PAIN

PAIN

- pain is a protective modality
- International Association for the Study of Pain (IASP): „Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage“.
- pain threshold: the minimum intensity of a stimulus that is perceived as painful, the intensity at which a stimulus begins to evoke pain varies

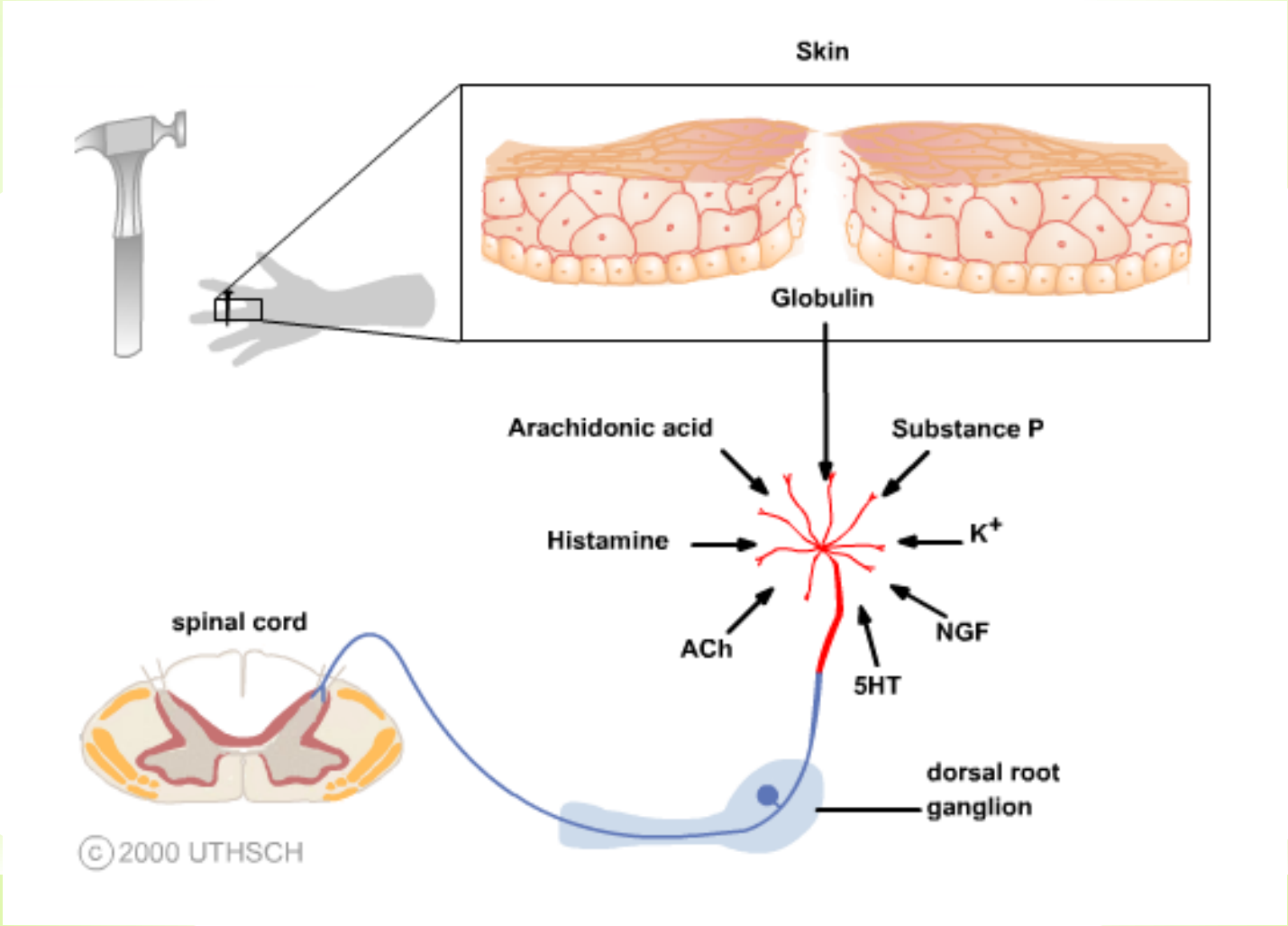
Nociceptors/nocisensors

- nocere – to injure or to hurt in Latin
- are activated by noxious mechanical, thermal or chemical stimuli
- detect signals from damaged tissue or the threat of damage
- free nerve endings found in the skin, muscles, joints, bones and viscera

Nociceptors

- nociceptors of Aδ fibres (5-30 meters/sec)
  - Aδ mechanical nociceptors
  - Aδ thermal nociceptors
- nociceptors of C fibres (0.5-2.0 meters/sec)
  - C polymodal nociceptors – react to thermal, mechanical and chemical stimuli
- silent nociceptors (MIA = mechanically insensitive afferents) - responsive after inflammation and tissue injury

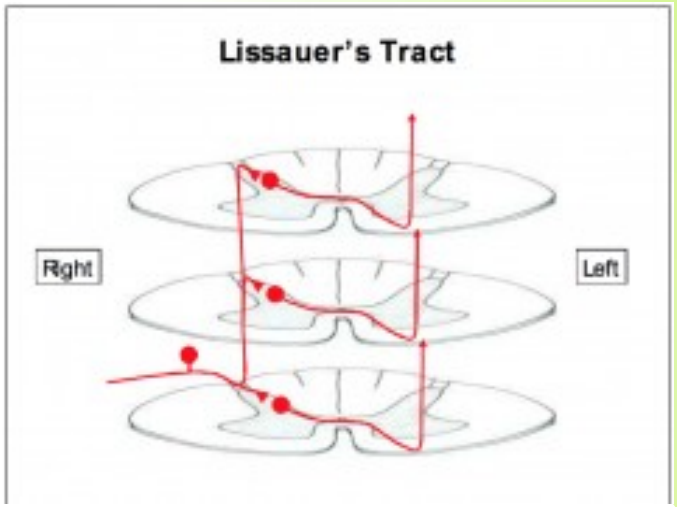
Factors that activate nociceptors

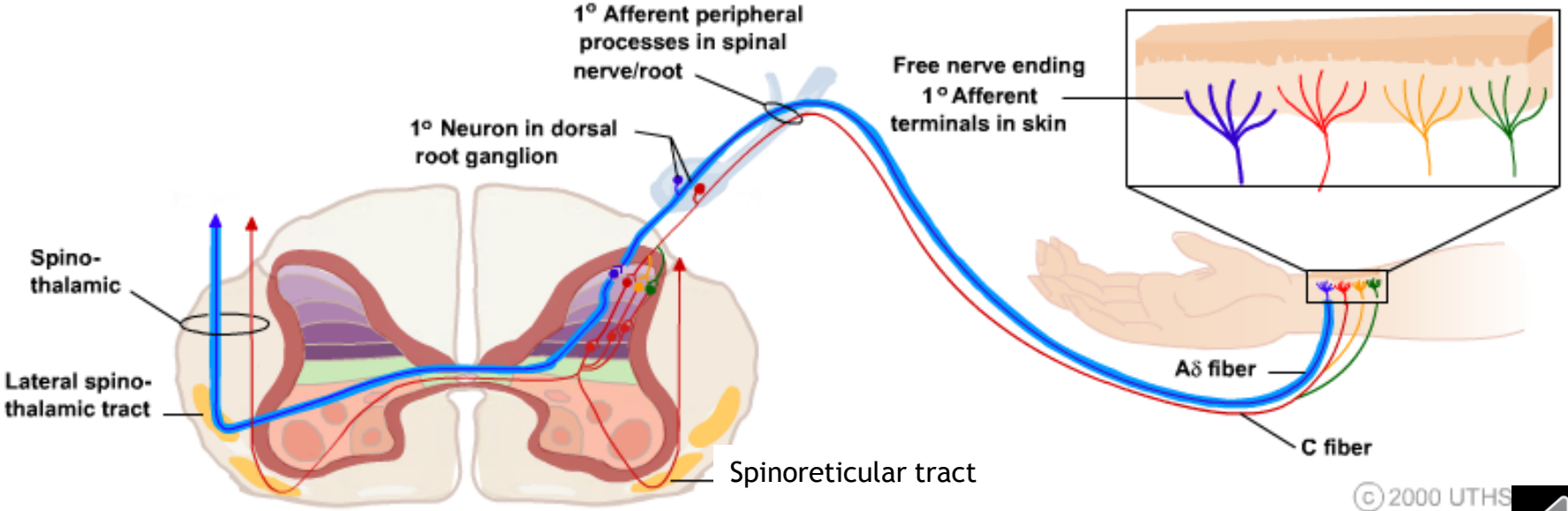


- **Peripheral sensitization**
- **Central sensitization** = activity- or use-dependent neuronal plasticity in the spinal cord
  - **hyperalgesia** - exaggerated or prolonged response to noxious inputs
  - **allodynia** - pain induced by normally innocuous inputs

Nociceptive afferents

- Aδ fibres – thin myelinated fibres
  - sharp, localized pain
- C non-myelinated fibres
  - dull, non-localized pain





Pain pathways from the trunk and limbs

PALEOSPINOTHALAMIC PATHWAY

- tr. spino-reticulo-thalamicus
  - diffuse, non-localized pain
  - autonomic and reflexive responses to pain stimuli
  - emotional and affective reactions to pain
  - intralaminar nuclei of the thalamus, hypothalamus
  - postcentral gyrus, insula and cingulate gyrus

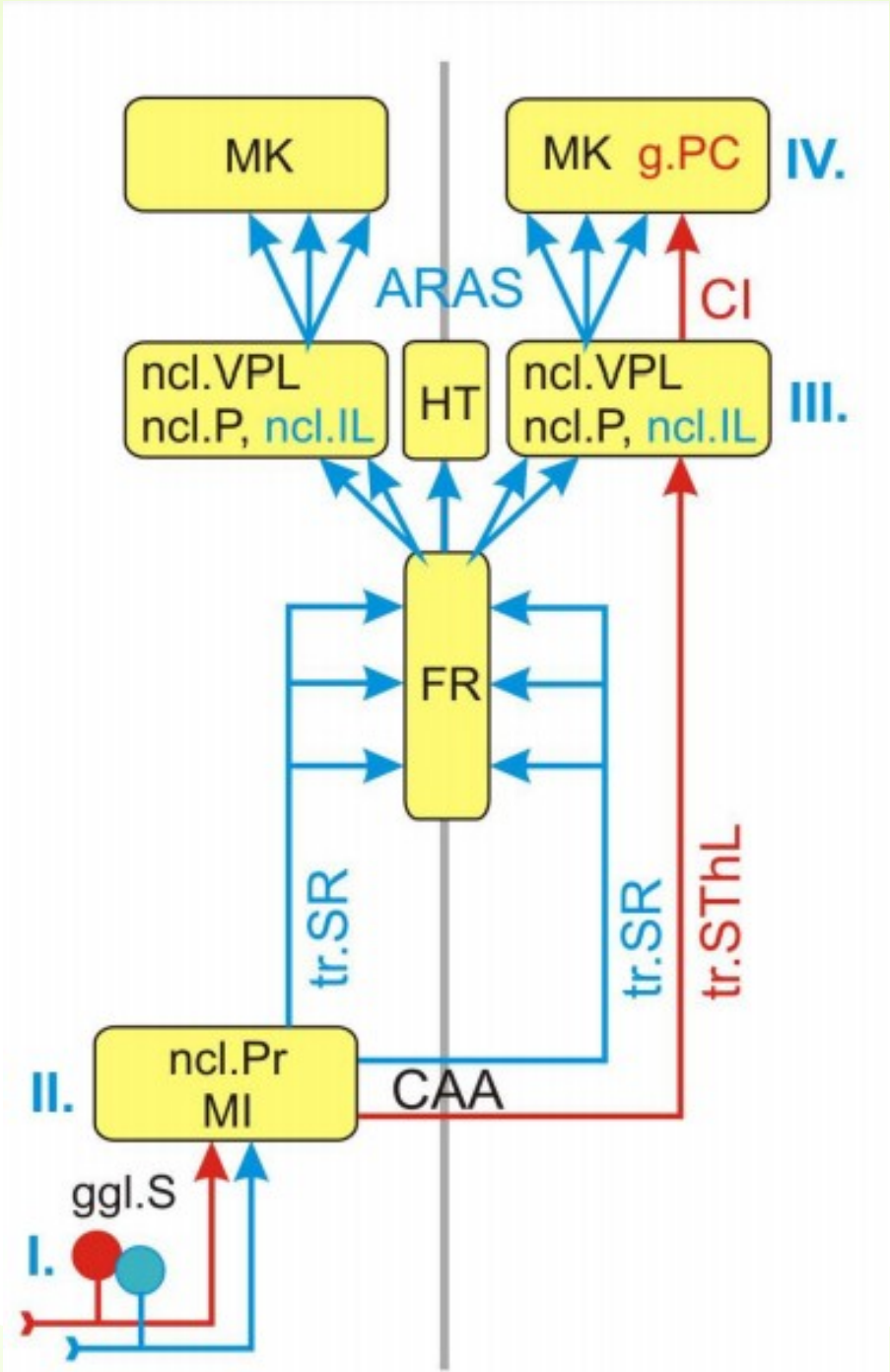
NEOSPINOTHALAMIC PATHWAY

- tr. spino-thalamicus lat.
  - sharp, well localized pain
  - somatotopic representation
  - ventral posterolateral (VPL) and posterior nucleus of the thalamus
  - postcentral gyrus

Cortex

Thalamus

Spinal cord



Paleospino-thalamic pathway

Neospino-thalamic pathway

Pain pathways from the

TRACTUS TRIGEMINO-RETICULO-THALAMICUS

- diffuse, non-localized pain

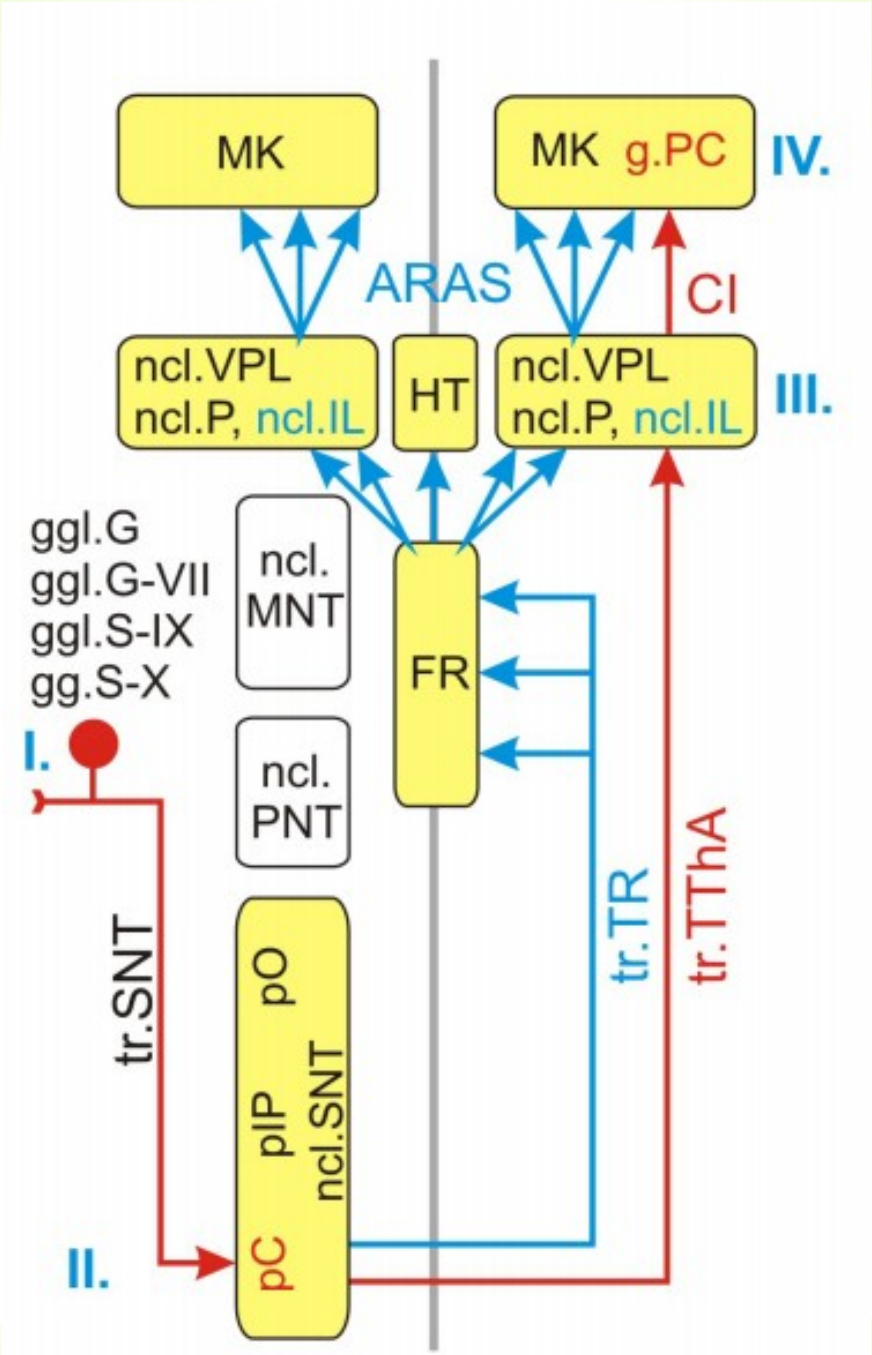
TRACTUS TRIGEMINO-THALAMICUS ANTERIOR

- sharp, well localized pain

Cortex

Thalamus

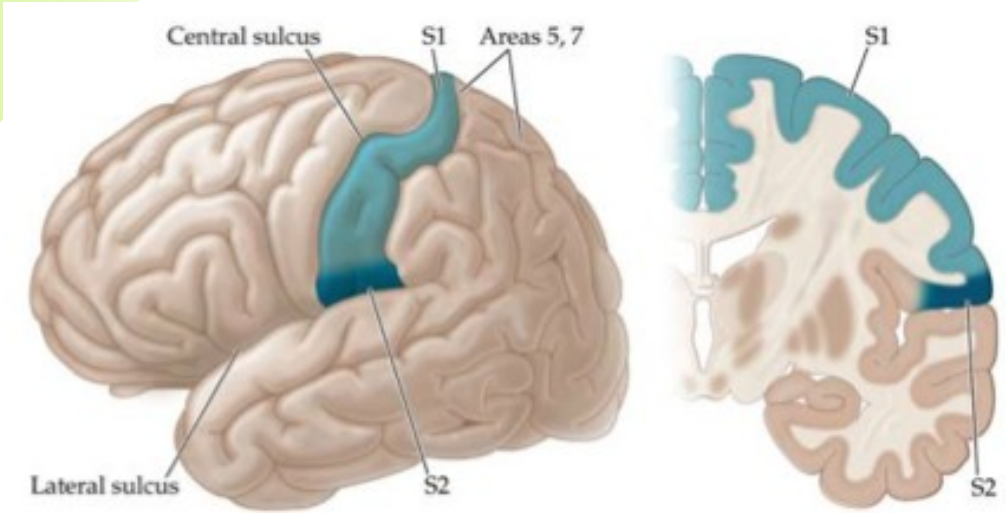
Medulla

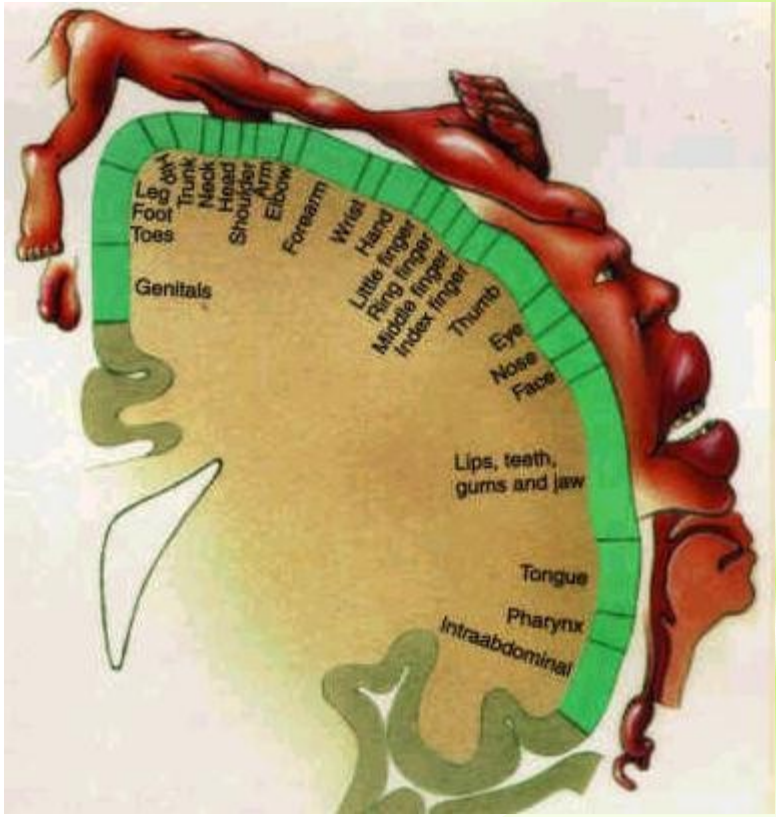


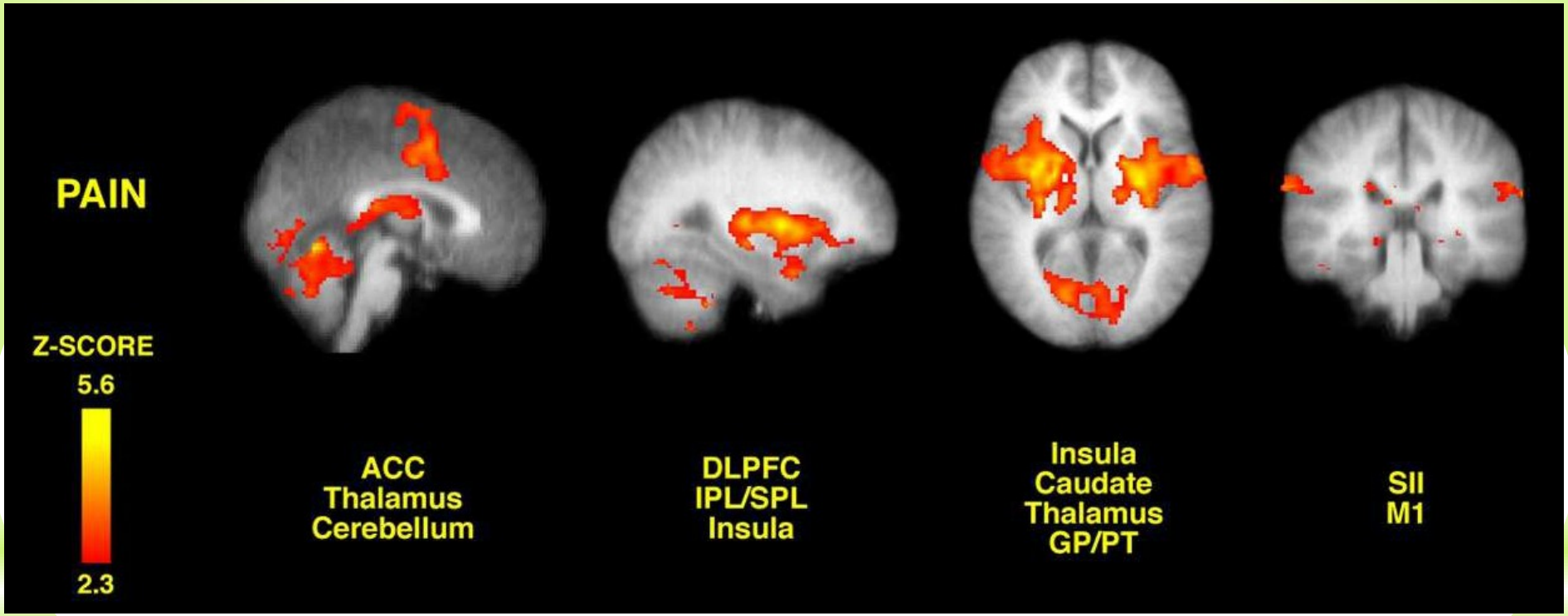
The phylogenetically old, **paleospinothalamic and trigemino-reticulothalamic**, pathways through the RF are concerned with the arousal and affective (emotional) aspects of somatic sensory stimuli.

In contrast, the direct, **neospinothalamic and anterior trigeminothalamic,** pathways are analytic, encoding information about modality, intensity, and location.

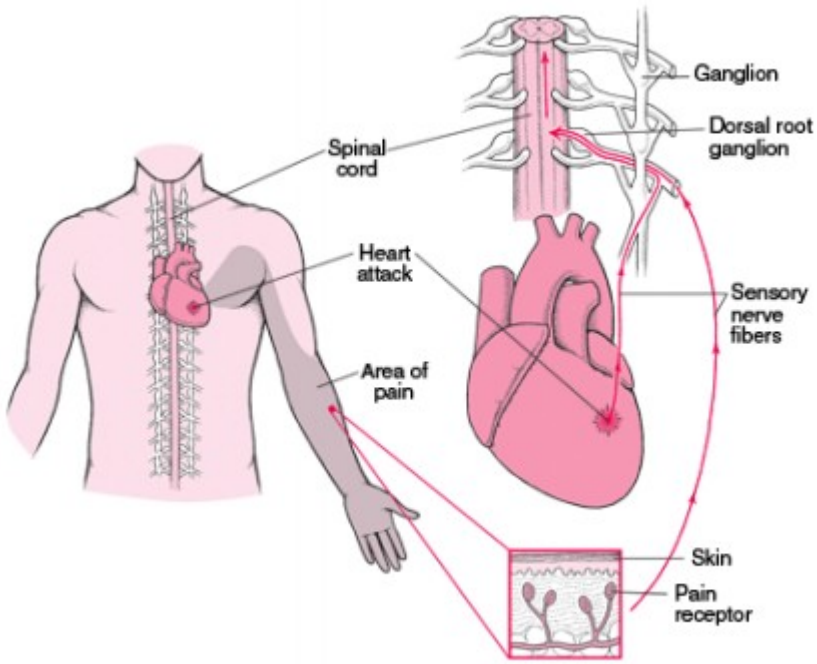
Primary somatosensory (somesthetic) cortex (SI)

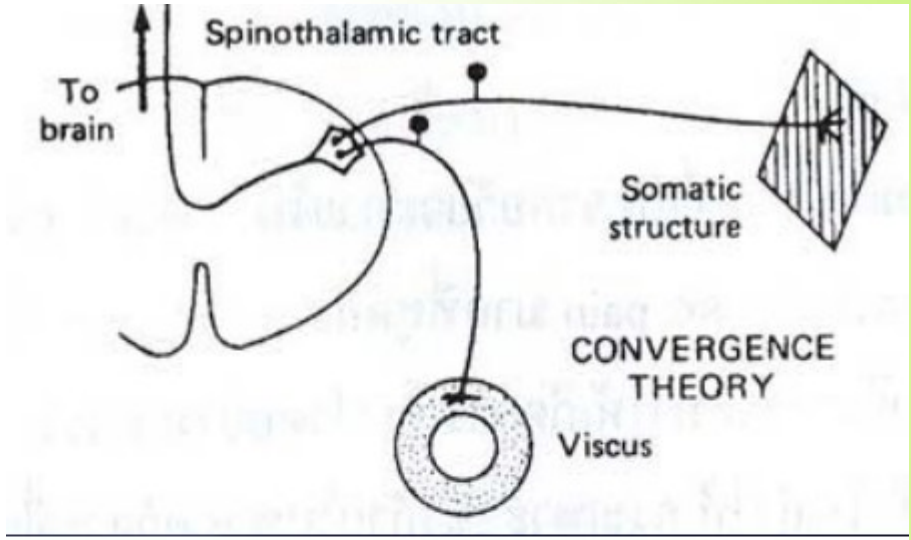


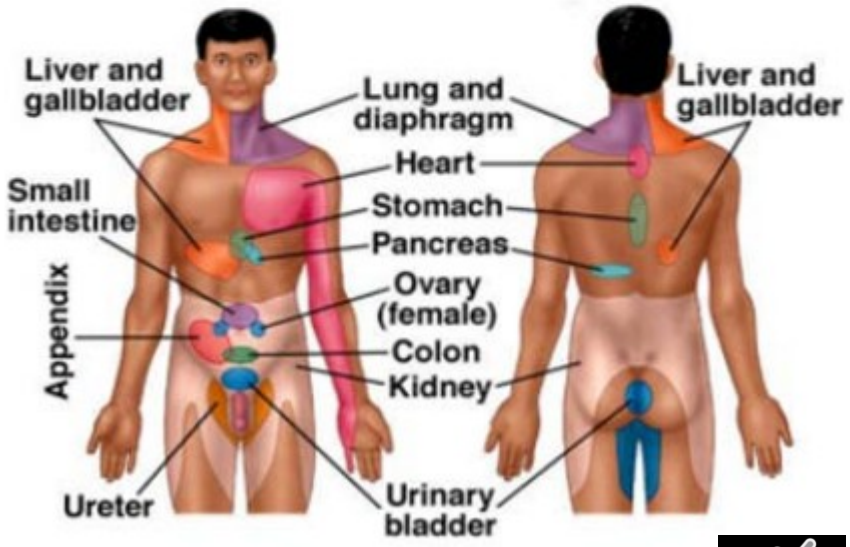



PAIN
Z-SCORE
5.6
2.3
ACC
Thalamus
Cerebellum
DLPFC
IPL/SPL
Insula
Insula
Caudate
Thalamus
GP/PT
SII
M1

Referred pain







Common dermatome hypothesis
Convergence theory
Facilitation or irritable focus
Learned phenomenon

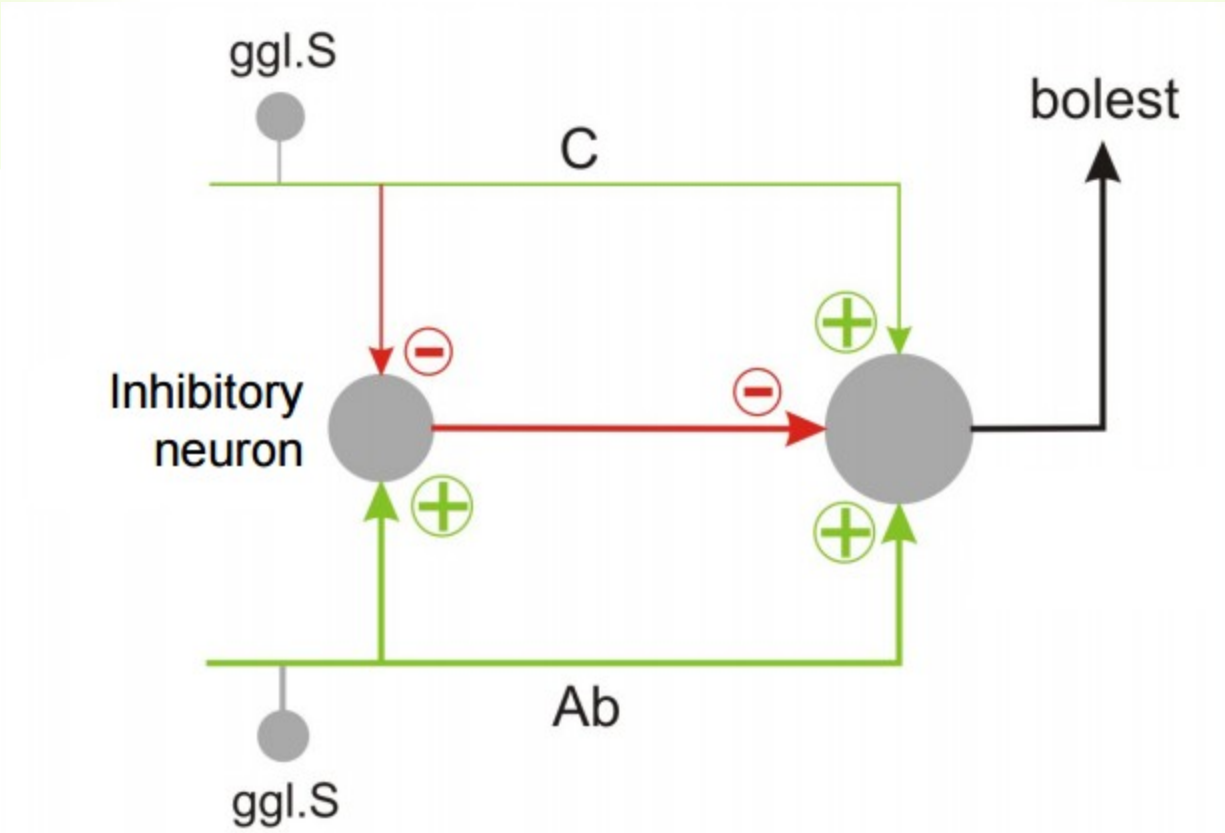
Dental Pain

- Aβ + Aδ fibres – tingling, vibration, touch, sharp pain
- C fibres – dull ache
- pulp + dentin – enormous number of free nerve endings
- periodontal ligament – Ruffini mechanoreceptors and proprioreceptors
- inflammed pulp or periapex – peripheral and central sensitization – hyperalgesia, allodynia and spontaneous pain
- referred orofacial pain – both source and referral site
- wide area of pain – difficulty to locate the pathology

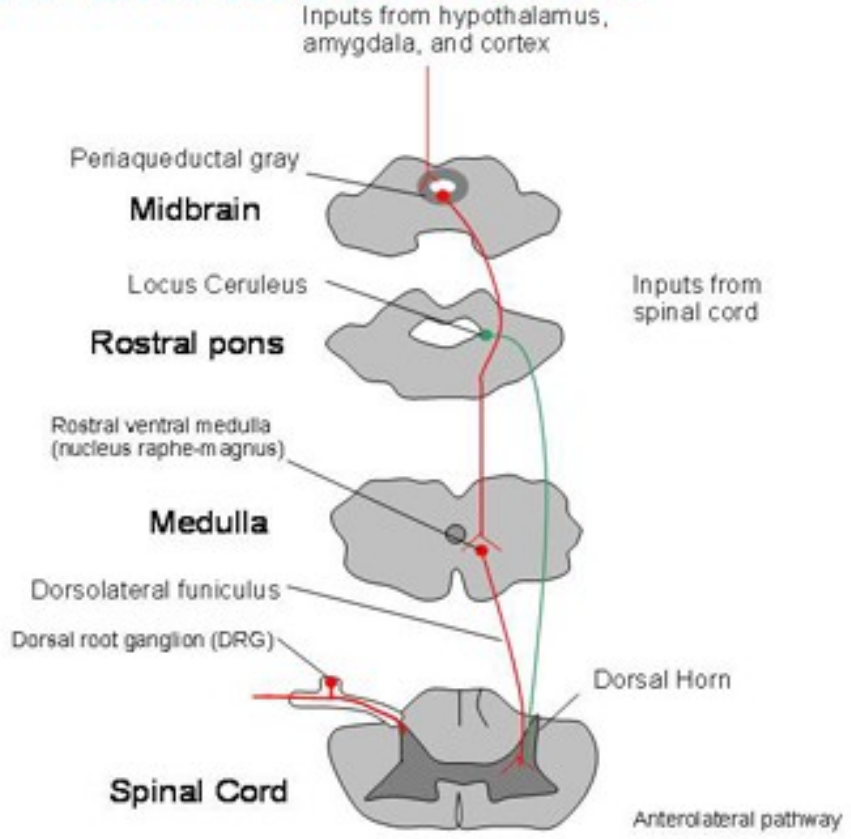
MODULATING SYSTEMS OF NOCICEPTIVE PATHWAYS

- level of modulation of nociceptive pathways
  - spinal cord (“gate control theory”)
  - RF of brain stem
  - periaquaeductal gray matter (PAG)

“Gate control theory”

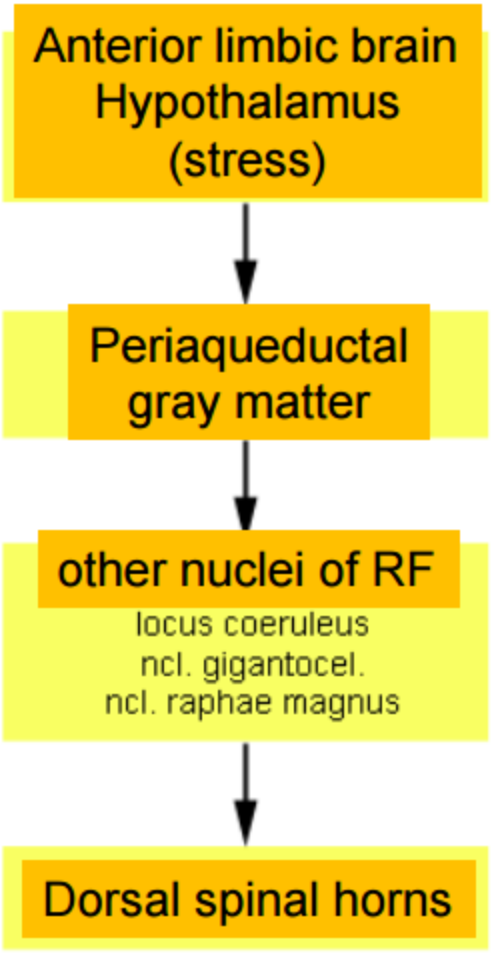


Central Pain Modulation



Stress-induced analgesia

(both opiate and non-opiate forms)



SOMATOMOTOR PATHWAYS

Necessary components of proper motor control

- Volition
- Coordination of signals to many muscle groups
- Proprioception
- Postural adjustments
- Sensory feedback
- Compensation for the physical characteristics of the body and muscles
- Unconscious processing
- Adaptability

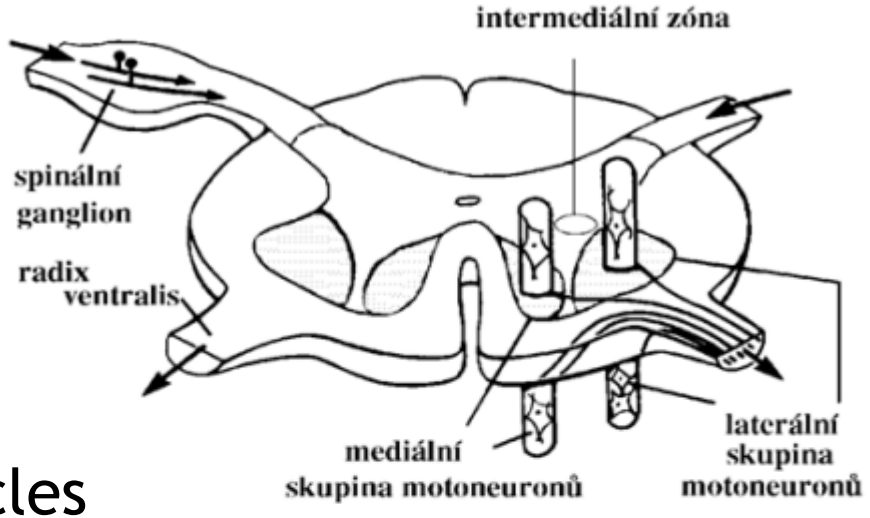
Levels of movement regulation

- spinal cord
- brain stem
- cortex

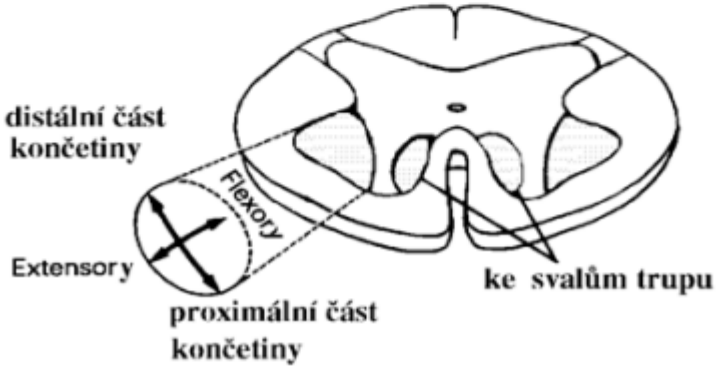
- cerebellum
- basal ganglia

Lower motor neurons – spinal cord

- α motoneurons
- γ motoneurons

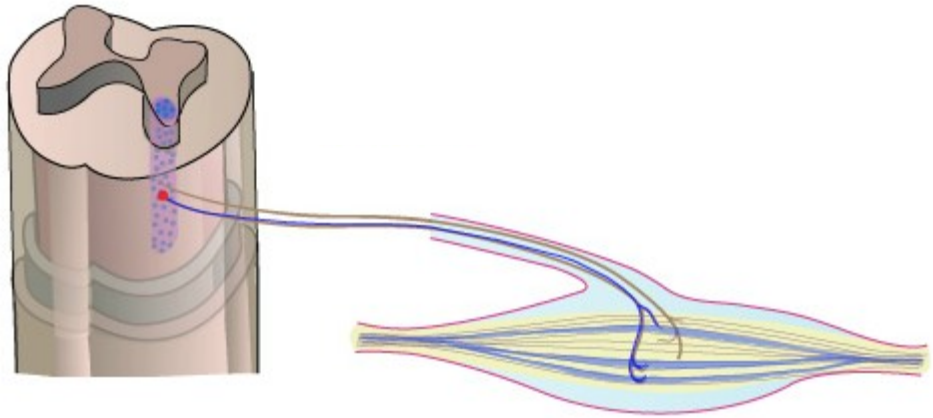


- Somatotopic organization
  - medial column – axial muscles
  - lateral column – limb muscles
  - anteriorly – extensors
  - posteriorly - flexors



- **Motor neurons** have highly branched, elaborate dendritic trees, enabling them to integrate the inputs from large numbers of other neurons and to calculate proper outputs.

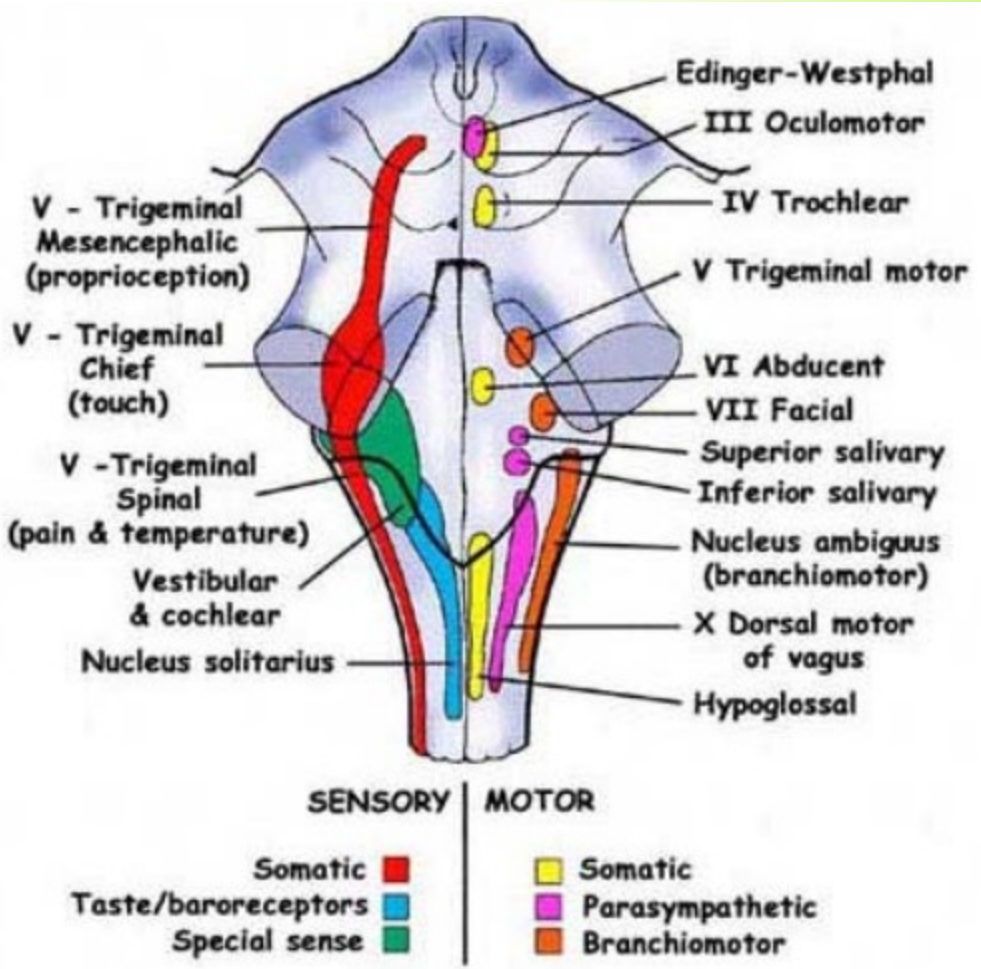
- The combination of an individual motor neuron and all of the muscle fibers that it innervates is called a **motor unit**.



- size of motor unit
  - small motor unit – 1 motoneuron innervates several muscle fibers (extraocular muscles, muscles of hand)
  - large motor unit – 1 motoneuron innervates 500 – 1000 muscle fibers (back muscles)

Lower motor neurons – brain stem

- Somatomotor nuclei
  CN III, IV, VI, XII
- Branchiomotor nuclei
  CN V, VII, IX, X, XI

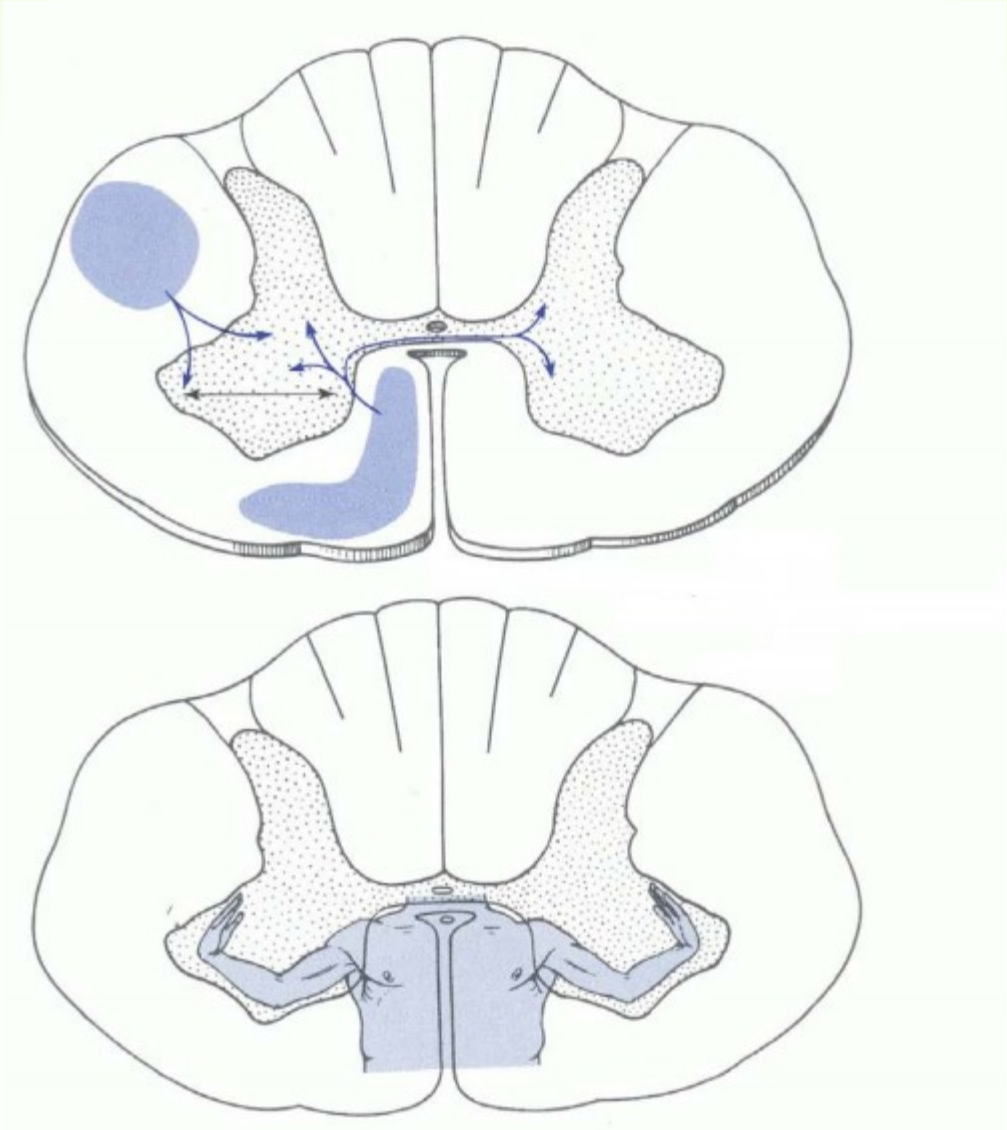


Supraspinal system of movement control

- Medial system
  - bilateral
  - terminates on the interneurons or the medial column of lower motor neurons
  - controls maintenance of balance and postural movements

- Lateral system
  - mostly cross the midline and descend contralaterally
  - terminates on the interneurons or the lateral column of lower motor neurons
  - controls fine manipulative movements of the hand and fingers

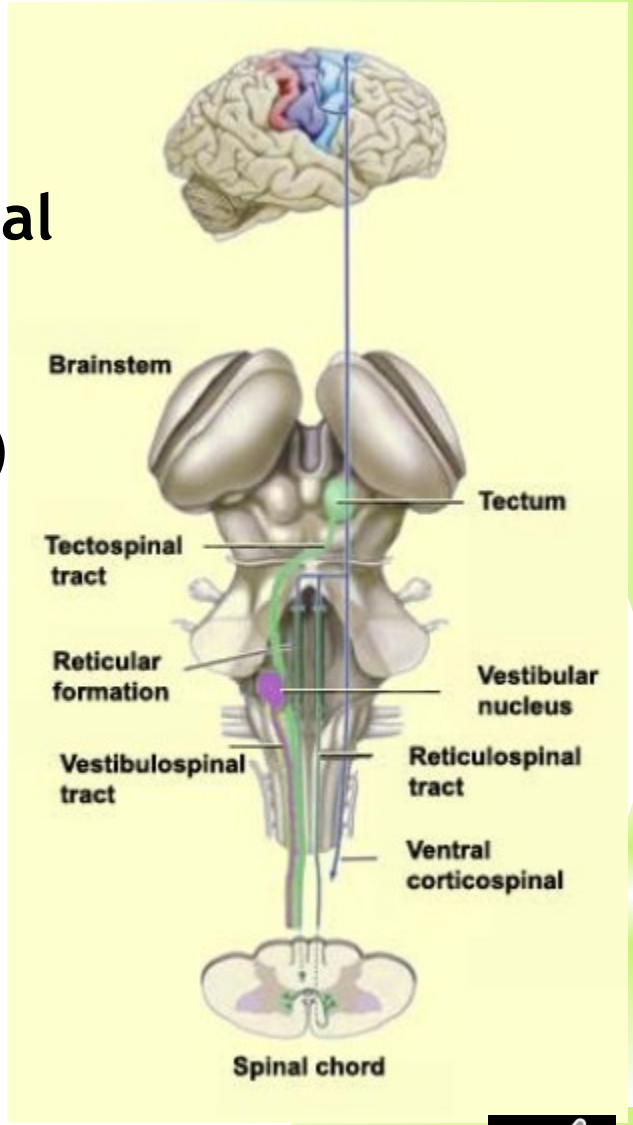
- The “third” motor system
  - aminergic pathways of the brain stem



Medial system

- Subcortical pathways
  - **Medial** (MLF) and **lateral vestibulospinal tracts** - control of balance and postural movements, head movements
  - **Tectospinal tract** (sup. colliculus, MLF) – coordination of movements of the head and eyes during watching
  - **Medial** (pontine) and **lateral** (medullary) **reticulospinal tracts** - control of postural movements

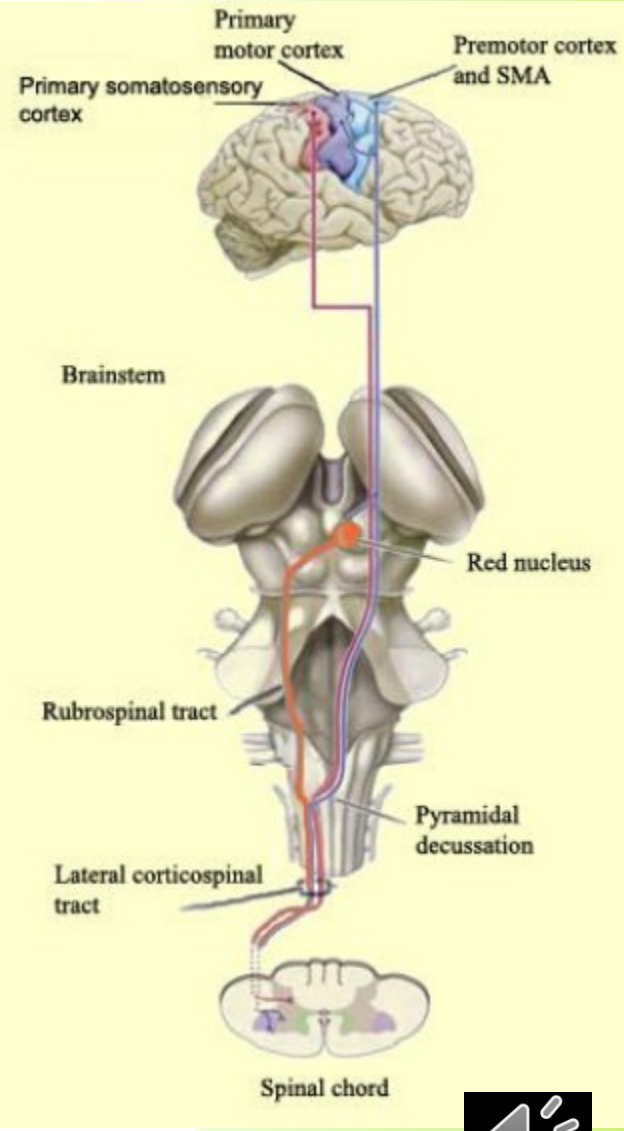
- Cortical pathways
  - **Anterior corticospinal tract** - medial column of lower motor neurons



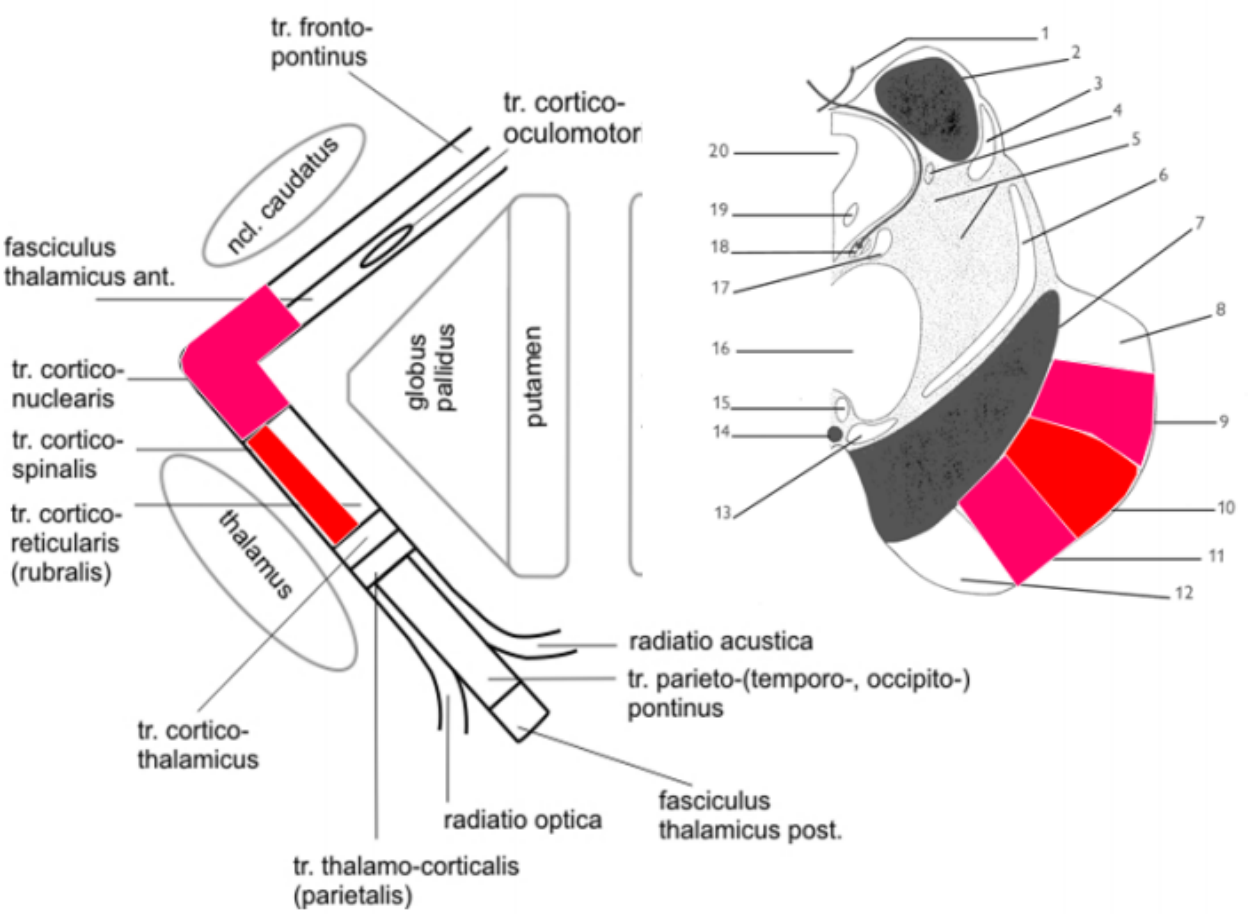
Lateral system

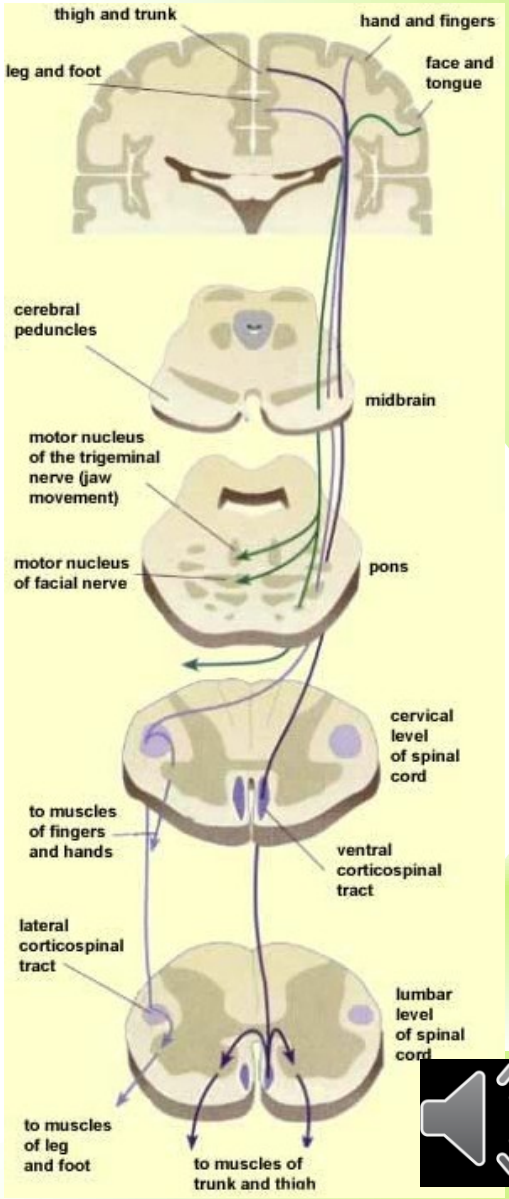
- Subcortical pathways
  - **Rubrospinal tract**
    - contralaterally descends to the lateral column

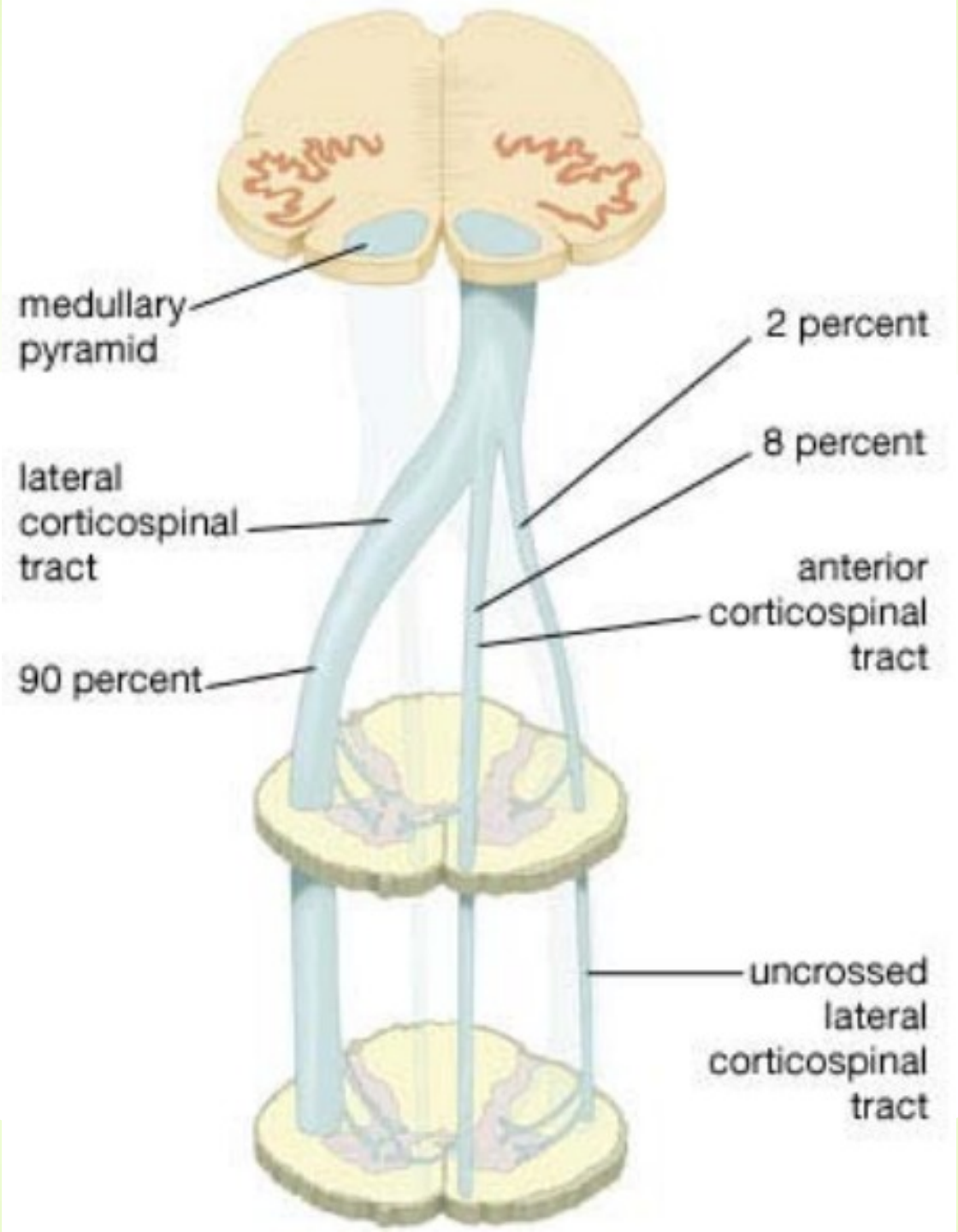
- Cortical pathways
  - **Lateral corticospinal tract**



Corticospinal and corticonuclear tracts






medullary pyramid
2 percent
8 percent
lateral corticospinal tract
anterior corticospinal tract
90 percent
uncrossed lateral corticospinal tract

DIRECT MOTOR PATHWAYS (PYRAMIDAL):

- corticospinal tract
- corticonuclear tract

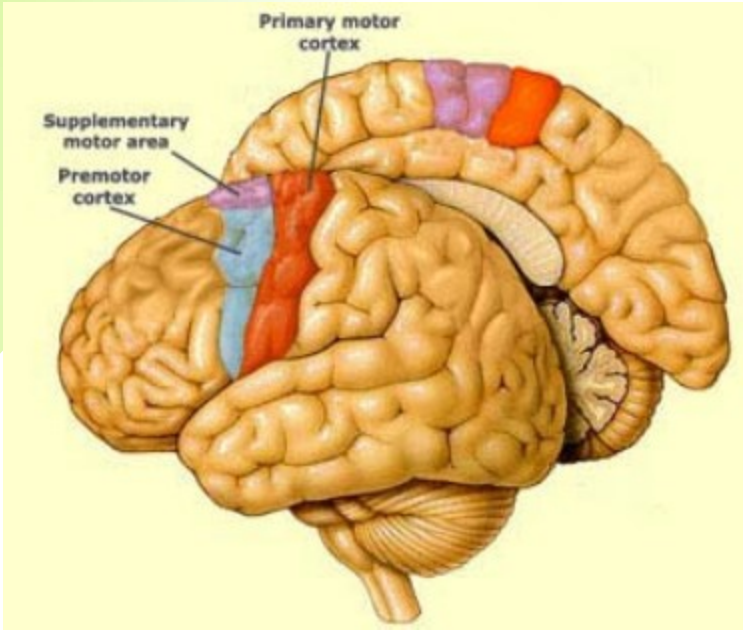
INDIRECT MOTOR PATHWAYS (EXTRAPYRAMIDAL):

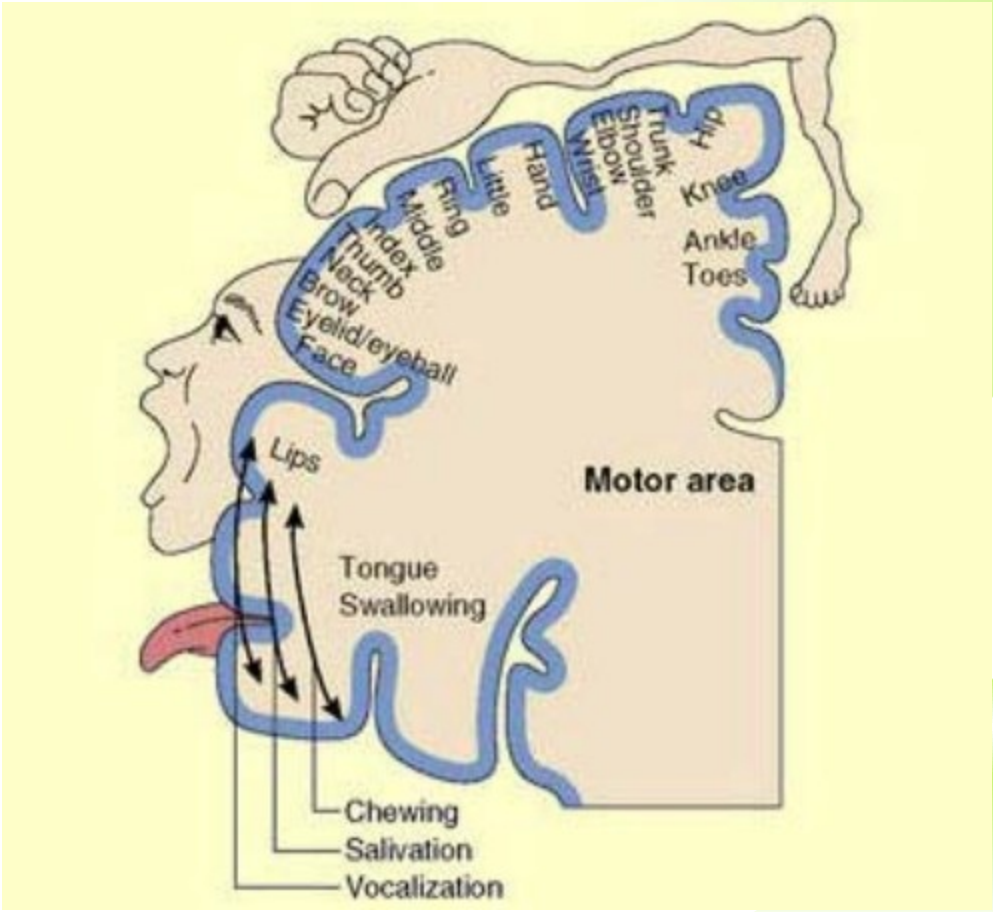
- corticorubrospinal tract
- cerebellorubrospinal tract
- corticoreticulospinal tracts
- cerebelloreticulospinal tracts
- corticotectospinal tract
- cerbellovestibulospinal tracts

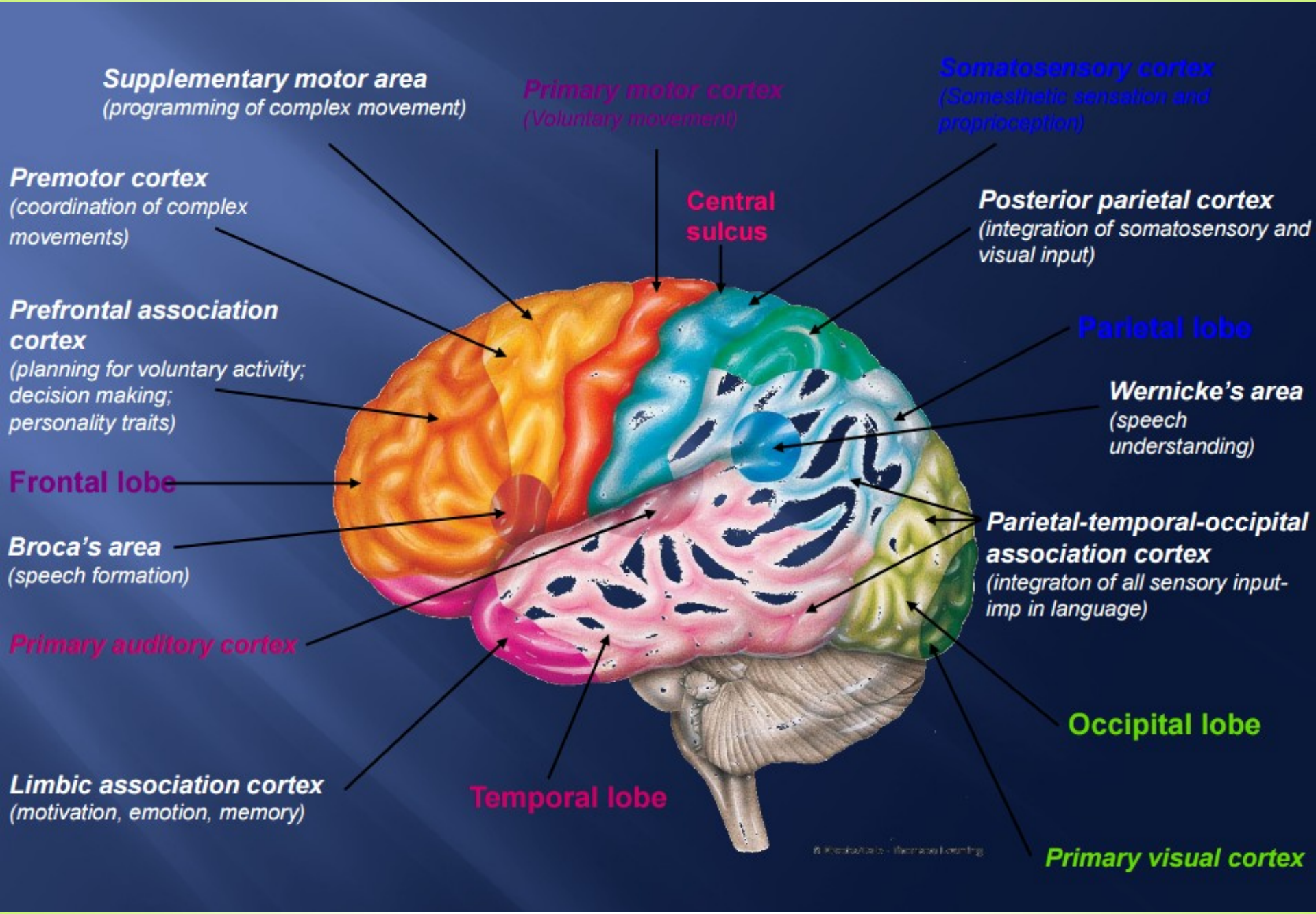
The third system

- the oldest one
- nuclei of RF – **raphespinal** and **coeruleospinal tracts**
- control of involuntary emotional movements

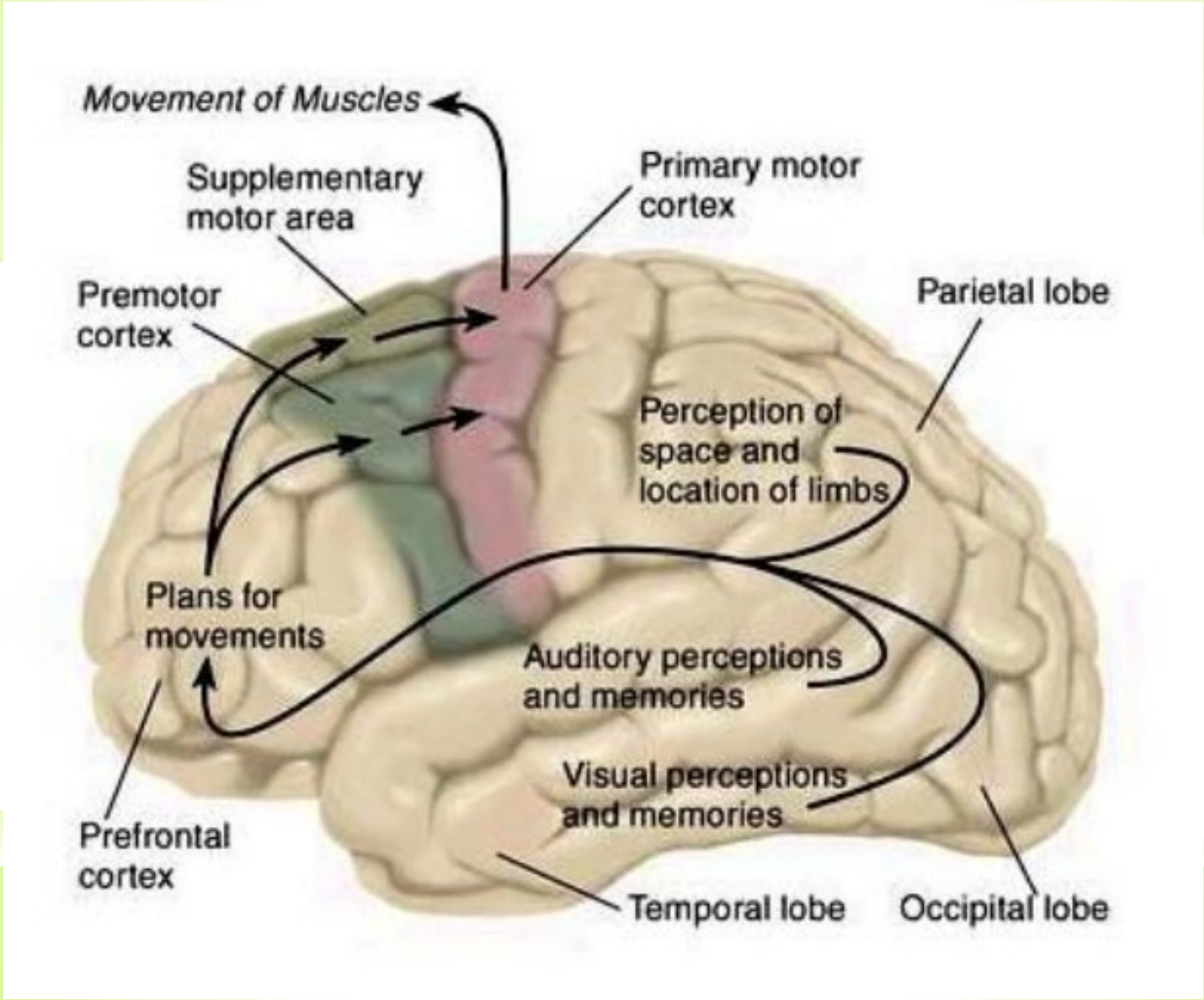
Motor cortex






Supplementary motor area
(programming of complex movement)
Primary motor cortex
(Voluntary movement)
Somatosensory cortex
(Somesthetic sensation and proprioception)
Premotor cortex
(coordination of complex movements)
Central sulcus
Posterior parietal cortex
(integration of somatosensory and visual input)
Prefrontal association cortex
(planning for voluntary activity; decision making; personality traits)
Parietal lobe
Wernicke's area
(speech understanding)
Frontal lobe
Broca's area
(speech formation)
Parietal-temporal-occipital association cortex
(integraton of all sensory input-imp in language)
Primary auditory cortex
Occipital lobe
Limbic association cortex
(motivation, emotion, memory)
Temporal lobe
Primary visual cortex

Planning of movements



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