Indian Institute of Science
Centre for BioSystems Science and Engineering
BSSE Seminar

26th February 2020 (Wednesday), 12:00 PM, CES Seminar Hall, 3rd floor, Biological Sciences Building

Cooperation, Resistance, and Spatial Patterning in Microbial Communities

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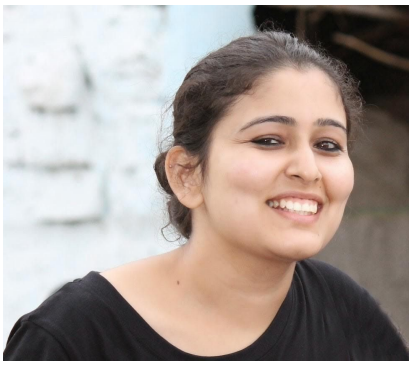
ABOUT THE SPEAKER



Anupama graduated with a Ph.D. in Mathematics from Banaras Hindu University, where she first started applying mathematics to understand the rich dynamics of complex systems such as the spread of infectious disease and other contagious processes across a population. After that, she joined the Computational Biology Group at the Institute of Mathematical Sciences, Chennai as a Postdoctoral Fellow to study epidemic spread on complex networks, with the focus on understanding how heterogeneity at individual-scale such as social contact structure and vaccine uptake decisions, leads to emergent collective outcomes at the population level which guide the epidemic trajectory. For her second postdoctoral work, Anupama joined the group of Prof. Kevin Wood in the Department of Biophysics at the University of Michigan, where she started doing experiments comprising microbial colonies exposed to antibiotic stress. She combined the quantitative data from these experiments with mathematical modeling to investigate the emergent spatio-temporal dynamics of microbial communities adapting to antibiotic stress.

ABSTRACT

Antimicrobial resistance reflects a combination of processes operating at different scales. The molecular mechanisms underlying antibiotic resistance are increasingly understood, but less is known about how these molecular events give rise to spatiotemporal behavior on longer length scales. In addition, antibiotic resistance can reflect collective phenomena, leading to microbial communities that are significantly more resilient than the individual constituent cells.

In this talk, I will discuss my work on the population dynamics of mixed bacterial colonies comprised of drug-resistant and drug-sensitive cells undergoing range expansion under antibiotic stress. Using the opportunistic pathogen E. faecalis with plasmid-encoded (beta-lactamase) resistance as a model system for the colony-growth experiments, we track colony expansion dynamics and visualize spatial pattern formation in fluorescently labeled populations exposed to ampicillin, a commonly-used beta-lactam antibiotic. We find that resistance to ampicillin is cooperative, with sensitive cells surviving in the presence of resistant cells, surprisingly, even at drug concentrations lethal to sensitive-only communities.

Our mathematical models indicate that the observed dynamics are consistent with long-range cooperation, and experiments confirm that resistant colonies provide a protective effect to sensitive cells on length scales multiple times the size of a single colony. Furthermore, in the limit of small inoculum sizes, we experimentally show that populations seeded with (on average) no more than a single resistant cell can produce mixed communities in the presence of drug. Our results suggest that beta-lactam resistance can be cooperative even in spatially extended systems where genetic segregation typically disfavors exploitation of locally produced public goods. This long-range cooperation in spatially extended settings was not known or predicted from earlier studies.