Two (2) graduate (Ph.D.) positions in the Laboratory of Molecular Modeling, Faculty of Chemistry, University of Gdańsk, Poland

Project title: "Correlated mean-field interactions propagated along polypeptide chain as a key to understanding the structure formation, dynamics, and allostery of proteins and physics-based modeling thereof"

Project leader: prof. dr hab. Józef Adam Liwo

Position name: Graduate Student (stypendysta/doktorant)

Requirements:

1. M.Sc. degree in Chemistry, Physics, Biology, Bioinformatics, Biotechnology or related disciplines or evidence that the degree will be conferred by December 1, 2024.
2. Command of English at least sufficient to read scientific papers and for communication.
3. Knowledge of molecular quantum mechanics, statistical mechanics, and methods of computational chemistry. Experience in running and analysing the results of molecular dynamics simulations is desirable.
4. Knowledge of statistical methods of data analysis. Familiarity with Principal Component Analysis and machine learning is desirable.
5. Knowledge of the basic principles of protein structure organization.
6. Ability to work with UNIX-operated workstations at least at the medium-advanced level, including the ability to write UNIX scripts. Basic literacy in Fortran/C/C++ desirable.

Project information:

Proteins are macromolecules with highly organized structures and highly concerted dynamics, which are manifested as allosteric communication enabling, e.g., signal transduction, and in motility inherent in molecular motors. Very accurate methods based on Artificial Intelligence, such as AlphaFold in the first place, have recently been developed for modeling protein structures but we are still far from understanding how interatomic interactions converge into certain structural patterns and concerted motions. The bottom-up coarse-grained approaches can be used to find the solution of this problem.

In our laboratory, we are developing the UNRES coarse-grained model of proteins, in which a polypeptide chain is represented by the alpha-carbon trace with united peptide groups and united side chains as interaction sites. This model is efficient in simulating protein structure and dynamics, enabling 1000-fold extension of the simulation timescales compared to all-atom approaches. The physical basis of UNRES enables us also to interpret the components of the coarse-grained force field as pre-determined blocks of interactions that organize protein structure and dynamics. When all-atom approaches are used, such organized patterns could be discerned only by applying Principal Component Analysis and similar techniques. Recently, we discovered new coarse-grained terms that

correspond to long-range collective interactions along extended and helical sections of polypeptide chains.

The aim of this project is (i) to determine how long-range correlations between amino-acid residues sitting on distant parts of the polypeptide chain, which do not interact with each other directly contribute to the formation of protein tertiary structure, (ii) to use the obtained results in enriching the coarse-grained UNRES force field in the respective effective energy terms, which will presumably enhance its power to correctly predict global complicated folds, (iii) to investigate if and how these correlations contribute to the protein dynamics, especially to allosteric interaction and to the exceptional performance of molecular rotatory motors.

Tasks assigned to the positions include:

1. Parameterization and implementation of the new energy terms in the UNRES force field and calibration and testing the force field with these terms.
2. Analysis of the Protein Data Bank and AlphaFold databases to determine the influence of the long-range multibody terms propagating along the sequence responsible for the formation of regular patterns in protein structures.
3. Investigating the collective motions of selected proteins which lead to allosteric communication by means of all-atom and coarse-grained (UNRES) molecular dynamics and identifying the long-range coarse-grained correlation terms responsible for these motions.
4. Investigation of the dynamics of rotatory molecular motors by means of coarse-grained and auxiliary all-atom molecular dynamics to determine the origin of their ability to convert thermal motion into rotatory motion with exceptionally high efficiency.

Stipend conditions:

1. 4-year stipend contract.
2. Monthly gross stipend from project funds: 5000 PLN. This sum includes obligatory social security taxes.
3. The successful candidates will be enrolled in the Graduate School of Chemistry at the University of Gdańsk. Ph.D. candidates currently affiliated with the Graduate School can apply.
4. Estimated start date: February 25, 2025.

Application package must include the following:

1. Cover letter.
2. CV including the list of publications.
3. A copy of M.Sc. diploma or a certificate that the applicant has the M.Sc. degree (scan/electronic version acceptable).

4. Recommendation letter from the supervisor of the M.Sc. work. Additional recommendation letters (e.g., from the mentor of the B.Sc. work) can also be submitted.

The applicant is obliged to submit, together with the documents listed above, the information clause (agreement to process personal data for the purpose of application), which can be downloaded from the page of the University of Gdańsk or obtained from the project leader.

The application package can be submitted in person to the Office of the Dean of the Faculty of Chemistry, University of Gdańsk, ul. Wita Stwosza 63, 80-308 Gdańsk, Poland, mailed to Prof. J.A. Liwo to the above address or, preferably, emailed to Prof. J.A. Liwo to **adam.liwo@gmail.com**; the cover letter can be included in the email body, scans of the other documents attached to the email.

Selected candidates will be invited for an interview, which will be conducted in person at the Faculty of Chemistry, University of Gdańsk or online. The candidates will be notified of the time and form of the interview by email.

Any questions should be sent by email to Prof. Liwo at
adam.liwo@ug.edu.pl or **adam.liwo@gmail.com**.

Application should be submitted by **December 1, 2024**. Applications submitted after this date will be considered until 2 candidates for the positions are finally selected.