The bacterial eyespot

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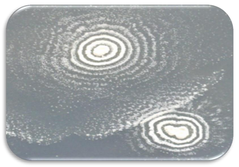
Abstract

This project aims at creating a regulatory system in the bacteria *Escherichia coli*. Our main goal is to engineer a single strain of bacteria able produce concentric patterns on the dishes. The challenge is to model a regulatory mechanism which mimics both cell differentiation and cell-to-cell communication observed in eukaryotes.
We chose to create four operons (a total of 21 assemblies): three to allow the communication and expression of a visible phenotype, the forth containing the genes needed for signal transduction. Each of the three first operons will respond to a specific quorum-sensing system (QSS) and trigger another QSS resulting in a chain reaction communicating a unique signal to all bacteria nearby.

Introduction

Some eukaryotes display complicated patterns, like the butterfly shown on the left. These patterns are du to very precise genetic regulations.



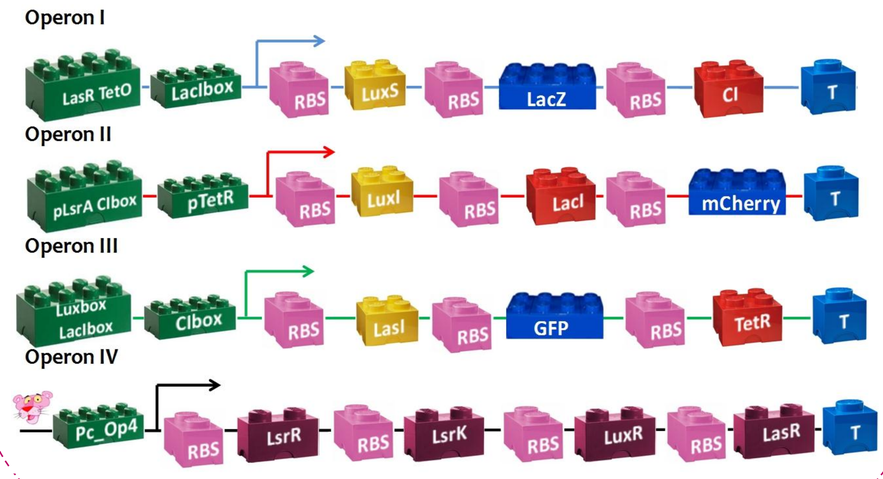
The fungi shown on the right was the inspiration for our project. However, some prokaryotes can also draw patterns during their growing phase*.
We decided to create a bacteria able to grow and display different phenotypes, depending on its location on the plate. This means this bacteria should be able to express different colors with the same genetic background.

*Ben-Jacob *et al.*, Annual Review of Microbiology 1998

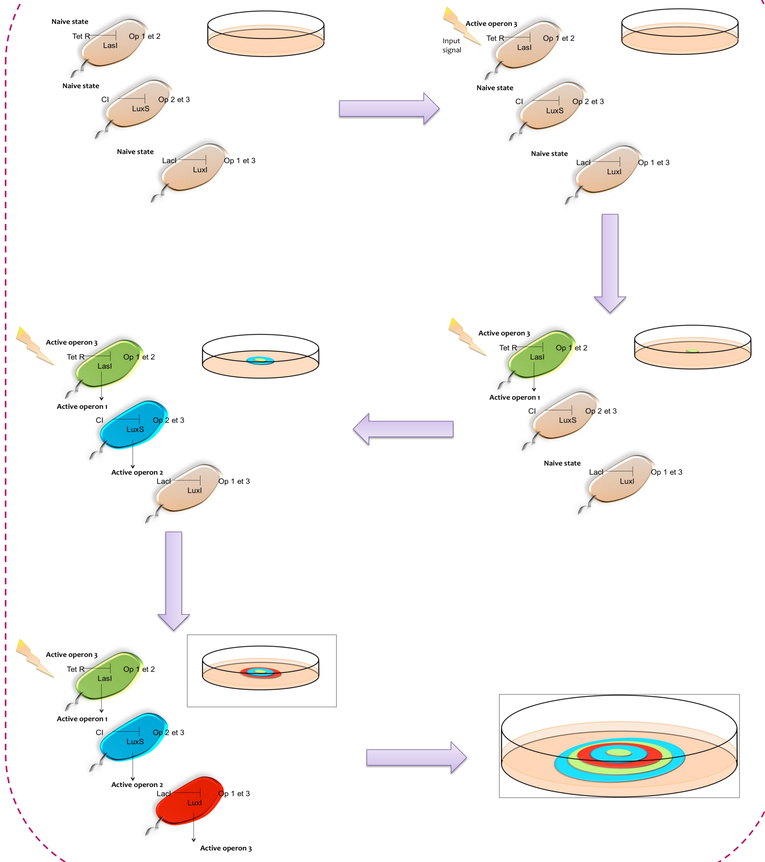
The project

We chose to create 4 operons:
- the first three allow cellular communication and expression of a visible marker
- the fourth one contains genes to enable signal transduction between neighboring cells.

Each cell of the grid can be in 4 different states: naive, state1, state2, state3. On the following steps the state of the cell is determined by the signal from neighboring cells.
To realize these constructions 20 assemblies were needed !!



The system



Modelling

The challenge consist of modelling a regulation mechanism that mimic the cellular differentiation and cellular communication seen for eukaryotes.
We have decided first to make a modeling and simulation software of that regulation system. This first step will permit us to test several parameters and try some variations of the concentration and others factors involved (reduction of the activity of some operon, etc).
The next rules are applied on each cells of the grid for each turn:
- if a bacteria is in a native state and have close neighbor(s), she is candidate to be activated.
- if a bacteria is in a native state and haven't close neighbor(s), she will remain into her native state.
- if a bacteria is in an “activated” state and have close neighbor(s), she has an opportunity to change the neighbor state's.

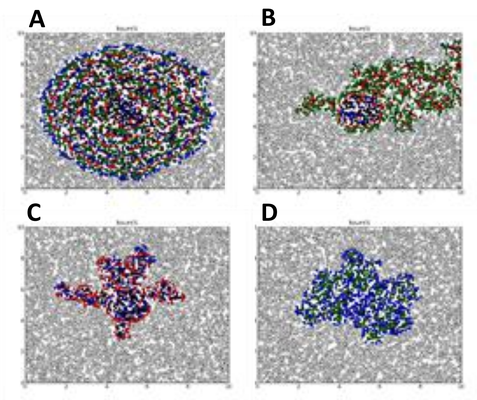
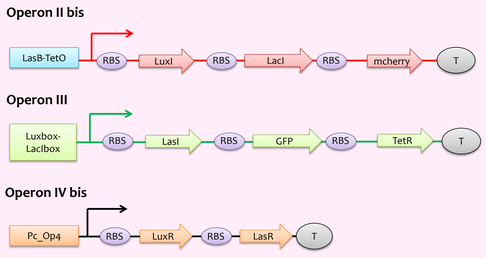


Fig. 1. Results from different simulations with varying certain parameters. (A) Simulation of the desired cell behavior. (B) Operon 1 malfunction. (C) Operon 2 malfunction. (D) Operon 3 malfunction.

Conclusion and Perspectives

- 10/20 assemblies completed. ⟶ Finish the assemblies left !
- Operon II fully obtained with different promoters. ⟶ Test it under different conditions.
- Moving to a simpler system, with only three operons to build up : ⟶ Only 3 assemblies left to the end to test *in vivo* this simpler system.



A new project in 2013 !!!