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Envirobot RTD 2013

FNSNF

A Microfluidic Tool to Use Bacterial Chemotaxis for Biosensing

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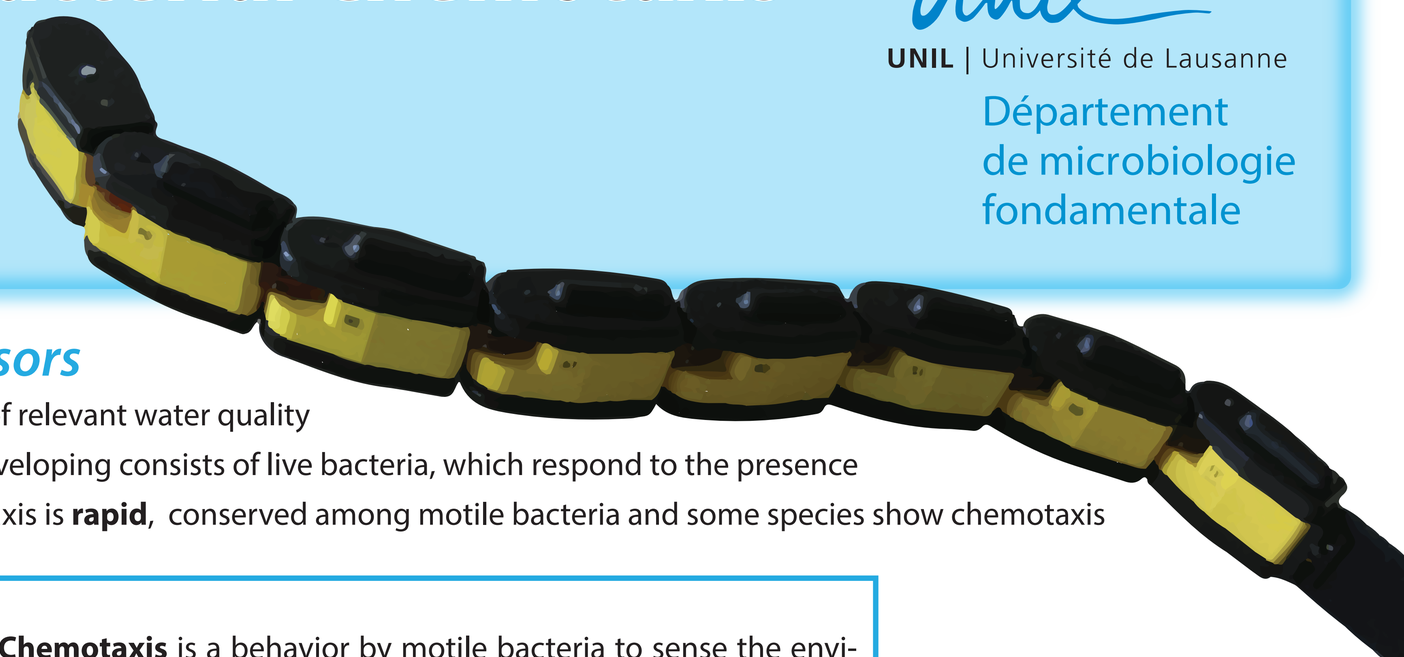
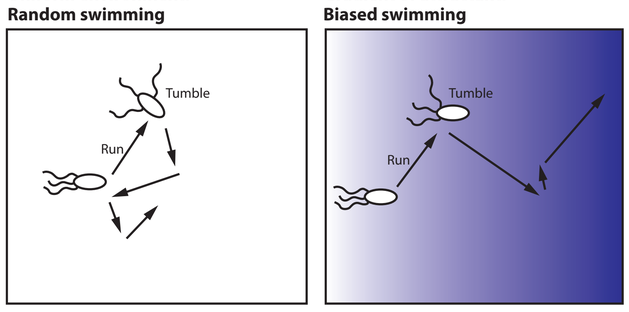


Envirobot and bacterial chemotaxis-based biosensors

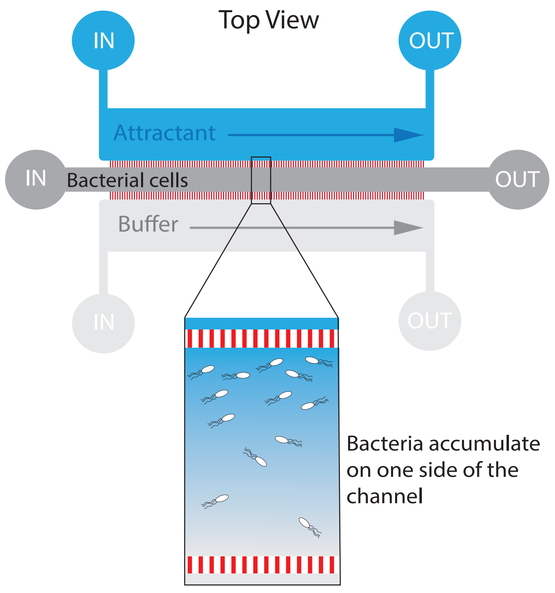
ENVIROBOT is a **robot** that will be able to self-navigate, sample and measure a set of relevant water quality parameters through a variety of incorporated sensors. One of the sensors we are developing consists of live bacteria, which respond to the presence of target chemicals by changing their swimming pattern (i.e., chemotaxis). Chemotaxis is **rapid**, conserved among motile bacteria and some species show chemotaxis towards **toxic compounds**.



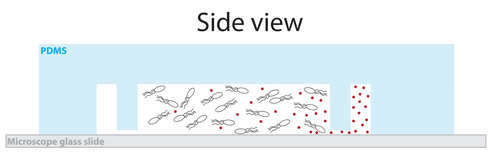
Chemotaxis is a behavior by motile bacteria to sense the environment and swim in the direction of or away from chemical compounds. In a uniform environment bacteria swim randomly to explore the maximum space but when they are in presence of a gradient of attractant, they bias their swimming direction towards the highest concentration of attractant.

PDMS Microfluidic chip

In order to measure chemotaxis quantitatively, we use microfluidic chips in which we can create and bring cells into a microscale gradient.



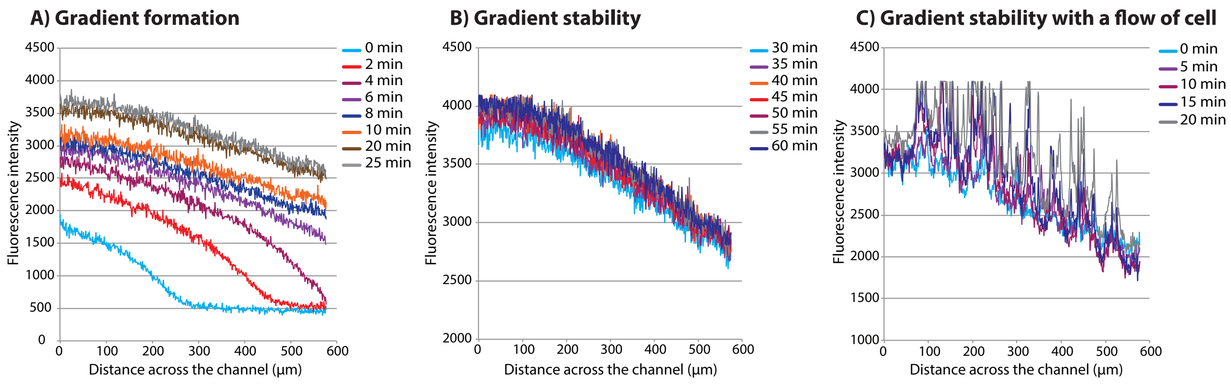
The chip is composed of three parallel channels connected by filters.
By flowing attractant and buffer solutions in the side channels, we create a gradient in the middle channel, where cells are introduced.



Filters prevent the cells to pass in the side channels thanks to their small height.

Gradient formation

The gradient formation was tested with the fluorescent dye DAPI. Water and DAPI were flowed in the side channels and the fluorescence was measured perpendicularly to the middle channel, first without flow, then with a flow of cells in the middle channel.

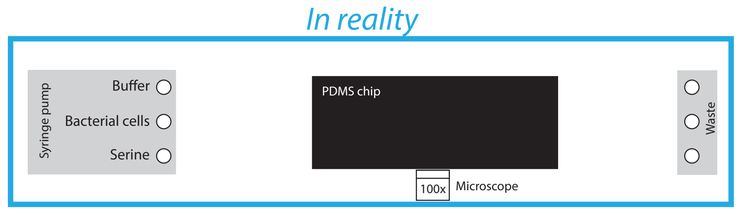


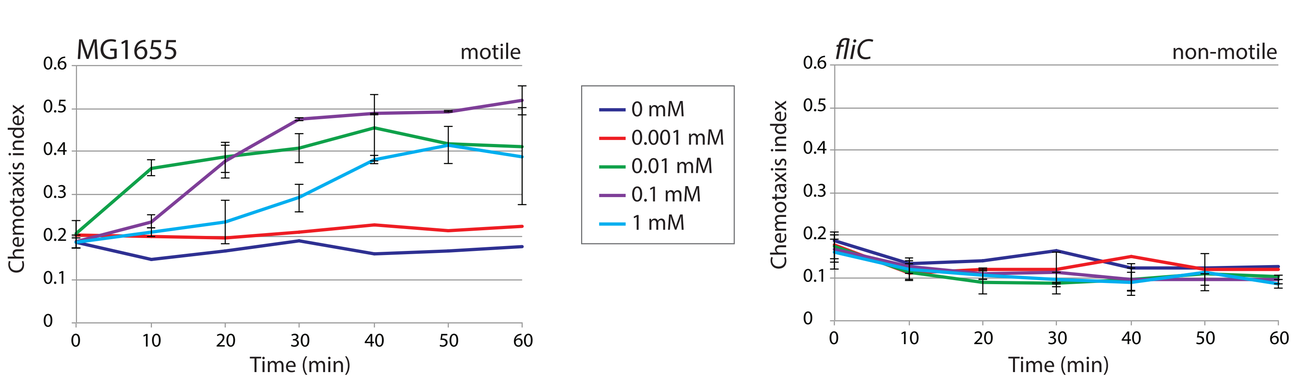
The formation of the gradient is fast (about 10 min) and is stable over more than 1 hour, even when we apply a flow of cells in the middle channel.

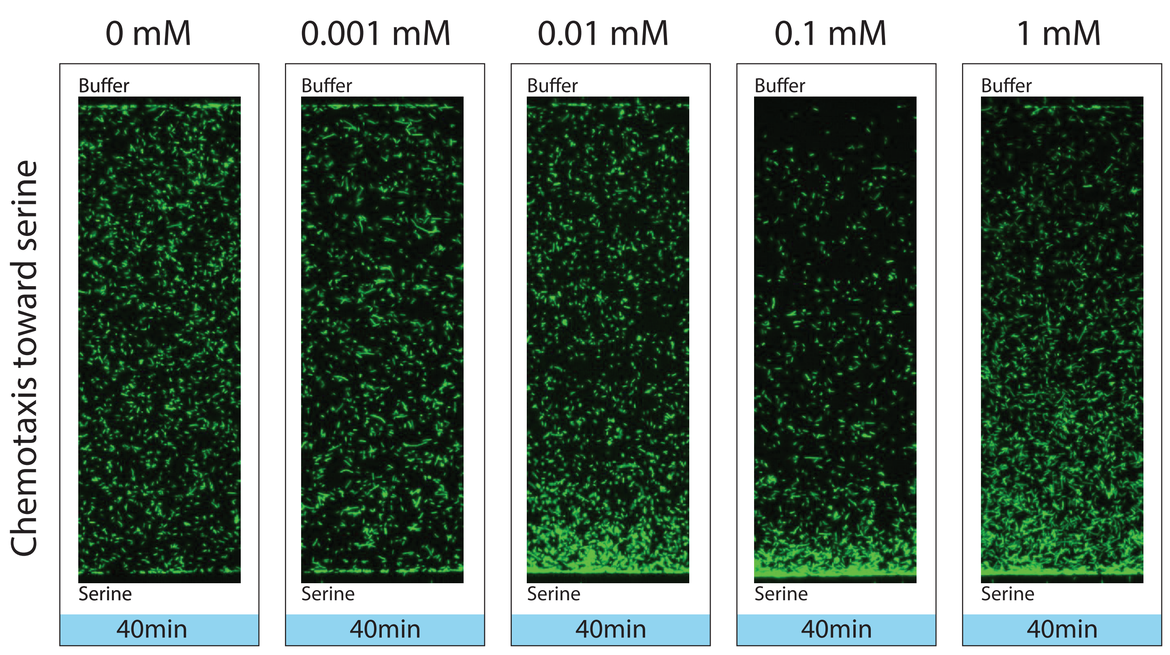
Chemotaxis assays

The chemotactic response of *Escherichia coli* MG1655 towards serine as chemoattractant was measured. We used the non-swimmer *fliC* mutant as internal negative control.
Pictures were taken near the beginning of the filter and fluorescent profiles were extracted from digital images. A ***chemotaxis index*** was calculated which corresponds to the proportion of cells that are in the 100 µm zone closest to the source of serine.

In reality







We can measure chemotaxis response of *E. coli* toward serine in our PDMS chip. The bacteria start to respond at a gradient produced from 0.01 mM serine in the side channel and show a **fast response** (10 min). The amplitude of the response is the highest with 0.1 mM serine and bacteria response to 1 mM with a delay.

Perspectives

We developed a PDMS microfluidic chip that generates **fast gradients** of small molecules. Bacteria can be introduced and react to the gradient with an accumulation on one side of the channel. As proof of concept we showed that we can measure **rapid chemotaxis response** of *E. coli* towards serine.
Since serine is not a pollutant, we will now focus on responses of **other species** of bacteria such as *Pseudomonas* that show chemotaxis towards e.g., naphtalene.
Finally another **method of detection** has to be developed in order to implement such a device inside the Envirobot.

envirobot