DIAGNOSTIC METHODS IN NERVOUS SYSTEM

pathological physiology seminar

Outline

Morphological investigation methods (imaging)

1 Computational tomography

2 Positron emission tomography (PET)

3 (Nuclear) magnetic resonance

4 Functional magnetic resonance

Electrophysiological diagnostic methods

5 Electroencephalography (EEG)

6 Evoked potentials (EP)

7 Electromyography (EMG)

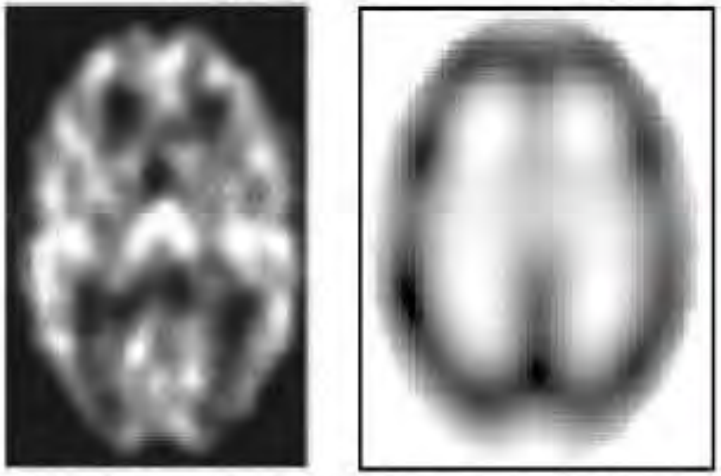
8 Other methods (electro-oculography, retinography, etc.)

Samples of imaging methods

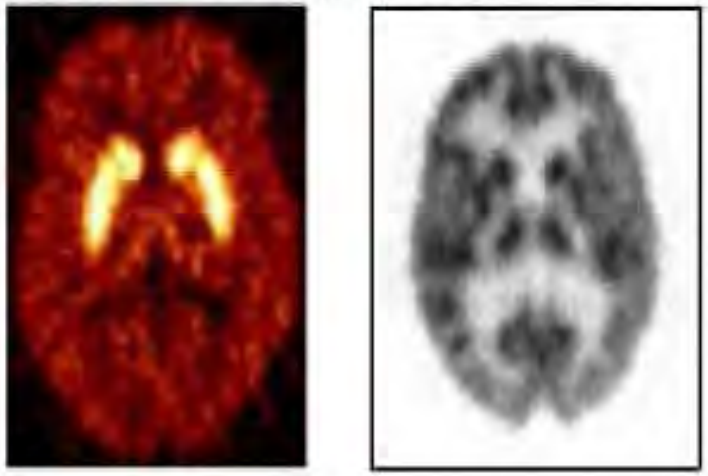
CT - rentgenová výpočetní tomografie

MR - tomografie magnetickou rezonancí

ultrazvukově zobrazení B (brightness) - mode



SPECT - jednofotonová emisní výpočetní tomografie



PET - pozitronová výpočetní tomografie

Computer tomography

Principle: One head with the X-ray source rotates on one side and another head with array of X-ray detector rotates on the other side of the skull. The radiodensity of individual pixels is recalculated from the summed densities as the two heads rotate and scan the skull from many angles. Numerical algorithms in computer are used to get the densities.

Spatial resolution: as sensitive as 1 mm. This method does not have ***time resolution***.

Application: White and gray matter, blood and cerebrospinal fluid are distinguished. Pathologic processes inside skull or spinal canal are visualized.

Positron emission tomography

Principle: Radioactive isotopes ^{11}C, ^{13}N, ^{15}O and ^{18}F emit positrones. They collide with electrons and emit two quanta of gamma rays.

Spatial resolution: 8 mm, ***time resolution***: no theoretical limit, in practice, only times in the range of 1 s are used.

Application: Application of radioactive deoxy-glucose marks tissues with active metabolism.

(Nuclear) magnetic resonance

Principle: Detects atoms with an odd atomic weight and also their neighboring atoms in chemical compounds. Amongst natural isotopes, especially ^{1}H, ^{14}N, ^{19}F, ^{23}Na and ^{31}P are useful, most of them ^{1}H.

Spatial resolution: 1 mm, ***time resolution***: no theoretical limit, in practice, only times in the range of 1 s are used

Application: Analogous, as in computer tomography. More sensitive for demyelinization processes.

Functional magnetic resonance (fMRI)

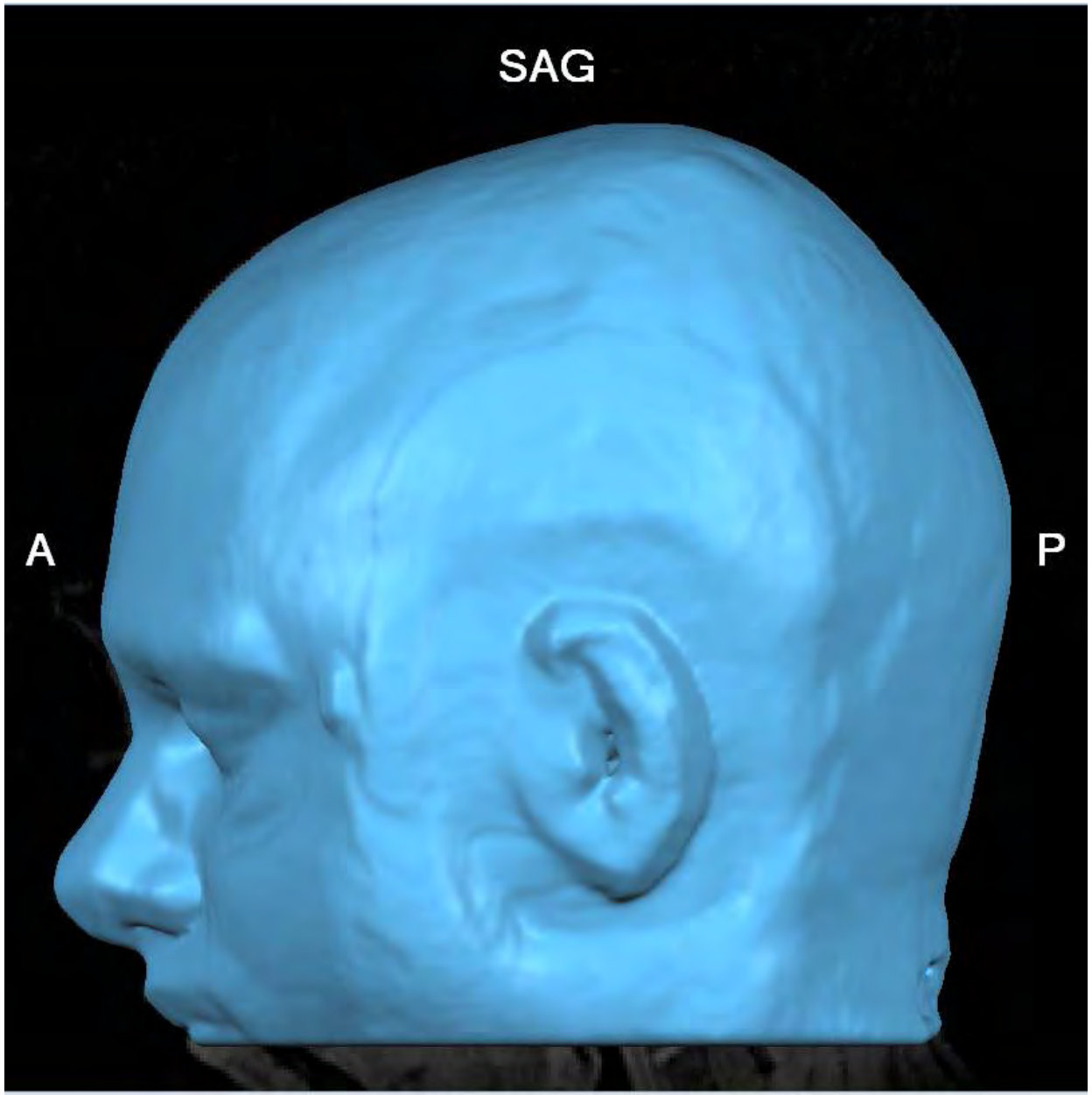
Principle: Detects BOLD (blood oxygen level dependent fMRI) signal.

Spatial resolution: 1 mm, ***time resolution***: no theoretical limit, in practice, only times in the range of 1 s are used

Application: Analogous, as in computer tomography. Shows a succession of areas as they are activated.

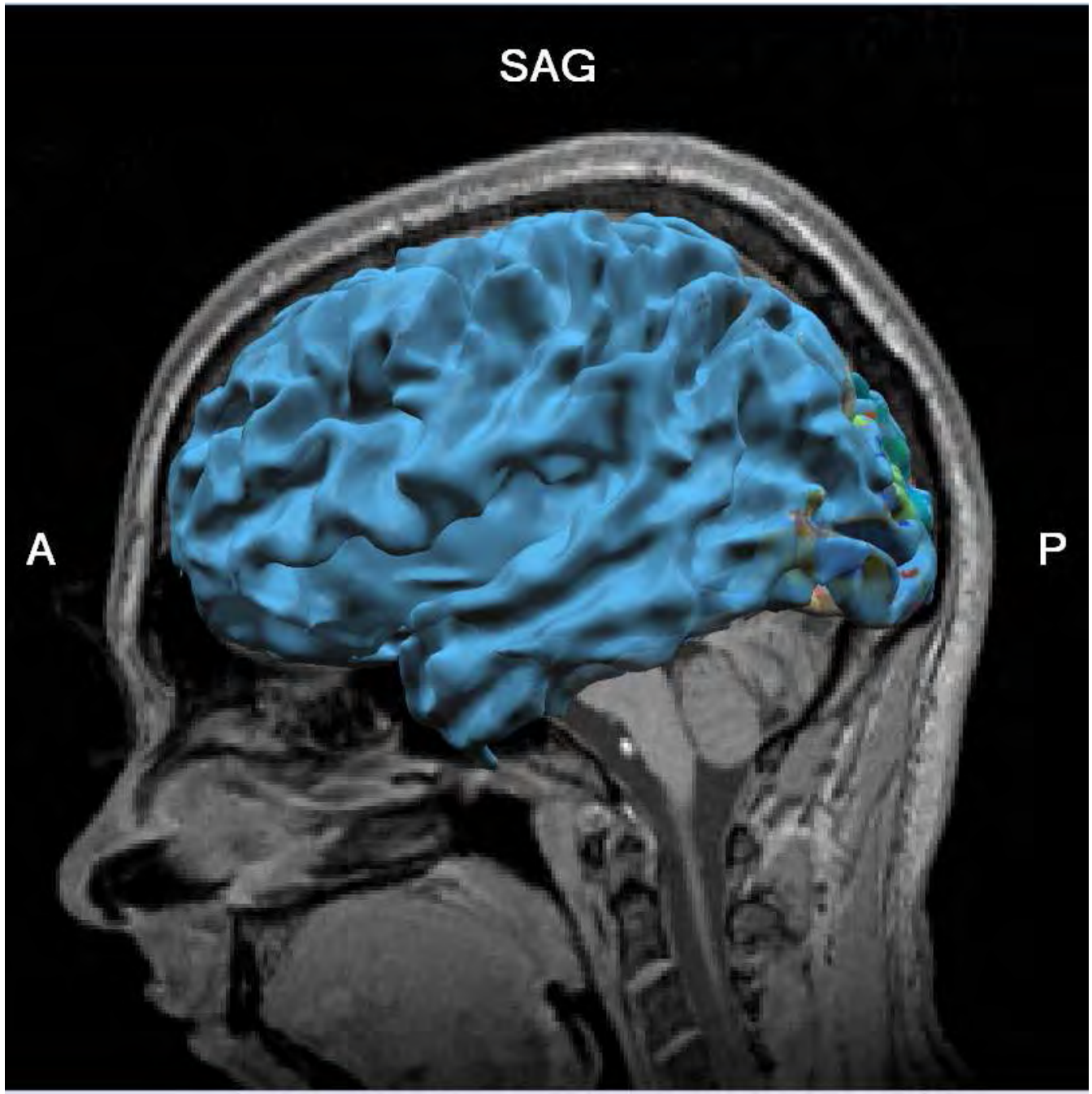
fMRI

Head surface shown by the „3.0 T Trio Siemens“ magnet



fMRI

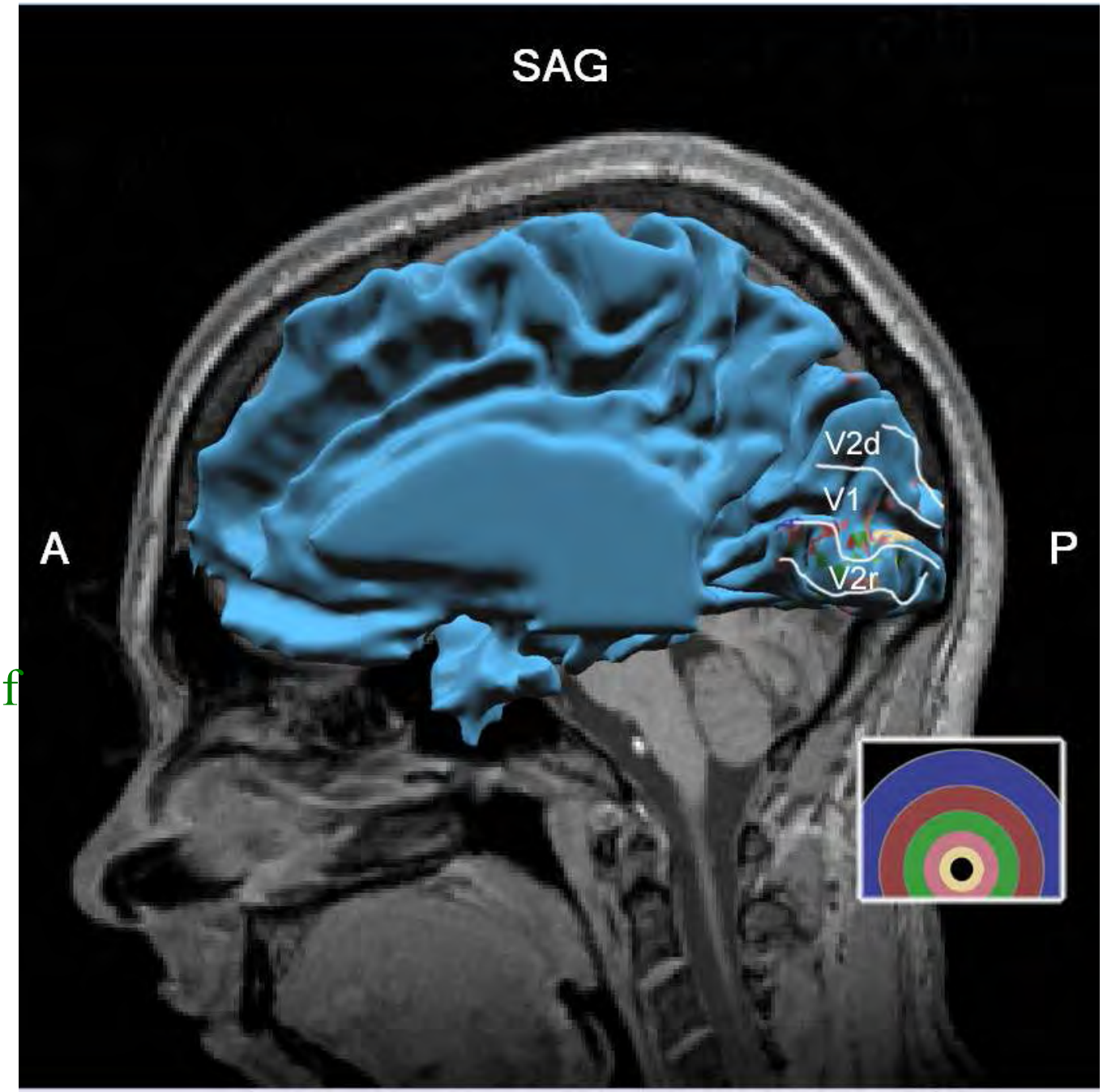
Outer surface of cerebral hemisphere is shown.

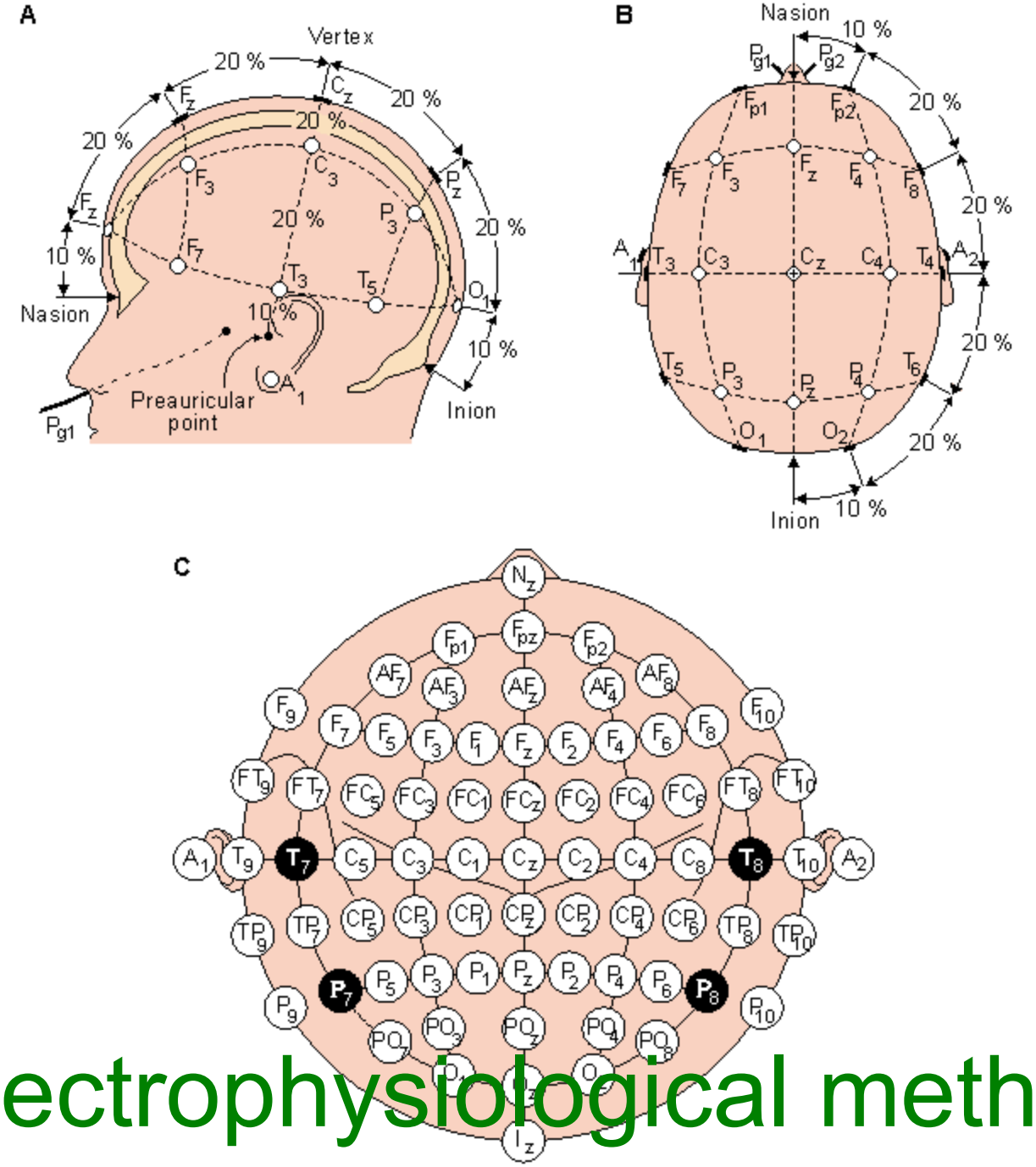


fMRI

Inner surface of cerebral hemisphere is shown.

Concentric color rings show stimulation in rings centered at the yellow spot of retina and color code shows its place in visual areas.





Electrophysiological methods

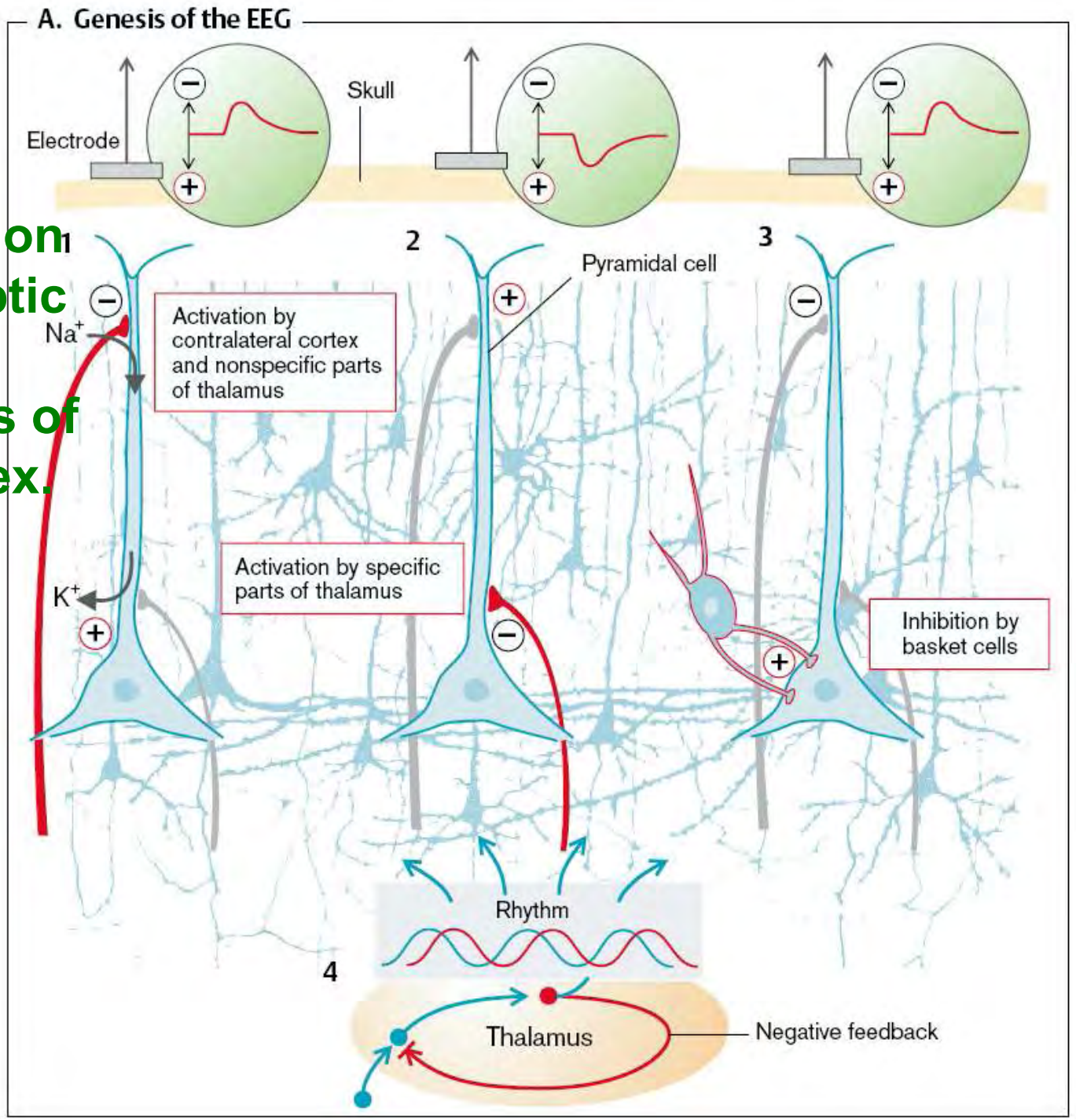
Electro-encephalo-graphy (EEG)

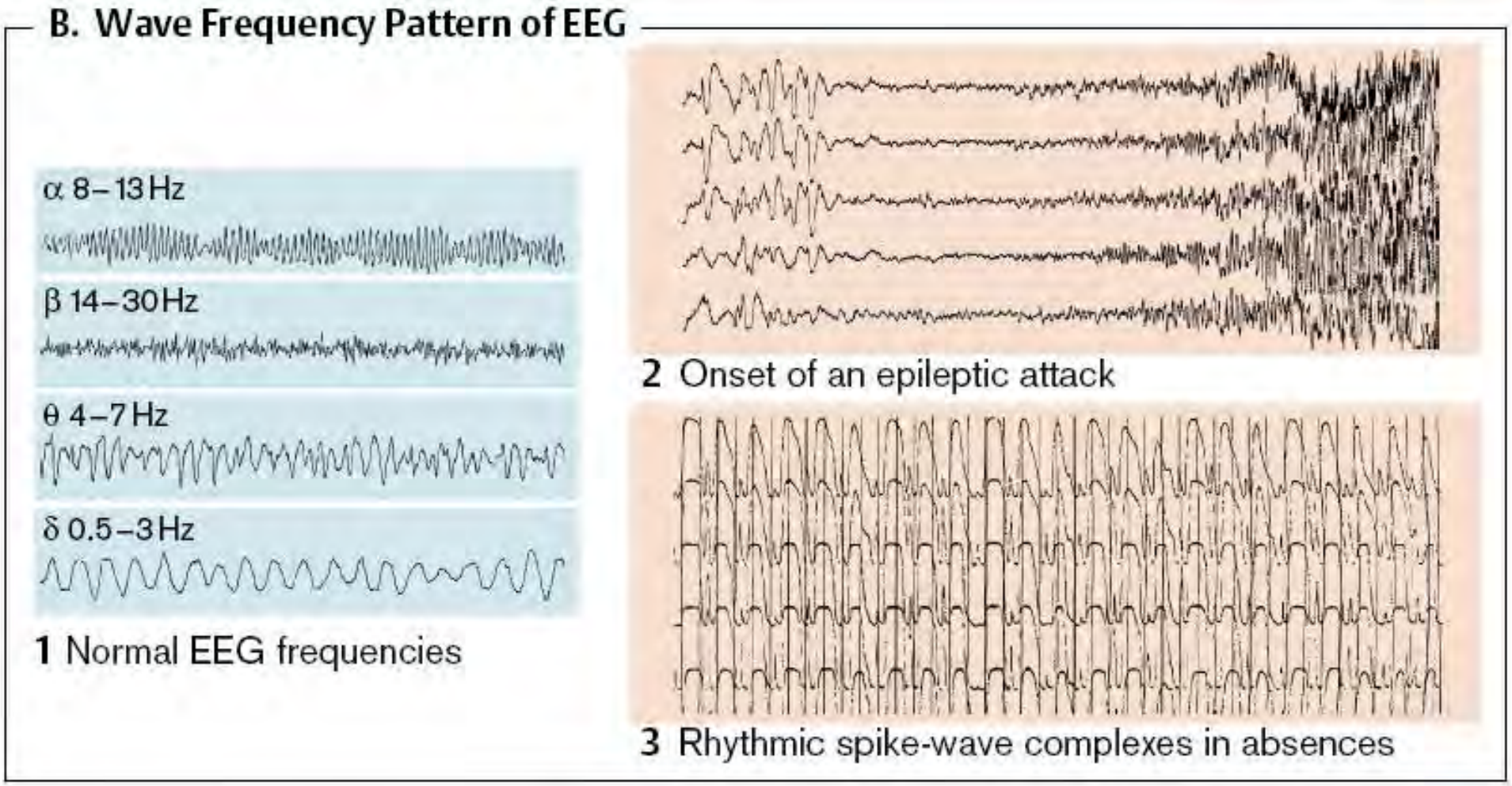
Principle: The EEG signal is result of net excitatory and inhibitory post-synaptic activity in surface layers of cerebral cortex. On the surface of the skull this is sometimes called macro-EEG, as compared to micro-EEG recorded at the cortex surface during surgeries.

Spatial resolution: due to crosstalks coarser than 1 cm, ***time resolution***: better than in imaging, in the range of 1 ms.

Application: Epilepsy, sleep disorders, also in investigation of sensory systems.

Summation and synchronization of post-synaptic potentials in surface layers of cerebral cortex.





Normal findings: EEG waves:

Alpha waves, 8-13 Hz, parieto-occipital region, marked in closed eyes

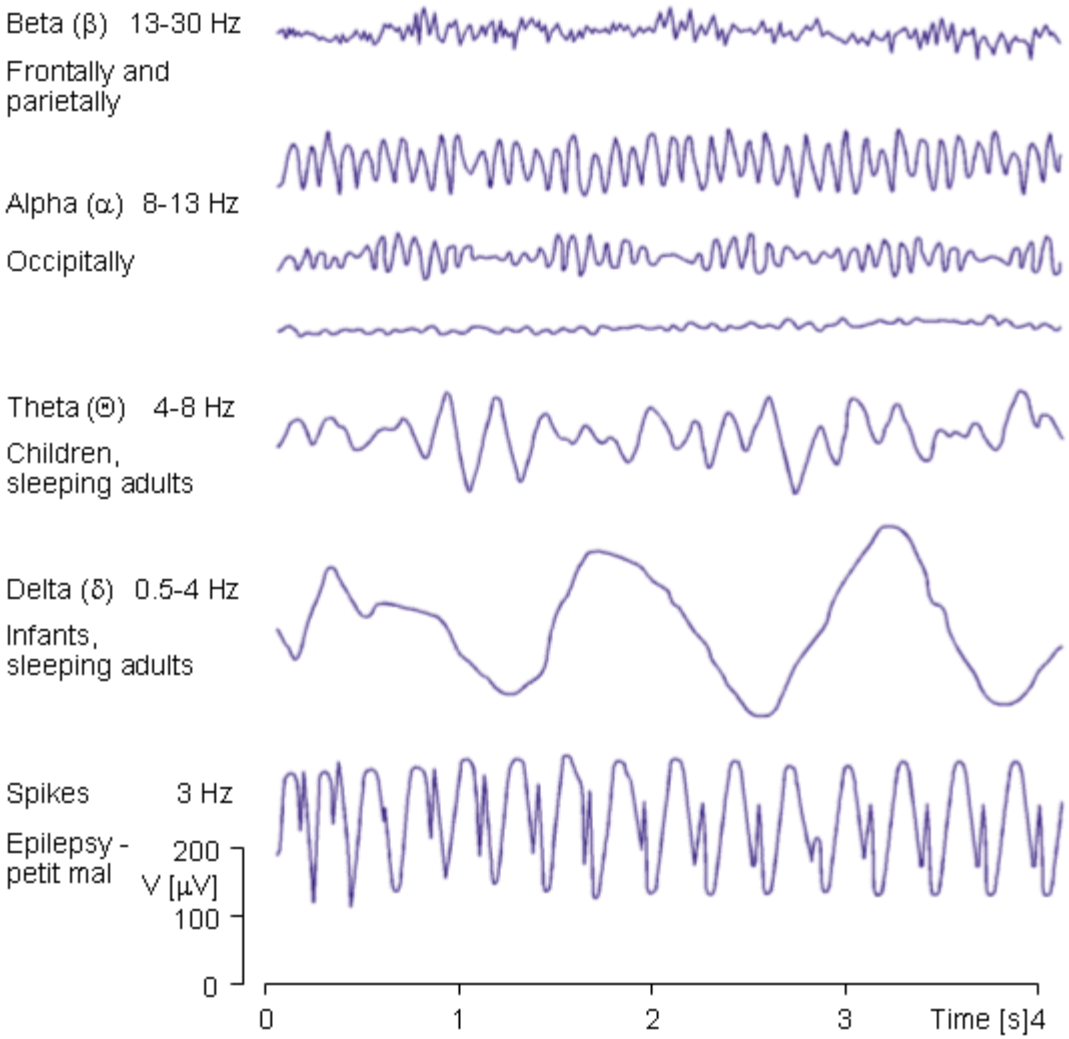
Beta waves, 14-30 Hz, frontal region

Gamma waves, 40-60 Hz, are not regularly used due to interference with electric power net.

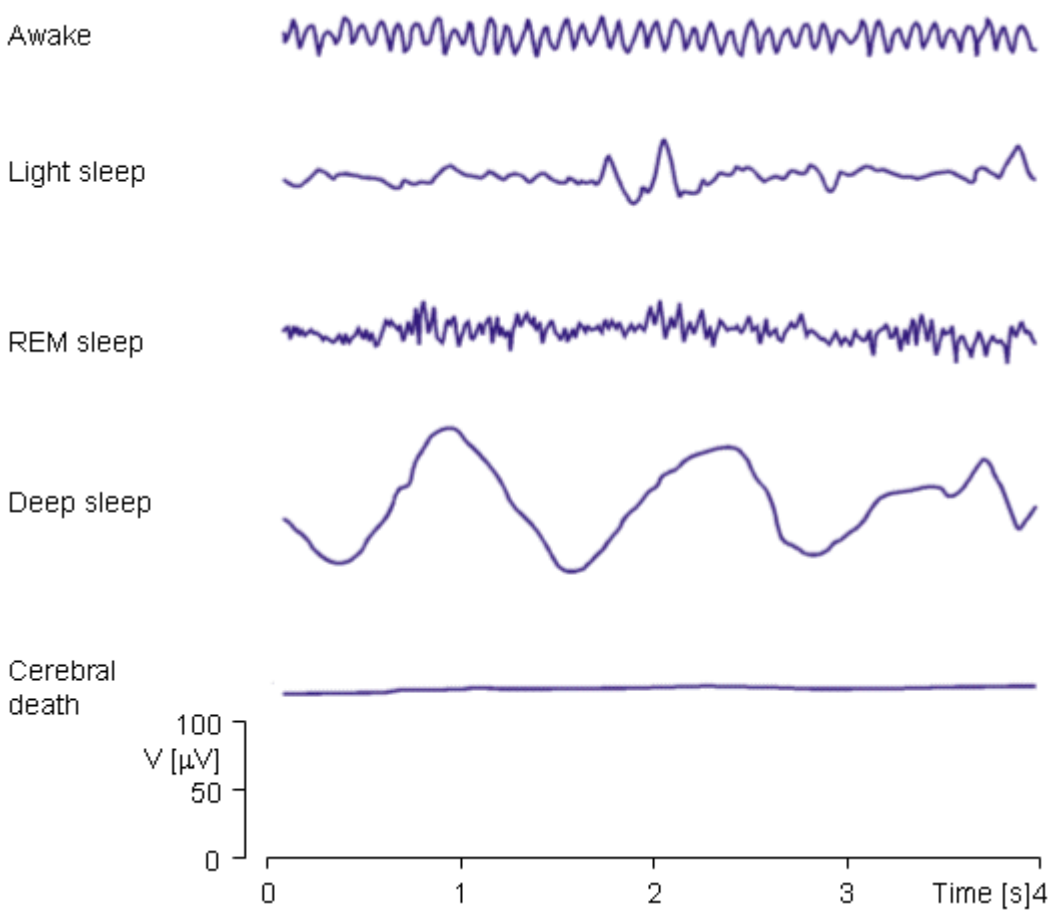
Delta waves, < 4 Hz, e.g in synchronous phase of sleep.

Theta waves, 4-7 Hz, e.g in synchronous phase of sleep.

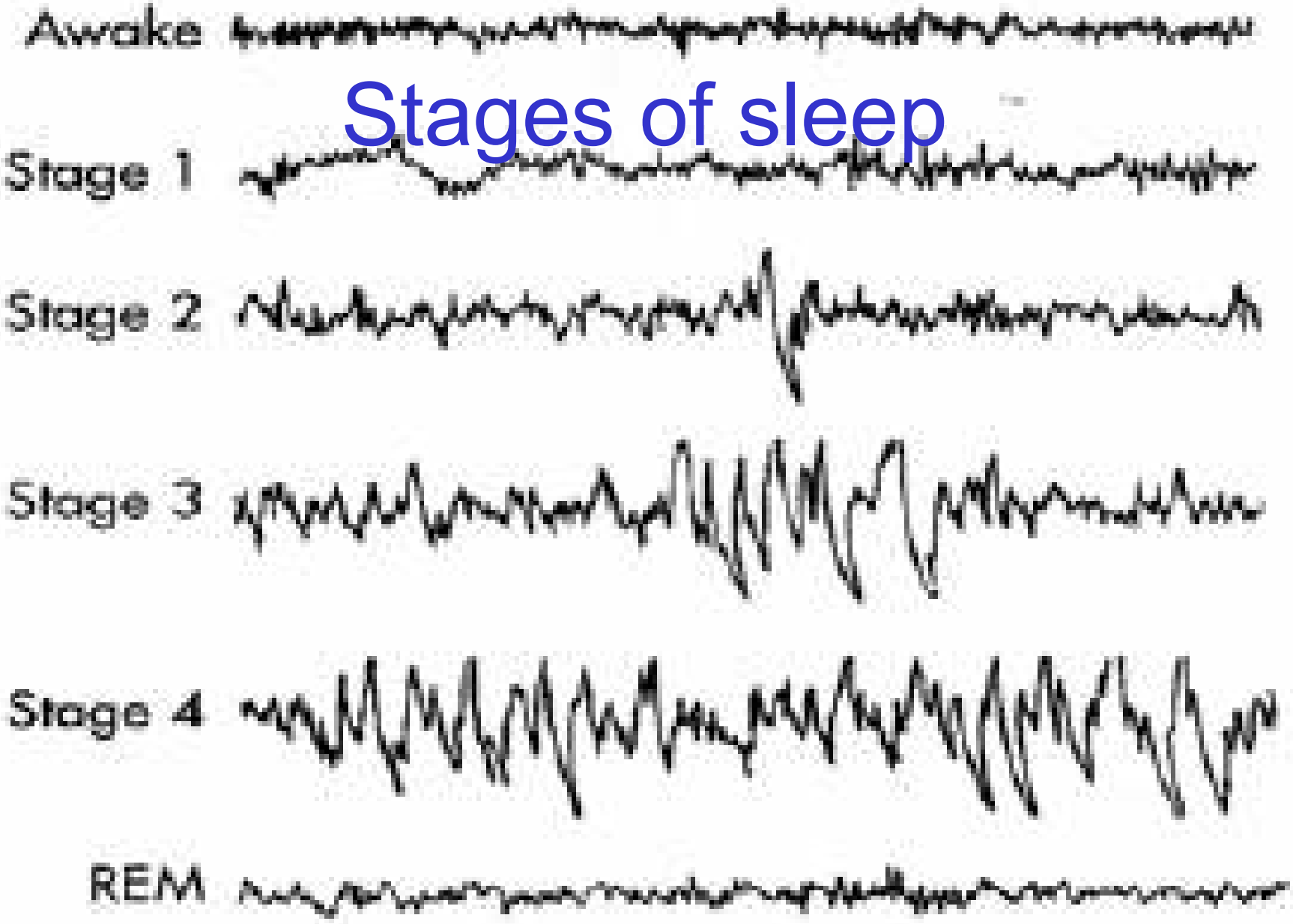
EEG Waves


Beta (β) 13-30 Hz
Frontally and parietally
Alpha (α) 8-13 Hz
Occipitally
Theta (Θ) 4-8 Hz
Children, sleeping adults
Delta (δ) 0.5-4 Hz
Infants, sleeping adults
Spikes 3 Hz
Epilepsy - petit mal
200
V [μV]
100
0
0
1
2
3
Time [s]4

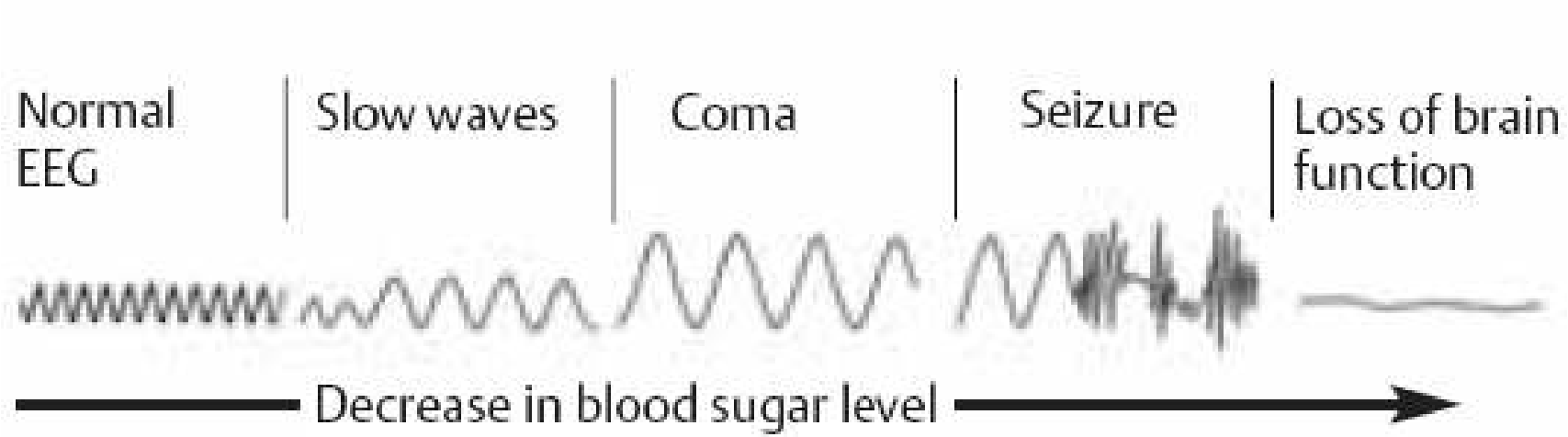
Wakefulness, sleep, death



Stages of sleep



Hypoglycemia



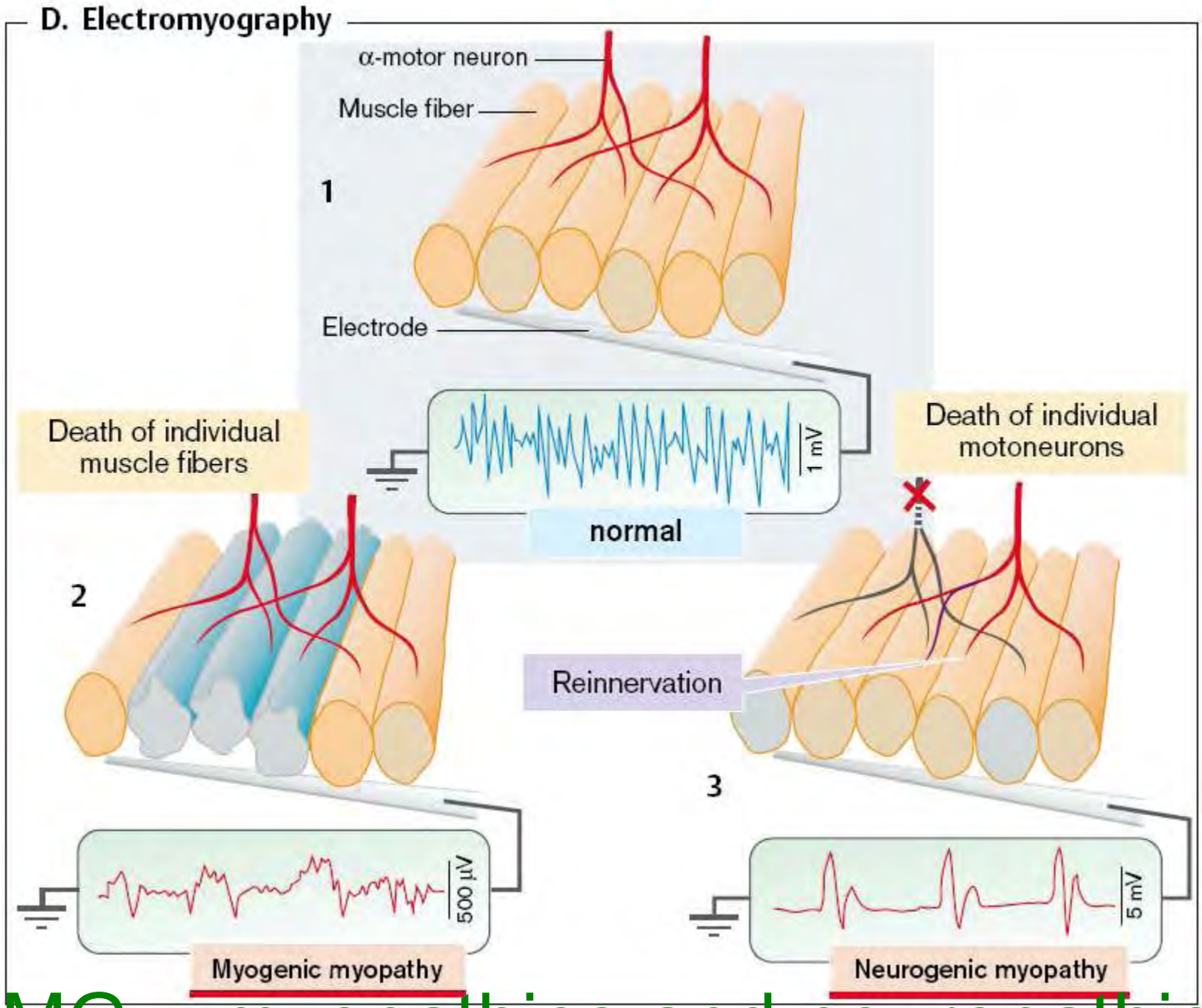
EEG changes in hypoglycemia

Electromyography (EMG)

Principle: Recording from needles, shows recruitment of muscle fibers by motoneuron stimulation, myo-pathies and neuro-pathies can be distinguished.

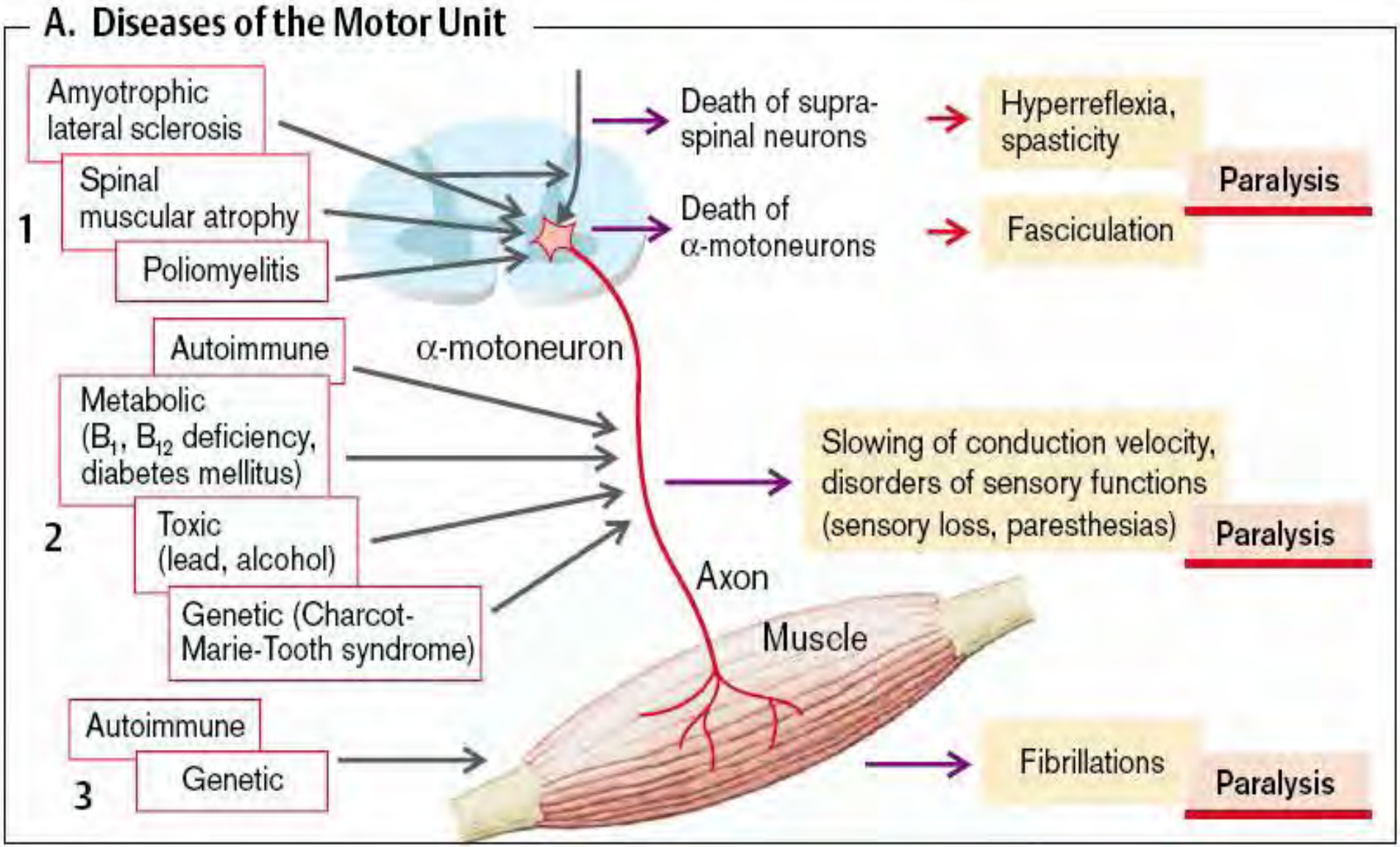
Spatial resolution, time resolution: as in EEG

Application: Disorders of neuro-motor unit.



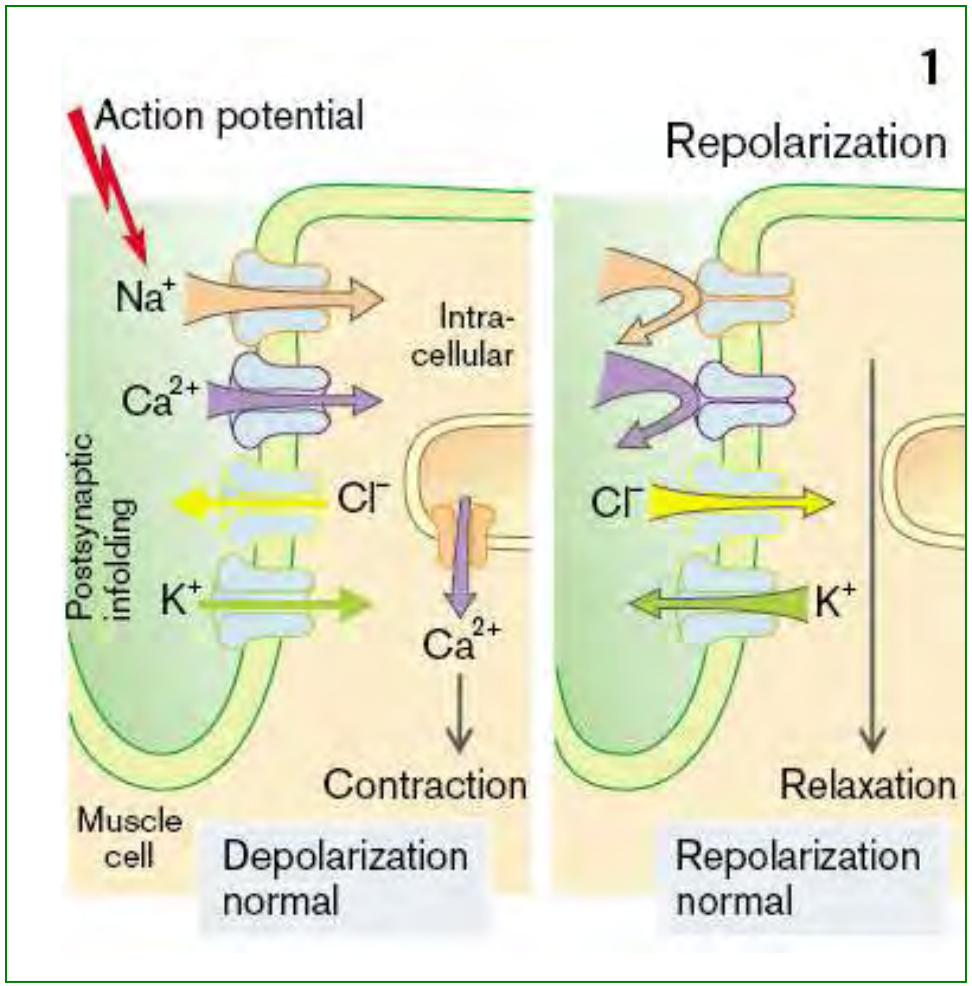
EMG – myopathies and neuropathies

Diseases of the motor unit

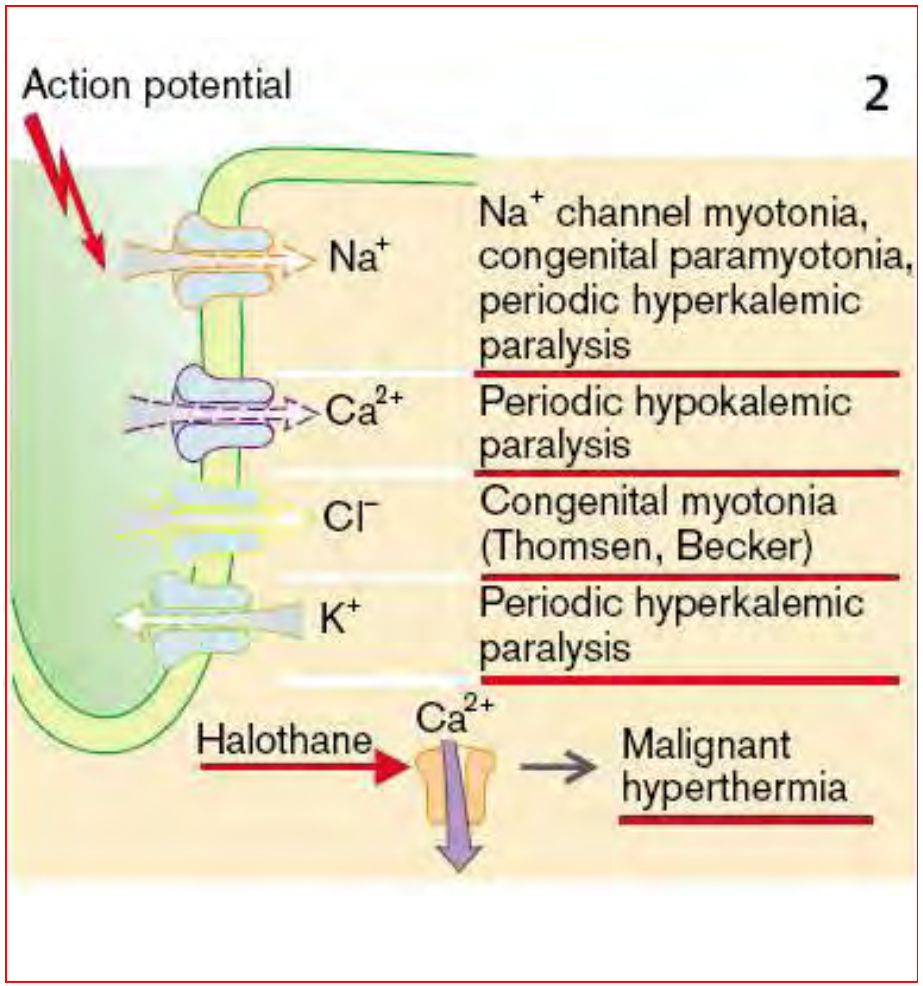


Myotonias

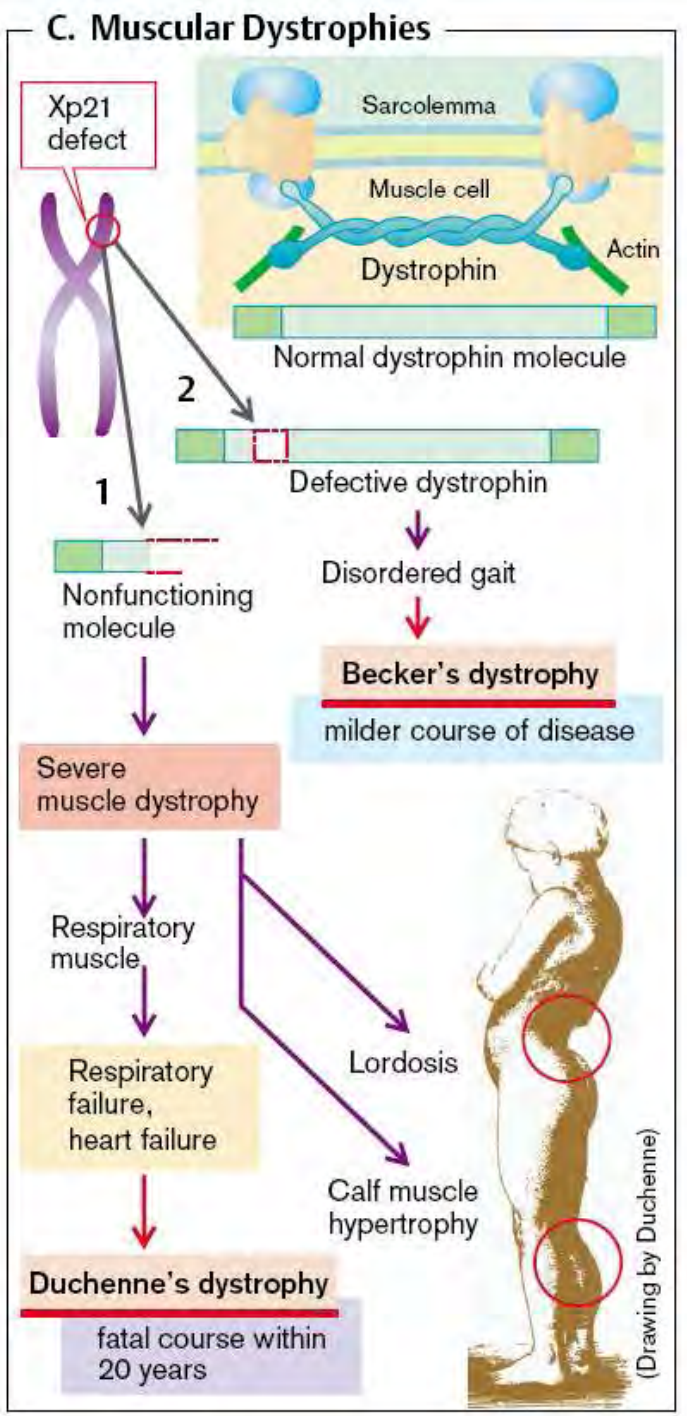
Norm



Pathology



Muscular dystrophies



E. Creatine Metabolism