# Simulating Membrane Channels

- Brief Introduction to Membrane and a few examples of Membrane Channels

- Aquaporin Water Channels

  - How to model membrane proteins in membrane

  - How much can we learn from simulations?

  - How to analyze the data? Where to look?

- Nanotubes and today's exercises

  - Nanotubes as simple models for water channels

  - Theory and MD simulation of water transport through channels

Why Do Living Cells Need Membrane Channels (Proteins)?

- Living cells also need to exchange materials and information with the outside world
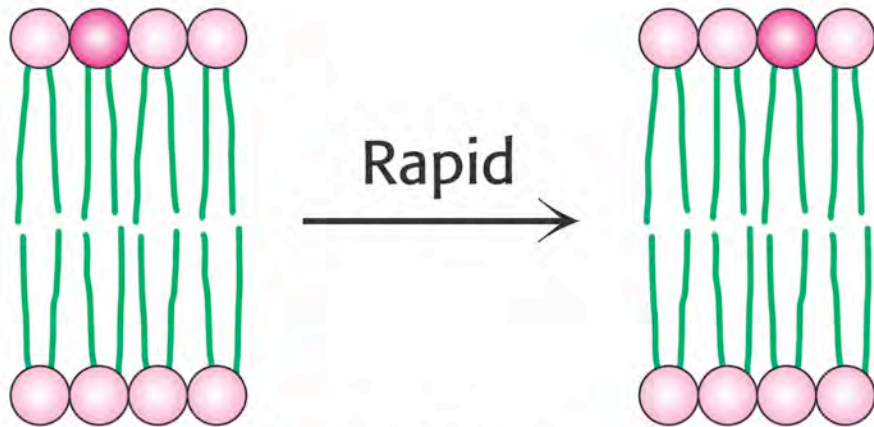
... however, in a highly <u>selective</u> manner.

Extracellular (outside)

Cytoplasm (inside)
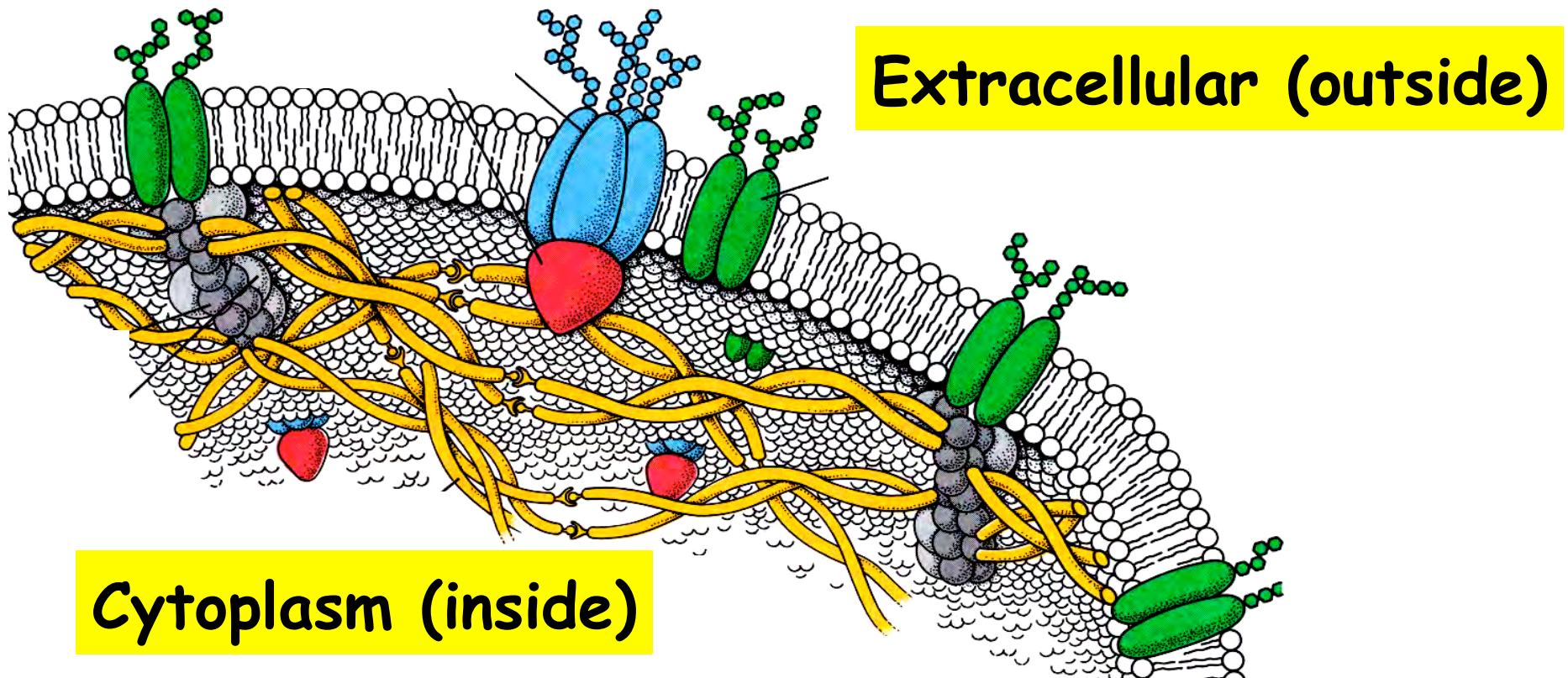
Lipid Bilayers Are Excellent For Cell Membranes

- **Hydrophobic interaction is the driving force**

- **Self-assembly in water**

- **Tendency to close on themselves**

- **Self-sealing (a hole is unfavorable)**

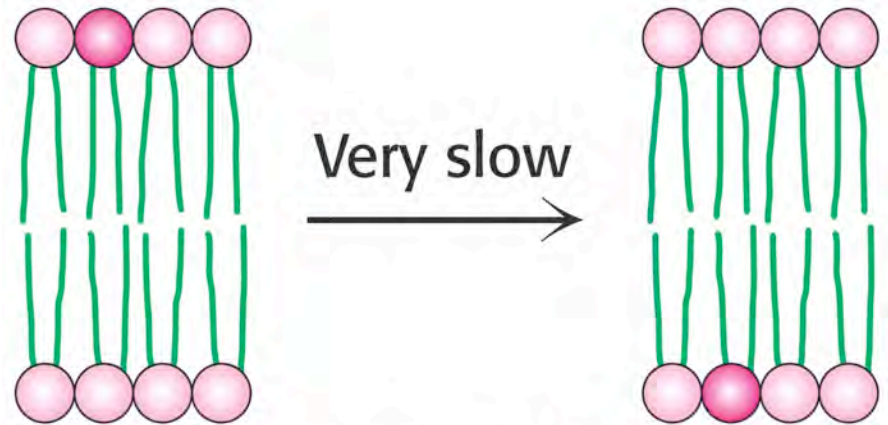- **Extensive: up to millimeters**
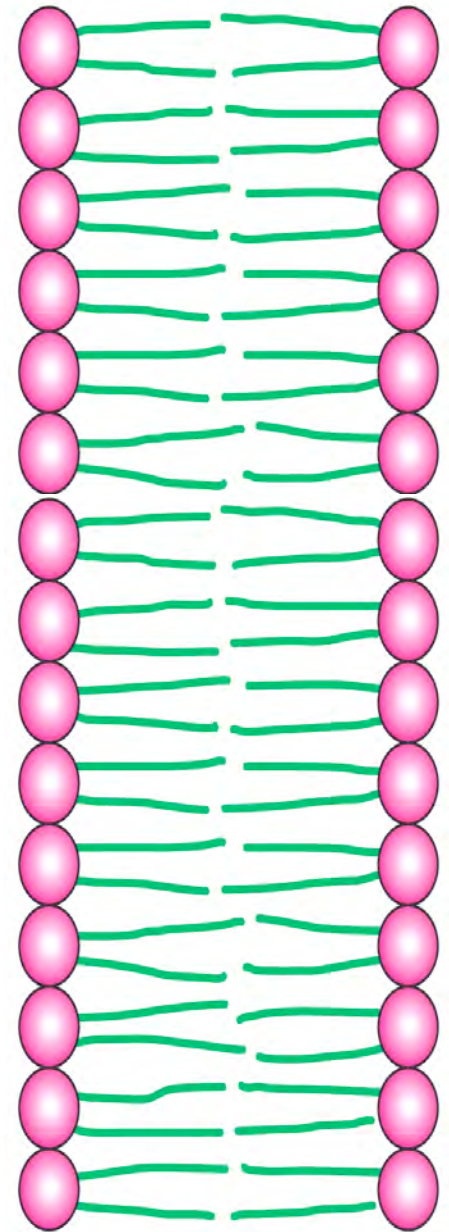
Lipid Diffusion in Membrane

Rapid

Lateral diffusion

$D = 1\ \mu m^2.s^{-1}$

50 Å in ~ 2.5×10^{-5} s

~9 orders of magnitude difference

$D_{lip} = 10^{-8}\ cm^2.s^{-1}$

$D_{wat} = 2.5 \times 10^{-5}\ cm^2.s^{-1}$

Very slow

Tranverse diffusion (flip-flop)

Once in several hours!

(10^4 s)

Fluid Mosaic Model of Membrane

Lateral Diffusion Allowed

Flip-flop Forbidden

Ensuring the conservation of membrane asymmetric structure
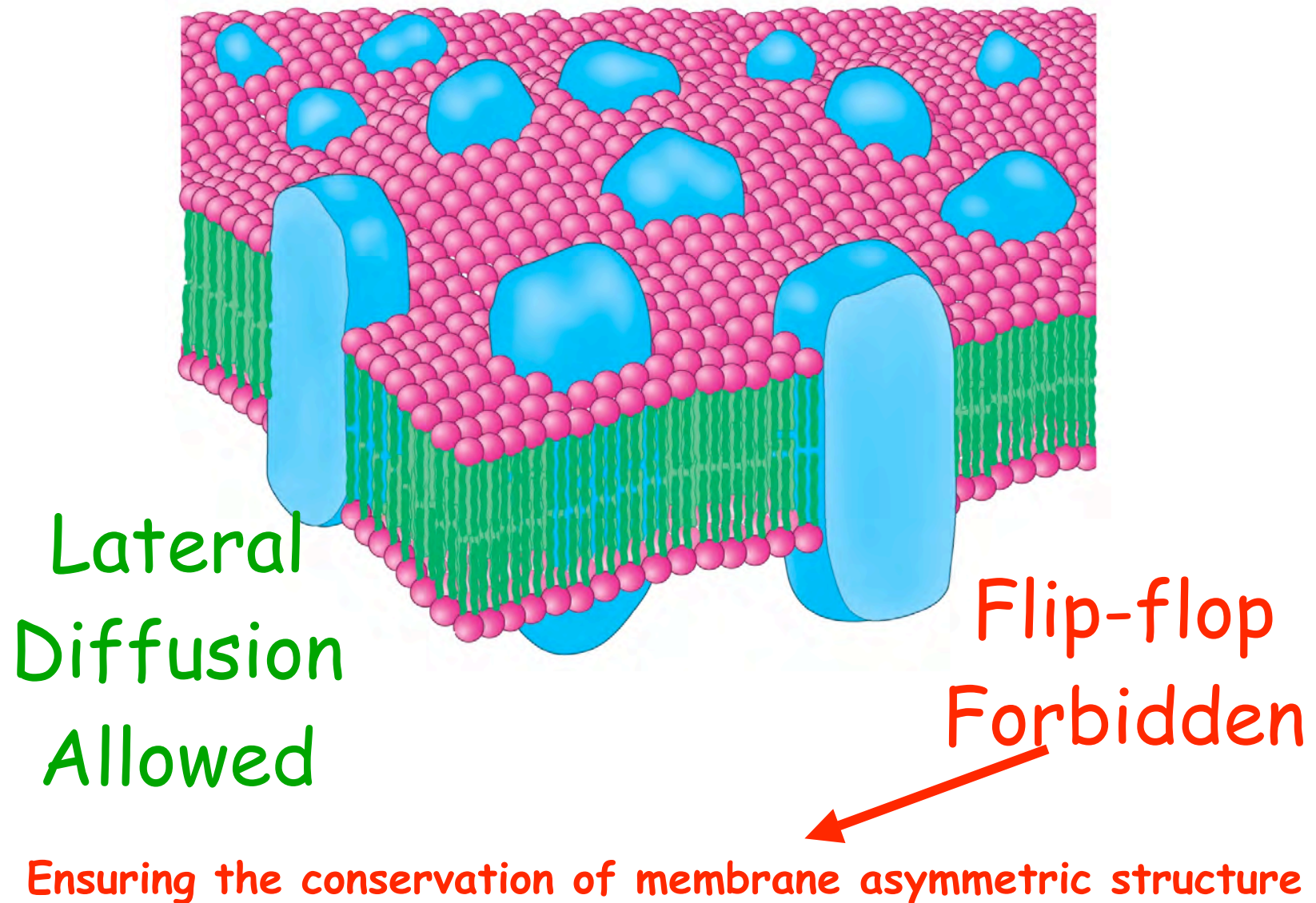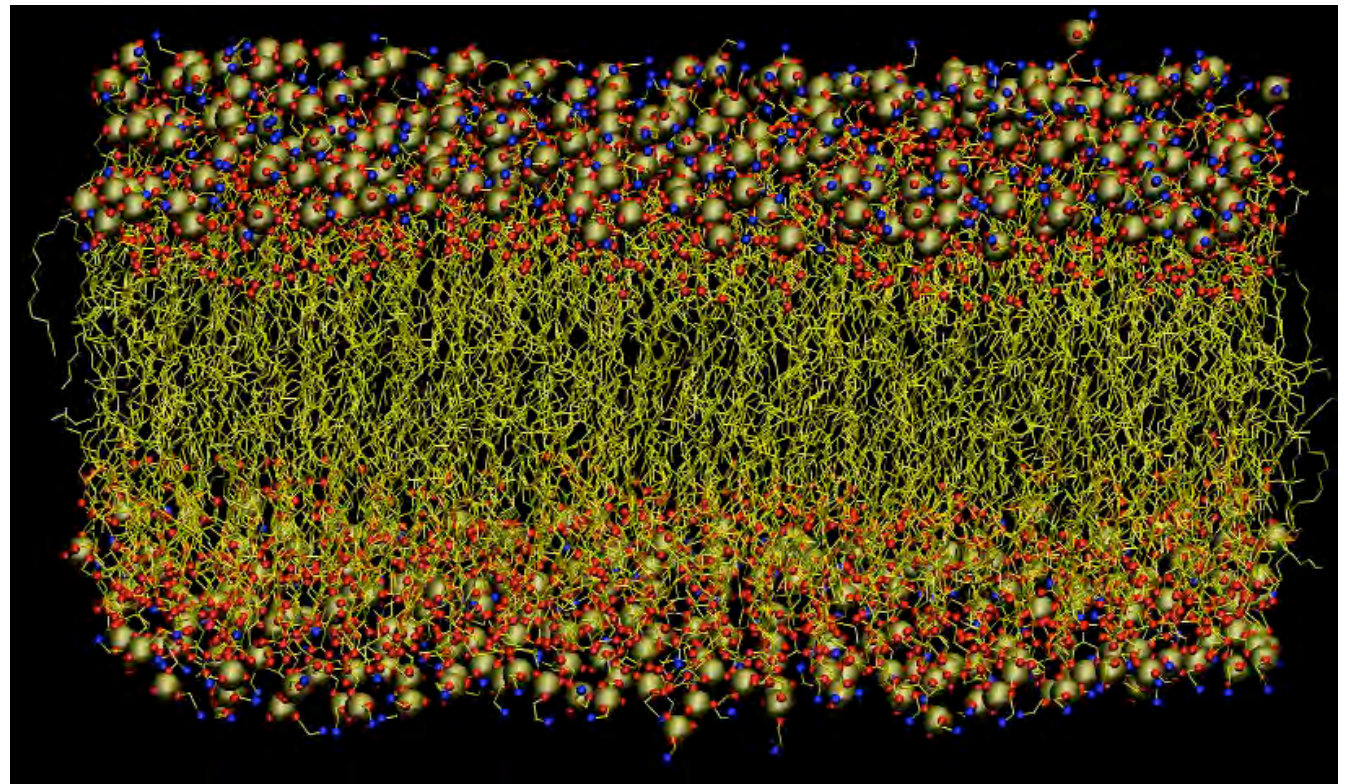
Technical difficulties in Simulations of Biological Membranes

- Time scale

- Heterogeneity of biological membranes ☹
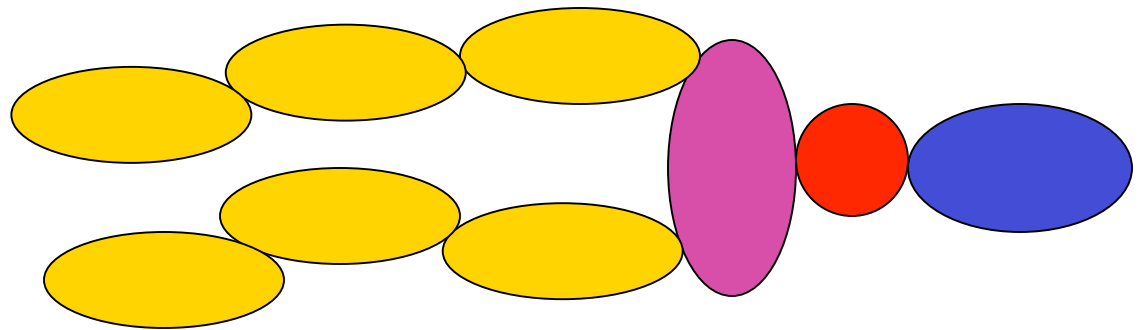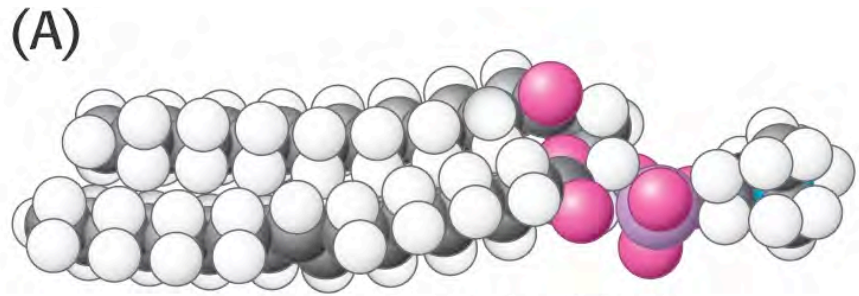
60 x 60 Å

Pure POPE
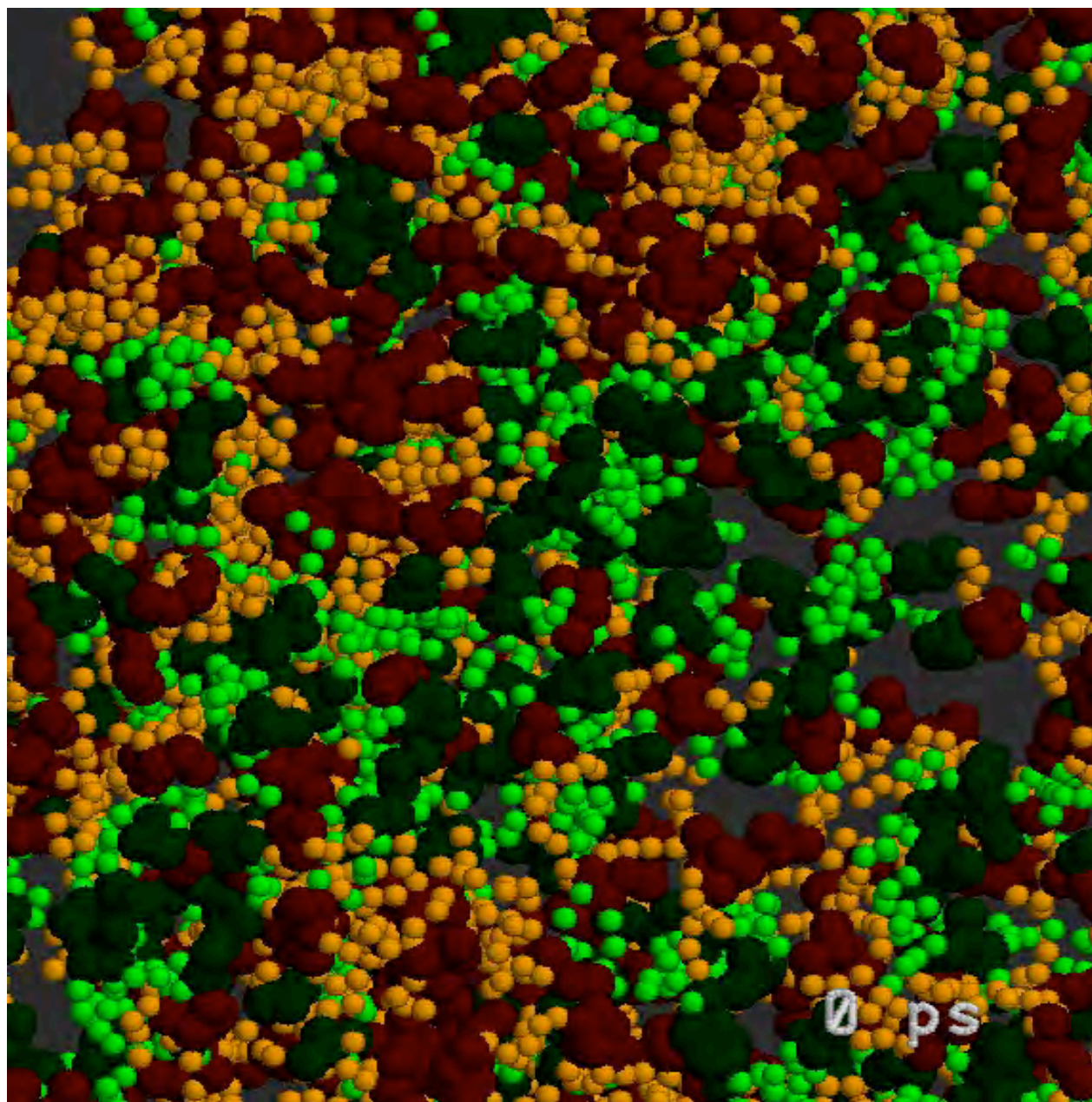
5 ns

~100,000

atoms

Coarse grain modeling of lipids

150 particles

9 particles!

(A)

Also, increasing the time step by orders of magnitude.

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Protein/Lipid ratio

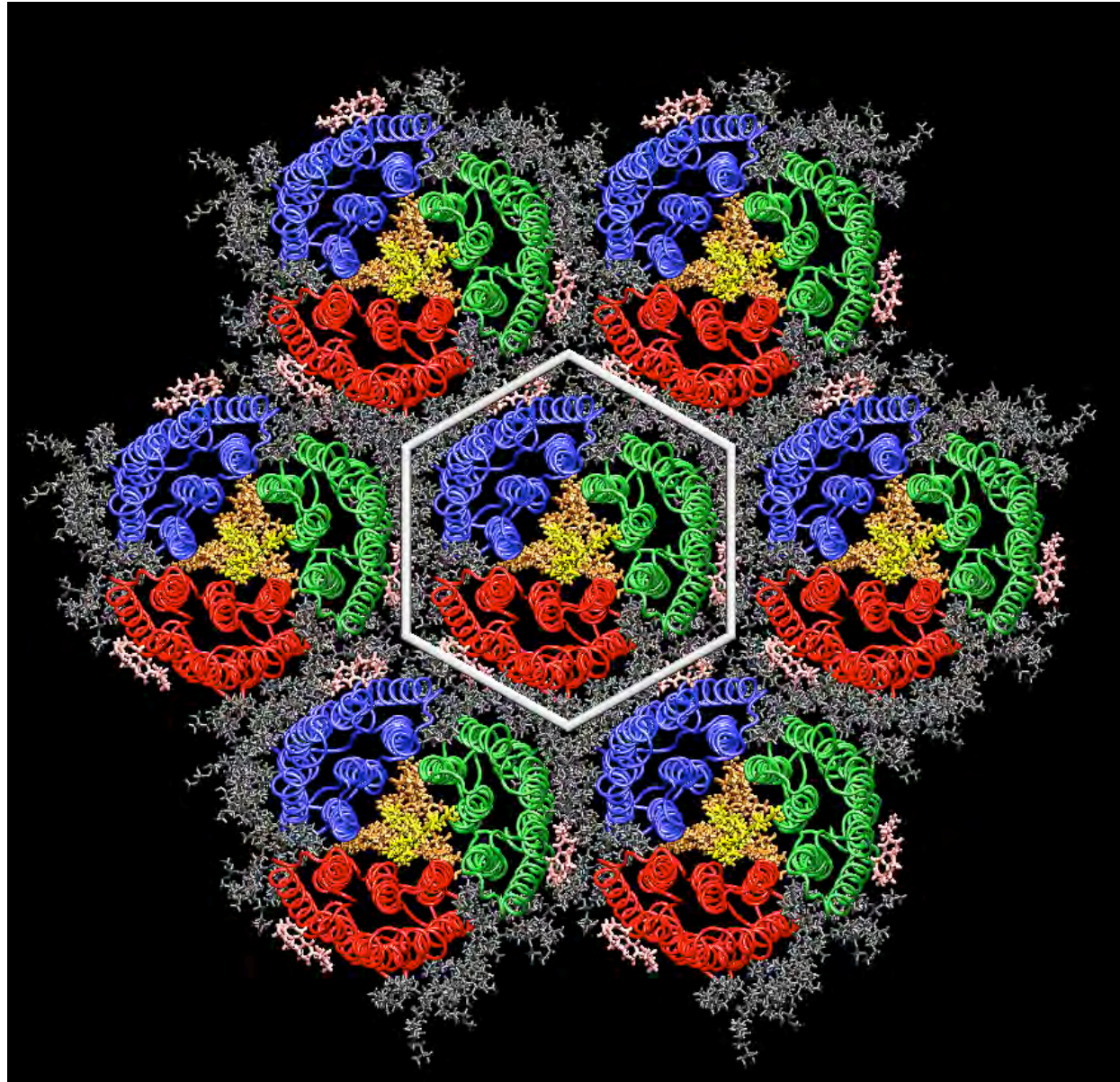- Pure lipid: insulation (neuronal cells)
- Other membranes: on average 50%
- Energy transduction membranes (75%)
  Membranes of mitocondria and chloroplast
  Purple membrane of halobacteria

- Different functions = different protein composition

Protein / Lipid Composition
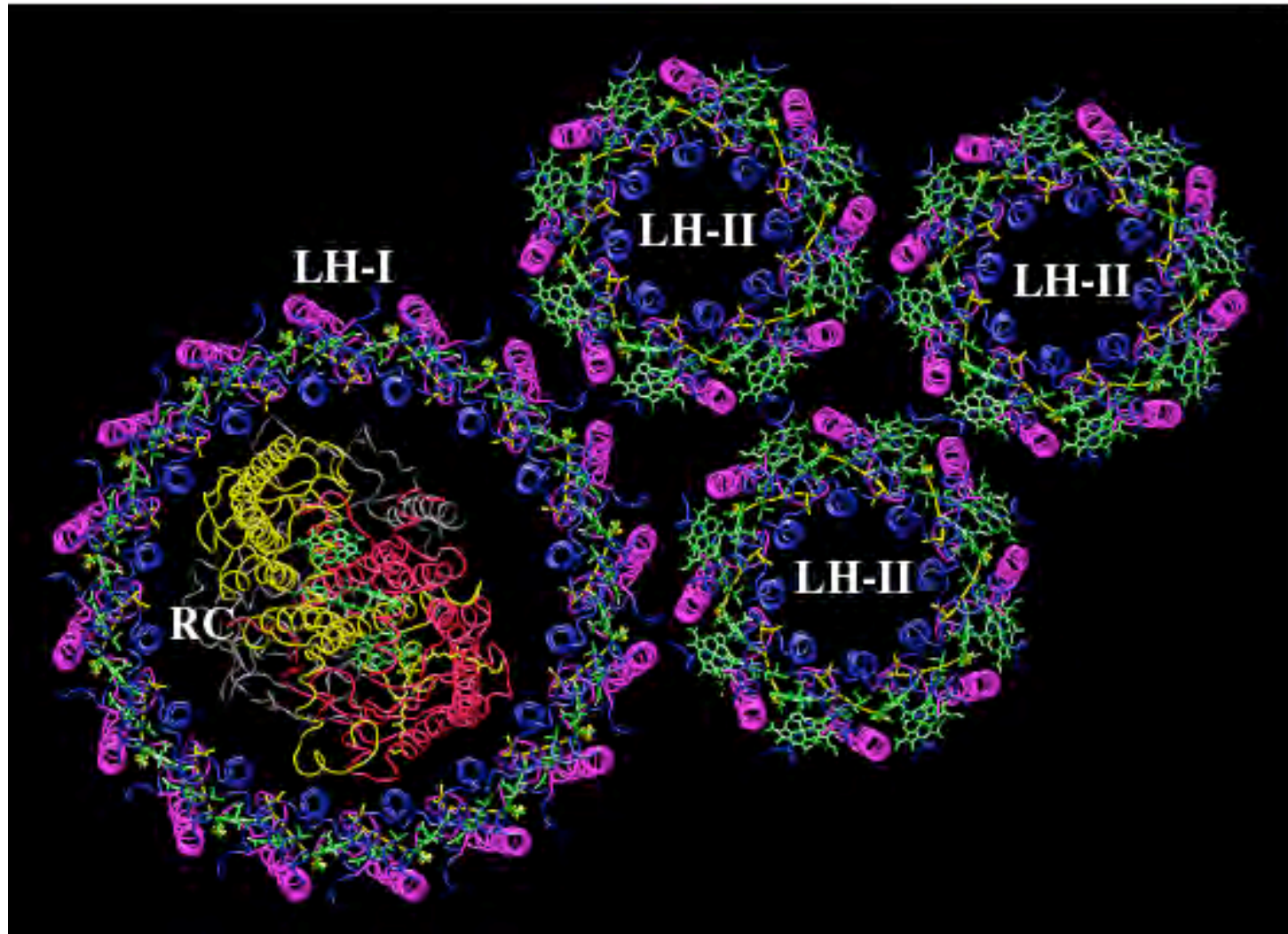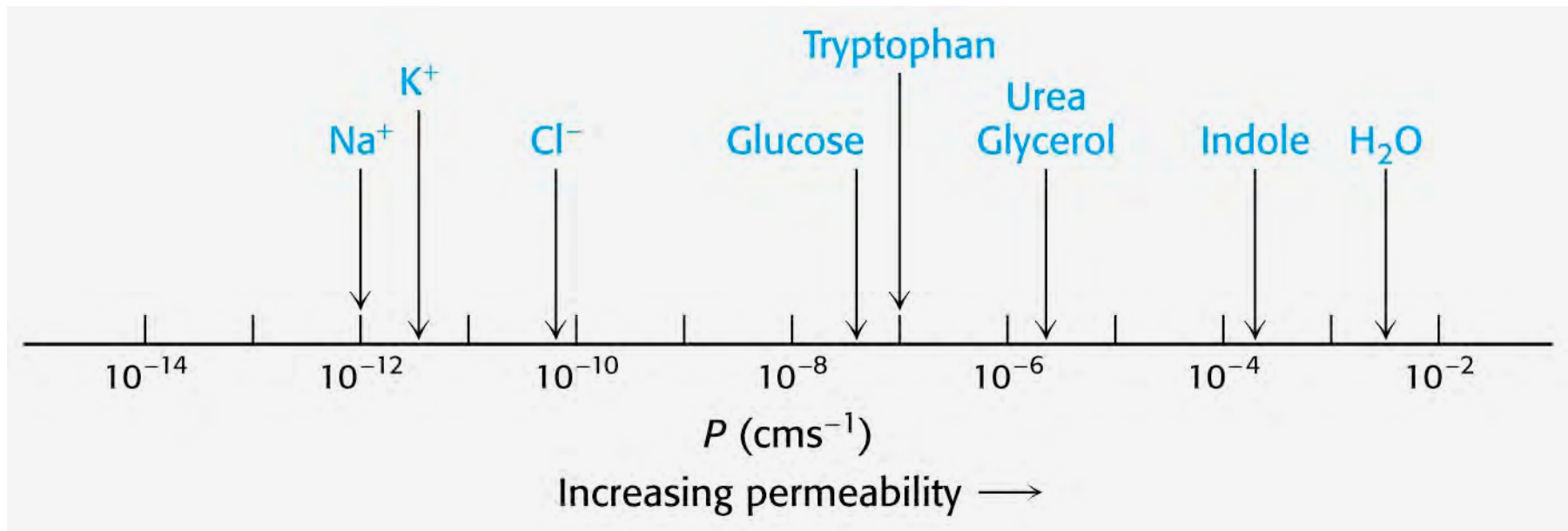

Light harvesting complex of purple bacteria

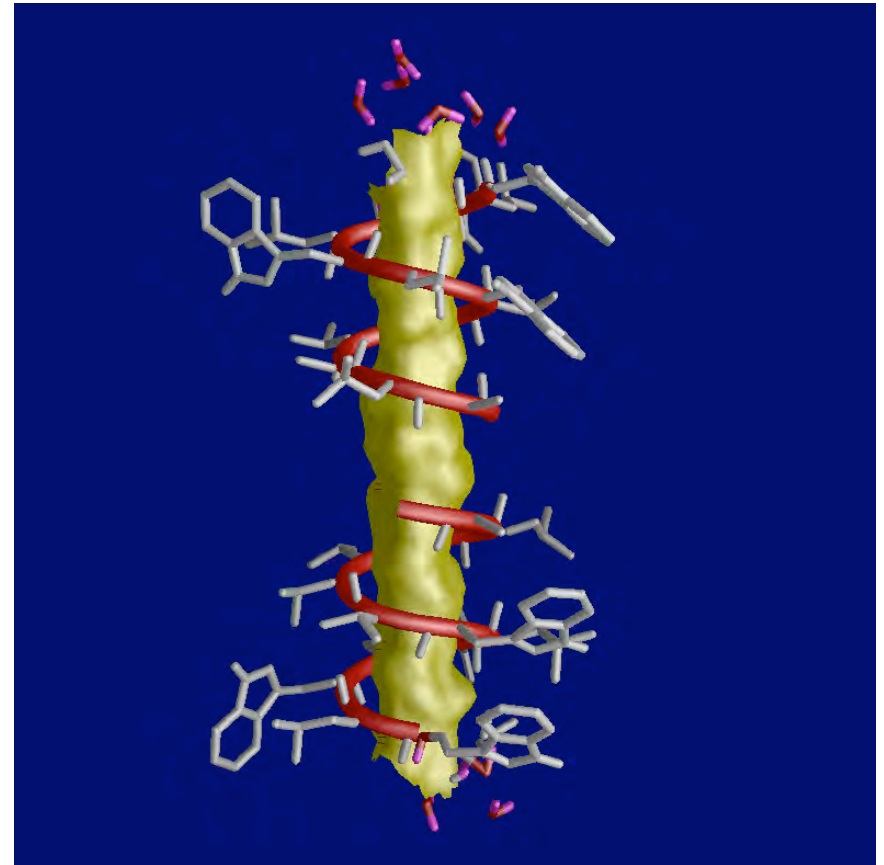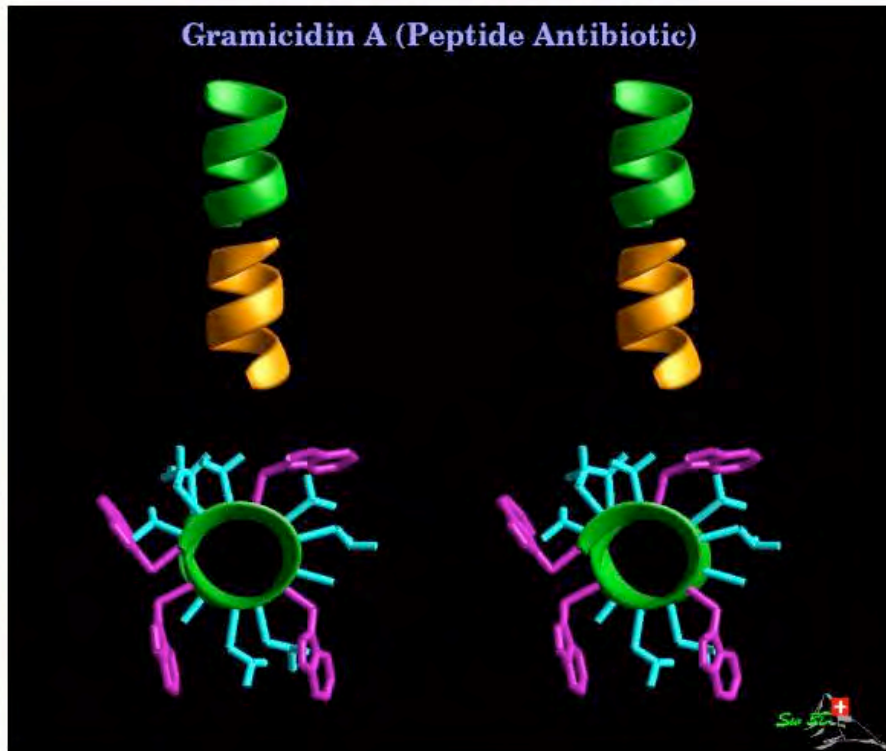# Protein / Lipid Composition

The **purple membrane** of halobacteria

Bilayer Permeability

- Low permeability to charged and polar substances
- Water is an exception: small size, lack of charge, and its high concentration
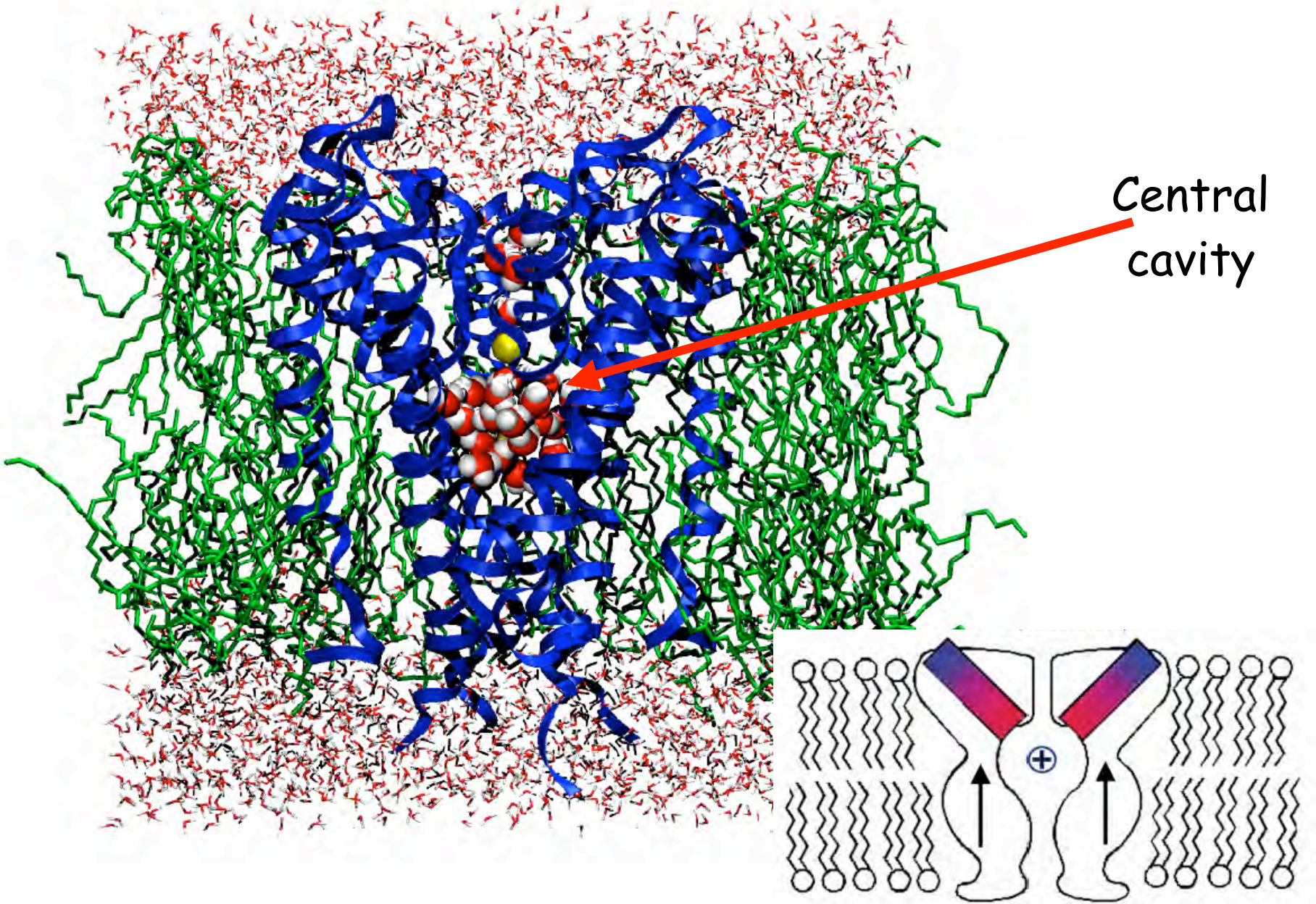- Desolvation of ions is very costly.

Gramicidin A
an ion leak inside the membrane

Through dissipating the electrochecmical potential of membrane, gramicidin A acts as an antibiotic.

Central cavity

K binding sites in the selectivity filter