Counting Bacteria in Boxes:
How do bacteria colonize surfaces?

The colonization of surfaces by bacteria raises many societal issues related to antibiotic resistance and waste management. Microscopy can now image individual bacteria with unprecedented resolution, which improved our understanding of late colonization stages. Our grasp on initial surface establishment, crucial to address colonization at its roots, is limited. In this early stage, bacteria number fluctuations – due to surface adhesion, division, or motility – are large, challenging current analysis tools and theories. These fluctuations can result in more tight or sparse aggregates, which dramatically affect the long-term colonization dynamics. How do individual dynamics and intermittent adhesion determine these aggregate patterns and dynamics? And how do they influence collective growth?

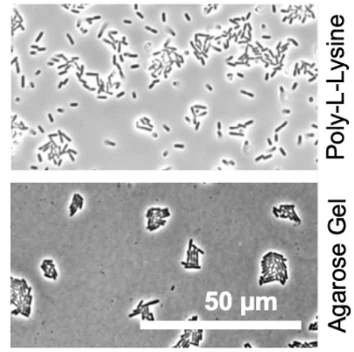

Fig.1. Tight and Sparse *E. Coli* aggregates. From [1]

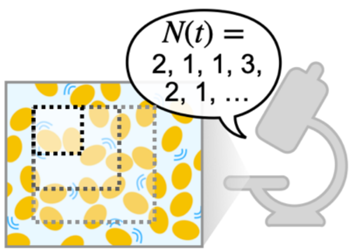

Fig.2. Principle of the Countoscope: Counting particles in boxes

To make progress on these questions, we will use a new analysis technique relying on number fluctuations called the ``Countoscope'' [2]. The principle is like a game! We count the number N(t) of particles (bacteria, colloids or cells) in analysis boxes over time. The number of particles in a box fluctuates due to microscopic dynamics such as diffusion, adhesion, motility etc. Interpreting experimental N(t) requires building advanced theories – that remain to be established in this colonization context. These theories can then disentangle processes and quantify dynamics from the time-dependent statistics of N(t).

Here we will, on the one hand, count the number of bacteria in various box sizes on experimental images. On the other hand, we will develop minimal models to interpret these counts. This internship will be in collaboration with Eleonora Secchi (ETH Zurich) who investigates bacteria on surfaces in microfluidic channels experimentally. The results could broaden our understanding in microorganism colonization, which has numerous biomedical and industrial applications.
The internship can lead to a PhD, with the aim of understanding how microorganisms colonize and modify their environments. This has applications in **soil remediation**, such as in analyzing how fast pollutant compounds are consumed by microorganisms or in **biodegradation such as in composts**.

Tools used: Analytical work and/or stochastic simulations, related to soft matter/statistical/biological physics

A few references

[1] Y. K. Wang et al., Sci. Rep. 2019, https://www.nature.com/articles/s41598-019-55798-0
[2] E.R. MacKay, S. Marbach, B. Sprinkle, A. Thorneywork, Arxiv 2023, https://arxiv.org/abs/2311.00647

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