Development of a predictive model for phage-bacteria interaction

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The prevalence and impact of bacteriophages in the ecology of bacterial communities coupled with their ability to control pathogens turns essential to understand and predict the existing dynamics between phage and bacteria populations. The success of phage therapy is dependent on the knowledge of the phage replication kinetic properties in the presence of the host as well as on the prediction, controlling and optimization of phage production for future application. To achieve this knowledge it is important to develop mathematical models able to explain and simulate the population dynamics of phage and bacteria.
We have developed a mathematical model using delay-differential equations to predict the interaction between a broad-host-range Salmonella phage and its pathogenic host. The model takes into consideration the main biological parameters that rule phage-bacteria interactions likewise the latent period, burst size, bacterial growth rate, substrate uptake rate among others. The experimental validation of the model was performed in a bioreactor and it was found that the bacterial growth rate is critical to understand and predict the phage growth and bacterial control. By modelling the adsorption rate as a function of the bacterial growth rate it was possible to accurately predict the behaviour of the phage-bacteria population. The model generates data with a good agreement with the experimental observations and explains how a lytic phage and its host bacteria are able to coexist. Consequently, the model can be used to explain the structure of ecological communities of phages and bacteria and also to optimize phage production and guide the experimental studies of population dynamics by identifying and evaluating the relative contribution of phage and bacteria in the course and outcome of an infection.

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