

NEUROINFORMATIKA

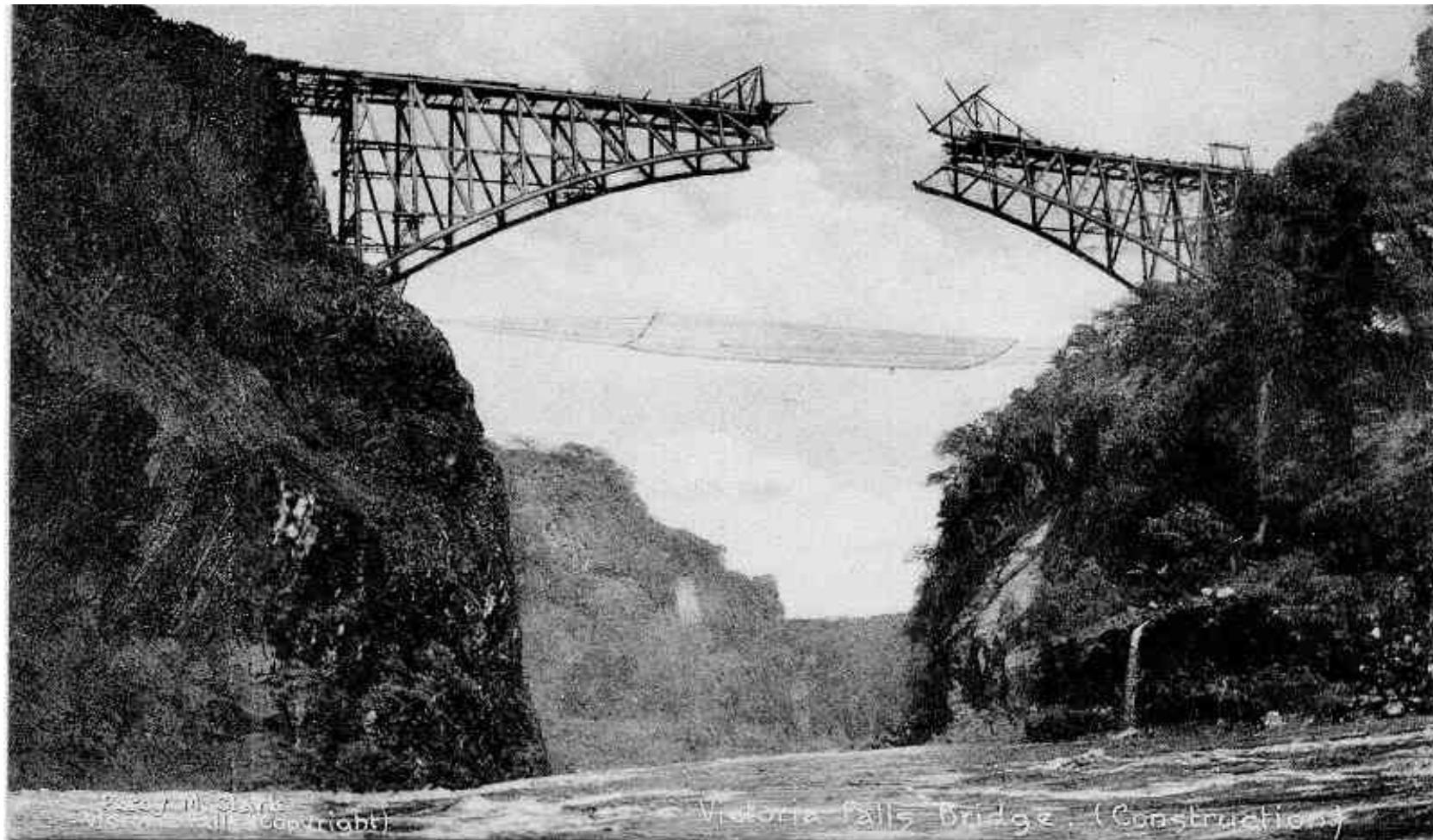
Zoltán Somogyvári

&

László Zalányi

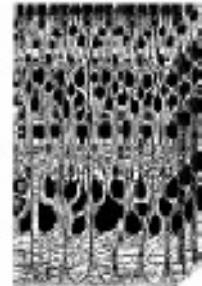
MTA Wigner Research Centre for Physics

Computational Neuroscience



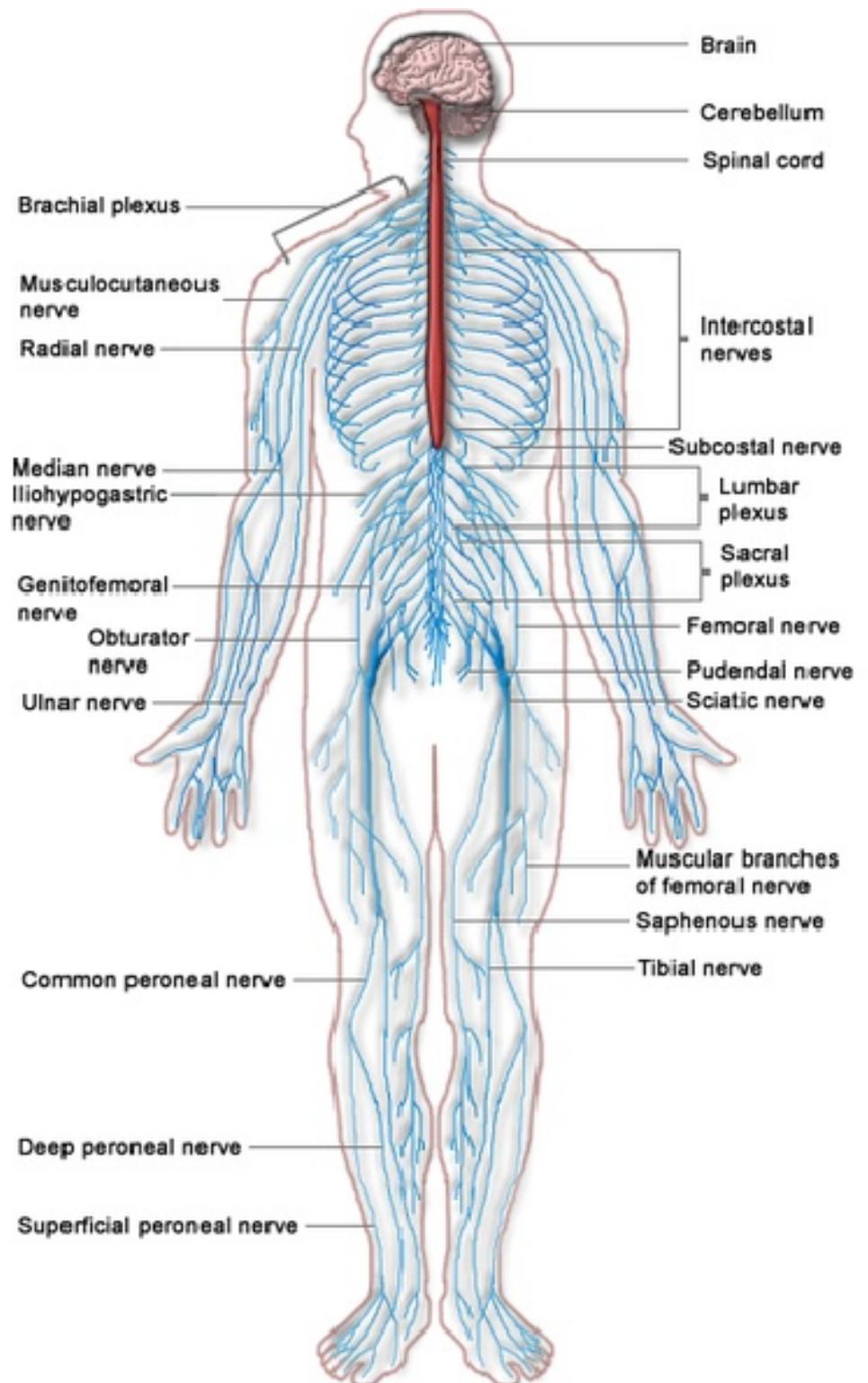
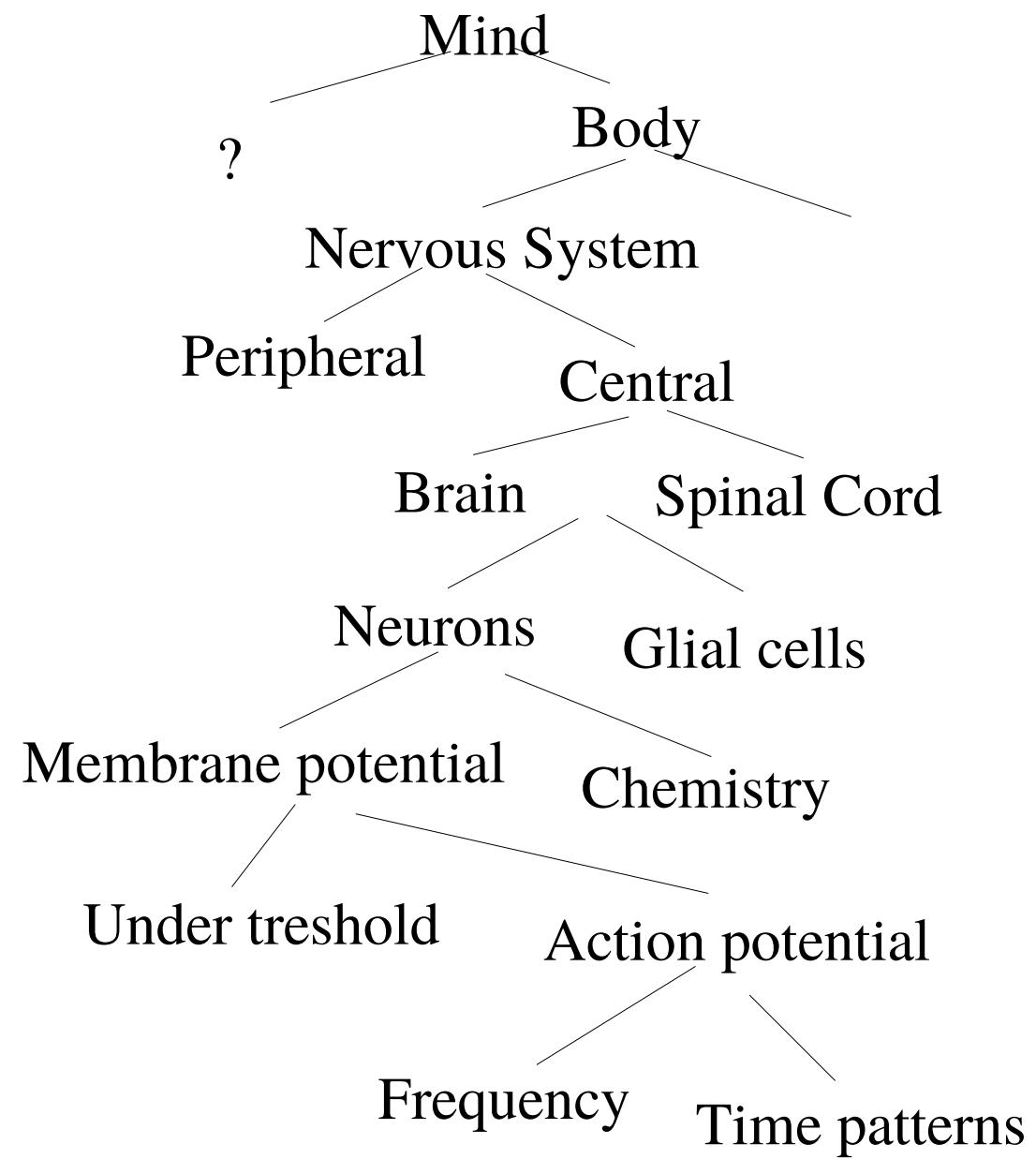
Structure – Dynamics – Implementation – Algorithm – Computation - Function

The brain and the computer

	1 mm ³ of cortex		1 mm ² 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	

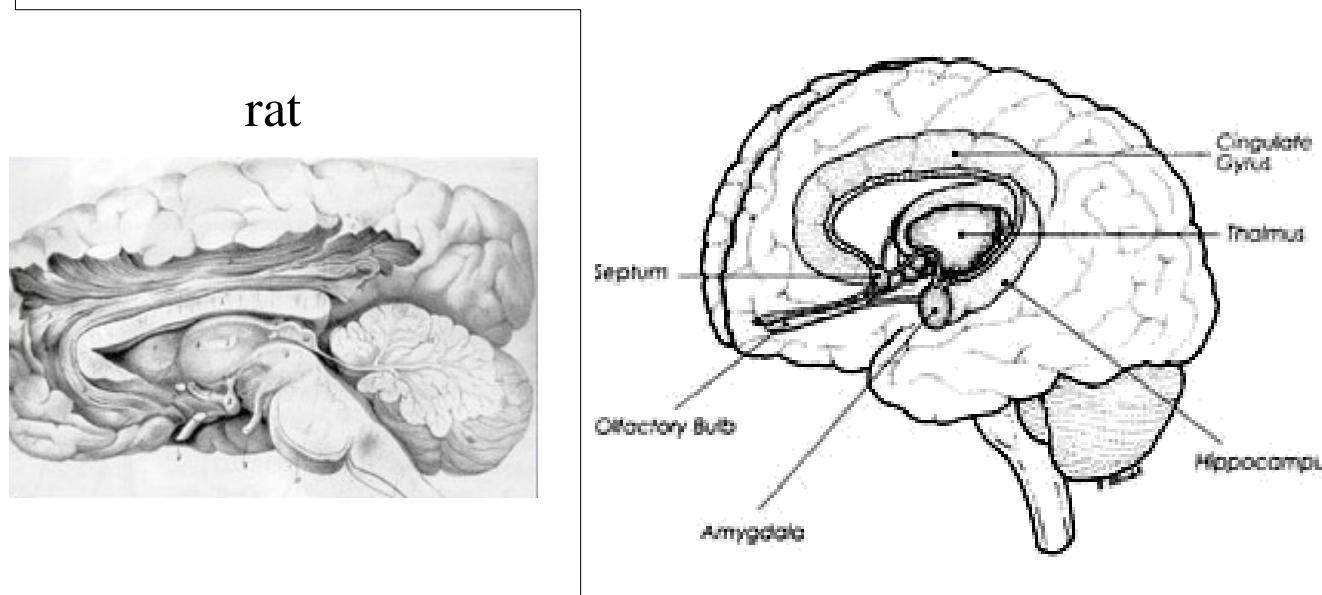
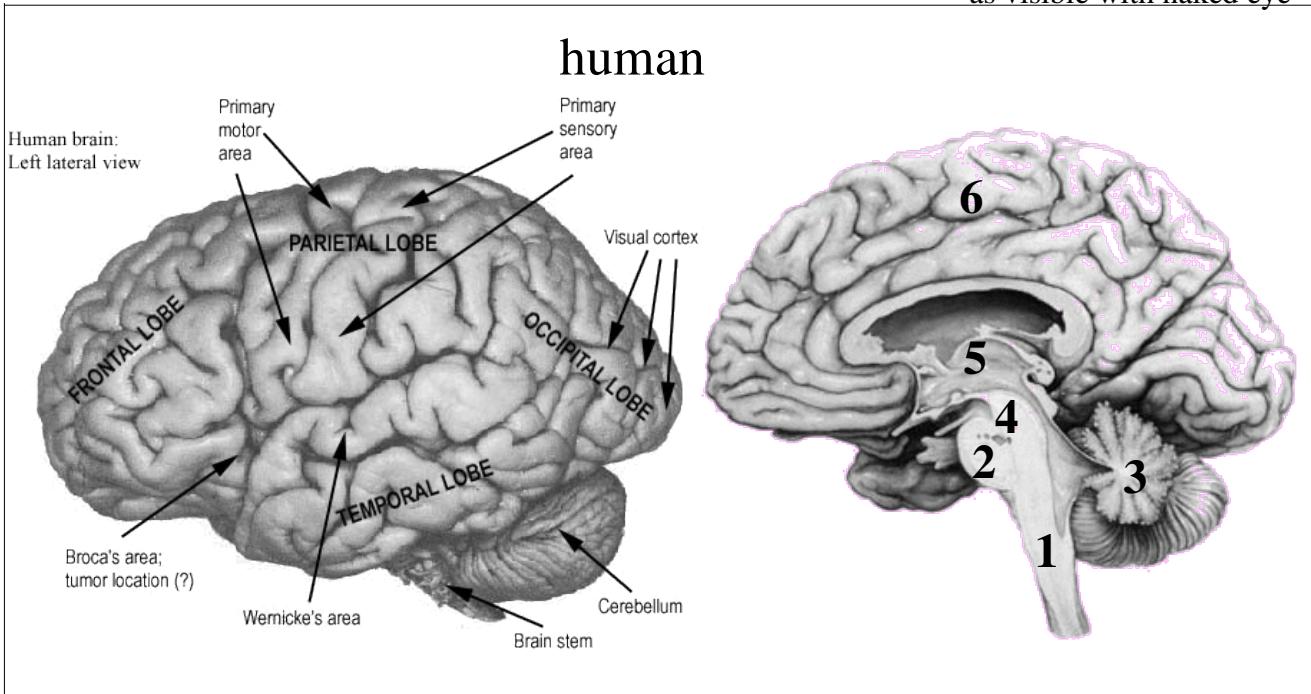
	Whole brain		Whole CPU	
Weight	1.3 kg		~0.4kg	
Power	20 W		27 W	
Units	10^{11} neurons		10^8 transistors	
connections	1×10^{15}		2×10^9	
wiring	8 million km of axons		2 km of wire	

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

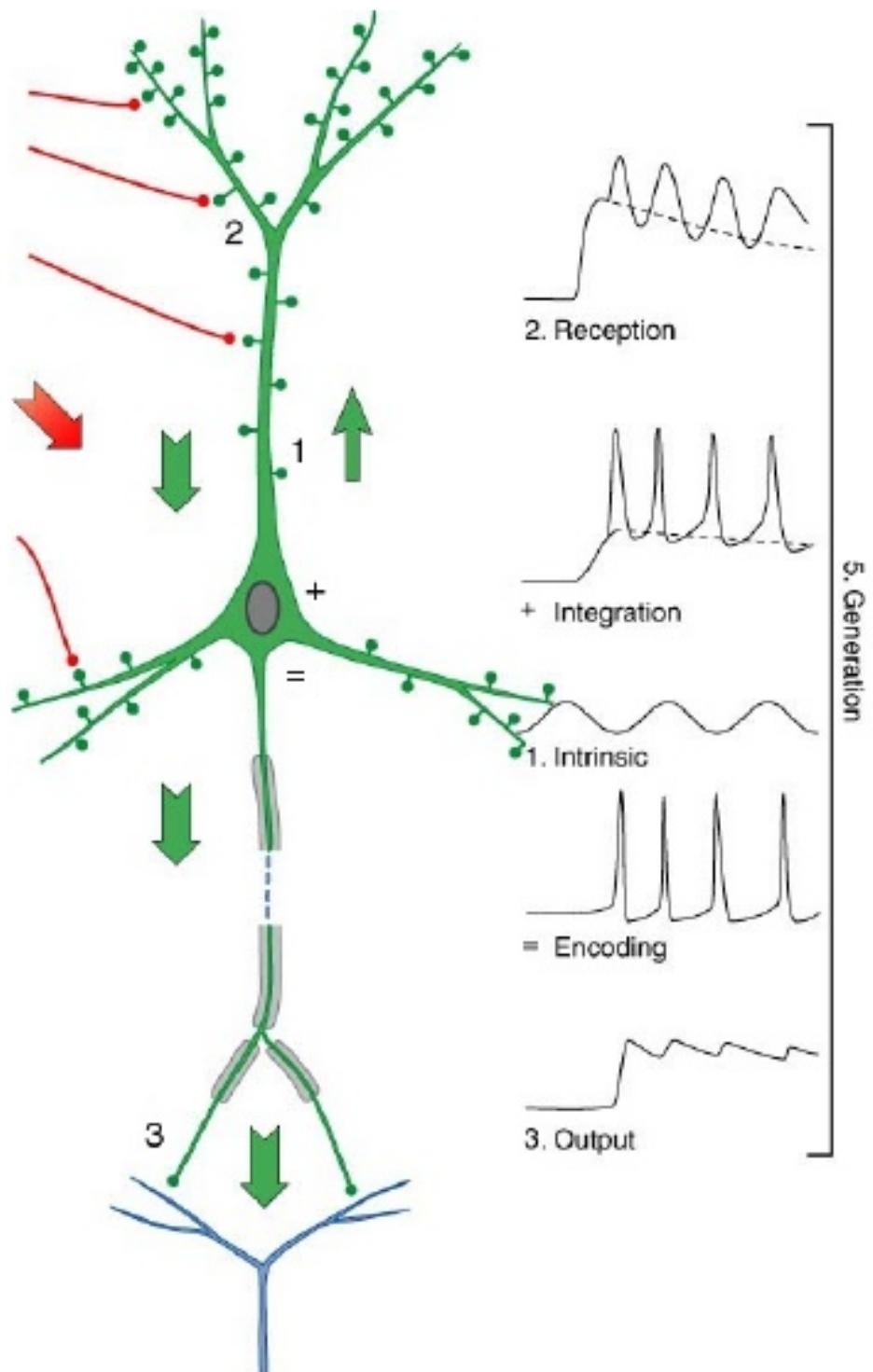
output

communication

background

speed up

amplification

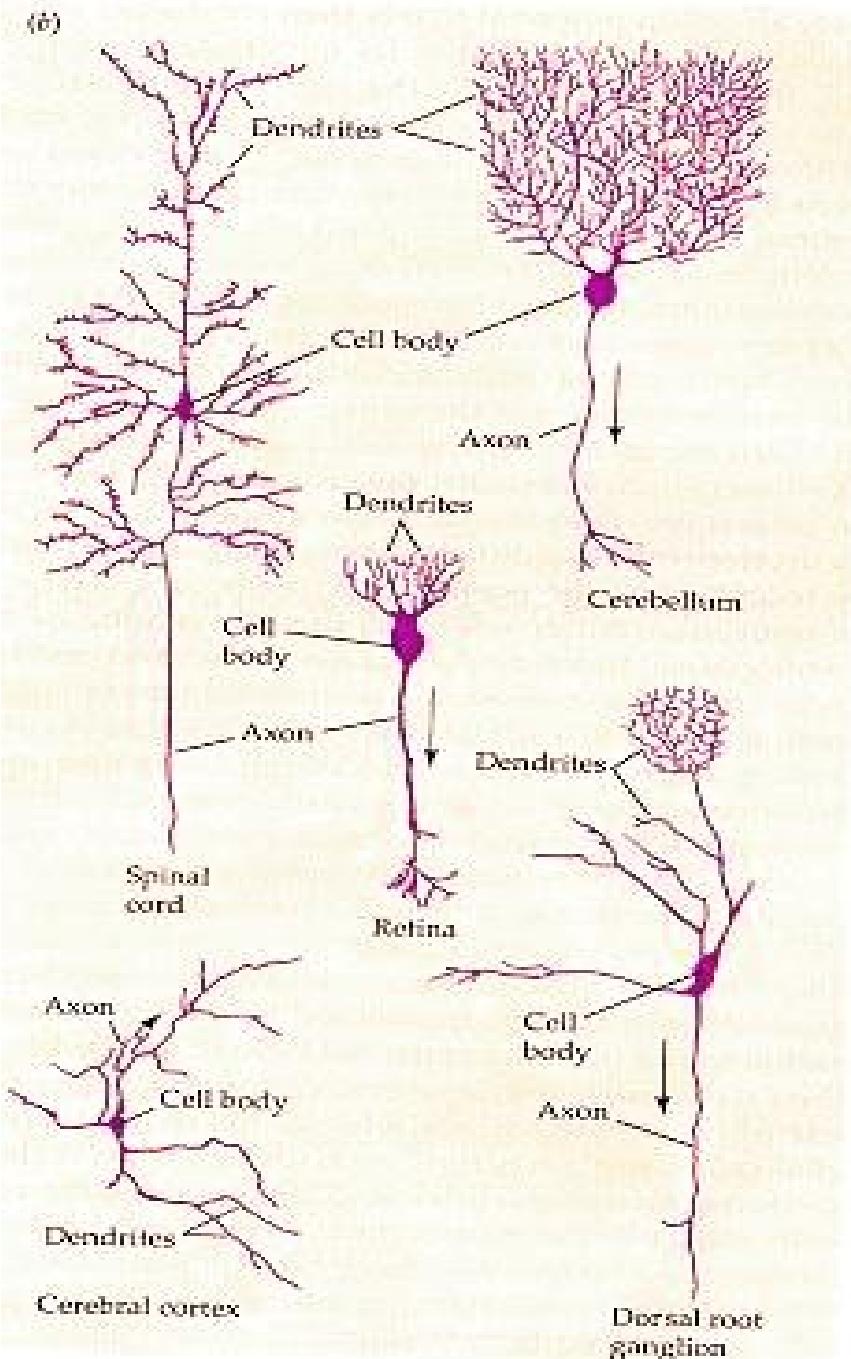


Types of neurons

Pyramidal cell
in the cerebral cortex

Bipolar cell
in the retinal

Reticular cell
in the thalamus

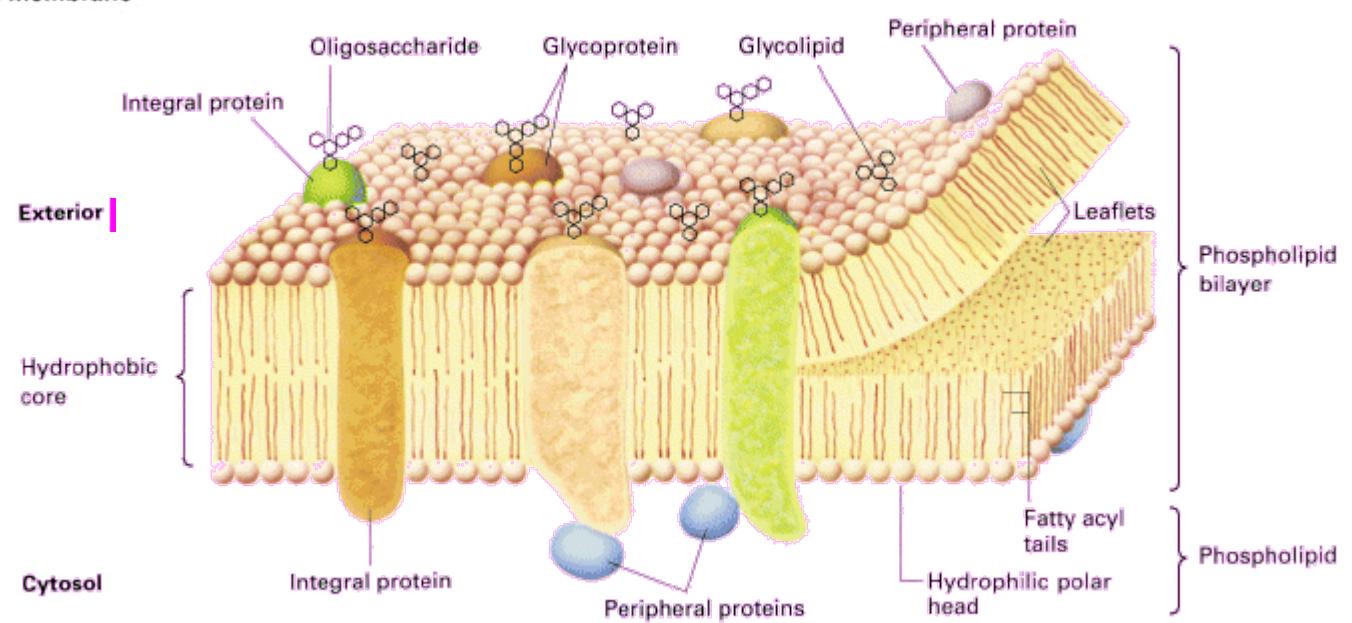
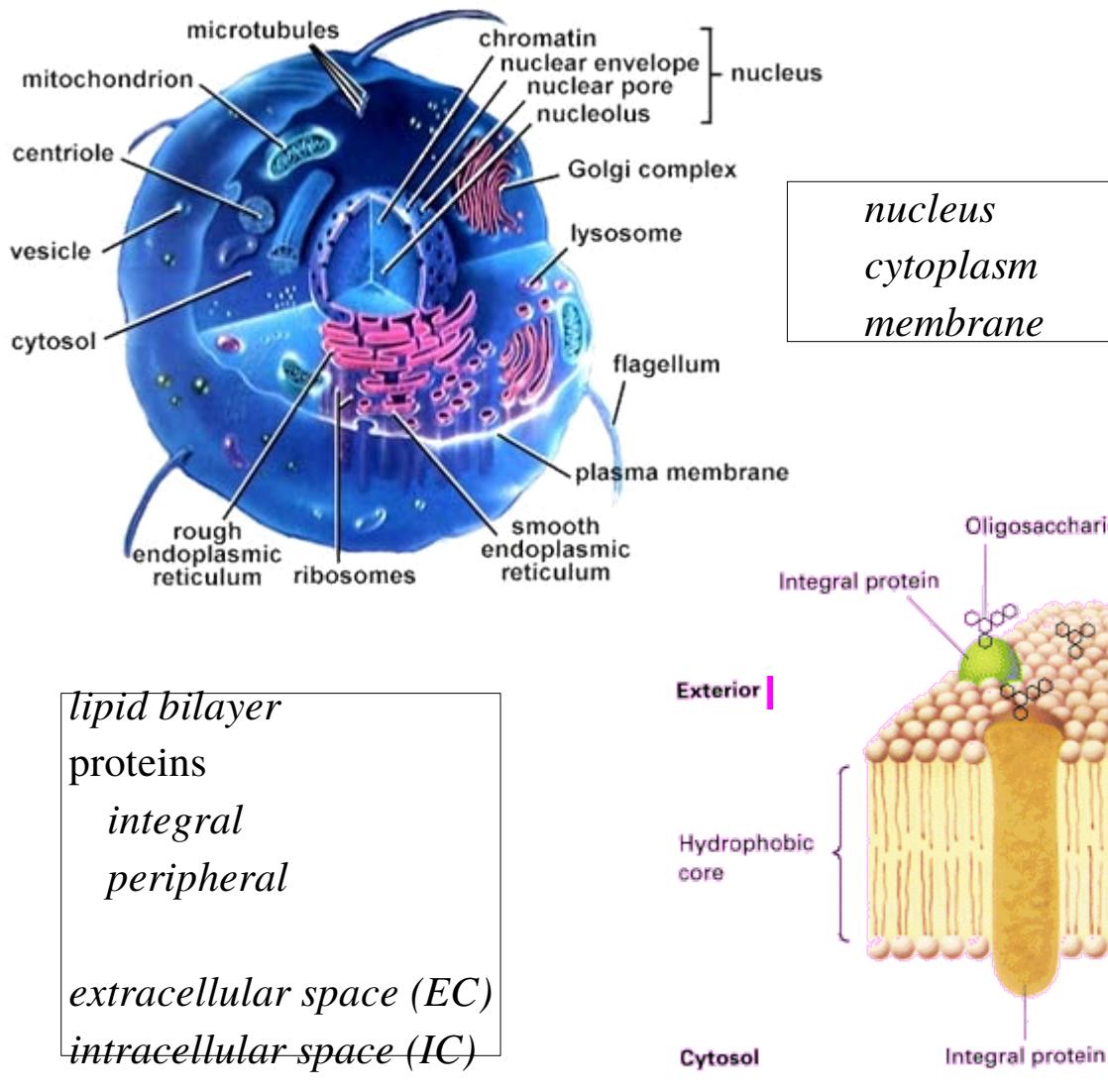


Purkinje cell
in the
cerebellum

Mitral cell
in the
olfactory bulb

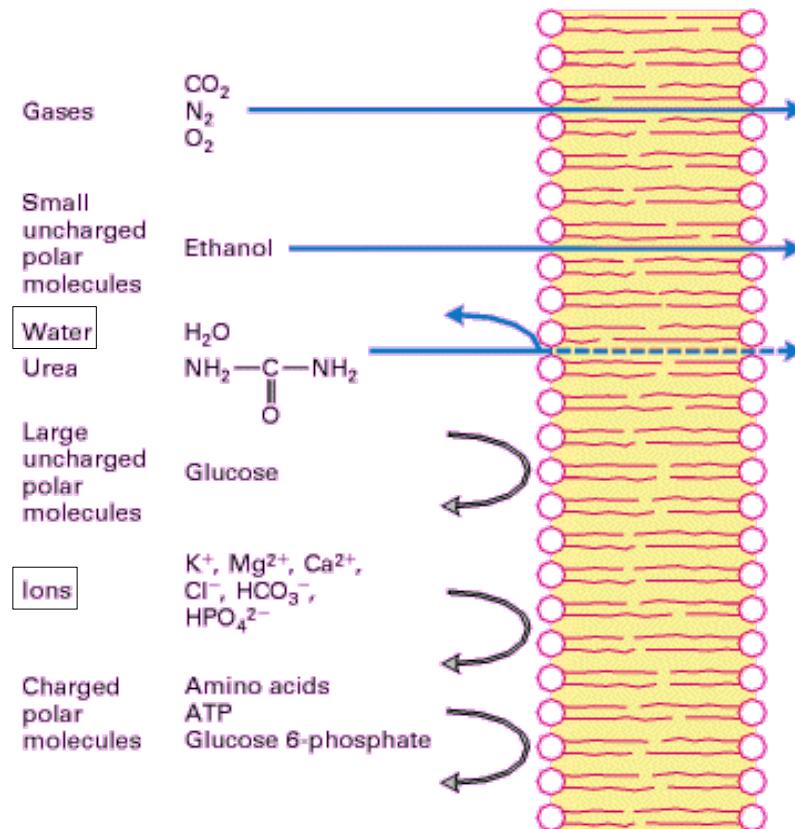
The cell

with electron microscope



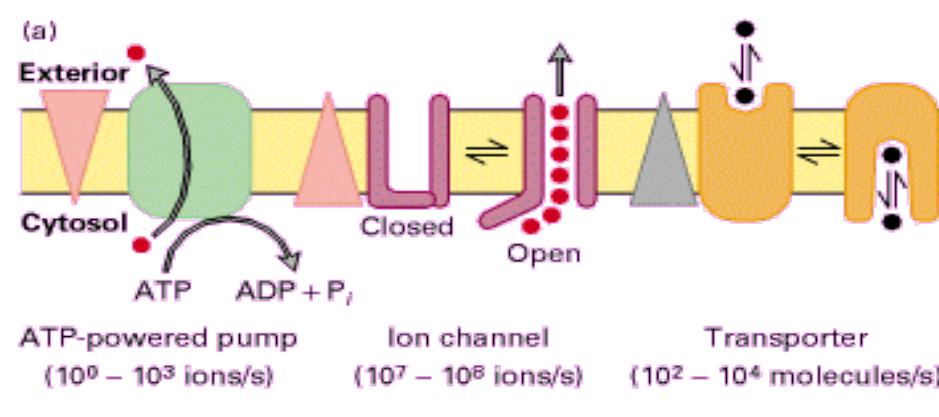
Trough the cell membrane

Different permeability, for different ions and molecules

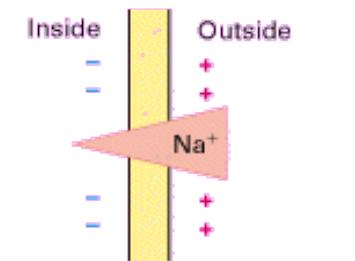
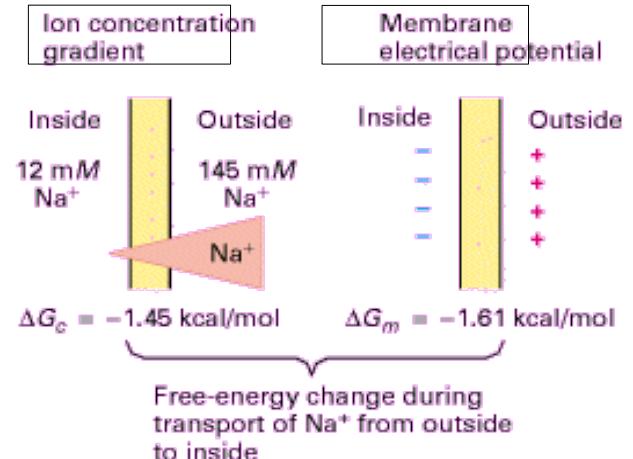


Membrane transport, trough proteins

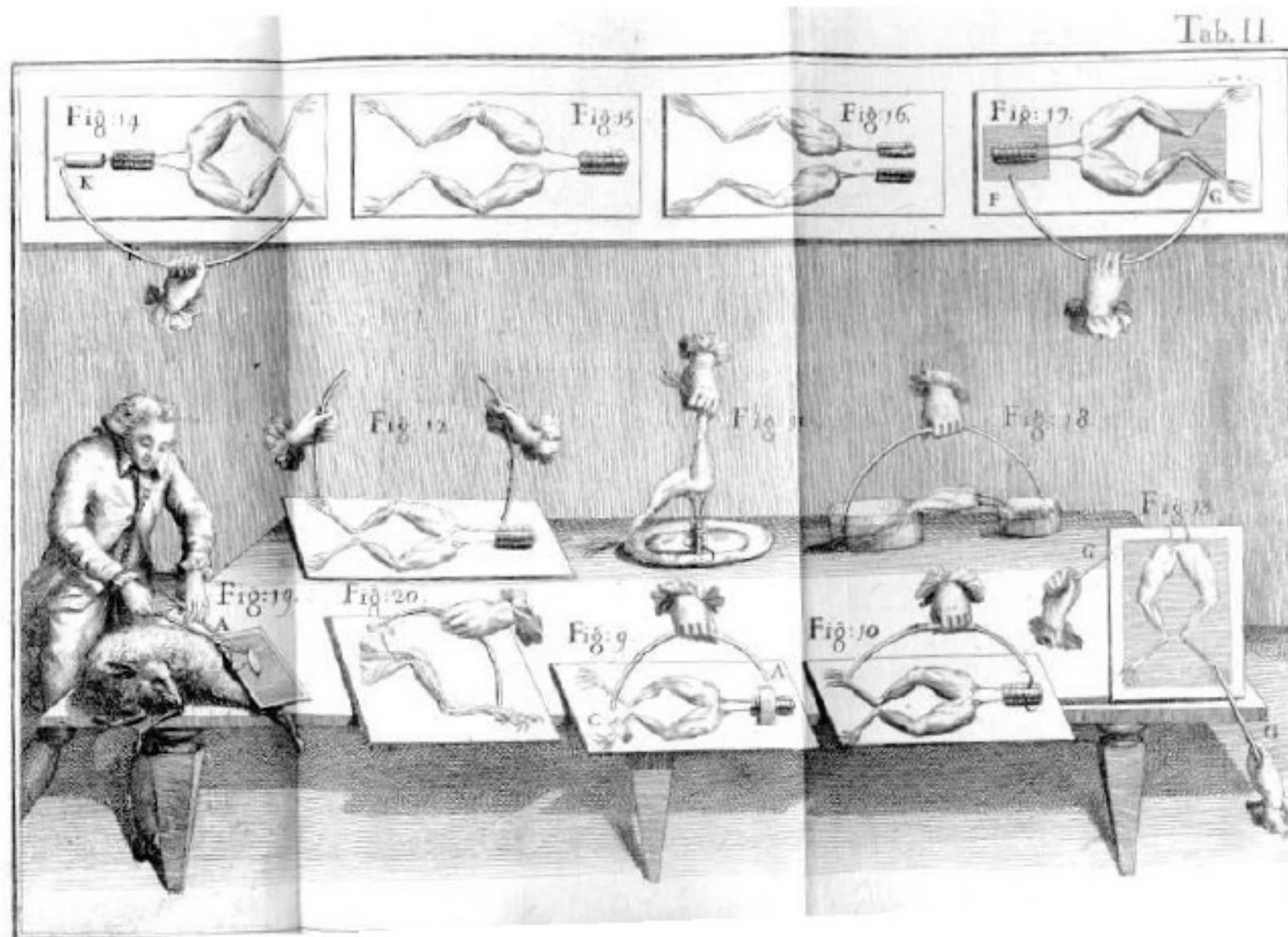
- pumps (+energy!)
- channels
- transporters



Forces of ion transport



Discovery of the electricity in animals



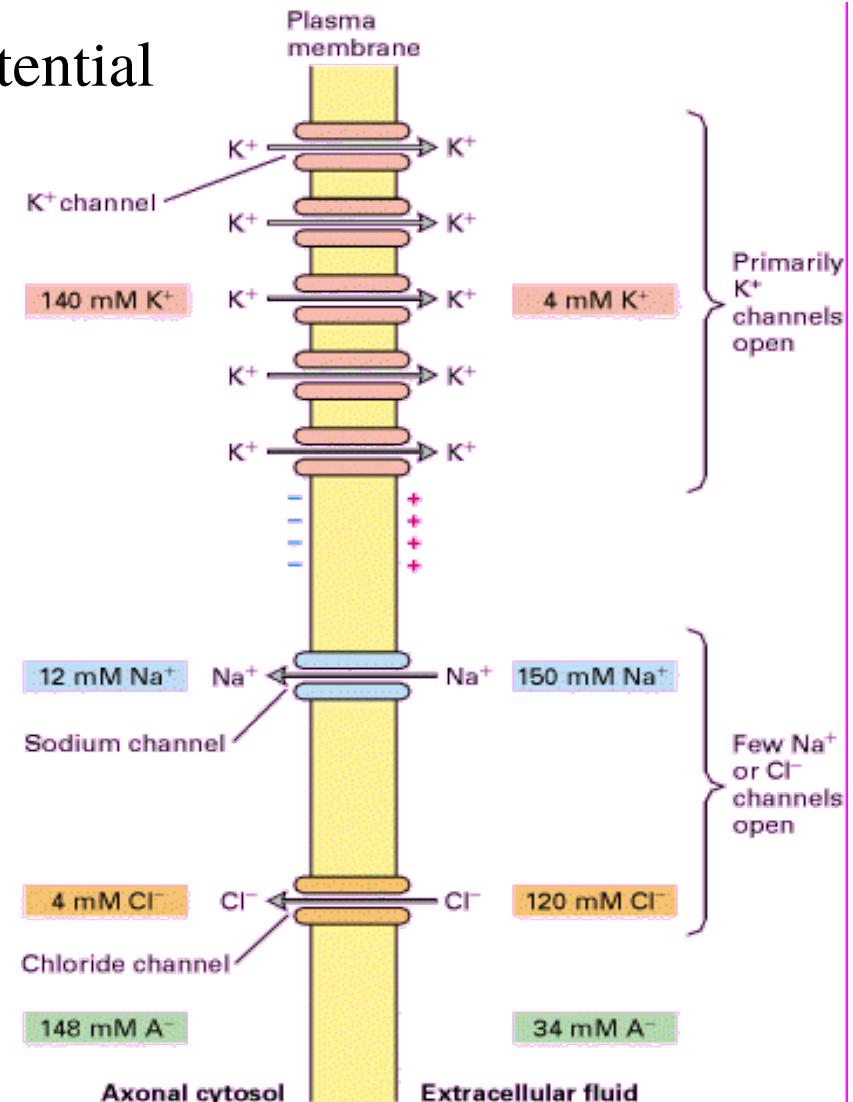
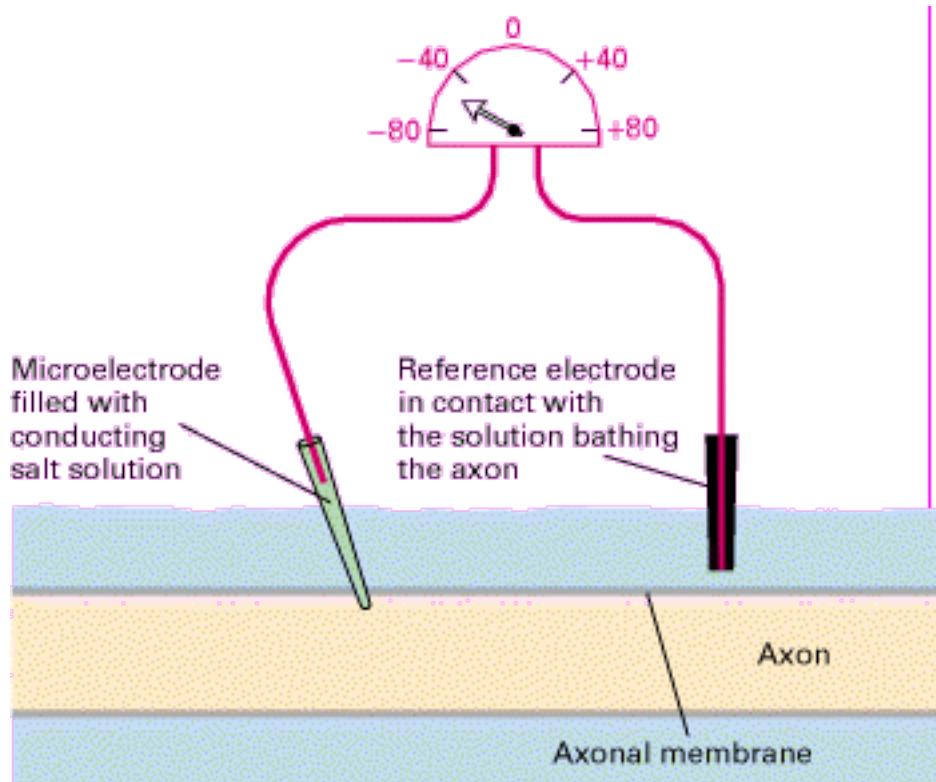
Galvani, De Viribus - Electricitatis in Motu Musculari. 1792.

The electric neuron: resting potential

with electrode

The phenomenon:

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

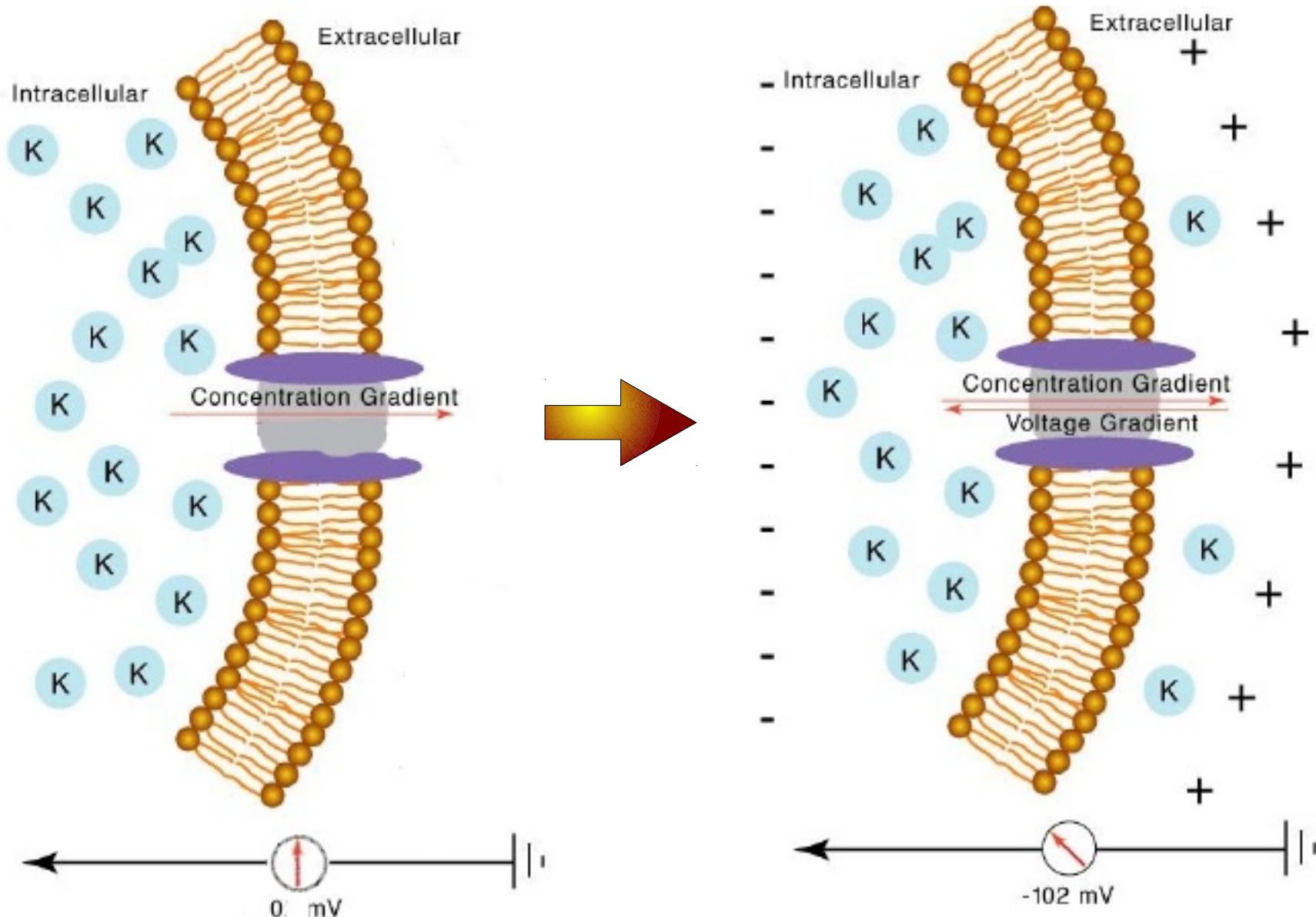


Reason:

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



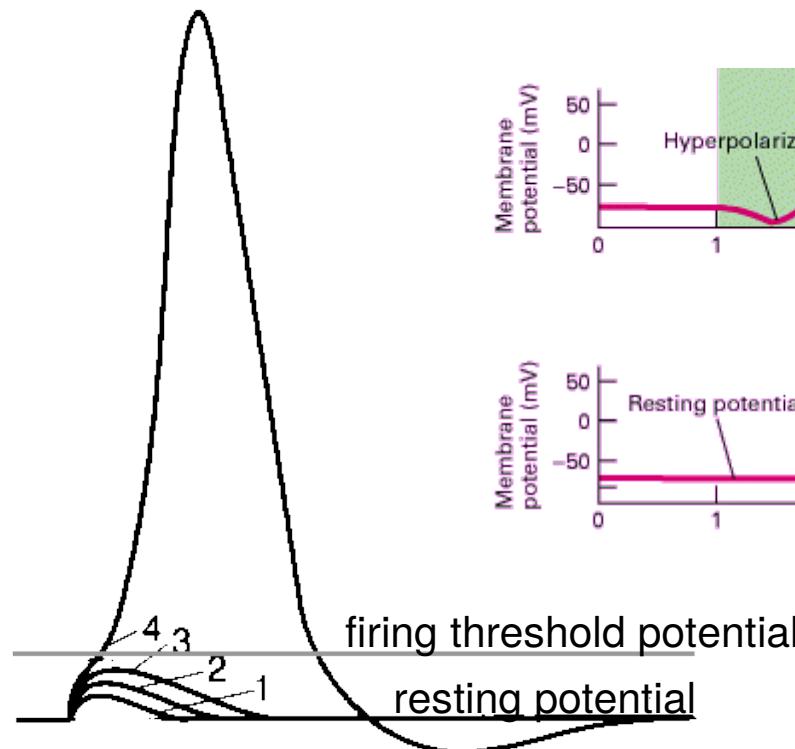
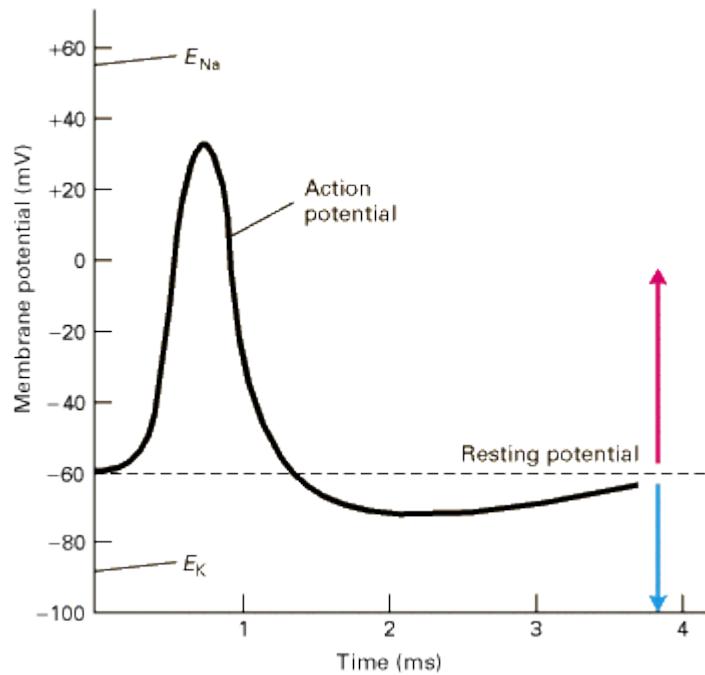
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The electric neuron: action potential

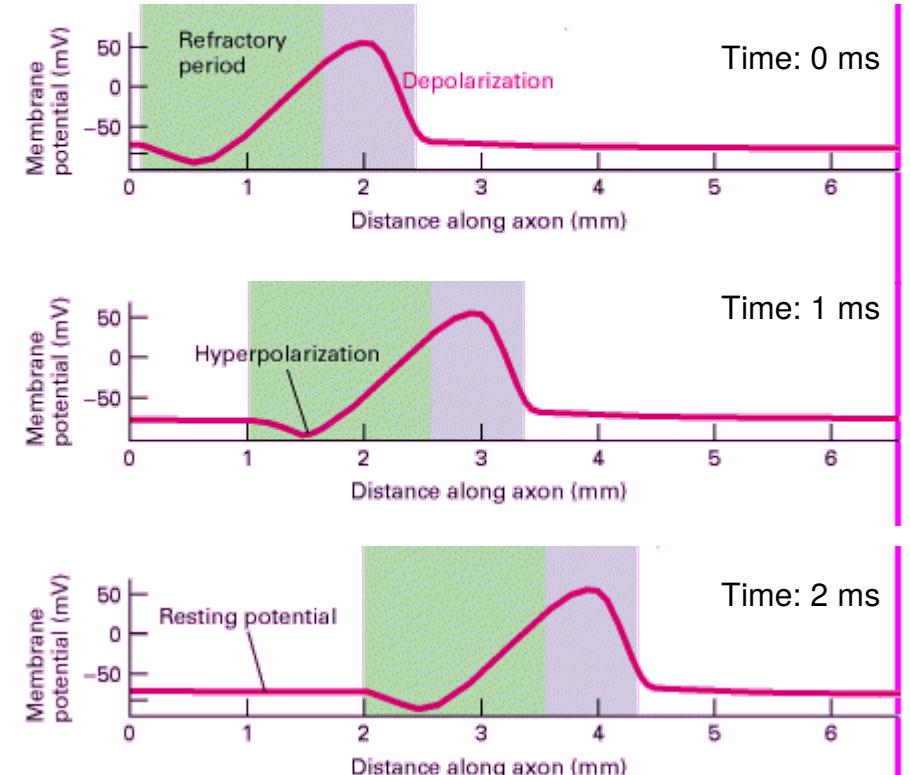
with electrode

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

Depolarization (\uparrow) and hyperpolarization (\downarrow)

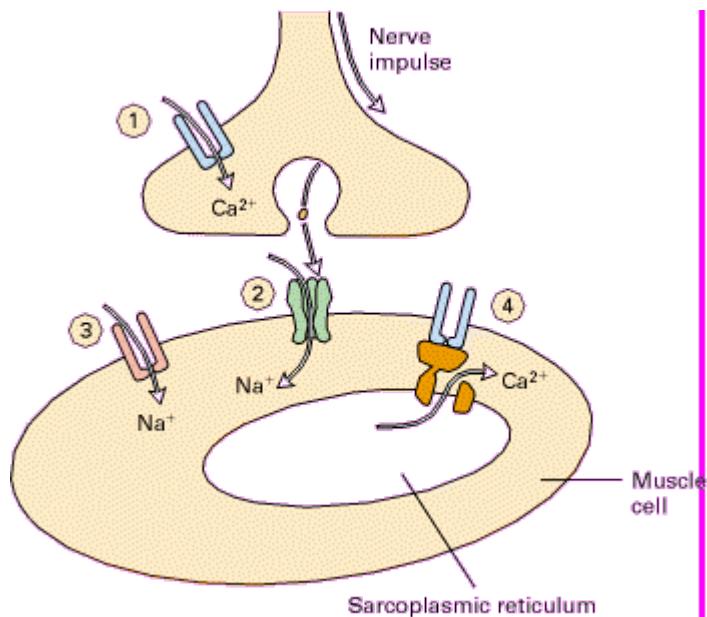
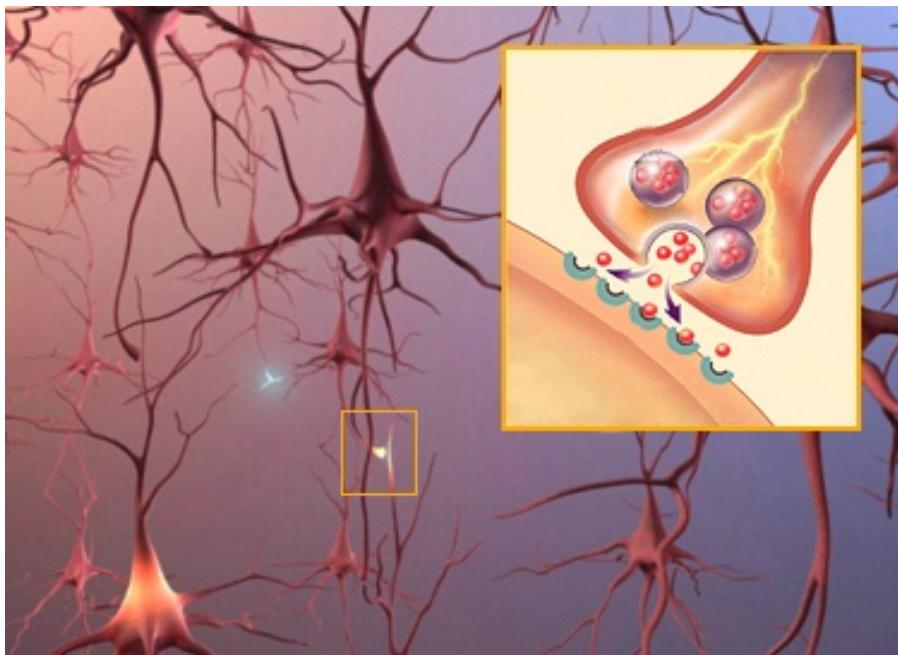


Traveling action potential

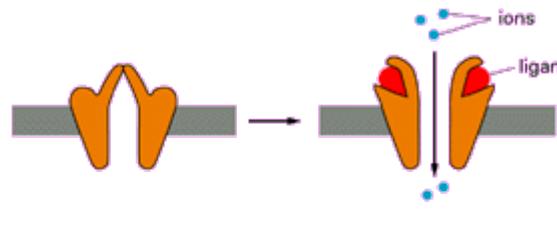


The action potential is an 'all or none' phenomenon

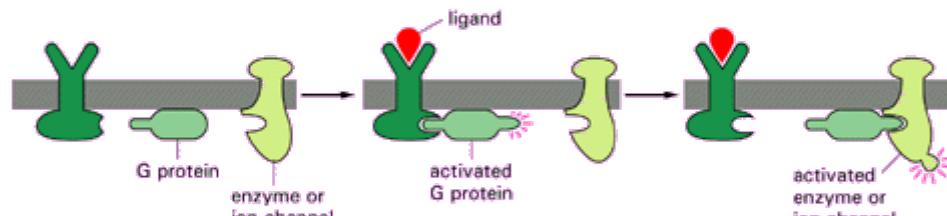
Between two neuron: The synapse



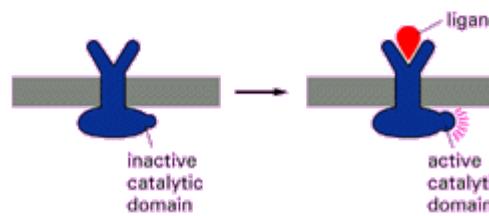
(A) ION-CHANNEL-LINKED RECEPTOR



(B) G-PROTEIN-LINKED RECEPTOR



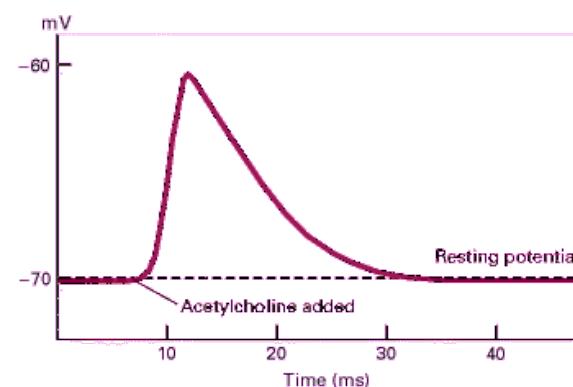
(C) ENZYME-LINKED RECEPTOR



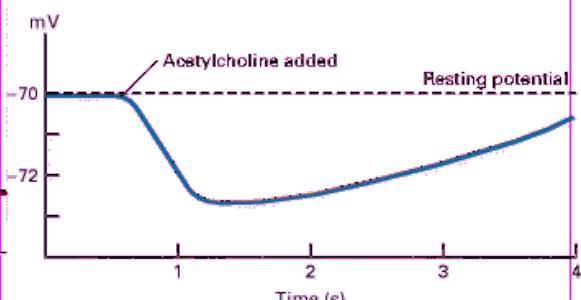
Ionotropic (A) and metabotropic (B,C) receptors

Excitatory and inhibitory postsynaptic potentials

(a) Excitatory synapse



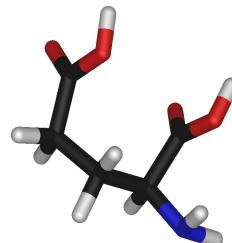
(b) Inhibitory synapse



Excitatory and inhibitory neurotransmitters

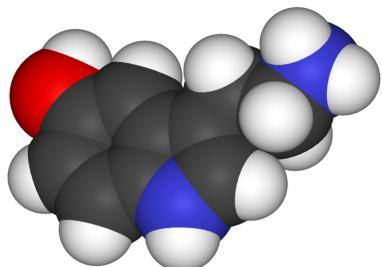
Glutamat

(information transmission)



Serotonin

(mood, wake/sleep)



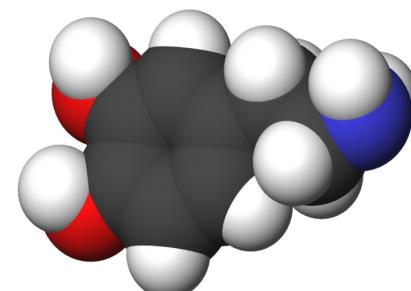
Acetylcholin

(neuromuscular junction)



Noradrenaline

(arousal)

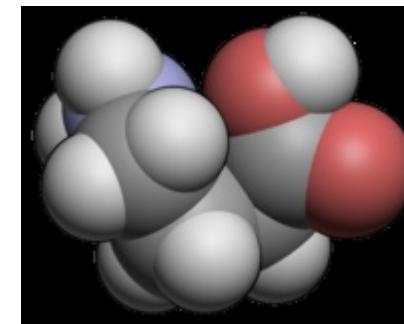


Dopamine

(reward system,
Parkinson disease,

schizophrenia)

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



Glycine

(in the periphery)

