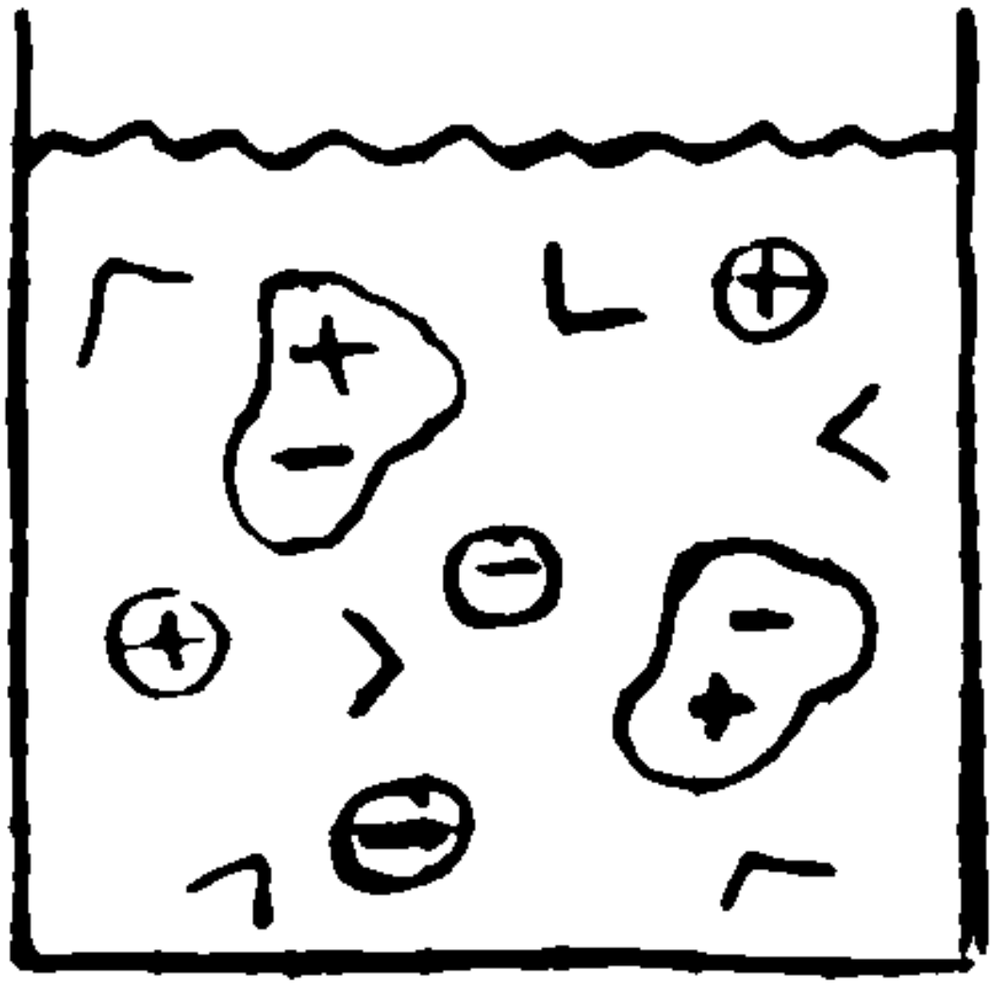
Mesoscopic Simulations of Many-body Protein Interactions

NSC'09, October 2009

Mikael Lund
Department of Theoretical Chemistry
Lund University

Proteins in aqueous salt solutions



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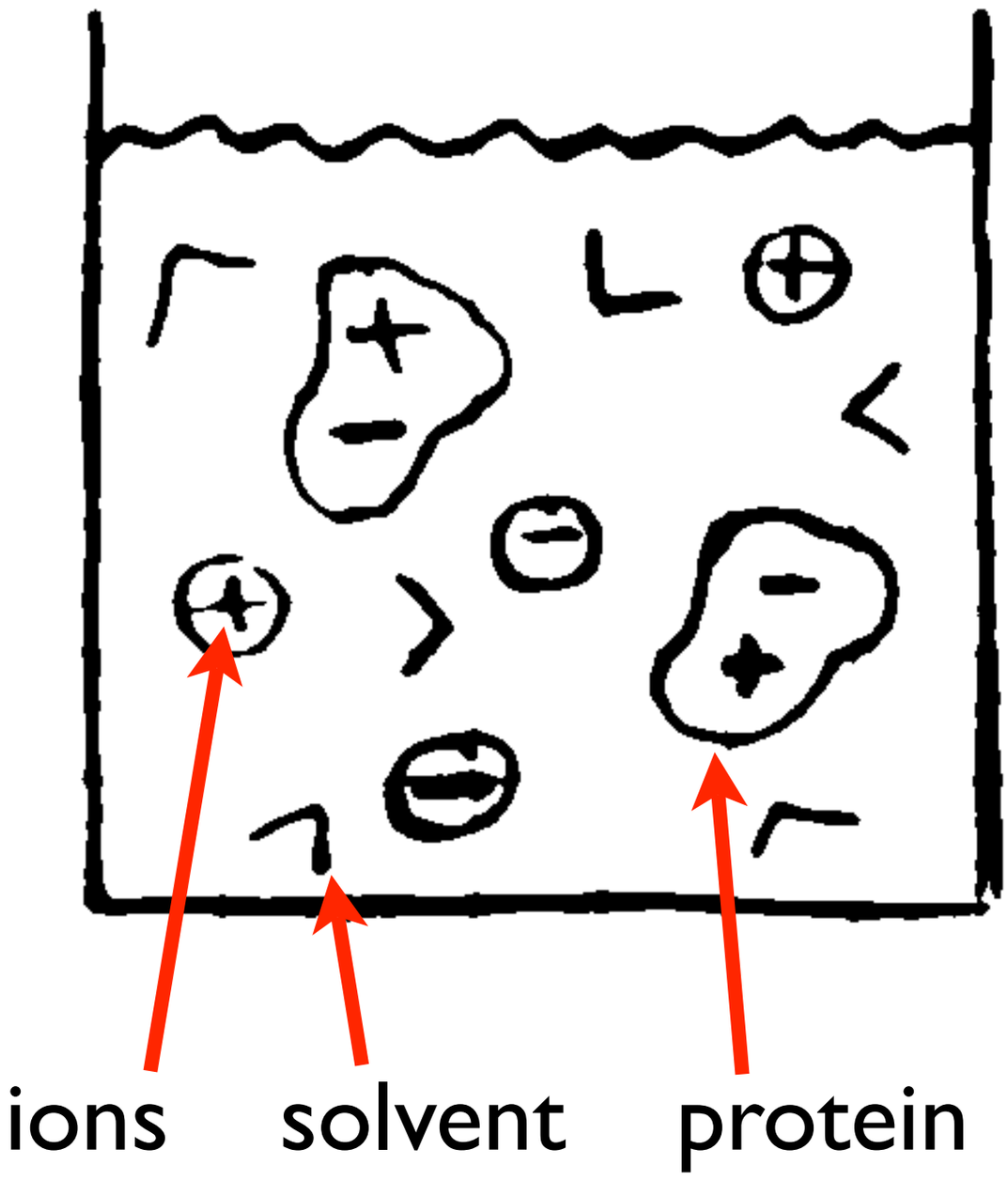

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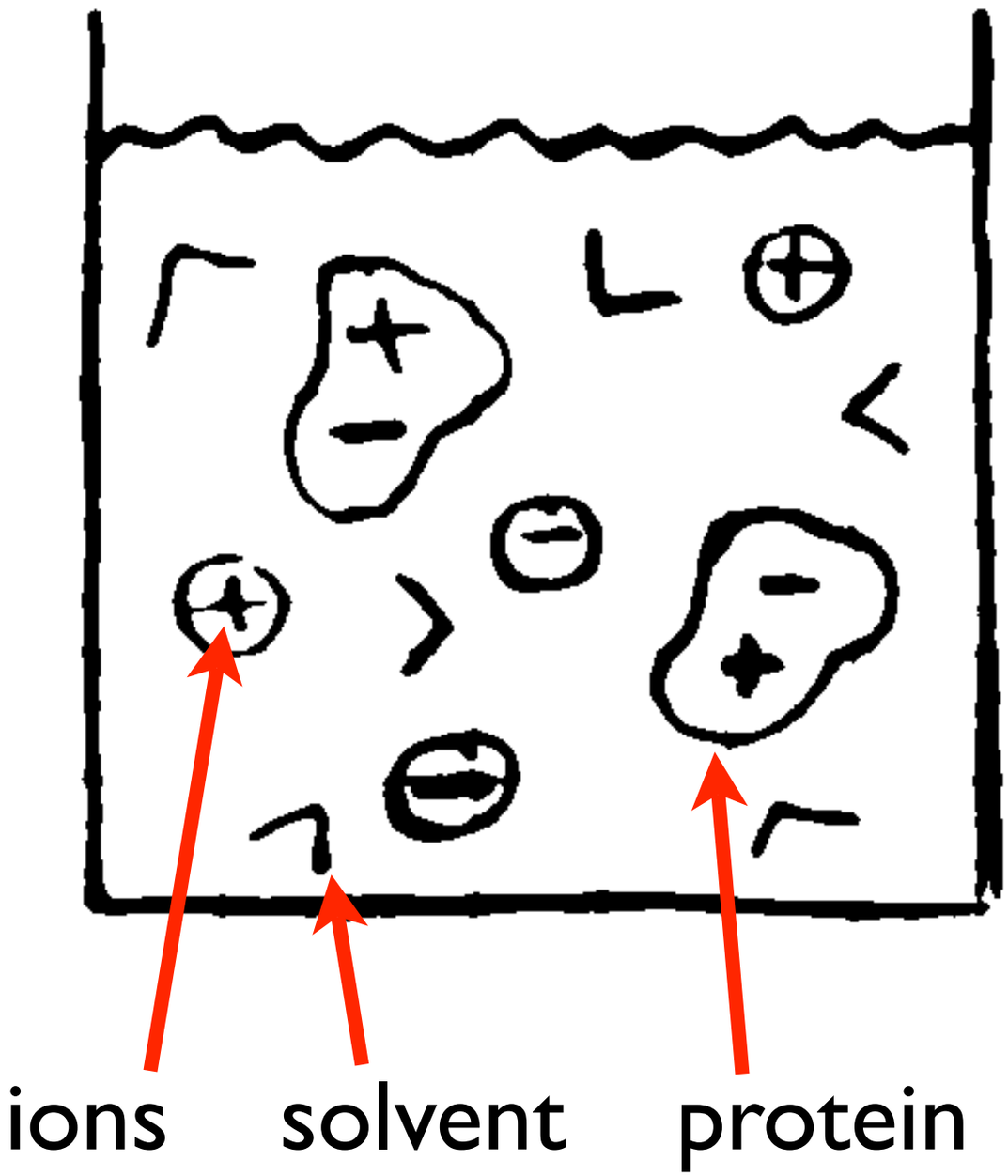
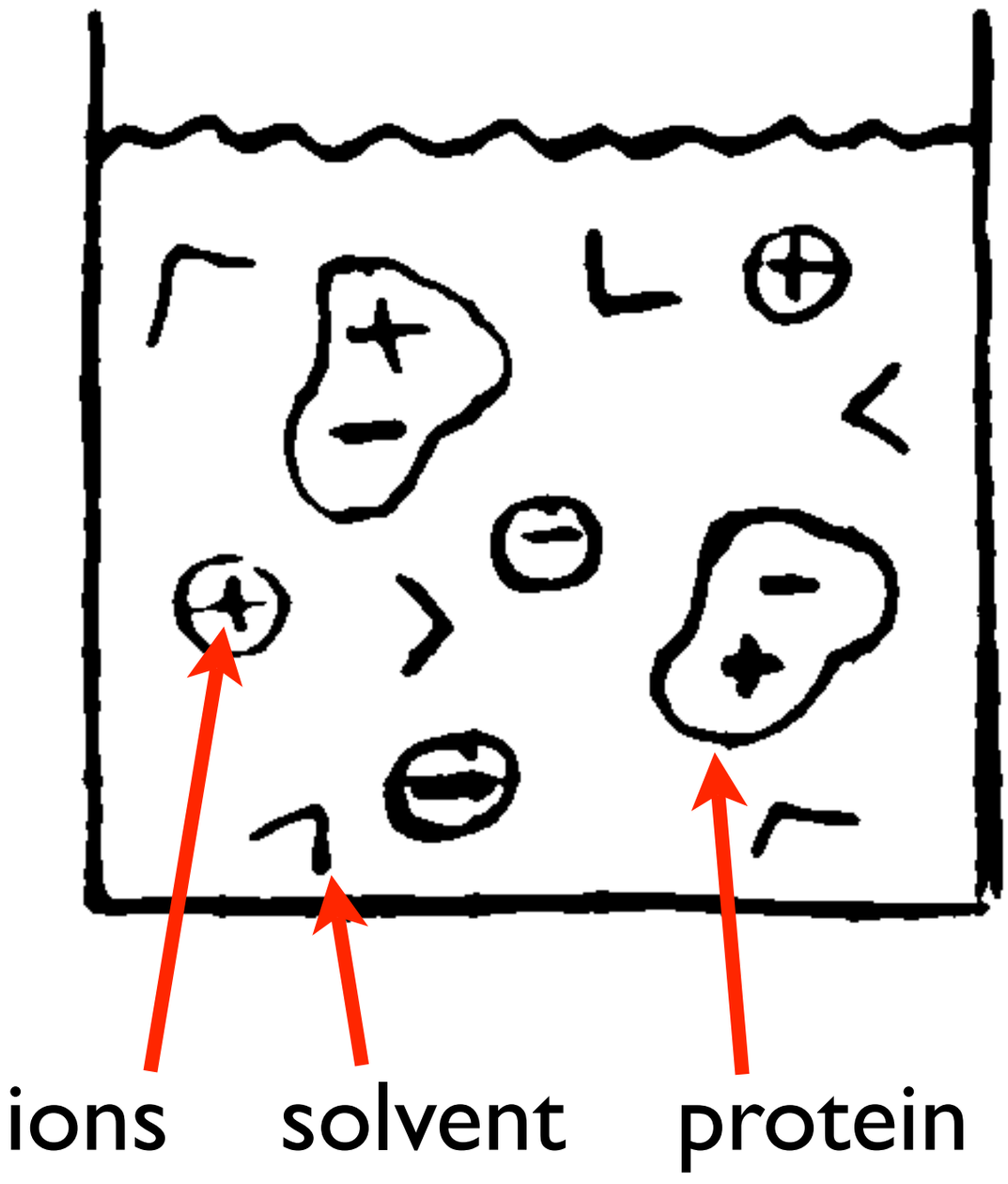


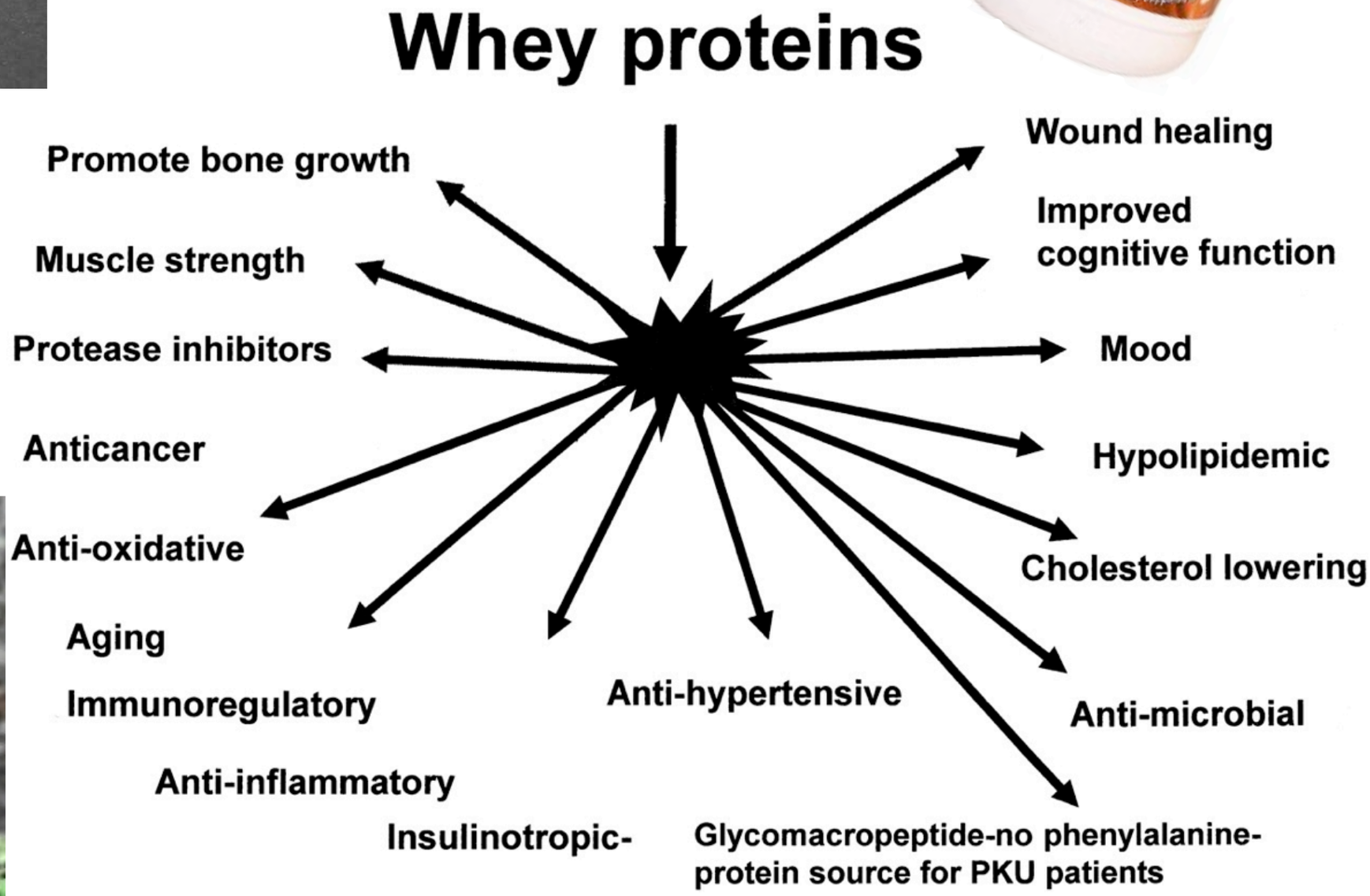
- Biological applications (strictly defined conditions)

Proteins in aqueous salt solutions



- Biological applications (strictly defined conditions)
- Technical applications (wider range of conditions)

beta-lactoglobulin (65%)
alpha-lactalbumin (25%)
Serum albumin (8%)



Milk↔Egg Interactions!

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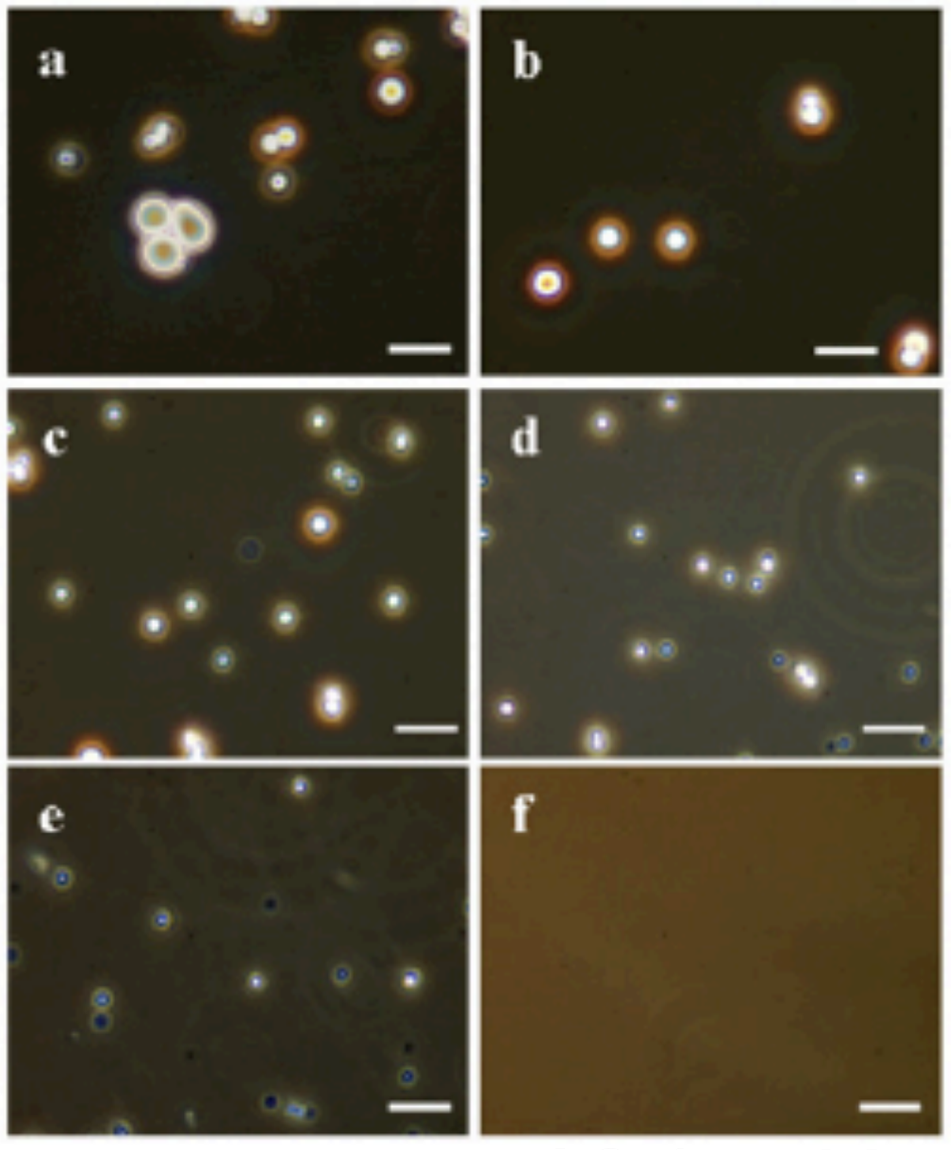
M. Nigen et al. / Food Hydrocolloids 23 (2009) 510–518

1:1 mixture of lysozyme and α-lactalbumin in salt solutions

4 mM



124 mM

Milk↔Egg Interactions!

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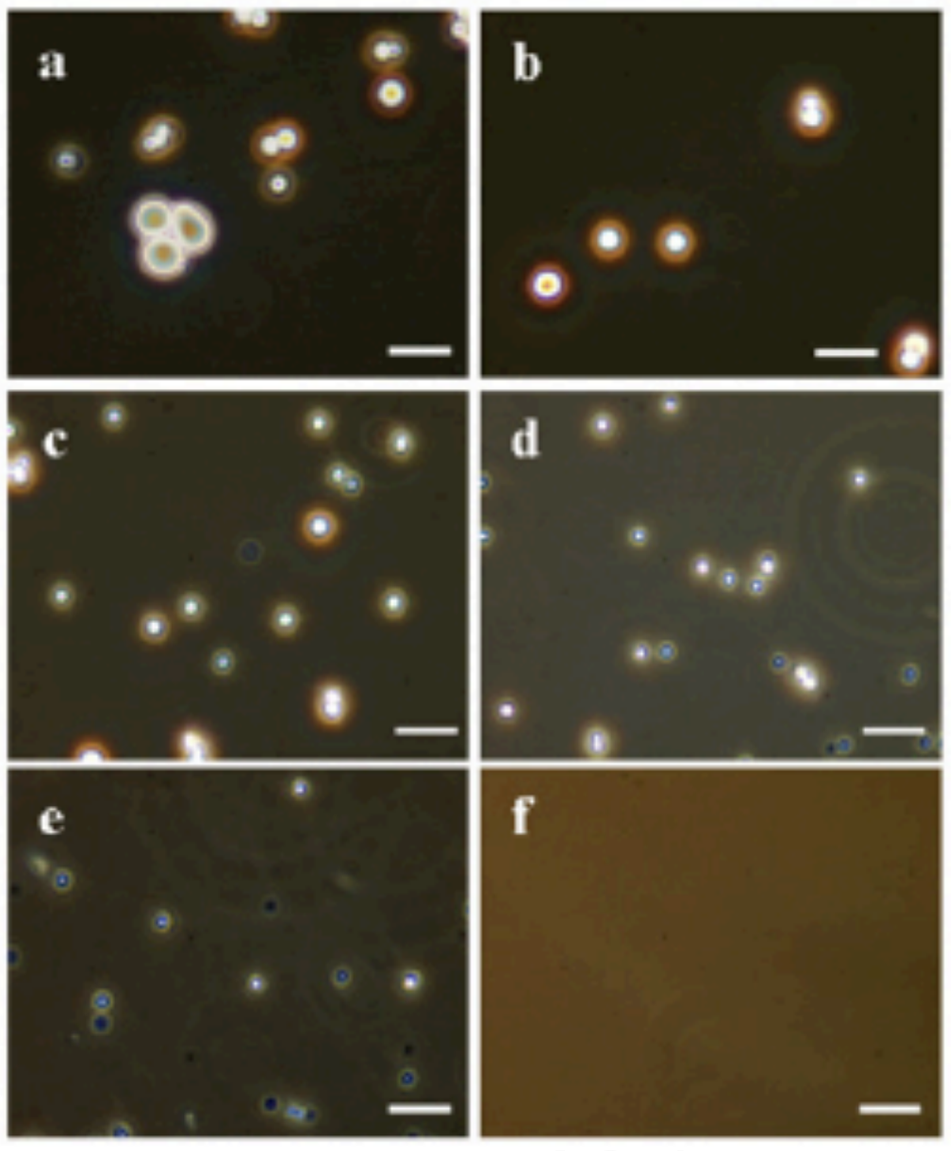
1:1 mixture of lysozyme and α-lactalbumin in salt solutions

Rich salt and pH specific behavior.

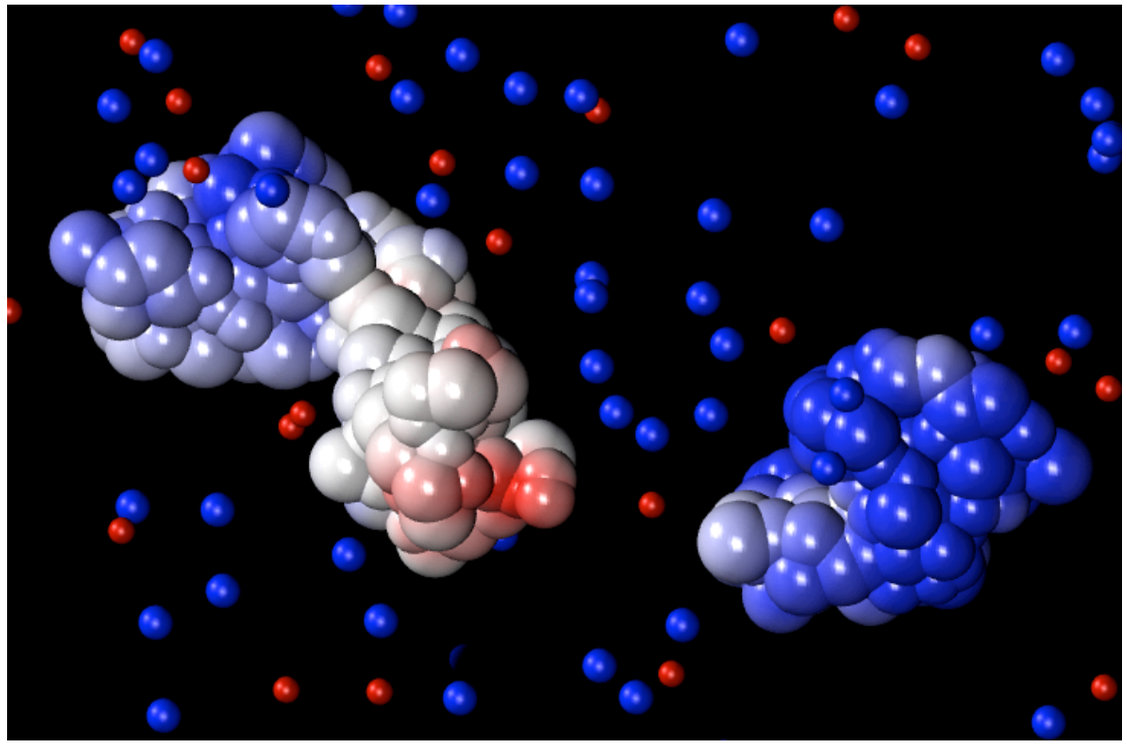
4 mM



124 mM

Model

- Two (or more) proteins:
  lys & αLac.
- Explicit salt
- Continuum solvent
- Metropolis MC, NVT



$$U = \sum_{i \neq j}^{N_{\text{all}}} \frac{e^2 q_i q_j}{4\pi\epsilon_0\epsilon_r r_{ij}} - \sum_{i}^{N_a} \sum_{j}^{N_b} C_{\text{vdW}} kT / r_{ij}^6 + hs$$

JPCB 2009, 113:10459

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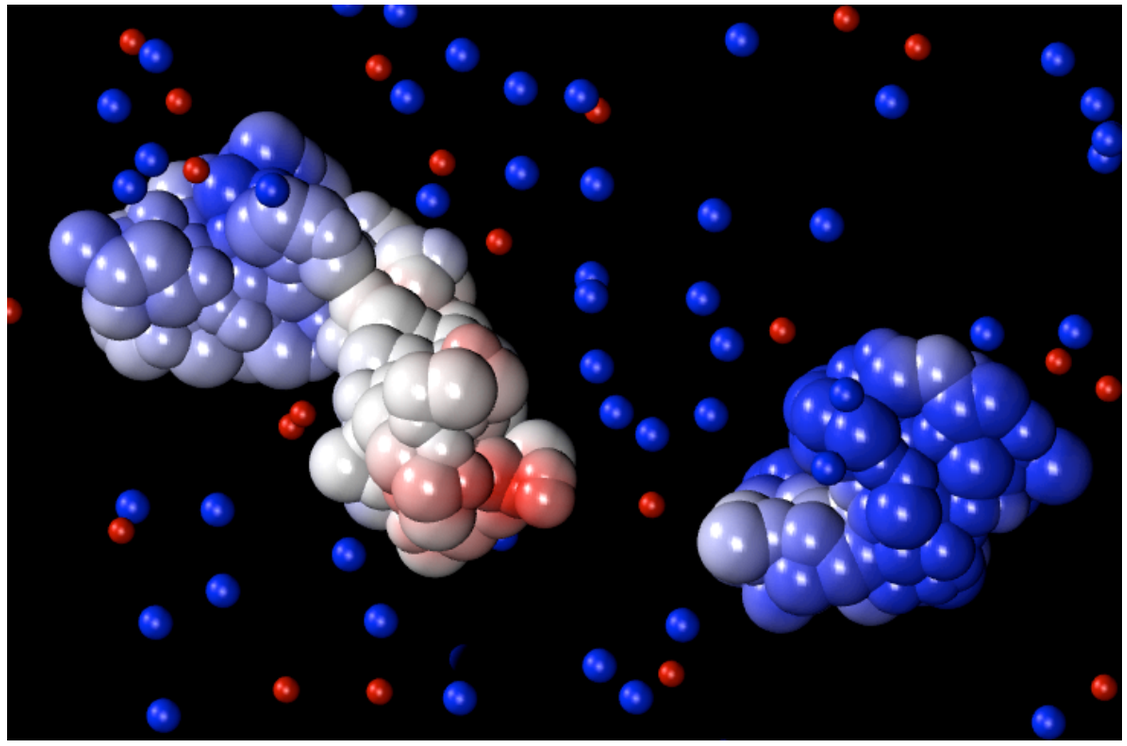

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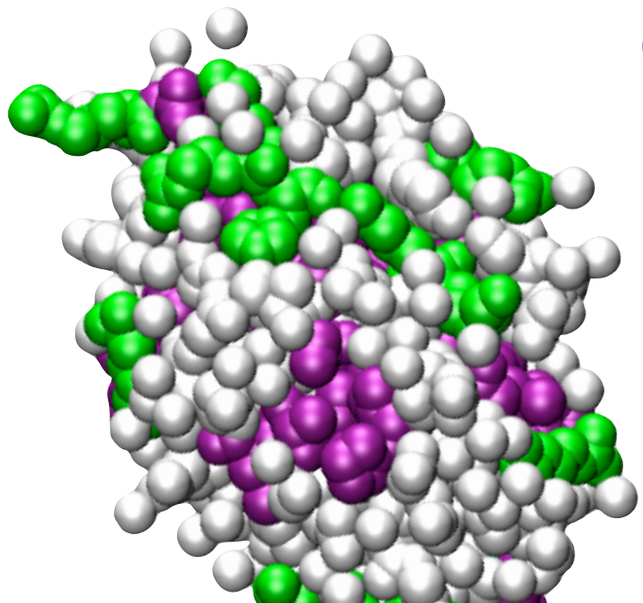

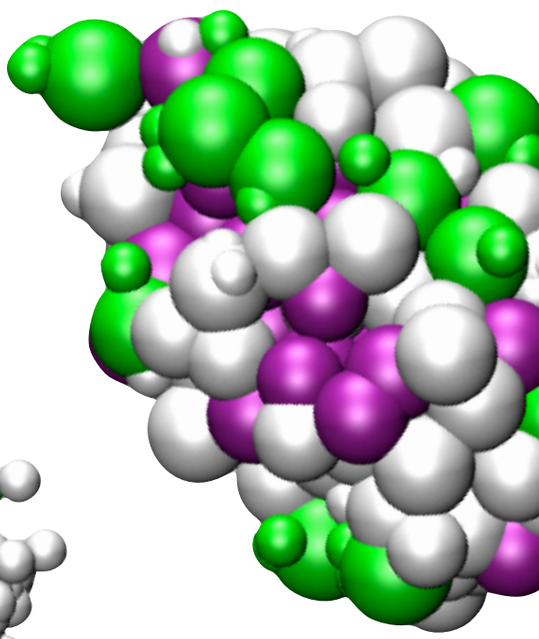

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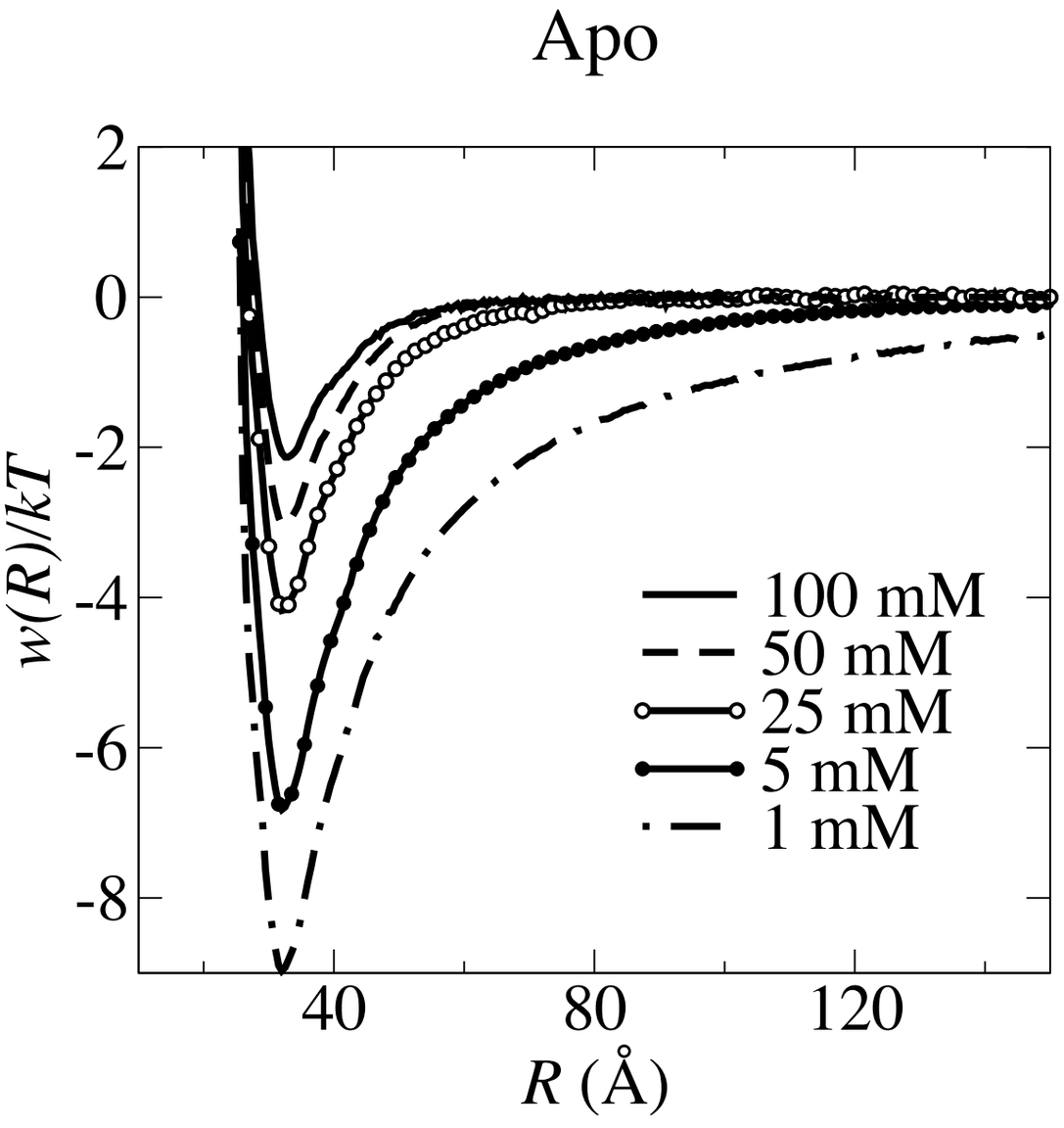
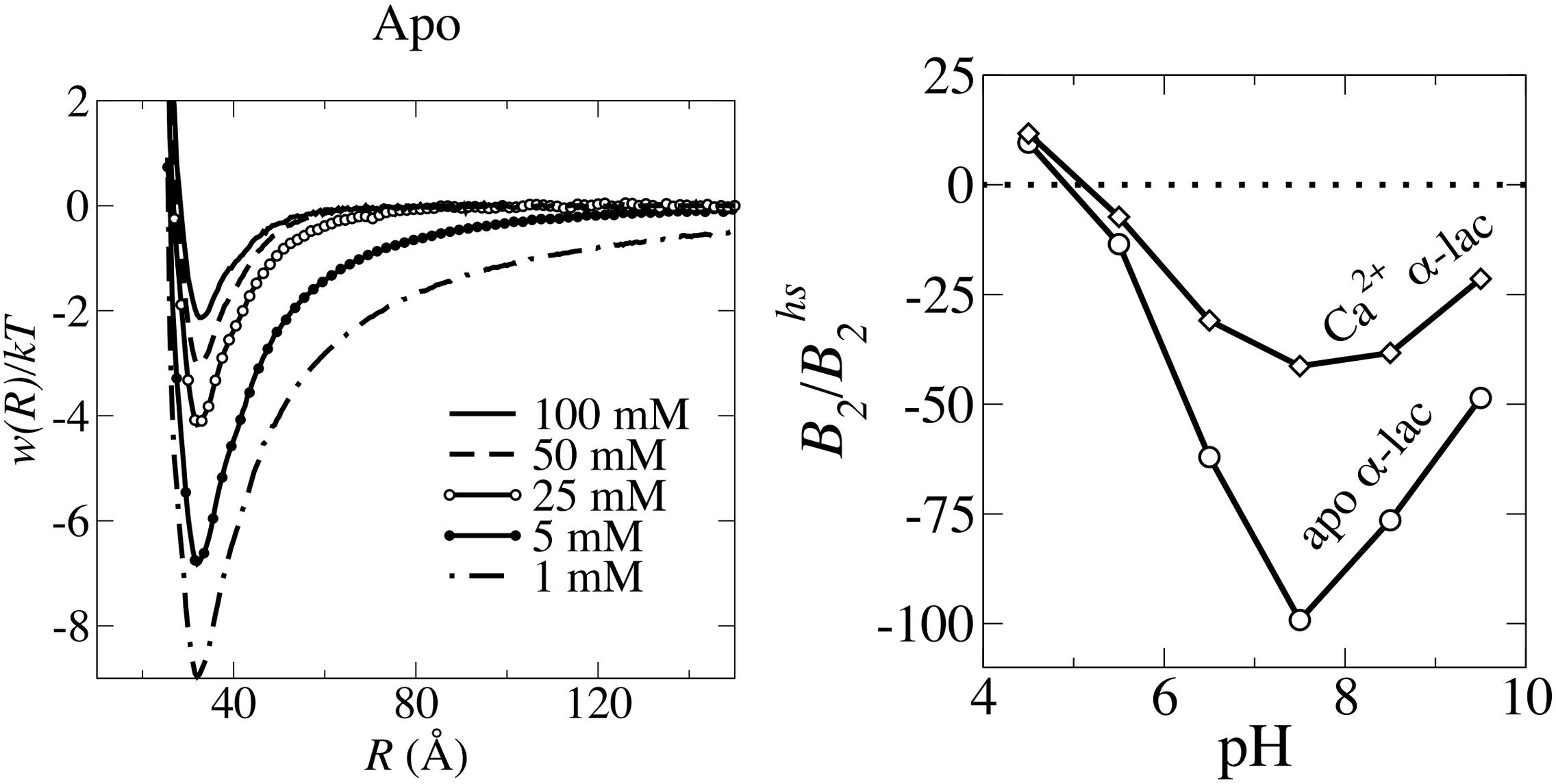
Interaction free energy



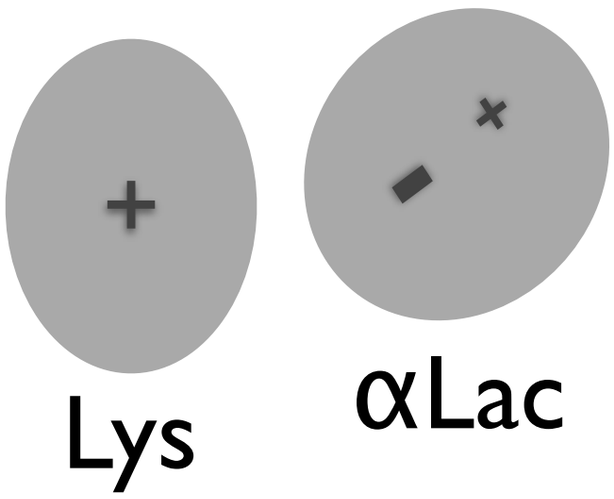
PCCP 2009, 11:8879

Interaction free energy



PCCP 2009, 11:8879

Alignment



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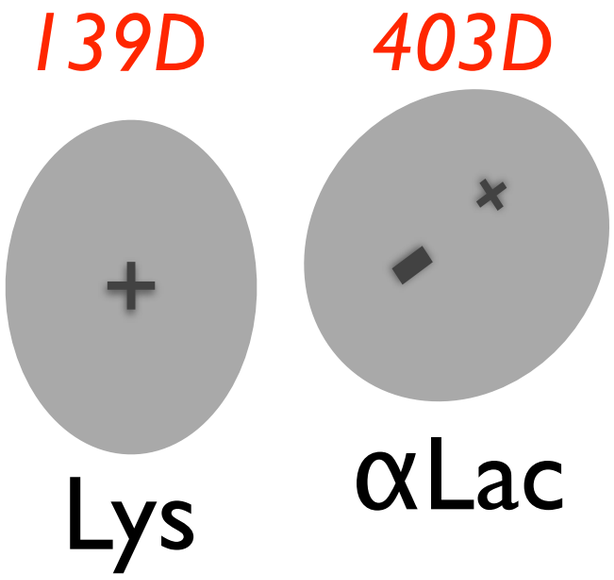

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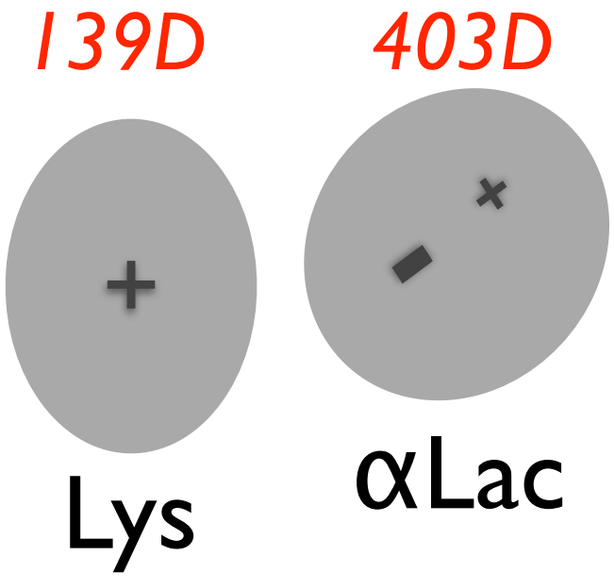
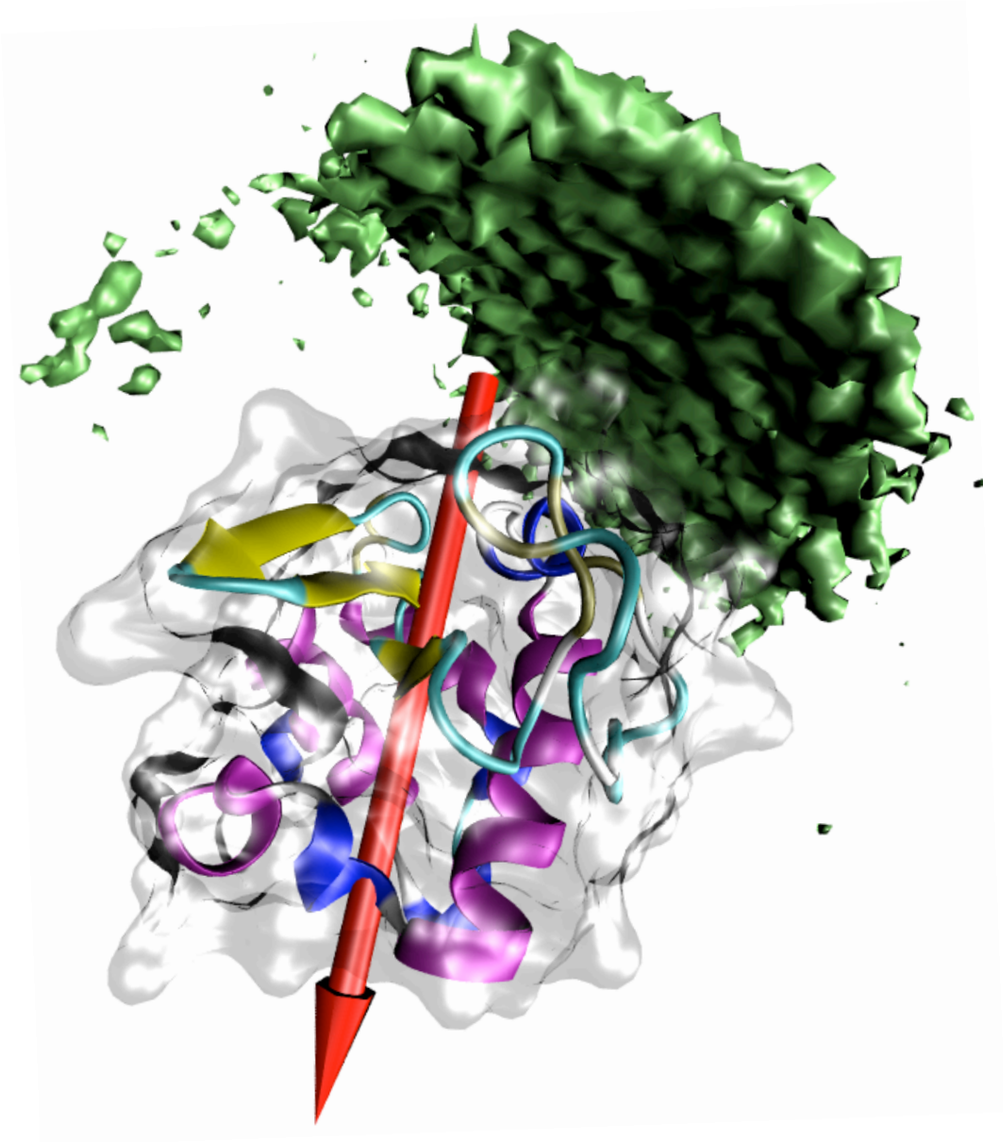
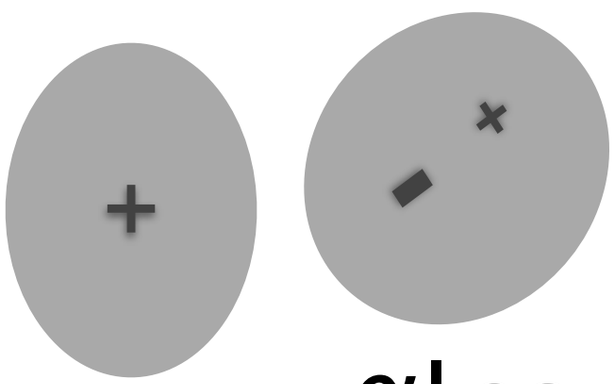


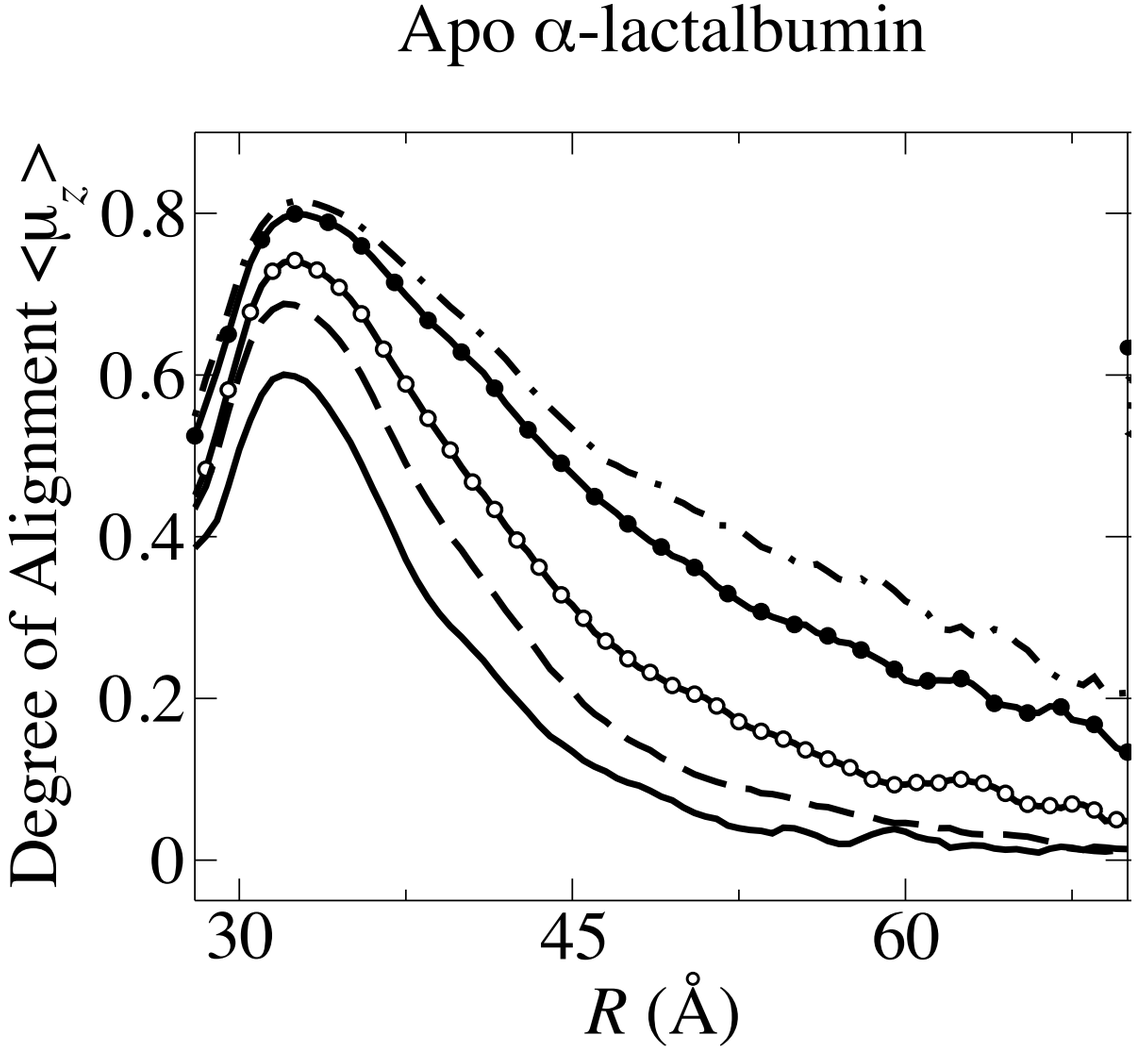


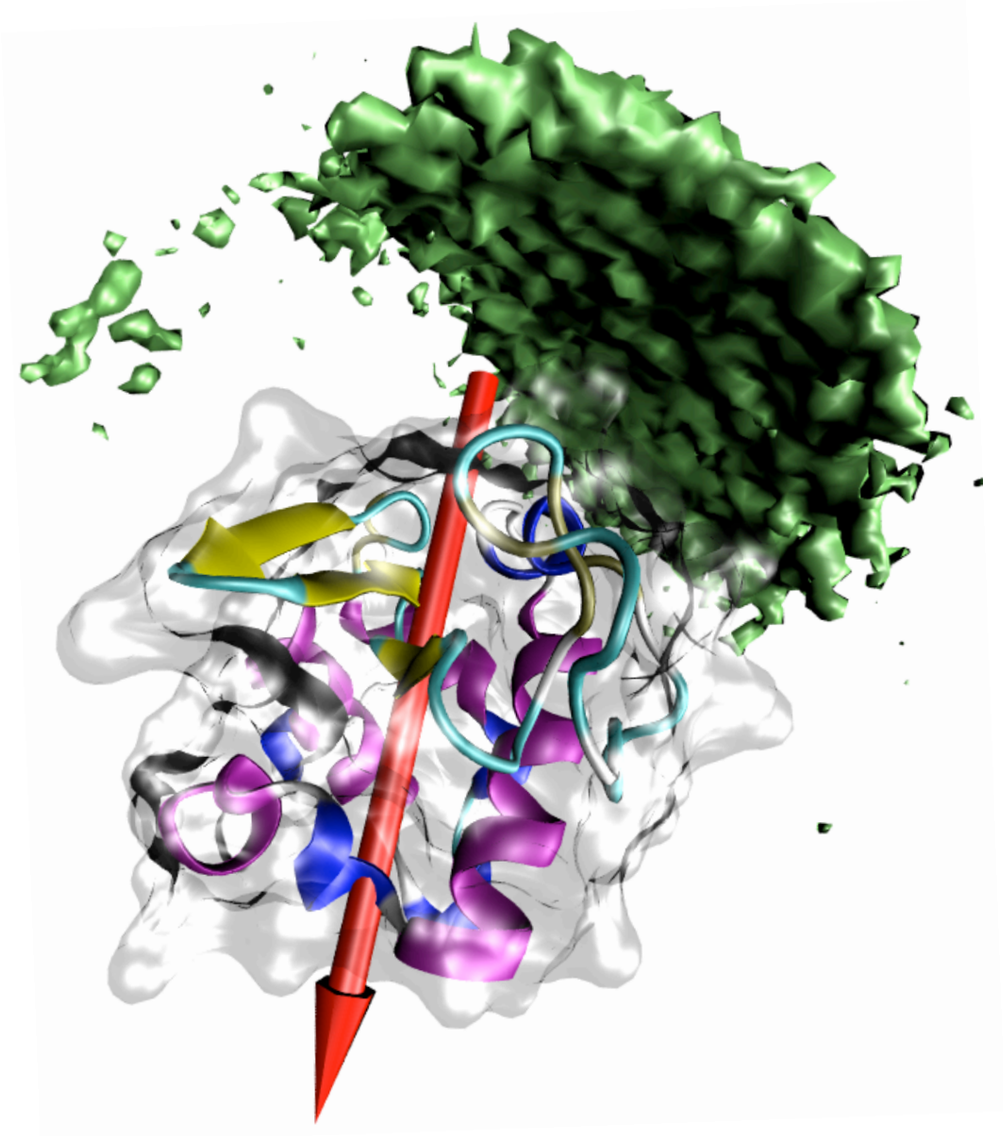
Alignment

139D *403D*



Lys αLac





More coarse graining

- explicit to implicit salt (DH level)
- More protein simplifications

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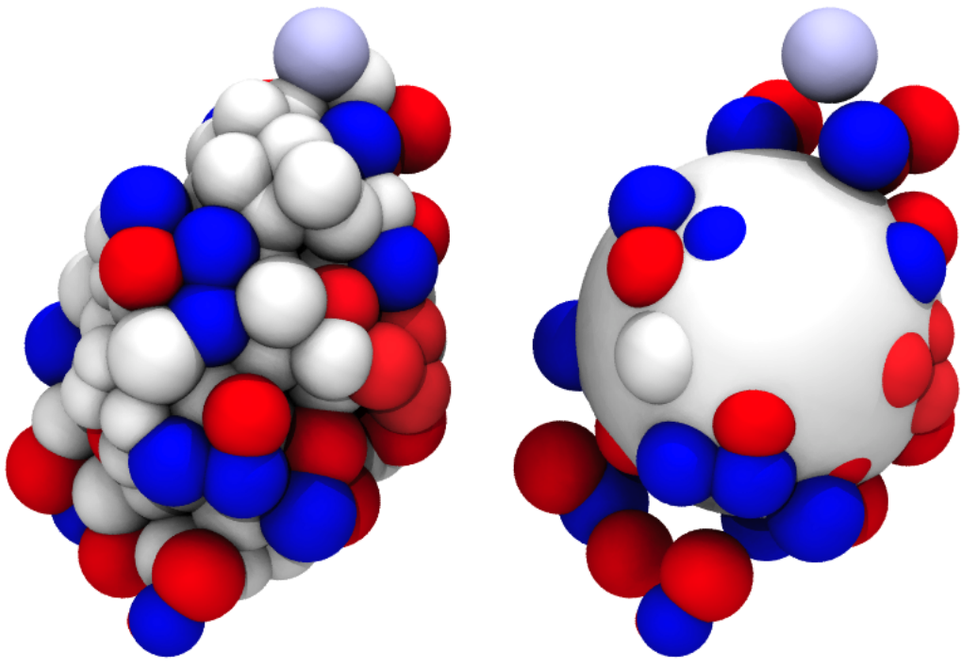

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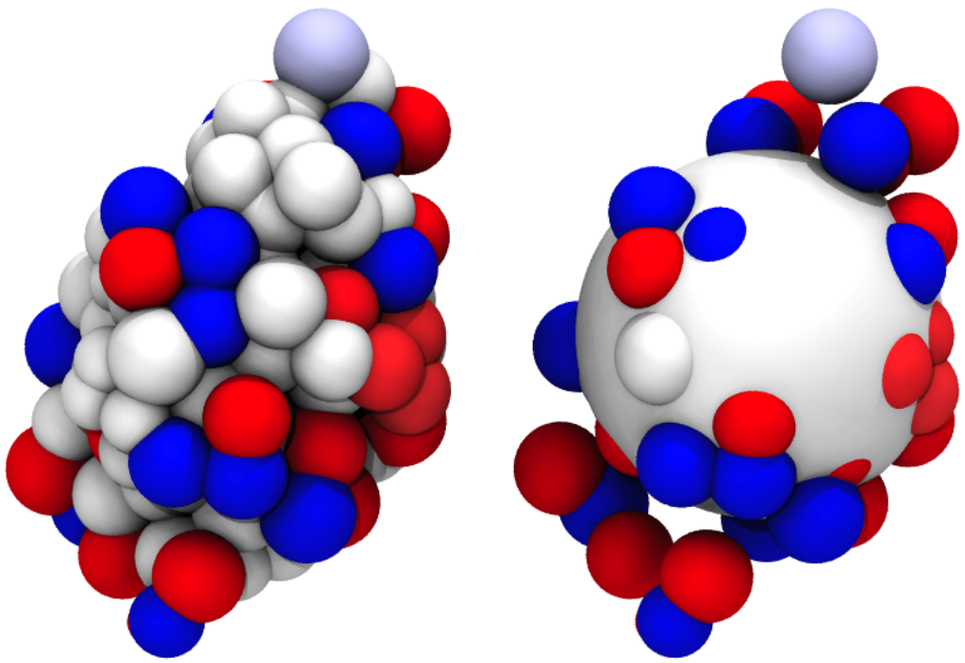
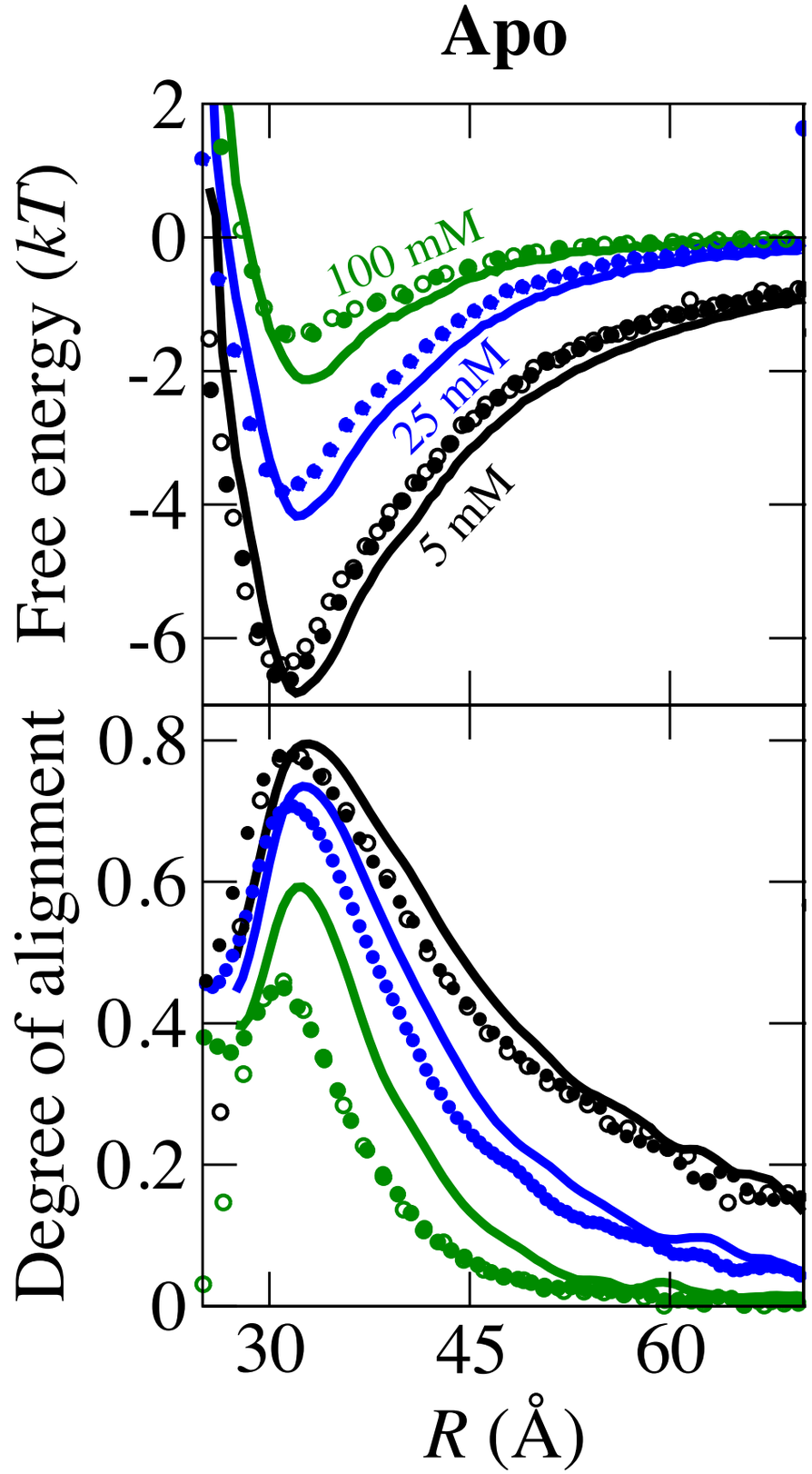
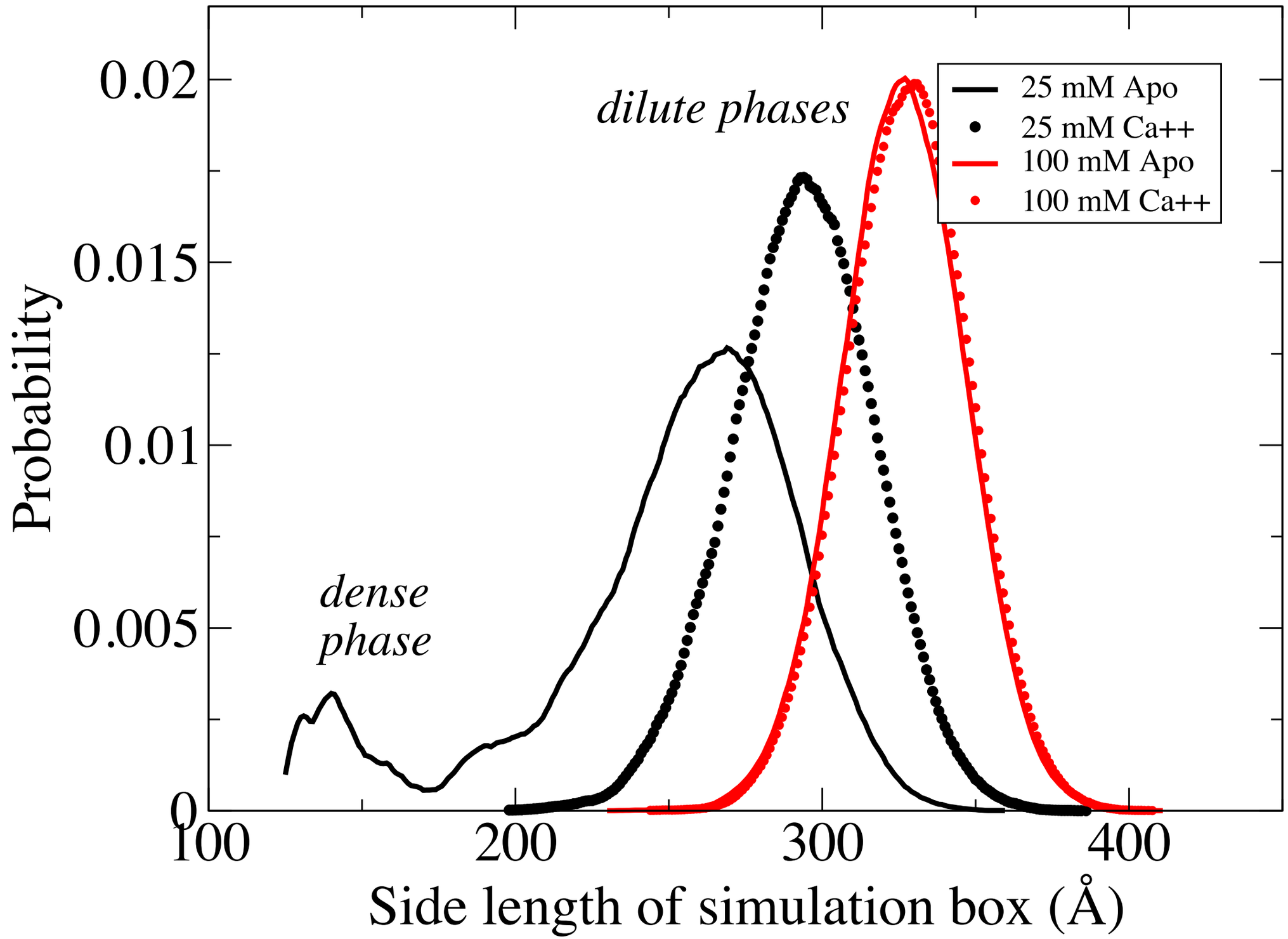




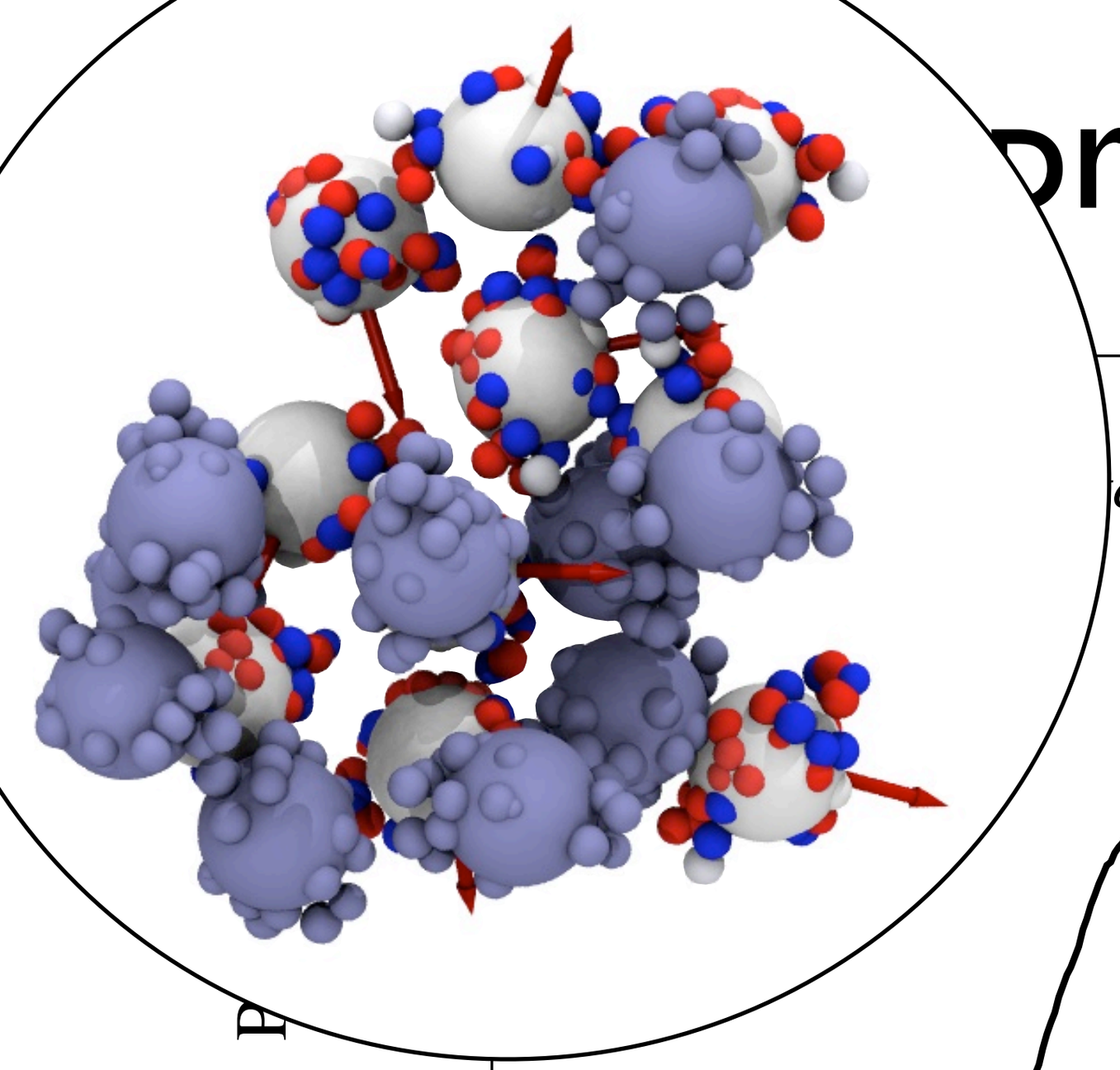
Many proteins

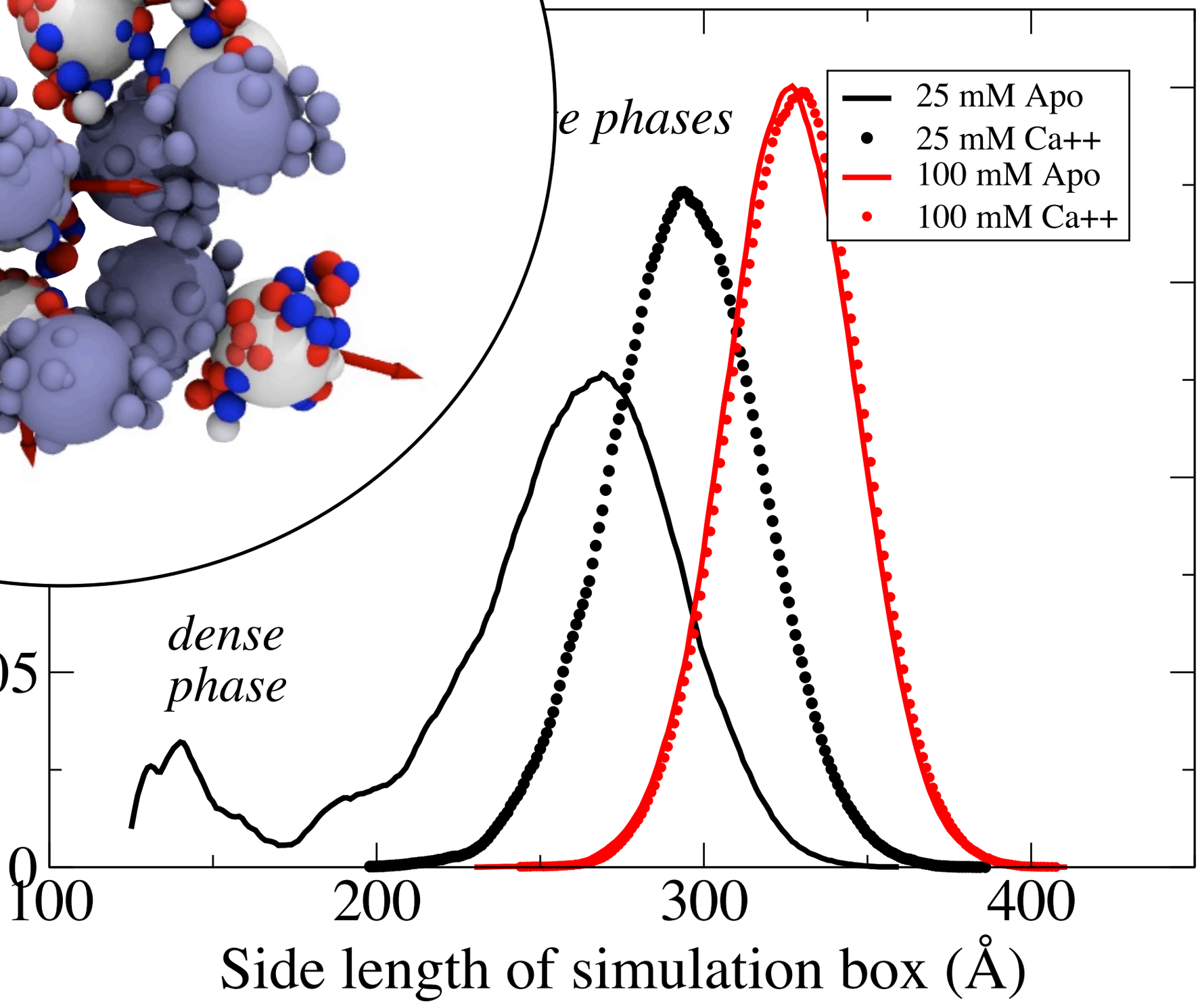
- 40 proteins
- NVT to NPT ensemble

Many proteins



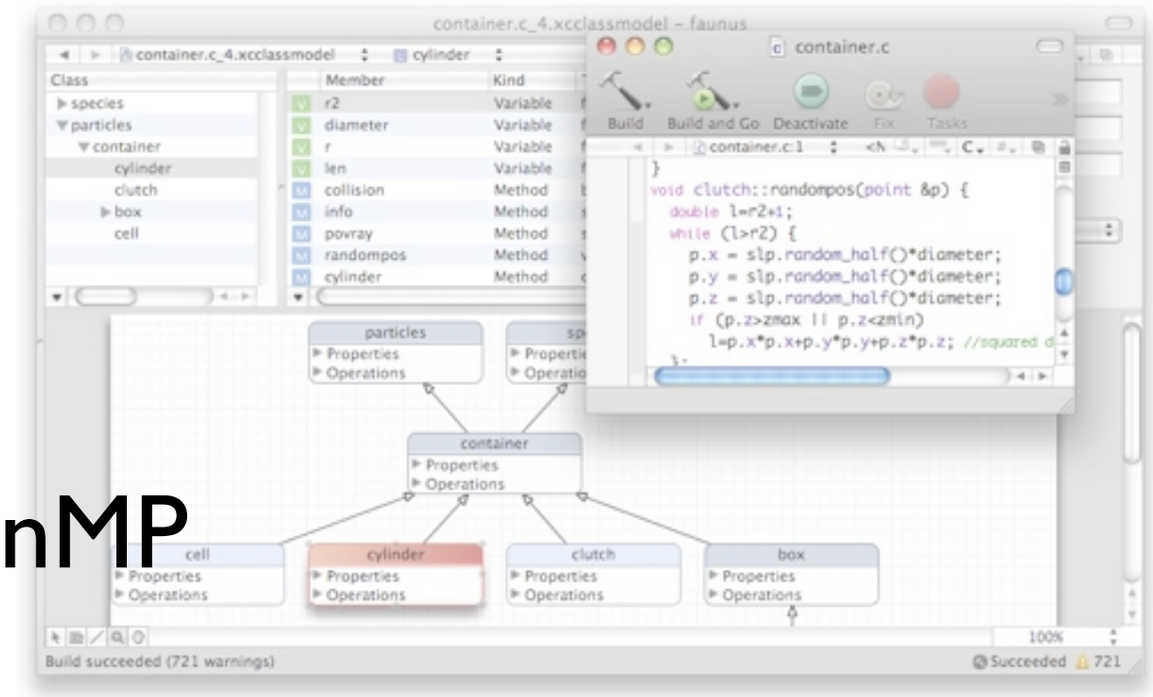
proteins




e phases
25 mM Apo
25 mM Ca++
100 mM Apo
100 mM Ca++
dense
phase
0.005
0
100
200
300
400
Side length of simulation box (Å)

http://faunus.sourceforge.net

- Object oriented C++ class library
- Python bindings
- Gromacs trajectories, OpenBabel, CMake, OpenMP parallelization, Doxygen
- Open Sourced - GPL.



Source Code Biol. Med. 2008, 3:1

Thanks to:

- Anil Kurut, Istanbul University
- Björn Persson, Lund University
- The OMM Linnaeus Center of Excellence, Lund University.