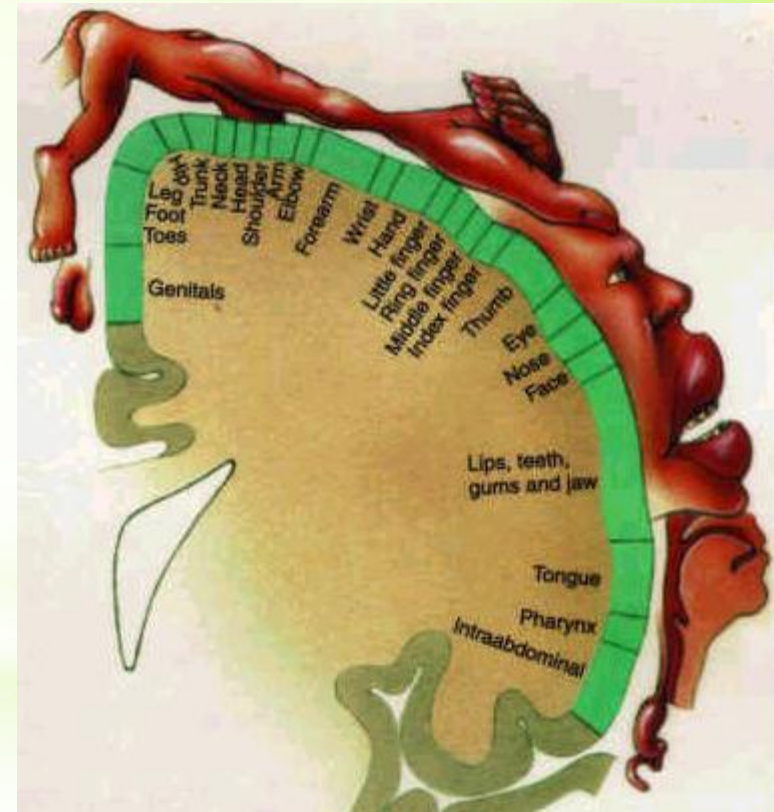
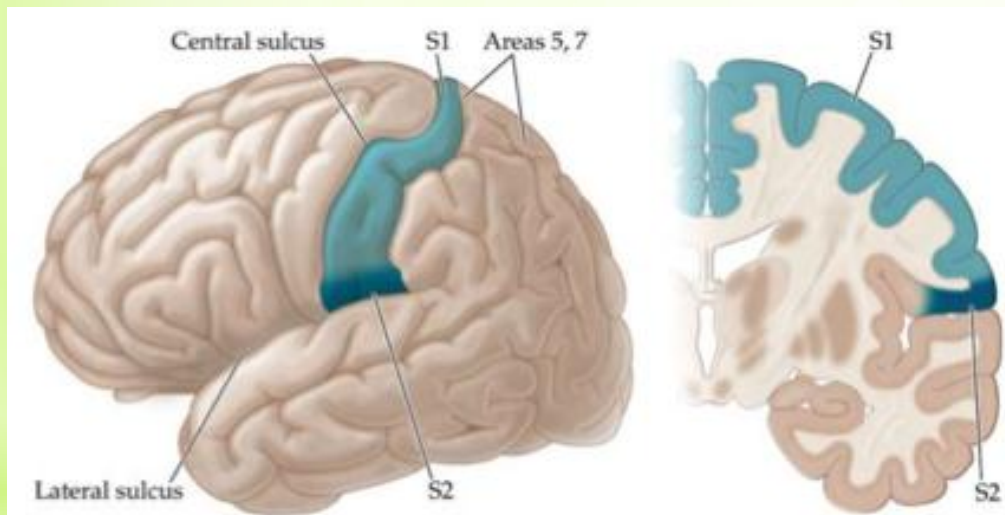
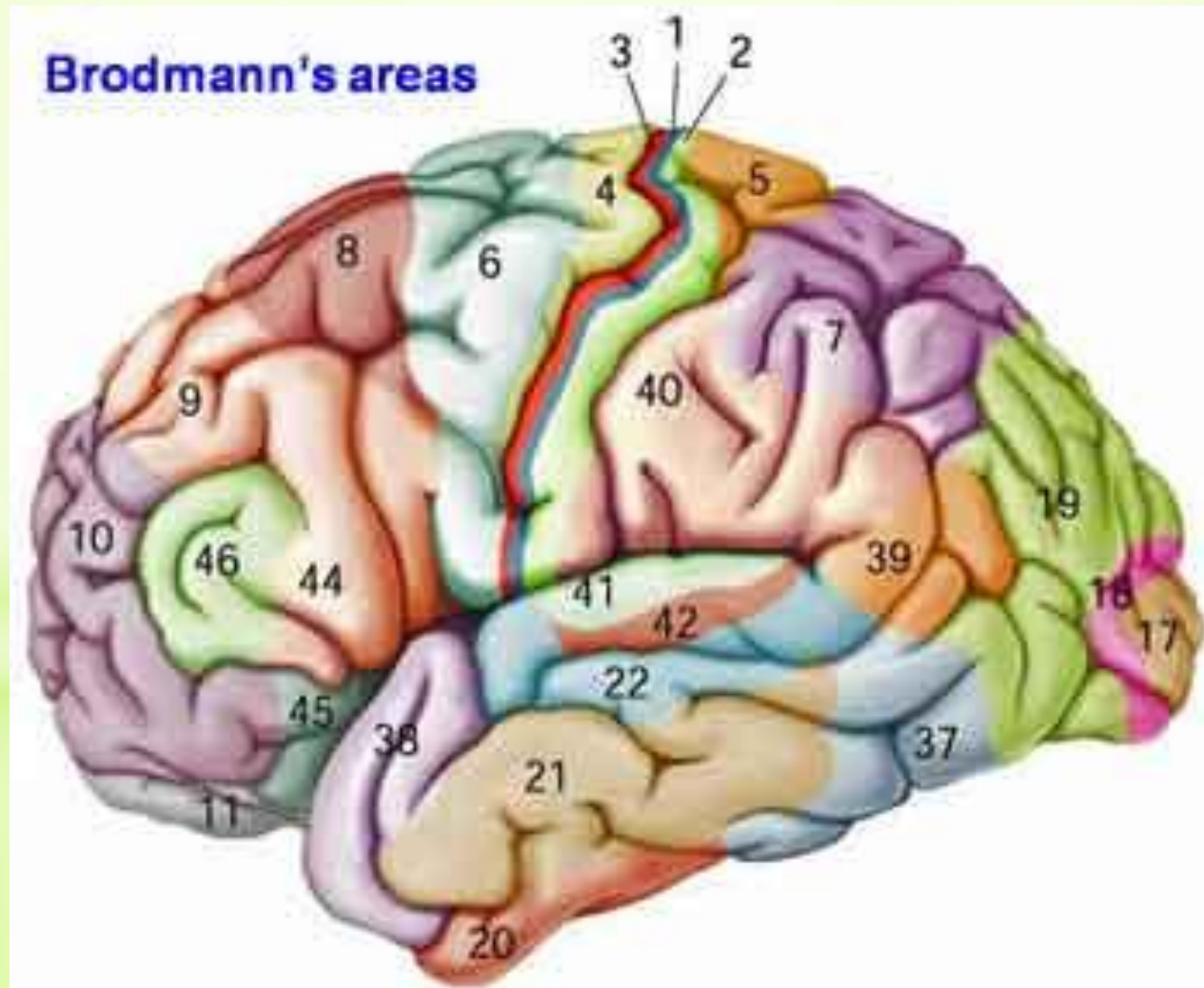


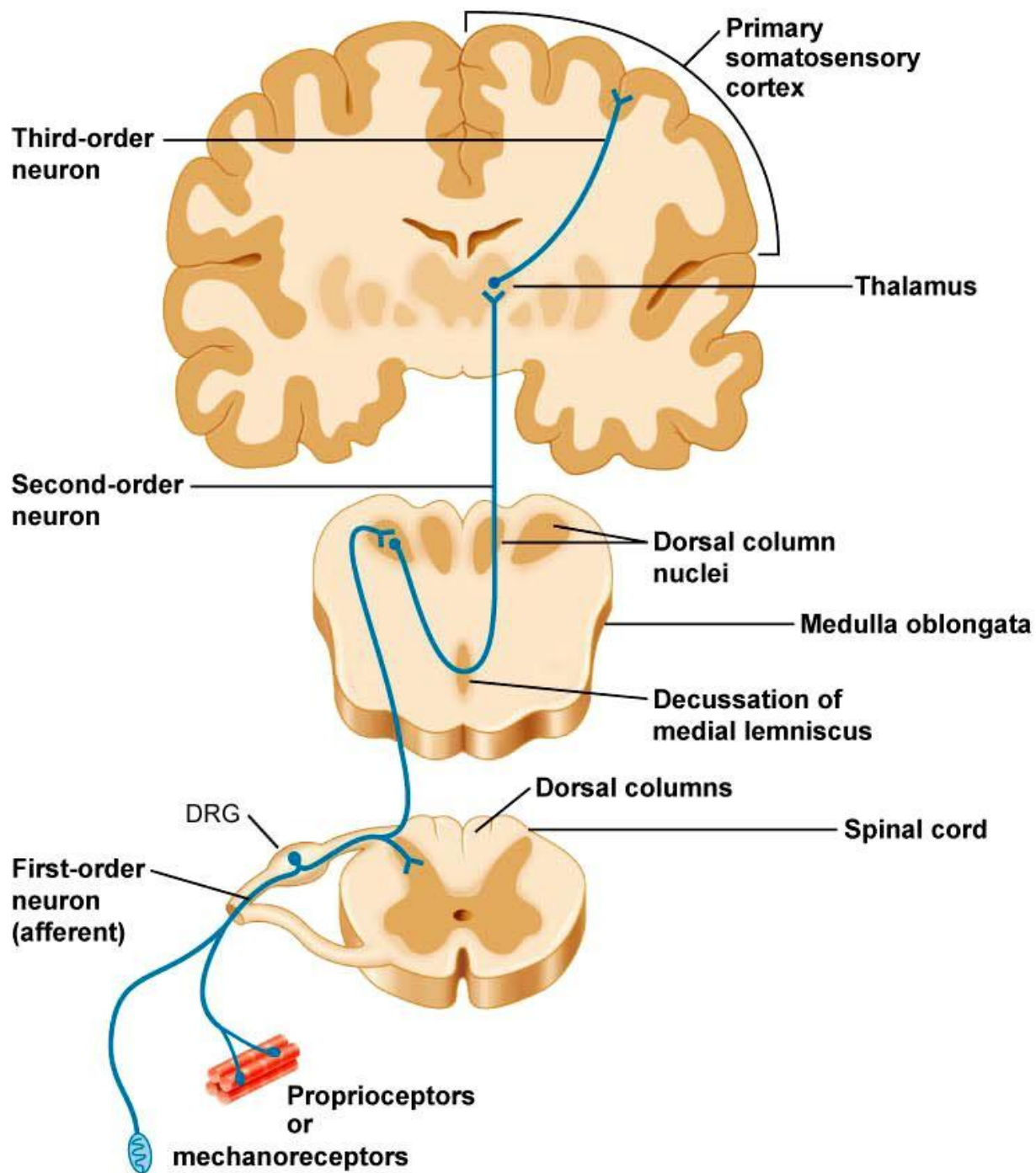
CENTRAL REPRESENTATION OF THE TOUCH

Primary somatosensory (somesthetic) cortex (S1)

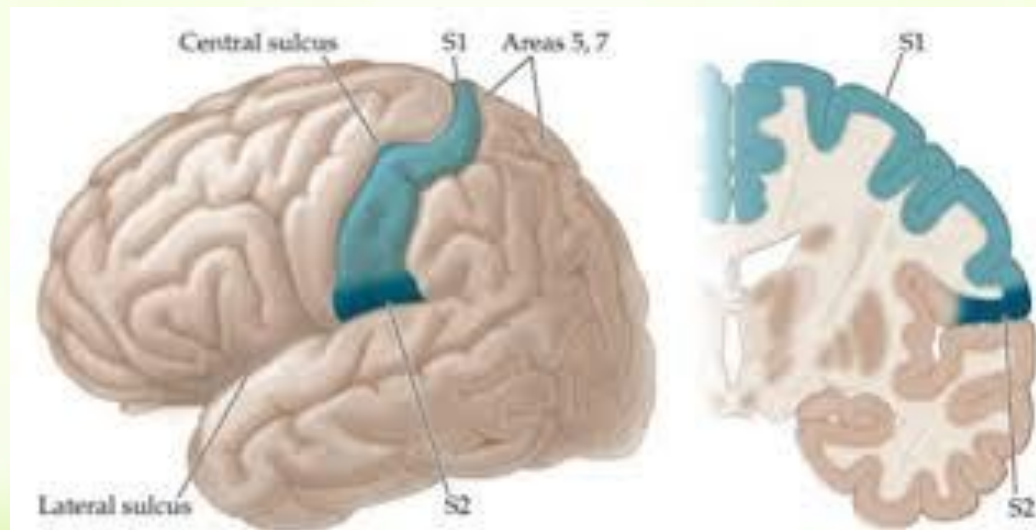


Somatic sensory association area





Secondary somatic sensory area (SII)



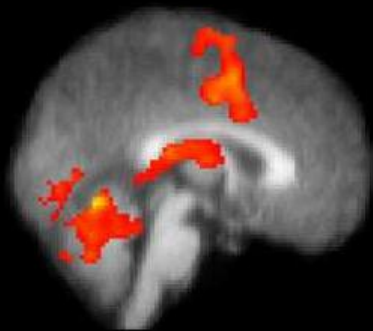
PAIN

Z-SCORE

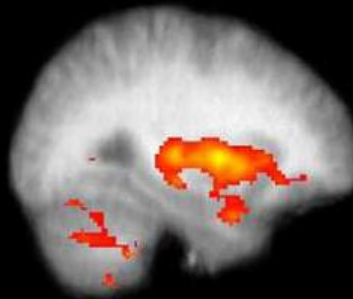
5.6



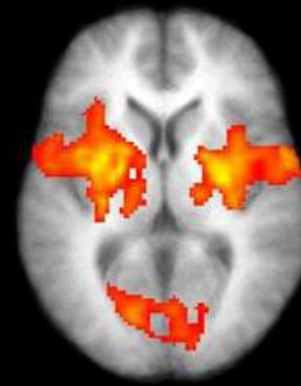
2.3



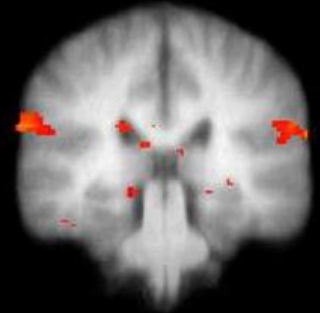
ACC
Thalamus
Cerebellum



DLPFC
IPL/SPL
Insula



Insula
Caudate
Thalamus
GP/PT



SII
M1

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: individual and social influences

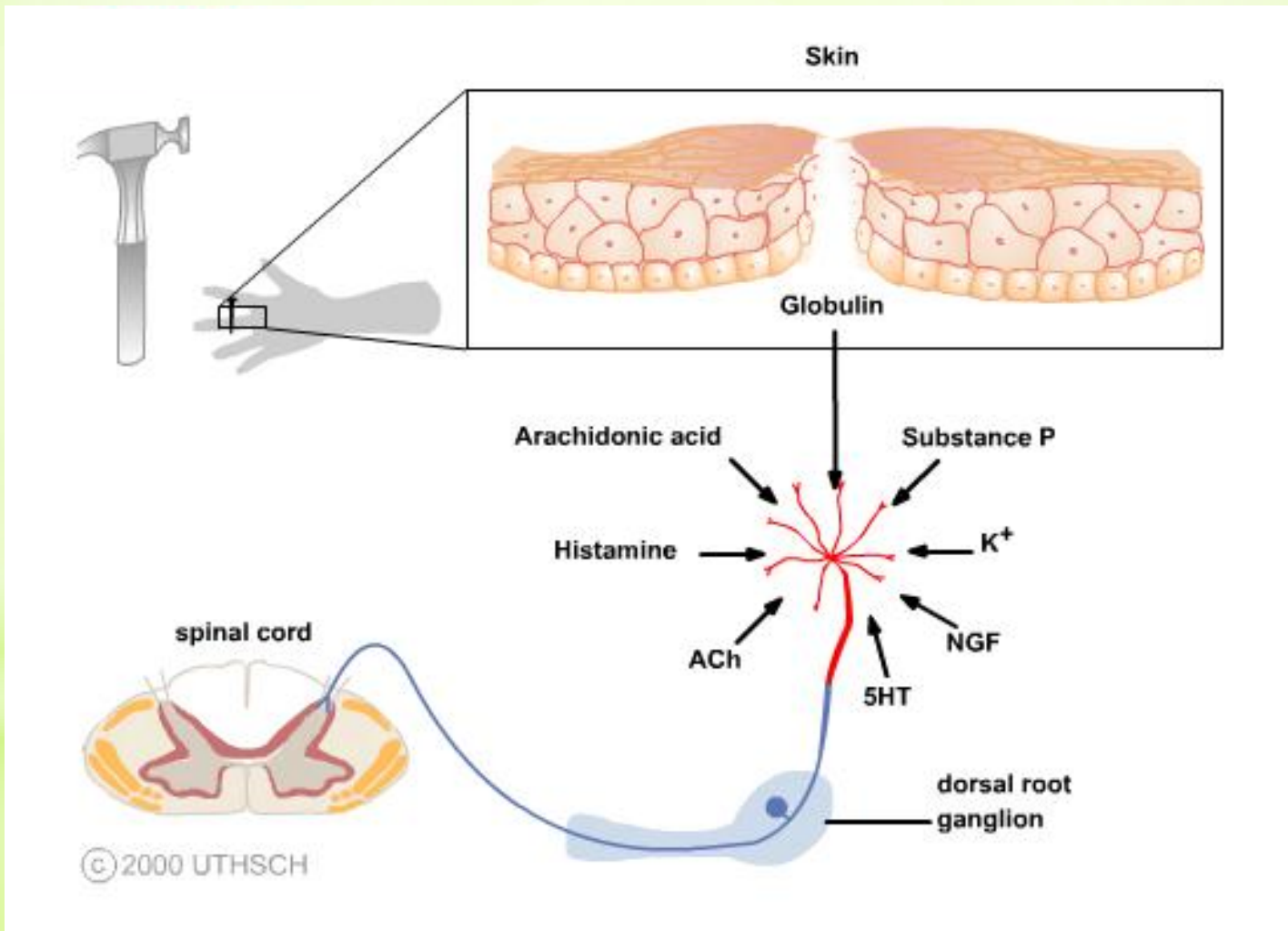
Nociceptors/nocisensors

- ❑ nocer - 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 A δ fibres (5-40 meters/sec)
 - A δ mechanical nociceptors
 - A δ 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

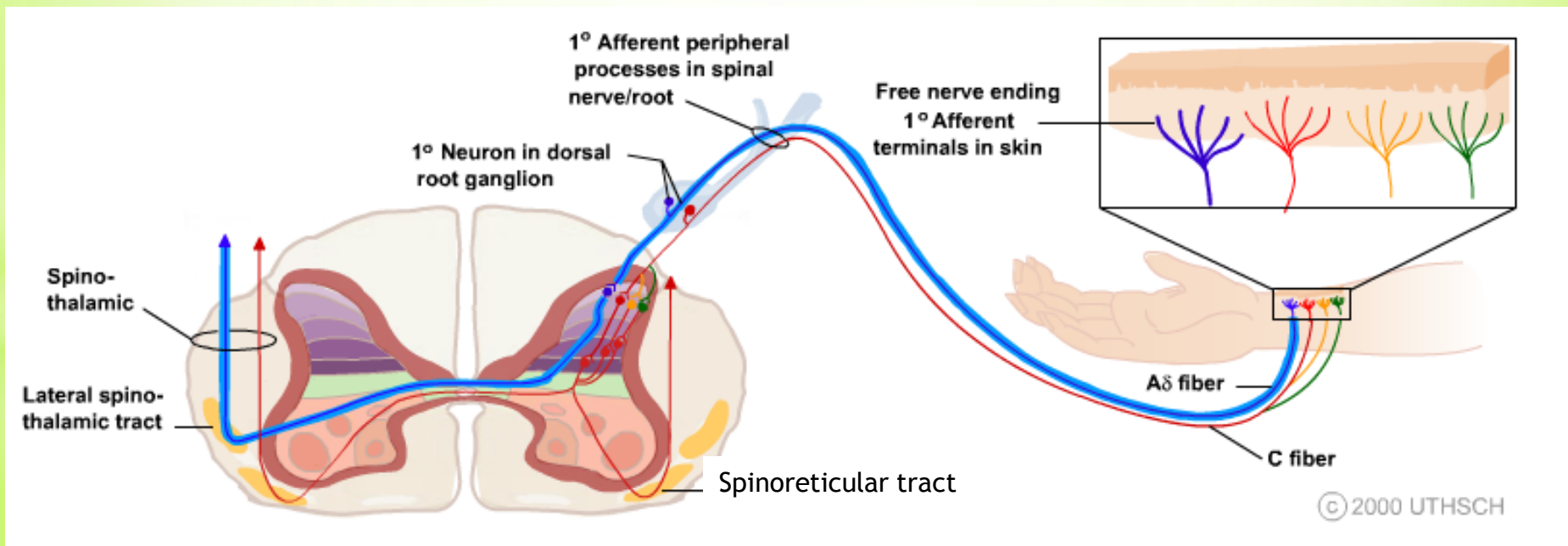
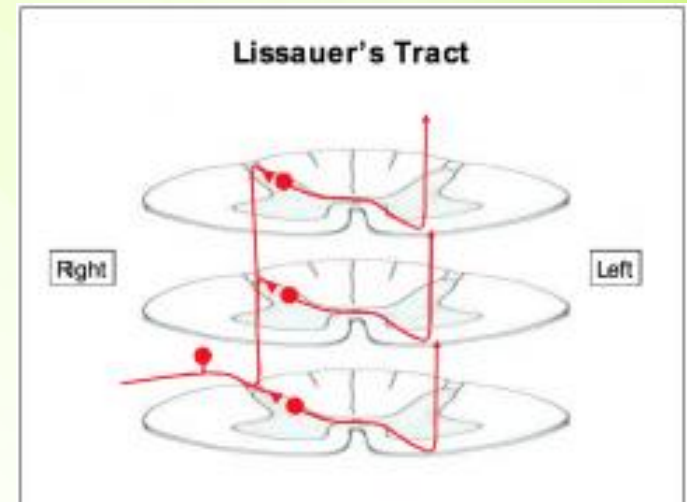
Factors that activate nociceptors



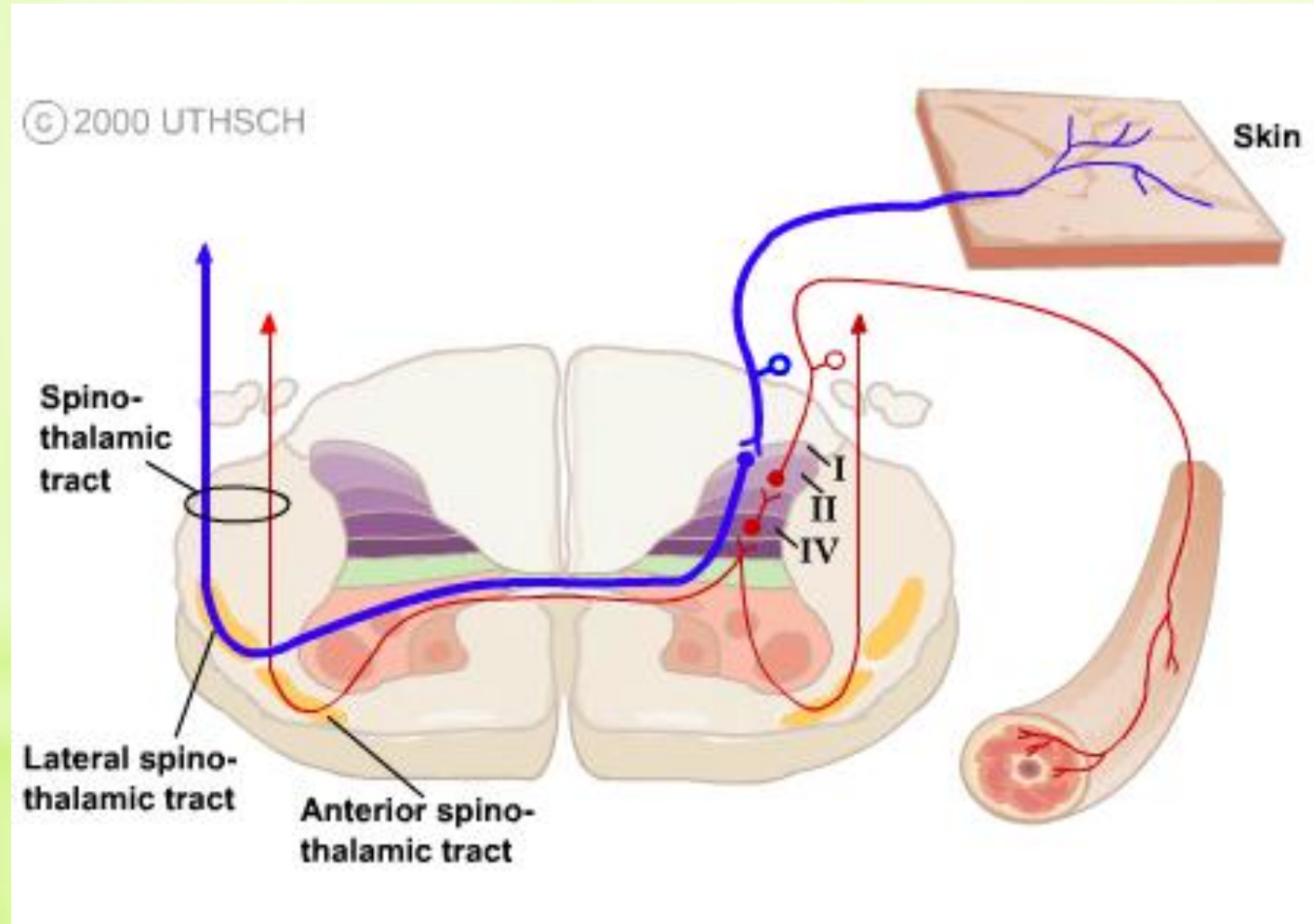
- ❑ **Peripheral sensitization**
- ❑ **Central sensitization** = activity- or use-dependent neuronal plasticity in the spinal cord
 - **hyperalgesia** - exaggerated or prolonged response to noxious inputs
 - **allodynia** - pain induced by normally innocuous inputs

Nociceptive afferents

- ❑ A δ fibres - thin myelinated fibres
 - sharp, localized pain
- ❑ C non-myelinated fibres
 - dull, non-localized pain



The noxious information from visceral organs and skin are carried to the CNS in different pathways



Pain pathways from 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
 - postcentral gyrus, insula and cingulate gyrus

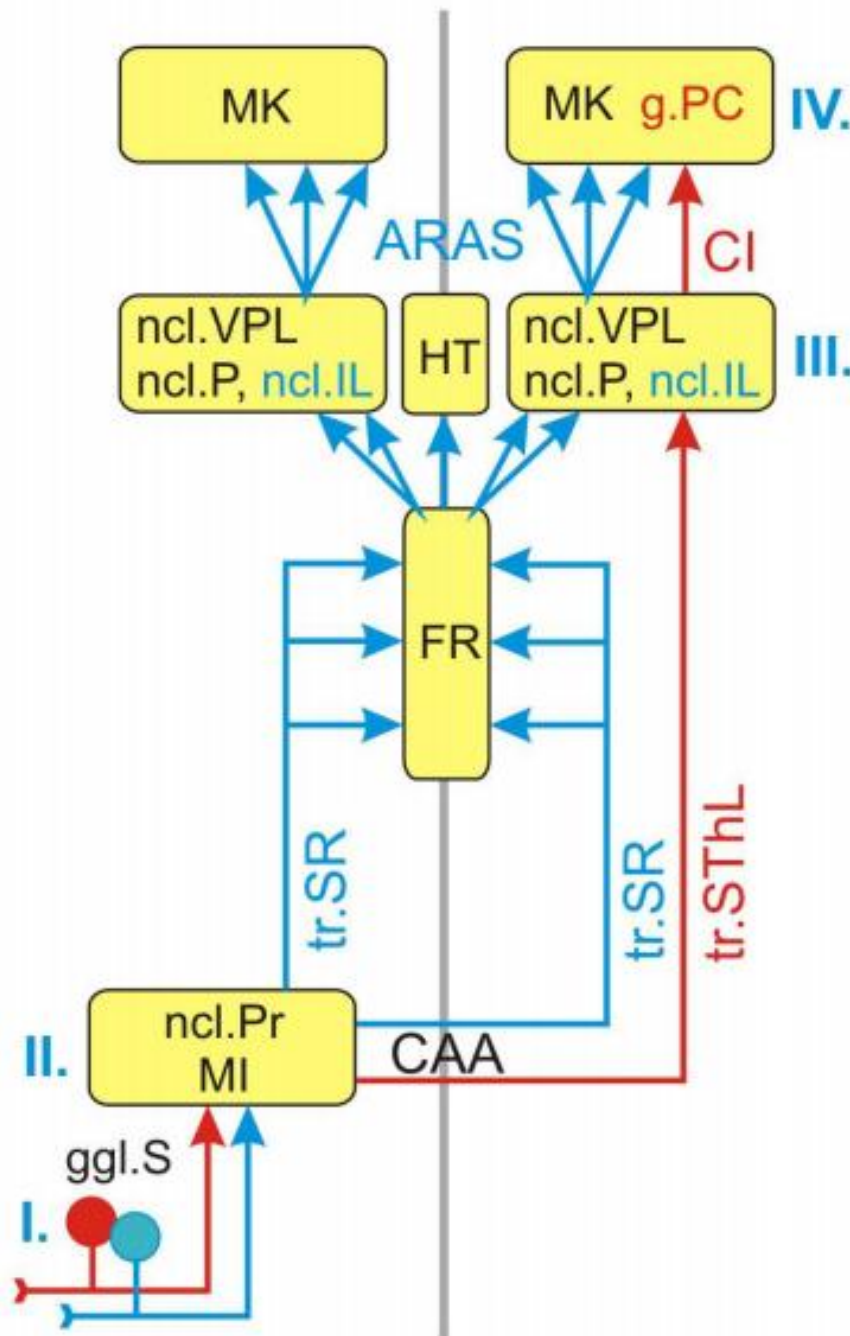
NEOSPINOThALAMIC PATHWAY

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

Cortex

Thalamus

Spinal cord



Paleospinothalamic pathway

Neospinothalamic pathway

Pain pathways from head

TRACTUS TRIGEMINO-RETICULO- THALAMICUS

- ❑ diffuse, non-localized pain

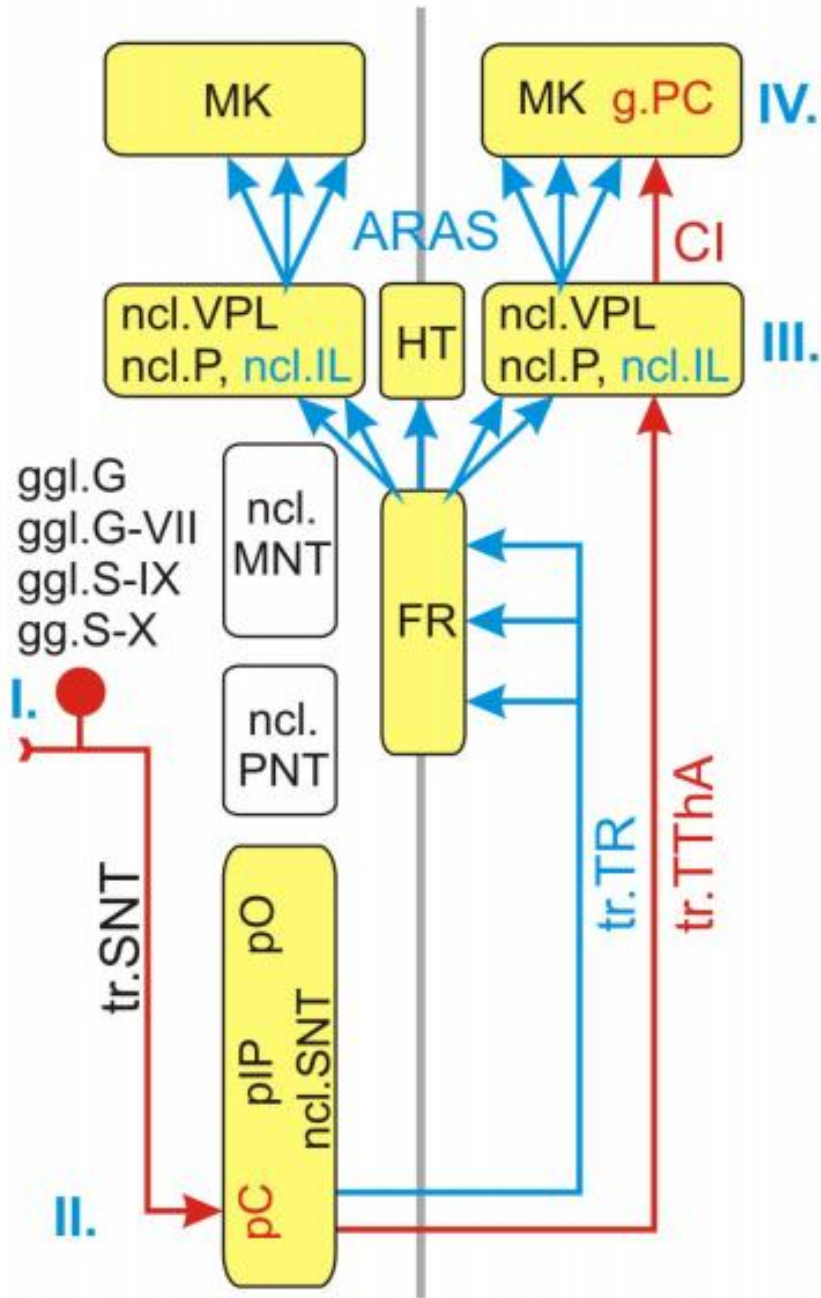
TRACTUS TRIGEMINO- THALAMICUS ANTERIOR

- ❑ sharp, localized pain

Cortex

Thalamus

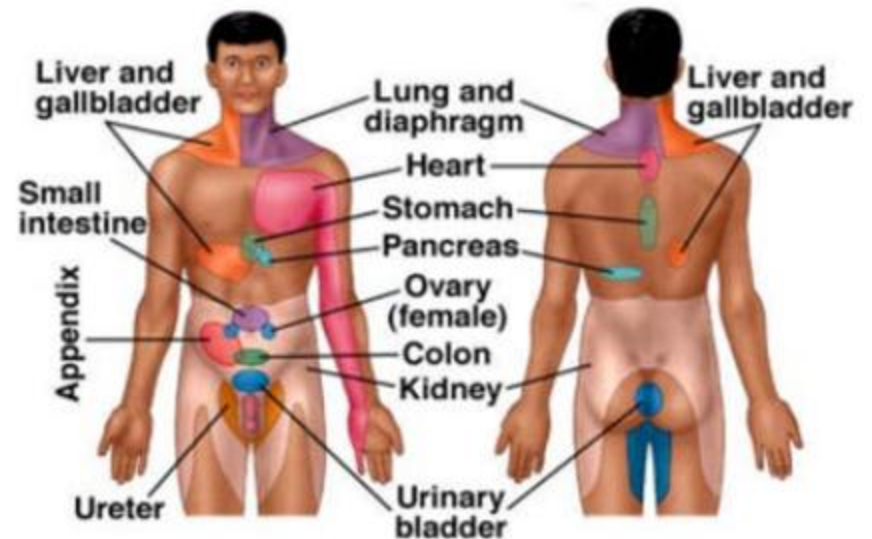
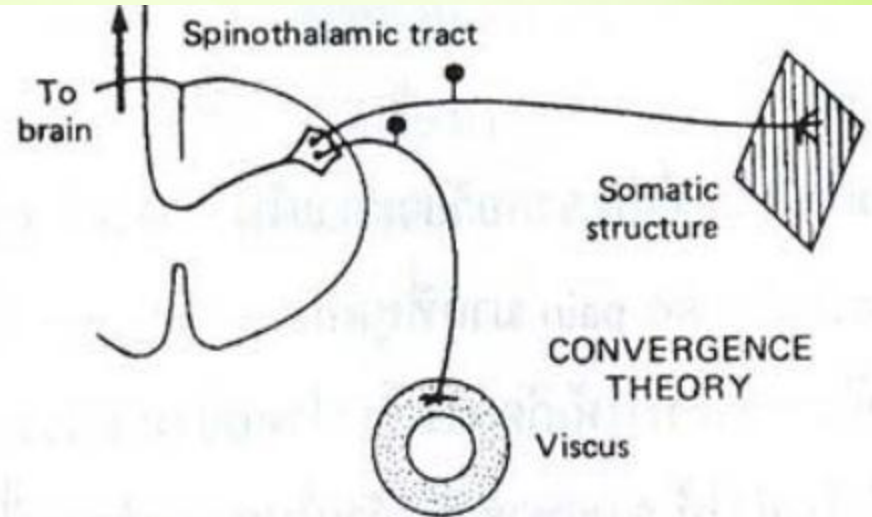
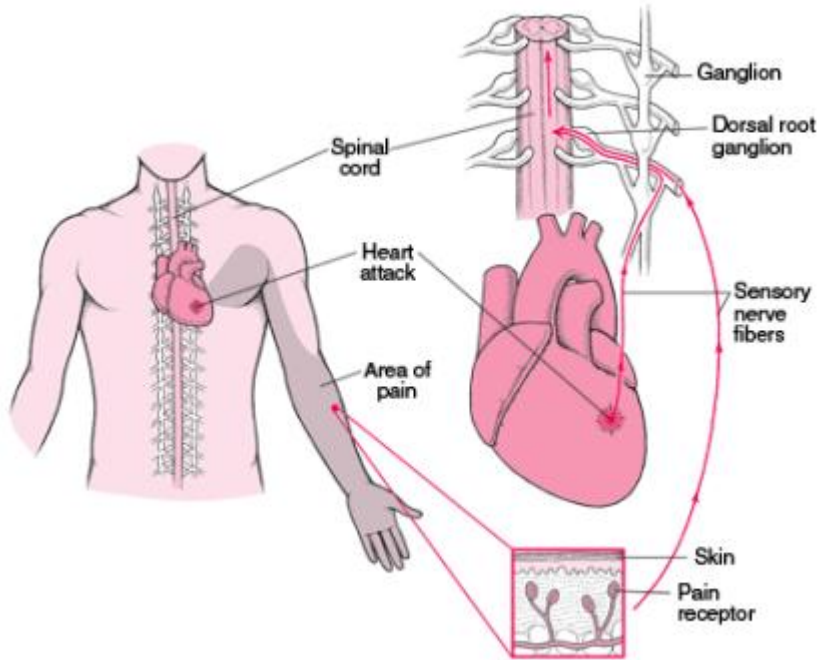
Medulla



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.

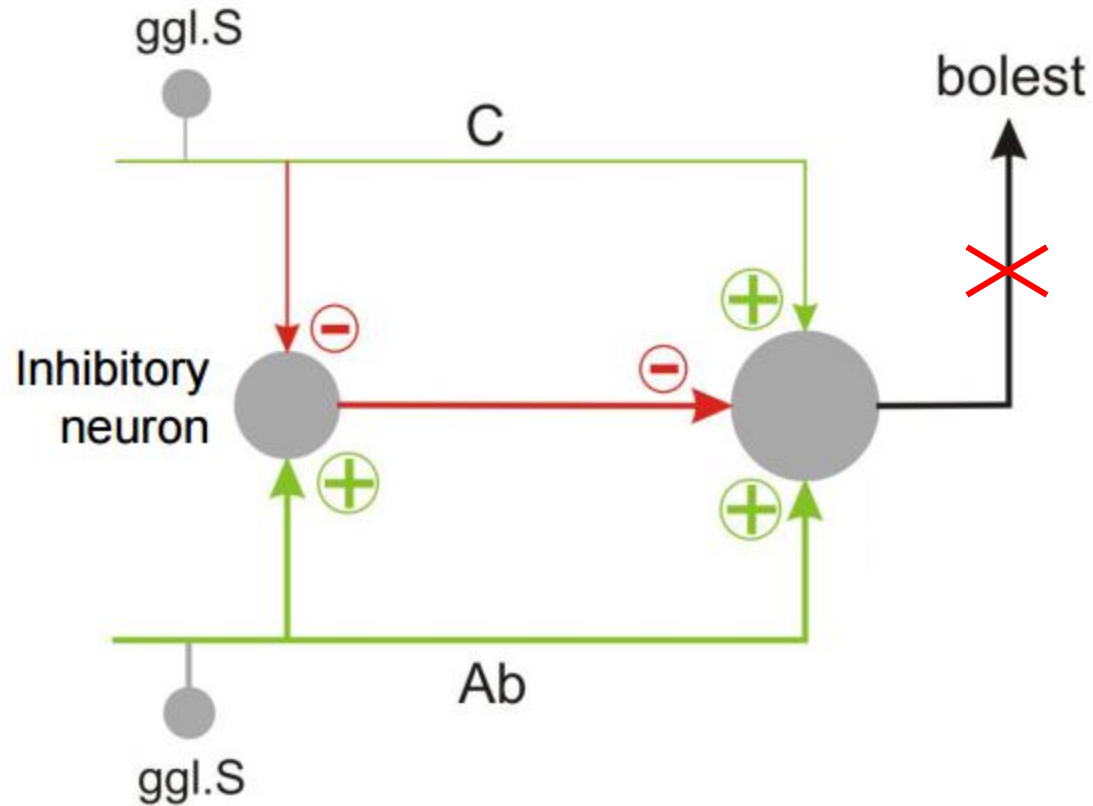
Referred pain



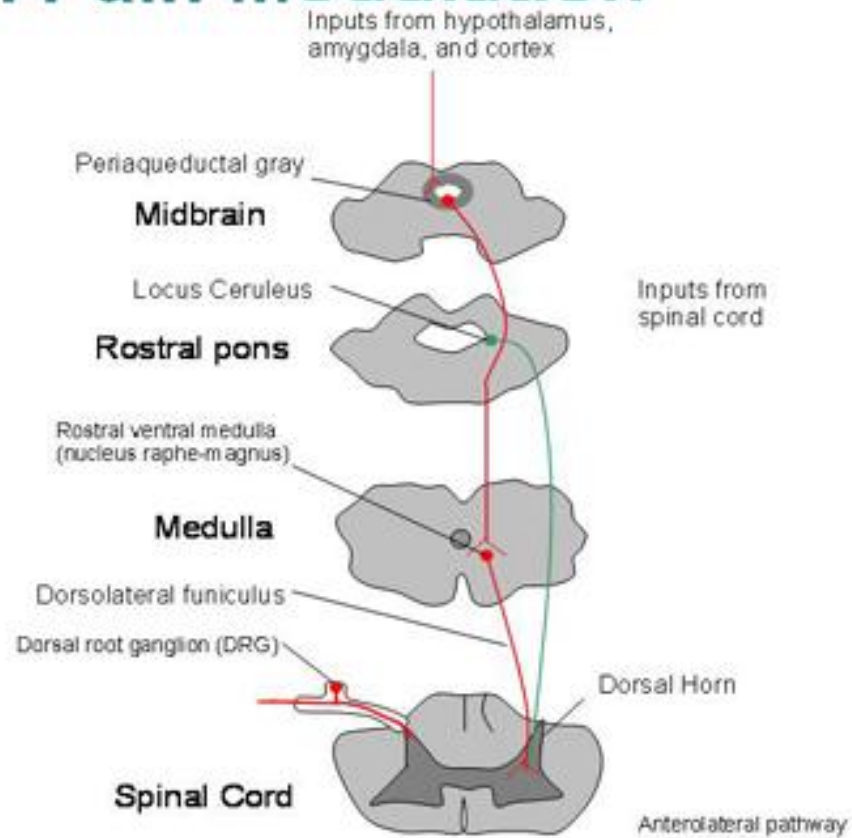
MODULATING SYSTEMS OF NOCICEPTIVE PATHWAYS

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

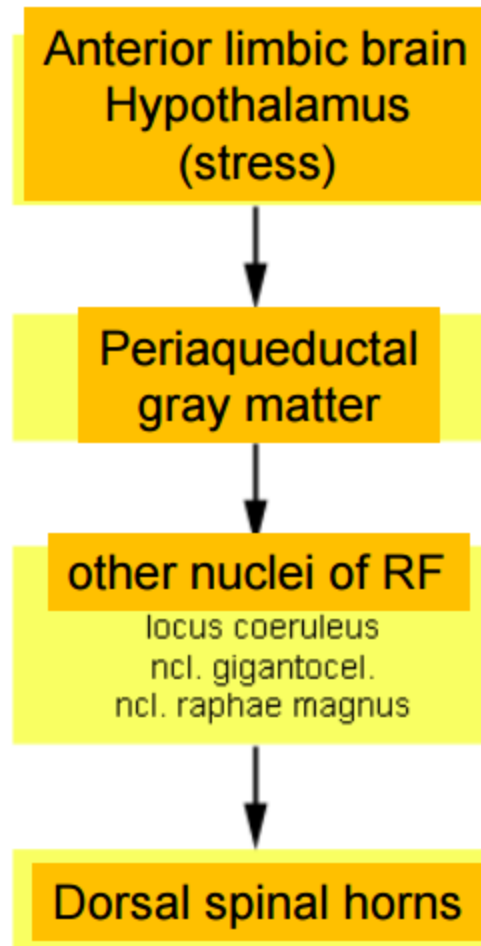
“Gate control theory”



Central Pain Modulation



Stress-induced analgesia



SOMATOMOTOR PATHWAYS

Some 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
-

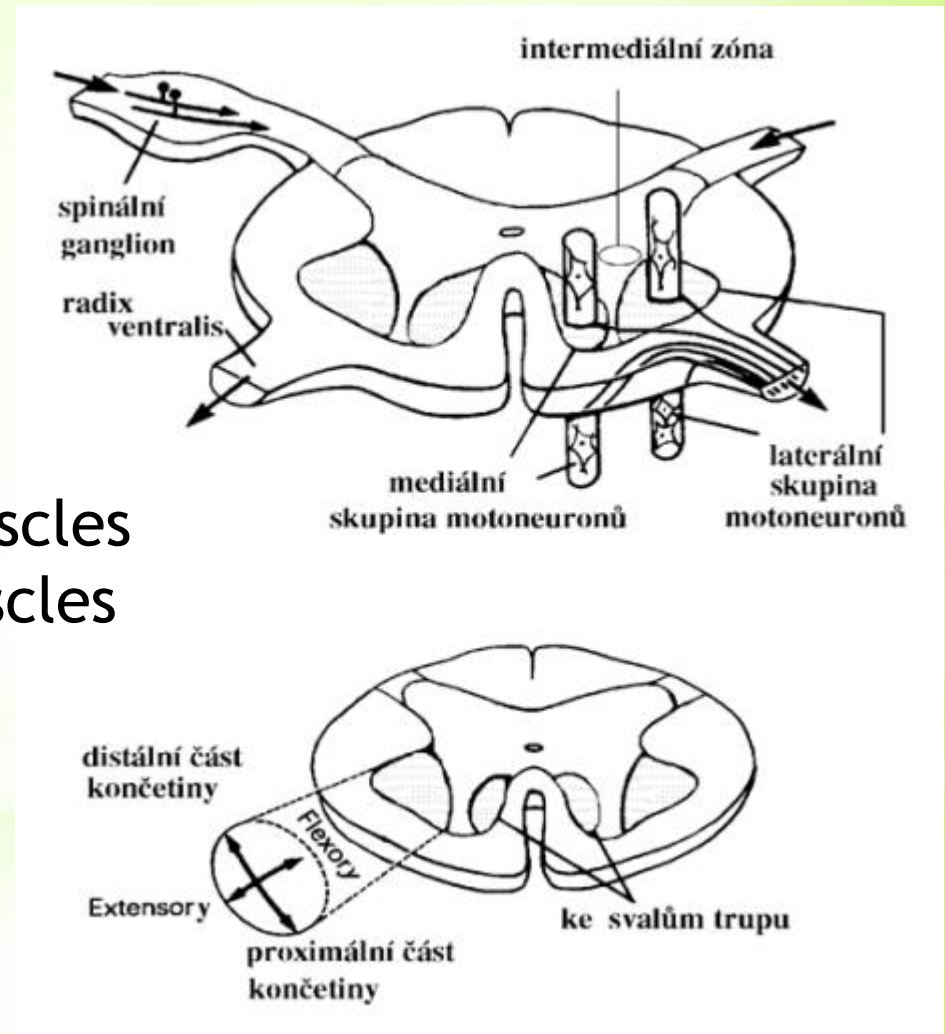
- cerebellum
- basal ganglia

Lower motor neurons - spinal cord

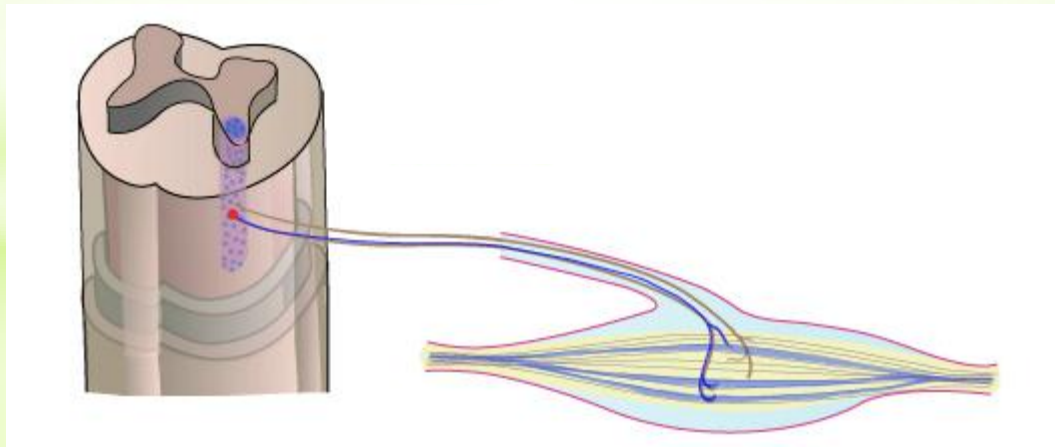
- α motoneurons
- γ motoneurons

- **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**.

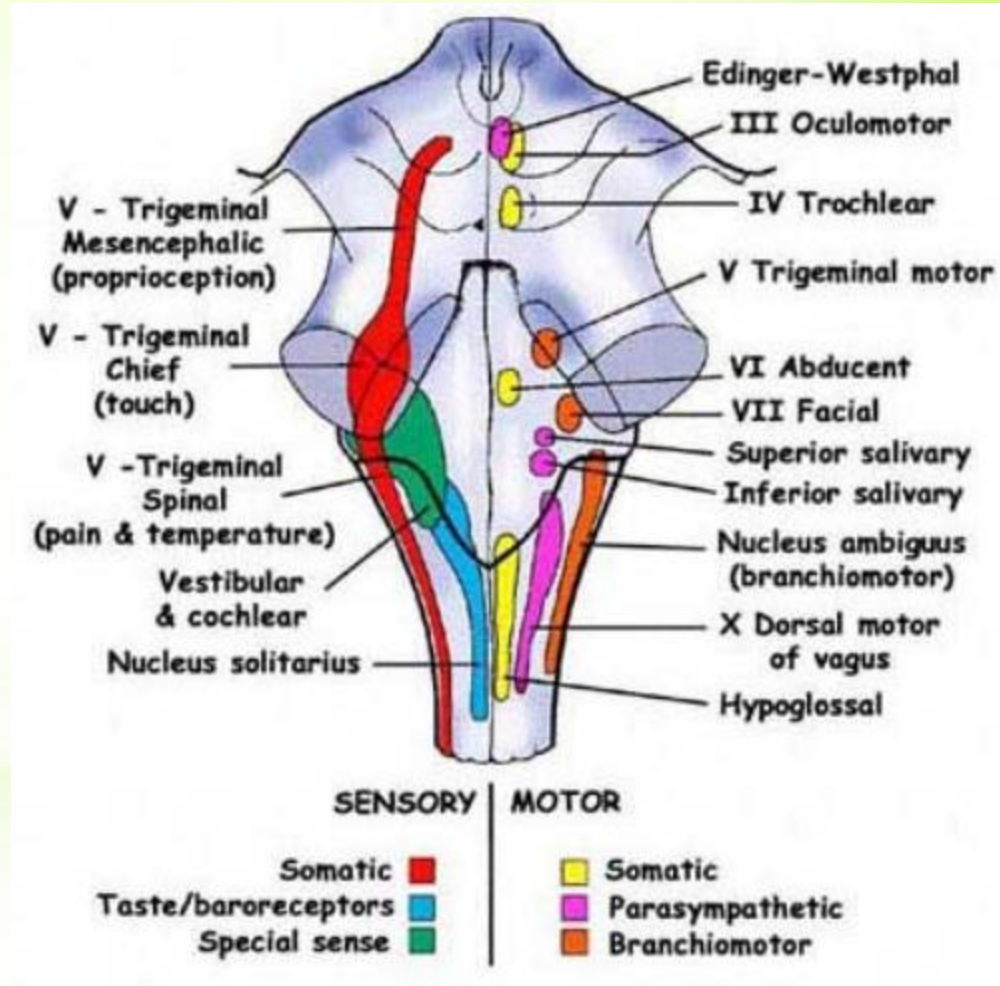


□ size of motor unit

- 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

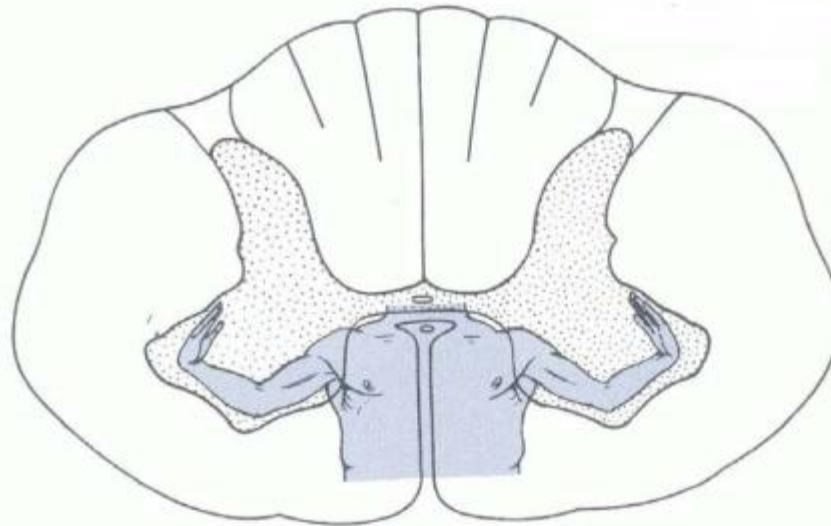
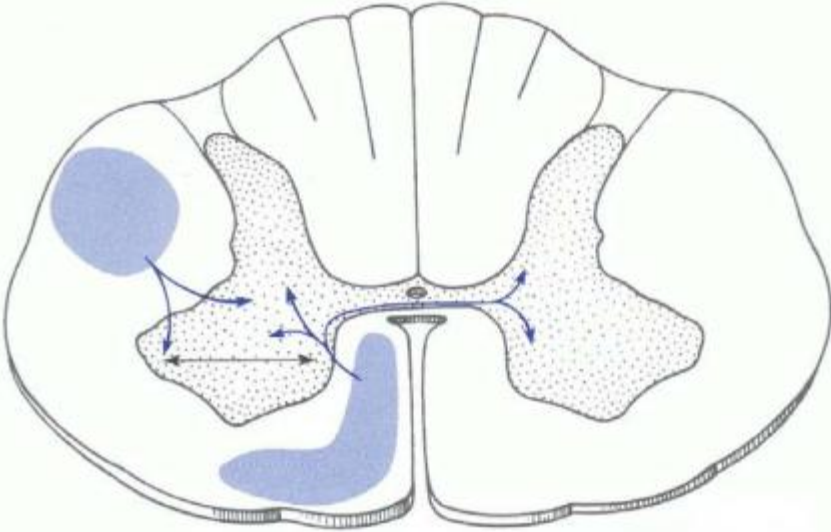


Supraspinal system of movement control

- ❑ 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

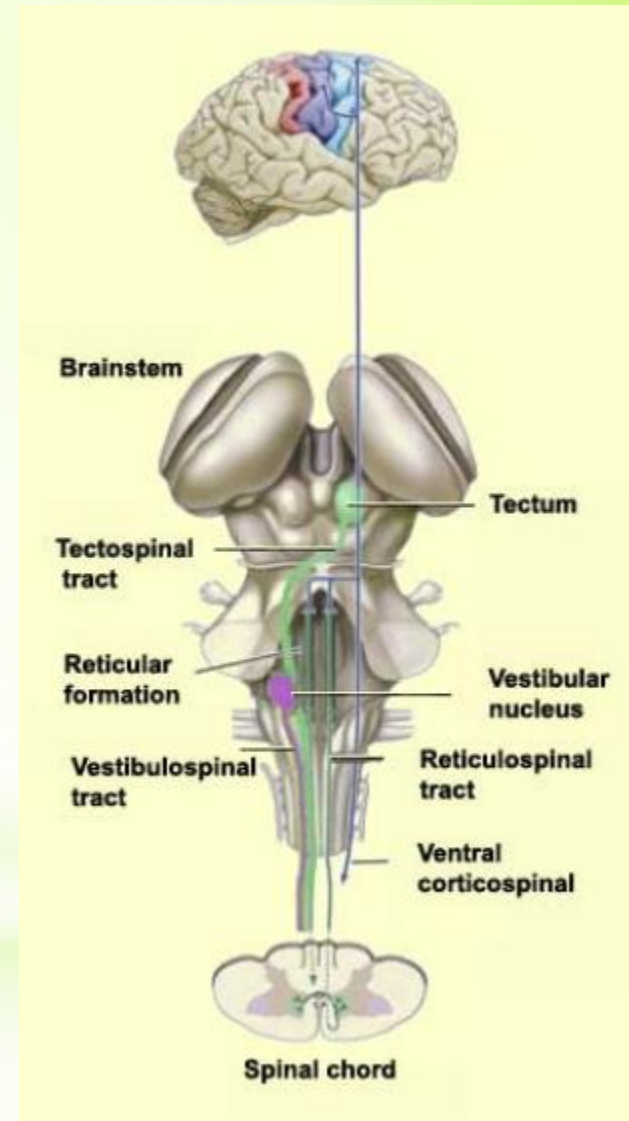
- ❑ The “third” motor system
 - aminergic pathways of the brain stem



Medial system

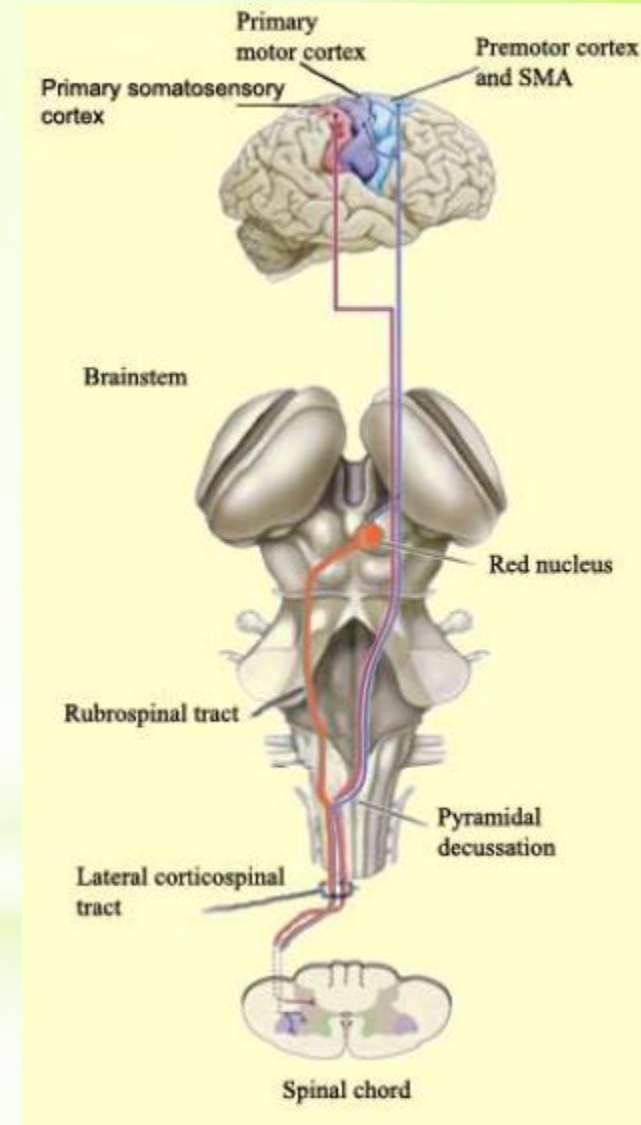
- ❑ Subcortical pathways
 - **Medial and lateral vestibulospinal tracts** - control of balance and postural movements
 - **Tectospinal tract** (sup. colliculus) - coordination of movements of the head and eyes during watching
 - **Medial (pontine) and lateral (medullary) reticulospinal tracts** - control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

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

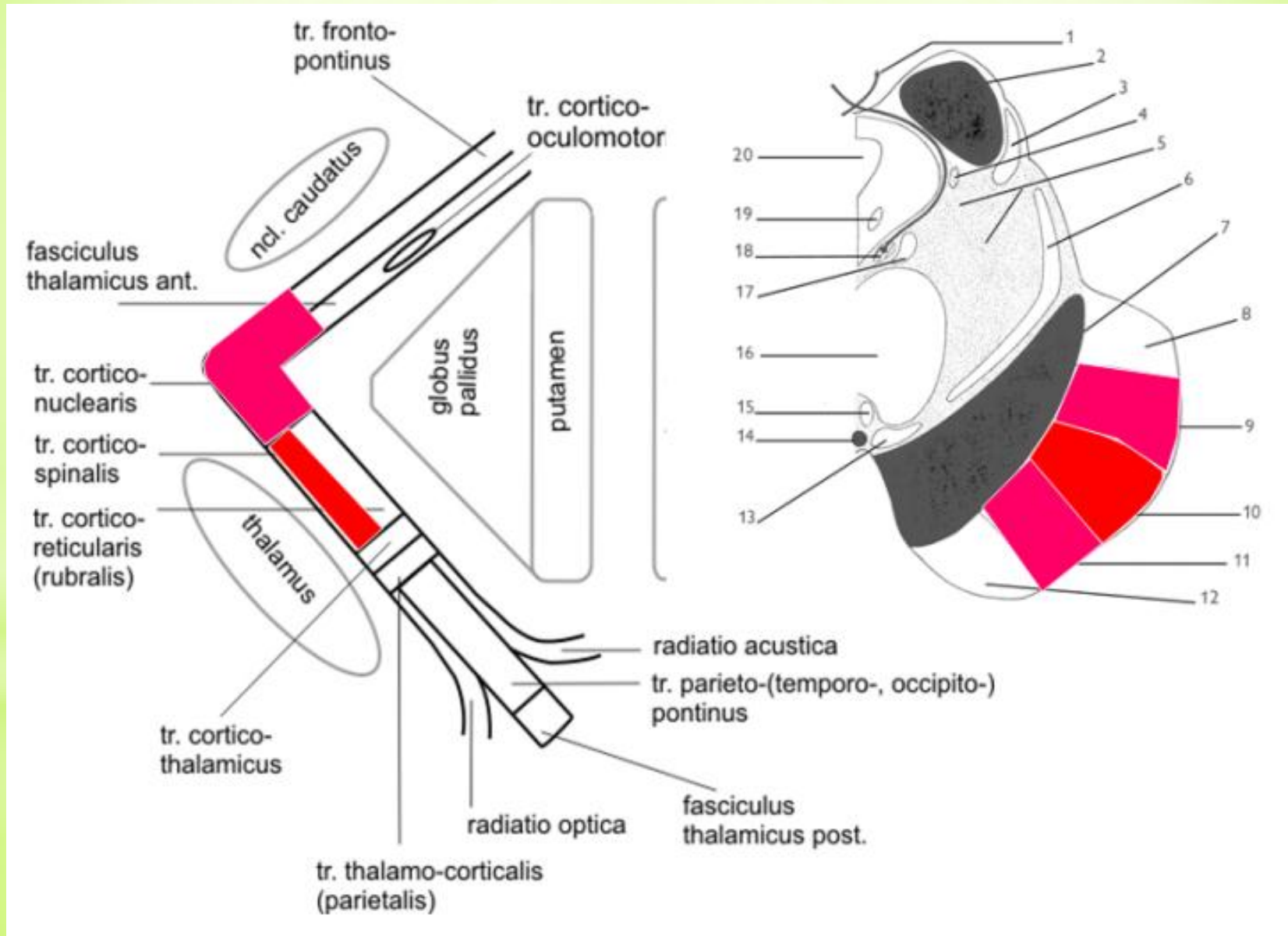


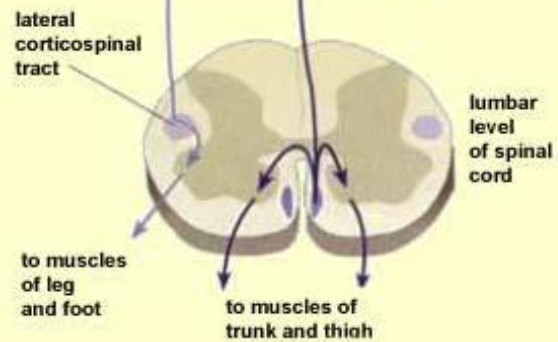
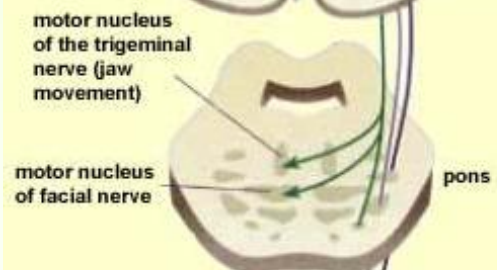
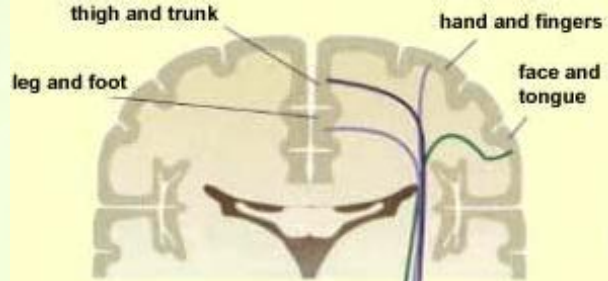
Lateral system

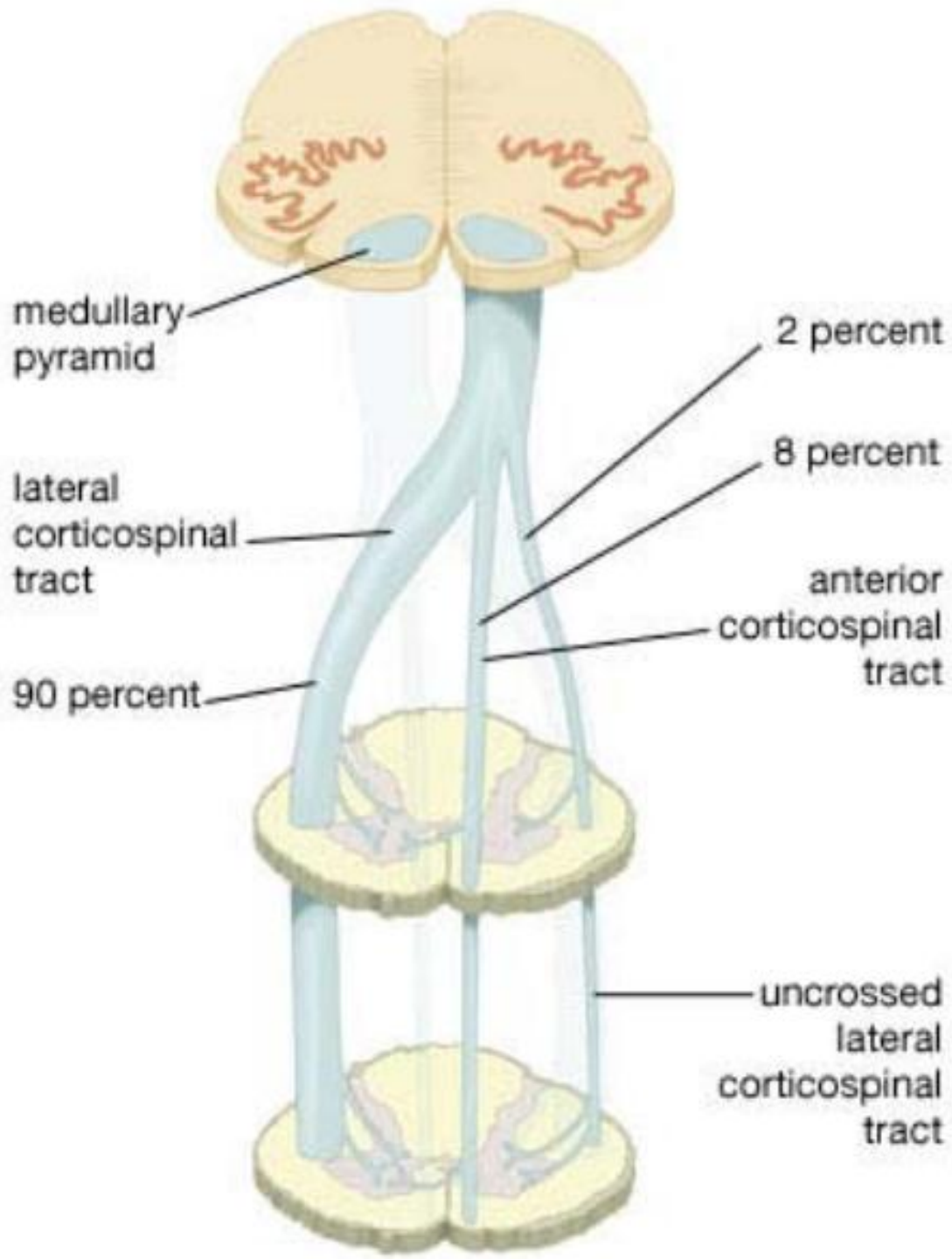
- ❑ Subcortical pathways
 - **Rubrospinal tract**
 - contralaterally descends to the lateral column
- ❑ Cortical pathways
 - **Lateral corticospinal tract**



Corticospinal and corticonuclear tracts



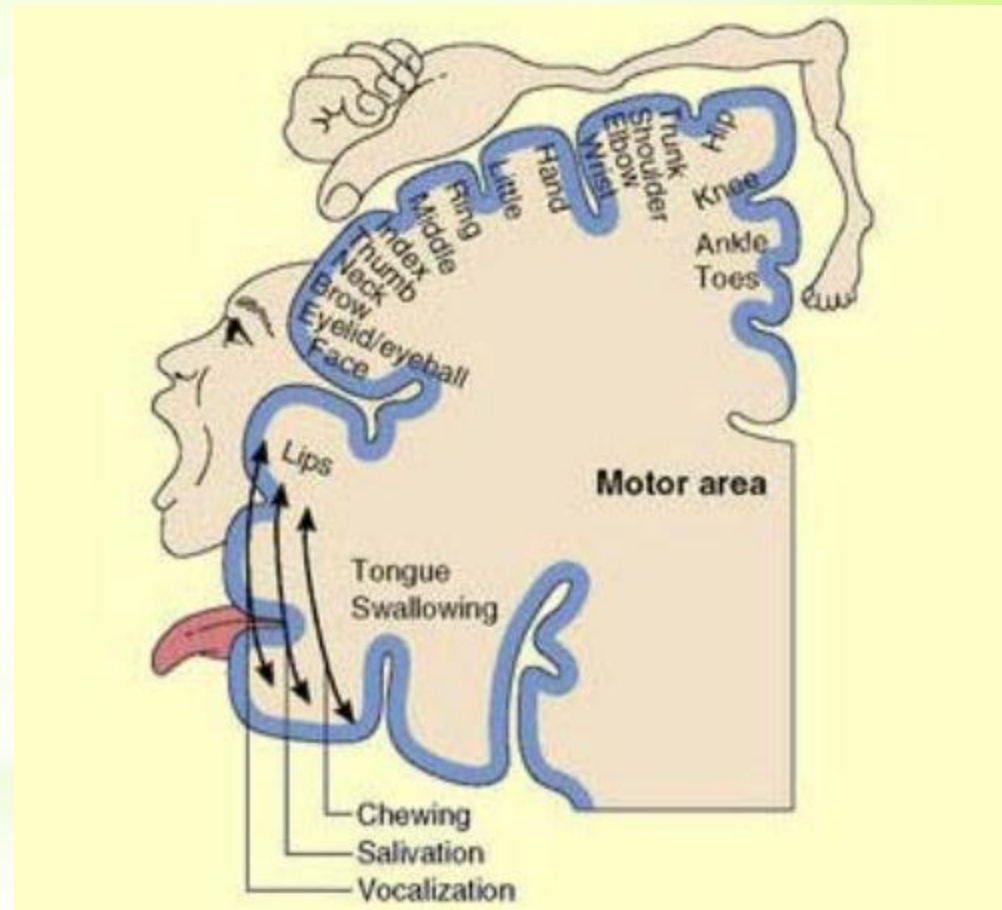
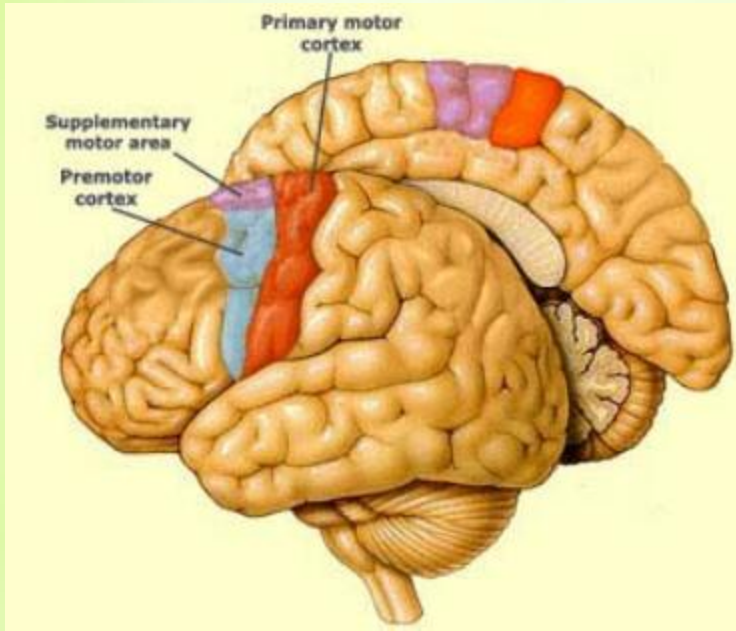


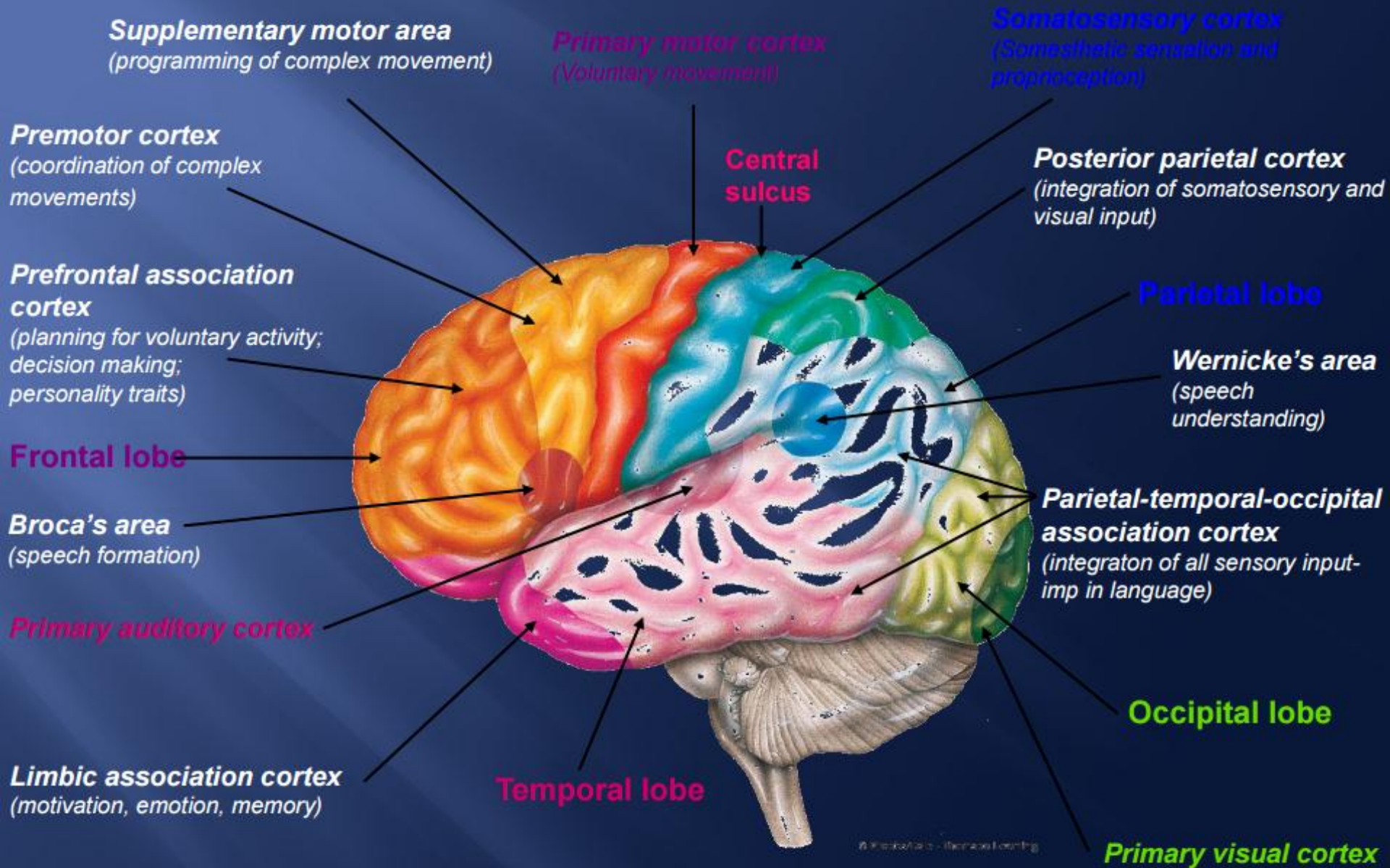


The third system

- ❑ 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
(integrator of all sensory input-imp in language)

Primary auditory cortex

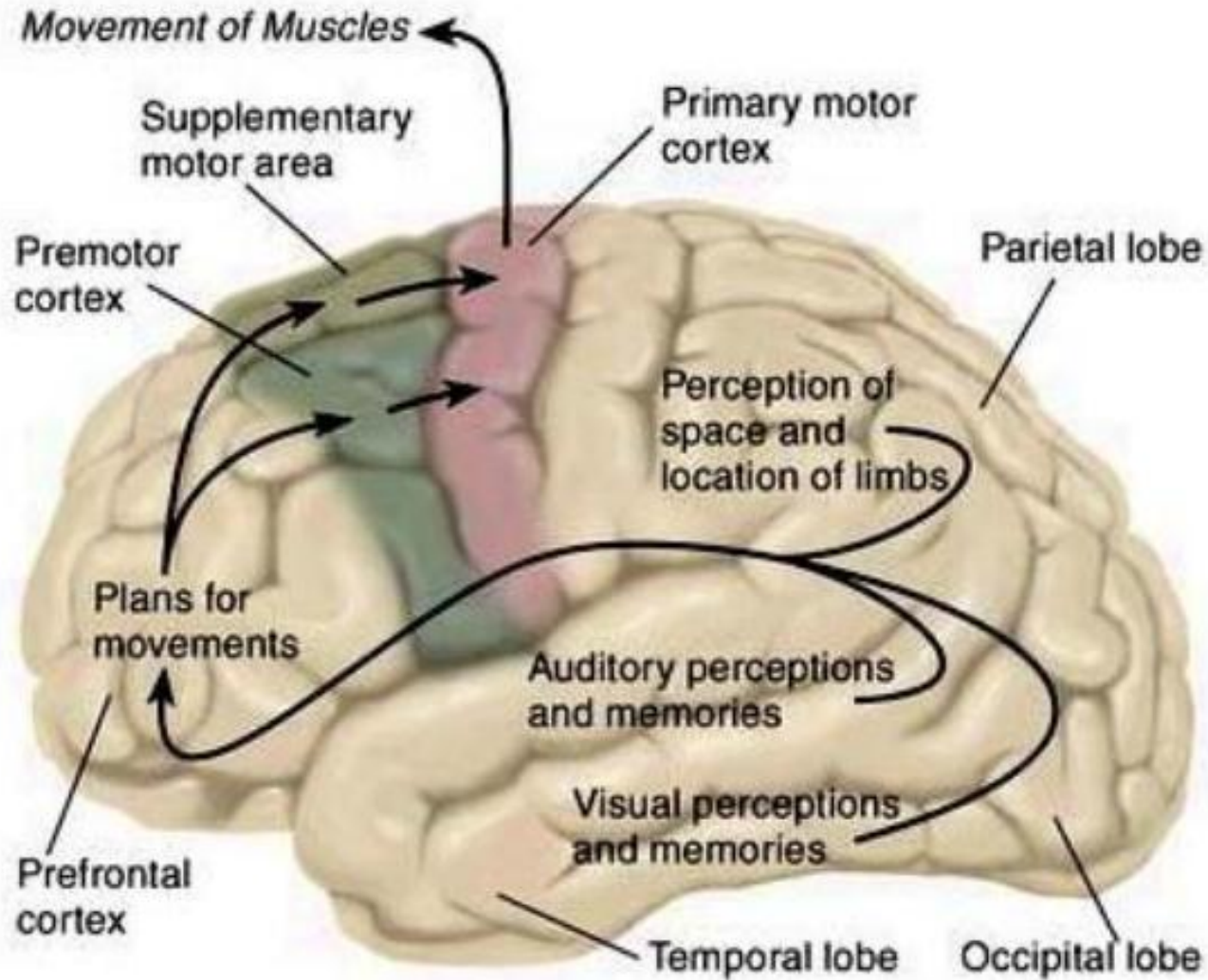
Occipital lobe

Limbic association cortex
(motivation, emotion, memory)

Temporal lobe

Primary visual cortex

Planning of movements



Illustrations were copied and lecture was prepared from:

**Noback CH.R. et al: The Human Nervous System:
Structure and Function. Humana Press, Totowa, New
Jersey, Sixth ed.**

**Neuroscience Online, the Open-Access Neuroscience
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University of Texas Medical School at Houston