



Tomasz Skóra

The interview with the author of the PhD thesis:

"Diffusion and reactions under crowding: Theory and simulations"

When did you decide to devote your time to science?

I went to the university already intending to become a scientist, although at the time, I was unaware of what that meant. Since childhood, I have been interested in science, especially chemistry. Probably the books from the cult series "Horrible Science" and in particular "Chemical Chaos" played a significant role in this. A slightly shabby copy still occupies an important place in my book collection, and I return to it from time to time.

While studying at the University of Silesia, I was following my plan and developing my scientific interests. I became involved in the activities of the "Aqua Regia" – Chemists' Scientific Circle. I moved to Jagiellonian University for my master's studies, where I quickly found a place in the Department of Theoretical Chemistry. I was introduced to the scientific craft there by Prof. Petelenz, who had the greatest influence on my idea of the work and ethos of a scientist. However, I decided to change my research subject and moved to the Institute of Physical Chemistry of the Polish Academy of Sciences, where I started in a slightly different research field on the frontier of biology, physics and chemistry. My advisor, Dr. Kondrat, taught me many aspects of research and networking. The doctorate was stressful at times, but it brought me a lot of satisfaction. I recommend it to everyone curious about the world but also humble and patient because the discovery process can be arduous.

Was it challenging to choose the direction of further development?

In the early stage of my studies, I did not attach myself to any specific issue or research area. In some sense, the subject found me — it was determined by the grant that funded my doctoral studies: diffusion in crowded environments. However, this is a vast field of study, so I had a lot of freedom in choosing the specific problems that I would explore in my doctoral thesis and the research methods that I would use for this purpose.

Please briefly present what your dissertation is about.

One of the major challenges of 21st-century science is understanding how biological cells work in terms of their building blocks (proteins, DNA, RNA and others). The most fundamental activities of biomolecules are their motion within the cell and undergoing chemical reactions. While we have gained extensive knowledge of these processes by isolating biological substances and studying them under controlled conditions, there has been growing evidence that these processes in cells occur differently than in test tubes. This is due, among others, to the fact that the cells are extremely crowded with macromolecules. My goal was to investigate what happens under the influence of this "crowding".

For instance, the slowdown of motion due to the crowding of the system with spheres is already a well-understood phenomenon. I decided to check, using computer simulations, what happens if elongated particles, instead of spheres, occupy the same volume. It turns out that the mobility slowdown is then substantially greater. Our collaborators from the RWTH Aachen University observed a similar effect in fluorescence correlation spectroscopy studies. Furthermore, I showed that crowding could cause reactions to become cooperative, which in practice manifests itself in their on-off behaviour upon changes in certain conditions, such as temperature or ion concentration. Biology is full of such on-off reactions, and it turns out that this feature can also arise due to crowding.

What was necessary to run your simulations?

In the beginning, I used the Brownian dynamics package BD BOX. Later, I developed my own package for similar simulations, pyBrown, and performed subsequent simulations using it. In both cases, the Helpdesk Team from Cyfronet supported me when I encountered any problems. I could always count on help when I wasn't sure about something or when something "stubbornly refused to cooperate". I participated in a free training course that introduced me to the issues related to the use of high-performance computers. During my doctoral studies, I had the opportunity to use Prometheus, at that moment, the fastest computer in Poland, which was very exciting in itself.

While scientific progress is based more on ideas than on tools, it must be acknowledged that supercomputers are a tool without which research in a field like mine would be limited. Thanks to the PLGrid infrastructure access, I could ask much more challenging research questions and maintain the quality of calculations. In my research, on the one hand, a single simulation had to be extremely long to allow the moving particles to "feel" that they were in a crowded environment. On the other hand, dynamics of this type are stochastic, and each simulation yields different results. What we want to obtain, i.e., diffusion coefficient, results from averaging the random motions of thousands of molecules. In addition, each simulation had to be run many times – in many copies. I recommend Cyfronet research resources to anyone encountering similar technical challenges in their research work.

How do you remember your doctoral studies?

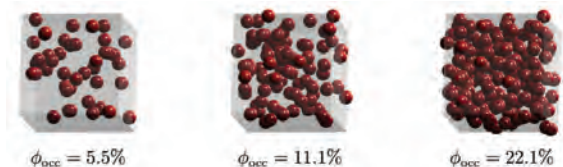
The work of a theorist is primarily solitary work. However, I had the pleasure of working with many different scientists. I owe it mainly to my advisor, who put great emphasis on research collaboration, for which I am very grateful to him.

The feeling of understanding brought the most joy. It's the feeling that the world has suddenly become less obscure somehow. Unfortunately, this feeling is rather sparingly and irregularly dosed. Hence patience and humility are recommended. Doctoral studies are not "just" more difficult than master's studies. It's not about grades, solving exercises, etc.; the main challenge is asking good questions. It's worth knowing this to save yourself the initial feeling of being lost.

What are your plans for the future?

The next stage of my career is a postdoc at the University of Utah in Salt Lake City. I plan to make the most of this time to start an independent research career after returning to Poland. Like footballers, I only think about the next game. When the time comes to take the next step in my career, I hope to be ready for this.

Thank you for the interview, and we wish you further success.



Biological systems are characterised by the so-called macromolecular crowding, which has a large impact on the mobility of molecules and the equilibria of chemical reactions. In my work, I studied these effects using computer simulations, representing macromolecules with simple models, such as spheres and chains of spheres, of different concentrations