Engineering Synbio: From Zero to Infinity

Yixian Yang, Alejandro Vignoni & Sonja Billerbeck
On behalf of the iGEM Engineering Committee
May 7th, 2022

About Engineering

What is Synthetic Biology and Engineering?

- An approach that is used to design and build biological systems
- SynBio uses engineering principles
- Ideas, rules, and concepts that need to be kept in mind when solving a practical problem

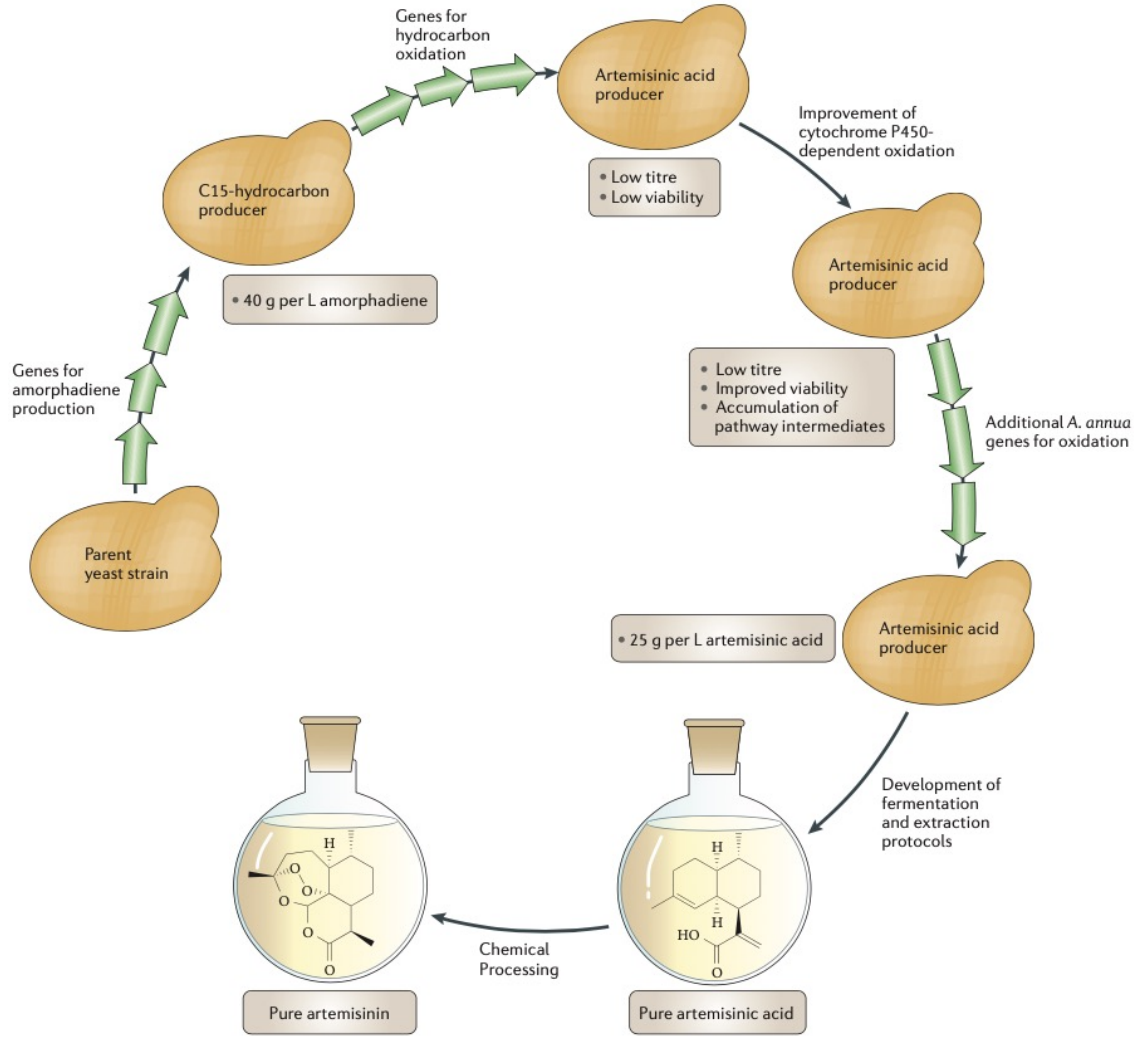
Why do we need Engineering ?

About Engineering

Artemisinin example

- Traditional: extract the compound from the “sweet wormwood” plant
- SynBio method: use engineered microorganisms to produce the compound

High efficiency, low cost, increased and regular output



Nature Reviews Microbiology , 2014

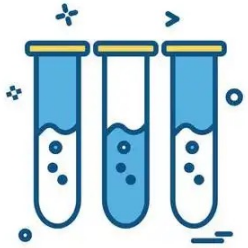
About Engineering

How do you engineer biological systems?

- What are the requirements for designing or building biological devices?
- What steps are necessary to successfully engineer biology?
- What principles need to be utilized?

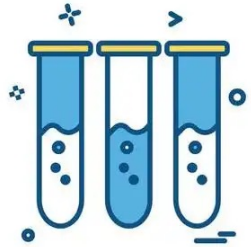
The iGEM Engineering Cycle will help!

iGEM Engineering Cycle



Design constraints based on intended purpose	Design project based on initial ideation
Build a prototype that meets the specifications	Build through wet and dry lab work
Test each part of the prototype and collect data	Test and measure the experimental system
Learn from the data and modified the initial design	Learn from the data and enter the next iteration

iGEM Engineering Cycle

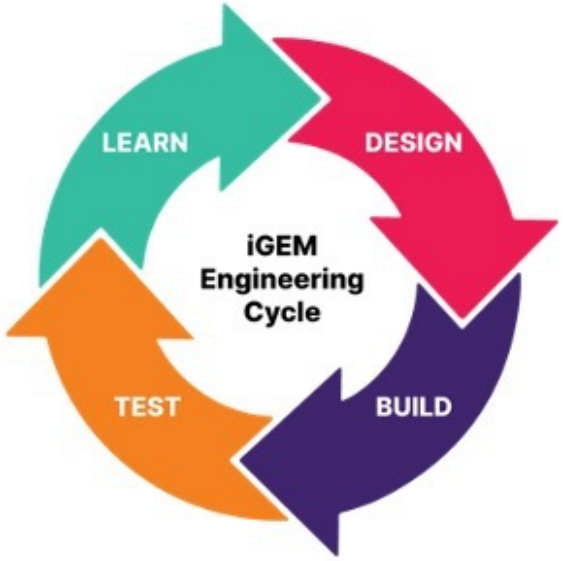


Design constraints based on intended purpose

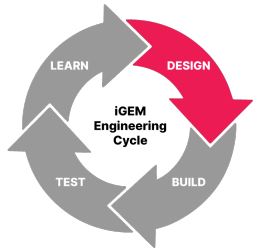
Build a prototype that meets the specifications

Test each part of the prototype and collect data

Learn from the data and modified the initial design



Design Stage

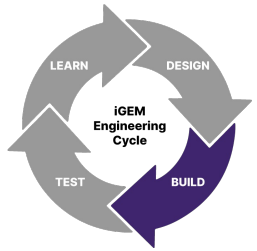


- **Purpose:** Create an outline that defines what is required to meet the aims of your project and use this to guide its development.

- **Consists of two sub-stages**
  - Define biological functions, devices, components, experiments and reagents, outputs or data
  - Set up models and simulations using computational tools (mathematical models, differential equations, metabolic networks, FBA, etc...)

- **Important things to consider**
  - Define the problem you are trying to solve, and an idea of what your solution is.
  - Go through iterations of DBTL while keeping your design modular

Build Stage

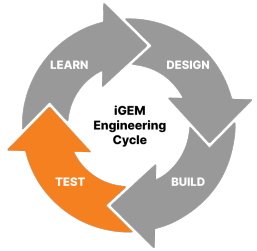


- **Purpose:** Build your genetic device or biological system using molecular biology techniques.

- **Important Things to consider**
  - What materials, reagents, and techniques will be needed and do you have access/expertise?
  - Can you build modular parts, which will make future iterations easier?

- **Tips to get started**
  - Make sure you know what techniques and what DNA assembly procedures you will conduct when you enter the build stage!
  - IDT and Twist Biosciences are providing DNA synthesis to help teams build their genetic devices, remember these considerations while in the design stage!

Test Stage

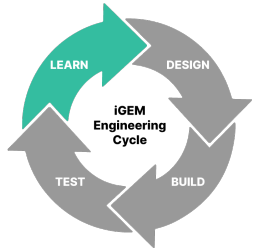


- **Purpose:** Determine whether your system is working as intended via testing your system and generating data.

- **Important Things to consider**
  - What are you testing for, and what measurement data are needed.
  - Is your data relevant, accurate, and reproducible? How to report them?

- **Tips to get started**
  - Use your design specification to determine the most important test cases and evaluate whether you have the equipment needed.
  - iGEM Measurement Validation/Protocols.io /Webinars (etc...)

Learn Stage

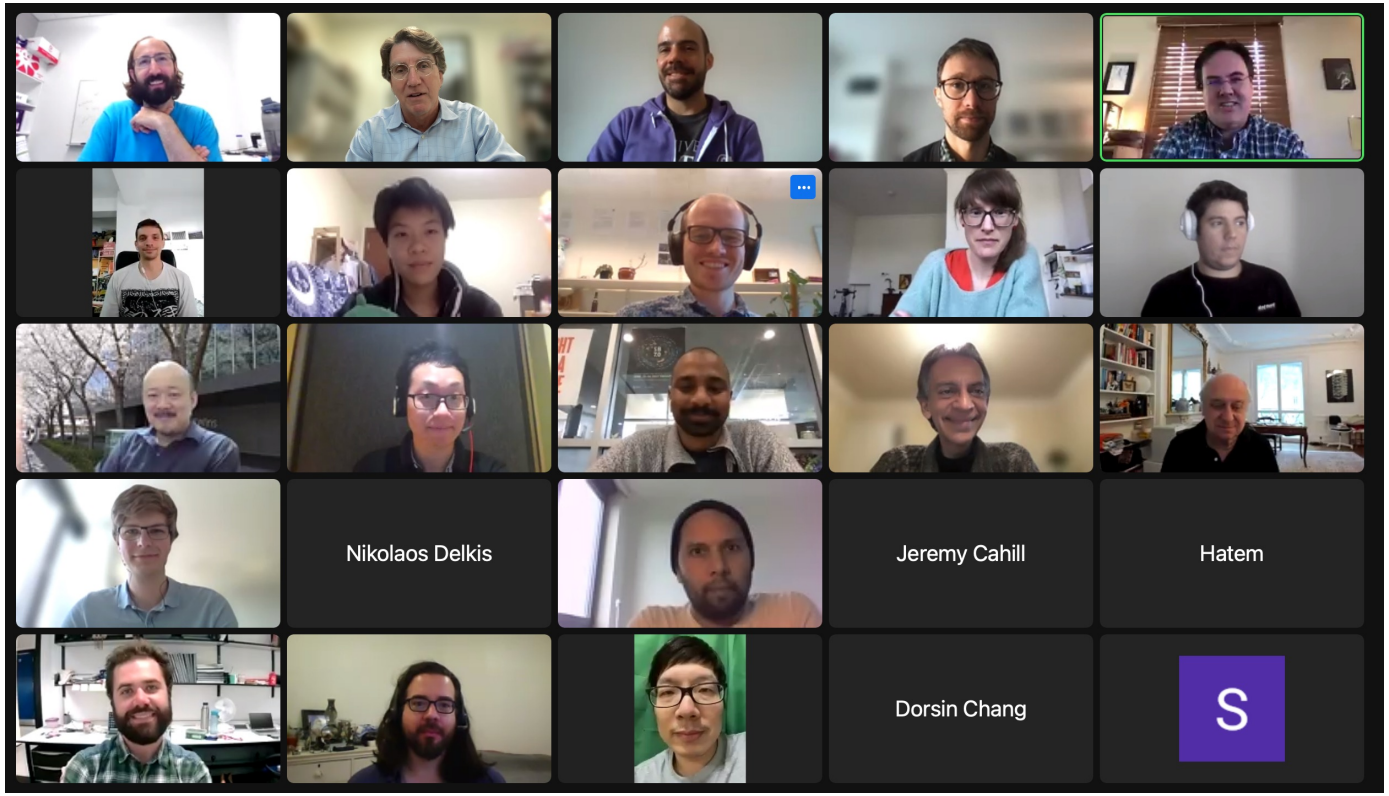


- **Purpose:** Analyze your experimental data and reflect back on how your system is functioning relative to what you expected when you originally designed it.
- **Important Things to consider**
  - What do you want to learn from your data? Where can your design be improved?
  - Does your system work as anticipated? How can this DBTL cycle be helpful?
  - Use data from the Test stage to feed you models from the Design stage to help you predict the next iteration.
- **Tips to get started**

  Stay humble. Think back to your initial design and make comparisons, reconsider your experimental results. Communicate with iGEM teams or experts/professors to find assistance.

Engineering Resources

- Webinar Series is coming
- Sponsors
- https://technology.igem.org/engineering/introduction
- engineering-help@igem.org



Engineering Committee 2022

Q&A Session