Cardiac Muscle Physiology

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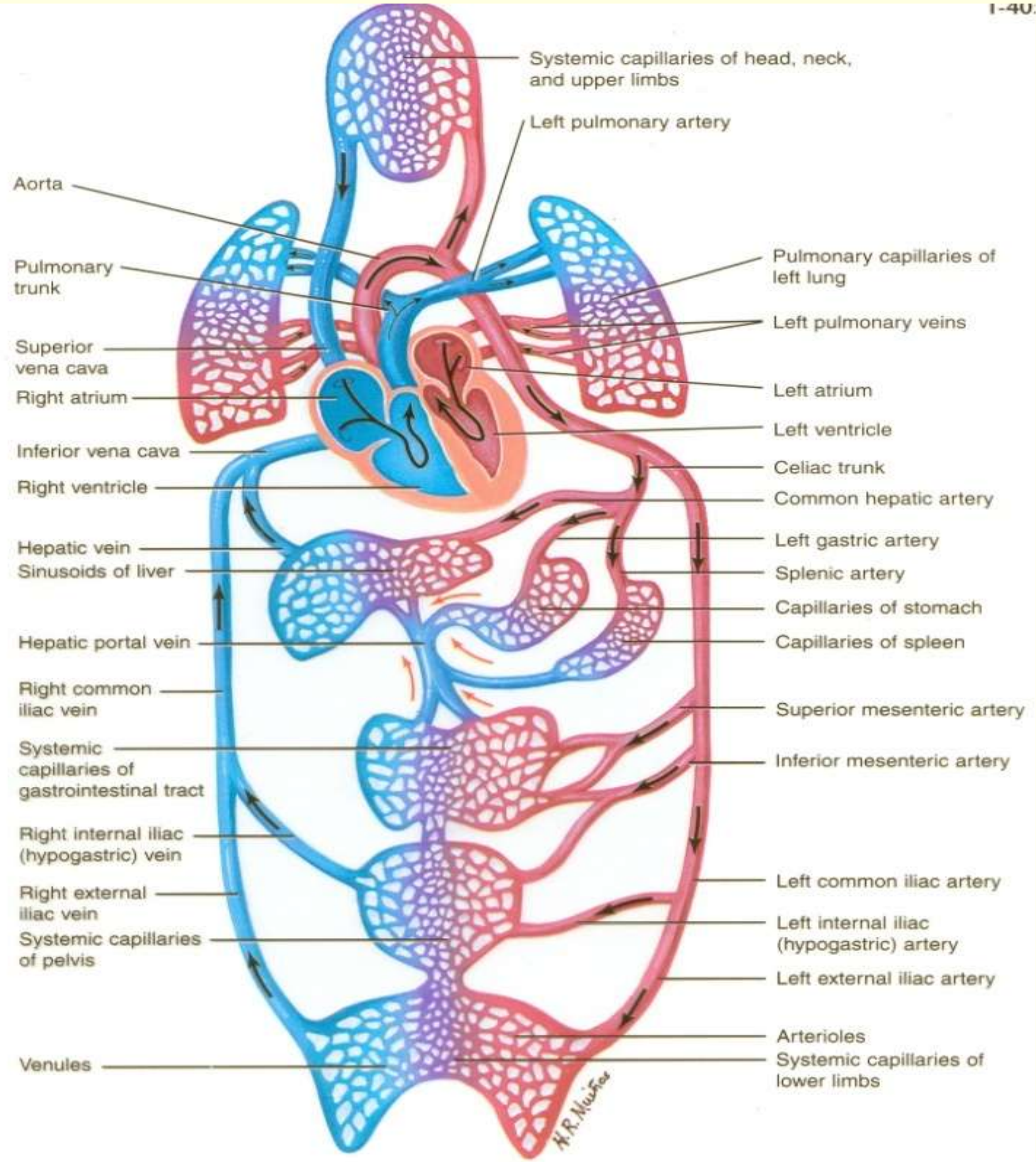
Objectives:

By The end of this lecture students should be able to:

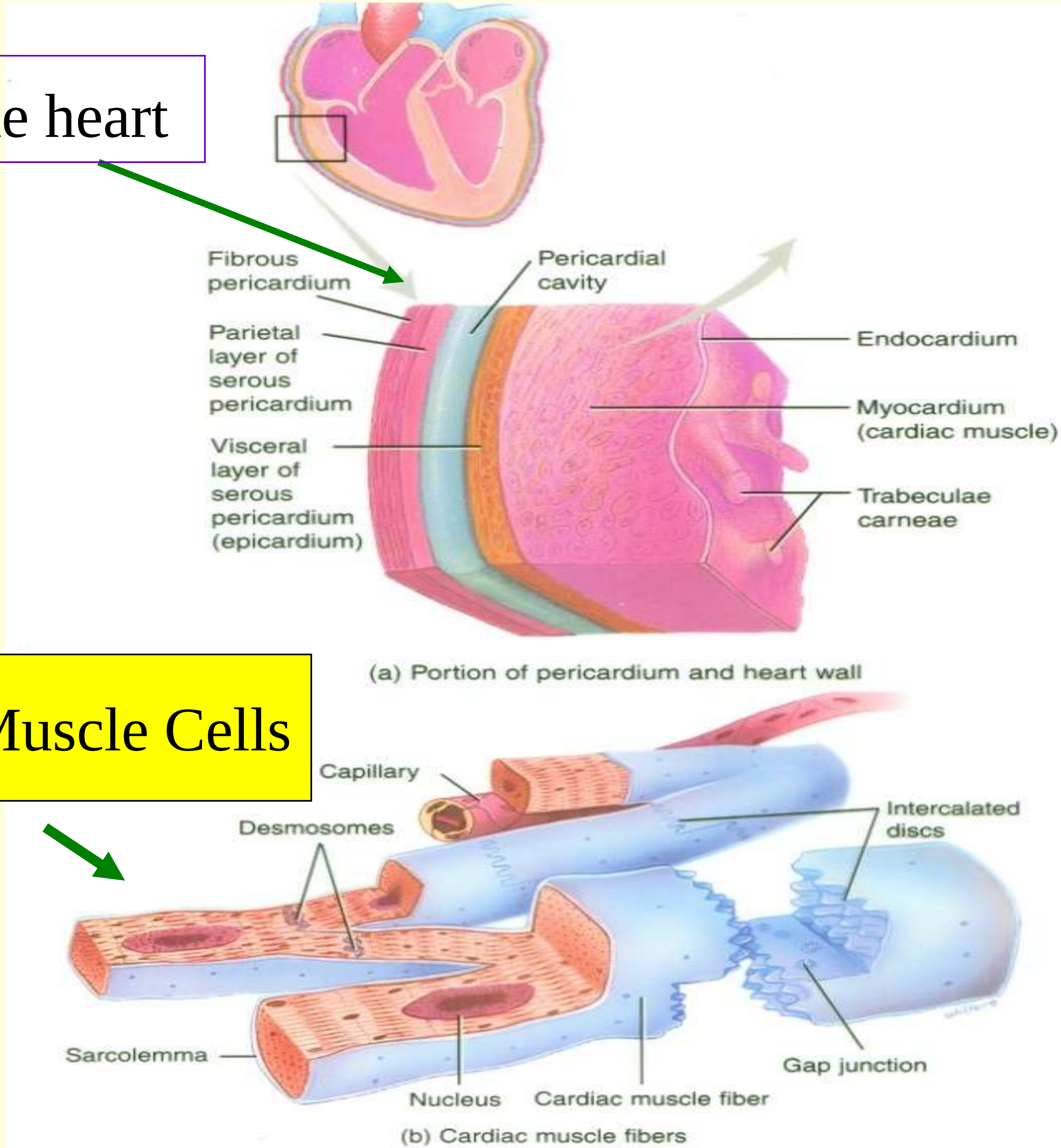
- Distinguish the cardiac muscle cell microstructure
- Describe cardiac muscle action potential
- Point out the functional importance of the action potential
- Outline the intracellular calcium homeostasis

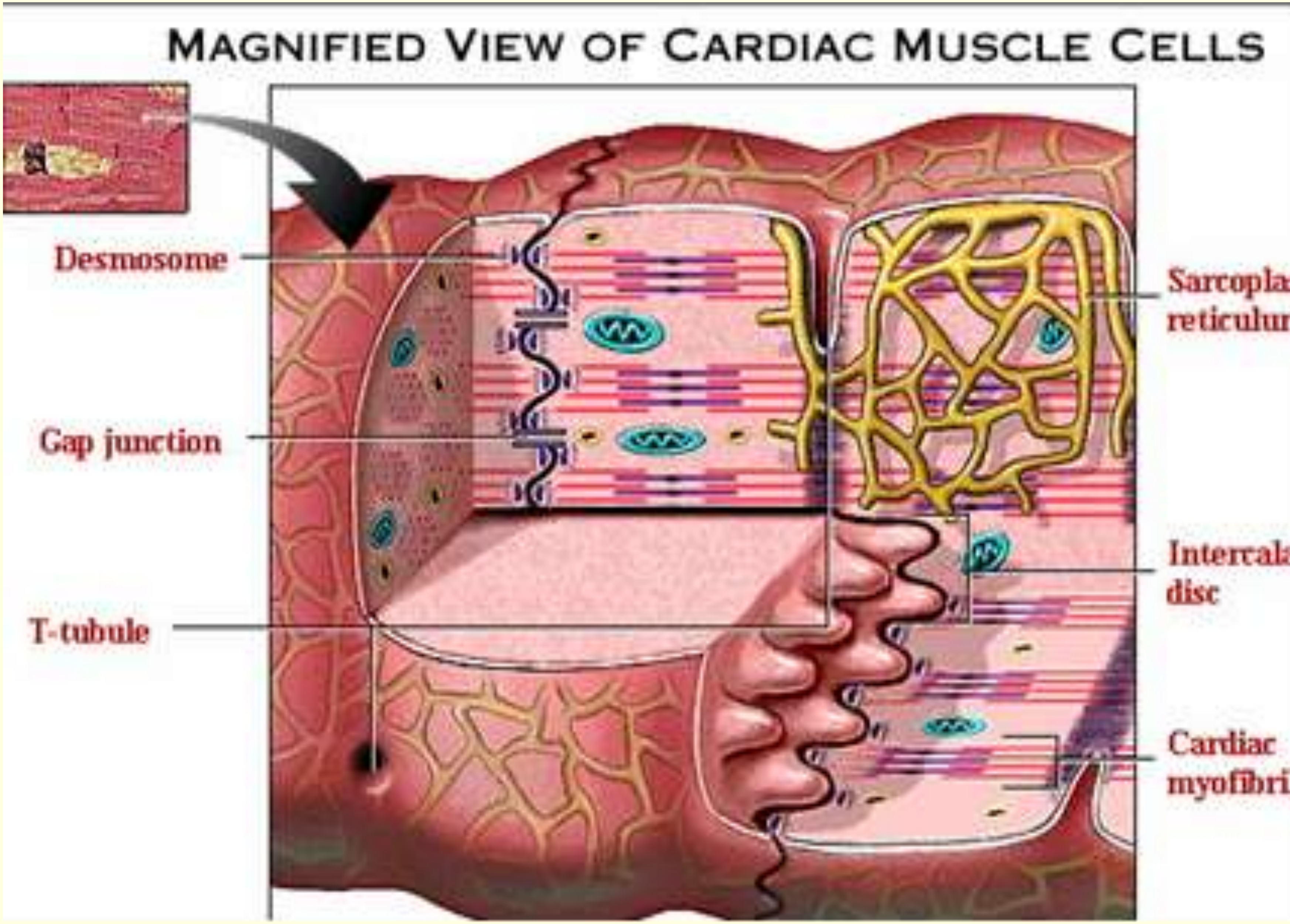


General plan of circulation

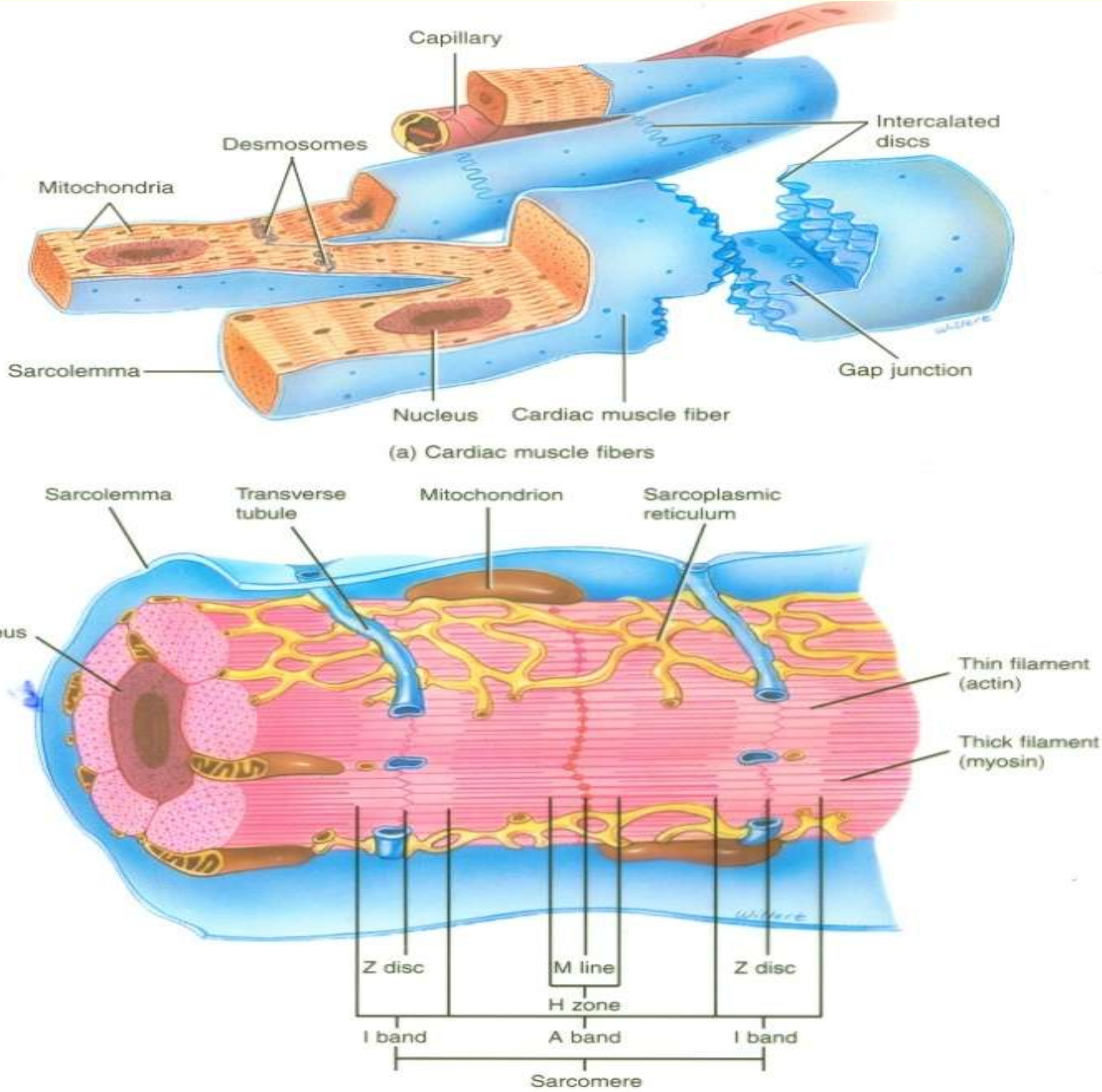
Wall of the heart

Cardiac Muscle Cells





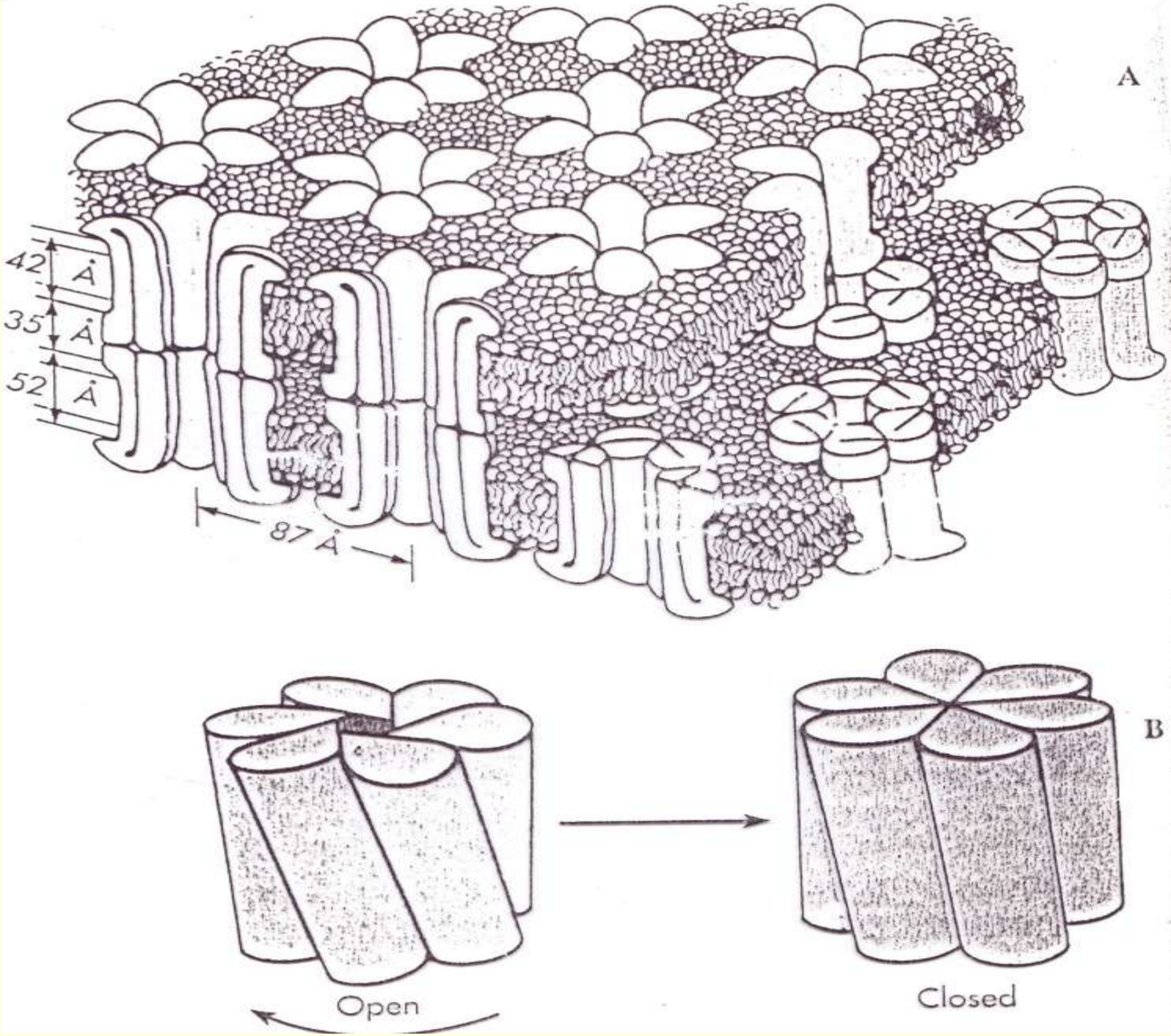
MAGNIFIED VIEW OF CARDIAC MUSCLE CELLS
Desmosome
Gap junction
T-tubule
Sarcoplas
reticulum
Intercala
disc
Cardiac
myofibril



(a) Cardiac muscle fibers

(b) Diagram based on an electron micrograph

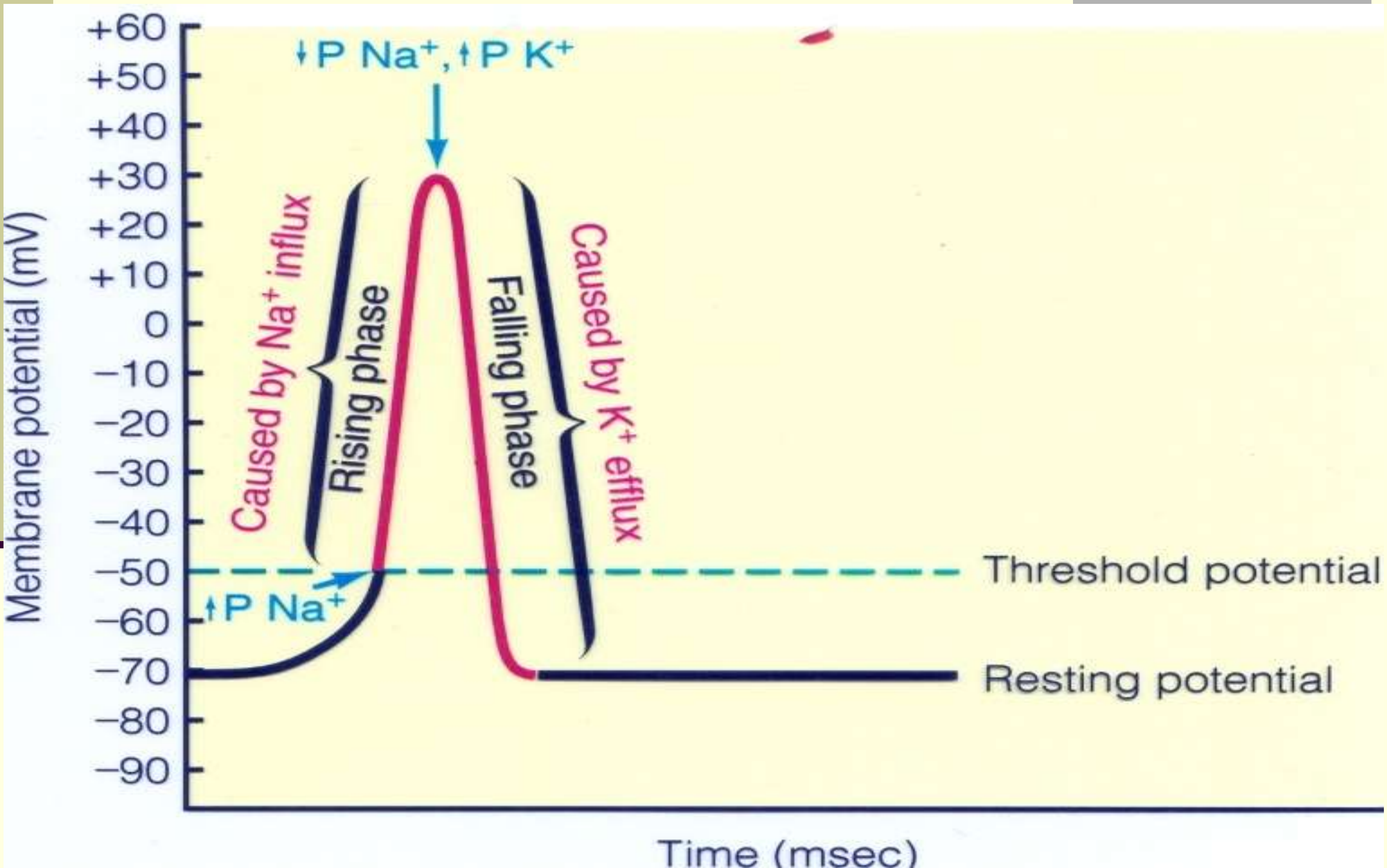
Gap junction channels

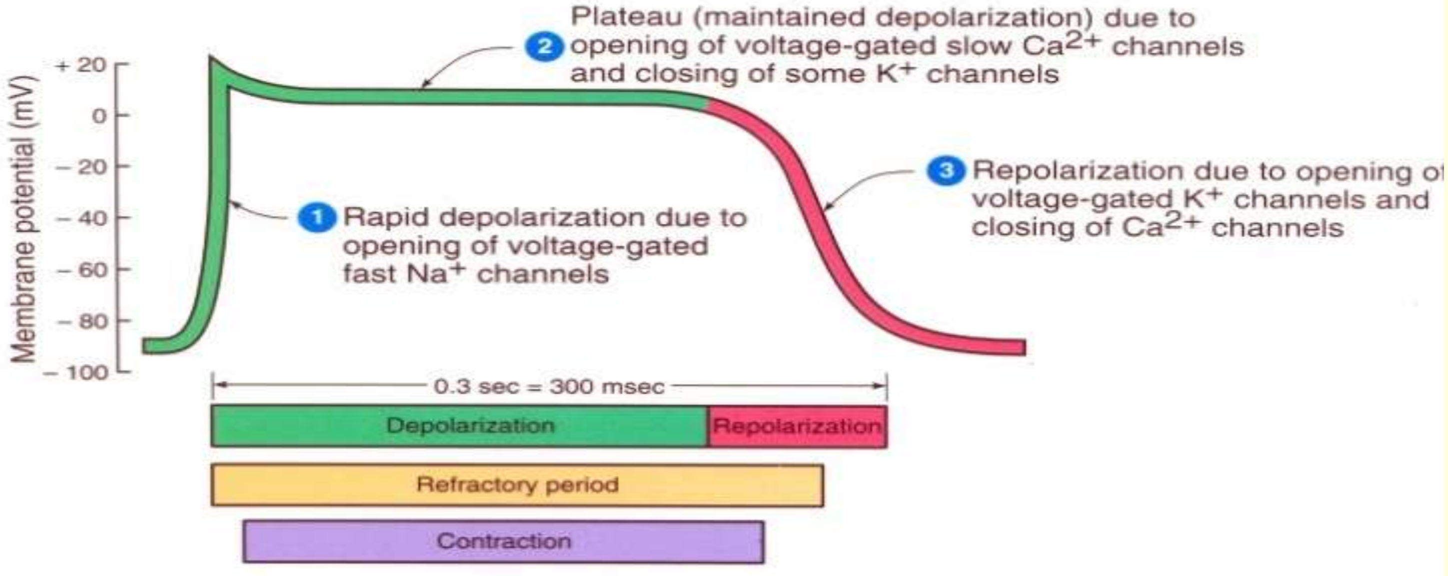


Cardiac Muscle Vs Skeletal Muscle

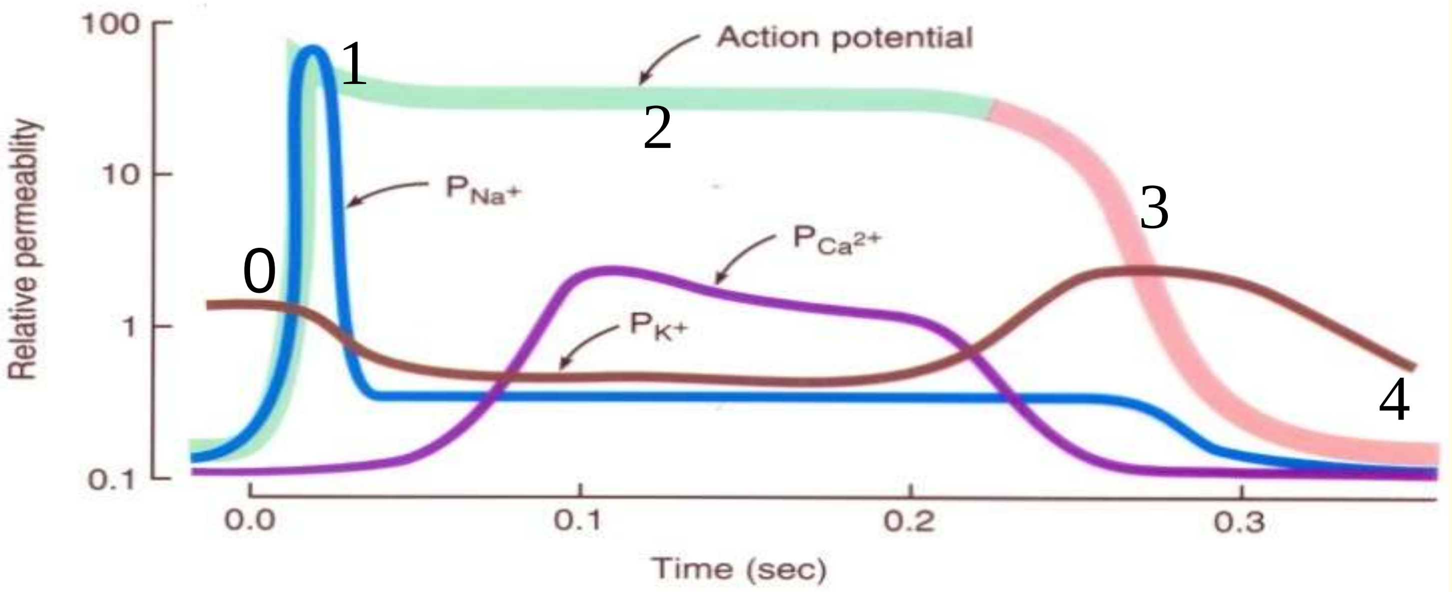
- Syncytium structure
- Gap Junction (electrical coupling) low resistance area
- Poorly developed Sarcoplasmic reticulum (SR)
- Transverse (T)Tubule more frequent in cardiac muscler
- Rich in mitochondria
- Low in nuclei

Permeability Changes and Ionic Fluxes During an Action Potential (skeletal Muscle)



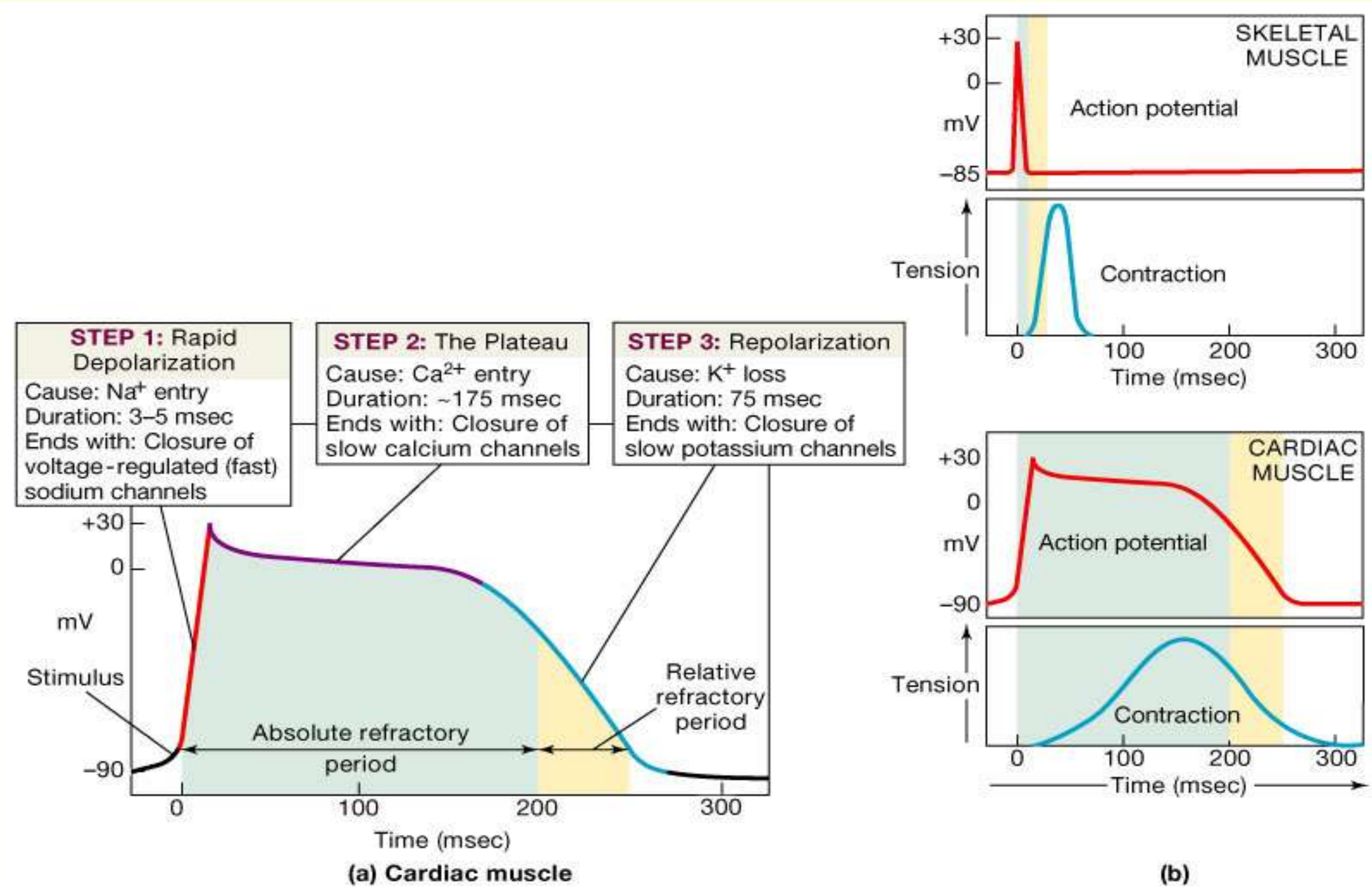


(a) Action potential, refractory period, and contraction



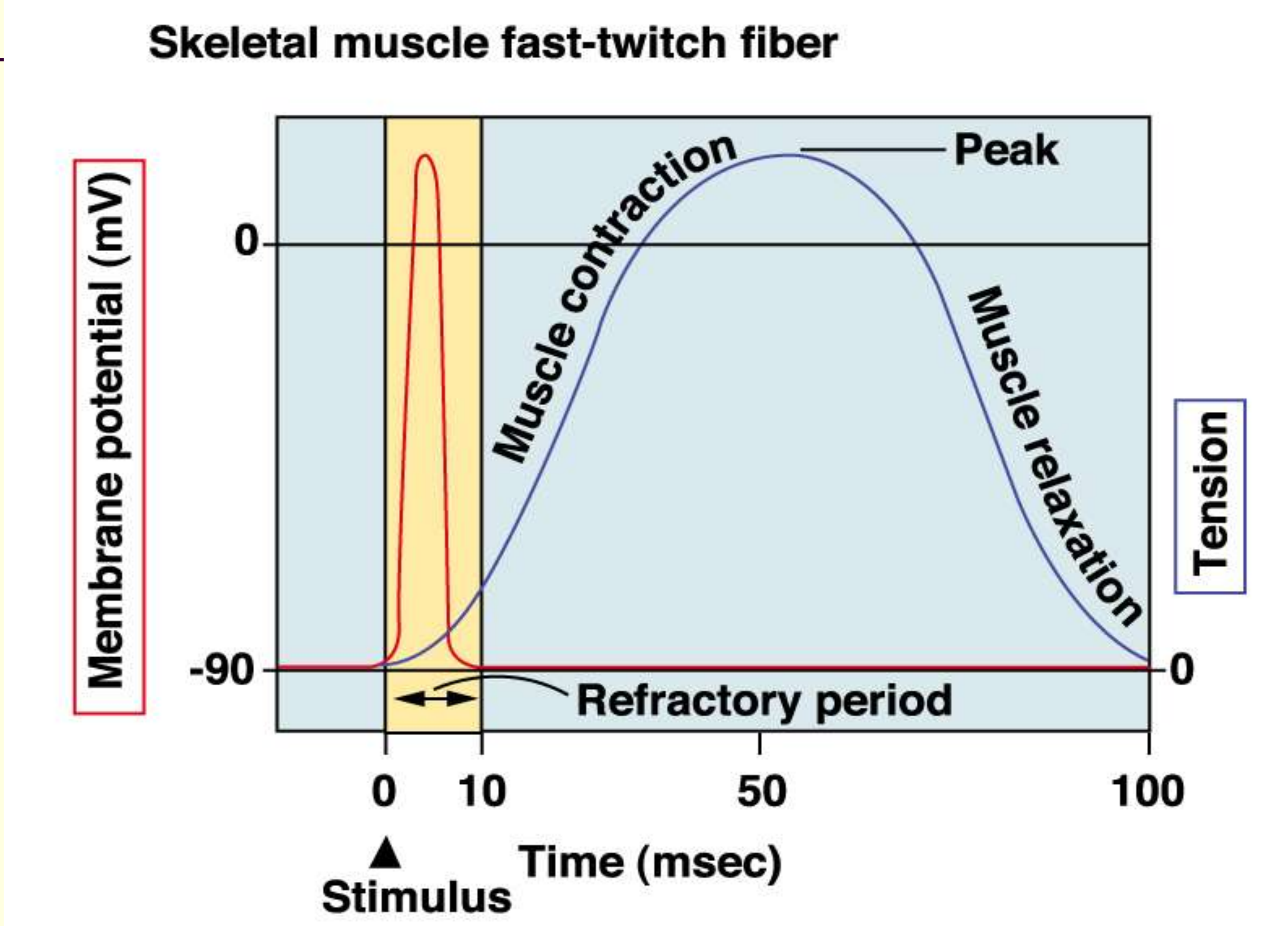
(b) Membrane permeability (P) changes

The Action Potential in Skeletal and Cardiac Muscle

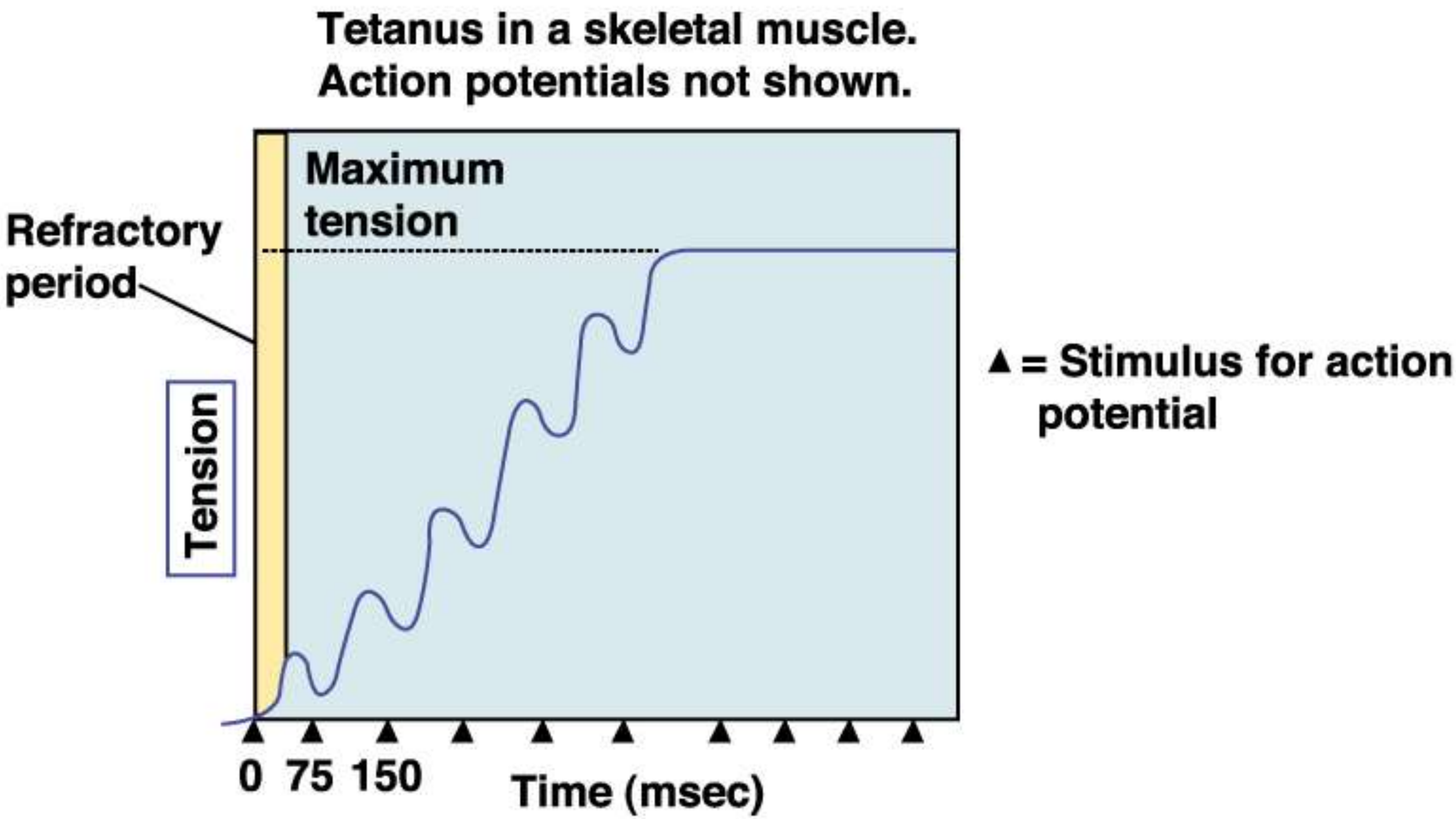


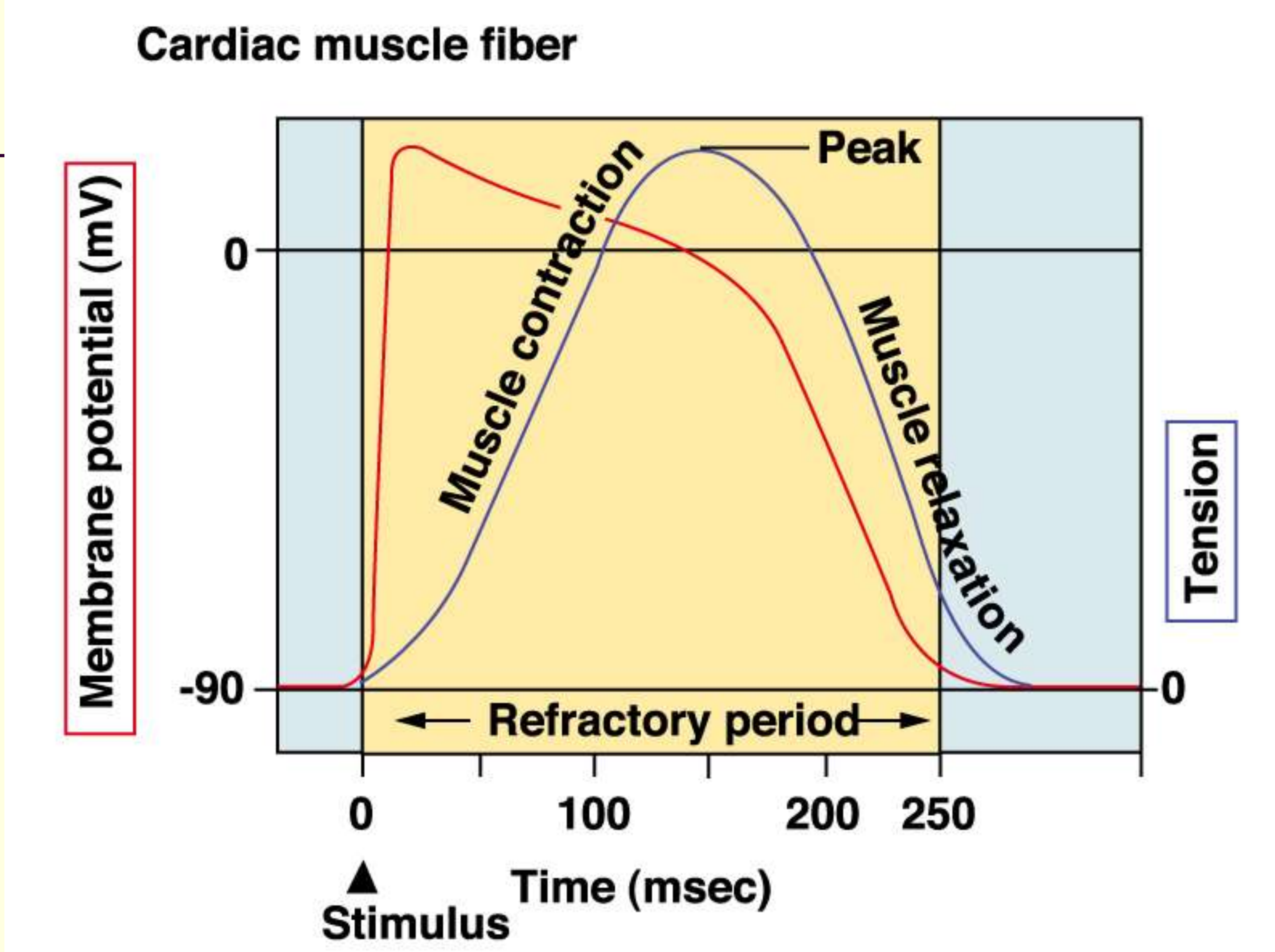
(a) Cardiac muscle (b)

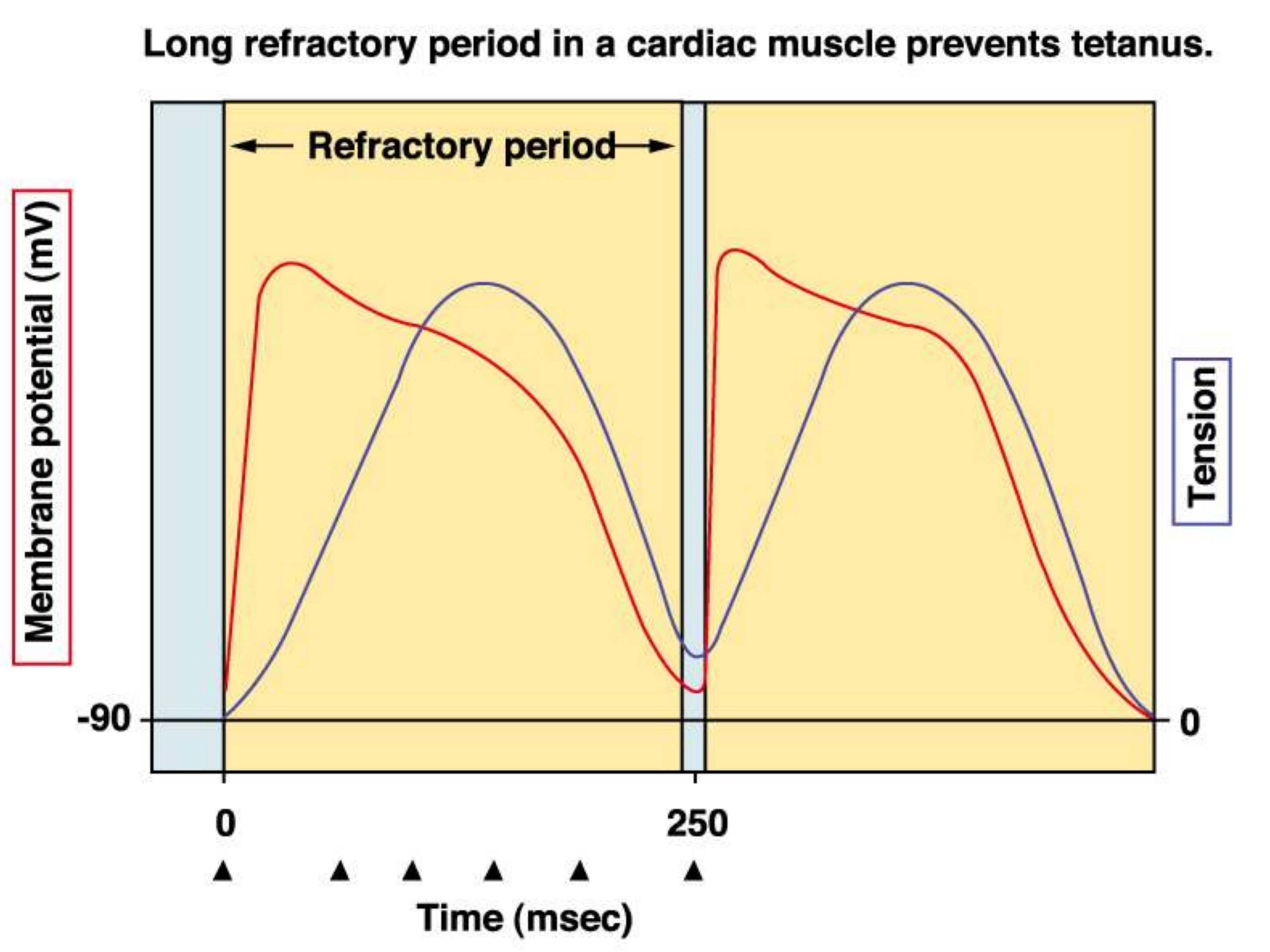
Figure 20.15



Skeletal muscle fast-twitch fiber
Membrane potential (mV)
0
-90
Peak
Muscle contraction
Muscle relaxation
Tension
0
Refractory period
0
10
50
100
Stimulus
Time (msec)

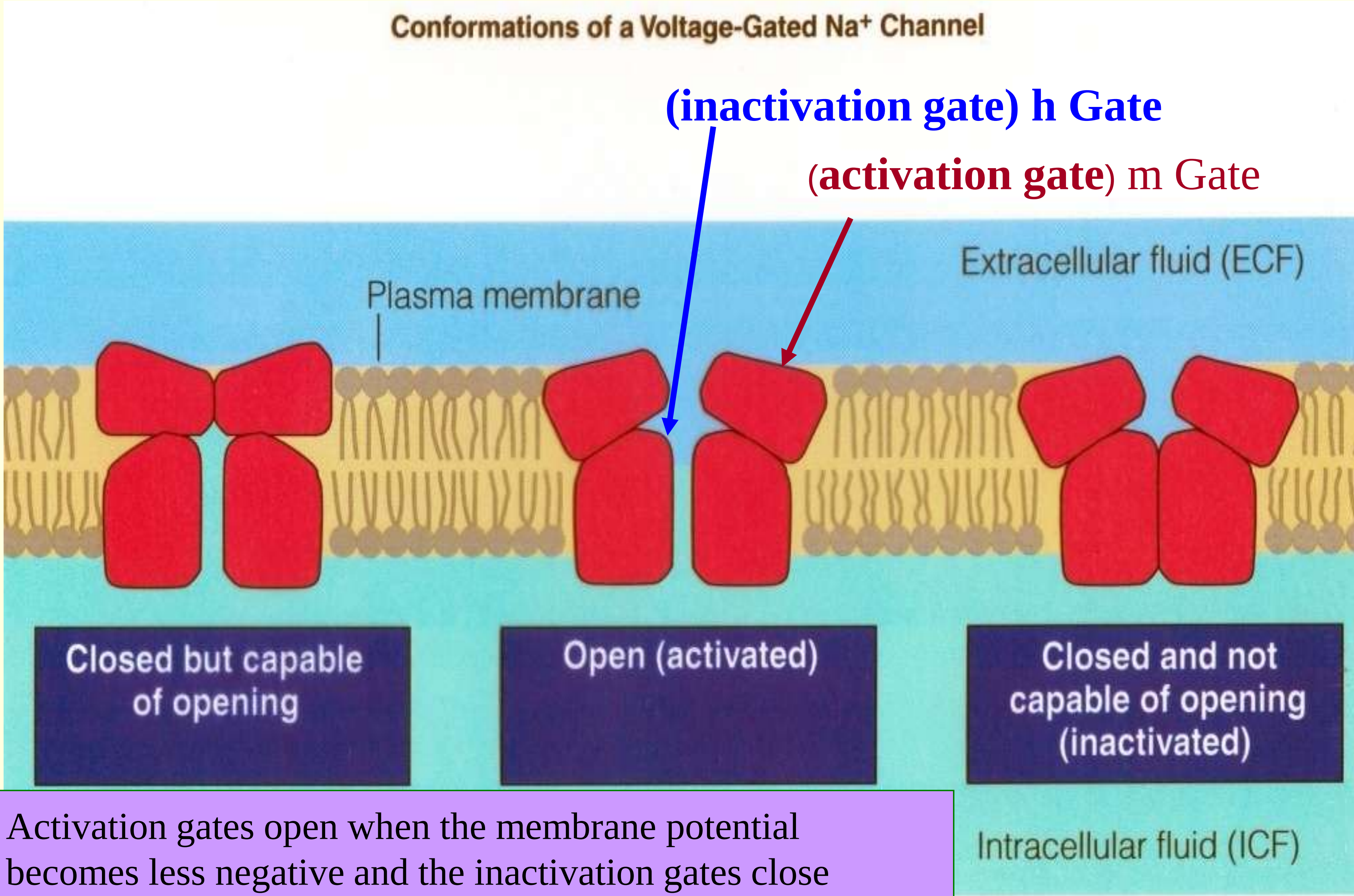

Tetanus in a skeletal muscle.
Action potentials not shown.
Maximum
tension
Refractory
period
Tension
▲ = Stimulus for action
potential
0
75
150
Time (msec)


Cardiac muscle fiber
Membrane potential (mV)
0
-90
Peak
Muscle contraction
Muscle relaxation
Tension
0
Refractory period
0
100
200
250
Time (msec)
Stimulus

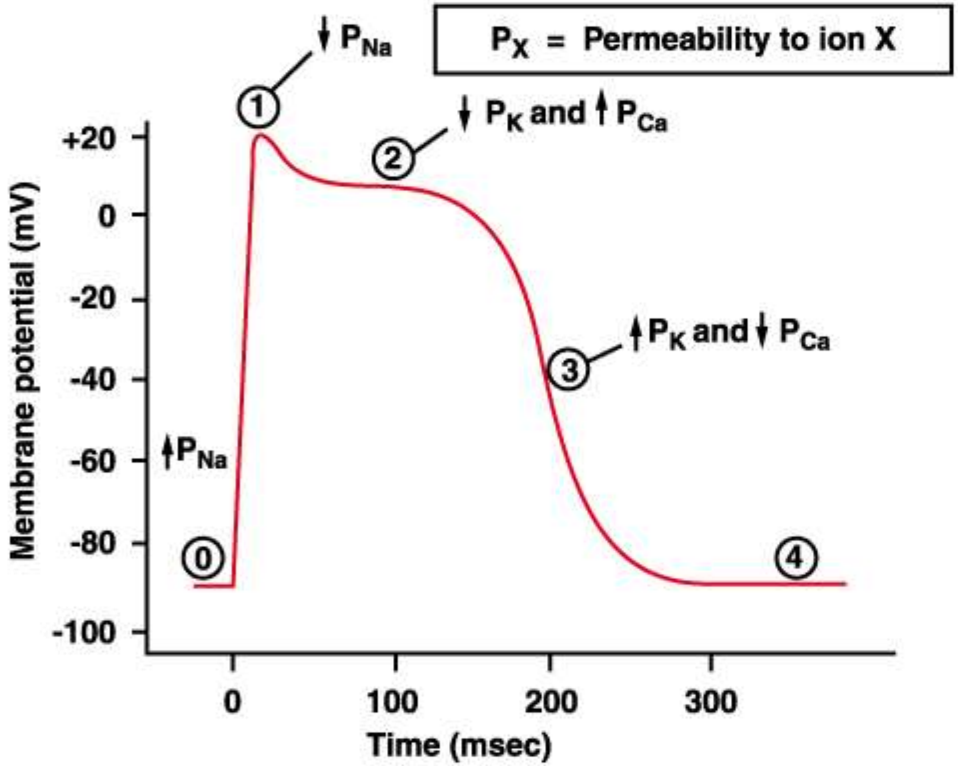

Long refractory period in a cardiac muscle prevents tetanus.
Refractory period
Membrane potential (mV)
Tension
-90
0
0
250
Time (msec)

Functional importance of Cardiac action potential

- The decrease in conductance (permeability) of potassium at phase 0 and 1 of the cardiac action potential contributes to the maintenance of depolarization in phase 2 (plateau)
- The long absolute refractory period prevent the occurrence of tetanus (maintained contraction without a period of relaxation) in the cardiac muscle.
- Skeletal muscle action potential is short that allows tetanus to occur

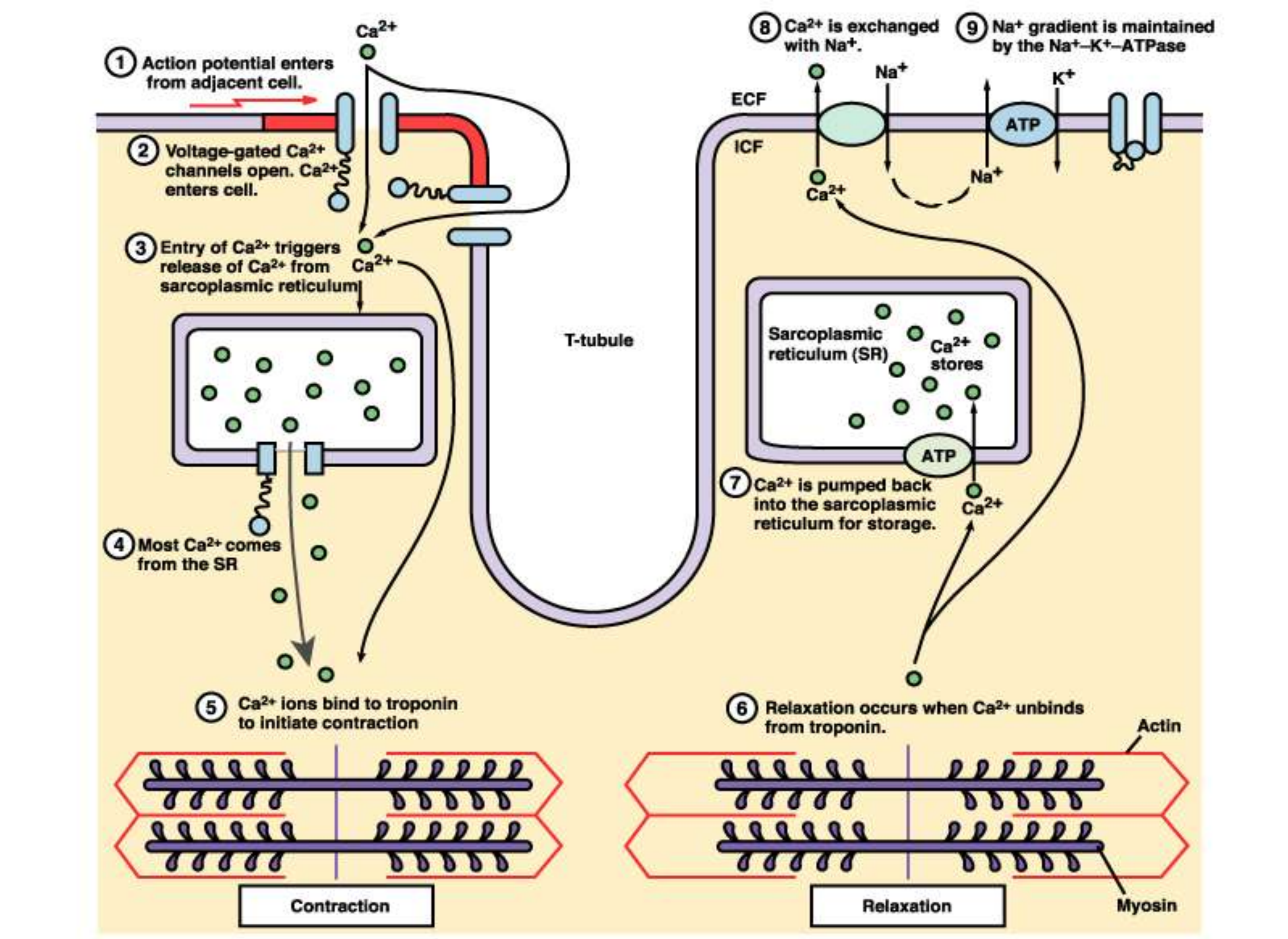


Activation gates open when the membrane potential becomes less negative and the inactivation gates close when the potential becomes less negative. The activation gate is fast but the inactivation is slow responding

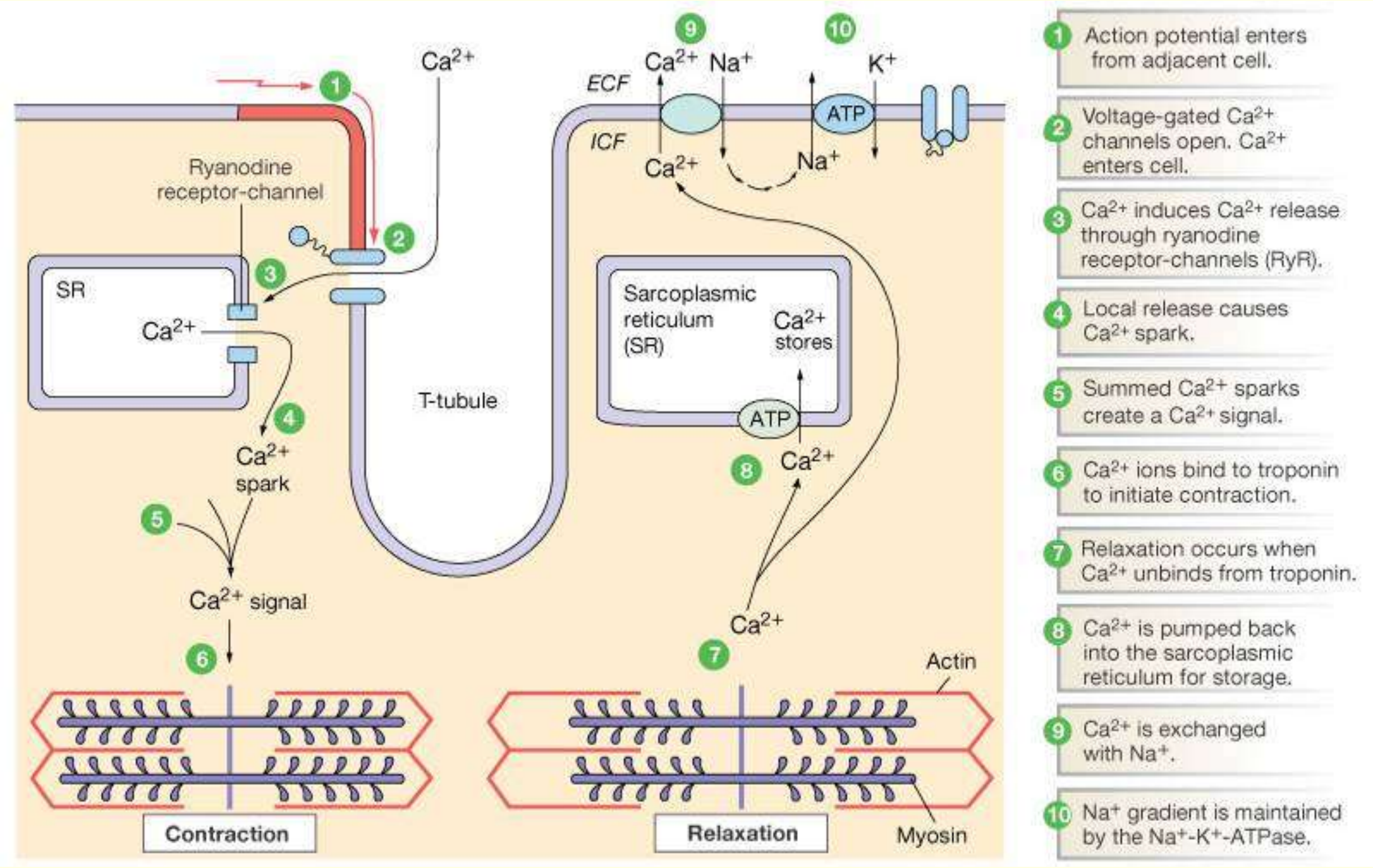


Phase	Membrane channels
0	Na^+ channels open
1	Na^+ channels close
2	Ca^{2+} channels open; fast K^+ channels close
3	Ca^{2+} channels close; slow K^+ channels open
4	Resting potential

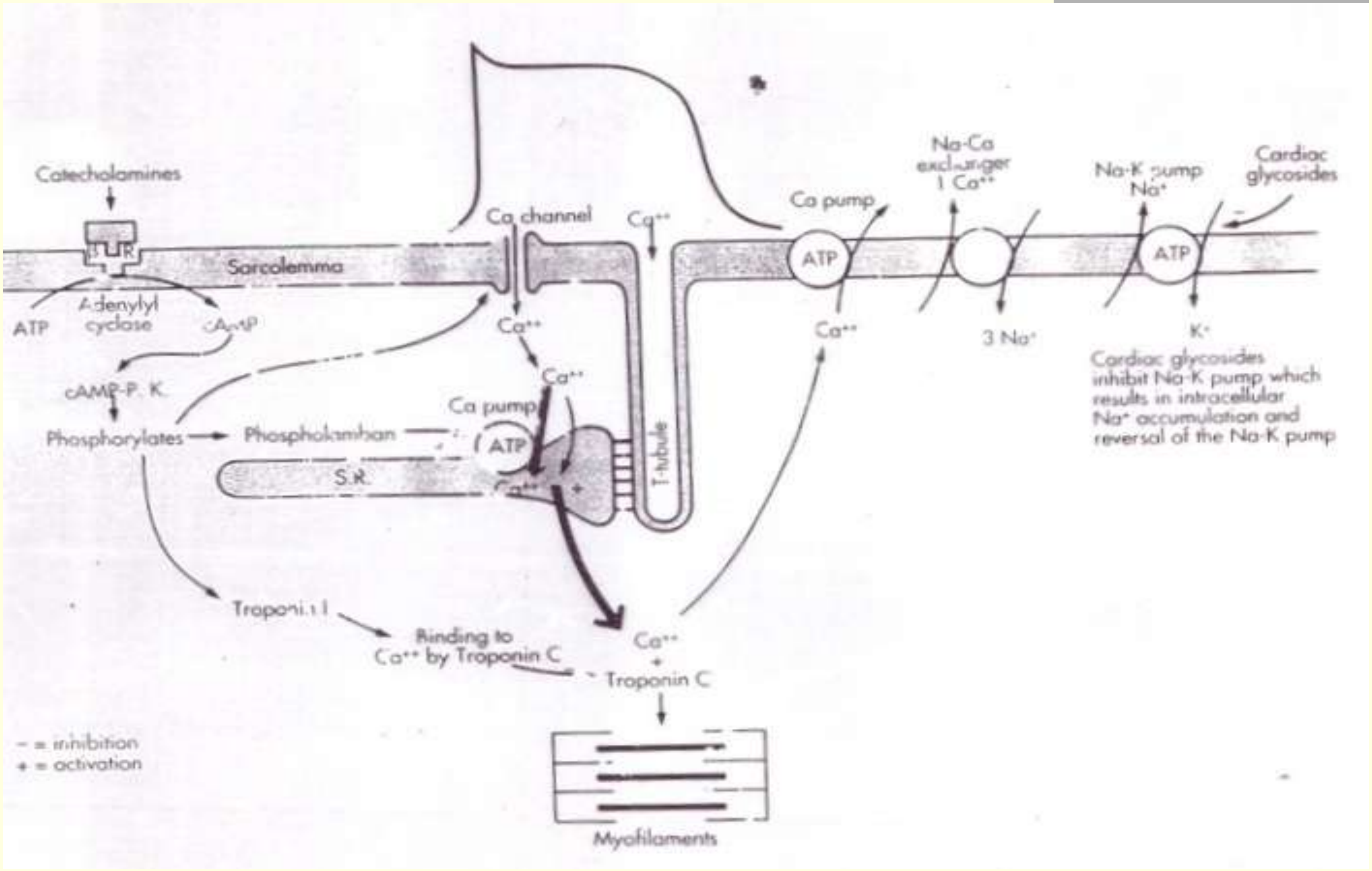
The importance of calcium influx through the slow voltage gated calcium channels



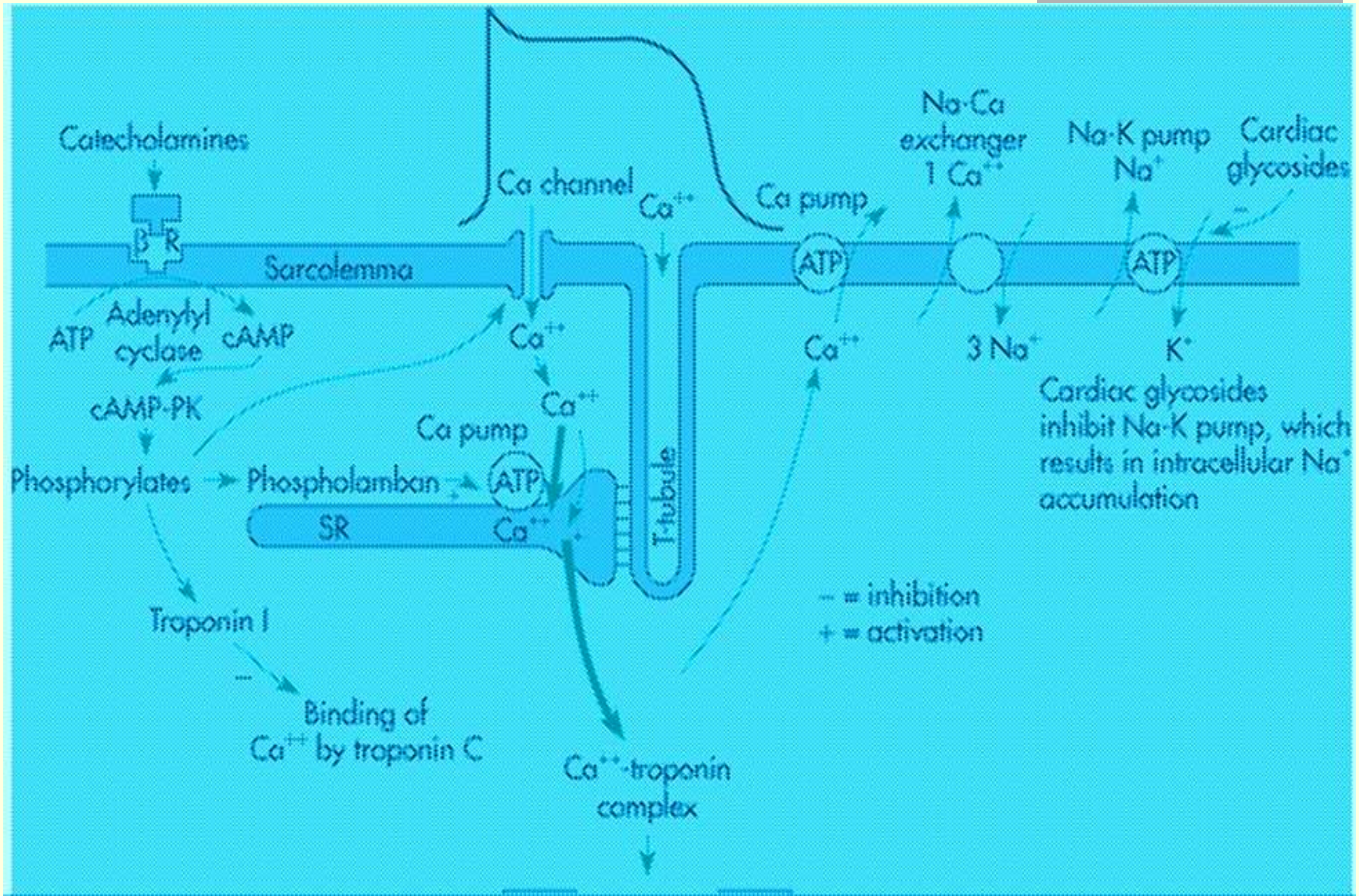
Mechanism of Cardiac Muscle Excitation, Contraction & Relaxation



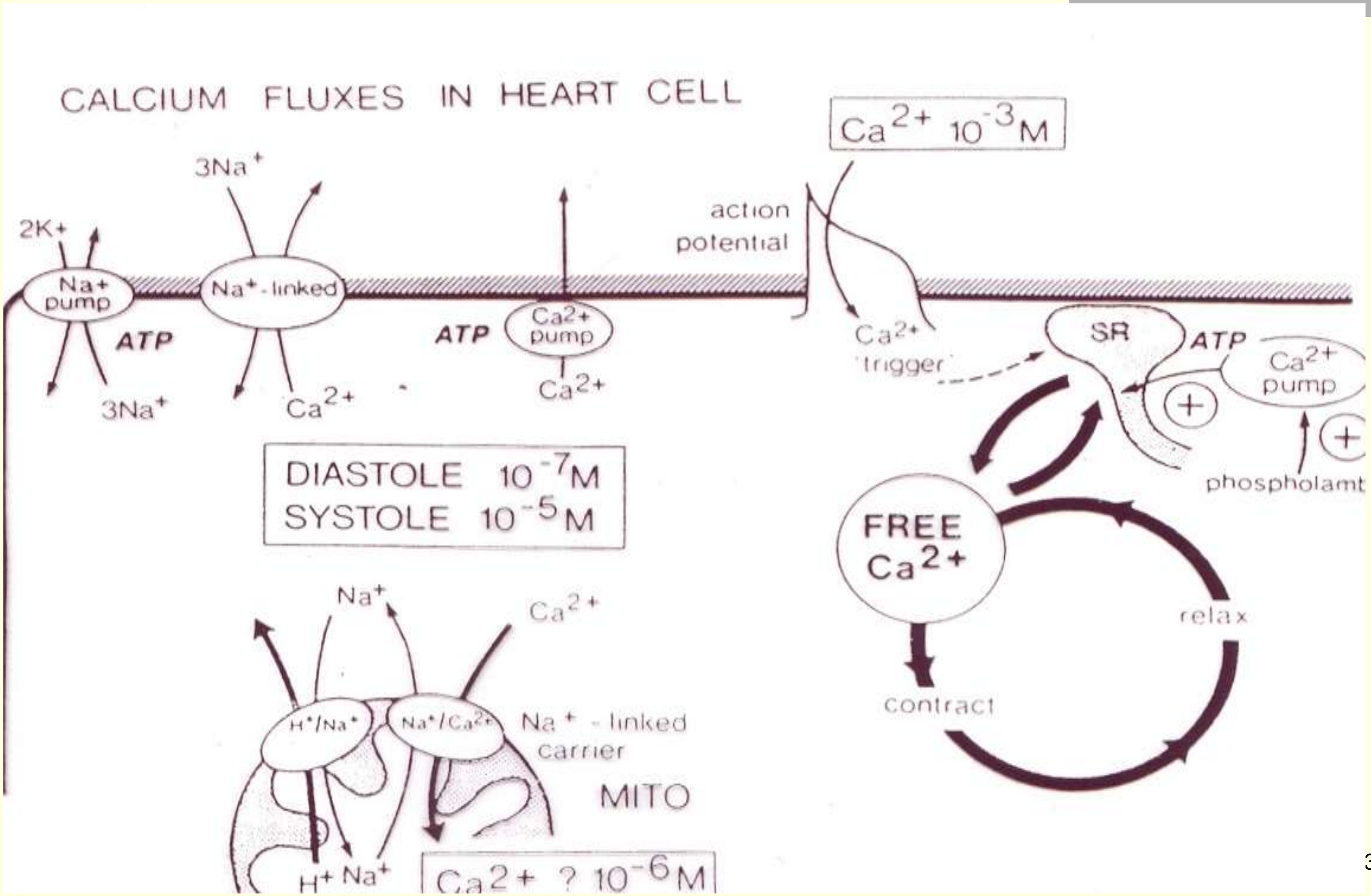
Intracellular Calcium Homeostasis…1



Intracellular Calcium Homeostasis…1



Intracellular Calcium Homeostasis…2



Cardiac Muscle action potential Vs. Skeletal Muscle

- Phase 0 –Depolarization phase (Na^+ influx)
- Phase 1 partial repolarization (Not in skeletal)
- Phase 2 Plateau (~ depolarization not in skeletal) slow calcium channels
- Phase 3 fast repolarization phase (K^+ repolarization()
- Phase 4 resting membrane potential

Thank You