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Modeling of cell proliferation in tissue growth

Abstract

In mathematical biology, there is much interest in building continuum models by scaling discrete agent-based models, governed by local stochastic rules. We shall discuss a particular example: a model for the process that leads to Hirschprungs disease, a potentially-fatal condition in which the enteric nervous system of a new-born child does not extend all the way through the intestine and colon, as well as various other stochastic models for foetal tissue growth. We start with a simple discrete-state Markov chain model proposed by Hywood in 2012 for the location of the neural crest cells that make up the enteric nervous system, and consider a variety of limiting regimes that lead to partial differential equation models that describe the dynamics of crest cell density as the whole gut grows. The initial discrete-state model has properties that are reminiscent of the totally asymmetric exclusion process with a variable-size lattice. When a neural crest cell proliferates, the size of the whole lattice increases by one and a cell from the underlying domain is left behind the proliferating cell. Since tissue growth is a significant cellular transport mechanism during embryonic growth, it has an indispensable role in the derivation of the correct partial differential equation description.

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