

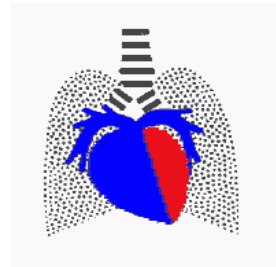
# The Heart physiology I.

(excitation, conduction, contraction...)

Milan Chovanec



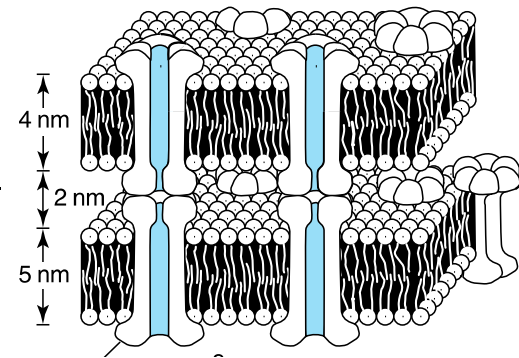
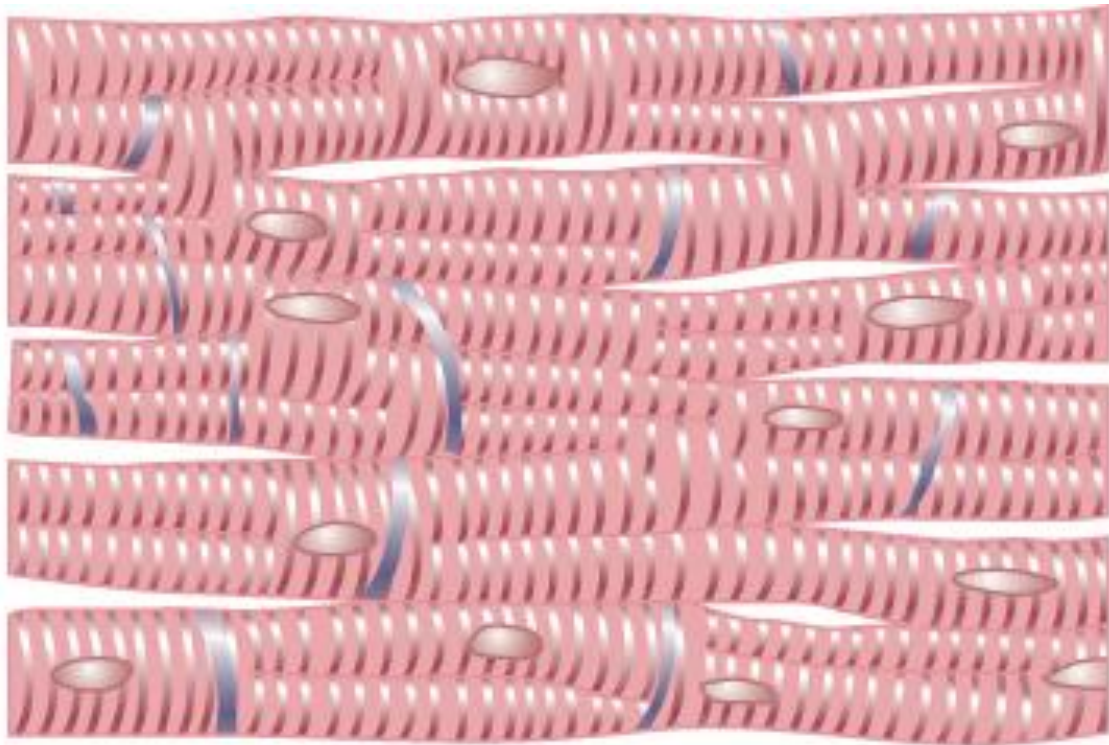
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# The Heart Physiology

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

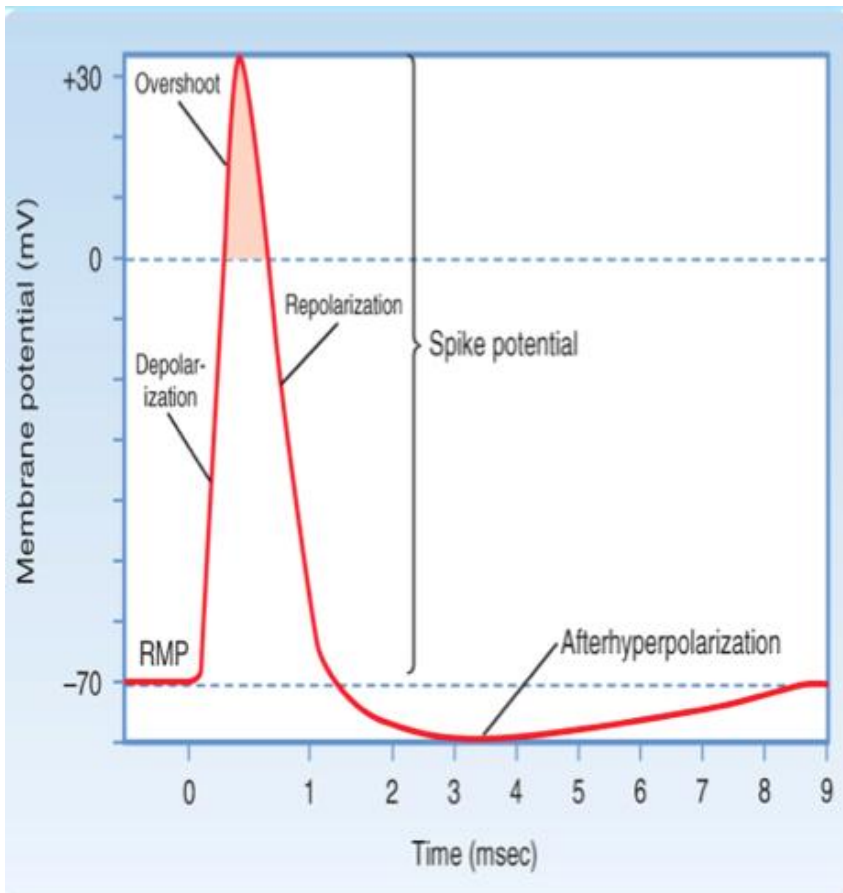
# Myocardium = syncytium



Gap junction = nexus

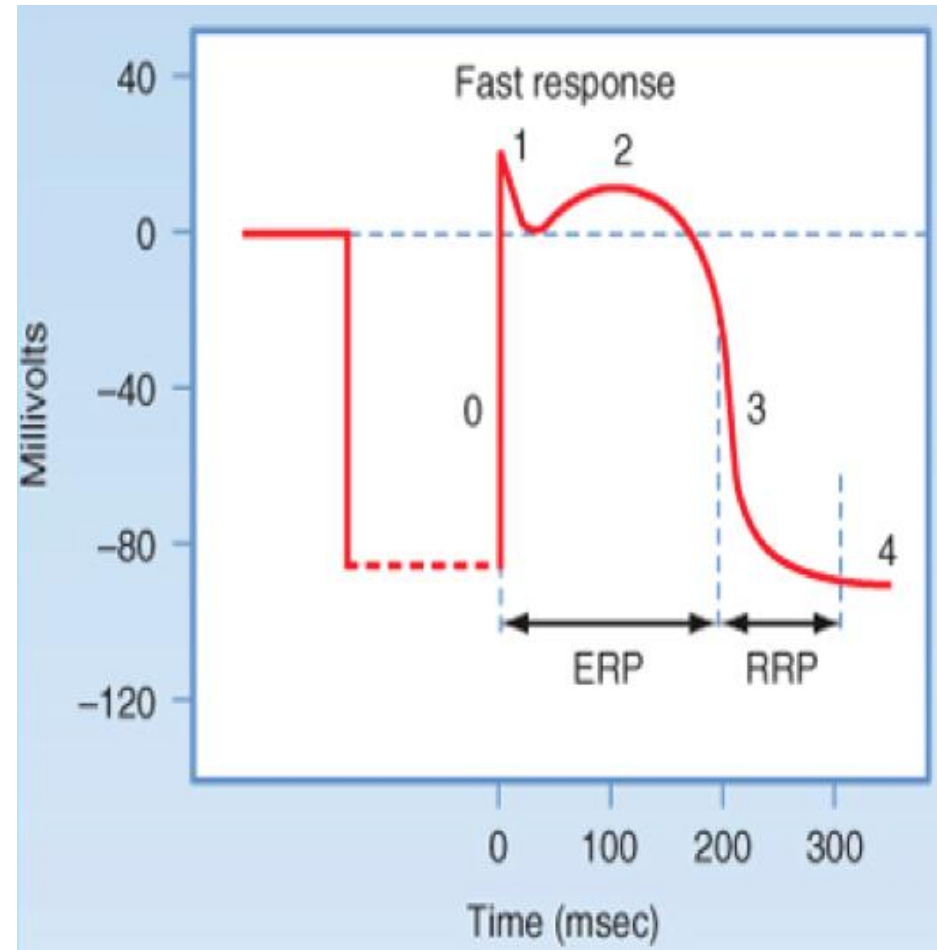
# Different types of the action potential in the heart

## Skeletal muscle, nerve

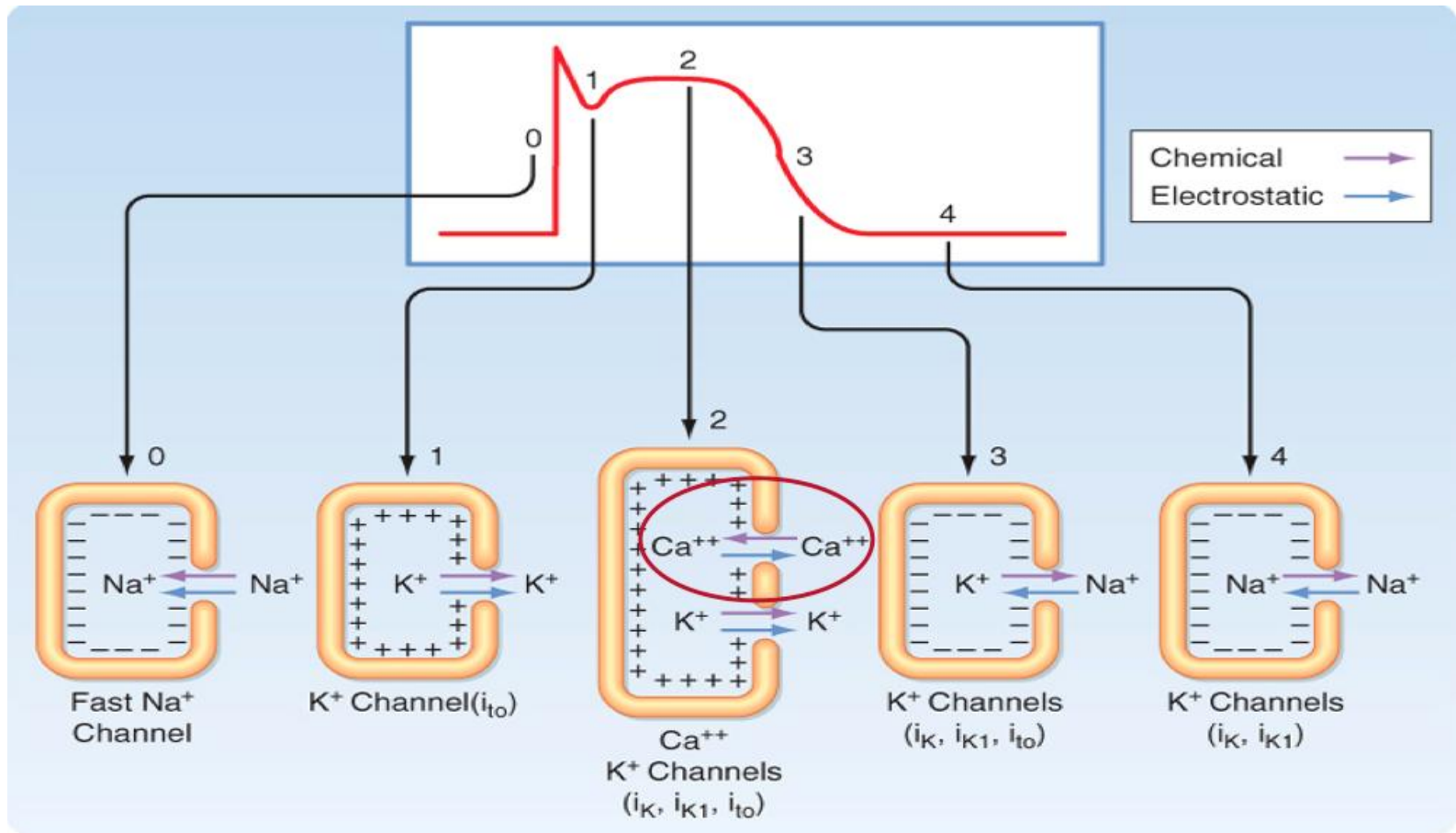


Koepfen & Stanton: Beme and Levy Physiology, 6th Edition.  
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## Myocardium

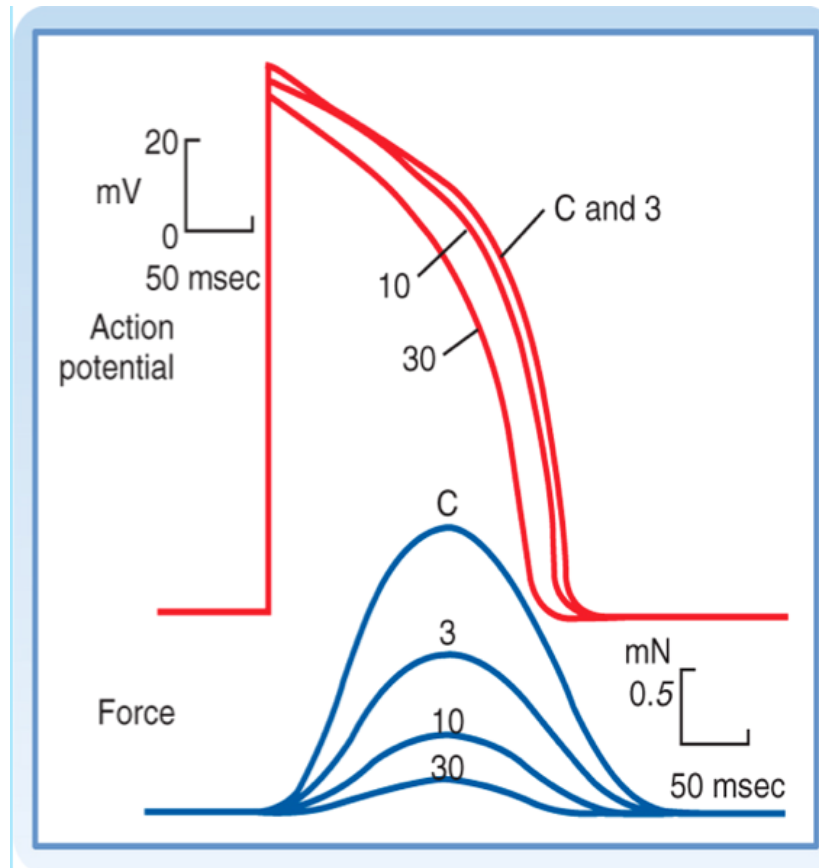


# Voltage gated $\text{Ca}^{2+}$ channels (L-type) are responsible for AP in the myocardium

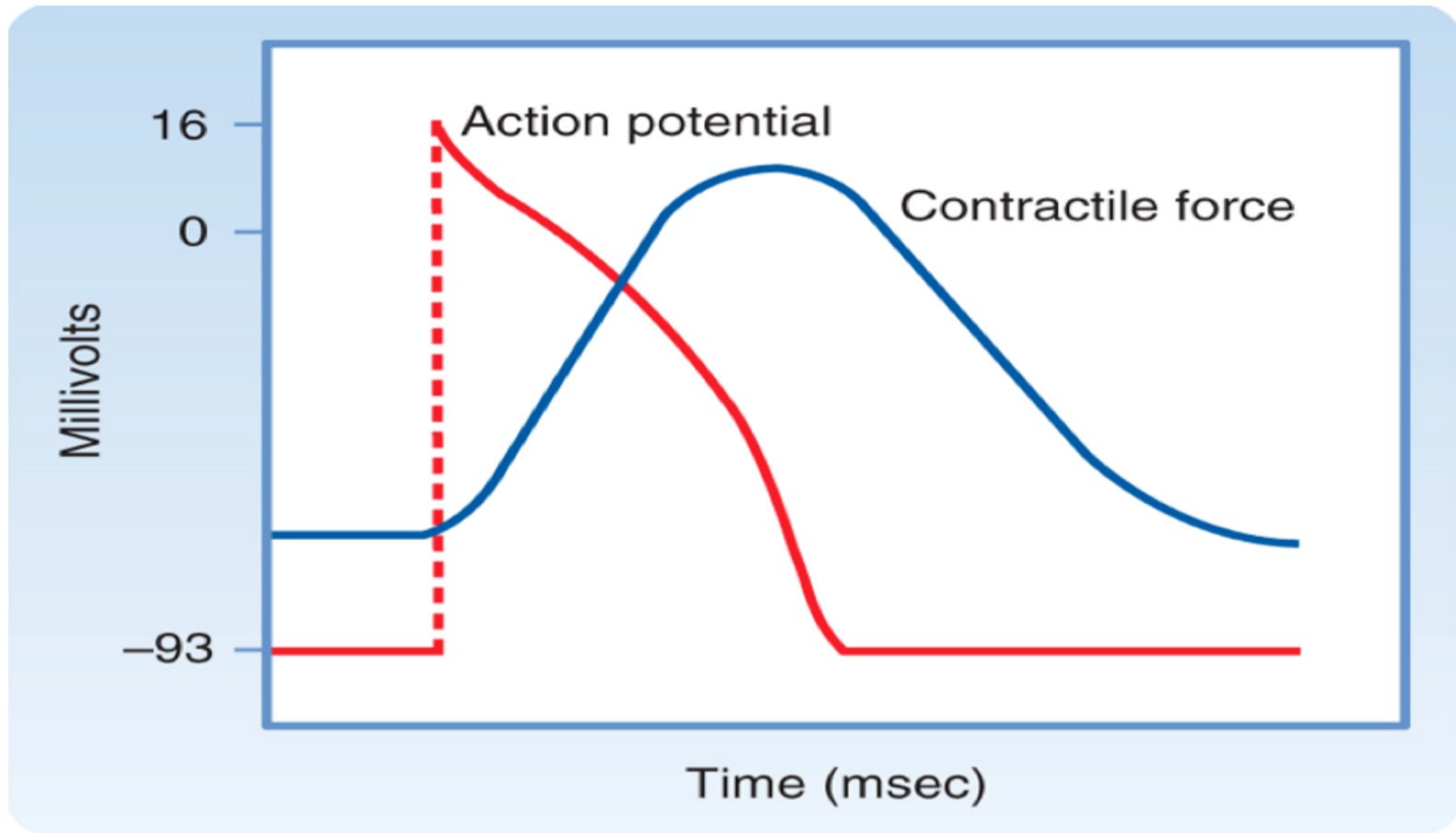


# Calcium influx plays role in strength and duration of the myocardial AP

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

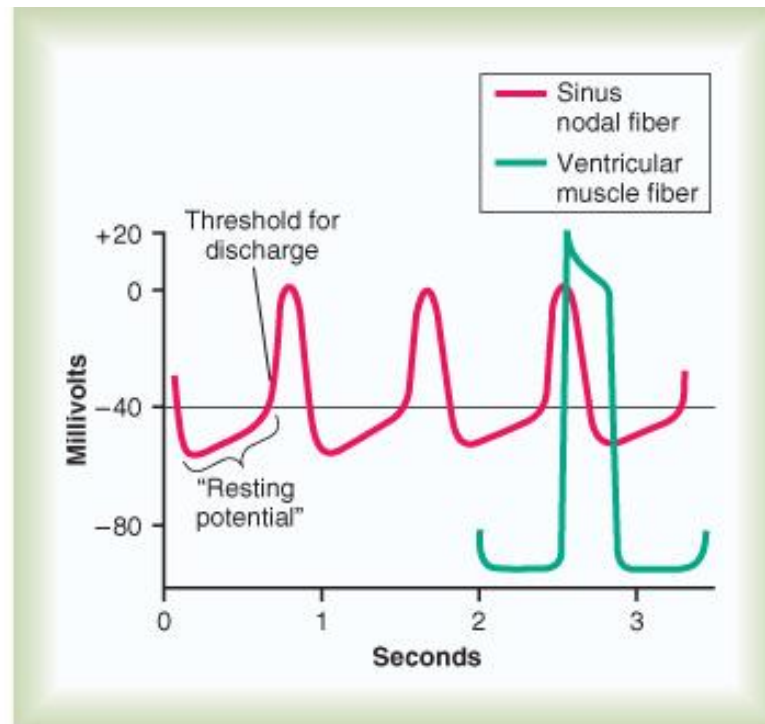


# Prolonged AP prevents tetanic myocardial contraction



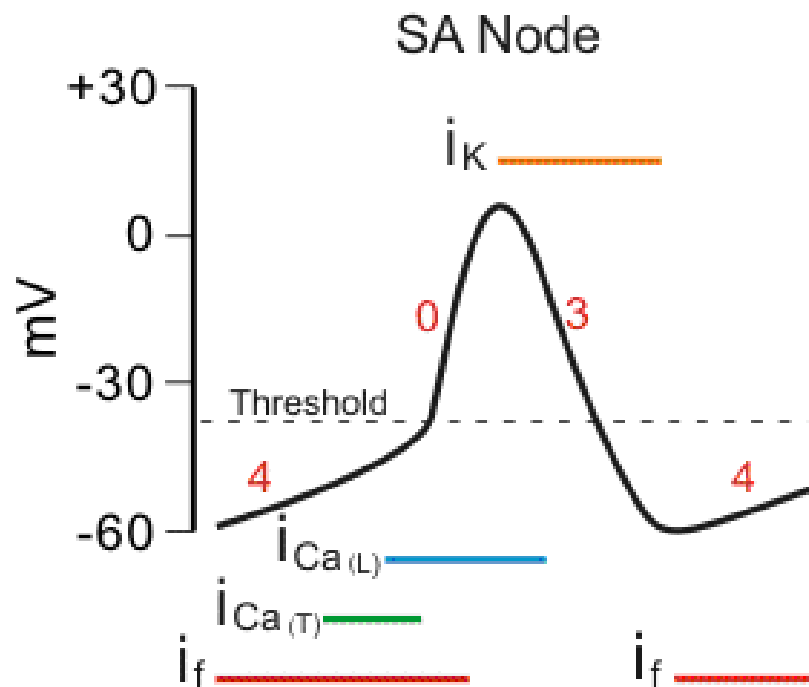
# Cardiac cells types

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





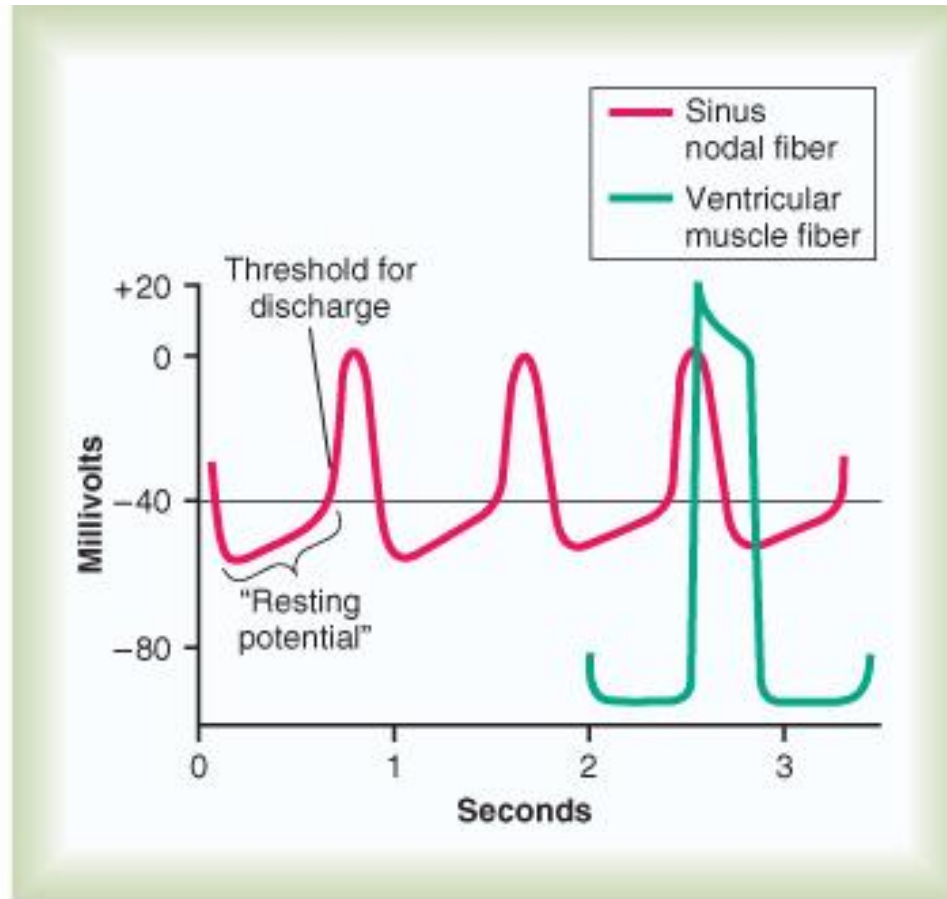
# Electrical conduction system AP



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

sinoatrial (SA) pacemaker action potential

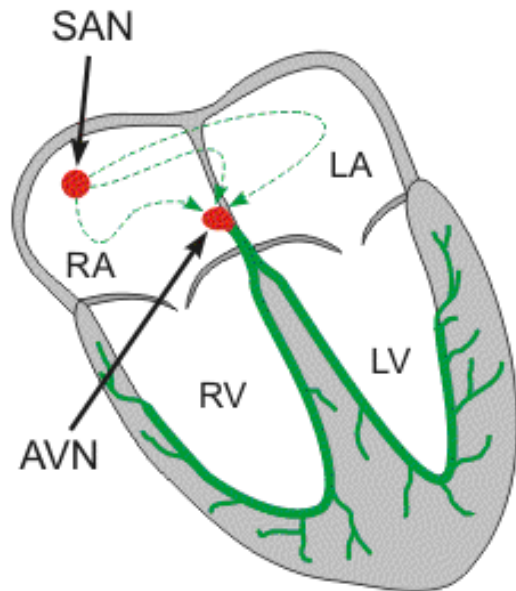
# Difference between AP of the working myocardium and the conduction system



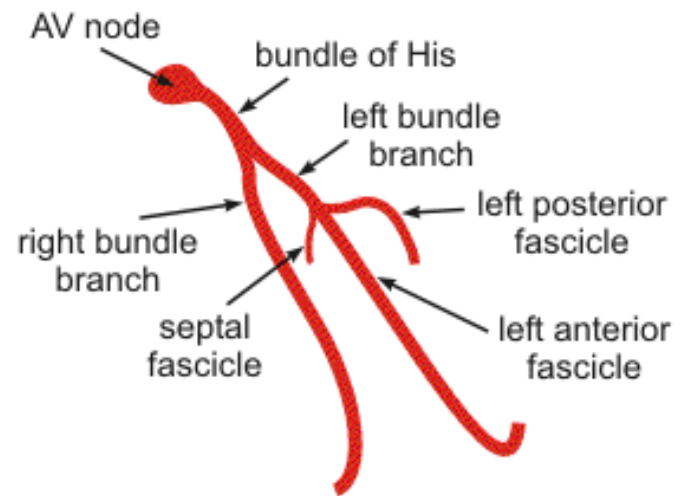
**RMP**



# Conduction 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

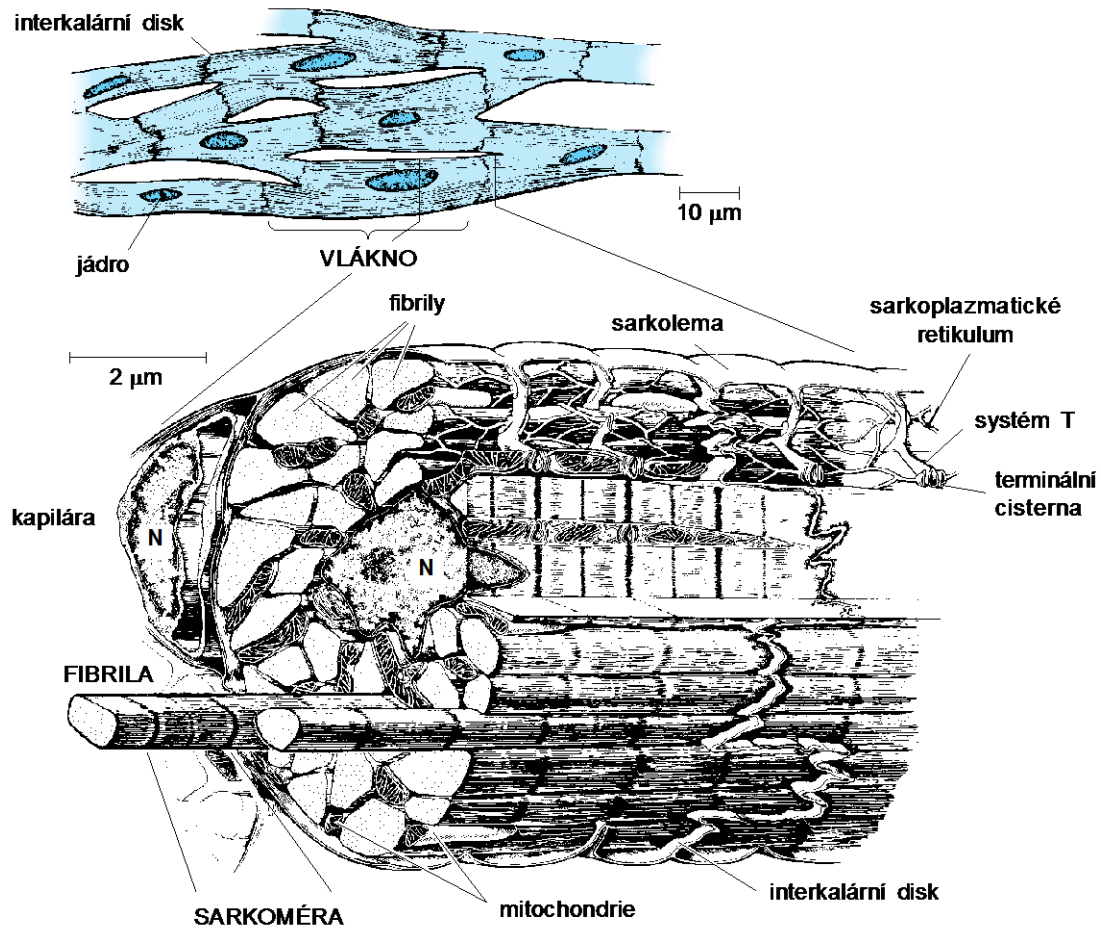
## Constant parameters:

- 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)
- $\text{Ca}^{2+}$  ions

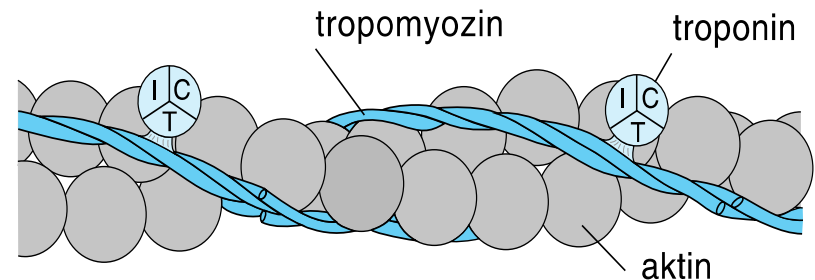
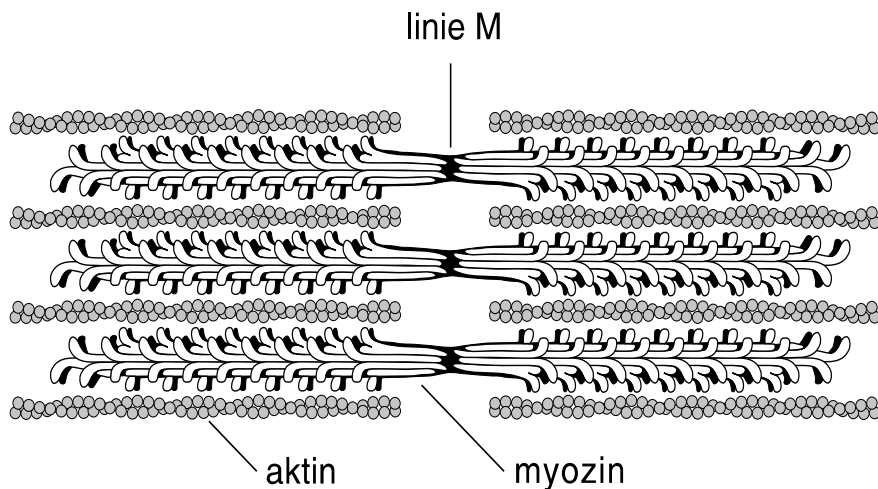
# Structure of the myocardium



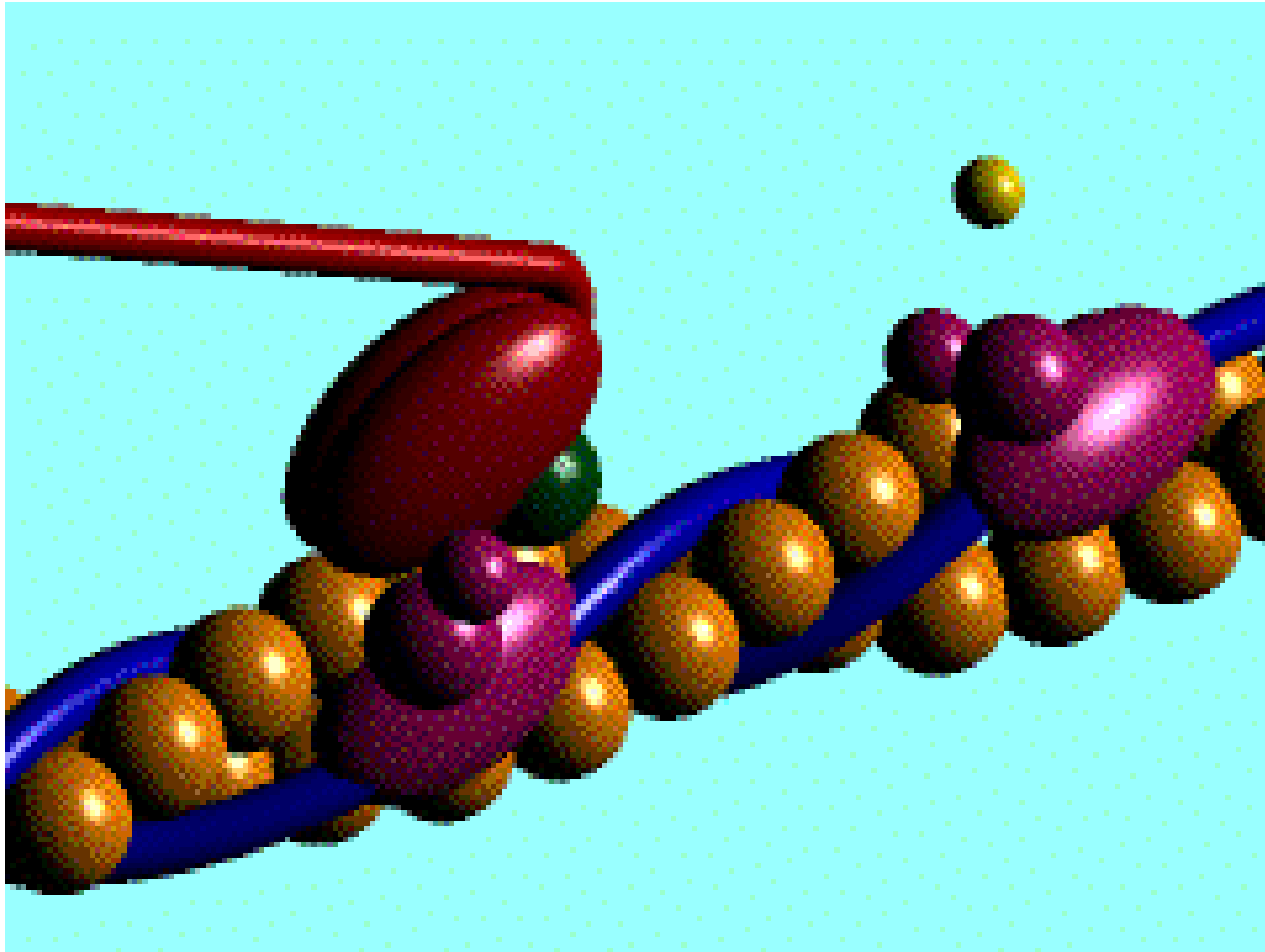


# Contractile elements

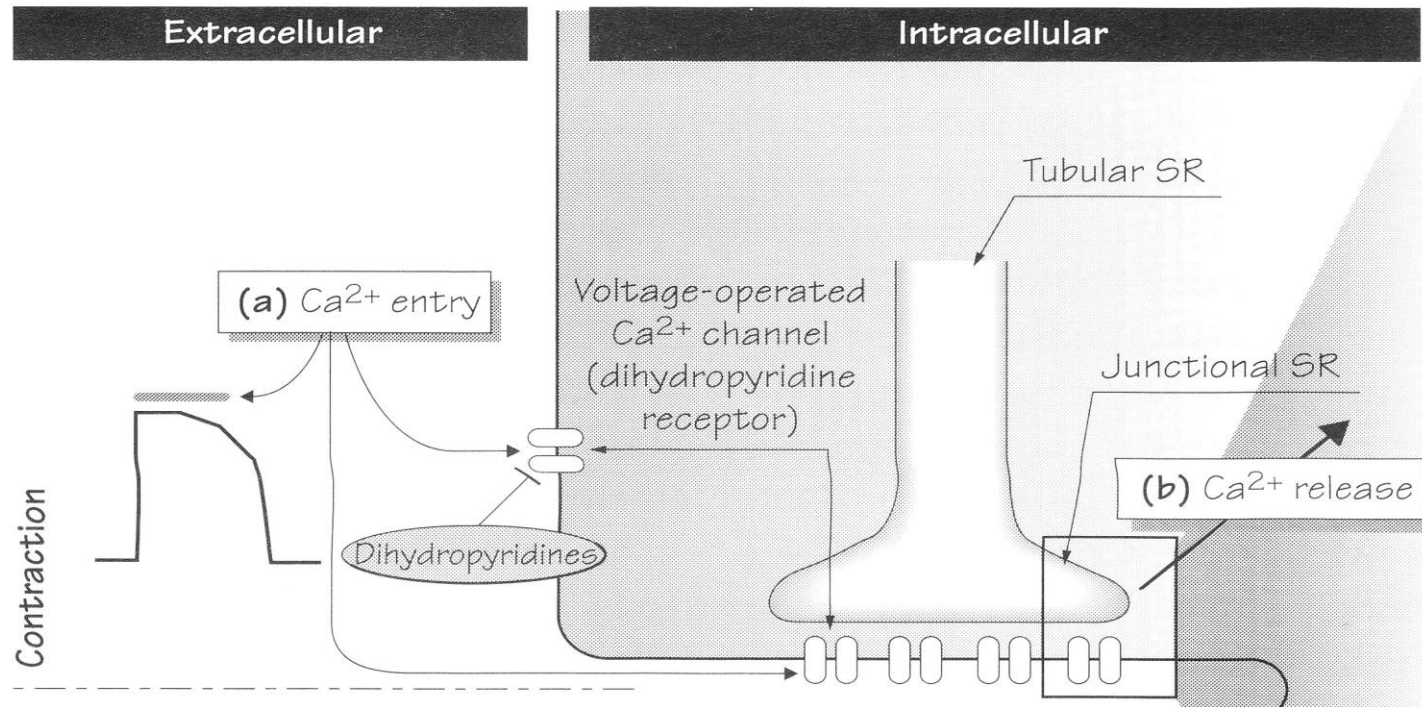
- Myosin – the heads=ATPase activity
- Actin
- Tropomyosin
- Troponin complex – TnT, TnC, TnI



# Actin and myosin interaction



# Excitation – Contraction coupling: initiation of the contraction mechanism

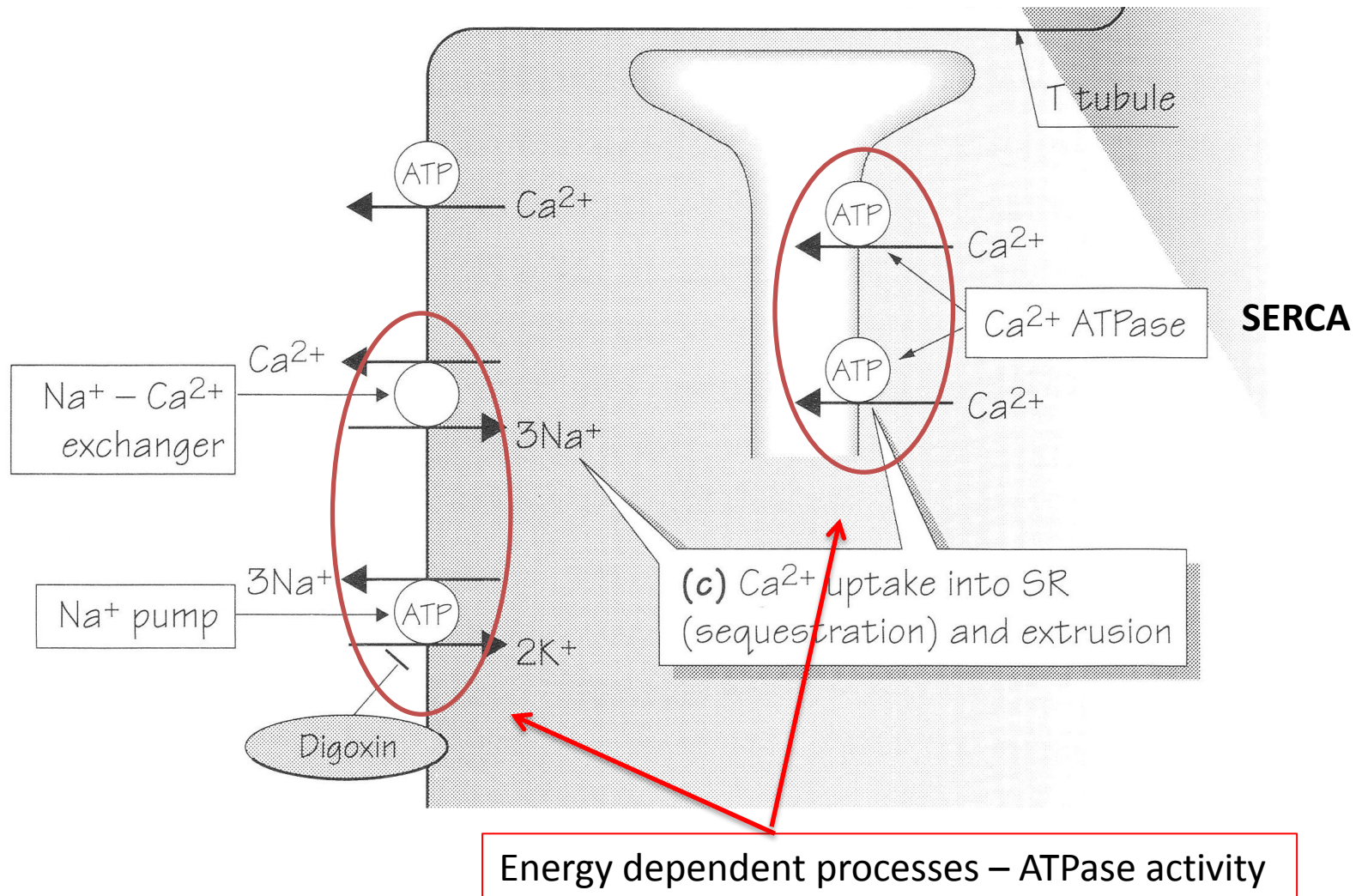


Calcium influx is essential to initiation of the myocardium contraction (about 20% of Ca<sup>2+</sup>), but this amount of calcium is not sufficient to induced whole contraction



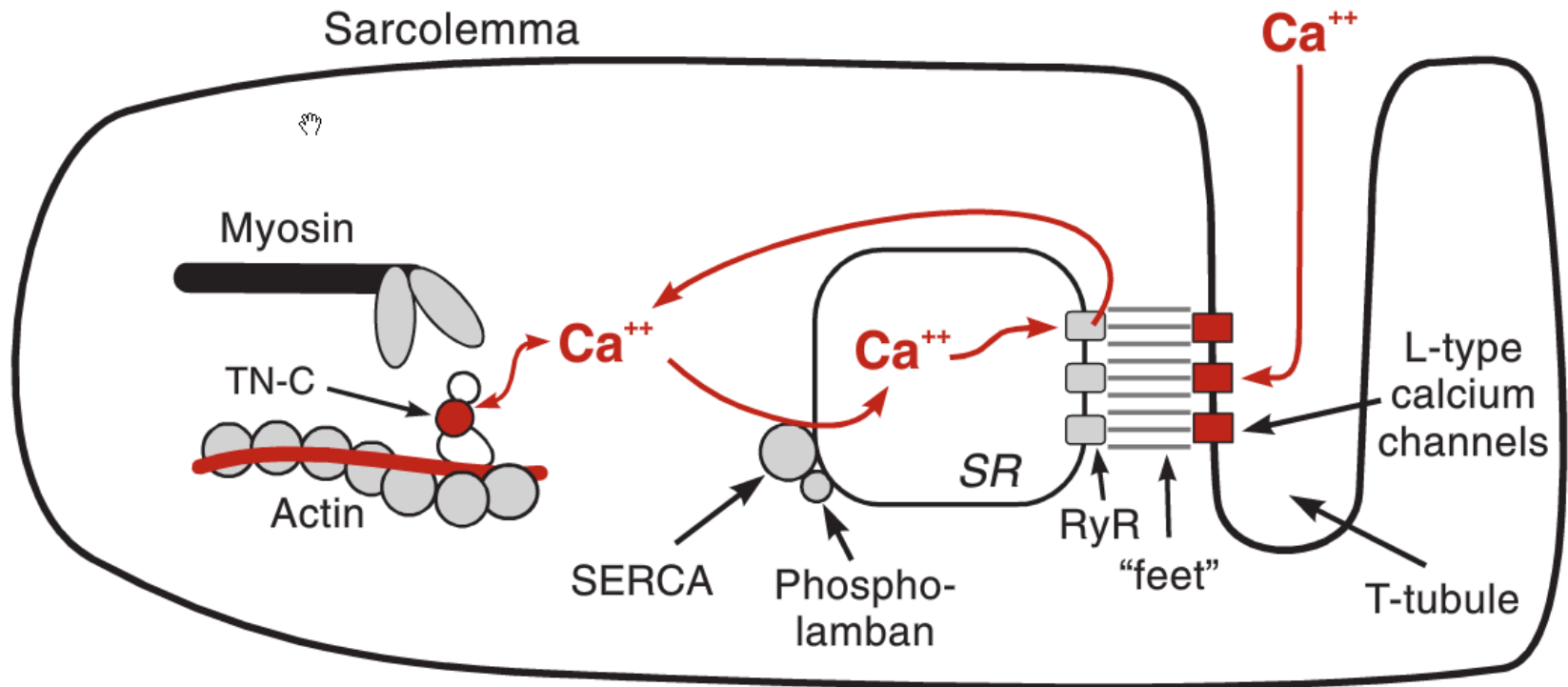
# Excitation – Contraction coupling: relaxation mechanism

Relaxation

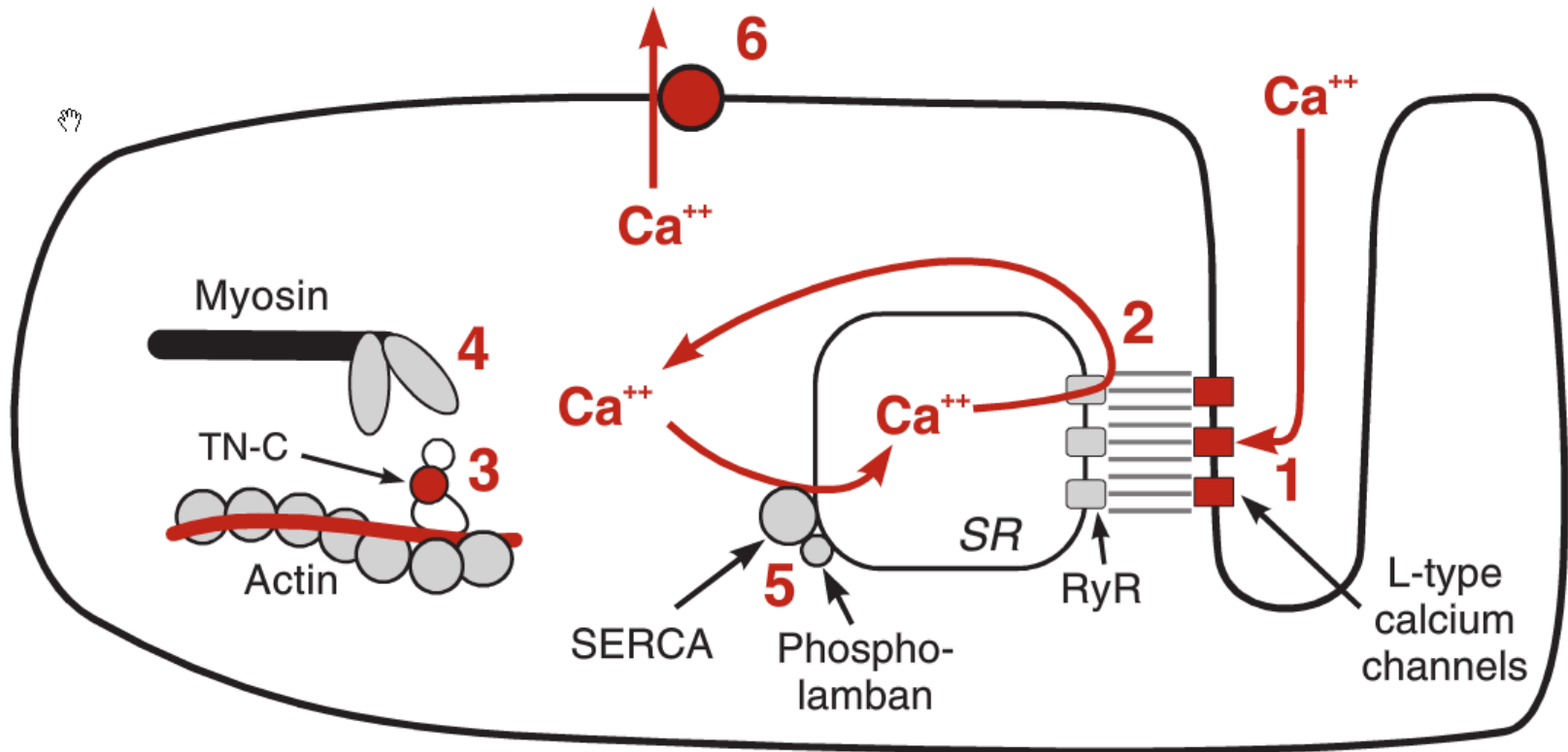


Energy dependent processes – ATPase activity

# Excitation – Contraction coupling

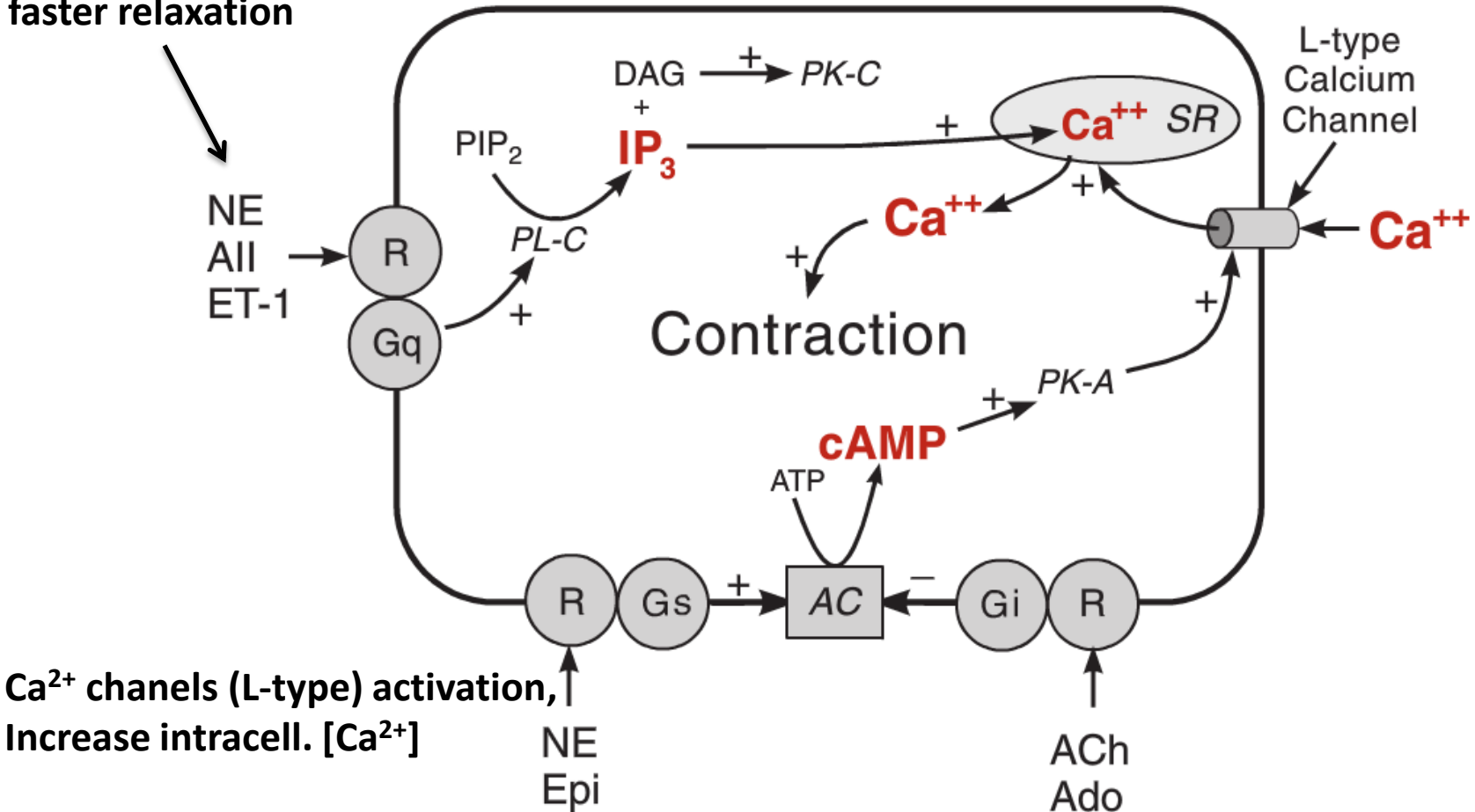


# Calcium ions during excitation – contraction coupling



# Homeometric regulation of contraction by catecholamins

Fosforylation of fosfolambam  
faster relaxation





Thank you

# Spřažení kontrakce - relaxace

