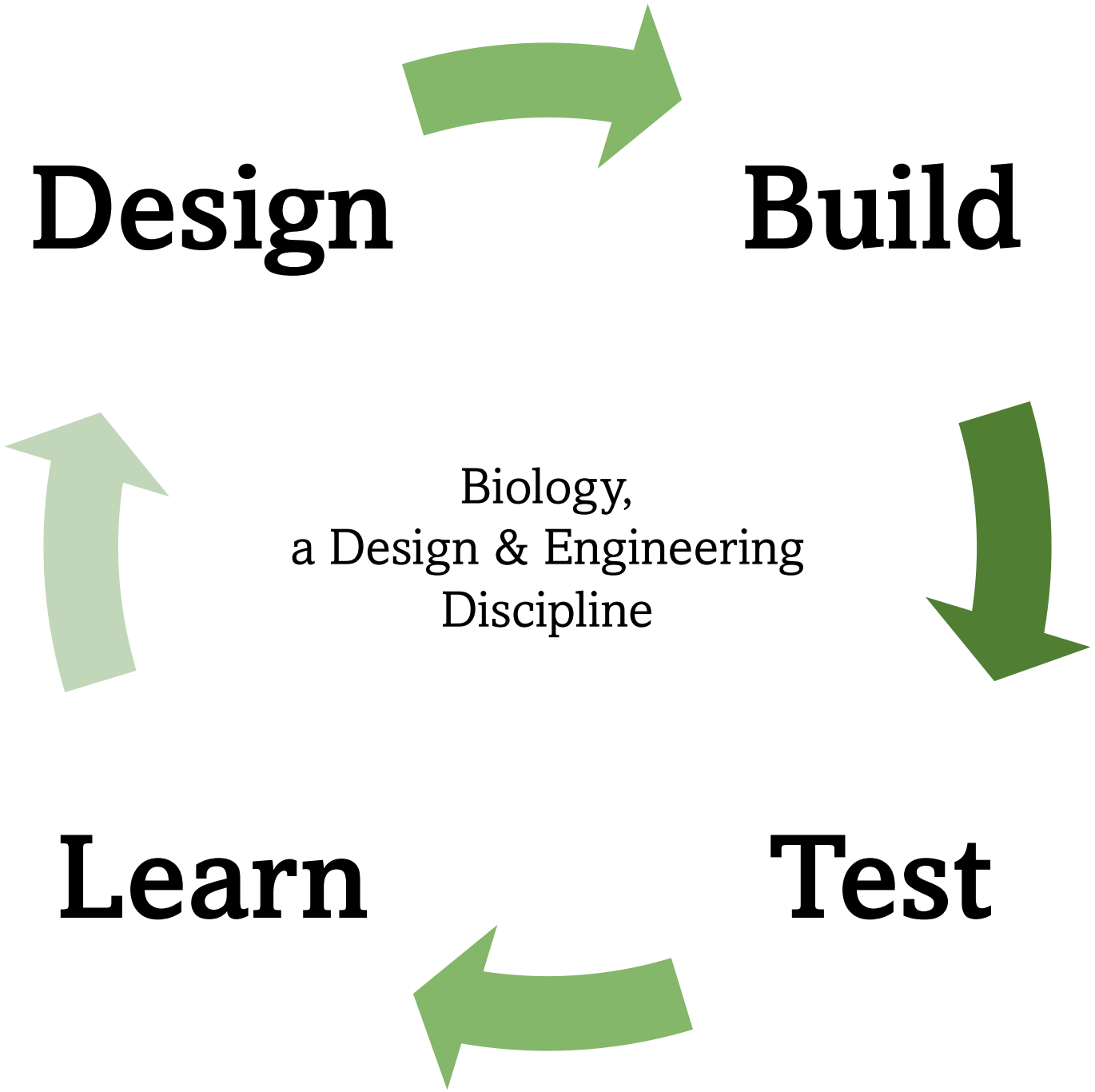
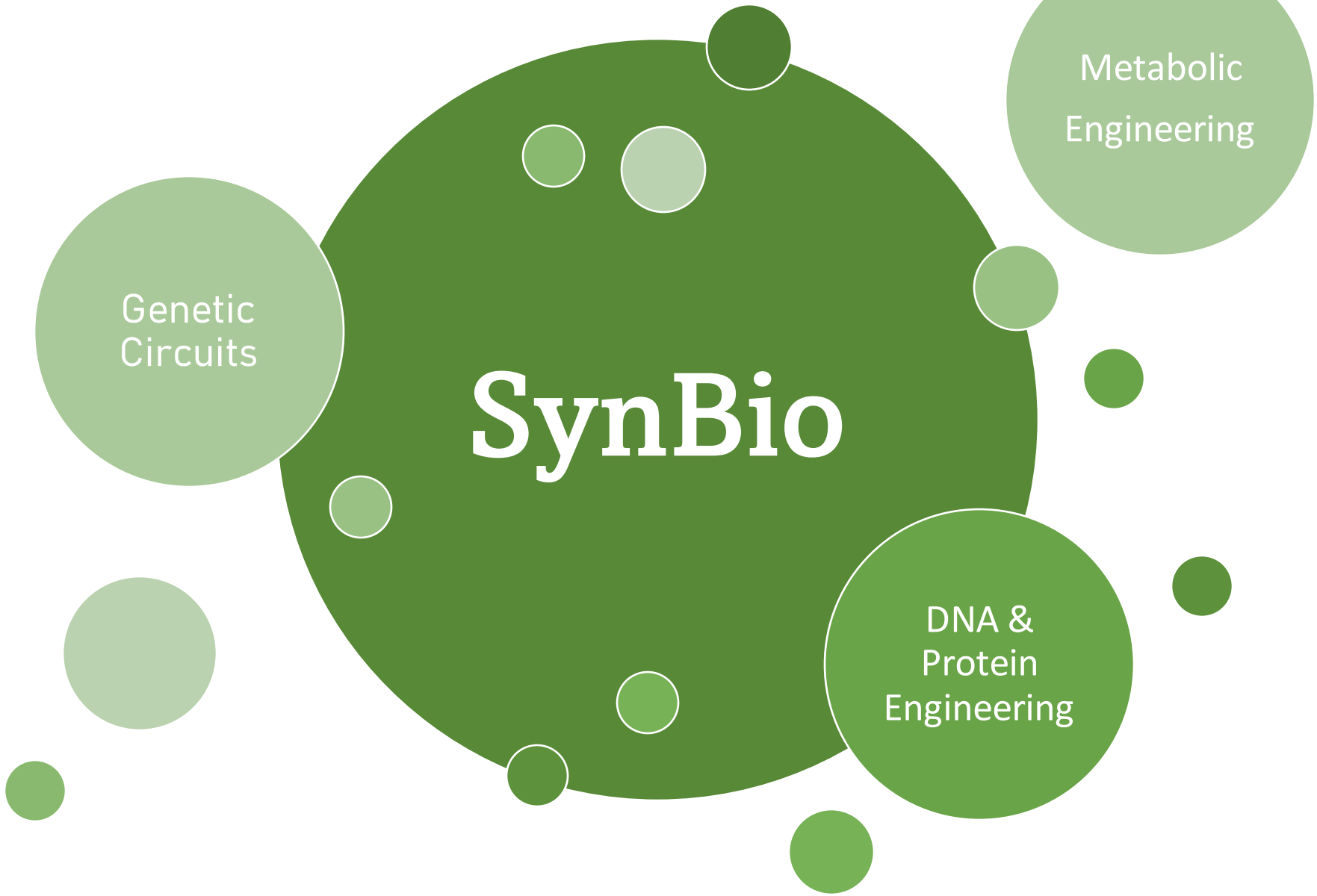
Synthetic Biology

Principles, Scope, and Interdisciplinary Applications

analysis to synthesis

changing the focus from the observation of evolutionary context and purpose of biological systems to understanding the compositional & relational logics to synthesis useful products.

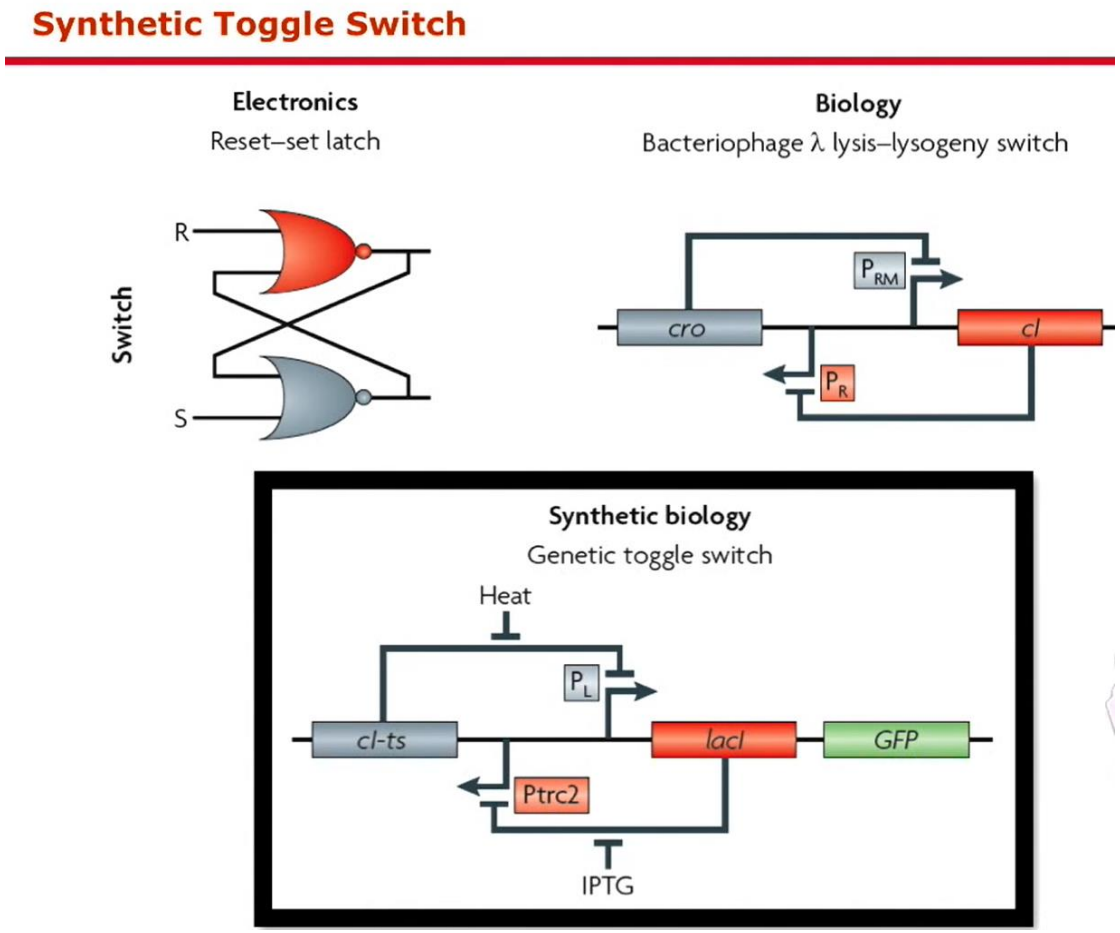

Design
Build
Test
Learn
Biology,
a Design & Engineering
Discipline


Metabolic Engineering
Genetic Circuits
SynBio
DNA & Protein Engineering

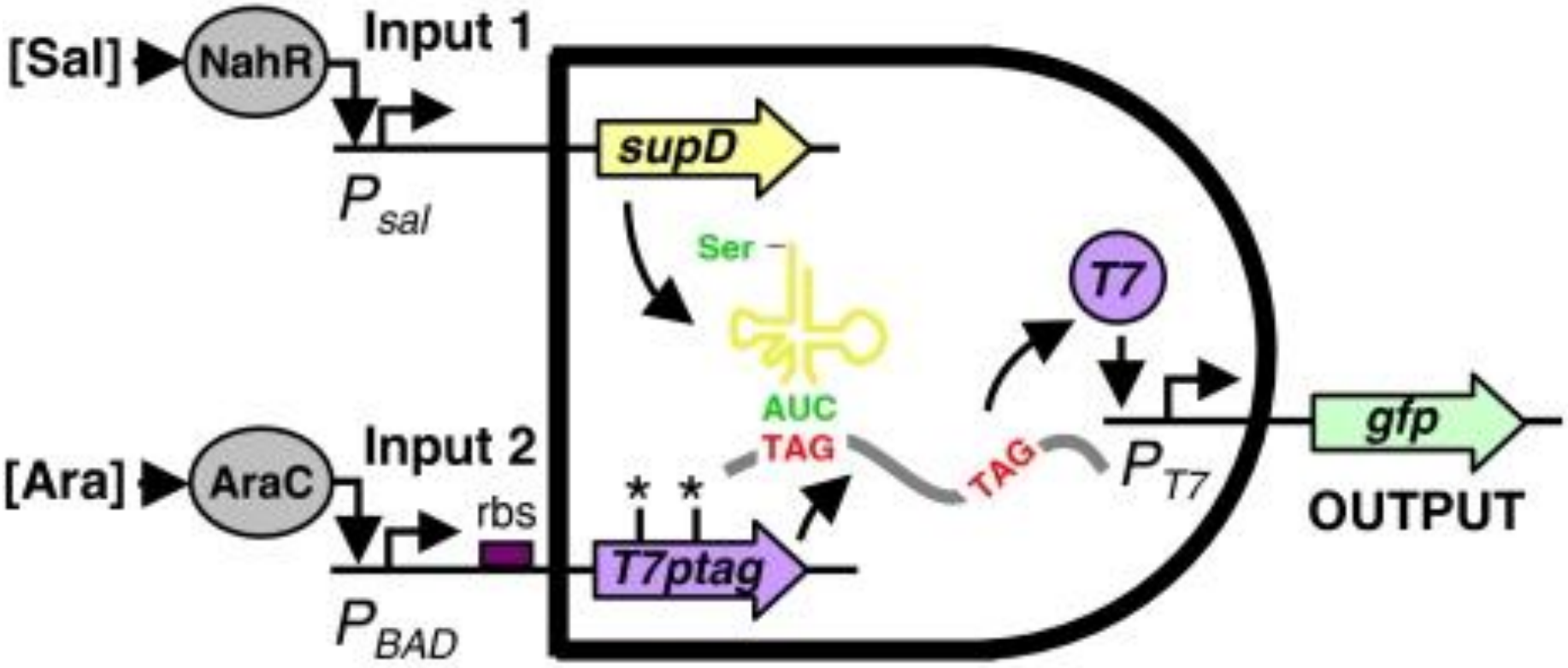
Genetic Circuits

- Cells function like complex circuits, that interact and communicate with their environments.
- Cells sense signals, and through networks of biochemical reactions trigger specific gene responses as outputs.
- These chemical outputs can be interpreted as digital signals of a Boolean logic gate.
- These signals can also be in the interpreted from light, electrical conductivity, mechanical changes, etc.

- Diagrammatic examples of:
  1. toggle switch- lysis-lysogeny switch (compared to set-reset latch)

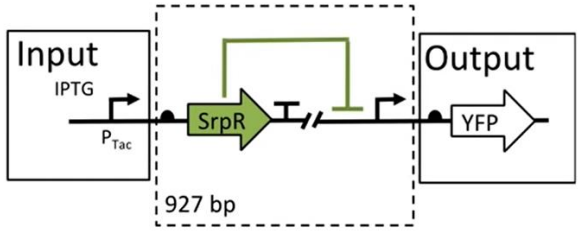


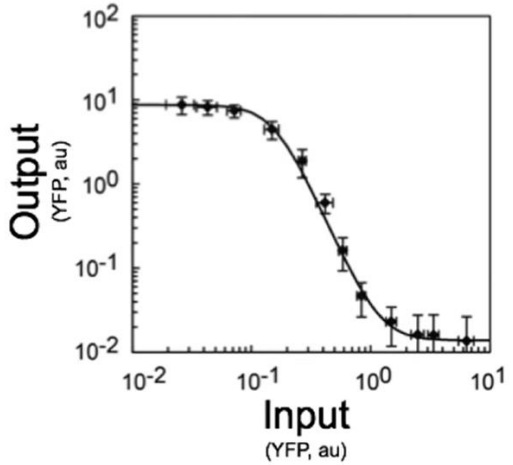
2. salicylate & arabinose creating AND gate



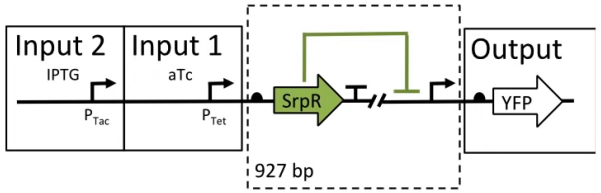
3. NOT gate (repressor that turns off promoter) & NOR gate (two input promoters)

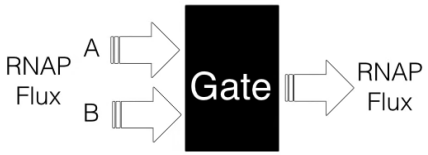
NOT Gate

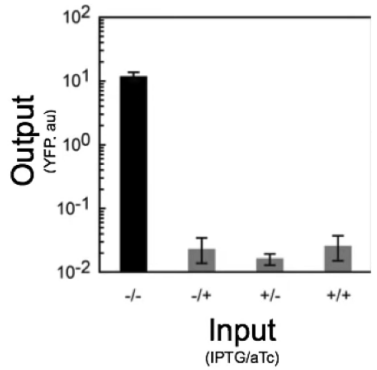




NOR Gate







Biosensors

- An analytical device, usually an engineered organism, which acts as a physiochemical detector
- The biological component is sensitive to/interacts with/binds to the analyte under study
- Biosensors can be used to detect toxins, heavy metals, etc. like bioluminescent bacteria has been used to detect petroleum pollutants.
- Also, an E. Coli reporter can find landmines by detecting TNT and activating a GFP (Green Fluorescent Protein)

Metabolic Engineering

- Altering metabolic pathways in cells to yield useful products
- Regulating the flow of certain reactions to facilitate the production of desired compounds
- This is done by blocking competing reactions, overexpressing the enzyme activation gene and enzyme engineering suited for the needs
- The focus is on getting the cell's regulatory networks to efficiently engineer the metabolism

Programming Living Cells:

1. Code is written for the desired circuit function (Using Verilog, for example)

2. Software models the circuit diagram which is then converted to a linear DNA sequence

3. The DNA is then synthesised from the sequence and then inserted in the cell to be executed by it

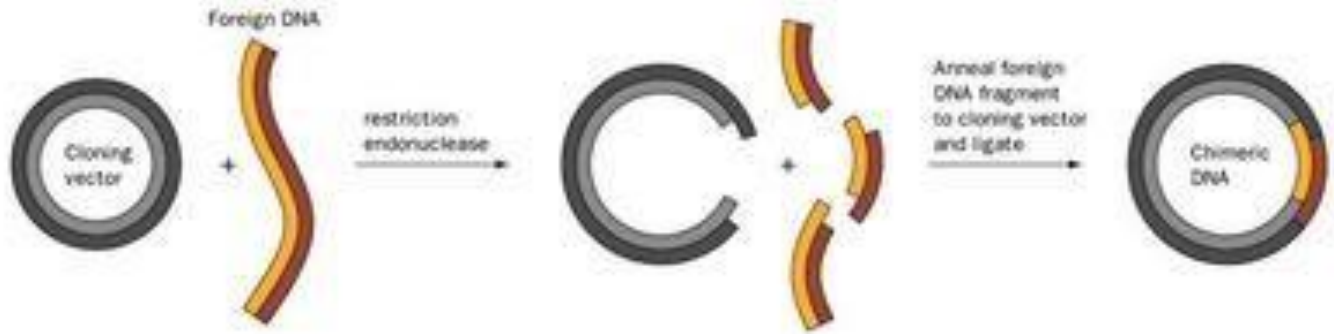
BioBRICKS

- Tool for twirking with DNA in E.coli
- Standardized DNA sequences

- Biobricks = Promoters+ Coding sequences+ RBS+ Plasmid Backbone + Terminators

- Biobrick: building legos?

Molecular Cloning:
Construction of a recombinant DNA



Non-directional??

BioBricks

Assembling the Future with Synthetic Biology

Step 1:
Choose Your Plasmid Base

Bacteria
2 x 6

OR

Yeast
2 x 8 (flat)

Step 2:
Pick a Promoter Sequence

Bacterial Promoters
- Red – Low Expression
- Green – Low Expression
- Blue – High Expression
- Yellow – High Expression
- Black – Inducible

2 x 2

Yeast Promoters
- Grey – Low Expression
- White – Low Expression
- Pink – High Expression
- Light Blue – High Expression
- Purple – Inducible

Step 3:
RBS
Pick a Ribosomal Binding Site (RBS)

Bacterial RBS
- Red
- Green
- Blue
- Yellow
- Black

1 x 2

Yeast RBS
- Grey
- White
- Pink
- Light Blue
- Purple

Step 4:
cDNA
Pick A Coding Sequence

- Red – Red Protein
- Yellow – Yellow Protein
- Green – Green Protein
- Blue – Blue Protein
- White – Banana Smell
- Light Blue – Wintergreen
- Pink – Insulin
- Purple – Malaria Vaccine
- Grey – Biofuels
- Black – Whatever you want!

2 x 3 or
2 x 4

Step 5:
Can your plasmid express the protein?

Georgia Tech

Georgia State University

ATLANTA SCIENCE FESTIVAL