T cell communication through cytokines follows a simple sink-diffusion model

Immune cells communicate by exchanging cytokines to achieve a context-appropriate response, but the distances over which such communication happens are not known. We used theoretical considerations and experimental models of immune responses in vitro and in vivo to quantify the spatial extent of cytokine communications in dense tissues. Using T cell exchange of IL-2 as a model system, we established that competition between cytokine diffusion and consumption generated spatial niches of high cytokine concentrations with sharp boundaries. The size of these self-assembled niches scaled with the density of cytokine-consuming cells, a parameter that gets tuned during immune responses. In vivo, we measured interactions on length scales of 80–120 mm, which resulted in a high degree of cell-to-cell variance in cytokine exposure. Despite the complexity of the immune organs, the profiles of cytokine fields both in vitro and in vivo quantitatively follow the predictions of a simple model, essentially without any free parameters.