In silico mouse model of infection and immunity

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An organism’s immune system tries to protect it by identifying the presence of pathogens and attempting to eliminate them. The defense is twofold: innate immune cells mobilize rapidly, while acquired immune cells slowly develop into pathogen-killing specialists. These responses incur collateral tissue damage, which anti-inflammatory mediators seek to control. This system of checks and balances is responsible for host survival. Experimental research has demonstrated how vastly complex these interactions are, indicating a place for theoretical and computational study. In this work we develop a comprehensive differential equation model of the immune system by considering interactions between immune system components in the presence of pathogen or tissue trauma. Through this step-by-step construction we explore the dependence of the anti-inflammatory mediators on pathogen levels, and also how they temper the immune response at the end of infection. We then challenge the “virtual mouse” with typical pathogens of varying virulence and observe the outcomes via model simulation. We find that anti- inflammation can downregulate the activation and proliferation of immune cells or promote apoptosis as cessation mechanisms, suggesting the need for *in vivo* experiments. Bifurcation theory describes how the outcomes of infection depend on model parameters, from which we conclude that initial insult and pathogen growth rate allow us to predict whether or not the *in silico* mouse overcomes the disease in a deterministic framework.