Mathematical Biology Seminar

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The role of motility and nutrients in bacterial colony formation and competition

Bacterial competition and colony formation are an important component in many applications such as plant roots colonization and medicine (specially dental clinic). Motility is a pivotal bacterial trait for the successful colonization of plant roots. Bacterial motility has two types of mechanisms --- undirected movement (chemokinesis) and directed movement (chemotaxis). Motivated by a series of petri dish experiments, we study undirected bacterial movement which was rarely considered in literature. To study bacterial competition and colony formation in a petri dish, we modify and extend the model in Wei et al. (2011) to obtain a group of more general and realistic PDE models in the explicit consideration of nutrient and multiple bacterial strains characterized by motility. We use different nutrient media such as agar and liquid in the theoretical framework to discuss the results of competition and colony formation. The consistency of our numerical simulations and experimental data illustrates the existence of undirected motility in bacteria. In agar case the motile strain has higher total density while in liquid case the immotile strain has similar or slightly higher total density. When we place two drops of these bacterial strains around the middle of the petri dish, we find that 1) in agar case after half a day, the density of motile strain is high on the boundary of the petri dish while the density of immotile strain is high in the middle of the petri dish; 2) in liquid case bacterial motility is not that important because liquid nutrient moves almost infinitely fast compared to bacterial movement. Furthermore, we find that in agar case as bacterial motility increases, the extinction time of motile bacteria decreases without competition but increases in competition. When the nutrient media vary from agar to liquid, the extinction time of motile strain decreases while the extinction time of immotile strain increases, and the total density ratio of motile to immotile decreases dramatically. In addition, we show the existence of traveling-wave solutions mathematically and numerically. In the end of my talk, I will introduce an extension of our model to incorporate renewable resource for discussing the competition of the slow and fast diffusers.