

What is Synthetic Biology?

Implementation of engineering principles and mathematical modeling to the design and construction of biological parts, devices, and systems with applications in energy, medicine, and technology.

Synthetic Biology

Genetic engineering on a new scale.

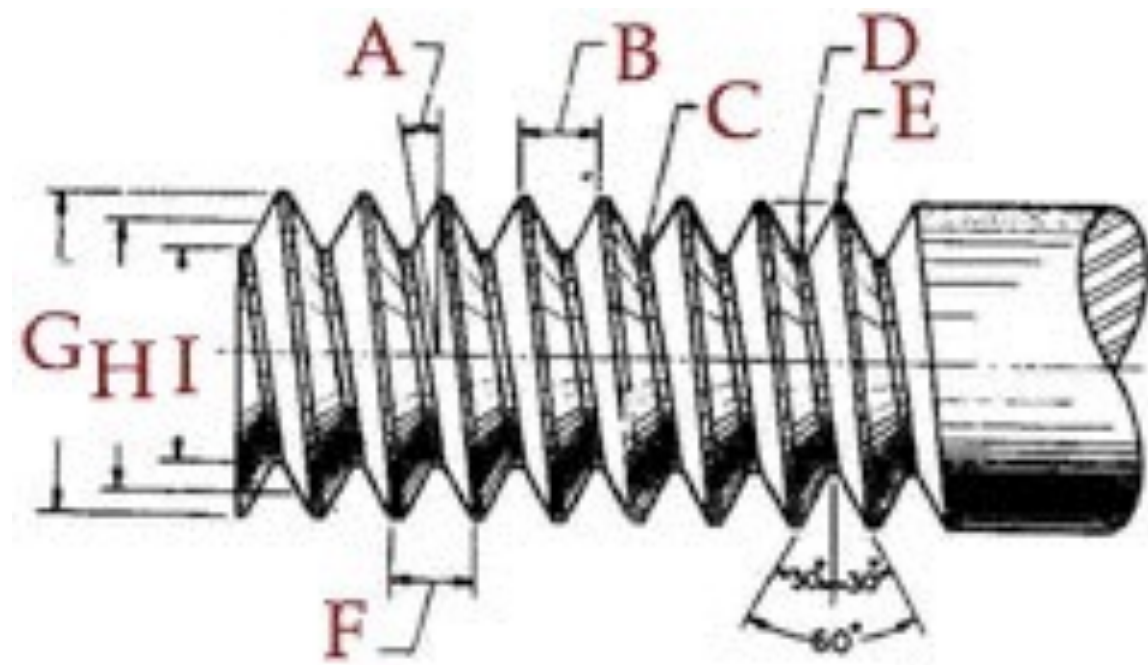
Four Characteristics:

- Standardization
- Modularity
- Abstraction
- Modeling of Designs

Standardization

On a Uniform System of Screw Thread

“In this country, no organized attempt has as of yet been made to establish any system, each manufacturer having adopted whatever his judgment may have dictated as best, or as most convenient for himself.”

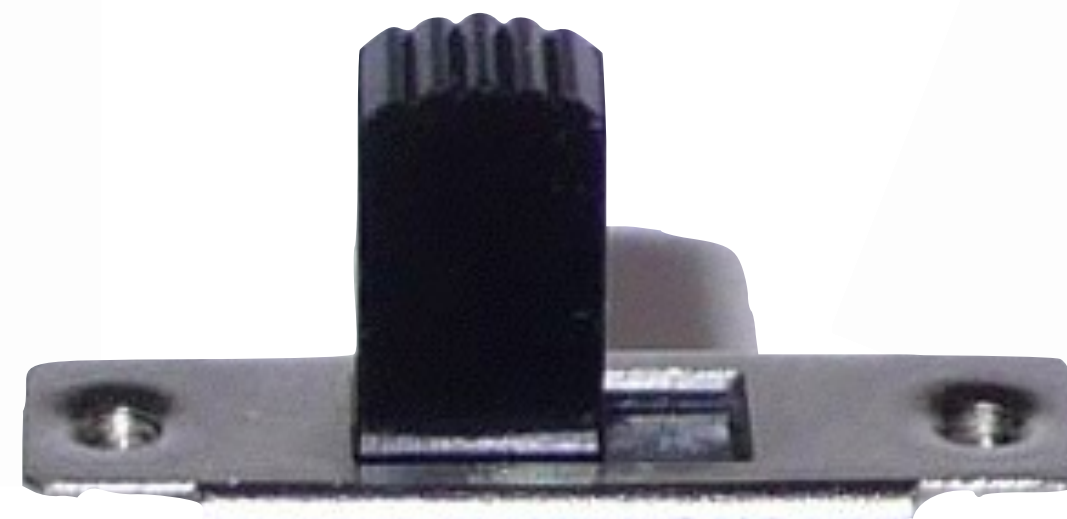
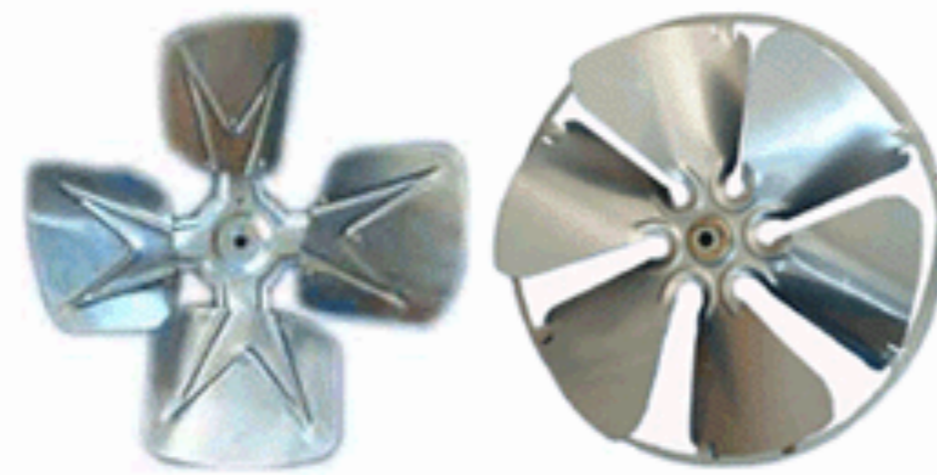
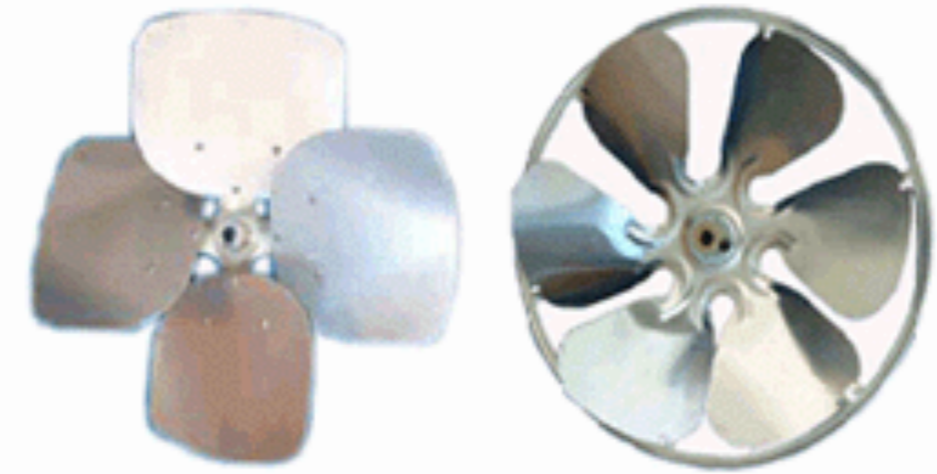
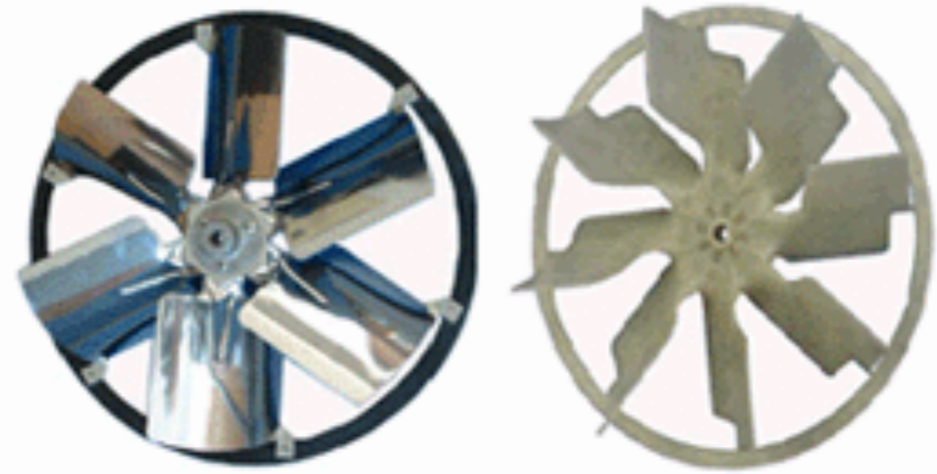


William Sellers April 21, 1864

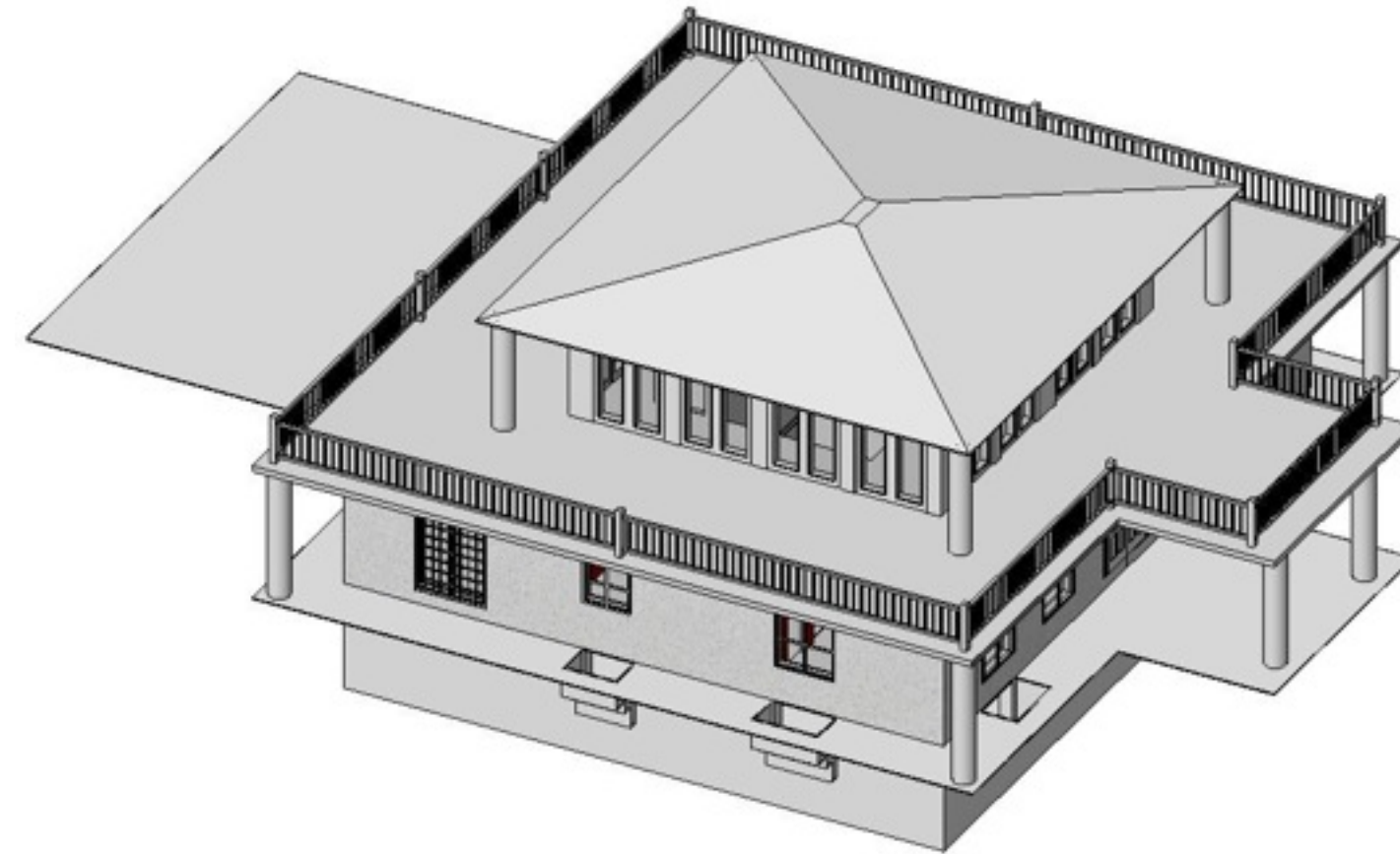
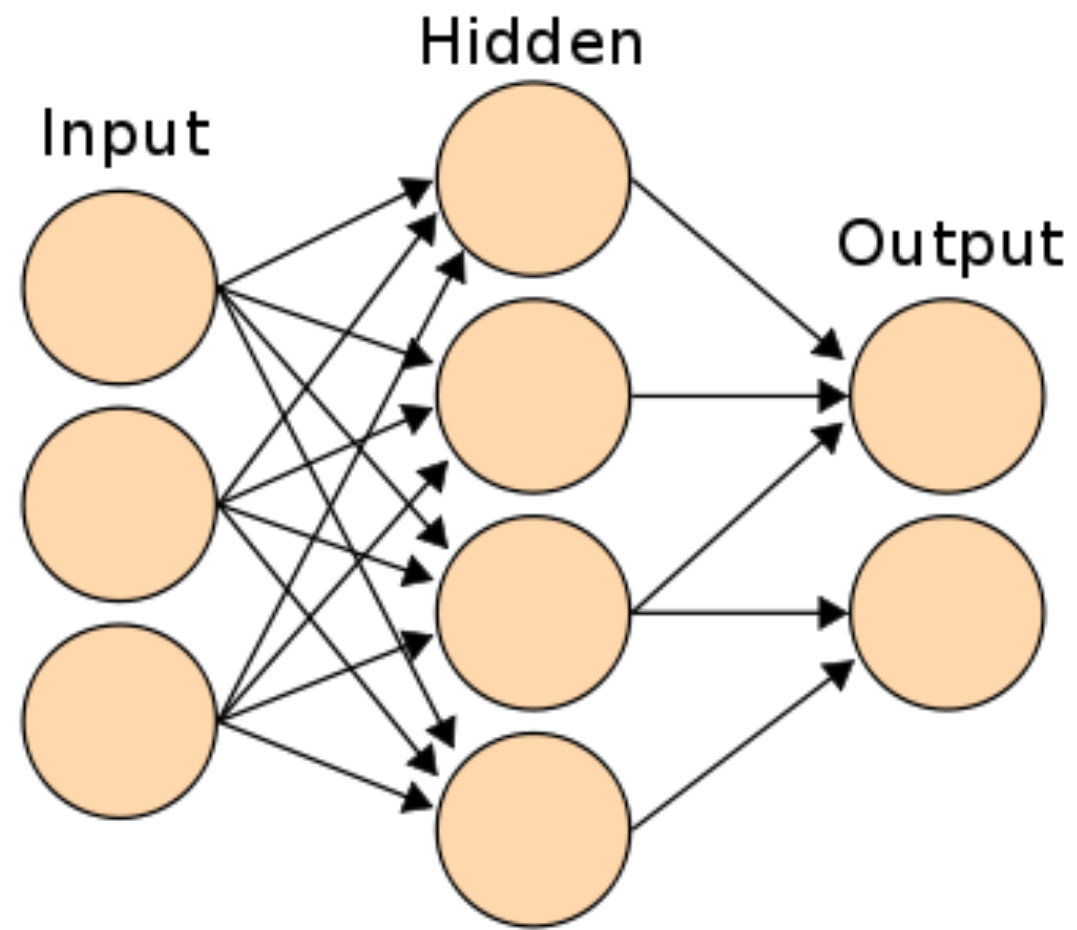
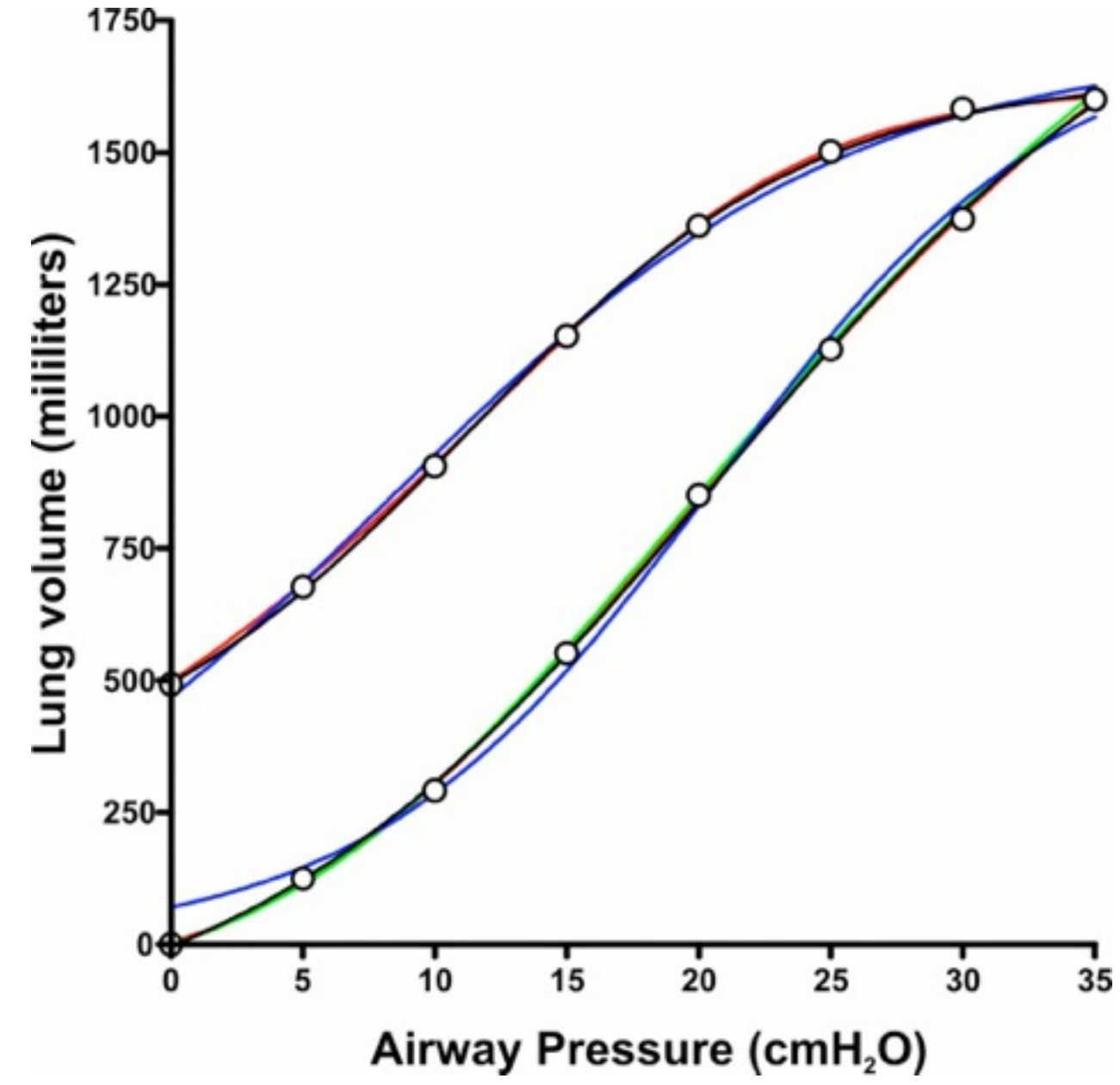
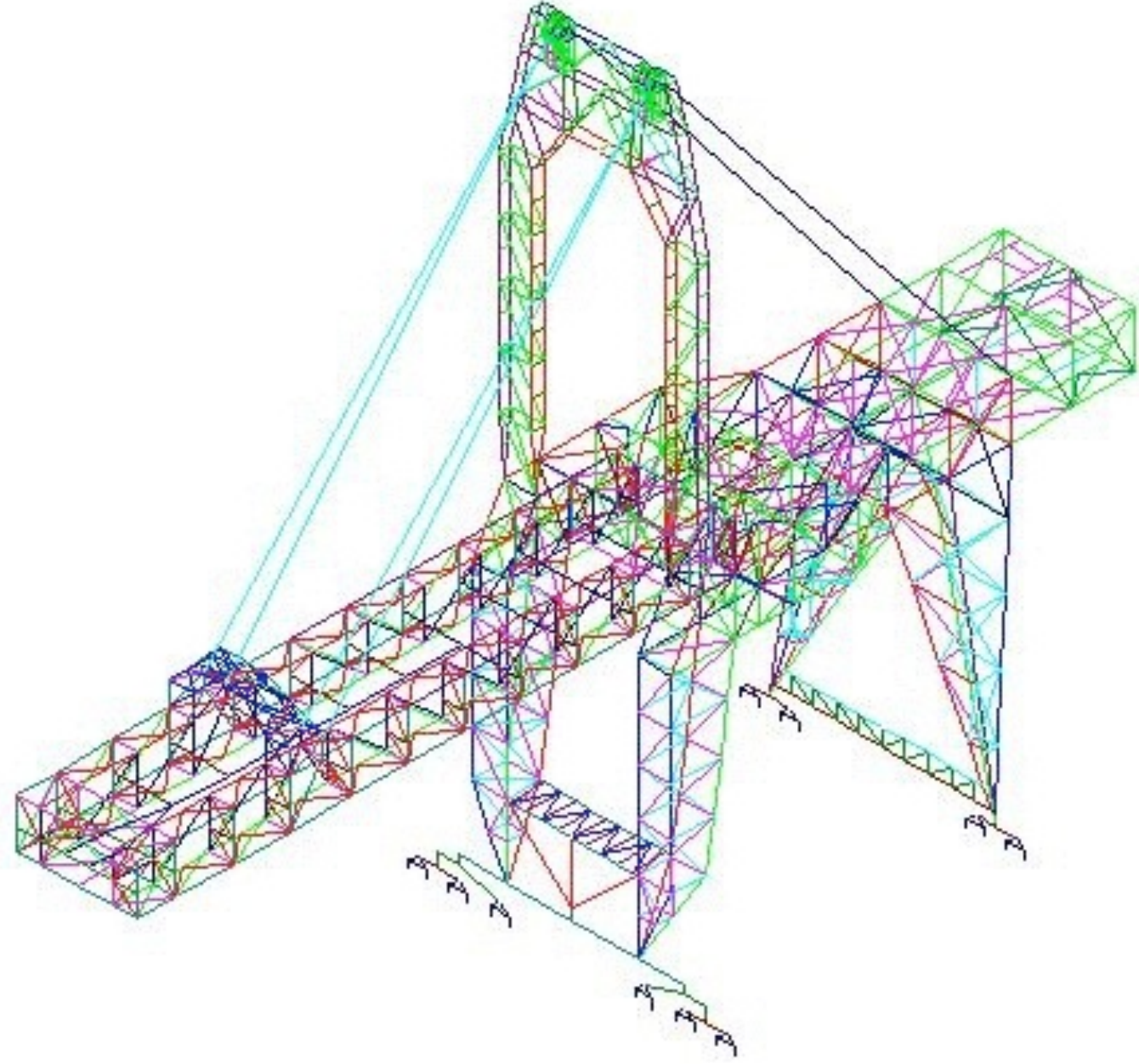
Modularity



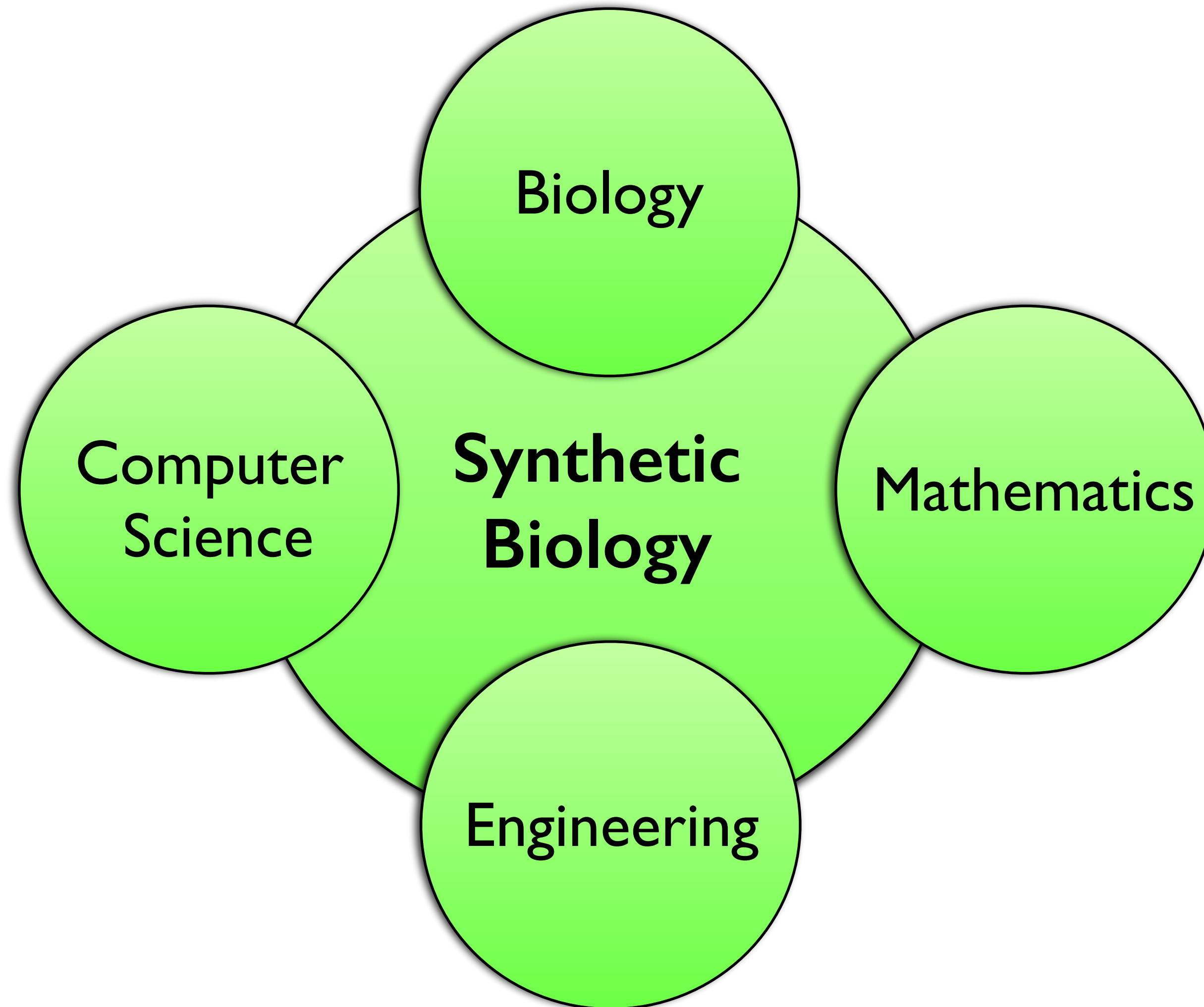
Abstraction



Modeling of Designs



Synthetic Biology



Modular Programmed Evolution of *E.coli* for Optimization of Metabolic Pathways

(research in progress)

Collaborative 2012 Research Team



Collaborative 2013 Research Team



Three Rules for Student Research

1. Everyone must learn.



Three Rules for Student Research

1. Everyone must learn.

2. Everyone must have fun.



Three Rules for Student Research

1. Everyone must learn.
2. Everyone must have fun.
3. We try to contribute to science.

1. Research [Open Access](#) [Highly accessed](#)
54451 **Solving a Hamiltonian Path Problem with a bacterial computer**
Accesses Jordan Baumgardner, Karen Acker, Oyinade Adefuye, Samuel Crowley, Will DeLoache, J
Heard, Andrew T Martens, Nickolaus Morton, Michelle Ritter, Amber Shoecraft, Jessica T
Amanda Valencia, Mike Waters, A Malcolm Campbell, Laurie J Heyer, Jeffrey L Poet, Tod
Journal of Biological Engineering 2009, **3**:11 (24 July 2009)
[Abstract](#) | [Full text](#) | [PDF](#) | [PubMed](#) | [f1000](#) | [▶ Editor's summary](#)



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ENGINEERING

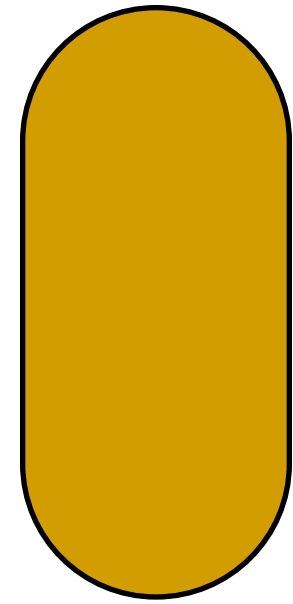
2. Research [Open Access](#) [Highly accessed](#)
46629 **Engineering bacteria to solve the Burnt Pancake Problem**
Accesses Karmella A Haynes, Marian L Broderick, Adam D Brown, Trevor L Butner, James O Dickson, W Lance Harden, Lane H
Heard, Eric L Jessen, Kelly J Malloy, Brad J Ogden, Sabriya Rosemond, Samantha Simpson, Erin Zwack, A Malcolm
Campbell, Todd T Eckdahl, Laurie J Heyer, Jeffrey L Poet
Journal of Biological Engineering 2008, **2**:8 (20 May 2008)
[Abstract](#) | [Full text](#) | [PDF](#) | [PubMed](#) | [1 comment](#) | [▶ Editor's summary](#)

25 undergraduate co-authors

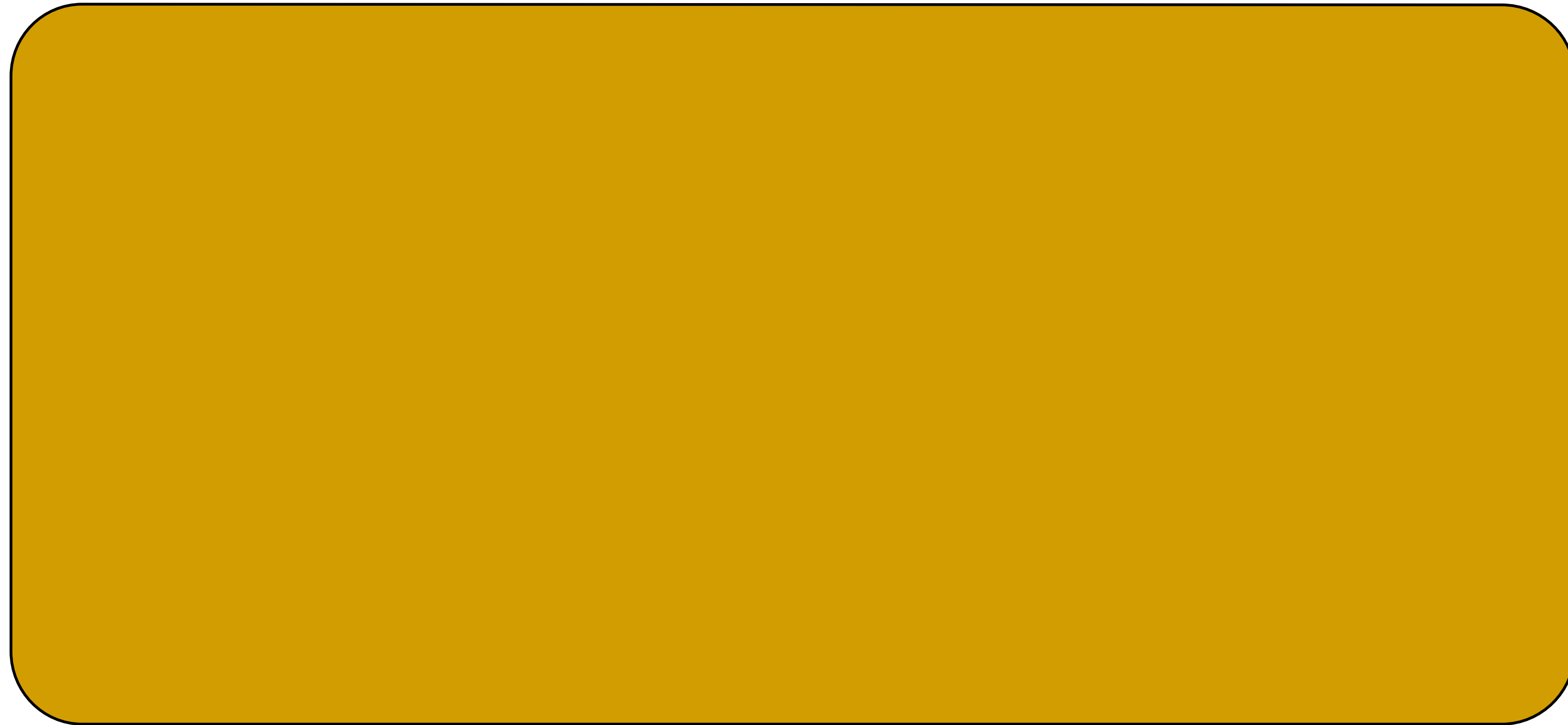
3. Methodology [Open Access](#) [Highly accessed](#)
30051 **Engineering BioBrick vectors from BioBrick parts**
Accesses Reshma P Shetty, Drew Endy, Thomas F Knight
Journal of Biological Engineering 2008, **2**:5 (14 April 2008)
[Abstract](#) | [Full text](#) | [PDF](#) | [PubMed](#) | [Cited on BioMed Central](#)

Papers of the year 2008 & 2009

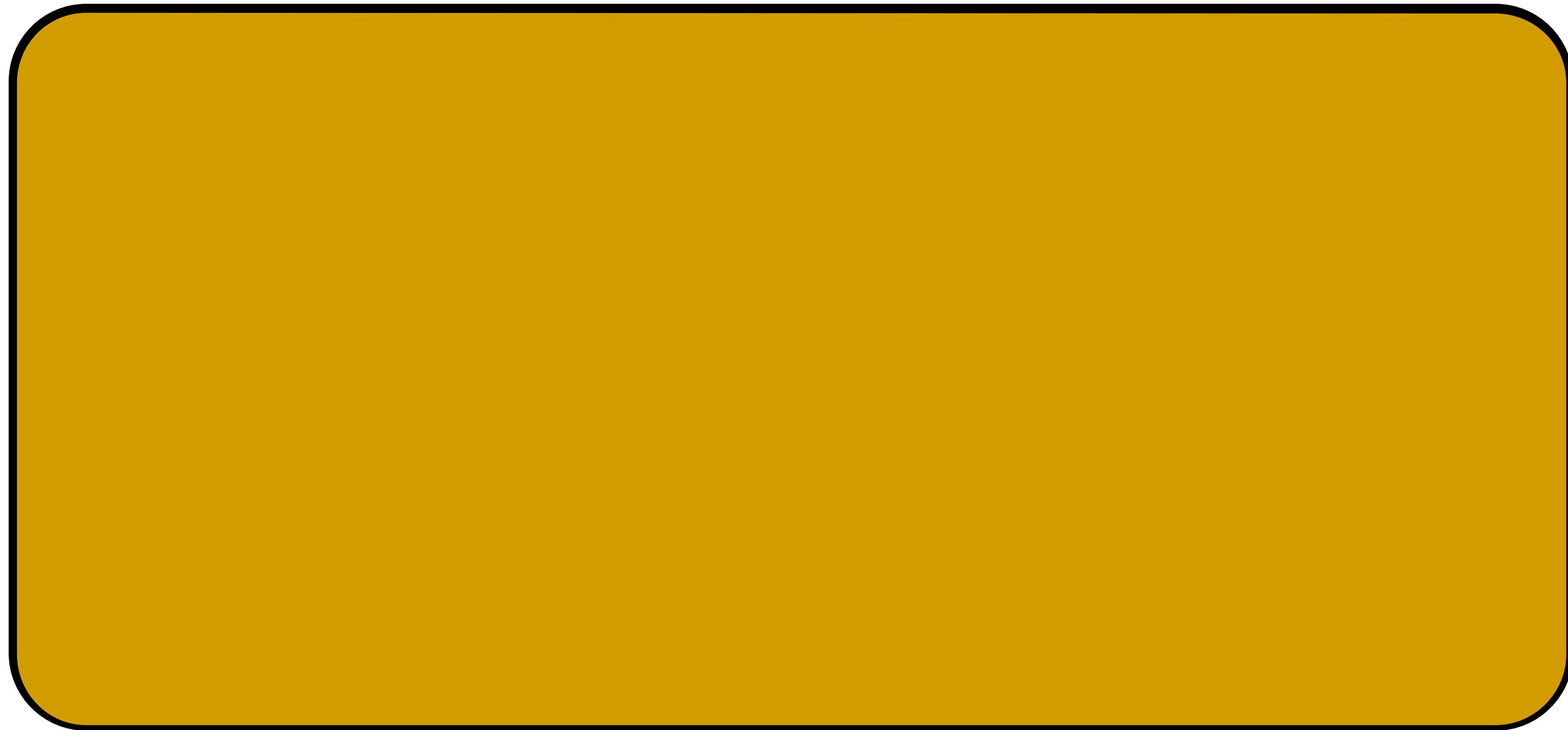
Make *E. coli* Optimize Drug Production



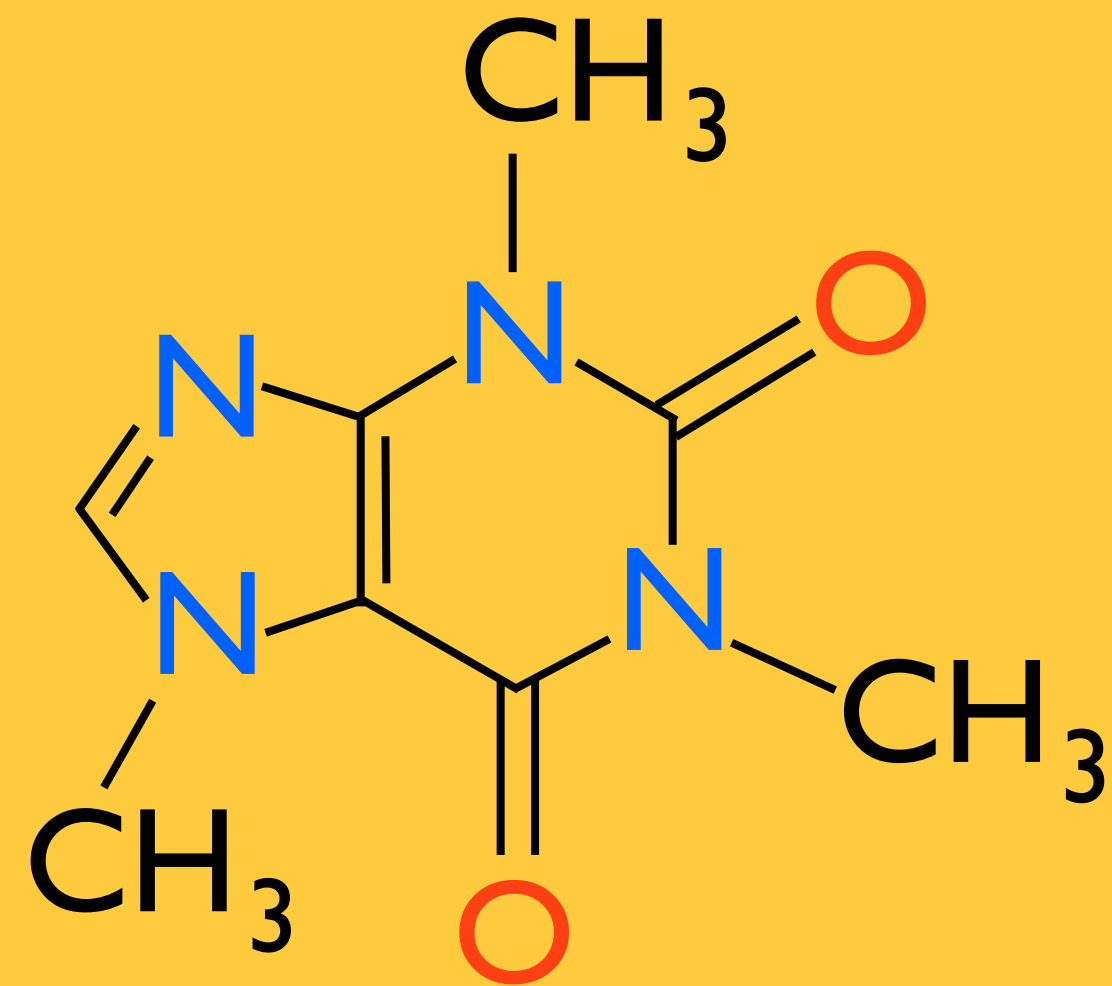
Make *E. coli* Optimize Drug Production



Make *E. coli* Optimize Drug Production

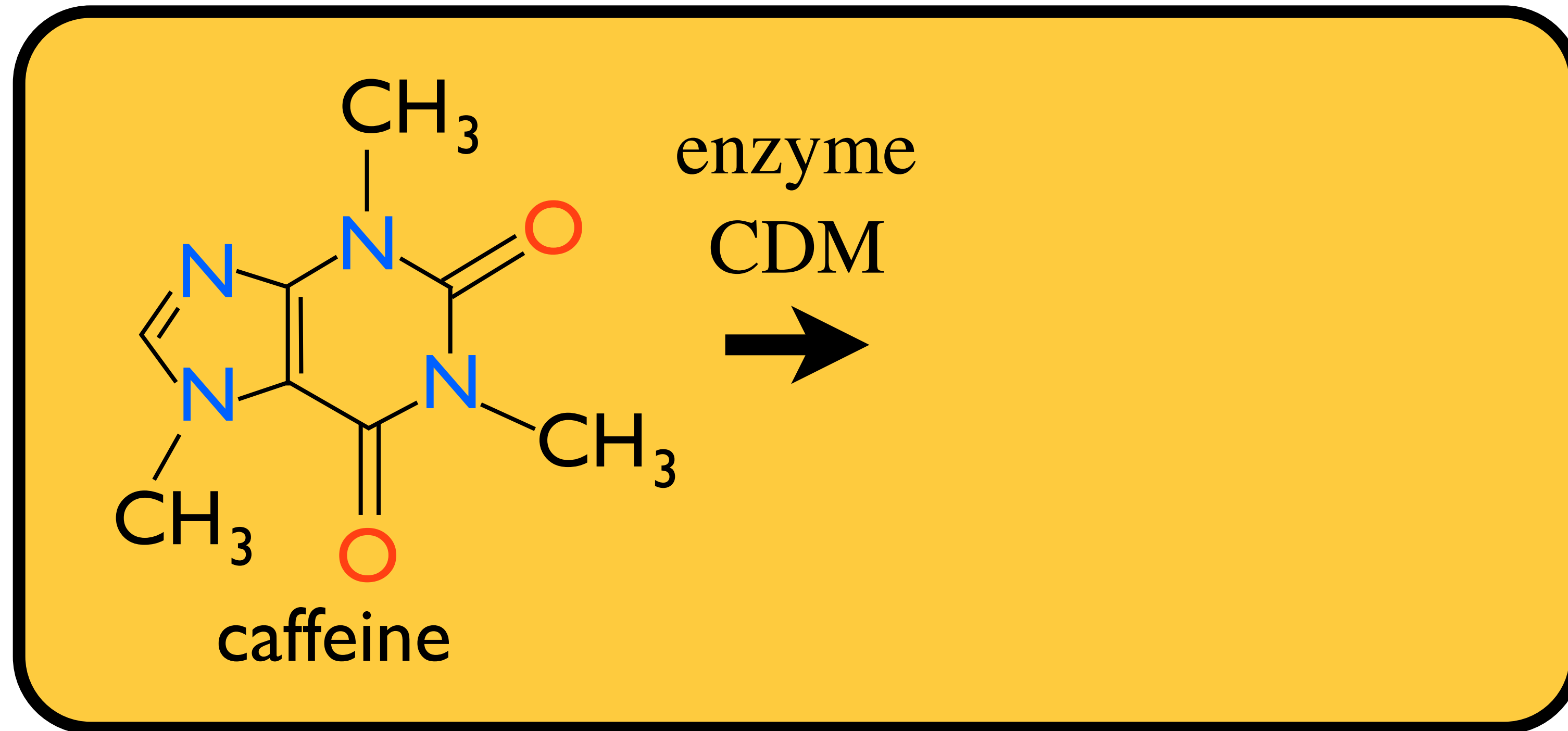


Make *E. coli* Optimize Drug Production

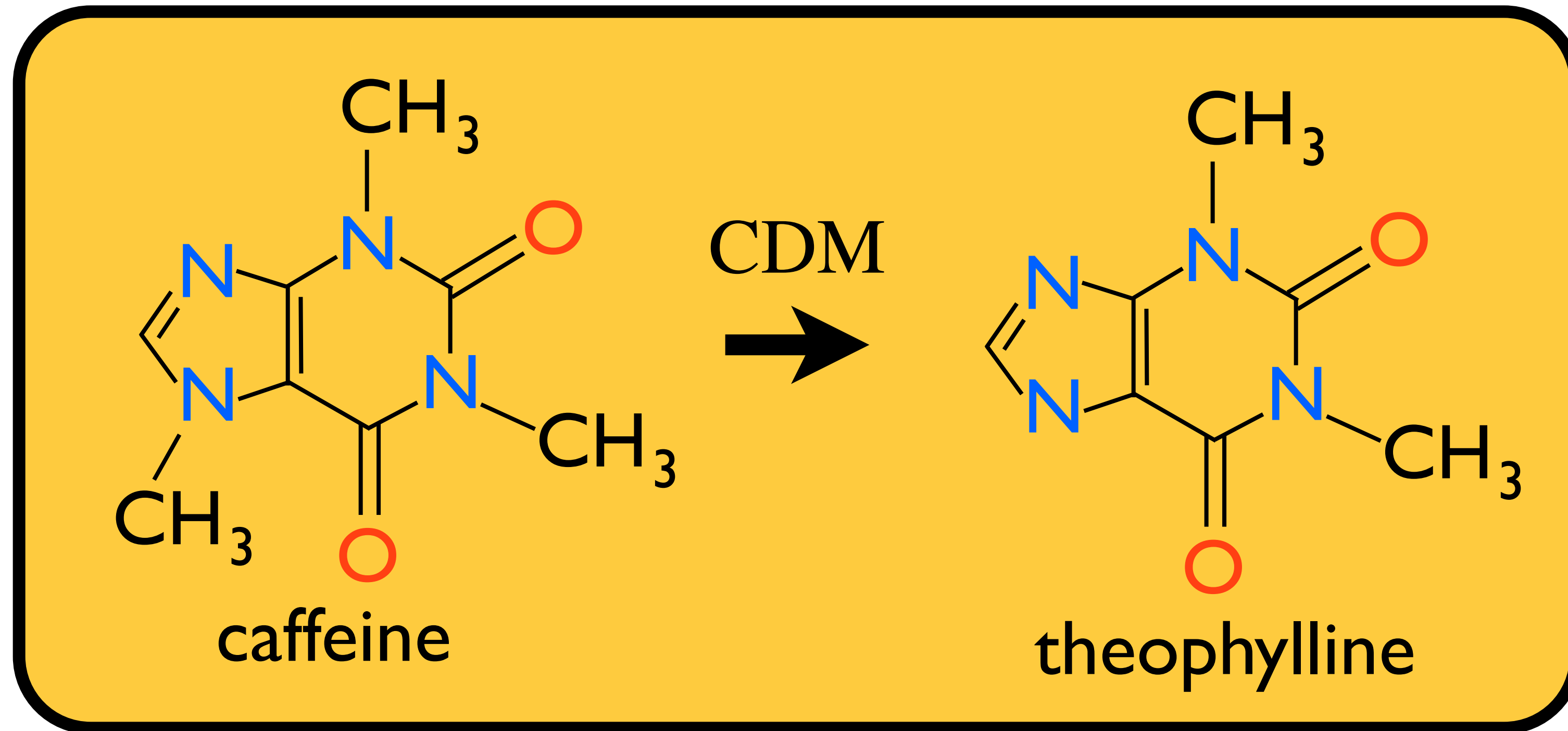


caffeine

Make *E. coli* Optimize Drug Production

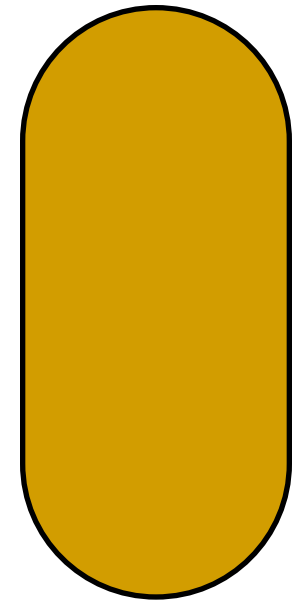


Make *E. coli* Optimize Drug Production

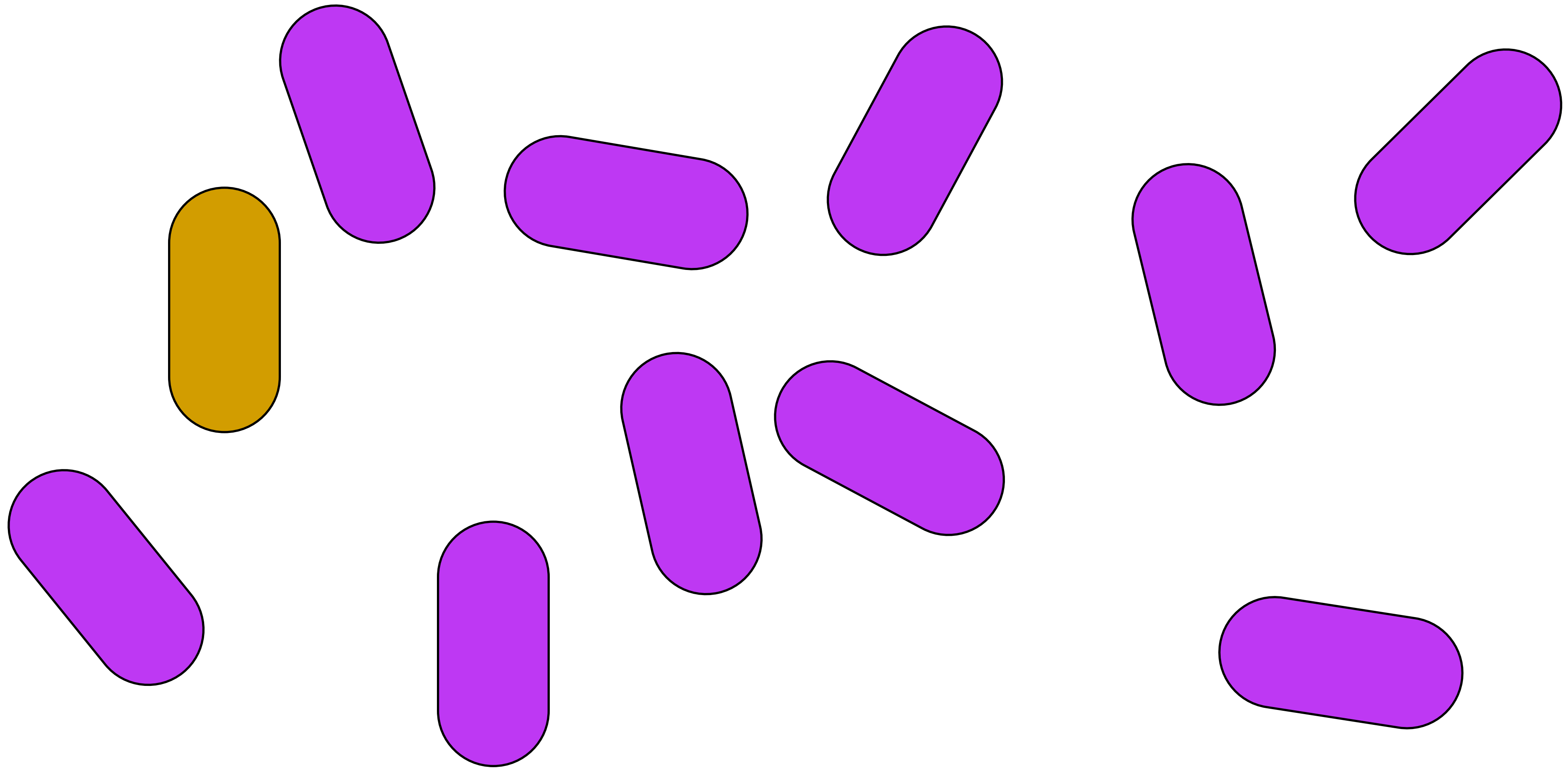


asthma medication

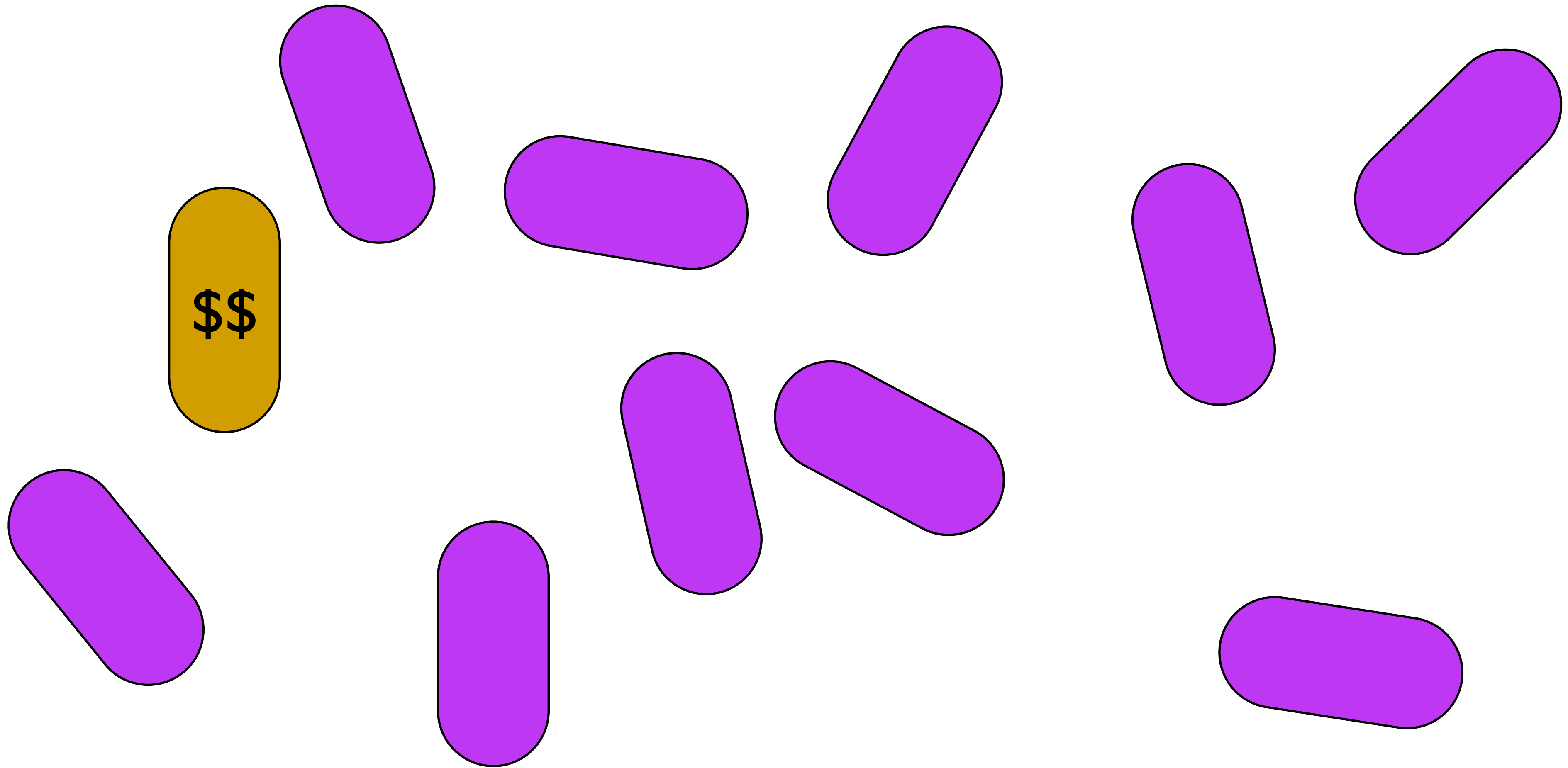
What Makes Optimization Difficult?



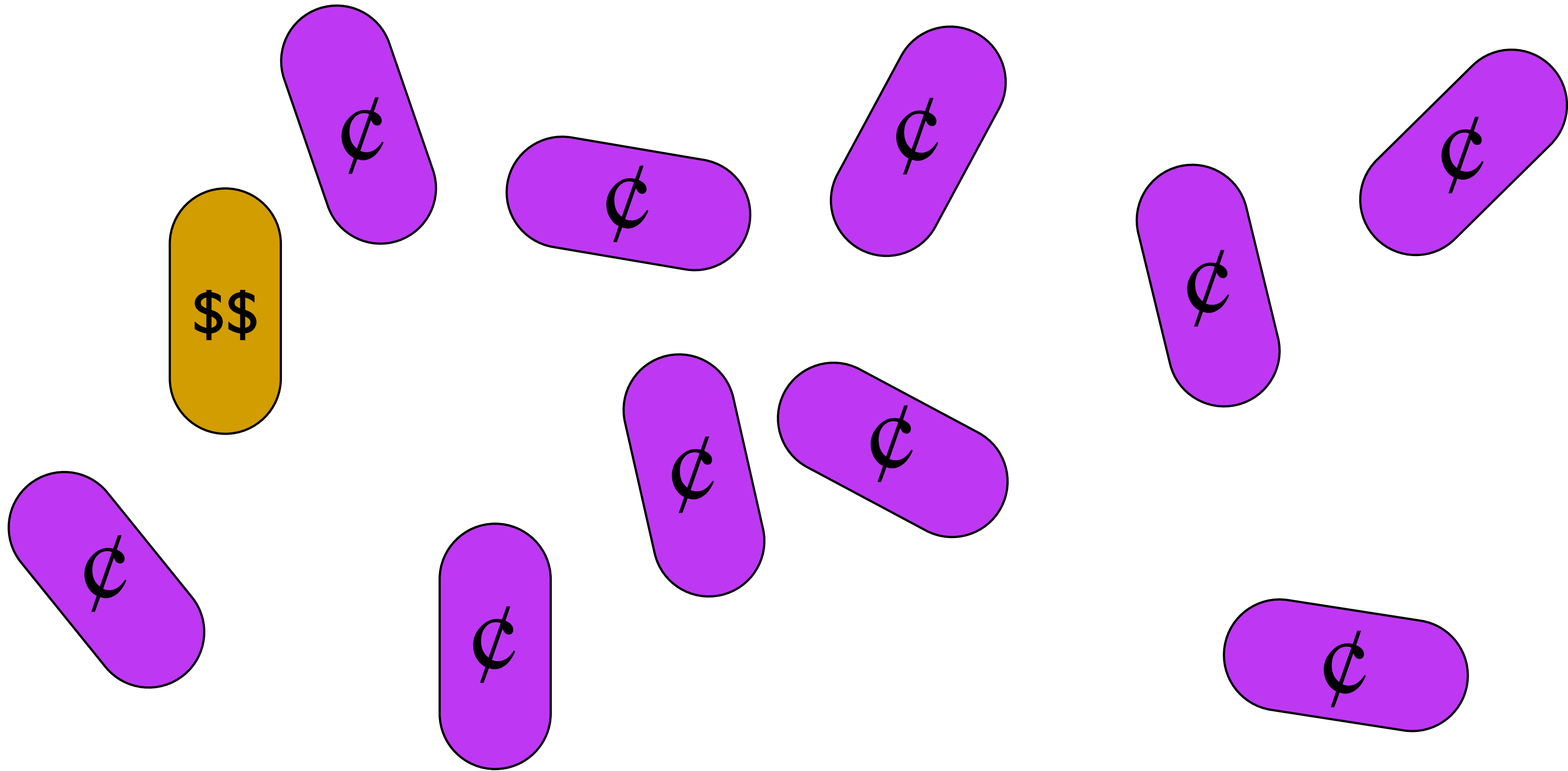
What Makes Optimization Difficult?



What Makes Optimization Difficult?



Natural Selection



Synthetic Selection



Synthetic Fitness



Synthetic Fitness

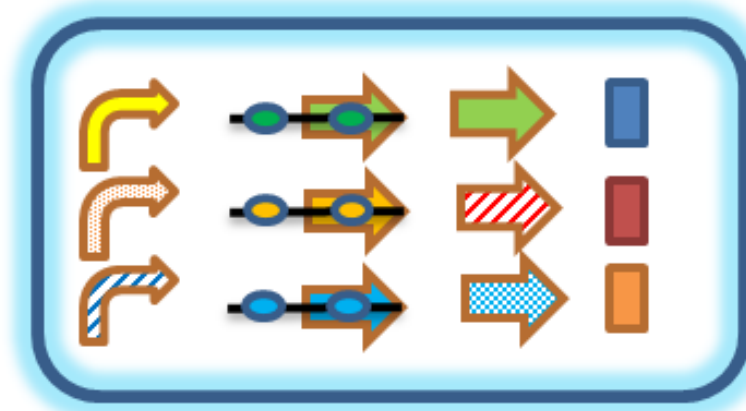


Engineering Programmed Evolution

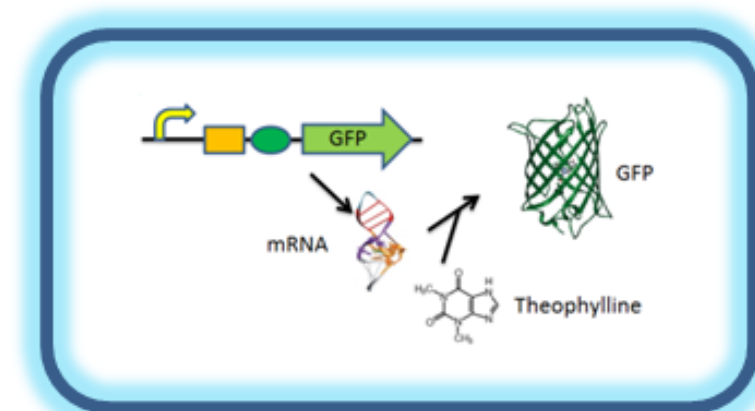
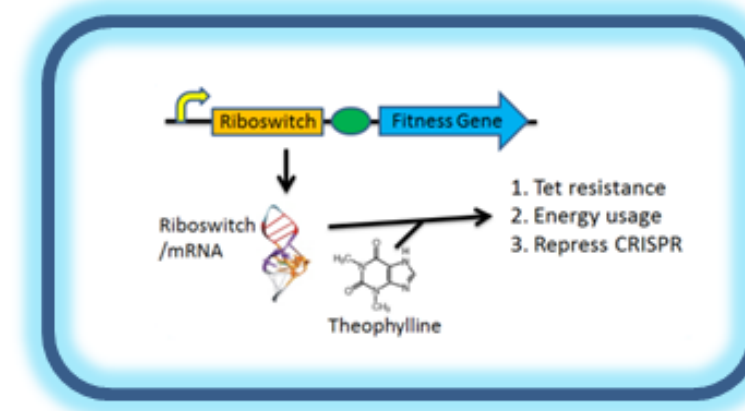


Programmed Evolution

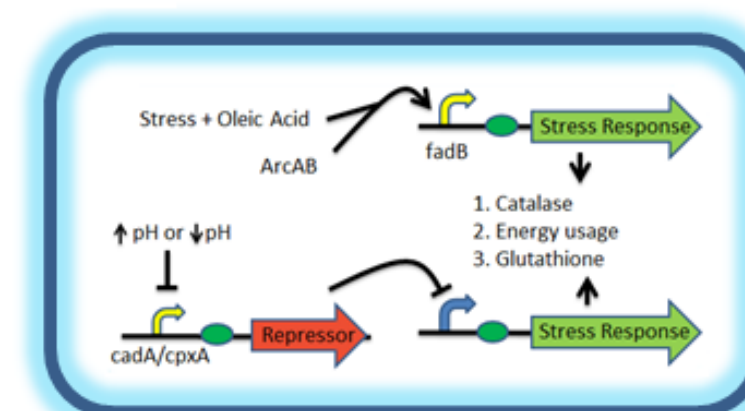
Combinatorics Module



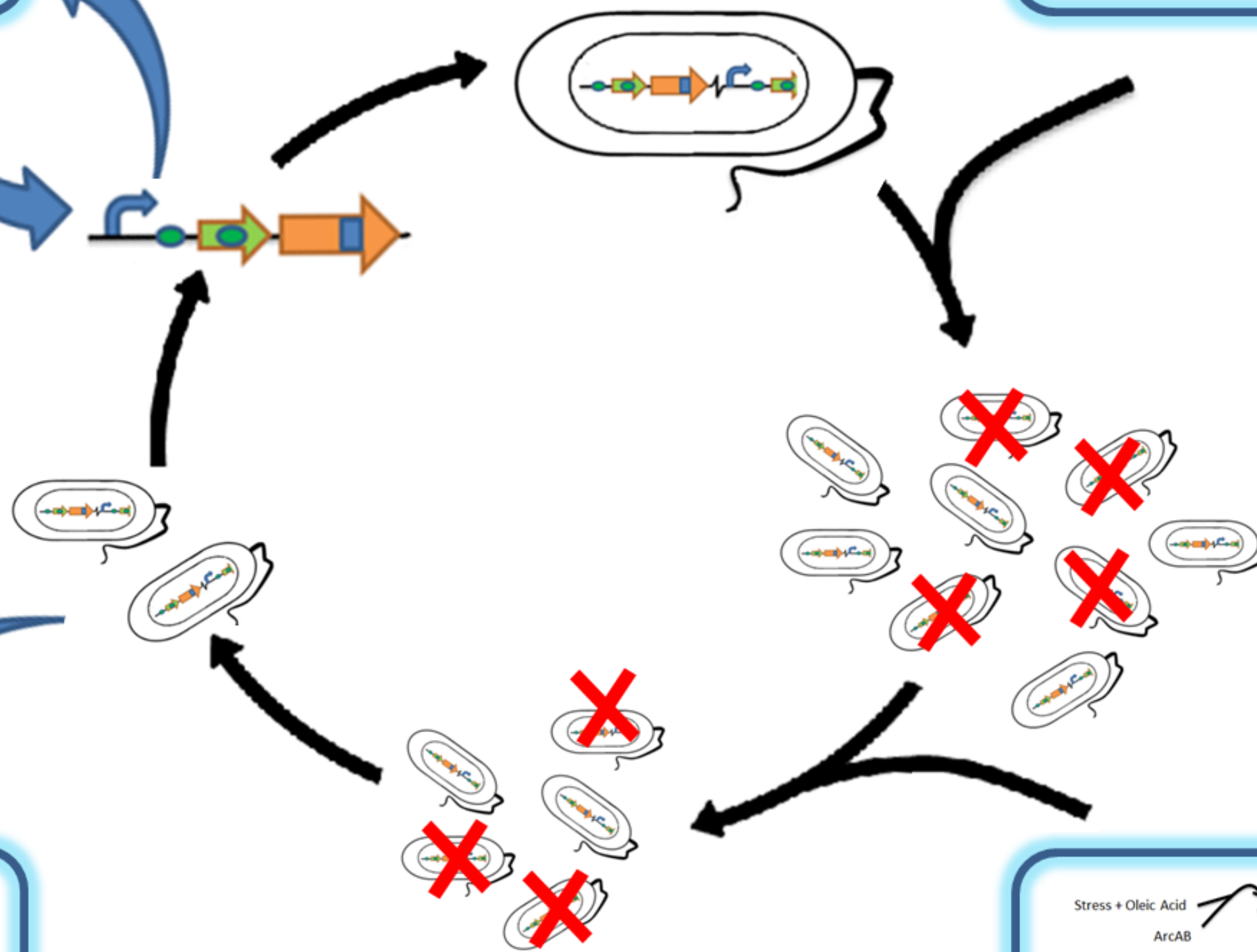
Fitness Module



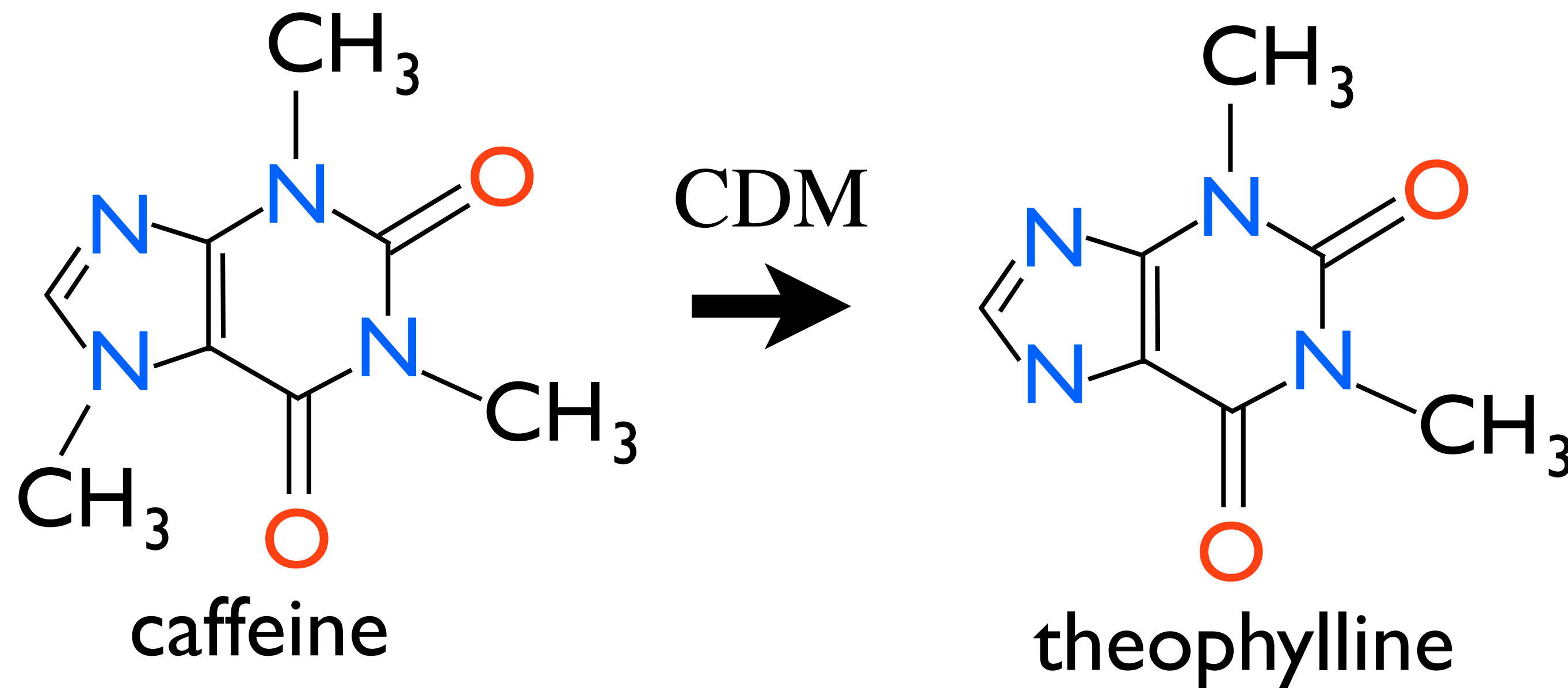
Biosensor Module



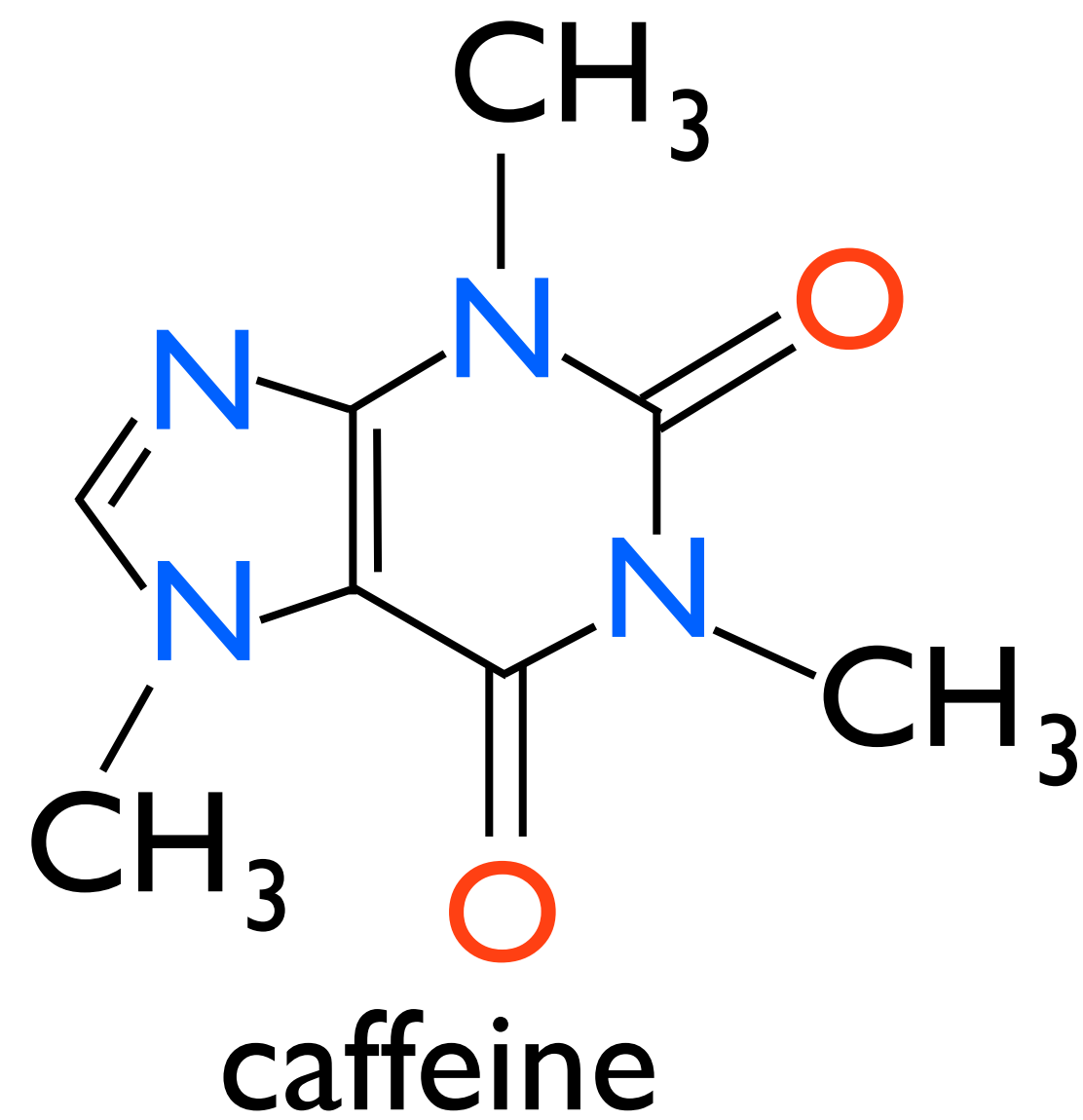
Stress Response Module



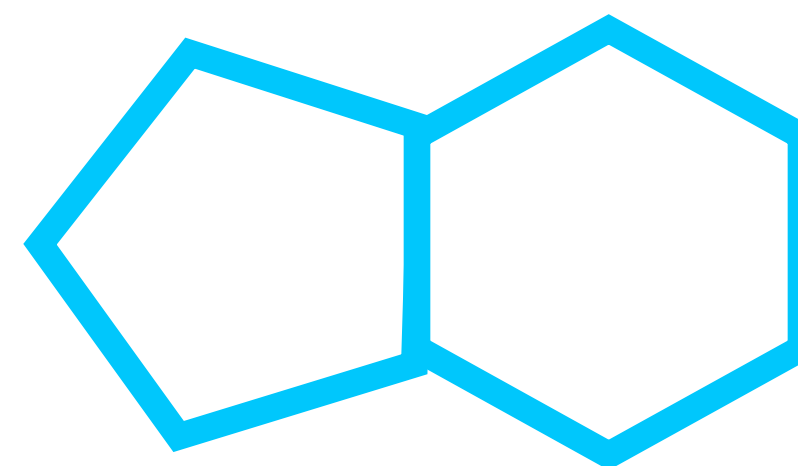
How to Build a Biosensor



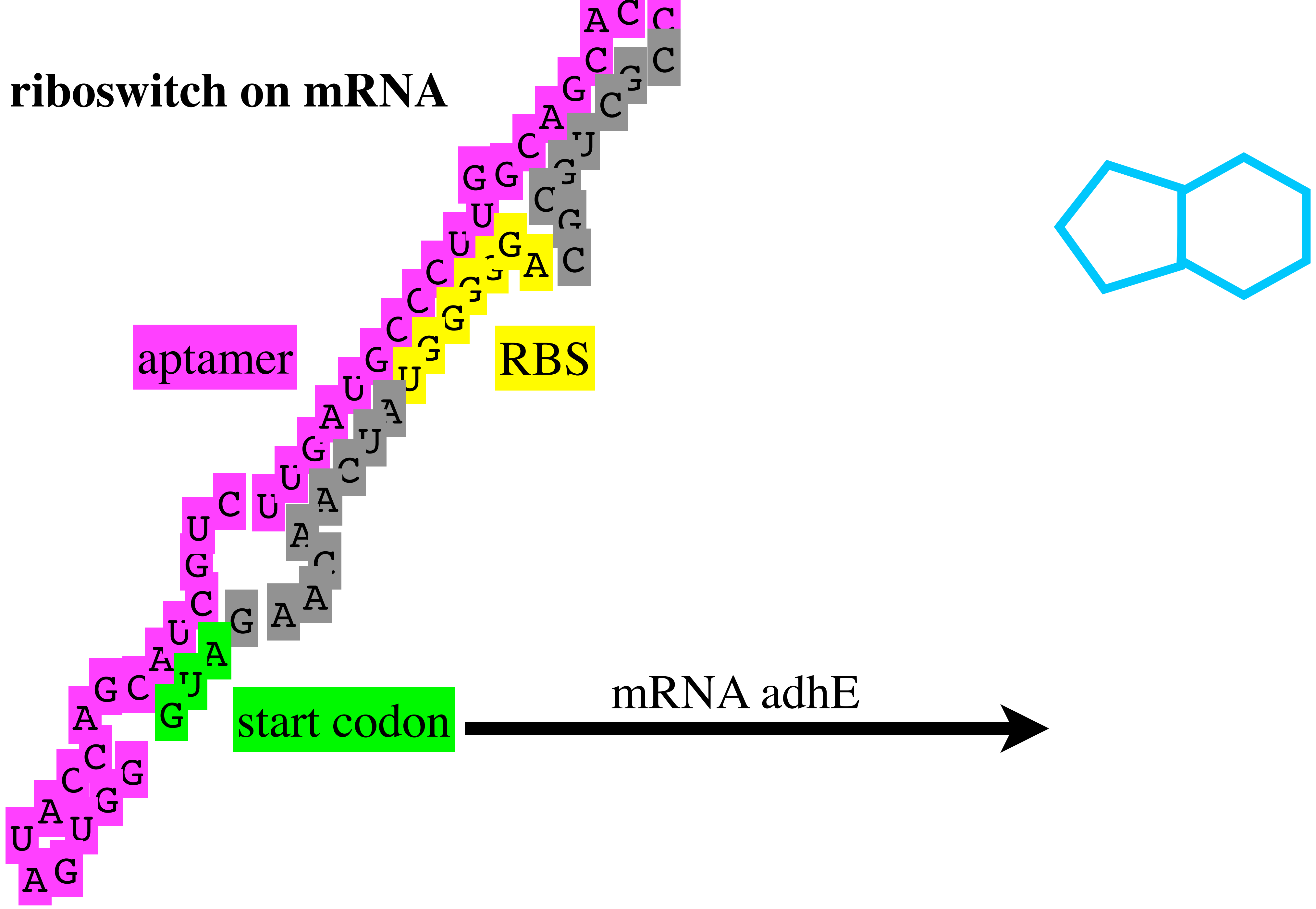
How to Build a Biosensor



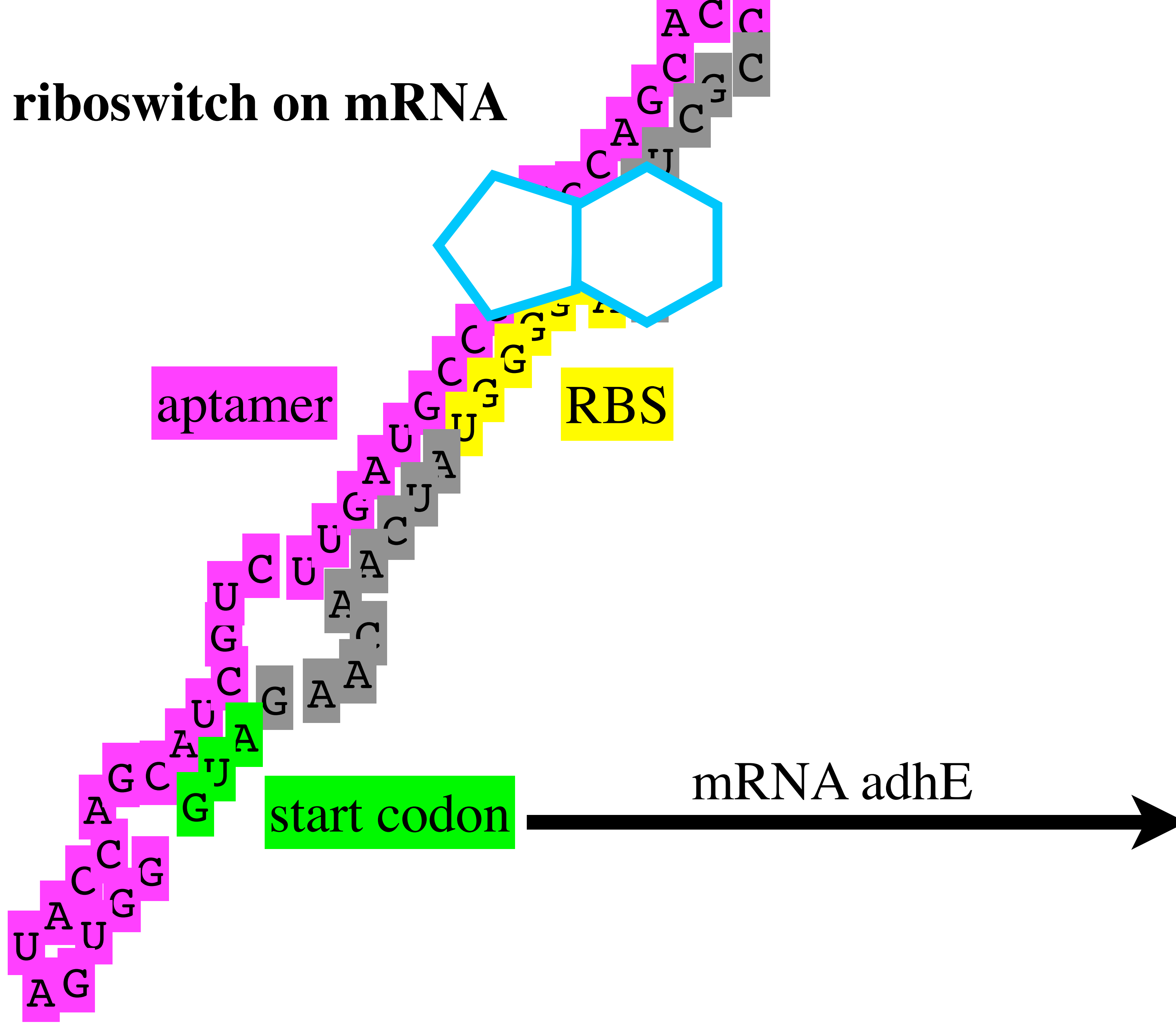
CDM
➔

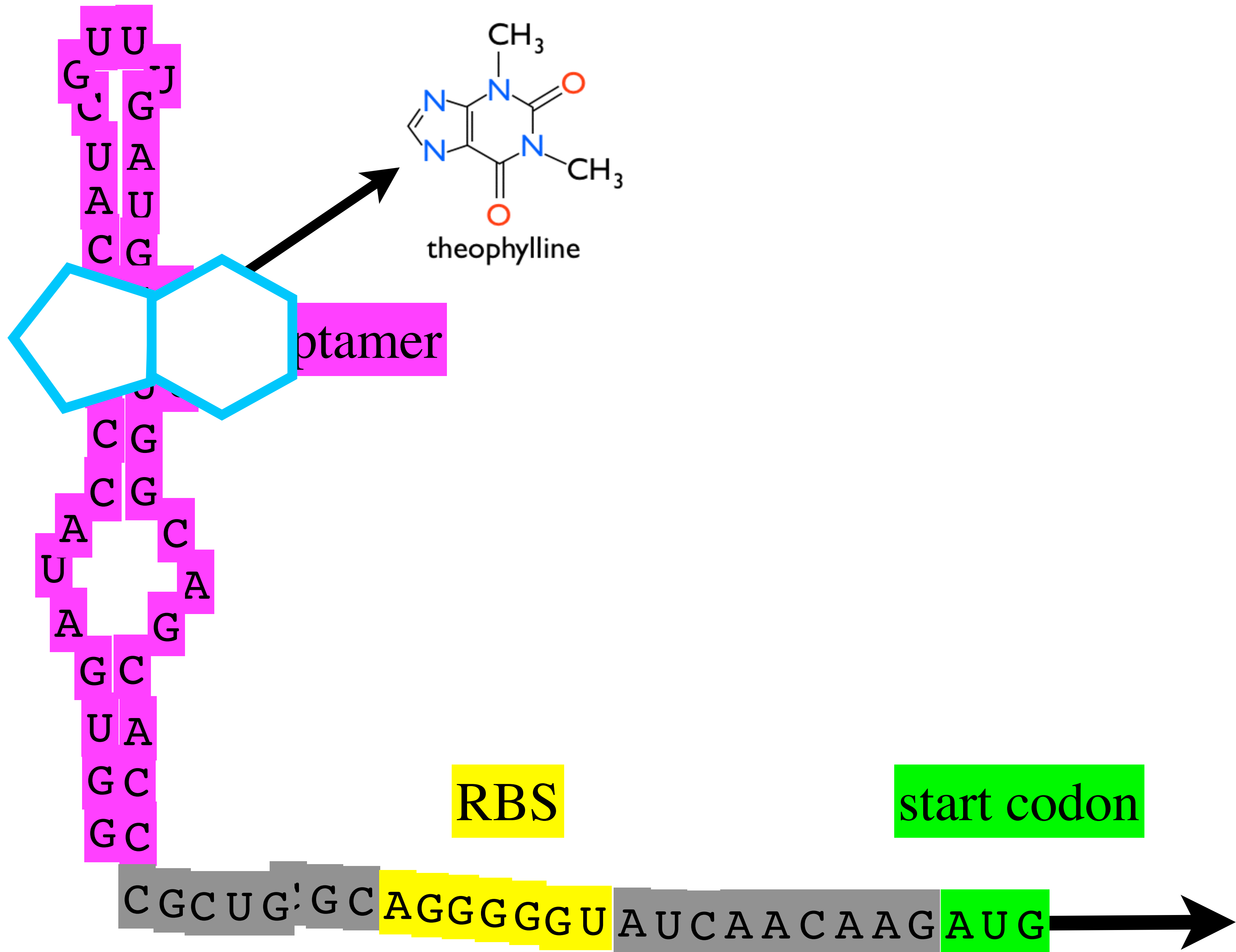


riboswitch on mRNA

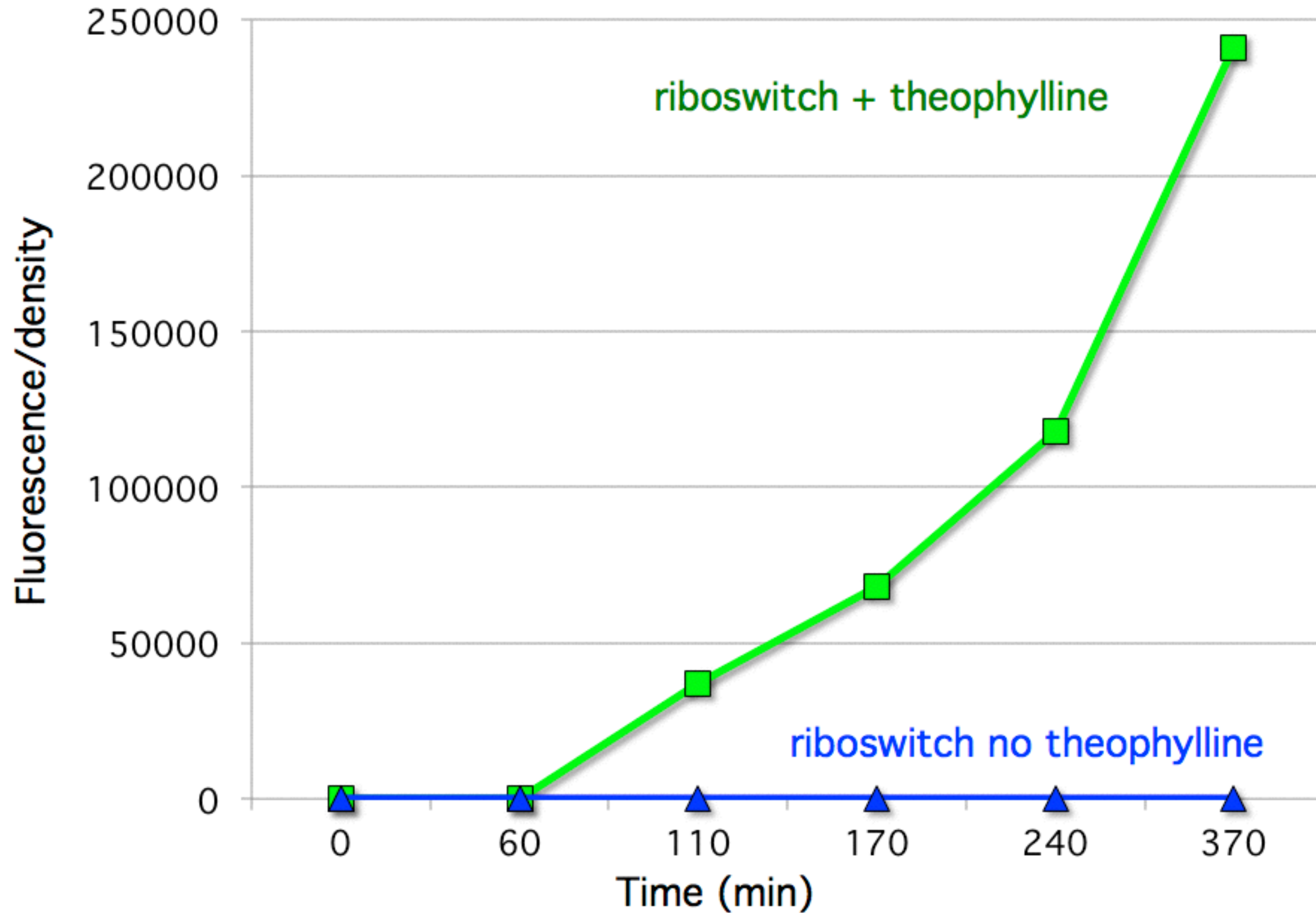


riboswitch on mRNA

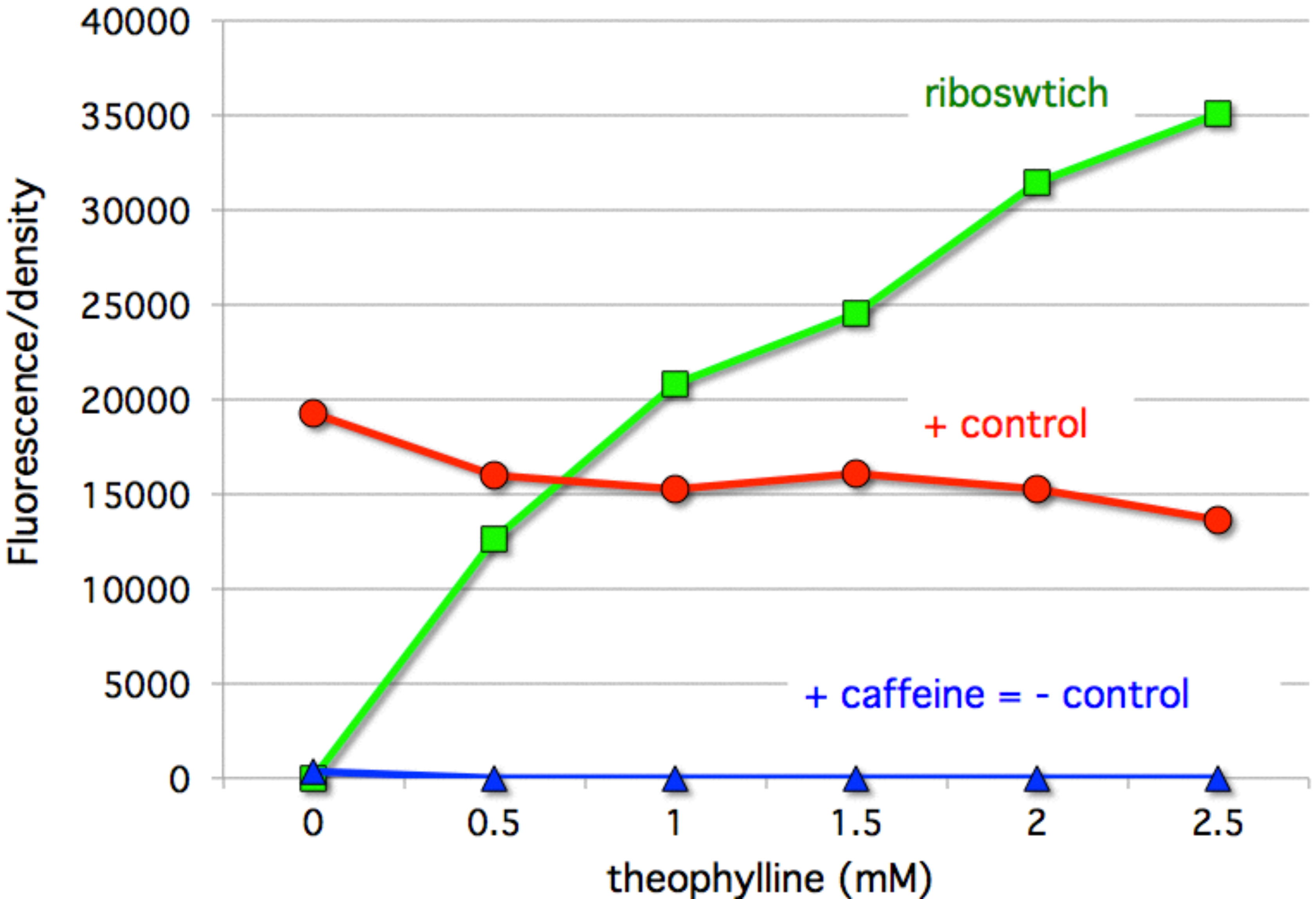




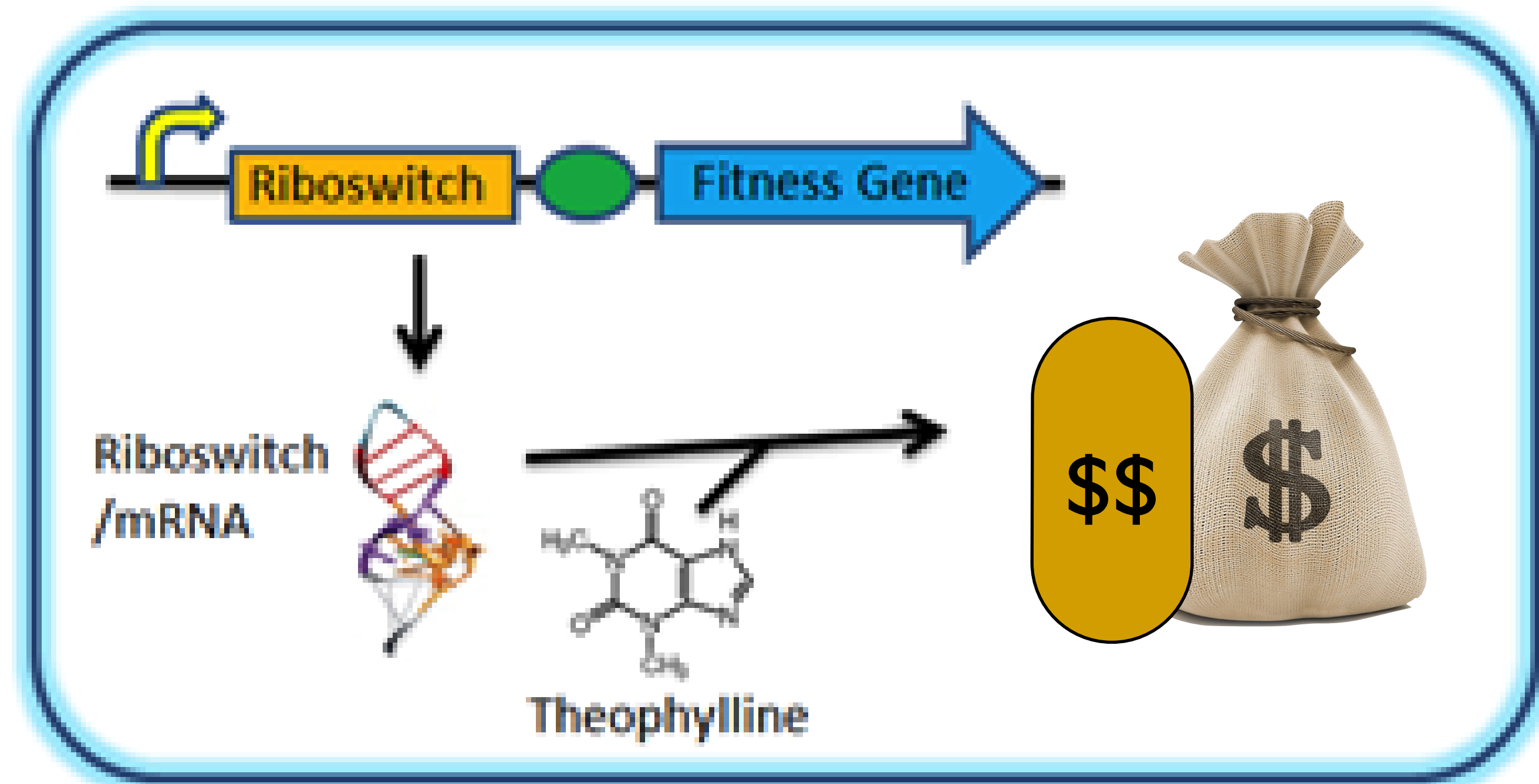
Biosensor Detects Theophylline



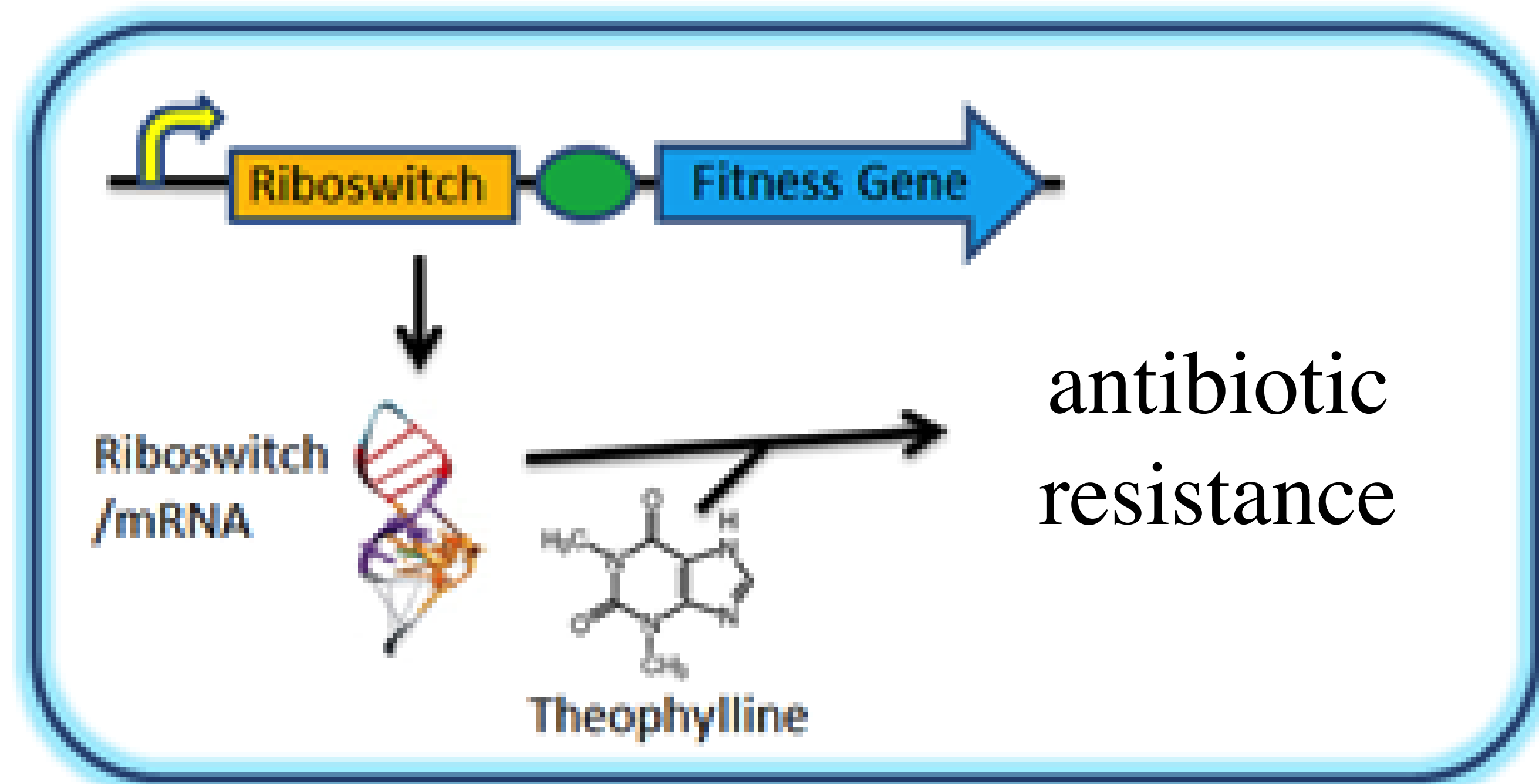
Biosensor Detects Theophylline



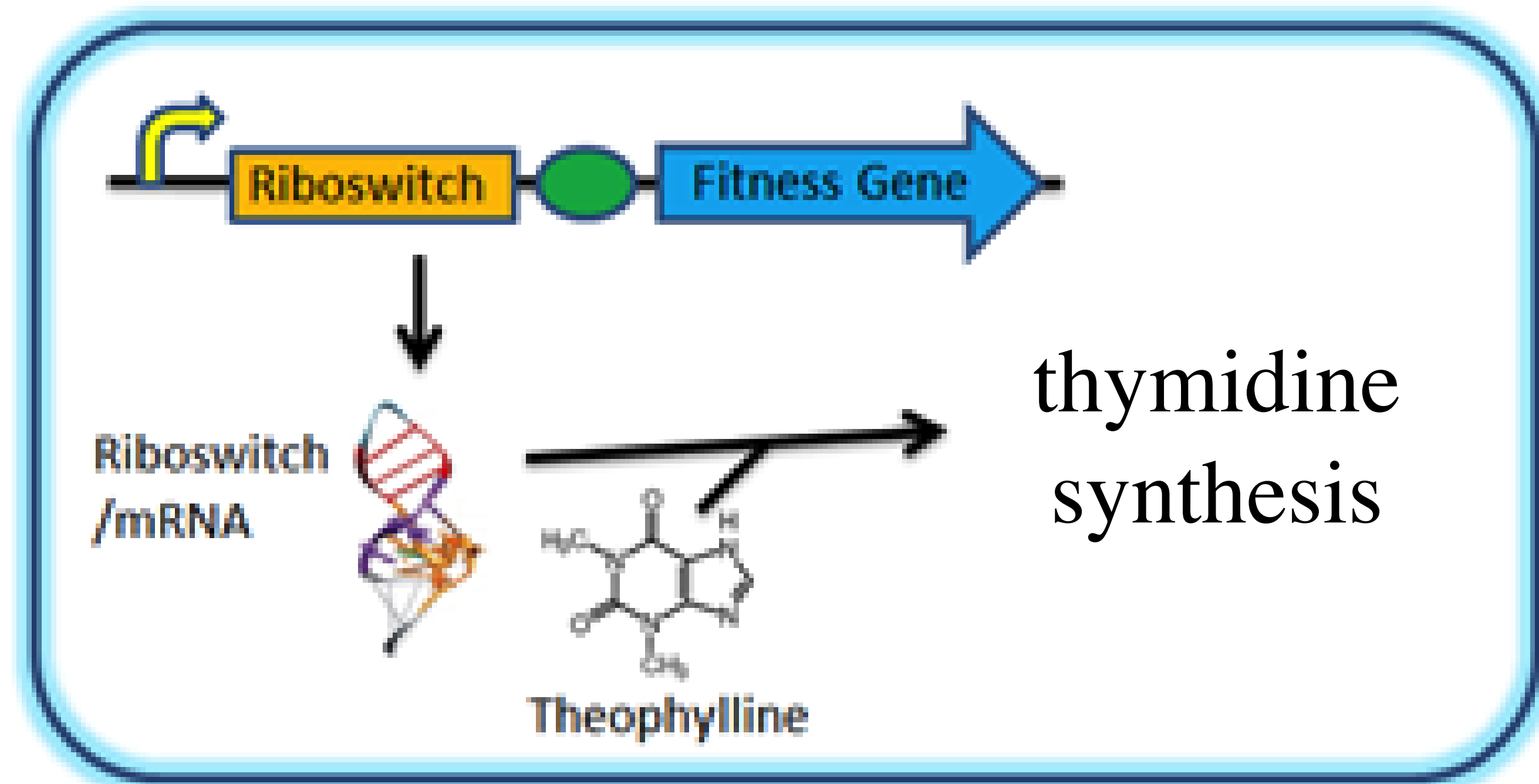
Fitness Module



Fitness Module



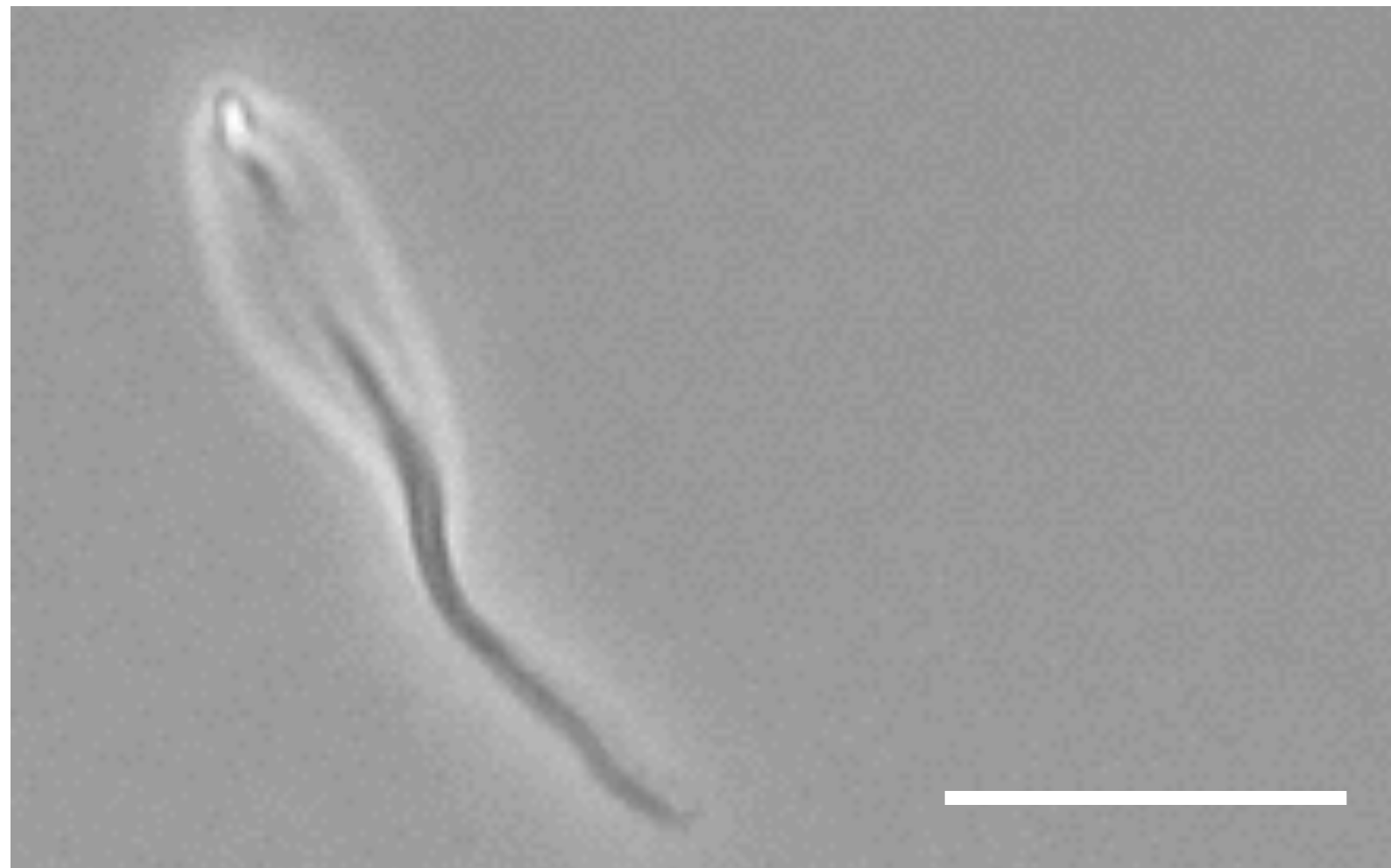
Fitness Module



Develop New Fitness Module

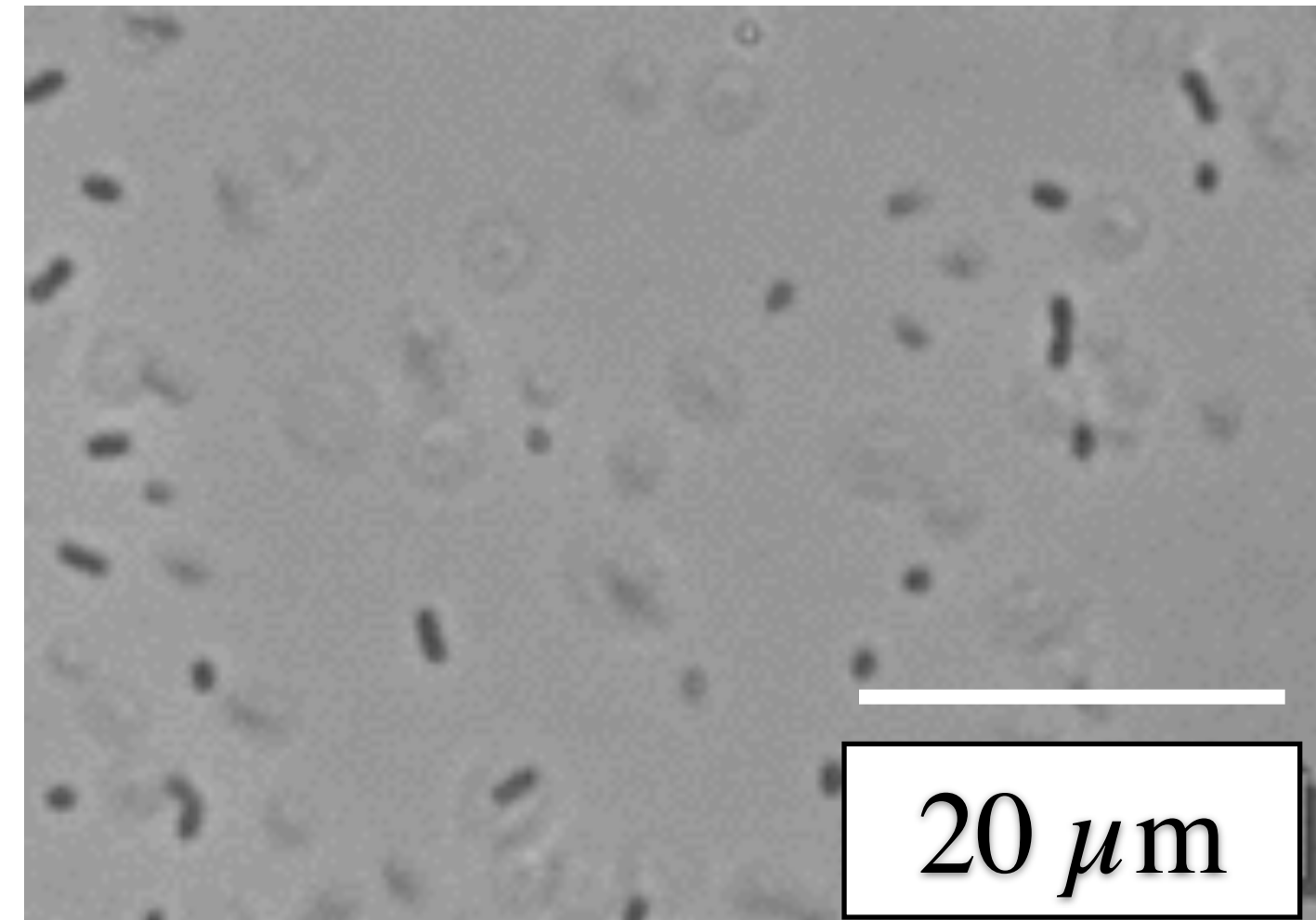
Elizabeth Brunner '16

thyA⁻ mutant



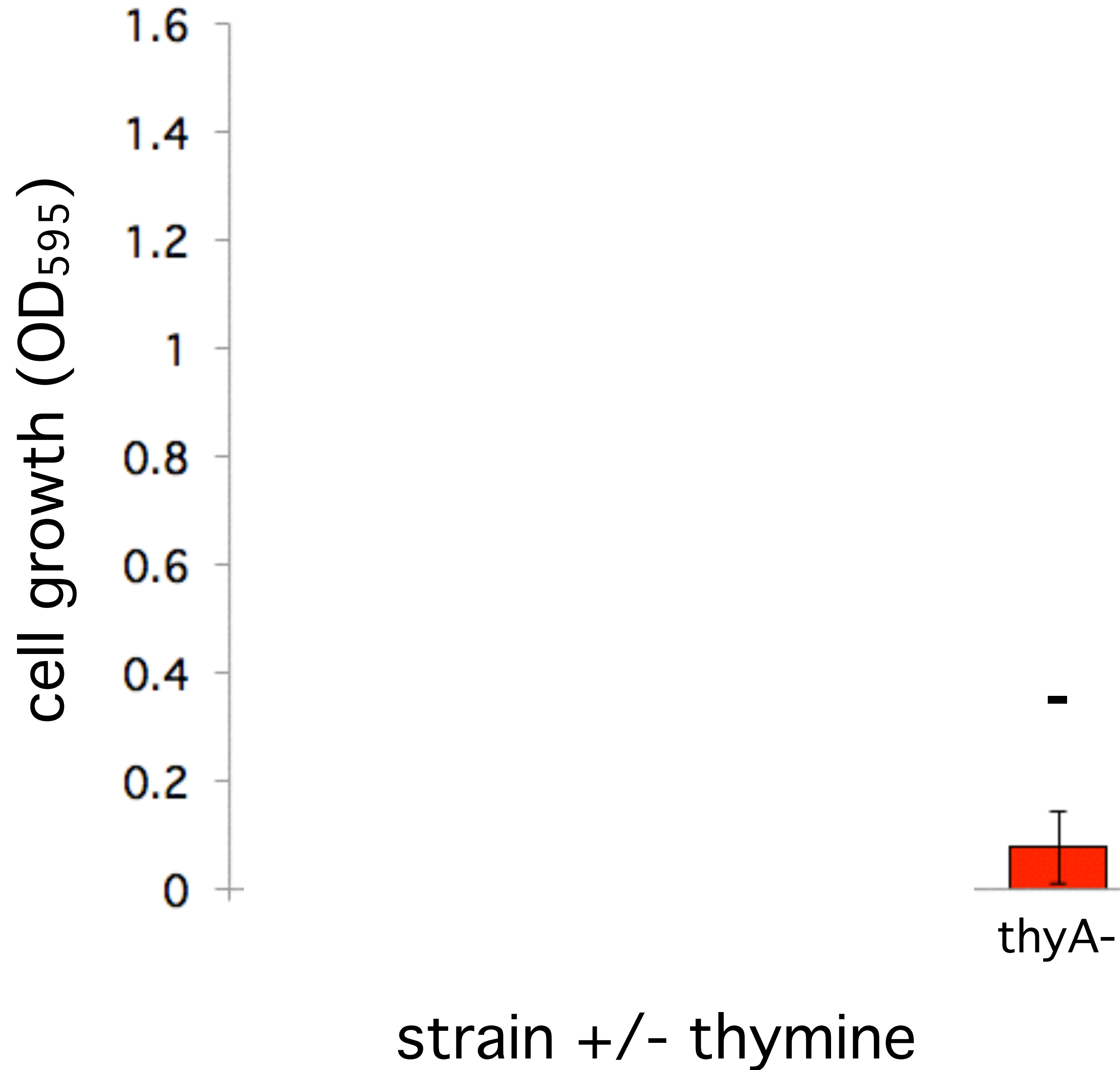
no DNA synthesis
no cell division

J100135

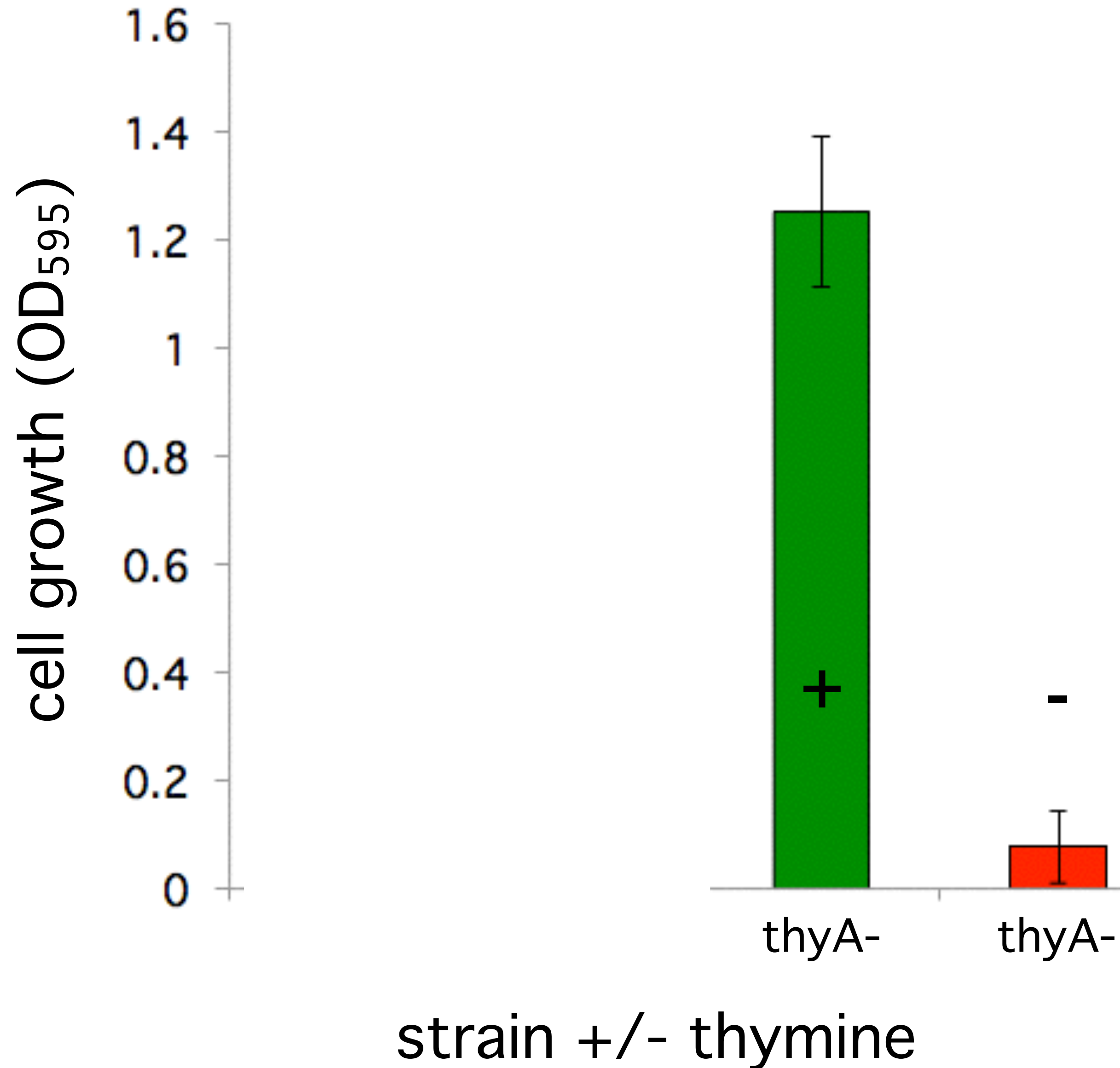


thyA⁻ mutant
+ *thyA* transgene

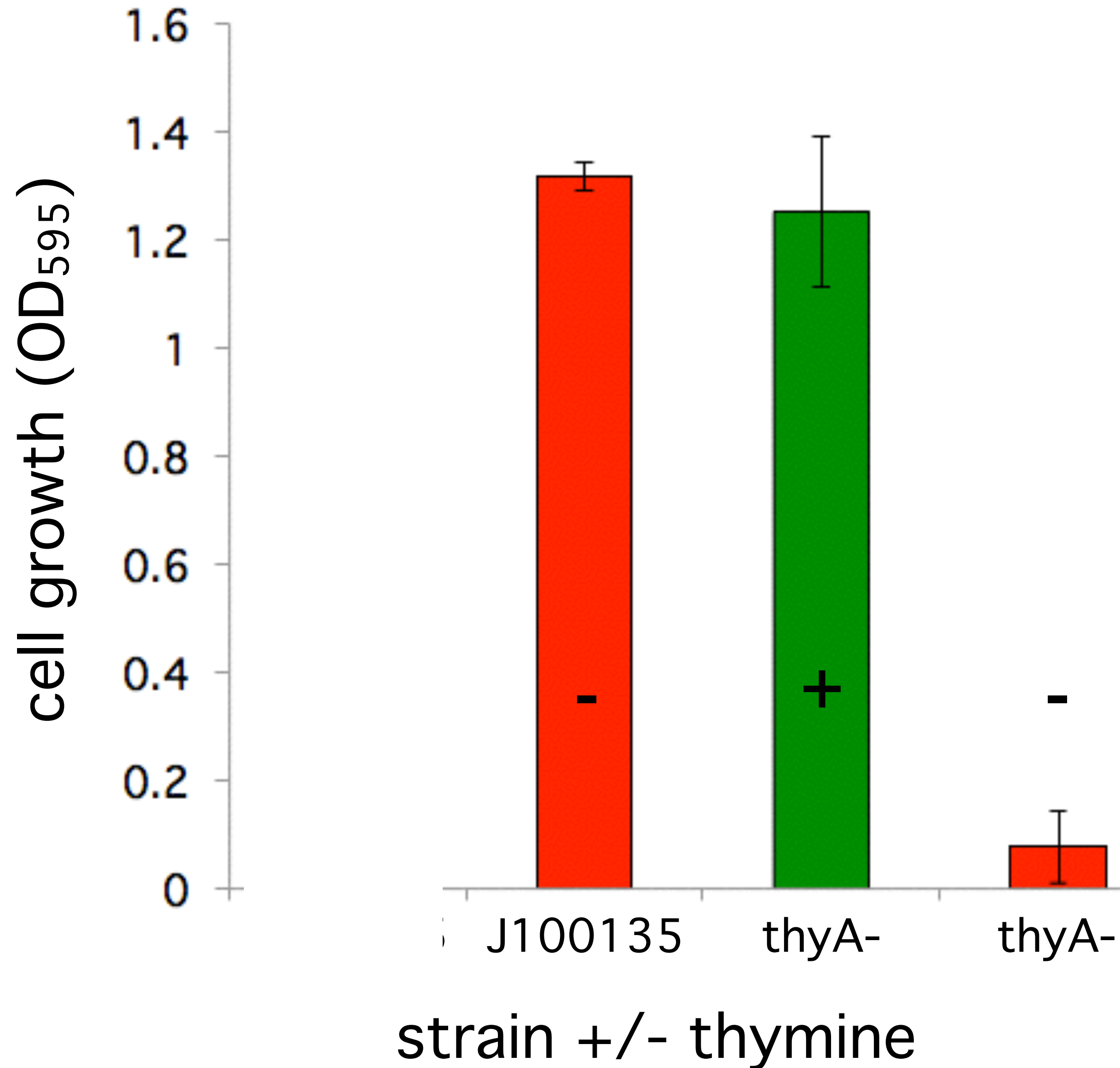
thyA Fitness Module



thyA Fitness Module



thyA Fitness Module



thyA Fitness Module

