Meet the researcher

Daniele Proverbio

Isn't biomedicine about living creatures? Actually, that's only part of the story.

A couple of years ago, I joined the Luxembourg Centre for Systems Biomedicine (LCSB) for my PhD. I don't spend any time in the lab, I don't grow cells or work with fish or mice, but I do make my own small contribution to biology and medicine with paper, pens and computers.

But isn't biomedicine about living creatures, you might ask? Actually, that's only part of the story. Mathematics and computer science are becoming increasingly important in biomedicine, which presents a lot of exciting opportunities! These disciplines help us better understand the world around us, make sense of its workings and investigate future outcomes. They help complement the "what" with the "how" and the "why".

In particular, I focus on modelling the dynamics of biological systems. Studying the dynamics of a system means studying its evolution in time; how it behaves, how it changes and what drives its development. Modelling means turning the system's most relevant characteristics into equations and algorithms and applying mathematical rules to investigate how they interact and how well they explain the observed data. The goal is to move beyond an approximate description of a system – "it works more or less like this" – and instead to develop solid, reliable models that confirm our initial beliefs and predict future outcomes.

Among the many exciting areas of systems dynamics research, my favourite one deals with critical transitions. We observe critical transitions whenever we see something changing in an abrupt and drastic manner: a cell suddenly becoming cancerous or an epileptic seizure, for instance. Though they might seem different, these two examples have something in common when considered from a dynamics perspective. They both begin with a stable condition – the cell is healthy, brain activity is normal – which rapidly deteriorates in a short time.

The central question here is: can we assess the risk of a critical transition when the system is still stable? This is a challenging task. It combines the complexity of living systems with the historical challenges of physics and systems dynamics, and requires a careful combination of abstract modelling, data analysis and multidisciplinary collaboration. I need to interpret what biologists are telling me is going on, consider the appropriate functions with mathematicians and look for optimal solutions with engineers. This requires flexible thinking, but the promise of better understanding these phenomena and developing a risk-alert system is a compelling reward.

Another thing that I love about being a physicist and a modeller is the possibility of using my expertise in different areas of research, which has led to a number of side projects with colleagues. For example, we have a cool ongoing project on synchronisation, another kind of dynamic phenomenon. When systems are made up of many units – think about a flock of birds, a school of fish or insect swarms – they often tend to move in unison and work in coordinated fashion. Our goal is to analyse the properties of synchronisation in 3D which, in the long run, will be useful for control and synthetic engineering.

Another side project I'm working on explores how deep learning might be applied to medicine. With a team of colleagues, we trained an automatic algorithm to assist practitioners in identifying COVID-related lesions in the lungs. We even participated in a global challenge powered by Nvidia and the American National Institutes of Health (NIH), winning fifth place! It's amazing to be at the forefront of this rapidly evolving area and being able to reliably assess its promises and limitations. I feel I'm in the ideal position to explore the world around me – how it evolves and how it develops. This is what intrigues me the most and being involved in all these projects is simply amazing. Exciting years ahead! ◆

Daniele Proverbio believes in the value of multidisciplinary research and in the interaction of science and society. To this end, he graduated in Physics of Complex Systems, while also attending the Scuola di Studi Superiori (SSST) in Turin, an excellence school that focuses on multidisciplinary problems like bioethics, AI and warfare. Currently, he's pursuing a PhD in Computational Sciences for Biomedicine and an MBA. He also manages an Instagram channel for science communication and is involved in several other projects.