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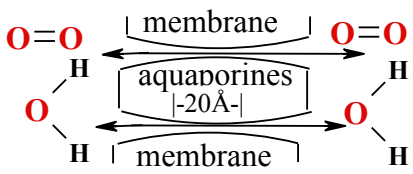
The Water channels, allow the passive but **selective** movement of **Water** and O_2,**NO**,**CO** across **cell wall** and **subcellular membrane**s like as mitochondria, endoplasmic reticulum, peroxisomes, Golgi, lysosomes.... .
Aquaporins have been classified into **two** sub-families:
I) strict **Aquaporins** that only allow the passage of **Water**, O_2, **NO**, **CO** and II) the less **selective** **aquaglyceroporin**s that **trans**port **Water** and other neutral **solute**s , such as **Glycerol**, CO_2 or **urea**.

Recently, the identification and characterization of a number of archaeal and bacterial **Aquaporins** suggested the existence of a **third** sub-family; one that is neither a strict **Aquaporin** nor an **aquaglyceroporin**. The function and phylogeny of this **third** family is still a matter of debate.

Water channels H_2O common O_2, NO, CO: an overview

AQP0	+ Cl^-, NO_3^- **eye-lens** cells; thin **junction**s between **fiber** cells **AQP0** with a measured **Water** permeability 15-fold lower than that of **AQP1** at **pH 6.5**; **AQP0** is reduced a further three fold at **pH 7.5** **AQP0** induce a gating effect **close** conformations of extracellular **loop** A **Met176**,**His40** **AQP0** becomes more **constrained** near the **conserved Ar/R constriction** site
AQP1-	+ Cl^-, NO_3^-,Aqua**glycero**porins:**red blood** cell (RBC), apical & basolateral **membranes** of **epithelial** brain cell, **rodent brain cell** AQP1-null humans **kidney** proximal-tubule **water** reabsorption **gastrointestina**l tract **Water** absorption in the teleost **intestine** the ovary and in the oocyte ; salivary gland ;
AQP2	urinary bladder granular **kidney** cells & subcellular vasopressin regulated urine concentration (25% of the **blood** filtrate) **trans** located from the cytoplasmic pool to the apical plasma **membrane** of the granular cells of the pelvic patch and urinary bladder
AQP3	+Aqua **glycero** porins, urea: **gastrointestina**l tract **Water** absorption**; rodent brain cell** astrocyte end-feet **Water** enters in the principal cell through **AQP**2 and exits through located in the basolateral **membrane**s trachea basal **AQP**3 & ciliated columnar **AQP**4 cells
AQP4	**Rodent**-brain;basolateral **membrane** of ciliated columnar cells alveolar epithelium;salivary gland
AQP5	stomach, duodenum, pancreas, airways, lungs, salivary gland, sweat glands, eyes, lacrimal glands, and the inner ear tears & pulmonary sub mucosal glands secretions apical **membrane& rodent brain** cells
AQP6	+ Cl^- , NO_3^- multi permeable **channel;lens** cells; may play a **role** in the body acid–base **homeostasis** in the intracellular vesicles of acid-secreting intercalated cells of the RCD colocalized with the H^+-ATPase be Hg^{2+}-inhibit able **Water channel** function is activated by Hg^{2+} and low **pH**
AQP7	+ Aqua**glycero**porins, urea; **kidney** proximal tubule **epithelium** cell **glycerol** reabsorption ; together with **AQP**1 in the brush border in the concentration of urine taking place in the proximal nephron 75% of the **blood** filtrate which is 150–180 L per day
AQP8	NH_4^+;**lens** & **kidney** intracellular proximal tubule & small **intestine** absorptive:**epithelium** cell in the concentration of urine taking place in the proximal nephron also in mitochondria 75% of the **blood** filtrate which is 150–180 L per day & **rodent brain cell**
AQP9	+Aqua**glycero**porins, urea purines, pyrimidines & monocarboxylates, arsenite ; apical **membrane** of brain & small **intestine** absorptive epithelial & rodent **brain** & glial cells
AQP10	+ Aqua**glycero**porins, urea ; small **intestine** absorptive epithelial cells
AQP11	"super **aquaporins**" or sub cellular; **kidney** cytoplasm of the proximal tubule & **rodent brain** cells
AQP12	"super **aquaporins**" or sub cellular



bilipid membrane cross size **55Å**

H_2O Channel is roughly **20-Å long** and has a diameter **1.1 Å**. **Water channel** proteins (**WCPSs**) are **trans membrane** proteins that have a specific three-dimensional structure with a **pore** the **SF radius 1.1** *Å* is close average **to radius** of **water H–O–H** longitudinal **1.4** Å and **0.55 Å** bent size of dipole.
It can be permeated by **Water** & O_2, **NO**, **CO** molecules as solutes.
Aquaporins are large families (over 450 members) that are present in all kingdoms of life. **Water** permeability, allowing permeation of **3×10^9 water** molecules per **monomer** per second **AQP**1 and other, which strictly prevents the conduction of protons H^+.

Serine, Tyrosine, Threonine Phosphorylation to trigger the **me**mbrane **traffic**king of **AQP**1, **AQP**2, **AQP**5, and **AQP**8, and the gating of **AQP**4.
Cation conductance has been induced in **AQP**1 by activation of cyclic **GMP**–dependent pathways and was blocked by Hg^{2+}

Red blood cells against **colligative osmomolar concentration in water** solutions

Water and oxygen osmosis against osmo molar concentration gradient crosses cell membranes

Osmosis is organised for **H_2O** and **O_2** movement against concentration gradients-difference of colligative properties $\Delta C_{osm} = i\Delta C_M$ through an **Aquaporins** across cell **membranes** to form the osmotic pressure:

$$\pi = i\Delta C_M RT \text{ (kPa)},$$

where R=8,3144 J/(mol•K) universal gas constant,
T temperature in Kelvin's degree (K) T=t°+273.15 (if t=37° than T=37°+273.15=310.15 K).

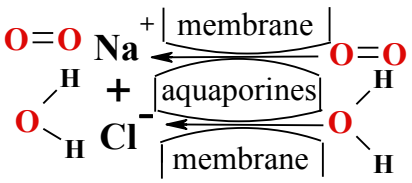
Note: Transfer **water** and oxygen molecules through membrane aquaporin tunnel in erythrocytes with rate $3 \cdot 10^9$ sec^{-1} in both directions transfer 3000 oxygen molecules in one second.

Mechanism of osmosis through membrane aquaporins drive colligative concentration gradient

Na^+Cl^- => $Na^+ + Cl^-$ m=2 electrolyte dissociation **α=1** the concentration gradient doubled as **i** is 2
$i=1+\alpha(m-1)$=1+1(2-1)=2; $i\Delta C_M = 2\Delta C_M = \Delta C_{osm}$ and pressure on membrane is $\pi = 2\Delta C_M RT = \Delta C_{osm} RT$.

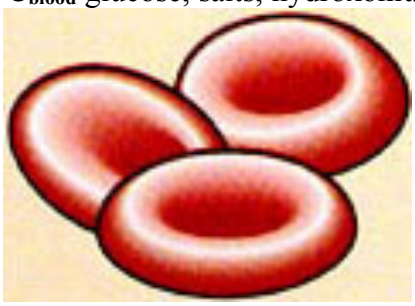
Press => on membrane to right.

Water H_2O, **O_2** oxygen flow left side against the concentration gradient from 0 to C_{osm}=0.305 M because **Na^+Cl^-** ions make osmo molar concentration left side $C_{left} - C_{right} = C_{osm} - 0 = C_{osm} = iC_M$ and close **H_2O**, **O_2** flow to right side.

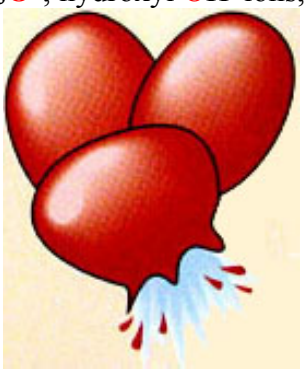


$C_{blood} = C_{osm} = i_1C_1 + i_2C_2 + i_3C_3 + ... = \Sigma i_k C_k = 0{,}305$ M

Human erythrocytes red blood cells with osmo molar concentration 0.305 M of all solutes sum $\Sigma i_k C_k$: C_{blood} glucose, salts, hydroxonium **H_3O^+**, hydroxyl OH^- ions, amino acids, proteins, bicarbonate etc.

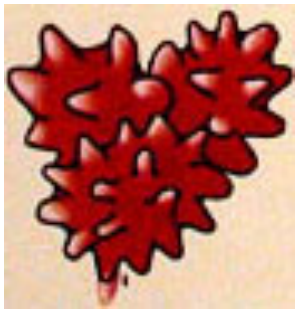


Isotonic medium
C_{blood}= 0.305 M



Hypotonic medium distilled water 0 M or at least osmo molar concentration **$C_{Hypoton}$**<=0,2 M.

Hypotonic **water** medium the flow is greater towards the cell against the concentration gradient-difference 0.305 - 0,2=0,105 M and the cell puffs up until its membrane is broken but content leak in plasma.



Hypertonic solution
$C_{Hyperton}$ >= 0,4 M .
Hypertonic salt solutions to apply foe purulent wounds, because pumps **water** toxic compounds out and stimulates **blood** circulation.

Osmosis **H_2O** and **O_2** against concentration gradient through alveolar epithelial membrane

A) Oxygens **O_2** from **AIR** 20.95% **O_2**↑gas assimilation reaction dissolution in water to form O_{2aqua} exothermic ΔH_r=-55,7 $^{kJ}/_{mol}$ and exoergic ΔG_r= -27,7 $^{kJ}/_{mol}$ as water soluble oxygen :

1) $O_{2AIR} + H_2O \Leftrightarrow H_2O + O_{2aqua} + Q + \Delta G$. Penetrate in Human body through aquaporins by concentration gradient from $[O_2] = 9{,}768 \cdot 10^{-5}$ M to venous blood $[O_{2aqua}] = 0{,}426 \cdot 10^{-5}$ M.

2) $\Delta GO_2 = RT\ln([O_{2Blood}]/[O_{2aqua}]) = -4{,}29$ $^{kJ}/_{mol}$ exoergic entrance human organism;

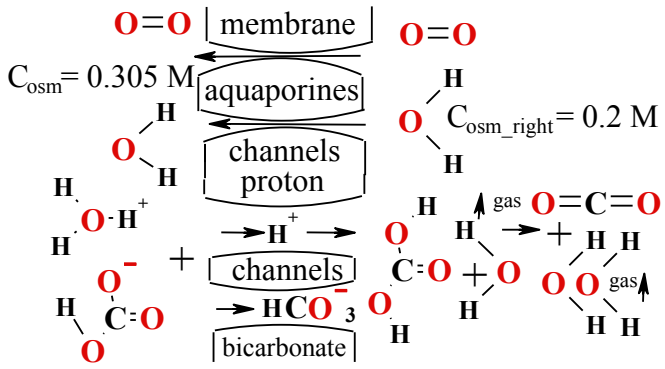
3) $O_{2aqua} + H_2O \xrightarrow{Aquaporins} H_2O + O_{2aqua} + \Delta G$ against concentration gradient 0,305 M / 0,2 M:

$\Delta GH_2O = RT\mathbf{ln}([H_2O]_{right}/[H_2O]_{left}) = -8{,}3144 * 310{,}15 * \mathbf{ln}(0{,}305/0{,}2) = -1.088$ $^{kJ}/_{mol}$

exoergic ΔG **O_{2+}**= -5,379$^{kJ}/_{mol}$. **Deoxy** hemoglobin **Hb_T** adsorbs 4 O_{2aqua} from blood plasma of inspired fresh AIR releases four protons $4H^+$ and 4 **HCO_3^-** stabilizing arterial $[O_2] = 6 \cdot 10^{-5}$ M concentration **$4O_{2aqua}$** + $(H^+His63{,}58)_4Hb_T \Leftrightarrow Hb_R(O_2)_4 + 4H^+$.

Total exothermic ΔH_r= -55,7 $^{kJ}/_{mol}$ and exoergic ΔGO_2= -27.7+ - 4.29+ -1.088 = -33.078 $^{kJ}/_{mol}$

Osmosis is **water** and oxygen flow left side against gradient of concentration 0.2 M to C_{osm}=0.305 M because water and oxygen flow to right side closed by made left side osmo molar $C_{left}-C_{right}=C_{osm}-C_{osm\_right}=\Delta C_{osm}$ concentration as difference ΔC_{osm}=0.105 M. $C_{osm}=i_1C_1+i_2C_2+i_3C_3+\ldots=\Sigma\, i_kC_k$=0,305 M; C_{osm_right}=0,2 M; ΔC_{osm}=0.305–0.2=0.105 M



Breath out H_2O , CO_2 in endothermic but exoergic reactions on alveolar epithelial surface

B)

$$Q_{aqua}+CO_{2aqua}+2H_2O\leftarrow^{CA}\rightarrow H_3O^+ + HCO_3^-\leftarrow^{Membrane}\rightarrow H_3O^+ + HCO_3^- \Leftrightarrow H_2O+H_2CO_3+Q_{gas}\leftrightarrow H_2O+CO_2\uparrow_{gas}+H_2O.$$

endothermic ΔH_r= 9.75 $^{kJ}/_{mol}$; athermic ΔH_r= 0 $^{kJ}/_{mol}$; exothermic ΔHr=-9.76 $^{kJ}/_{mol}$; endothermic ΔH_r=20.3 $^{kJ}/_{mol}$; endoergic ΔG_r=58.4 $^{kJ}/_{mol}$; exoergic ΔG_r=-22.5-1,96 $^{kJ}/_{mol}$; exoergic ΔGr=-58.2 $^{kJ}/_{mol}$; exoergic ΔG_r= -8,54 $^{kJ}/_{mol}$;

B) $$Q_{aqua}+CO_{2aqua}+2H_2O \leftarrow^{CA}\rightarrow H_3O^+ + HCO_3^- + Q\leftarrow^{Membrane}\rightarrow H_2O+CO_2\uparrow_{gas}+H_2O\uparrow_{gas}.$$

endothermicΔH_r=9.75 $^{kJ}/_{mol}$; endothermic ΔH_r=54,5 $^{kJ}/_{mol}$; summary endothermic ΔH_r=64,25 $^{kJ}/_{mol}$;

endoergic ΔG_r=58.4 $^{kJ}/_{mol}$; exoergic ΔG_r= -82,1 $^{kJ}/_{mol}$; summary exoergic ΔG_r= -23,7 $^{kJ}/_{mol}$;

Venous **deoxy Hb_T shuttle** adsorbs four **oxygen** $4O_{2Hb}$ molecules, create $4H^+$, promoting CO_2 breathe out as increase production of H^+ , HCO_3^- 473*6•10^{-5} M=0,0284 M=$[HCO_3^-]=[H^+]$ amounts shifts equilibrium to right $H^+ + HCO_3^- + Q\leftrightarrow H_2O+CO_2\uparrow_{gas}$ via membrane channels. So pH=7,36 remains constant, as bicarbonate ion and hydrogen ion produce CO_2 right side.

The epithelial cell surface of ***lungs*** has the specific building. S=950 nm x 950 nm= 0.9 μm^2 is surface area with super thin 0.6 nm **water** layer volume: 0.5415•10^{-3} μm^3 = 0.5415•10^{-18} L. Created acidity in thin **water** layer volume increases up to pH=5.5 if one proton H^+ crosses the membrane channels reaching the surface. Hydrogen ion concentration is: $[H_3O^+]=10^{-pH}=10^{-5.5}$ M. Respiration in ***lungs*** Hemoglobin released protons H^+ during oxygen adsorbtion for total amount concentration:

$[O_{2Hb}]=[H_3O^+]$=473*6•10^{-5} M= 0,0284 M forms hydrogen ion concentration gradient:

$[H_3O^+]_{right}/[H_3O^+]_{left}=10^{-5,5}/0{,}0284$, which drives exoergic ΔG = -22,5 $^{kJ}/_{mol}$ proton movement through epithelial cell membrane proton channels: $H_3O^+_{left}\leftarrow^{proton\_channel}\rightarrow H_3O^+_{right}+\Delta G$. General process $H_2O+CO_2\uparrow_{gas}+H_2O\uparrow_{gas}$ require heat supply endothermic ΔH=54,5 $^{kJ}/_{mol}$ to drive spontaneous

ΔG= -82,0679 kJ/mol products evaporation $CO_2\uparrow_{gas}$ and $H_2O\uparrow_{gas}$ keeping moisture H_2O on surface of membrane. Hydrogen ions water acidity shift endothermic ΔH_r= +54,5 $^{kJ}/_{mol}$ and exoergic ΔG_r= -82,1 $^{kJ}/_{mol}$ decomposition $H_3O^+ + HCO_3^-$ breath out to AIR $CO_2\uparrow_{gas}$ with $H_2O\uparrow_{gas}$:

$$H_3O^+ + HCO_3^- + Q\leftarrow^{Membrane}\rightarrow H_2O+CO_2\uparrow_{gas}+H_2O\uparrow_{gas} + \Delta G_r = -82{,}1\ ^{kJ}/_{mol}.$$ exoergic .

Aquaporins are wide class of **membrane crossing channel** proteins**, which** are **integrated** in all living organisms: **animals, plants, bacteria**. On Cell membranes effecting Physiology, Biochemistry and Health. **Aquaporins** are large families (over 450 members) that are present in all kingdoms of life.