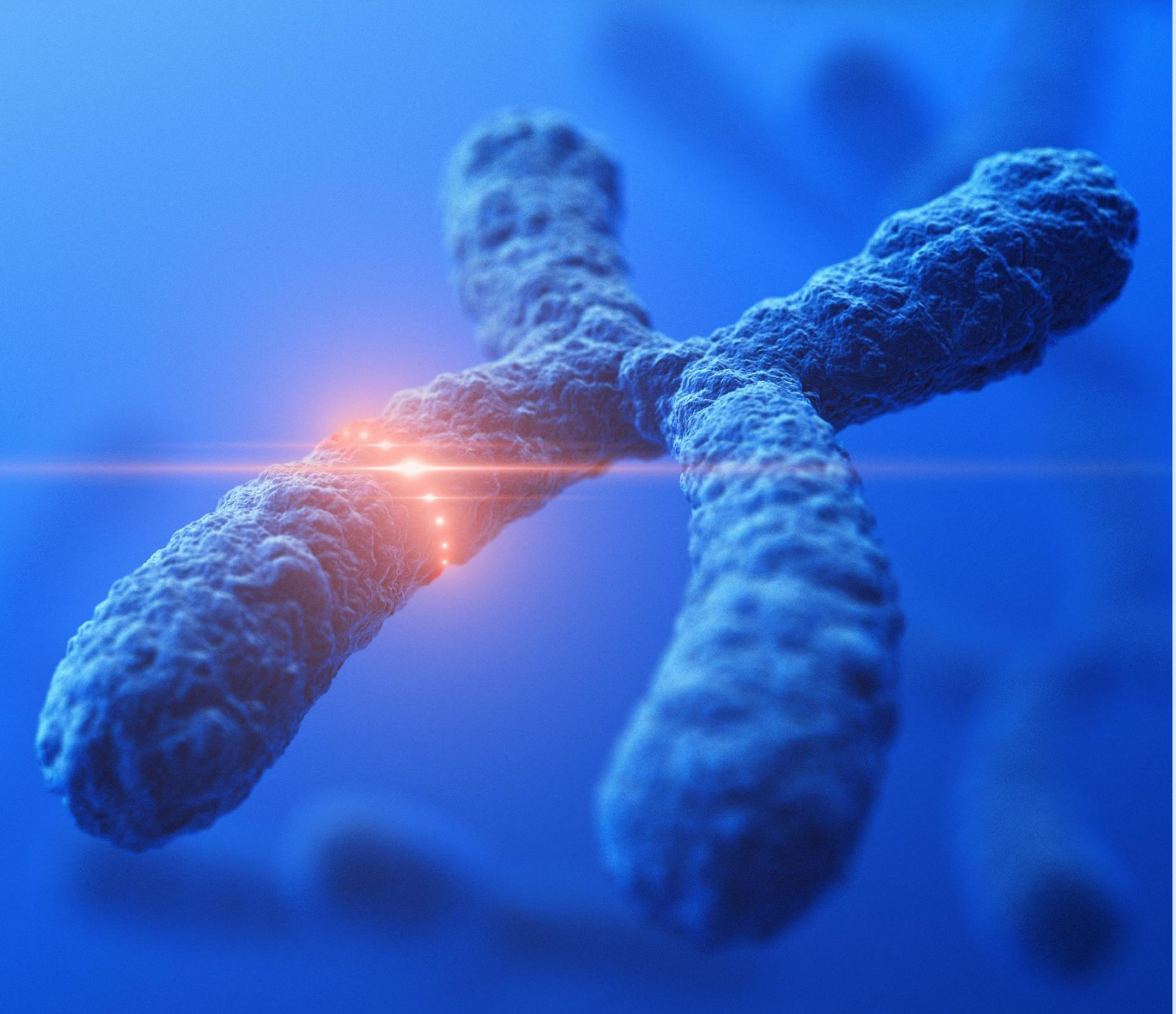


# 合成生物学与iGEM

主讲人
厦门大学
October 28, 2020

Part 1

# iGEM简介

# 什么是 iGEM

## 全球生命科学领域规模最大、学术影响力最高的国际赛事

INTERNATIONAL
GENETICALLY
ENGINEERED
MACHINE
COMPETITION

**国际遗传工程机器竞赛**

iGEM由美国**麻省理工学院**于 2003 年创办，至今已成功举办 17 届。

iGEM的全球社区包括来自全球45个国家和地区的40,000多名人士。

# iGEM 历史

2003 iGEM从MIT诞生

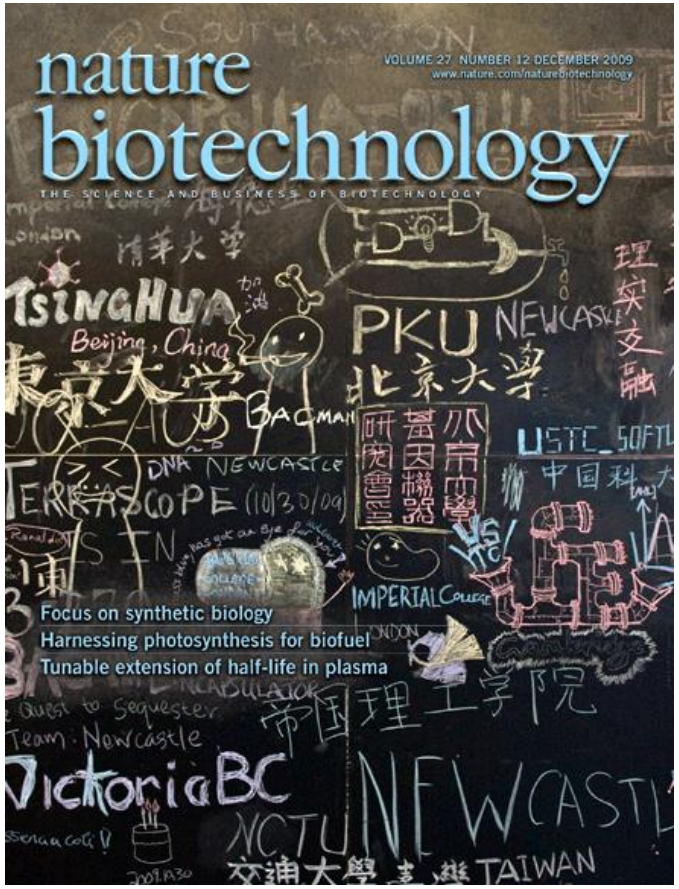
2004 iGEM扩展到北美

2007 iGEM推广到全球
中国团队首次参赛
（4支队伍）

2011 厦门大学首次参赛

2014 赛制改革，搬出MIT

2021 决赛场地移至巴黎




2009年，iGEM与合成生物学专题登上《Nature Biotechnology》封面


2018年《生物工程学报》开设iGEM专栏

# 什么是 iGEM

iGEMers在**1 年赛期**内利用**合成生物学**解决世界范围内的环境、医疗、生产、诊断等领域面对的问题。

- 使用标准化的**分子生物学技术**
- 利用标准化的**生物学“积木”（DNA）**
- 设计、构建、测试、表征生物系统

**用DNA对细胞“编程”**

# iGEM 项目实例（高校组）

## Imperial College
**伦敦帝国理工学院（2016）**

开发基因工程人工比率(GEAR)系统，以控制微生物群落中的种群比率


## Valencia_UPV
**西班牙瓦伦西亚理工大学（2018）**

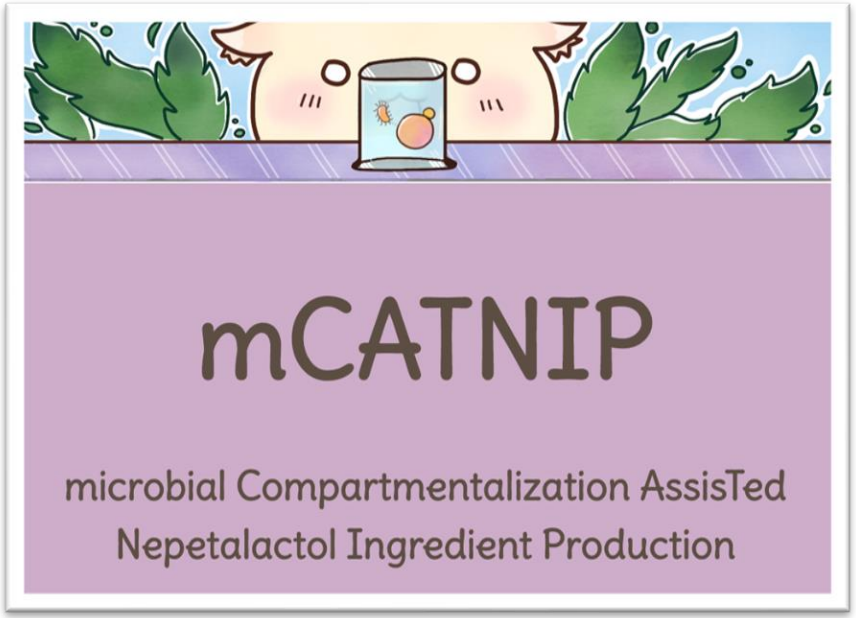
设计并制作一台生物工程打印机”Printeria”，使合成生物学部分实验操作自动化


## Calgary
**加拿大卡尔加里大学（2019）**

利用叶绿素酶促产物脱镁叶绿酸a解决油菜籽植物的“绿色种子”问题

# iGEM 项目实例（高中组）

## GreatBay China
**深圳大湾区联队（2018）**



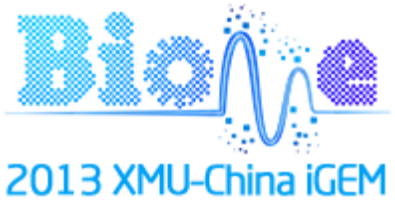

通过大肠杆菌和酵母菌之间的相互分工合成猫薄荷的活性成分：荆芥内酯

## GreatBay_SZ
**深圳大湾区联队（2019）**


利用大肠杆菌生产重组蛛丝蛋白，并实现生产中自染色

# iGEM 中的厦大人——10年参赛史









**2011年，厦门大学首次参加iGEM**


9


1

2013年2支参赛队： 实验队和软件队均斩获金奖

2014年取消洲赛前，多次提名亚洲赛区冠军

# iGEM 中的厦大人

| | |
|---|---|
| 2011 | 智能控制菌落密度 |
| 2012 | 逻辑门调控的荧光数字显示器 |
| 2013 | 基于群感效应的生物振荡传感器<br>生物砖优化评估软件E-Note |
| 2014 | 利用细菌趋化性画出圆锥曲线 |
| 2015 | L-叔亮氨酸的高效生产 |
| 2016 | 沉默抗生素抗性基因的工程菌 |
| 2017 | 模块化检测重金属工程菌及装置 |
| 2018 | 无细胞的检测与治疗 |
| 2019 | 工程菌模拟群体关系 |
| 2020 | **茶园中农残的高效处理手段** |

2011

2012

2013 Lab

2013 Software

2014

2015

2016

2017

2018

2019

# iGEM 2019 概况

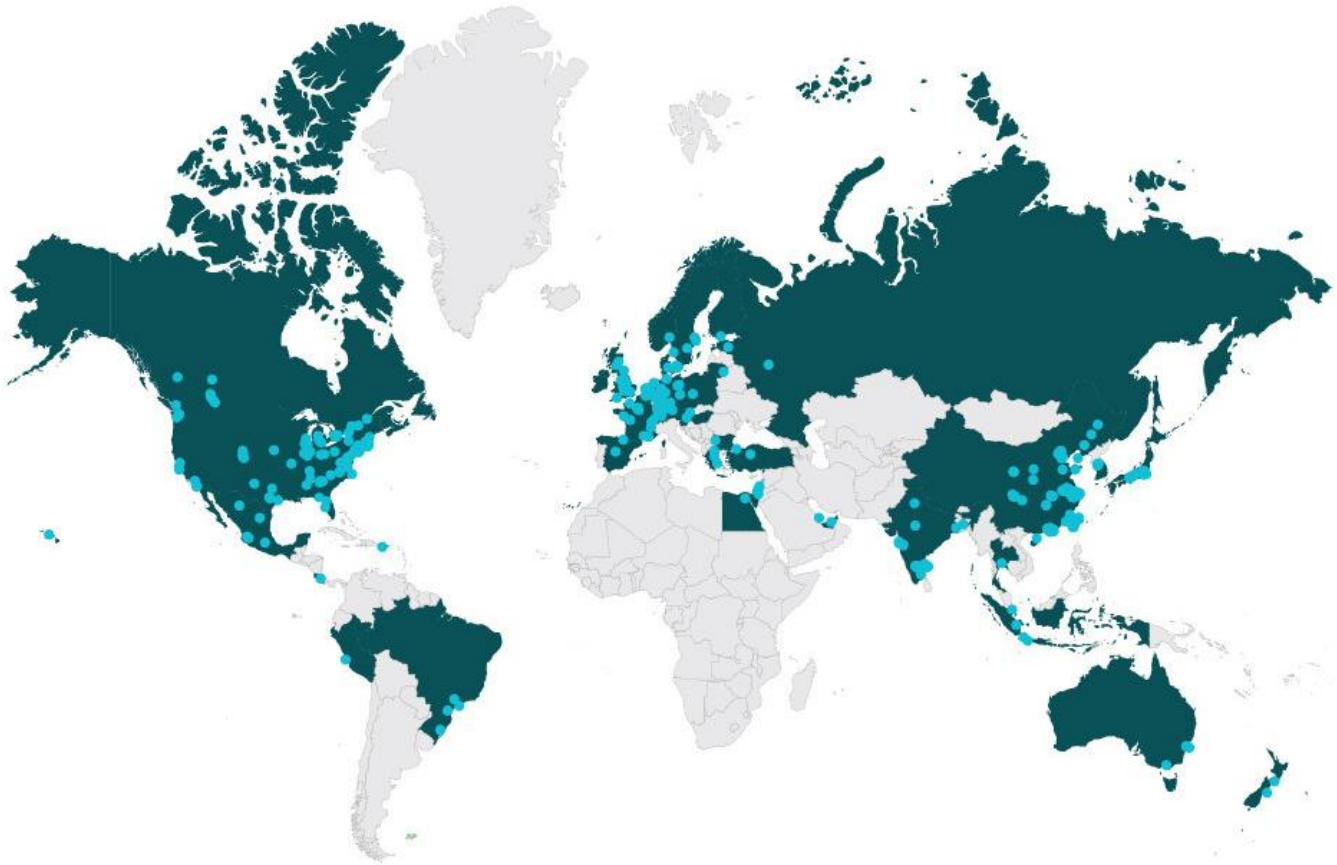
45 国家/地区

353 支队伍

7,000+ 参赛者

94,000+ 实验数据

24,0000+ DNA序列



# iGEM 2019 参赛队伍

## 国内高校

九校联盟(C9)

“双一流”院校

……

## 国际名校

Harvard

MIT

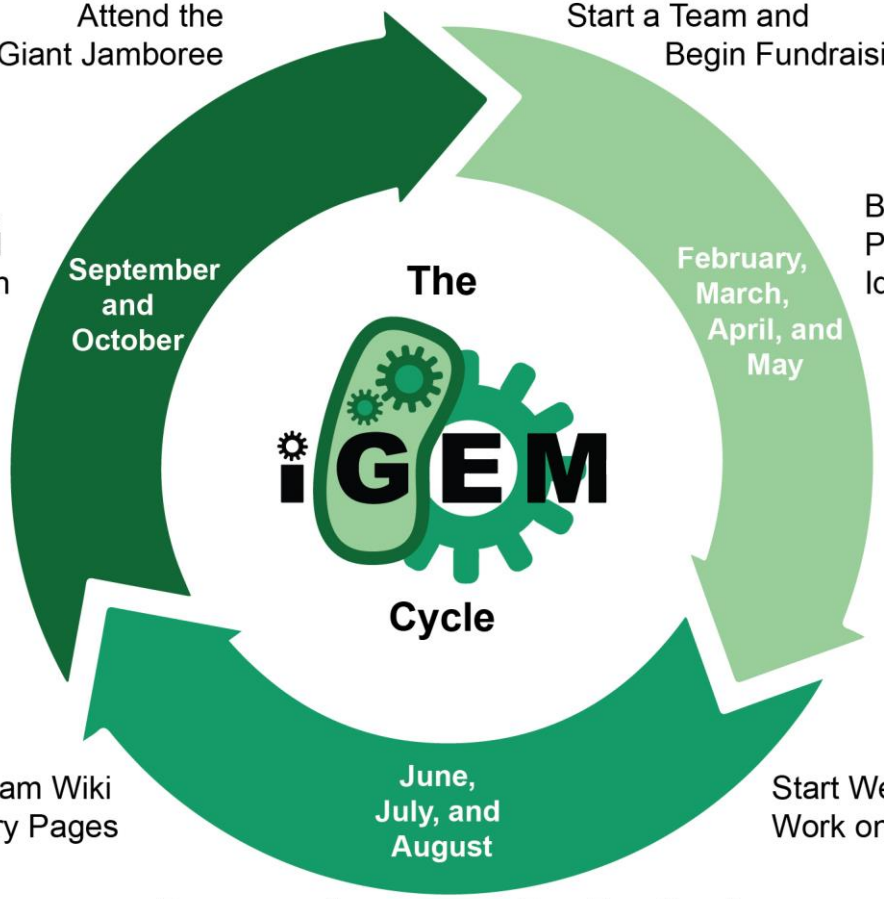
Cornell

Imperial College

……

**国内中学** 人大附中、北京四中、十一学校、南京外国语学校、深圳中学、深圳国际交流学院

# iGEM 比赛流程




Boston/Paris决赛

组建队伍

赛前准备

构想课题

结束实验

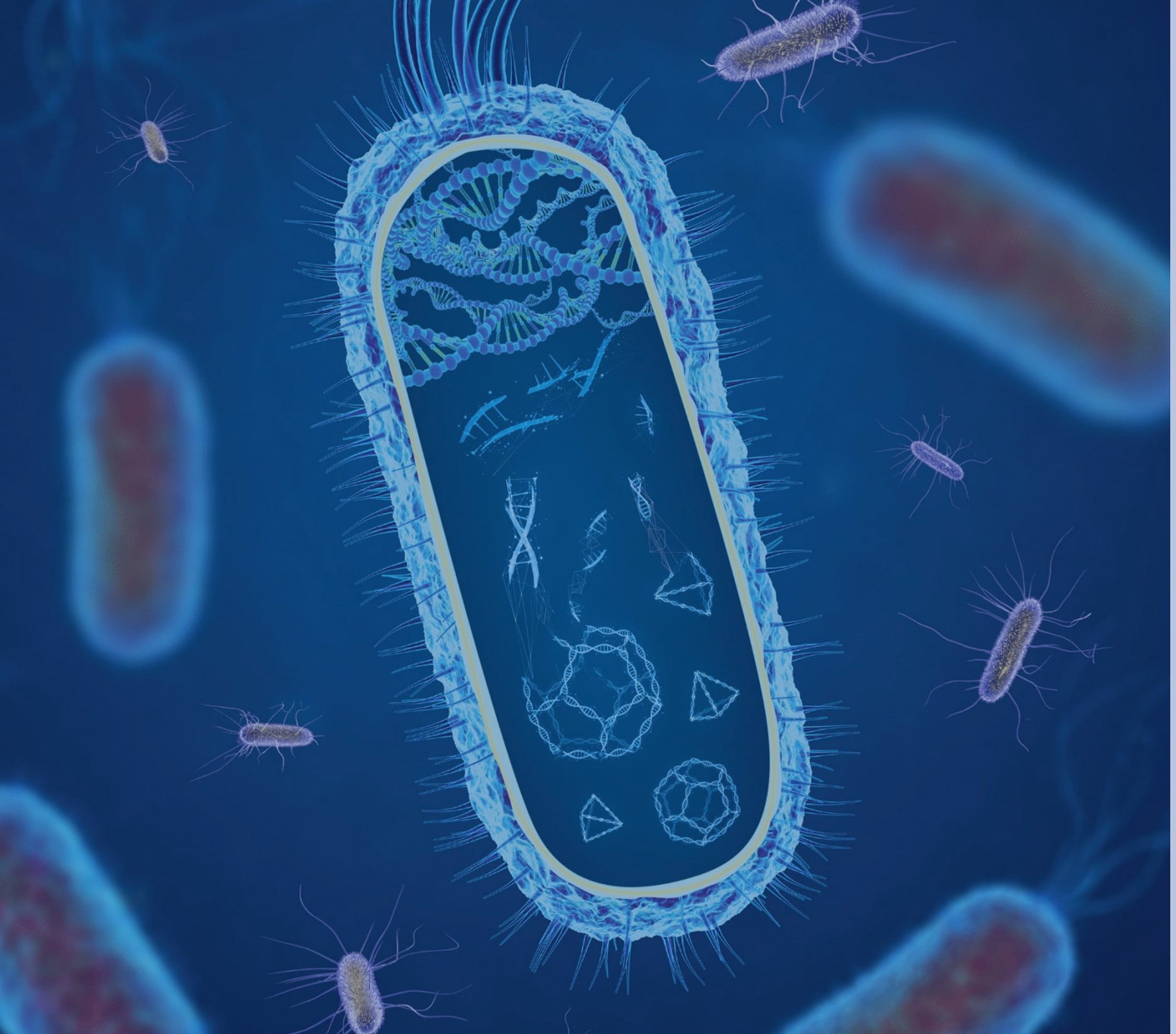
确立目标

网页搭建

实施任务

数据处理

进行实验



Part 2

# 合成生物学基础

# 合成生物学简谈

**通过改变细胞中的DNA，我们可以……**

- 治疗疾病
- 检测毒物
- 生产药物

**合成生物学：从零开始构建一套行使特定功能的生命系统**

# 为什么合成生物学脱颖而出

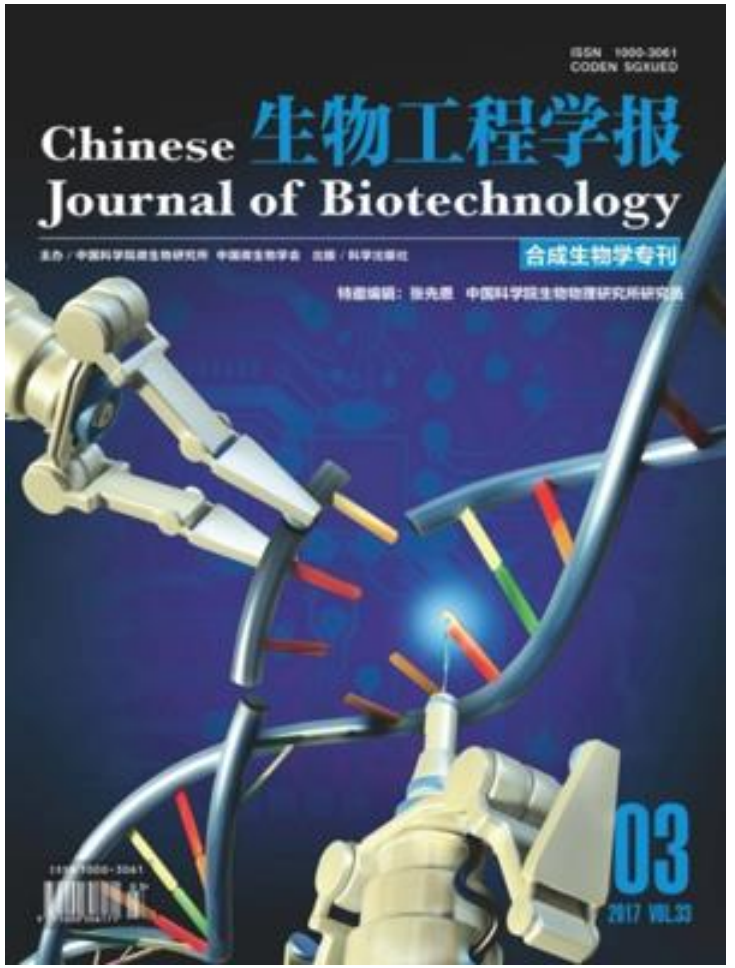
早在 2004 年，**合成生物学**就被美国麻省理工学院出版的《Technology Review》评为未来将改变世界的十大新兴技术之一。


TIP：人类基因组计划（HGP）正式启动于1990年，于2003年最终完成

# 为什么合成生物学脱颖而出

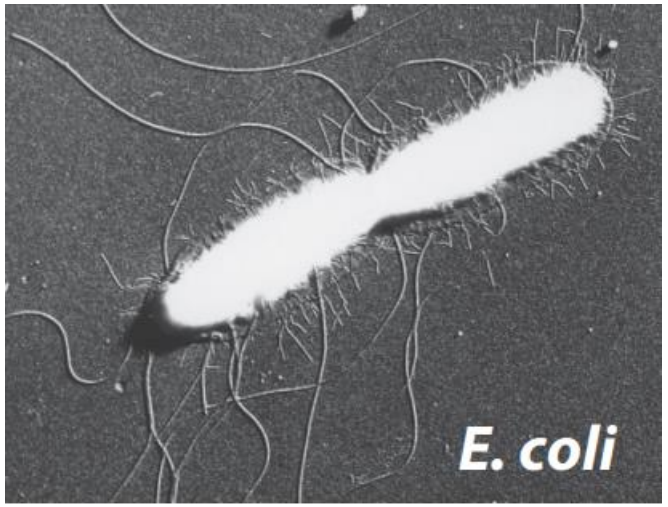
## 合成生物学的优势

- 细胞可自我复制
- 细胞更容易实现复杂的生物化学反应
- 可提供环境友好型解决方案
- 人们了解自然系统的途径之一



# 一个现实性的问题

**“我们仍处于并将长期处于合成生物学初级阶段”**




**细菌**

**2~20 μm**


**酵母**

**1~100 μm**

# 合成生物学 V.S. 基因工程

## 基因工程

Introducing one or two small changes to investigate a specific system

对特定生物系统（基因组）进行**小规模**编辑

## 合成生物学

Design new genomes and redesign existing genomes at a grand scale

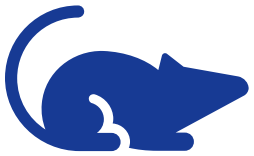
设计全新的基因组或对已有基因组进行**大规模**编辑

# 合成生物学 V.S. 基因工程

## 合成生物学

Design new genomes and redesign existing genomes at a grand scale

设计全新的基因组或对已有基因组进行**大规模**编辑



**充分研究的**
**模式生物**

**大规模**
**DNA测序数据**

**合成新序列的**
**分子级工具**

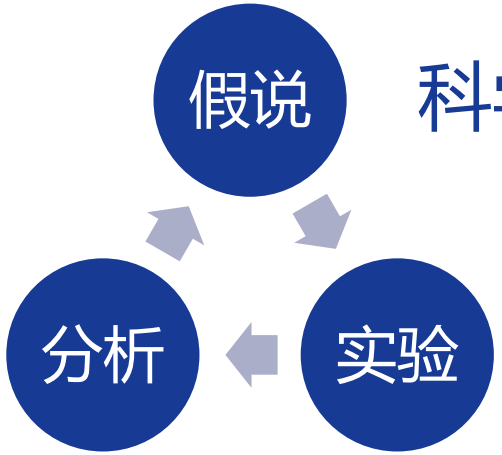
# 工程学与设计

## 何为工程学

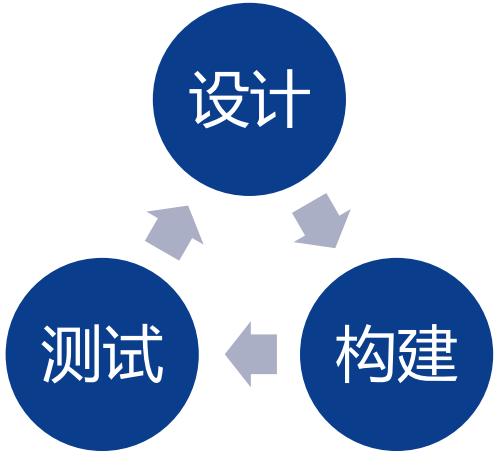
Build complex systems that behaves constituently, according to the design specification.

依照一定的设计规范
构建一套稳定运行的系统

如土木工程、化学工程、软件工程




科学研究三部曲




工程学三部曲

# 工程学用到的工具



机械工程



电子工程

## 合成生物学的工具是什么?

# 合成生物学的工具

## 理论基础

**分子生物学**

**Molecular Biology**

**基因工程**

**Genetic Engineering**

# 合成生物学的工具 #1：分子生物学

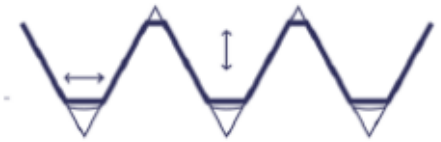
| Tool | Molecular Biology Technique | Natural Cellular Process |
| --- | --- | --- |
| Reading DNA | Sequencing | DNA Replication |
| Coping DNA | PCR | DNA Replication |
| Inserting DNA | rDNA with restriction enzymes and ligases | Defense from infection, DNA Recombination and Repair |

# 合成生物学的工具 #1：分子生物学

| 工具 | 分子生物学<br>相关技术 | 细胞内自然过程<br>（理论依据） |
| --- | --- | --- |
| 读取 DNA | DNA测序 | DNA复制 |
| 扩增 DNA | PCR | DNA复制 |
| 编辑 DNA | 利用限制酶与连接酶构建的rDNA（重组DNA） | 细胞的防御系统<br>DNA重组与修复 |

# 合成生物学的工具 #2：基因工程

## 合成生物学



标准化

抽象化

A+A+C+T+T...

“合成”

## 基因工程

重组DNA


DNA测序

PCR

# 合成生物学的标准化

iGEM wiki tools search PRODUCTION 2017 SERVER login

Registry of Standard Biological Parts

iGEM tools catalog repository assembly protocols help search BBa_

### Add and Document Parts

Start **adding and documenting** your parts now! Your parts should be well characterized and measured, and follow the Registry's requirements.

### Sample Submissions

iGEM teams do not need to send samples of their parts **this year.** We want teams to focus on the documentation of their parts! Teams must follow 2019 requirements for parts, including **BioBrick RFC10** or **Type IIS compatibility**.

### Update: Composite Parts

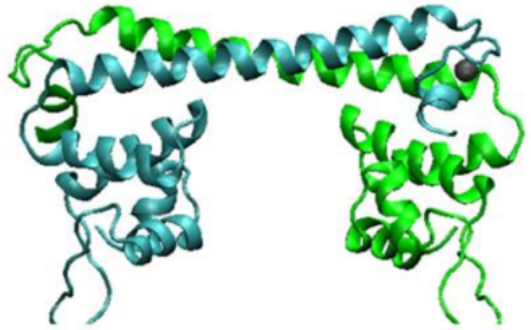
If you synthesized or used a different assembly system to create a composite part, you can now enter specific scars between subparts. If you have any issues with functionality, please contact **hq (at) igem (dot) org**.

## Featured Part

### Metal Binding and Sensing Parts

Every year, a number of iGEM teams complete a variety of biosensors and bioremediation projects that involve metal-binding and metal-sensing. Their focus may be on several pollutants or just one. iGEM teams have worked with metals like nickel, mercury, lead, arsenic, copper, amongst others.

We've put together a collection of projects and DNA parts that are responsible for both metal binding and metal sensing.



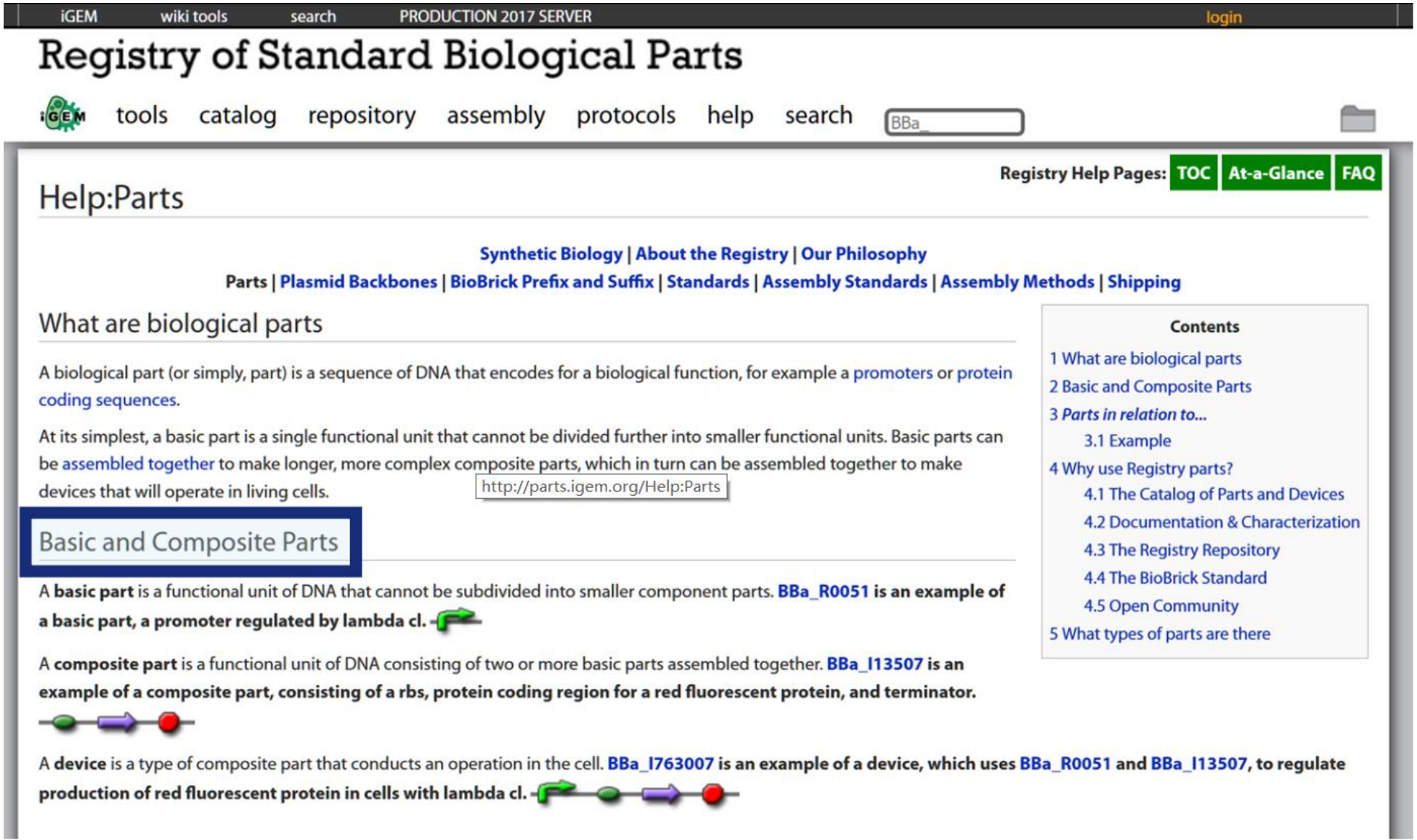
## DNA Synthesis Offer: IDT

IDT is once again generously offering **20 kb of DNA as gBlocks® Gene Fragments** free of charge to each iGEM 2019 team! Click here to go to IDT's partner offers page for more info.

## 2019 DNA Distribution

The iGEM 2019 DNA Distribution has started shipping to registered and approved iGEM teams! Be sure to read through the 2019 Distribution Handbook for storage instructions and how to use your kit!

# 合成生物学的抽象化



iGEM wiki tools search PRODUCTION 2017 SERVER login

Registry of Standard Biological Parts

iGEM tools catalog repository assembly protocols help search BBa_

Registry Help Pages: TOC At-a-Glance FAQ

Help:Parts

Synthetic Biology | About the Registry | Our Philosophy

Parts | Plasmid Backbones | BioBrick Prefix and Suffix | Standards | Assembly Standards | Assembly Methods | Shipping

## What are biological parts

A biological part (or simply, part) is a sequence of DNA that encodes for a biological function, for example a promoters or protein coding sequences.

At its simplest, a basic part is a single functional unit that cannot be divided further into smaller functional units. Basic parts can be assembled together to make longer, more complex composite parts, which in turn can be assembled together to make devices that will operate in living cells.

http://parts.igem.org/Help:Parts

## Basic and Composite Parts

A **basic part** is a functional unit of DNA that cannot be subdivided into smaller component parts. **BBa_R0051 is an example of a basic part, a promoter regulated by lambda cI.**

A **composite part** is a functional unit of DNA consisting of two or more basic parts assembled together. **BBa_I13507 is an example of a composite part, consisting of a rbs, protein coding region for a red fluorescent protein, and terminator.**

A **device** is a type of composite part that conducts an operation in the cell. **BBa_I763007 is an example of a device, which uses BBa_R0051 and BBa_I13507, to regulate production of red fluorescent protein in cells with lambda cI.**

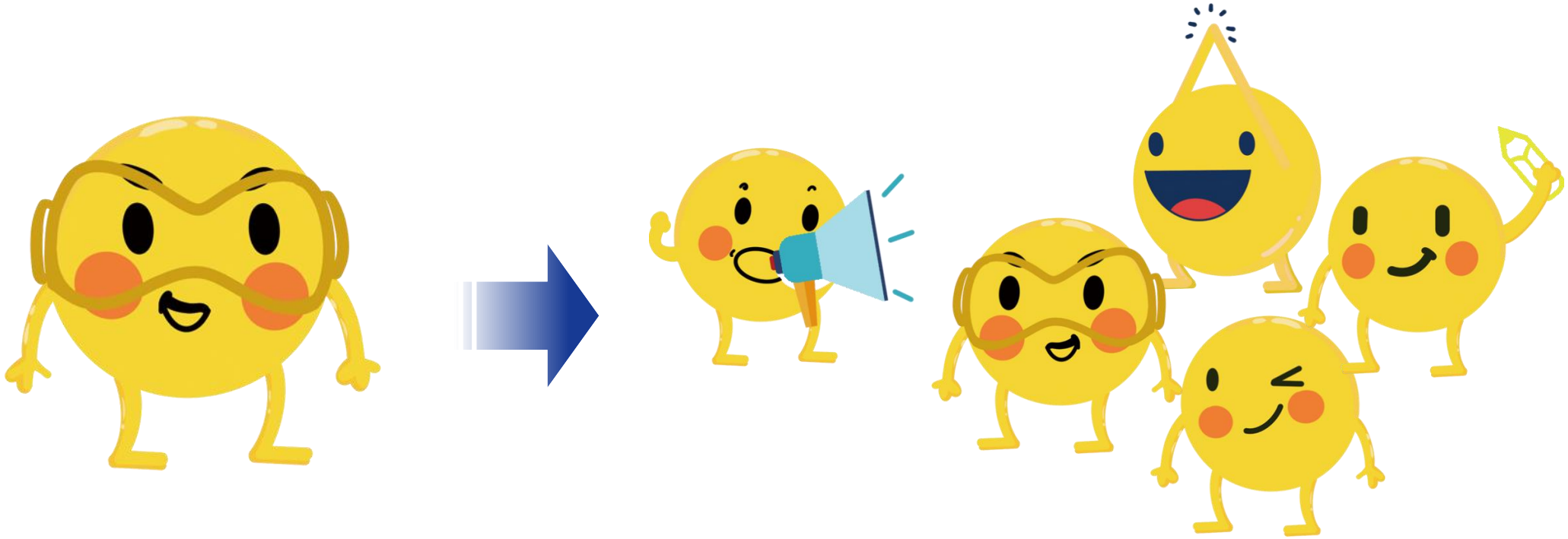
Contents

1 What are biological parts
2 Basic and Composite Parts
3 *Parts in relation to...*
  3.1 Example
4 Why use Registry parts?
  4.1 The Catalog of Parts and Devices
  4.2 Documentation & Characterization
  4.3 The Registry Repository
  4.4 The BioBrick Standard
  4.5 Open Community
5 What types of parts are there


Part 3

# XMU 2019
# 项目介绍

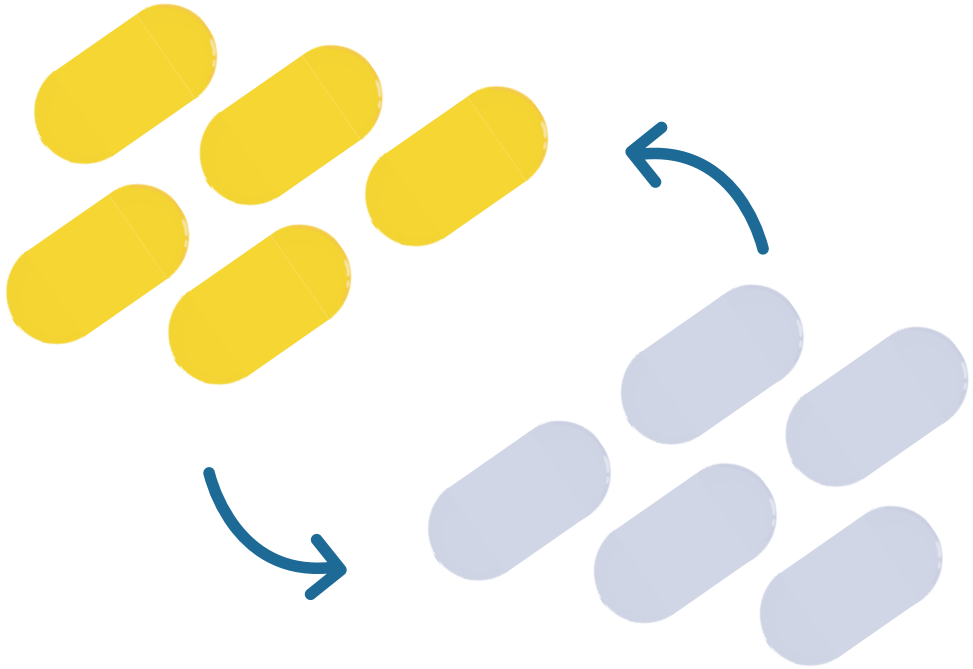
# Characters in Literature is More than …



Individual

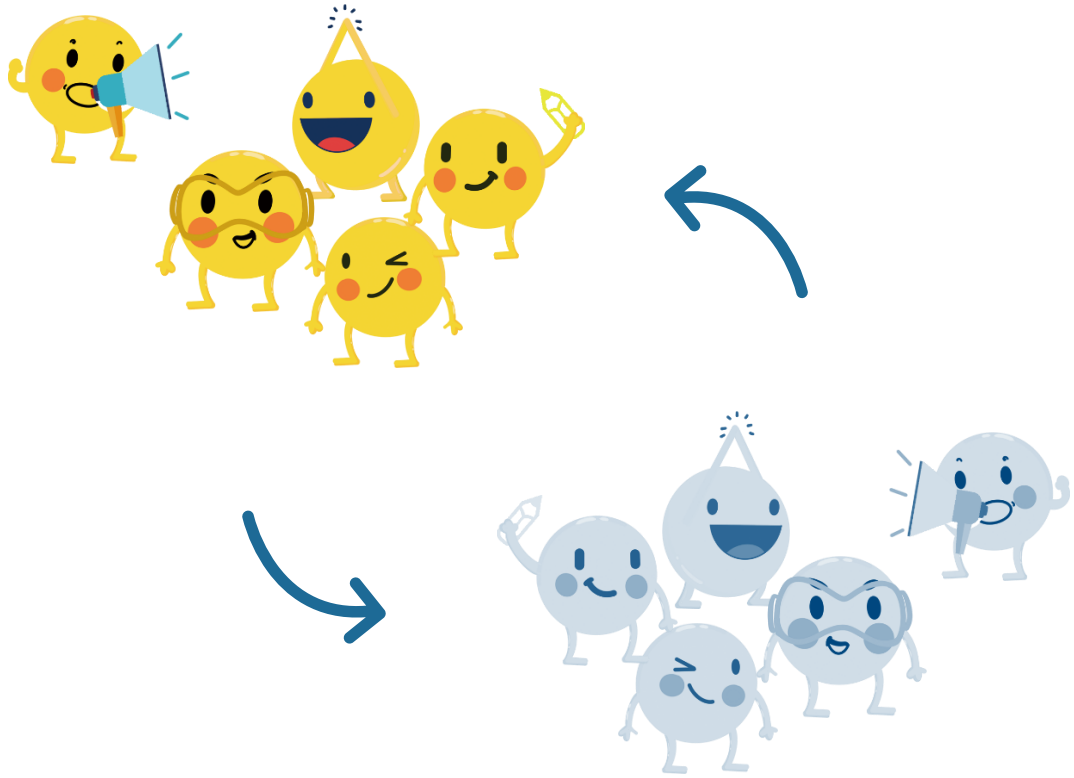
Group

# Our Project



Engineering bacteria:

*Escherichia coli*

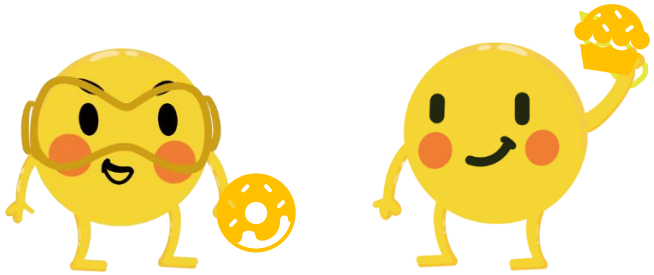


Group interactions

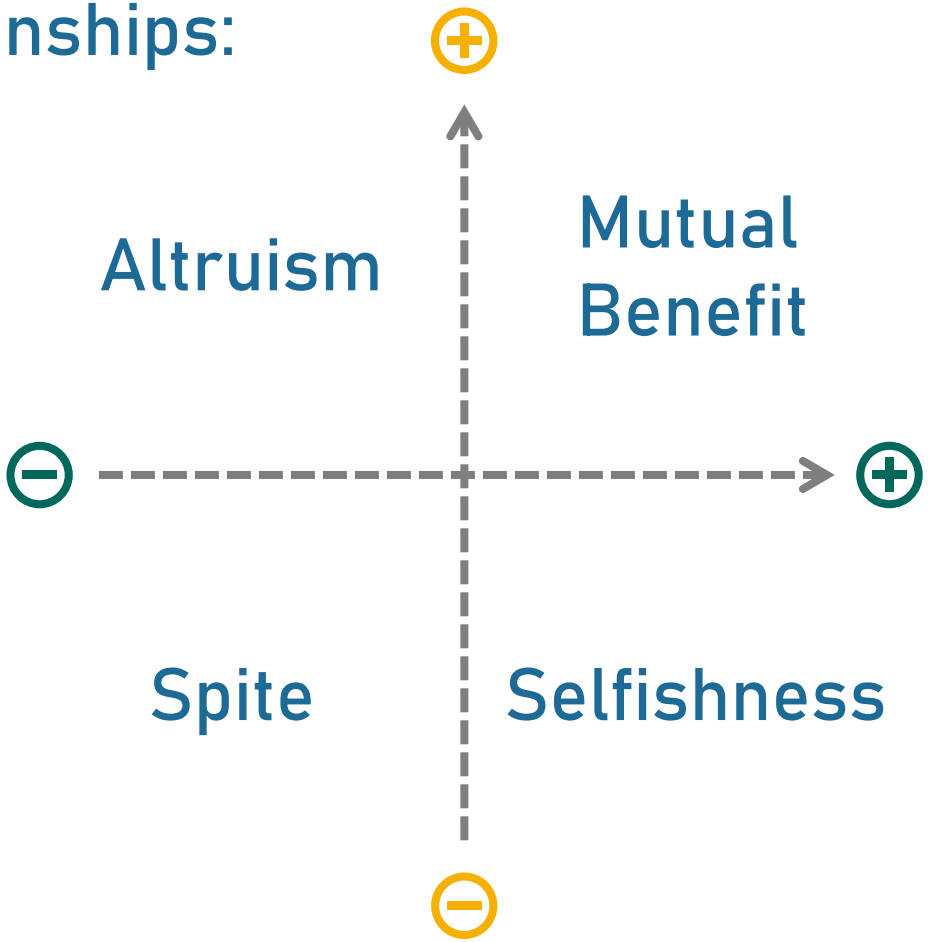
# Inspiration

## Prototype of Our Project – Binary relationships:

Positive



Negative



# Inspiration

## Optimization of Our Project

Interviewing Dr. Chao Chen

Social Relationships

↓

Behaviors in a Group

↙ Nature Factors ↓ Gene → **Plasmid**

↘ Nurture Factors ↓ Surrounding → **Culture Medium**

# Cooperative

*E. Coli*
Group A

We can't eat cellulose!

Cellulose: The sole carbon source

*E. Coli*
Group B

# Cooperative

*E. Coli*
Group A

We LOVE
Glucose!

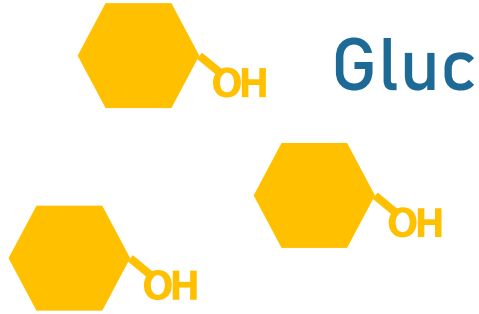

If cellulose was degraded by
their *cooperation* manner…

*E. Coli*
Group B

# Degradation of Cellulose

Cellulose

Glucose




Endoglucanase, CenA

From: *Cellulomonas fimi*

Exoglucanase, Cex

From: *Cellulomonas fimi*

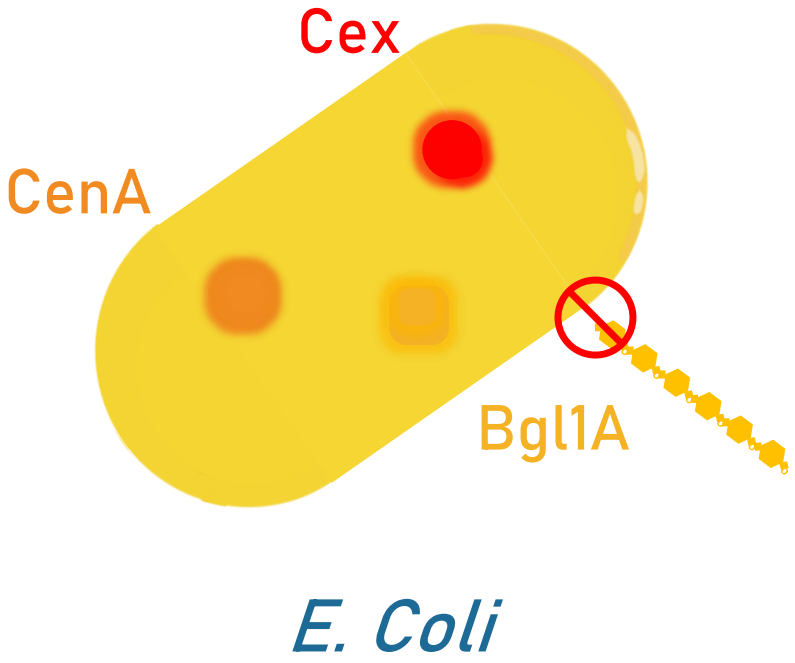

Cellobiose

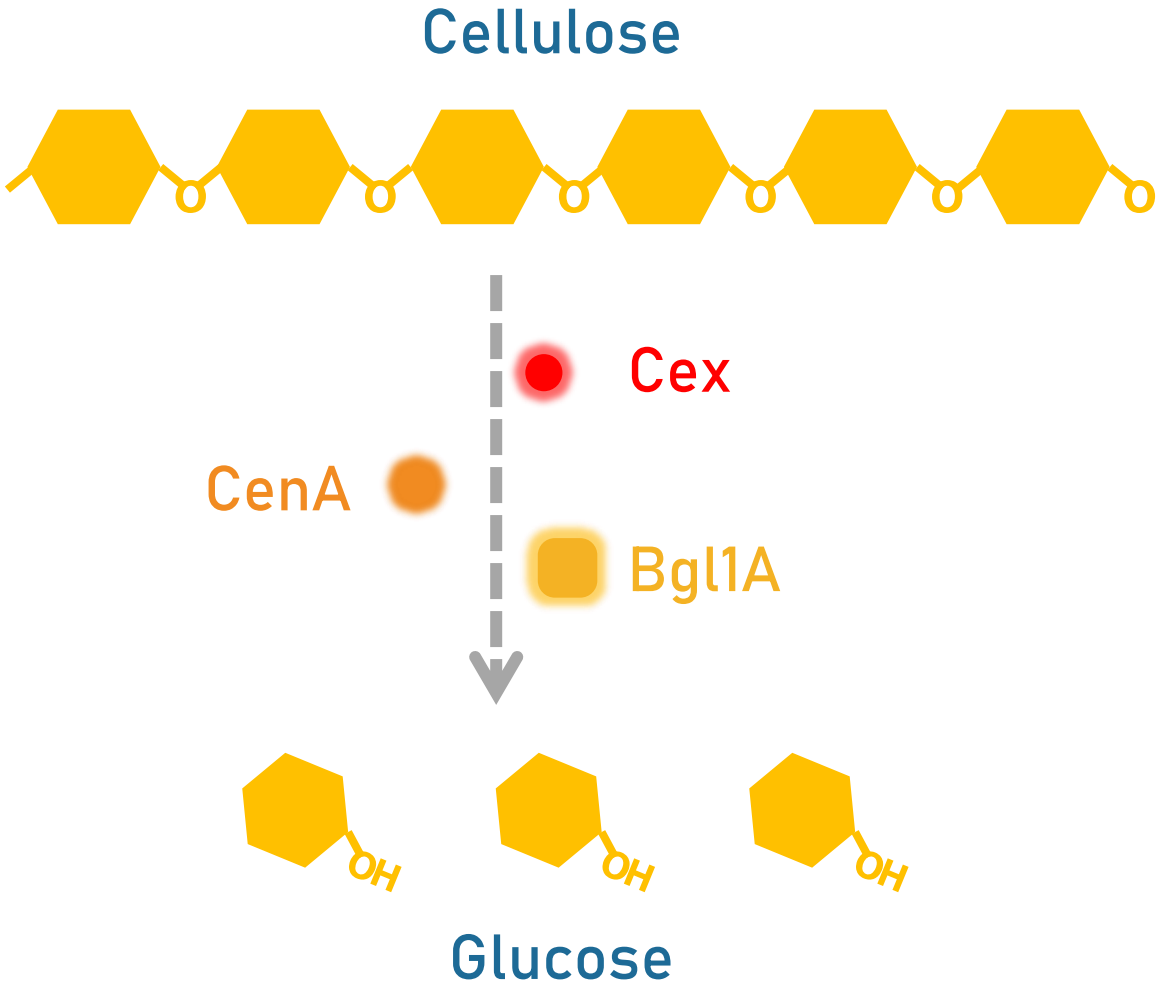
*β*-Glucosidase, Bgl1A

From: *Saccharophagus degradans*

G. Xie, *et al. Appl Environ Microbiol* 73, 3536-3546 (2007)

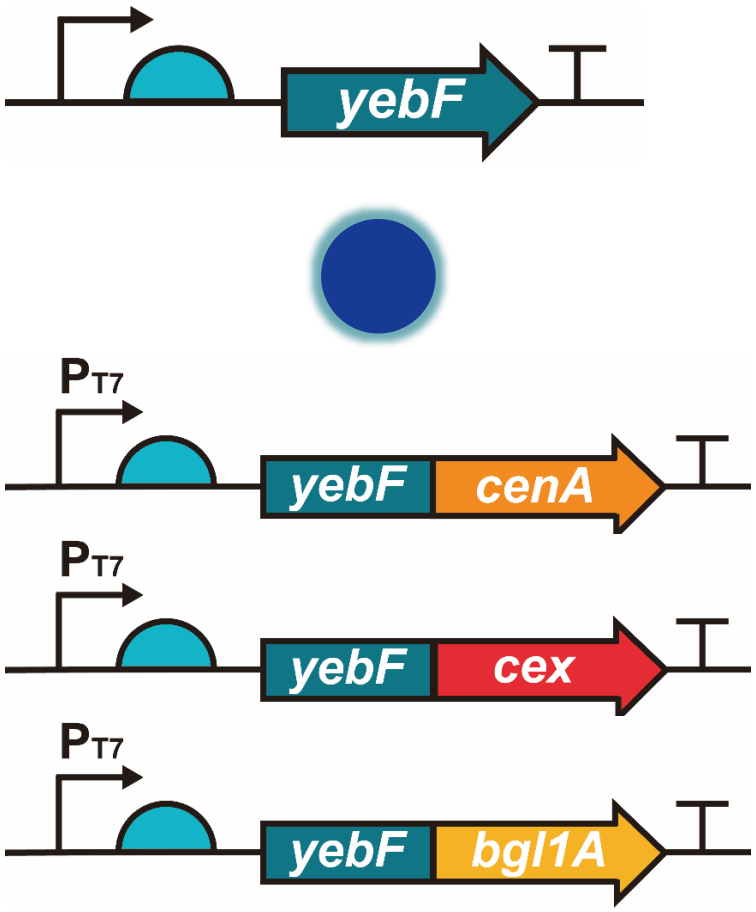
# Secretion

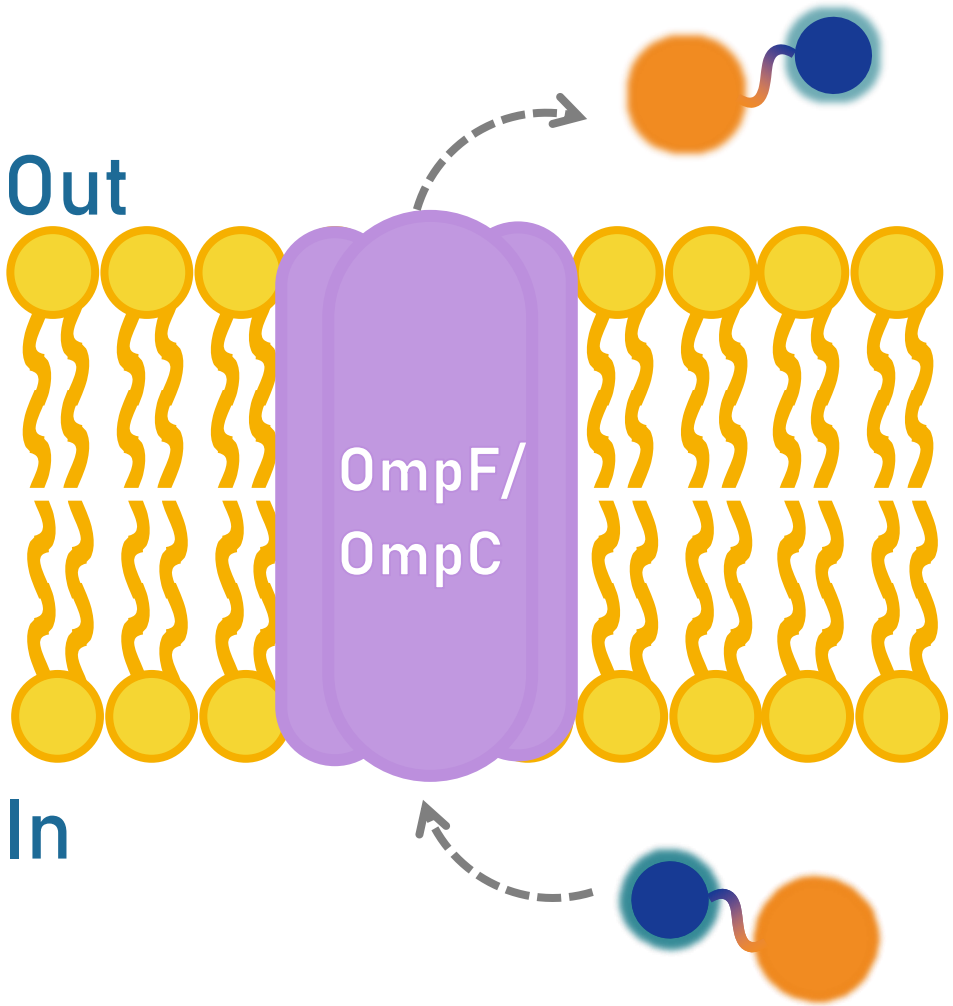

Cex
CenA
Bgl1A
E. Coli


Cellulose
Cex
CenA
Bgl1A
OH
OH
OH
Glucose

# Secretion

## Method I – Protein YebF

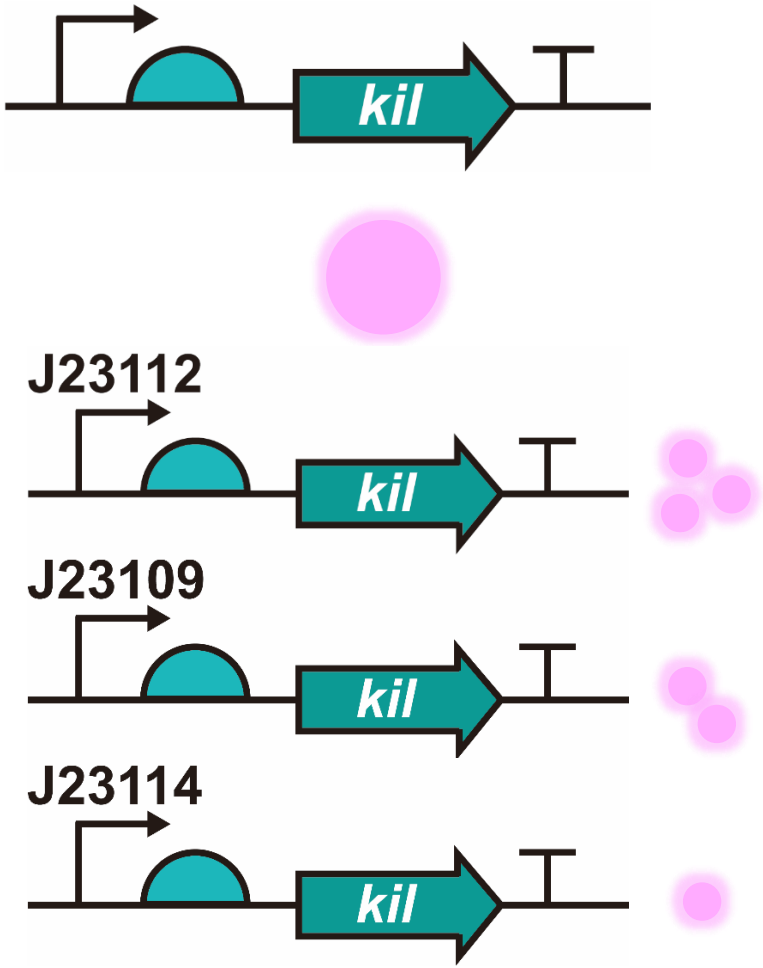


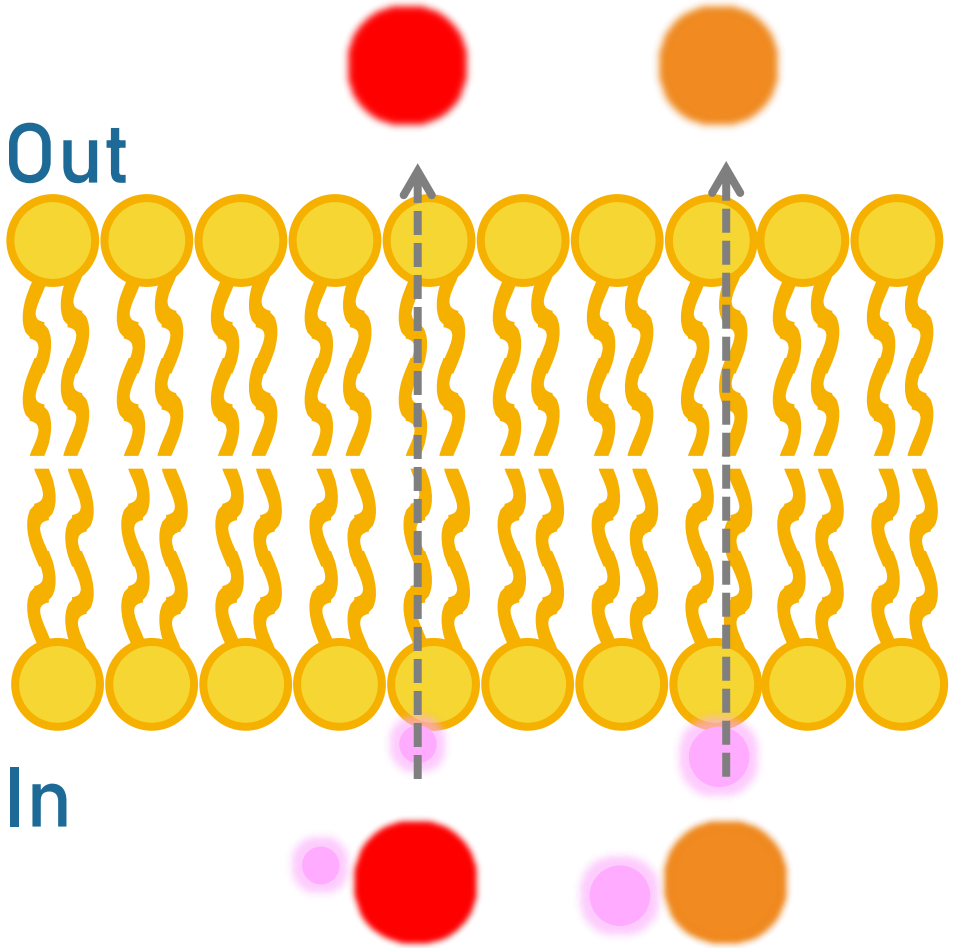




G. Zhang, *et al. Nat Biotechnol* 24, 100-104 (2006).
G. Prehna, *et al. Structure* 20, 1154-1166 (2012)

# Secretion

## Method II – Kil secretion cassette




G. Miksch, *et al.*, *Arch Microbiol* 167, 143-150 (1997).

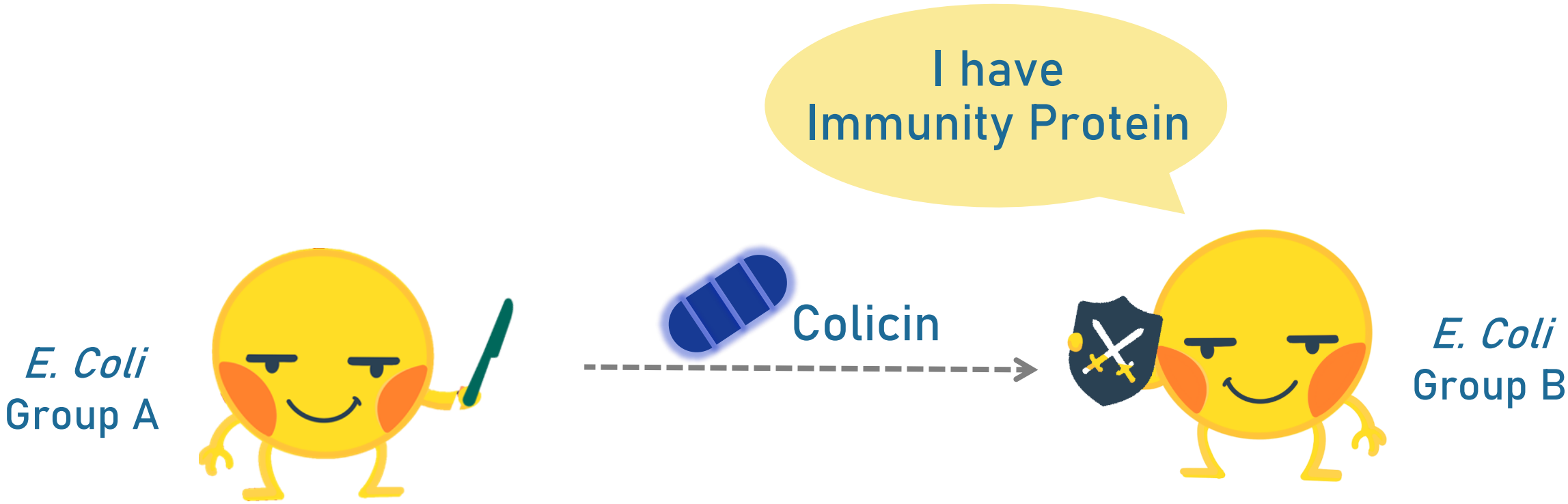
# Aggressive

*E. Coli*
Group A


*E. Coli*
Group B

Colicin kills other related bacteria if they cannot express specific immunity proteins

# Aggressive




Colicin kills other related bacteria if they cannot express specific immunity proteins

# Design


Colicin-N


Colicin-N Immunity Protein


N Lysis Protein (N Kil)

Colicin Kit N


Colicin-E1


Colicin-E1 Immunity Protein

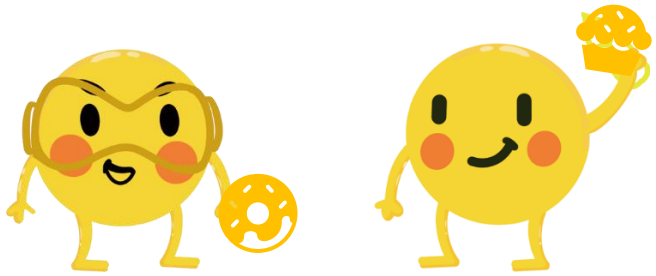

E1 Lysis Protein (E1 Kil)

Colicin Kit E1

A. P. Pugsley, *Mol Gen Genet* 211, 335-341 (1988).
H. S. Song et, al. *J Bacteriol* 173, 2935 (1991).

# Summary of Results

## Cooperative



- CenA
- Cex
- Bgl1A
- Kil secretion cassette
- YebF fused cellulase

## Aggressive

- Colicin-E1 & N
- Colicin-E1 & N Immunity Protein
- E1 & N Lysis Protein

# Integrated Human Practices

Southern China Regional Meeting


Literature Analysis

Interviewing Dr. Chao Chen

Interviewing Prof. Xianhai Zeng

The 7th CCiC Meeting

Visiting MCCC

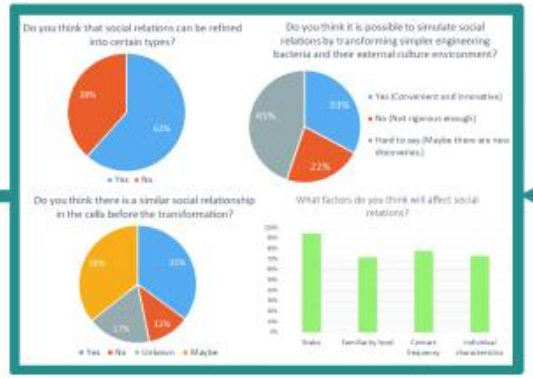
Collaborations

HUBU-WUHAN

UESTC

CellinCELL

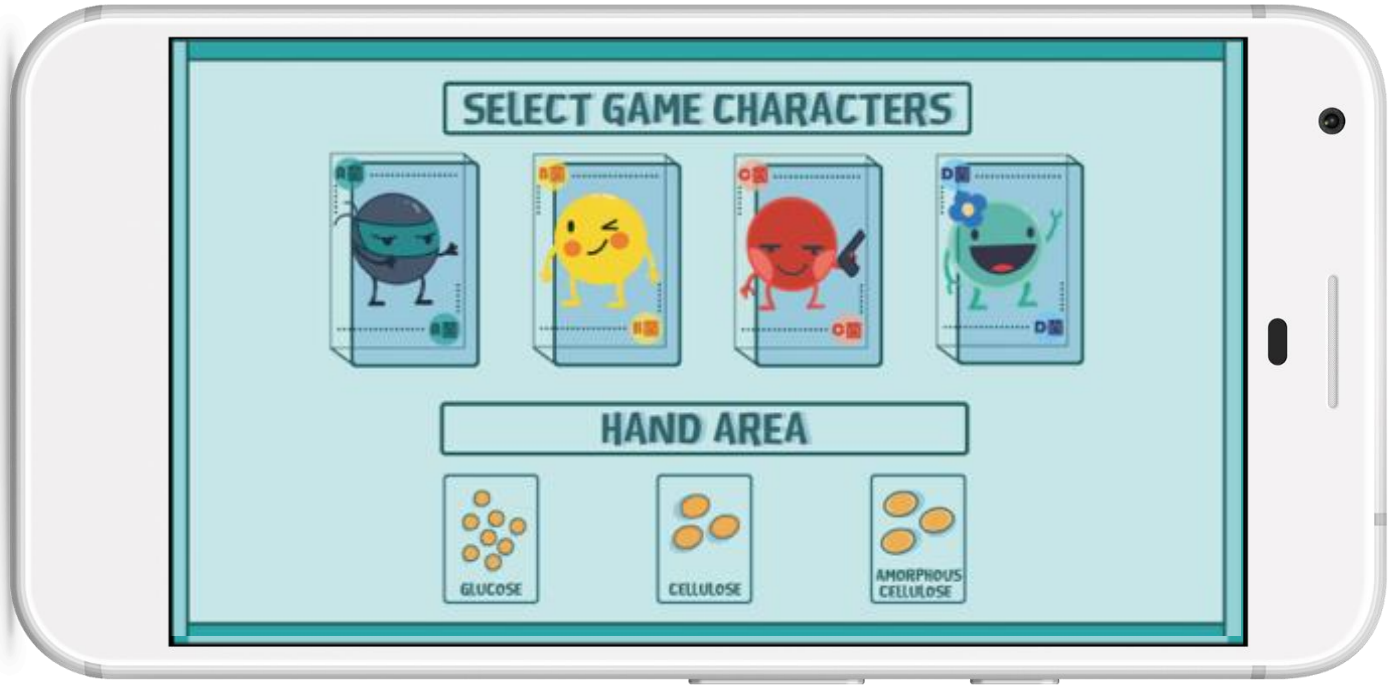
iGEM FAFU-CHINA




The Questionnaire

Interviewing Dr. Linbin Zhu

# Public Engagement




*Damn Germ*
for Android

Mobile Game – *Damn Germ*

# 问答时间

合成生物学与iGEM
主讲人
厦门大学
October 28, 2020