

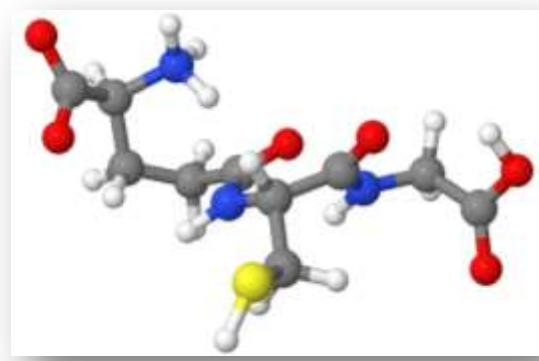
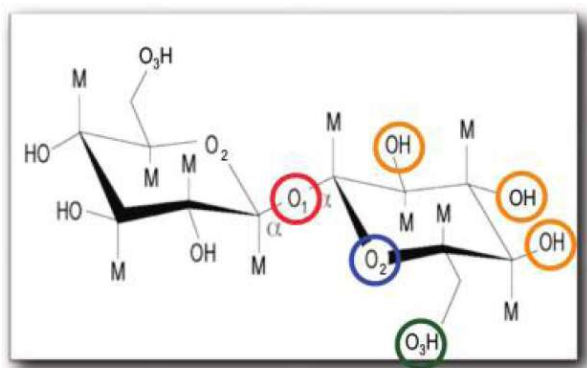





Hydration of Trehalose and Glutathione

Maria Antonietta Ricci

-  E. Scoppola
-  F. Bruni
-  S. E. Pagnotta
-  S. E. McLain
-  A. K. Soper

Roma Tre Italy
 Roma Tre Italy
 CSIC/UPV Spain/Roma Tre Italy
 Oxford University UK
 STFC-ISIS facility UK



-  Experimental method
-  Results
-  Perspectives



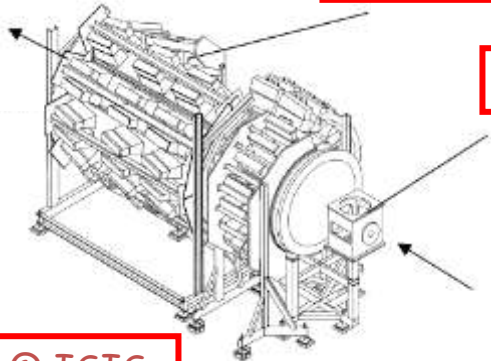
Experimental method

neutrons out

detectors

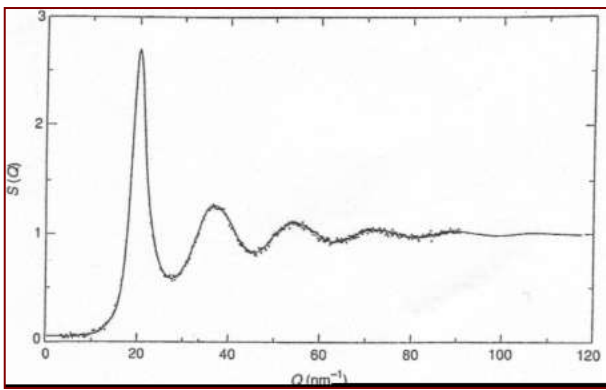
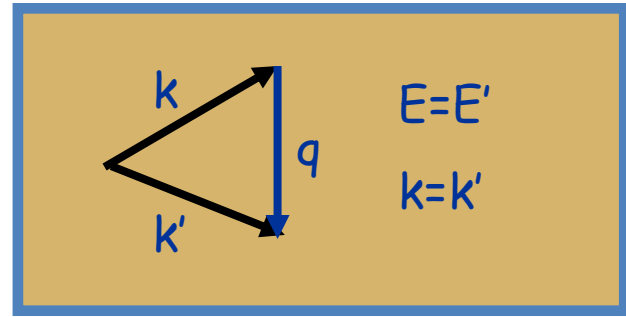
sample

neutrons in



SANDALS @ ISIS

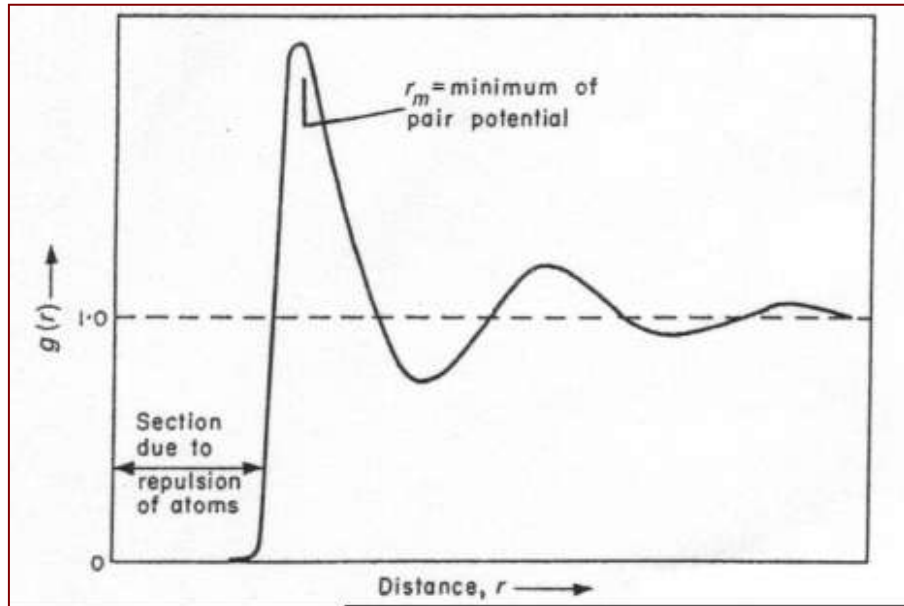
$$q = 2\frac{2\pi}{\lambda_e} \sin(\theta/2) \text{ with } \lambda_e = \frac{2\pi\hbar}{m(L_0+L_1)t}$$





Experimental method

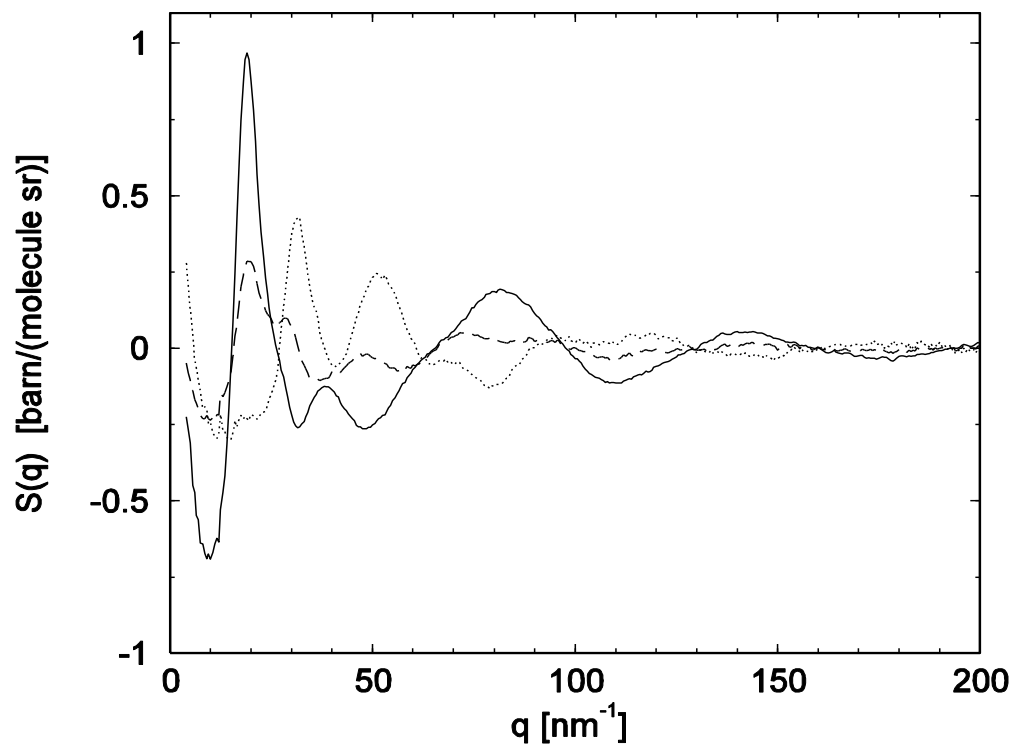
$$S(q) = 1 + \rho \int d^3r e^{i\vec{q} \times \vec{r}} [g(r) - 1]$$



$$n_{\alpha}^{\beta}(r) = 4\pi c_{\beta} \rho \int_{r_1}^{r_2} g_{\alpha\beta}(r) r^2 dr.$$



 Experimental method



$$F(Q) = \sum_{\alpha} \sum_{\beta \geq \alpha} w_{\alpha\beta} (S_{\alpha\beta}(Q) - 1)$$

$$Q = \frac{4\pi}{\lambda} \sin\theta$$

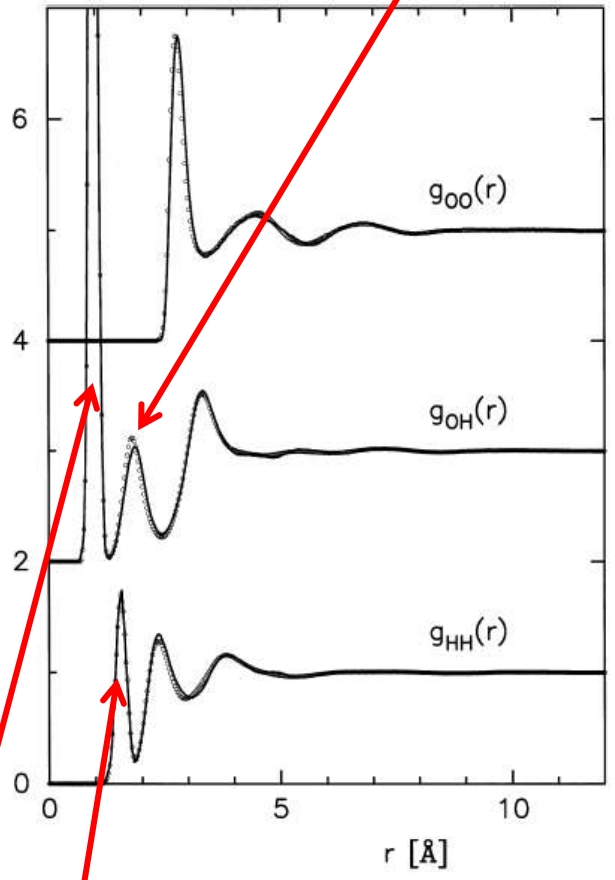
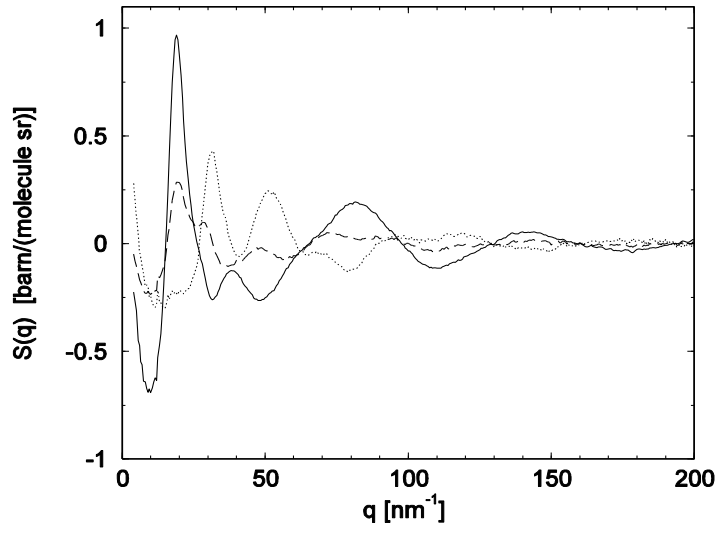
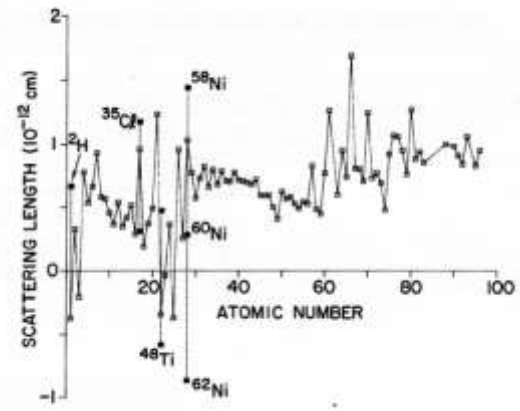
$$w_{\alpha\beta} = c_{\alpha} c_{\beta} b_{\alpha} b_{\beta} (2 - \delta_{\alpha\beta})$$

$$(S_{\alpha\beta}(Q) - 1) = 4\pi\rho \int_0^{\infty} r^2 (g_{\alpha\beta}(r) - 1) \frac{\sin(Qr)}{Qr} dr$$



Experimental method

H-bond peak @ 1.8 Å

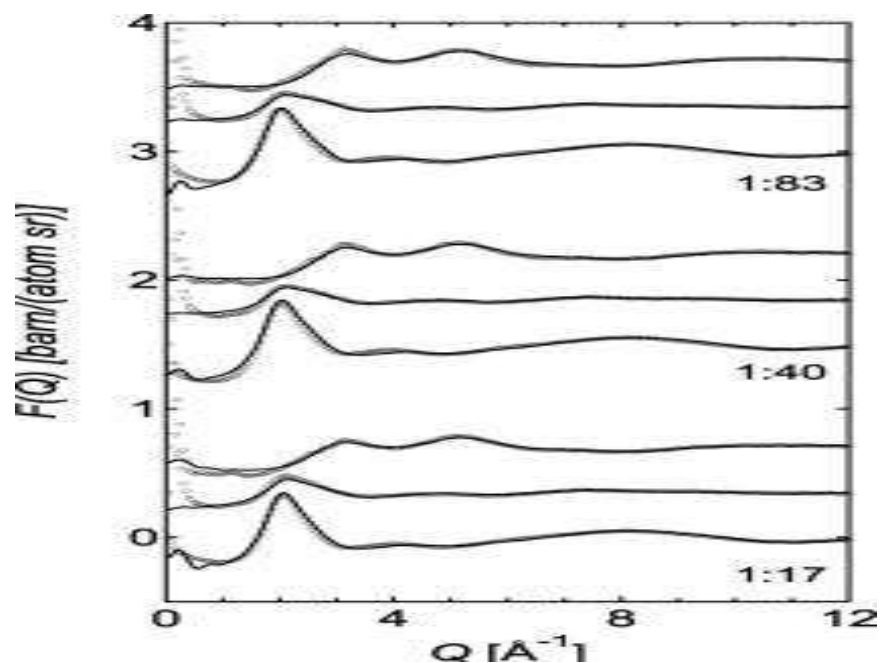
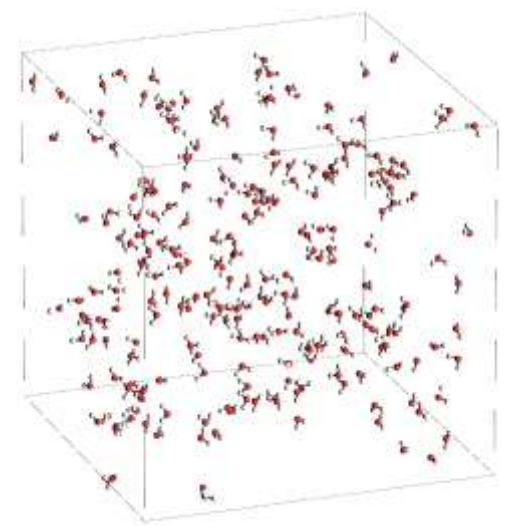
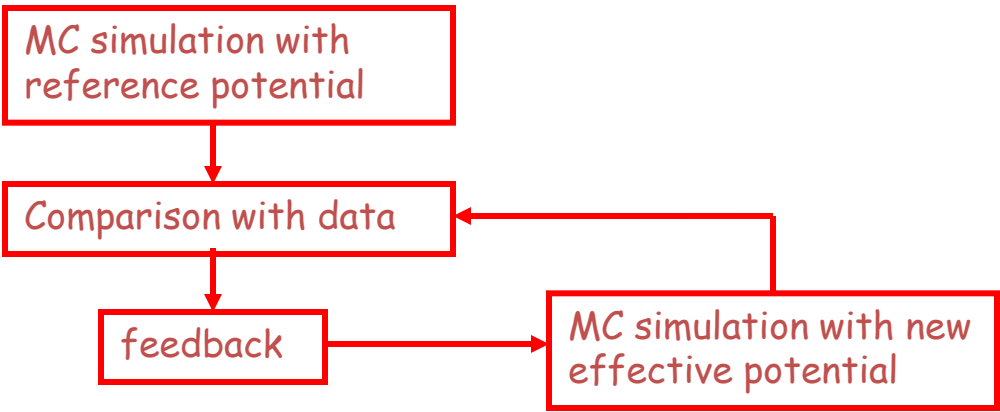


Intra-molecular peaks



Experimental method

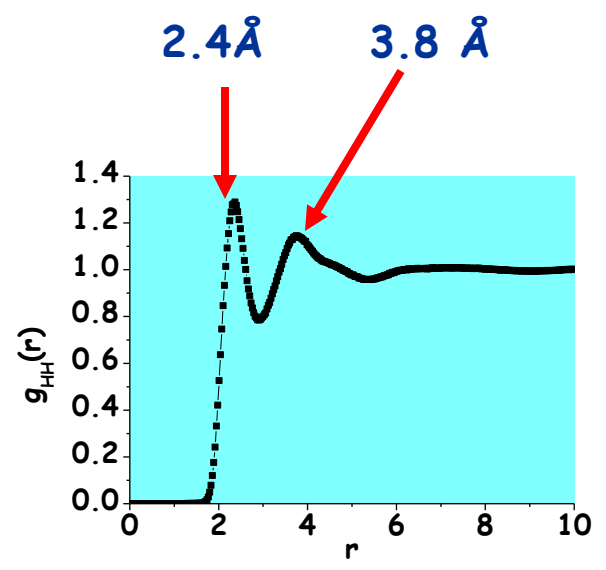
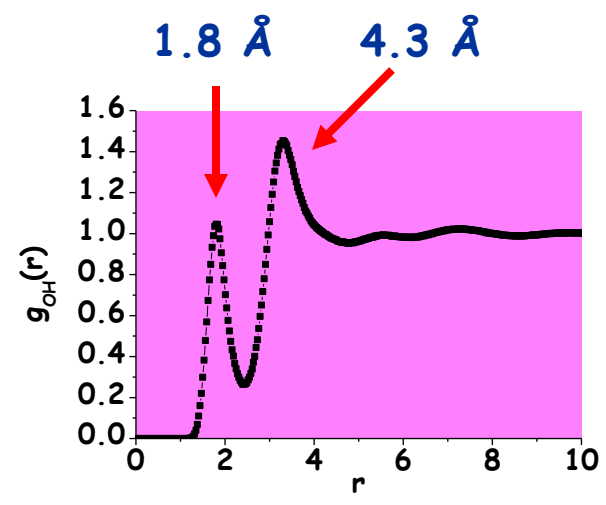
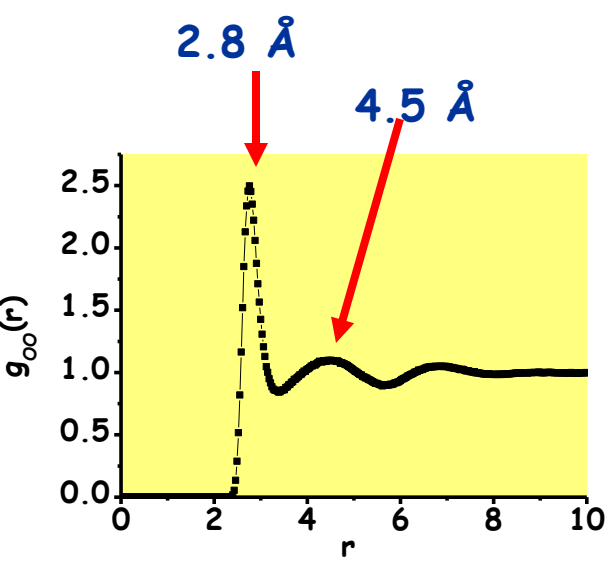
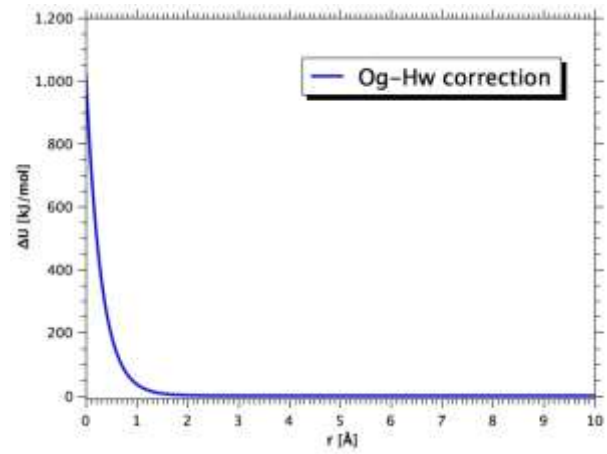
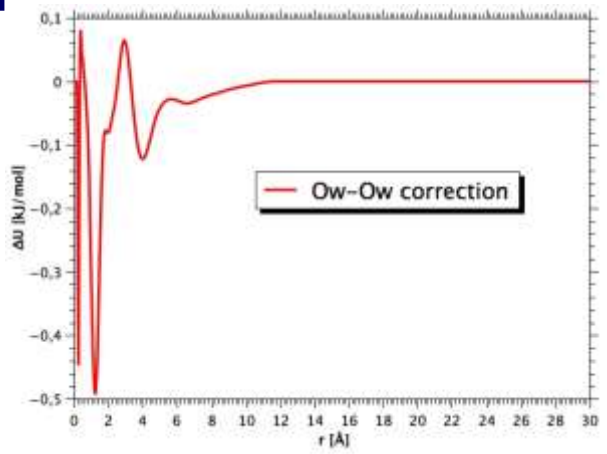
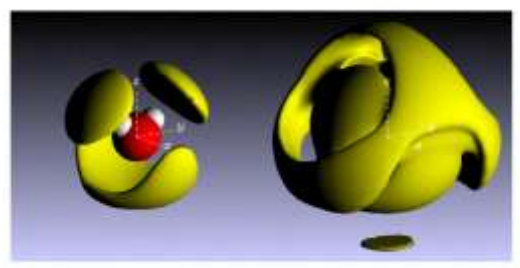
EPSR Monte Carlo Simulation



A. K. Soper, *Chem. Phys.* **202**, 295 (1996).
 A. K. Soper, *Chem. Phys.* **258**, 121 (2000).
 A. K. Soper, *Mol. Phys.* **99**, 1503 (2001).



Experimental method



Results

- How does water interact with the molecule of interest?
- Does water form H-bonds at specific sites?

Trehalose / water

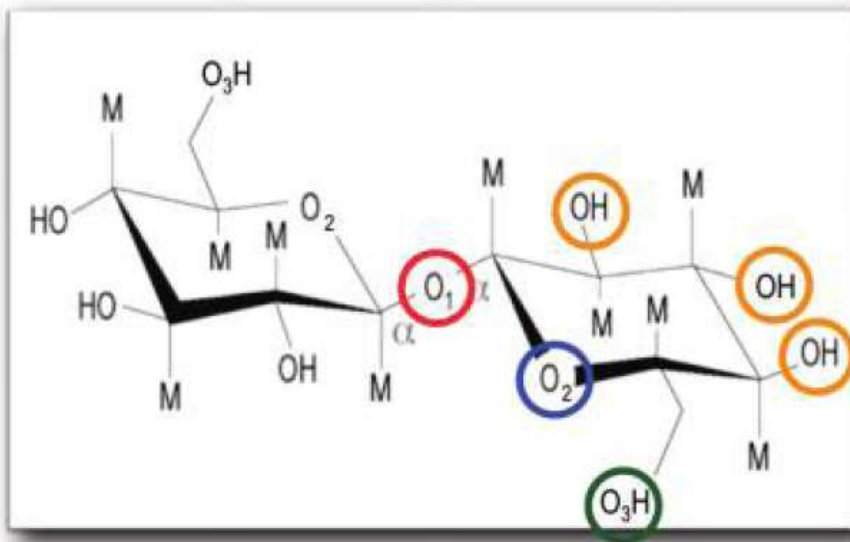


TABLE 1: Sample Density, Simulation Box Size, and Number of Water and Trehalose Molecules in the Simulation Box for the Two Samples Examined

sample	density (atoms/Å ³)	L _{box} (Å)	H ₂ O	trehalose
1:25	0.025	27.37	500	20
1:100	0.030	32.21	1000	10

TABLE 2: Parameters of the Lennard-Jones Potential and Fractional Charges Used in the Reference Potential Model, U_{ref}, to Start the EPSR Simulations

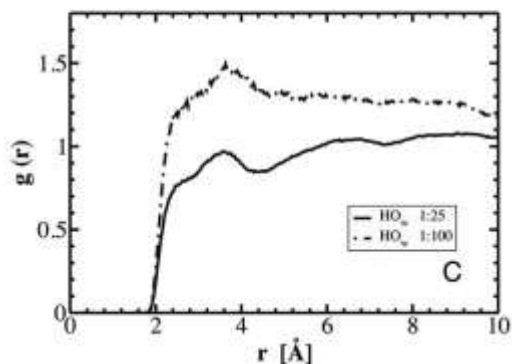
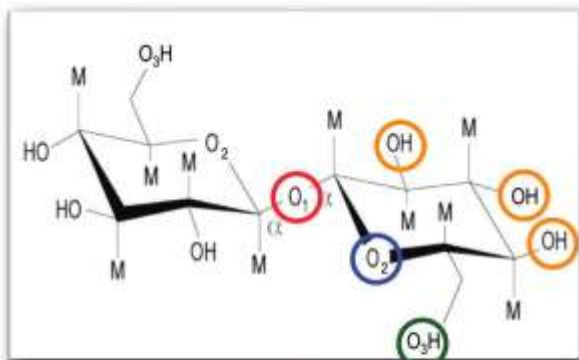
atom	ε (kJ/mol)	σ (Å)	q (e)
O _w	0.65	3.166	-0.8476
H _w	0.0	0.0	0.4238
O ₁	0.58576	2.9	-0.5
O ₂	0.58576	2.9	-0.5
O ₃	0.71128	3.1	-0.5
O	0.71128	3.1	-0.5
H	0.05	1.7	0.3005
M	0.12552	1.7	0.0
C	0.27614	3.5	0.258

S. E. Pagnotta,[†] S. E. McLain,[‡] A. K. Soper,^{¶,§} F. Bruni,^{*,||} and M. A. Ricci^{||}

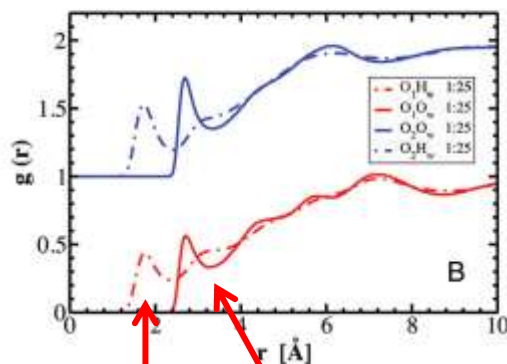
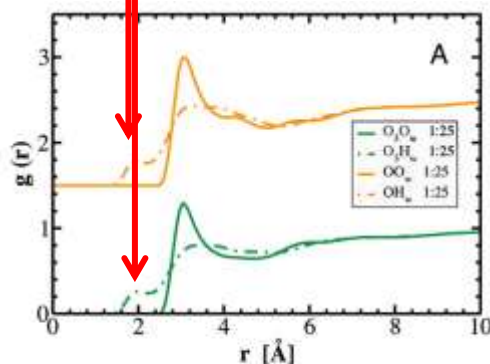
J. Phys. Chem. B 2010, 114, 4904–4908

Results

Trehalose / water



$\sim 1.97 \div 1.98 \text{ \AA}$



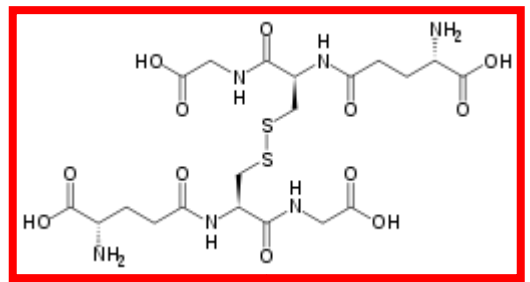
$\sim 1.74 \text{ \AA} \quad \sim 2.7 \text{ \AA}$

- The total number of water molecules within a distance of 4 Å is high.
- H-bonding at O₁ and O₂ sites → ~ 2 ÷ 3 strongly bonded water molecules (internal).
- Weak H-bonding at the O and O₃ sites → 1 water molecule at one of the O₃ sites and 2 water molecules in total at the O sites.
- No clear indication of H-bonding at the H sites.

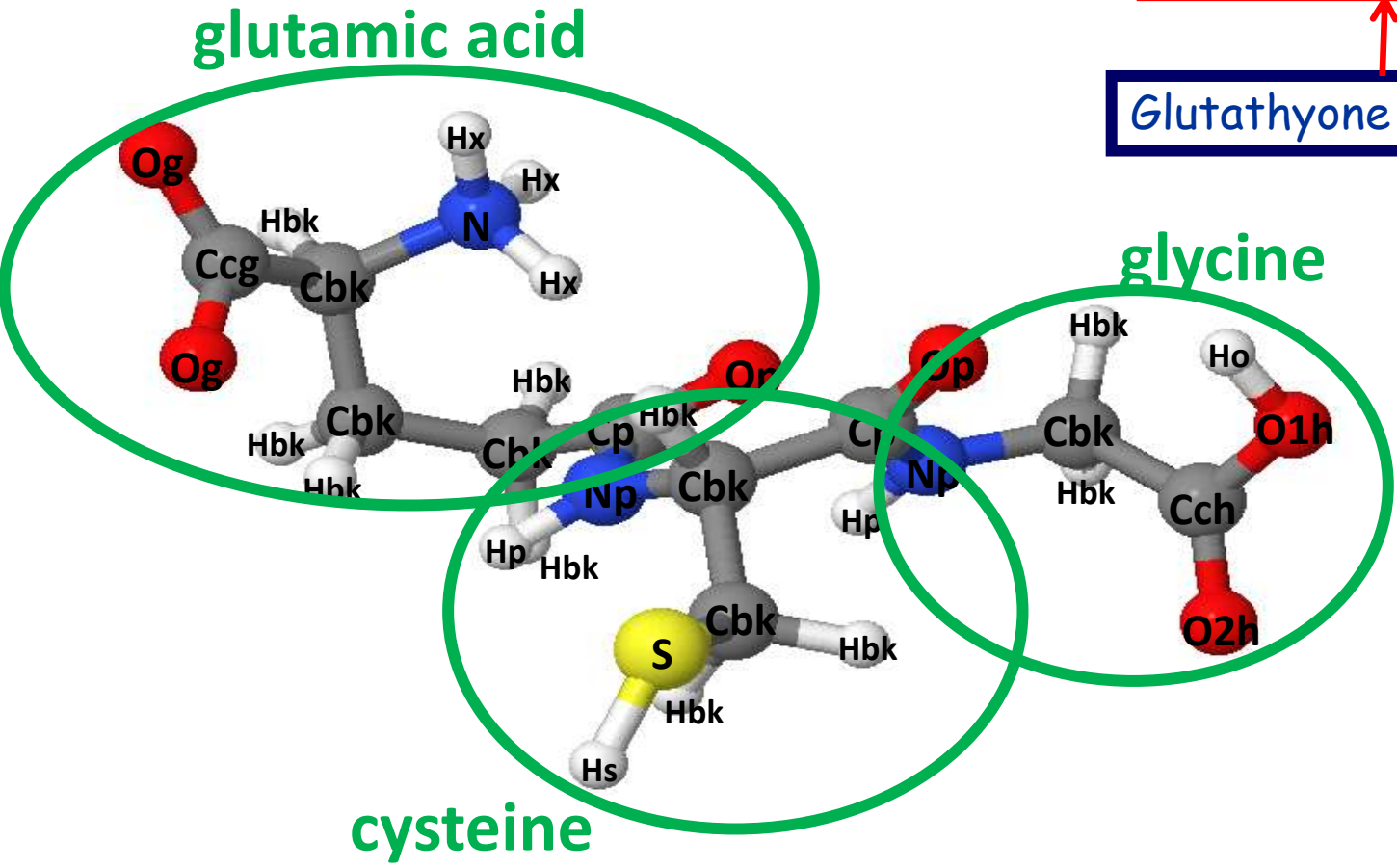
Shorter bond → stronger
Longer bond → weaker

Results

Glutathione / water



Glutathione disulfide



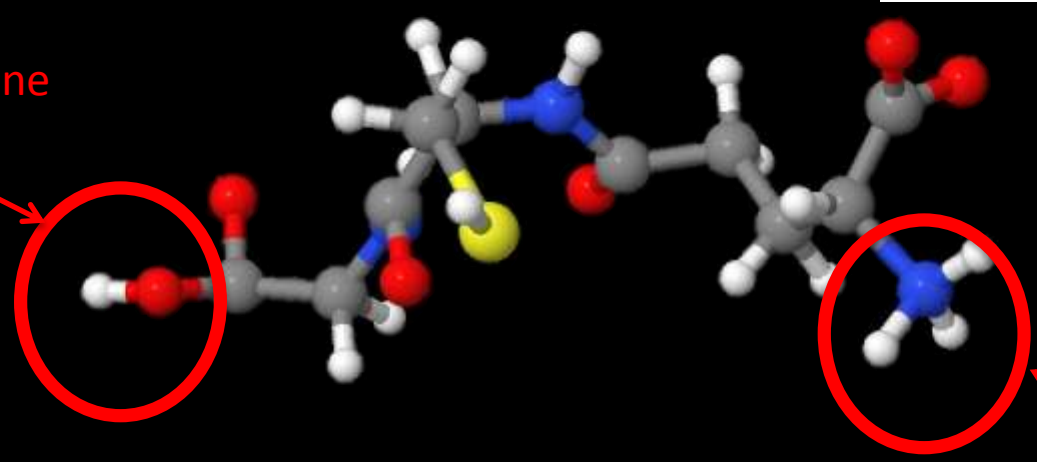
glutamic acid

glycine

cysteine

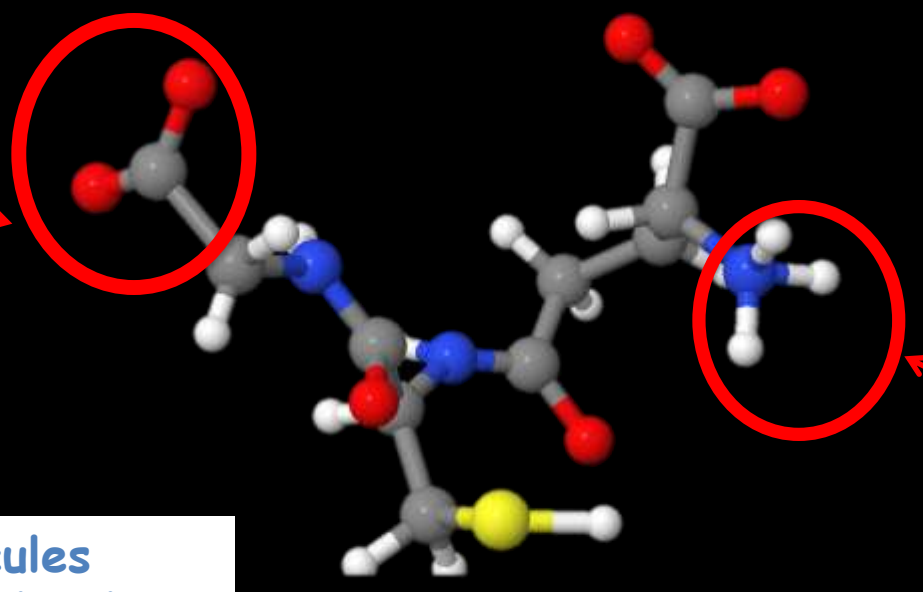
Hydrogen at the glycine side

70%



No hydrogen at the glycine side

30%

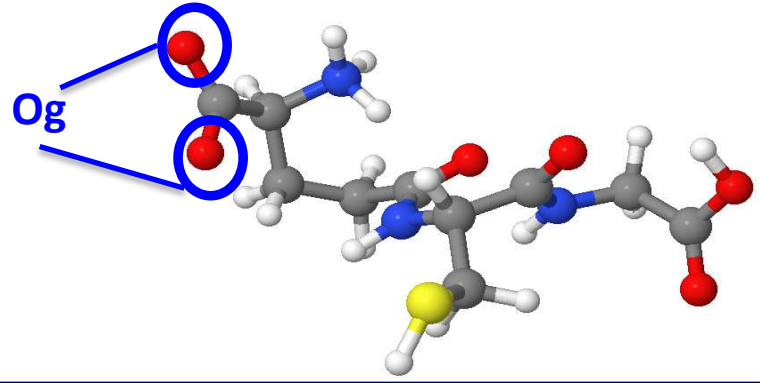
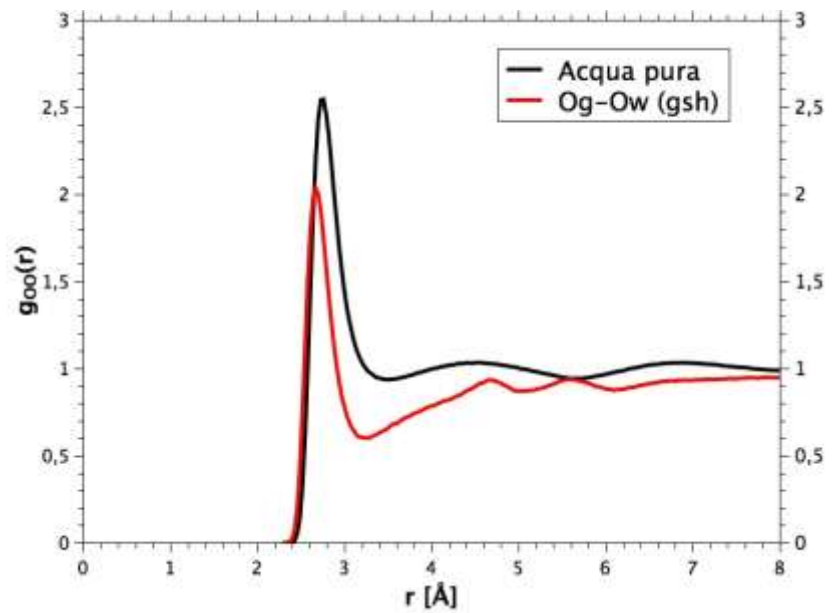


6600 water molecules
50 glutathione molecules

NOME	CARICA UNITARIA	EPSILON (kJ/mol)	SIGMA (Å)
Og	-0.8	0.87864	2.96
O1	-0.5	0.87864	2.96
O2	-0.5	0.87864	2.96
Op	-0.8	0.87864	2.96
Np	-0.57	0.71128	3.25
Hx	0.33	0	0
Ho	0.3	0	0
Hs	0.27	0	0
S	-0.45	1.046	3.55
N	-0.3	0.71128	3.25
Cbk	0.3	0.4142	3.8
Cc	0.18	0.43932	3.75
Ccg	0.7	0.43932	3.75
Cp	0.7	0.43932	3.75
Hbk	0	0	0
Hp	0.225	0	0
O1h	-0.5	0.87864	2.96
O2h	-0.5	0.87864	2.96
Cch	0.18	0.43932	3.75

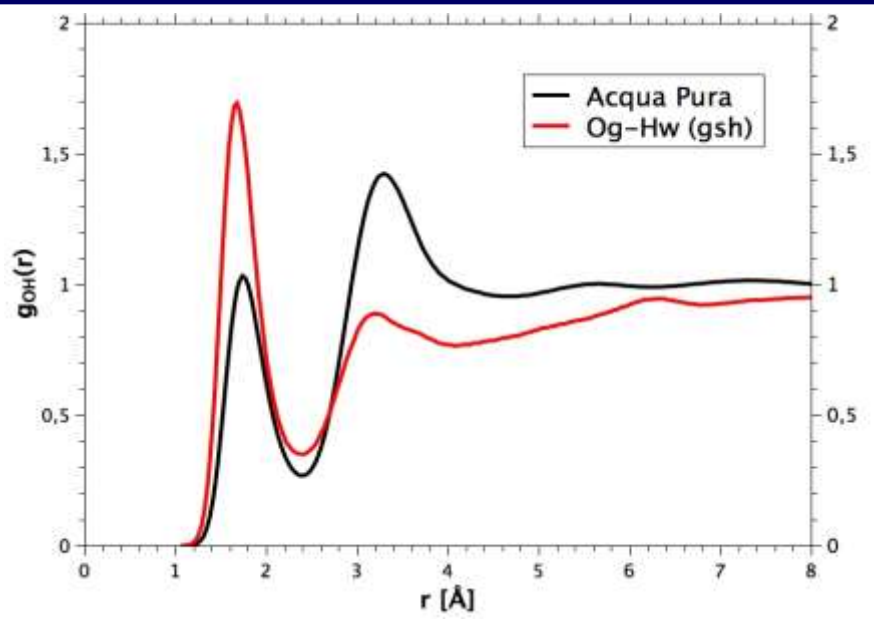
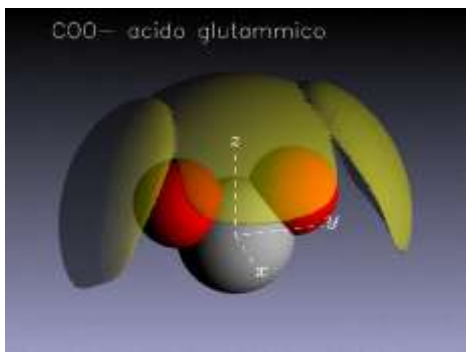
Results

Glutamic acid / carbossilic group - water



H-bond shorter than water-water

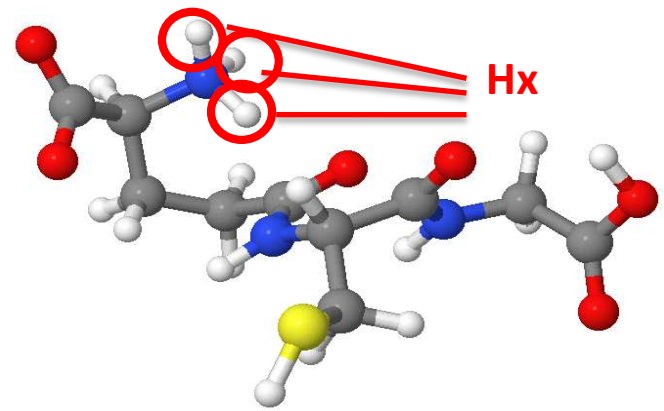
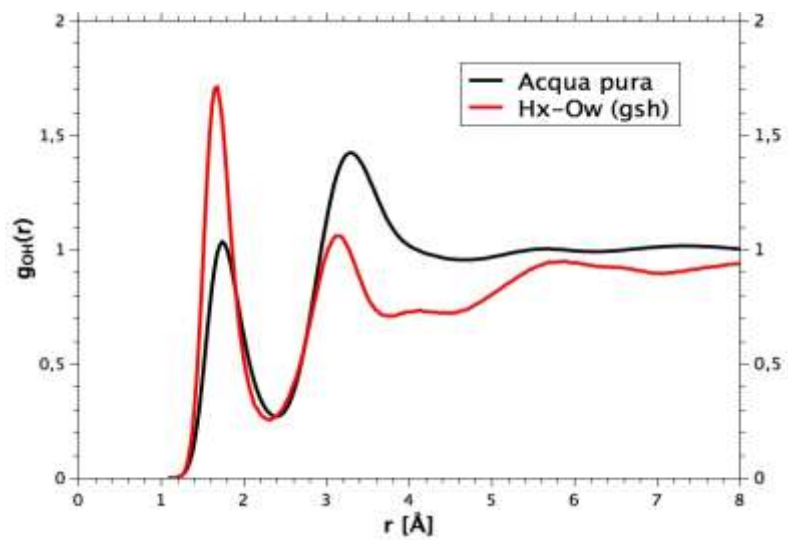
$n_{\text{Hbond}} \sim \text{water}$



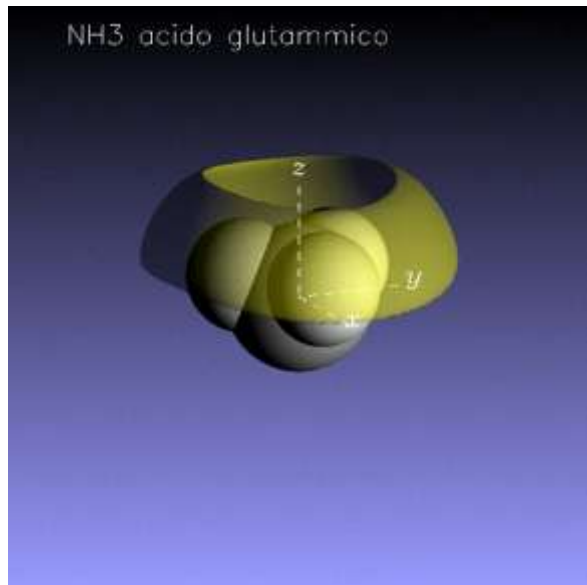


Results

Glutamic acid / aminic group - water



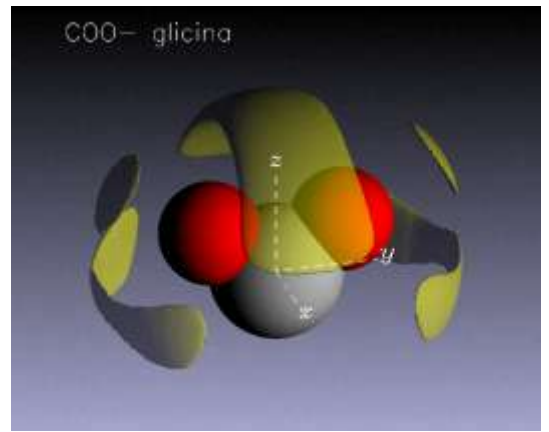
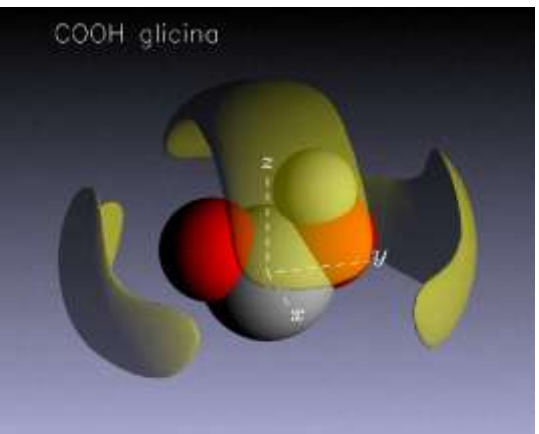
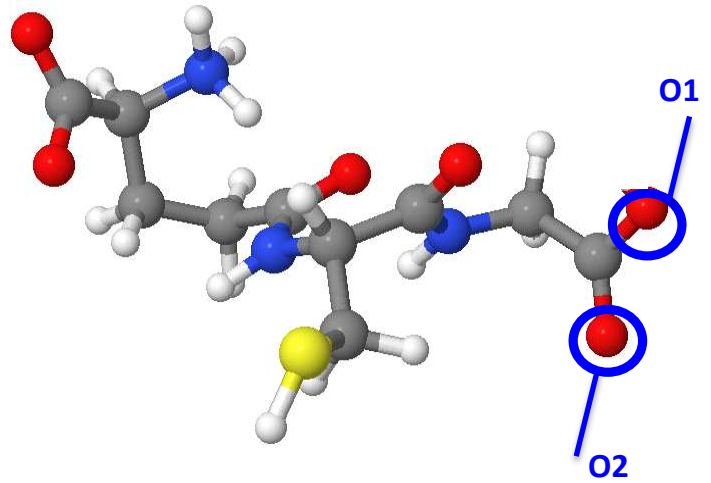
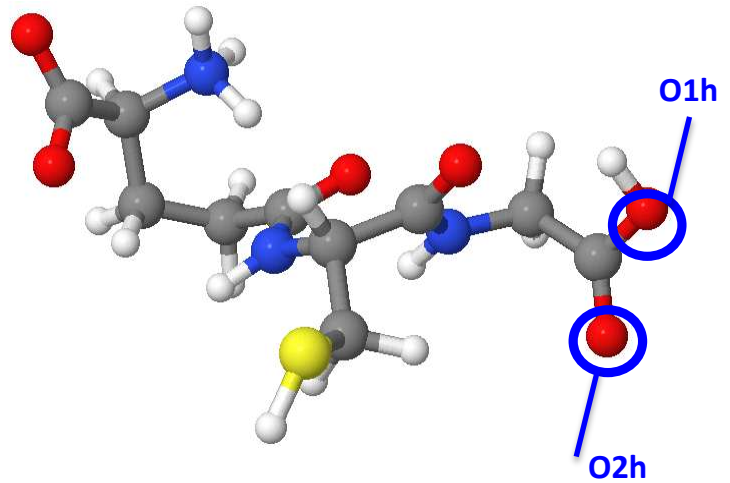
- H-bond shorter than water-water
- $n_{\text{Hbond}} \sim 1$



Results

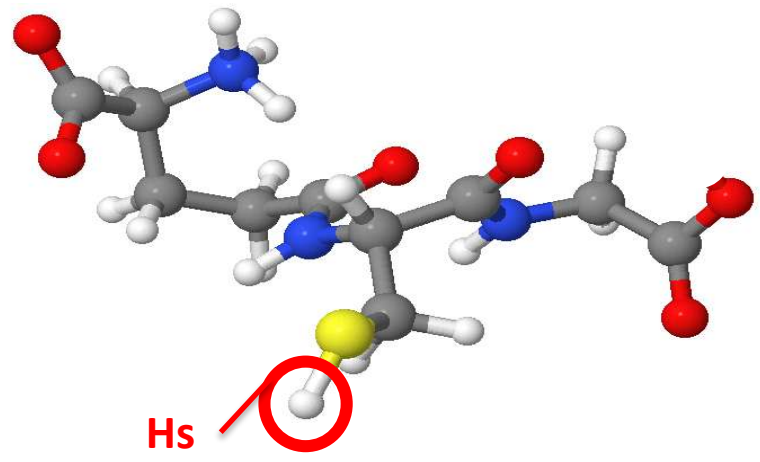
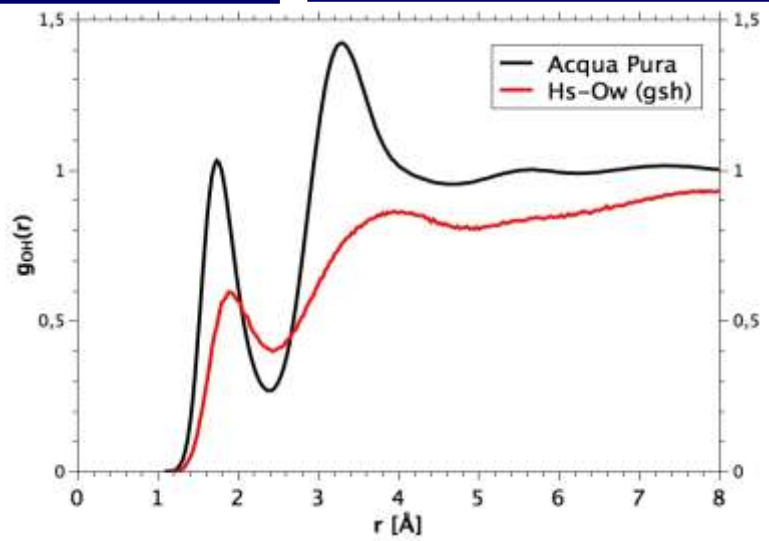
Glycine / carbossilic group - water

- H-bond shorter than water-water
- $n_{\text{Hbond}} \sim \text{water}$

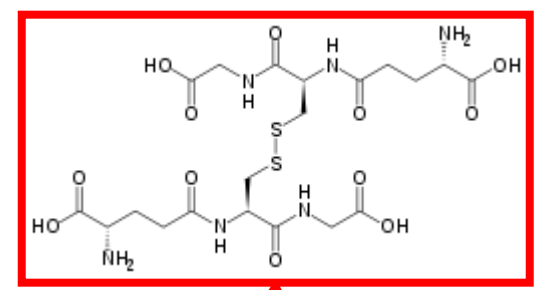


Results

Cysteine / SH group - water



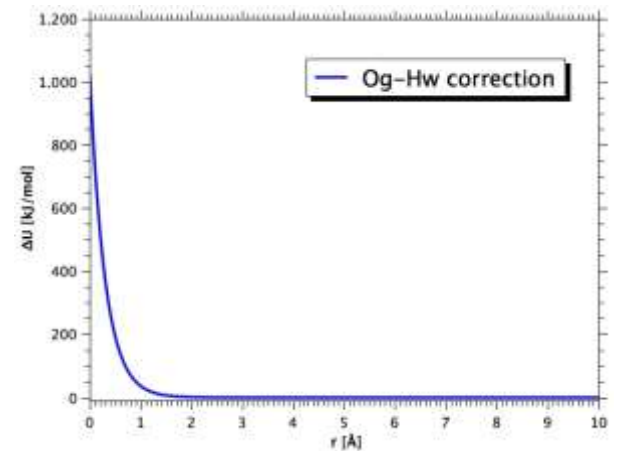
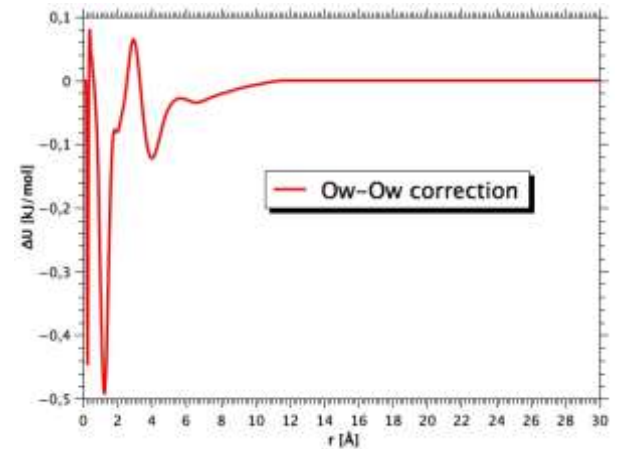
H-bond longer than water-water
 $n_{\text{Hbond}} \sim 0.6 \pm 0.5$
 The weakness of this H-bond is relevant to the glutathion function as antioxidant



Glutathione disulfide

Perspectives

- Studies of solutions of larger molecules will be possible in a near future.
- Studies of microemulsions and gelation phenomena are already in progress.
- The empirical potential may be used in molecular dynamics simulations.





Thank you for your attention

Funding Agency:
MIUR -Italy PRIN2008 WALTER
CNR - Italy