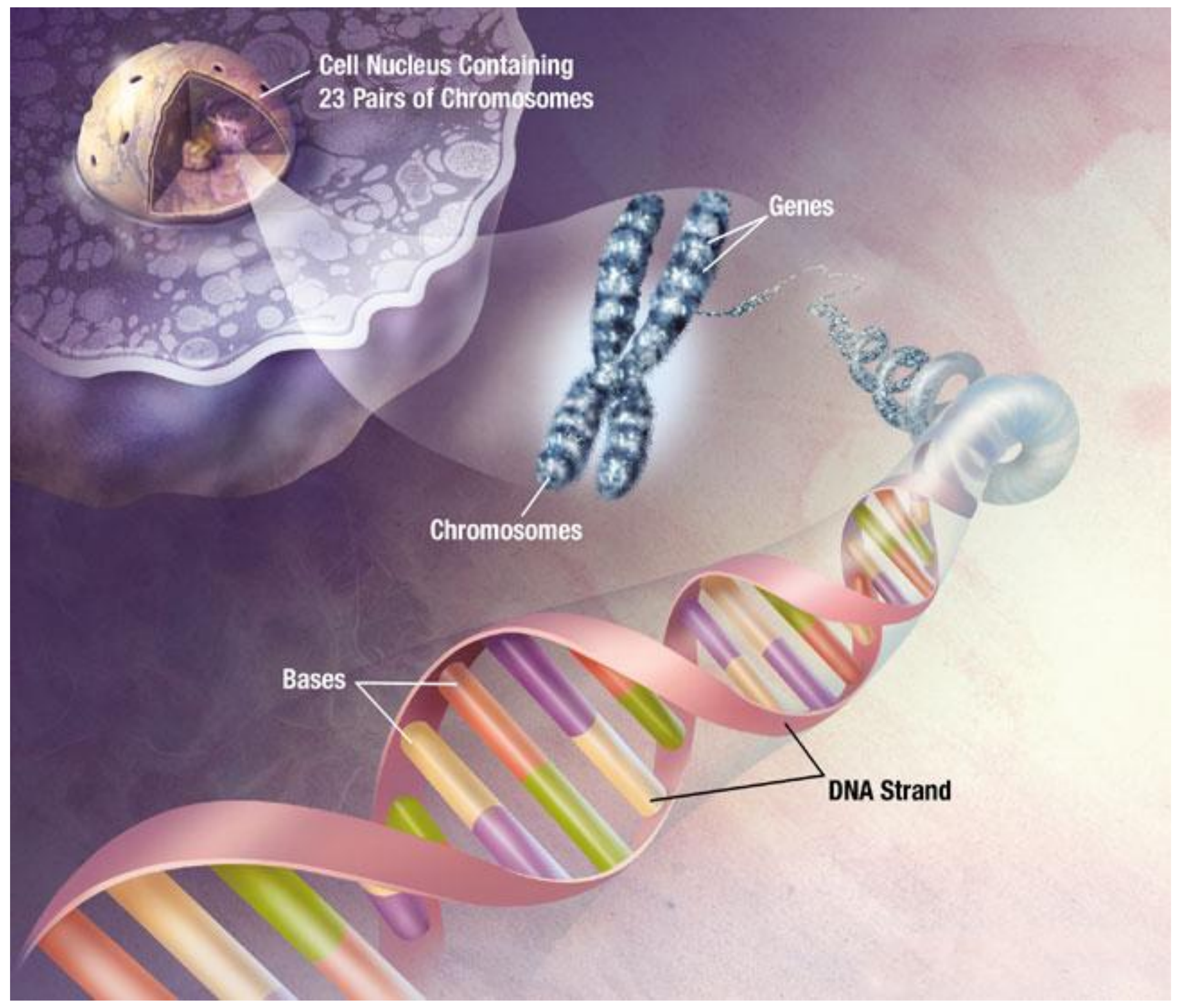
IPRO 302 Synthetic Biology: Engineering Novel Organisms

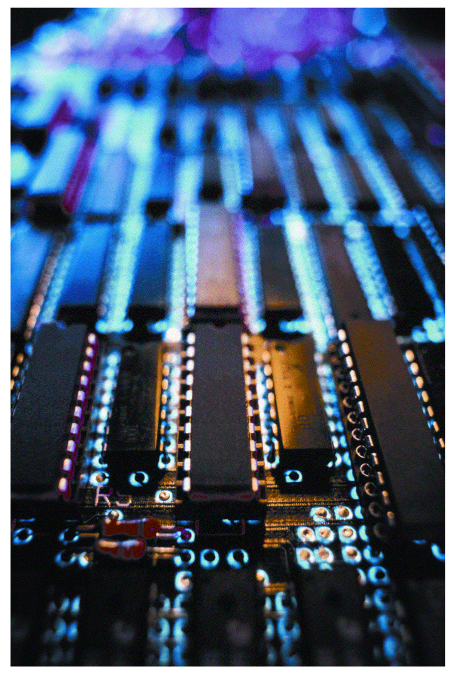
The Big Picture

The goal of this project is to learn how genes interact within an organism and to use this knowledge to manipulate them. In order to understand this, we are building a simple dynamic genetic system.



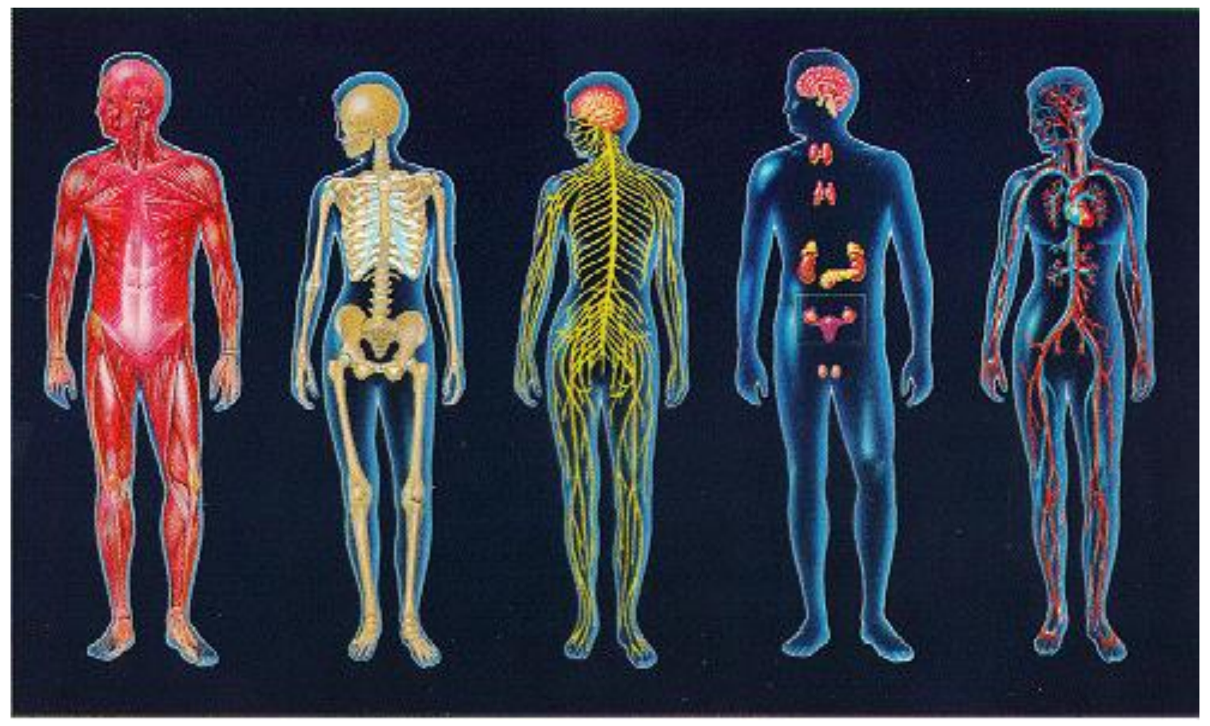
Starting From the Bottom Up

Simpler systems must be understood before more complex systems can be constructed. In the same way a computer is composed of circuits, genes are the basic elements of life. If the way genes interact can be understood, we can begin to construct our own biological systems.



When Pigs Fly…

This may seem like a fantasy, but with the technology learned from synthetic biology, it is possible to make organisms do things they wouldn't normally do in nature.



The human body is made up of several systems composed of smaller elements that are in turn controlled by genes and gene expression.

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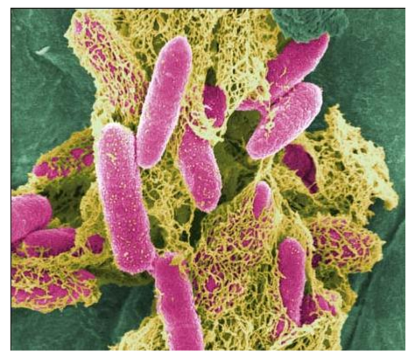
What We Have Learned

During the course of this project, we have achieved a better understanding of how genes interact. Also, we have improved upon specific methods for manipulating and assembling DNA into plasmids.

Applications

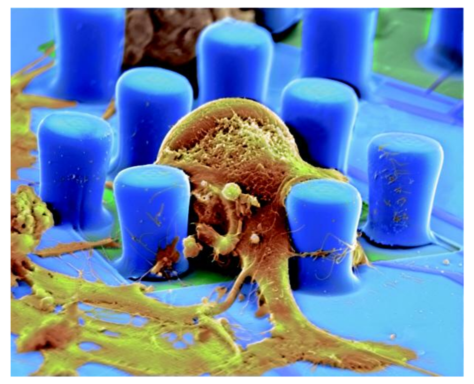
Bioremediation

Land mine detection



Photographic Biofilm

Insulin Production



Information processing

In Our Case

We are trying to modify bacteria to change their characteristic behavior in order to add functional components that we can manipulate. We chose to make an oscillatory system or genetic circuit in bacteria using proteins that fluoresce because the results can be monitored visually.

IPRO 302 Synthetic Biology: *Engineering Novel Organisms*

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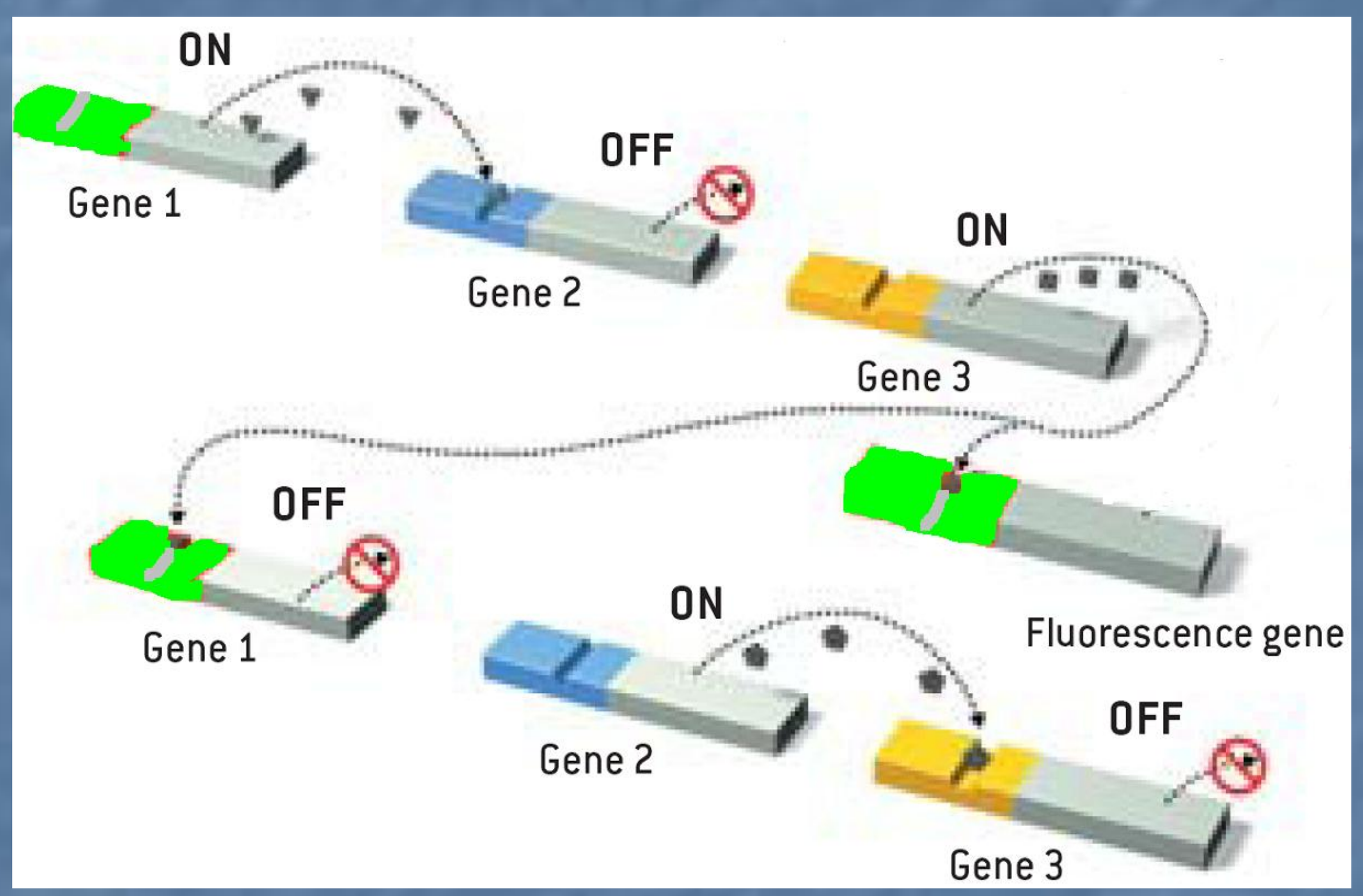
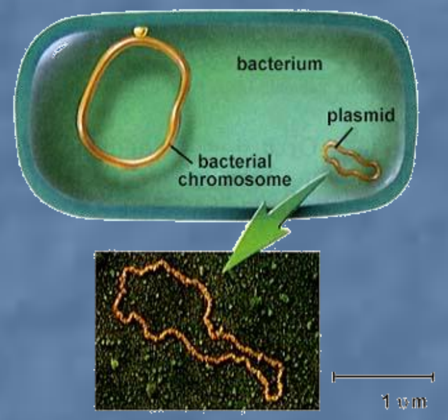
http://www.omega.cs.iit.edu/~ipro302

How Genetic Parts Work



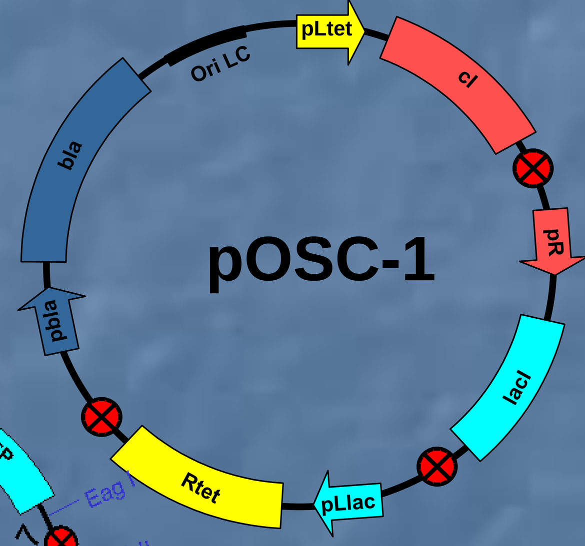
Biological oscillating system

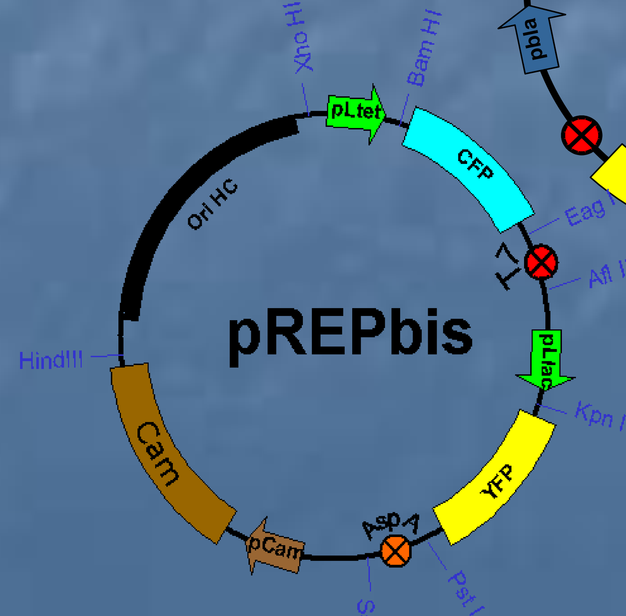
Physical Plasmids

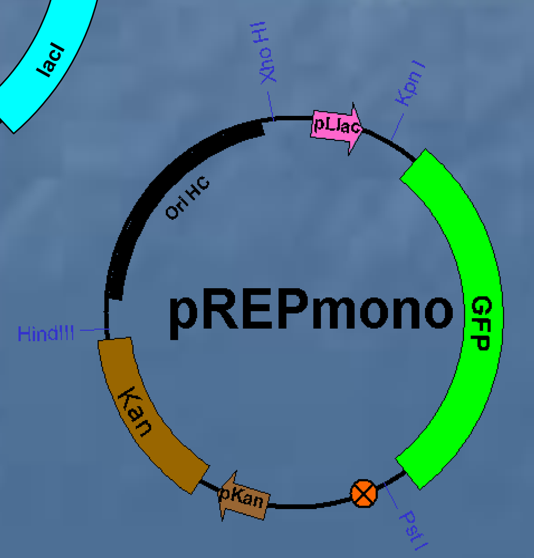


A plasmid is a circular piece of DNA which can be inserted into a bacterium such as E. coli.

The plasmid pOSC-1 initiates the oscillation.







pREP$_{bis}$ fluoresces alternately yellow and blue during the oscillation

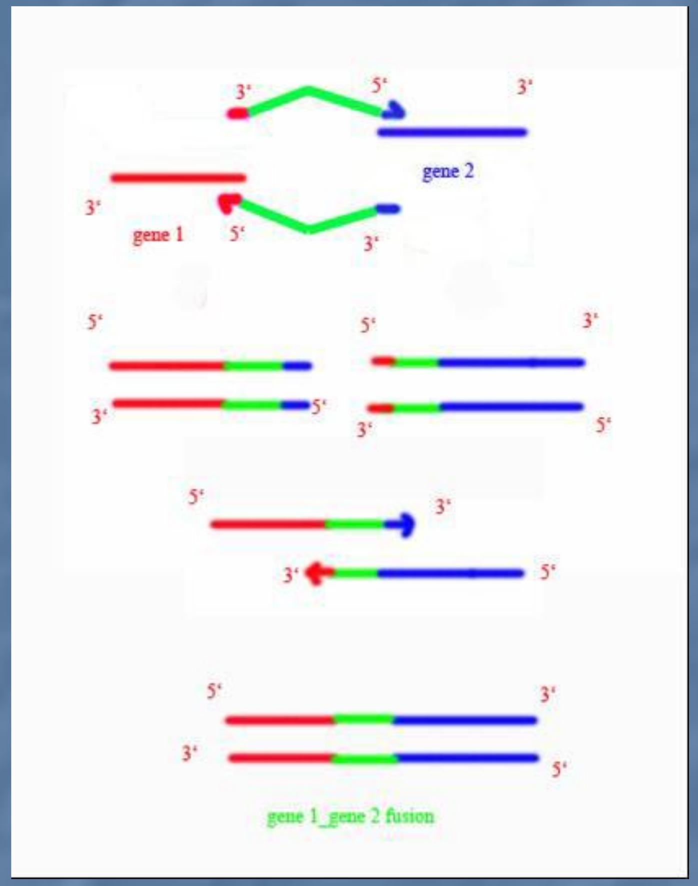
pREP$_{mono}$ blinks on and off with green, tracking the oscillation

Project Objective

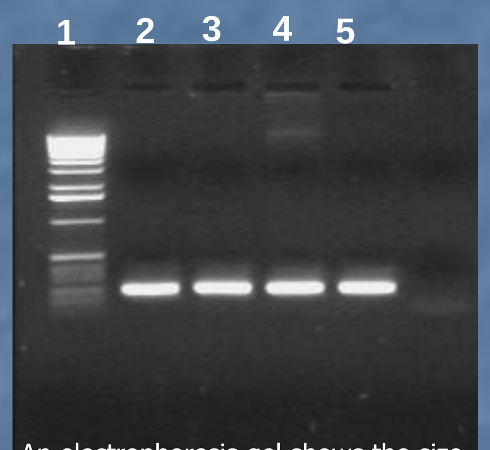
The goal of this IPRO was to obtain a better understanding of how biological systems work by modifying the behavior of a cell and learning to control its behavior.

To accomplish this task, a biological three state oscillator (genetic circuit) was inserted into *E. coli,* enabling it to fluoresce three different colors. (simple system).

Implementation



Fusion PCR

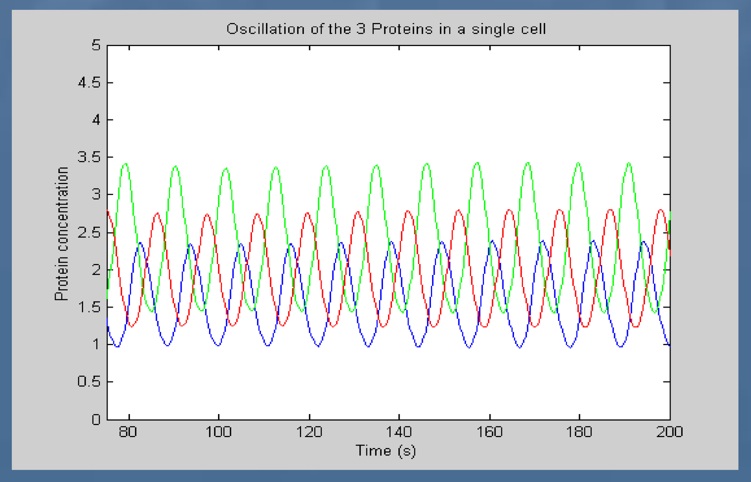


An electrophoresis gel shows the size of segments of DNA.

DNA captured into bacterial cells. The white colonies are selected because they contain the correct DNA.

Mathematical Modeling

The idea is to develop an accurate model of a biological system and then predict what the dynamics will be over time.



$$\frac{dm_i}{dt} = -m_i + \alpha\left(\frac{1}{1+p_j^n}\right) + \alpha_0 \qquad \frac{dp_i}{dt} = -\beta(p_i - m_i)$$

$$\frac{dm_j}{dt} = -m_j + \alpha\left(\frac{1}{1+p_k^n}\right) + \alpha_0 \qquad \frac{dp_j}{dt} = -\beta(p_j - m_j)$$

$$\frac{dm_k}{dt} = -m_k + \alpha\left(\frac{1}{1+p_i^n}\right) + \alpha_0 \qquad \frac{dp_k}{dt} = -\beta(p_k - m_k)$$

Results

This semester the genetic elements were linked together and plasmids, or circular DNA, were generated.

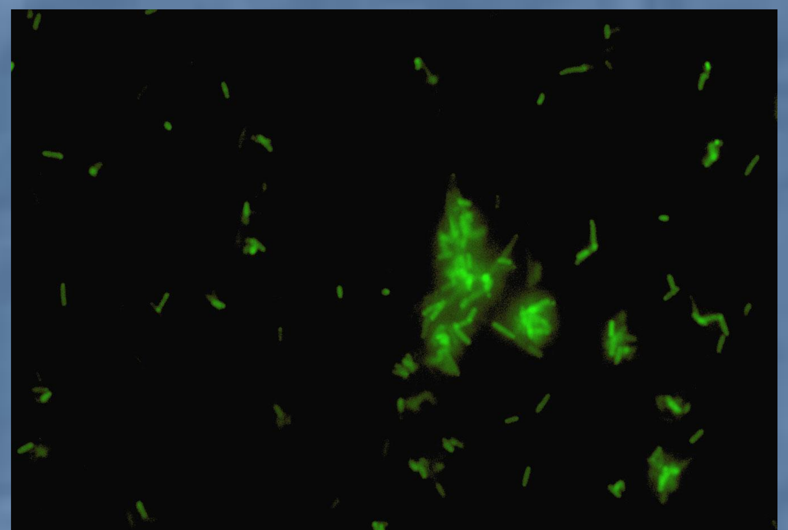


Photo of E. coli (plac_GFP) 400x mag. taken at November 29, 2005 13:30 hrs.

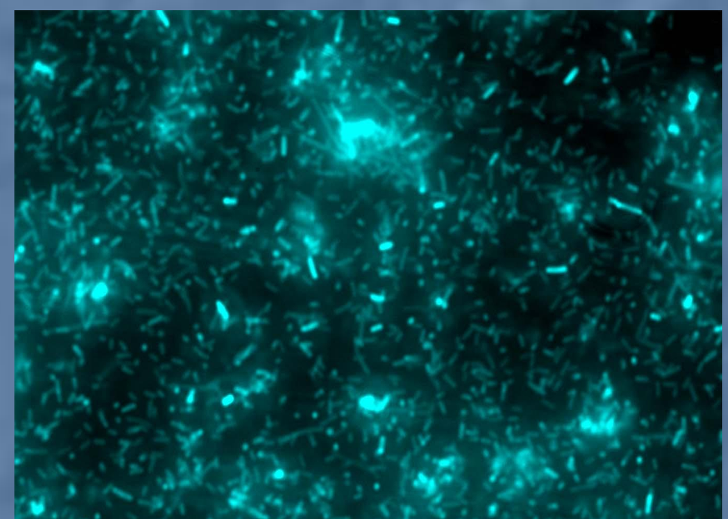


Photo of E. coli (ptet_cfp_t7) 400x mag. taken at November 29, 2005 18:45 hrs.

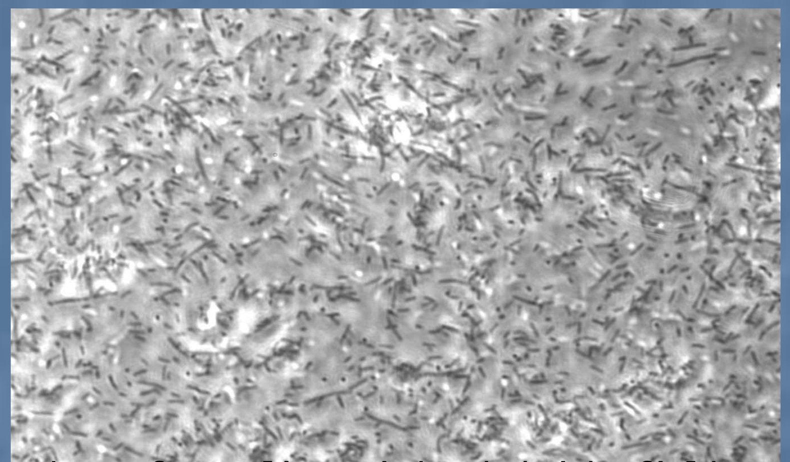


Photo of E. coli non-induced, bright field 400x mag. taken at November 29, 2005 18:35 hrs.

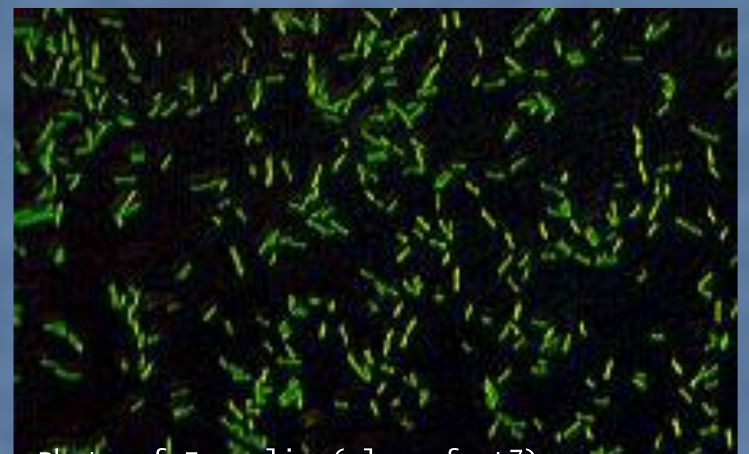


Photo of E. coli (plac_yfp_t7) 400x mag. taken at November 29, 2005 18:50 hrs.

Future Work

Synchronization can be achieved through cell-to-cell communication

Future work could include genetic engineering of more complex organisms such as vertebrates like the Zebrafish (*Danio rerio*)