Powerful in its simplicity

The development of free-electron lasers has enabled researchers to gain new insights into the complicated world of biology at the molecular level. Key components and processes in both photosynthesis and the immune system can now be studied in a completely new way. Filipe Maia was a member of the research team that was the first in the world to use the new technology to produce images of intact living bacteria.

Researchers have a new tool for studying cells, and life's tiniest components inside cells: the free-electron laser. Using a new type of light source with extremely intense and short beams, it cuts out the time-consuming, difficult and sometimes impossible crystallization stage. This is a new way of imaging biological particles. It offers new possibilities for studying hitherto unknown details in cellular function and behaviour, both in healthy and diseased cells. And it is a new way of studying pathogenic viruses and bacteria.

"It gives us wholly new opportunities to capture processes such as cell division and protein folding, and to see the structures within living cells in very high resolution. An important part of really being able to understand a cell's function is precisely that it is alive," says Filipe Maia, a researcher at the Department of Cell and Molecular Biology at Uppsala University, who helped develop the new technology.

When living cells are bombarded with an X-ray laser, the ultra-short light pulses generate a scattering pattern. This is recorded by a detector, connected in turn to a computer running unique software developed by the research team. Everything happens astonishingly quickly to exploit the extremely short gap between the beam hitting the cells and the sample exploding due to the exceedingly intense light beam.

"But it gives us long enough. We do have time to get an accurate image before the sample is destroyed. A single flash of the beam, focused on a micrometre-size area, delivers the same power as all the sunlight reaching the earth focused on a square millimetre. Few people believed this was possible," explains Filipe Maia. He says there is a huge difference between these images and those from traditional microscopy of living cells.

Now they want to push the technology further to see considerably smaller structures, with proteins next in line. However, distinguishing individual proteins requires significantly better resolution. Nothing is impossible, though, and Filipe is convinced they will succeed in the near future. He believes they will be seeing individual proteins within a few years.

The research team is particularly interested in photosynthesis and the photo-fixation of carbon dioxide in aquatic microorganisms, primarily from the Arctic and Antarctic oceans. Cyanobacteria too are well-studied, and Filipe Maia's team has used them in several studies. He is astride the border between computers and biology, and content to be increasingly forsaking the lab bench almost exclusively for computers.

"They are far easier to work with and, above all, it is much easier to keep things under control. We try to keep things as simple as possible. Computers are simpler than biological systems, which are very complex with many parameters coming into play. This makes replication difficult. Computers do exactly as they are told, however, and experiments can be repeated in exactly the same way every time. Working at the lab bench made things far more difficult – for me, at least," says Filipe Maia.

Filipe, who was born and raised in Portugal, has lived in Uppsala for a long time now. After gaining a PhD in Physics from Uppsala University in 2010, he went on to Berkeley in the USA for a few years as a postdoc. He is now back in Uppsala, and enjoying it. He says he appreciates everything being so relaxed here in Sweden, peacefully close to nature. He appreciates too the quintessentially Swedish fika, the coffee-pastry-conversation break.

"I never miss it. I do try to minimize other types of meetings, though," says Filipe Maia.