

Ion Channel and Membrane Excitability

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What are ion channels ?

- A selective pore protein on the plasma membrane
- These pores can open and close
- It allows 100 million ions to pass through each second

Where do they exit ?

- Plant and animal
- Excitable and non-excitable cells
- Membrane and intracellular organane
- Excitable cells include nerve, muscle and endocrines

Function of ionic channels

- Control of membrane potential
- Control of action potential upstroke
- Control of action potential duration
- Control of muscle contraction
- Control of cell volume
- Control of endocrine or transmitter release
- Control secretion of epithelial cells

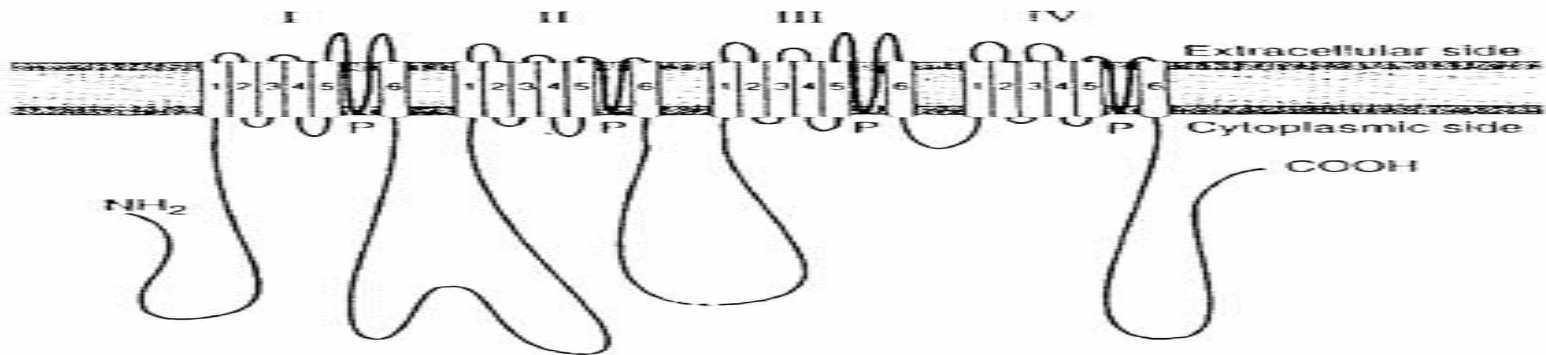
Classification of ion channels

- Sodium channels
- Calcium channels
- Potassium channels
- Chloride channels

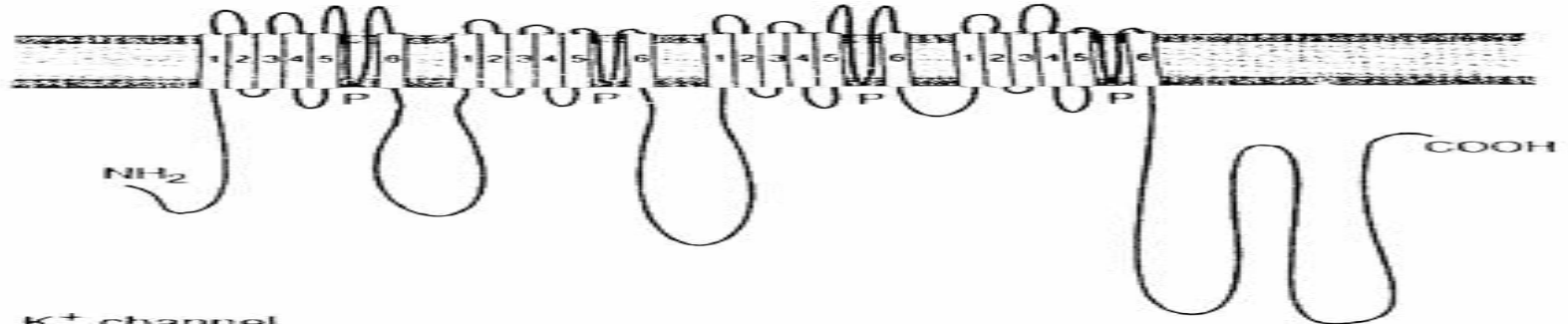
Structure of voltage-gated ionic channels

Primary sequence of ionic channels

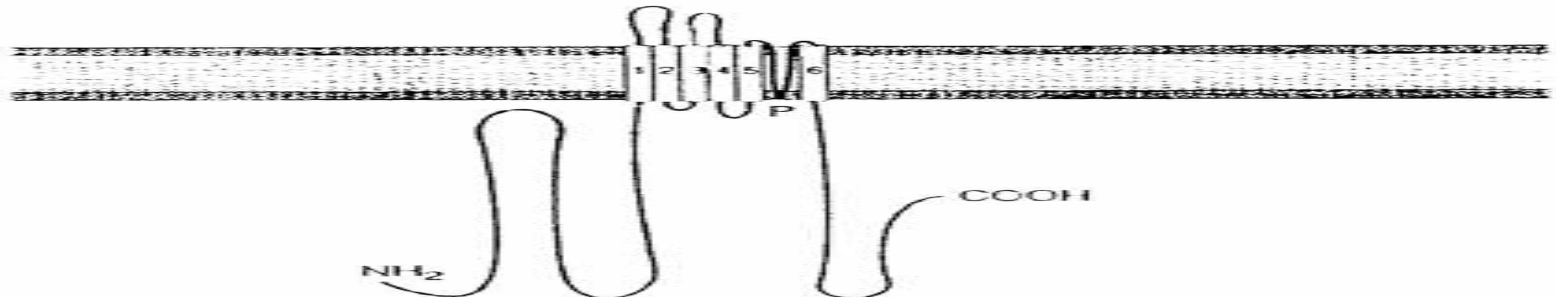
Na⁺ channel



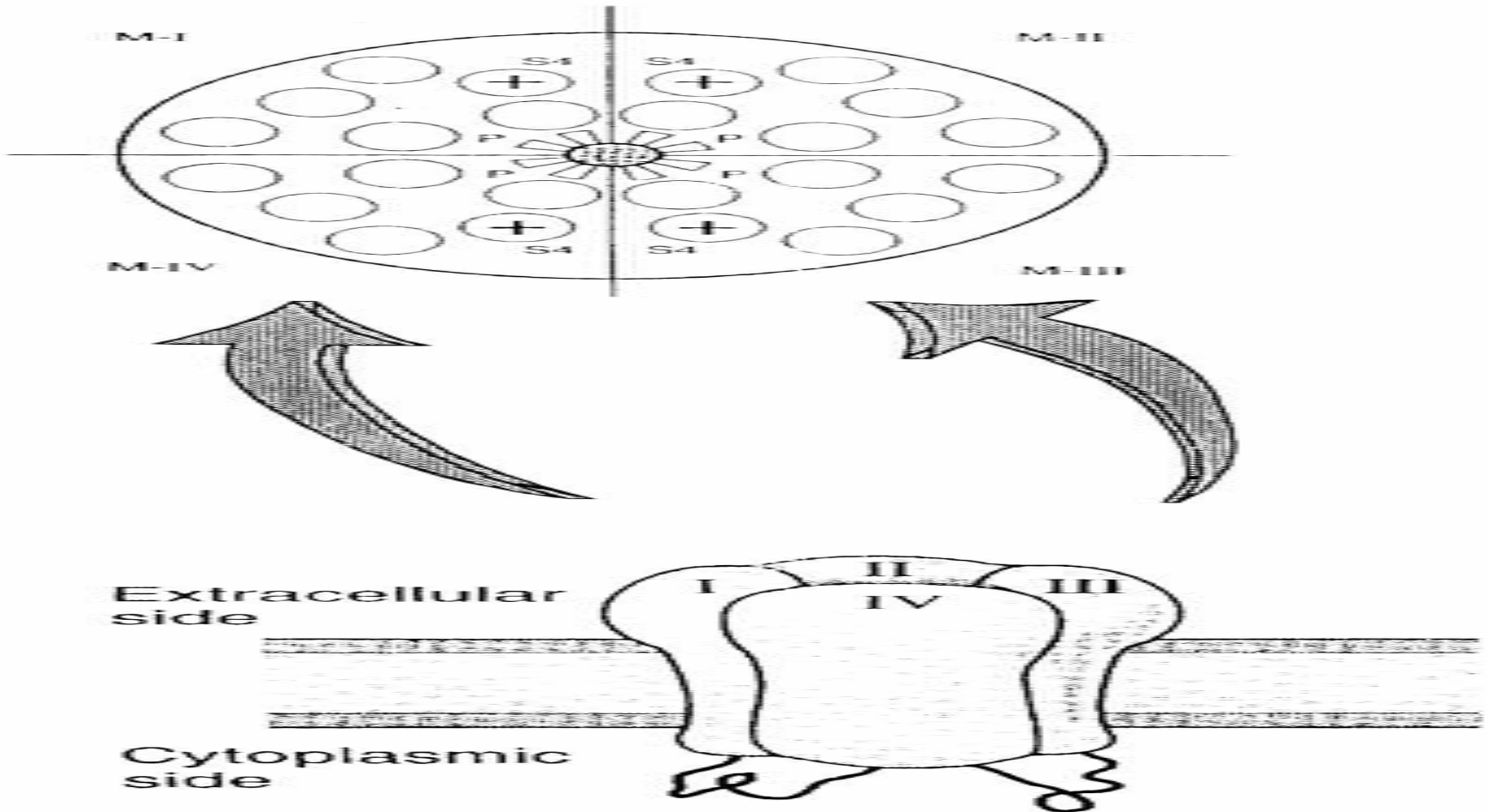
Ca²⁺ channel



K⁺ channel

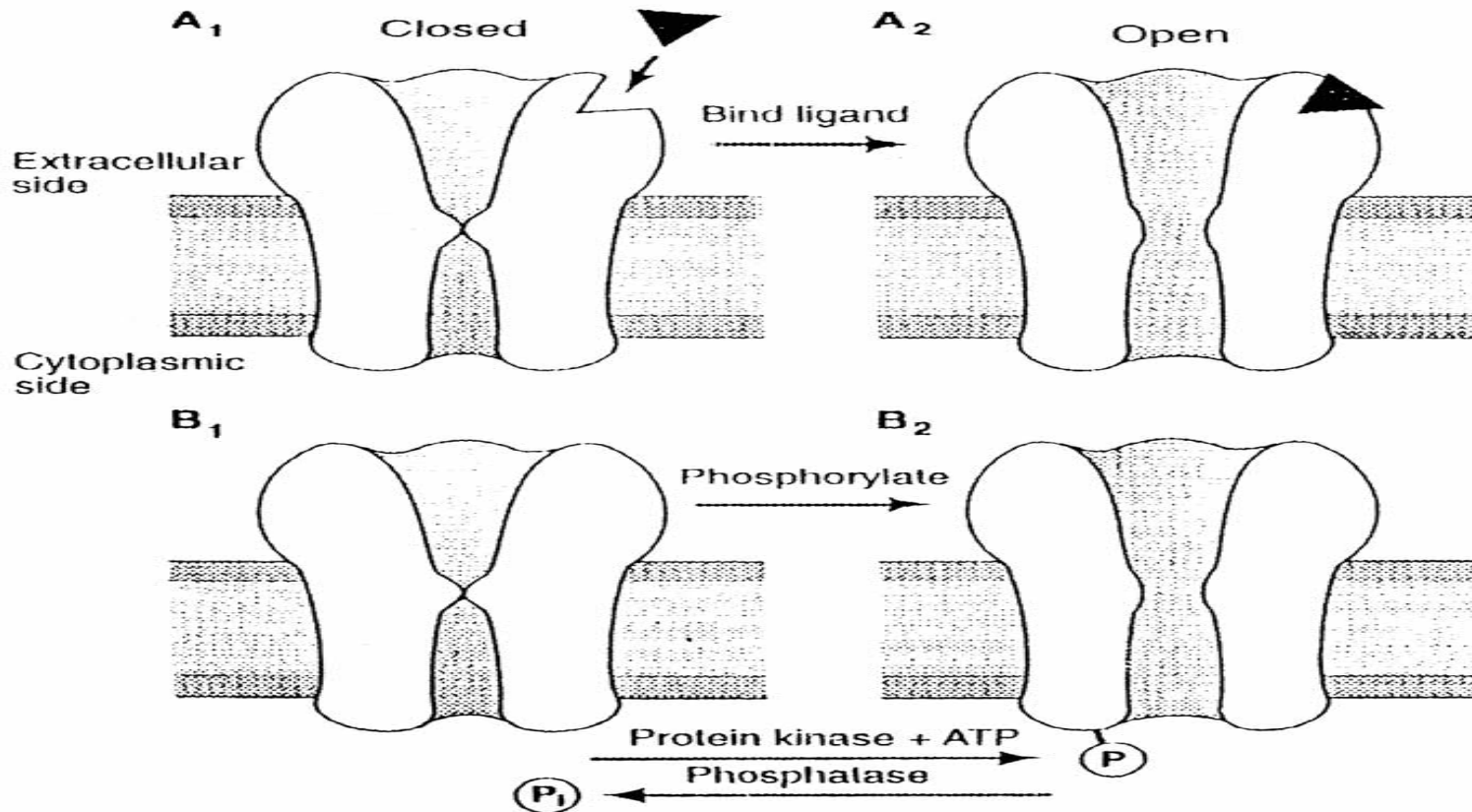


The postulated tertiary structure of voltage-gated Na^+ & Ca^{2+} channels



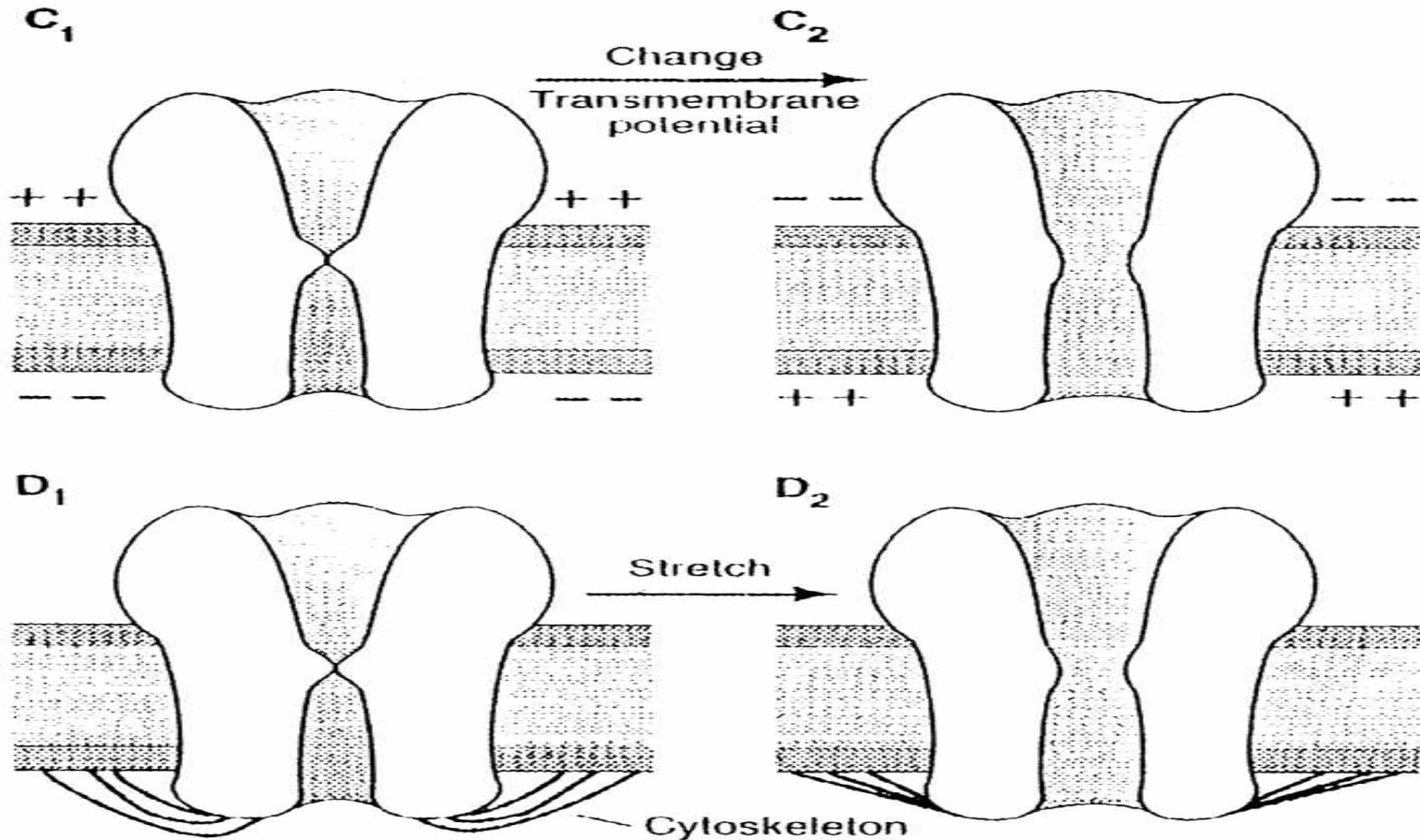
Mode of gating of ion channels

Mode of opening of ion channels



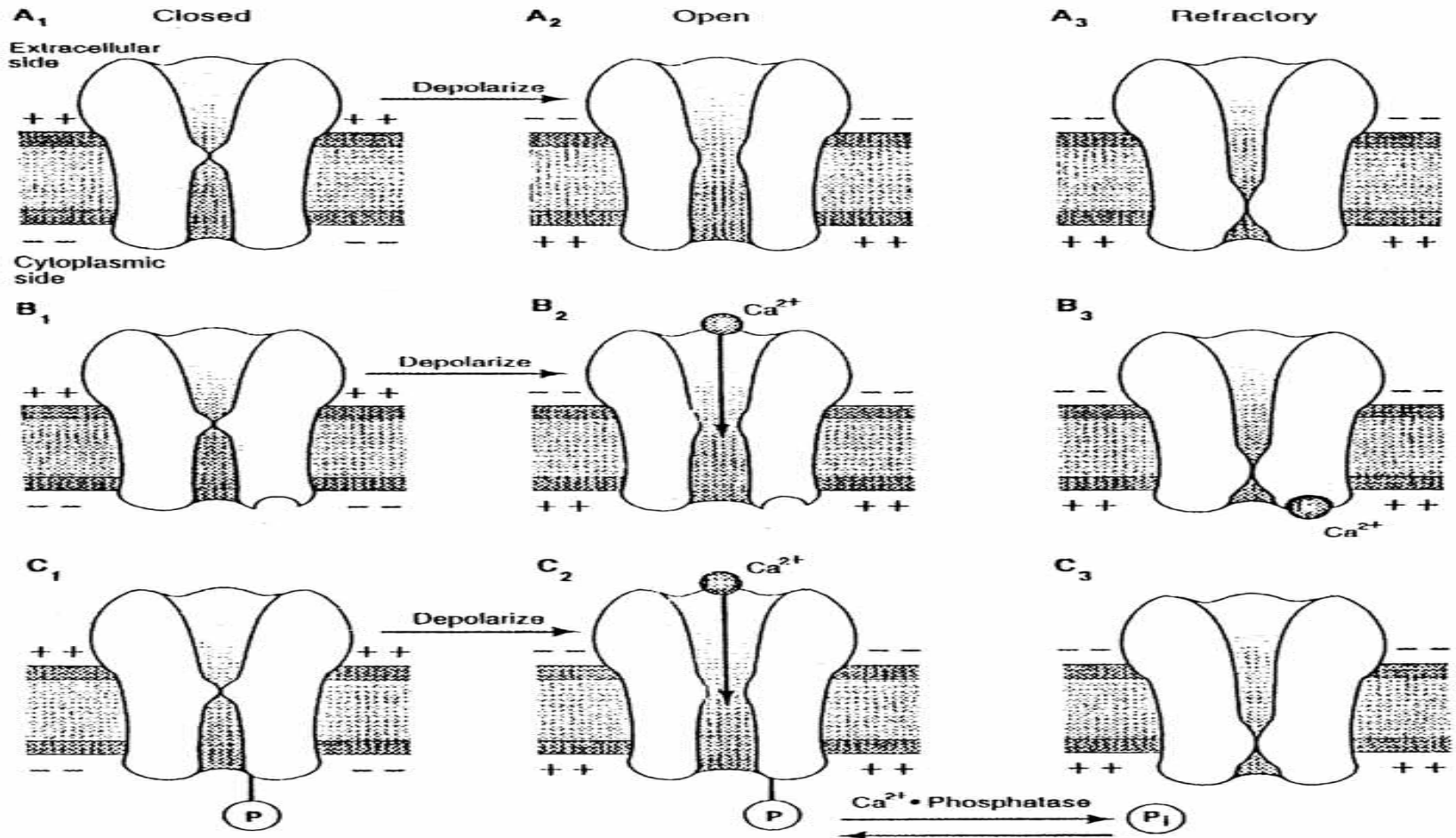
Mode of gating of ionic channels

Mode of opening of ionic channels



Mode of gating of ion channels

Mode of inactivation of ion channels



Gatings of voltage-sensitive ion channels by depolarization

Resting (R) State

Open (O) State

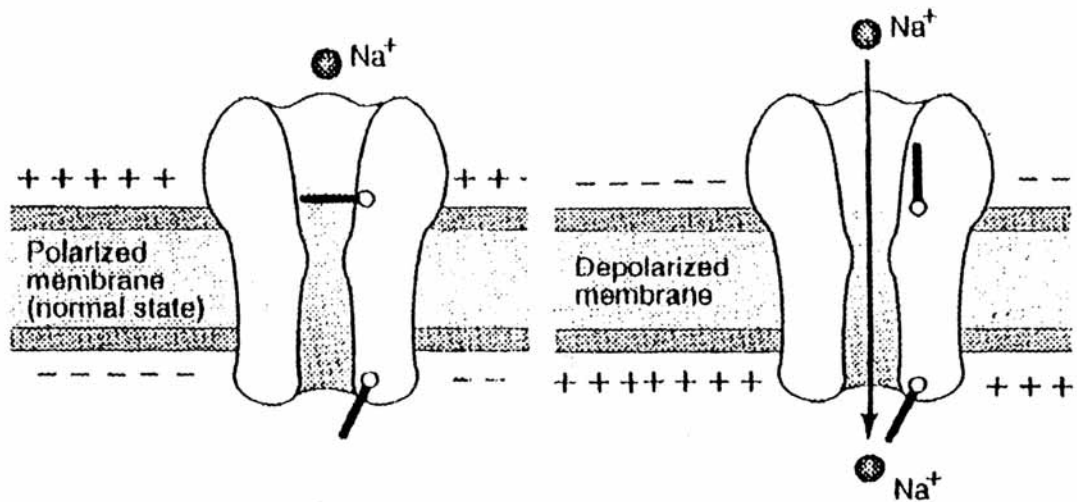
Open (O) State

Resting (R) State:
 I_{K1} & I_f channels

R State

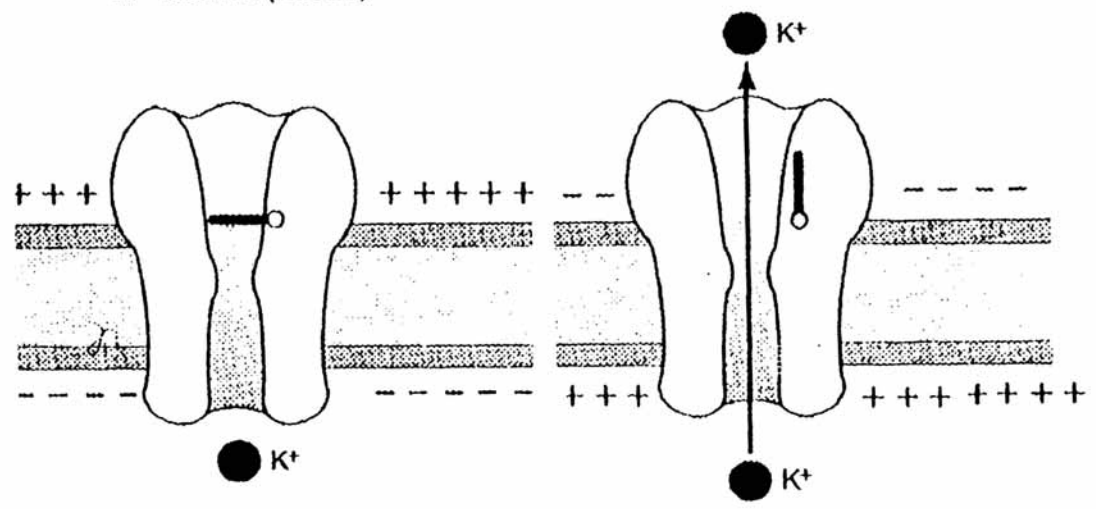
O State

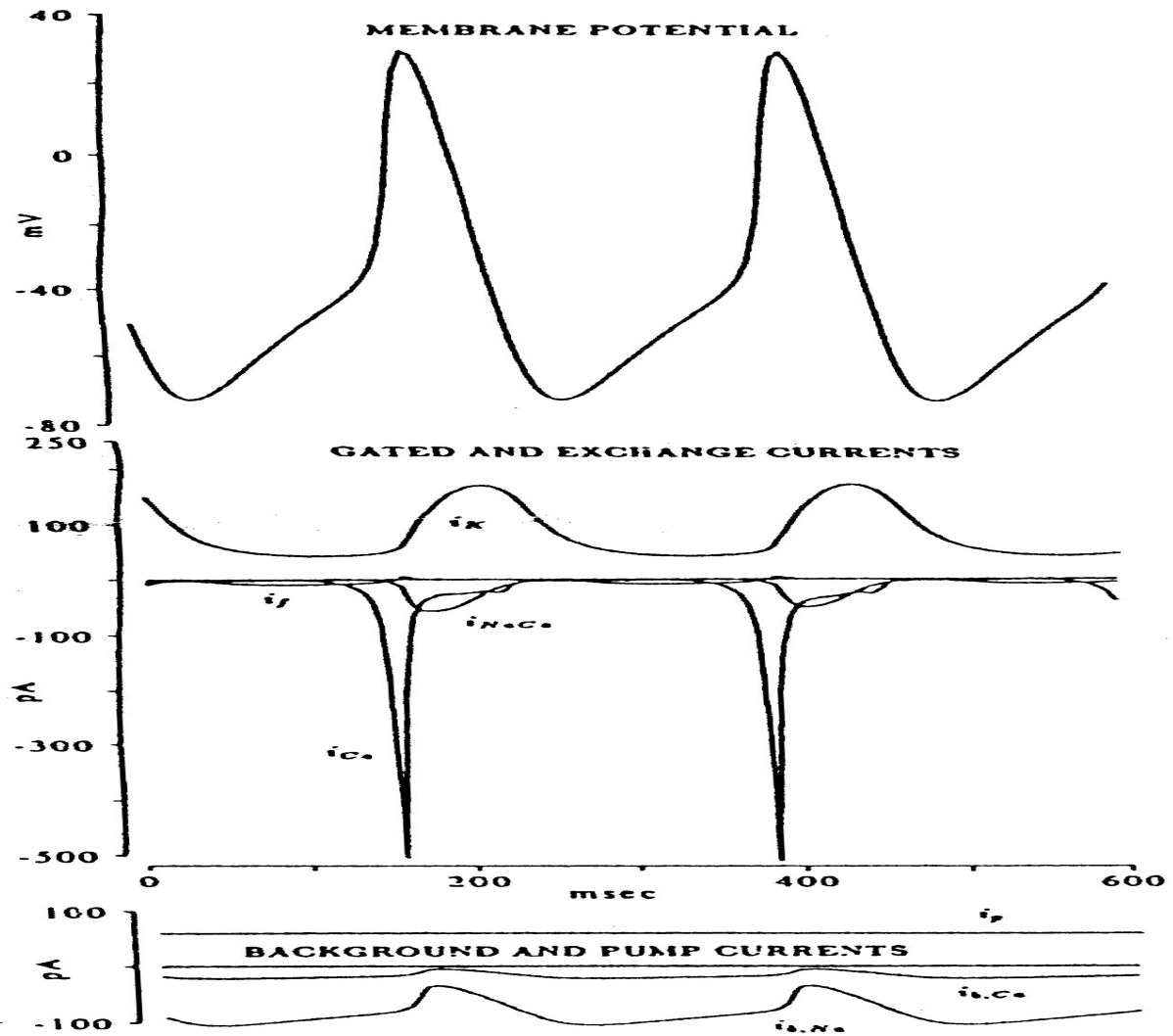
Inactivation (I) State



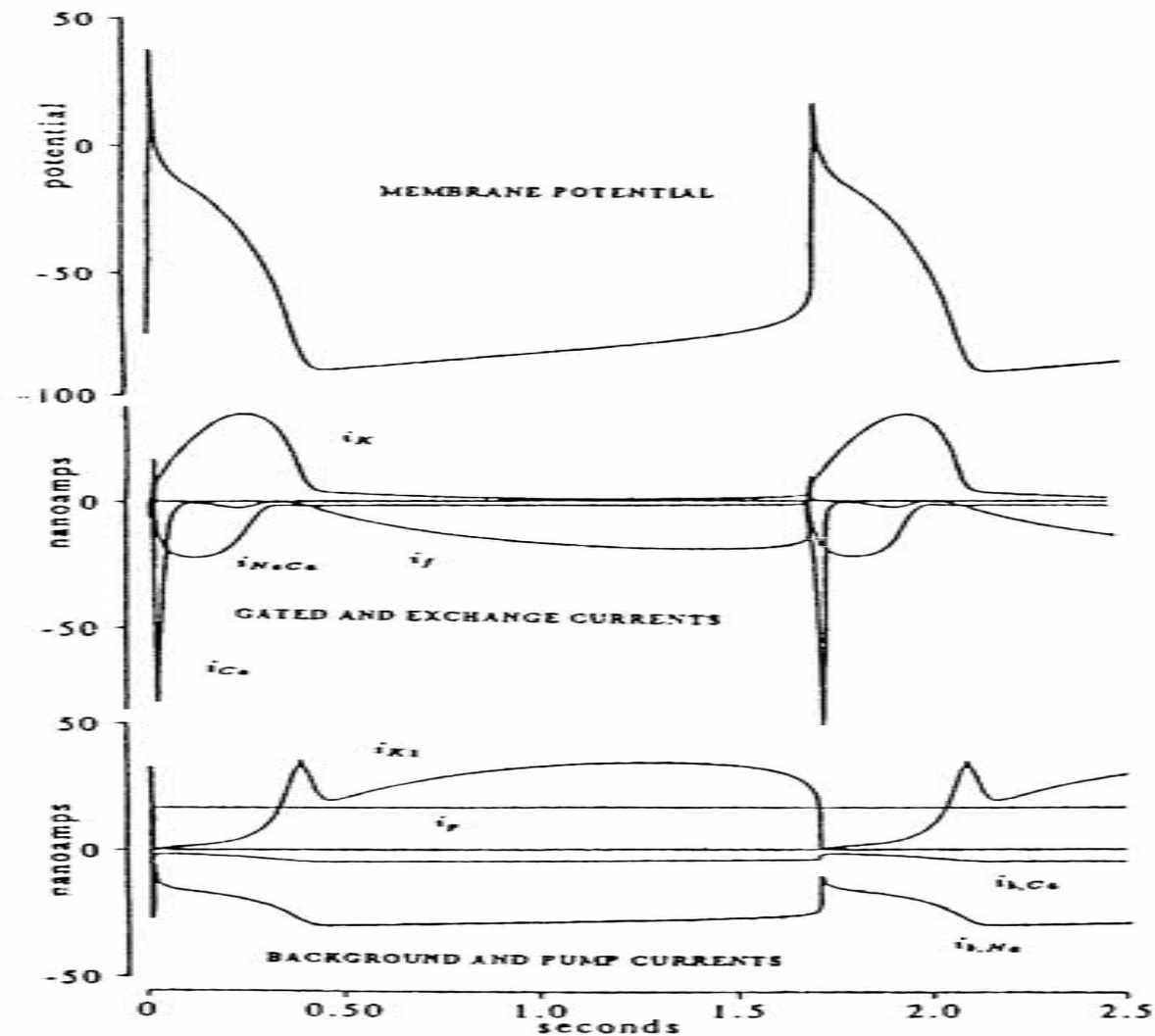
K^+ channel (closed)

K^+ channel (open)





Ionic mechanism in regulation of Purkinje fiber action potential



Properties and function of Na^+ channels

- Threshold : - 60 mV
- 100% inactivation : - 40 mV
- Function : Phase 0 depolarization, conduction of atrial & ventricular muscle & Purkinje fiber

Properties and function of T- type Ca^{2+} channel

- Threshold : - 50 mV
- 100 % inactivation : - 40 mV
- Function : Late half of diastolic depolarization in SA node

Properties and function of L- type Ca^{2+} channels

- Threshold : - 20 mV
- 100 % inactivation : 0 to +10 mV
- Function : Plateau phase of AP , trigger Ca^{2+} release from cellular store

Properties and function of

I_{to} channels

- Threshold : - 40 mV
- 100 % inactivation : - 40 mV
- Function : Phase 1 and phase 3 repolarization

Properties and function of I_K channels

- Threshold : - 30 to – 20 mV
- No inactivation on sustained depolarization
- Function : Phase 3 repolarization

Properties and function of I_{K1} channels

- Maintain at opened state before depolarization
- Change to closed state on depolarization
- Function : Maintain resting membrane potential, control membrane excitability

Properties and function of I_f channels

- Opened at resting or hyperpolarizing condition
- Change to close state on depolarization
- Function :Automaticity of Purkinje fiber and SA node

Functions of transmitter-gated ion channels

- To induce local change in membrane potential
- The magnitude of change is related to the amount of transmitter
- Transmitter can be excitatory or inhibitory

Different effect of excitatory and inhibitory transmitter

- Excitatory transmitter open channels permeable to Na^+ or Ca^{2+} ion
- Inhibitory transmitter open Cl^- or K^+ channels
- Excitatory transmitters include glutamate, serotonin, acetylcholine
- Inhibitory transmitter includes γ -aminobutyric acid (GABA) and glycine