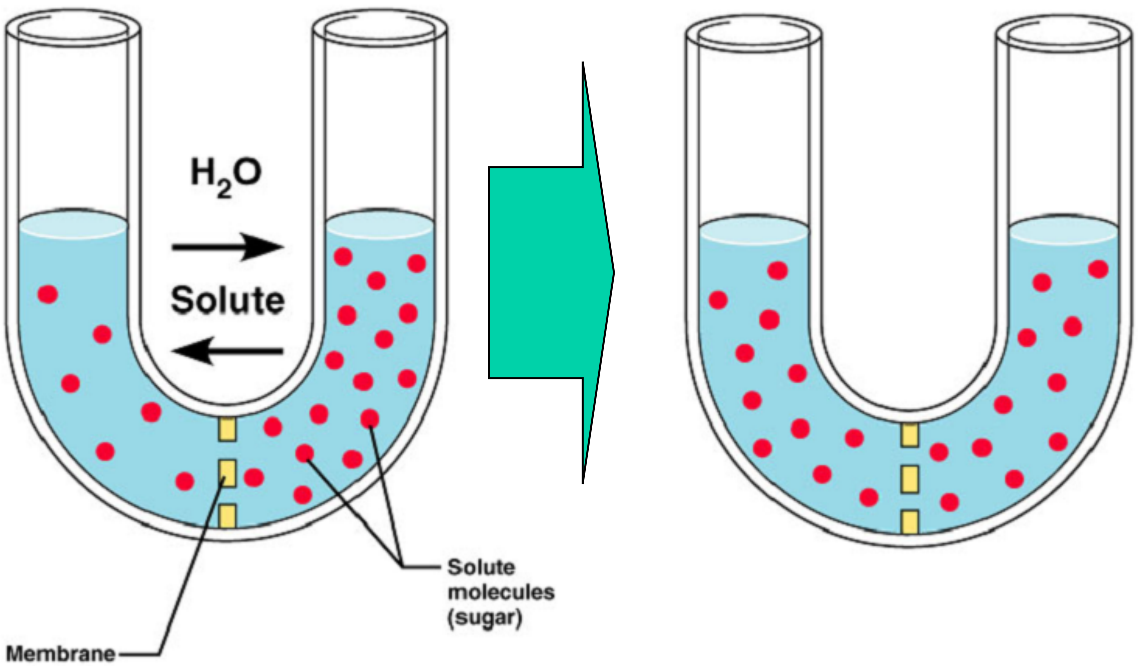
Osmosis


Osmosis
+PÜR MEDICAL SKINCARE
hydralift
firming gel mask
30 mL

Osmosis can be thought of as the driving force for particle motions along a gradient.

This is an entropic „force" that tends to make the concentration uniform in any region of space.



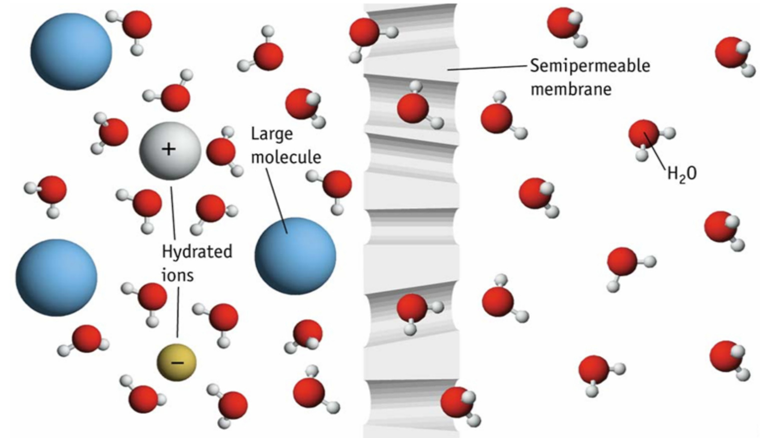
Membrane permeable to both solute molecules and water

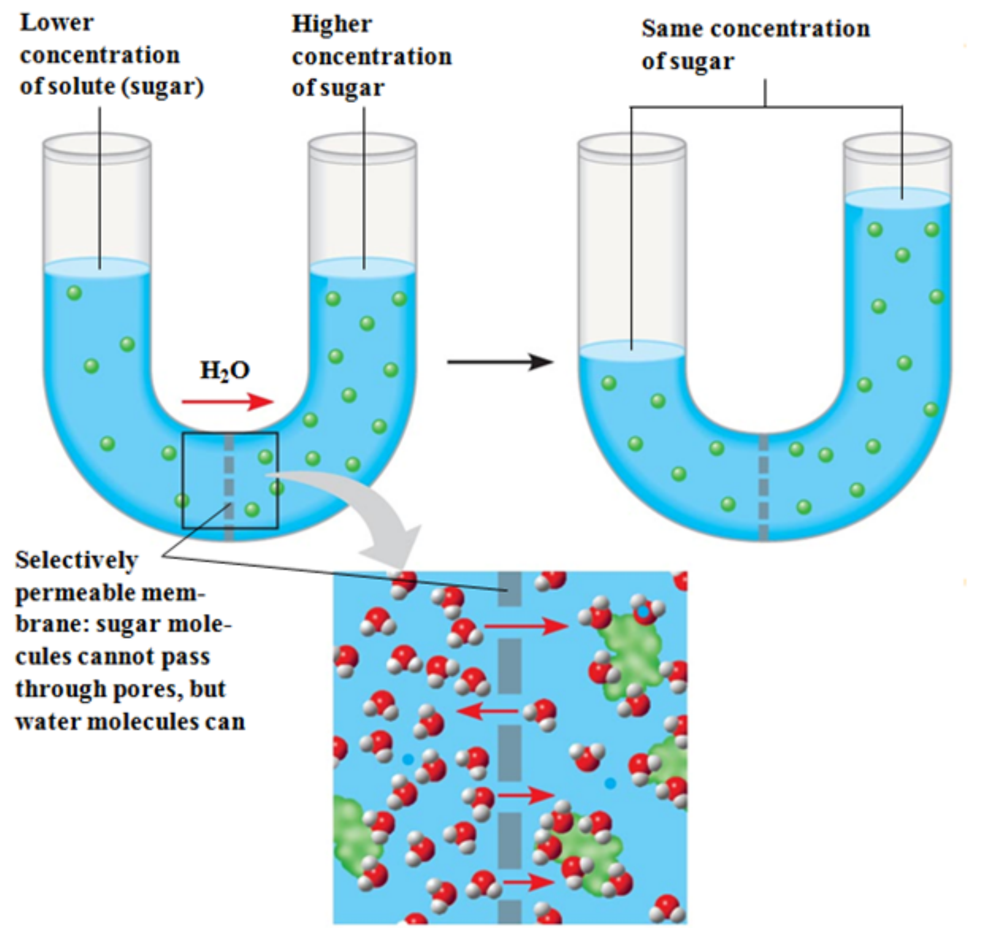
A semi-permeable membrane.

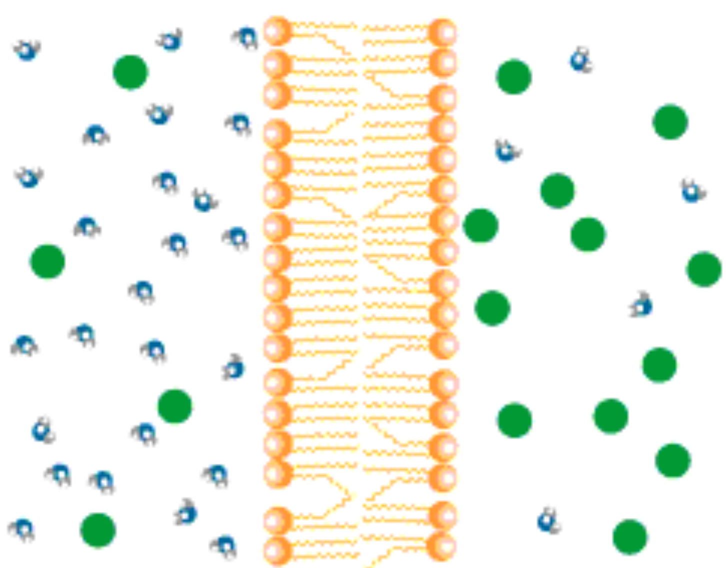
vant'Hoff's law (the osmotic pressure)

$$\Pi = \Delta P = \frac{RT}{V_w} C_s V_w = RTC_s$$

Osmotic pressure: force required to <u>prevent</u> osmosis.







Osmotically active = solutes which can't diffuse through the semipermeable membrane.

Way to measure osmolality:

Each Osm (of any solute) lowers the freezing point of water by ~ 2º C

vant'Hoff's law
(the osmotic pressure)

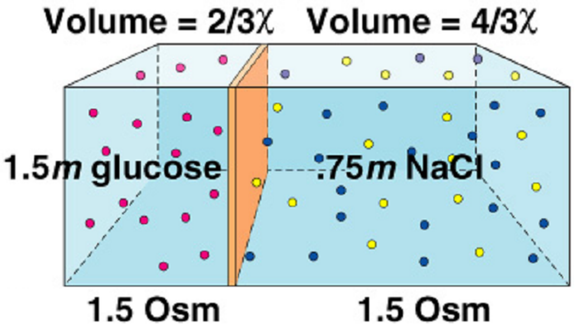
$$\Pi = \Delta P = \frac{RT}{V_w} C_s V_w = RTC_s$$

The osmolarity of a solution is equal to the molarity of the particles dissolved in it.

1. 10 mmoles/liter of glucose = 10 mosmoles/liter.

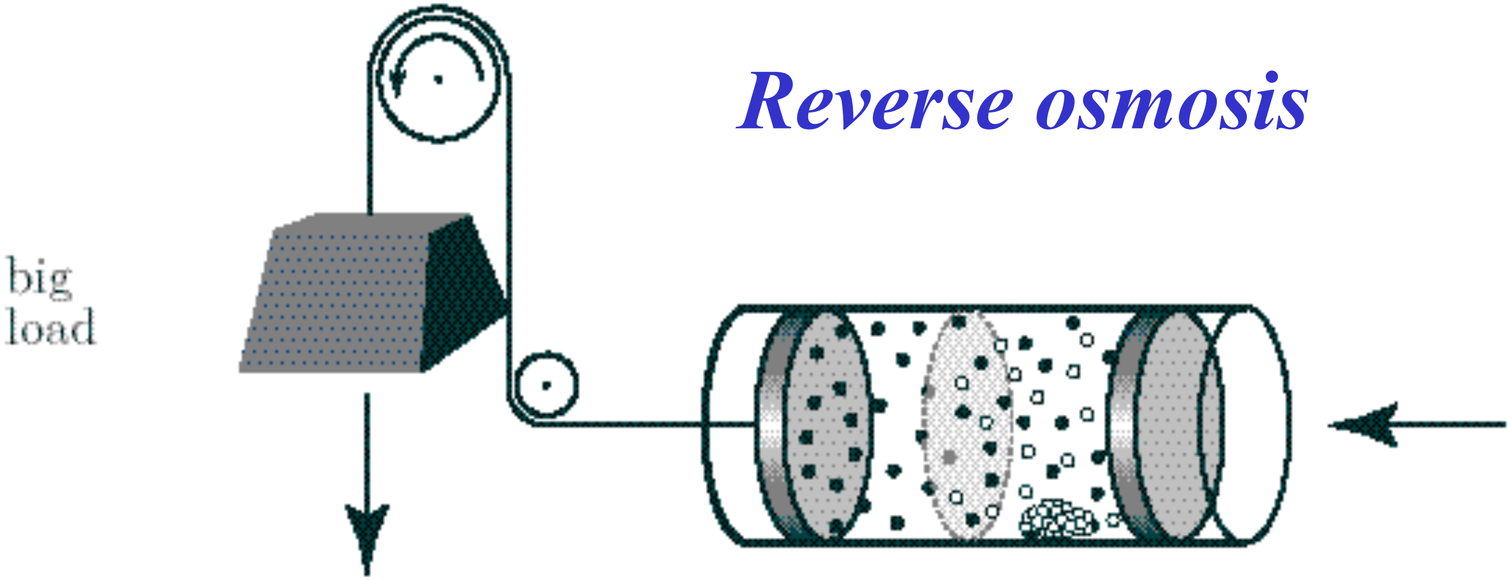
2. 10 mmoles/liter of NaCl = 20 mosmoles/liter.

3. 10 mmoles/liter of $CaCl_2$ = ???

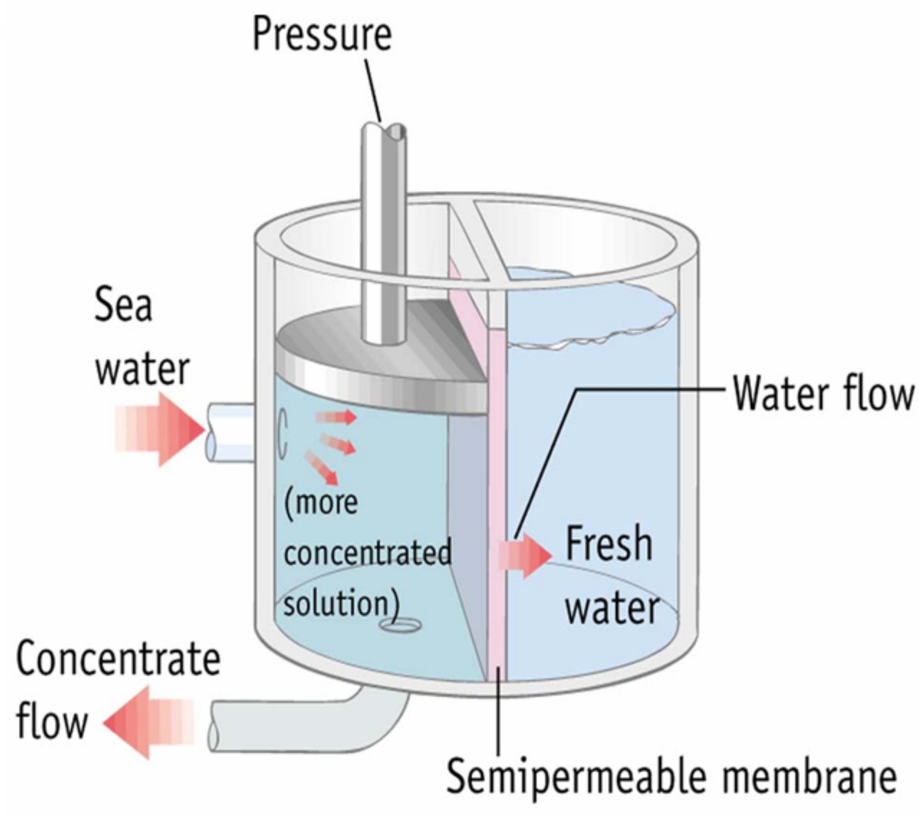


In a simple solutions the effect is additive.

Reverse osmosis

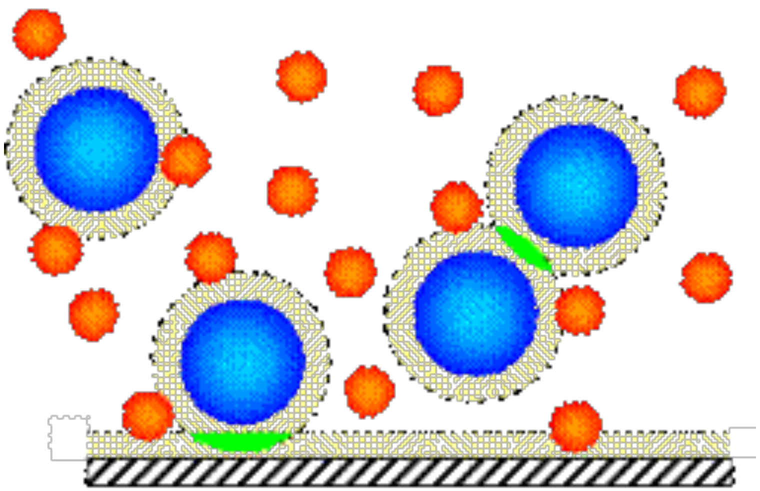


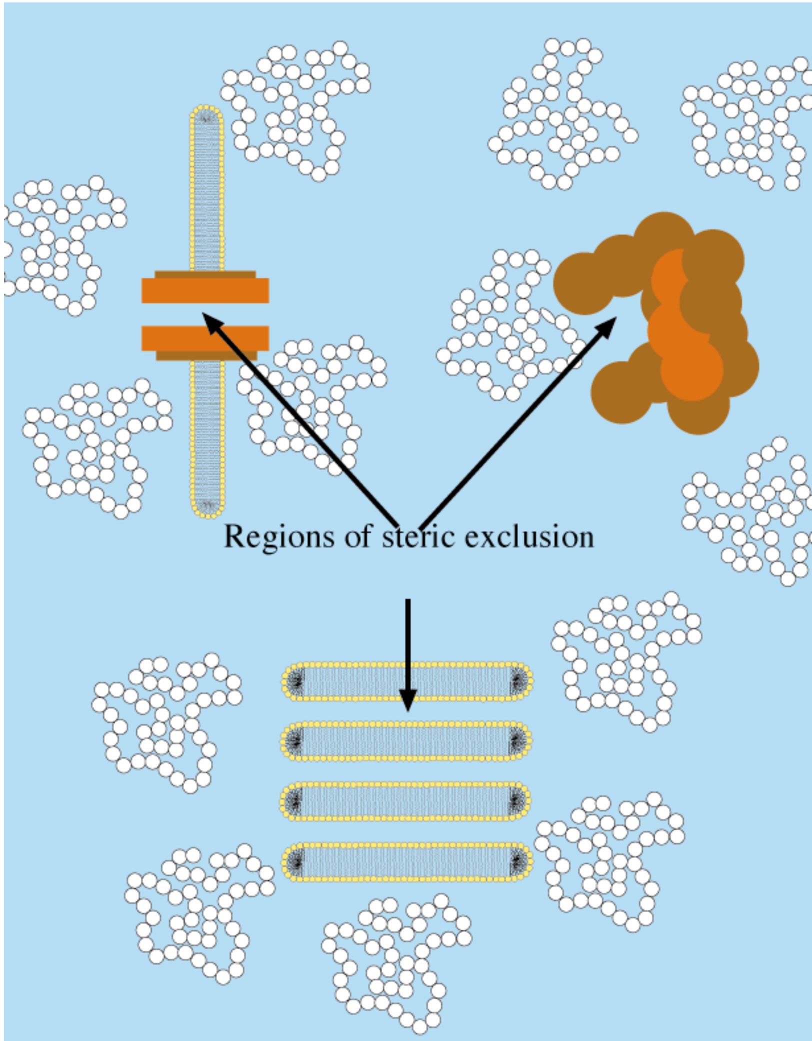
Reverse Osmosis is Used for Water Purification



Entropy driven aggregation

➢ Each of the large objects is surrounded by a depletion zone of thickness equal to the radius a of the small particles.



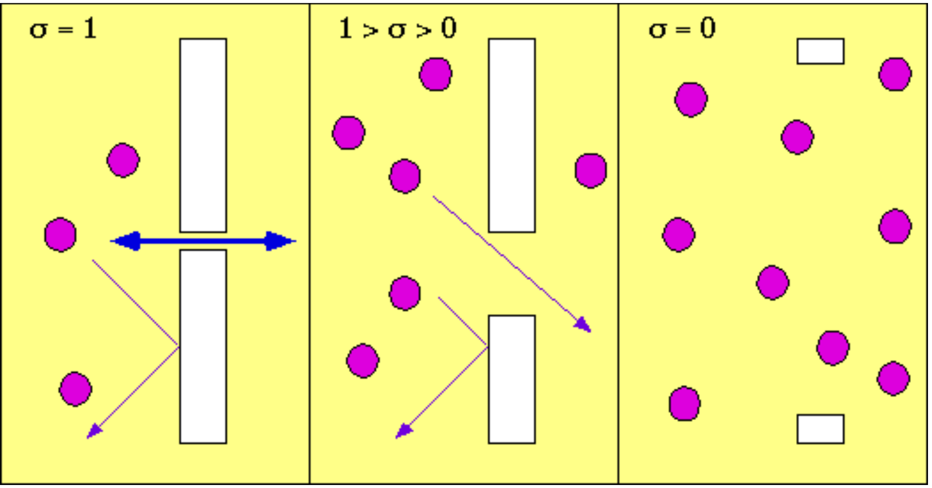


➢ The depletion zone reduces the volume available to the small particles – ***eliminating it would increase their entropy and hence lower their free energy***.

The osmotic pressure $$\Pi = gRTC$$

σ – selectivity/reflection coefficient

It is a measure of ***the probability of the molecule crossing the membrane***.



semipermeable membrane ***non-selective membrane***

The effective osmotic pressure depends on the reflection coefficient:

$$\Pi_{eff} = \sigma\Pi = \sigma gRTC$$

Bulk flow of water through barrier

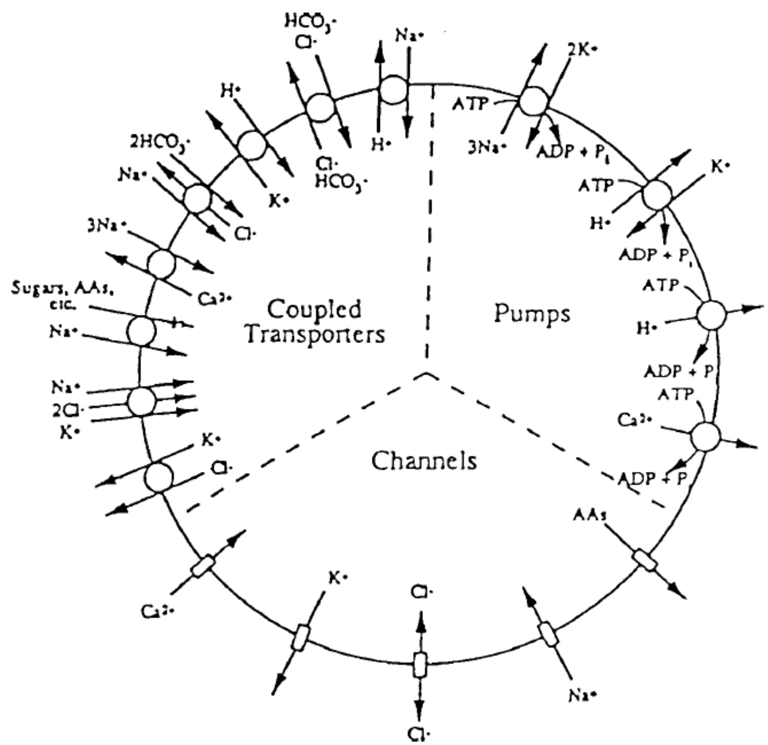
$$J_V = L_P\left(\Delta P - \sigma\Delta\Pi\right)$$

Important summary points about osmosis

1. The steady-state volume of the cell is determined by the concentrations of impermeant ions.

2. Permeant solutes redistribute according to the rules of electrodiffusion, and hence affect only the transient volume of the cell.

3. The more permeant the solute, the more transient its effects on volume.



The activation energy (E_a) required for water diffusion in an entirely aqueous environment – ***5 kcal/mol***.

The activation energy (E_a) required for water diffusion through the lipid bilayer – ***10-20 kcal/mol.***

Water Transport Across Cell Membrane

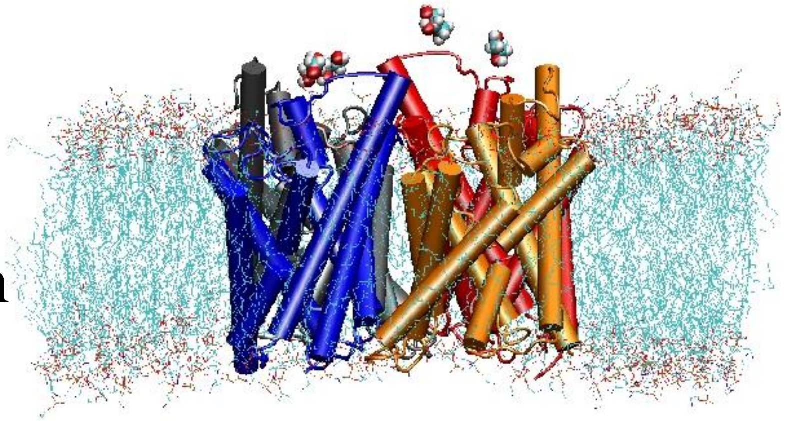
always passive; bidirectional; osmosis-driven

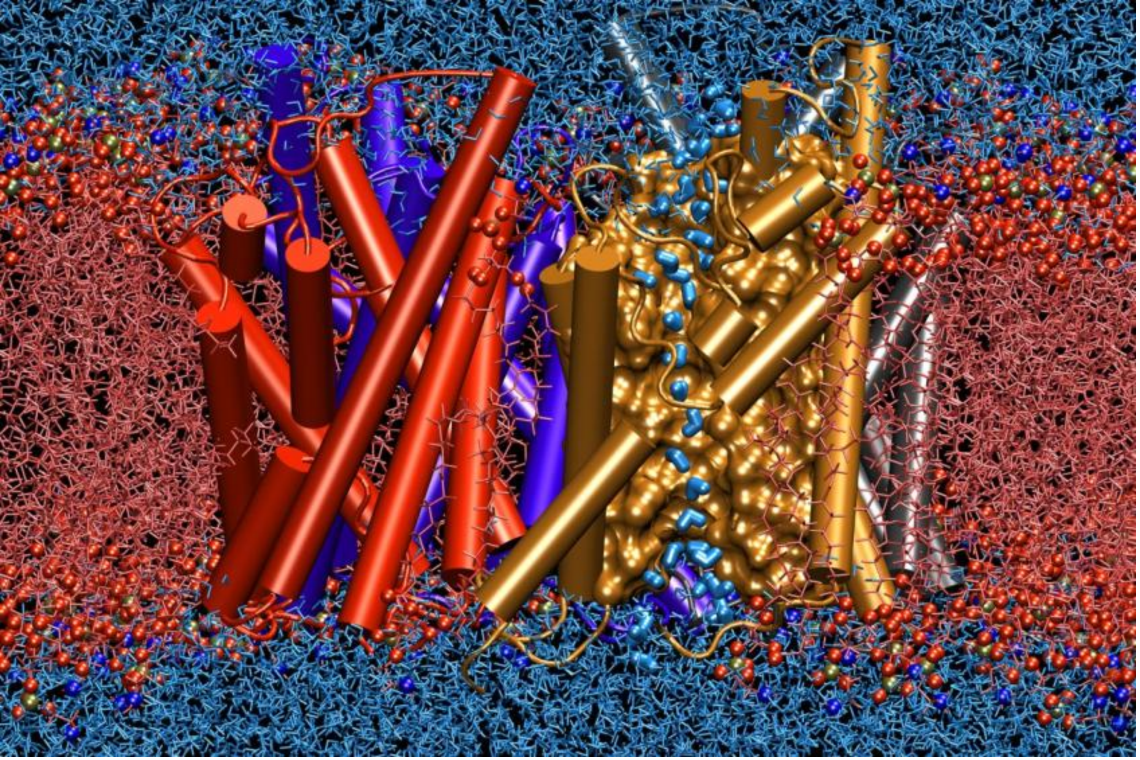
Diffusion through lipid bilayers

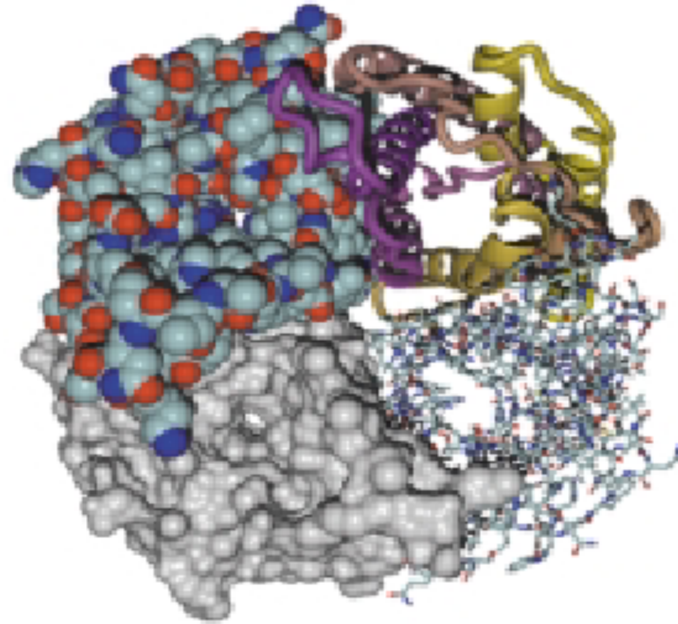
slow, but enough for many purposes

Channel-mediated

- Fast adjustment of water concentration is necessary (RBC, brain, lung).
- Large volumes of water needed to be transported (kidneys).

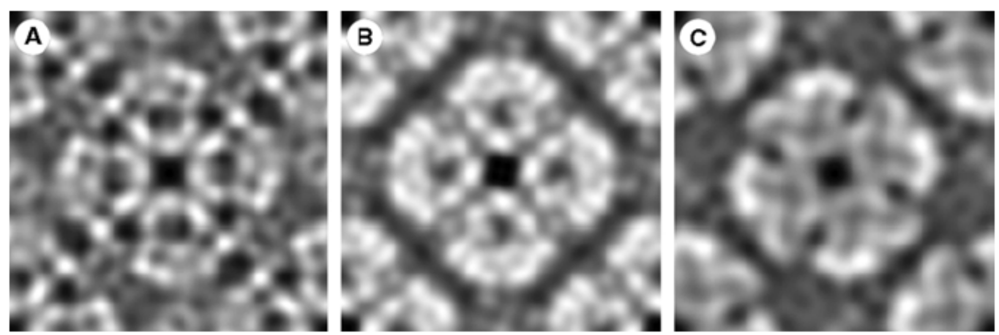






The AQP1 tetramer

Cryo-electron microscopy maps of water channel proteins (viewed from cytoplasmic side).

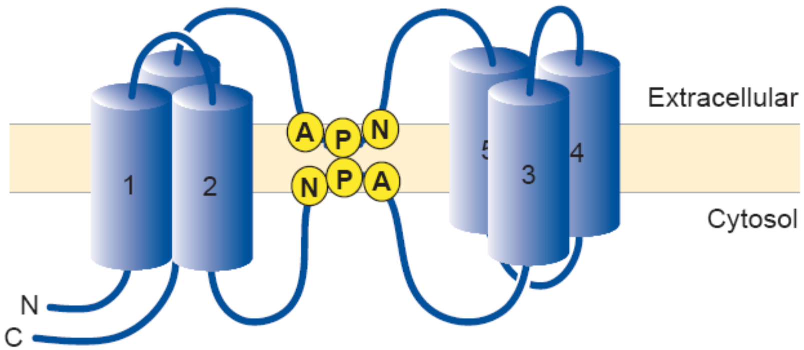


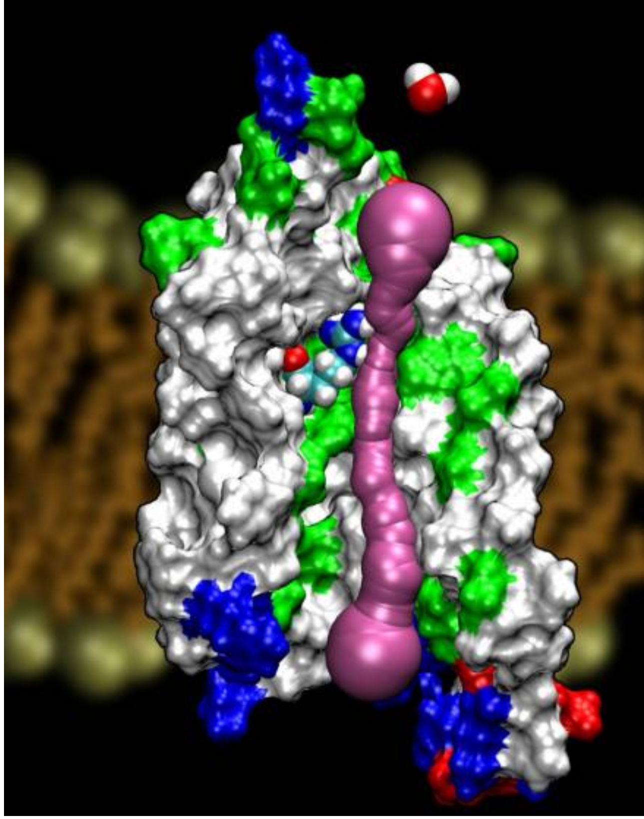
Red blood cell water channel AQP1

The lens fiber water channel MIP or AQP0

The bacterial water channel AqpZ

Topology of aquaporins

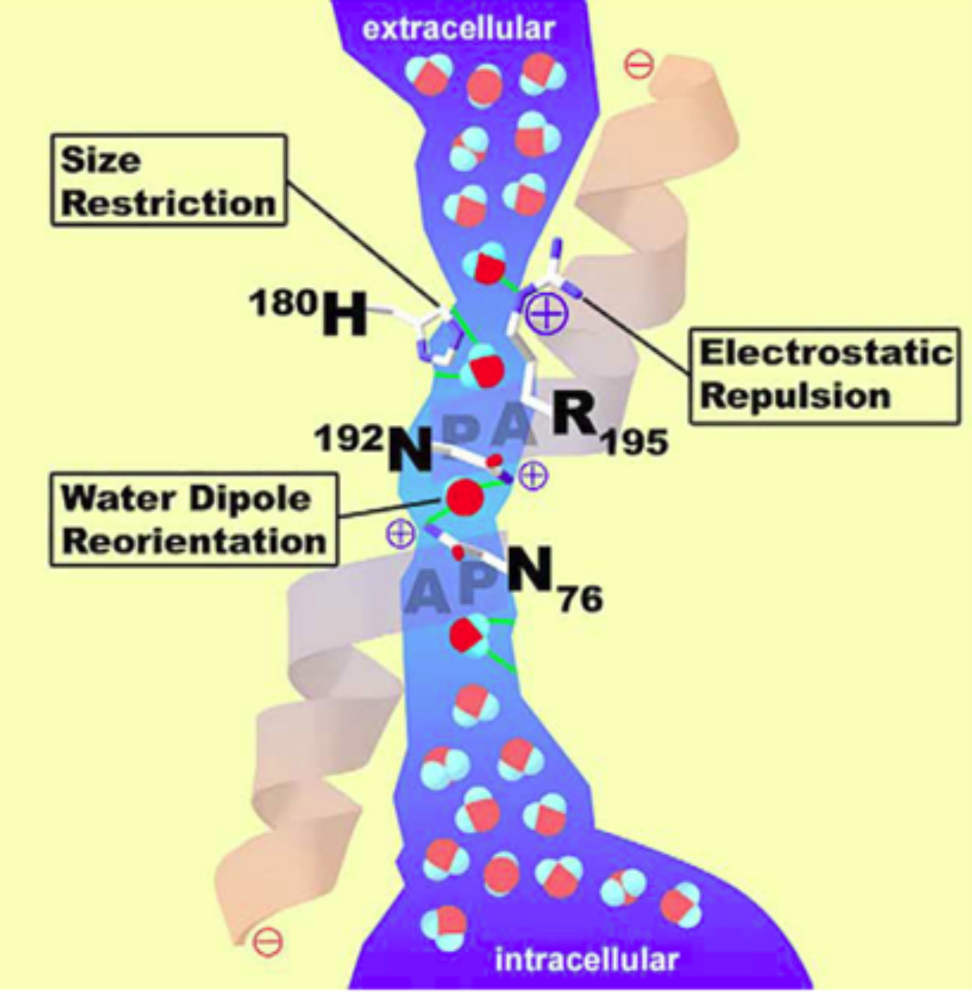




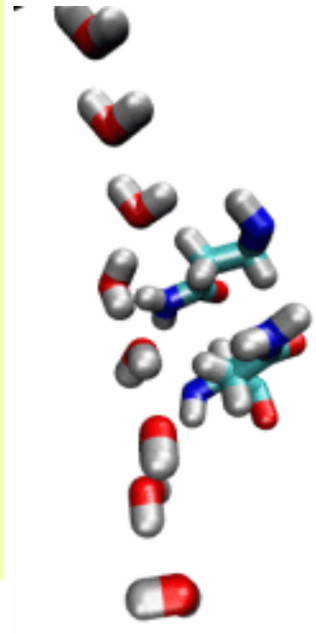
Six transmembrane domains and the conserved NPA-containing loops that form the selectivity filter of the water-conducting pore.

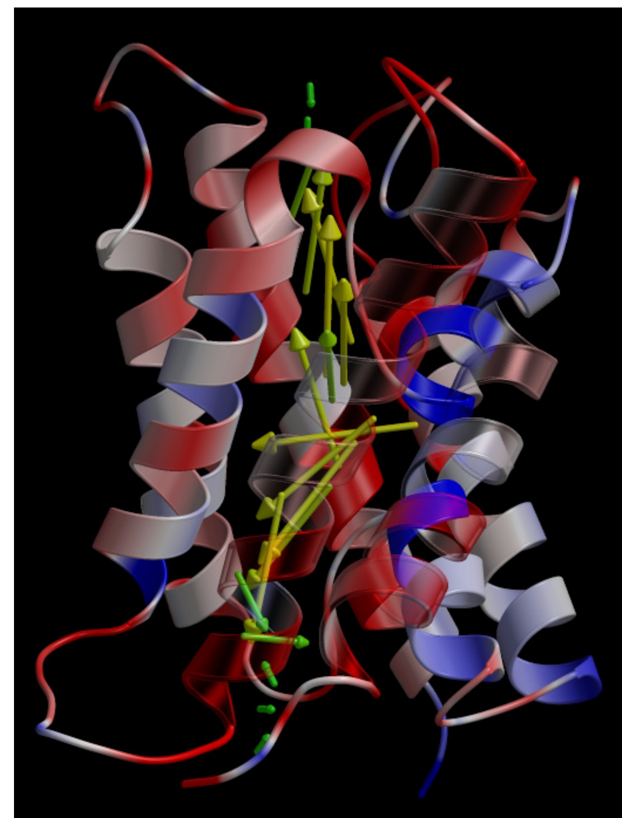
AQP1 comprises cone-shaped water-filled extracellular and intracellular vestibules that are separated by a 20 Å long channel ~2.8 Å at its narrowest point.

Hydrogen bonding between water molecules occurs within the AQP pore, except at its narrowest point.



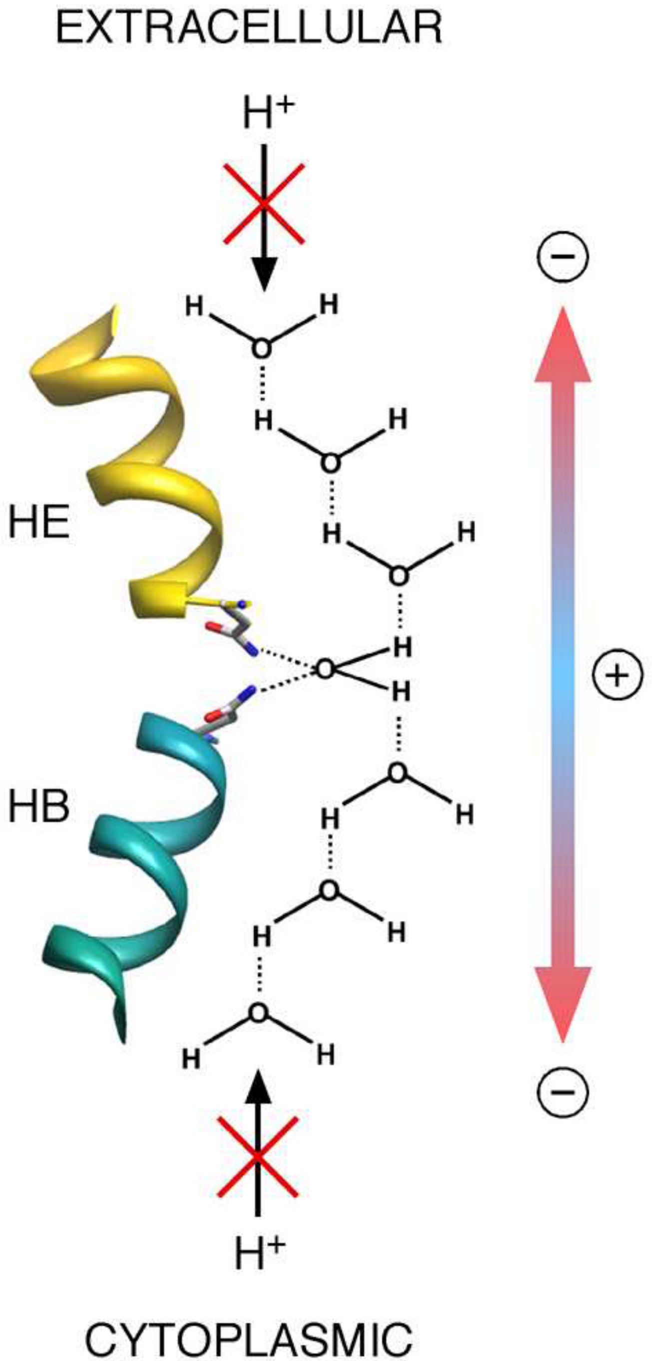
Water molecules rotate by about 180° during passage.





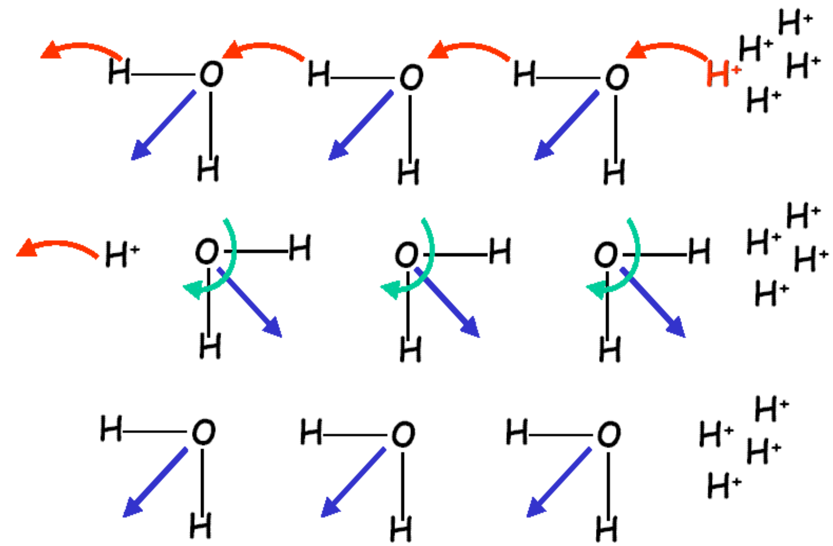
Water–water interactions are distorted with respect to bulk .

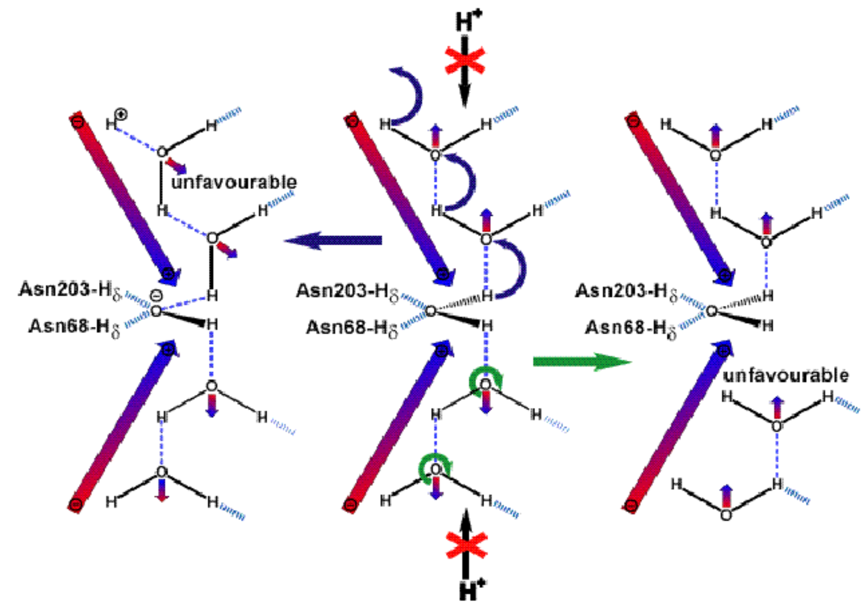
Peter Agre , David Kozono, FEBS Letters 555 (2003) 72-78



Impermeability for protons

Proton transfer in bulk water





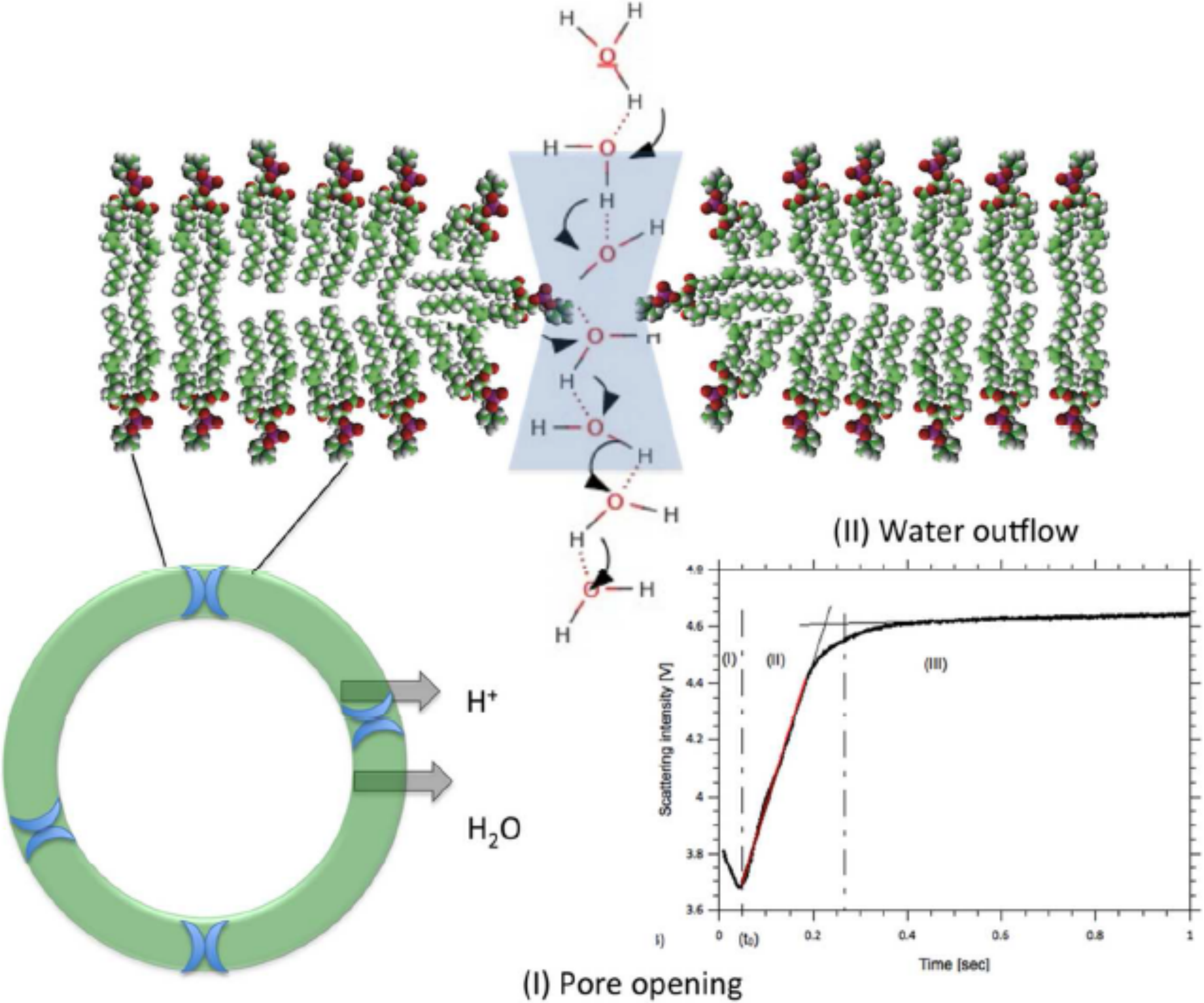
Physiology and pathophysiology of cell volume change

- ***Physiology: all cells are exposed to isosmotic volume perturbations***

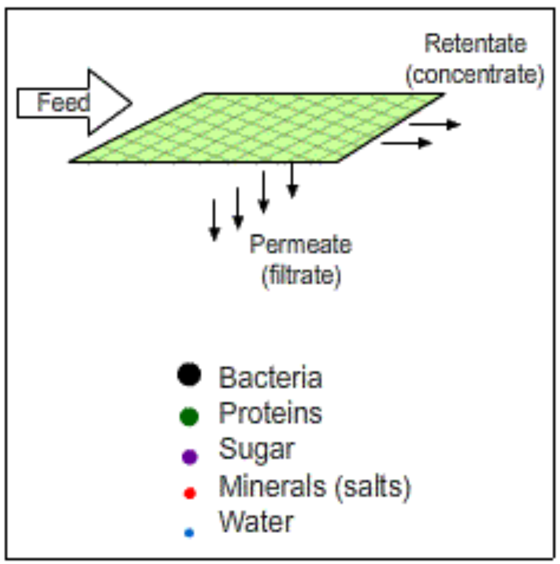
- ***Physiology: organisms and cells that live in osmotically unstable environments***

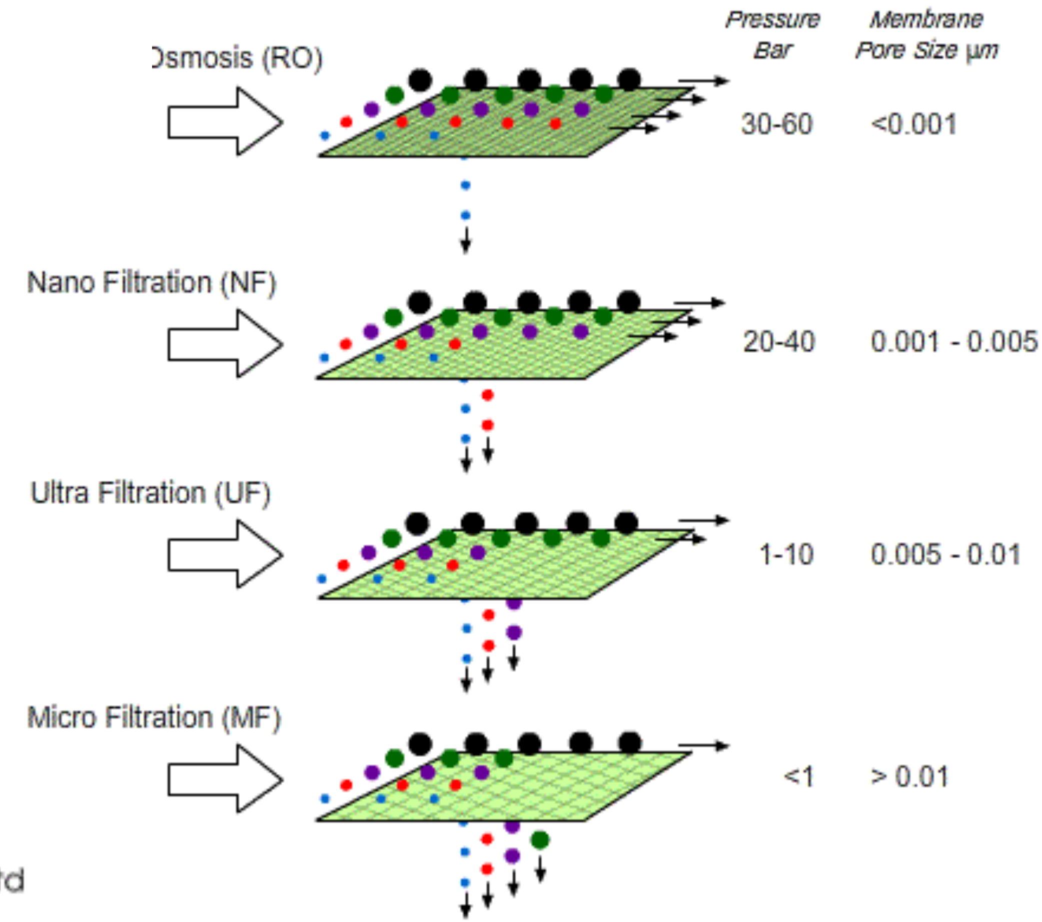
    >intertidal zone
    >gut
    >kidney

- ***Pathophysiology: e.g., systemic osmolality disturbances, anoxia and ischemia, reperfusion injury, diabetes, sickle cell crisis***



H+
H2O
(II) Water outflow
Scattering intensity [V]
3.6
3.8
4
4.2
4.4
4.6
4.8
(I)
(II)
(III)
0
(t0)
0.2
0.4
0.6
0.8
1
Time [sec]
(I) Pore opening





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