DEVELOPMENT OF AN ELECTRO-MECHANICAL SENSING DEVICE TO MONITOR BACTERIAL RESPONSE TO ANTIBIOTICS

Synopsis

The rapid expansion of bacterial resistance caused by our overuse of antibacterial therapeutics and cleaning products threatens to impact human health, food and water with unprecedented repercussions on global economies. This situation, which was recently coined the silent pandemic, has been exacerbated by the SARS-CoV-2 era. The World Health Organization estimates that about 0.7-1 million deaths/year are attributed to the failure of all antibacterial treatments to date and foresees this number to reach ≥10 million deaths/year by 2050. In the case of sepsis, each delay of 1 h in identifying the nature of the bacterial infection and its antibiotic susceptibility increases the mortality rate of 8%. In many cases, a period of 2 days to several weeks is required to finalize an antibiotic susceptibility test depending on the pathogen. Therefore, tools capable of rapidly carrying out its antibiogram are in high demand. Advances in nanoscale imaging and spectroscopy as well as (bio)sensors suggest that developing such a platform is within reach but requires the convergence and collaboration of several expertise.

This PhD work aims to develop a low-cost chip based on electro-mechanical sensing, capable of testing bacterial responses to antibiotics to accelerate treatment procedures with positive outcome for the patient. The rationale of the project stems from recent work using cantilever-based microsystems to study the nanoscale motion of bacteria by monitoring the deflection of the cantilever. The approach, combined with machine learning data analysis, enabled to distinguish pattern changes following treatments with antibacterial agents. While this work demonstrated the nanoscale motion and dynamics of bacteria to be an effective marker for antibiotic susceptibility tests, some limitations remain due to the low amplitude variations of the cantilever deflection induced by the bacterial motion, and other factors related to cantilever microsystems operation. To overcome some of these limitations, this project will evaluate an electro-mechanical sensing platform to monitor the nanomotion and dynamics of bacteria. The sensing platform will exploit the high sensitivity of electrical current to variations in the nanogaps between metallic nanostructures within a thin and deformable film. Upon deformation of the film or membrane, as the nanoscale gap between the nanostructures increases or decreases, current variations in the films will be measured. The development of the film, and the evaluation of the performance of the strain sensor resulting from it, will be pursued. The work will be supported by state-of-the-art nanofabrication and nanoscale characterization tools. Next, the capabilities for bacterial nanomotion will be studied by introducing bacteria on the sensor surface. Design optimization to accommodate for experimental factors such as liquid delivery, concentration variations, or anchoring of bacterial on or near the surface will be considered. Finally, development of the sensing platform to carry out antibiotic susceptibility tests, including design, data acquisition and data analysis, will be implemented. Combination with additional analytical tools such as infrared spectroscopy will be evaluated. The understanding of bacterial processes will be complemented by nanoscale functional analysis.

Supervisor(s) name(s), Affiliation(s), eMail address(es) for contact:
Etienne Puyoo, Institut des Nanotechnologies de Lyon, etienne.puyoo@insa-lyon.fr
Laurene Tetard, Institut des Sciences Analytiques, laurene.tetard@isa-lyon.fr

Proposed list of secondments:
University of Central Florida, Orlando, Florida, USA

Main ArchiFun theme involved:

- [ ] Host-pathogen interactions;
- [x] Mechanisms of bacterial resistance and cancer onsets;
- [ ] Neurodegenerative and autoimmune diseases;
- [ ] Translational research in prevalent diseases;
- [ ] Physiology and ecology;
- [ ] Neurosciences and cognition.

HORIZON-MSCA-2022-COFUND-01 Doctoral Programme – 101126656 Co-founded by the European Union