LECTURE 1: Synthetic Biology

Introduction to cellular system modelling

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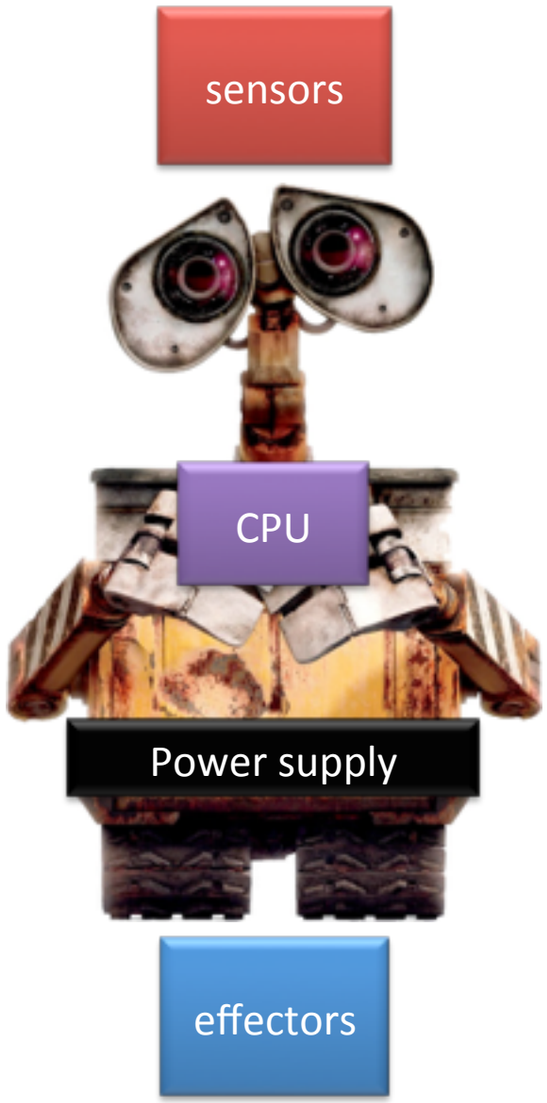
Summer 2015

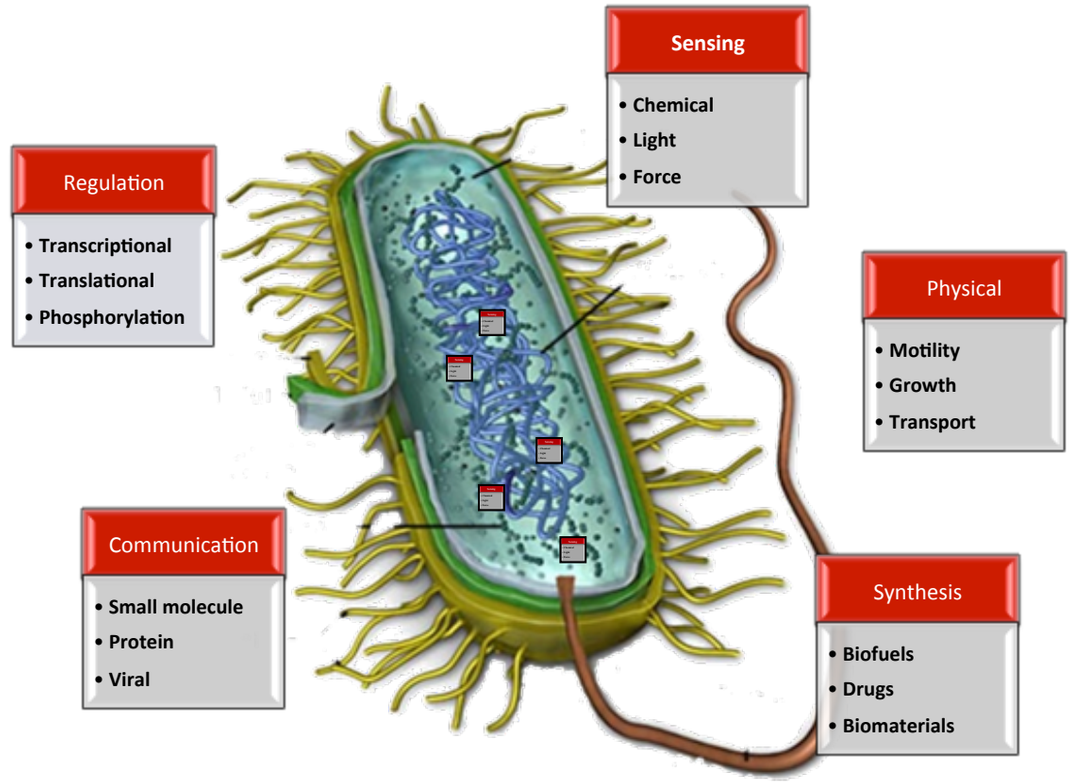
OUTLINE

- Robot cell
  - source
  - cpu
  - actuators
  - sensors
- Application
  - production
  - modern medicine
  - environment
- Basics
  - DNA
  - central dogma
  - metabolism
  - signalling
- Examples of simple synthetic devices
- Complex system design

SYNTHETIC BIOLOGY

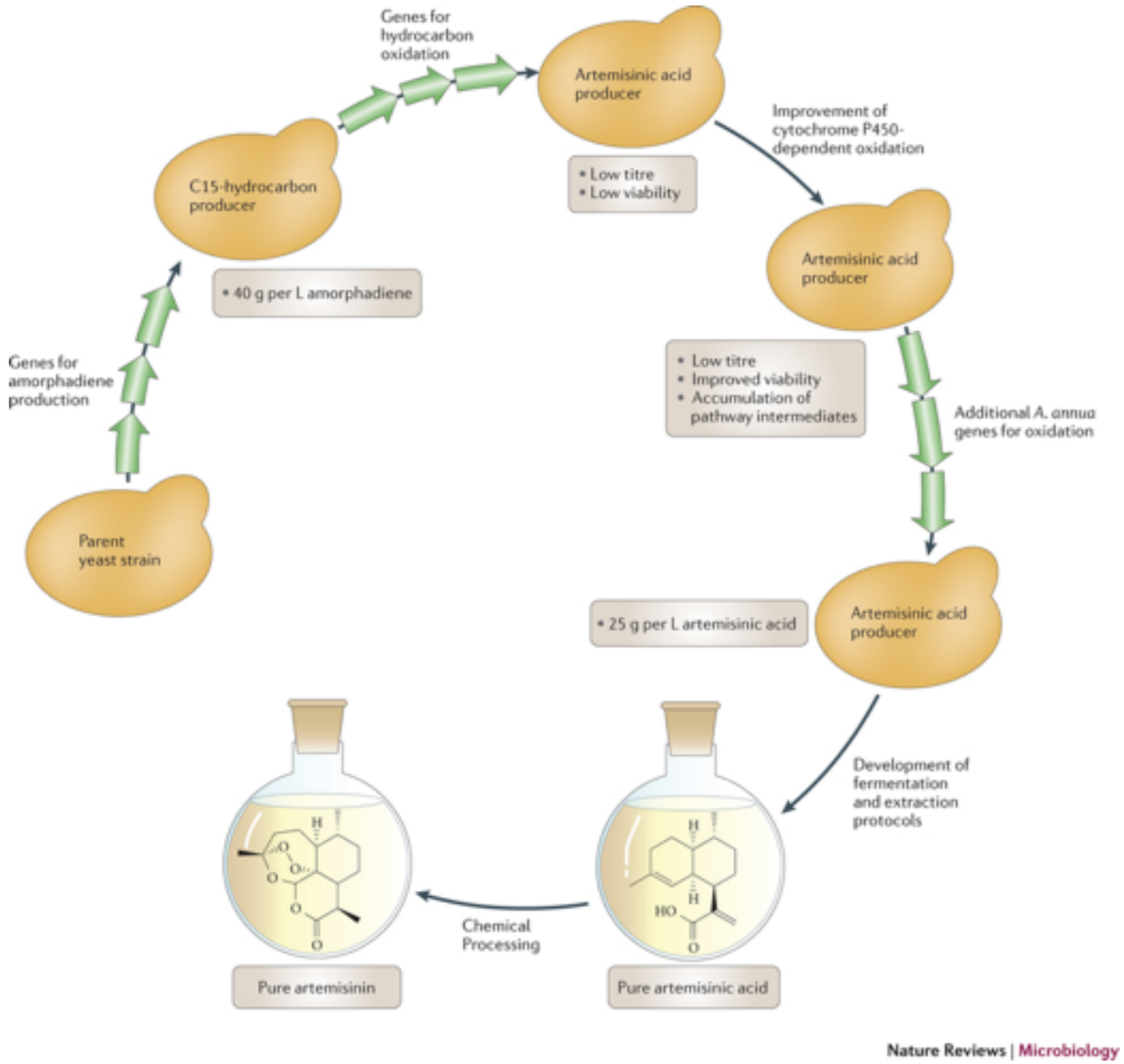
building up from parts to complex systems





SYNTHETIC BIOLOGY

applications - bioproduction



<u>MALARIA</u>

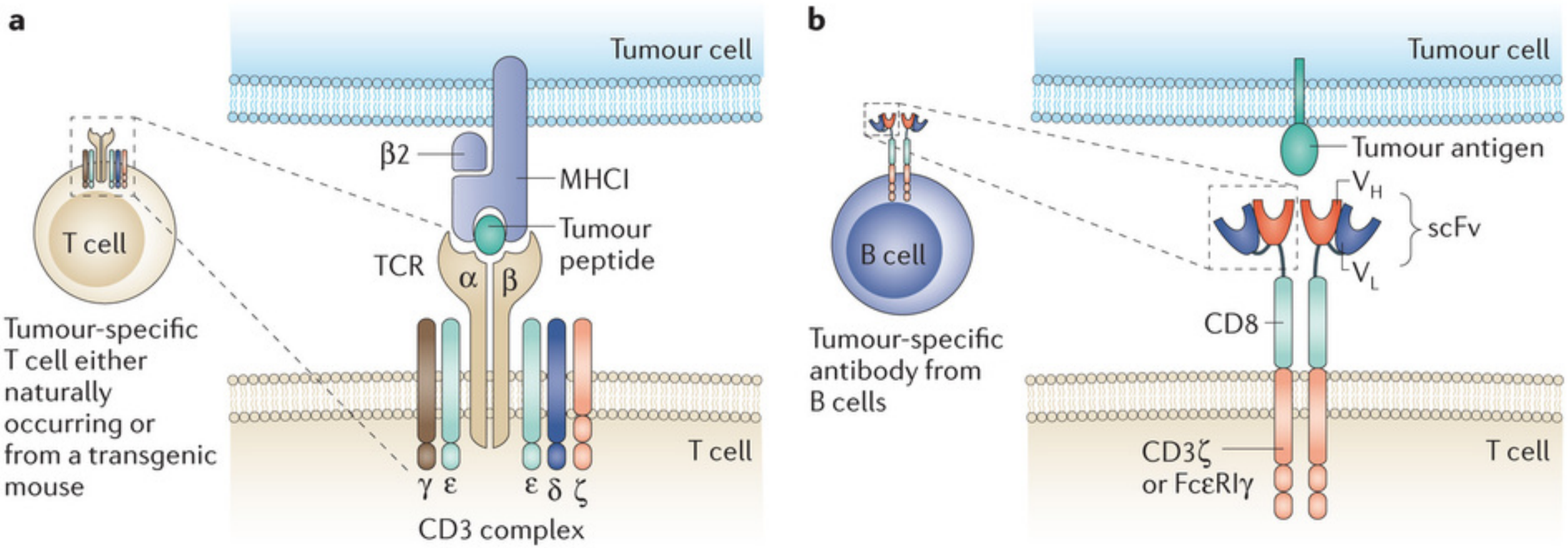
12 billion USD

198 million cases per year

drug artemisinin = $1100/kg

SYNTHETIC BIOLOGY

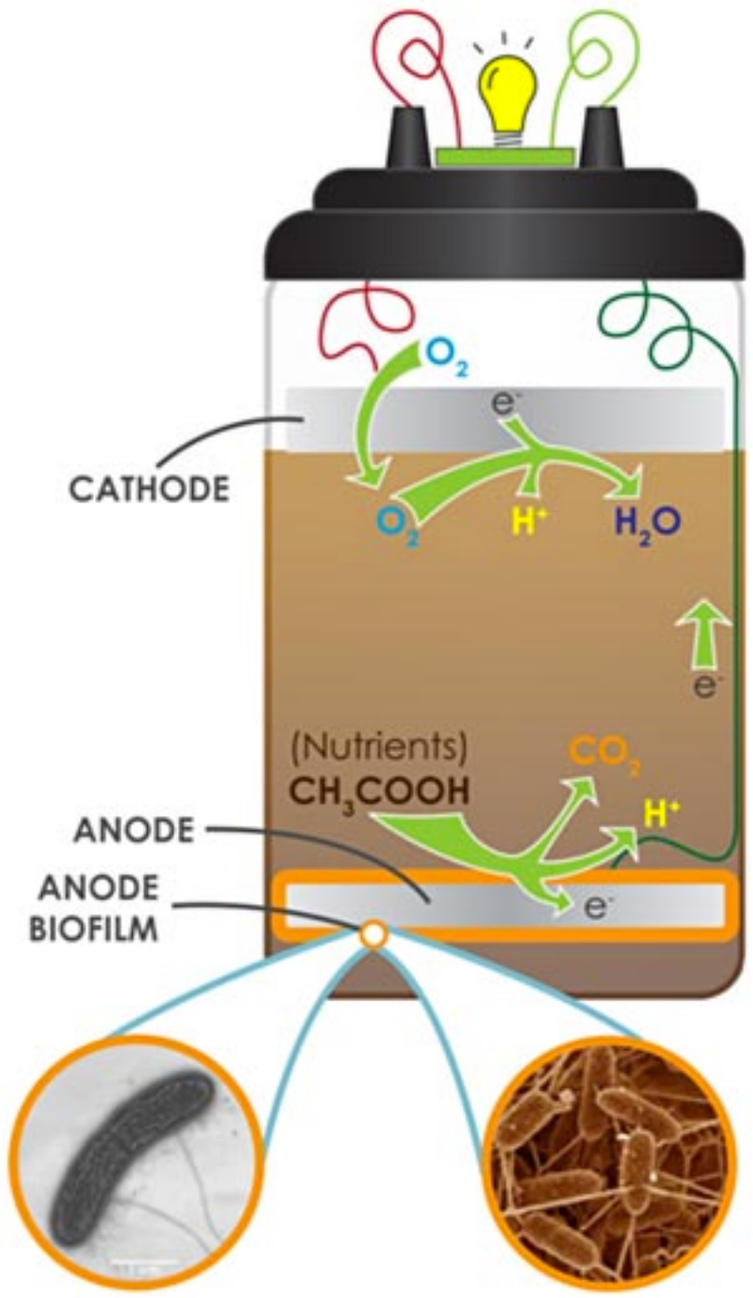
applications - medicine



Nature Reviews | Cancer

SYNTHETIC BIOLOGY

applications - ecology



MOLECULAR BIOLOGY

basics - DNA

MOLECULAR BIOLOGY

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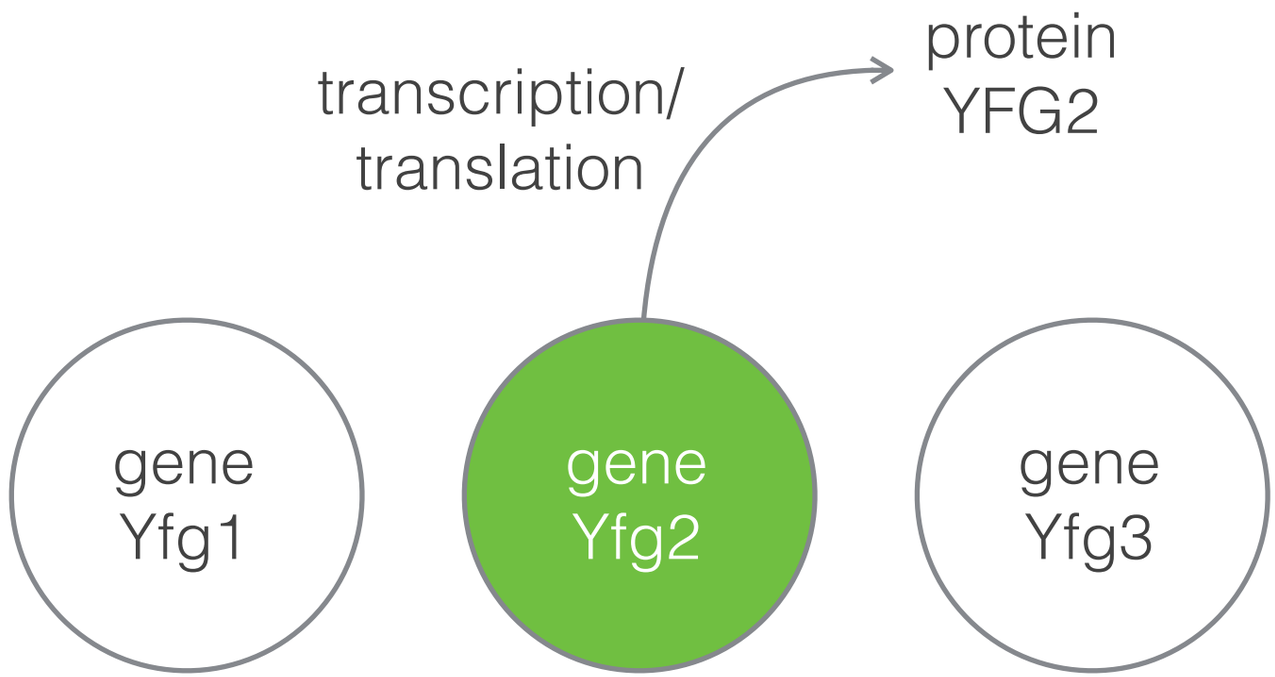
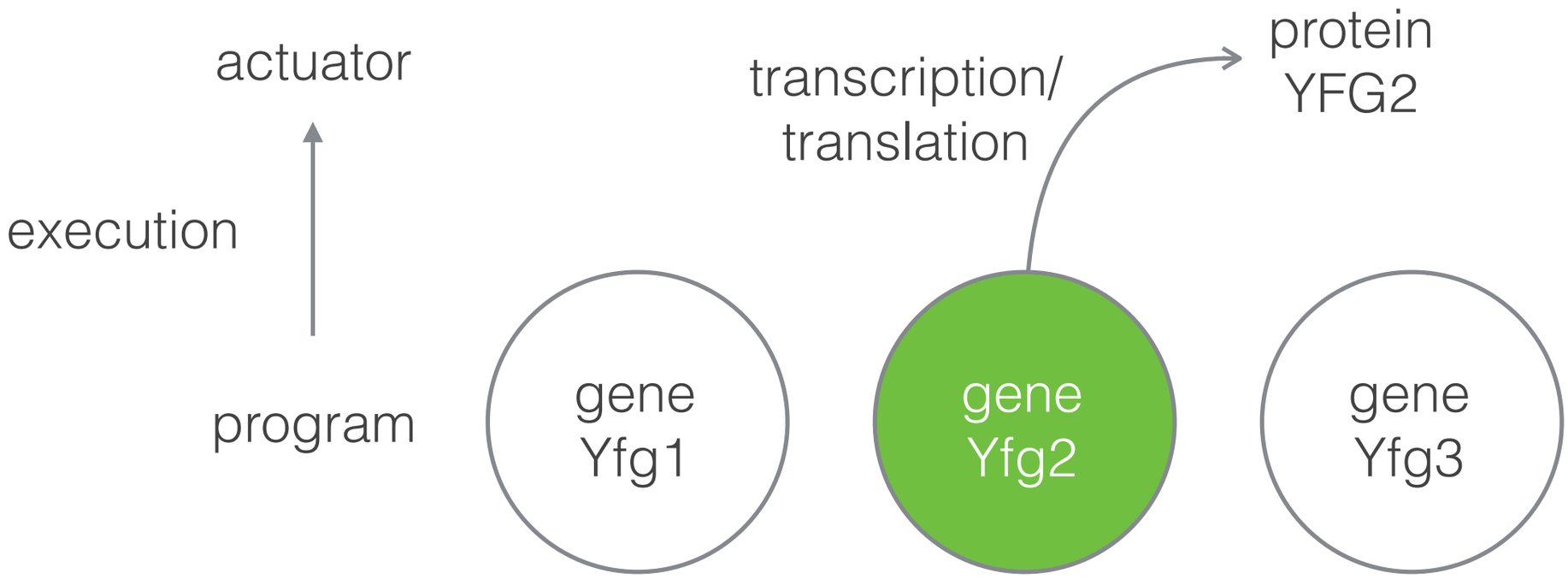
basics - DNA



MOLECULAR BIOLOGY

basics - DNA



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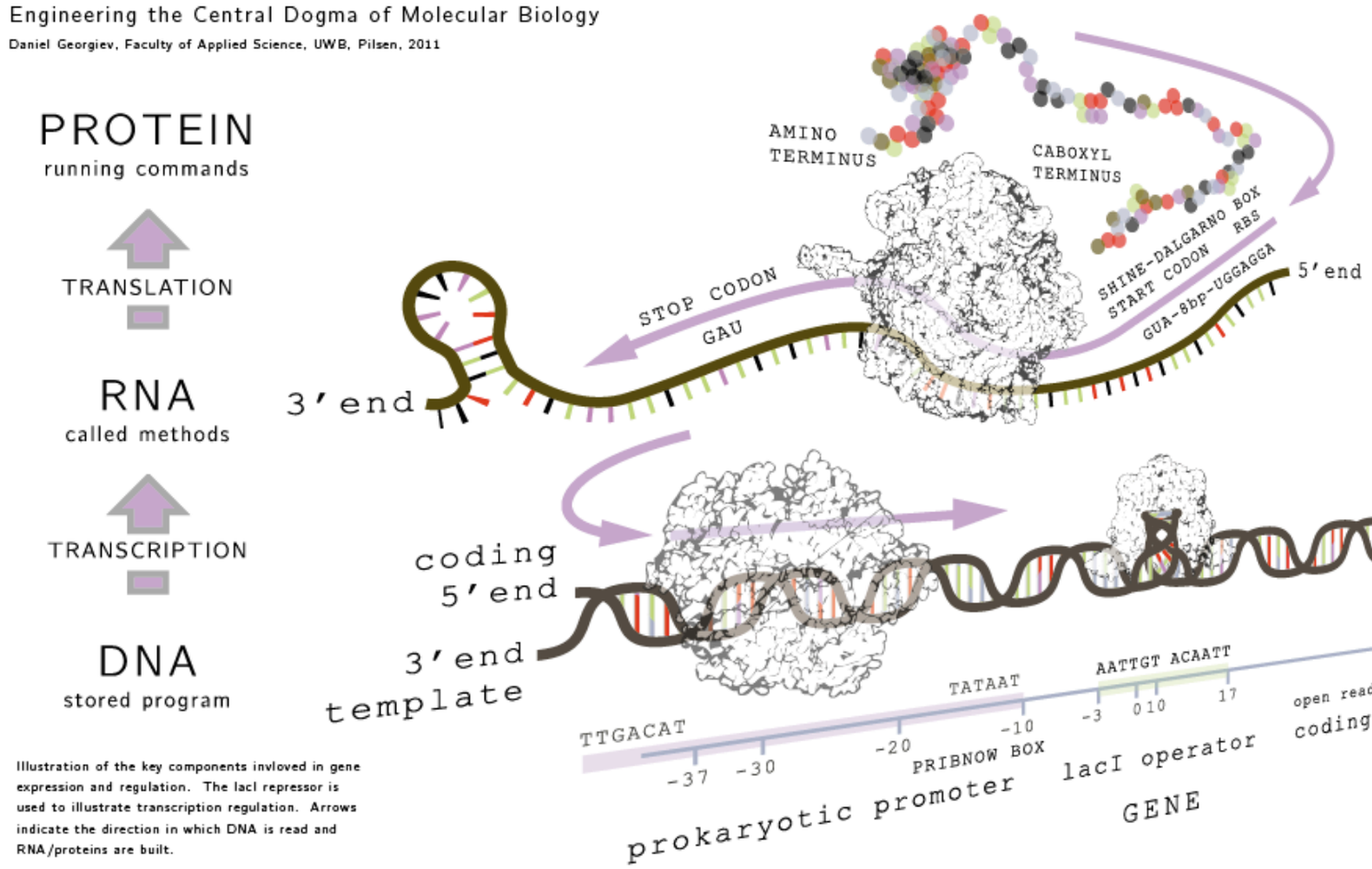
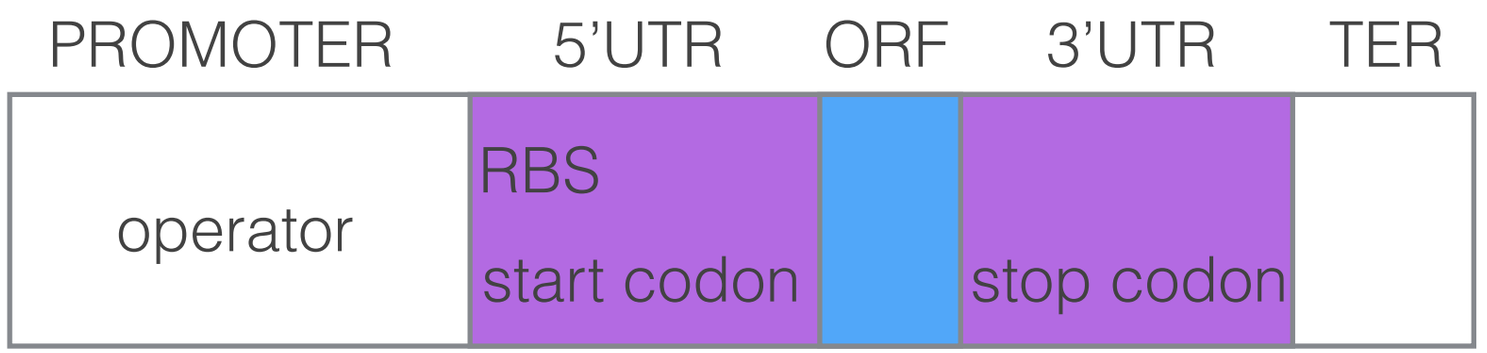


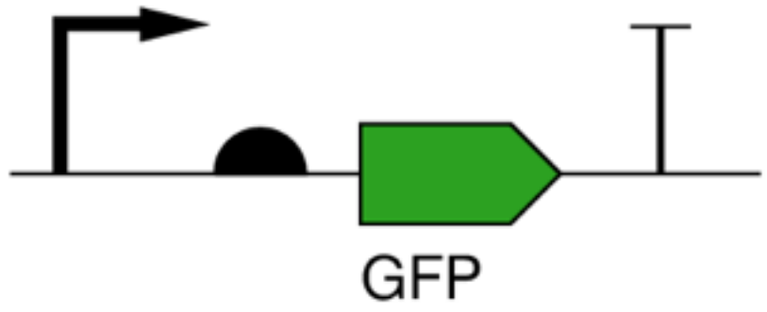
Illustration of the key components invloved in gene expression and regulation. The lacI repressor is used to illustrate transcription regulation. Arrows indicate the direction in which DNA is read and RNA/proteins are built.



MOLECULAR BIOLOGY

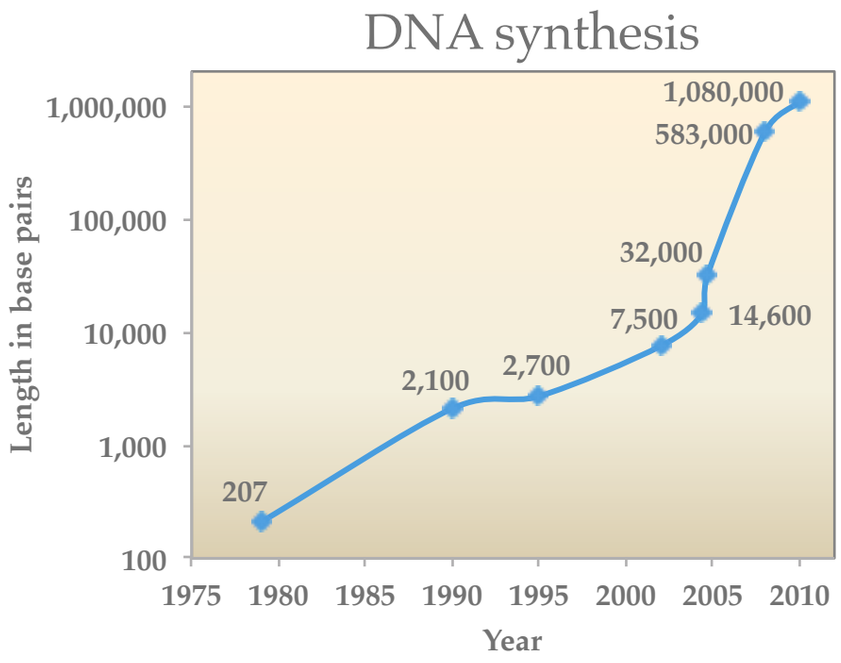
basics - DNA

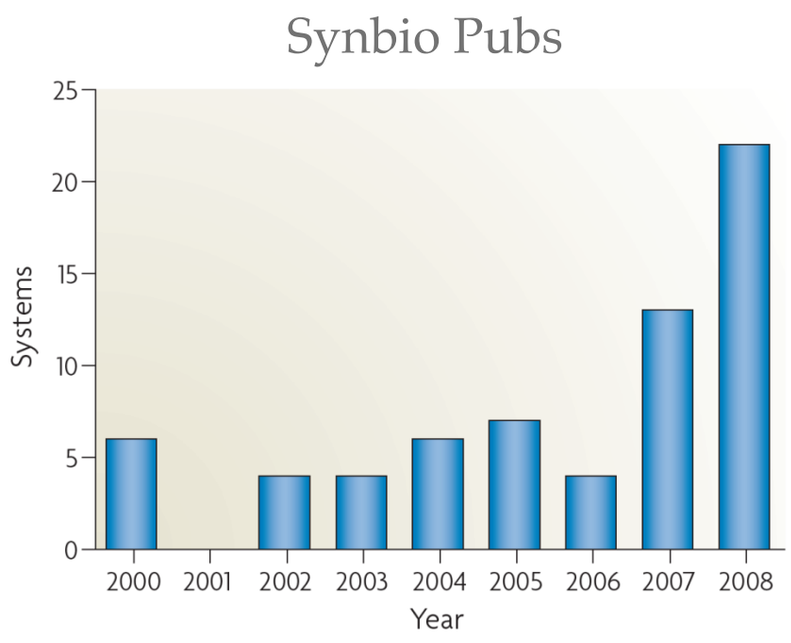
```
1  atggtgaatg tgaaaccagt aacgttatac gatgtcgcag agtatgccgg tgtctcttat
61 cagaccgttt cccgcgtggt gaaccaggcc agccacgttt ctgcgaaaac gcgggaaaaa ...
```



MOLECULAR BIOLOGY

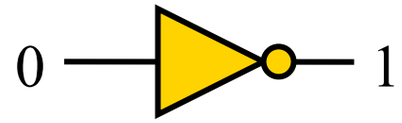
basics - DNA

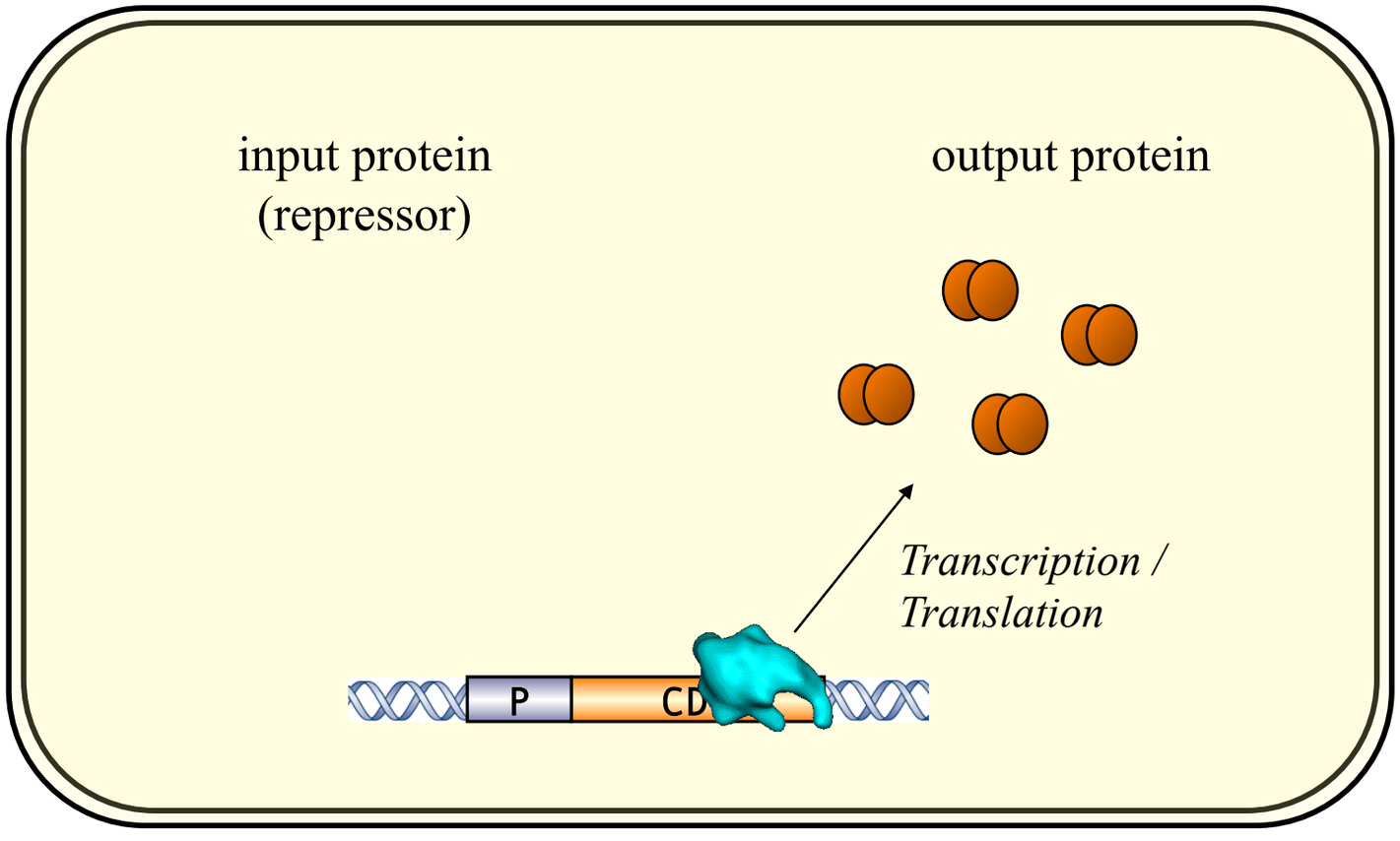




SIMPLE PARTS

inverter





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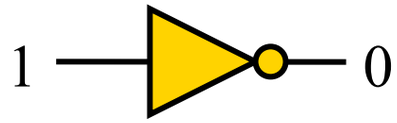
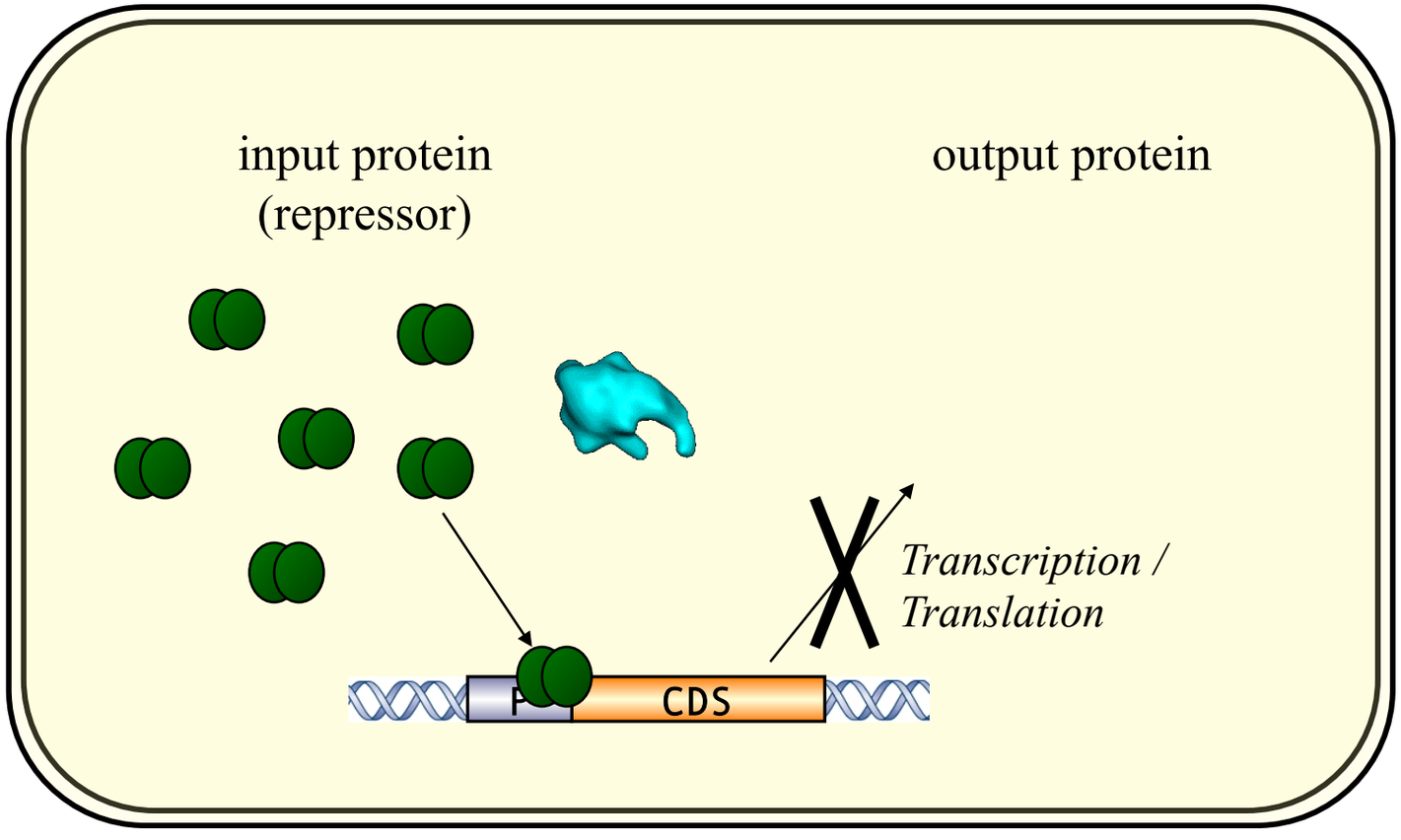
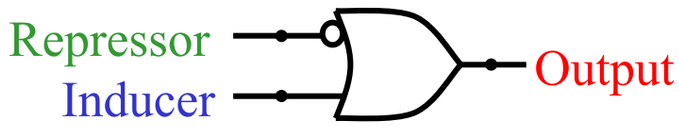


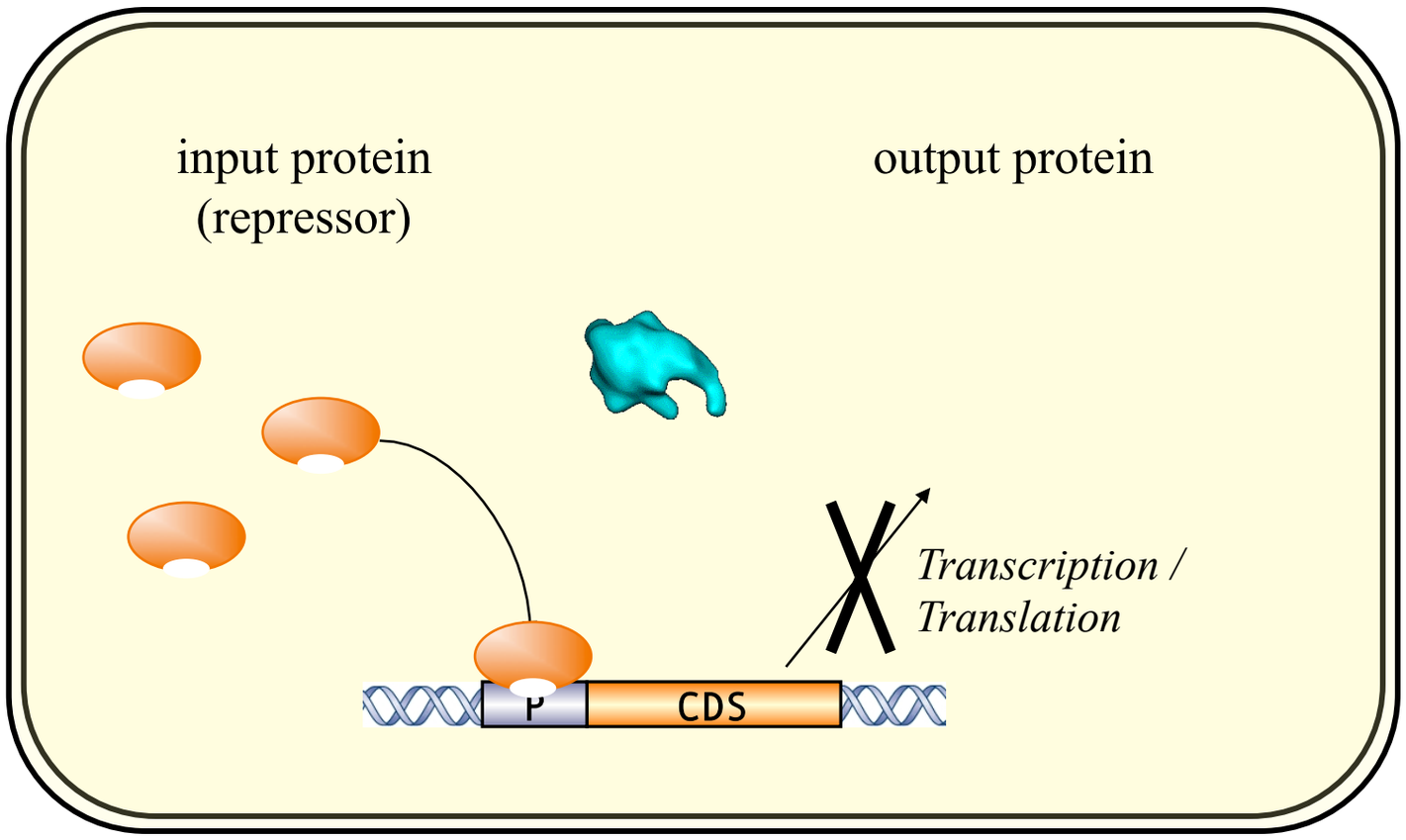


SIMPLE PARTS

implies gate



Repressor	Inducer	Output
0	0	1
0	1	1
1	0	0
1	1	1



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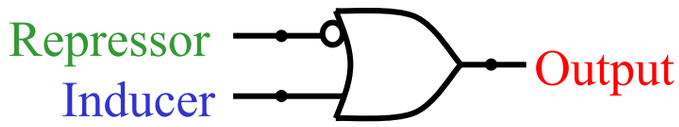

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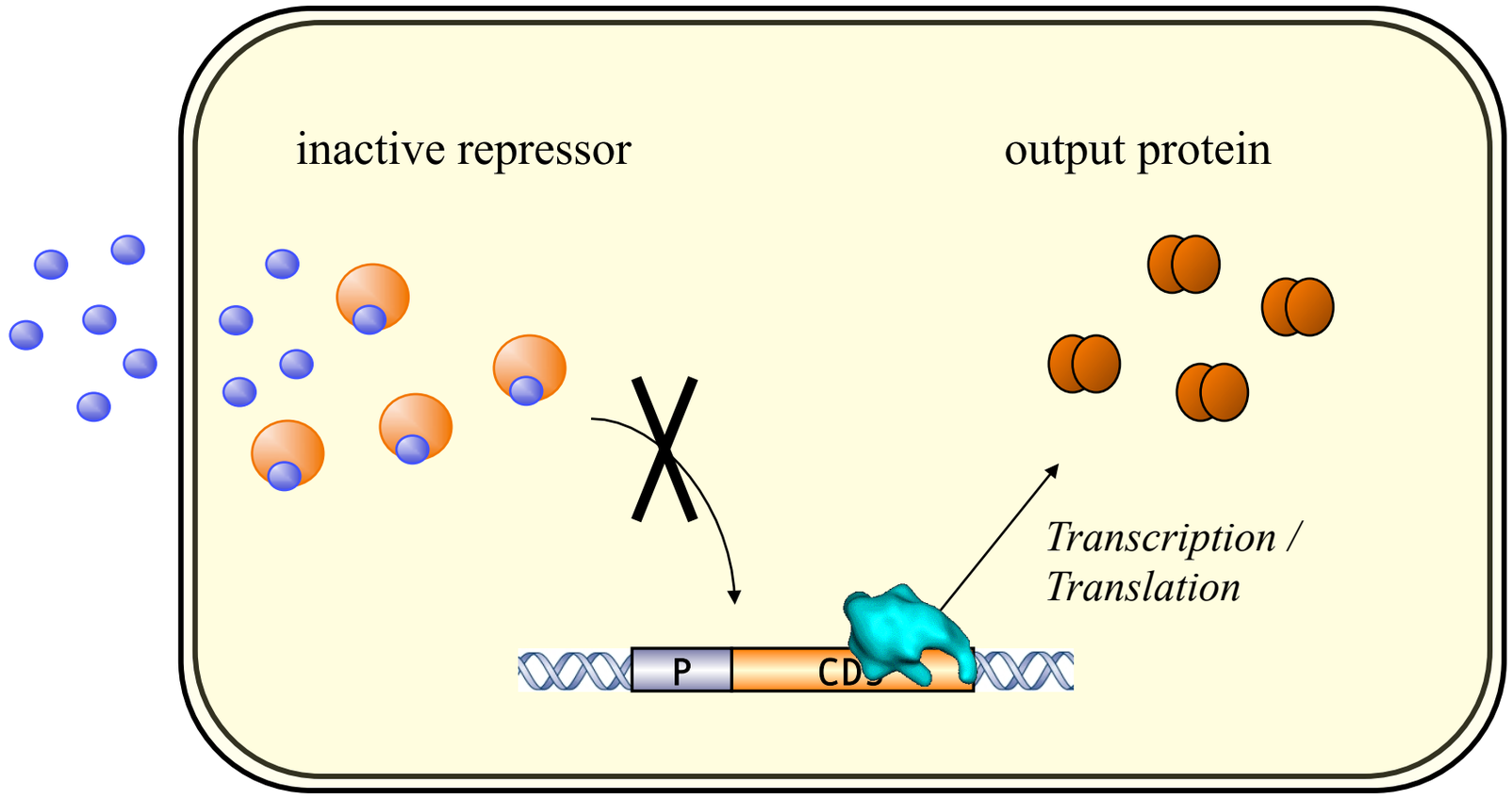
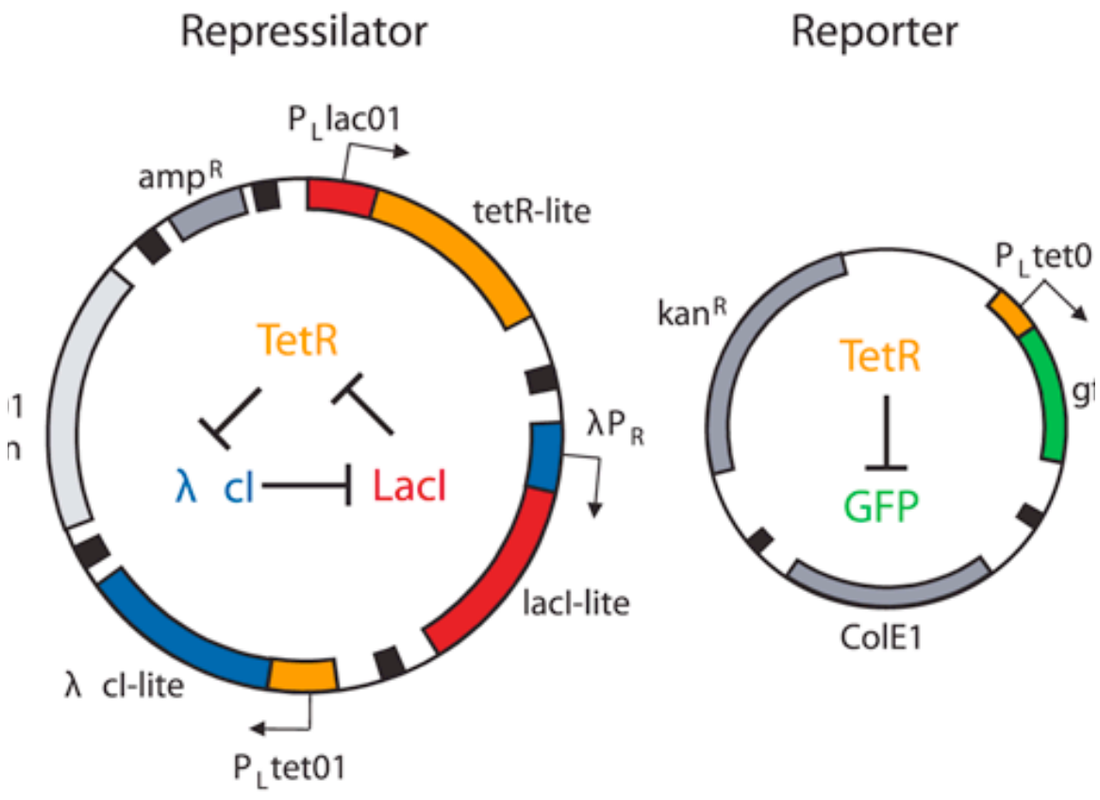


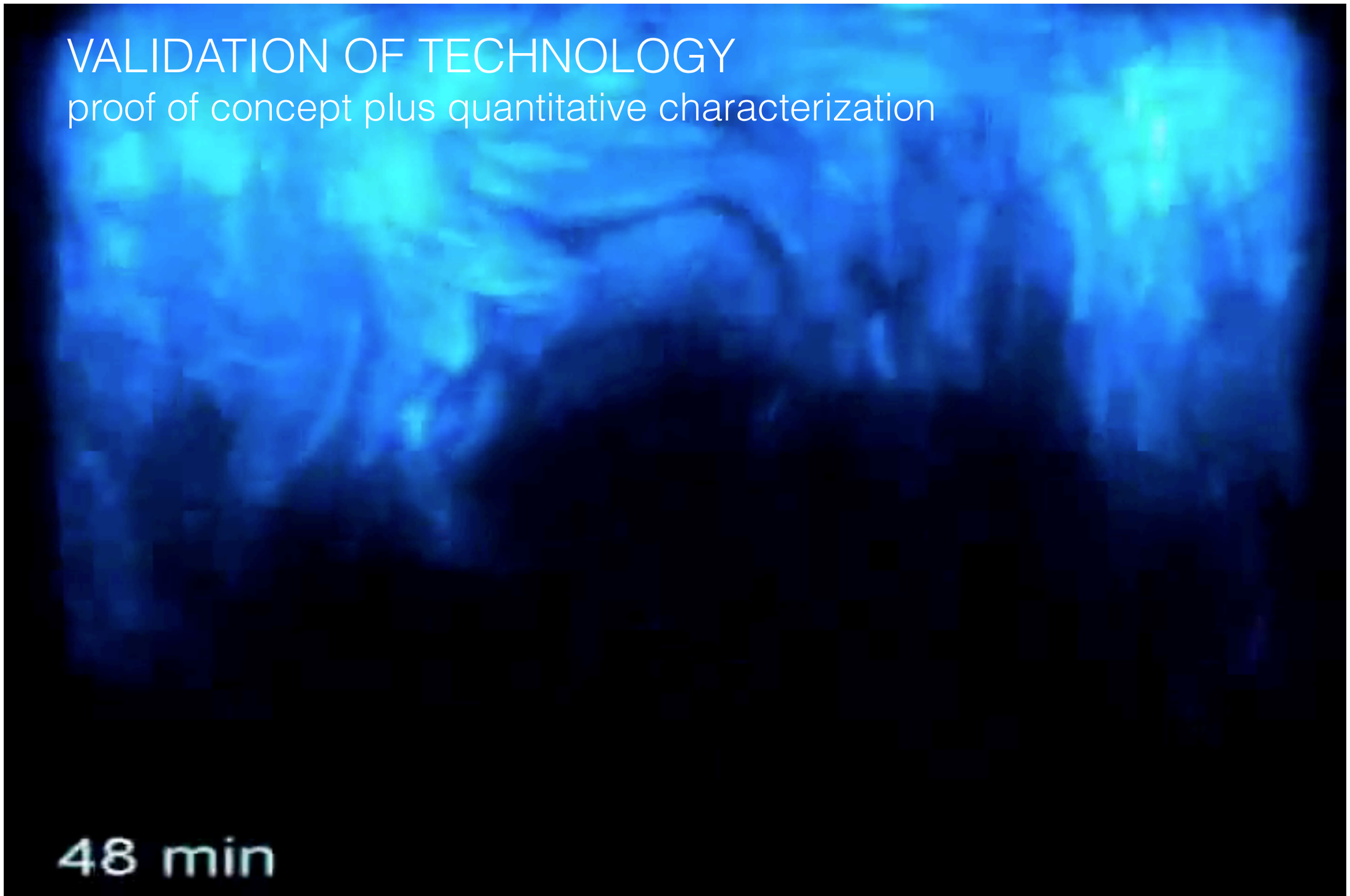
SIMPLE PARTS

oscillator



SIMPLE PARTS

oscillator

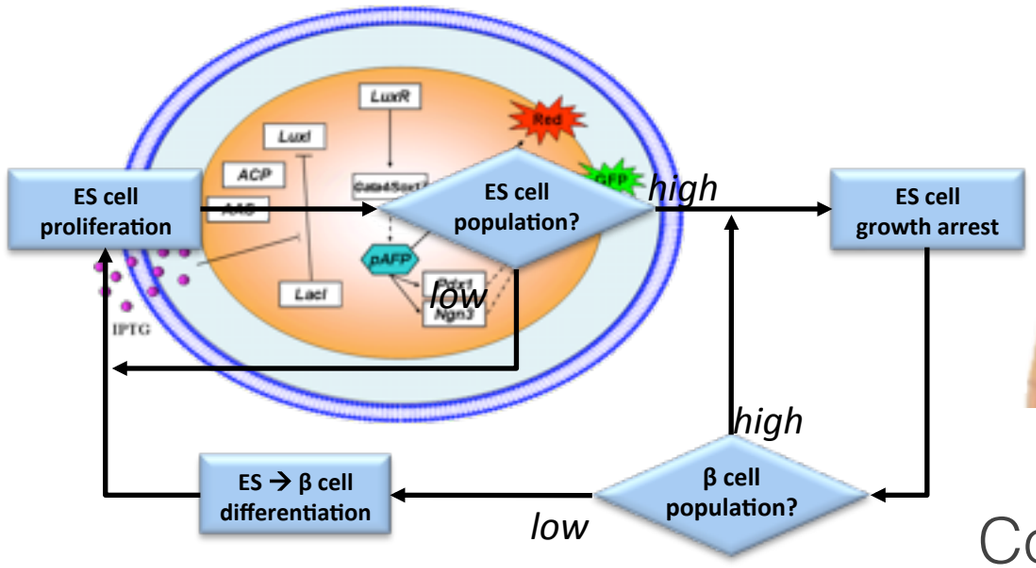


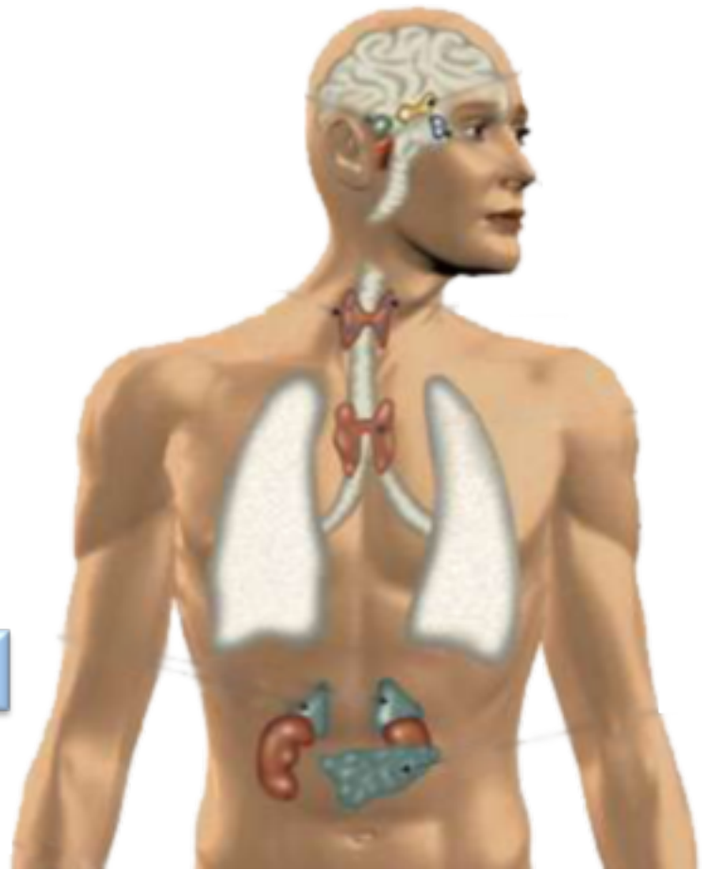
COMPLEX DESIGN

beta cell homeostasis with regulated ESC differentiation

7.8% of the US population has diabetes
In Diabetes Type I (10% of diabetics),
auto-immune response (slowly)
kills insulin-producing pancreatic β cells.

Goal:
Maintain population level of β cells using
auto-regulated differentiation of ES cells
that counter-balances auto-immune attacks.

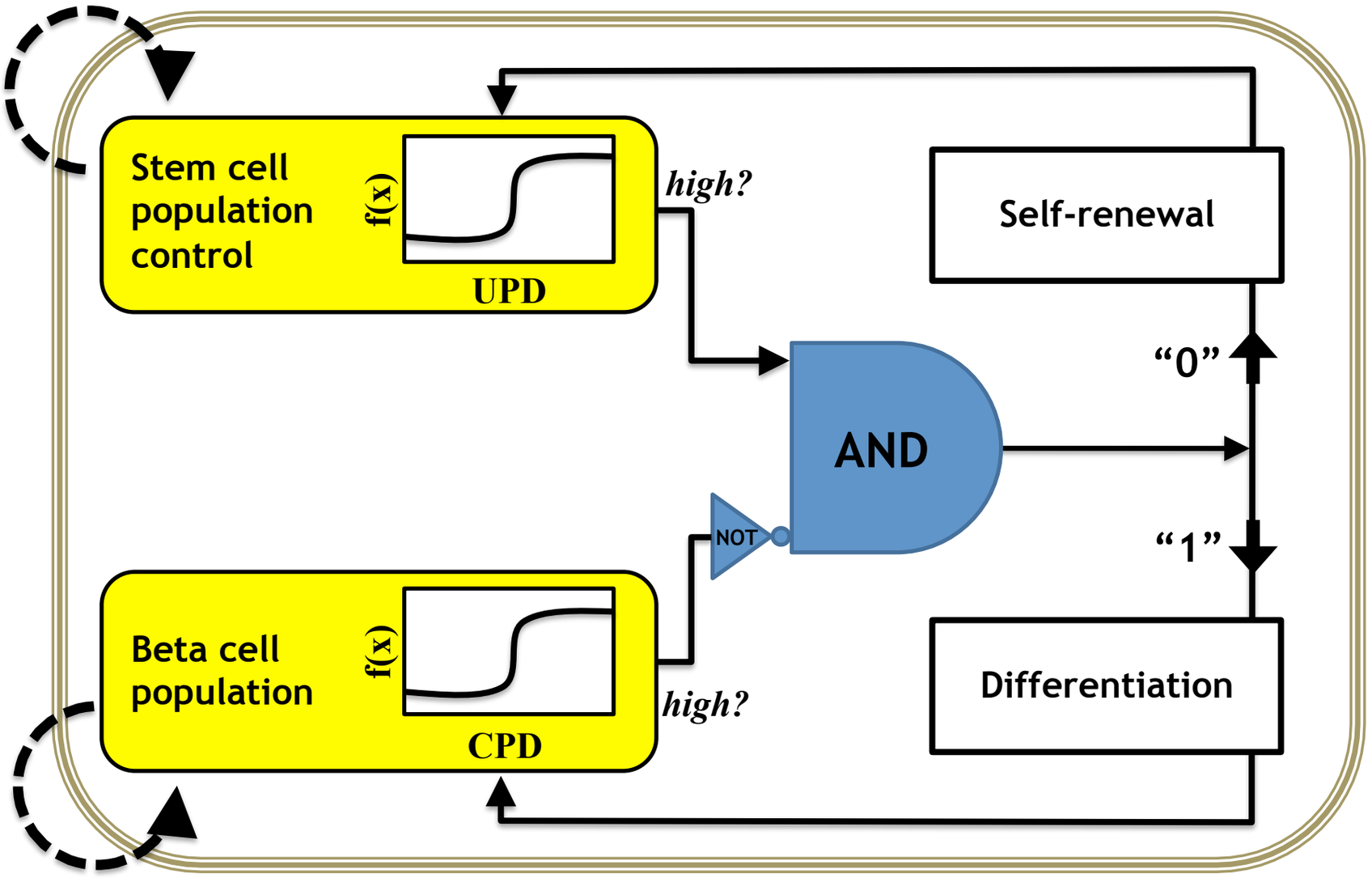




Complex system with 22 components
Design with ‘known’ modules!

COMPLEX DESIGN

beta cell homeostasis with regulated ESC differentiation



COMPLEX DESIGN

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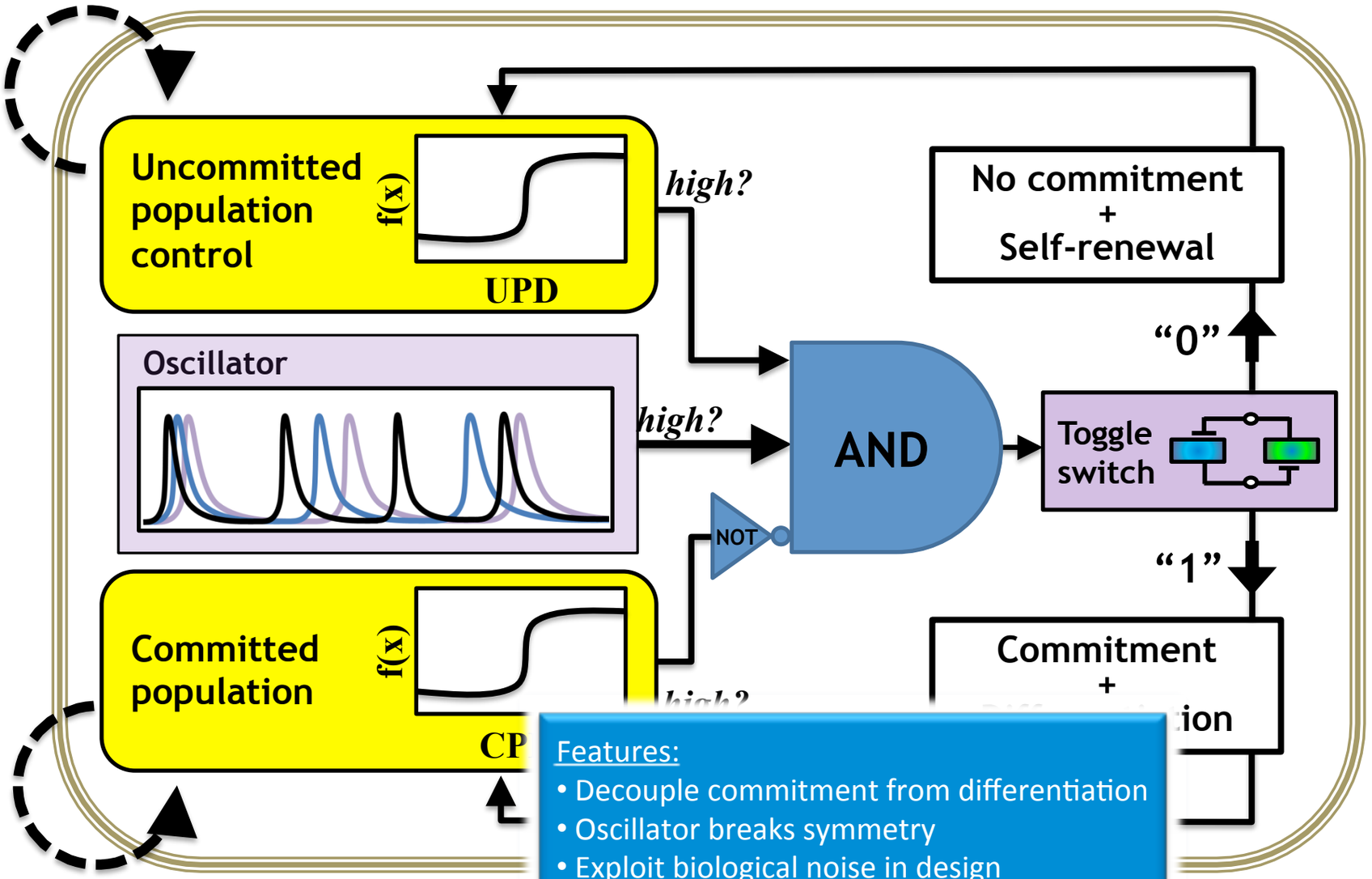

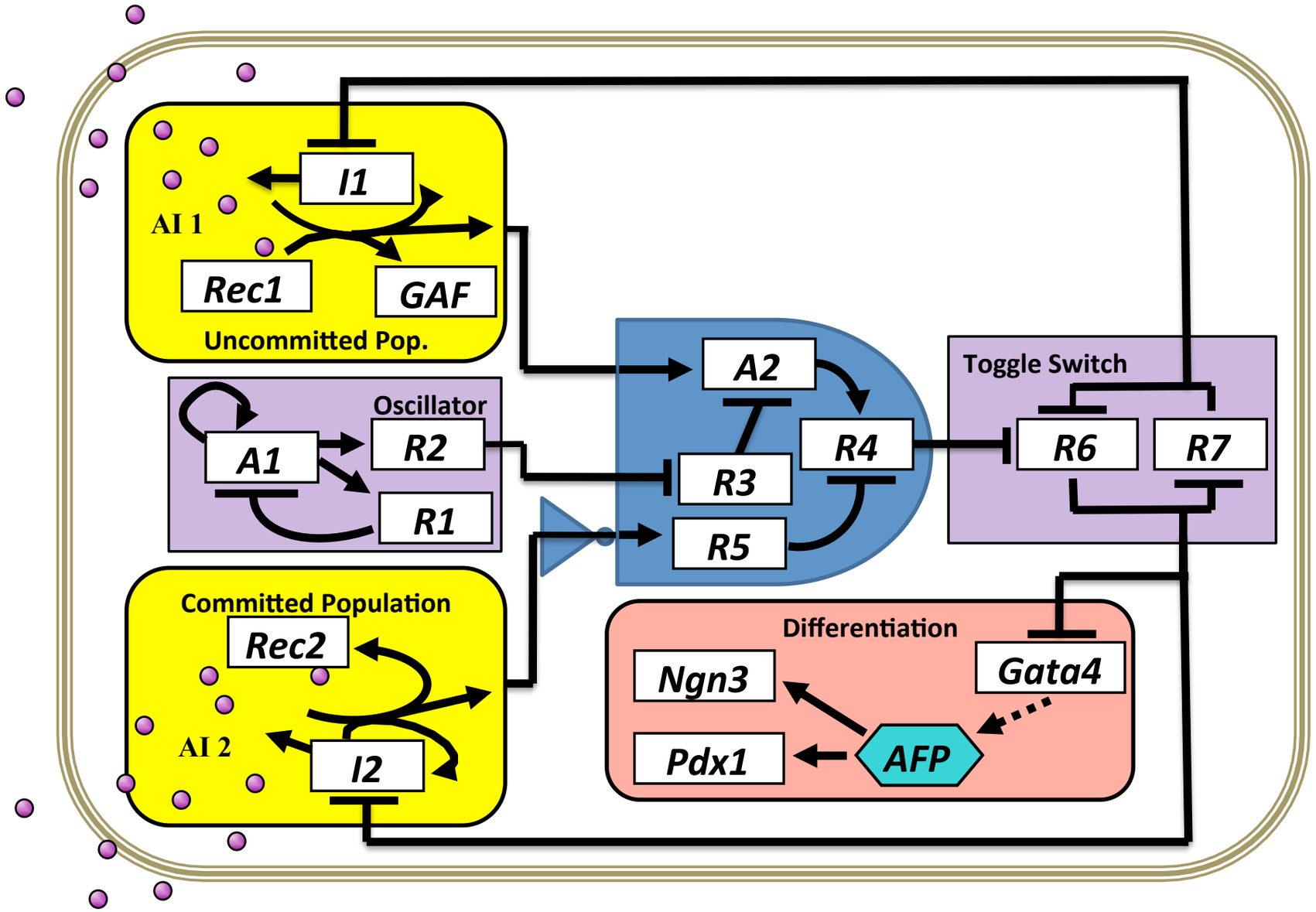

THE BIG PROBLEM

COMPLEX DESIGNS ARE NOT FEASIBLE WITH USING CURRENT ENGINEERING PRINCIPLES

SIMPLE PARTS

design and engineering approach is not scalable