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Modelling myelopoiesis with state-dependent delay differential equations

The production of white blood cells is modelled from hematopoietic stem cells (HSCs) through proliferating and maturing precursors to circulating neutrophils. The main cytokine that regulates this process is Granulocyte Colony Stimulating Factor (G-CSF). G-CSF regulates the differentiation rate of HSCs, the proliferation rate during mitosis, the maturation time, and the rate at which mature neutrophils are released into circulation from the bone marrow. We model the variable maturation time via an age-structured PDE model with variable ageing rate which results in a system of state-dependent delay differential equations. We also describe a new model of the G-CSF pharmacokinetics. Determining the parameters is another difficulty, but we show that the model derivation implies associated constraints which we apply in determining the parameters.