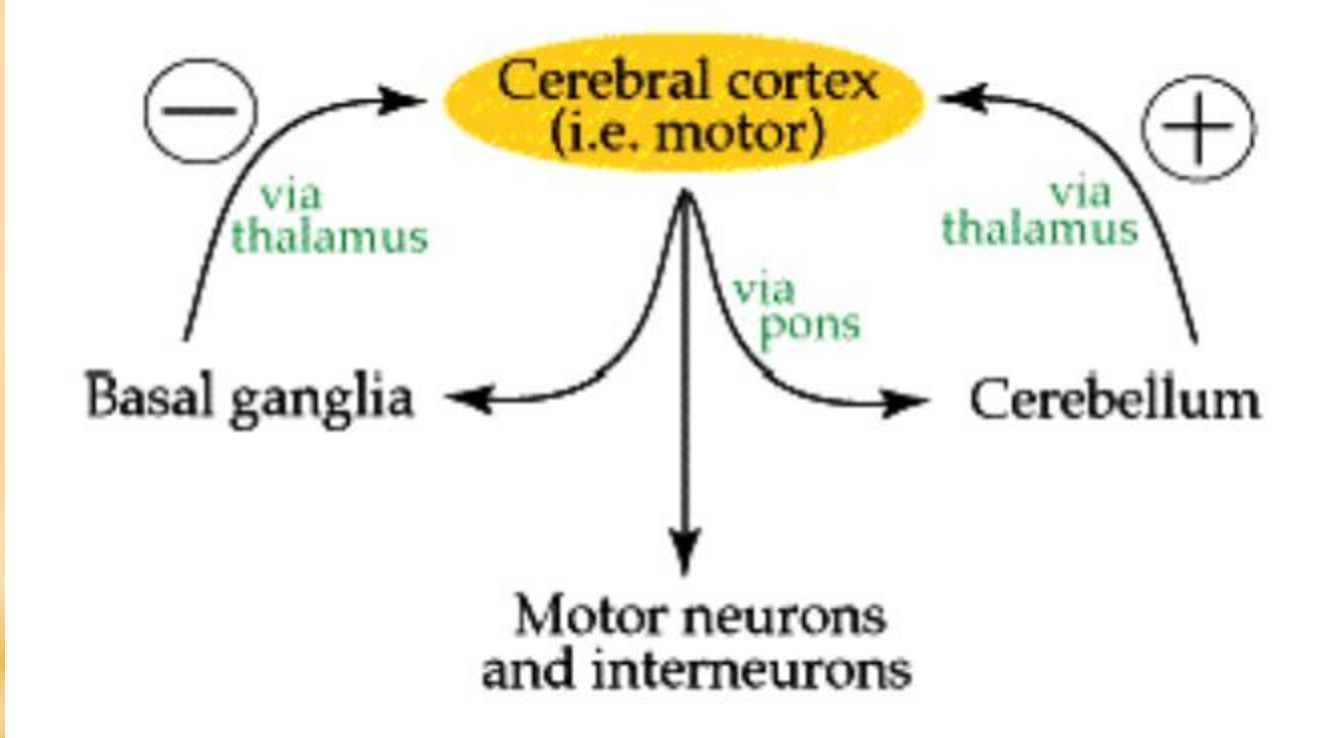
PATHWAYS OF THE CEREBELLUM AND BASAL GANGLIA


Cerebral cortex
(i.e. motor)
via
thalamus
via
thalamus
via
pons
Basal ganglia
Cerebellum
Motor neurons
and interneurons

CEREBELLUM

Functions:

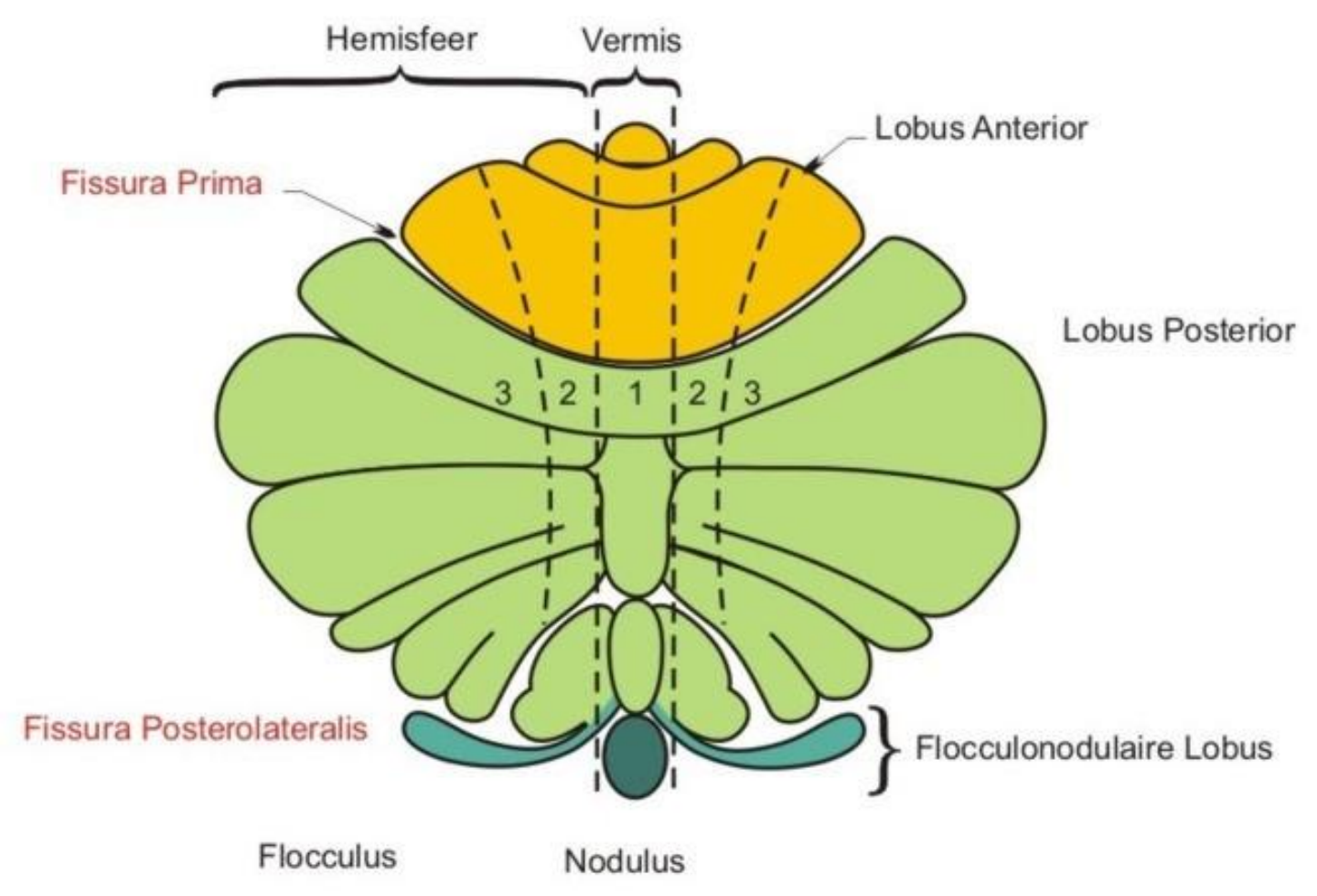
Maintenance of balance and posture

Coordination of voluntary movements

Motor learning

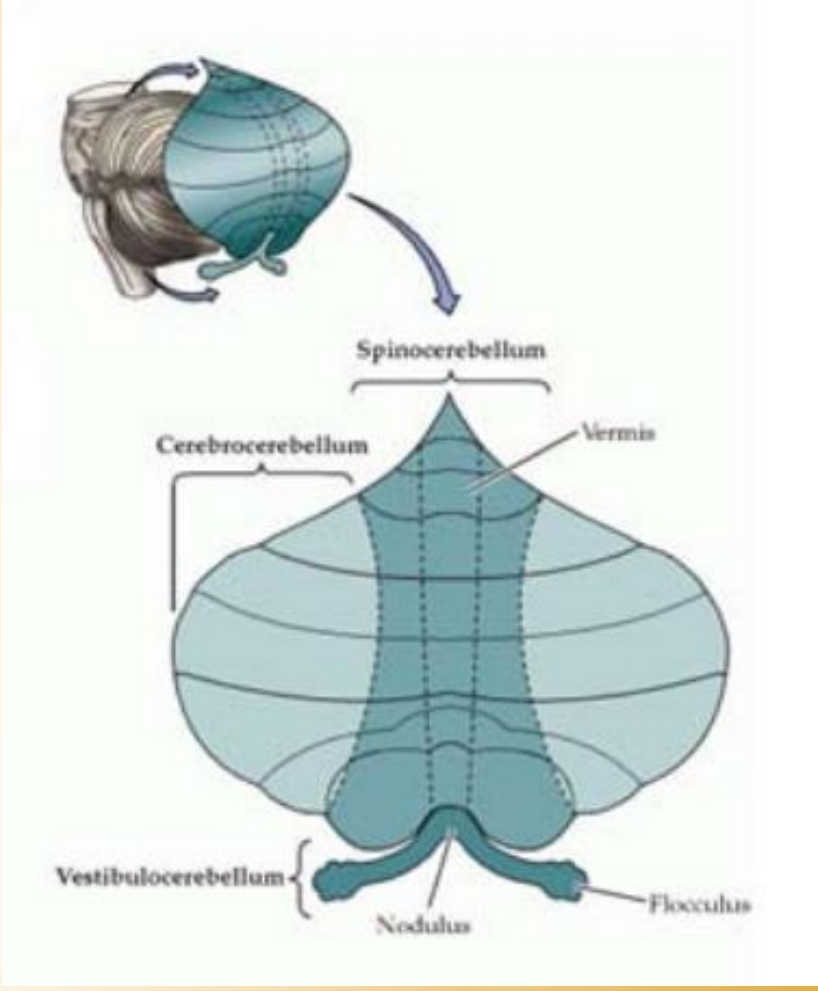
Cognitive functions

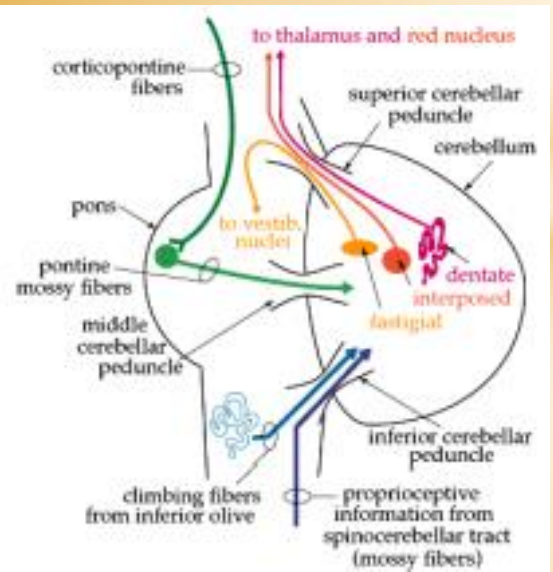
CEREBELLUM
Anatomical division



CEREBELLUM
Developmental division

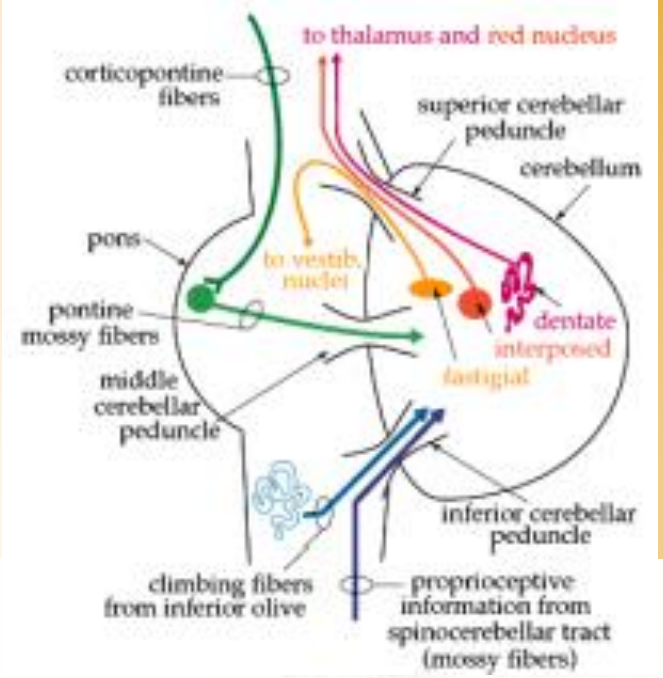
- **archicerebellum**
  - vestibulocerebellum
- **paleoocerebellum**
  - spinocerebellum
- **neocerebellum**
- cerebro- (ponto-) cerebellum

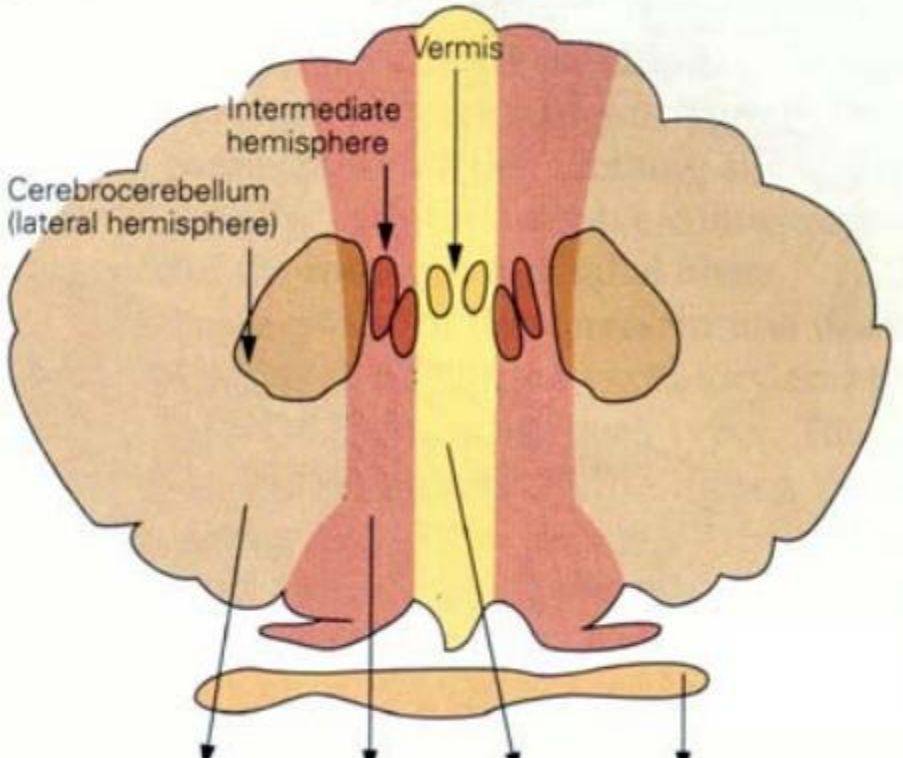


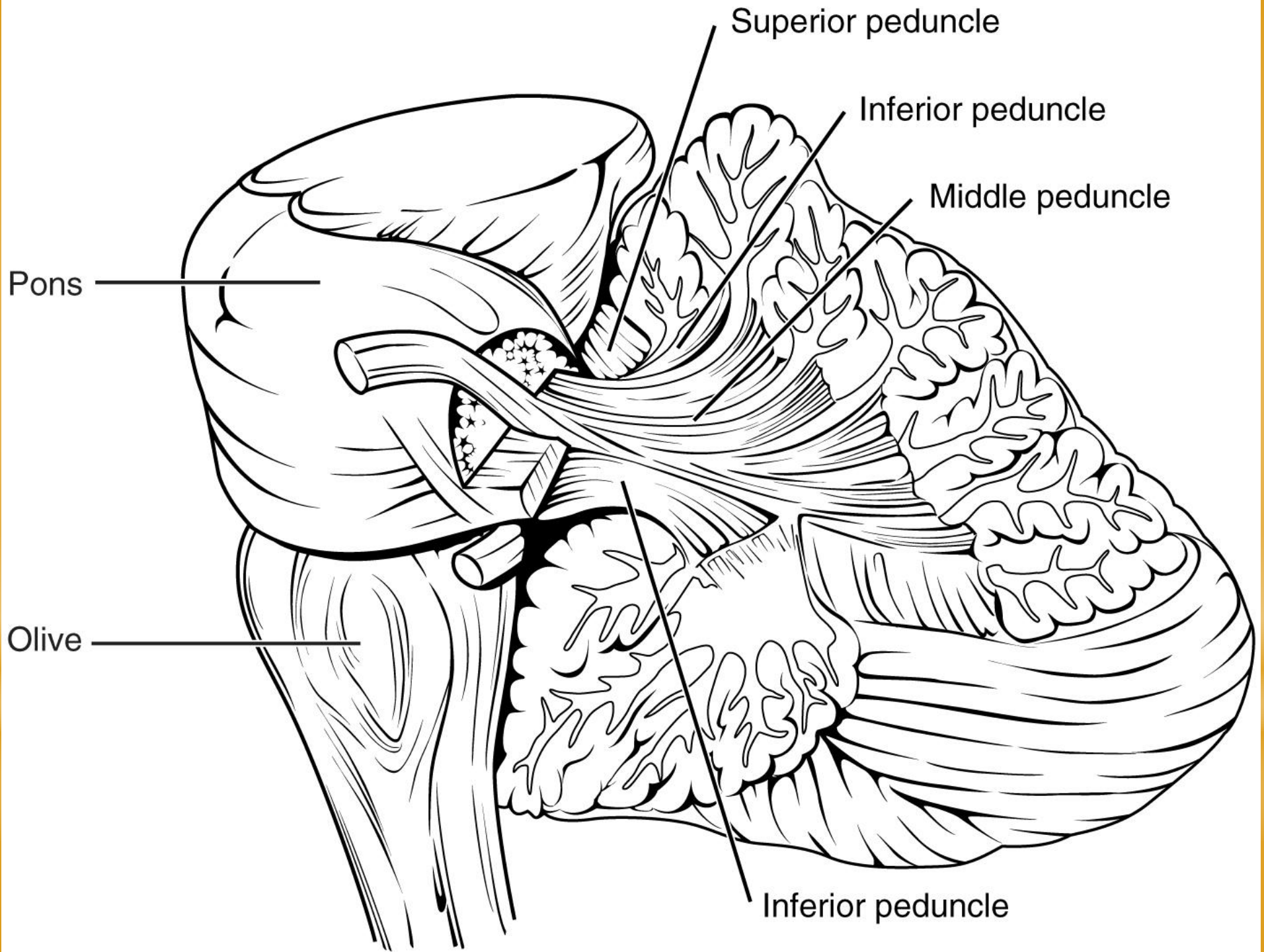


CEREBELLUM
Functional division

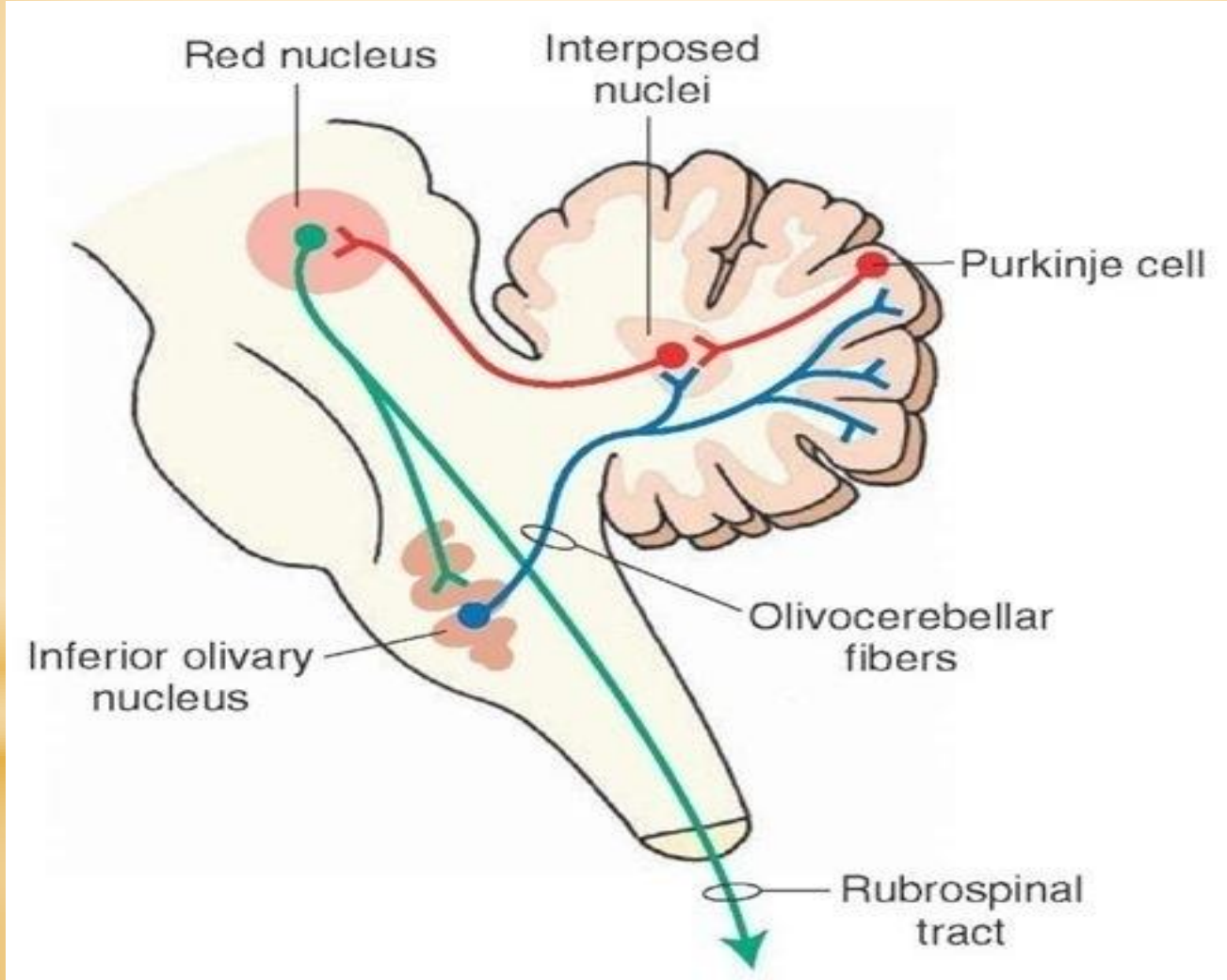
- **VC**
  - flocculonodular lobe
  - vestibular ncll.
- **SC - median zone**
  - vermis
  - ncl. fastigii
- **SC - paramedian zone**
  - intermediate cortex
  - ncll. emboliformis et globosus
- **CC - lateral zone**
  - cortex cerebellar hemispheres
  - ncl. dentatus



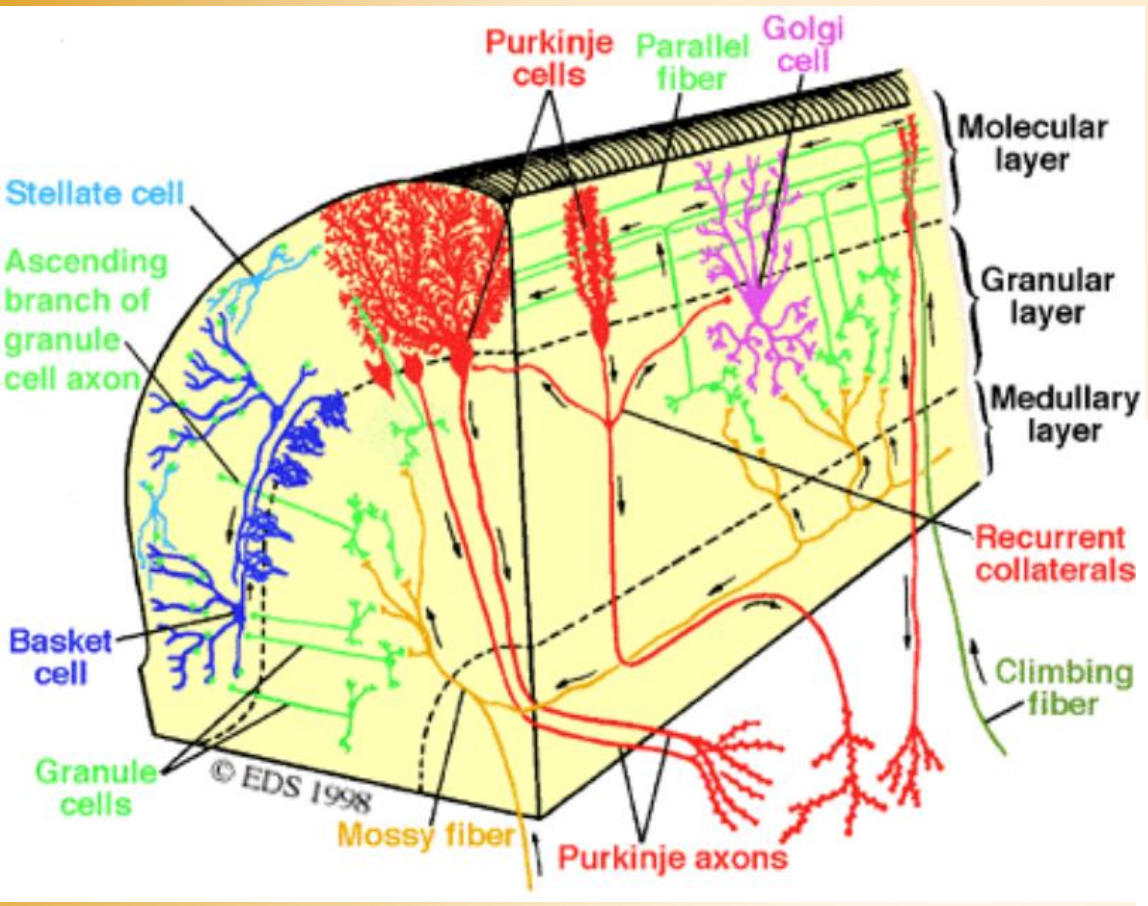


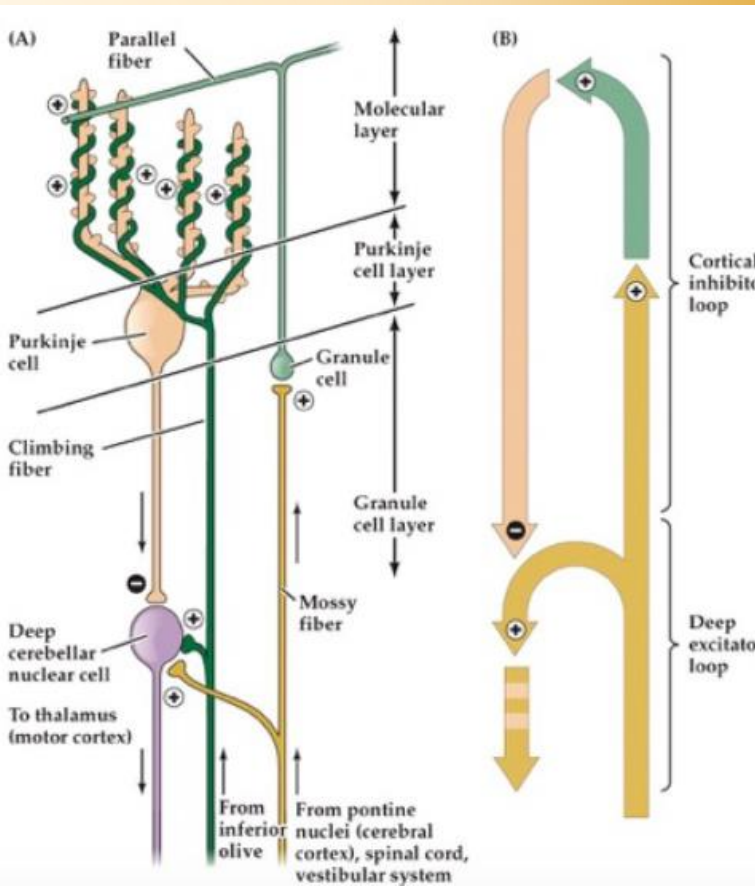

Superior peduncle
Inferior peduncle
Middle peduncle
Pons
Olive
Inferior peduncle

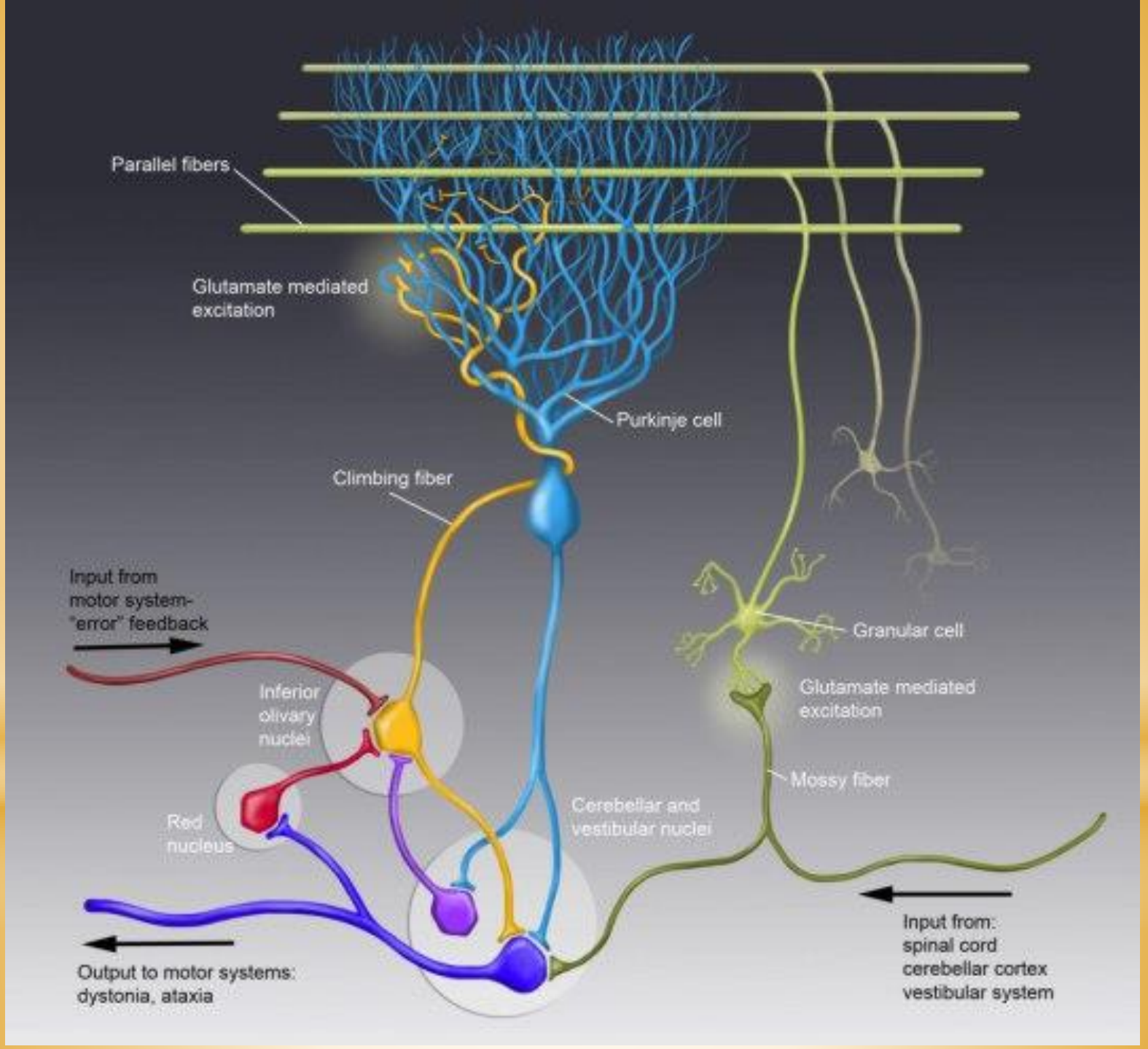
Rubro – olivary tract



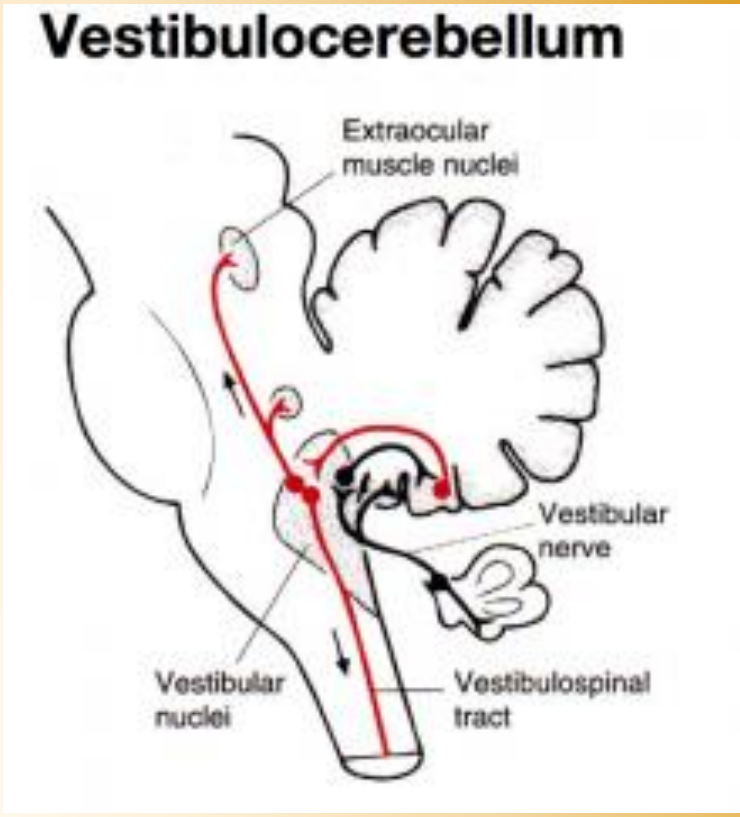
CEREBELLAR CORTEX






Parallel fibers
Glutamate mediated excitation
Purkinje cell
Climbing fiber
Input from motor system- "error" feedback
Granular cell
Glutamate mediated excitation
Inferior olivary nuclei
Mossy fiber
Red nucleus
Cerebellar and vestibular nuclei
Input from: spinal cord cerebellar cortex vestibular system
Output to motor systems: dystonia, ataxia

Connections of the vestibulocerebellum



Flocculonodular lobe (vestibulocerebellum) → Vestibular ncll.

Vestibulospinal tracts

Spinal motor neurons

Vestibulocerebellar tract

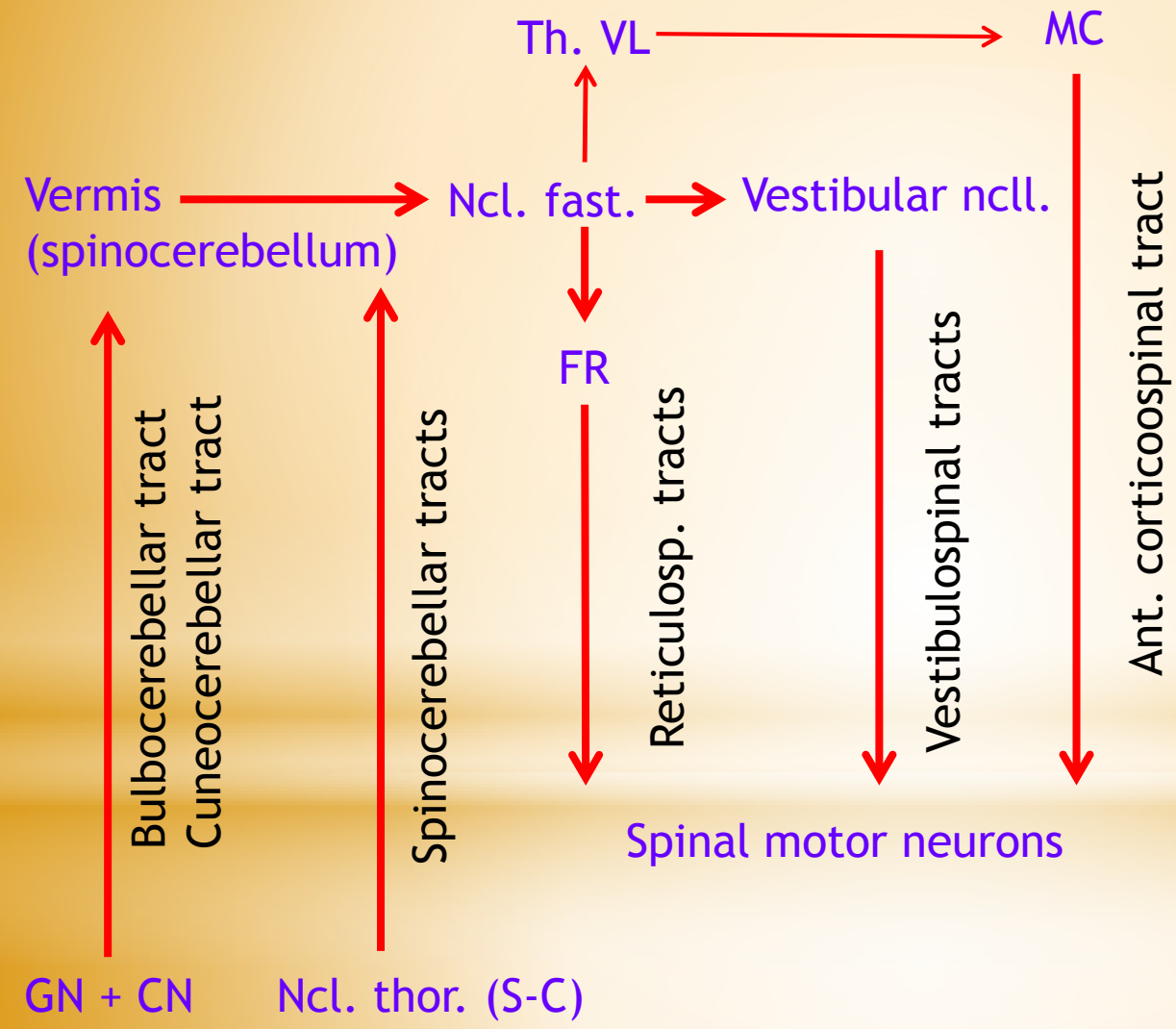
Pontine ncll.

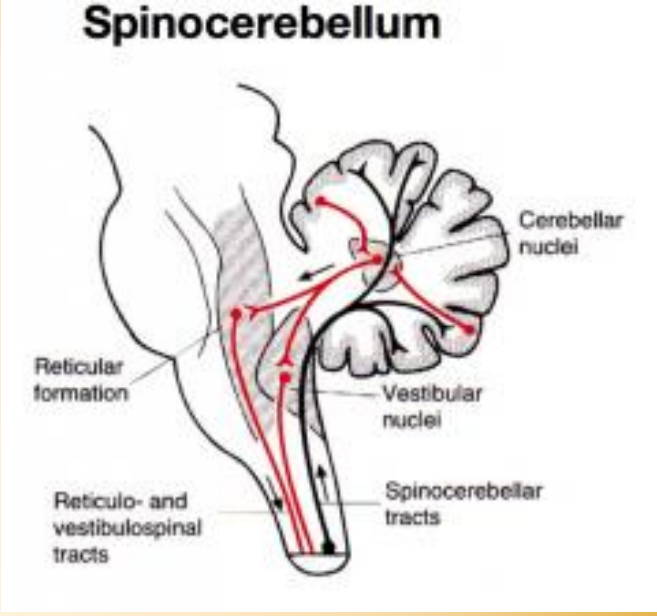
LGB + Sup.Col.

Vestibular apparatus

- **vestibular reflexes**
- **postural maintenance**

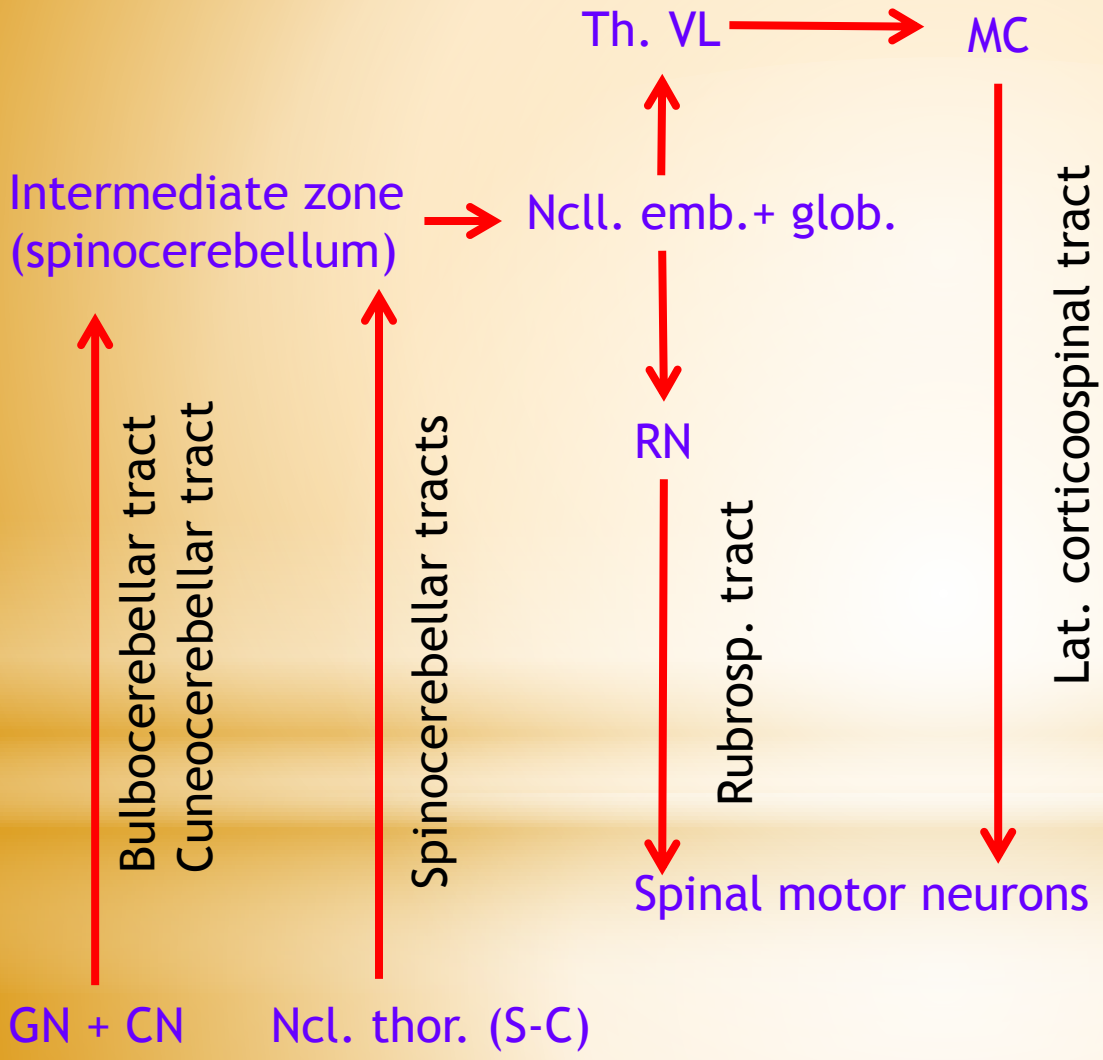
Connections of the spinocerebellum - median zone

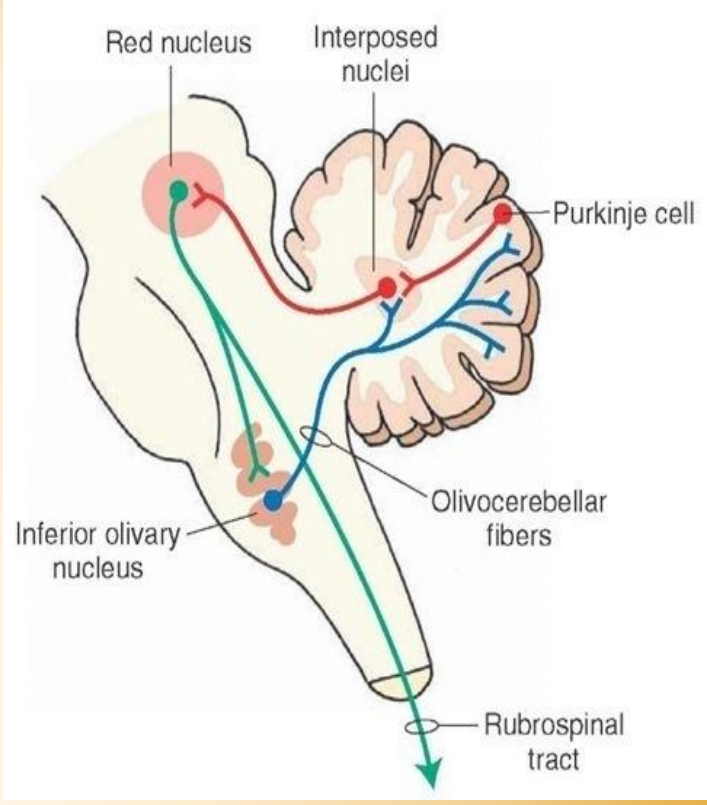




➢ **control of medial descending (motor) system**

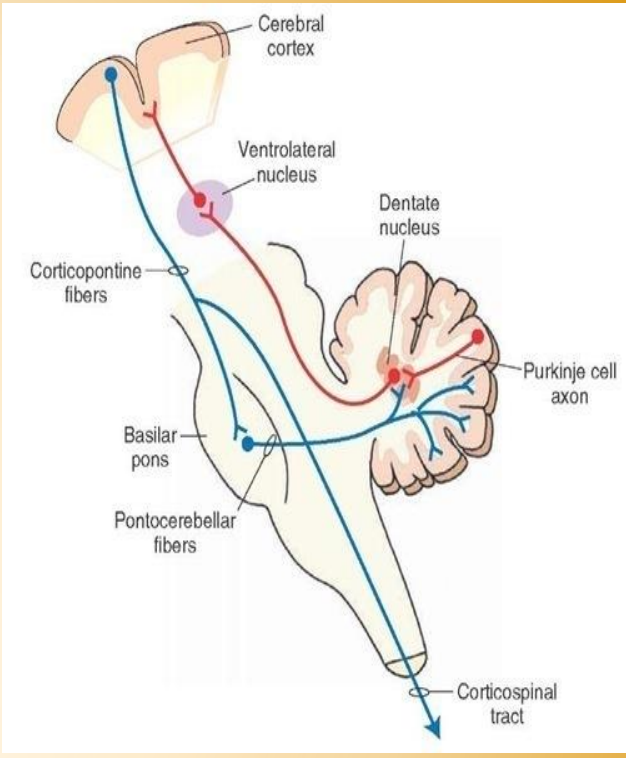
Connections of the spinocerebellum – paramedian zone





- **control of lateral descending (motor) system**

Connections of the cerebro(ponto)cerebellum - lateral zone



Motor cortex

Corticopontine tract

Pontine ncll.

Th. VL

Pontocerebellar tract

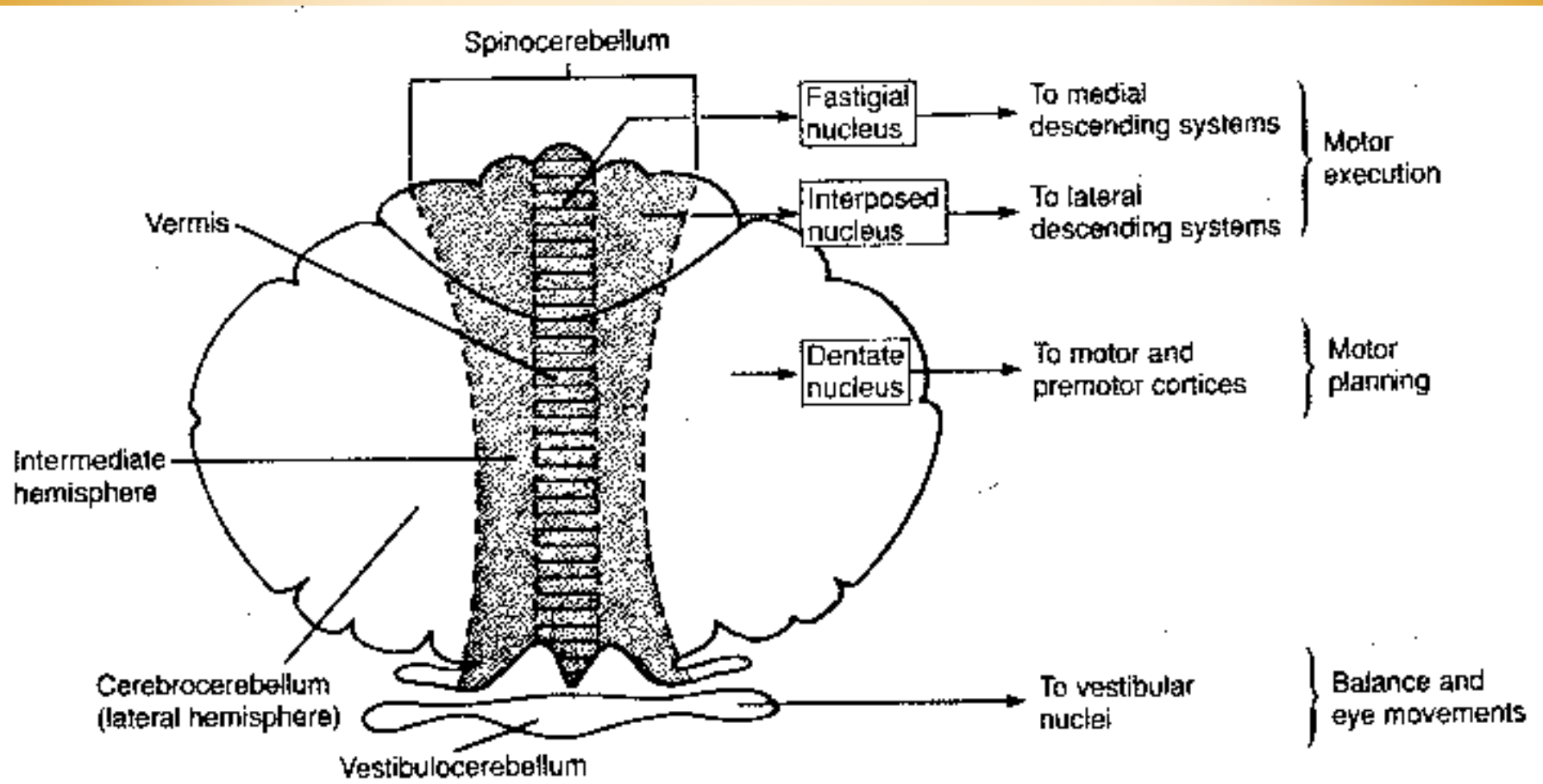
Ncl. dentatus

Lat. corticoospinal tract

Spinal motor neurons

Lateral zone (pontocerebellum)

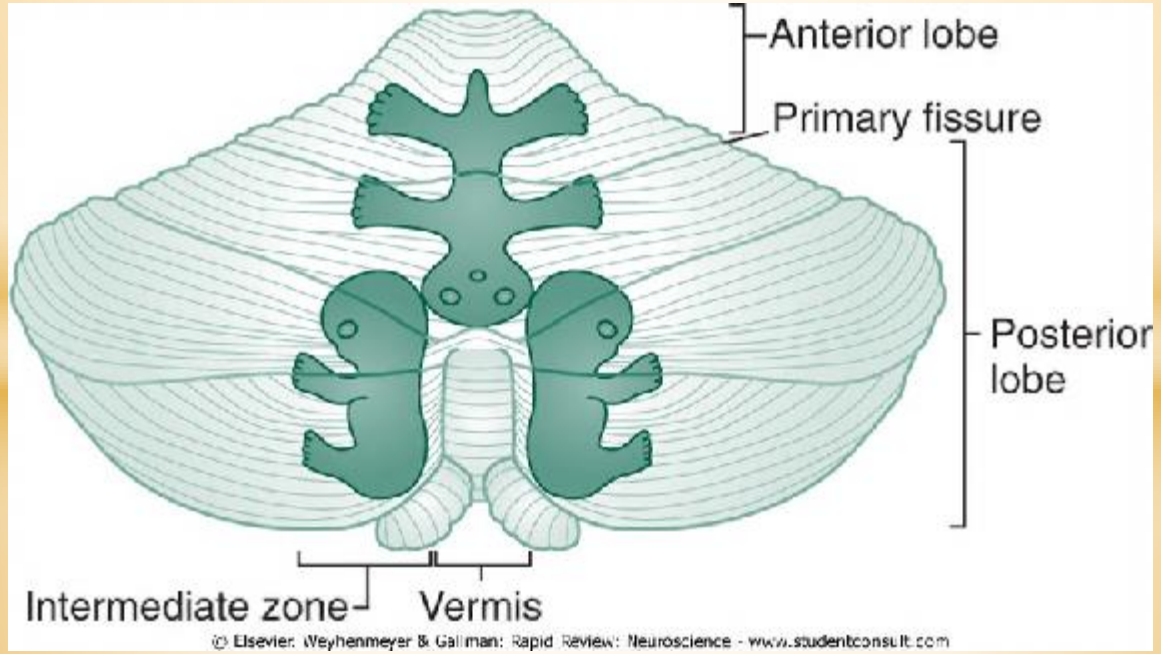
- **planning and timing of movements**
- **cognitive functions**


Spinocerebellum
Fastigial nucleus
To medial descending systems
Motor execution
Vermis
Interposed nucleus
To lateral descending systems
Dentate nucleus
To motor and premotor cortices
Motor planning
Intermediate hemisphere
Cerebrocerebellum (lateral hemisphere)
To vestibular nuclei
Balance and eye movements
Vestibulocerebellum

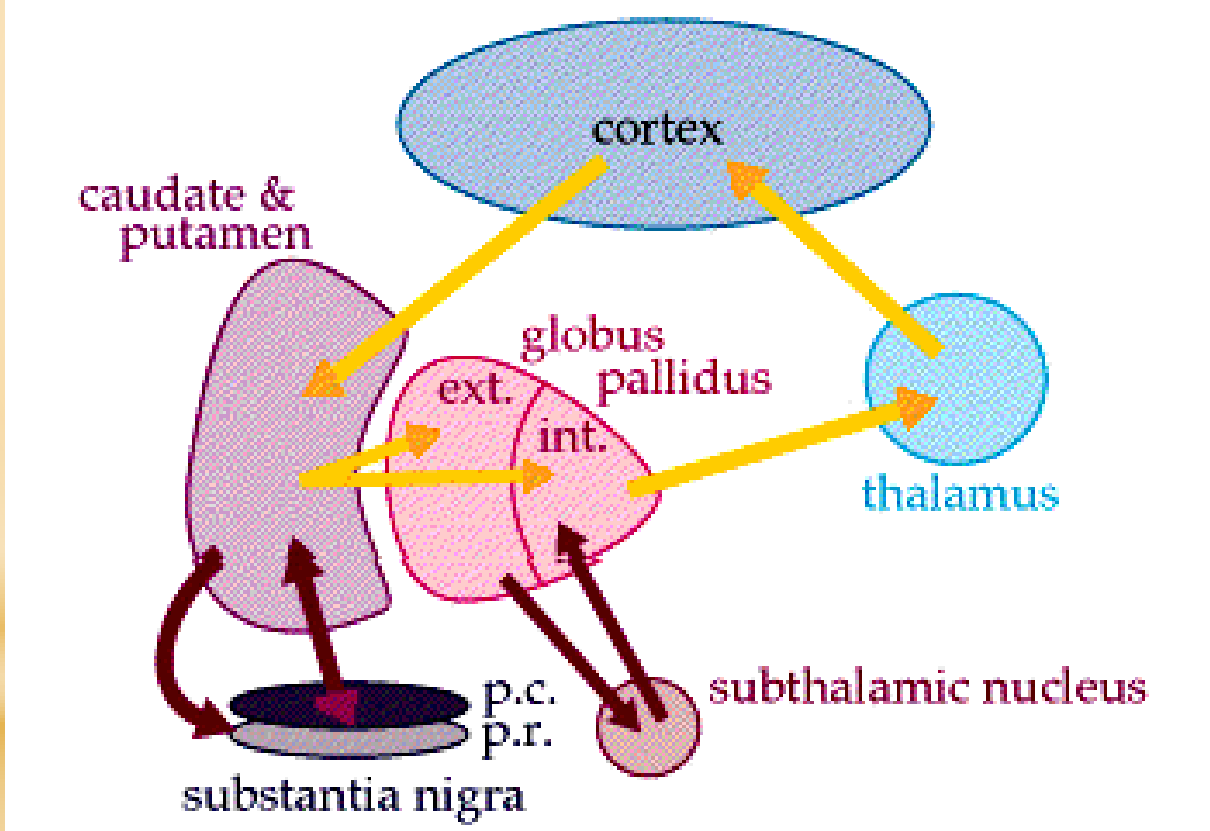
Somatotopic organization

Projection of both spinocerebellar pathways and motor cortex

- ipsilateral anterior lobe
- bilateral paramedian (intermediate) zone



BASAL GANGLIA



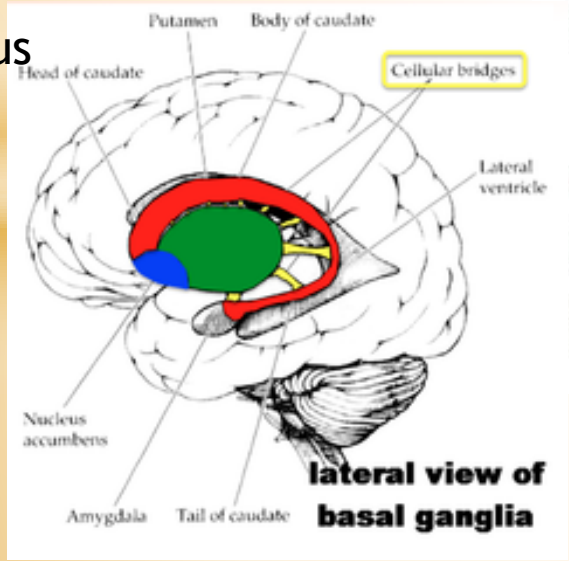
BASAL GANGLIA

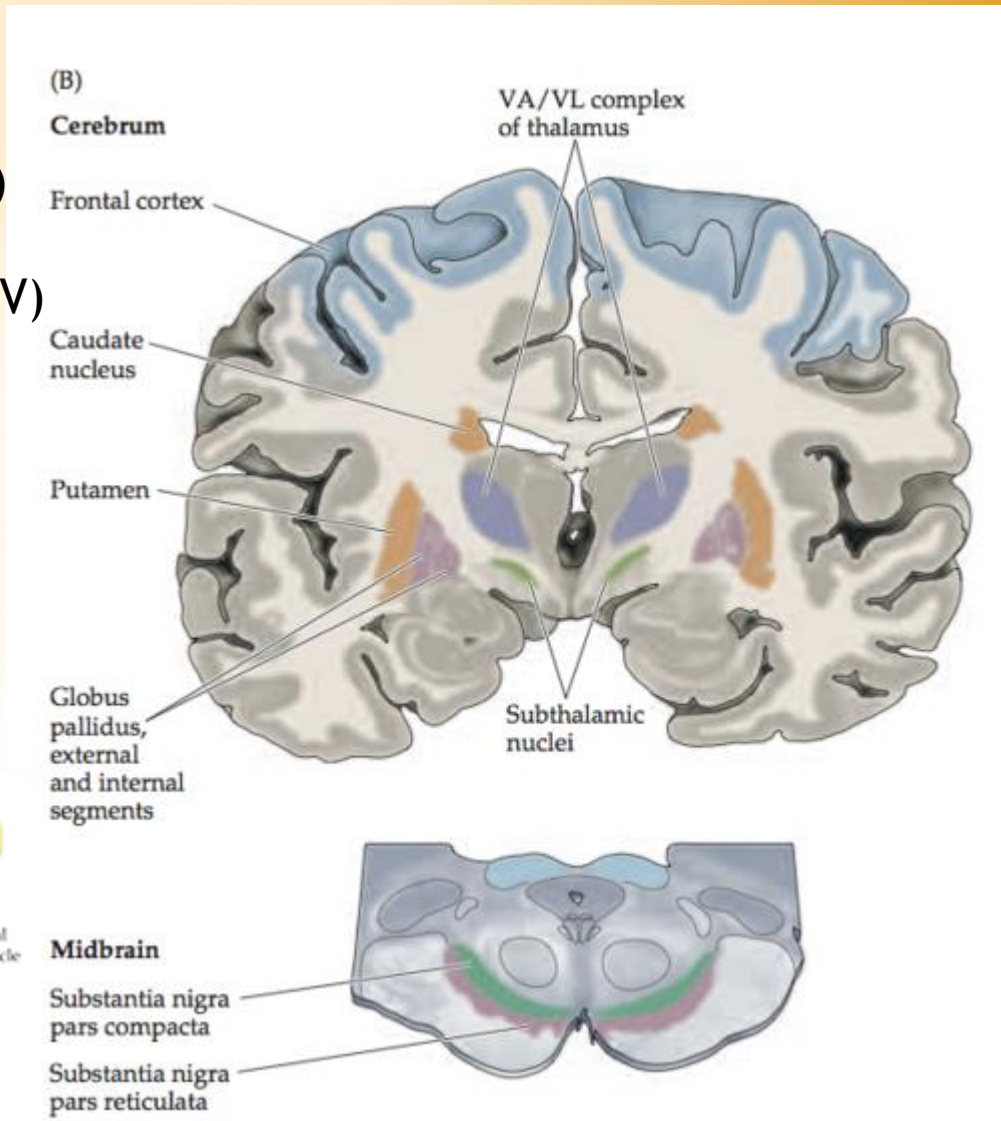
Striatum (neostriatum) – ncl. caudatus (D)
- putamen (D)
- ncl. accumbens (V)

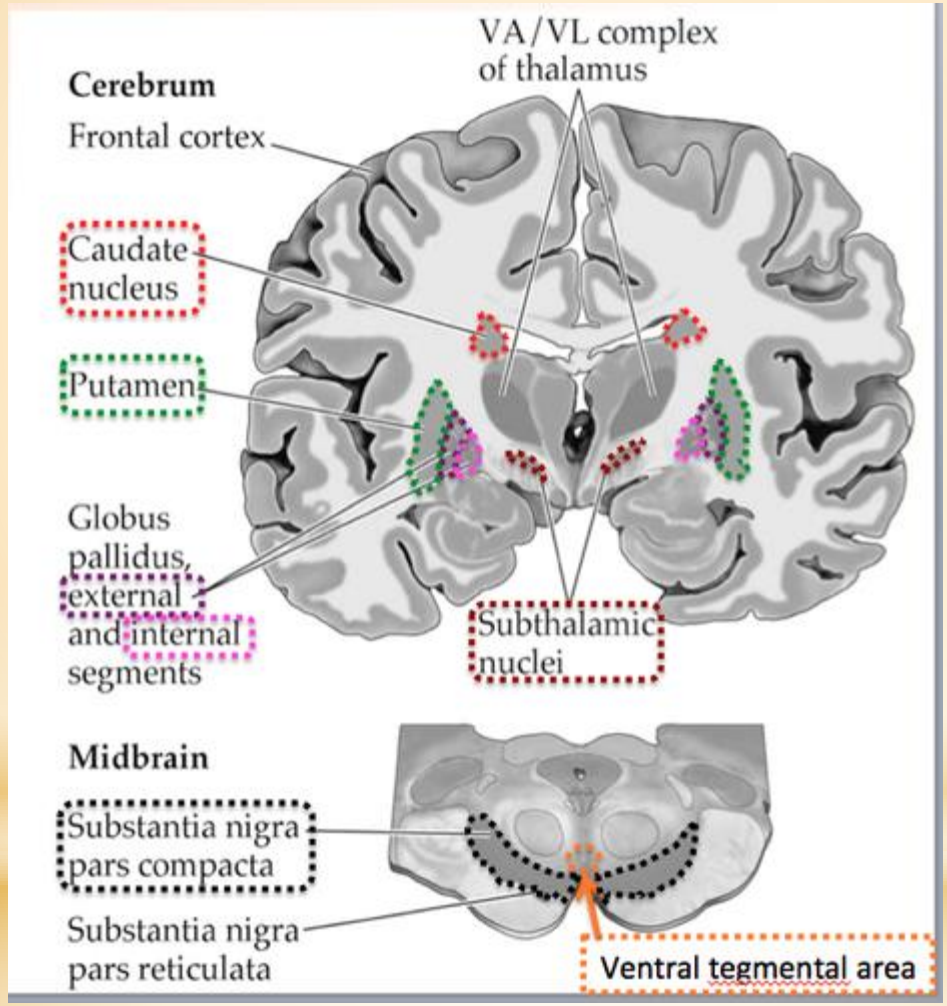
Pallidum (paleostriatum) – globus pallidus
ext.s. int.s.

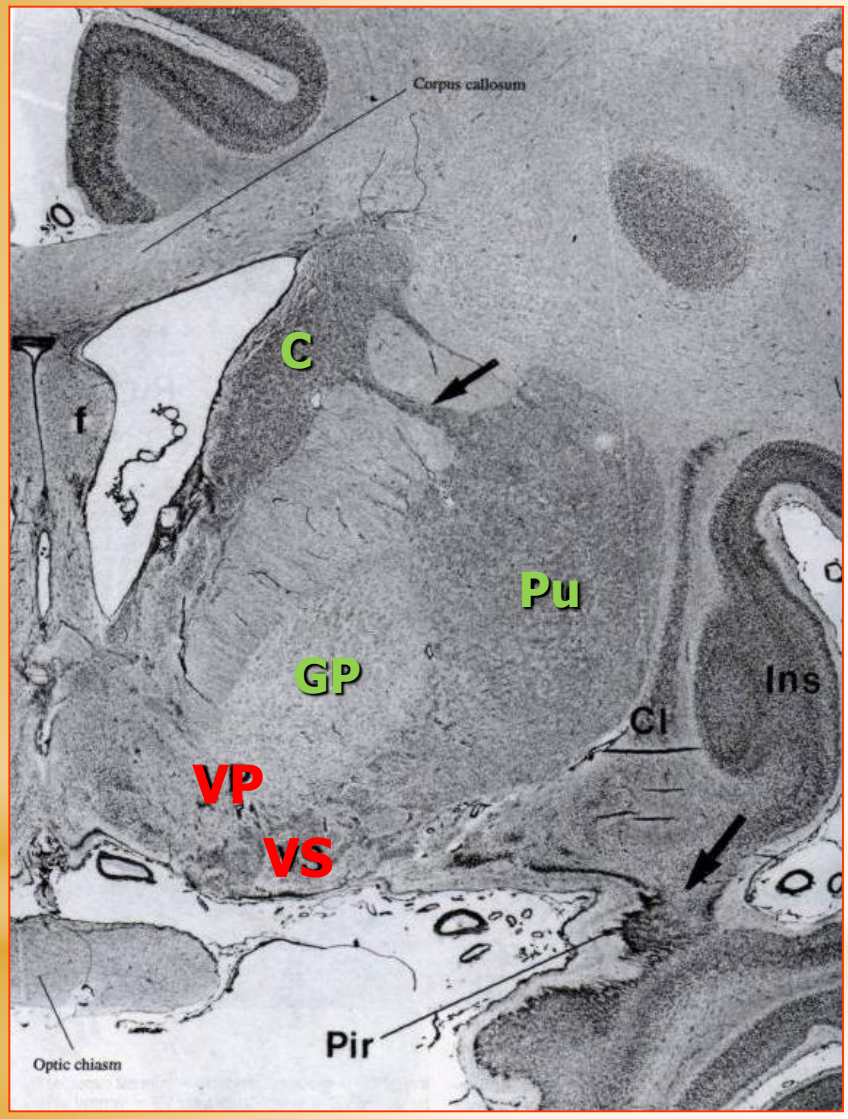
Substantia nigra – pars reticularis
- pars compacta

Ncl. subthalamicus






VA/VL complex
of thalamus
Cerebrum
Frontal cortex
Caudate
nucleus
Putamen
Globus
pallidus,
external
and internal
segments
Subthalamic
nuclei
Midbrain
Substantia nigra
pars compacta
Substantia nigra
pars reticulata
Ventral tegmental area



Ncl caudatus + putamen

= dorsal striatum

Globus pallidus

= dorsal pallidum

Substantia innominata:

VS = ventr. striatum

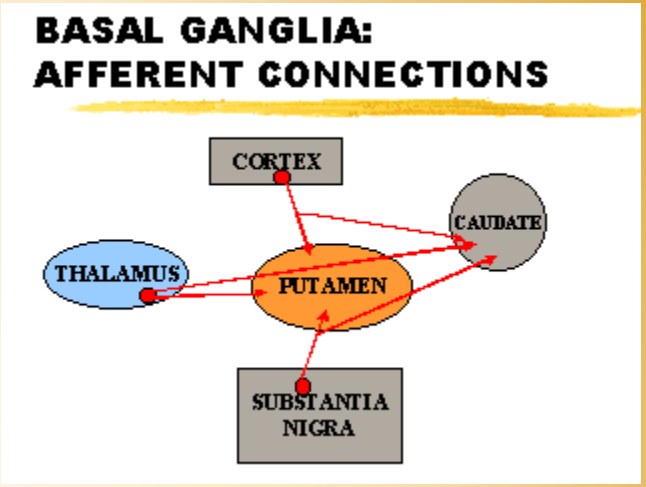
Ncl. accumbens septi

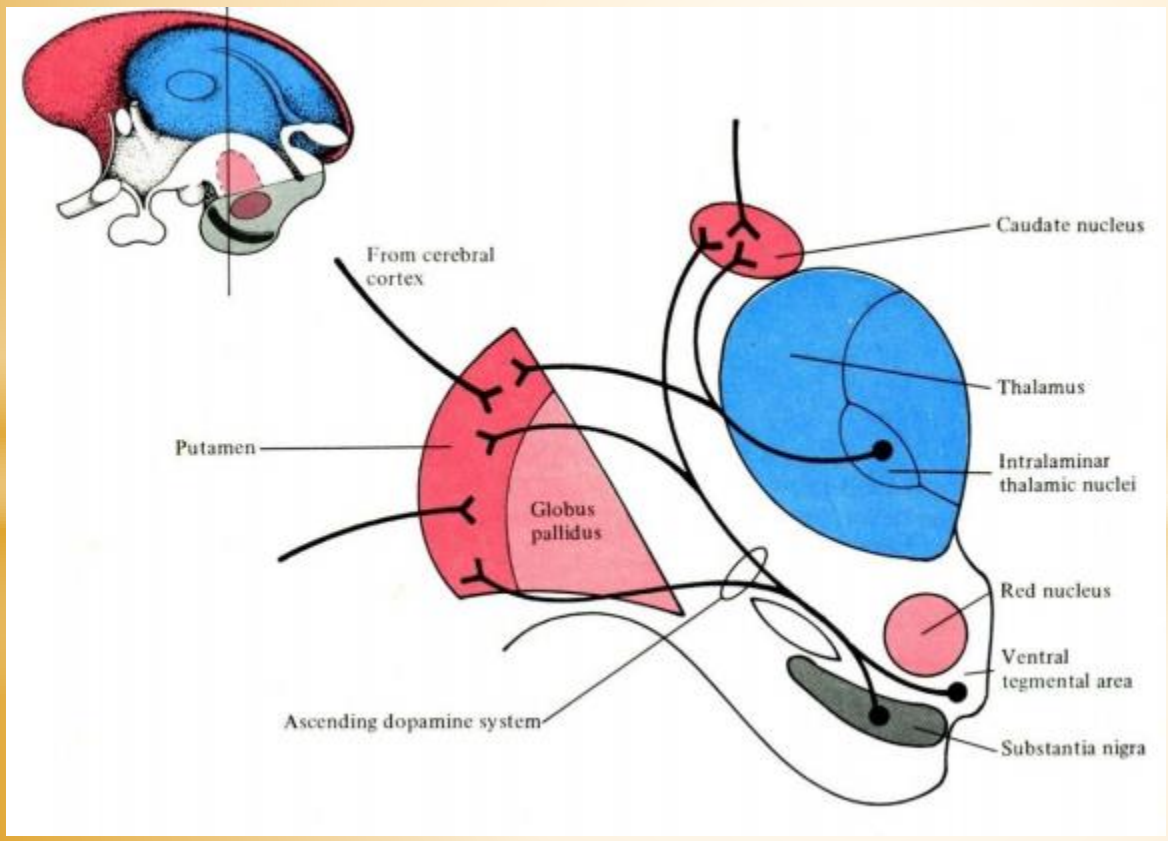
VP = ventral pallidum

Ncl. basalis Meynerti

Basal ganglia afferents:

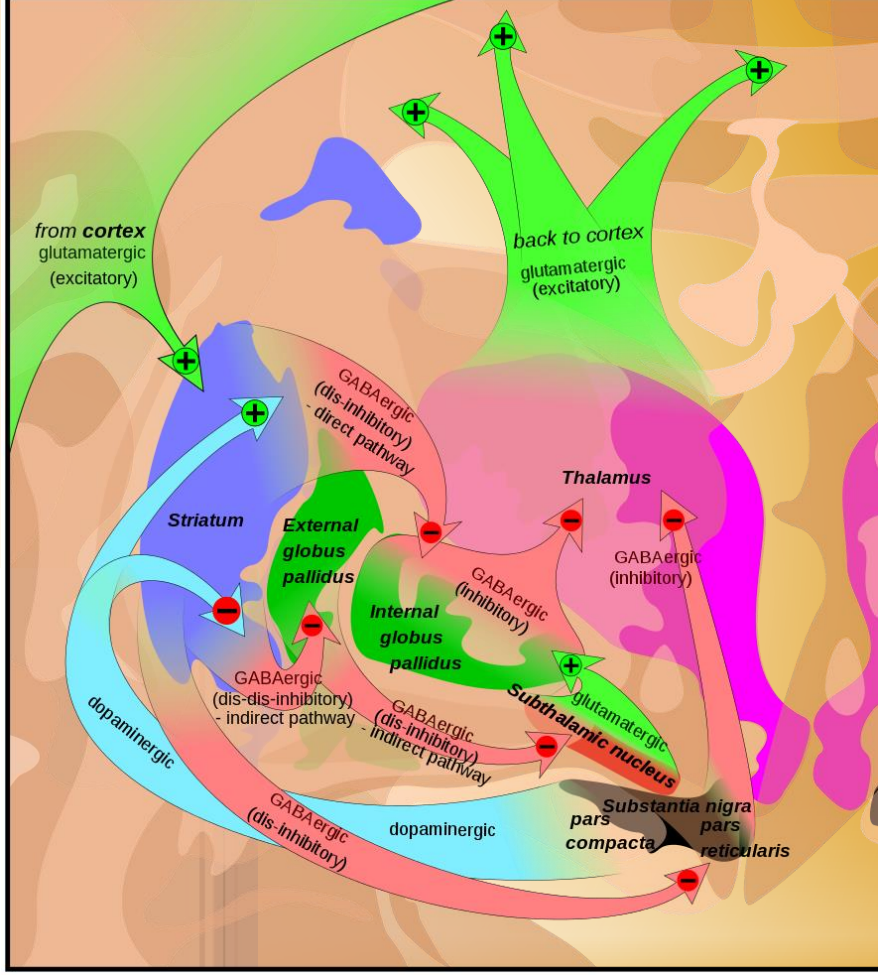
- cortex
- substantia nigra – pars compacta
- intralaminar ncll. of thalamus (CM)

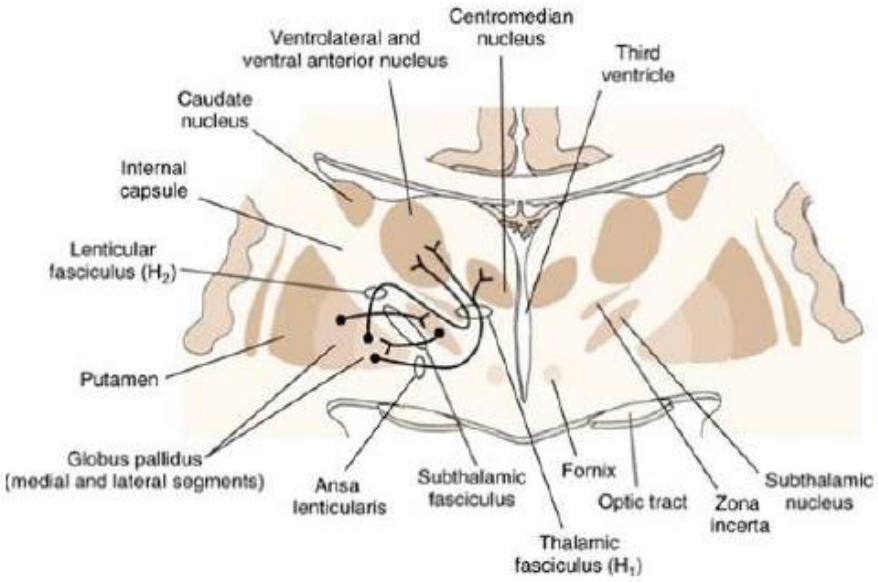




Basal ganglia efferents:

- GPi
- SN – pars reticularis
  - Th. VA/VL
  - Th. CM

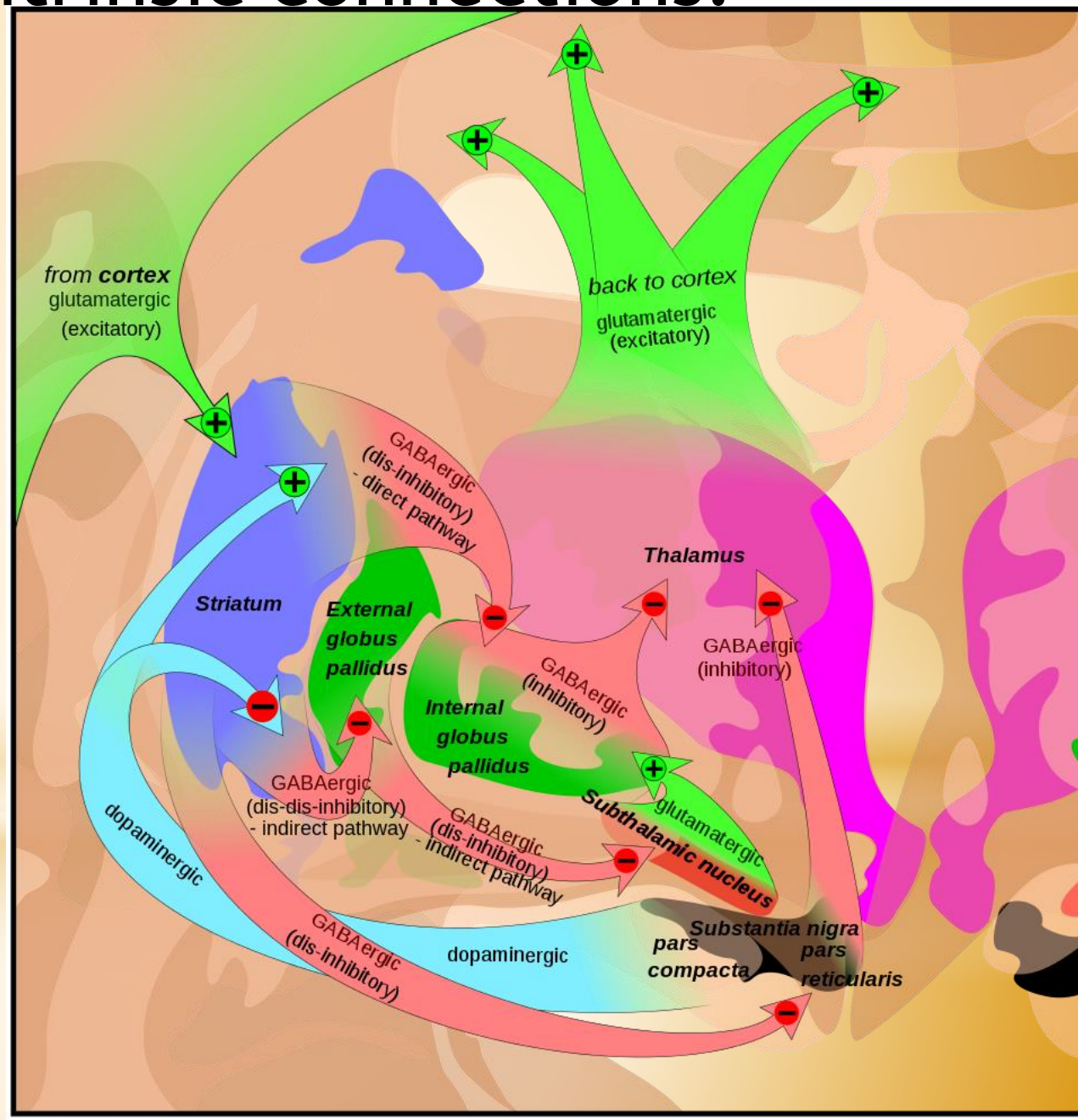




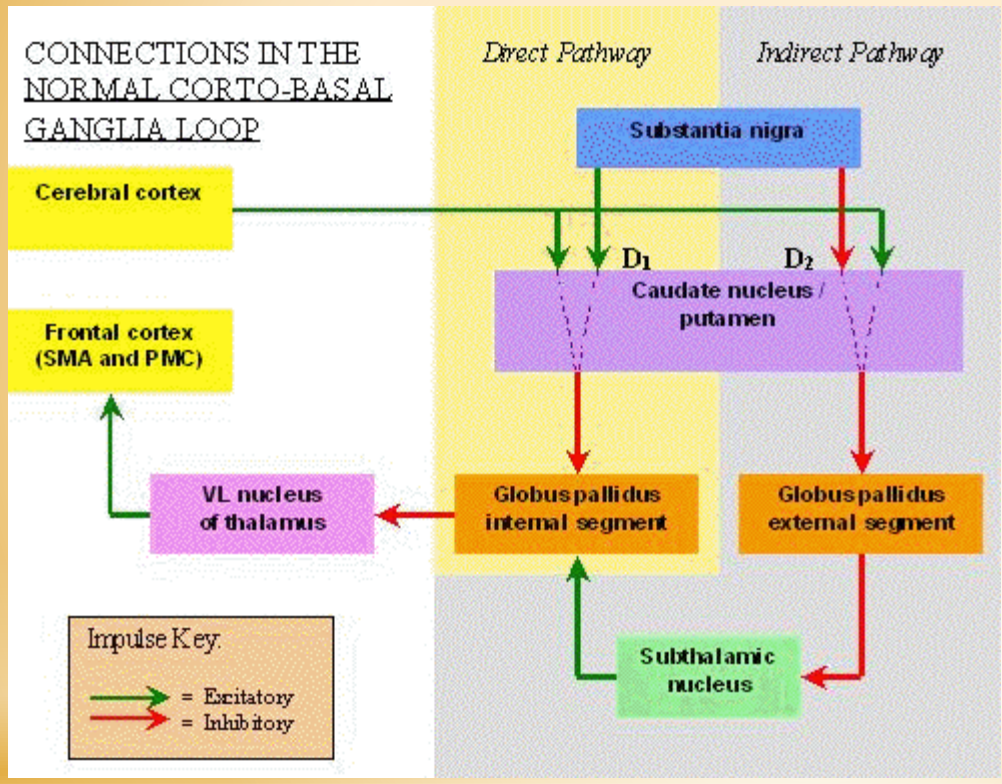
(ansa lenticularis + fasciculus lenticularis → fasciculus thalamicus)

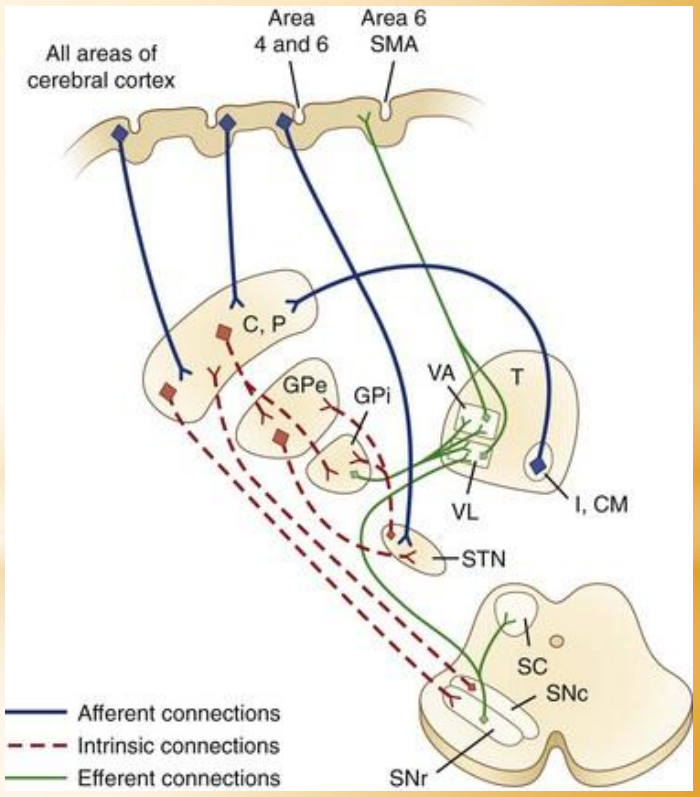
Basal ganglia intrinsic connections:

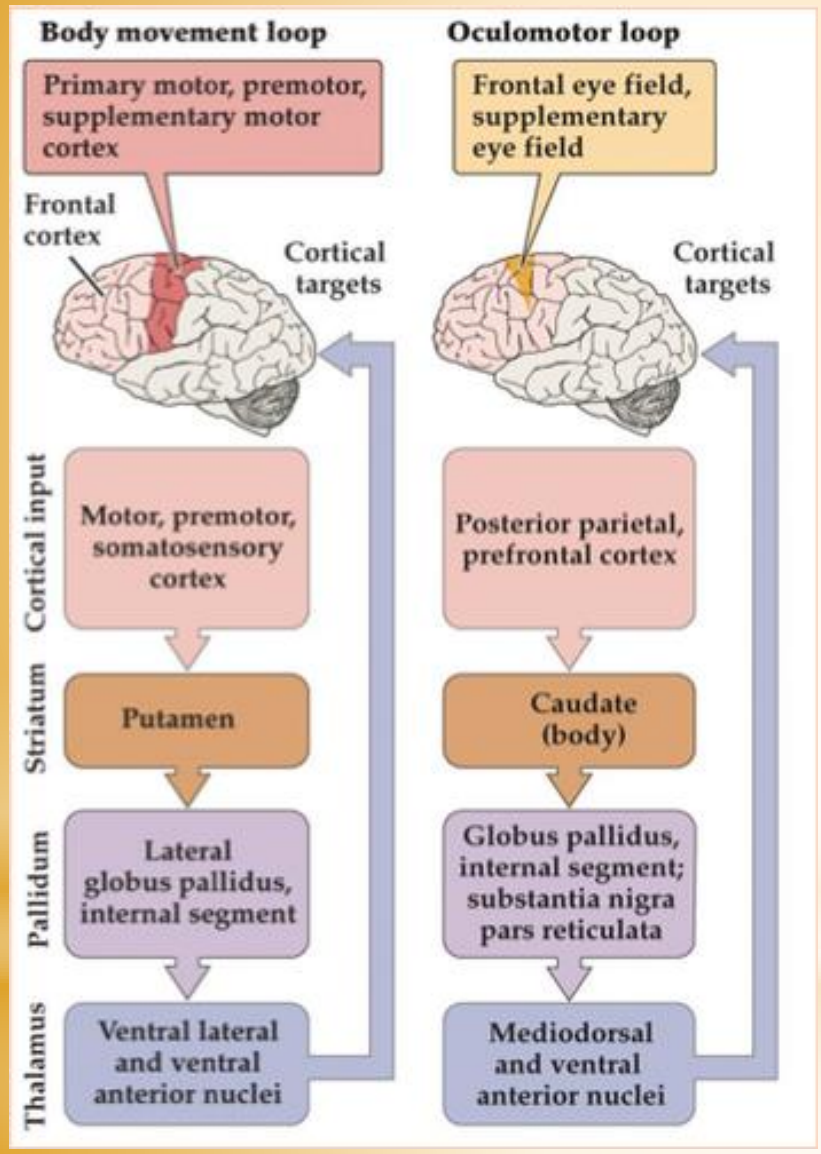
- Striatopallidal p.
- Striatonigral p.
- GPe → STN
- STN → GP, SNr.
- Nigrostriatal p.

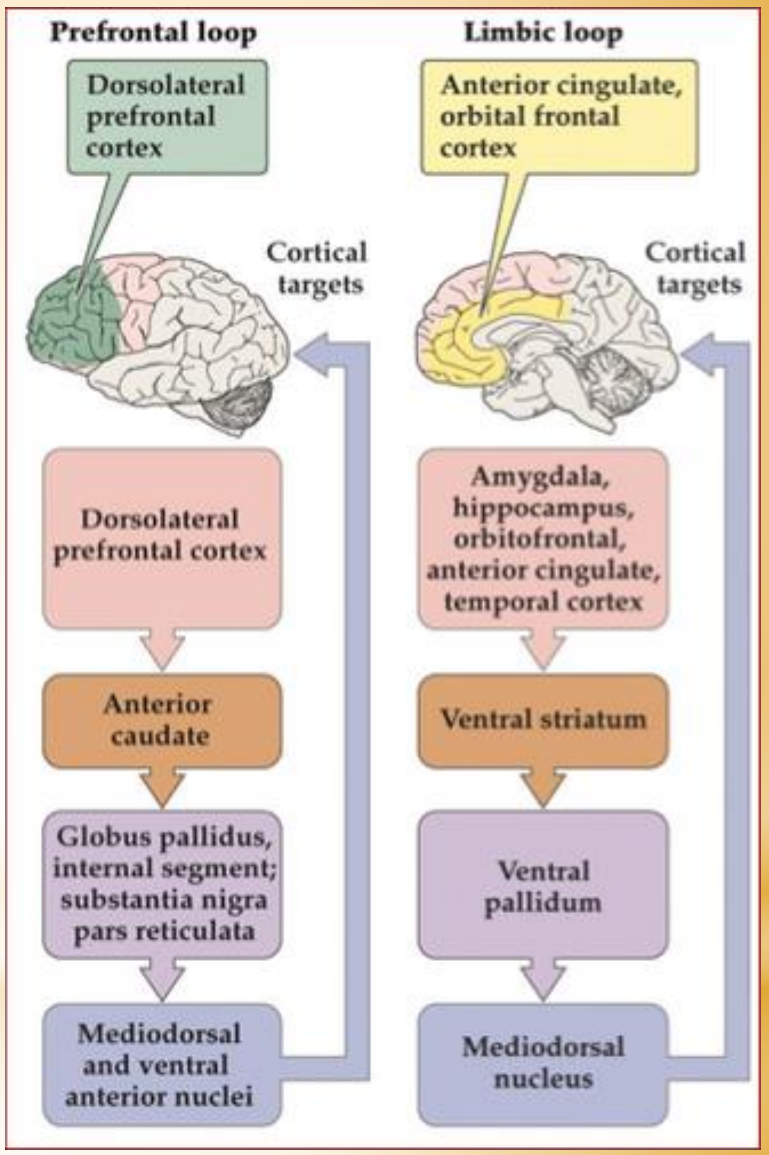


Motor loop


CONNECTIONS IN THE NORMAL CORTO-BASAL GANGLIA LOOP
Direct Pathway
Indirect Pathway
Substantia nigra
Cerebral cortex
D1
D2
Caudate nucleus / putamen
Frontal cortex (SMA and PMC)
VL nucleus of thalamus
Globus pallidus internal segment
Globus pallidus external segment
Subthalamic nucleus
Impulse Key:
= Excitatory
= Inhibitory


All areas of cerebral cortex
Area 4 and 6
Area 6 SMA
C, P
GPe
GPi
VA
T
VL
I, CM
STN
SC
SNc
SNr
Afferent connections
Intrinsic connections
Efferent connections


Body movement loop
Oculomotor loop
Primary motor, premotor, supplementary motor cortex
Frontal eye field, supplementary eye field
Frontal cortex
Cortical targets
Cortical targets
Cortical input
Striatum
Pallidum
Thalamus
Motor, premotor, somatosensory cortex
Posterior parietal, prefrontal cortex
Putamen
Caudate (body)
Lateral globus pallidus, internal segment
Globus pallidus, internal segment; substantia nigra pars reticulata
Ventral lateral and ventral anterior nuclei
Mediodorsal and ventral anterior nuclei


Prefrontal loop
Limbic loop
Dorsolateral prefrontal cortex
Anterior cingulate, orbital frontal cortex
Cortical targets
Cortical targets
Dorsolateral prefrontal cortex
Amygdala, hippocampus, orbitofrontal, anterior cingulate, temporal cortex
Anterior caudate
Ventral striatum
Globus pallidus, internal segment; substantia nigra pars reticulata
Ventral pallidum
Mediodorsal and ventral anterior nuclei
Mediodorsal nucleus

SPINAL MOTOR REFLEXES

SPINAL REFLEXES

- **type of afferents**
  - somatic spinal reflexes
  - visceral spinal reflexes

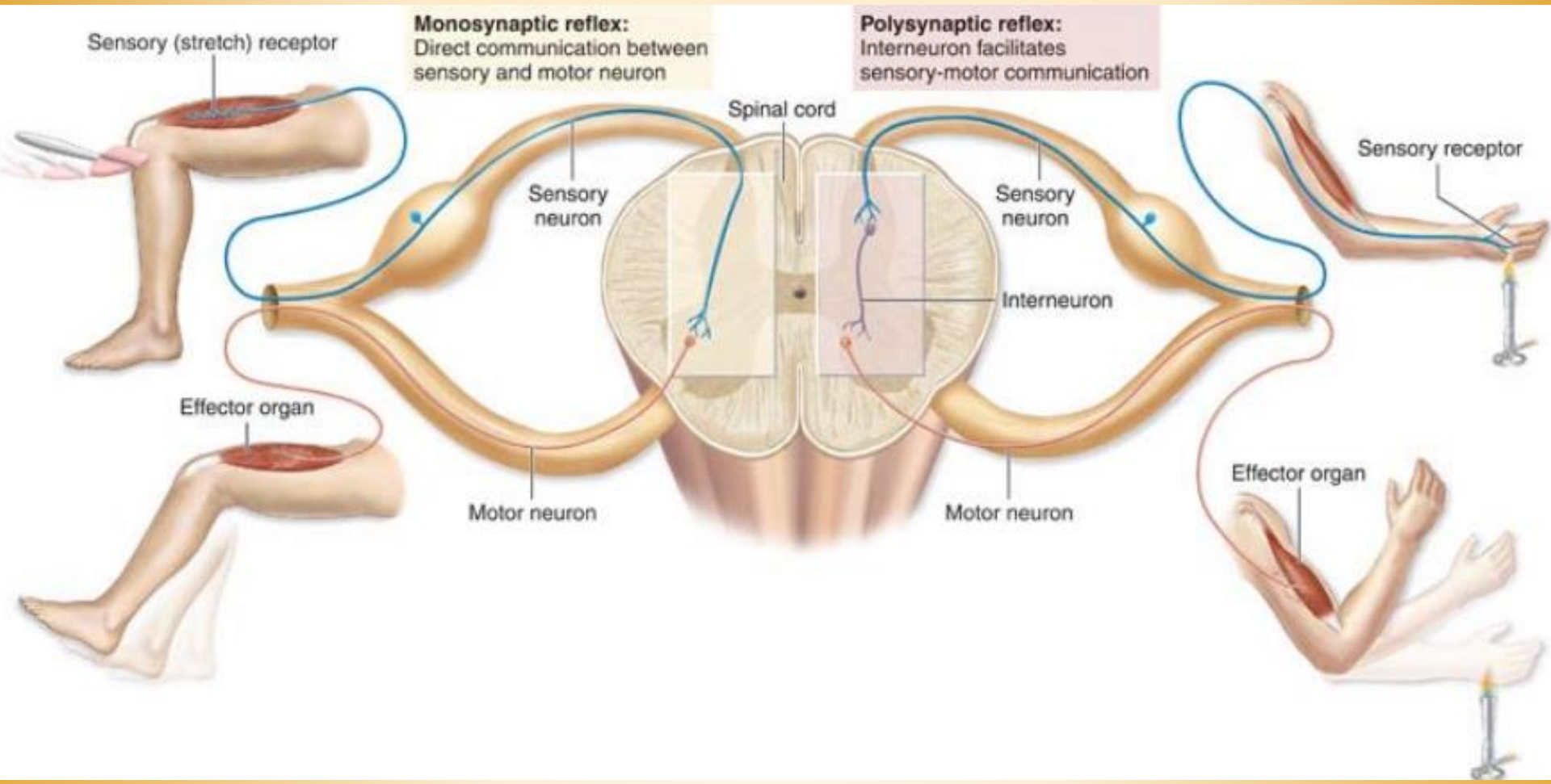
- **type of somatosensor**
  - proprioceptive reflexes
  - exteroceptive reflexes

- **number of involved spinal segments**
  - monosegmental spinal reflexes
  - polysegmental spinal reflexes

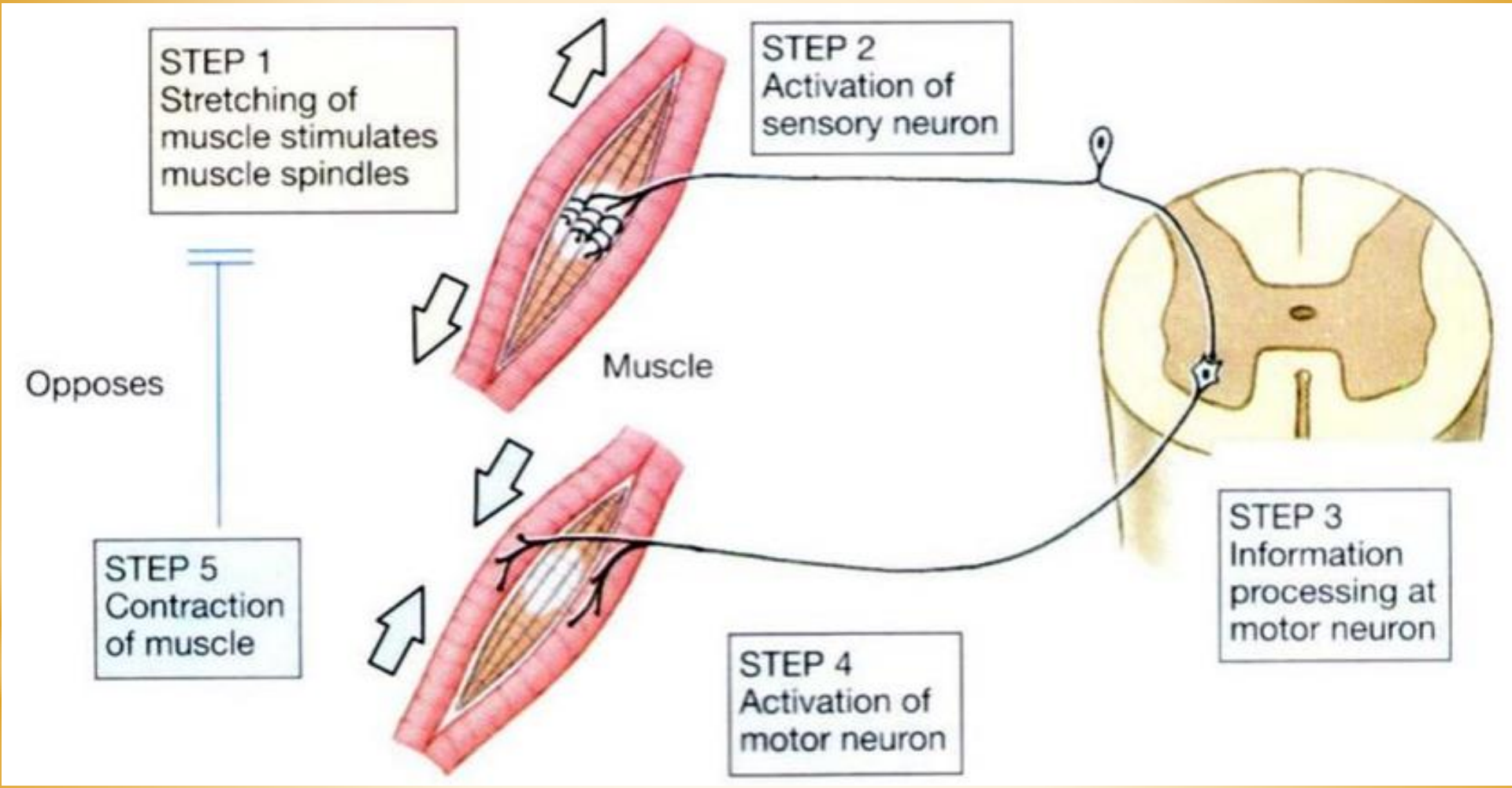
- **number of synapses**
  - monosynaptic reflexes
  - disynaptic reflexes
  - polysynaptic reflexes

Myotatic reflex

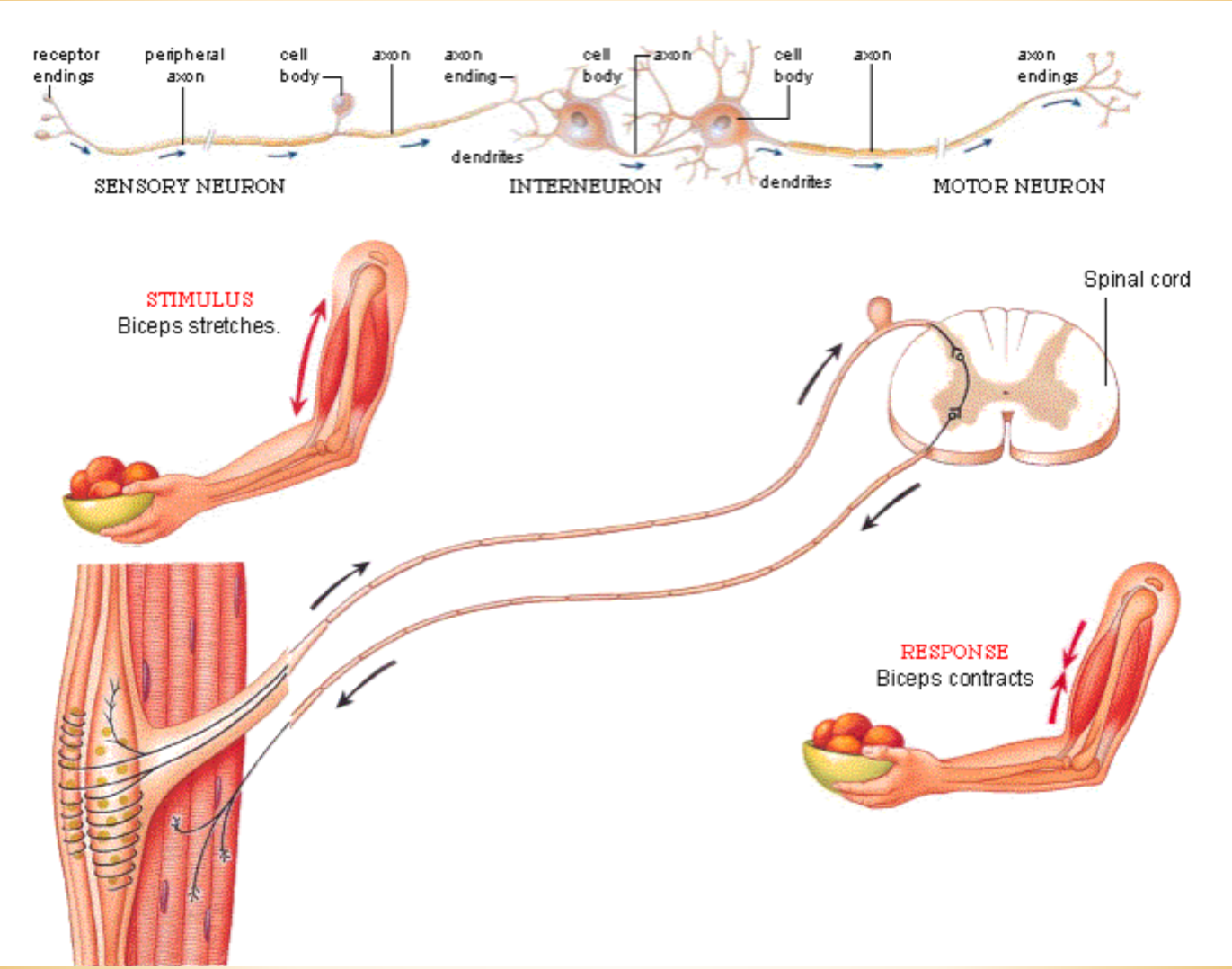
Withdrawal reflex



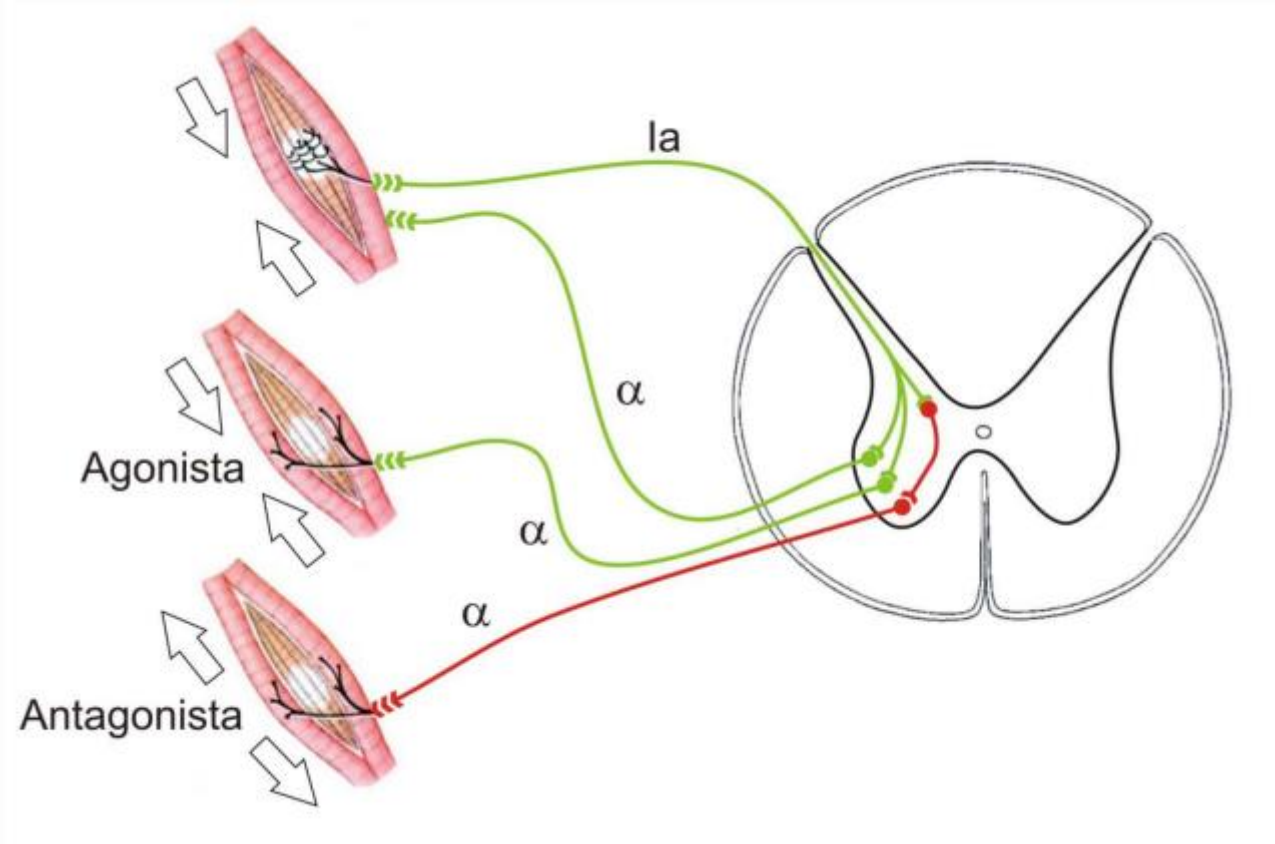
Myotatic (stretch) reflex



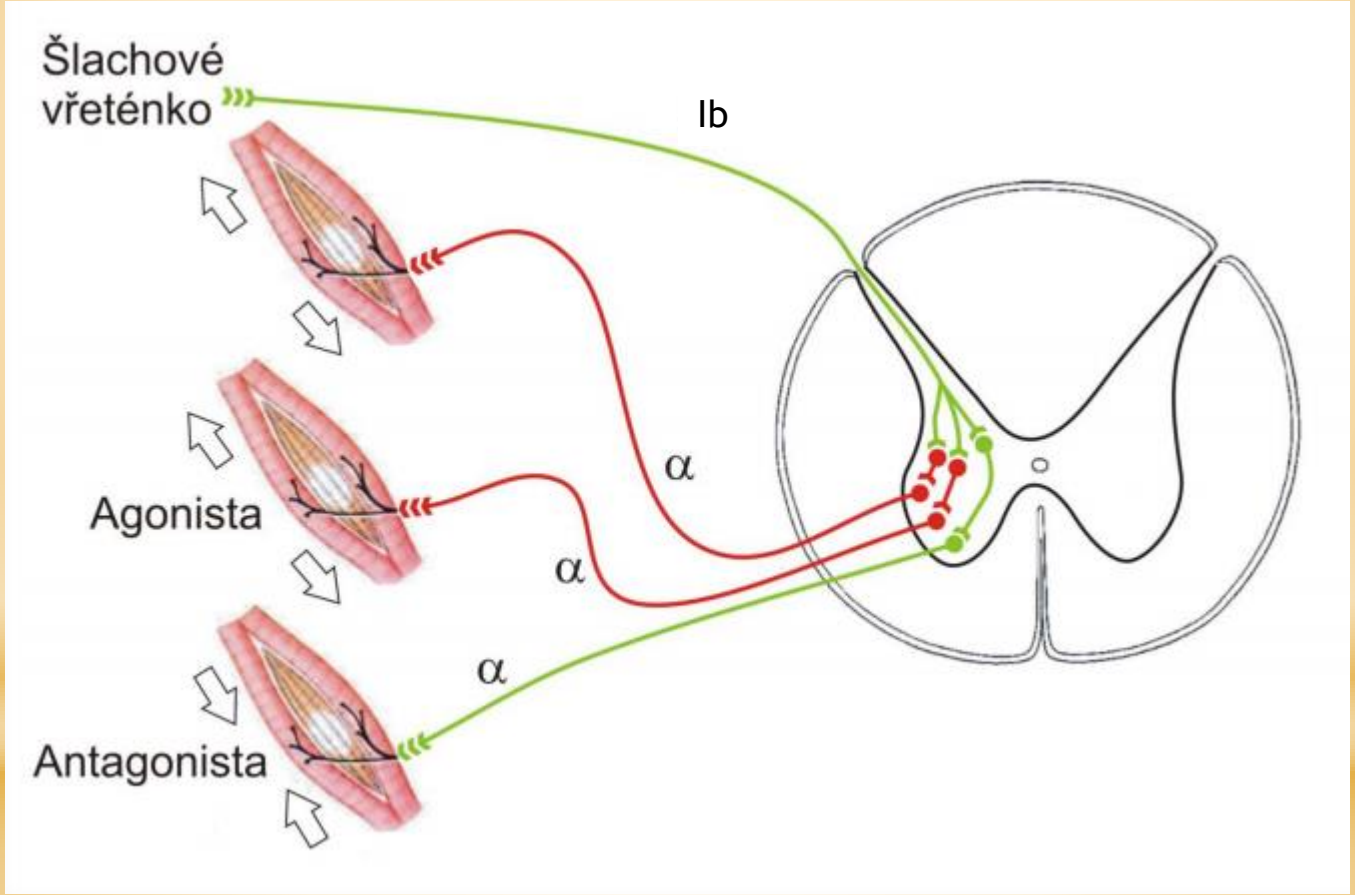
Myotatic (stretch) reflex



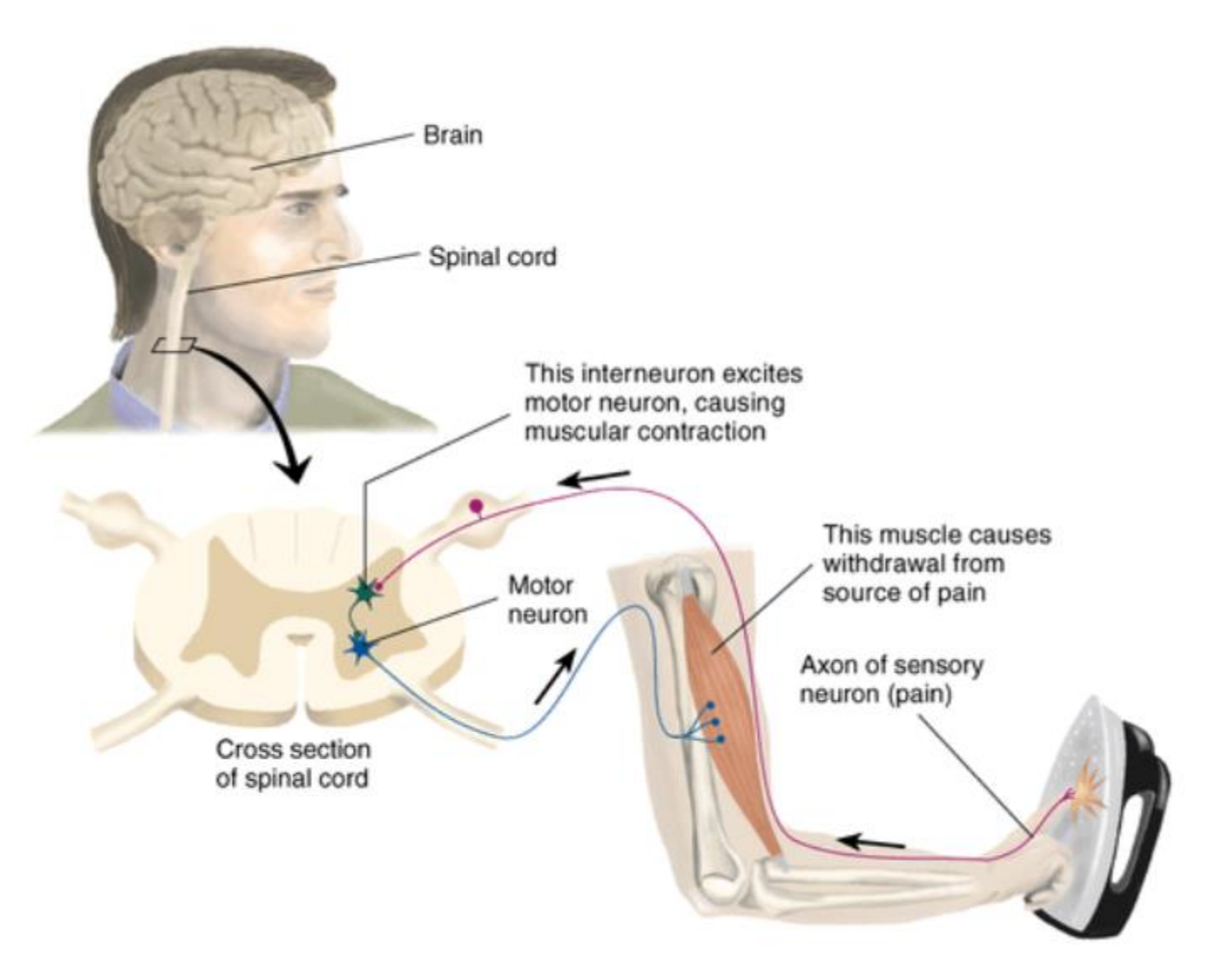
Myotatic (stretch) reflex



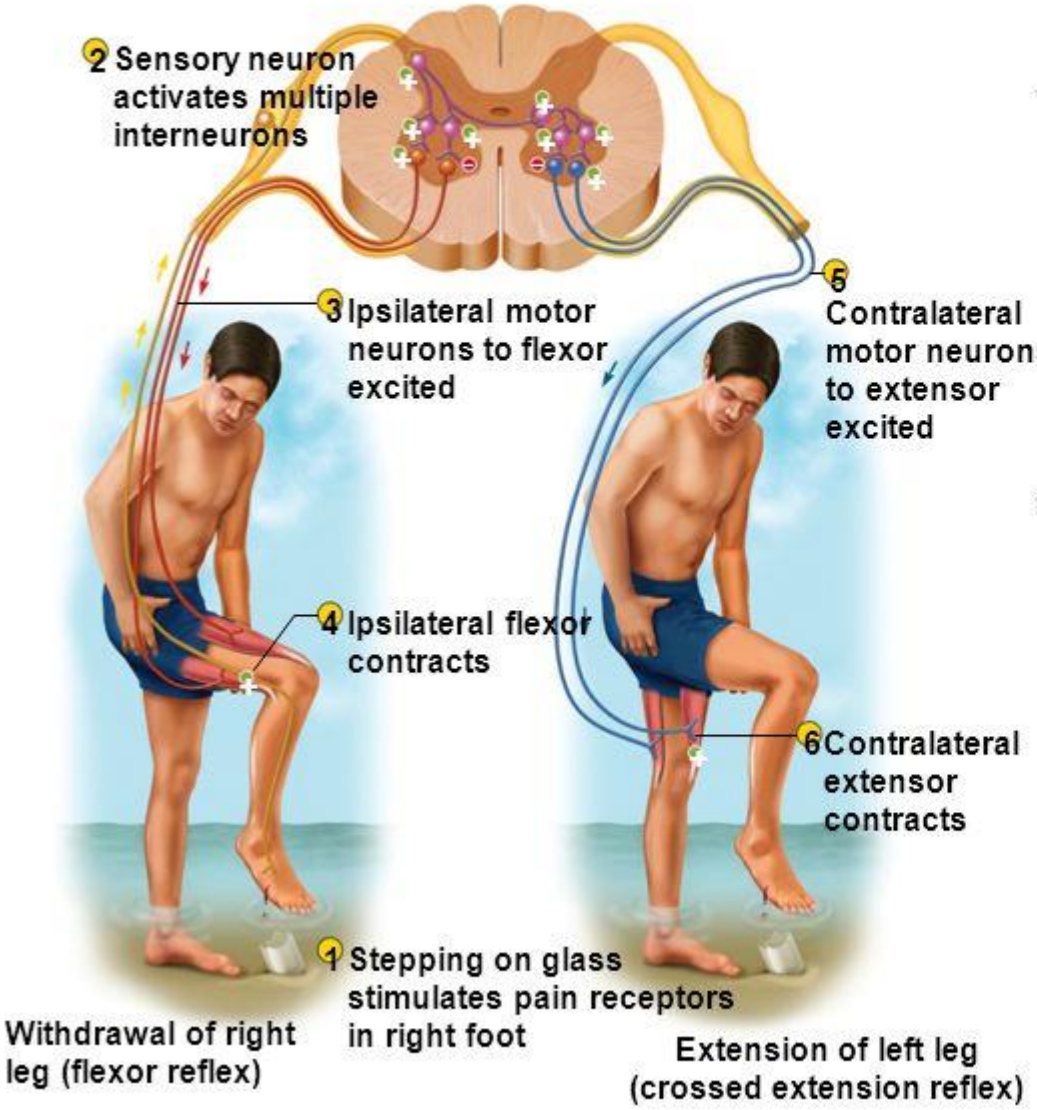
Reflex loop of Golgi tendon organ (inverse myotatic reflex)



Flexor (withdrawal) reflex

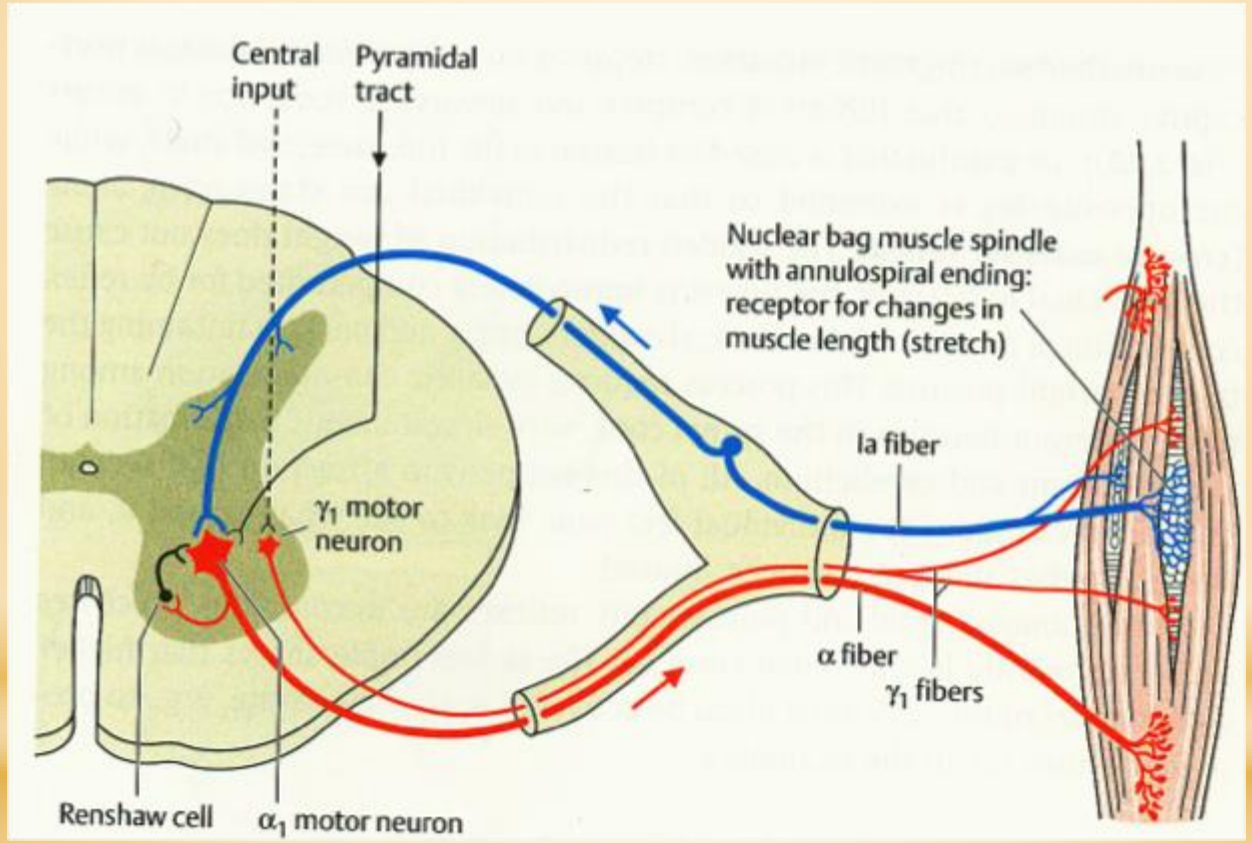


The Flexor (Withdrawal) Reflexes

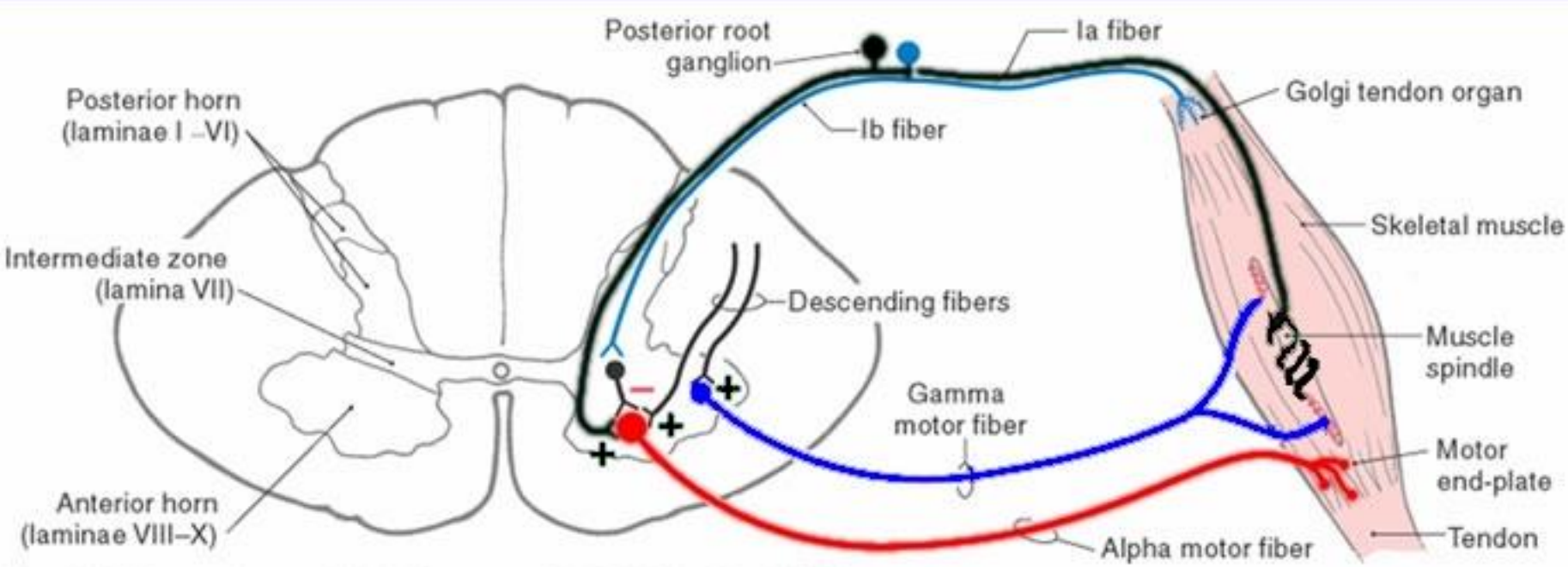


- **flexor reflex** – the quick contraction of flexor muscles resulting in the withdrawal of a limb from an injurious stimulus
- requires contraction of the flexors and relaxation of the extensors

Renshaw cells



Gamma loop

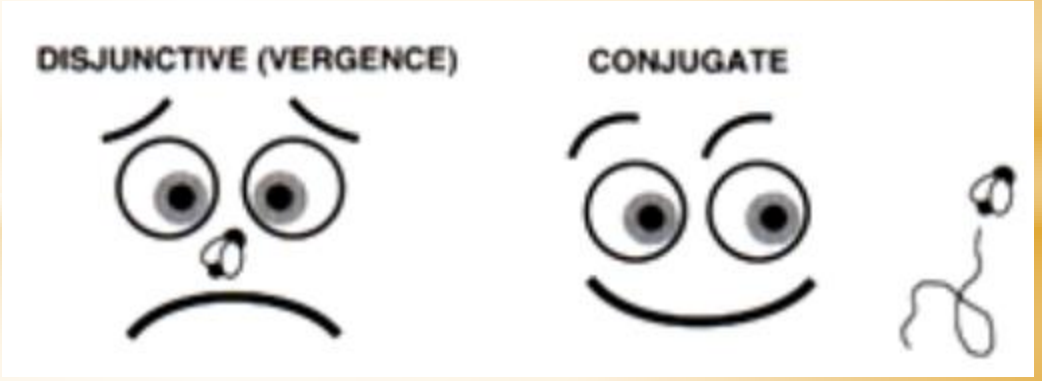


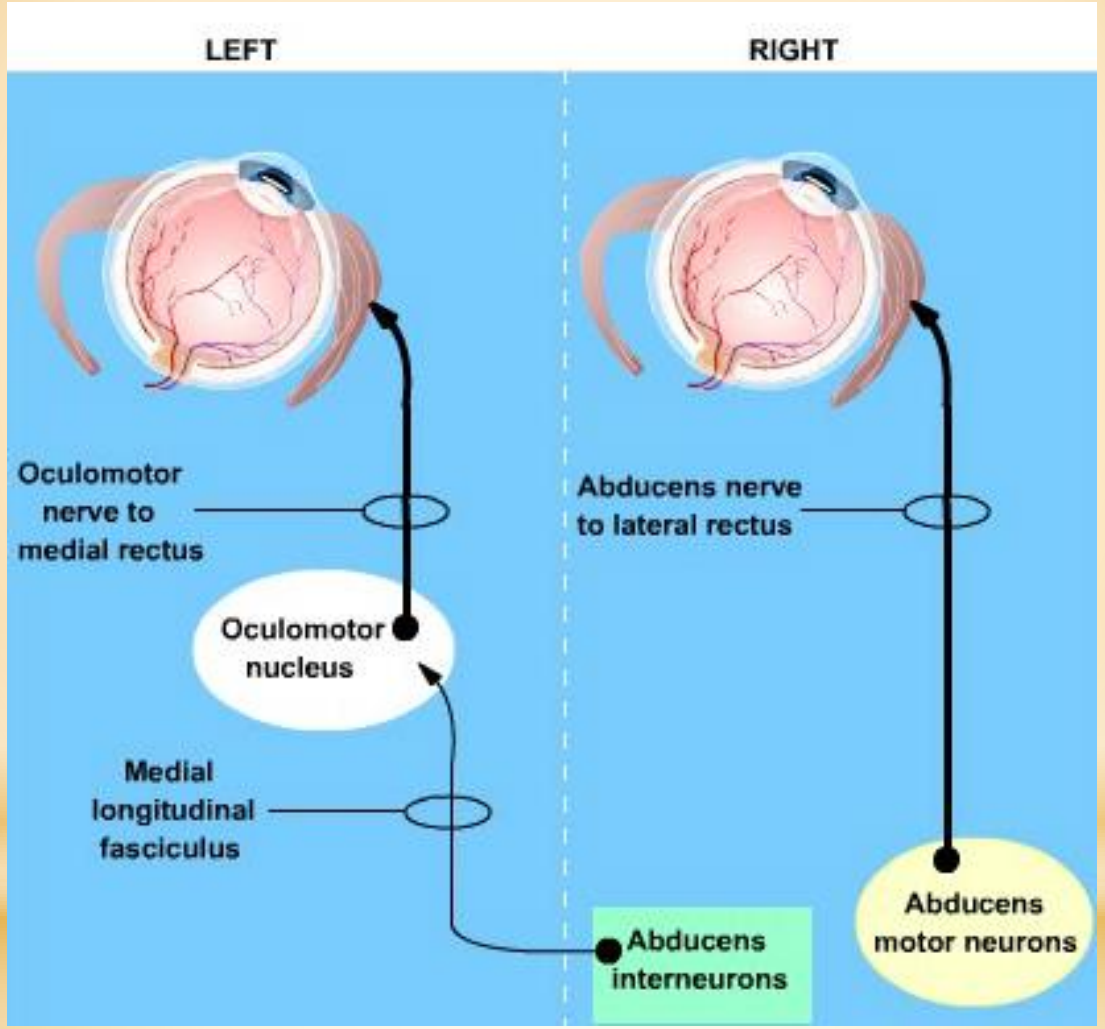
EYE MOVEMENTS

EYE MOVEMENTS

- Fovea centralis – area of most acute vision
- Coordination of 12 oculomotor muscles

- Eye movements
  - conjugated – both eyes in same direction
  - vergent - during motion of object to and from us
    - convergent
    - divergent




LEFT
RIGHT
Oculomotor nerve to medial rectus
Abducens nerve to lateral rectus
Oculomotor nucleus
Medial longitudinal fasciculus
Abducens interneurons
Abducens motor neurons

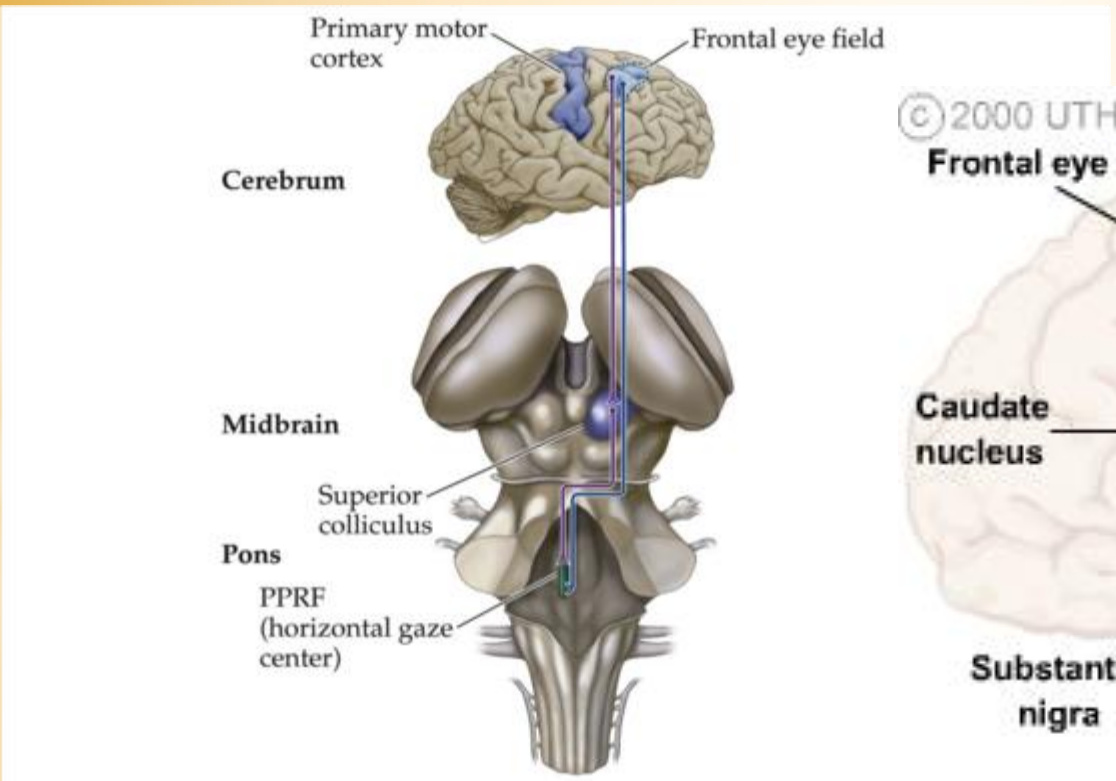
Four basic types of eye movements

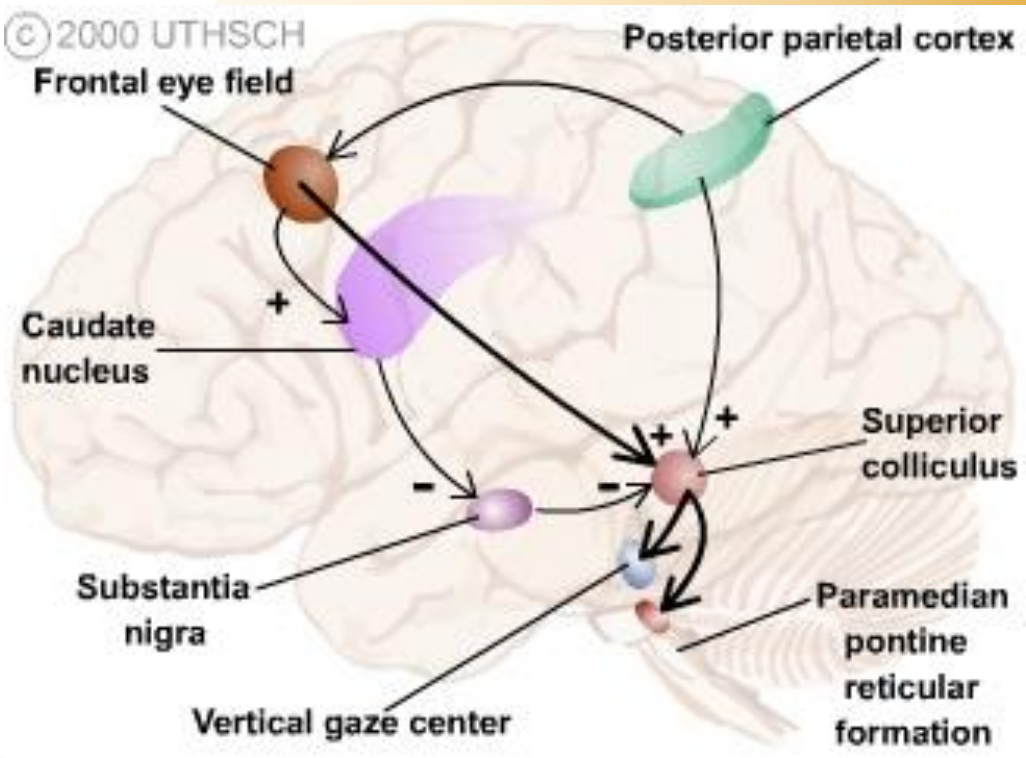
- Saccades
- Smooth pursuit movements
- Vergence movements
- Vestibulo-ocular movements

Saccadic eye movements

- ❑ horizontal gaze center - PPRF
- ❑ vertical gaze center – RF of the midbrain

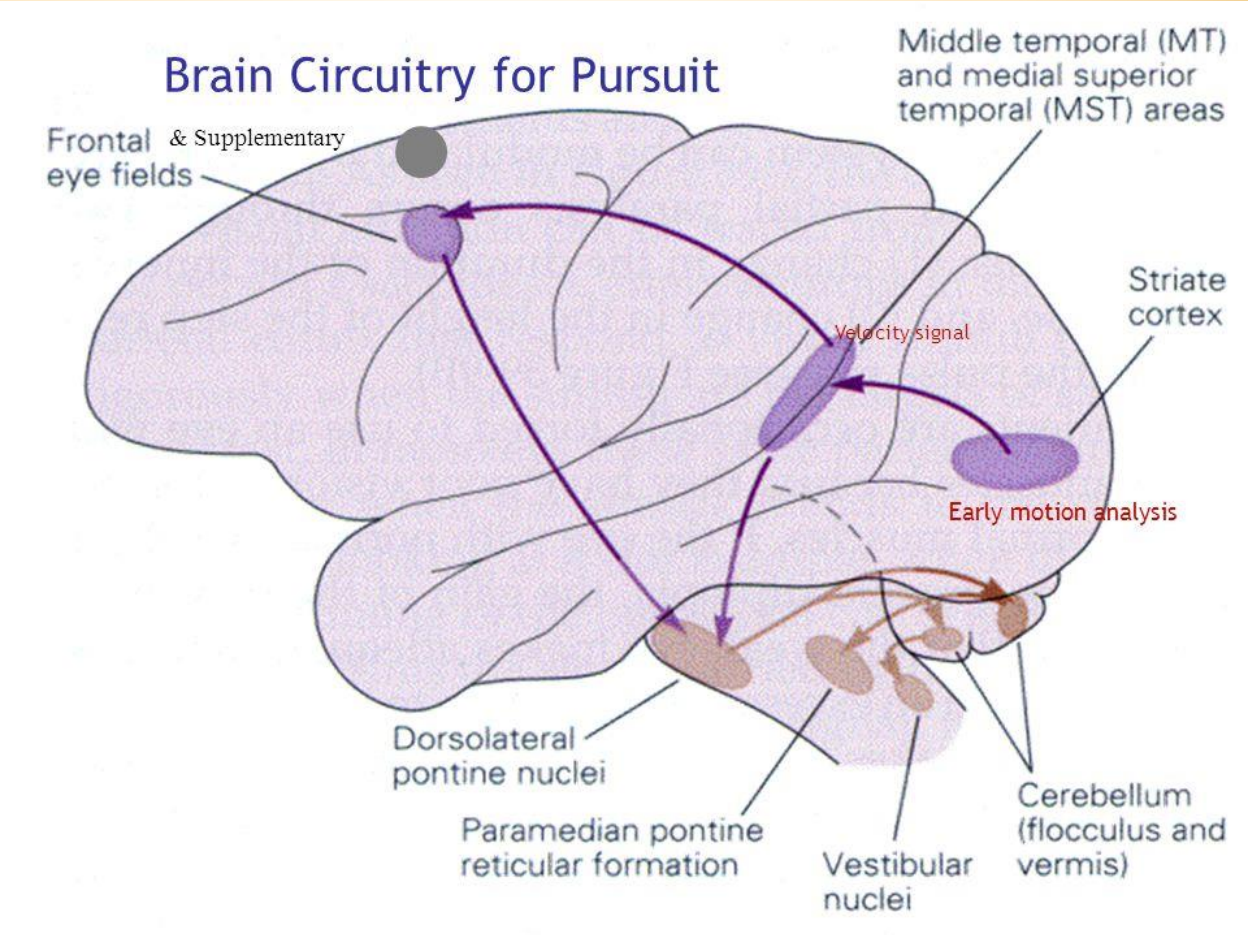
- ➢ superior colliculi – information from FEF, retina, auditory, and tactile i.





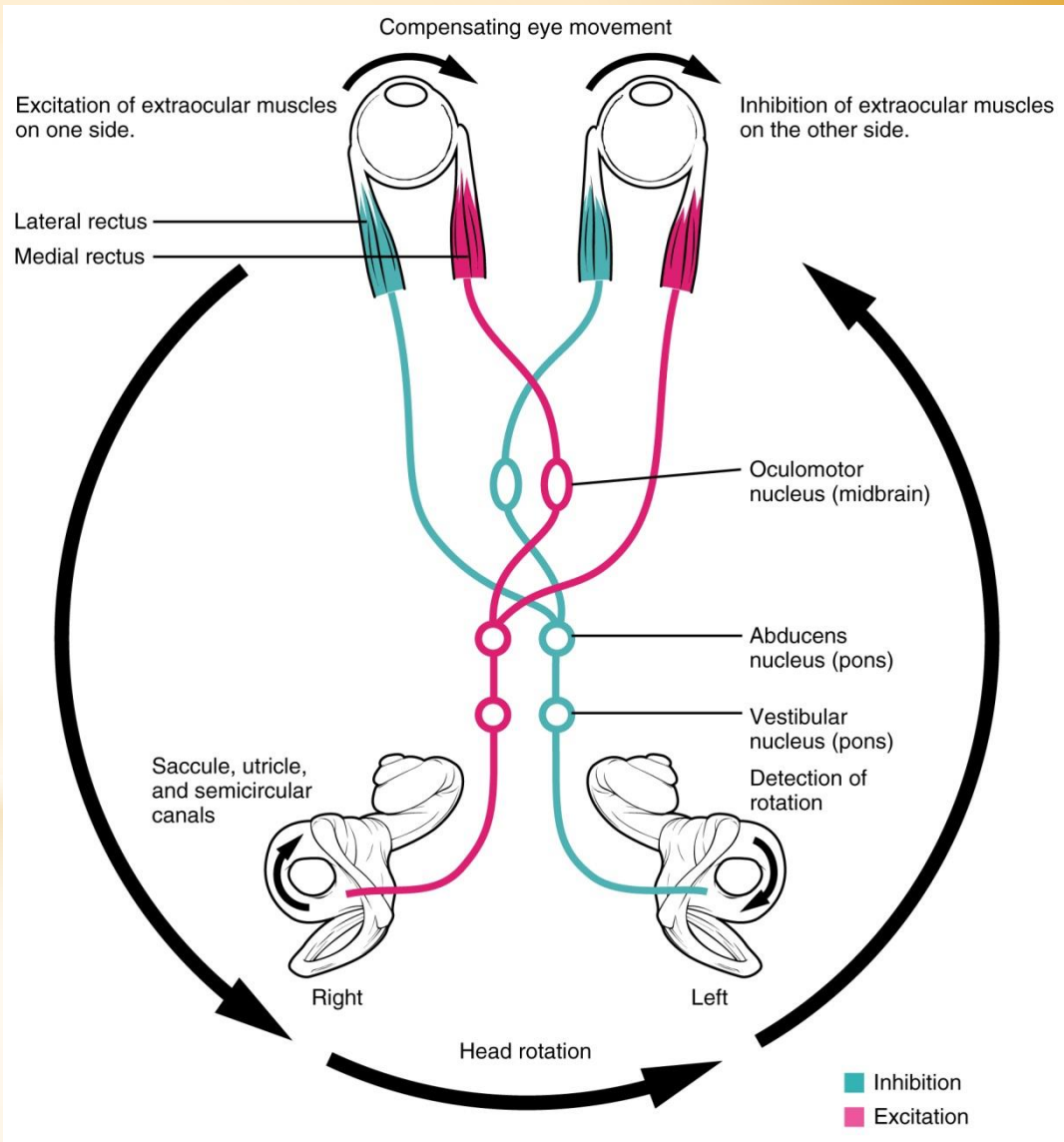
Smooth pursuit movements

- elicited by a moving visual target that the eyes follow voluntarily or under direction
- the moving visual target is required to initiate this eye movement

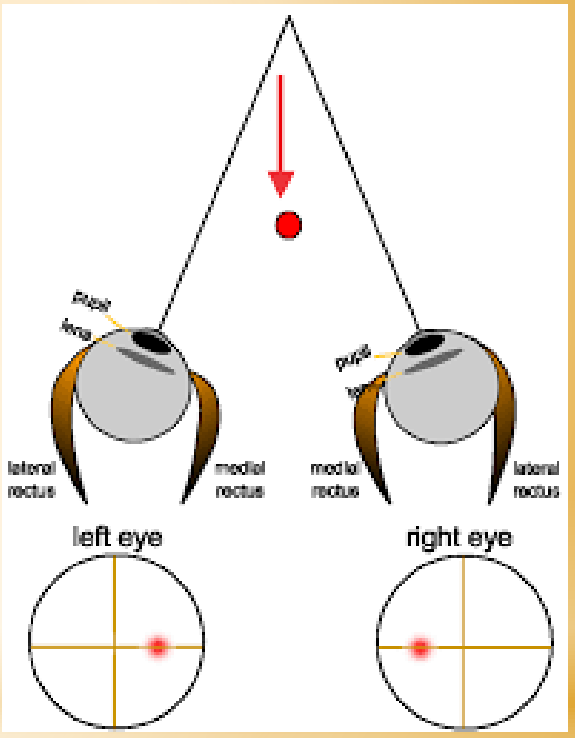


Vestibulo-ocular movements

- stabilize the eyes relative to the external world, thus compensating for head movements



Vergence movements



Illustrations were copied from:

Neuroscience Online, the Open-Access Neuroscience Electronic Textbook

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