Modelling the collective migration of neural crest cells

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Collective neural crest (NC) cell migration contributes to the formation of several spatially and biologically different tissues during vertebrate development. If NC cells fail to reach a target or populate an incorrect location, then those cells may undergo improper cell differentiation or uncontrolled cell proliferation. A wide range of mechanisms that drive collective cell migration is displayed by distinct types of NC cells that emerge at different axial levels and are affected by different local signals. The great variety of different mechanisms of migration and the experimental tractability of the NC system makes it a useful paradigm for understanding collective cell migration in general, providing insights into other systems, such as wound healing or tumour formation. However, there are still many open questions as to how NC cells interact with each other and their microenvironment.

In our work, we investigate the system with a computational hybrid model, which consists of a discrete, off-lattice model for cells coupled with a continuum, reaction-diffusion model for the chemoattractant concentration. We work in parallel with our experimental colleagues who perform imaging of chick embryos under certain perturbations. In particular, we use our models to explore the role of the water-specific channel AQP-1 on the migration of NC cells [1]. We also investigate the characteristics of domain growth to understand how it affects cell-cell and cell-microenvironment interactions [2]. In the final part of our work, we develop a single individual-based stochastic model to include different forces observed in Xenopus and chick. The model is used to compare and contrast the behaviour of NC cells in different organisms.

[1] McLennan R. M. C., McKinney J. M., Teddy J. A., Morrison J, C. Kasemeier-Kulesa D, A., Ridenour C. M., Giniūnaitė R., Robinson M., Baker R. E., Maini P. K., Kulesa P. M., Neural crest cells bulldoze through the microenvironment using water channel proteins to stabilize filopodia, Development, 2020 147: dev185231

[2] McKinney J. M., McLennan R. M. C., Giniūnaitė R., Baker R. E., Maini P. K., Othmer H. G., Kulesa P. M., Head Mesoderm Tissue Growth, Dynamics and Neural Crest Cell Migration, Developmental Biology, 2020; 461(2):184-196.