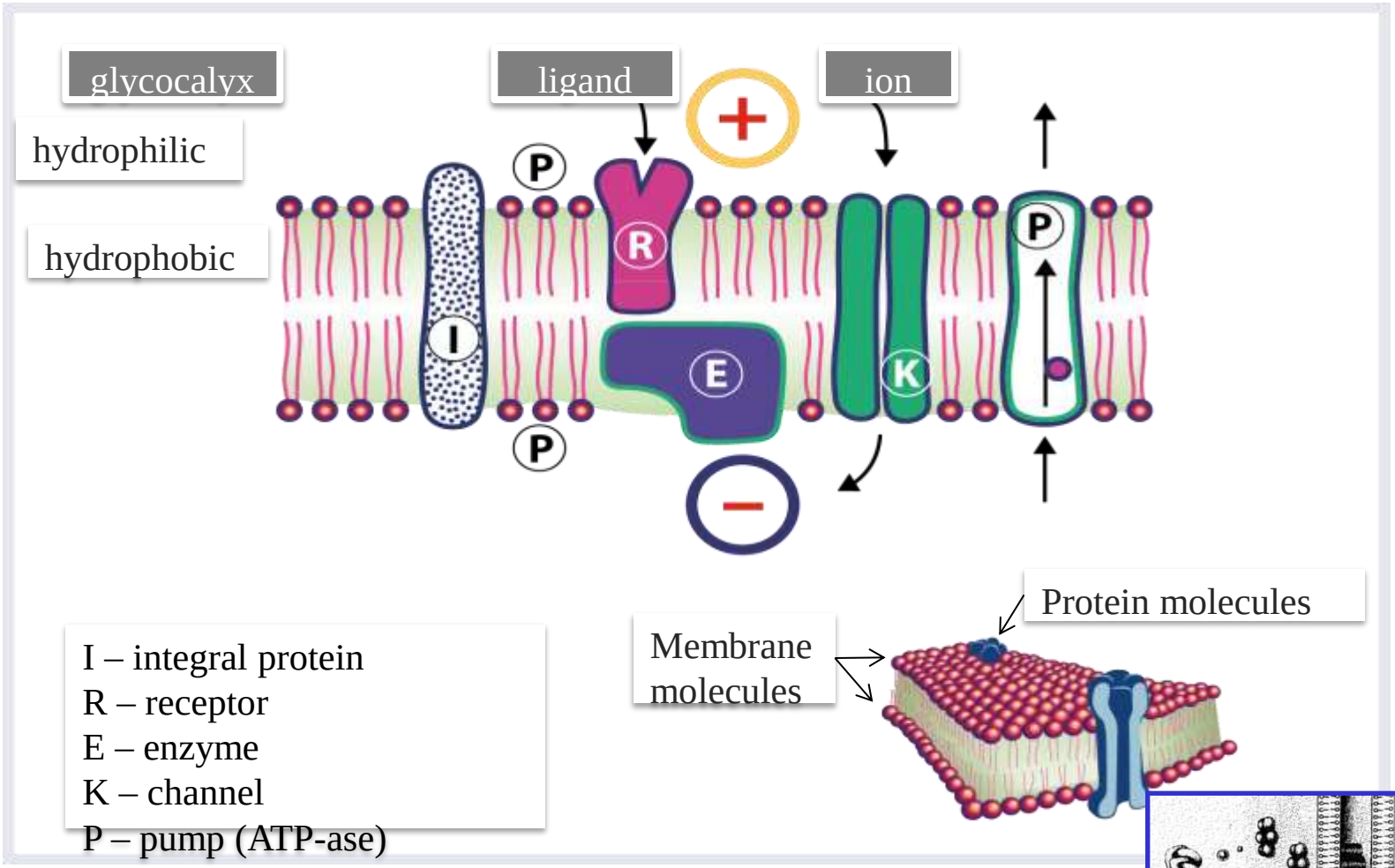
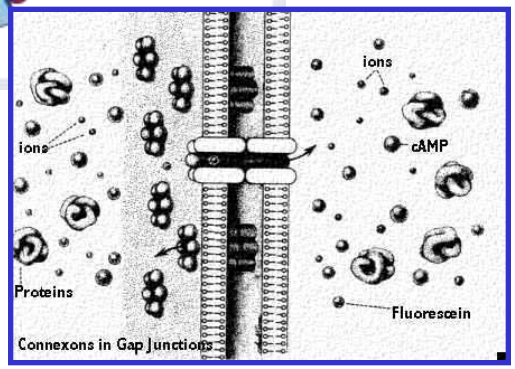
ELECTRICAL TRANSMISSION OF INFORMATION. PRINCIPLES OF NERVOUS AND MUSCLE ACTIVITY.

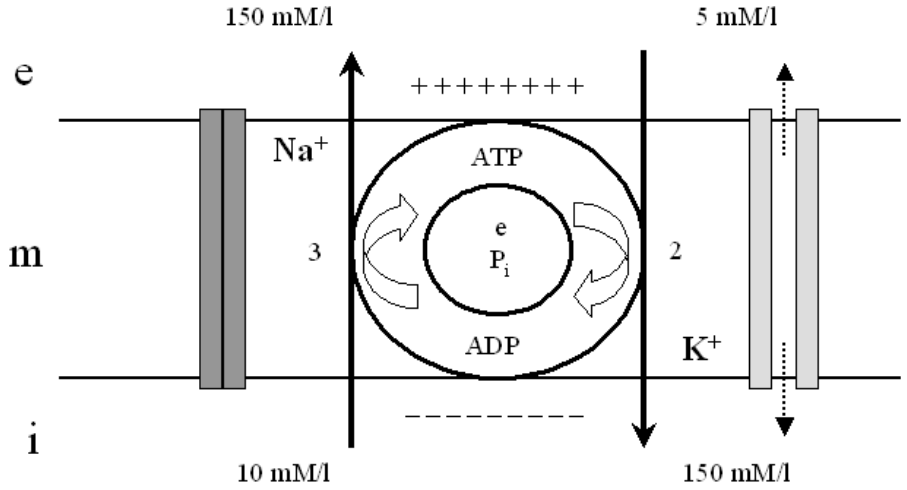
PLASMATIC MEMBRANE

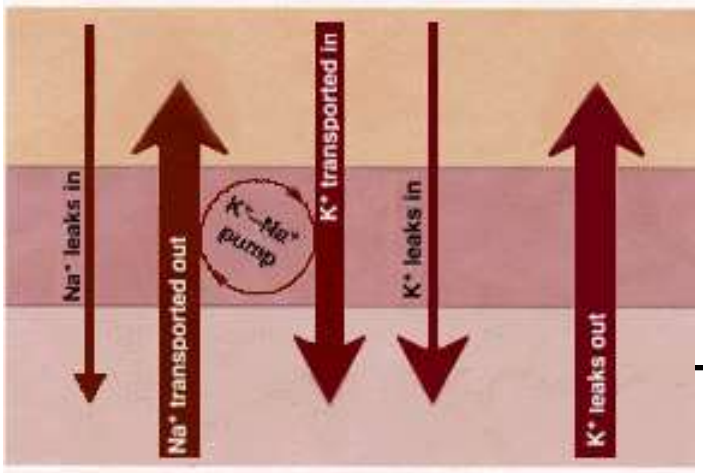


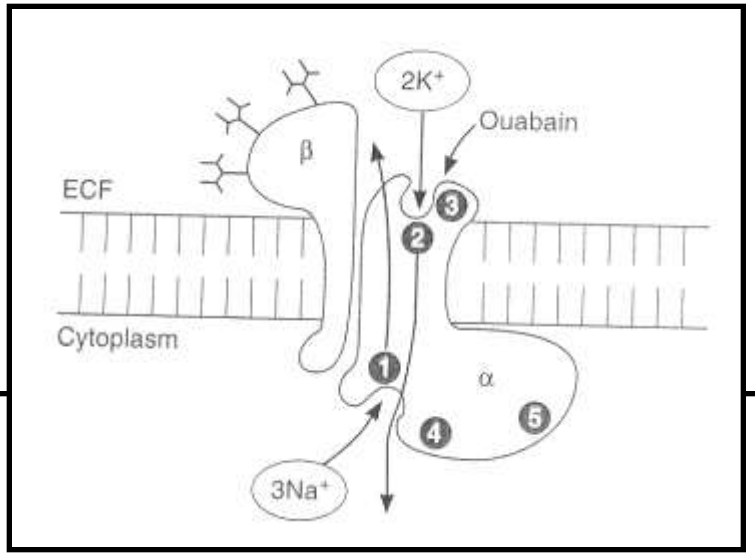
Nexus (gap junction)



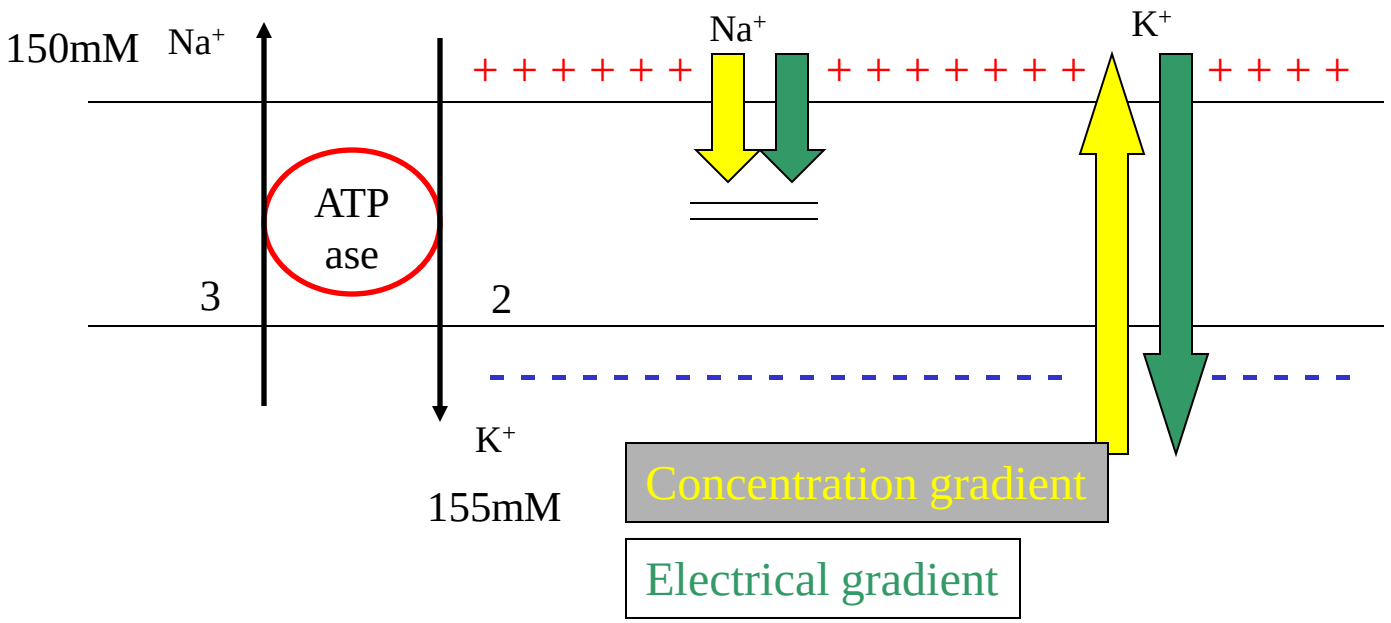
SODIUM-POTASSIUM PUMP







RESTING MEMBRANE VOLTAGE



Nernst equation:

$$E_x = \frac{R \cdot T}{F} \ln \frac{(Cx_{out})}{(Cx_{in})}$$

E_{Na} = +40 mV

E_K = -90 mV

E_{Cl} = -70 mV

E_{Ca} = +60 mV

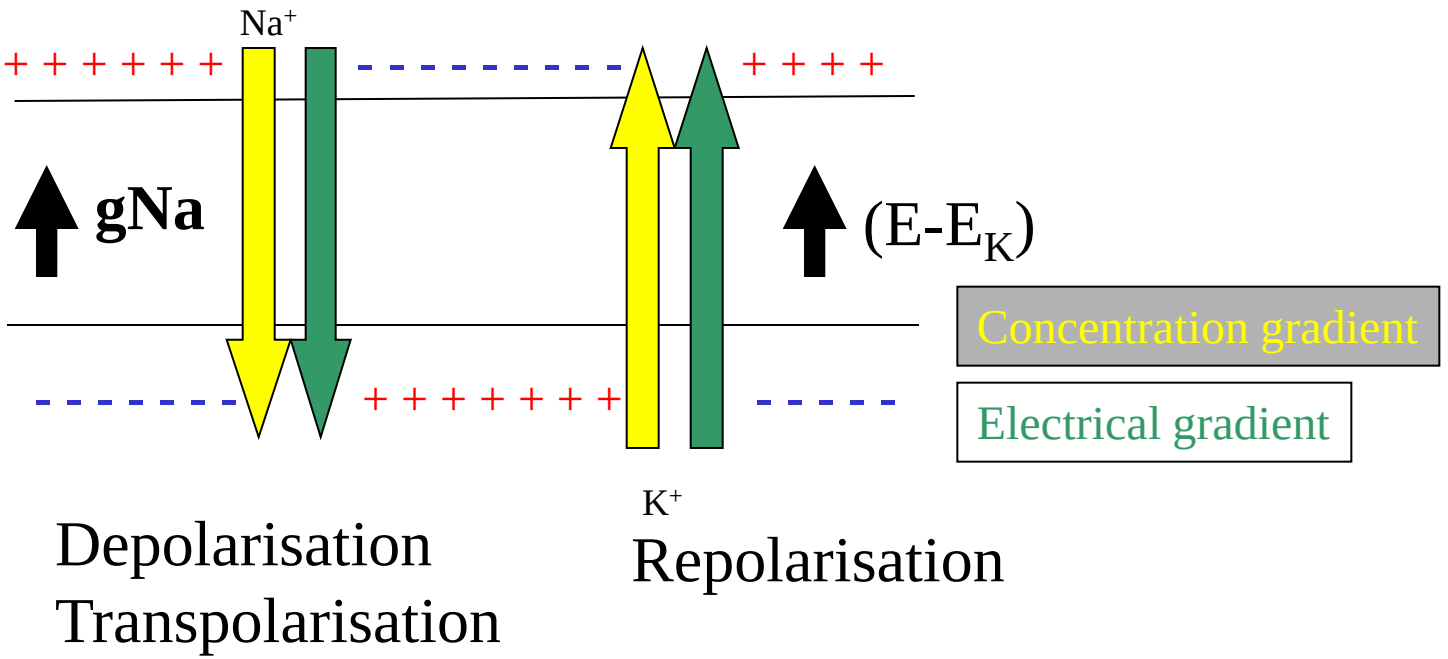
E_r = -85 mV

$I_x = g_x \cdot (E - E_x)$

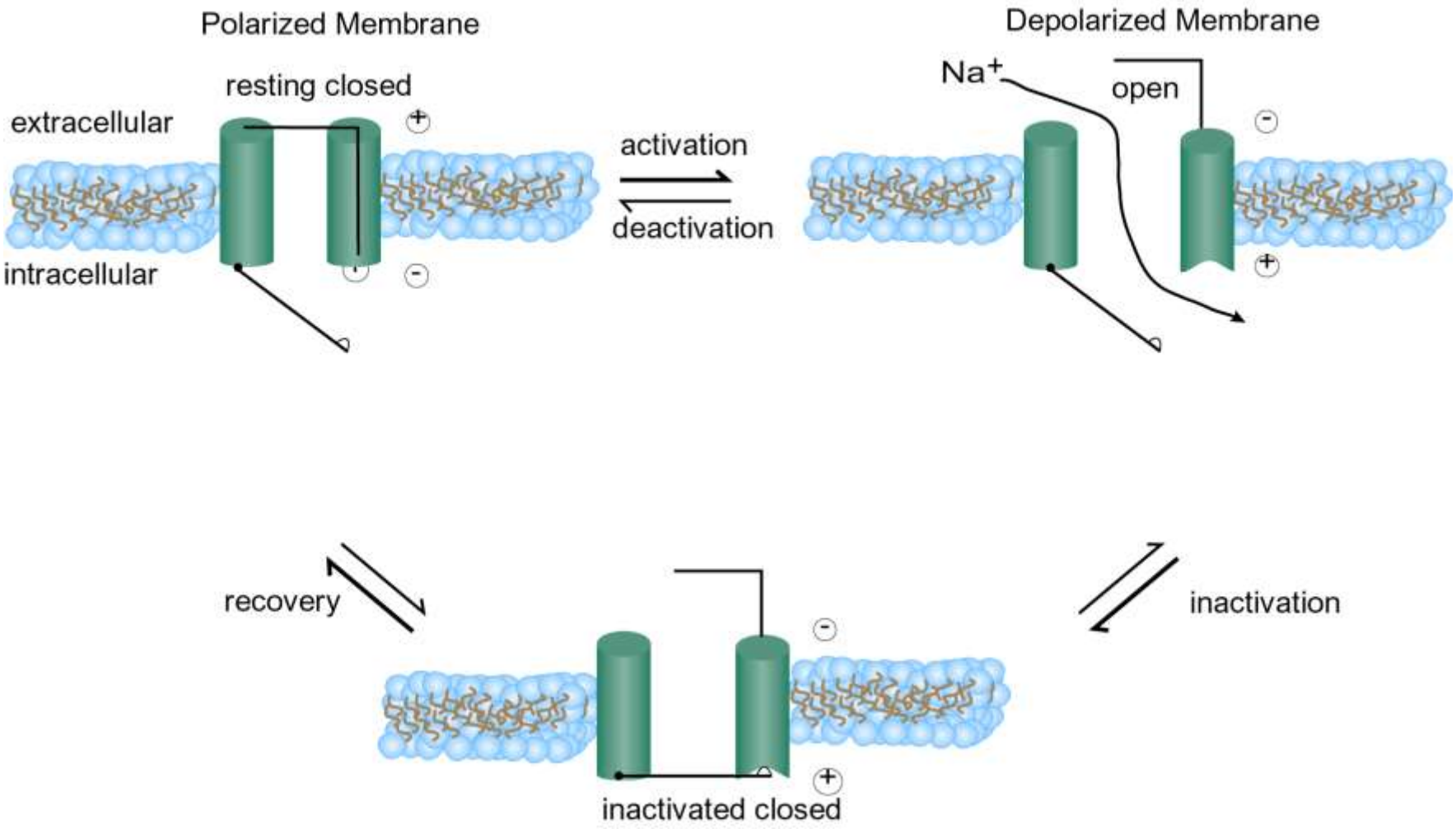
I – current, E – voltage, g – specific voltage and time-dependent conductance

RESTING MEMBRANE POTENTIAL IS A CONDITION OF EXCITABILITY AND DEPENDS ON HIGH RESTING MEMBRANE CONDUCTIVITY FOR POTASSIUM

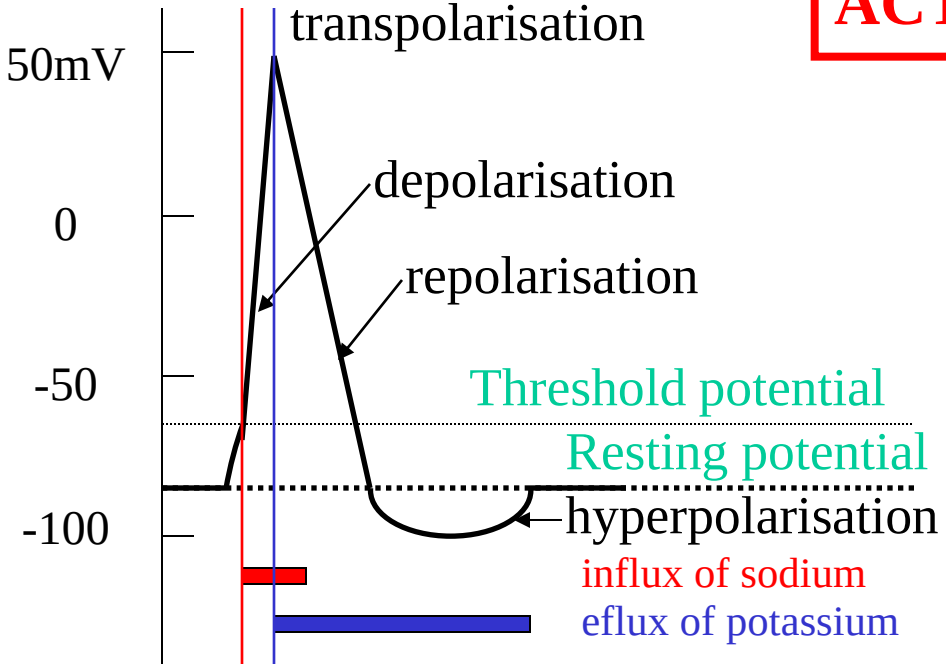
ACTION POTENTIAL



ACTION POTENTIAL IS A PROPAGATED ELECTRICAL SIGNAL GENERATED BY FAST SODIUM CURRENT INTO THE CELL

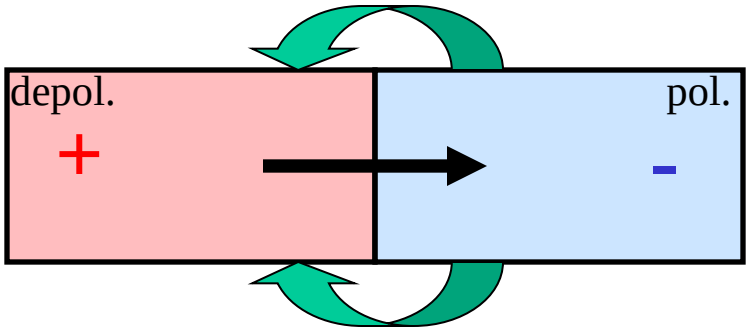

Polarized Membrane
resting closed
extracellular
intracellular
activation
deactivation
Depolarized Membrane
Na+
open
recovery
inactivation
inactivated closed

ACTION POTENTIAL

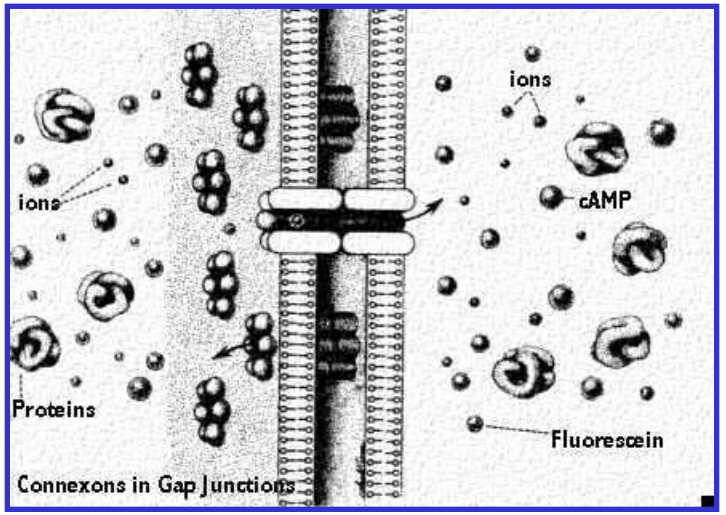


- Unit of excitation activity
- „All or nothing“ response
- Propagation without decrement („domino effect“)
- Refracterity

Local current



Propagation with decrement



Velocity of excitation propagation (depolarisation front) is a function of:

- Intensity of local currents
- Resistance outside the conductor (myelin)
- Resistance of the conductor (indirect relationship)

Nodes of Ranvier, saltatory conduction

Neuron

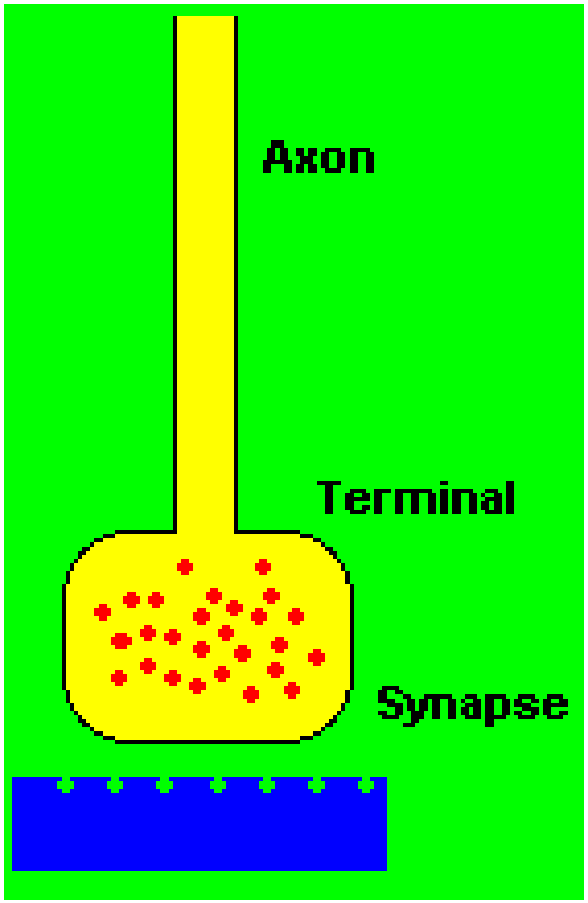
input section (coding of inf.)

transmission section (transmission of inf.)

output section (decoding of inf.)

SYNAPSIS

- excitatory
- inhibitory



Action potential
Calcium ions

Synaptic vesicles (exocytose)

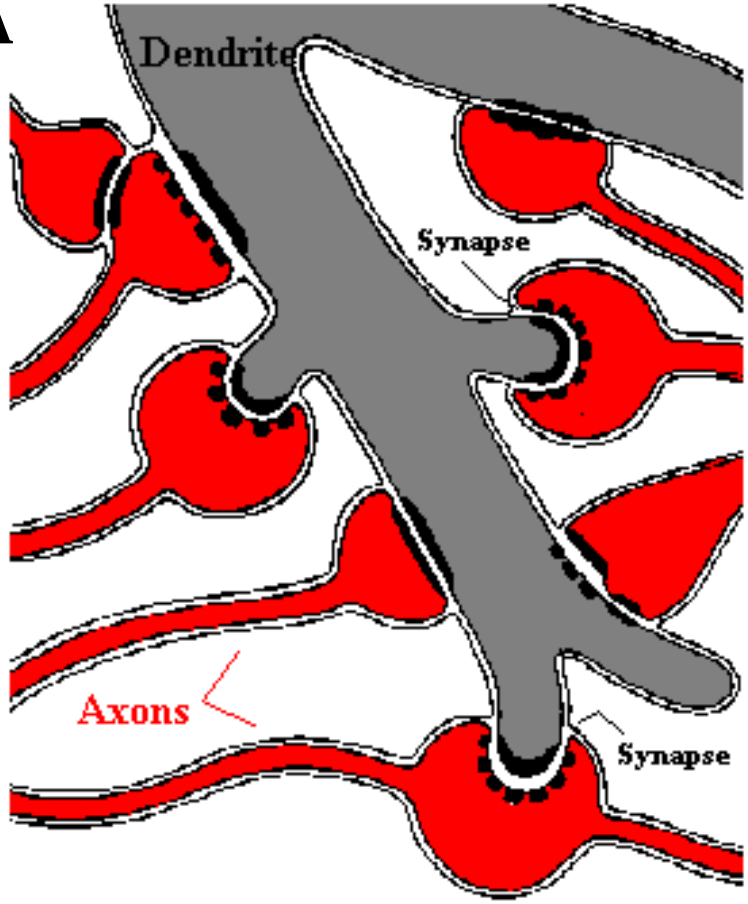
Neurotransmitter (mediator)

Presynaptic membrane

Synaptic cleft

Postsynaptic membrane
(local change of voltage)

A

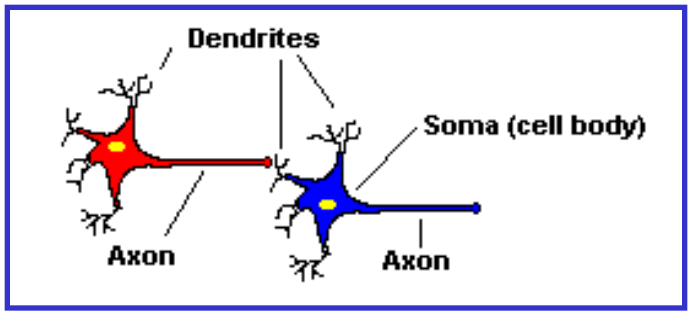


SYNAPSIS:

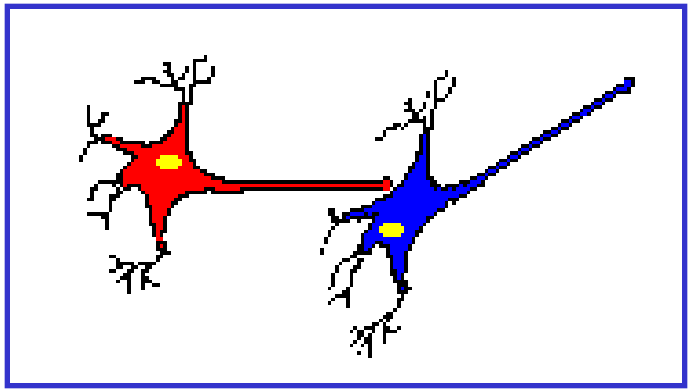
A – axodendritic

B – axosomatic

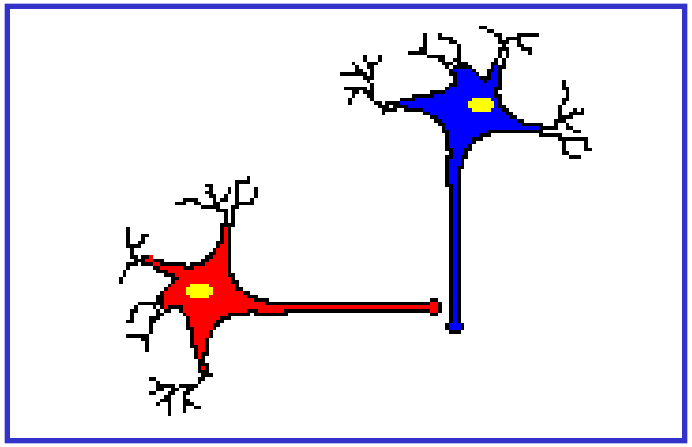
C - axoaxonal



A



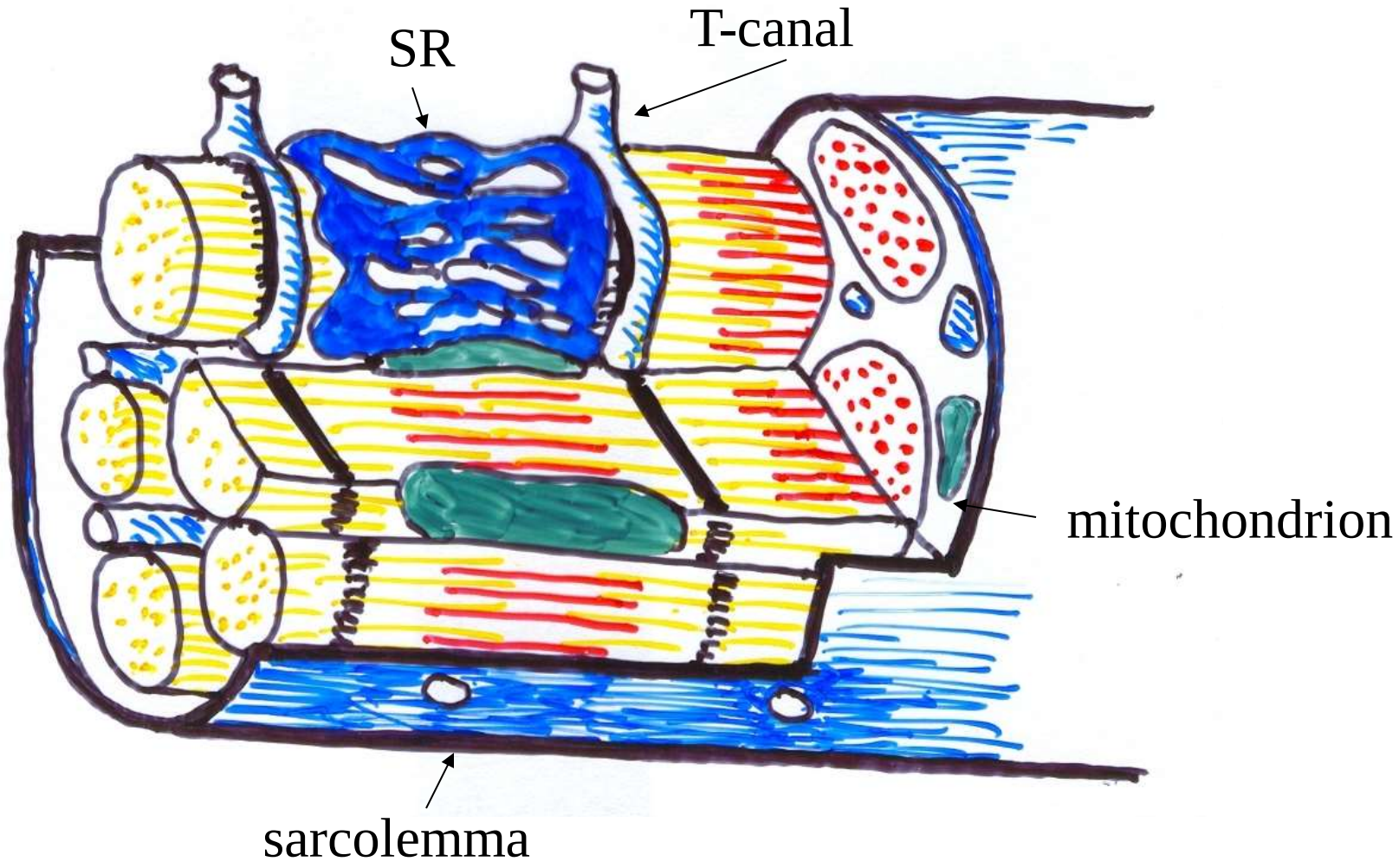
B

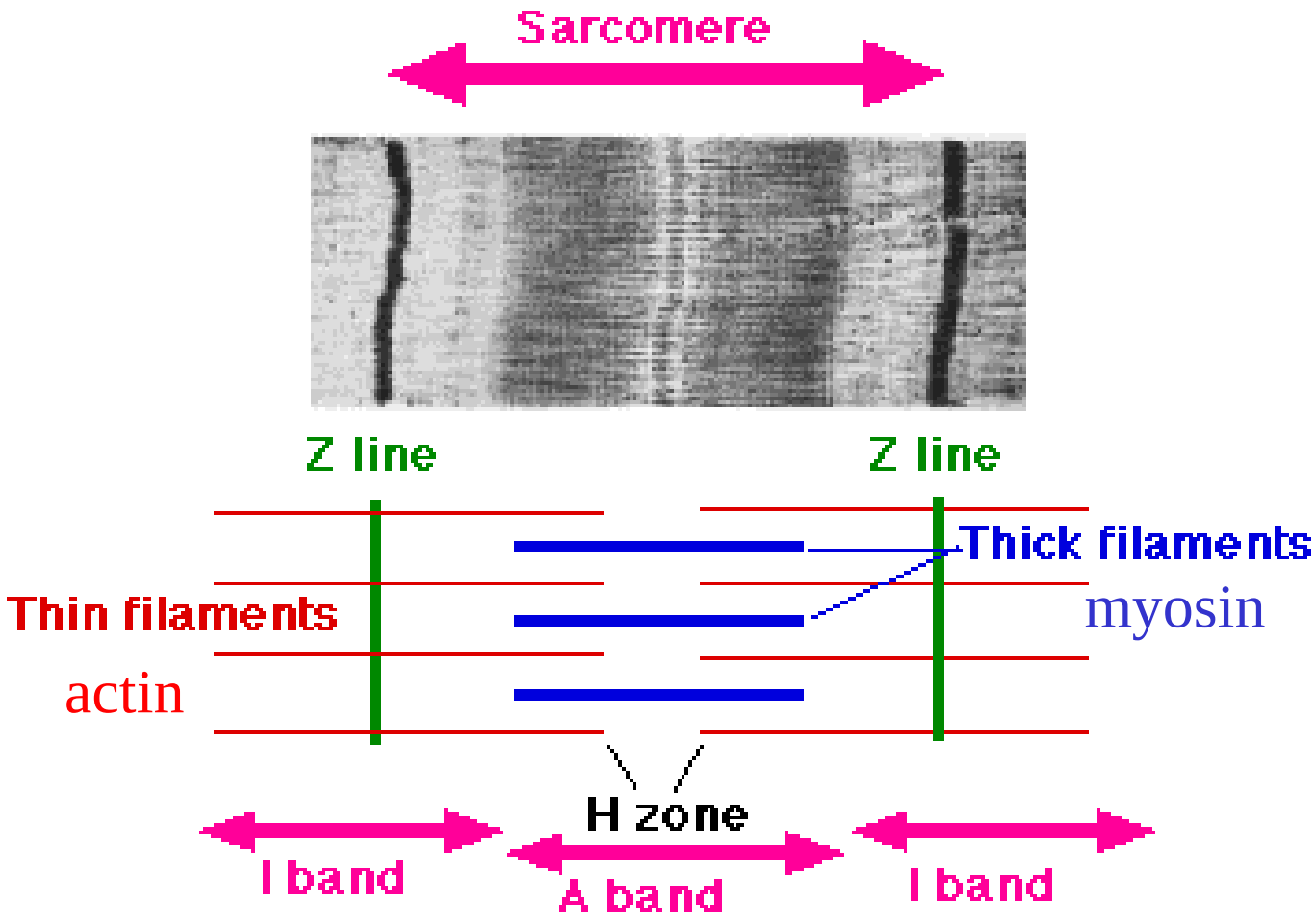


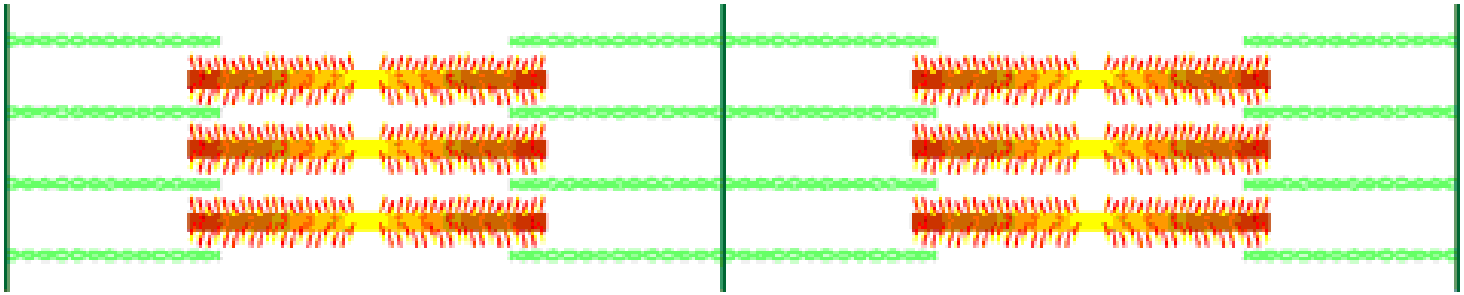
C

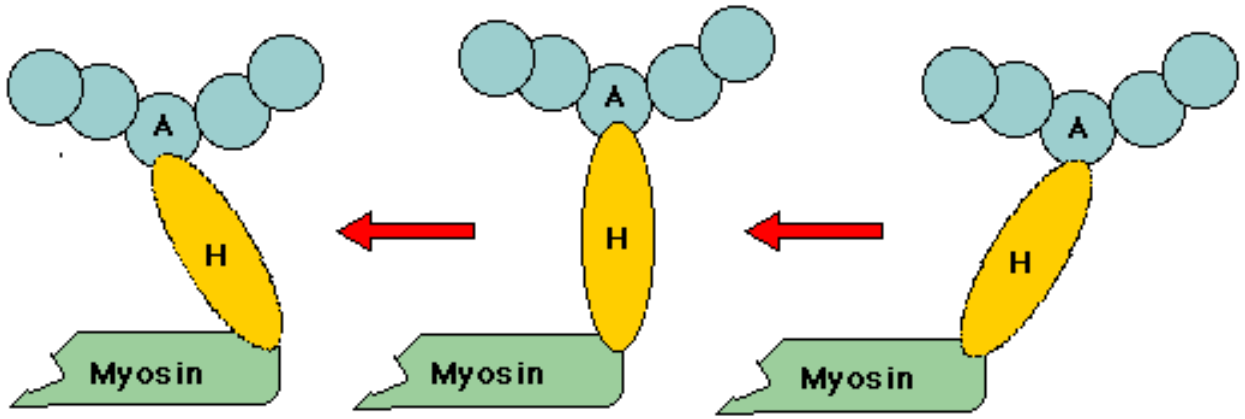
MUSCLE: striated, heart, smooth

MYOFIBRILE




Sarcomere
Z line
Z line
Thick filaments
myosin
Thin filaments
actin
H zone
I band
A band
I band

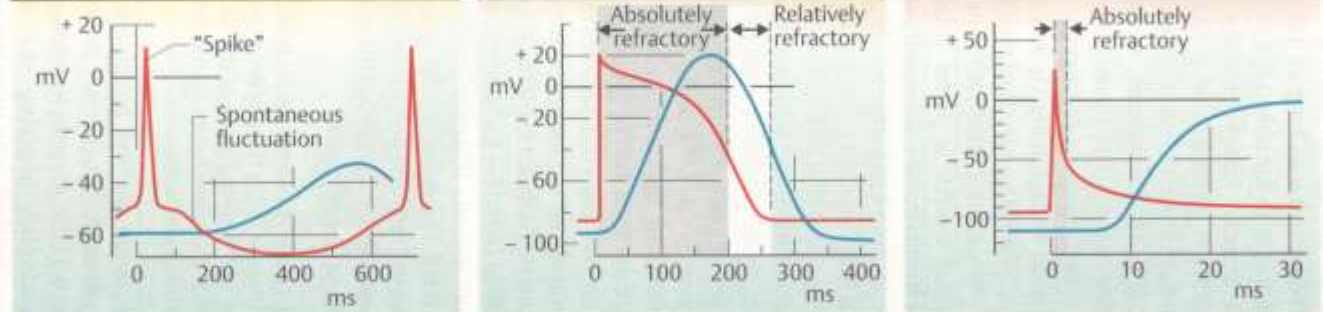



A
H
Myosin
A
H
Myosin
A
H
Myosin

Molecular motor

Structure and function	Smooth muscle	Cardiac muscle (striated)	Skeletal muscle (striated)
Motor end-plates	None	None	Yes
Fibers	Fusiform, short (≤ 0.2 mm)	Branched	Cylindrical, long (≤ 15 cm)
Mitochondria	Few	Many	Few (depending on muscle type)
Nucleus per fiber	1	1	Multiple
Sarcomeres	None	Yes, length ≤ 2.6 µm	Yes, length ≤ 3.65 µm
Electr. coupling	Some (single-unit type)	Yes (functional syncytium)	No
Sarcoplasmic reticulum	Little developed	Moderately developed	Highly developed
Ca^{2+} "switch"	Calmodulin/caldesmon	Troponin	Troponin
Pacemaker	Some spontaneous rhythmic activity ($1 s^{-1}$ – $1 h^{-1}$)	Yes (sinus nodes ca. $1 s^{-1}$)	No (requires nerve stimulus)
Response to stimulus	Change in tone or rhythm frequency	All or none	Graded
Tetanizable	Yes	No	Yes
Work range	Length-force curve is variable	In rising length-force curve (see 2.15E)	At peak of length-force curve (see 2.15E)

Response to stimulus



S. Silbernagl, A. Despopoulos: Color Atlas of Physiology