7th October, 2025
Yerevan, Armenia

Role of *ion gradients* and redox potential during anaerobic and aerobic conditions in *E. coli* and *S. cerevisiae*

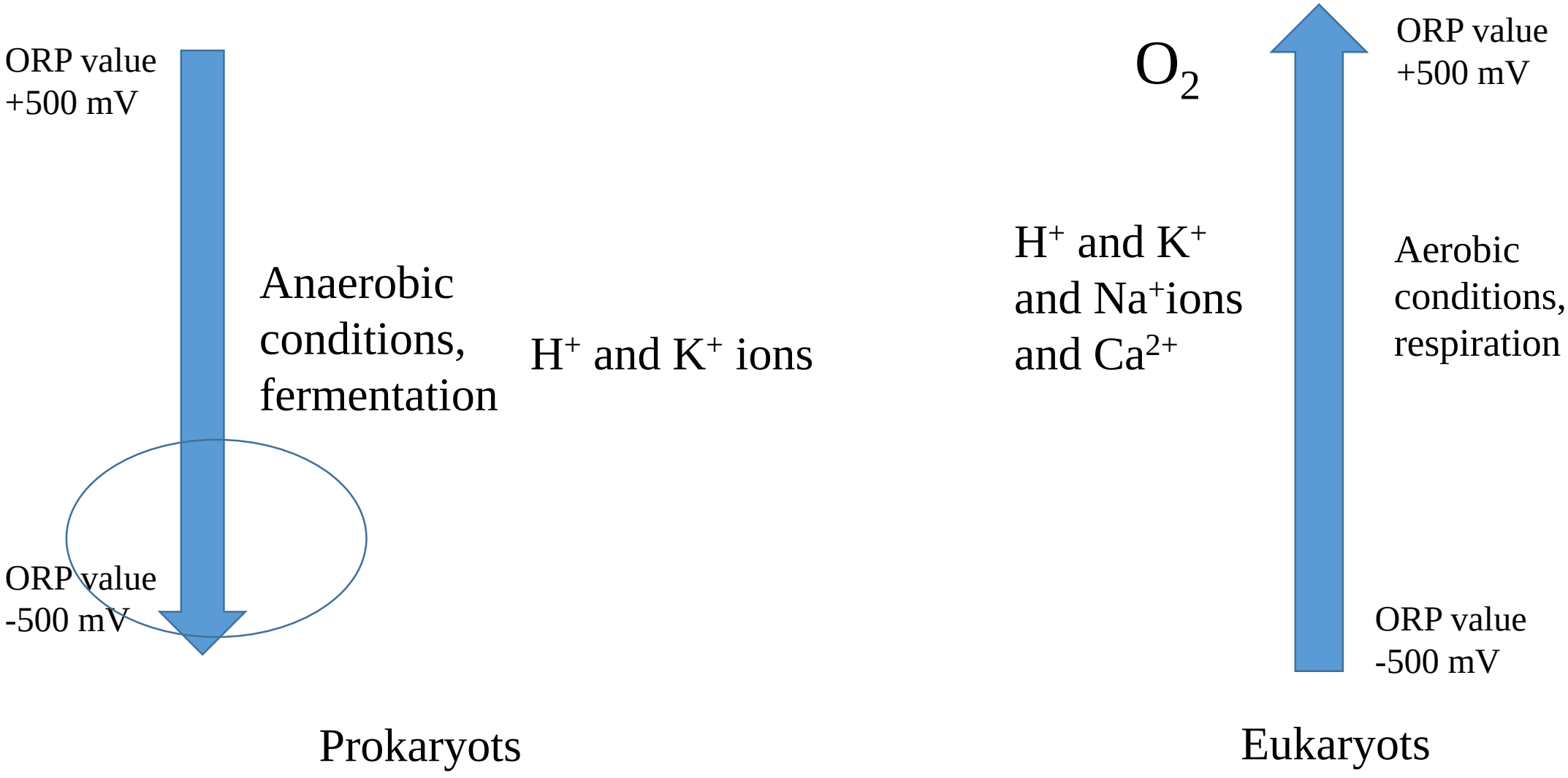
Prof. Dr. Karen Trchounian,
Yerevan State University, Yerevan, Armenia

Movement or motion

Our nature consists in motion; complete rest is death.

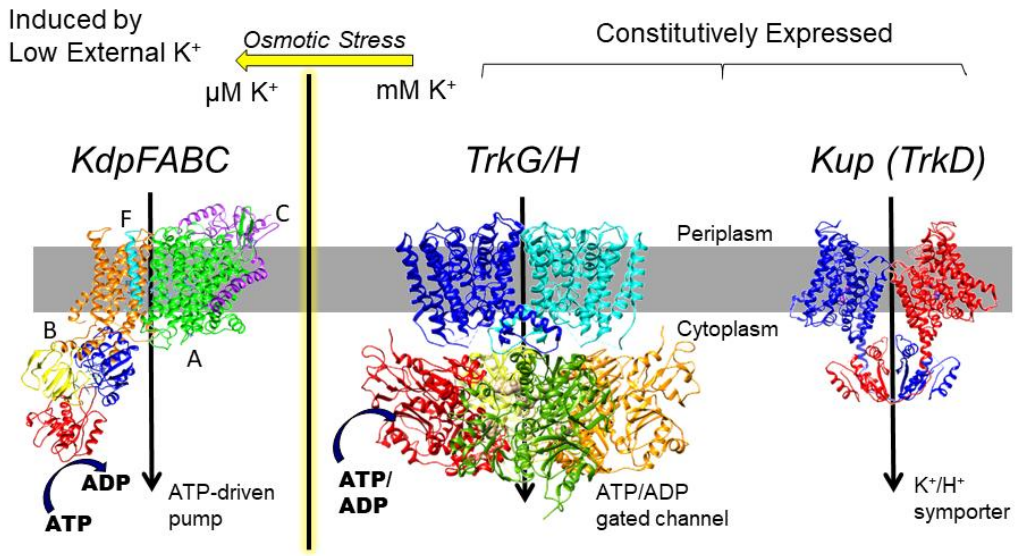
Blaise Pascal

Ion fluxes, redox potential, oxygen

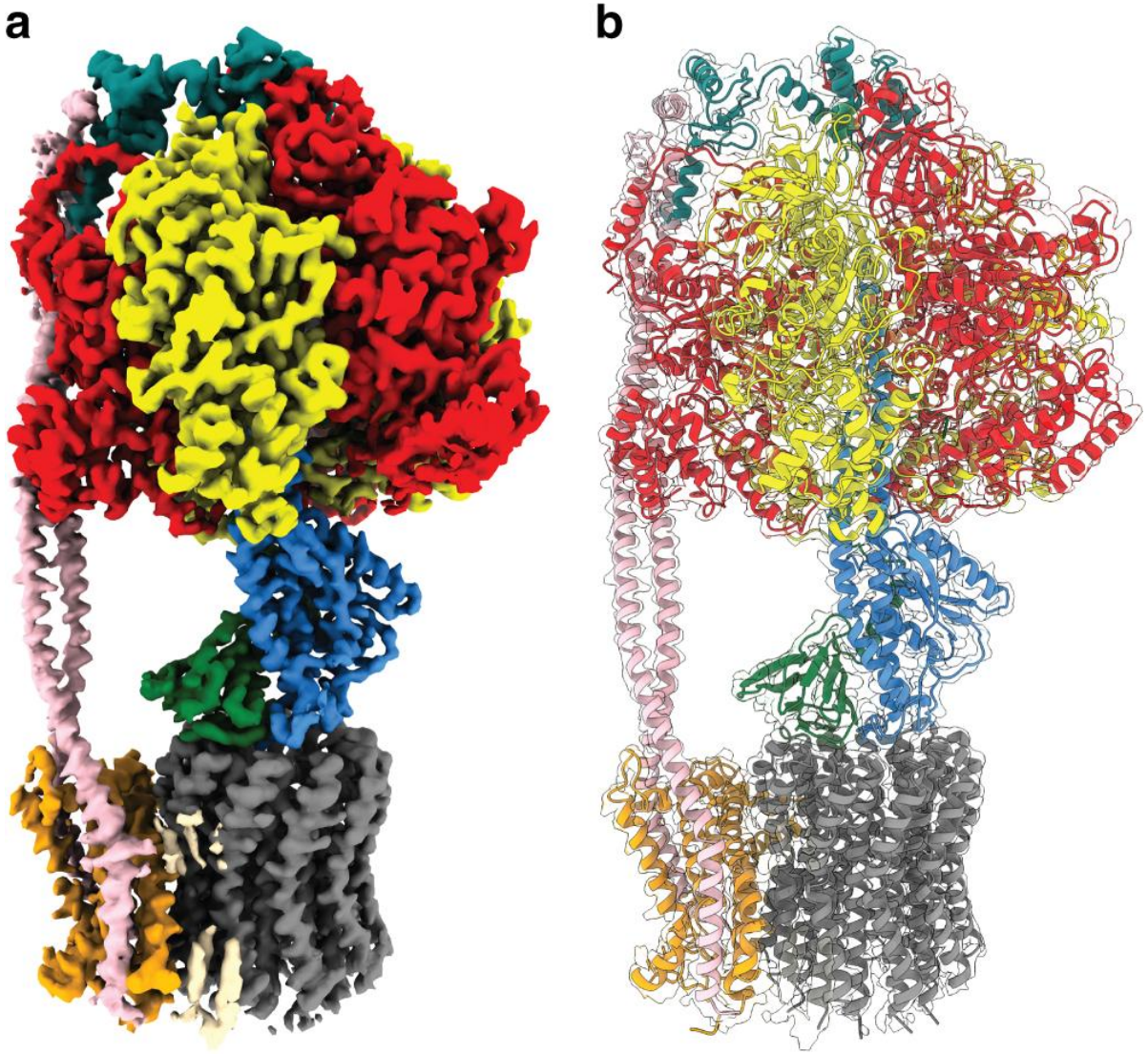


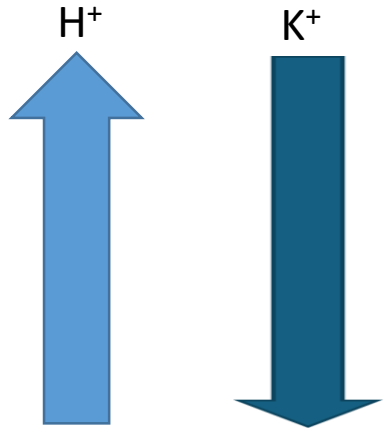
Potassium ions concentration in the cells

- In sea water (ocean) – 10 mM
- In bacteria/yeasts – 100 – 600 mM
- In mammalian cells – 100-150 mM
- In blood plasma - ~5 mM



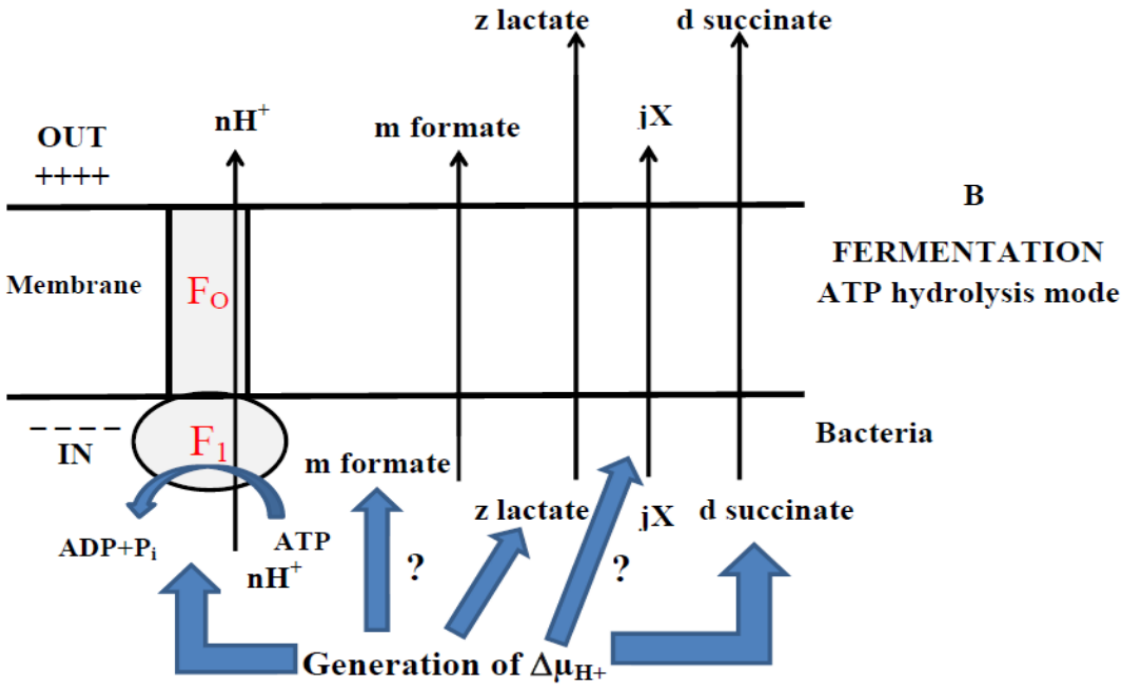
F_OF_1 ATP synthase

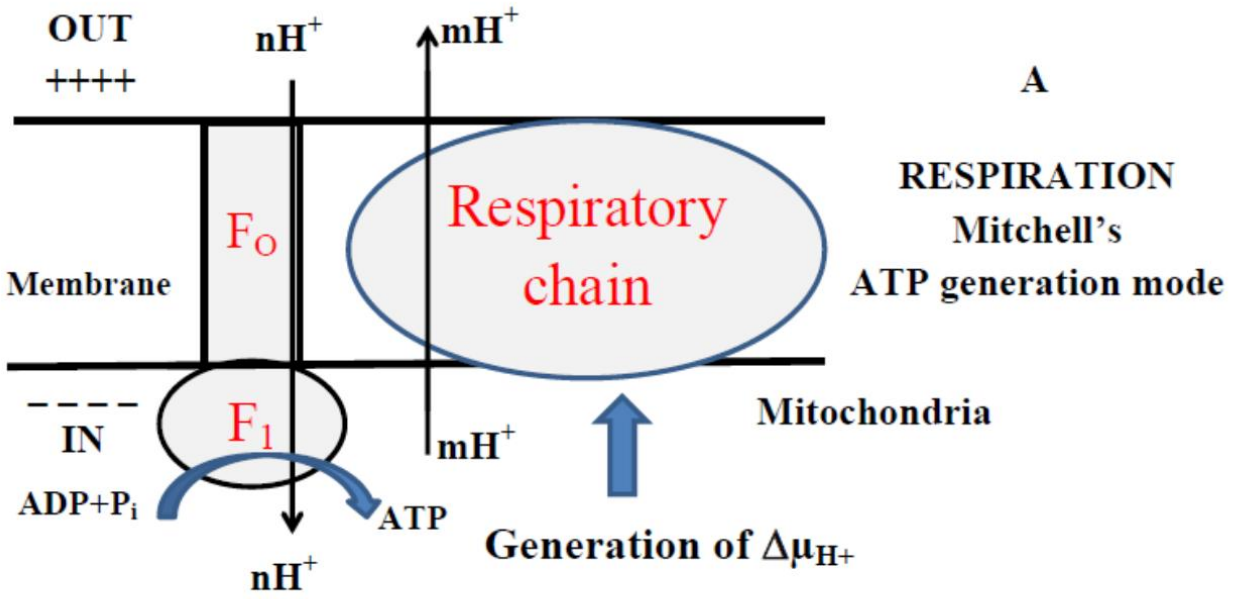




Sobti et al., 2020,
Nature communications

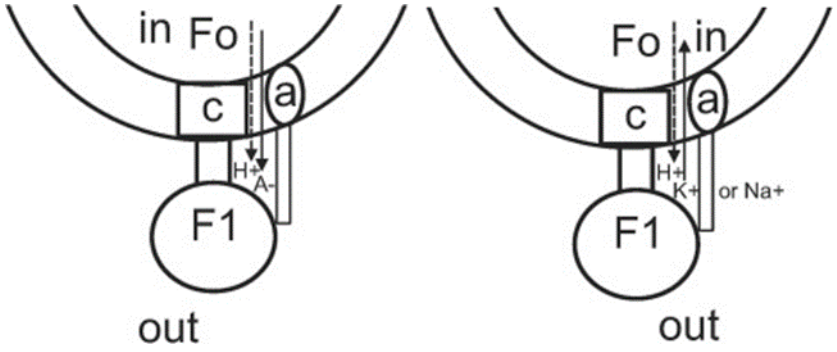
Fermentation and respiration





Trends in Biochemical Sciences, 2019, 44, 391-400

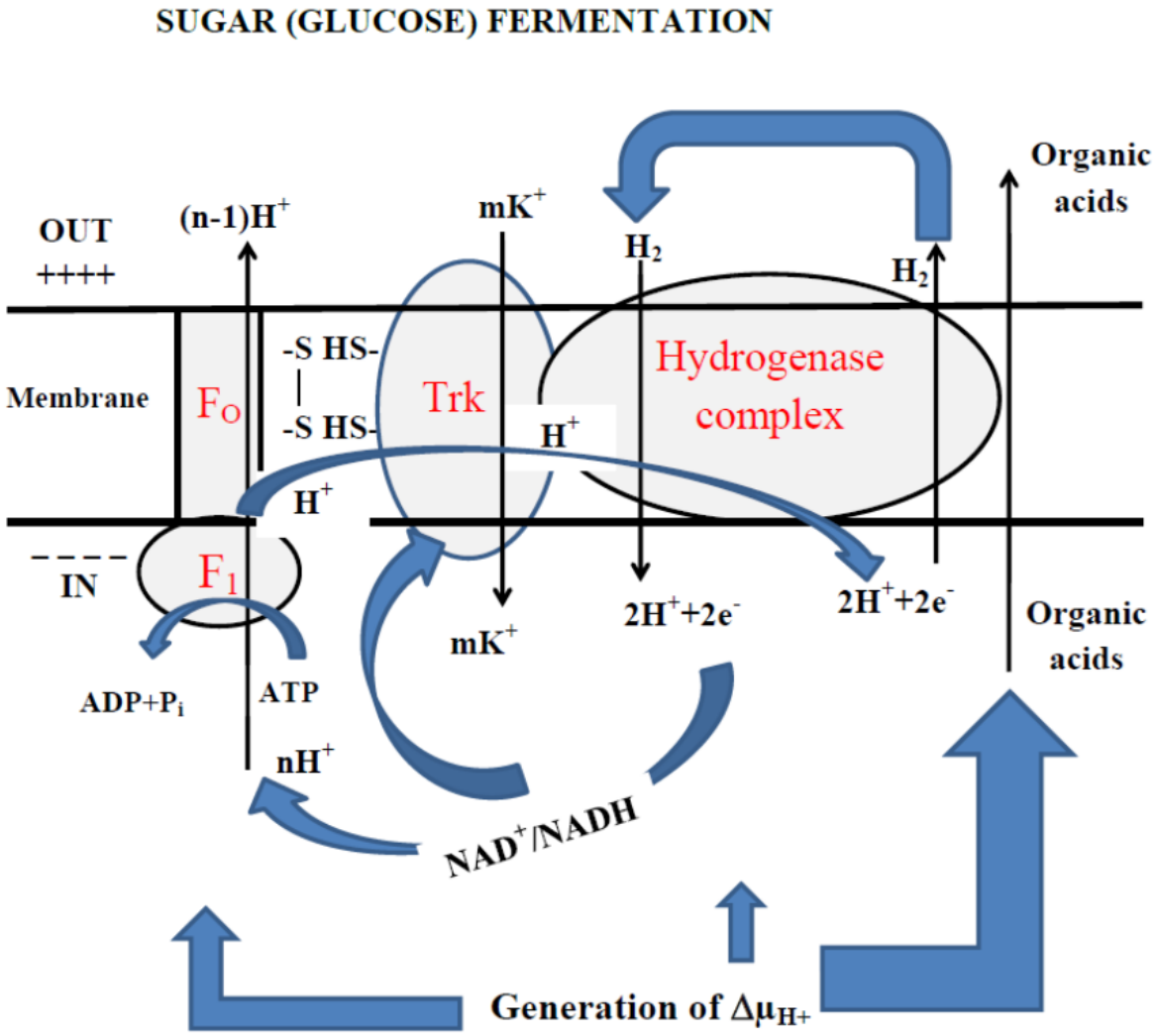
Nath's two ion theory



Nath's torsional mechanism was quantitative and contained mathematical equations that described the overall driving force of ATP synthesis arising from discrete proton and *anion/countercation* translocations in the membrane-bound F_O portion of F_1F_O-ATP synthase. These translocations occurred by a dynamically electrogenic but overall electroneutral mode of ion transport in the F_O portion of the ATP synthase that did not violate overall electroneutrality.

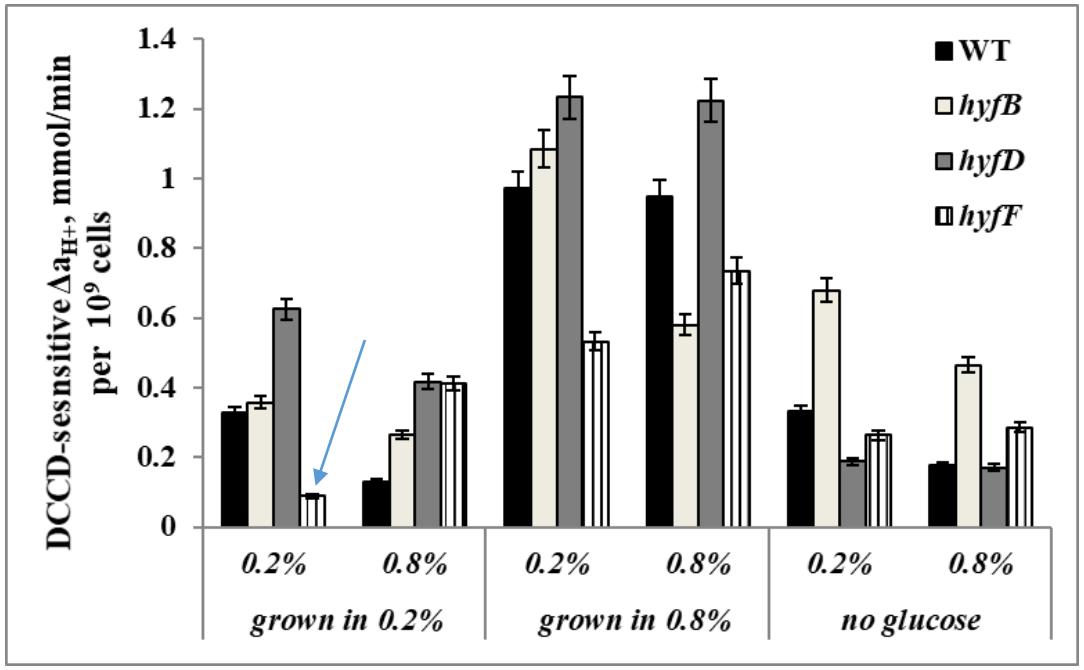
Nath 2017. Biophysical Chemistry, 230, 45-52

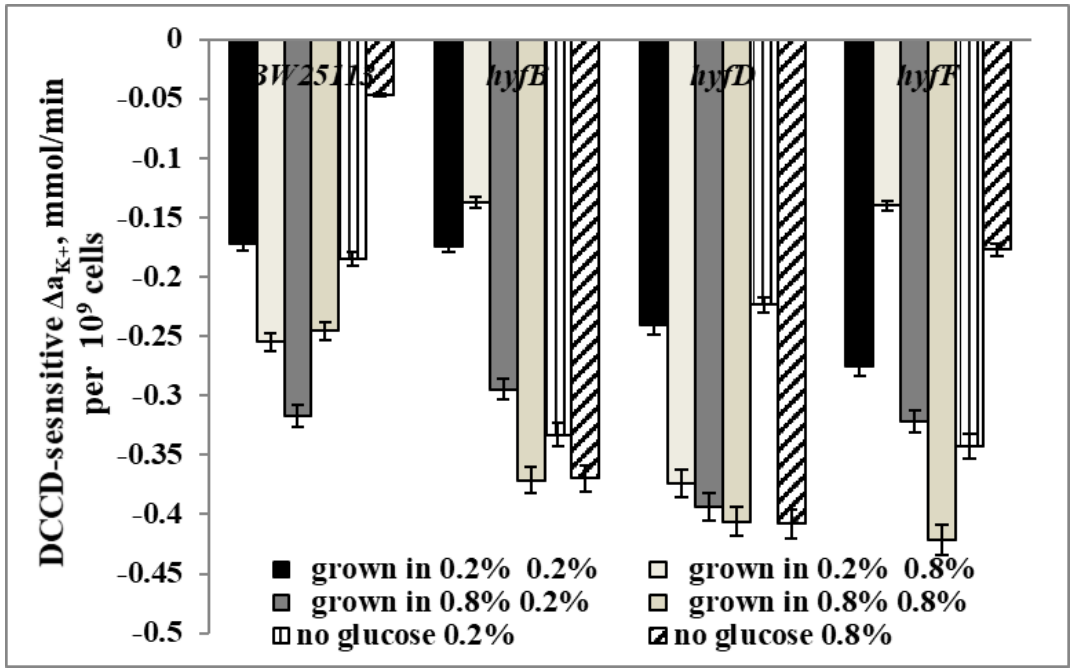
Ion gradients, F_OF_1, hydrogenases



Trends in Biochemical Sciences, 2019, 44, 391-400

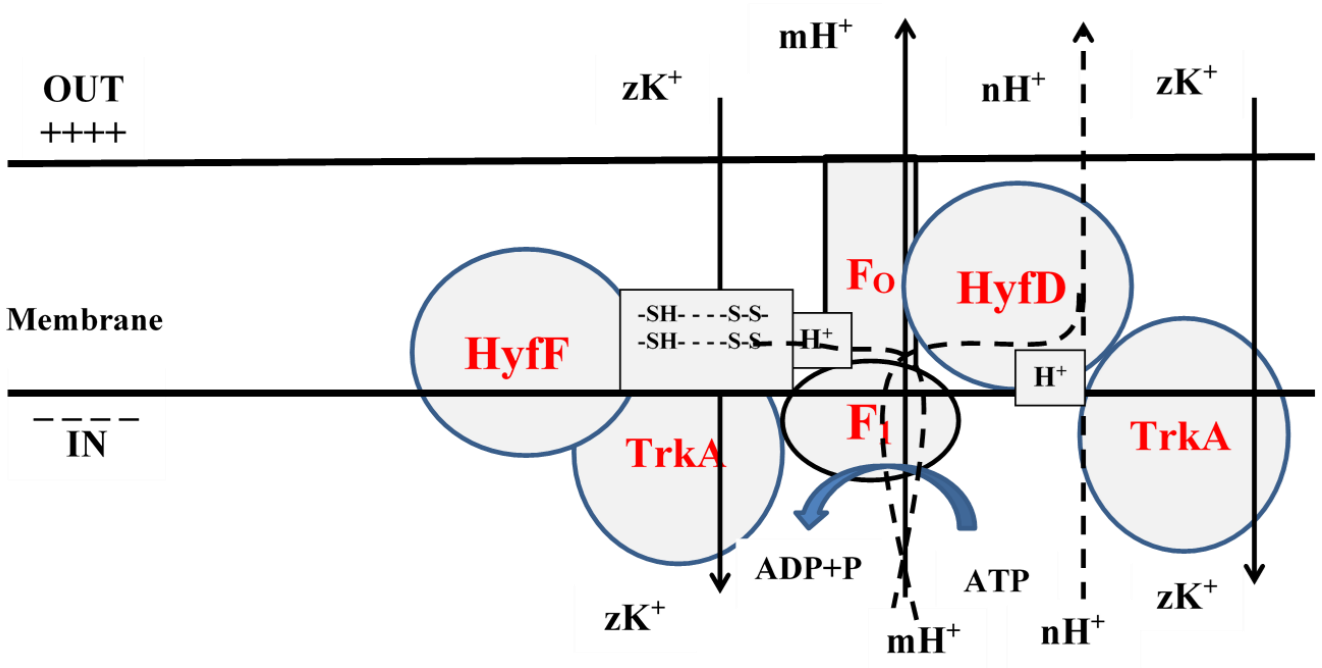
DCCD sensitive proton and potassium fluxes in Hyd-4 mutants





- In *hyfF* mutant grown on 2 g L^{-1} DCCD sensitive proton flux was absent and this depends on glucose concentration

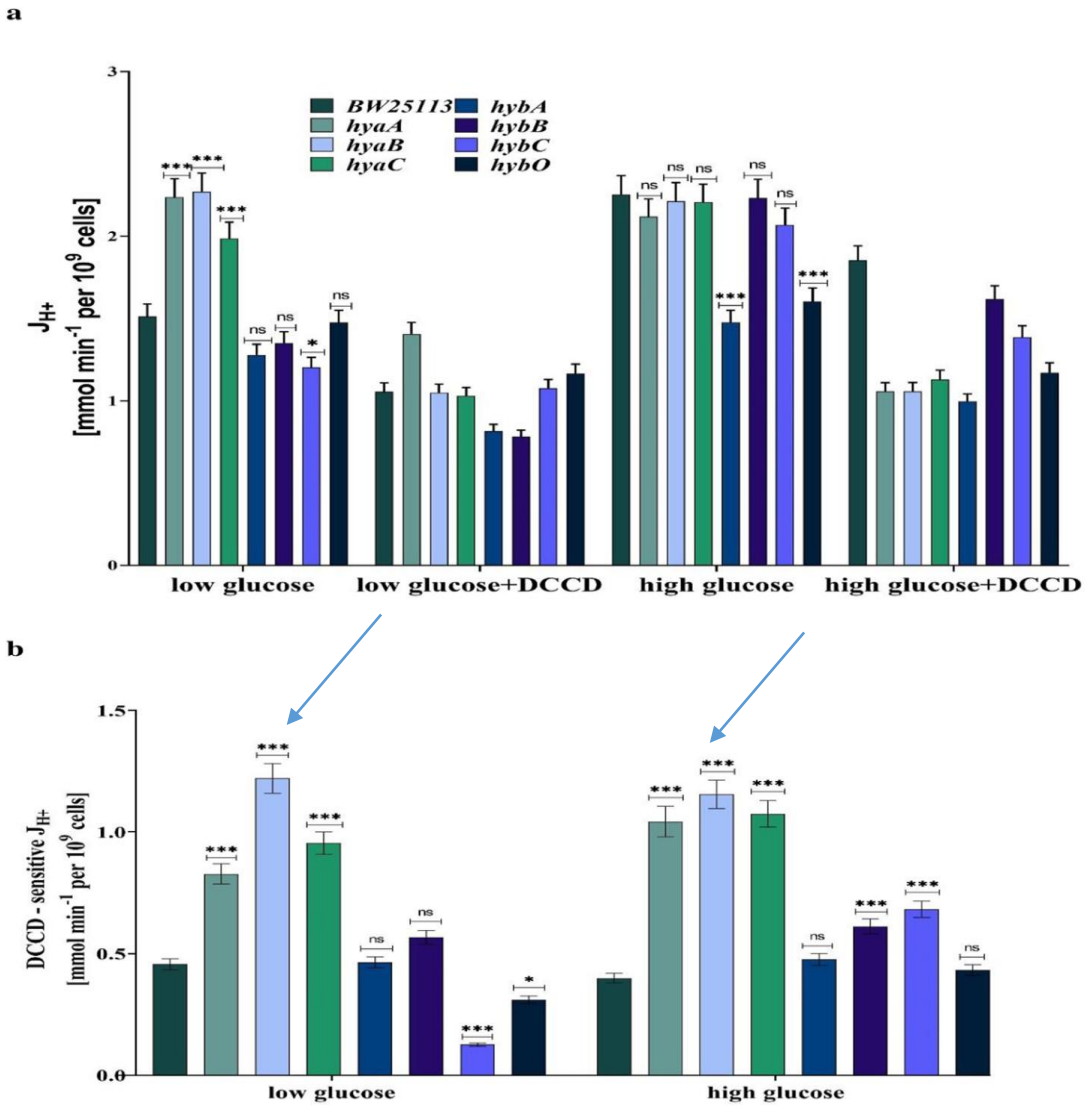
Schematic working model of Hyd-4 subunits



Strain	No glucose		Grown on 2 g L^{-1} glucose		Grown on 8 g L^{-1} glucose	
	2 g L^{-1}	8 g L^{-1}	2 g L^{-1}	8 g L^{-1}	2 g L^{-1}	8 g L^{-1}
WT	1.8	3.73	1.9	0.51	3.06	3.85
hyfB	2	1.25	2.1	1.93	3.75	1.48
hyfD	0.84	0.42	2.3	1.11	4.2	3.01
hyfF	0.77	1.6	0.32	2.94	1.66	1.74

- *Vanyan and Trchounian, 2022 Journal of Bioenergetics and Biomembranes, 54, 69-79*

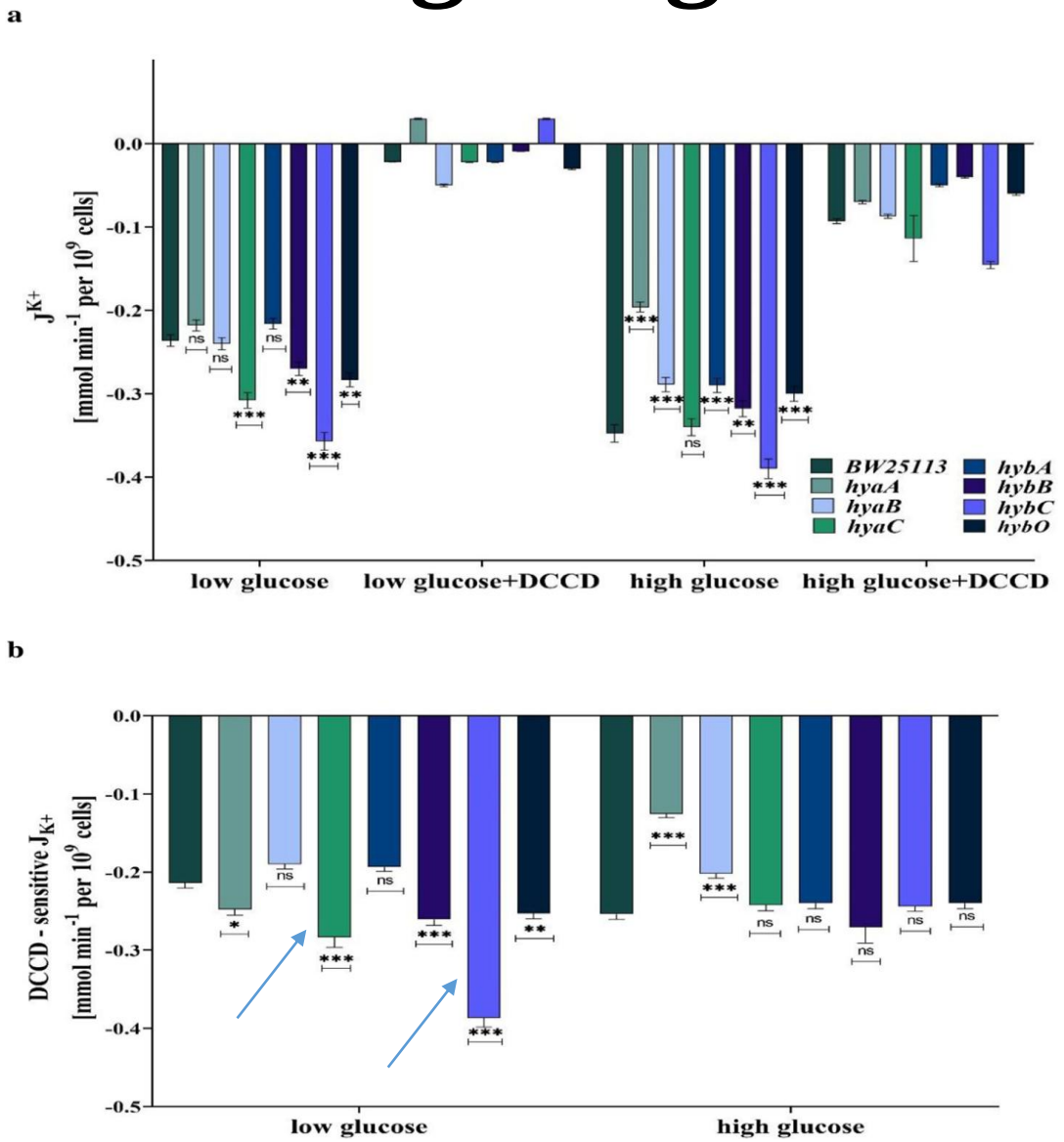
Total and DCCD sensitive H^+ ion fluxes with 2 g L^{-1} glucose



- In *hyaB* (Hyd-1) mutants DCCD sensitive H^+ flux is increased ~ twice

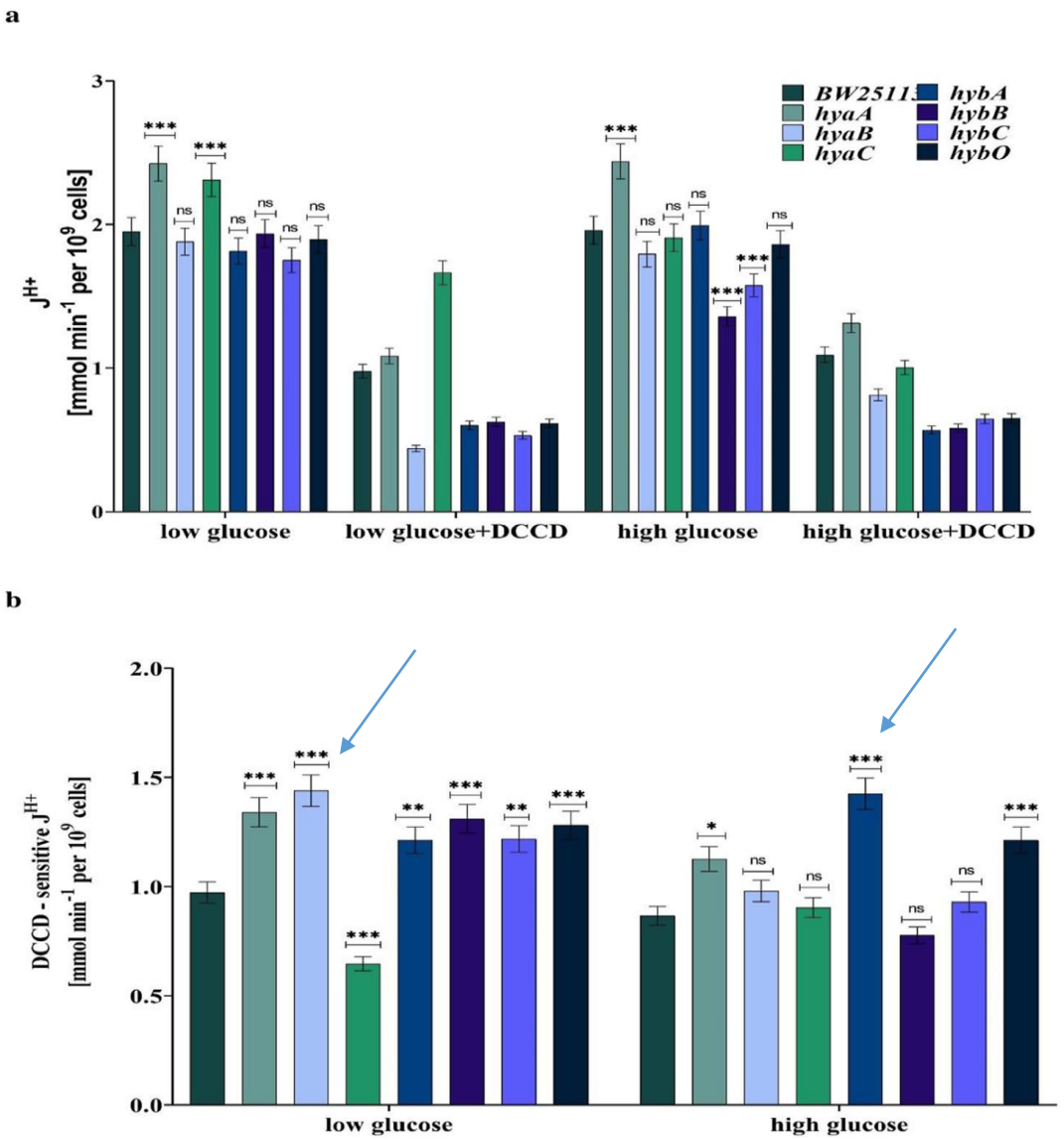
- ***Vanyan and Trchounian, 2024, Biochimie, 227,205-216***

Total and DCCD sensitive K^+ ion fluxes with 2 g L^{-1} glucose



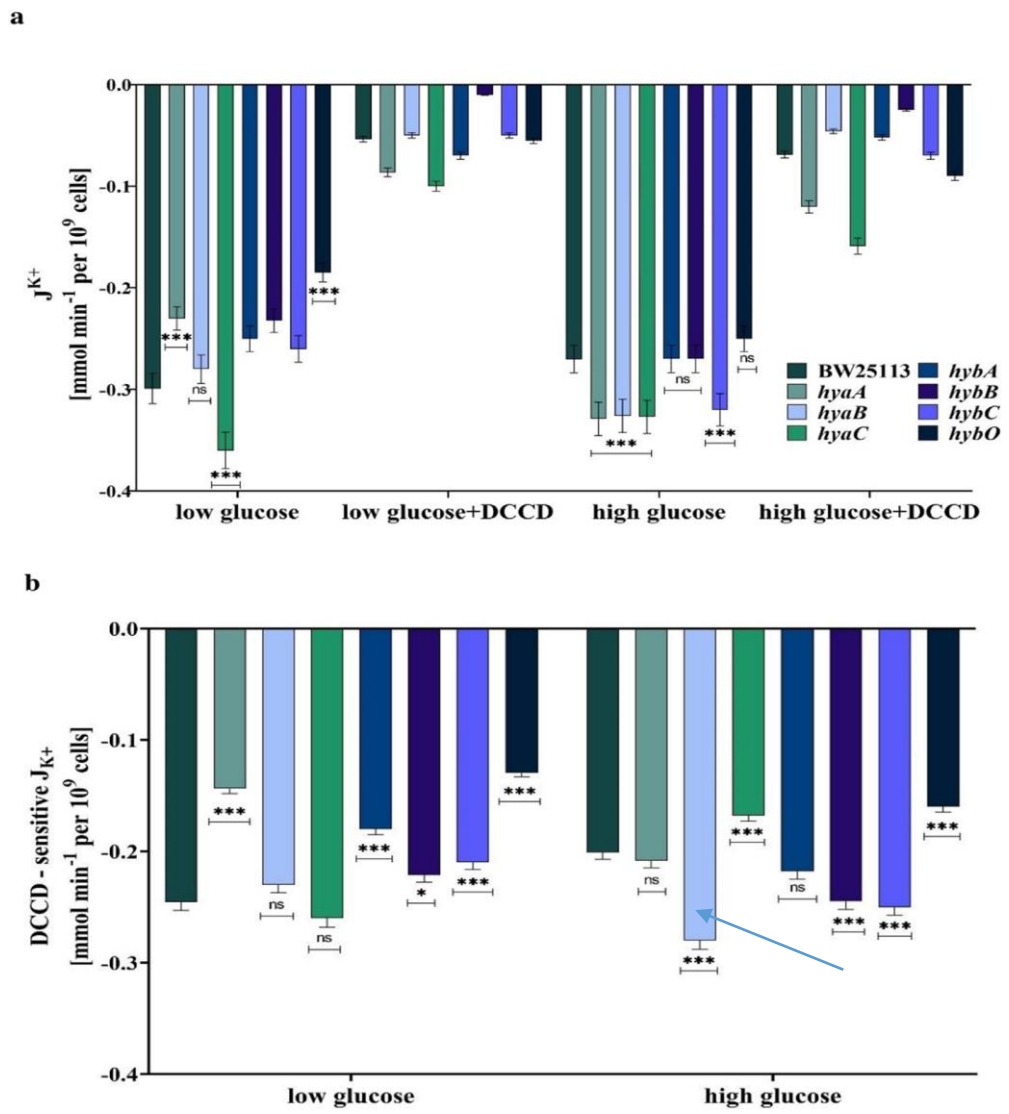
- In *hybC* mutants DCCD sensitive K^+ flux is increased ~ twice

Total and DCCD sensitive H^+ ion fluxes with 8 g L^{-1} glucose



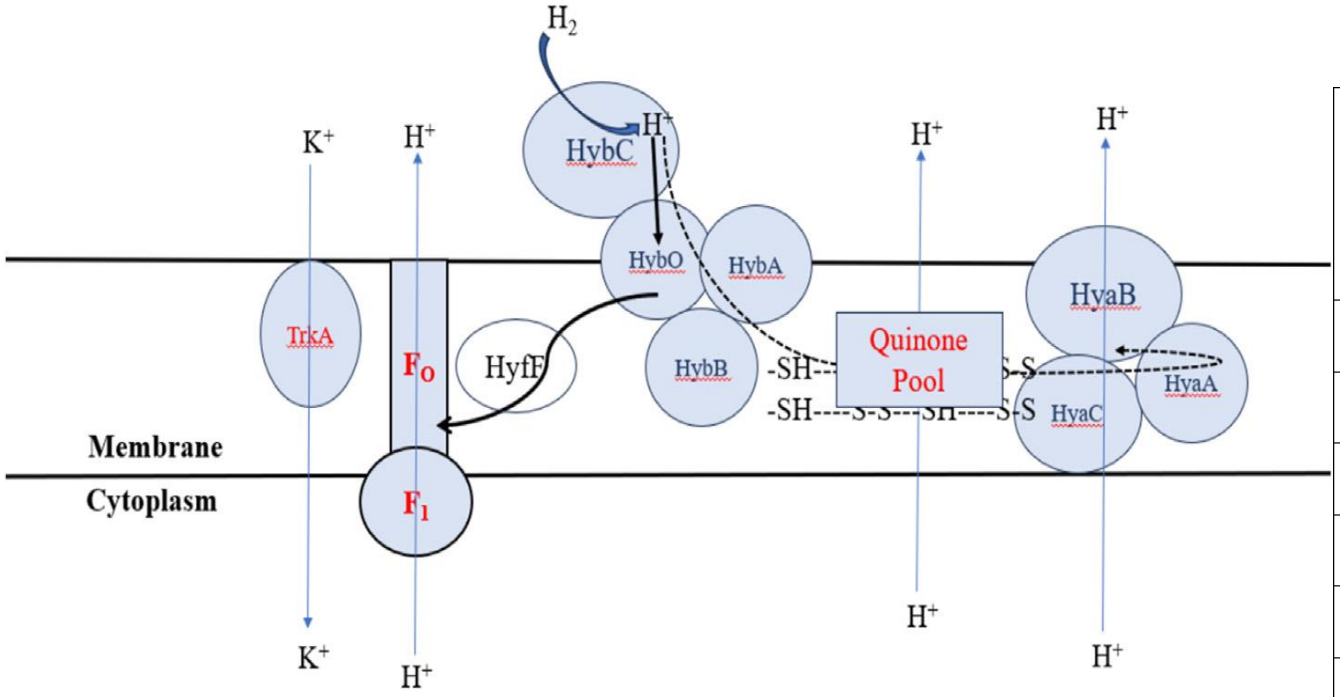
- In *hyaB* mutants DCCD sensitive H^+ flux is increased ~ 50% (low glucose assays)
- In *hybC* mutants DCCD sensitive H^+ flux is increased ~ 50% (high glucose assays)

Total and DCCD sensitive K^+ ion fluxes with 8 g L^{-1} glucose



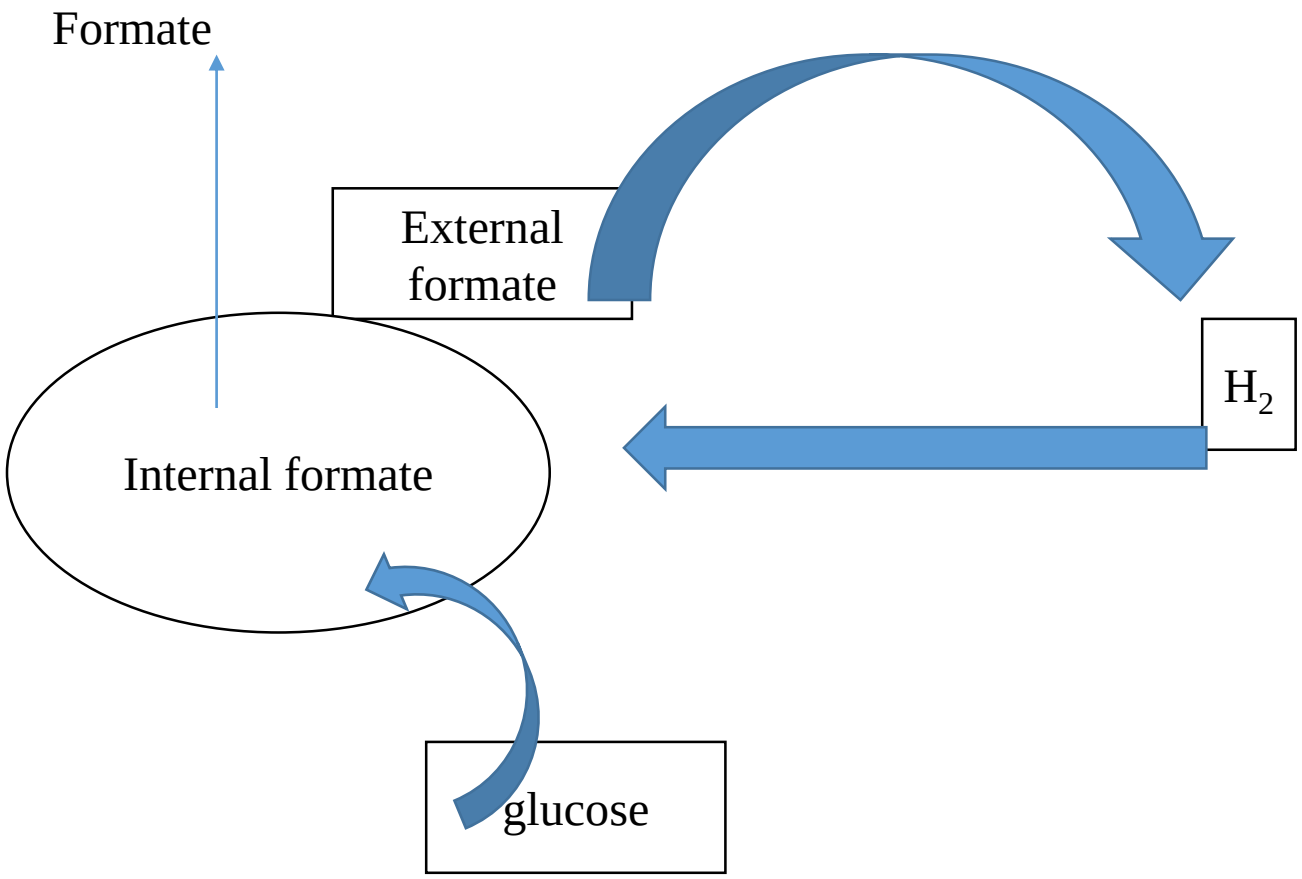
- In *hyaB* mutant DCCD sensitive K^+ flux is increased ~ 50%

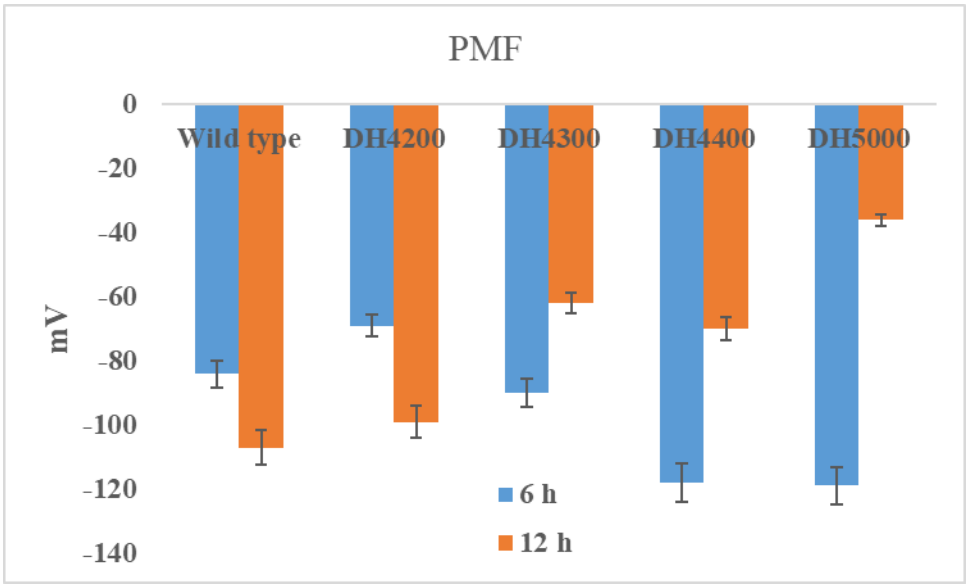
Schematic working model of Hyd-1 and Hyd-2



Strain	Cells grown on 2 g L^{-1} glucose		Cells grown on 8 g L^{-1} glucose	
	Added to the assays 2 g L^{-1}	Added to the assays 8 g L^{-1}	Added to the assays 2 g L^{-1}	Added to the assays 8 g L^{-1}
BW25113	2.7	4.3	5.6	2.1
hyaA	3.3	8.4	9.3	5.4
hyaB	6.4	5.7	6.3	3.5
hyaC	3.34	4.5	2.5	5.4
hybA	2.4	2	6.7	6.5
hybB	2.2	2.2	5.9	3.2
hybC	0.33	2.8	5.8	3.7
hybO	1.3	1.8	9.9	7.6

Internal/External formate



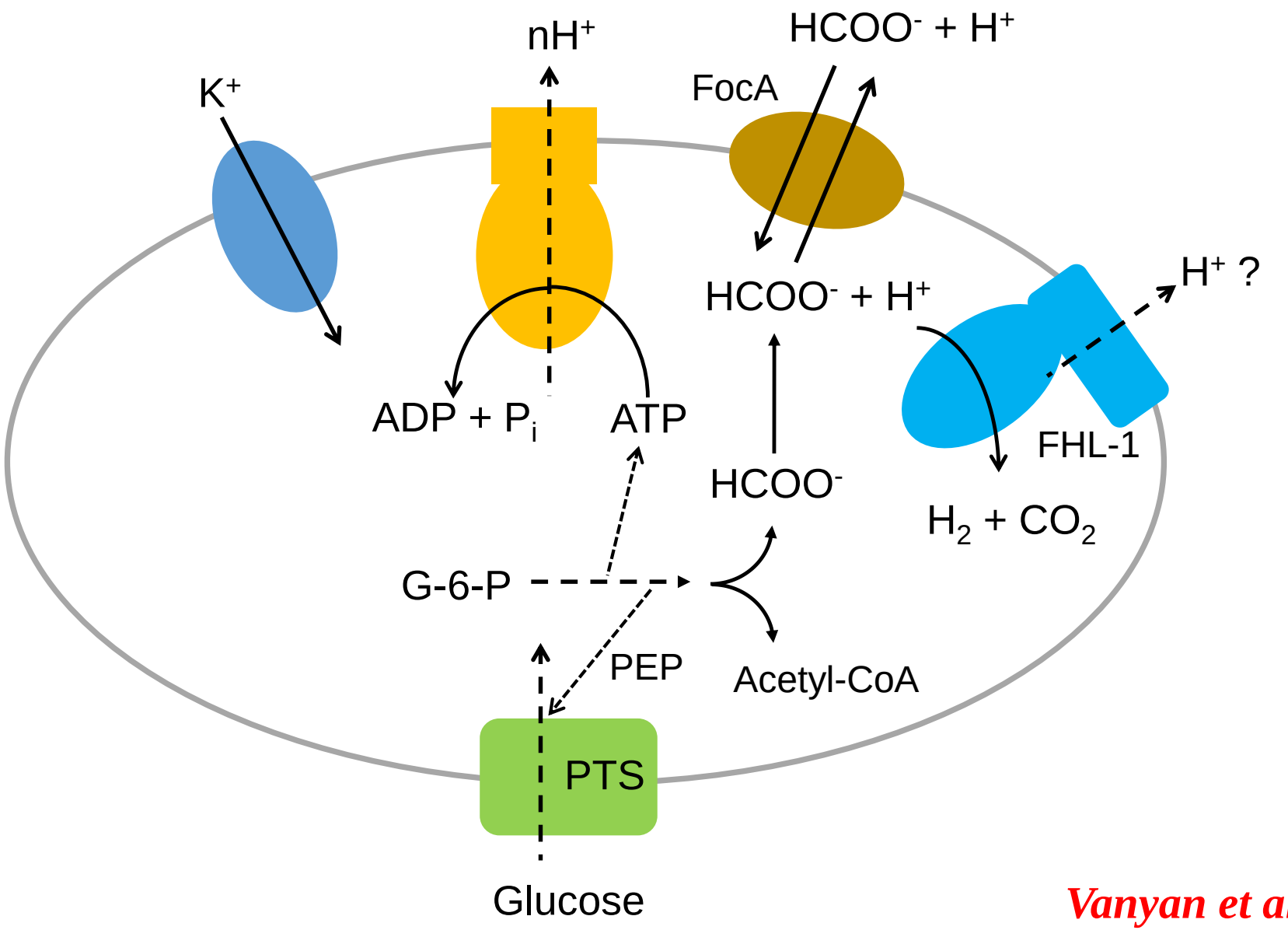


DH 4200 – all formate is effluxed out
DH 4300 – formate is not exported
DH 4400 – export but not import

Unpublished data

Charge Balance

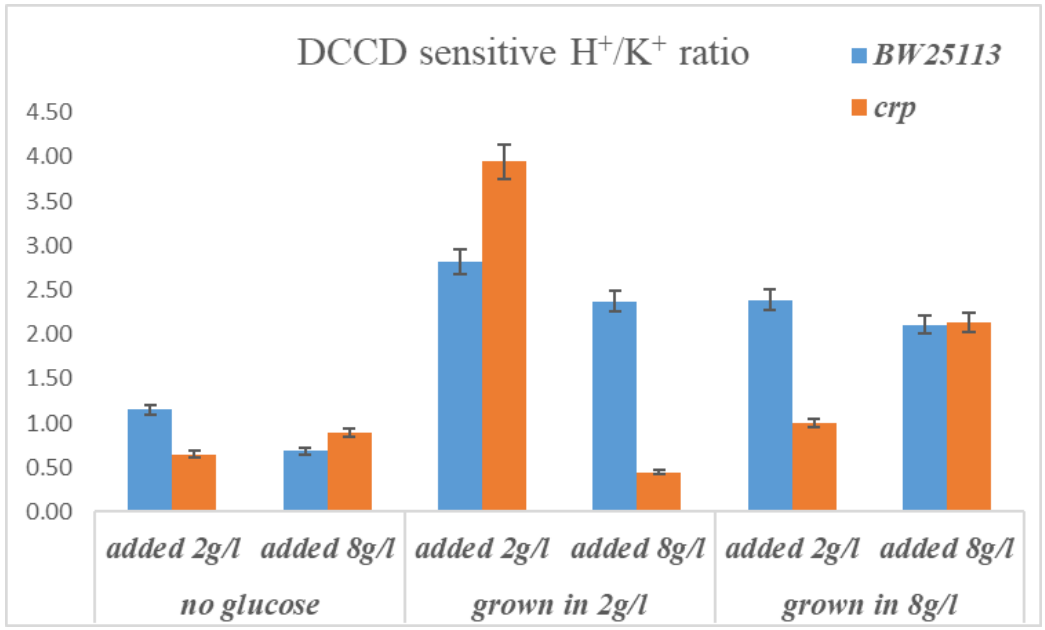
pH Balance

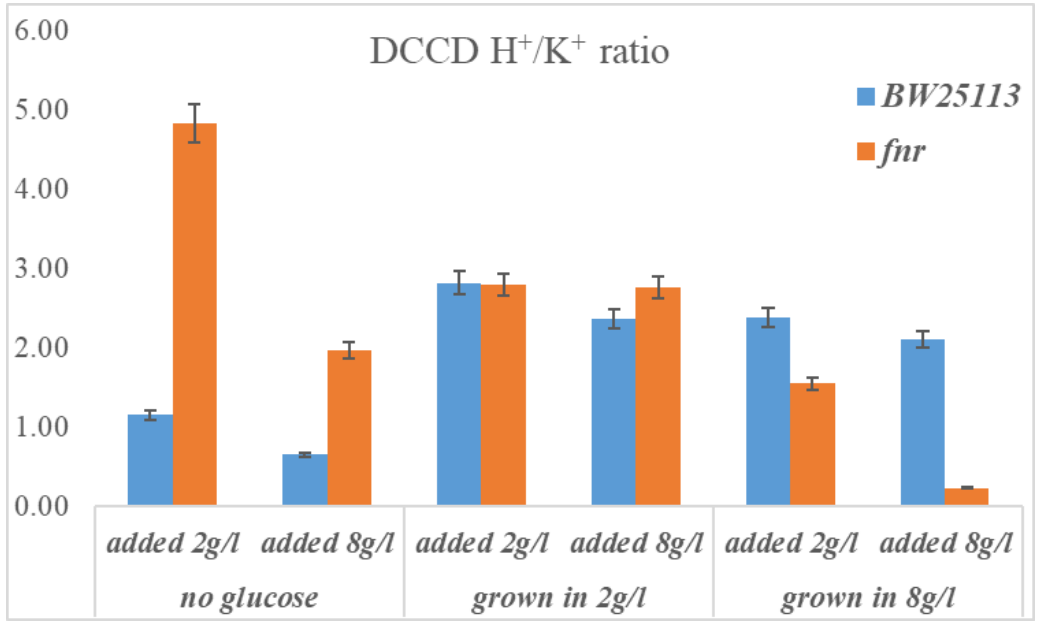


Prof. Gary Sawers (Germany)

Vanyan et al., (2024). Archives of Biochemistry and Biophysics, 752, 109877.

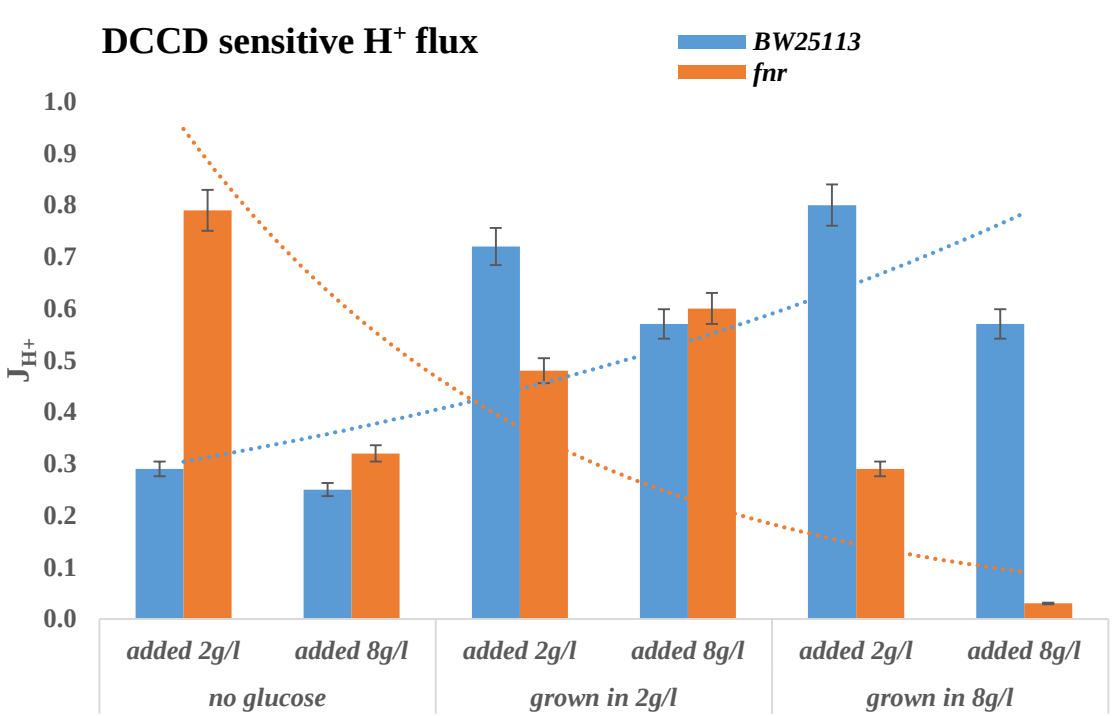
Role of FNR and CRP on glucose dependent ion fluxes

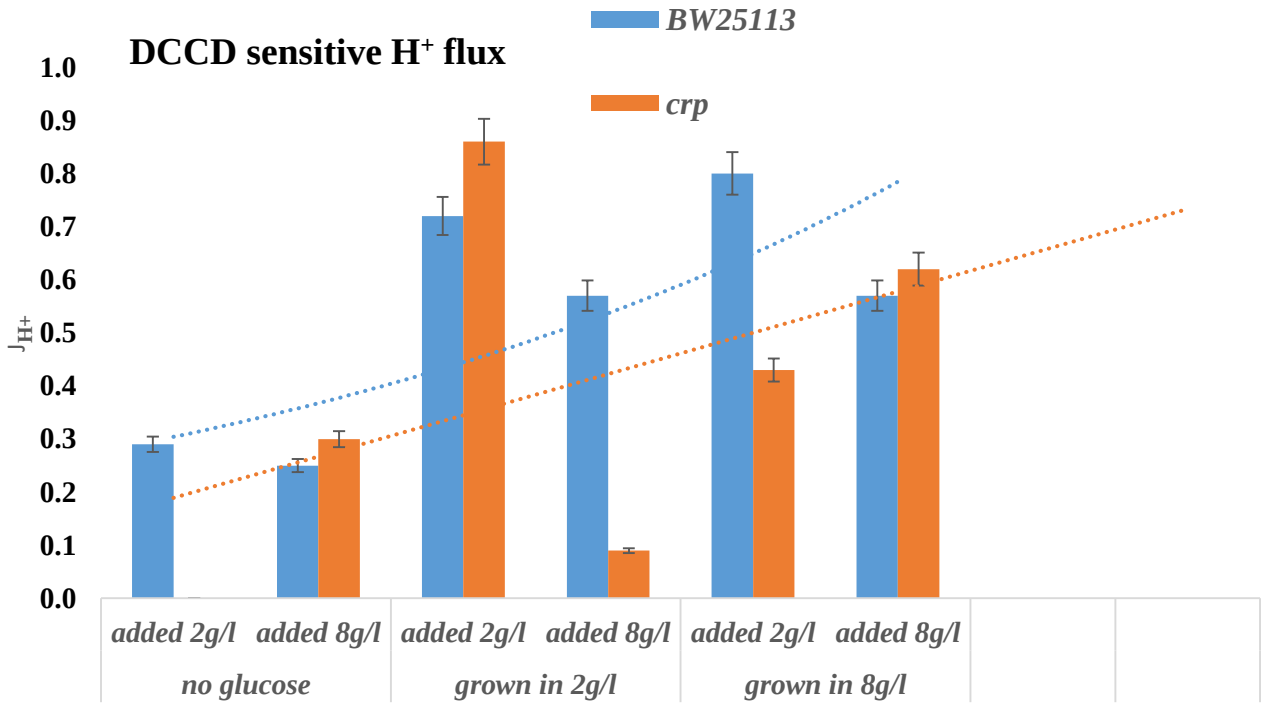




Unpublished data

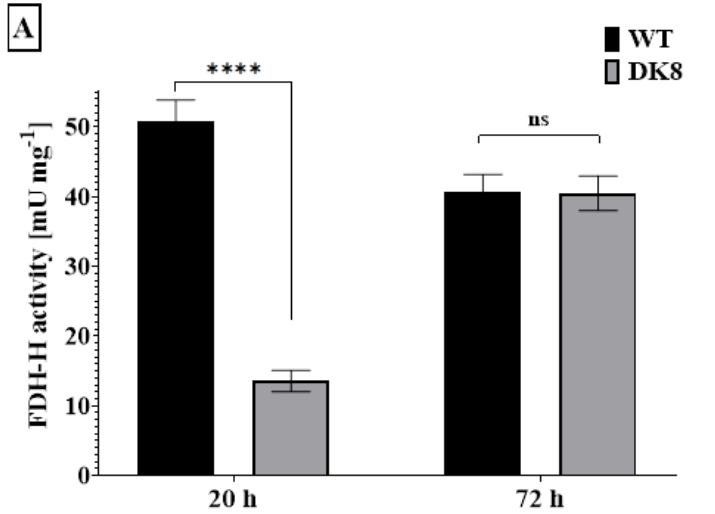
DCCD sensitive H^+ flux in FNR and CRP mutants

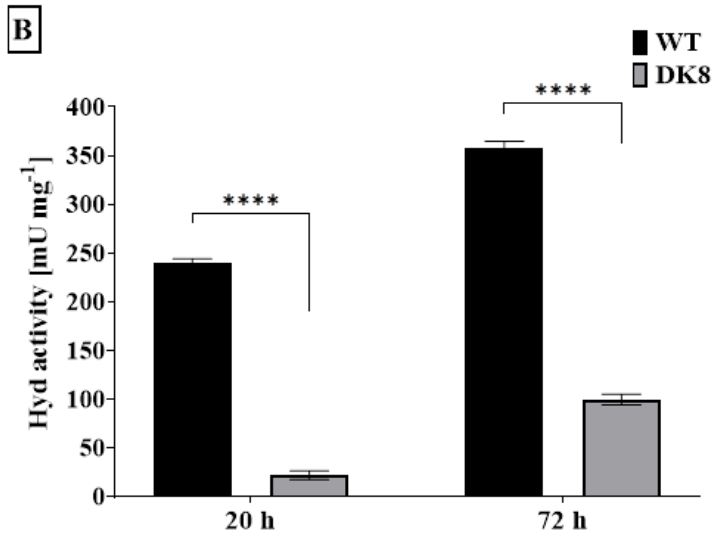




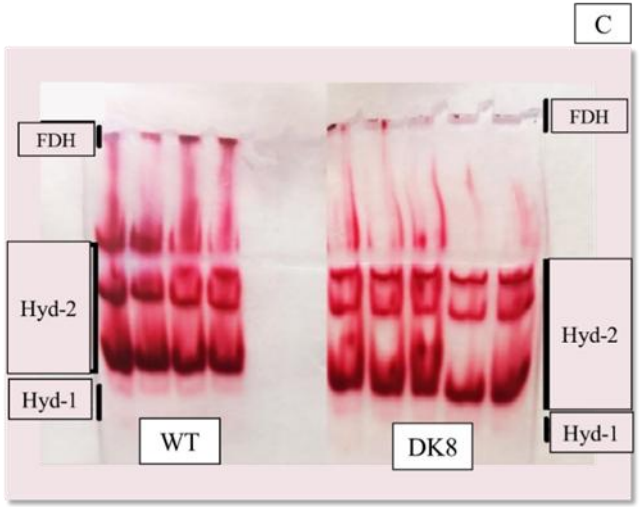
Unpublished data

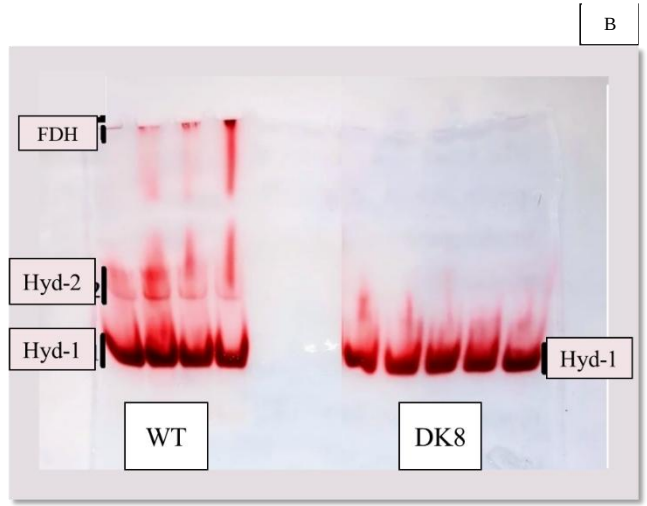
FDH-H and Hyd activities in DK8 mutant





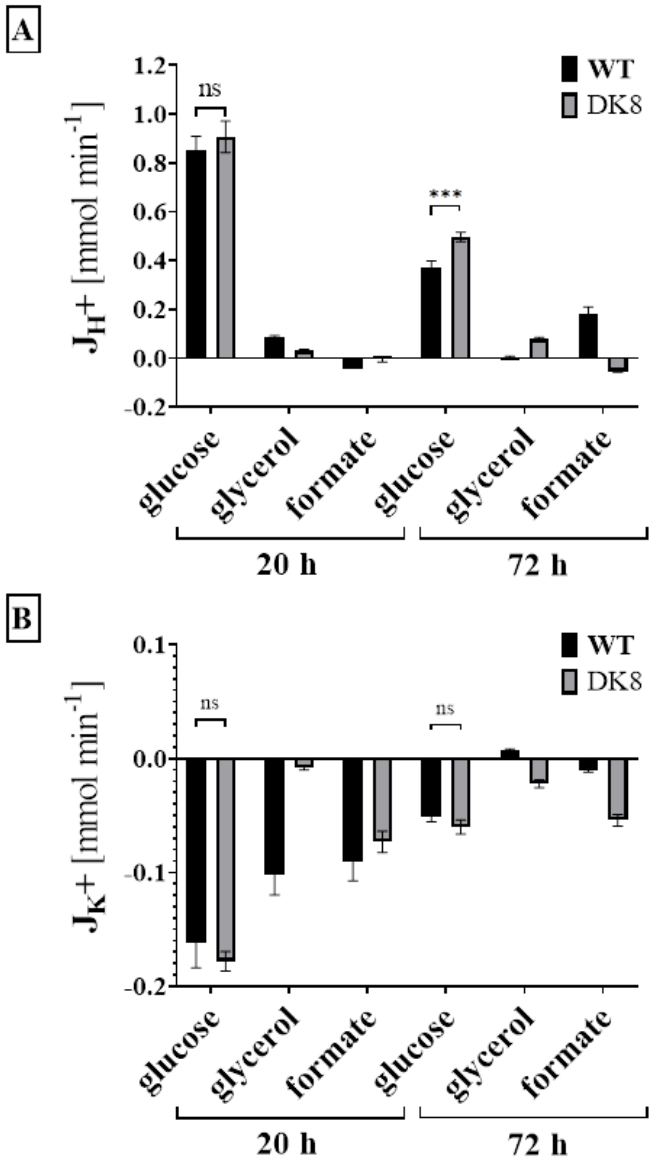
- ✓ Relationship between F_OF_1 and FDH-H at 20h but 72 h grown cells
- ✓ Hyd activity depends on active F_OF_1 on both growth phases





Gevorgyan and Trchounian Accepted (2025) Sci rep

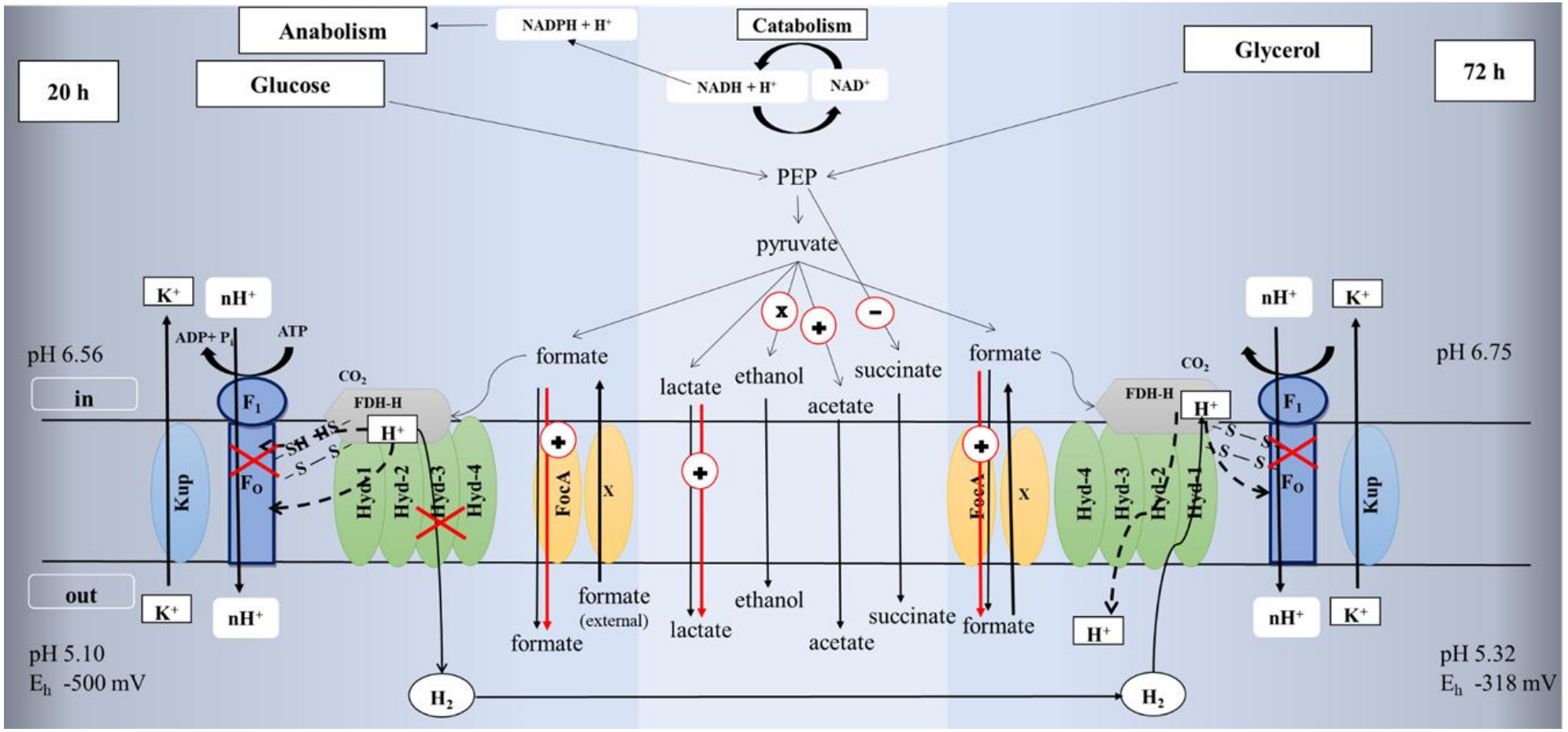
Ion fluxes in DK8 mutant



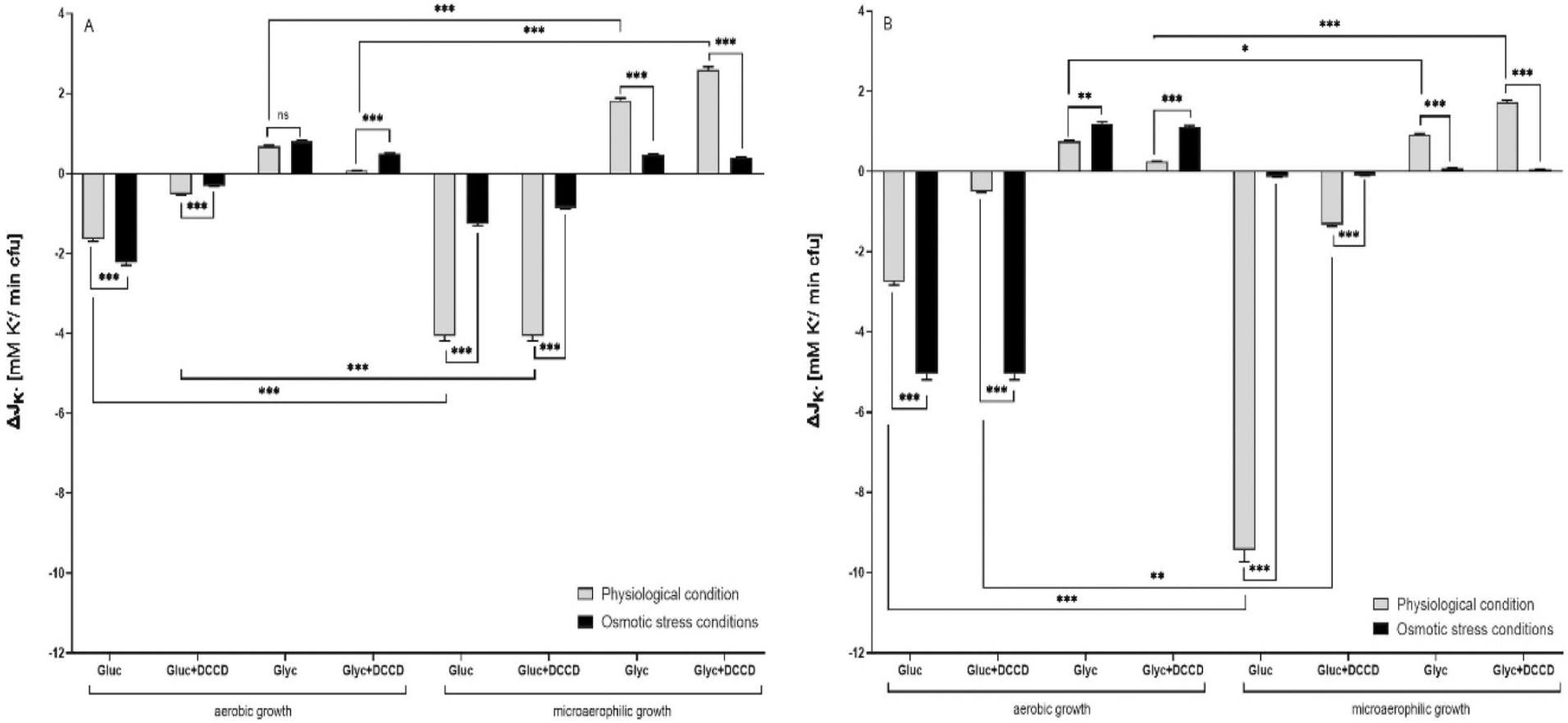
- ✓ **Relationship between F_OF_1 and FDH-H at 20h but 72 h grown cells**
- ✓ **Hyd activity depends on active F_OF_1 on both growth phases**

Gevorgyan and Trchounian Accepted (2025) Sci rep

Schematic working model of the cells grown 20 h and 72 h

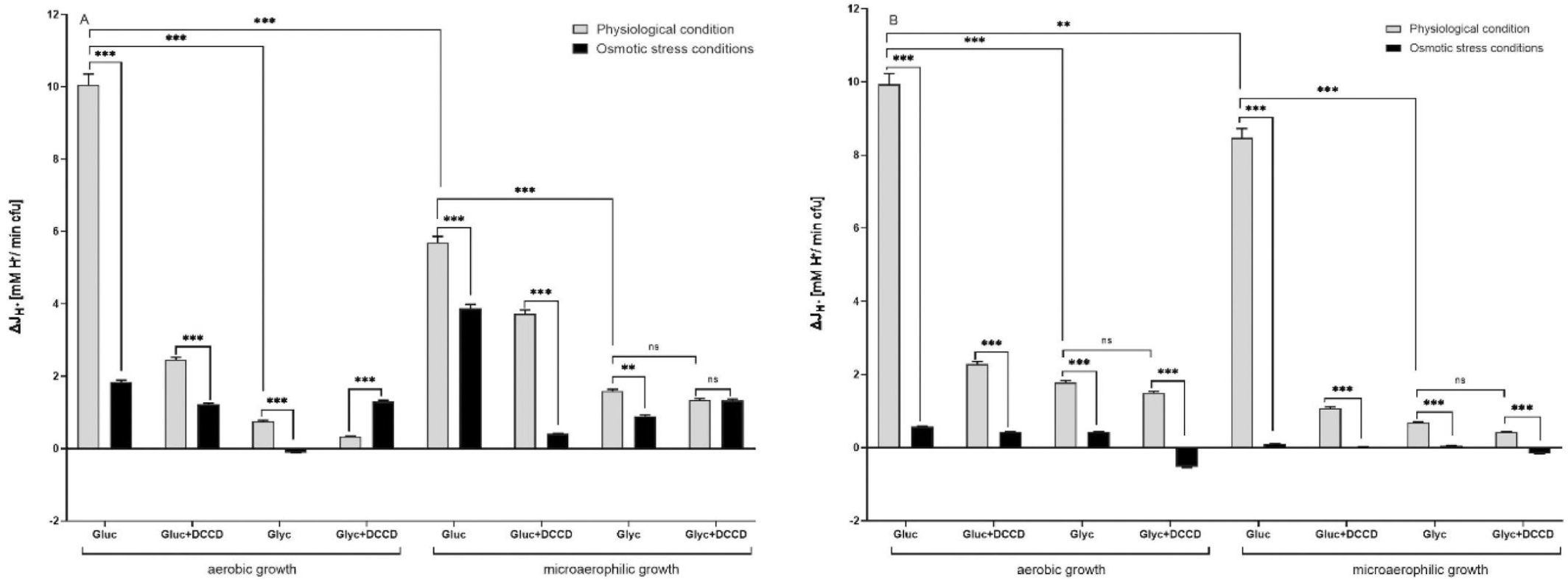


Potassium transport in yeasts



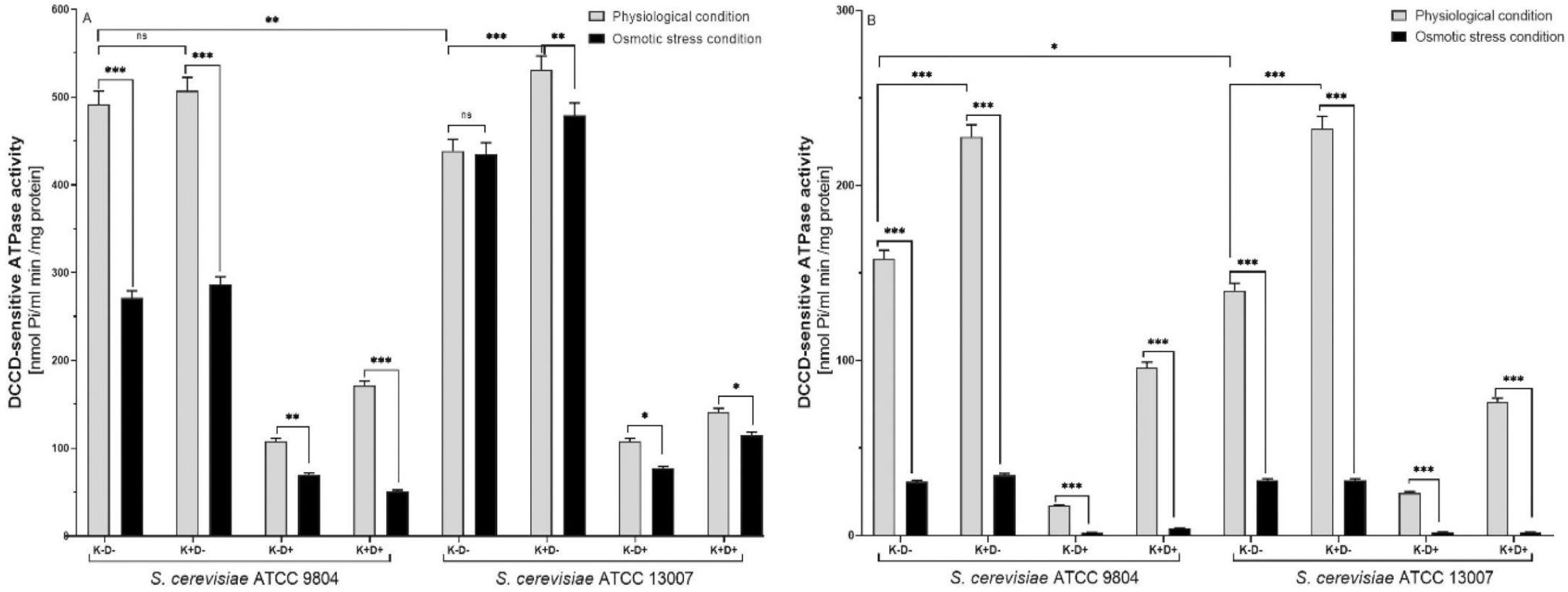
Shirvanyan, A., Trchounian, K.
Sci Rep **14**, 23982 (2024).

Proton transport in yeasts



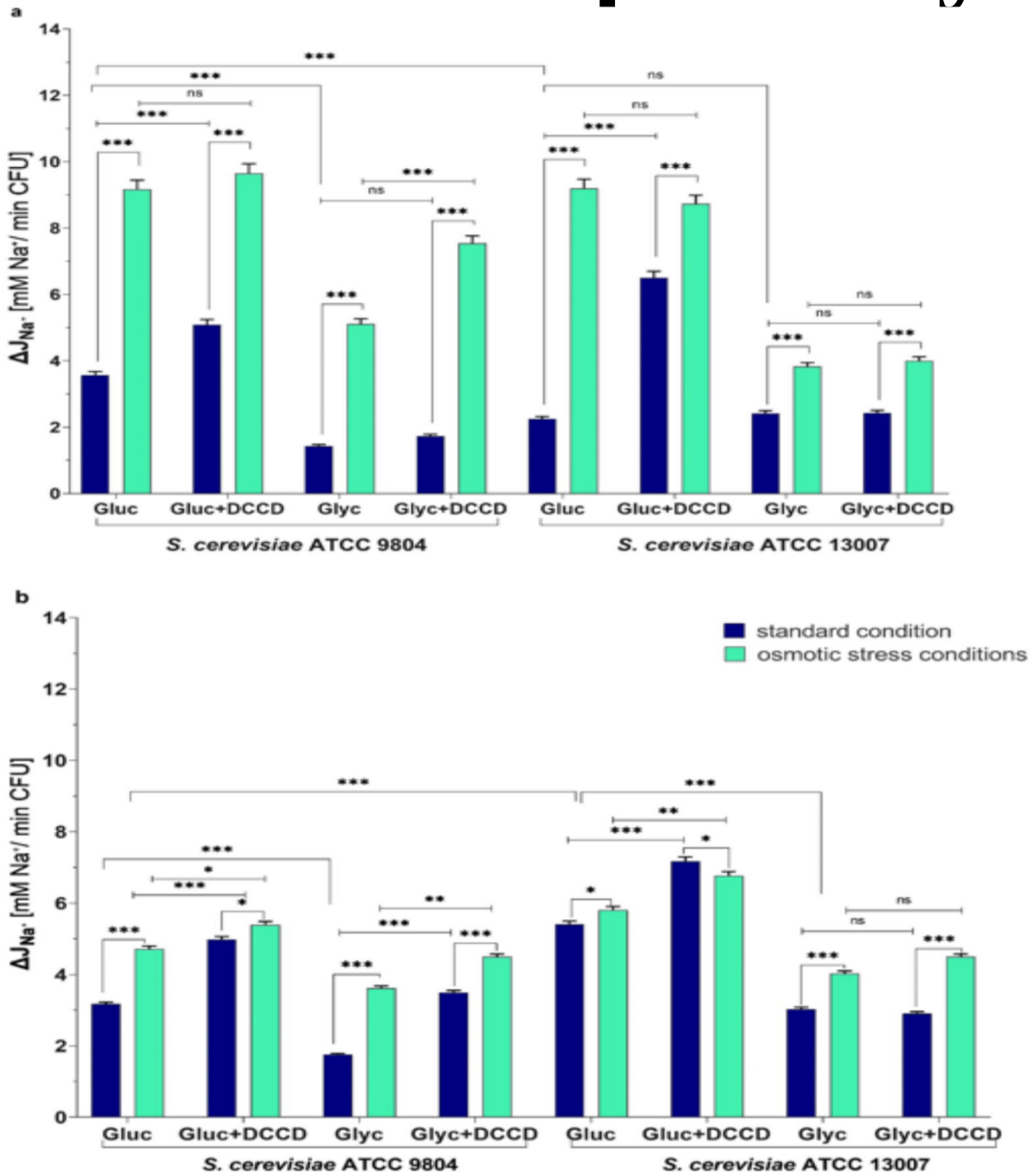
Shirvanyan, et al., Proc. Biochem. 133, 309-318 (2023).

ATPase activity in yeasts



Shirvanyan, et al., Proc. Biochem. 133, 309-318 (2023)

Sodium transport in yeasts



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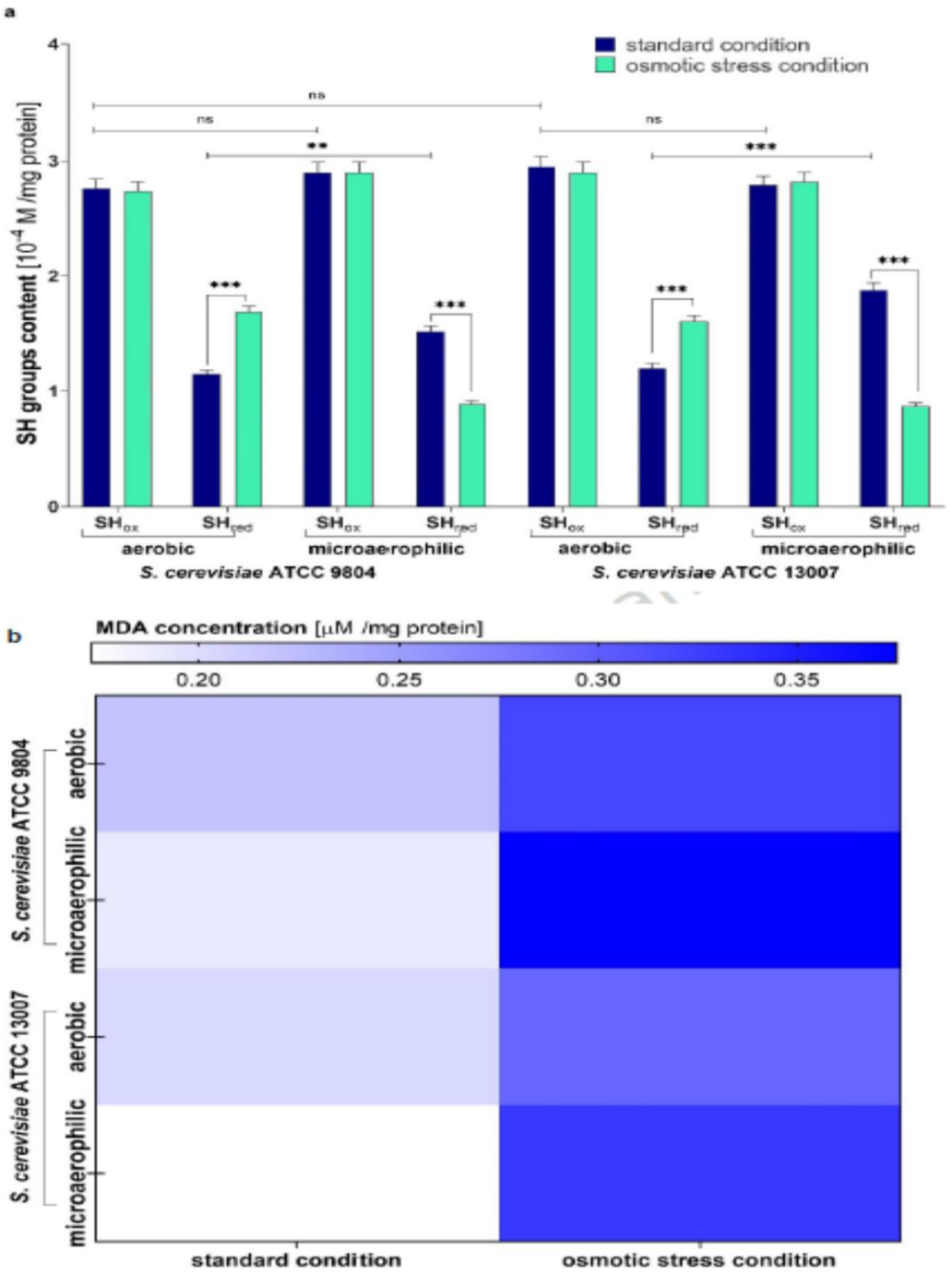
Sci Rep **14**, 23982 (2024).

Thiol groups in yeasts

- Thiol groups are important for overcoming stress



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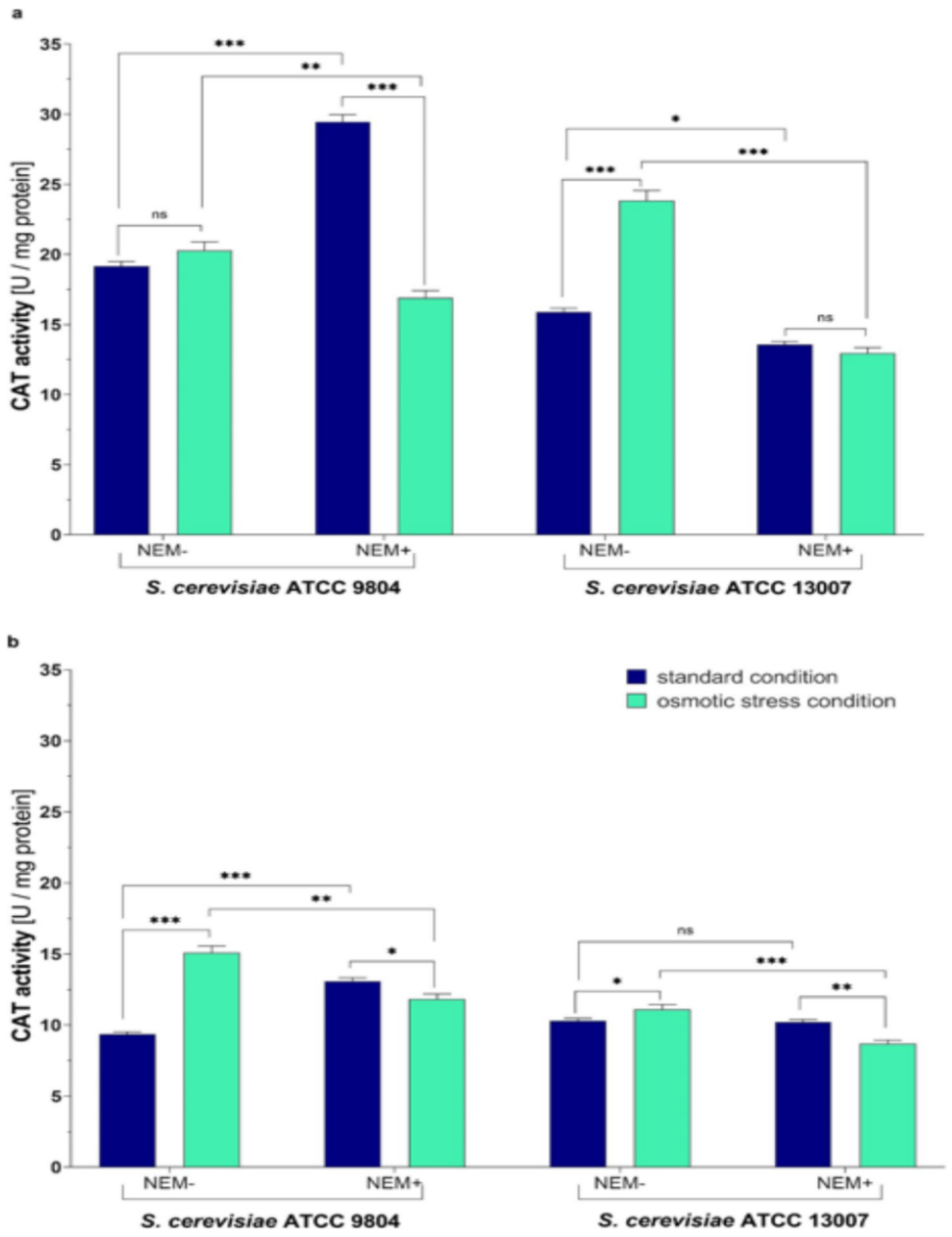
Catalase activity in yeasts



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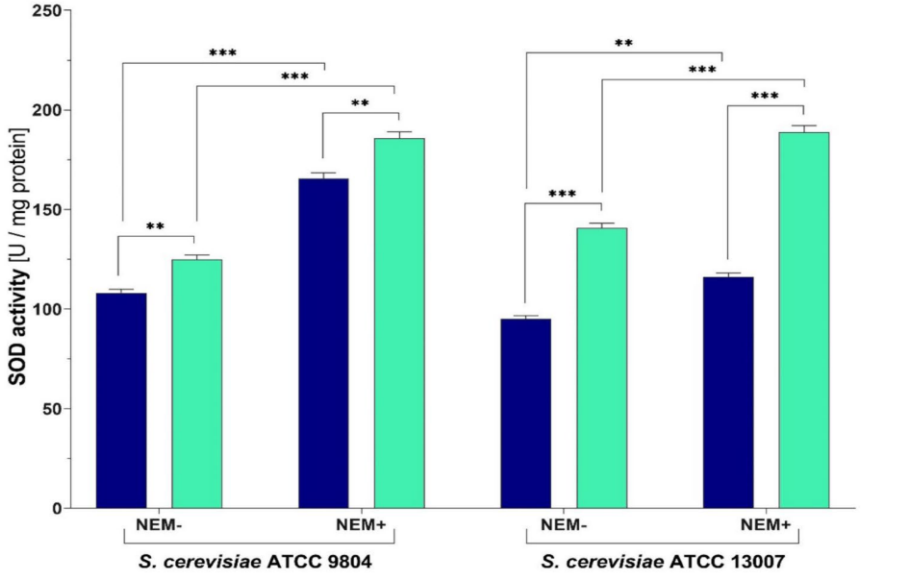
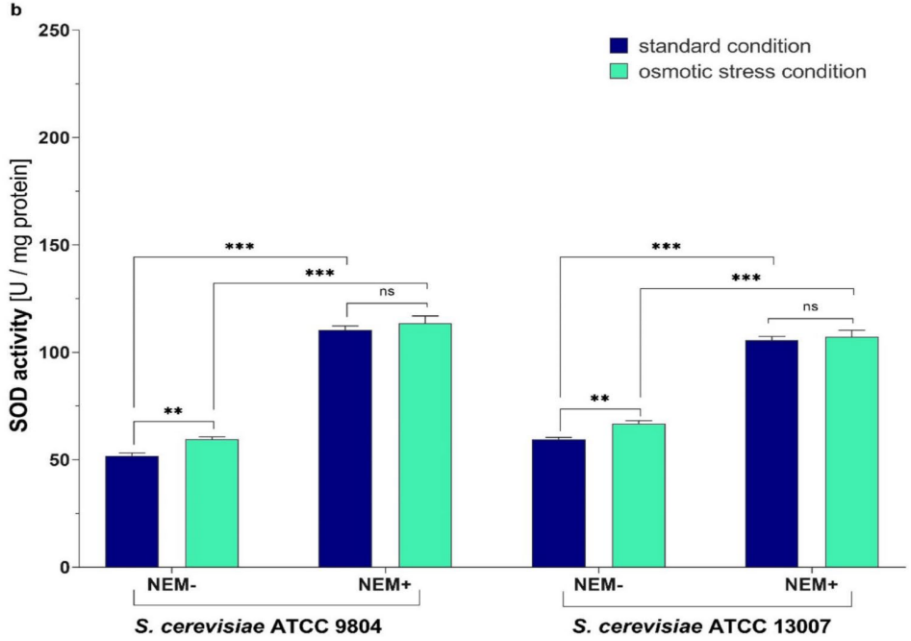
SOD activity in yeasts





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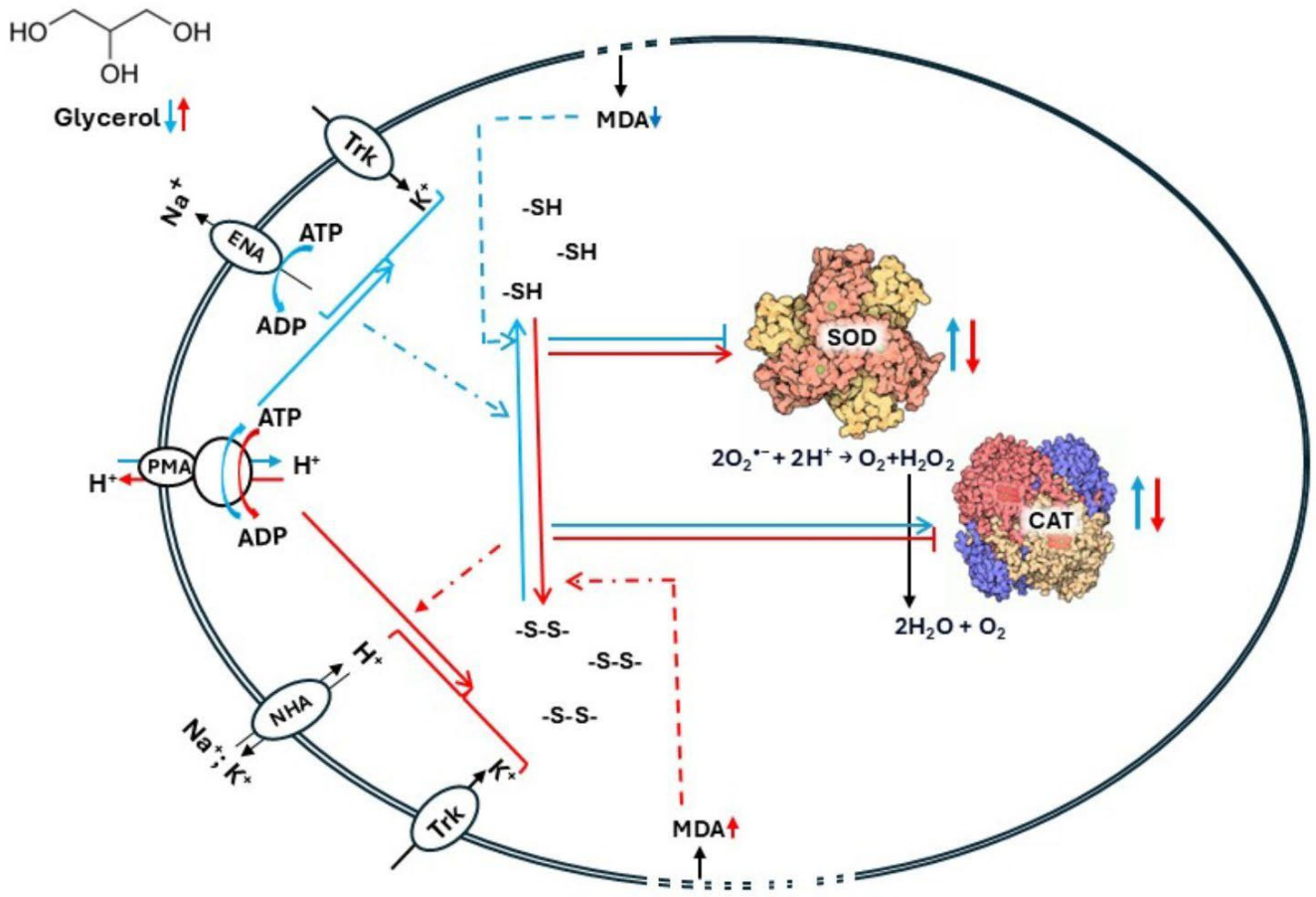
Sci Rep **14**, 23982 (2024).

Schematic working model suggested for th yeasts



Shirvanyan, A., Trchounian, K.
Sci Rep **14**, 23982 (2024).

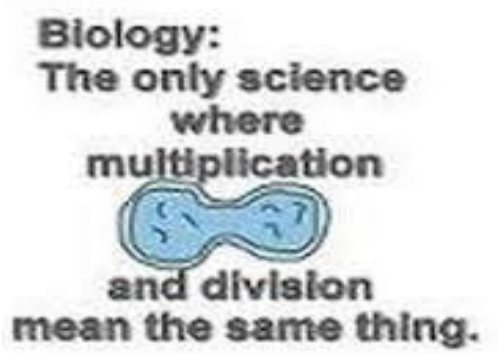
Questions to think for and revisit

- **Do we know much about adding glucose as media component for cell growth or?**
- **Are the main principles during respiration applicable for fermentation? Is it possible to apply the classical bioenergetics knowledge for anaerobic fermentative conditions?**

- **Anaerobic hydrogenases are mimicking aerobic respiratory complexes?**
- **Bacteria and yeast have similar ion gradient regulatory mechanisms for pH homeostasis?**

Dr. Heghine Gevorgyan
Dr. Liana Vanyan
Dr. Anahit Shirvanyan
Lilit Grigoryan

Prof. Anna Poladyan, YSU
Prof. Gary Sawers, MLU



Higher Education and Science Committee grants, Armenia