HUMAN PHYSIOLOGY (normal)

LECTURE 5. Special Physiology of CNS. The Forebrain and Cerebral Cortex

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The Limbic System

Limbic system is a **complex system** of **cortical** and **subcortical structures** that form a ring around the hilus of cerebral hemisphere. **Limbus** means **ring**

The limbic system functions in **linking emotion and motivation** (amygdala), **learning and memory** (hippocampal formation), and **sexual behavior** (hypothalamus)

Functions of limbic system:

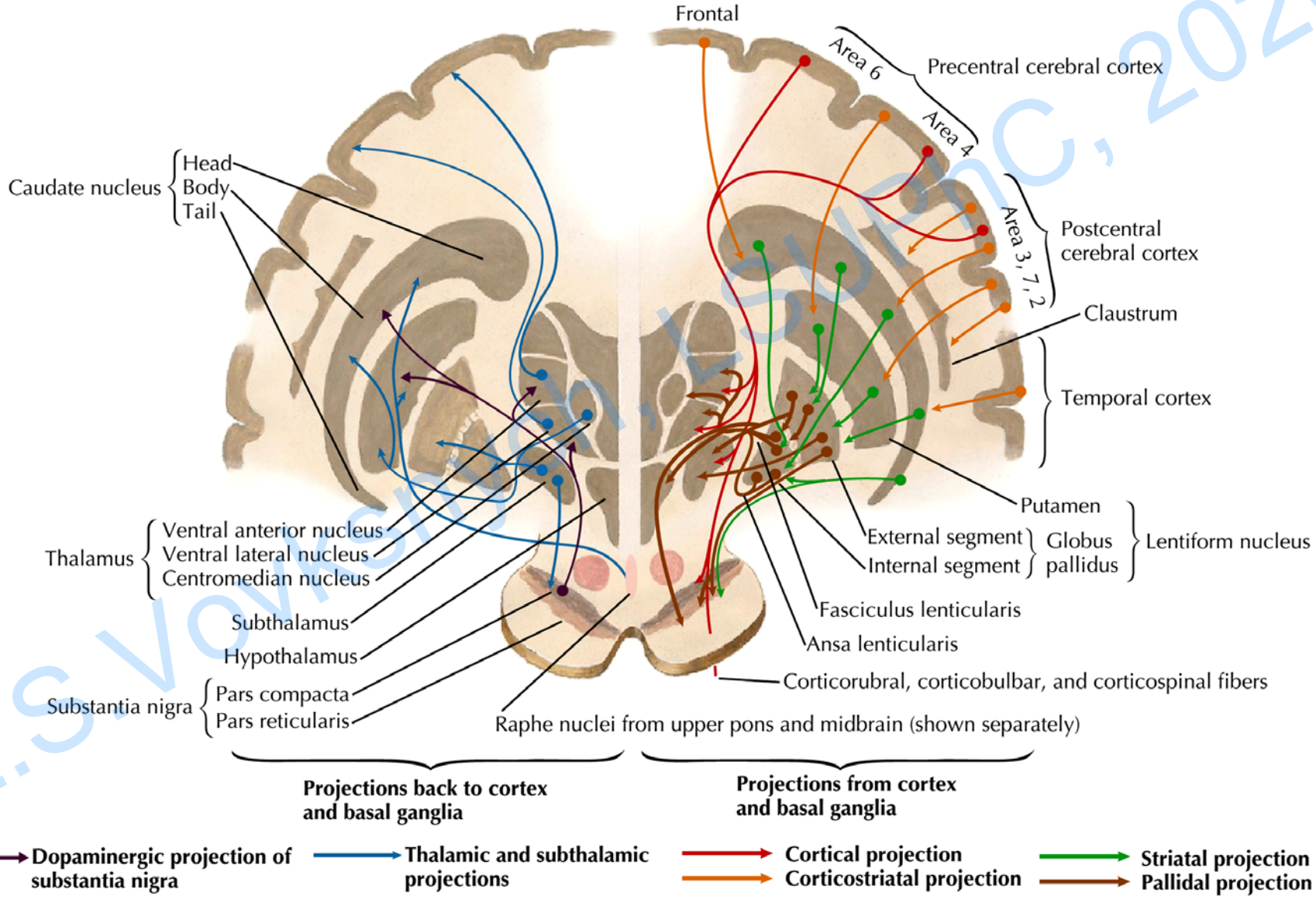
- **Olfactory** center (piriform cortex and amygdaloid nucleus)
- Role in **emotional** state (is maintained by hippocampus along with hypothalamus)
- Role in **Memory** (hippocampus and Papez circuit)
- Role in **Motivation** (reward and punishment centers present in hypothalamus and other structures of limbic system are responsible for motivation and the behavior pattern)

The Basal Nuclei (Ganglia)

Basal ganglia are the scattered masses of **gray matter** submerged in **subcortical substance** of cerebral hemisphere. They form the part of extrapyramidal system of the control of motor activities.

The basal ganglia consist of the **striatum** (caudate nucleus and putamen) and the **globus pallidus**. The **substantia nigra** and the **subthalamic nucleus**, which are reciprocally connected with the basal ganglia, are often included as part of the basal ganglia.

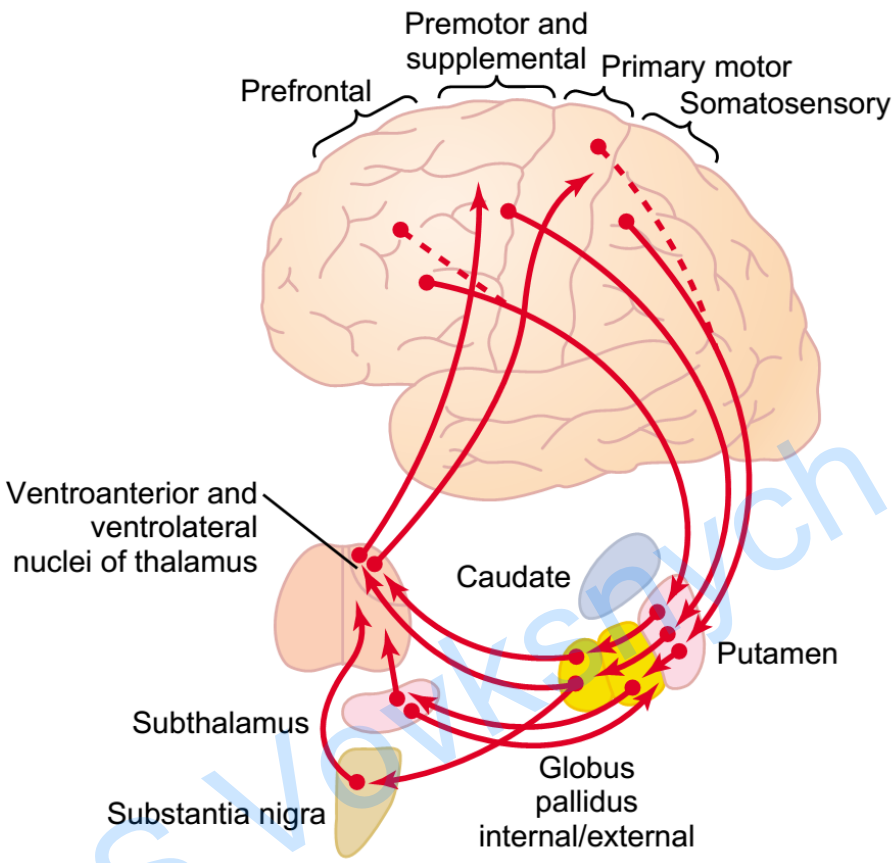
The Basal Nuclei (Ganglia)

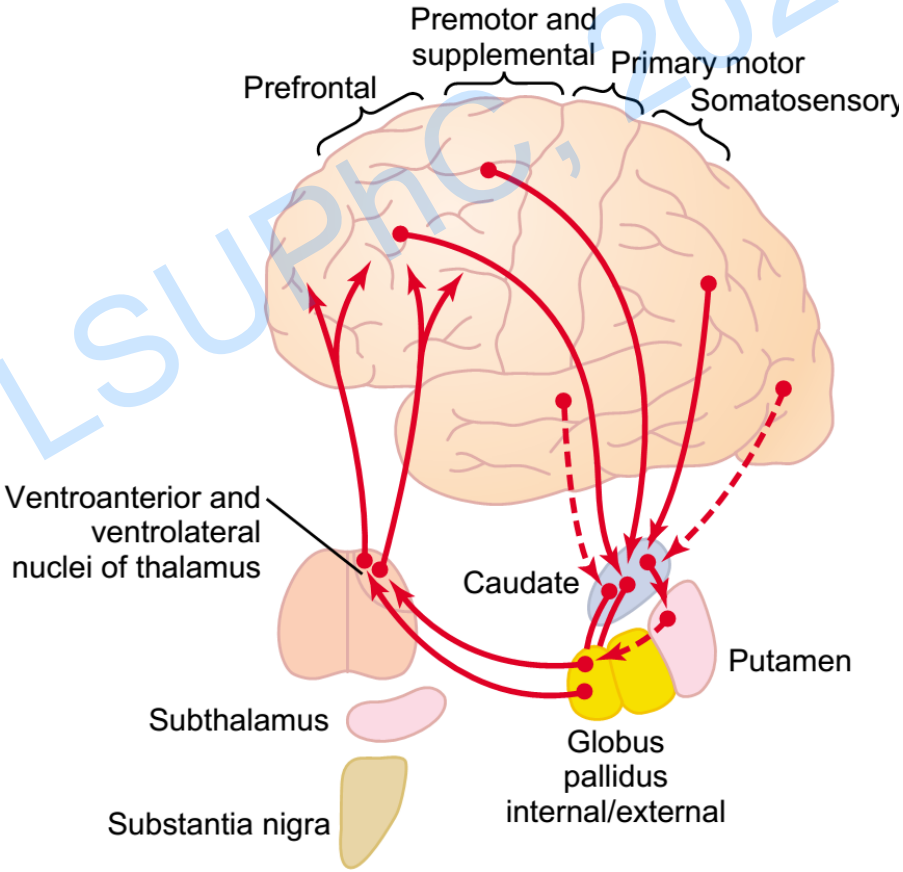


Functions of Basal Ganglia

- Control of **Muscle Tone** (influence on gamma motor neurons through descending inhibitory reticular system in brainstem)
- Control of **Motor Activity**
  - **Voluntary Movements** are initiated by cerebral cortex, but controlled by basal ganglia
  - **Conscious movements** (cognitive control of activity)
  - **Subconscious movements** (take place during trained motor activities, i.e. skilled activities such as writing)
- Control of **Reflex Muscular Activity** (particularly **visual** and **labyrinthine reflexes** are important in maintaining the **posture**)
- Control of **Automatic Associated Movements** (movements which take place along with some motor activities, i.e. swing of the arms while walking)

Functions of Basal Nuclei (Ganglia)





Role of basal ganglia in subconscious execution of learned patterns of movement

Role of basal ganglia in cognitive planning of movement

Disorders of Basal Nuclei (Ganglia)

Parkinson disease

- **Static tremor** or resting tremor (occurs during rest, disappears during work)
- **Slowness of movements** (bradykinesia), difficulty in the initiation of voluntary activity (akinesia) or the voluntary movements are reduced (hypokinesia).
- **Absence of the automatic associate movements**, the face becomes mask-like
- **Rigidity of limbs** (increased muscle tone, affects both flexor and extensor muscles equally)
- **Loose of the normal gait**.
- **Speech problems**

Chorea (abnormal involuntary movement, rapid jerky movements, mostly involves the limbs)

Athetosis (slow rhythmic and twisting movements)

Huntington Chorea (chorea, hypotonia and dementia)

The Cerebral Cortex

- **Neocortex** is the phylogenetically new structure of cerebral cortex. Has six layers.

- **Allocortex** is the phylogenetically oldest structure of cerebral cortex. It has **less than six layers** of structures. It is divided into **two divisions** namely, **archicortex** and **paleocortex**, which form the parts of **limbic system**

The Cerebral Cortex

Cerebral cortex consists of **gray matter** that surrounds the deeper white matter. Neocortex is formed by **six layers** of structures

- I – **molecular** layer (small fusiform cells, dendrites or axons from cells)
- II – **external granular** layer (large number of round, polygonal or triangular small cells. Dndrites of these cells pass into molecular layer, axons end in the deeper layers)
- III – **external pyramidal** layer (small pyramidal cells)
- IV – **internal granular** layer (smaller cells of stellate type, layer contains many horizontal fibers)
- V – **internal pyramidal** layer (large pyramidal cells, well develop in precentral (**motor**) cortex. Pyramidal cells in this region are otherwise known as **Betz cells** or giant cells. Axons pass out of cortex)
- VI – **polymorphous** (multiform) layer (small spindle-shaped cells)
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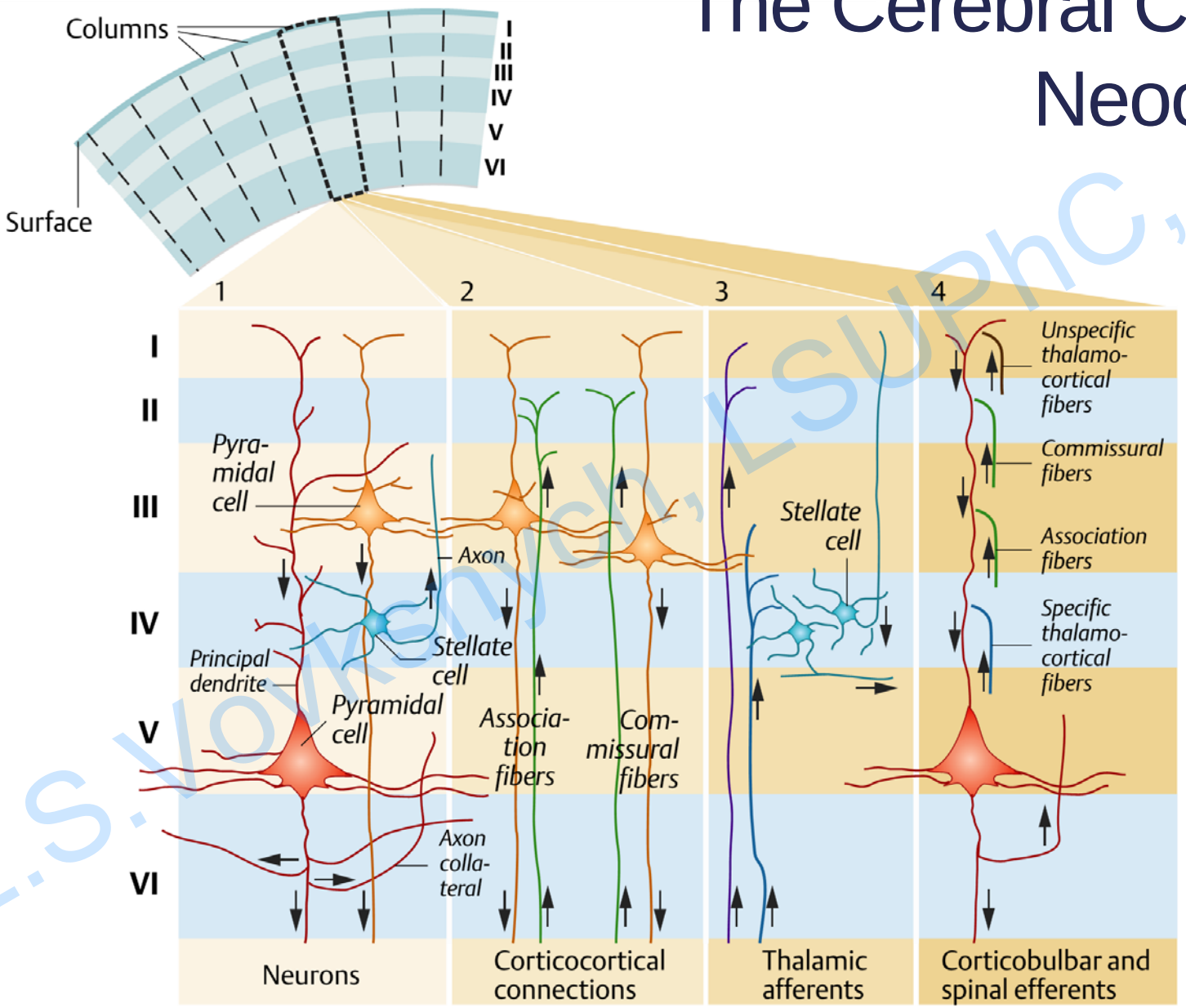
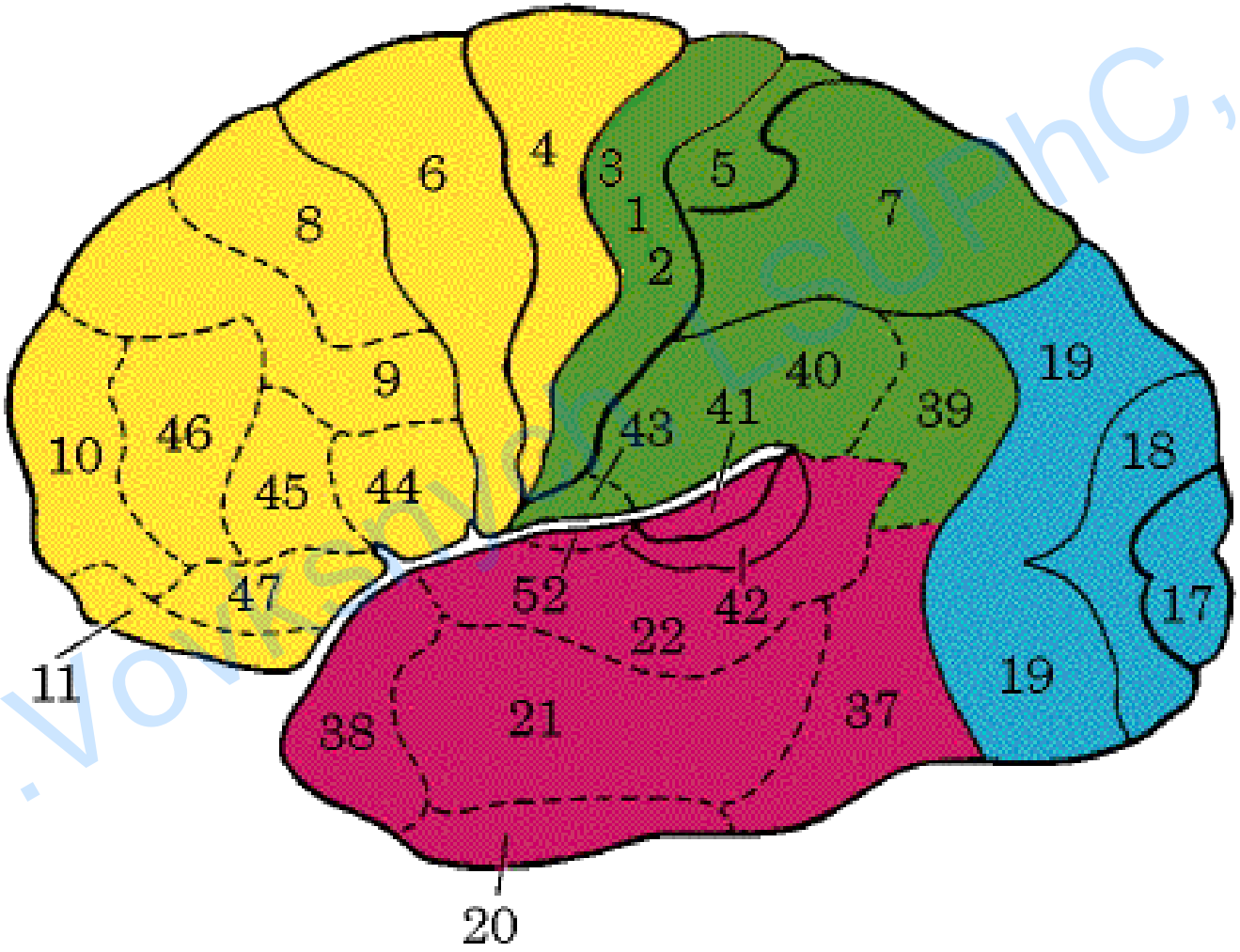
The Cerebral Cortex. Neocortex



Brodmann area of Cerebal Cortex

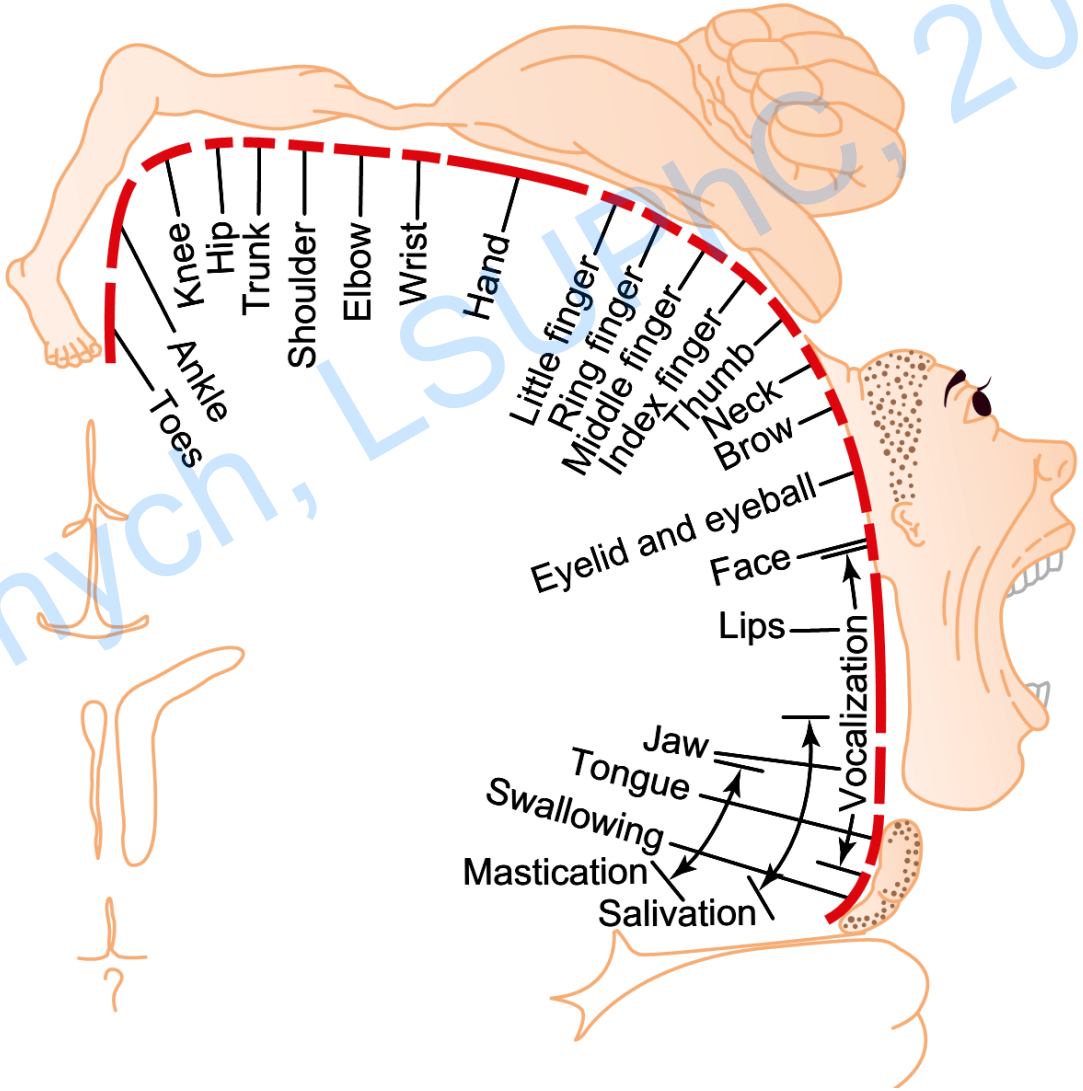


The Cerebral Cortex. Motor cortex

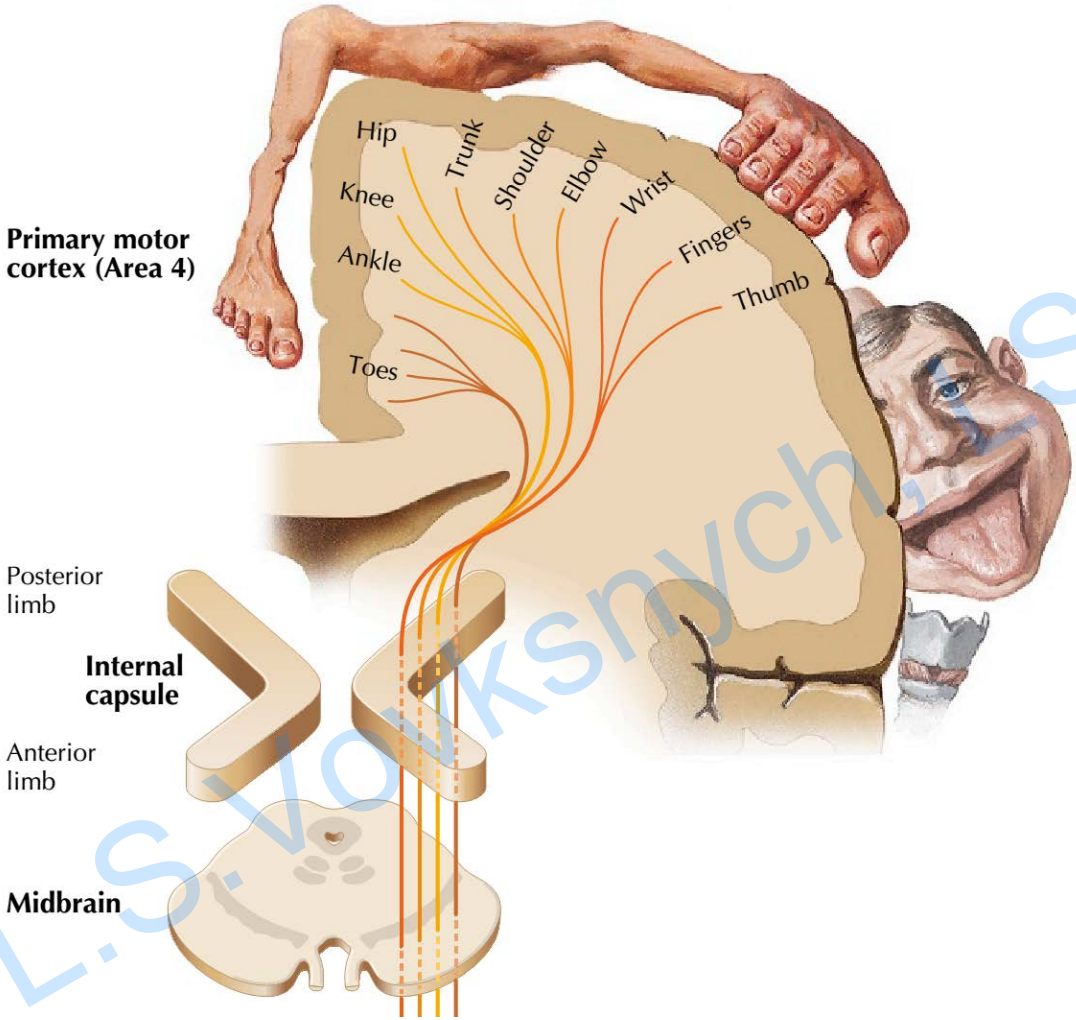
- **Primary motor area** extends throughout the **precentral gyrus** (Areas 4 and 4S)
- The **giant pyramidal cells** (**Betz cells**) are present in ganglionic layer
- Fibers of pyramidal tracts arise from the Betz cells and form **corticospinal tracts** to motor neurons in anterior gray horn of opposite side
- Fibers **are also projected to** corpus striatum, red nucleus, thalamus, subthalamus, pontine nuclei and reticular formation
- Primary motor area is concerned with **initiation of voluntary movements and speech**

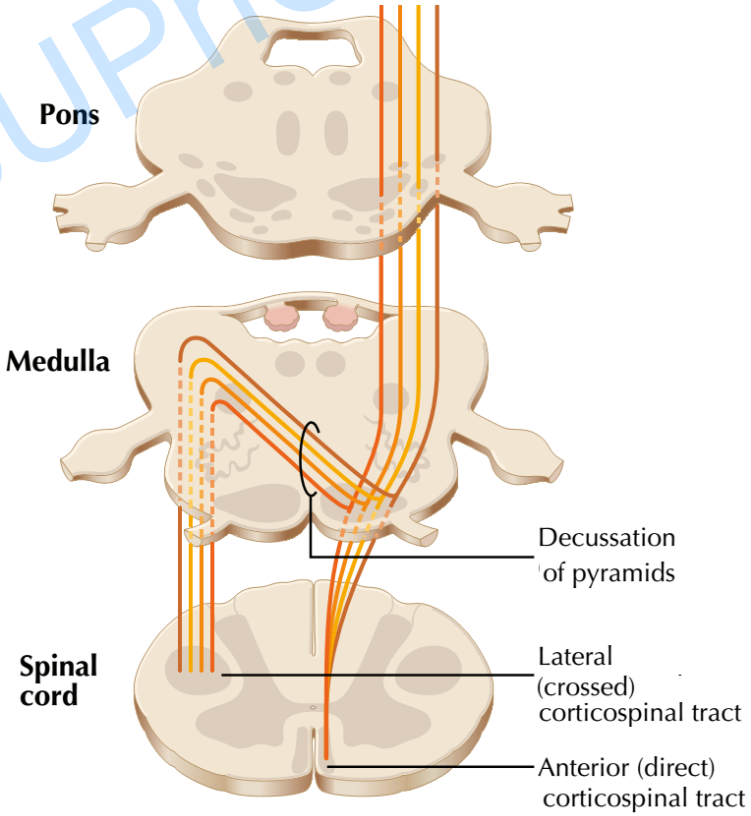
Motor Cortex

Degree of **representation of the different muscles** of the body in the motor cortex



Corticospinal tract





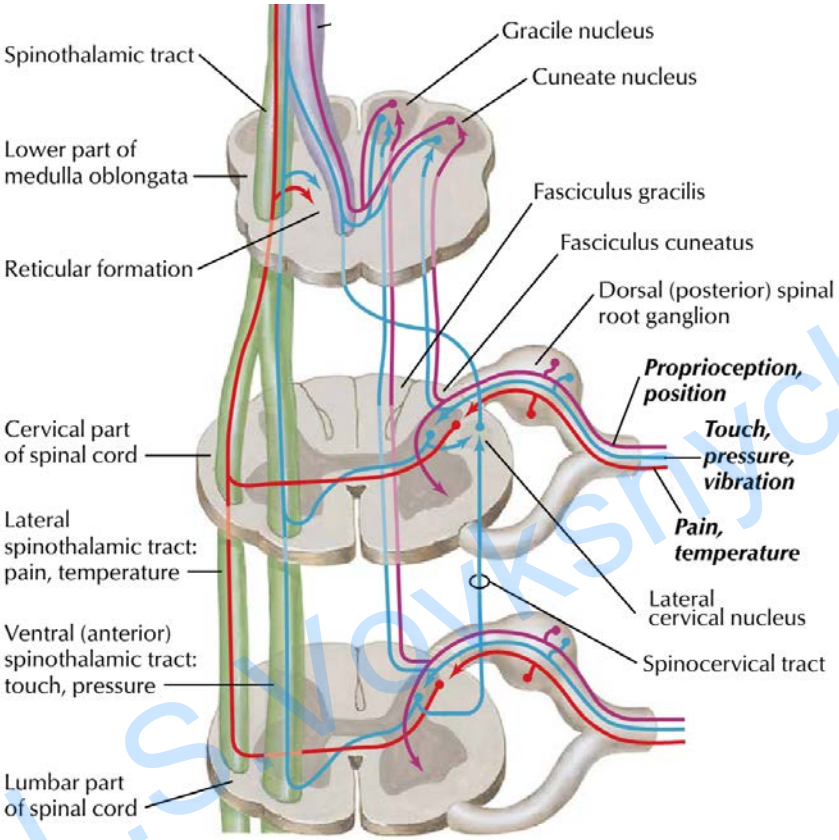
Premotor Cortex

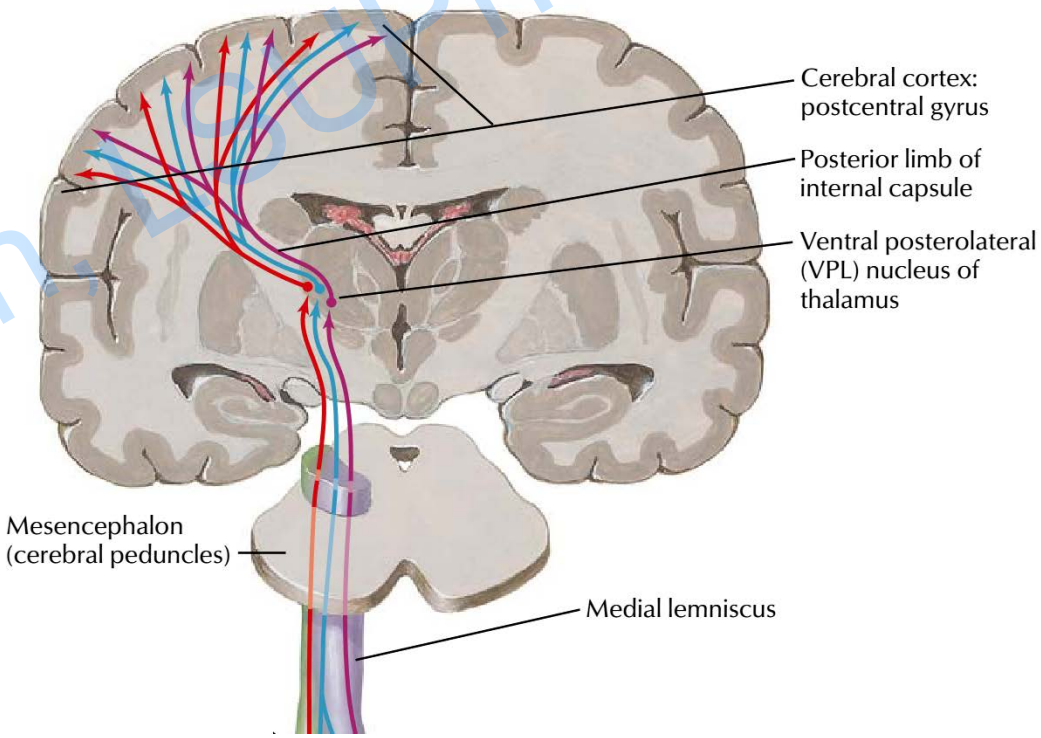
- **Premotor area** includes areas 6, 8, 44 and 45, is **anterior to primary motor area** in the precentral cortex.
- It is concerned with **coordination of movements** initiated by area 4.
- It helps to make the **skilled movements** more accurate and smooth
- Initiates the voluntary scanning **movements of eyeballs** independent of visual stimuli
- **Broca area** (motor area for speech, areas 44 and 45) is responsible for movements of tongue, lips and larynx, which are **involved in speech**

Sensor cortex. Somatosensory area

- Somatosensory area - in the posterior lip of central sulcus, in the **postcentral gyrus** (areas 3, 1 and 2)
- Responsible for perception and integration of **cutaneous and kinesthetic sensations**. It receives sensory impulses from cutaneous receptors (touch, pressure, pain, temperature) and proprioceptors of opposite side through thalamic radiation
- Sends sensory **feedback** to the premotor area
- Somesthetic association area is situated posterior to postcentral gyrus (areas 5 and 7)
- Is concerned with synthesis of various sensations perceived by somesthetic area

Somatosensory system of the body





Sensor cortex

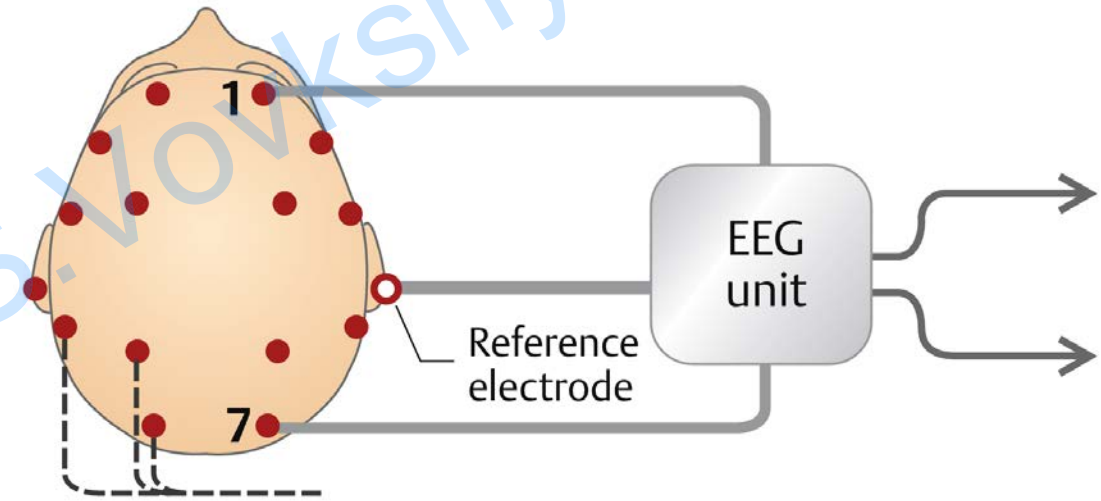
- **Primary auditory area** (Areas 41 and 42 of superior temporal gyrus) is concerned with the perception of auditory sensation (sound). **Wernicke area** is responsible for the interpretation of auditory sensation
- **Auditory association area** (area 22) is concerned with interpretation of auditory sensation
- **Primary visual area** (area 17) concerned with **perception** of visual sensation
- **Secondary visual area** (area 18) concerned with **interpretation** of visual sensation and storage of memories of visual symbols

Association area of Cortex

- **Prefrontal cortex** is the **anterior part of frontal lobe** of cerebral cortex, in front of areas 8 and 44
- It forms the **center for the higher functions** like emotion, learning, memory and social behavior.
- It is the center for **planned actions**, is the seat of **intelligence**
- It is responsible for the **personality** of the individuals

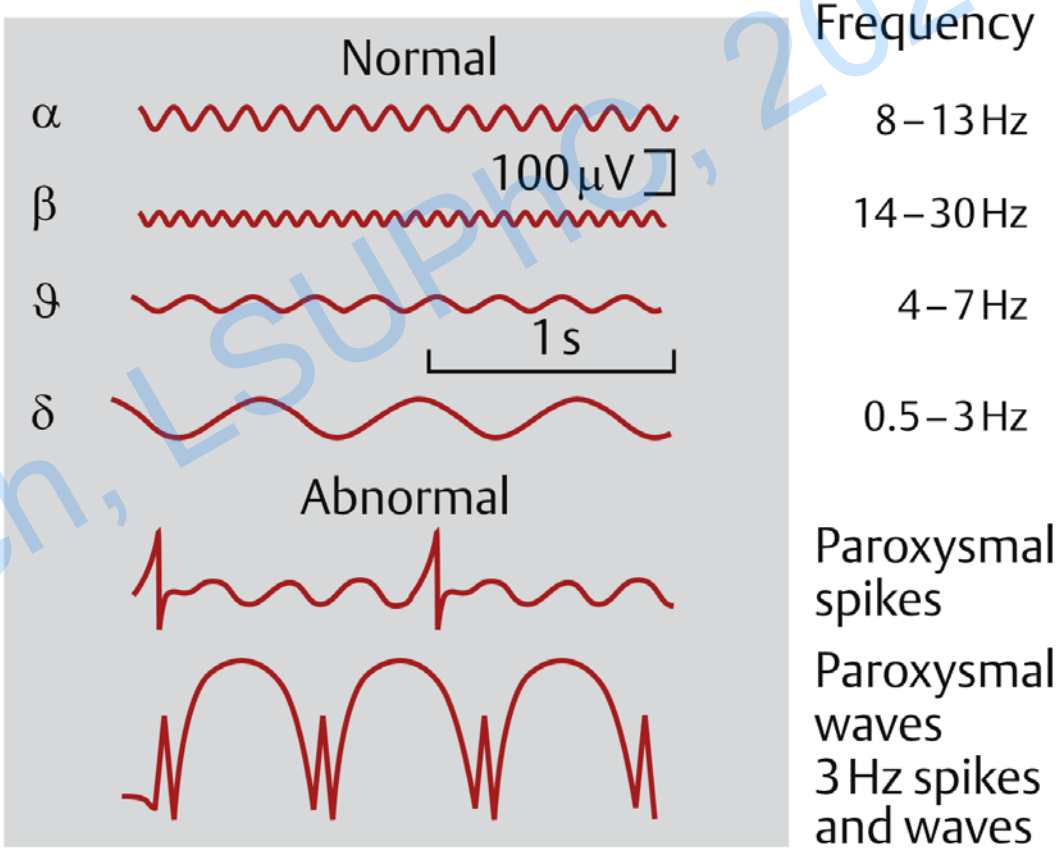
Electroencephalography (EEG)

- **Collective fluctuations** of electrical potentials (brain waves) in the cerebral cortex can be recorded by **electroencephalography** using **electrodes** applied to the **skin over the cranium**
- The electrical activity level can be distinguished based on the **amplitude** and **frequency** of the waves.



EEG waves

- **α waves** (10 Hz, 50 μV) predominate when subject is **awake and relaxed** (with eyes closed)
- **β waves** (20 Hz) appear when the eyes are opened, other **sensory organs are stimulated**, or the subject solves problem
- **γ waves** (30 Hz) appear during **learning activity**
- **θ waves** appear when drowsiness **descends to sleep**
- **δ waves** appear during **deep sleep**



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