Building Reliable Genetic Devices Using Unreliable Ones

Elza Erkip[1], Dennis Shasha[2]

[1] Polytechnic Institute of New York University
[2] Courant Institute of Mathematical Sciences

September 18, 2013

Synthetic Biology

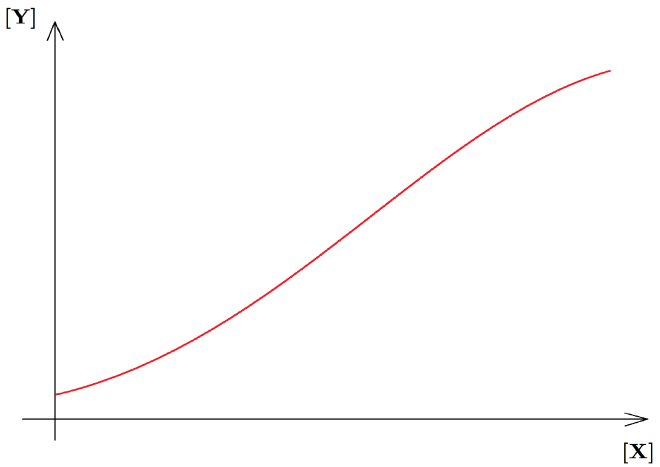
- Designing protein circuits that will live inside cells
- An Application : Cancer Treatment
  - Can be used to treat liver, bone, and skin cancers
  - Engineer bacteria to seek out and invade cancer cells
  - Need to prevent healthy cells from being killed
- State of art:
  - Standardization of parts: Biobricks
  - Other applications: smarter drugs, biofactories, biofuel cells, ...
  - Market for synthetic biology in 2013 expected as over $2.4 billion (BCCC research, June 2009)
- Issues:
  - Relability
  - Regulations

Our Approach

- Use information theory to create more reliable biocircuits.
- Cancer Application
  - Current cancer treatments (chemo, radiation) kill too many healthy cells (race to kill cancer before killing patient)
  - Reliable cancer-targeting by bacteria means that fewer healthy cells are killed
- Why information theory?
  - Biocircuits designed using electrical circuit analogy
  - Building blocks: biological logic gates, clocks, FFs, ...
  - Information theoretic tools for reliable digital components

Motivating Example

- Genetic Switch: $\mathcal{X} \longrightarrow \mathcal{Y}$



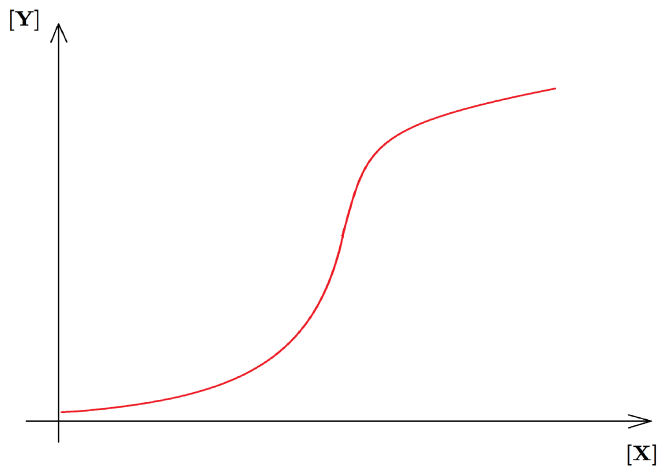


Figure: *Unreliable response* *Reliable response*

- Information theory: Use many unreliable switches to obtain a reliable one
- Extensible to larger circuits
- General goal: Compiler from logical circuit to realization with reliability guarantees.

External Funding

- NSF
  - Communication and Information Foundations
    - Information theory, including emerging applications to biology
- NIH
  - Smart and Connected Health