20.109
Synthetic Biology Module
Lecture #5

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Genetic Edge Detection Algorithm

- Pseudocode:
  
  \[
  \begin{align*}
  &\text{IF NOT (light)} \\
  &\quad \text{produce signal} \\
  &\text{IF signal AND NOT (NOT light)} \\
  &\quad \text{produce pigment}
  \end{align*}
  \]

- Produce signal –
  generate diffusible communication signal

- Produce pigment –
  produce black pigment

A synthetic genetic edge detection program. Tabor JJ, Salis HM, Simpson ZB, Chevalier AA, Levskaya A, Marcotte EM, Voigt CA, Ellington AD. Cell. 2009 Jun 26;137(7):1273. Figure 1B, 1C
Abstract operation of the system

- Dark sensor
- Processing Module
- Output
Detailed operation of the system
Bacteriophage $\lambda$: Lysis/Lysogeny
Gene regulation mechanisms in $\lambda$

- **Transcription**
  - Repression
  - Activation
  - Termination / anti-termination
- **Translation**
  - Ribosome binding site
  - mRNA decay
  - anti-sense mRNA
Rho-independent termination

![Diagram of the trp operon and mRNA with nucleotide sequences](image)
Antitermination

**TERMINATION**

Only region 1 is transcribed

- Region 1
- Region 2
- Promoter → Terminator
- RNA polymerase terminates

**ANTITERMINATION**

Both regions 1 and 2 are transcribed

- Promoter → Terminator → Antitermination factor enables polymerase readthrough
Translation Initiation with RBS

RBS-1: ATTTAAGGAGGAAATTAAAGCATG  strong
RBS-2: TCACACAGGAACCGGTTCGATG
RBS-3: TCACACAGGAAGGCCTCGATG
RBS-4: TCACACAGGACGCGCGGATG  weak
The stability of cytoplasmic mRNAs varies.

### TABLE 11-1 Half-Lives of Messenger RNAs

<table>
<thead>
<tr>
<th>Cell</th>
<th>Cell Generation Time</th>
<th>mRNA Half-Lives*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escherichia coli</td>
<td>20–60 min</td>
<td>3–5 min</td>
</tr>
<tr>
<td>Saccharomyces cerevisiae (yeast)</td>
<td>3 h</td>
<td>22 min</td>
</tr>
<tr>
<td>Cultured human or rodent cells</td>
<td>16–24 h</td>
<td>10 h</td>
</tr>
</tbody>
</table>

*mRNA Half-Lives*  
Average  
Range Known for Individual Cases

Antisense RNA regulates translation of transposase mRNA in bacteria
The $\lambda$ Genetic Map
Patterns of Gene Expression

The diagram illustrates the patterns of gene expression during the lysogeny and lysis processes. It shows the transitions from very early, early, and late stages to lysis and lysogeny.

- **Very Early**: Initial stage of gene expression.
- **Early**: Developmental stage with specific gene activation.
- **Late**: Stage where gene expression continues.
- **Lysis**: Process where the host cell is destroyed by the virus.
- **Lysogeny**: Stage where the virus integrates into the host genome without directly killing the cell.
Protein N Anti-Termination
The Decision

![Diagram showing the decision process in bacterial infection, with options for lysis and lysogeny influenced by bacterial proteases.](image-url)
Late Lytic
Late Lysogenic
Setting the Switch with CII

Diagram A shows the regulatory pathways involving CII and Cl. The equations for Cl(t) and ΔCl(t) are indicated, along with the process of translation and regulation at the mRNA and protein levels.

Diagram B illustrates the change in transcription rates (Op/s) as a function of Cl molecules per cell, with a lysogenic range shown.

Diagram C presents the change in transcription rates (Op/s) as a function of Cl concentration (log[Cl (M)]) with two distinct peaks representing PR and PRM.
The Entire λ Circuit