Mathematical modelling of the CD8$^+$ T cell immune response to heterogeneous tumours

Emma Leschiera$^1$, Luís Almeida$^1$, Chloe Audebert$^{1,2}$, Tommaso Lorenzi$^3$

$^1$Laboratoire Jacques-Louis Lions, Sorbonne Université, 75005 Paris, France.
$^2$Institut de biologie Paris-Seine, Laboratoire de Biologie Computationnelle et Quantitative, Sorbonne Université, 75005 Paris, France.
$^3$Department of Mathematical Sciences “G. L. Lagrange”, Politecnico di Torino, 10129 Torino, Italy.

The number of sub-populations generating a tumour, as well as the immunogenicity of tumour cells are two major components of intra-tumour heterogeneity (ITH) and play a key role in the immune response against solid tumours. Mathematical models allow to evaluate the influence of these two effects on anti-tumour immunity in a controlled manner. Separating these two components, we can investigate their effects on tumour aggressiveness independently or together. In this talk, we present a spatially explicit stochastic individual-based model capturing the interactions between tumour cells and CD8$^+$ T cells. Considering different initial compositions of the tumour, we investigate how ITH affects the anti-tumour immune response. In our model, ITH can vary with the number of tumour antigens (i.e. the number of sub-populations of tumour cells) and with the level of antigen presentation (i.e. the immunogenicity of tumour cells). Computational simulations show that both components play a role in the anti-tumour immune response. In addition, our results reproduce qualitatively biological experiments. Finally, we reformulate the individual-based model, and we introduce a continuum model formally obtained as the deterministic continuum limit of such individual-based model.