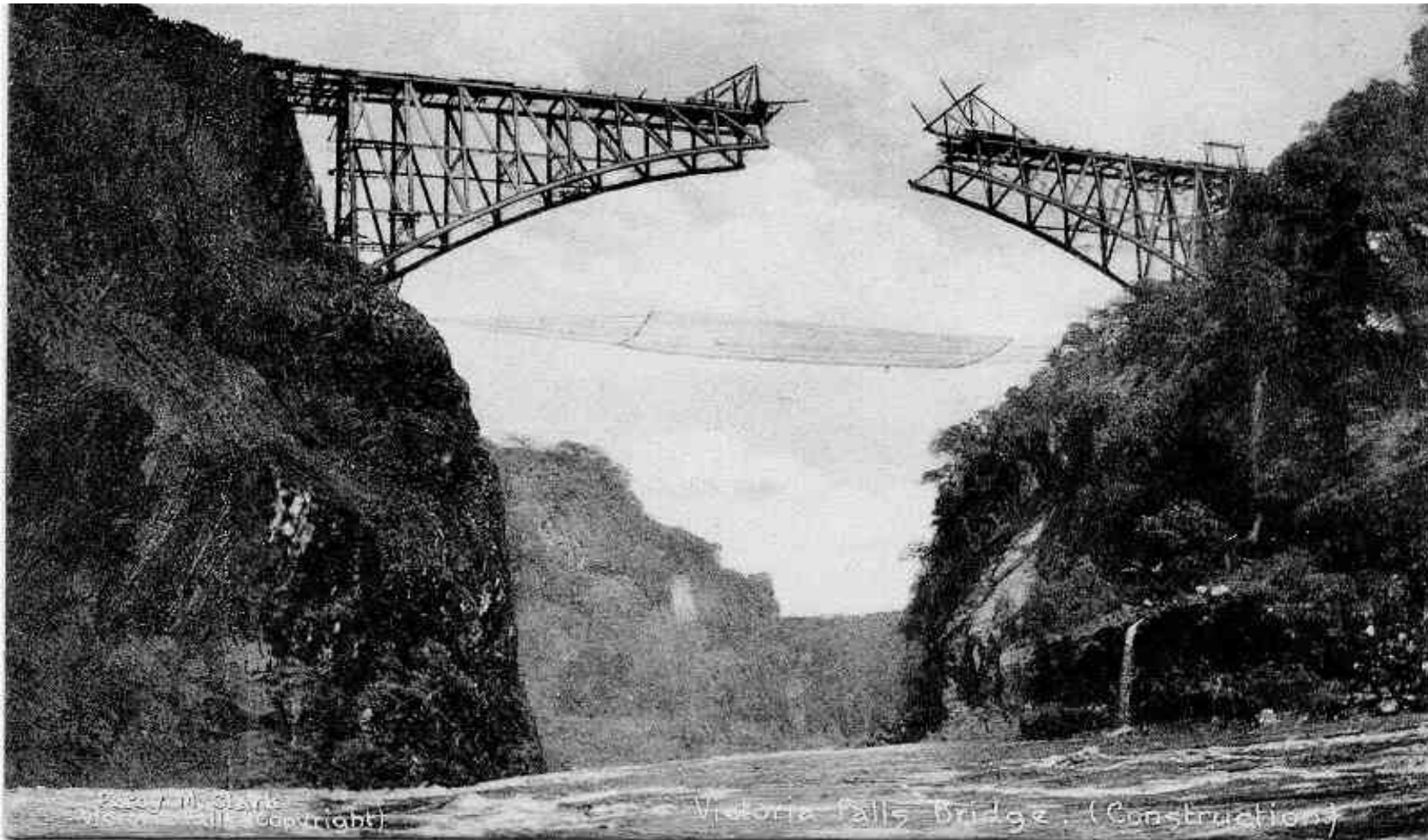


# NEUROINFORMATIKA

*Zoltán Somogyvári  
&  
László Zalányi*

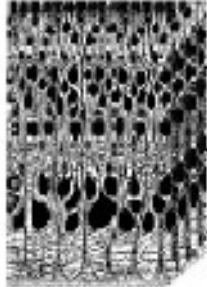
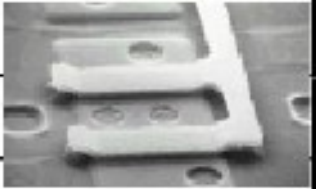
MTA Wigner Research Centre for Physics



# Computational Neuroscience



Structure – Dynamics – Implementation – Algorithm – Computation - Function

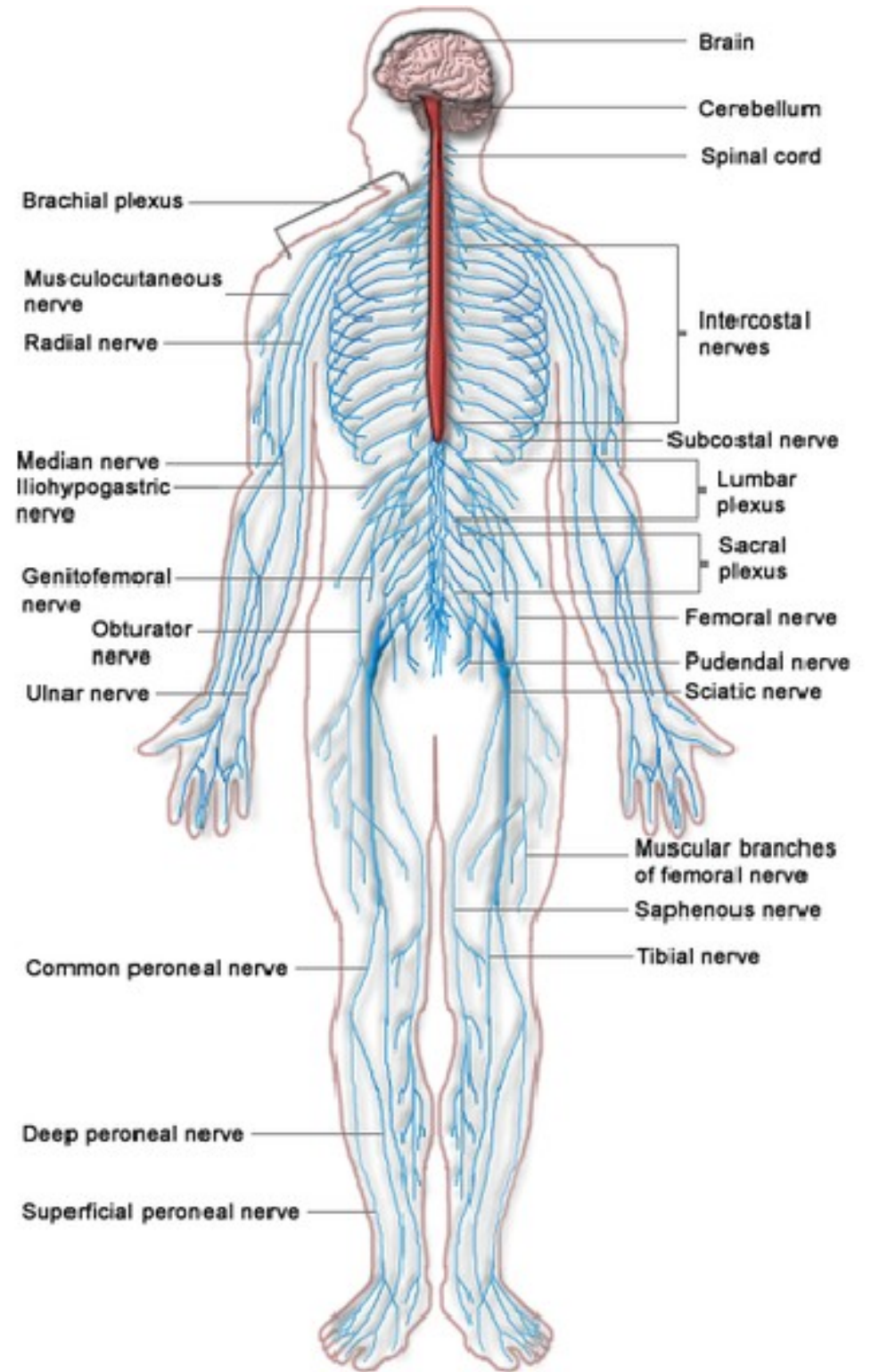
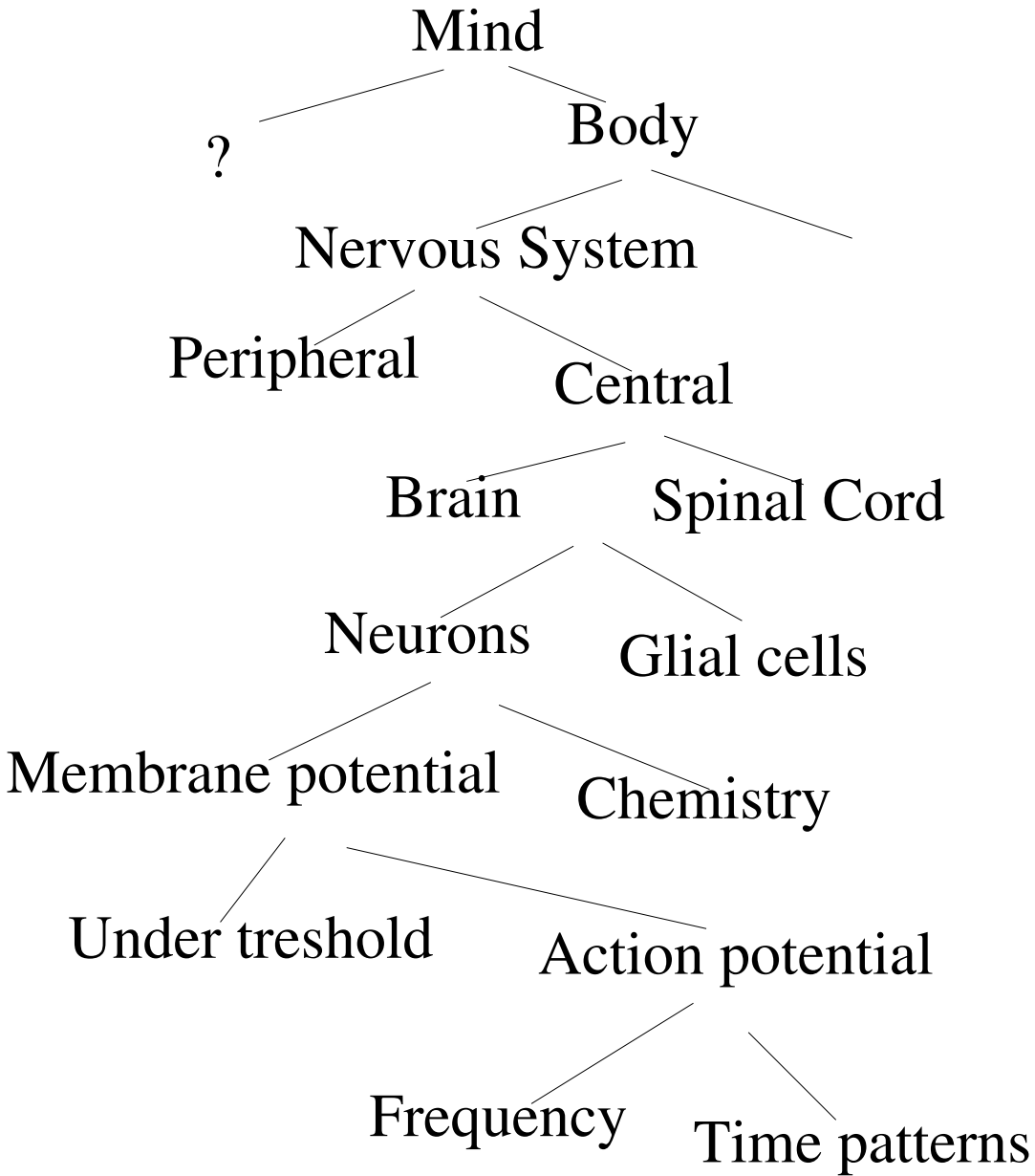
# The brain and the computer

	1 mm <sup>3</sup> of cortex		1 mm <sup>2</sup> of a CPU	
Number of units	50,000 neurons		1 million transistors	
Connections/unit	10,000		2	
Total connections	500 million		2 million	
Wiring	4 km of axons		0.002 km of wire	

	Whole brain		Whole CPU	
Weight	1.3 kg		~0.4kg	
Power	20 W		27 W	
Units	10 <sup>11</sup> neurons		10 <sup>8</sup> transistors	
connections	1 × 10 <sup>15</sup>		2 × 10 <sup>9</sup>	
wiring	8 million km of axons		2 km of wire	

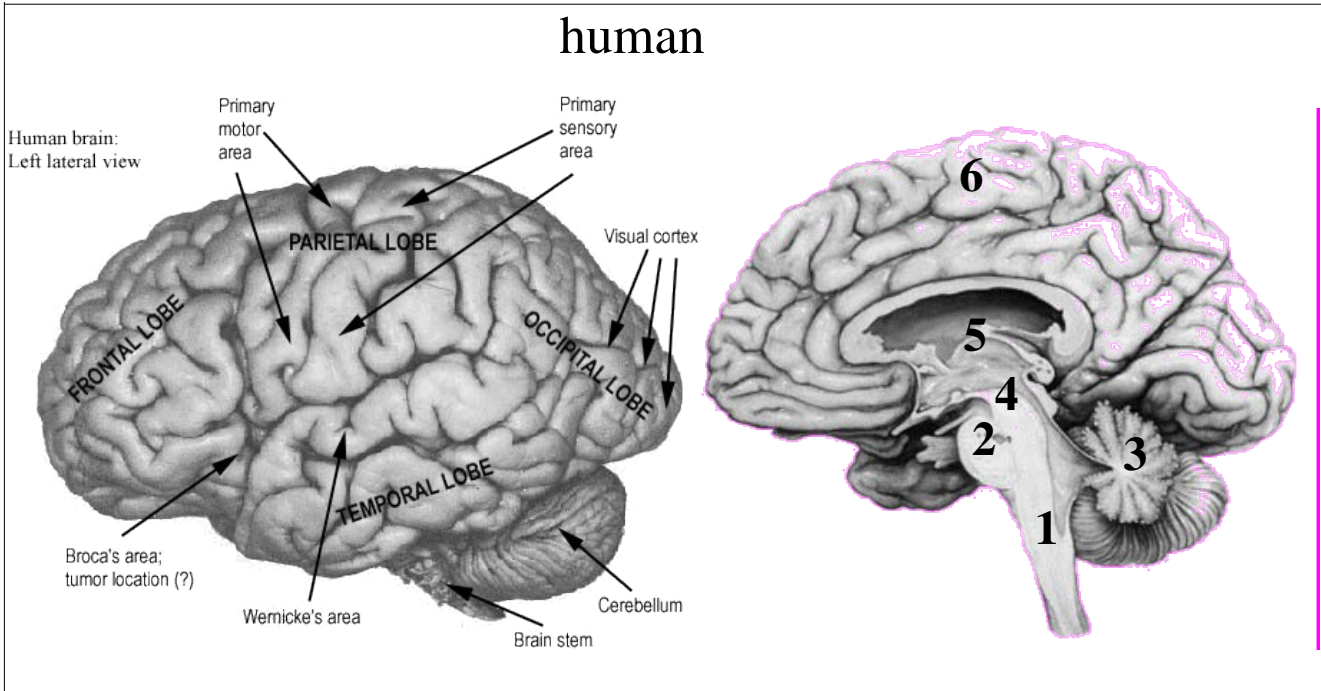
AMD Epyc: 170W, 13140 million transistors, 92million /mm<sup>2</sup>

# Hierarchy of description



# Brain of vertebrates (mammals)

as visible with naked eye



1. *medulla oblongata*

2. *pons*

3. *cerebellum*

4. *mesencephalon*

5. *metencephalon*

◆ *thalamus*

◆ *hypothalamus*

◆ *epithalamus*

6. *telencephalon*

◆ *ganglia basalis*

◆ *cortex*

■ *paleocortex*

■ *archicortex*

➢ *hippocampus, ...*

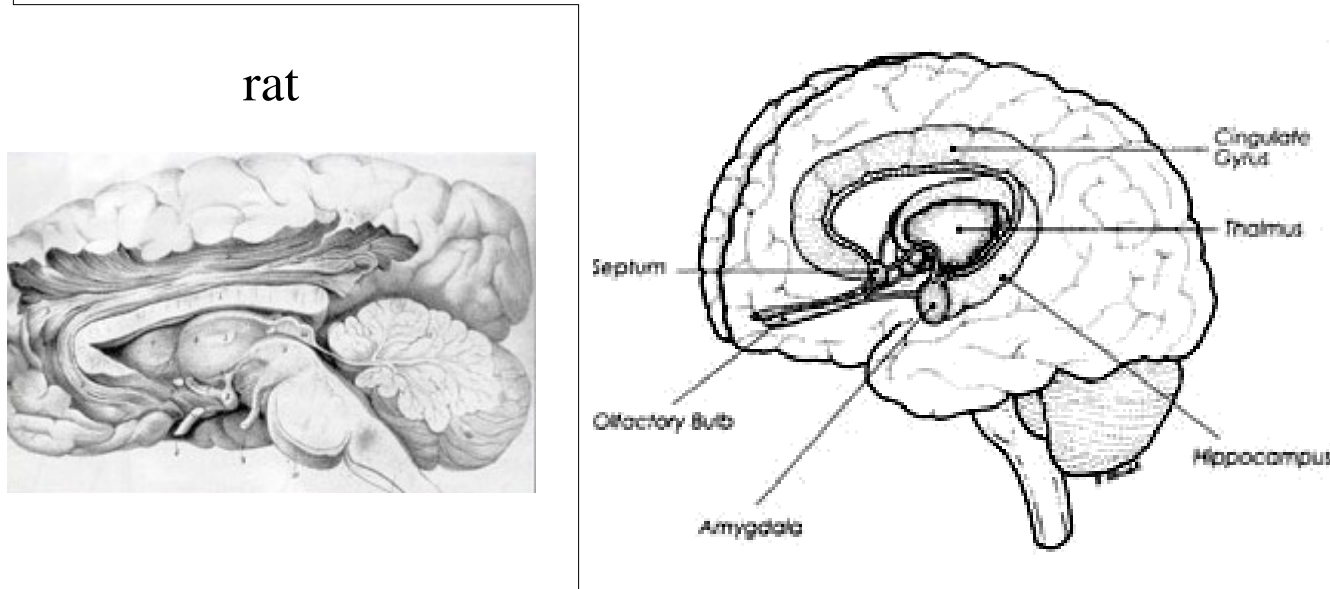
■ *neocortex*

➢ *lobus frontalis*

➢ *lobus parietalis*

➢ *lobus occipitalis*

➢ *lobus temporalis*





# Elementary unit of the nervous system: The neuron

## Parts of the neuron:

dendrite  
soma  
nucleus  
axon  
initial segment  
terminal

synapse

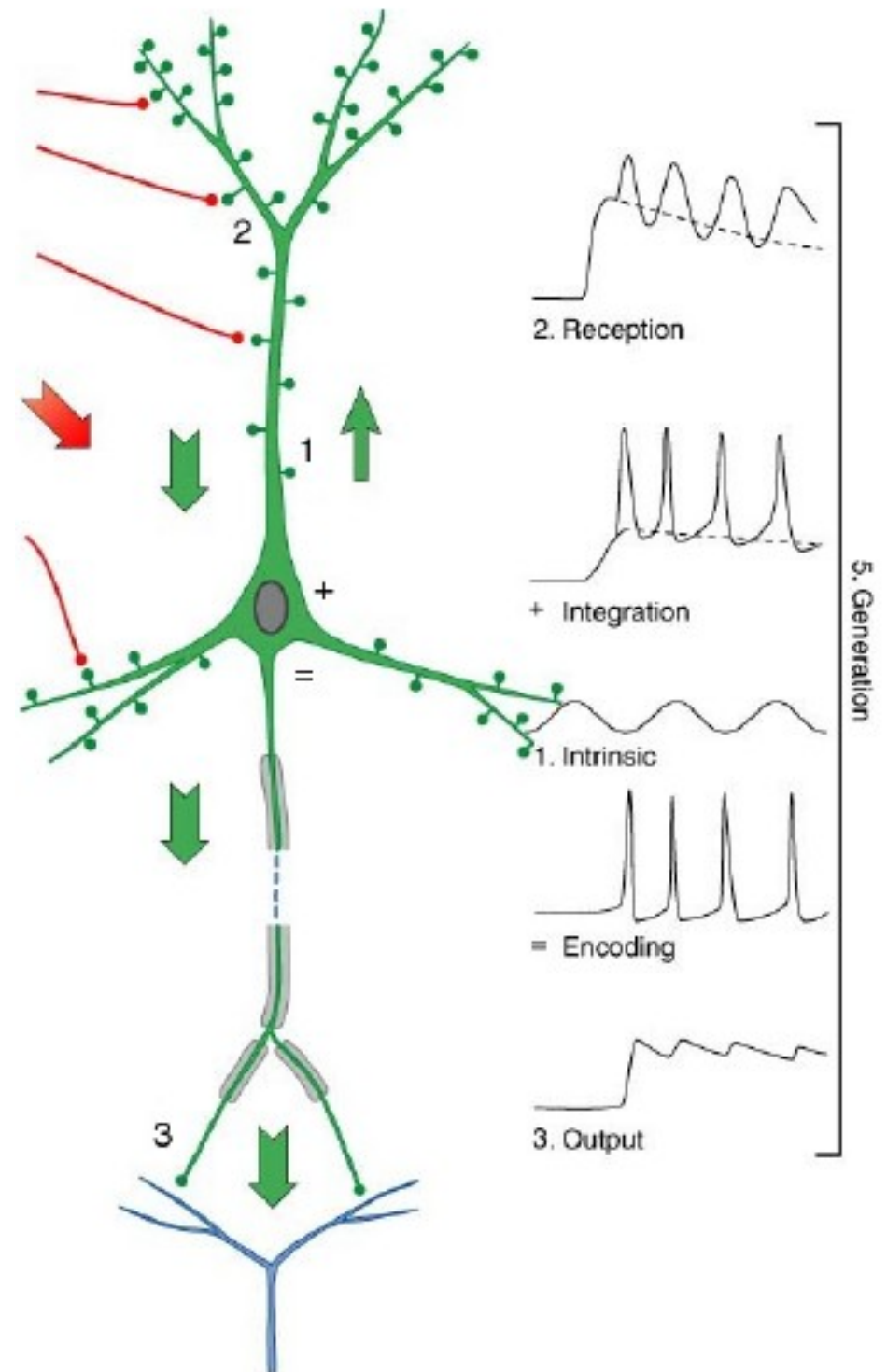
glia  
myelin sheath  
Ranvier-nodes

## Function:

reception  
integration  
reproduction  
transmission  
encoding  
output

communication

background  
speed up  
amplification

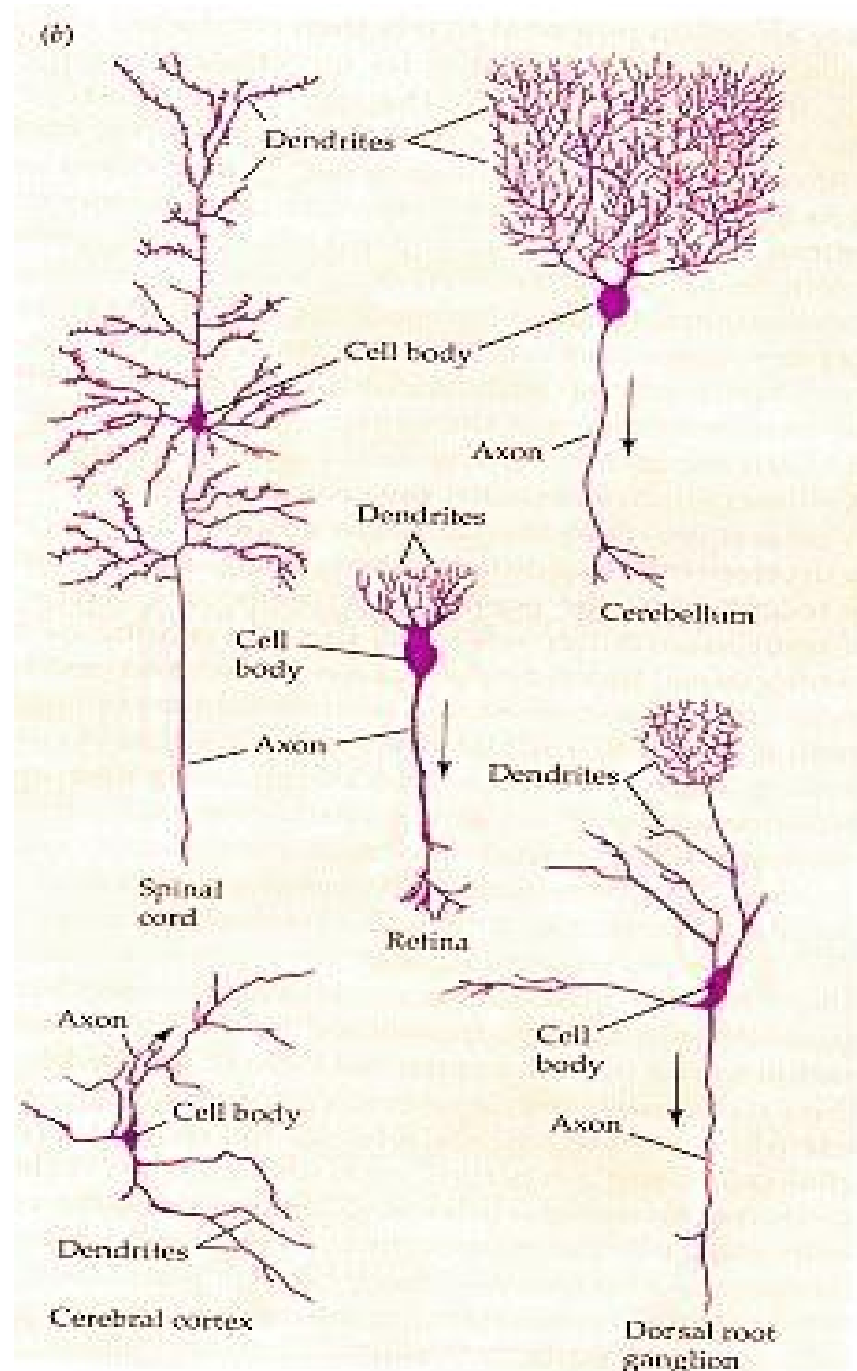


# Types of neurons

Pyramidal cell  
in the cerebral  
cortex

Bipolar cell  
in the retinal

Reticular cell  
in the  
thalamus

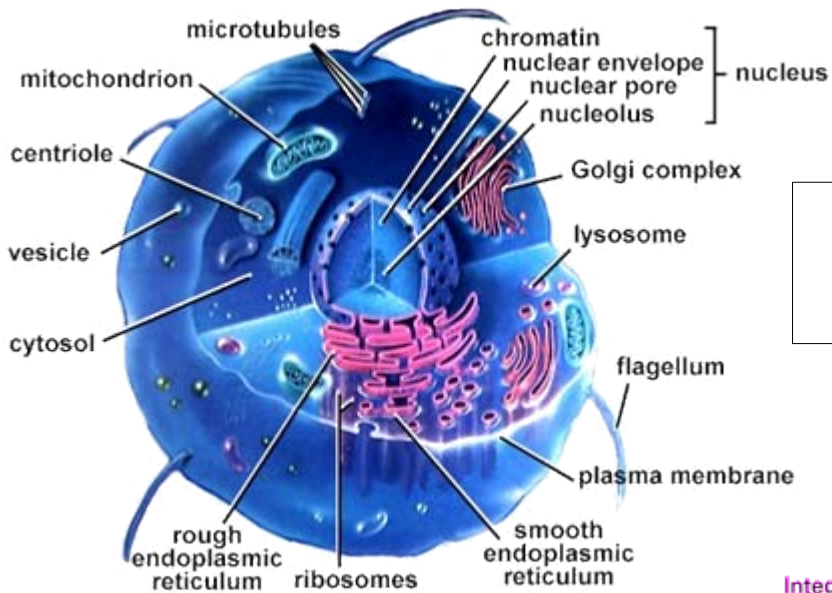


Purkinje cell  
in the  
cerebellum

Mitral cell  
in the  
olfactory bulb

# The cell

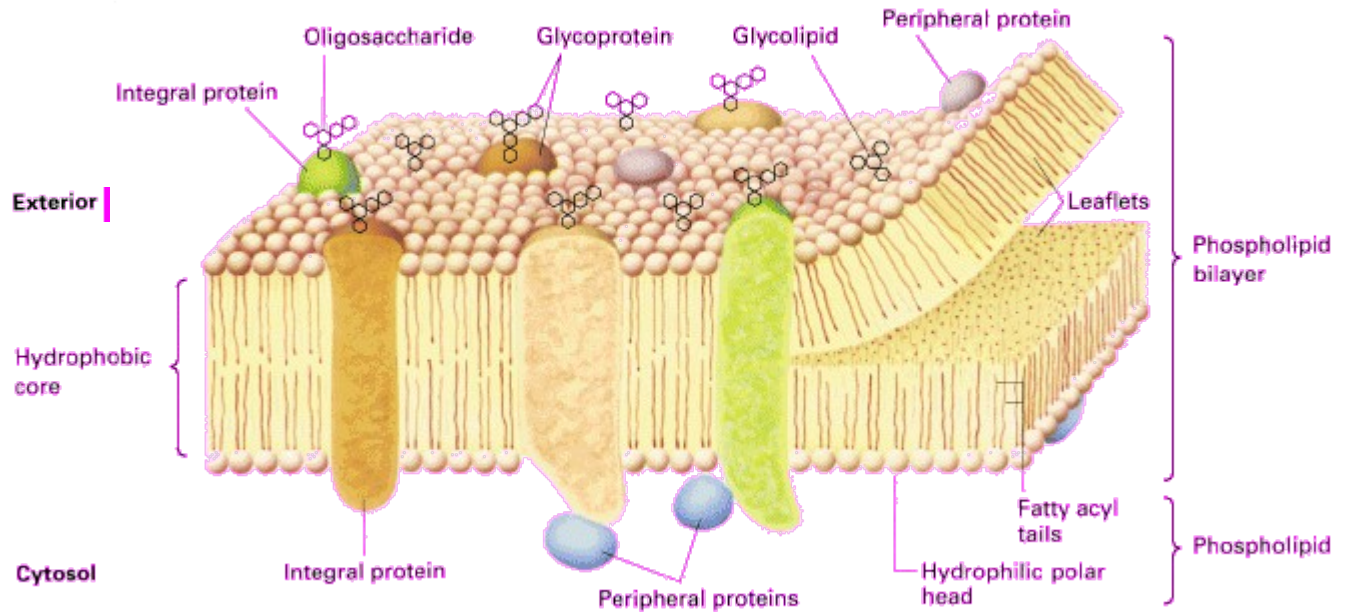
## with electronmicroscope



*nucleus  
cytoplasm  
membrane*

*lipid bilayer  
proteins  
integral  
peripheral*

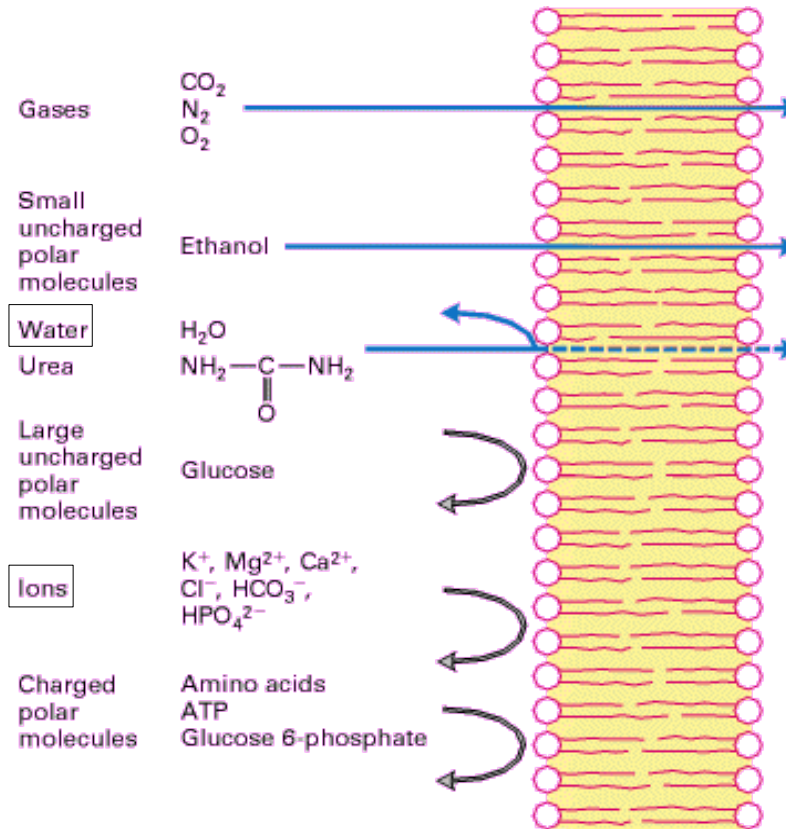
*extracellular space (EC)  
intracellular space (IC)*



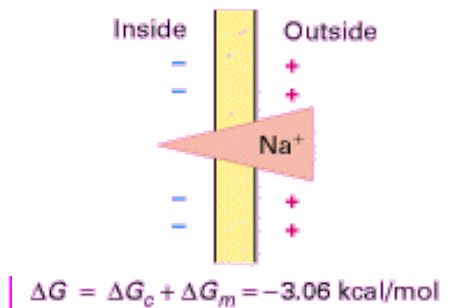
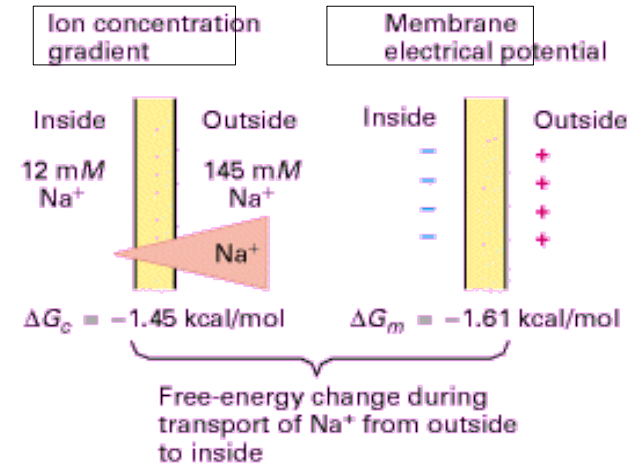


# Trough the cell membrane

Different permeability, for different ions and molecules

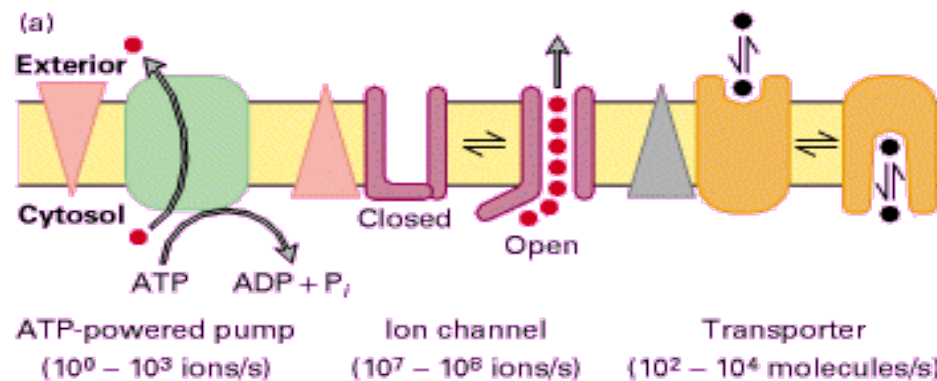


## Forces of ion transport

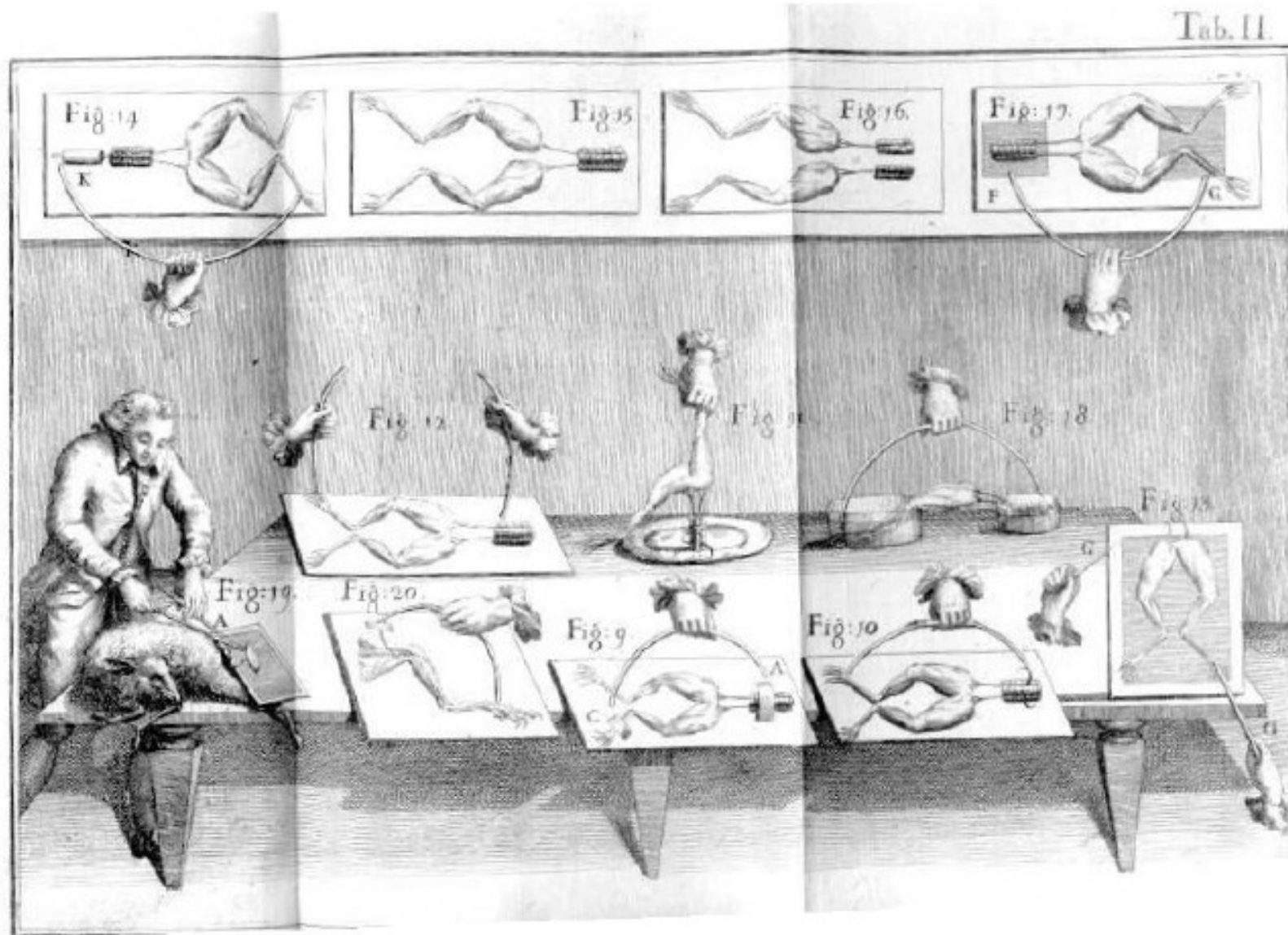


Membrane transport, through proteins

- pumps (+energy!)
- channels
- transporters



# Discovery of the electricity in animals

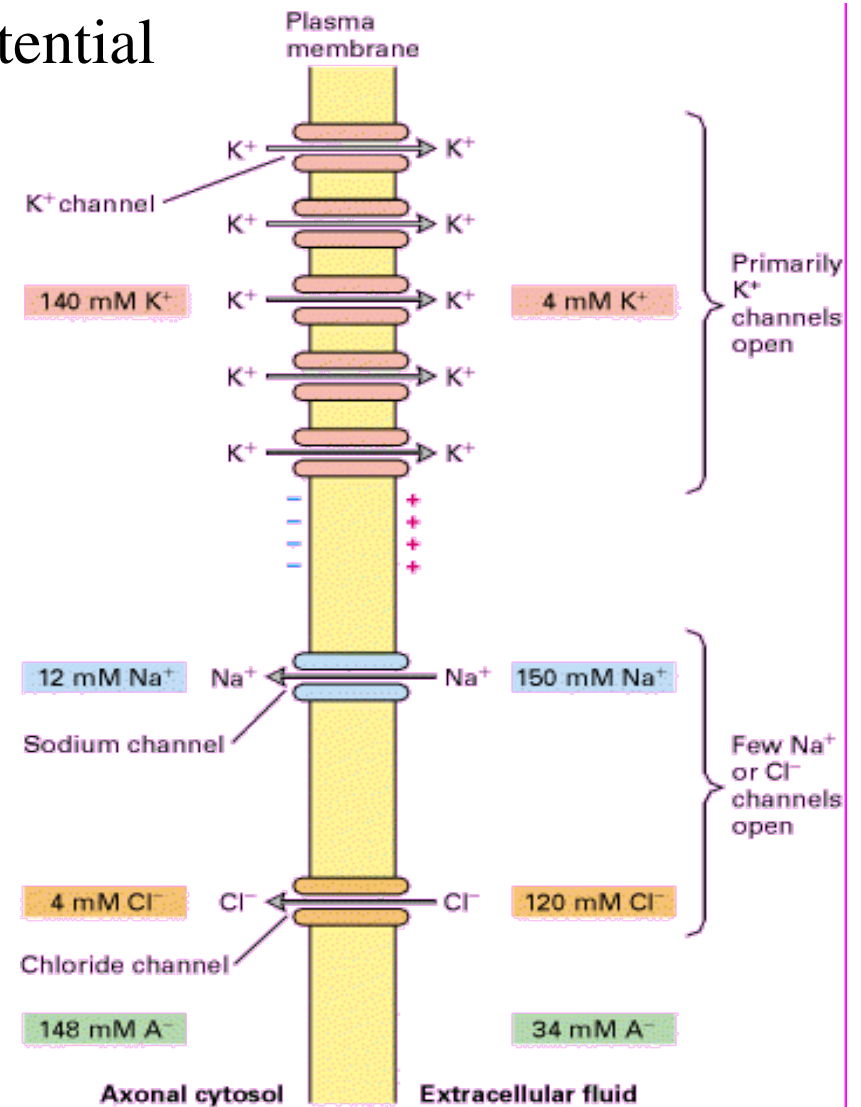
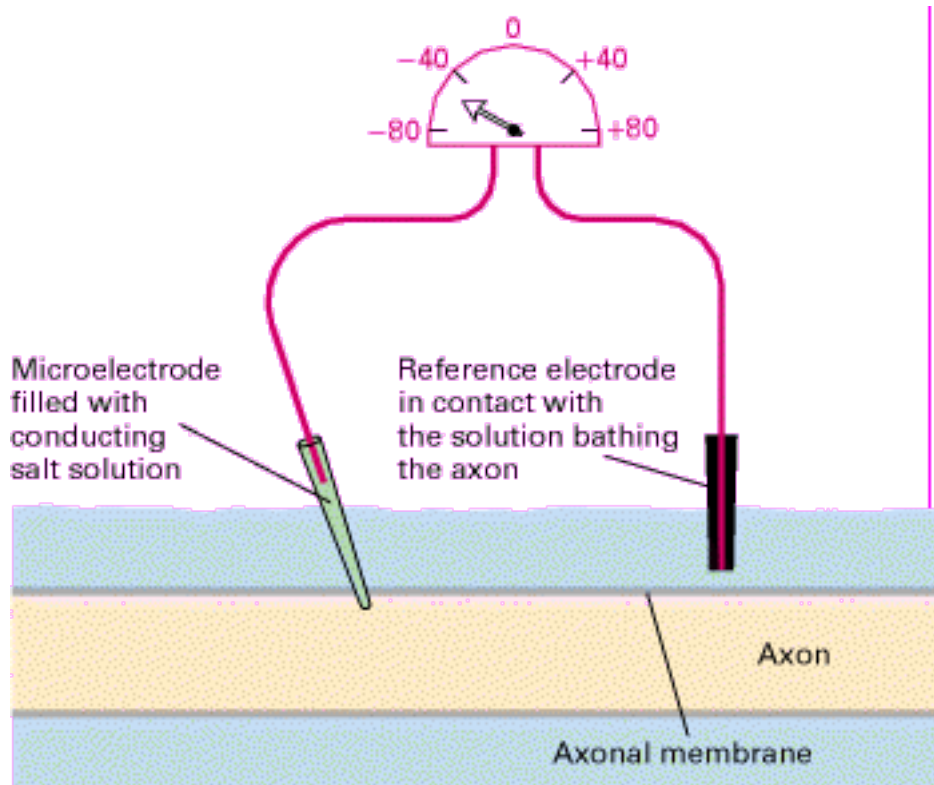


Galvani, De Viribus - Electricitatis in Motu Musculari. 1792.

# The electric neuron: resting potential with electrode

## The phenomenon:

Potential difference between the two side  
EC and IC of the membrane

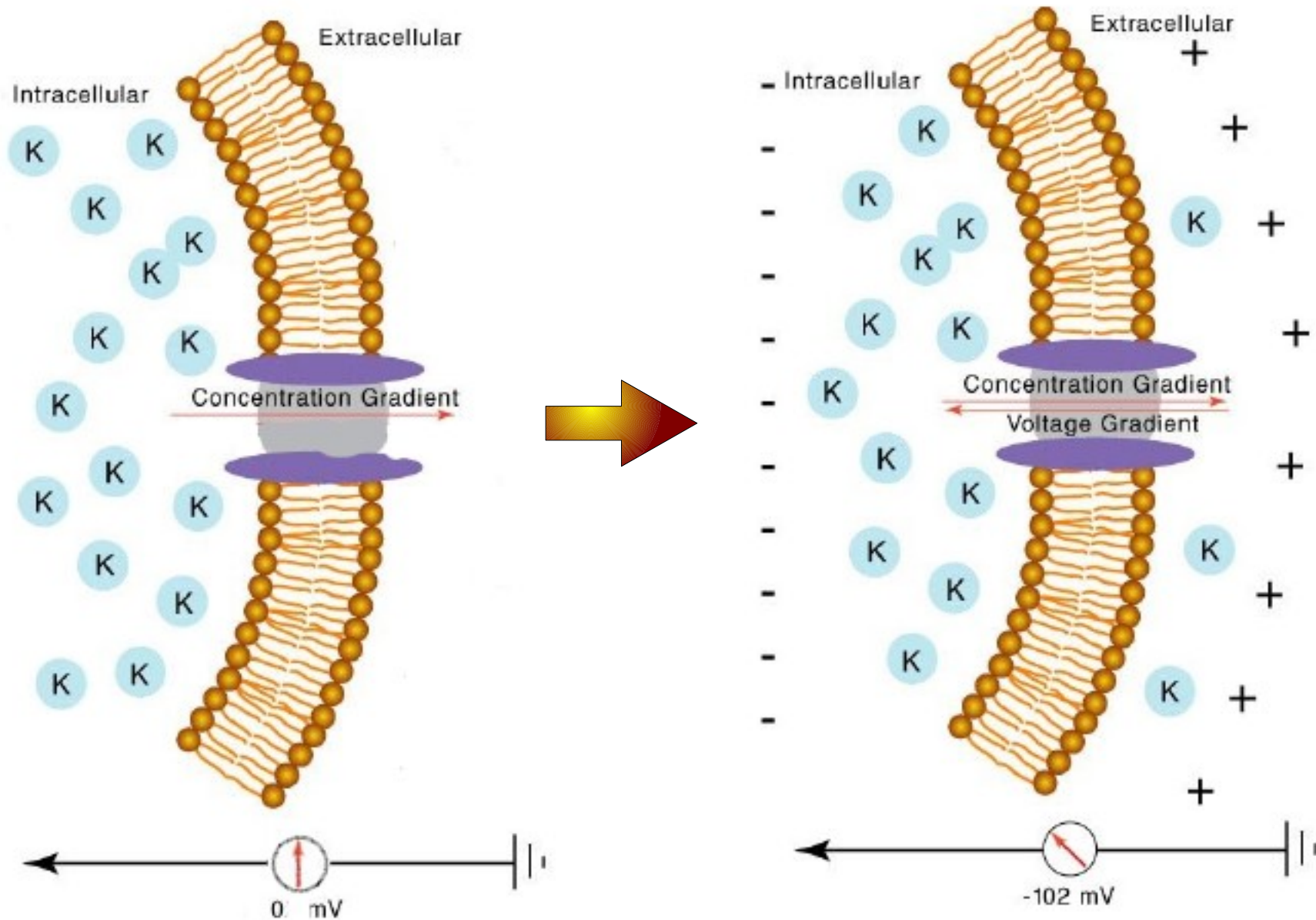


## Reason:

on the two different sides of the membrane:

- different concentrations of ions on
- the two side of the membrane
- different permeability for different
- ions

# The generation of the resting potential



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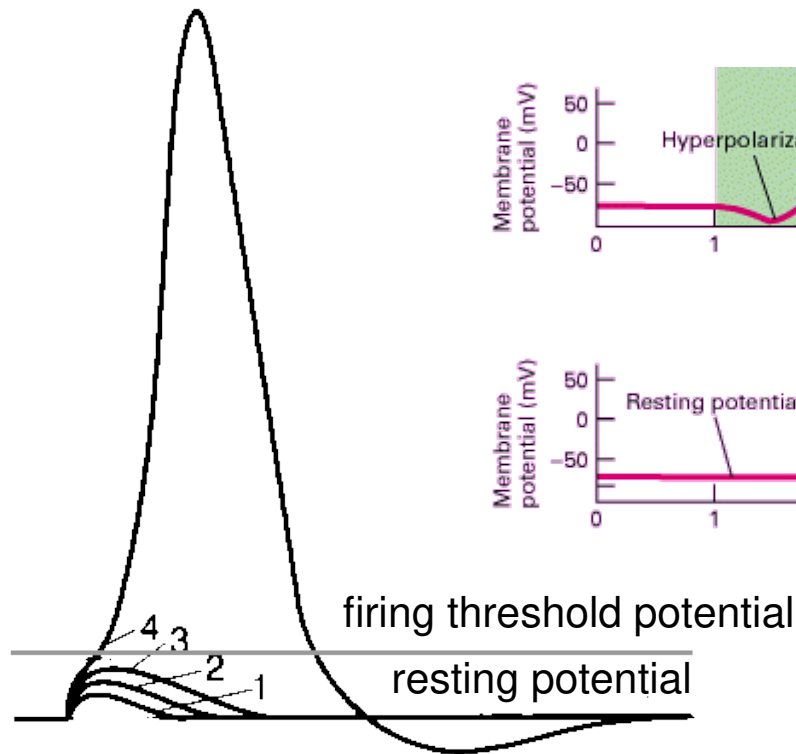
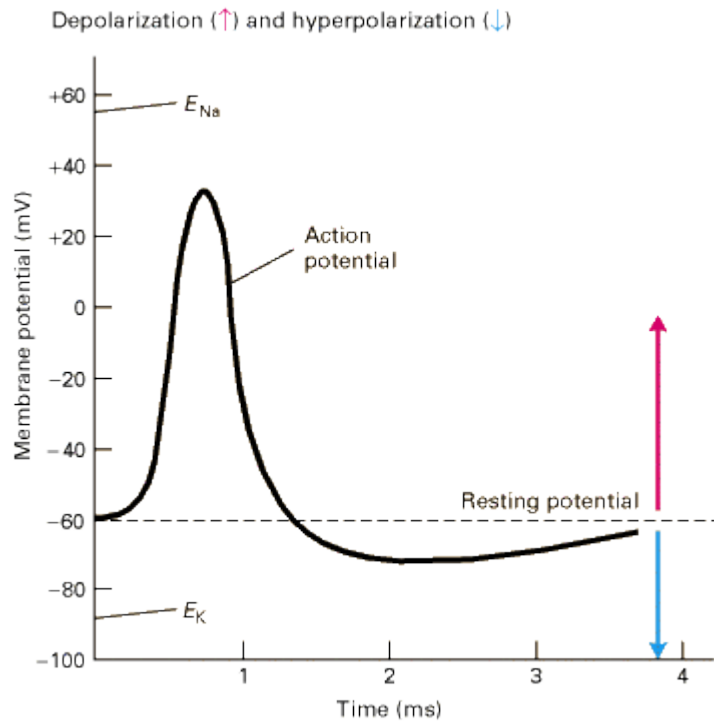
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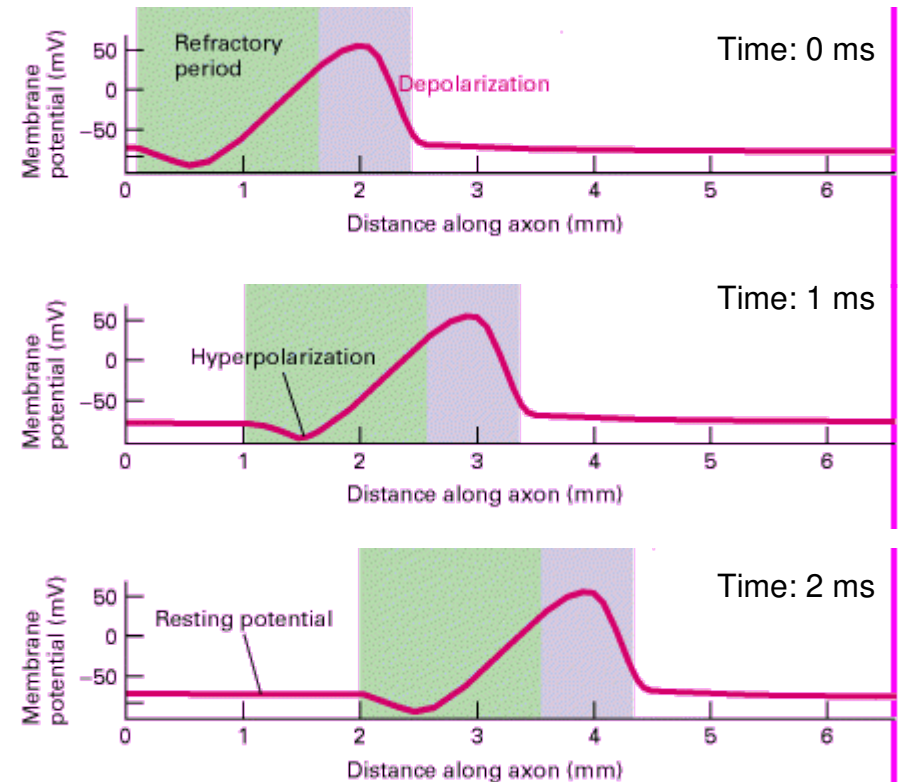
# The electric neuron: action potential

with electrode

What is the action potential?  
A short change in the membrane potential



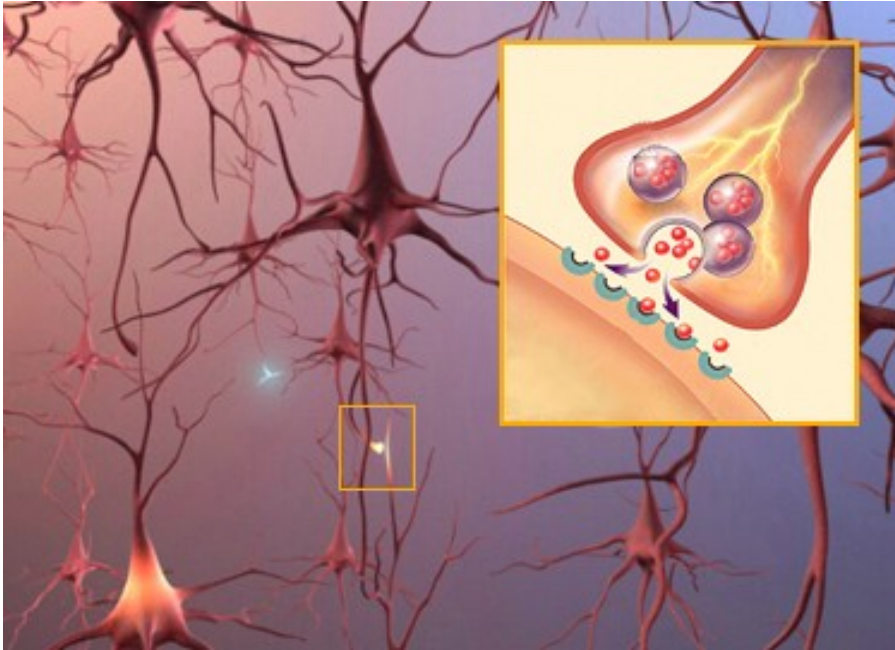
## Traveling action potential



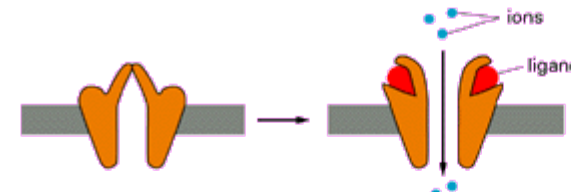
The action potential is an 'all or none' phenomenon



# Between two neuron: The synapse

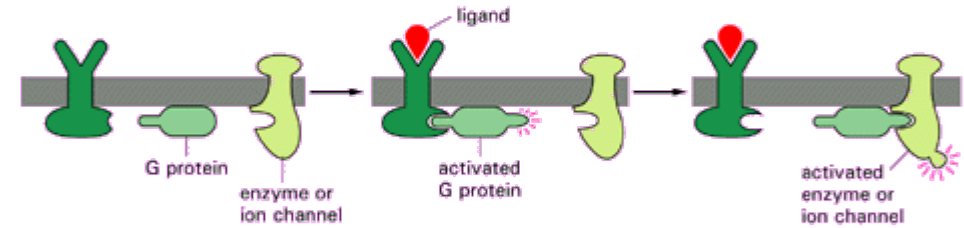


(A) ION-CHANNEL-LINKED RECEPTOR

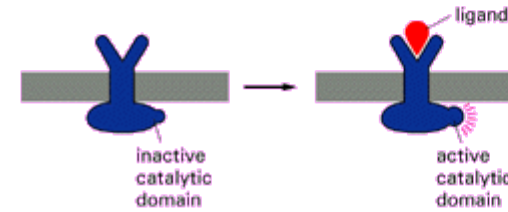


Ionotropic (A) and metabotropic (B,C) receptors

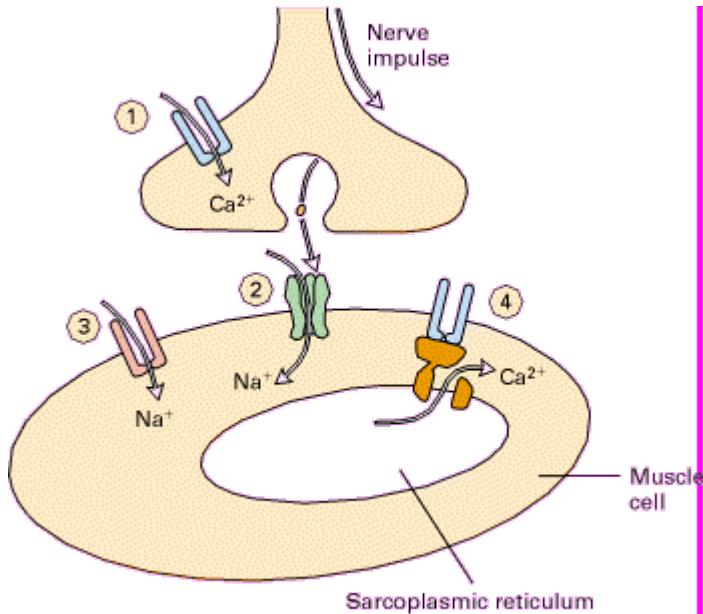
(B) G-PROTEIN-LINKED RECEPTOR



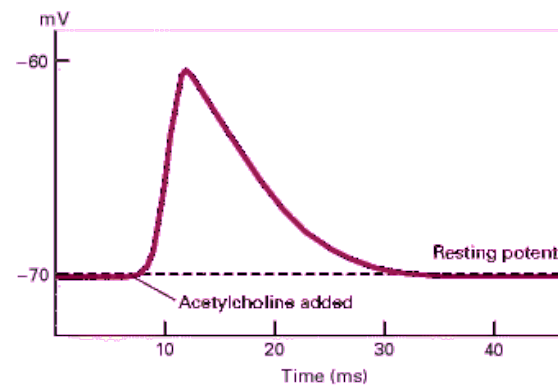
(C) ENZYME-LINKED RECEPTOR



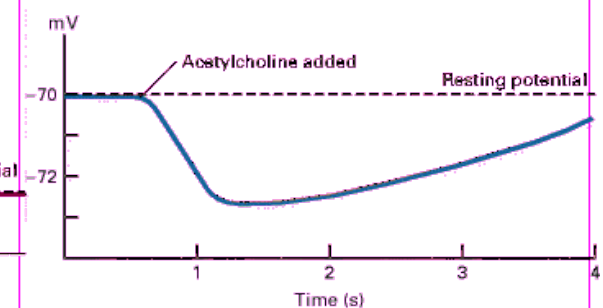
## Excitatory and inhibitory postsynaptic potentials



(a) Excitatory synapse



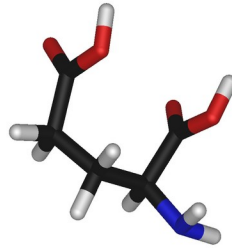
(b) Inhibitory synapse



# Excitatory and inhibitory neurotransmitters

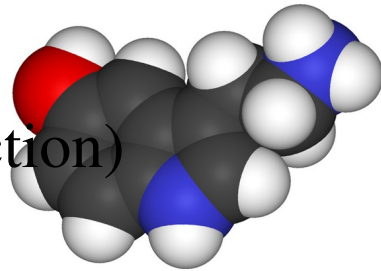
## Glutamat

(information transmission)



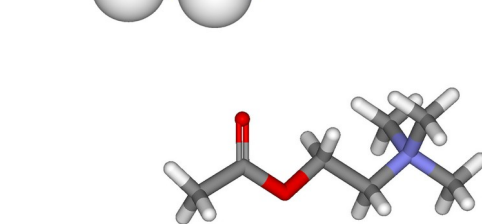
## Serotonin

(mood, wake/sleep)



## Acetylcholin

(neuromuscular junction)

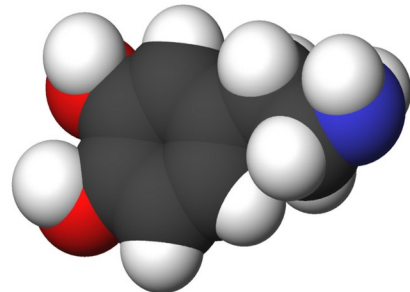


## Noradrenaline

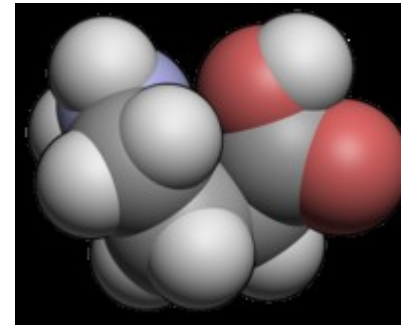
(arousal)

## Dopamine

(reward system,  
Parkinson disease,  
schizophrenia)



GABA-gamma aminobutyric acid  
(in the central neural system)



## Glycine

(in the periphery)

