Lecture 12: Genomes

Goal: Model interactions between gene regulatory elements, discuss common motifs in genetic circuits

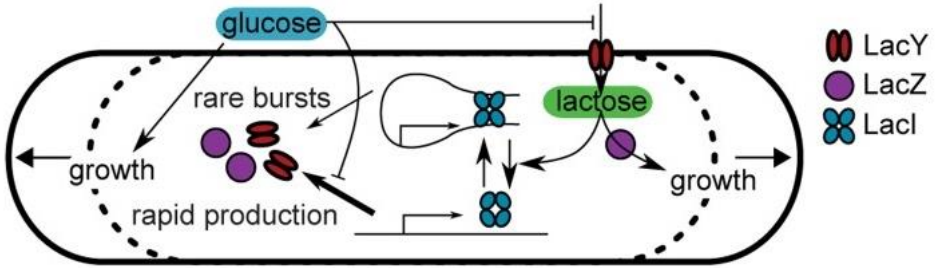
- Genetic switches
- Genetic oscillators

Reading: PBOC Chapter 19.3.2, 19.3.3

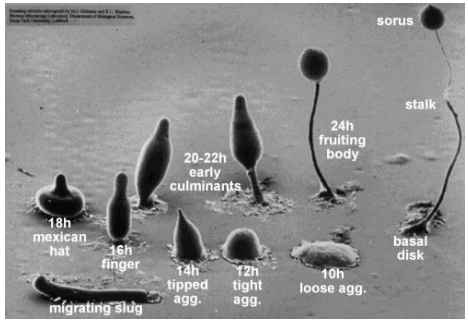
Genomes

How do cells make decisions?

- Even simple organisms make complex decisions
- Cells respond to stimuli by producing proteins
  - Stimulus: sugar. Response: make proteins to digest sugar.
  - Stimulus: DNA damage. Response: make DNA repair proteins.
- How much to make, and when to make it?
- Single cells lack an obvious “brain”
- How is the computation achieved?



Escherichia coli



Dictyostelium discoideum

Gene regulation

Elements of genetic circuits

Structural Genes - code for protein and RNA molecules that are required for normal enzymatic or structural functions in the cell.

Regulatory Genes - code for protein and RNA molecules whose function is to regulate the expression of other genes. “Transcription factors”

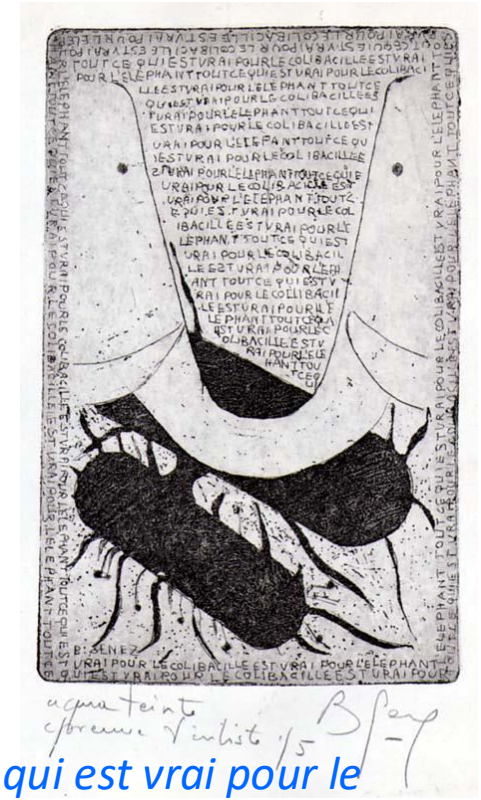
Numbers: ~1600 transcription factors vs. ~20,000 protein coding genes in human genome

Gene regulation

Elements of genetic circuits

Monod (Nobel Laureate 1965)

The biochemical processes that take place within an organism's cells are controlled by the genes found inside DNA molecules. Jacques Monod and François Jacob proved how the genetic information is converted during the formation of proteins by means of a messenger, which proved to the substance we now know as RNA. Different cells work in different ways at different times, however. This too is regulated by genes. In the early 1960s Monod and Jacob mapped the intricate processes that determine how genes are expressed or suppressed in a self-regulating process.



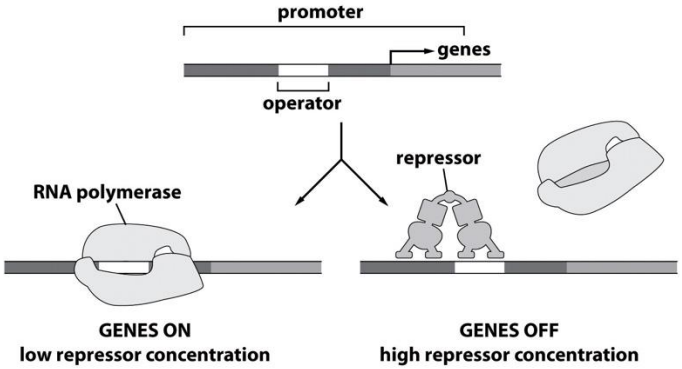
"Tout ce qui est vrai pour le Colibacille est vrai pour l'éléphant."

Genome regulation

Recall:

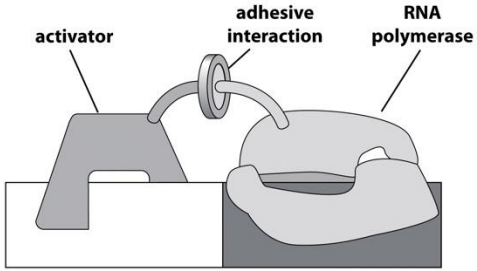
Genetic networks: Molecules

negative regulation



X ⊣ Y

positive regulation



X → Y

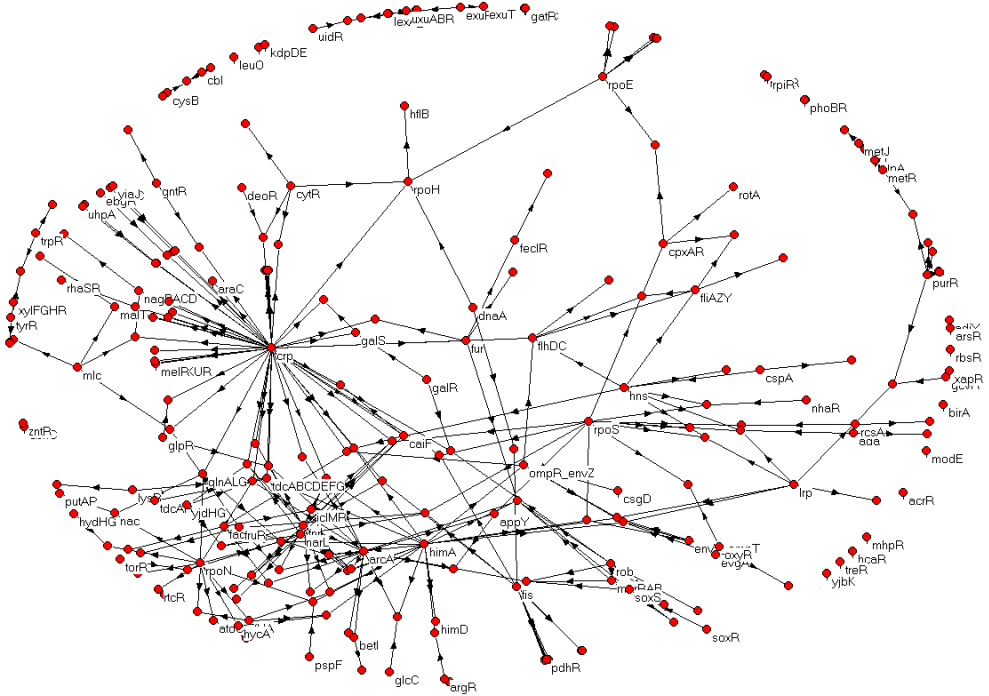
Repressors and activators change the probability of RNA polymerase binding to the promoter of a gene

Genome regulation

Recall:

Genetic networks: E. coli transcription

each edge has a direction, a sign, and a numerical value



Genome regulation

Recall:

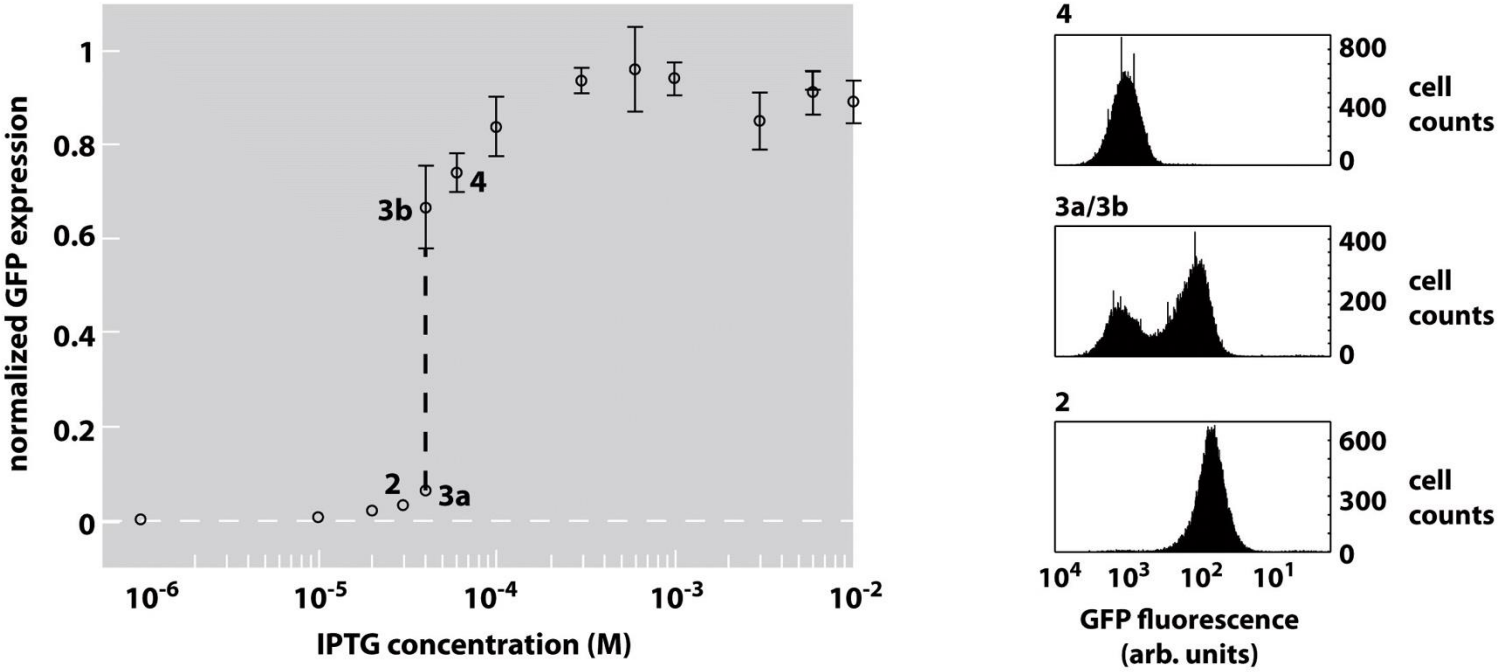
Genetic networks: Molecules

negative autoregulation

positive autoregulation

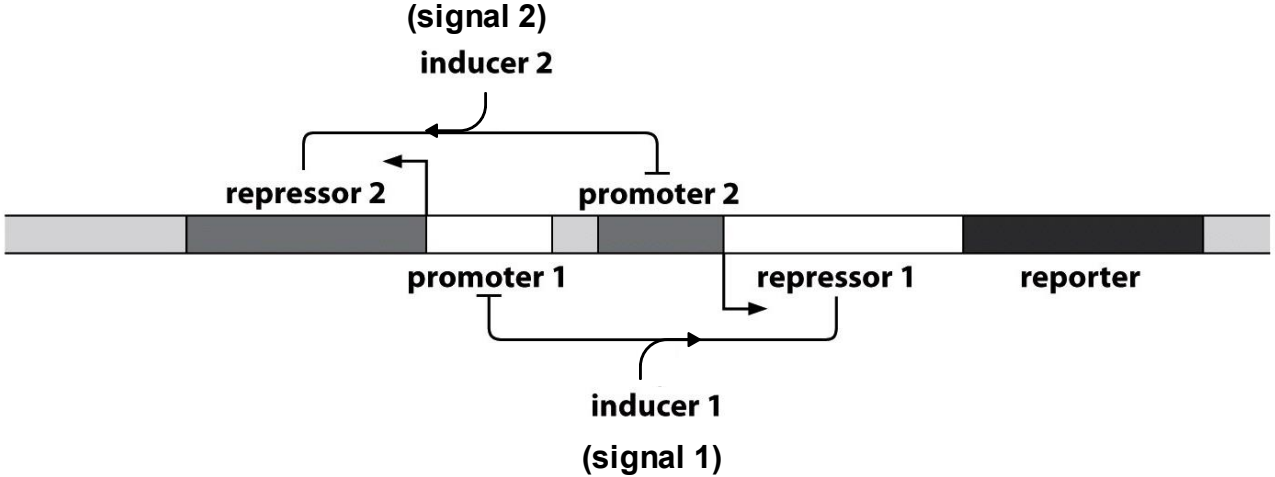
Genome regulation

Genetic networks: Switches



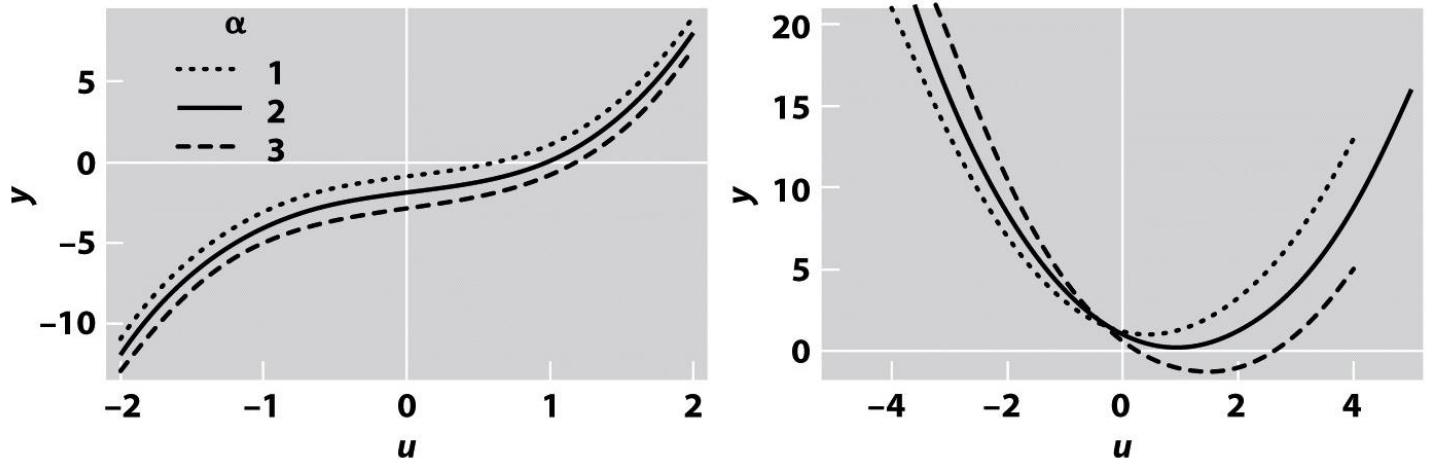
Genome regulation

Genetic networks: Switches



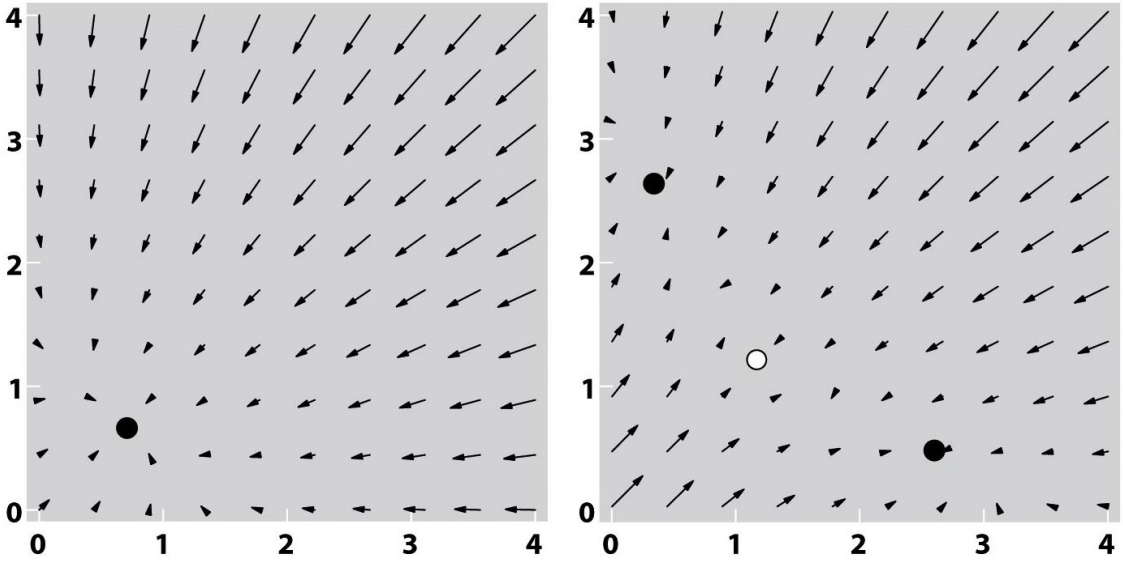
Genome regulation

Genetic networks: Switches



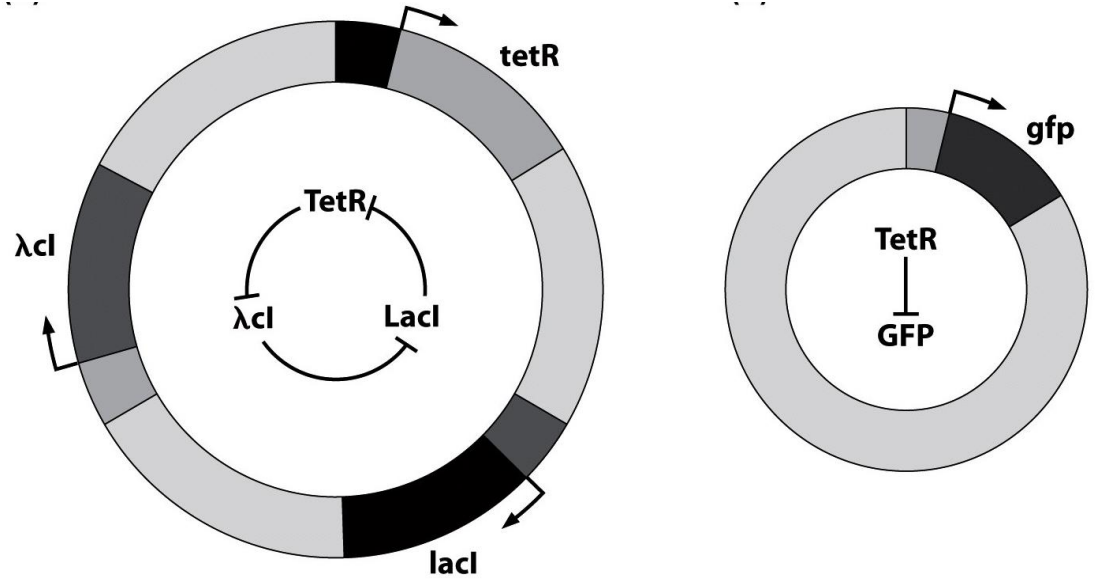
Genome regulation

Genetic networks: Switches



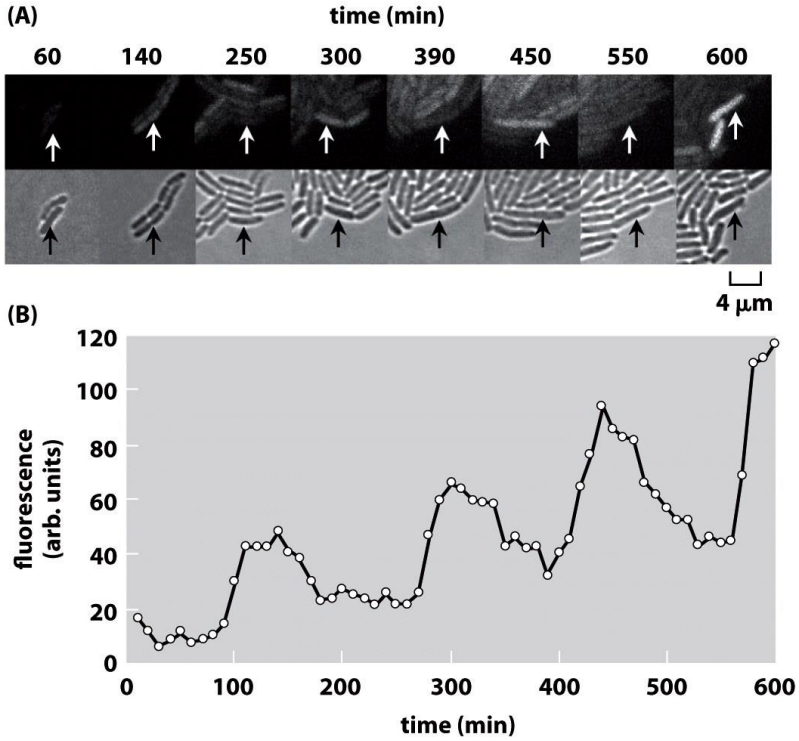
Genome regulation

Genetic networks: Oscillators



Genome regulation

Genetic networks: Oscillators



Lecture 12: Genomes

Summary:

Course overview