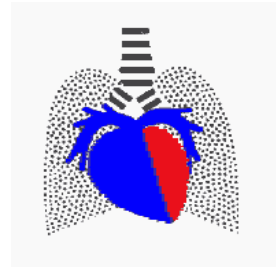


The Heart physiology I.

(excitation, conduction, contraction...)

Milan Chovanec

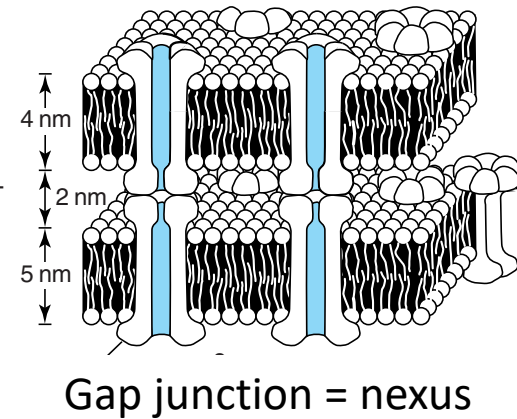
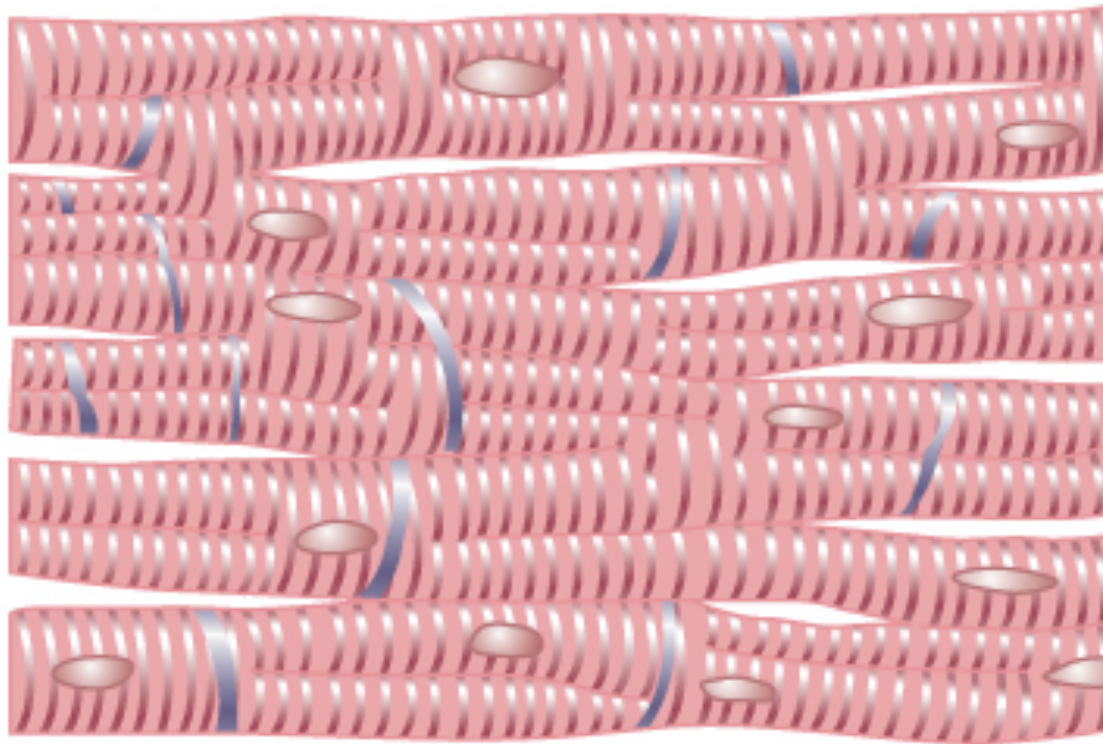
Department of Physiology
2nd Medical School, Charles University, Prague



The Heart Physiology

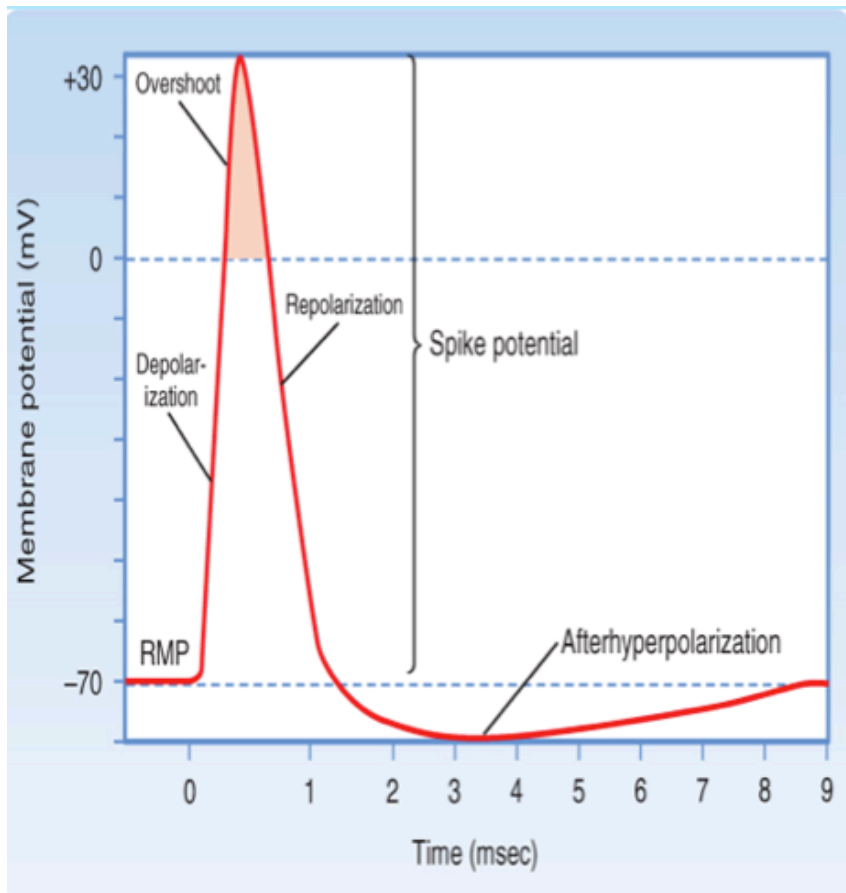
- The heart action potential (working myocardium)
- The heart automaticity and electrical conduction system
- Excitation – Contraction coupling in the heart muscle cells

Myocardium = syncytium



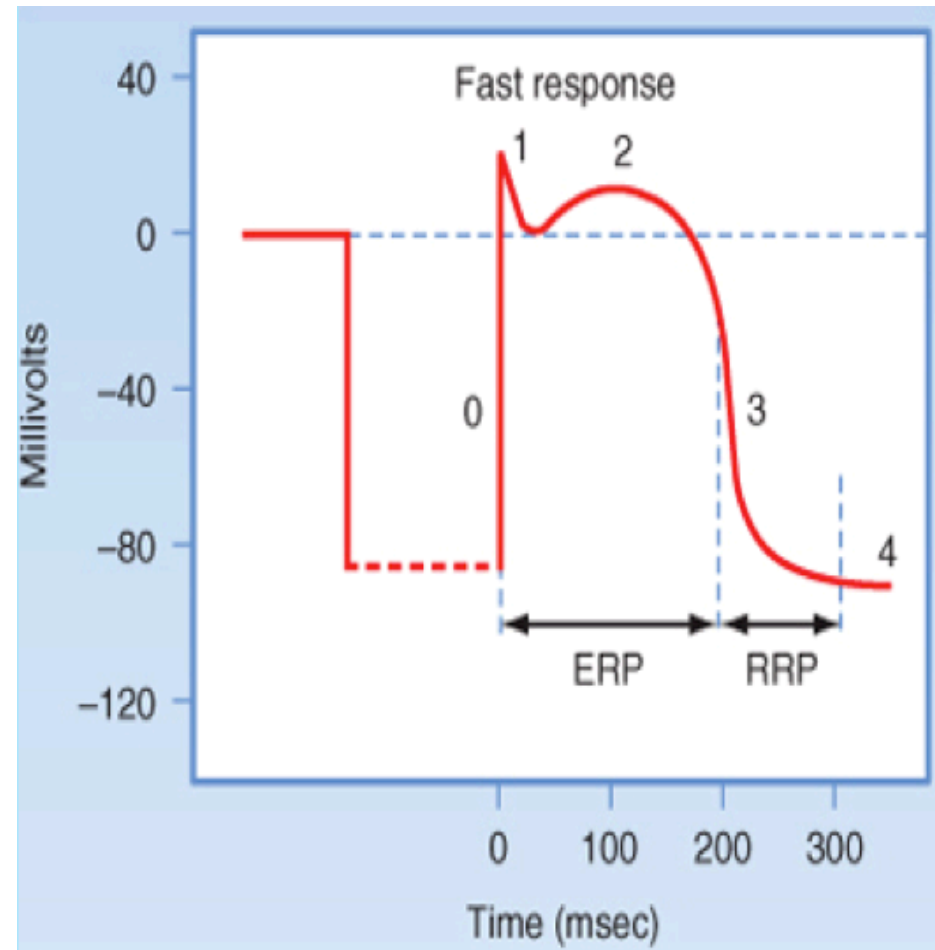
Different types of the action potential in the heart

Skeletal muscle, nerve

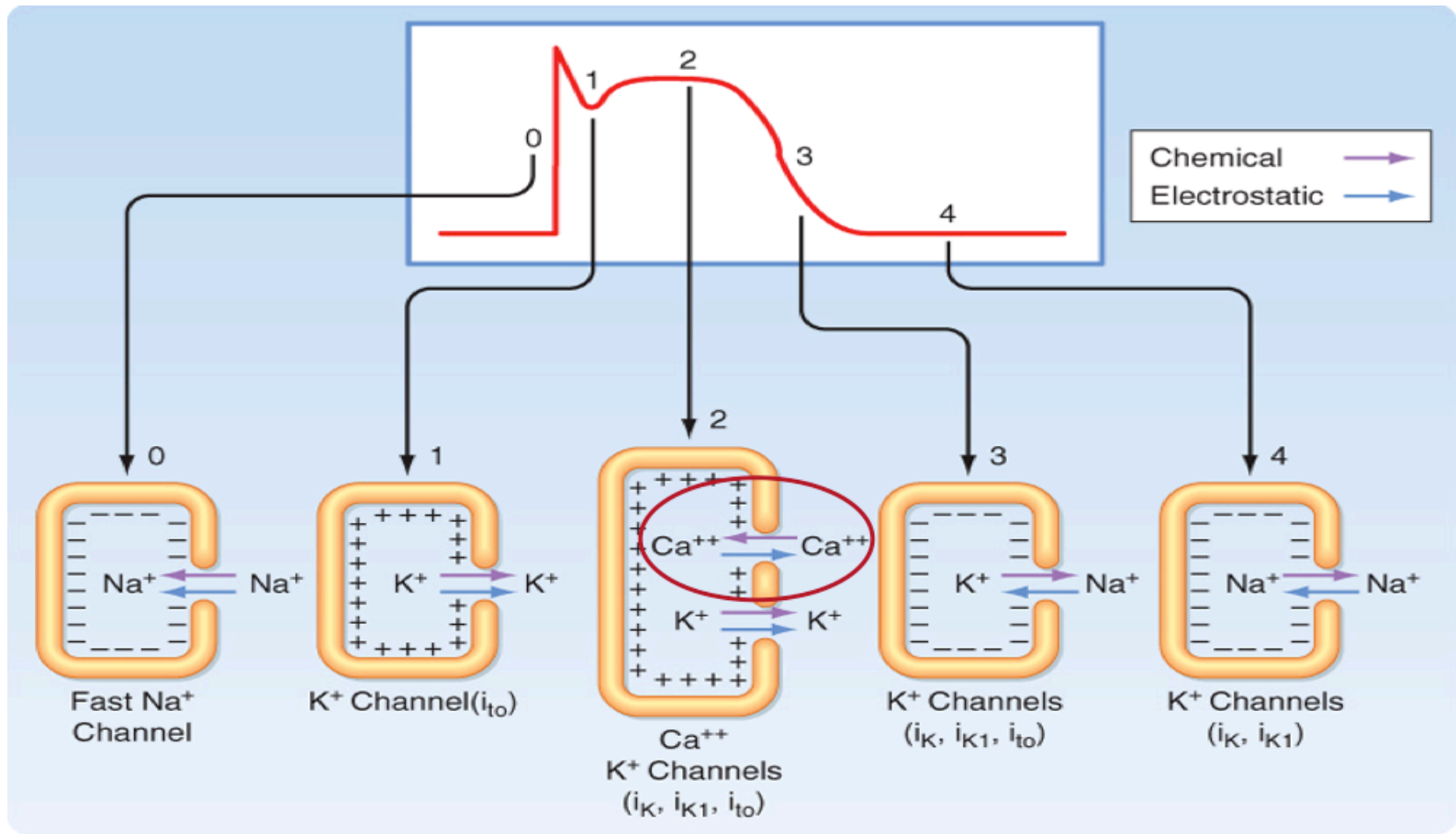


Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.
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Myocardium

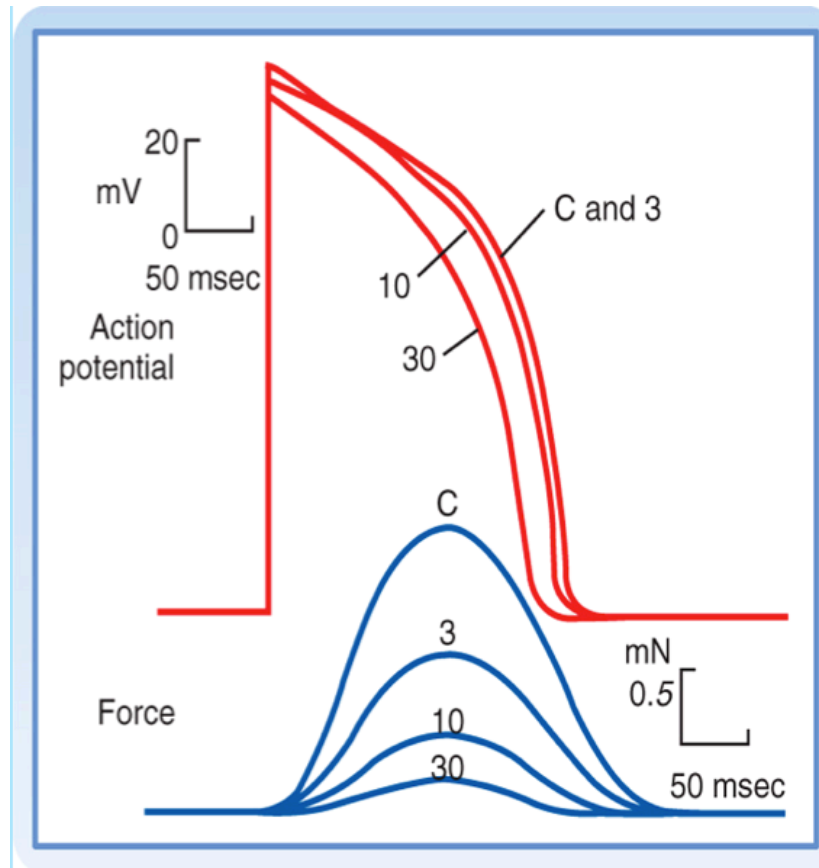


Voltage gated Ca^{2+} channels (L-type) are responsible for AP in the myocardium

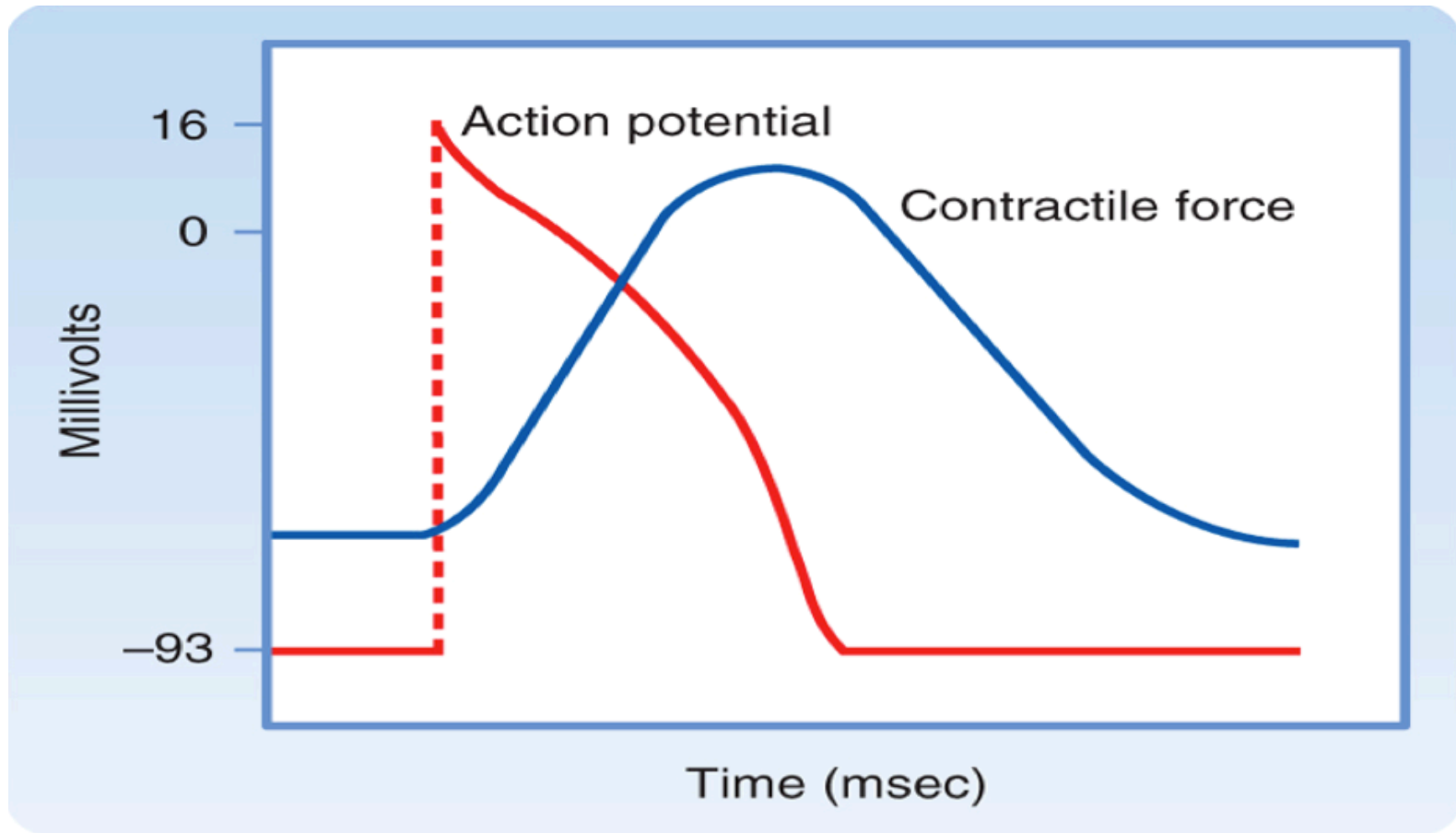


Calcium influx plays role in strength and duration of the myocardial AP

Relationship between the strength + duration of the AP and calcium channels blocker (Verapamil)

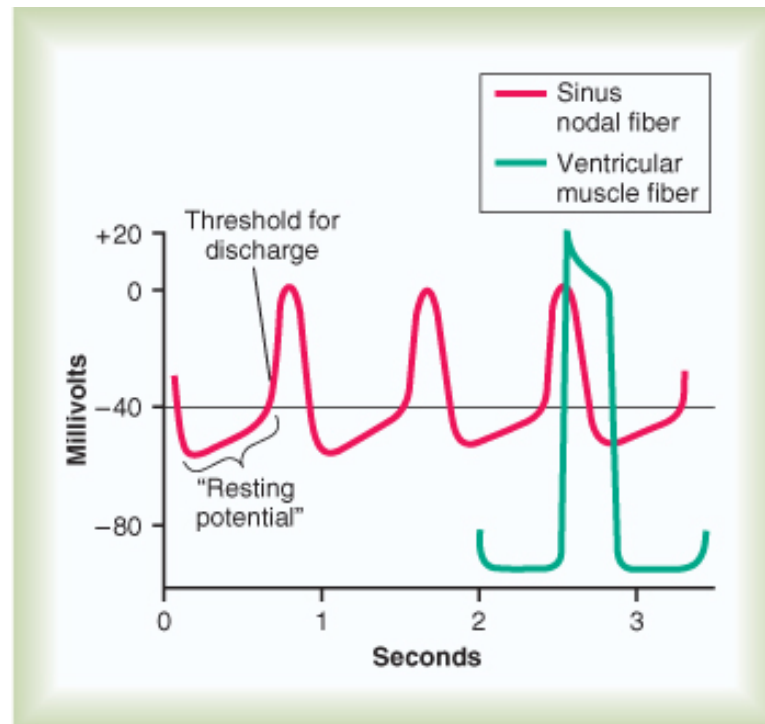


Prolonged AP prevents tetanic myocardial contraction

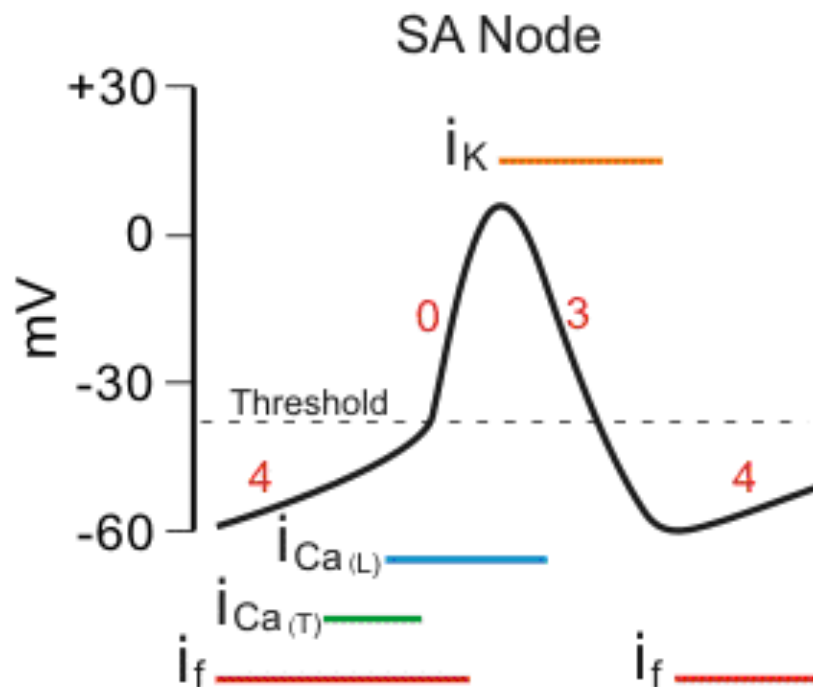


Cardiac cells types

- working myocardium cells, about 99%
- electrical conduction system cells, about 1%



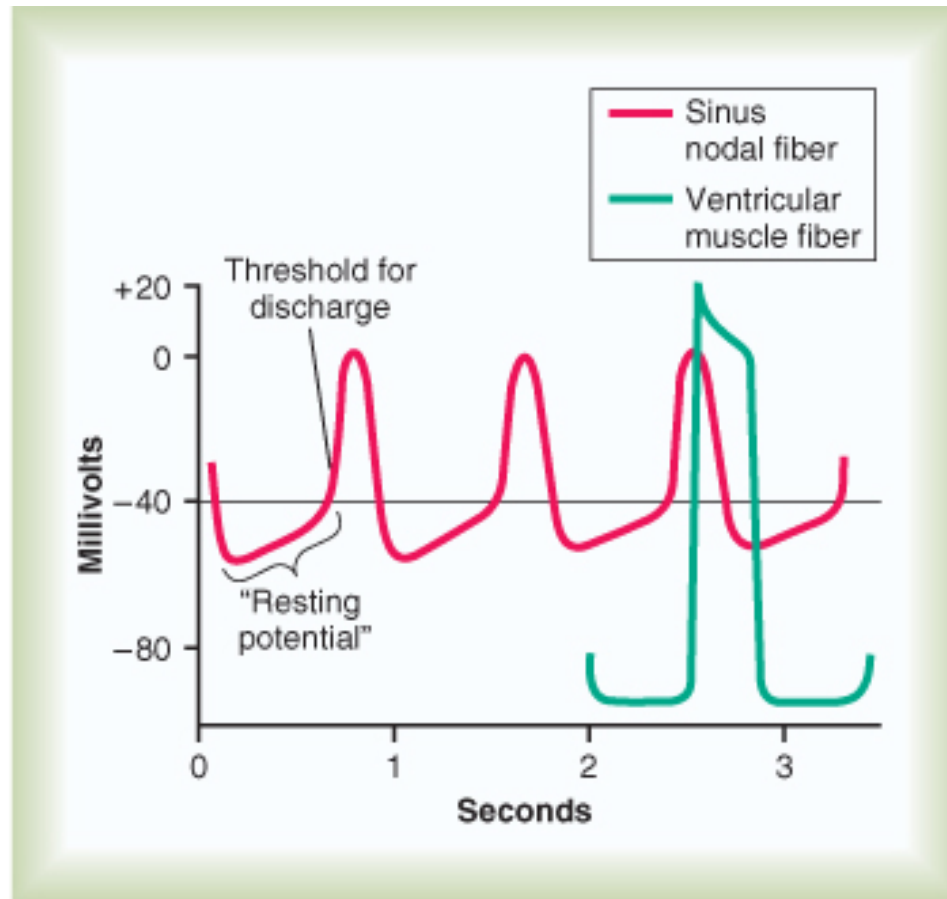
Electrical conduction system AP



i_f – „funny current“, Na^+ - channels
 $i_{Ca(T)}$ – „transient“ Ca^{2+} channels
 $i_{Ca(L)}$ – „long lasting“ Ca^{2+} channels

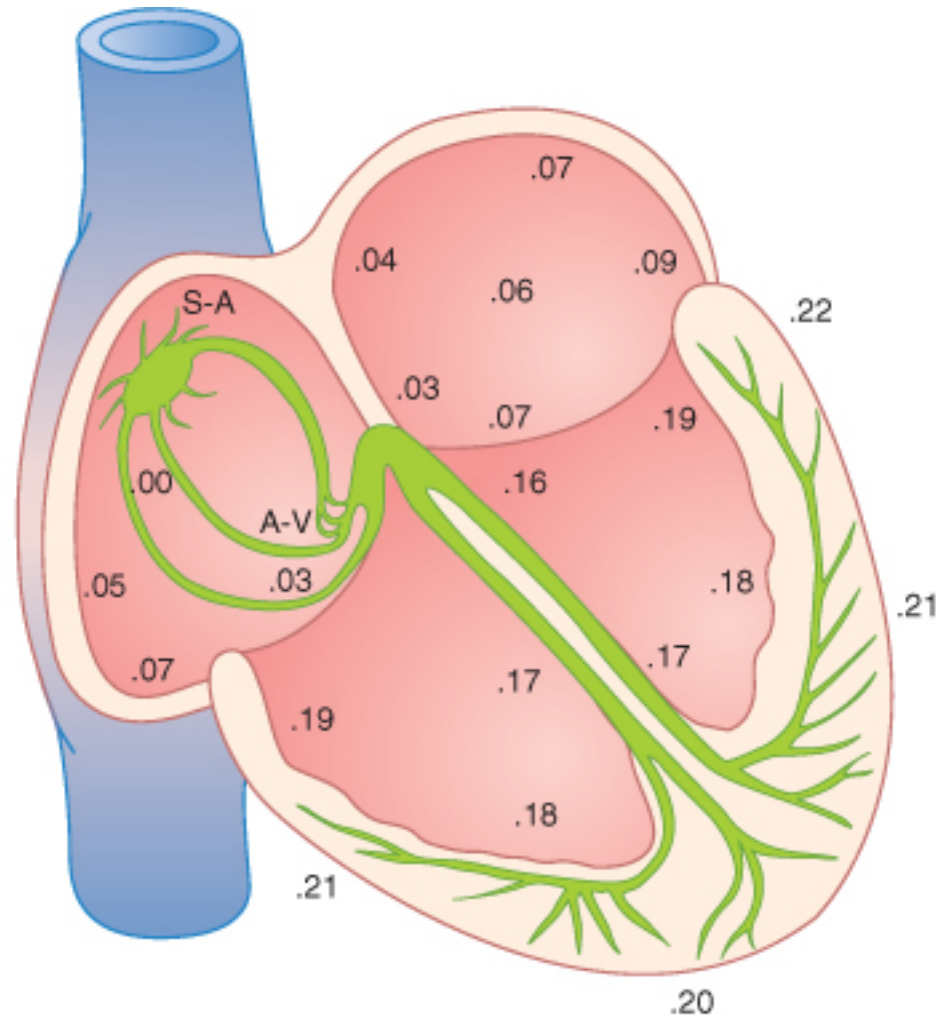
sinoatrial (SA) pacemaker action potential

Difference between AP of the working myocardium and the conduction system

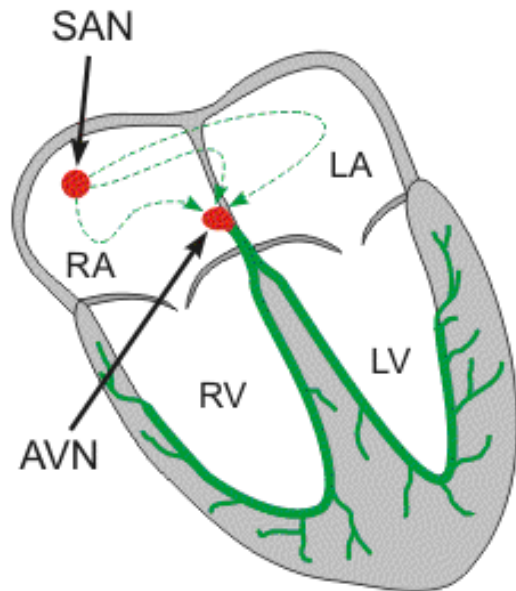


RMP

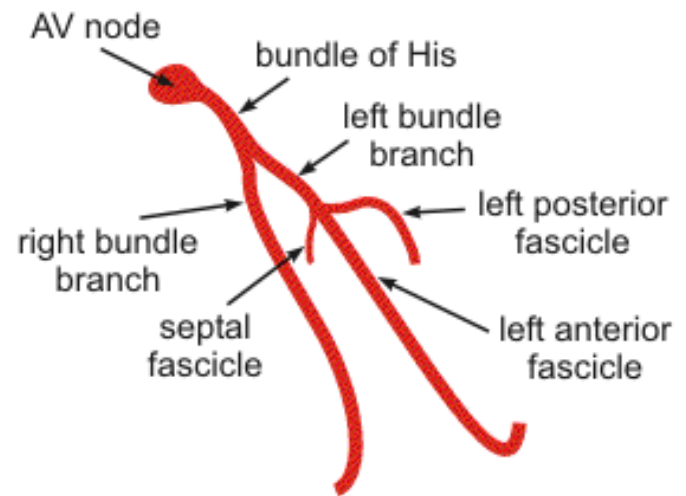
Conduction system of the heart



Conduction of the heart



SAN, sinoatrial node; AVN, atrio-ventricular node; RA, right atrium; LA, left atrium, RV, right ventricle; LV, left ventricle.



The heart AP propagation



Electrical characterization of the myocardium

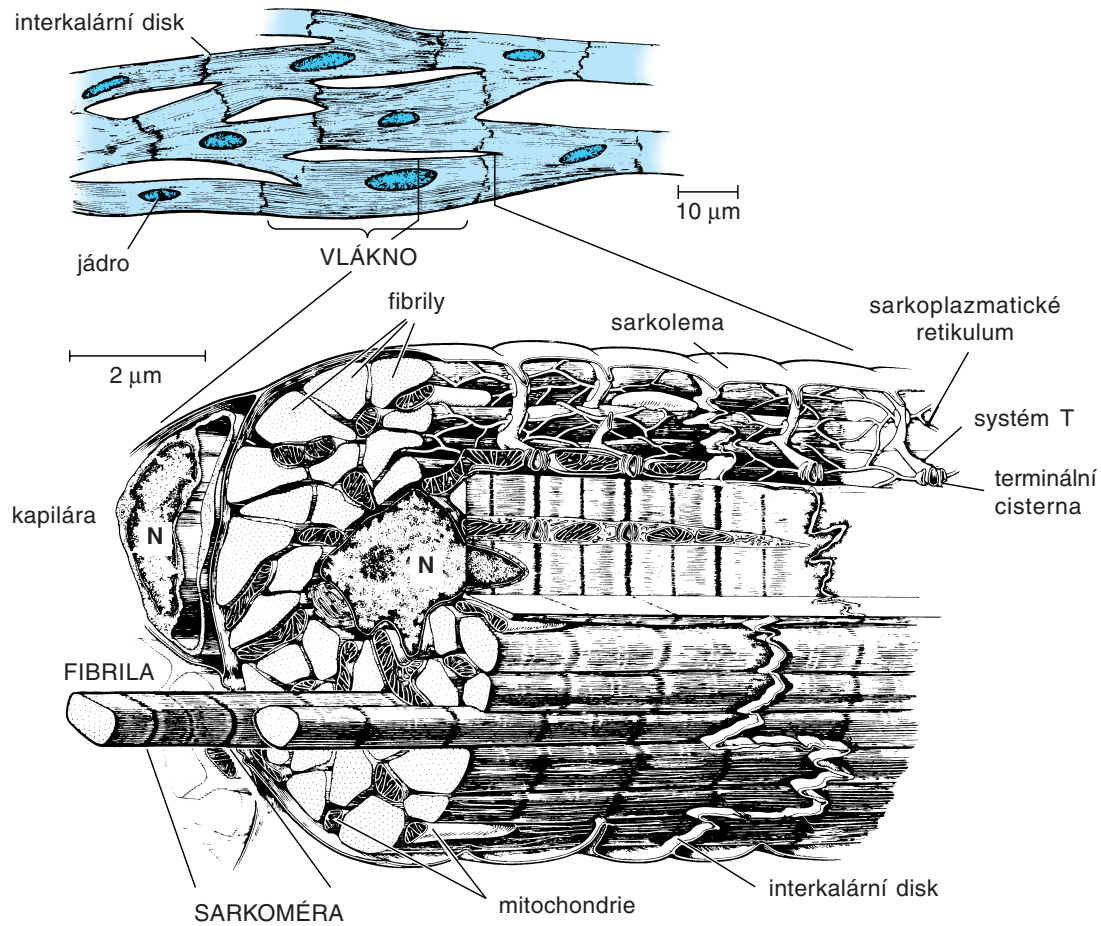
Constant parameters:

- velocity of the activation
- refractory period of the myocardium
- anatomical dimensions

Excitation – Contraction coupling in the cardiac muscle

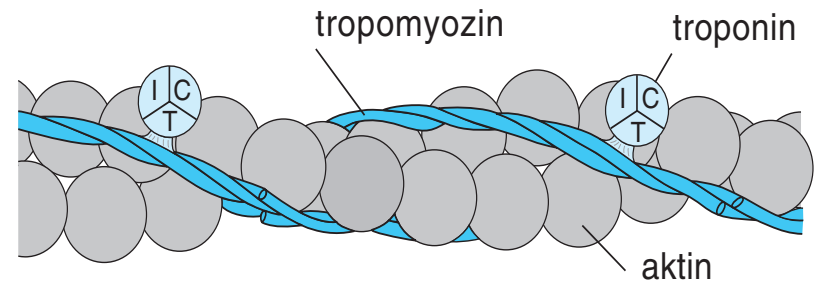
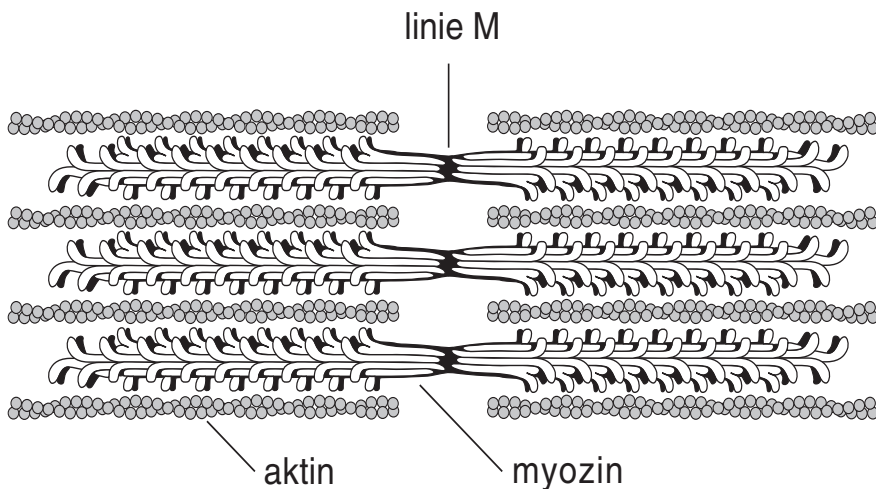
- Spontaneous the heart AP (automacity)
- Gap junctions
- T-tubules
- Contractile elements
- SR
- Mitochondria (ATP)
- Ca^{2+} ions

Structure of the myocardium

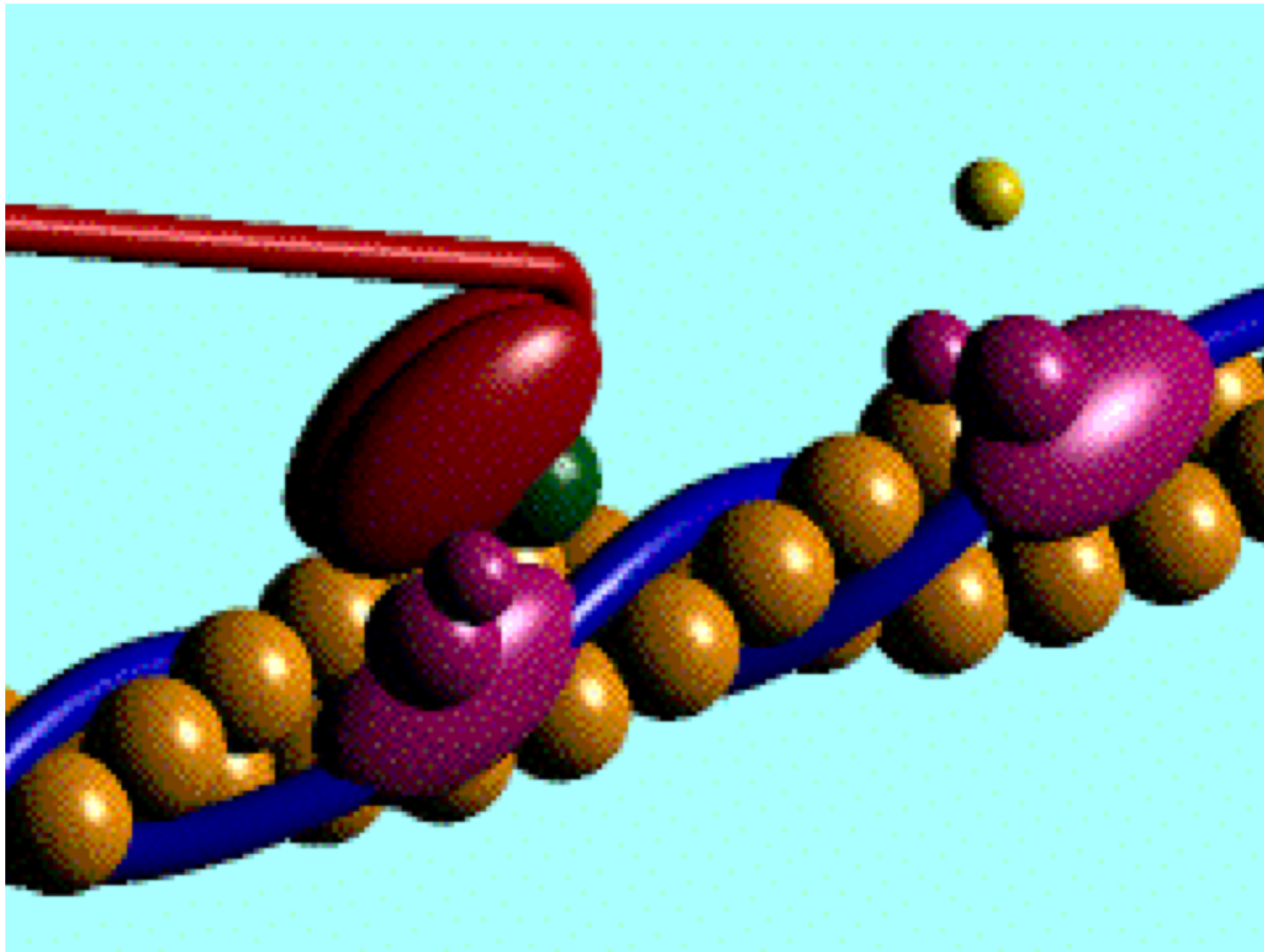


Contractile elements

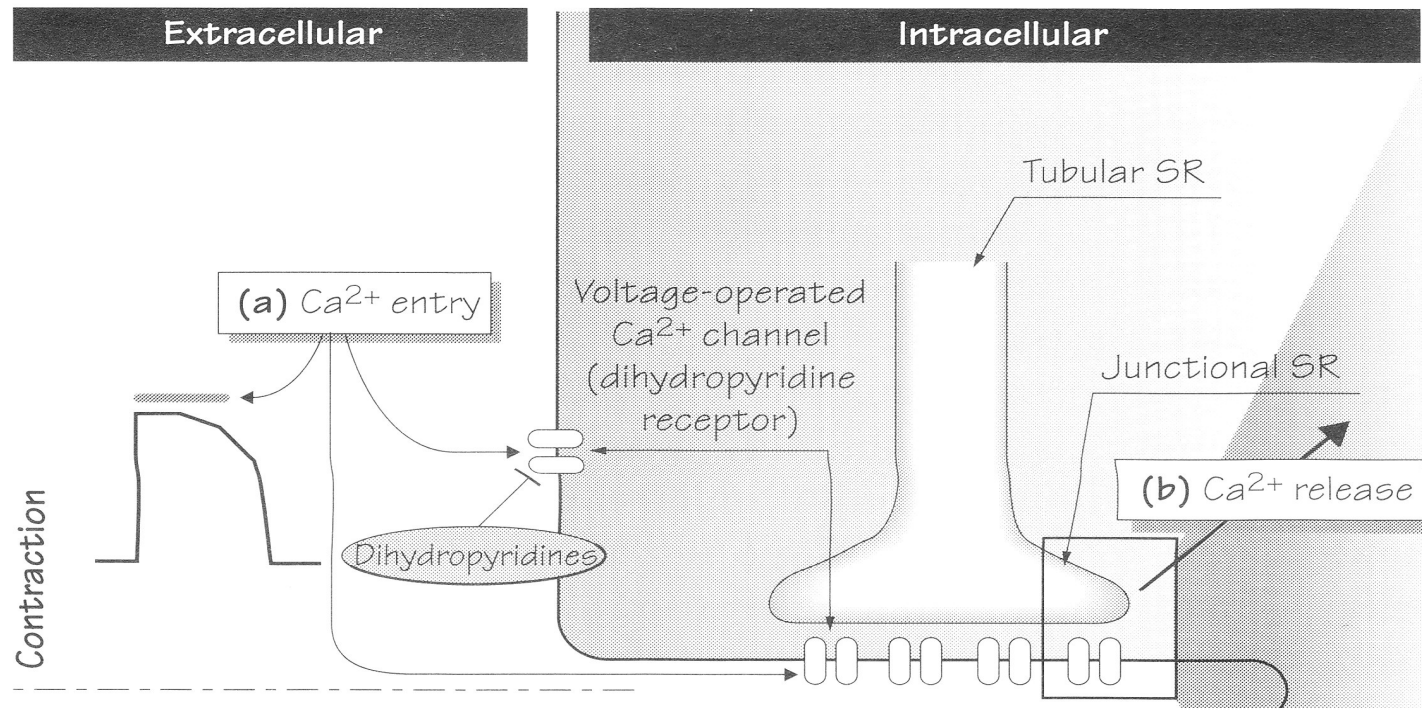
- Myosin – the heads=ATPase activity
- Actin
- Tropomyosin
- Troponin complex – TnT, TnC, TnI



Actin and myosin interaction



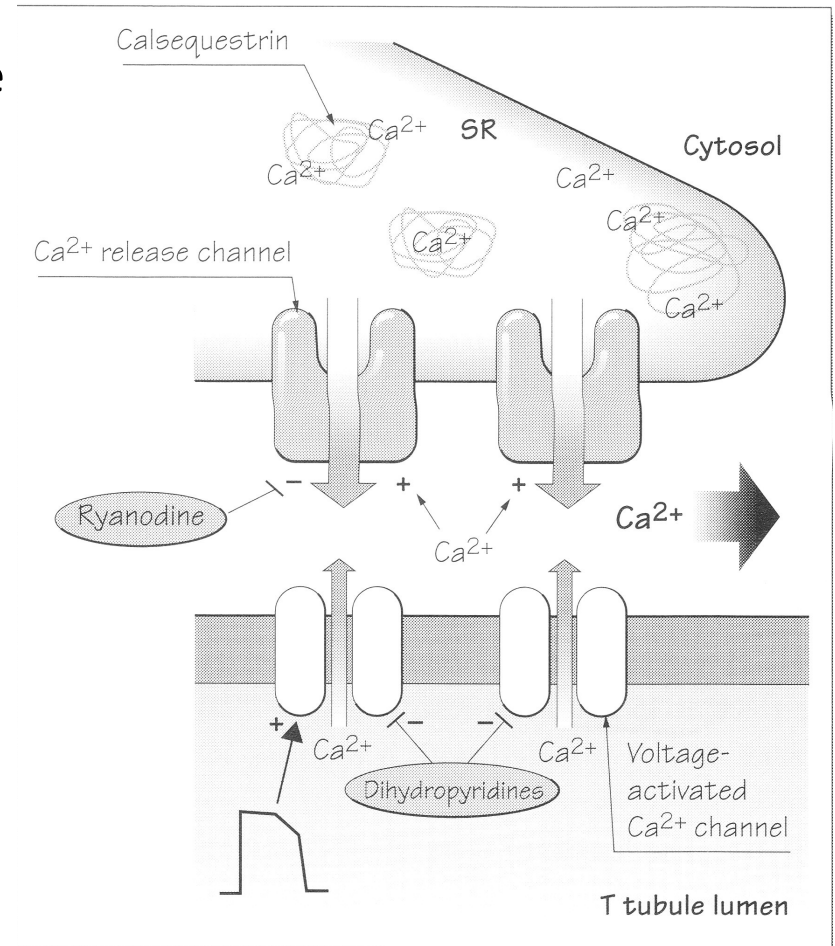
Excitation – Contraction coupling: initiation of the contraction mechanism



Calcium influx is essential to initiation of the myocardium contraction (about 20% of Ca²⁺), but this amount of calcium is not sufficient to induced whole contraction

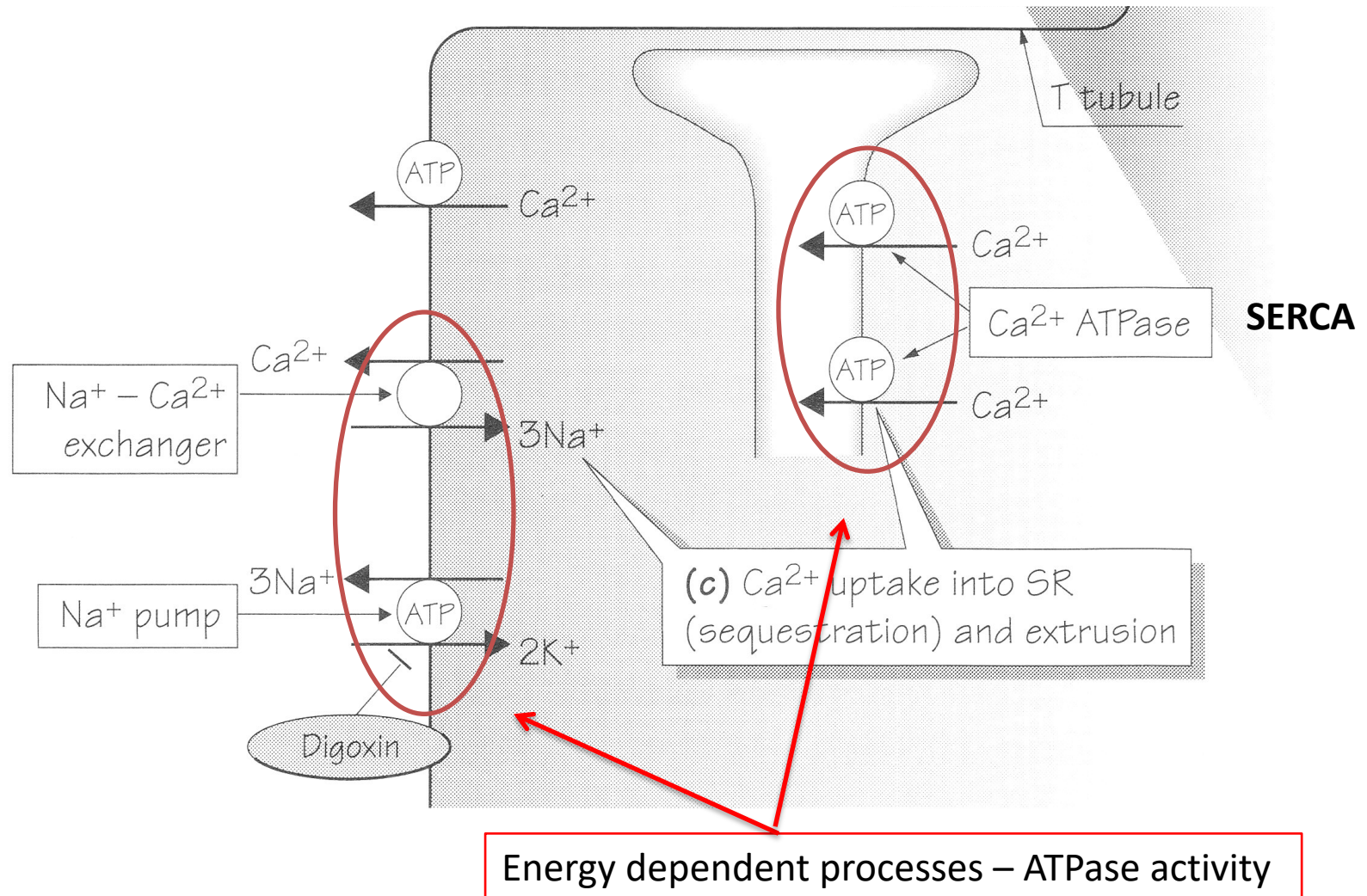
Excitation – Contraction coupling: calcium release from SR

- CIRC – calcium-induced calcium release
- Calcium supply from SR is about 80% of amount essential for contraction

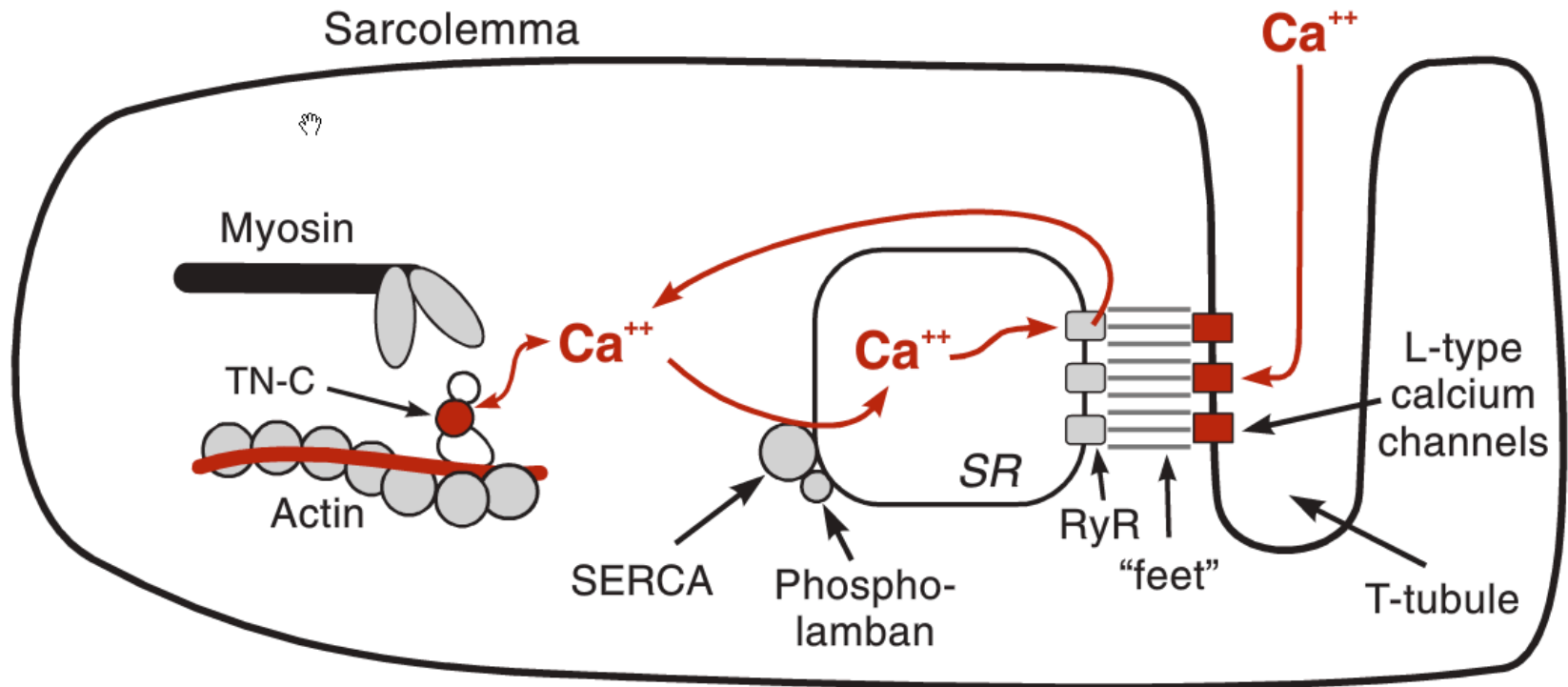


Excitation – Contraction coupling: relaxation mechanism

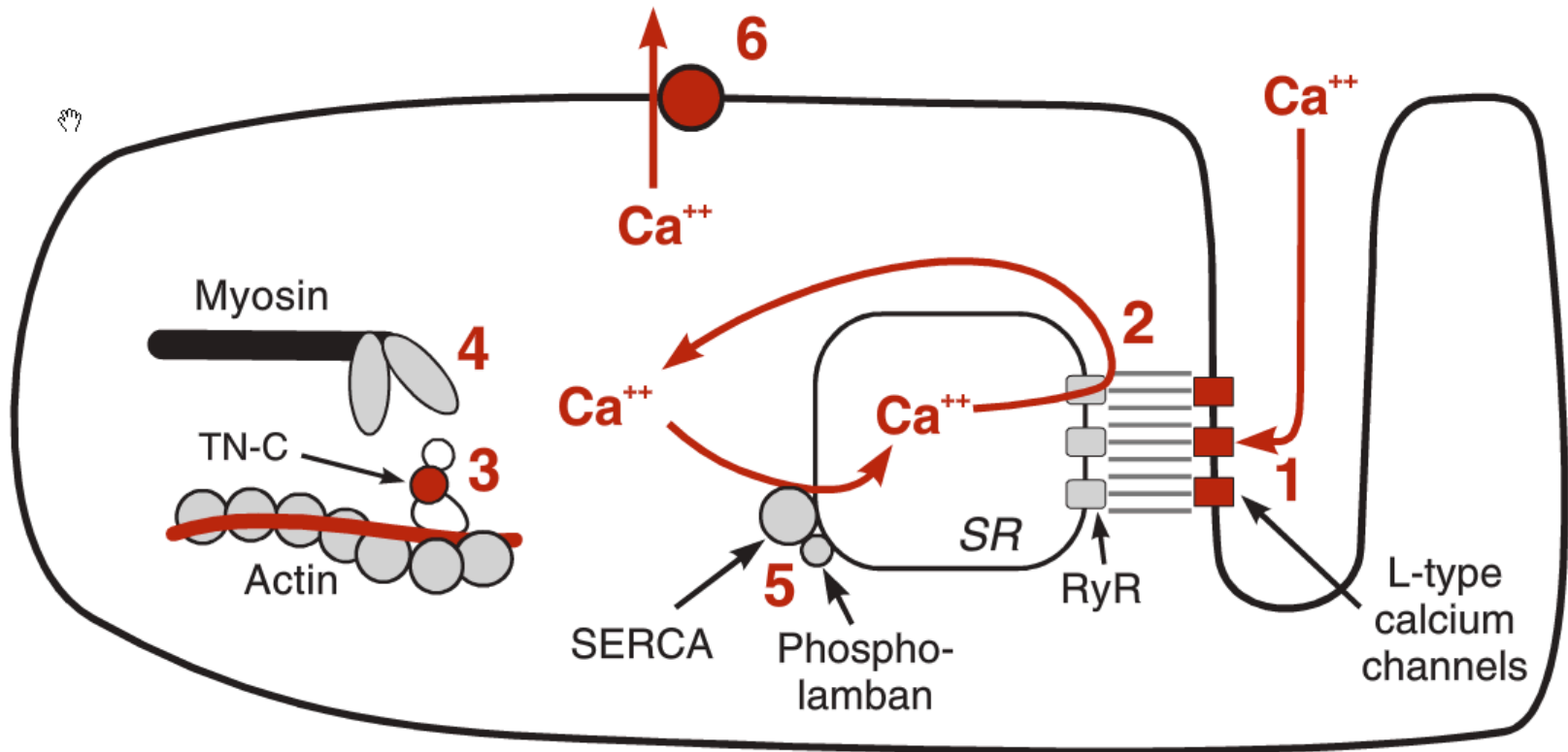
Relaxation



Excitation – Contraction coupling

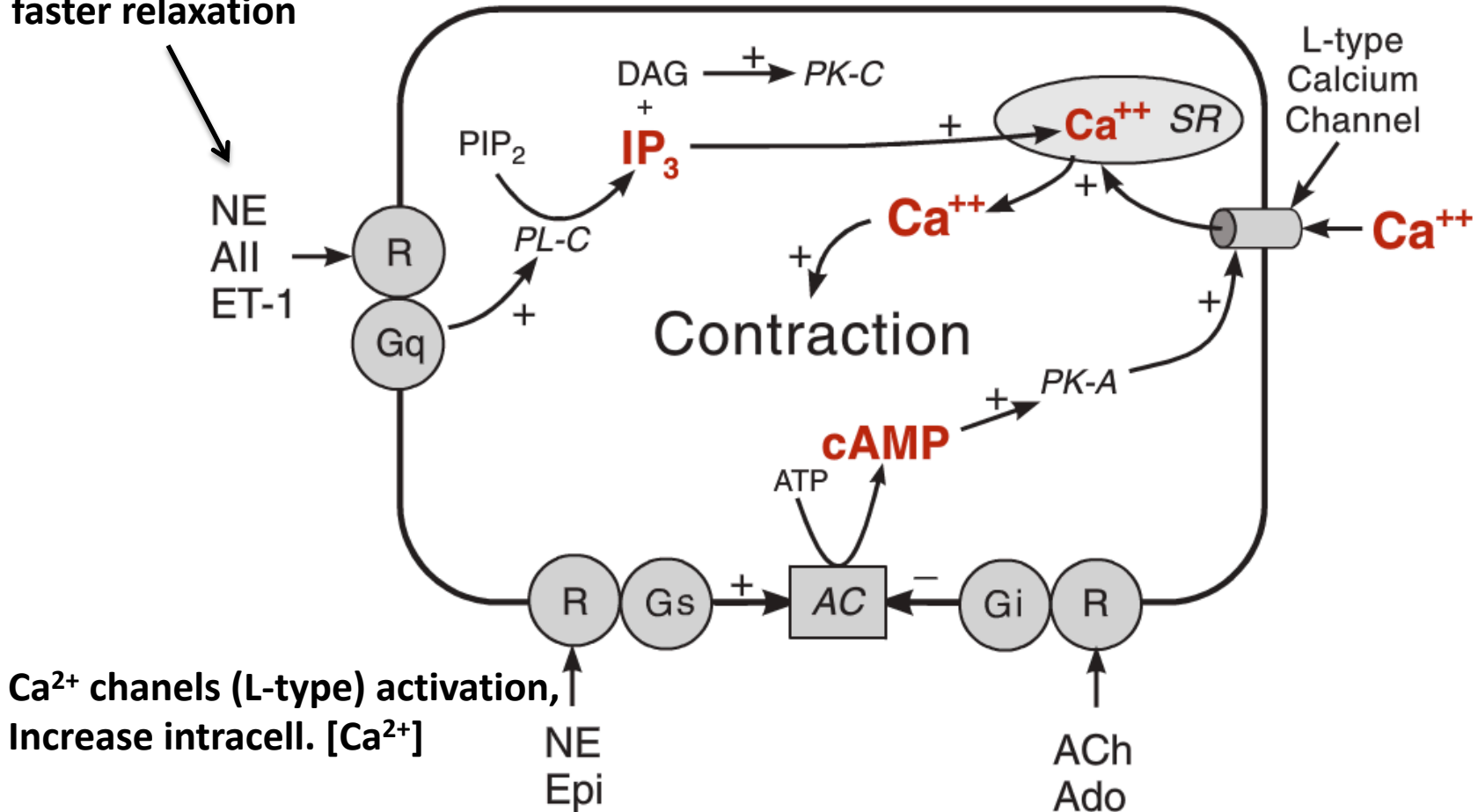


Calcium ions during excitation – contraction coupling



Homeometric regulation of contraction by catecholamins

Fosforylation of fosfolambam
faster relaxation



Thank you

