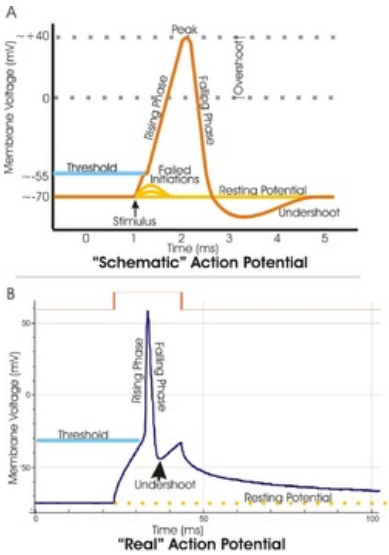
Ionic and molecular basis of nerve fiber action potential, comparison of AP and PSP

Action potencial(excitement) arises from a **change** in resting equilibrium(change of polarization) on the membrane. This change is caused by spreading voltage that changes activity of voltage-gated ion channels.



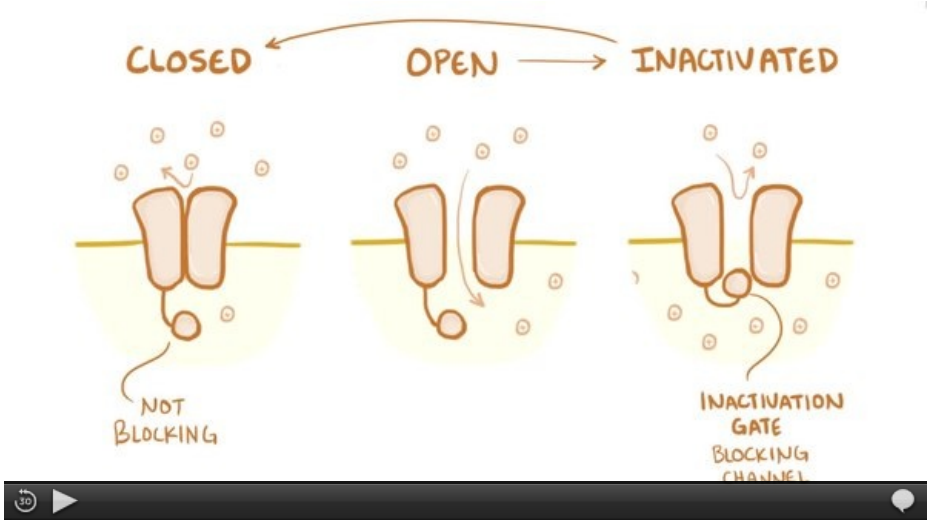
Action potential

The principle of action potential formation

The excitation occurs in place, where outbalance the voltage-gated channels. These channels follows the rule-**all or nothing**. It means that excitement will only occur when there is **sufficient stimulus**, which is called **threshold stimulus**(the most often about 5-15 mV higher than value of resting membrane potential). At this value the **voltage-gated Na+ channels are opened**. Sodium ions then can go in intracelular space according to concentration gradient and electric gradient. Interior side of membrane becomes **more positive** than outer side of membrane. This condition is called **depolarization**. In case, when **outer side of membran** is **more electronegative** than interior side of membrane we talk about **transpolarization.** Along with sodium channels are opened slowly the **kalium channels**, whose opening **is delayed**. Opening of this channels reaches a maximum at closure of sodium channels. Due to the flow of K+ ions along the direction of concentration gradient, the polarity begins to **come back to original values** and we are talking about **repolarization.** In case of deepening the original membrane potencial we use the term **hyperpolarization.** Accomplisment of original values of resting membrane potencial is conditioned by activity of Na+/K+ ATPase, which overpumps ionts againts concentration gradient.

Refractory phase

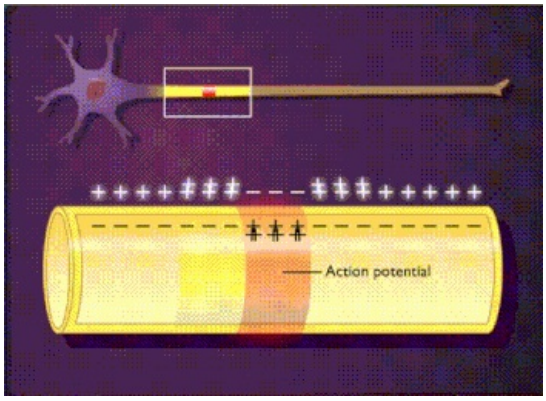
Condition, when is not possible to stimulate the nervous cell so that action potential occurse. Refractory phase can be **relative** which means that we are able to evoke an action potential with suprathreshold stimulus. Refractory phase can be also **absolute** which means that we are able to evoke an actional potential with none stimulus.



Neuron action potential

Conduction of excitement

Actional potential is spreading **without decrement**, which means that it is not losing intensity. It is caused by emergence of **local stream.** Local streams arise above place, where the ion distribution occurred. As a result of the creation of these streams is depolarization of membrane in the **adjacent fiber section**. Local streams **speed up** the conduction of excitement. In case of extension of fiber(e.g isolation by myelin sheath) occurs to effect local streams in next section, which is isolated, so it is faster than unmyelinated. It is called **saltatory conduction of actional potential.**



Action potential propagation in unmyelinated axon

Actional potential of different tissues

Actional potential wich is descibed above applies to all capable cells of generating an excitation. This general pattern is describing general model at nervous cell. At different cells it differs in e.g value of treshold, duration, ion channels etc.

Effects of Calemia

Calemia is value of K+ ECT. Higher surface of K+ ECT(**hyperkalemia**) slightly depolarizes the membrane, because concentration gradient for K+ is limited so i tis not possible full repolarization after depolarization. The cell is not excitable. It could be also call as calium depresion. Irritation during hypercalemia is increased at first but after are blocked the voltage-gated channels and excitment is reduced(higher than 5,3 mmol/l)→shortening of actional potential. The voltage reaches to thresholds more easily.

Hypocalemia(less than 3,7 mmol/l) occures hyperpolarization→extension of actional potential. Neuron come up to threshold harder.

Comparison of AP and PSP

Basics differents between AP an PSP are circumstances. AP arises according to rule everything or nothing. PSP is directly proportional to the quant of poured out neurotransmiters. They are different in voltage and duration.

Parameter	AP	PSP
meaning	Transmission of excitement whithout quality changeover long distances	Processing, connection of individual PSP and decision whether AP should be created
behaviour	Everything or nothing	Continuous, it can have various values
amplitude	About 100mV	About 1-10 mV
duration	About 10-40 ms	About 1-5 ms
Ion channels	Voltage-gated	chemical
Permeability for	Na+, K+-fast channels	K+-leak channels
location	axons	Postsynaptic membrane
spreading	Without decrement	With dekrement, the signal strength decreases

Literature

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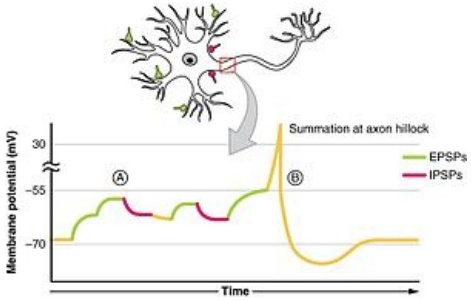

PSP summation

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