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Clocking Out: Modelling Phage Induced Lysis of Bacteria

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Abstract

Bacteriophage are viruses that infect and kill bacteria. Phage lambda lyses its host bacterium at a precisely scheduled time after infection. Lysis timing is determined by the action of phage holins, small proteins that induce hole formation in the bacterium's inner membrane. We present a two-stage nucleation model of lysis timing, with the nucleation of condensed holin domains on the membrane followed by the nucleation of holes within holin domains. We recover the accurate lysis timing seen experimentally, and show that the timing accuracy is approximately optimal for the phage. We also explore lysis delay following premature host death due to cyanide poisoning, and predict that holin-holin interactions depend on the bacterial membrane potential.