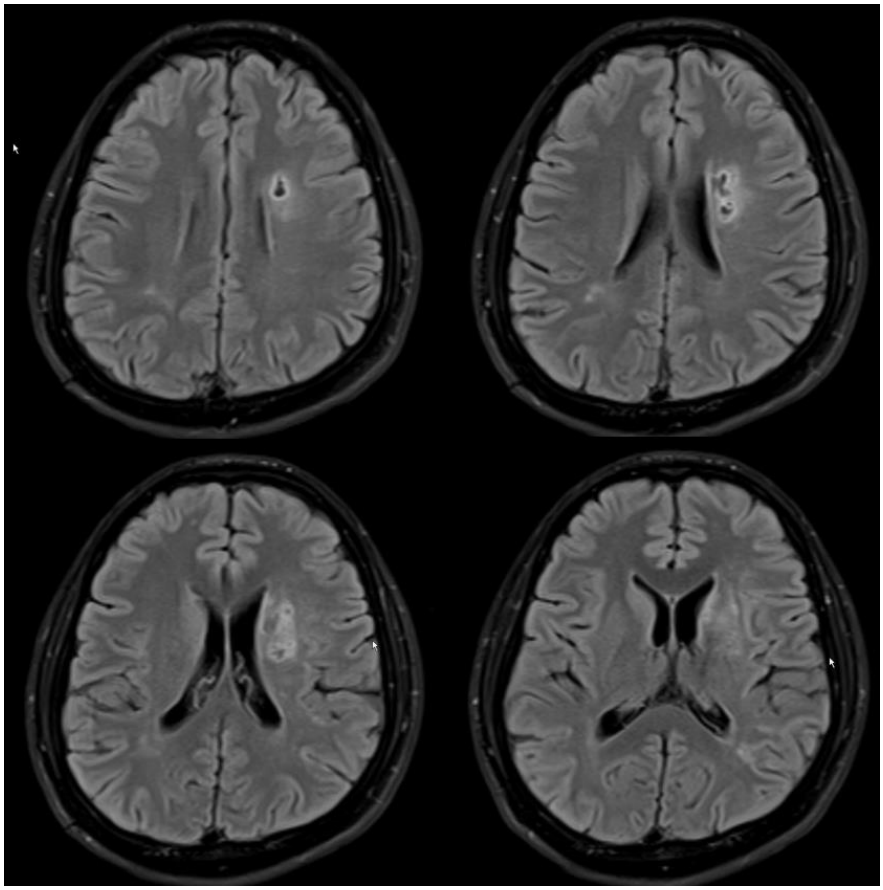
Anteromedial central arteries – branches of A_1 and AComA.

- supply anteromedial **thalamus & corpus striatum**, anterior **hypothalamus**.

Anterolateral central (s. **lenticulostriate**, **lateral striate**) **arteries** – branches of M_1; čia priklauso ir viena A_2 šaka – *medial striate* (s. *recurrent of Heubner*) *artery* – it is simply the most medial of lenticulostriates

- įeina per *ANTERIOR PERFORATED SUBSTANCE*.
- supply:
  1) **capsula interna** – *viršutinę* dalį ir didesnę *anterior limb* dalį **!**
  2) didžiąją **corpus striatum** dalį – putamen, caudate (išsk. globus pallidus ir tail of nucl. caudatus) **!**

Classic Heubner infarct:



Posteromedial central arteries – branches of P_1 and PComA.

- supply:
  1) medial part of **pedunculus cerebri** – P_1 branches entering *POSTERIOR PERFORATED SUBSTANCE* (interpeduncular fossa dugnas).
  2) posterior **hypothalamus**
  3) anteromedial (?) **thalamus** (*thalamo-perforating arteries*)

     artery of Percheron (*posterior thalamo-subthalamo-paramedian artery*) - single small artery from right or left P_1 (or top of BA) - divides in subthalamus to bilaterally supply inferomedial and anterior **thalamus** and **subthalamus**; occlusion leads to profound level of consciousness alterations!

Posterolateral central arteries – branches of P_2.

- supply posterolateral **thalamus** (*thalamo-geniculate arteries*).

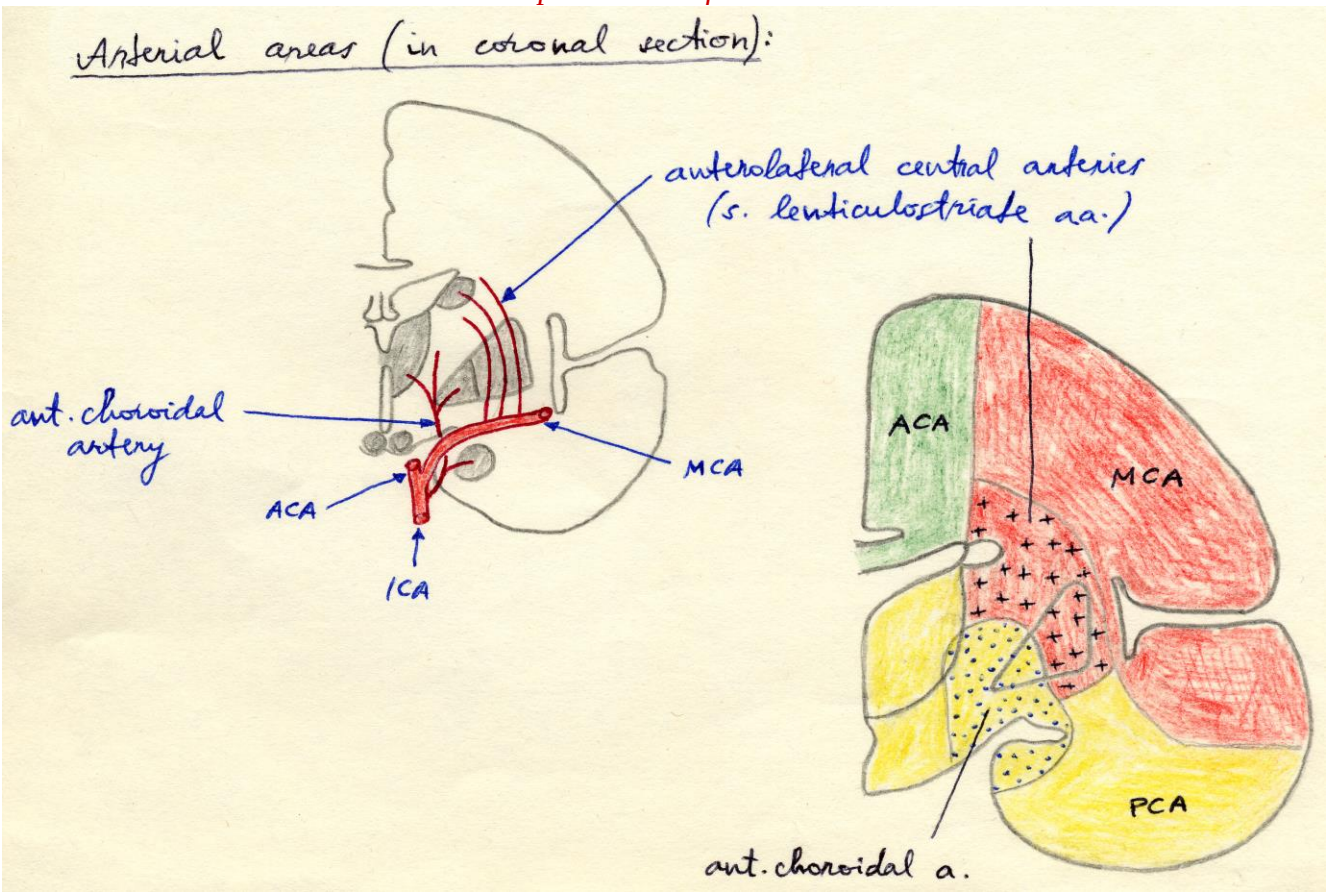
Anterior choroidal artery (AChA) (branch of supraclinoid ICA) – long subarachnoidal course and relatively small caliber.

- ***proximal (cisternal) segment*** - passes caudally across and below optic tract (medial to uncus), and then laterally (through crural cistern and around cerebral peduncle) → enters inferior horn of lateral ventricle through *CHOROIDAL FISSURE* of temporal lobe.
- ***distal (plexal) segment*** - goes posteriorly in cleft of temporal horn; terminates near lateral geniculate body (or may extend around pulvinar).
  - rich anastomoses between AChA and lateral posterior choroidal artery, PComA, PCA - occlusion is usually tolerated fairly well!!! (internal capsule infarct occurs in 15%)
- supplies:
  1. **choroidal plexus** of temporal horn
  2. **capsula interna** – apatinę *posterior limb* dalį ir visą *retrolenticular limb* → hemiplegia
  3. medial **globus pallidus***, tail of **nucl. caudatus**
  4. **piriform cortex** and **uncus**, **amygdala**, **hippocampus** and **dentate gyri.**
  5. ventrolateral **thalamus** → hemisensory deficits
  6. lateral geniculate body, **optic tract** and origin of optic radiations → various homonymous field cuts

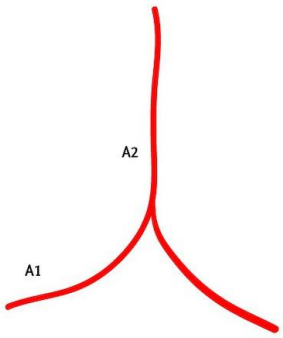
*ligation of AChA was utilized in treatment of Parkinsonism sometimes without ill effect

Posterior choroidal arteries (PChA) (branches of P_2):
medial PChA – **choroidal plexus** of 3rd ventricle, dorsomedial **thalamus**;
lateral PChA – **choroidal plexus** of lateral ventricle.

- > 50% normal individuals have *incomplete circle of Willis*:



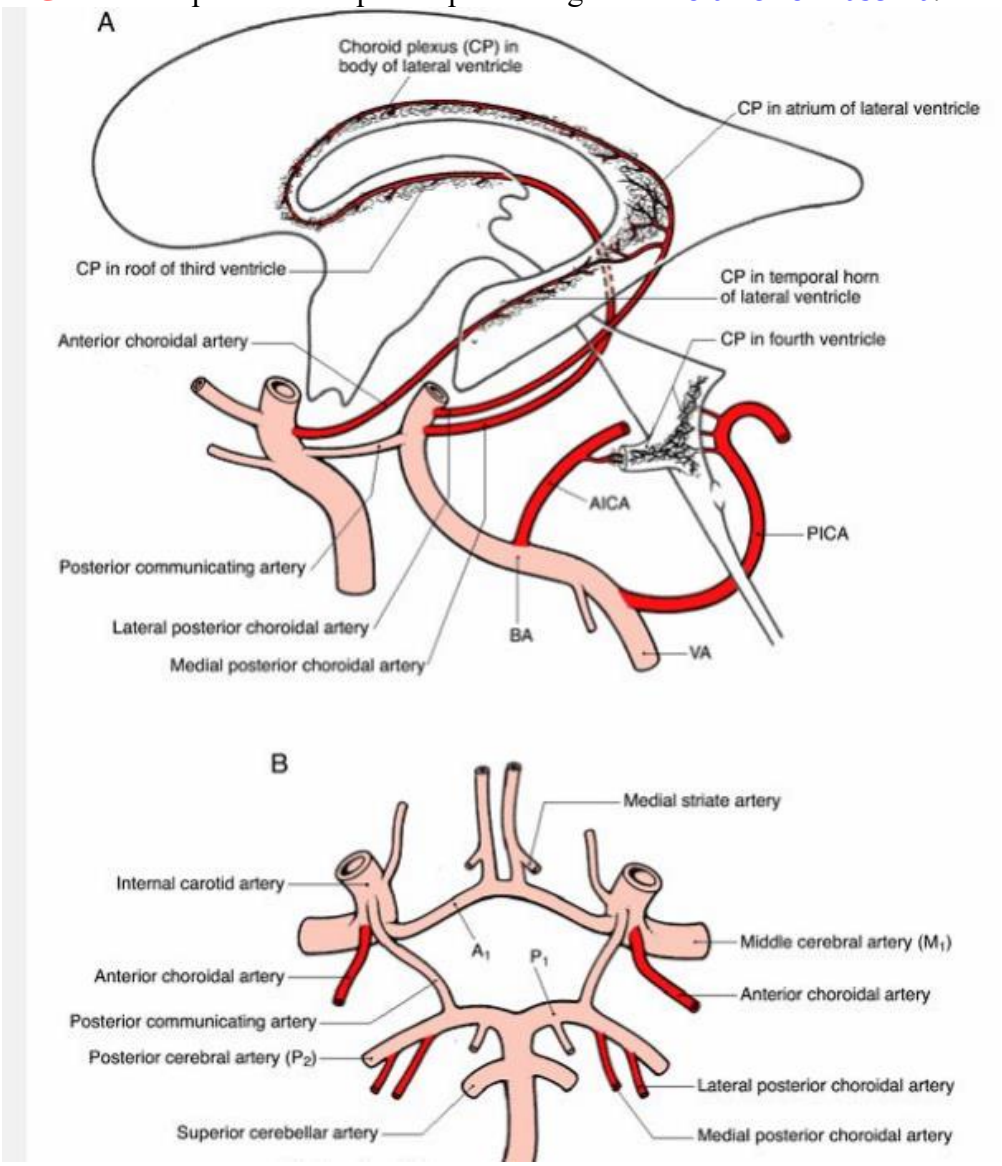
- **AZYGOS ACA** – when both hemispheres are fed by one side ACA (has branch to opposite side) and *opposite proximal A2 is missing*.



Azygous anatomy

CHOROID PLEXUS

- anterior and posterior (medial + lateral) choroidal arteries → plexuses of lateral and third ventricles.
- PICA → choroid plexus in fourth ventricle.
- AICA → clump of choroid plexus protruding out of foramen of Luschka.



INTERNAL CAPSULE

Anterior limb, whole **upper part** – anterolateral central arteries (medial striate a. – rostromedial part of anterior limb).

Genu – tiesioginės ICA šakelės.

Lower part of **posterior limb**, **retrolenticular limb** – anterior choroidal artery.

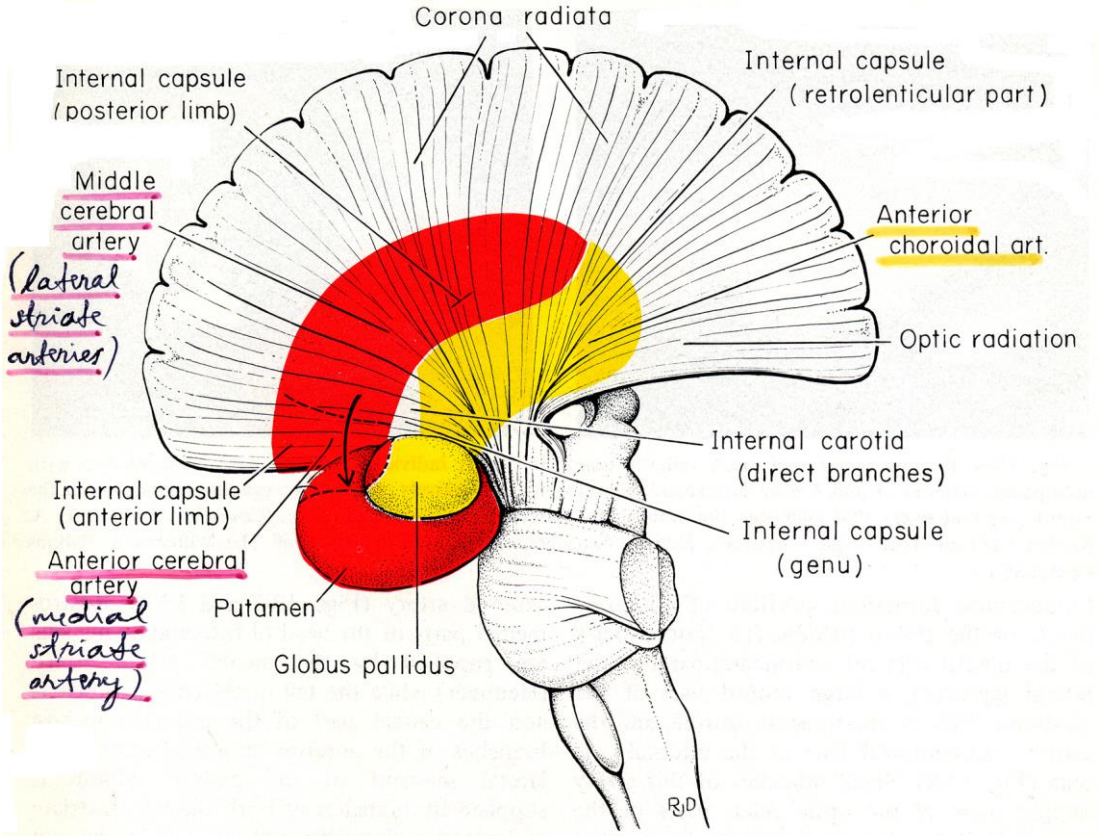
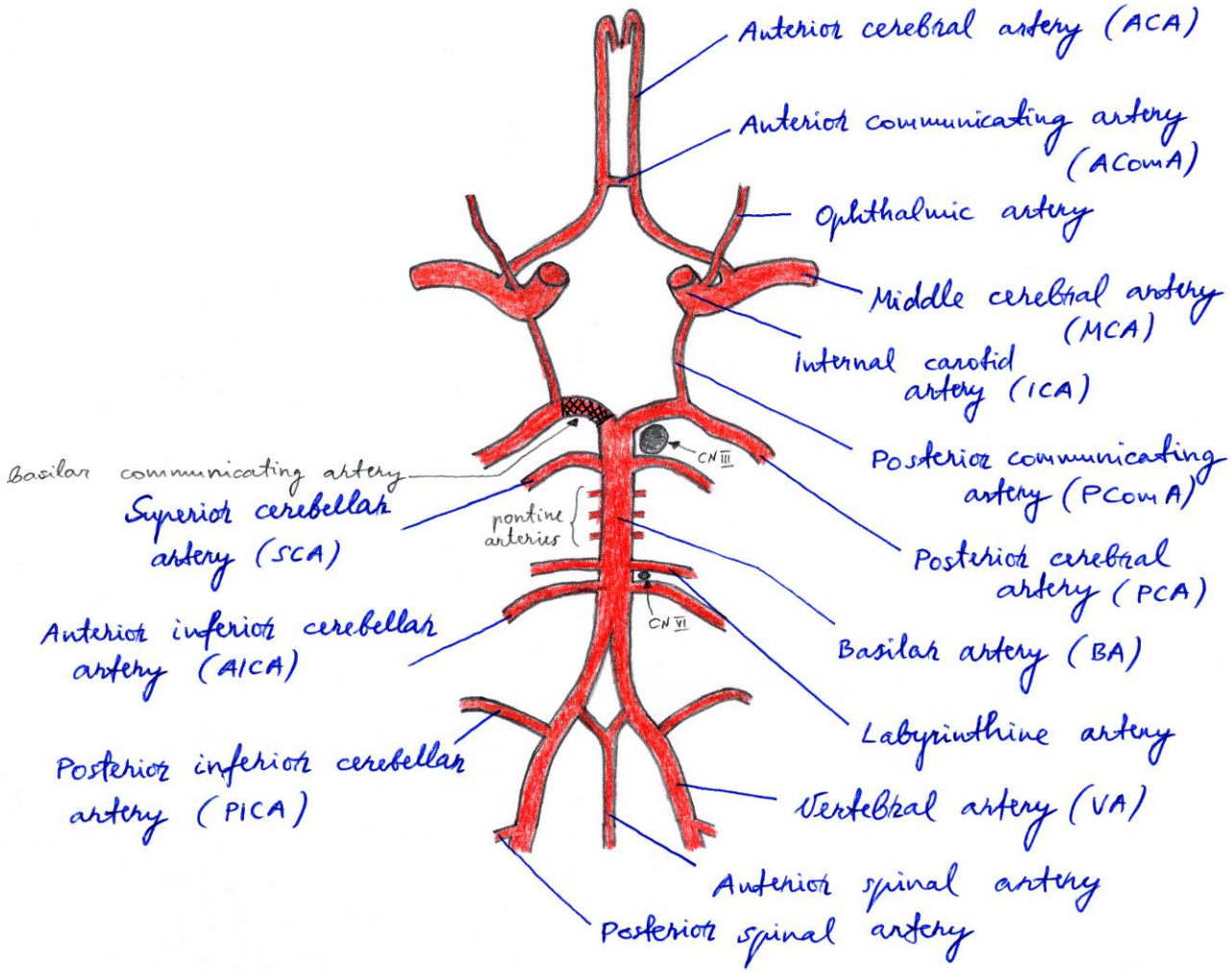


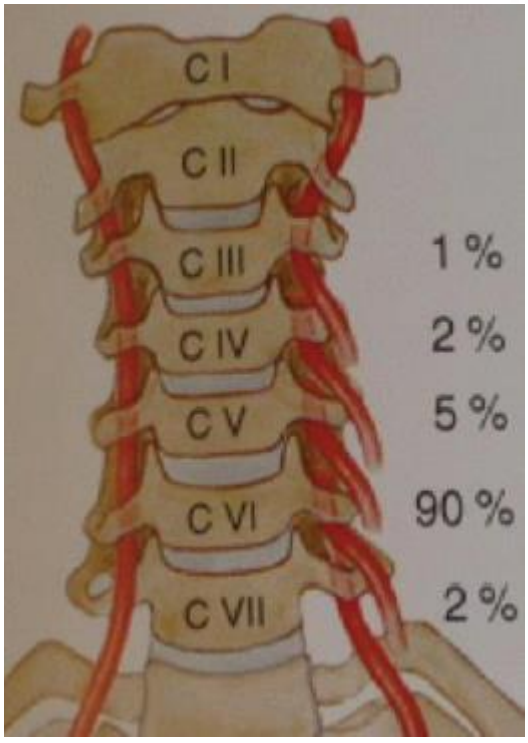
Fig. 13-8. Diagram of the blood supply of the internal capsule and corpus striatum. The putamen and globus pallidus are shown rotated ventrally away from their normal position adjacent to the internal capsule. Regions supplied by branches of the middle and anterior cerebral arteries are shown in *red*; portions of the internal capsule and corpus striatum supplied by the anterior choroidal artery are in *yellow*. Direct branches of the internal carotid artery supply the genu of the internal capsule

POSTERIOR CIRCULATION

- supplies ≈ 20% of total brain.

- left VA is dominant in 75% cases.
- 2% V2 prasideda nuo C7
- tarp SCA ir PCA praeina CN3, tarp AICA ir A. LABYRINTHI praeina CN6 – ***aneurizmos*** gali spausti atitinkamus nervus.
- fetal PComA prevalence ≈ 25%
- 20-30% individuals have hypoplasia of P_1 segment – i.e. **fetal origin** of PCA from ICA.



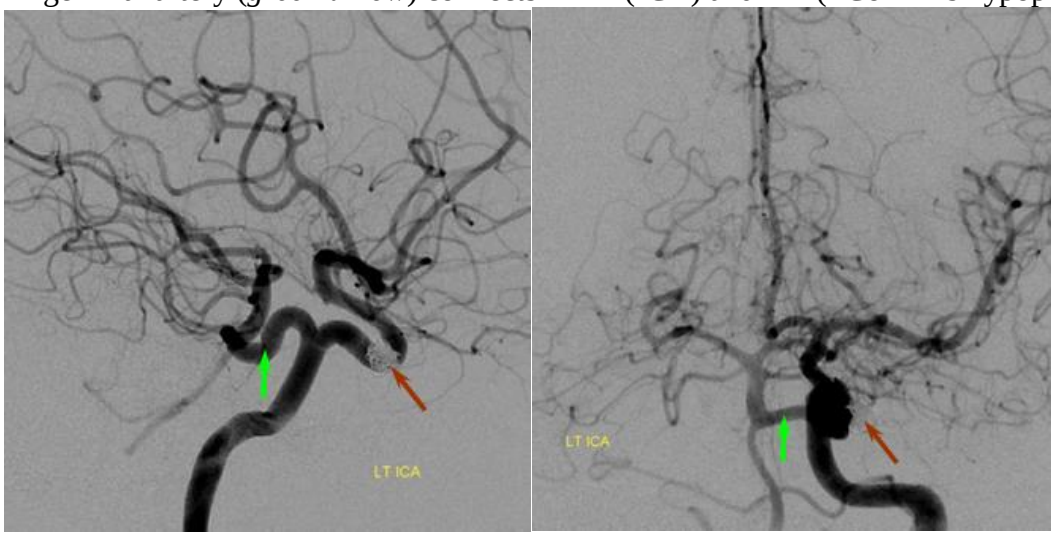


Carotico-vertebral anastomoses:

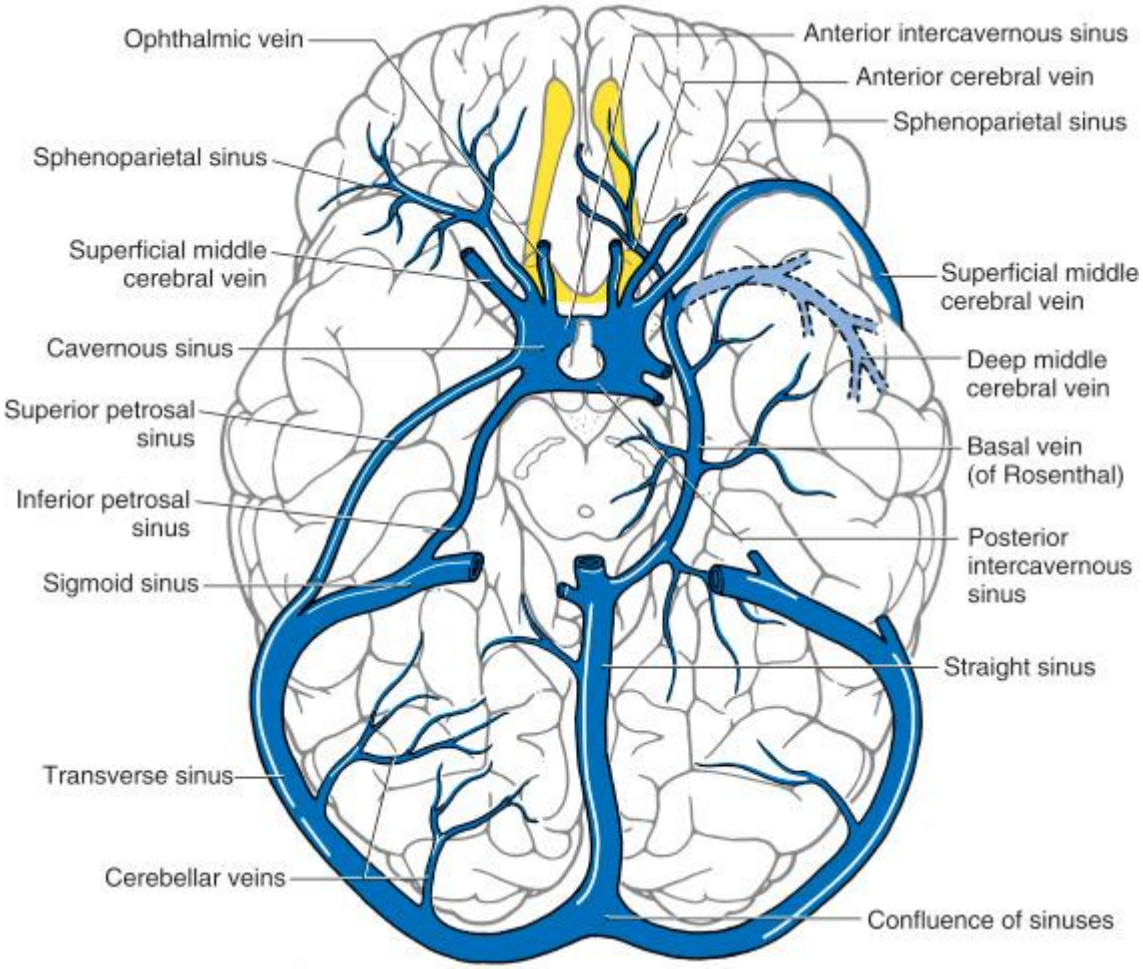
Artery	Origin	Termination	Route
Pro-atlantal intersegmental	Cervical ICA	VA	Via foramen magnum

Artery	Origin	Termination	Route
Hypoglossal	ICA	VA	Via hypoglossal canal
Otic (exceptionally rare)	Petrous ICA	BA	Via internal auditory meatus
Trigeminal (< 1% normal people; some say it is 100% just below imaging resolution)	Cavernous ICA (meningohypophyseal trunk)	BA trunk (between AICA and SCA)	Transdural (follows the course of CN5)

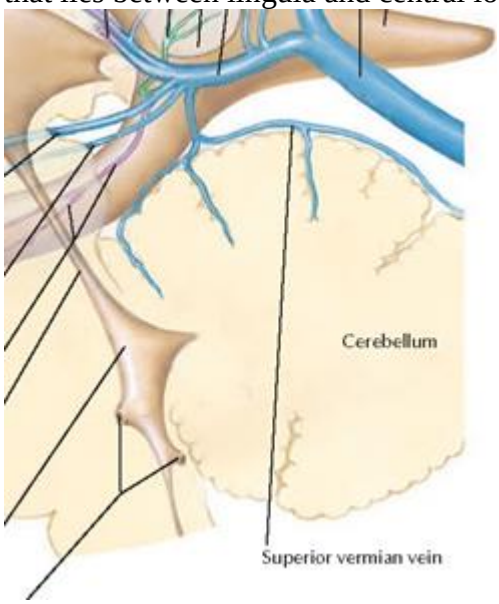
Trigeminal artery (*green arrow*) connects MHT (ICA) and BA (PComA is hypoplastic):



BRAIN - veins



superior vermian vein runs over top of vermis → **precentral cerebellar vein** (single midline vein that lies between lingula and central lobule of vermis) → vein of Galen

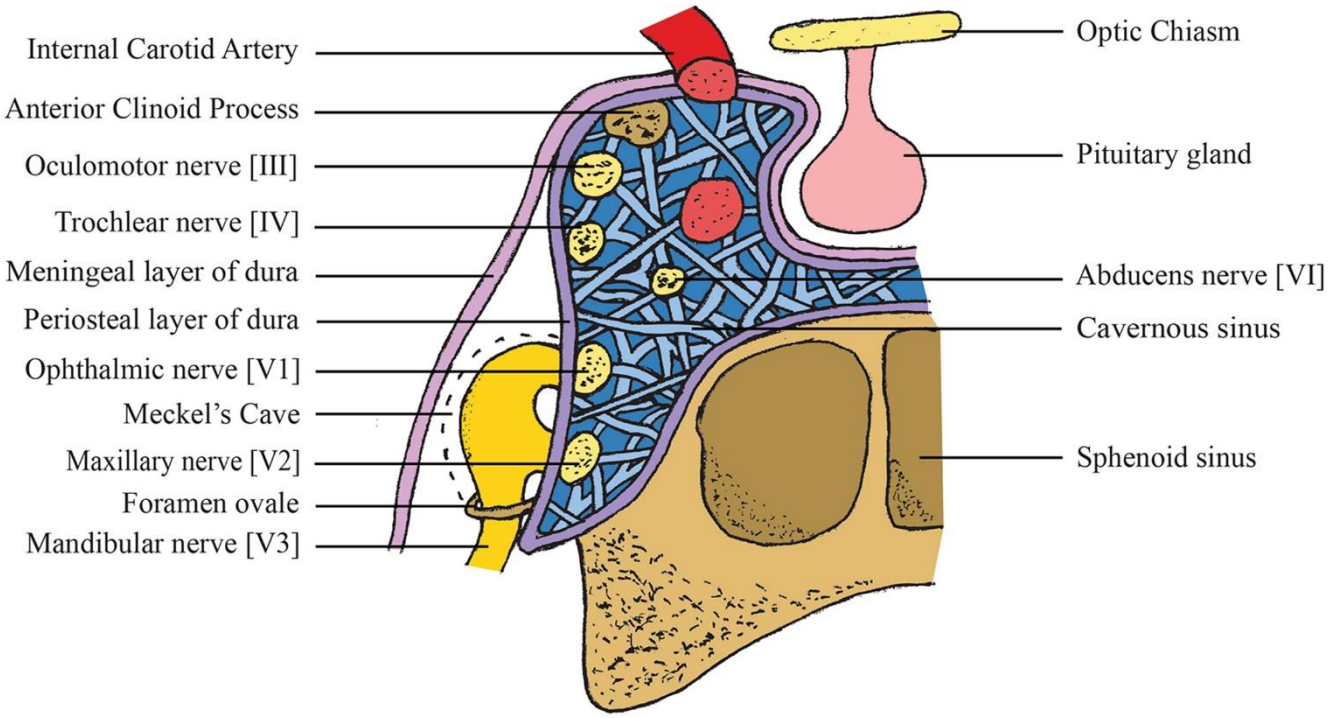


OPHTHALMIC VEINS

- receive blood from **facial triangle**, thus, need ECA or CCA injection (unless there is CC fistula – reverses flow direction in ophthalmic veins).

SINUS CAVERNOSUS

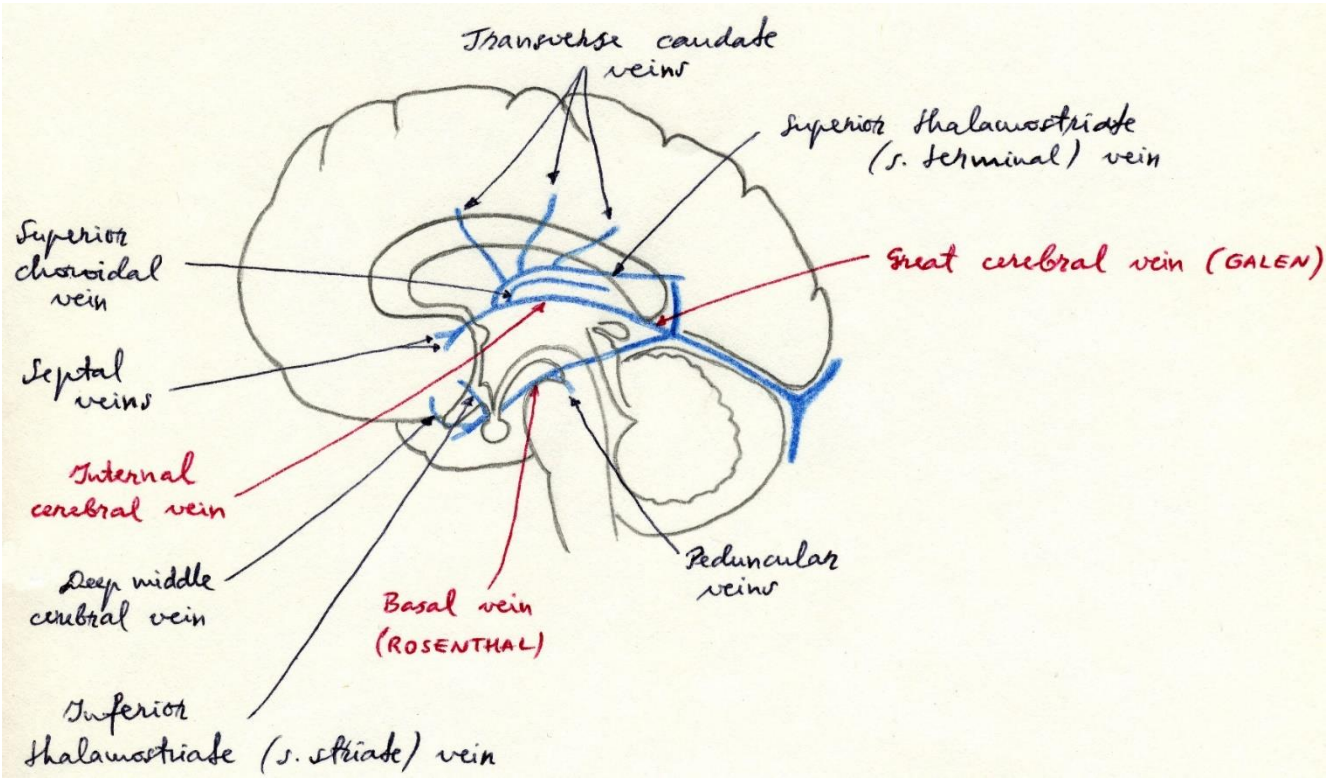
- viduje praeina: a. carotis int., **CN6**.
- šonine sienele praeina: CN3, CN4, $CN5_1$ (apačioje praeina $CN5_2$).



INTERNAL CEREBRAL VEIN

- susidaro iš trijų venų (ties **interventricular foramen**):
    1) **(anterior and posterior) septal veins**.
    2) **superior thalamostriate** (s. **terminal**) **vein** – eina kartu su *STRIA TERMINALIS*; įteka *(transverse) caudate veins*, *lateral vein of lateral ventricle* (deep parts of parietal and temporal lobes).
    3) **superior choroidal vein** ← lateral ventricles rezginiai

1) and 2) meet (forming **venous angle**) at posterior lip of Monro foramen



BASAL VEIN (ROSENTHAL)

– some experts say, it is superficial vein just runs on inferior surface!

Deep veins = Internal cerebral vein system

- prasideda ties *VALLECULA* susiliejus dviem venų sistemoms:
    1) **anterior cerebral veins** (lydi ACA) ← orbital cortex, rostral corpus callosum
    2) **deep middle cerebral vein** (lies in depth of lateral fissure) ← insular & opercular regions, basal ganglia