MEDICAL UNIVERSITY - PLEVEN
FACULTY OF MEDICINE
DIVISION OF PHYSICS AND BIOPHYSICS

Lecture № 4

Coordination. Cerebellum. Syndromes of cerebellar and non-cerebellar equilibrium disturbances

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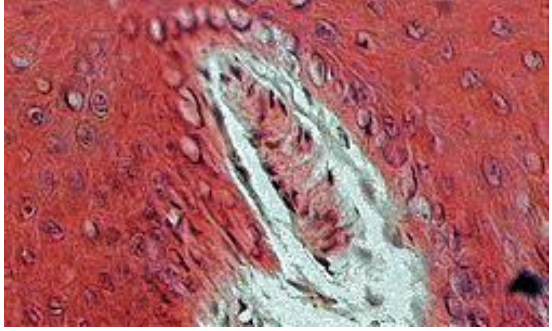
Coordination of movements

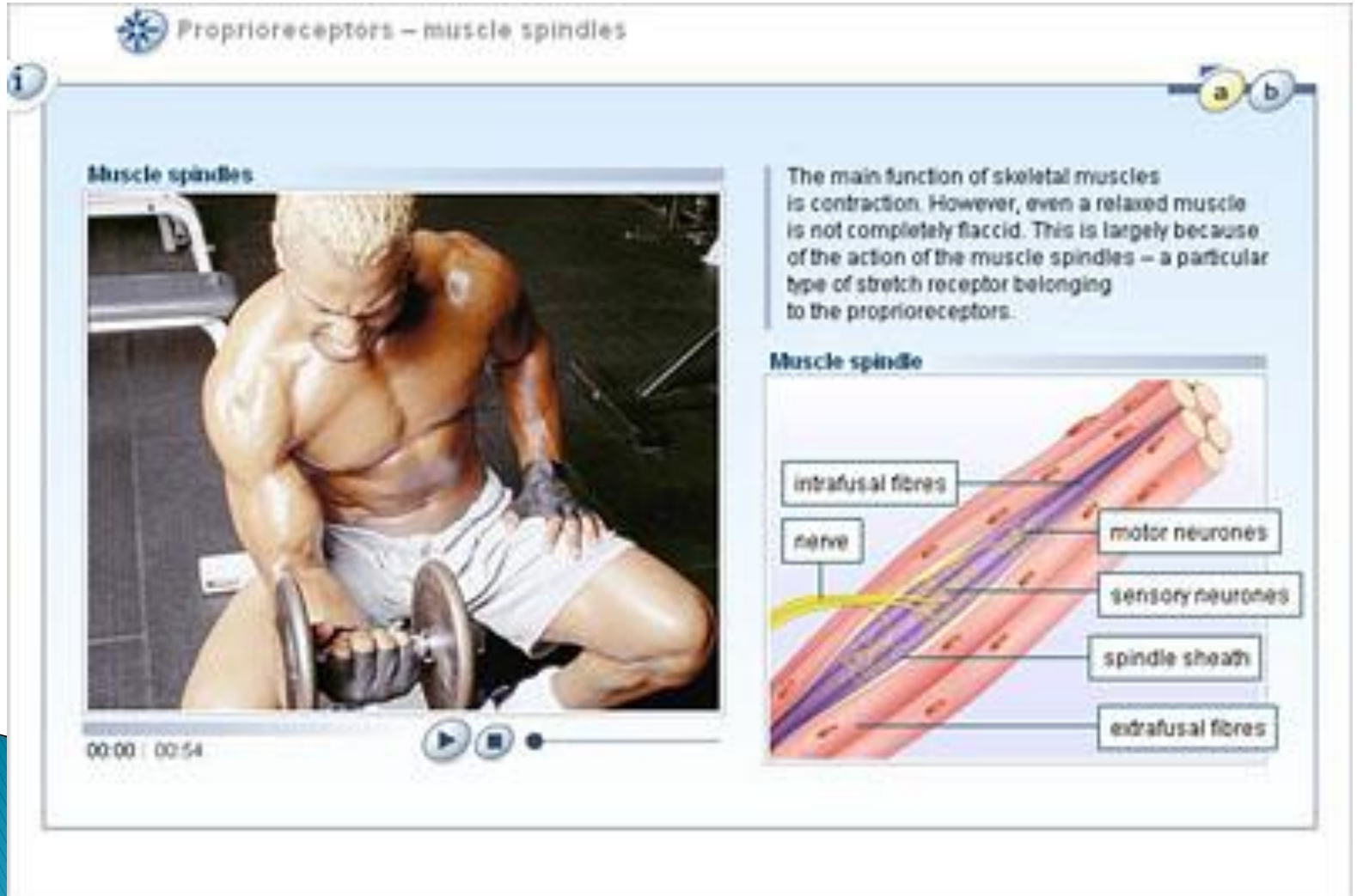
- **Is a function of CNS, which provides fluid and fluent progress of movement/s in time and space.**

Systems, involved

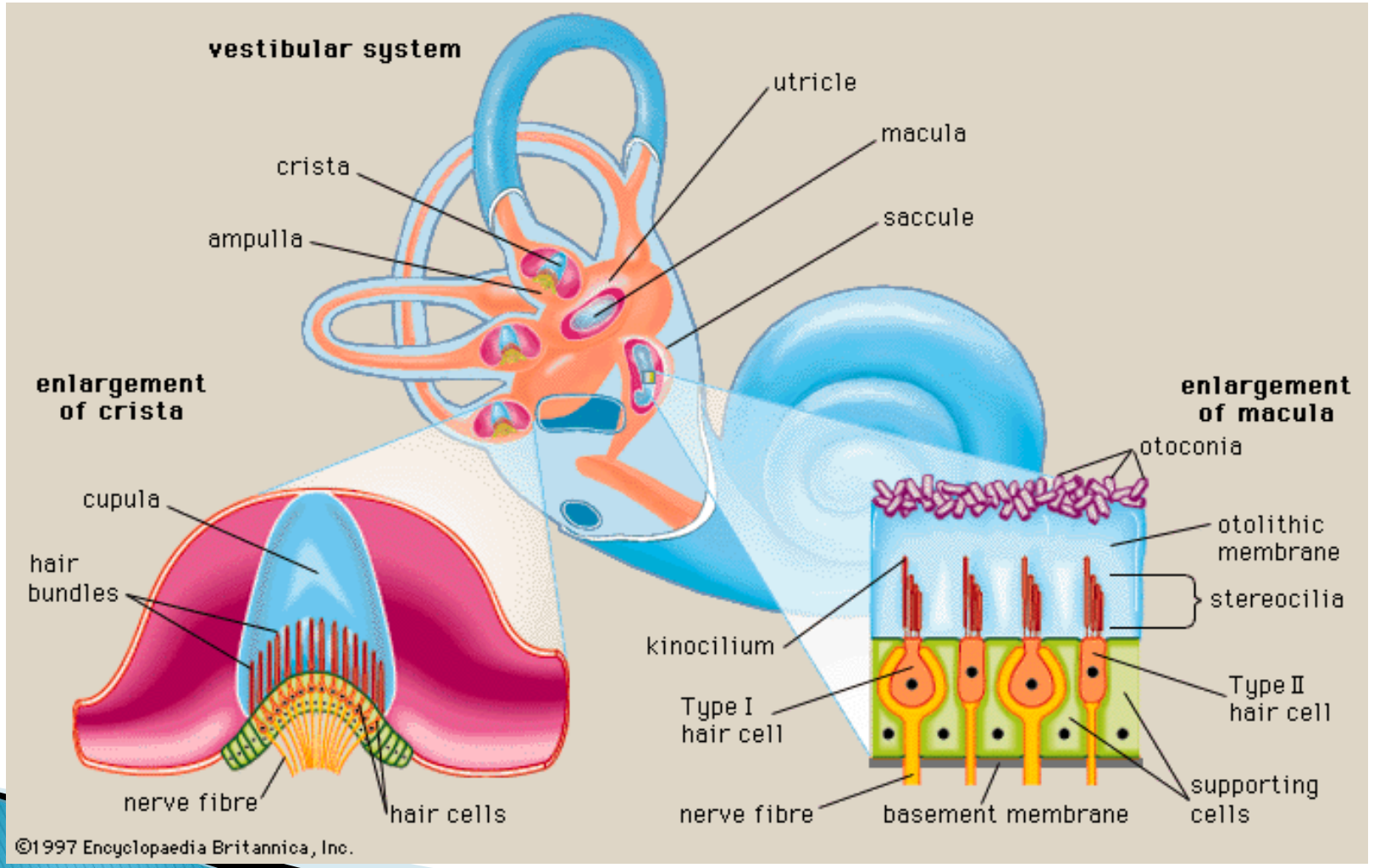
- Proprioception,
- Vestibular system,
- Visual system,
- Cerebellum,
- Cortical zones (incl. cortical kinesthetic analyzer).

Proprioreceptors: respond to joint position and movements, changes of spindles in axial and proximal muscles





Vestibular receptors: detect changes of head position in space



Visual, acoustic and cutaneous receptors: provide additional information for head and body position

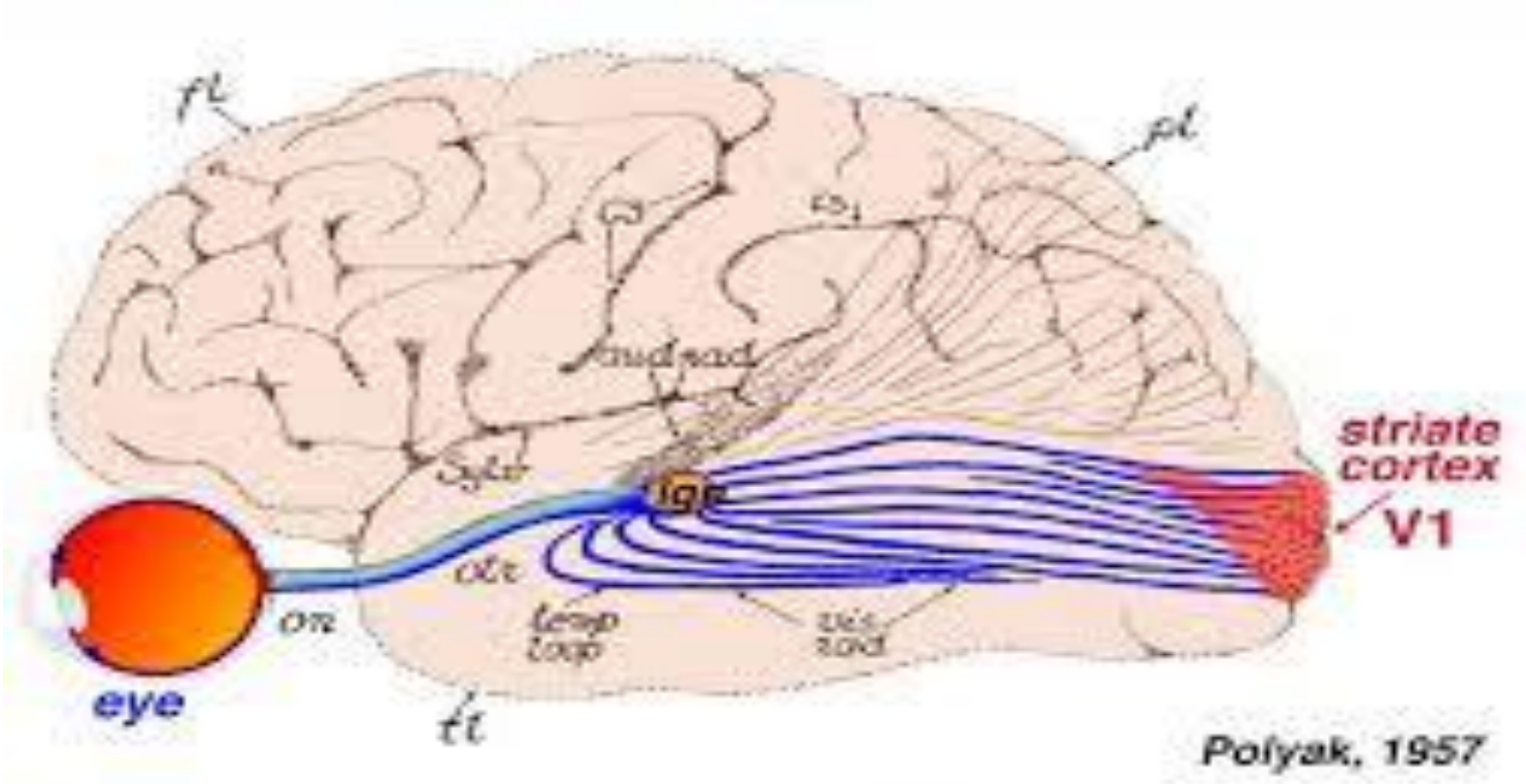
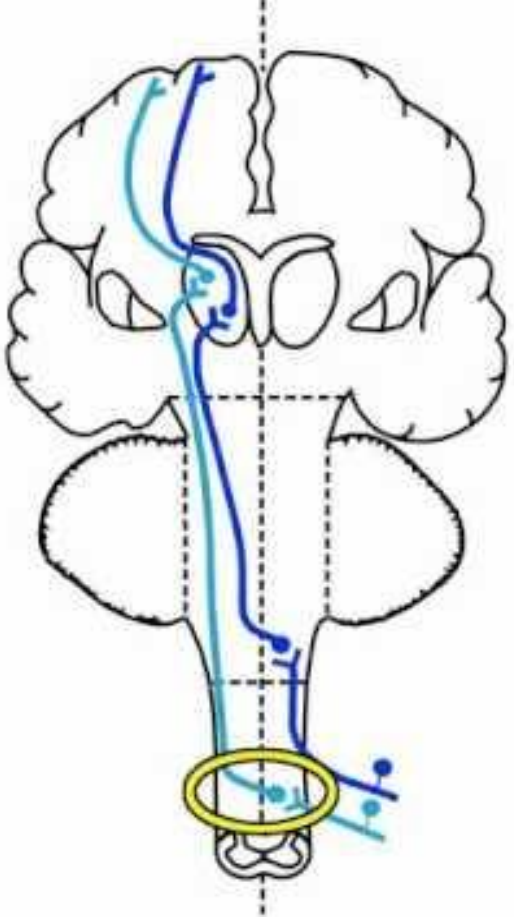


Figure 8. Visual input to the brain goes from eye to LGN and then to primary visual cortex, or area V1, which is located in the posterior of the occipital lobe.
Adapted from Polyak (1957).



Sensory tracts

- **Blue-skin**: sensory pathway (pain, temperature)
- **Dark blue**: deep sensation (Goll and Burdach fasciculi)

STRUCTURES OF THE NERVOUS SYSTEM WHICH PROVIDE INFORMATION ABOUT POSTURE AND MOVEMENTS

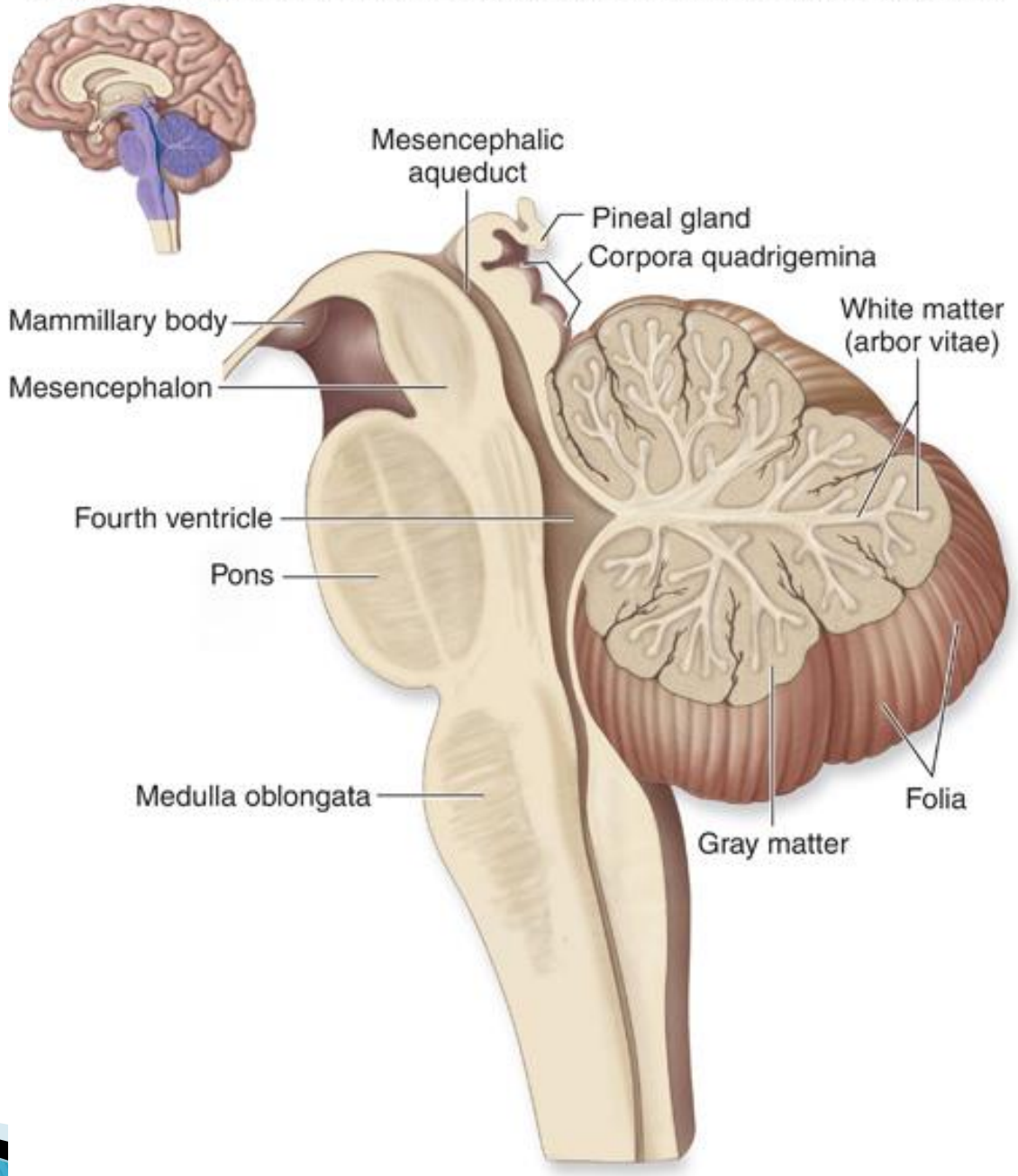
- **Vestibular system** – control of autonomic functions, coordination, co-coordination of movements of head and eyes →vestibular and reticular nuclei, vestibulospinal and reticulospinal tracts, medial longitudinal fasciculus;
- **Cerebellum** – equilibrium, coordination of agonists and antagonists;
- **Cerebral cortex** (frontal, temporal, parietal lobes)→ corticopontocerebellar pathways with information about the planned voluntary movements;
- **Basal ganglia** (receive from the cortex and send back to it signals for the planned and ongoing movements).

Cerebellum controls and corrects the direction, speed and duration of the voluntary movements

Cerebellum

- Cerebellum (Latin, little brain): only 10 % total volume of the brain but more than half of all its neurons;
- arranged in a highly regular manner as repeating units but with input and outputs from different parts;
- Cerebellum is the main nervous structure that completes the integration between sensory information and motor output;
- the cerebellum is provided with extensive information (40 times more axons project into the cerebellum than exit from it);
- three sections of cerebellum: (i) gray matter: cerebellar cortex (ii) white matter (iii) 3 deep nuclei: fastigial, interposed, dentate;
- Coordination center for maintenance of equilibrium and muscle tone;
- Control of ongoing movement;

The effect of cerebellar actions is ipsilateral because of a double decussation of the fibers within this system.



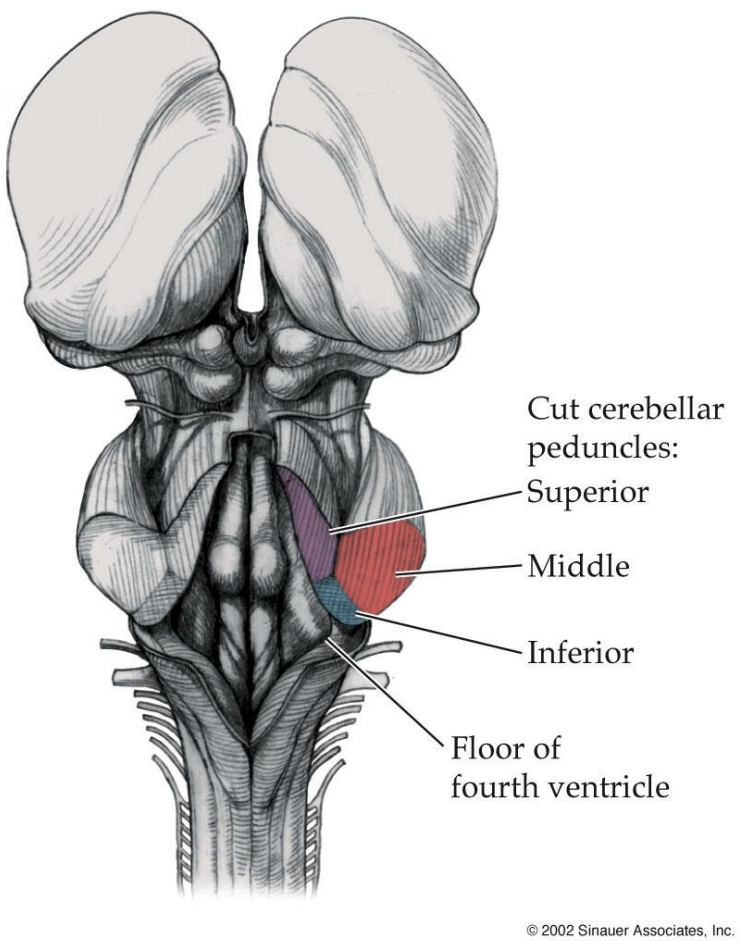
(a) Midsagittal section

External architecture

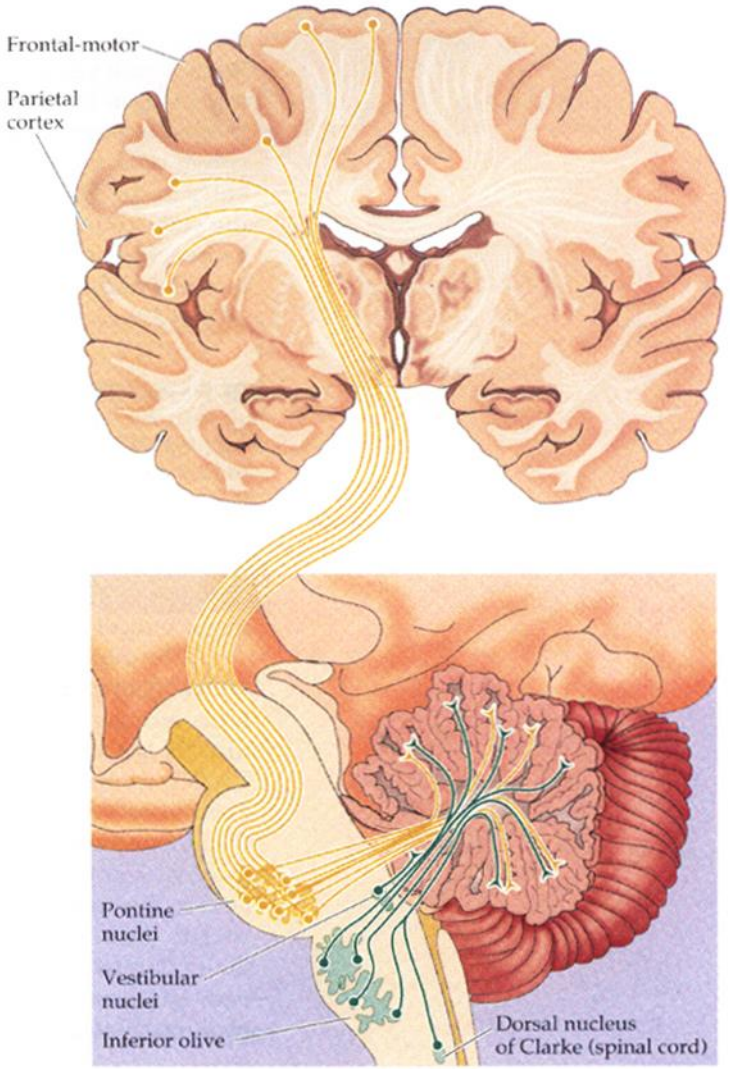
- Occupies the posterior cranial fossa
- Is separated from the cerebrum by the tentorium
- Is divided into two **cerebellar hemispheres** and a small worm-like central portion, called **vermis**
- Connects with the subdivisions of the brain stem by pairs of peduncules:
  - Superior cerebellar peduncles – brachia conjunctiva
  - Middle cerebellar peduncles – brachia pontis
  - Inferior cerebellar peduncles – corpora restiformia

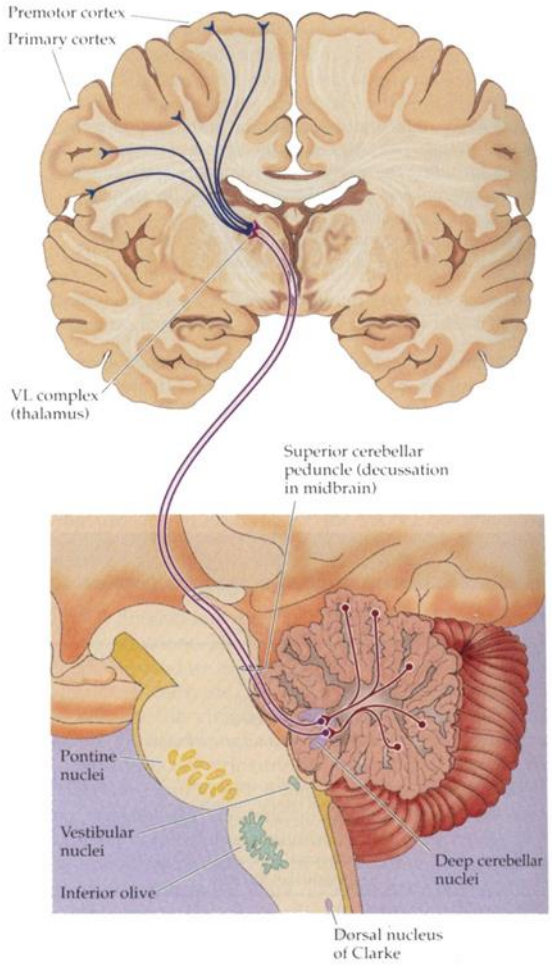
Afferent and Efferents

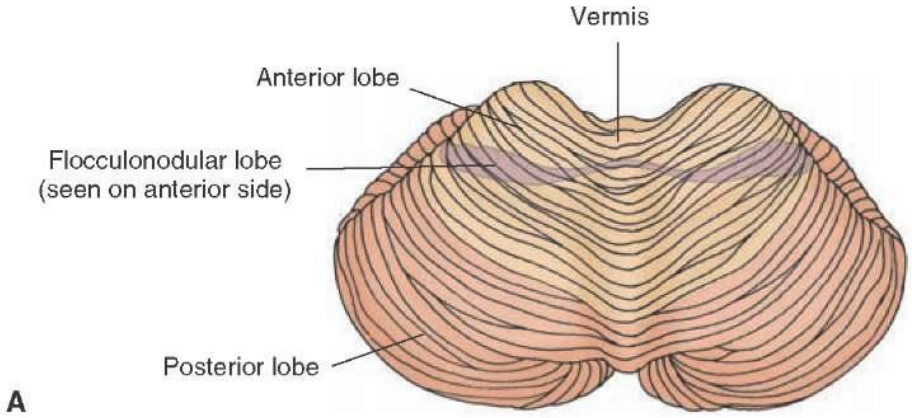
- Superior Cerebellar Peduncle (brachium conjunctivum)
  - Connects with midbrain
- Middle Cerebellar Peduncle (brachium pontis)
  - Connects with pons
- Inferior Cerebellar Peduncle (restiform body)
  - Connects with medulla



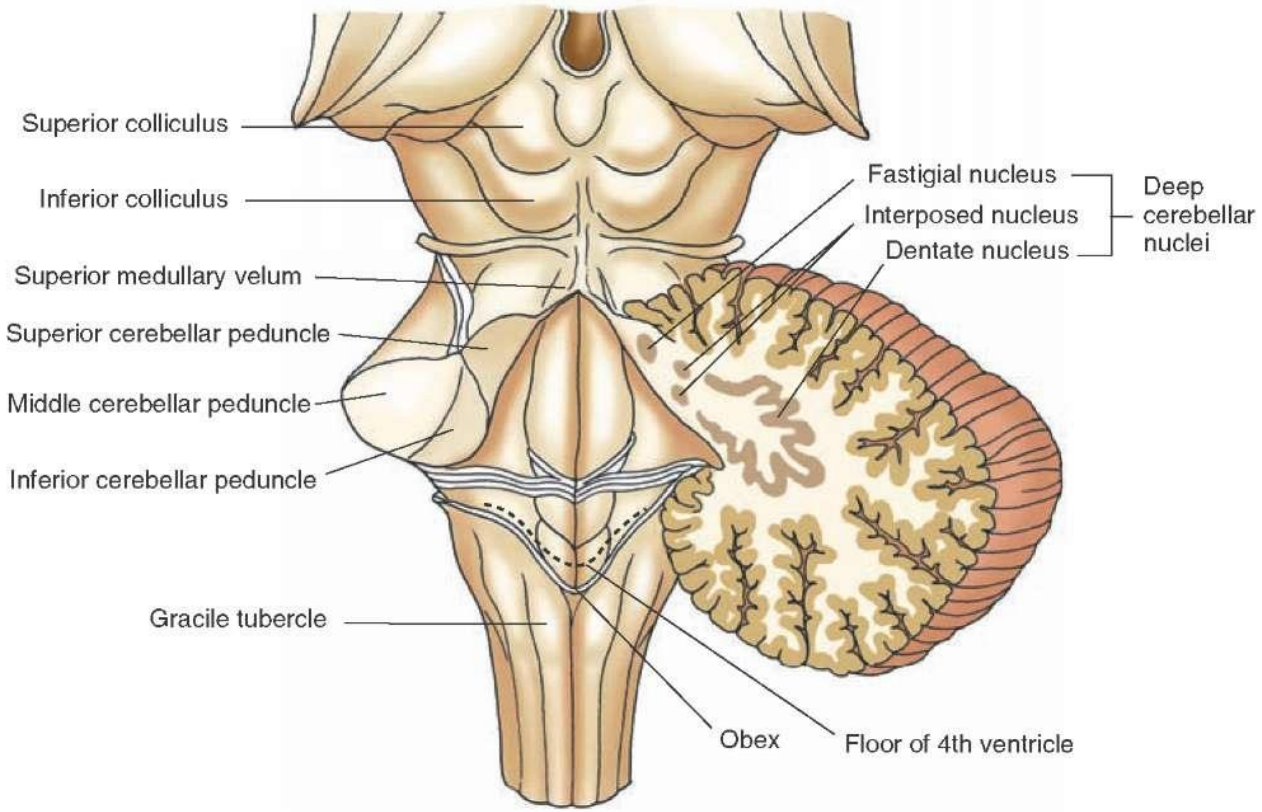
Inputs and Outputs of Cerebellum






Vermis
Anterior lobe
Flocculonodular lobe
(seen on anterior side)
Posterior lobe

A


Superior colliculus
Inferior colliculus
Superior medullary velum
Superior cerebellar peduncle
Middle cerebellar peduncle
Inferior cerebellar peduncle
Gracile tubercle
Fastigial nucleus
Interposed nucleus
Dentate nucleus
Deep cerebellar nuclei
Obex
Floor of 4th ventricle

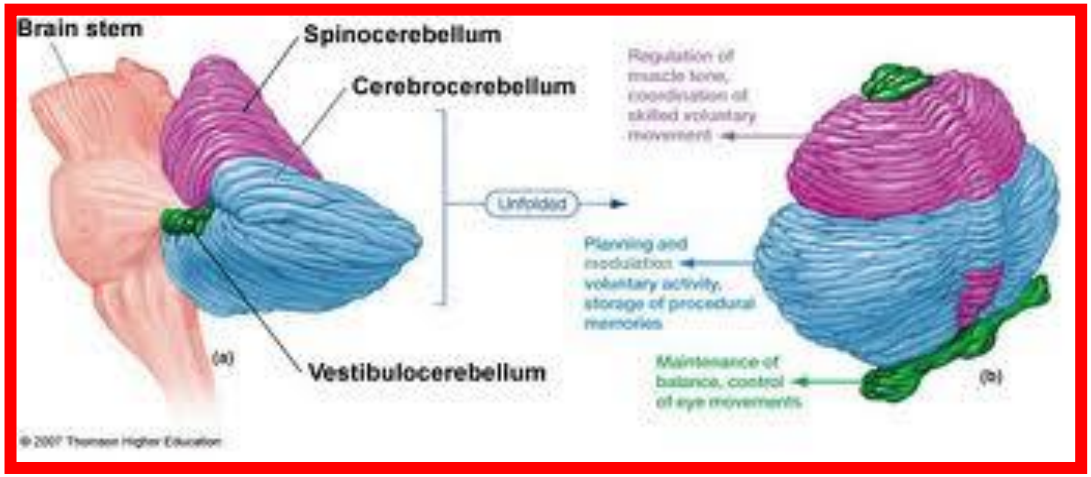
B

CEREBELLUM:
functional division

- **Archicerebellum**
  (flocculonodular lobe)– vestibulocerebellum

- **Paleocerebellum**
  (anterior lobe) – spinocerebellum

- **Neocerebellum**
  (posterior lobe) pontocerebellum



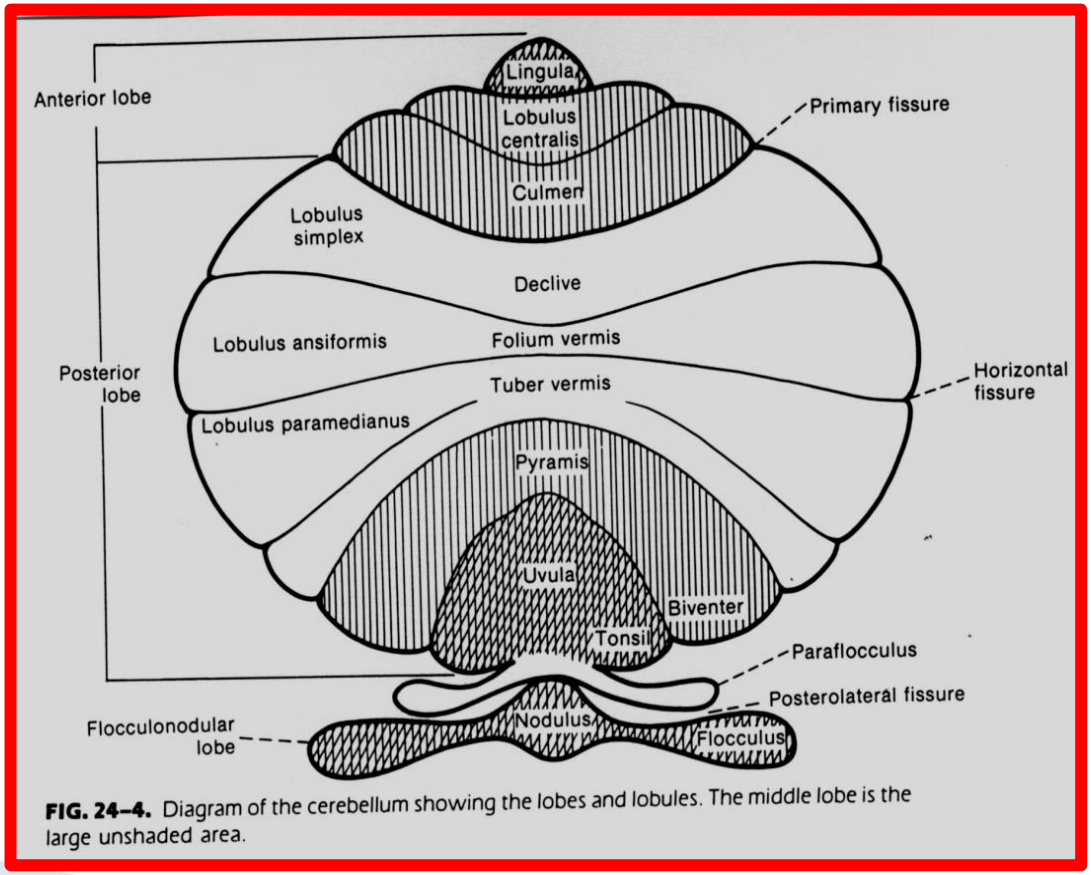
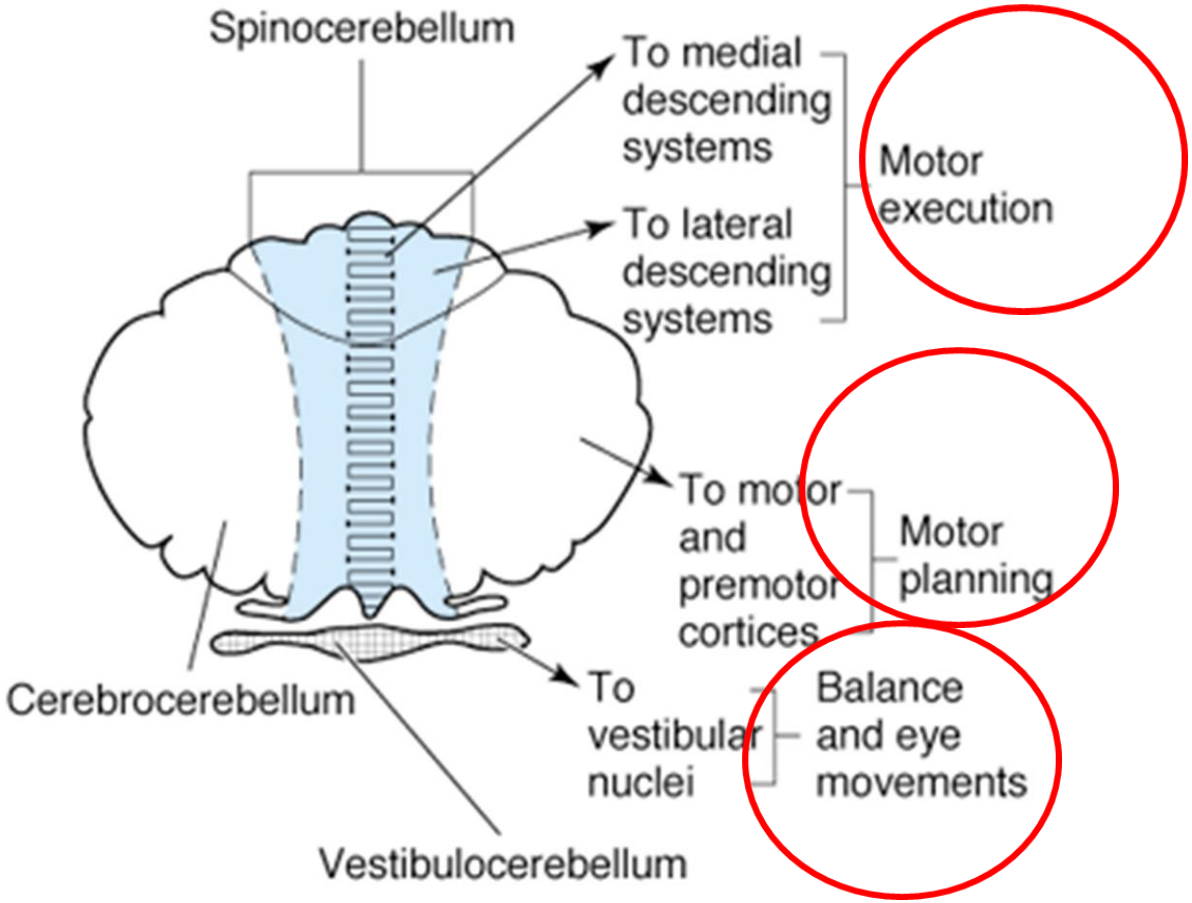
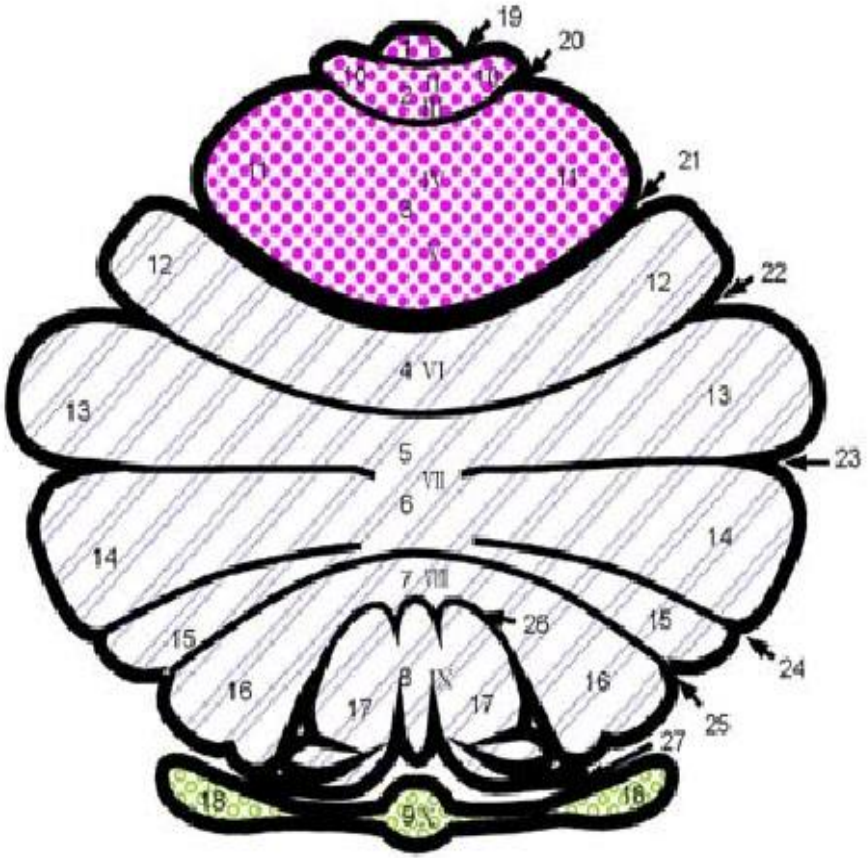


FIG. 24–4. Diagram of the cerebellum showing the lobes and lobules. The middle lobe is the large unshaded area.


Spinocerebellum
To medial descending systems
To lateral descending systems
Motor execution
To motor and premotor cortices
Motor planning
To vestibular nuclei
Balance and eye movements
Cerebrocerebellum
Vestibulocerebellum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4 VI
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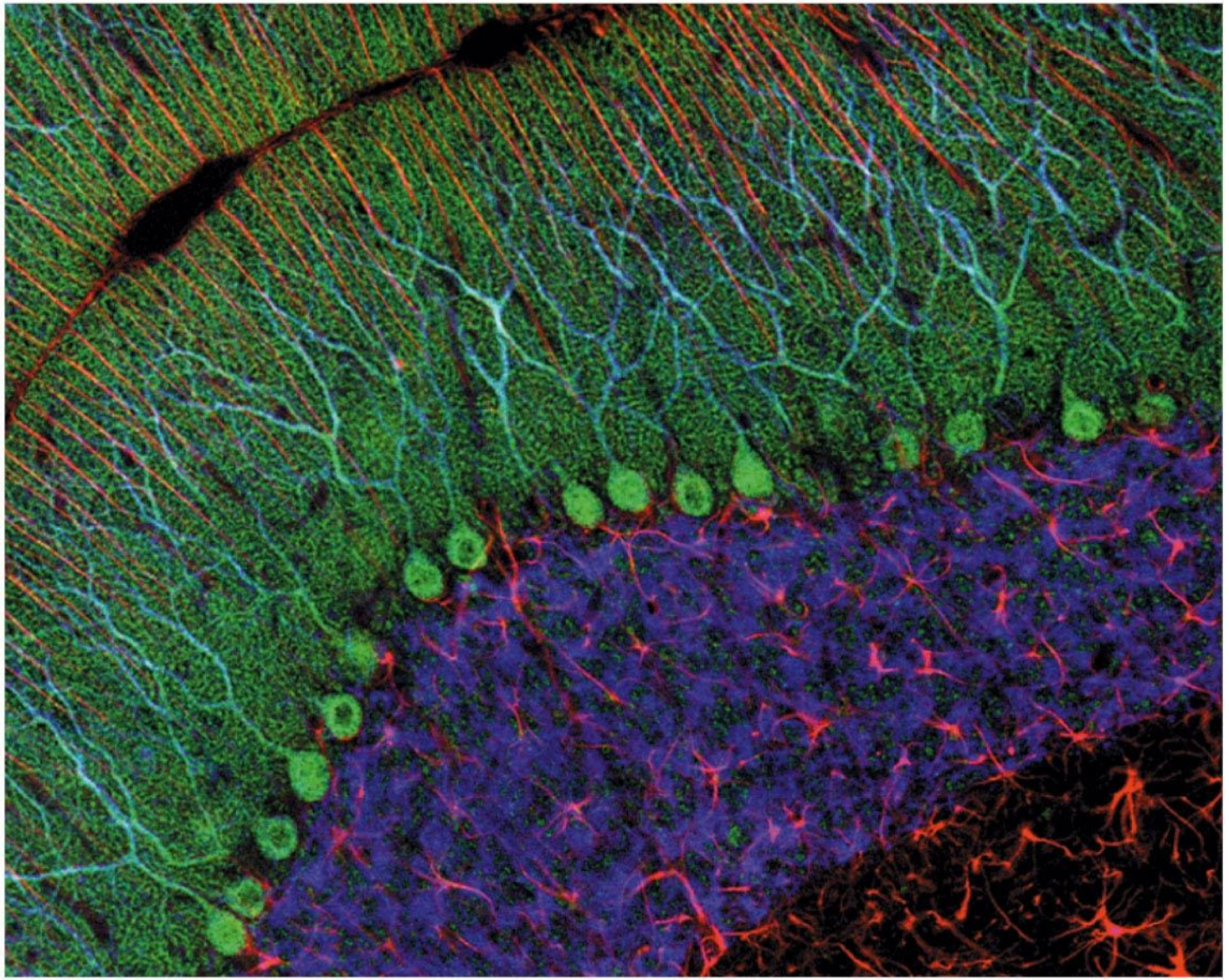
VII
6
7 VIII
8
IX
9 X
Spinocerebellum
Pontocerebellum
Vestibulocerebellum

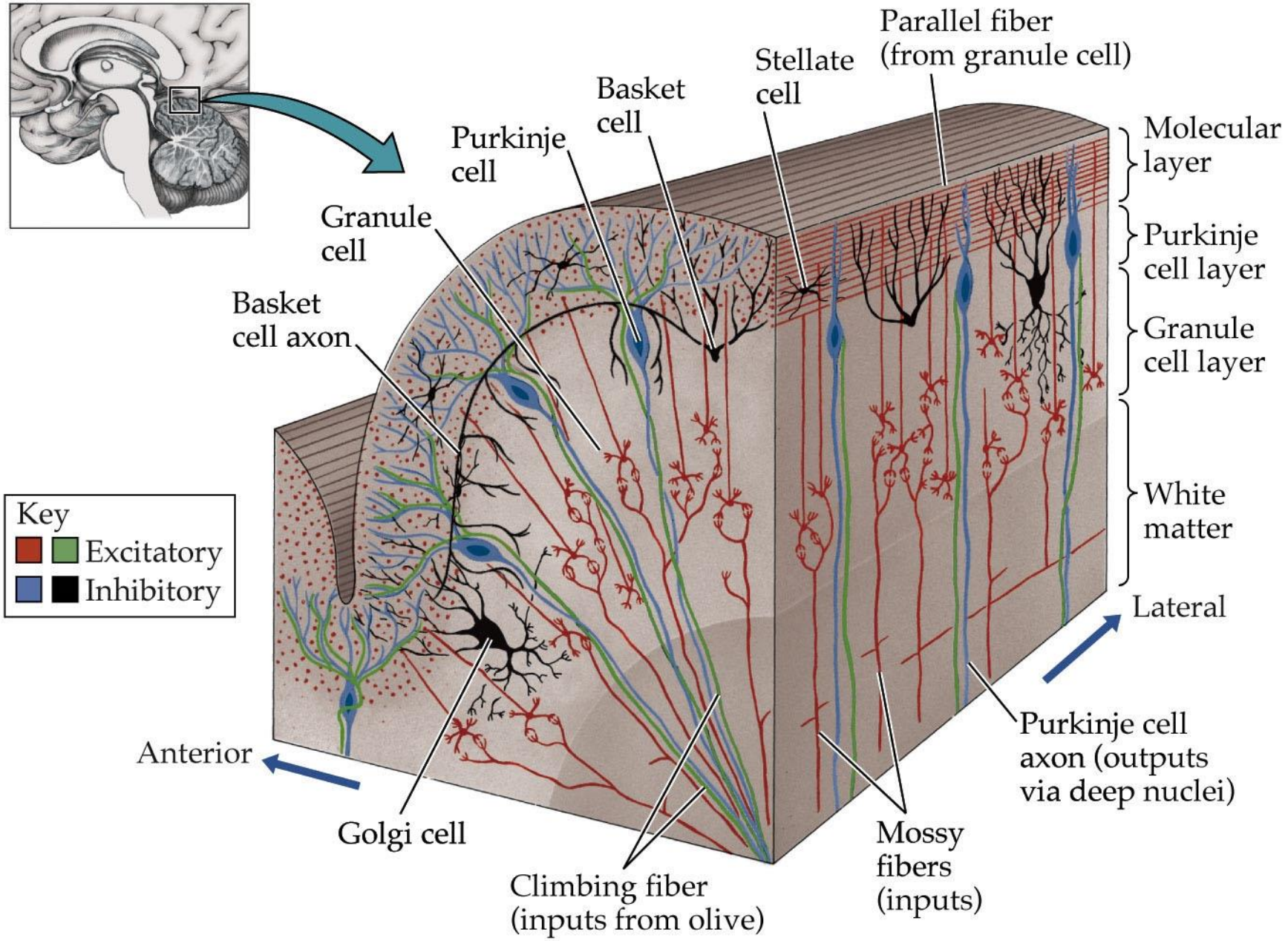
Internal architecture

- 1. Cortex of the cerebellum – consists of three layers
  - **Molecular layer** /stratum moleculare/ – contains small neurons /stellate and basket cells/ and dendrites of Purkinje's cells
  - **Purkinje's cells layer**/stratum gangliosum/ – contains only these large cell bodies
  - **Granular layer**/stratum granulosum/ – contains granules cells

(C)



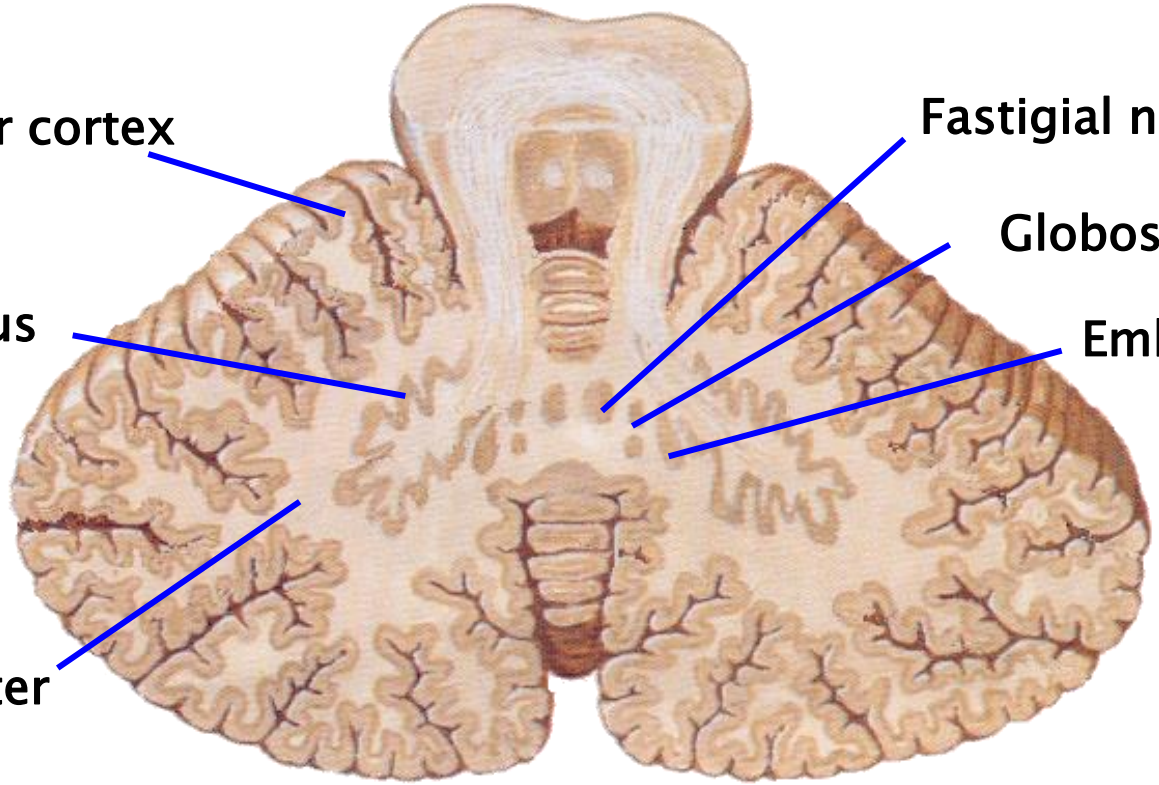
(Courtesy of Tom Deerinck and Mark Ellisman, NCMIR.)



Internal architecture

- 2. White matter of the cerebellum consists of afferent and efferent fibers:
- 3. Nuclei of the cerebellum:
  - -Fastigial nucleus
  - -Globose and emboliform nuclei
  - -Dentate nucleus
- 4. Cerebellar connections in the peduncles
- 5. Cerebral feedback circuits
  - -Main closed loop via pontine nuclei
  - -Additional feedback loop by the triangle of Guillain-Mollaret

Internal structures



Physiology and pathophysiology

- The combined effect of the **palleocerebellum** and **archicerebellum** results in control of skeletal muscle tone and coordination of agonist and antagonist muscle groups, subserving normal gait and stance;
- Lesions of the **palleocerebellum** produce truncal ataxia, which consists of staggering in all directions;
- Lesions of the **neocerebellum** produce ataxia, dysmetria, assynergia, dysdiadochokinesia, intention tremor, muscular hypotonia, scanning speech.

Functions

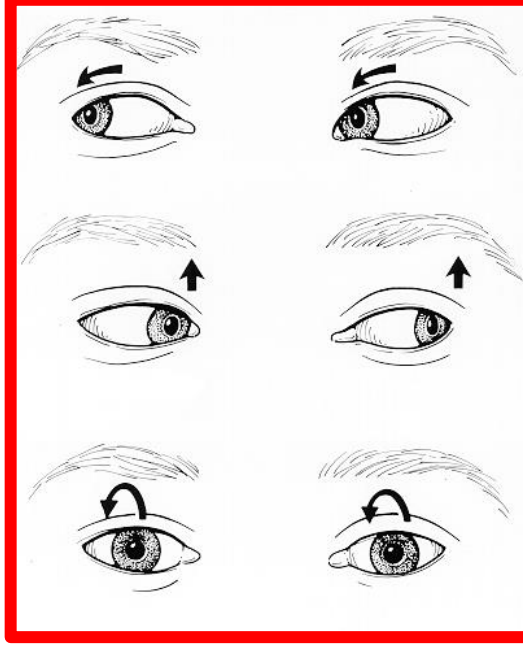
- **Archicerebellum**
  Damage of flocculonodular part leads to severe gait ataxia and body ataxia (**truncal or axial ataxia**).

- **Paleocerebellum**
  Damage – leads to **truncal ataxia** and **muscle hypotonia**

- **Neocerebellum**
  Damage leads to **impairment of fine muscle coordination** – intention tremor and dysmetria of limbs.

Cerebellar dysfunction signs:

- **Ataxia:** loss of fluidity and stability of movements
  - **static**
  - **locomotor**
  - **dynamic**
- **Dysmetria:** inability to obtain the target
  - **hypometria**
  - **hypermetria**
- **Dyssynergia (asynergia) :** loss of phyisiologic synergia
- **Dysdiadochokinesia (adiadochokinesia):** inability to make alternative reciprocal movements.
- **Intention tremor**
- **Muscular hypotonia**
- **Scanning speech**
- **Nystagmus**



To keep her balance the child with ataxia walks bent forward with feet wide apart. She takes irregular steps, like a sailor on a rough sea or someone who is drunk.

Cerebellar Syndromes

Syndrome of cerebellar hemisphere lesion

- Instability of stance, unilateral;
- Instability of gait, unilateral;
- Unilateral muscular hypotonia;
- Unilateral limb ataxia;
- Cerebellar dysarthria;

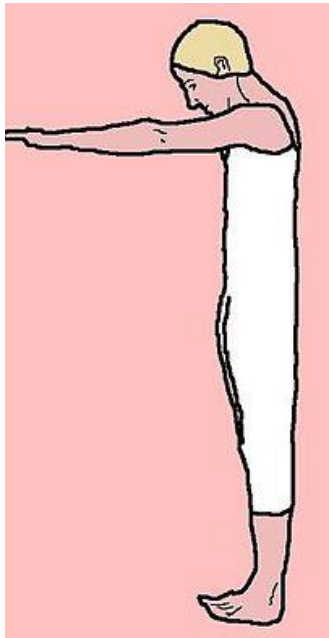
.

Syndrome of midline (vermis) lesion:

- Instability of stance;
- Instability of gate;
- Romberg negative
- Truncal ataxia

Clinical examination: tests

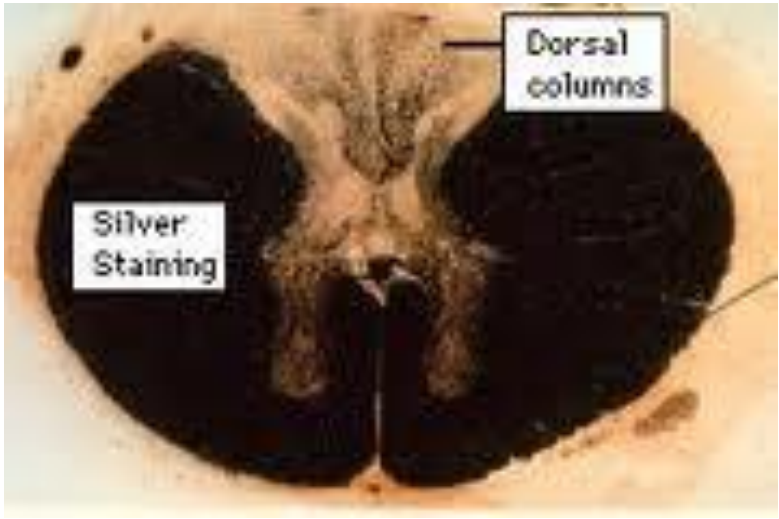
- Gate and posture: Romberg's test;
- Test for detection of locomotor ataxia;
- Nystagmus?
- Finger to nose and heel to shin probes;
- Test for rebound phenomenon;
- Dysdiadochokinesia;
- Barany's finger test;
- Assessment of muscle tone;
- Assessment of spontaneous speech and handwriting



Topographic syndromes of disturbed coordination

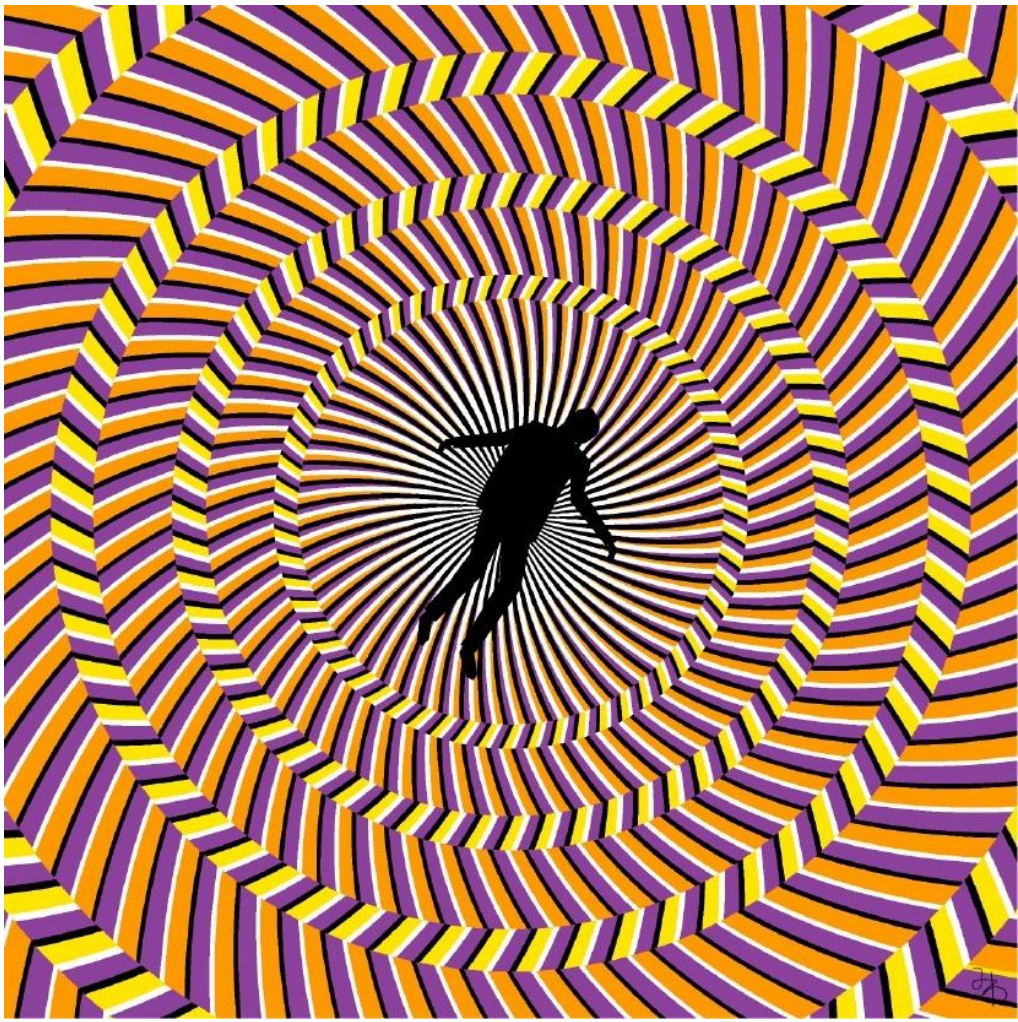
Sensory and spinal ataxia:
damage of proprioception

- When?
- Romberg – positive (with closed eyes), peripheral damage, impaired deep sensorium (how to examine it?)



Vestibular ataxia

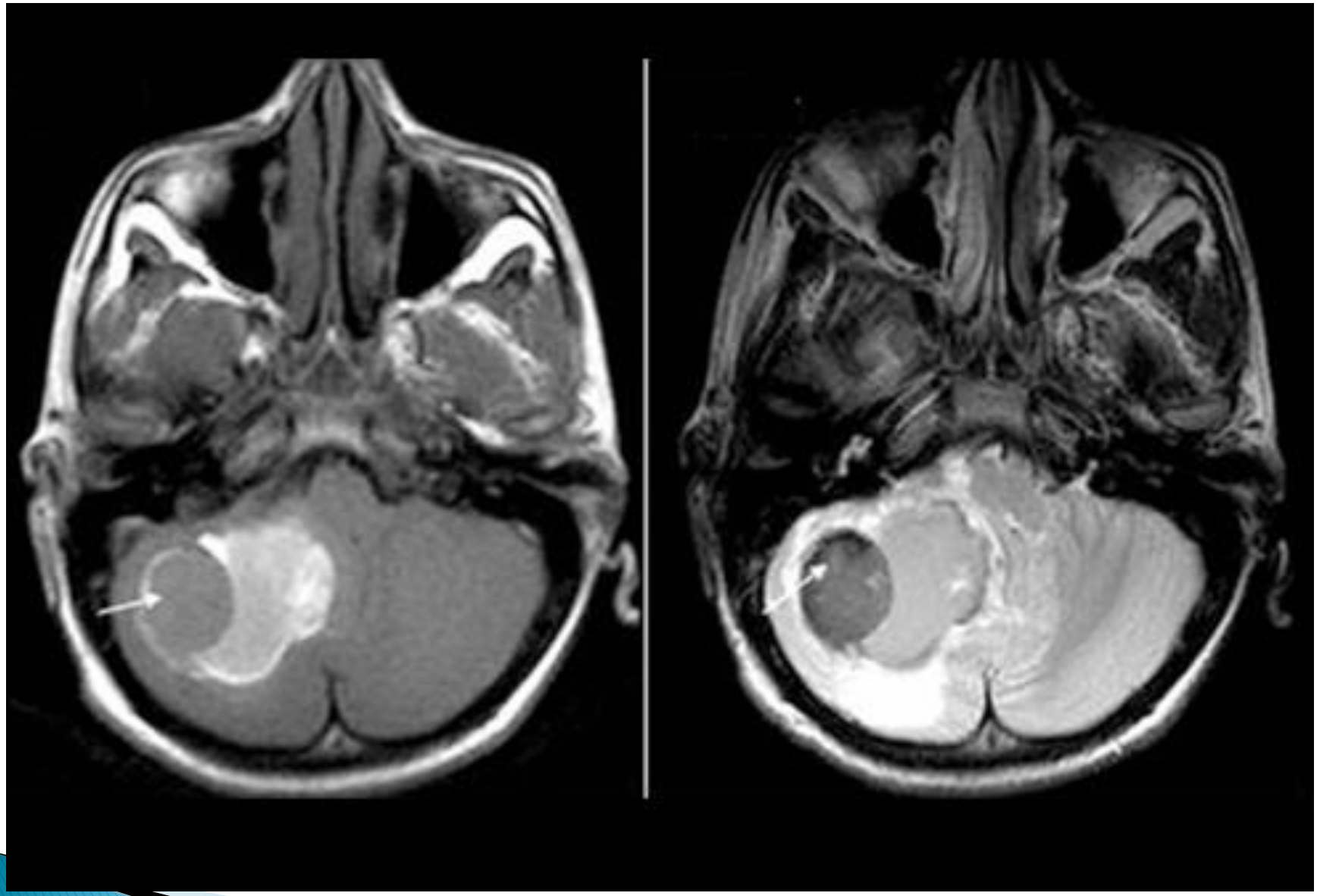
- Nystagmus (horizontal, rotatory, rare vertical;
- No nystagmus in fixed position of eyes;
- Severe vegetative reactions – vomitus, nausea;
- Systemic vertigo



Cerebellar ataxia

Neocerebellum lesion syndrome:

- Dynamic ataxia, ipsilateral flattering;
- Adiadochokynesia;
- Dysmetria;
- Intention tremor;
- Nystagmus (through the side of damage);
- Ipsilateral muscle hypotonia;

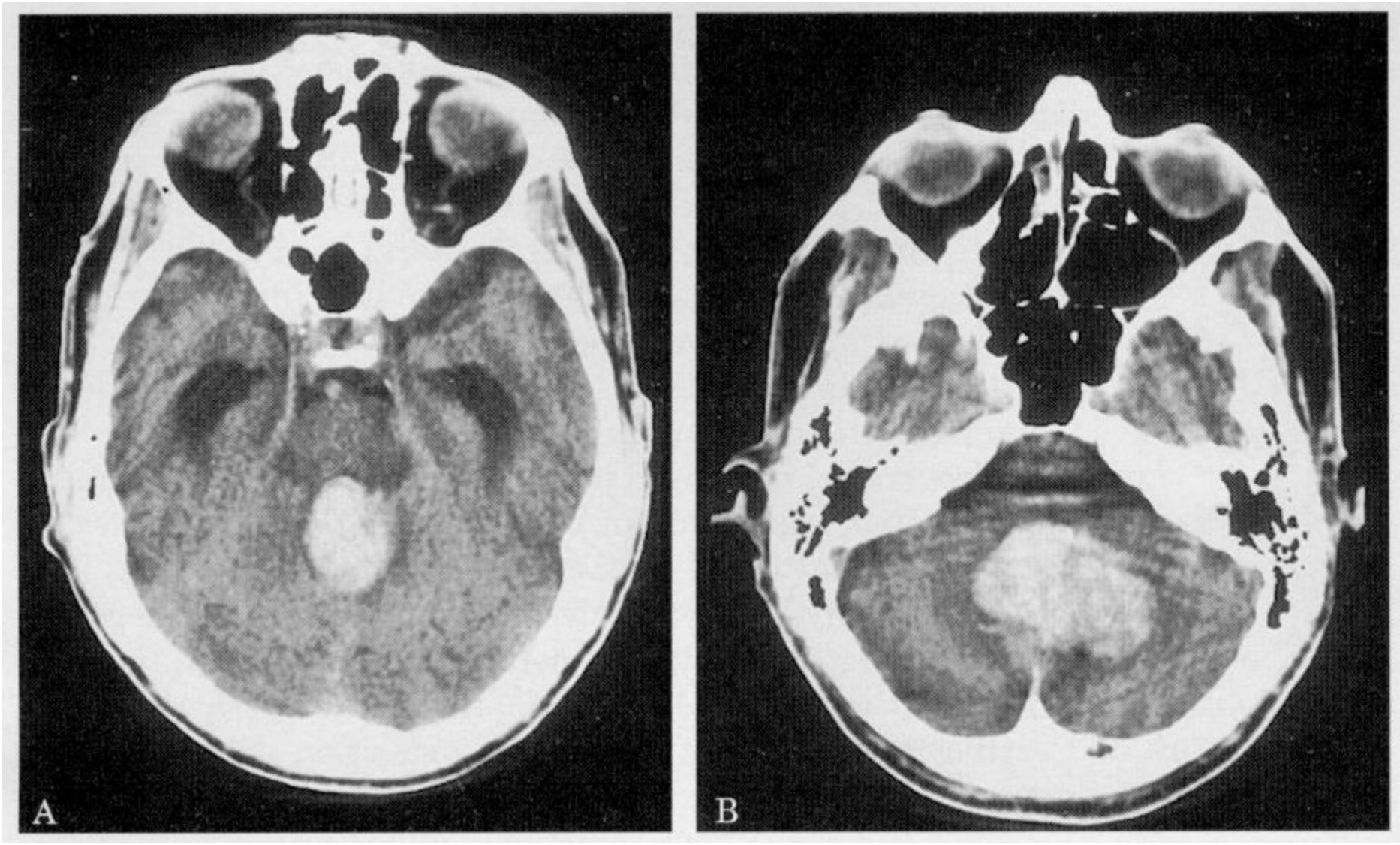


Vermis lesion syndrome

- Truncal ataxia;
- Negative Romberg (flattering with eyes closed and open);
- Flattering in every positions, posterior falls;
- Muscle hypotonia.

Syndrome of pancerebellar disorders

Combines features of midline and bilateral hemispheric disease

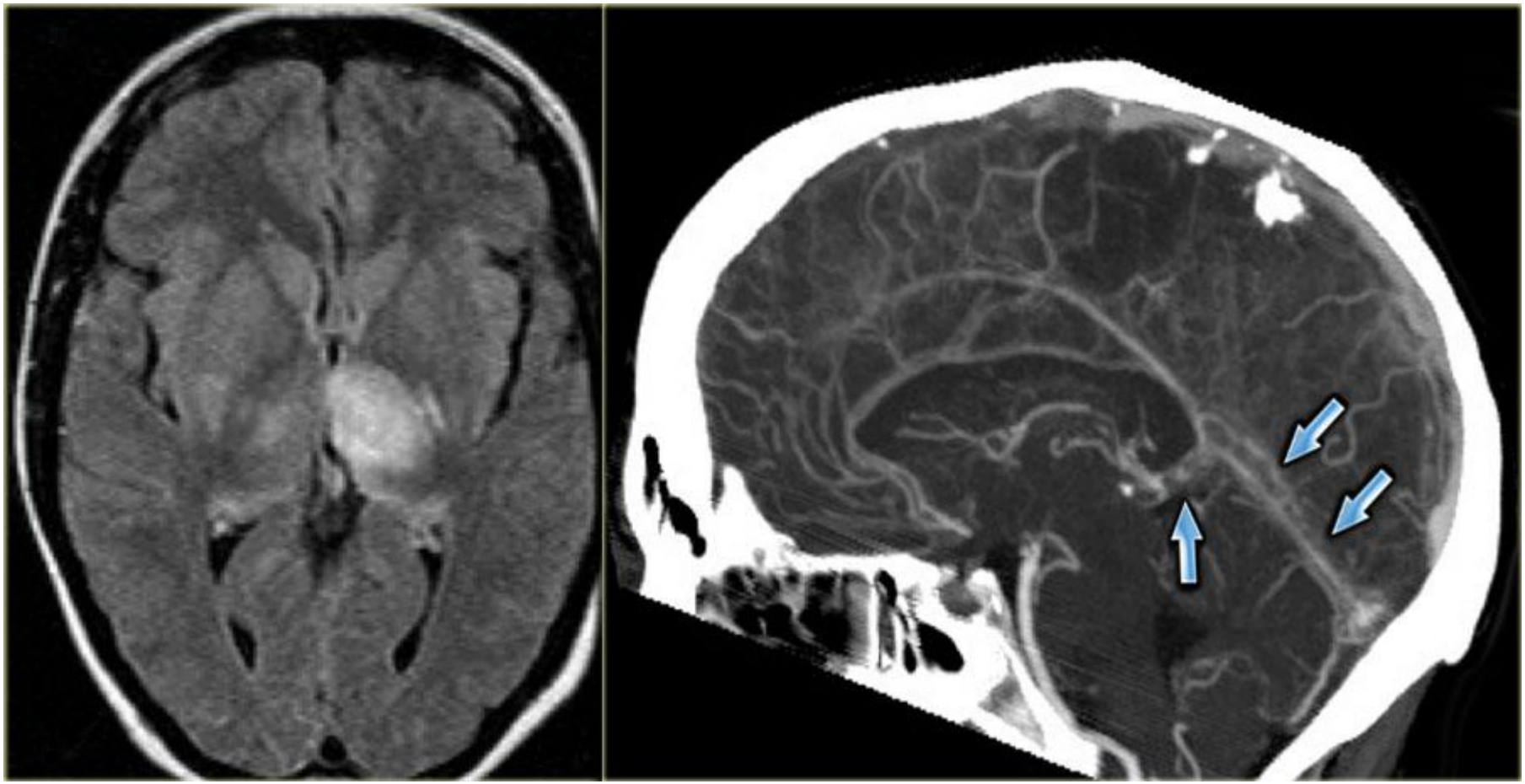

A
B

Thalamic ataxia

- Present thalamic pain;
- Ataxia manifested in the contralateral limbs;
- Aggravated after patient closes eyes.

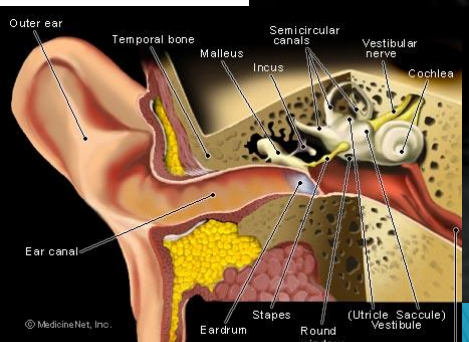
Frontal, parietal, occipital ataxia

- **Static and dynamic ataxia contra laterally**



	Cerebellar	Vestibular	Sensory
Dysarthria	May be present	Absent	Absent
Nystagmus	Often present	Present	Absent
Vertigo	May be present	Present	Absent
Limb ataxia	Usually present	Absent	Present(only in the legs)
Stance/Romberg	Unable to stand with feet together	May be able to stand with feet together	Able to stand with feet together and eyes open, but unable with eyes closed
Vibratory and position sense	Normal	Normal	Impaired
Ankle reflexes	Normal	Normal	Depressed or absent

Imbalance>>>


Outer ear
Temporal bone
Malleus
Incus
Semicircular canals
Vestibular nerve
Cochlea
Ear canal
Eardrum
Stapes
Round
(Utricle Saccule) Vestibule
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