



# iGEM x 合成生物學 小講堂



生醫資訊研究所 暨 系統與合成生物學研究中心

張傳雄老師、張菁芬老師

2022 iGEM NYCU-Taipei 成員



# NYCU ON-CAMPUS SYNBIO SYMPOSIUM



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## PART I

### INTRODUCTION TO SYNTHETIC BIOLOGY

## PART II

### AN INTRODUCTION TO IGEM

## PART III

### WHAT DID NYCU-TAIPEI DO THIS YEAR?



# **PART 1**

## **INTRODUCTION TO SYNTHETIC BIOLOGY**



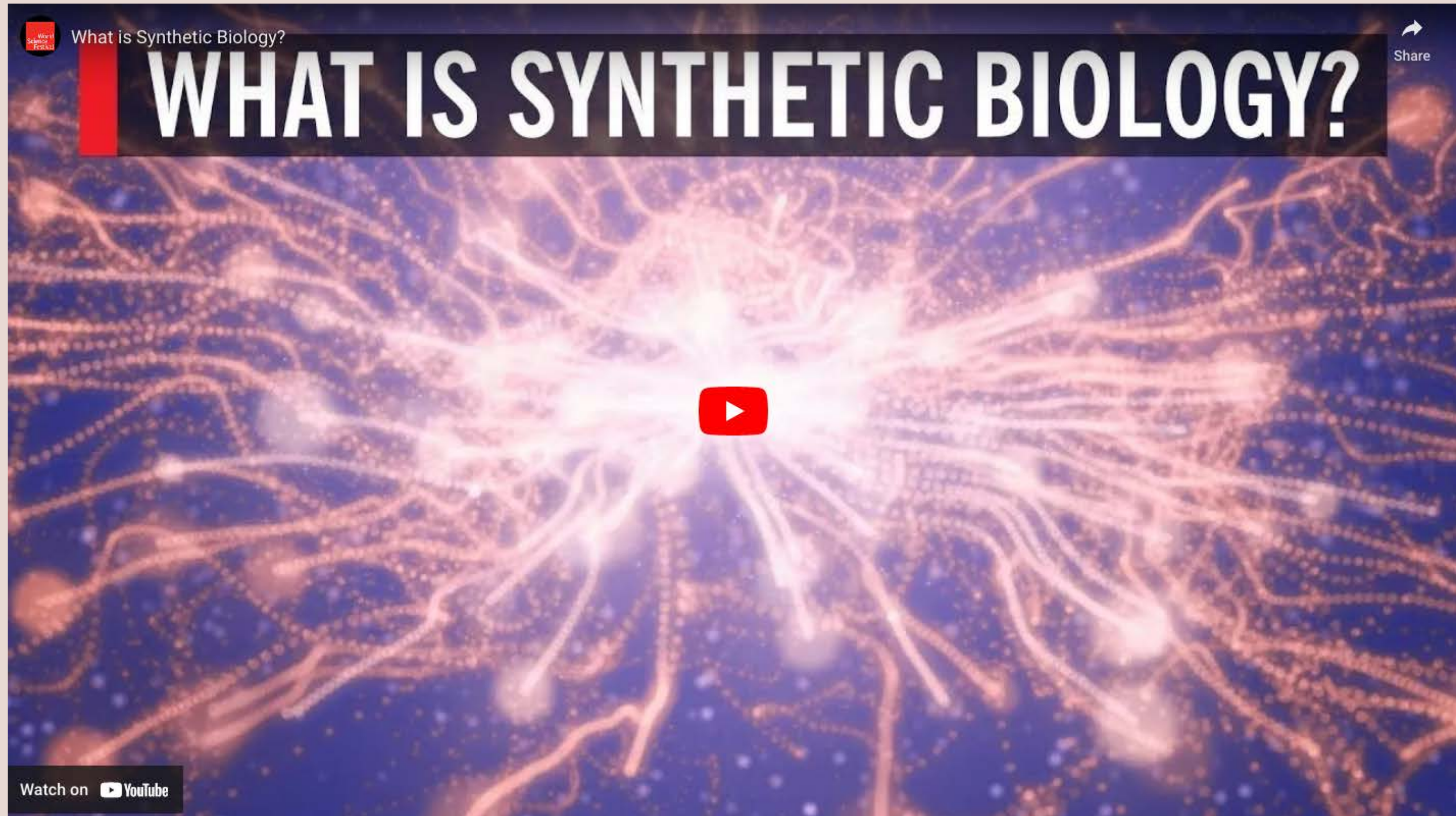
BREAKING FOUNDATION AT THE TURN OF THE MILLENNIUM

# Synthetic biology (n.)

*"Synthetic biology is the engineering of biology."*



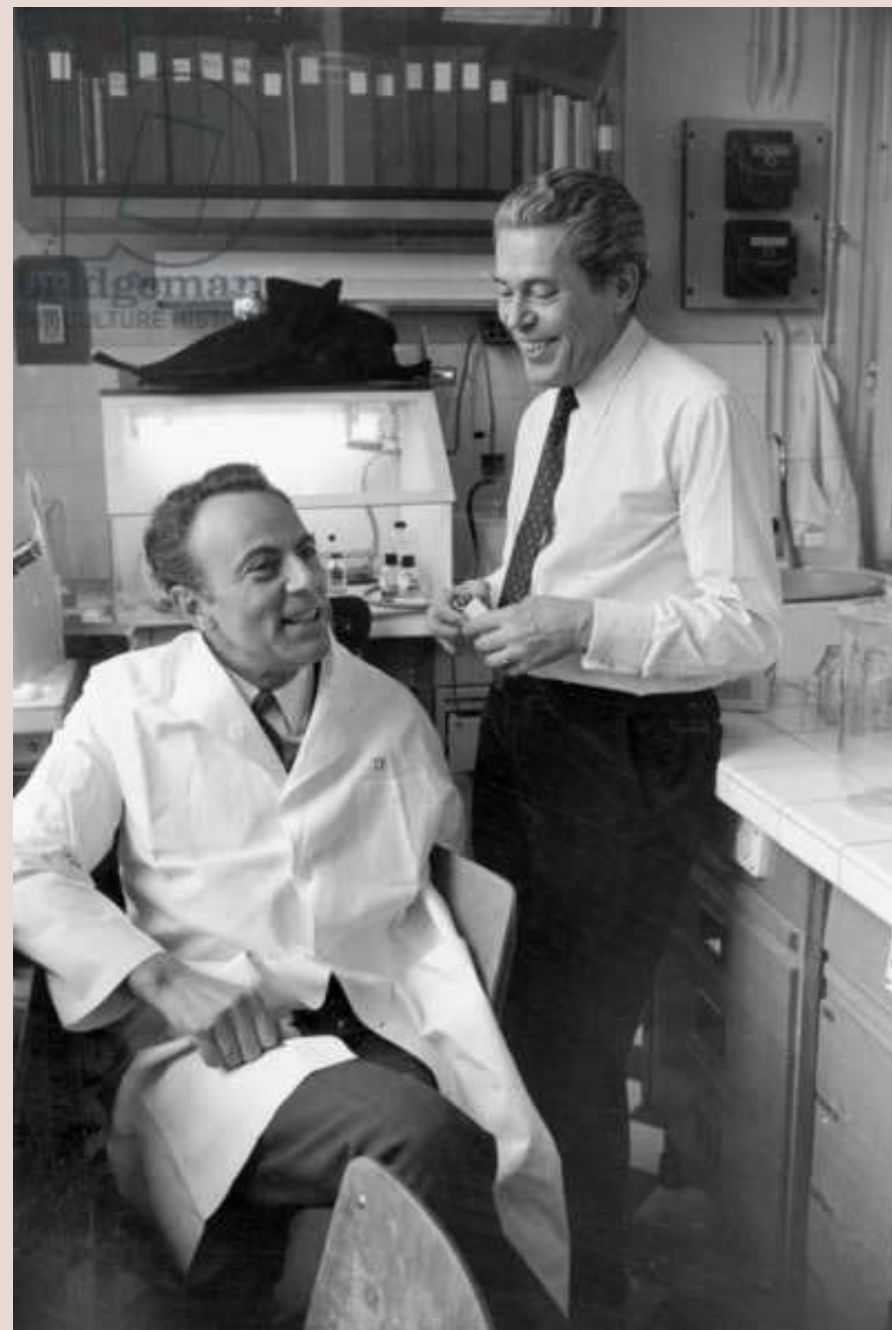
# INTRODUCTORY VIDEO





# WHAT SHAPED SYNTHETIC BIOLOGY?

1961–1999: IN ITS EARLY AGES



Francois Jacob & Jacques Monod

- Study of the *lac* operon in *E. coli*
- Development of molecular cloning and PCR
- DNA sequencing & high-throughput techniques
- The rise of "systems biology"

REGULATORY  
NETWORKS

Top-down approach

MOLECULAR  
PARTS

Bottom-up approach

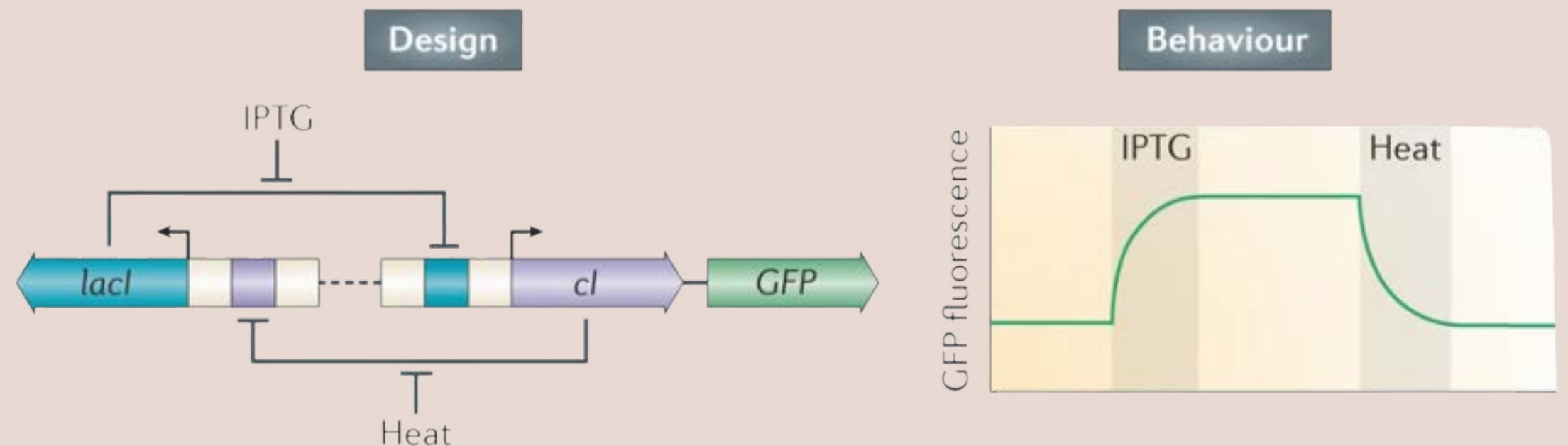
# WHAT SHAPED SYNTHETIC BIOLOGY?

## 2000-2003: THE FOUNDATIONAL YEARS



James J. Collins, Ph.D.

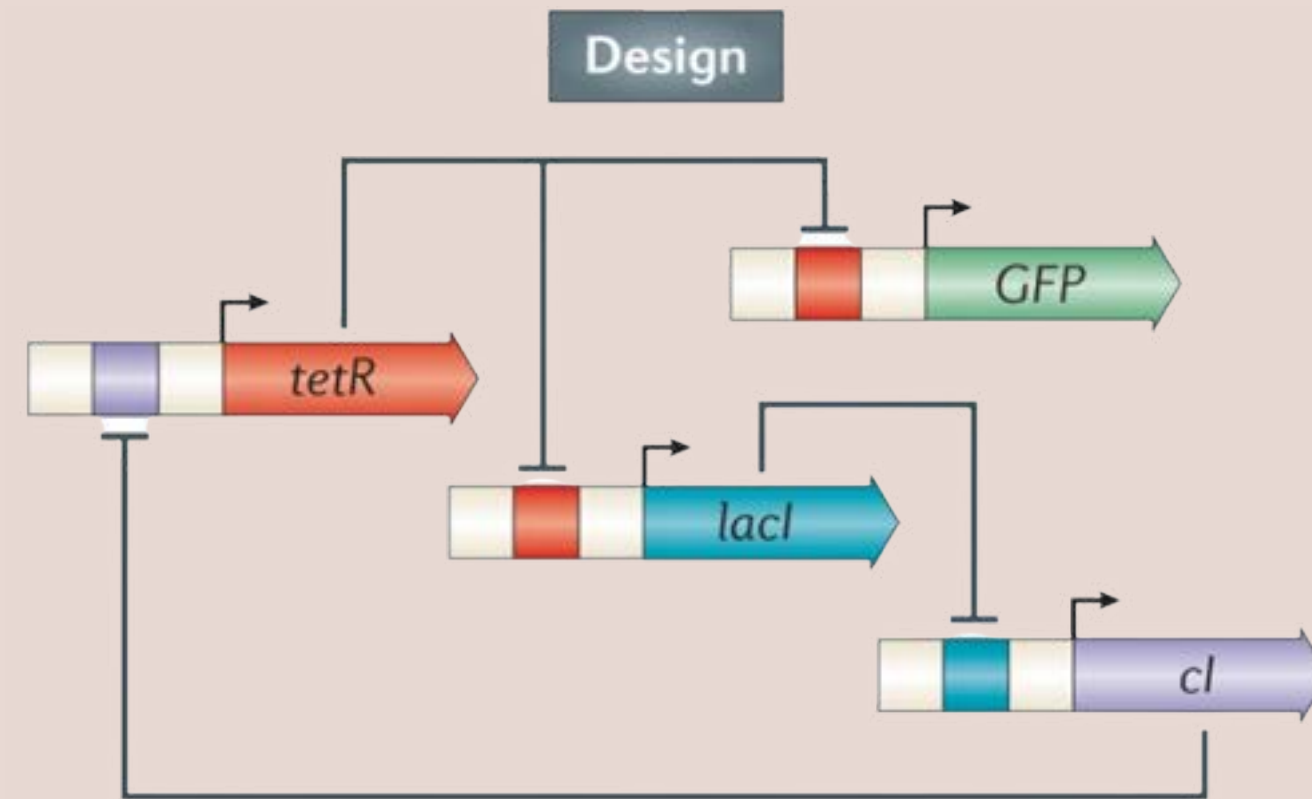
- Creating simple gene regulatory circuits in *E. coli*
- The "Toggle switch"



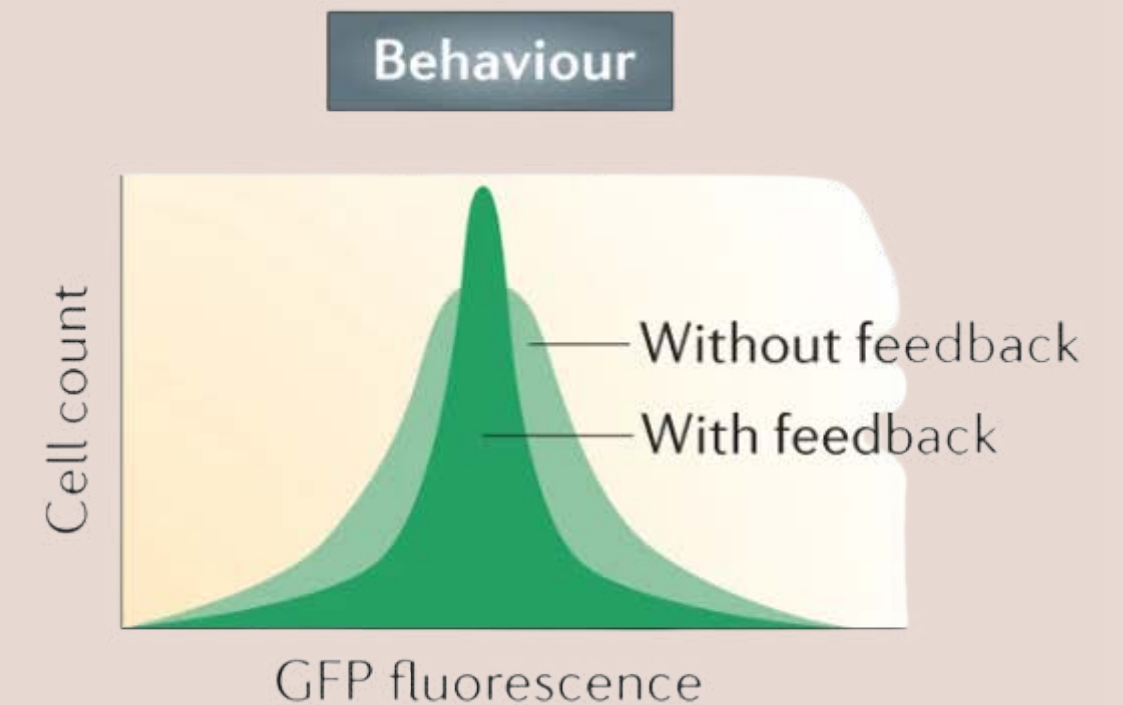
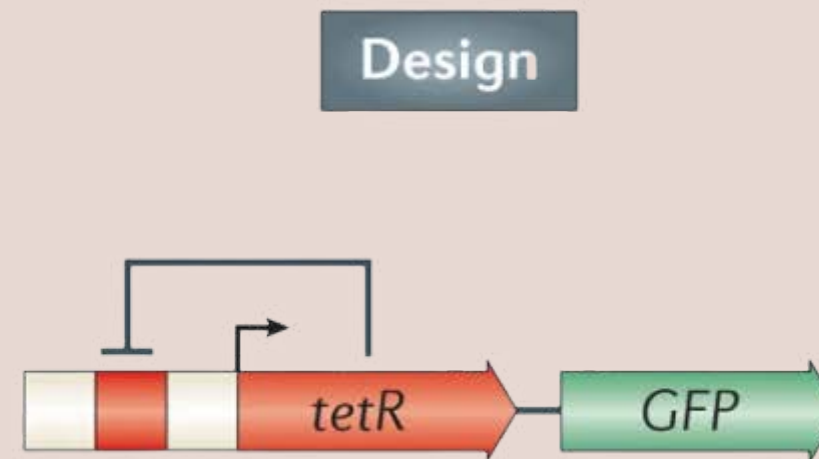


# OTHER EXAMPLES OF GENE CIRCUITS

Repressilator



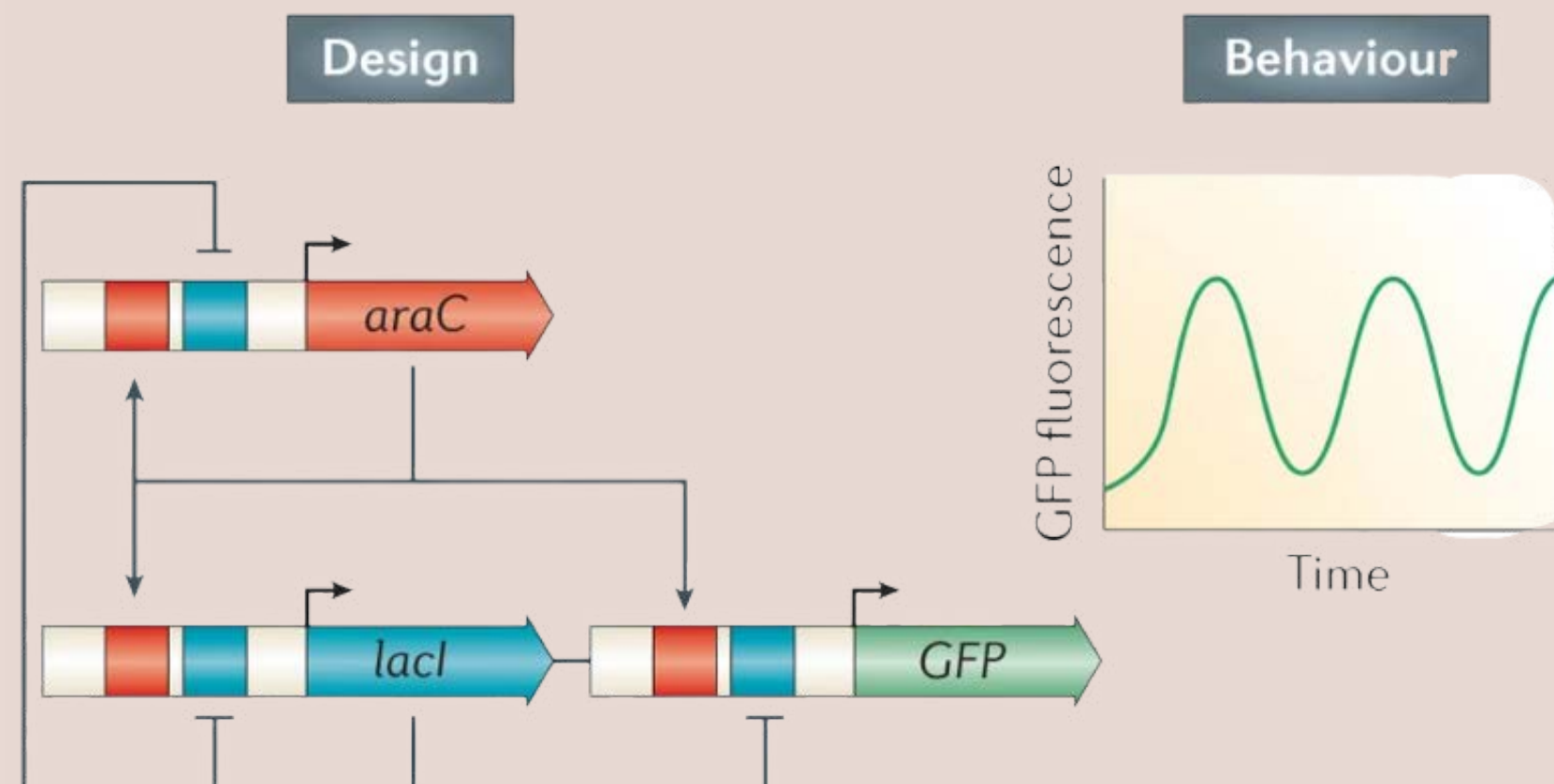
Autoregulatory circuit



# WHAT SHAPED SYNTHETIC BIOLOGY?

2004–2007: EXPANSION AND GROWTH    2008–NOW: INCREASE IN PACE AND SCALE

- 2004: First international synthetic biology conference held at MIT
- Novel circuit design: logic gate, RNA-based systems
- More complex and application-based designs

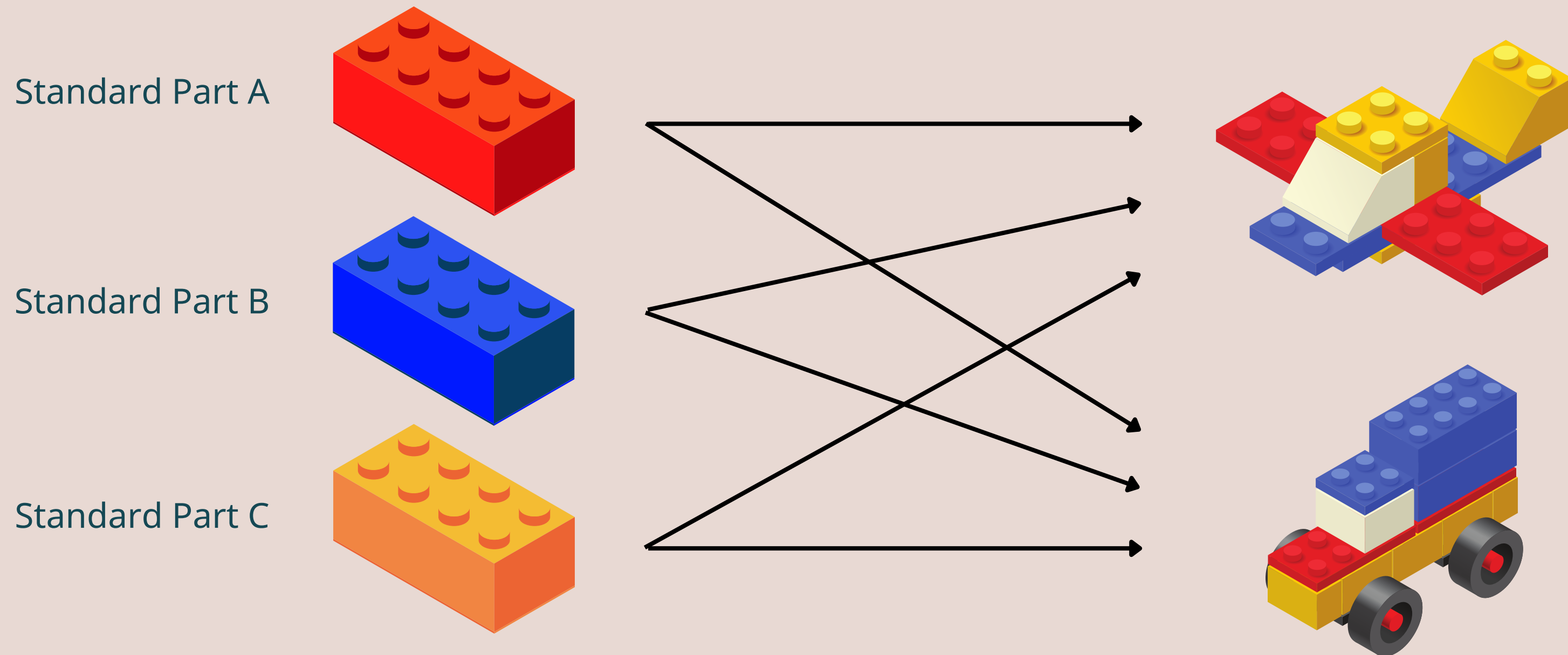


Jeff Hasty, Ph.D.



# SO...WHAT IS SYNTHETIC BIOLOGY?

The assembly of **standardized and modular parts** which enables the synthesis of 'biological systems' in a rational and systematic way.



**COMMON QUESTIONS**

**SYNTHETIC BIOLOGY**

**VS**

**GENOME EDITING**





- Both involve changing an organism's genetic code
- Genome editing: **small addition/deletion** of an organism's DNA
- Synthetic biology: involves **greater changes**

Cross-species



Synthesizing novel DNA sequences



# COMMON QUESTIONS

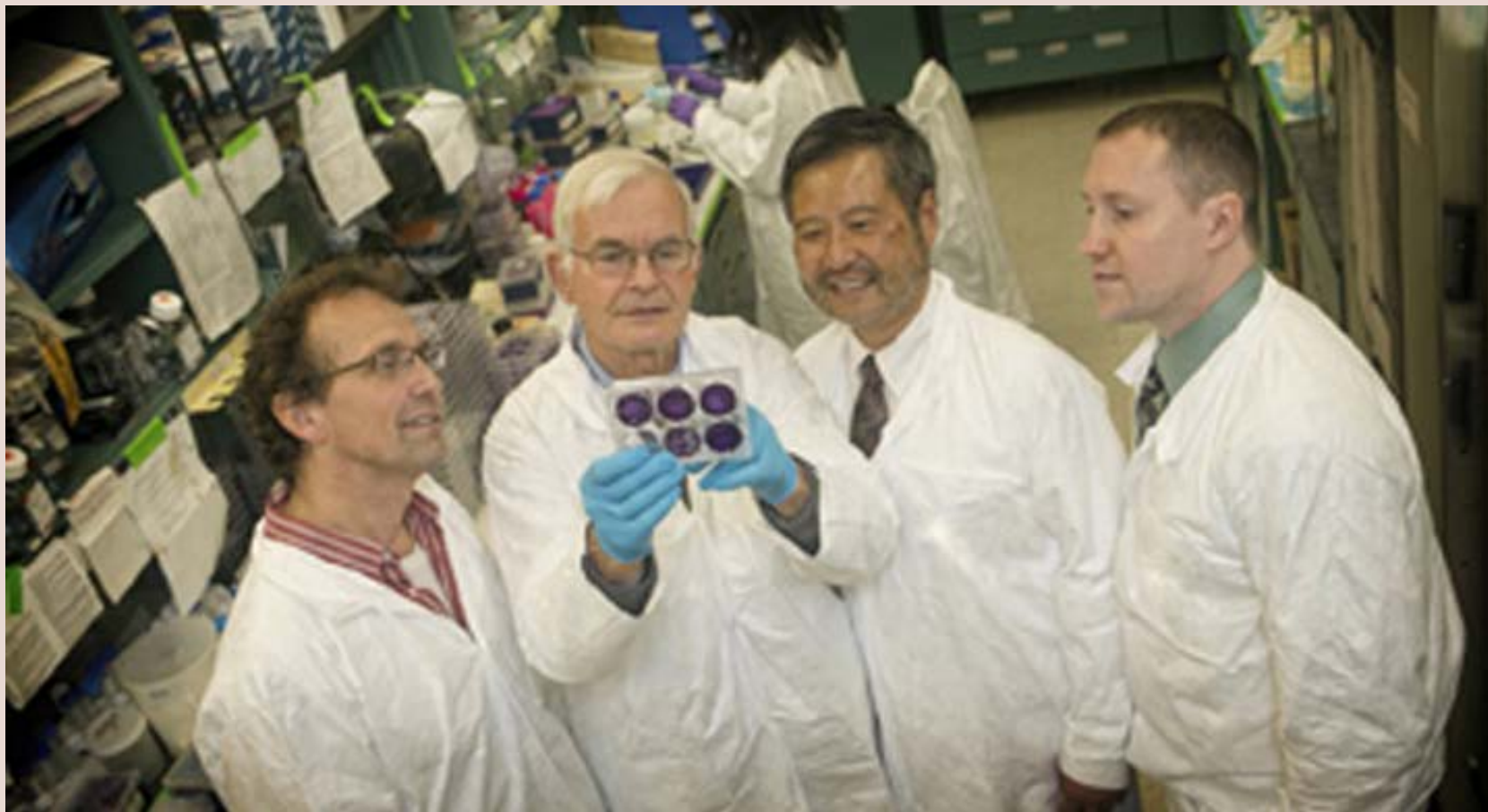
? IS IT POSSIBLE TO ?  
SYNTHESIZE AN ENTIRE GENOME



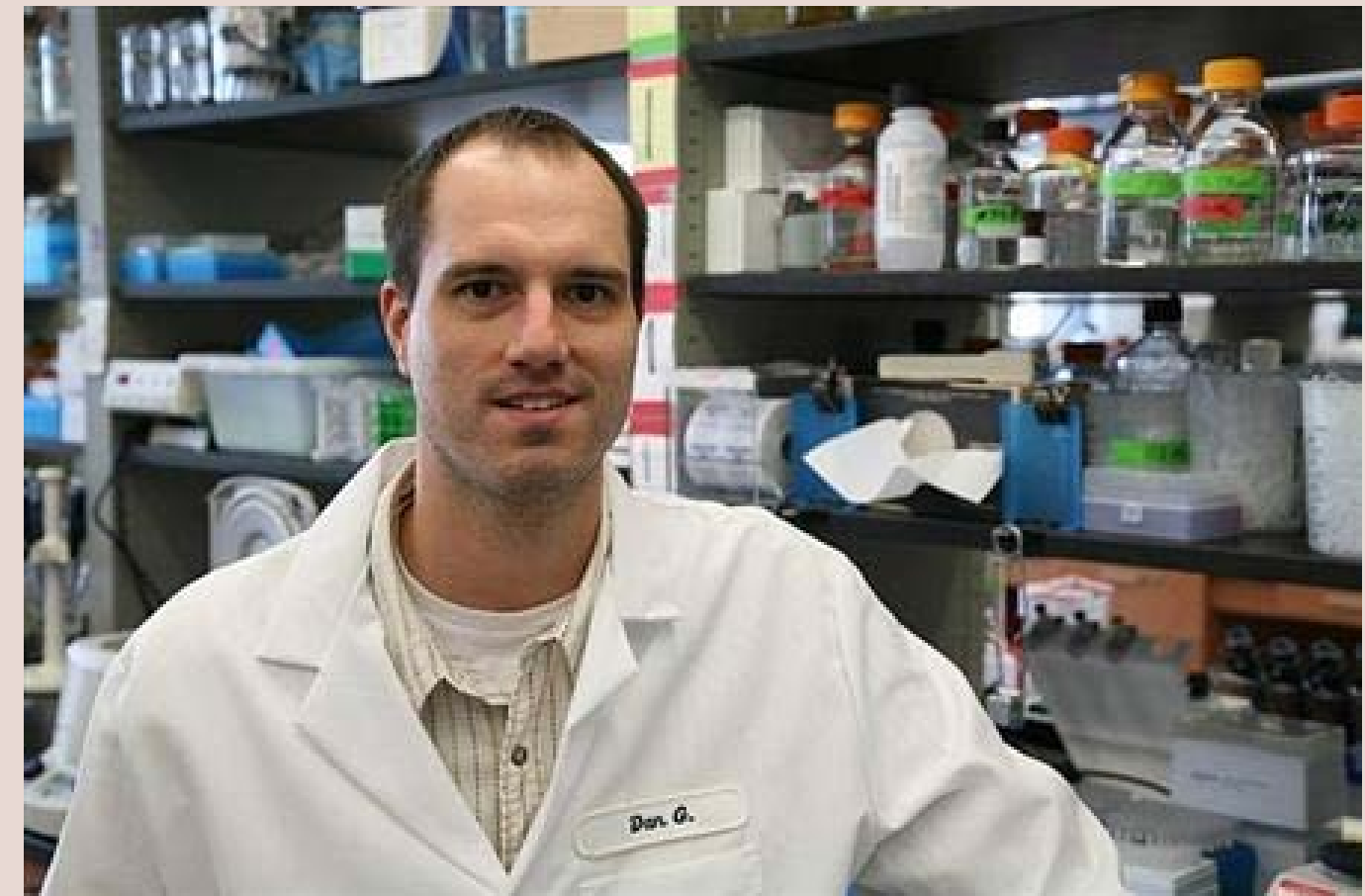
# YES!

2002: Live poliovirus artificially synthesized

2008: Synthesis of the *Mycoplasma genitalium* genome



Jeronimo Cello, Aniko Paul, and Eckard Wimmer



Daniel G. Gibson Ph.D.

## Public health and safety concerns?

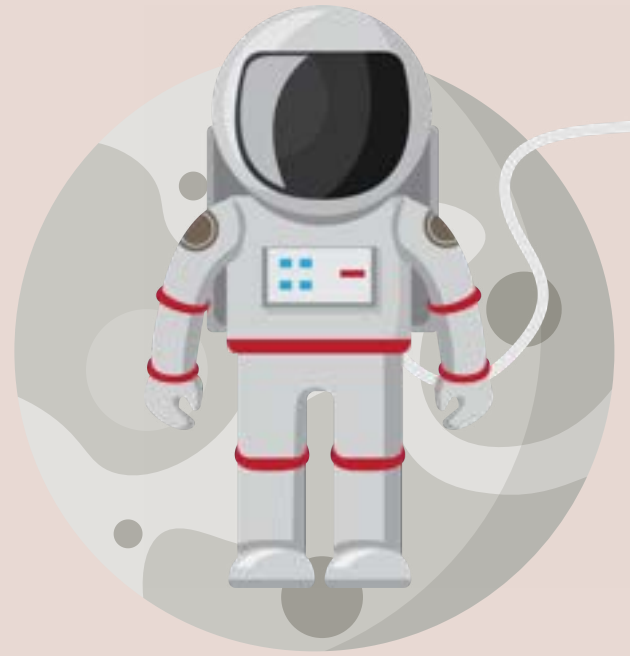
## COMMON QUESTIONS

**DOES SYNTHETIC BIOLOGY  
HAVE ITS OWN CHALLENGES**





# “OUTSIDE-THE-LAB” VS LABORATORY SETTINGS



- Stable under variable storage conditions?
- Can it be run on minimal resources and equipment?
- Is it operable without experienced professionals?

# ECOSYSTEM BIODIVERSITY AND CONSERVATION

- Is synthetic biology "reshaping" nature?
- Or instead... offering "extraordinary opportunities" for conservation?



**THE FUTURE LIES ON US!!**

# HOW IS SYNTHETIC BIOLOGY APPLIED IN REAL LIFE?



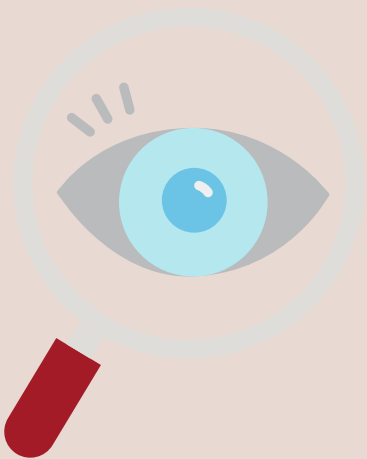
## HEALTHCARE AND LIFE SCIENCES

- Yeast engineered to produce rose oil
- Rice modified to produce beta-carotene



## AGRICULTURE AND ENVIRONMENT

- Microorganisms harnessed for bioremediation
- Corn-specific nitrogen-fixing bacteria



## PROTEIN SCREENING

- Automated platform for rapid antibody screening
- Test of effective enzyme variants

....AND MANY MORE!!!



**PART 2**

**AN  
INTRODUCTION  
TO IGEM**





# iGEM

**I**nternational  
**G**enetically  
**E**ngineered  
**M**achine  
Competition

# HOW TO START MY IGEM JOURNEY?



Dr. Fluotato

## STEP ONE

→ An Introduction to iGEM

## STEP TWO

→ How to Recruit an iGEM Team?

## STEP THREE

→ The 13 Deliverables

## STEP FOUR

→ Medals Criteria & Special Prizes





# **STEP 1**

## **AN INTRODUCTION TO IGEM**



# THE HISTORY OF IGEM

"Can Students Work Together To **Build Working Biological Devices**  
Within a Summer?"



2003

## FOUNDATION

Founded by MIT,  
The United State



2004

## START-UP

"iGEMers are pioneers in  
synthetic biology."

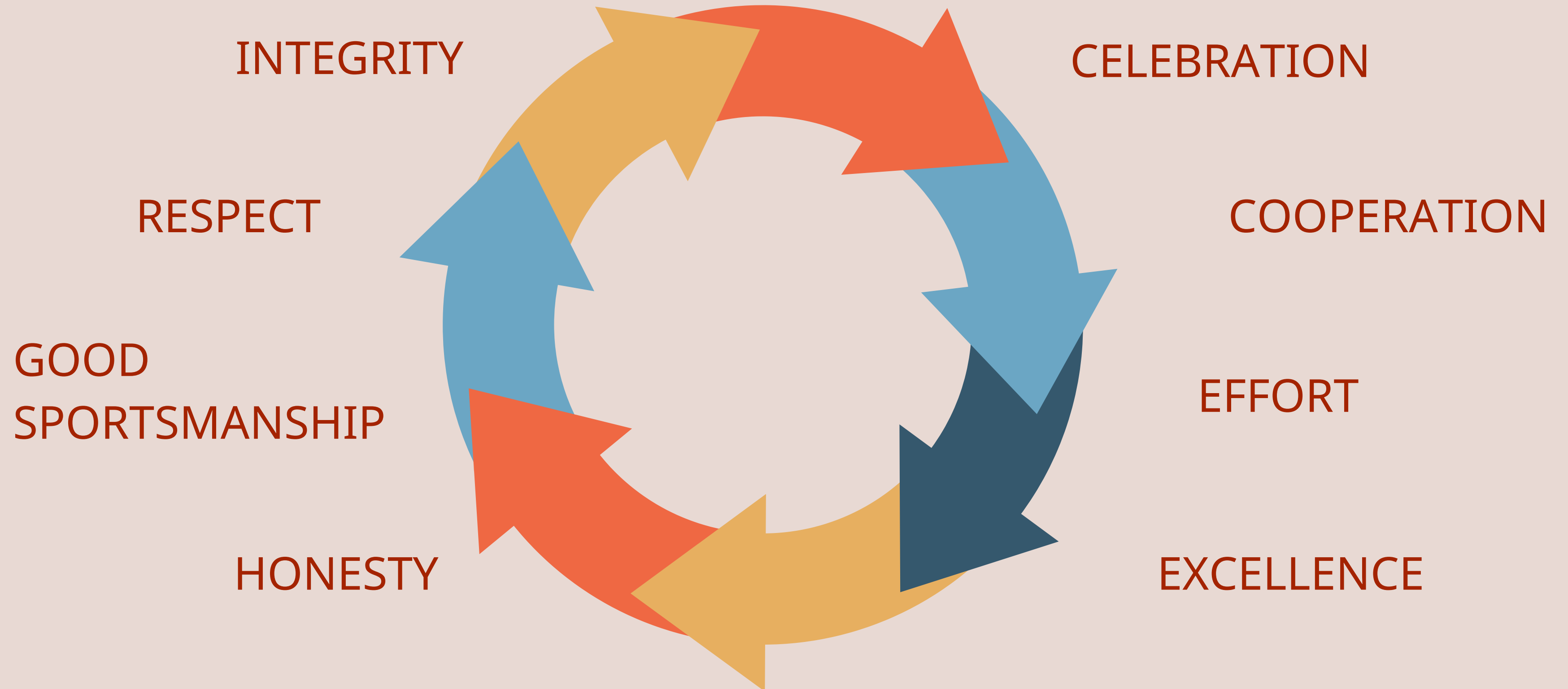


NOW!

## EVERY YEAR COMPETITION

Use **synthetic biology** to tackle  
problems however they see fit.

# THE IGEM VALUES



# TRACKS

**Diagnostics    Therapeutics    Climate Crisis    Environment    Conservation    Food & Nutrition**



**Biomanufacturing**



**Industrial  
Scale-Up**



**Energy**



**Foundational  
Advance**

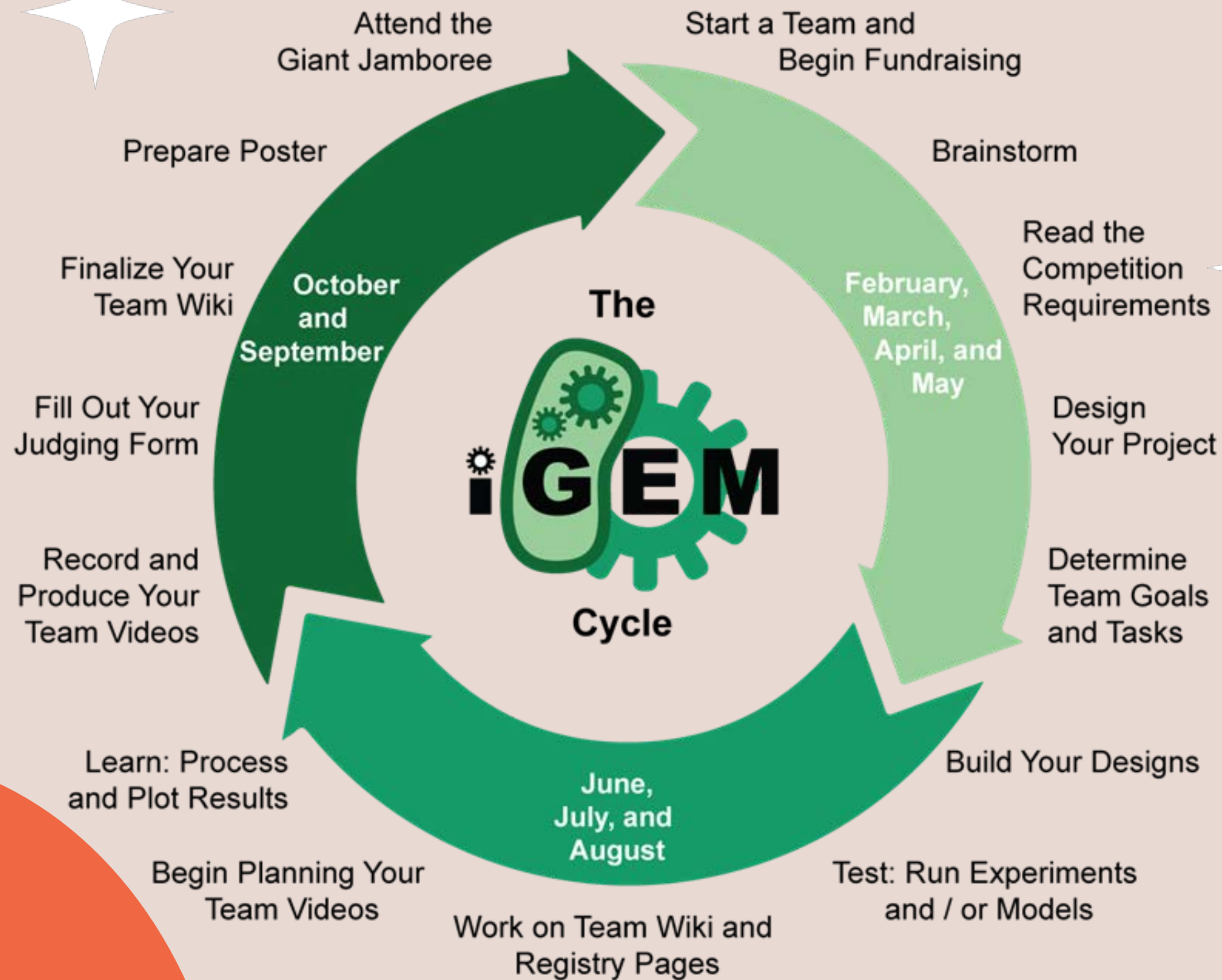


**Software & AI    High School**





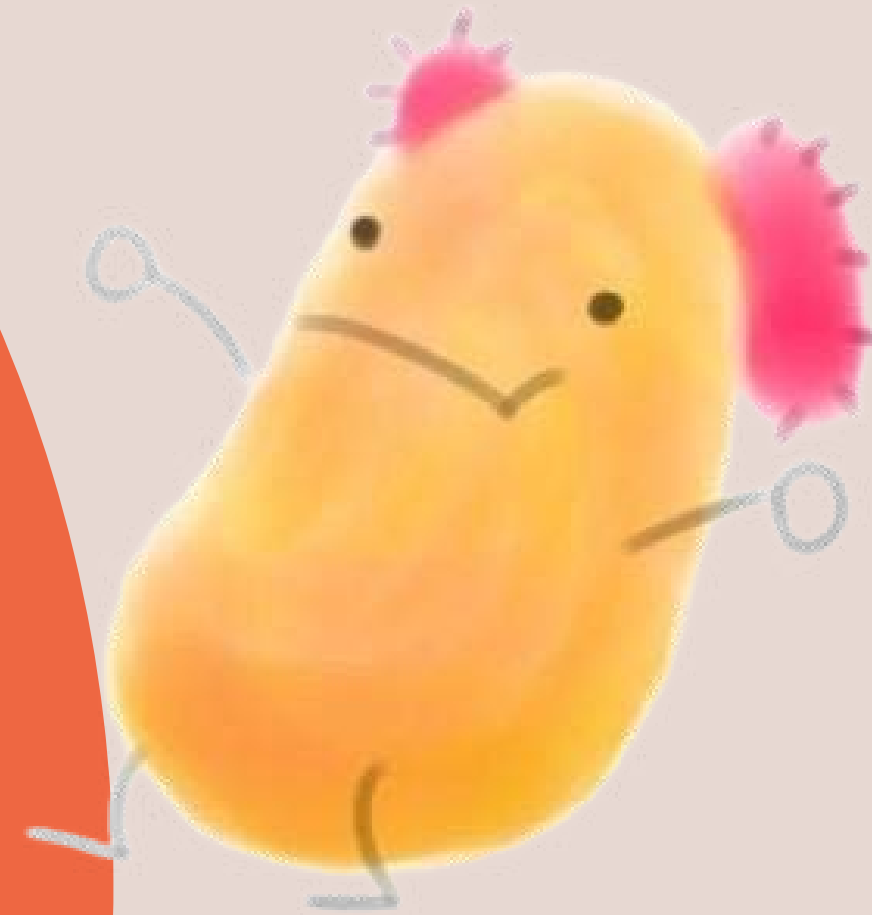
# THE IGEM CYCLE





## **STEP 2**

# **HOW TO RECRUIT AN IGEM TEAM?**



# HOW TO RECRUIT AN IGEM TEAM?





# WET LAB

**DESIGN PLASMID AND EXECUTE EXPERIMENTS TO ACHIEVE OUR PROJECT GOALS.**

- Design the experiments
- Design or Improve a part
- Use biological techniques to build constructs





# DRY LAB

THE CREATION OF  
COMPUTER-GENERATED  
MODELS OR SIMULATIONS,  
AND THE DEVELOPMENT OF  
THE HARDWARE DEVICE.

- Software Tool
- Modeling
- Hardware Device



# HUMAN PRACTICES

**THE STUDY OF HOW OUR WORK AFFECTS THE WORLD, AND HOW THE WORLD AFFECTS OUR WORK.**

- Experts consultation
- Entrepreneurship visiting
- Collaboration
- Proposed Implementation
- Education & Communication



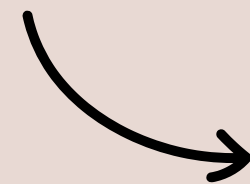
# WIKI

HOW WE WILL COMMUNICATE  
OUR ENTIRE PROJECT TO THE  
WORLD.

- Design the WIKI page
- Including Programming and artwork design

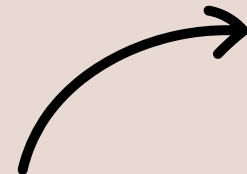
# Which group should I join?

- Programming skills (Python, C++, MATLAB)
- Interested in predicting outcomes using software tools
- Has experience in 3D modeling or deep learning



Dry Lab

- Creative, lots of inspiration
- Coding ability (HTML, CSS, JS)
- Interested in artwork and layout design



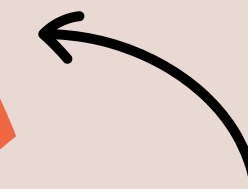
WIKI

Wet Lab

- A fresh liver
- Willing to accept failure (and doesn't give up)
- Interested in doing hands-on work
- Has experience in an microbiological lab



Human Practices



- Enjoy communicating with people
- Interested/has experience in publicizing a project/product
- Good word processing & oral skills

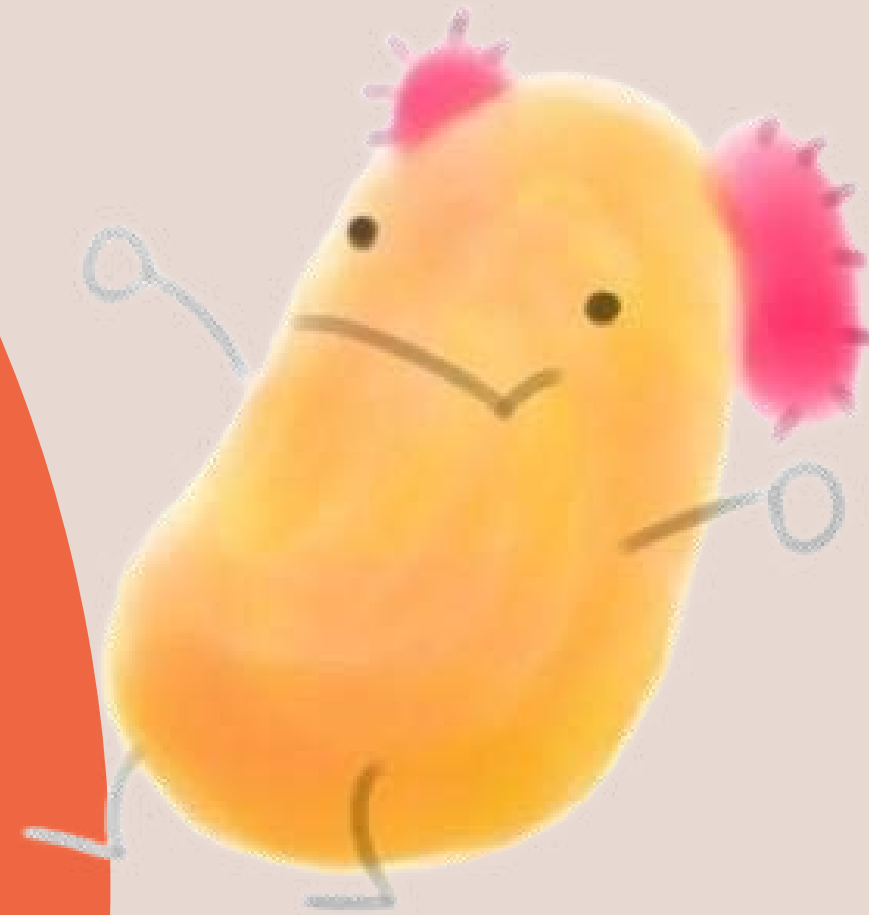
iGEM is a **multidisciplinary** team!!





**STEP 3**

**THE 13  
DELIVERABLES**



# THE DELIVERABLES

1.

## SAFETY FORMS

"Identifying and managing **risks** from the technology is **everyone's responsibility.**"



2.

## JUDGING FORM

Where we declare our team's completion of **medal criteria** and **special prizes**.

A screenshot of the iGEM Synthetic Biology judging form. It is titled "Synthetic Biology based on standard parts" and "Team: BIT/Judging Form". It contains fields for Team, iGEM Year, Track, Project Name, and Project Abstract. Below this is a section for "iGEM Medal for Health & Medicine Teams" with a list of requirements and a table for medal criteria. The table has columns for "Part Number(s)", "Date", and "Status". It lists requirements for a Bronze Medal (at least one new standard BioBrick Part or Device), a Silver Medal (at least one new standard BioBrick Part or Device), and a Gold Medal (at least one new standard BioBrick Part or Device). The form also includes a section for "Additional Requirements for a Silver Medal" and a section for "Additional Requirements for a Gold Medal".

3.

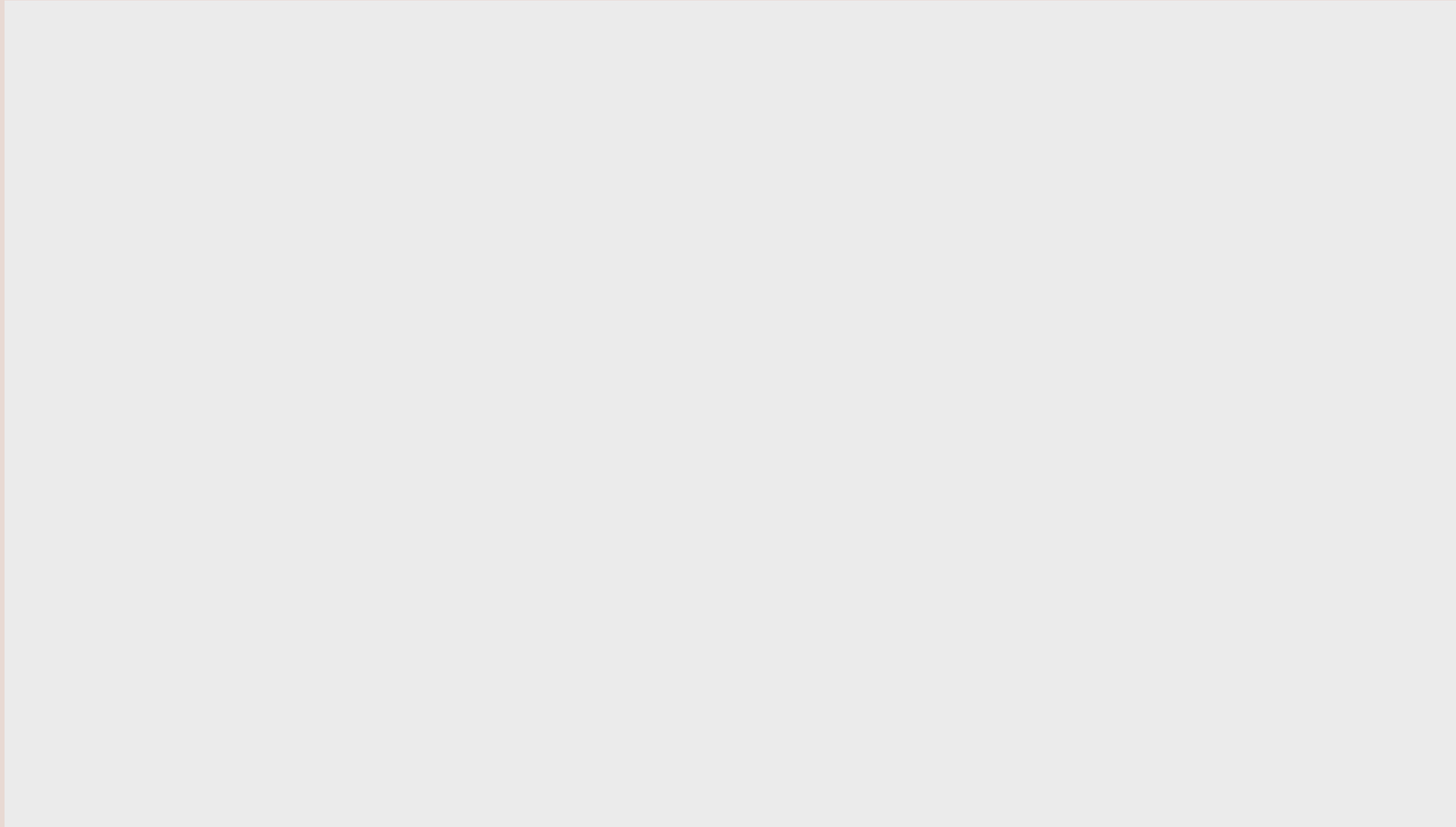
## PROMOTION VIDEO

A 2-min introduction to our project:

- The problem
- Our solution
- The engineering
- Its impact



# OUR PROMOTION VIDEO



# THE DELIVERABLES

4.

## TEAM WIKI

How we will communicate our entire project to the world.

5.

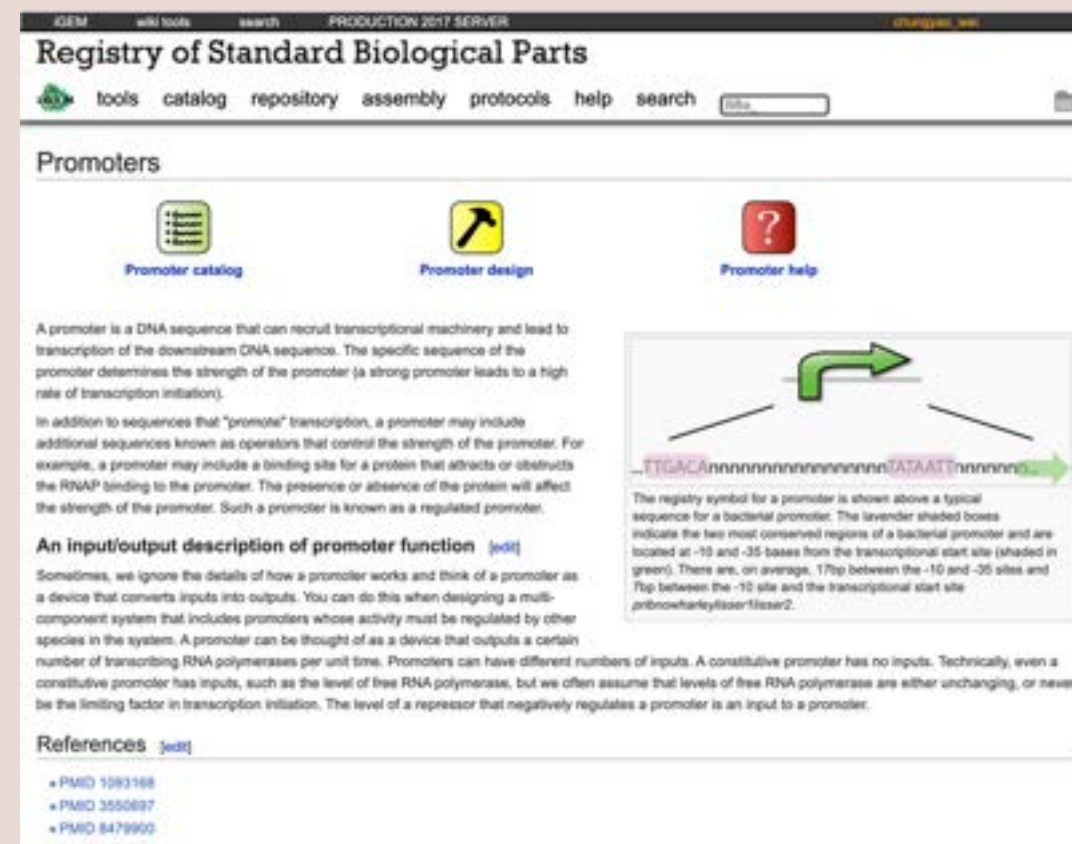
## PART PAGES

A growing **collection of genetic parts** that can be mixed and matched to build **synthetic biology devices and systems**.

6.

## PROJECT ATTRIBUTION

About what we did ourselves and what we had help with.



Chih-Sung Yu

Chief of Yi-Ching Yuan Elderly Long-Term Care Center. Mr. Yu provided us with critical opinions on long-term health care for the elderly community.



Mr. Clapper

Director of Scientific Research at Taipei American School. Mr. Clapper provided us with the *E. coli* strain Nissle 1917.



iGEM team  
TAS Taipei

The iGEM team from Taipei American School. Team TAS Taipei kindly helped us perform a confirmatory experiment.



# THE DELIVERABLES

## 7. PROJECT DESCRIPTION

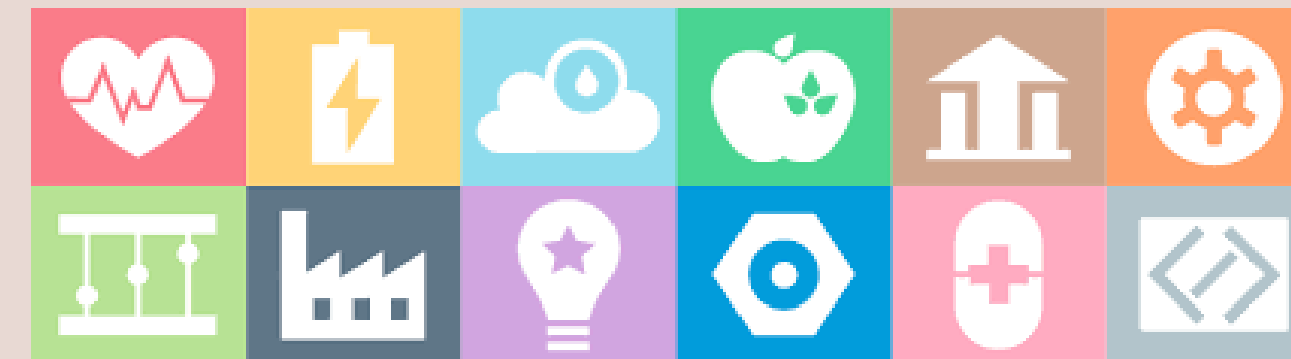
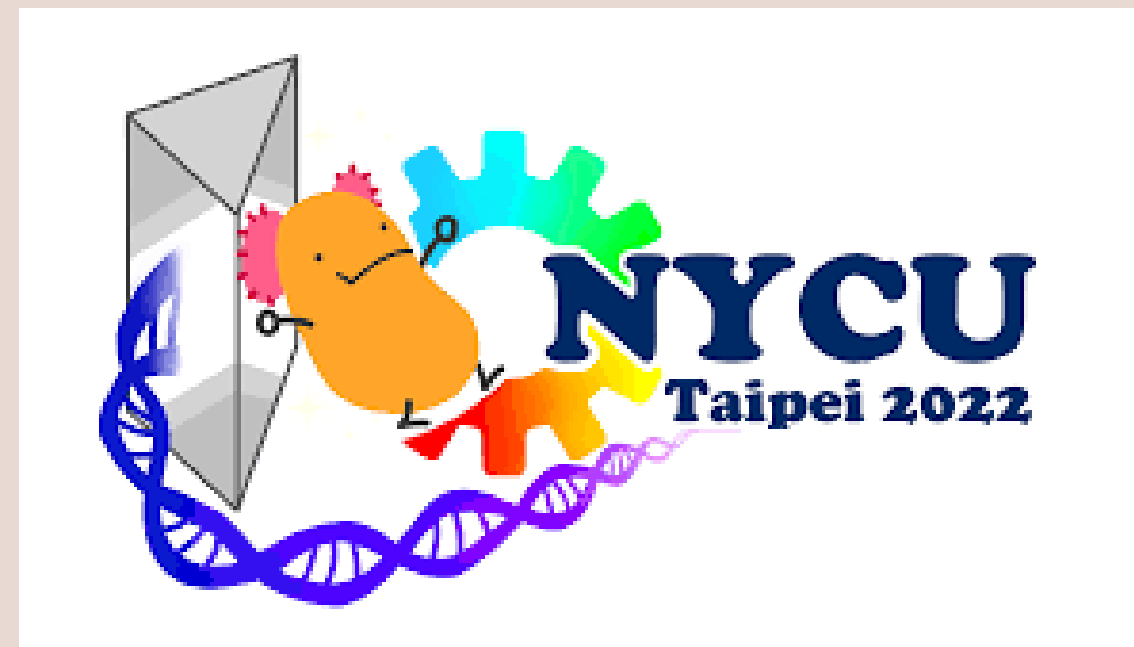
A **detailed introduction** to our iGEM project.

## 8. TITLE AND ABSTRACT

Accurately **reflect the work we completed** in our team project and provide **a brief summary** of our project.

## 9. TRACK SELECTION

The purpose of the iGEM tracks is to help teams **focus on their projects**.



# THE DELIVERABLES

**10.**

## TEAM ROSTER

The **official record of everyone** who is involved with the iGEM team.

**11.**

## TEAM PRESENTATION

To **communicate our project to others** in an informative and engaging manner.

**12.**

## TEAM BOOTH

This interactive space will be used by teams **to talk to other Jamboree attendees and iGEM teams about their project.**

**13.**

## JUDGING SESSION

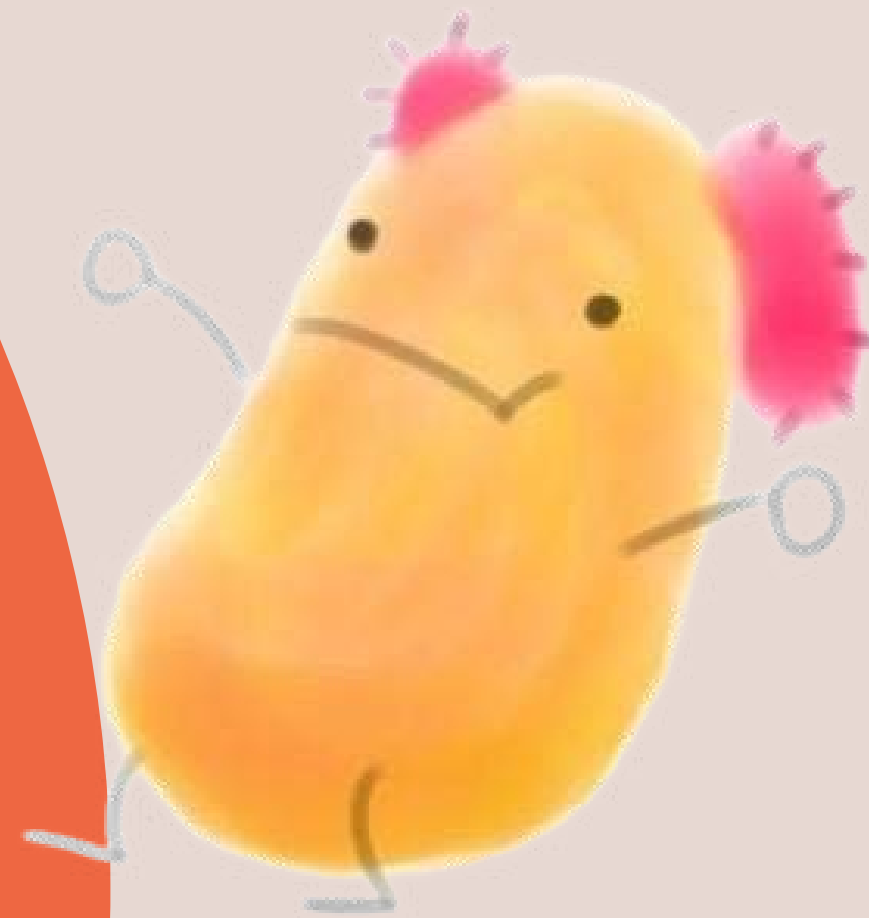
This is the opportunity to **deliver our project presentation, and have in-depth question/answer time** with our judging panel.





## **STEP 4**

## **MEDAL CRITERIA & SPECIAL PRIZES**



# MEDALS & CRITERIA



**1.**  
**BRONZE MEDAL**

- Competition Deliverables
- Project Attributions
- Project Description
- Contribution



**2.**  
**SILVER MEDAL**

- Engineering Success
- Collaboration
- Human Practices
- Proposed Implementation



**3.**  
**GOLD MEDAL**

3 of the 6 criteria must be met.

- Integrated Human Practices
- Improvement of an Existing Part
- Project Modeling
- Proof of Concept
- Partnership
- Education & Communication

BEST MEASUREMENT

# SPECIAL PRIZES

**1.**

**BEST EDUCATION**



**2.**

**BEST HARDWARE**



**3.**

**INCLUSIVITY  
AWARD**



**4.**

**BEST INTEGRATED  
HUMAN PRACTICE**



**5.**

**BEST  
MEASUREMENT**



**6.**

**BEST MODEL**



**7.**

**BEST NEW  
BASIC PART**



**8.**

**BEST NEW  
COMPOSITE PART**





# SPECIAL PRIZES

**9.**

**BEST PART  
COLLECTION**



**13.**

**BEST SOFTWARE  
TOOL**



**10.**

**BEST PLANT  
SYNTHETIC  
BIOLOGY**



**14.**

**BEST  
SUPPORTING  
ENTREPREURSHIP**



**11.**

**BEST  
PRESENTATION**



**15.**

**BEST SUSTAINABLE  
DEVELOPMENT IMPACT**



**12.**

**SAFETY AND  
SECURITY AWARD**



**16.**

**BEST WIKI**



## PART 3

WHAT DID  
NYCU TAIPEI DO  
THIS YEAR?



# NYCU-Taipei 2022

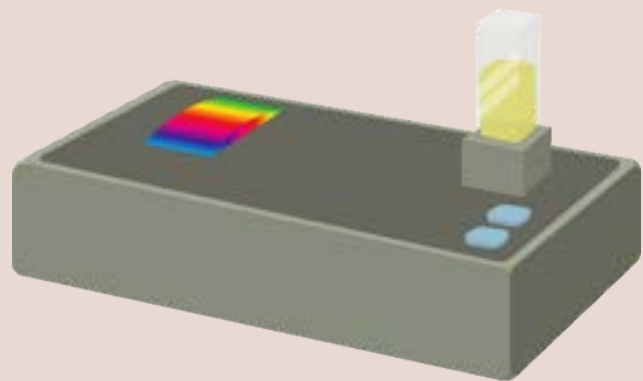
## E. COLOR





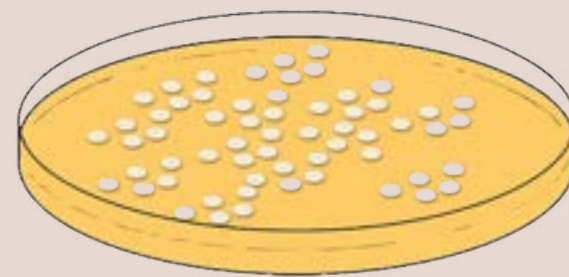
# BACKGROUND

- *E. coli* is an important model organism in many fields of research.
- Monitoring bacterial growth status is vital for determining the accurate induction time point for protein production.
- Various approaches have been developed to monitor microbial growth, each with advantages and shortcomings.



## **OD600 measurement**

Precipitants in liquid culture  
reduce accuracy



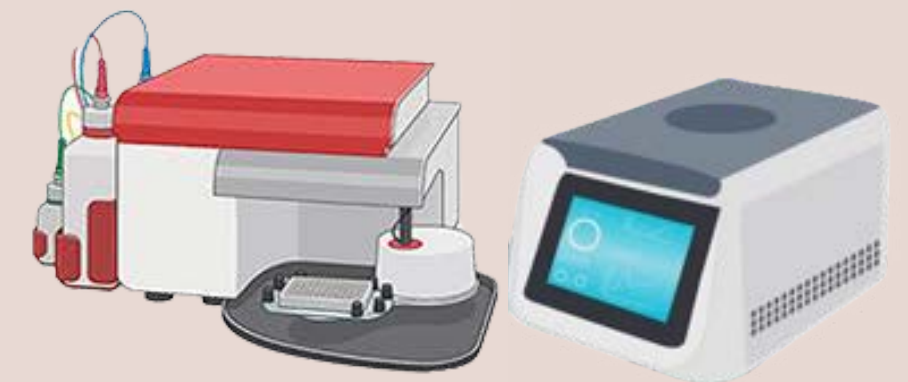
## **Culture cell count**

Requires time for bacteria  
to grow into colony



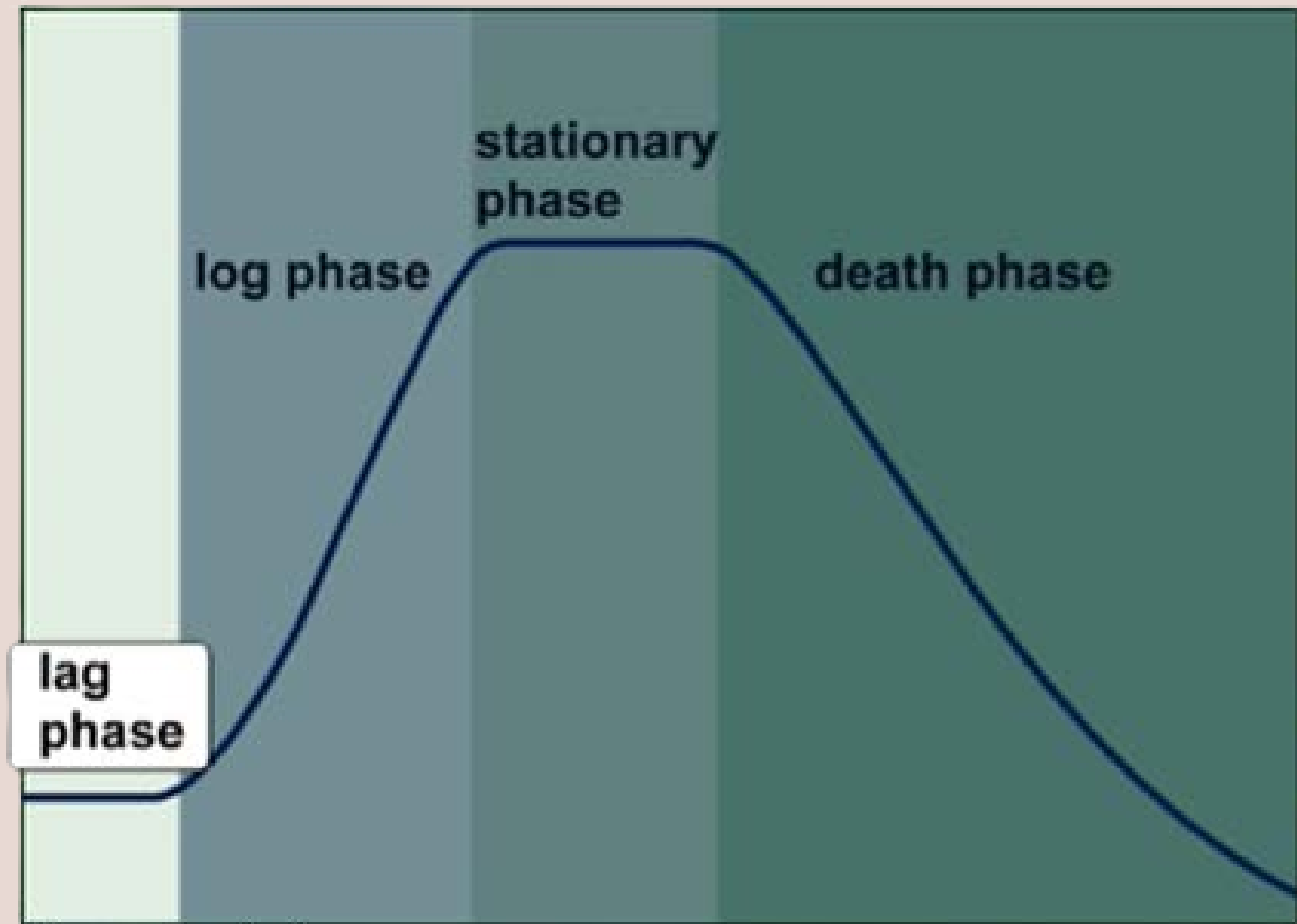
## **Biochemical assay**

Expensive reagents  
Do not provide true cell count



## **Flow cytometry / qPCR**

Expensive and  
technique-demanding





# GOALS

## **1. Improve the working environment of microbiological researchers**

- Allow users to remotely trace bacteria growth
- Save time, manpower and the possibility of introducing variables to bacterial culture
- Increase accessibility by reducing cost and technical threshold

## **2. Enhance the efficiency and yield of mass production**

- Assist in determining the induction time point for protein expression
- Increase drug production (e.g. monoclonal antibodies) in the pharmaceutical industry

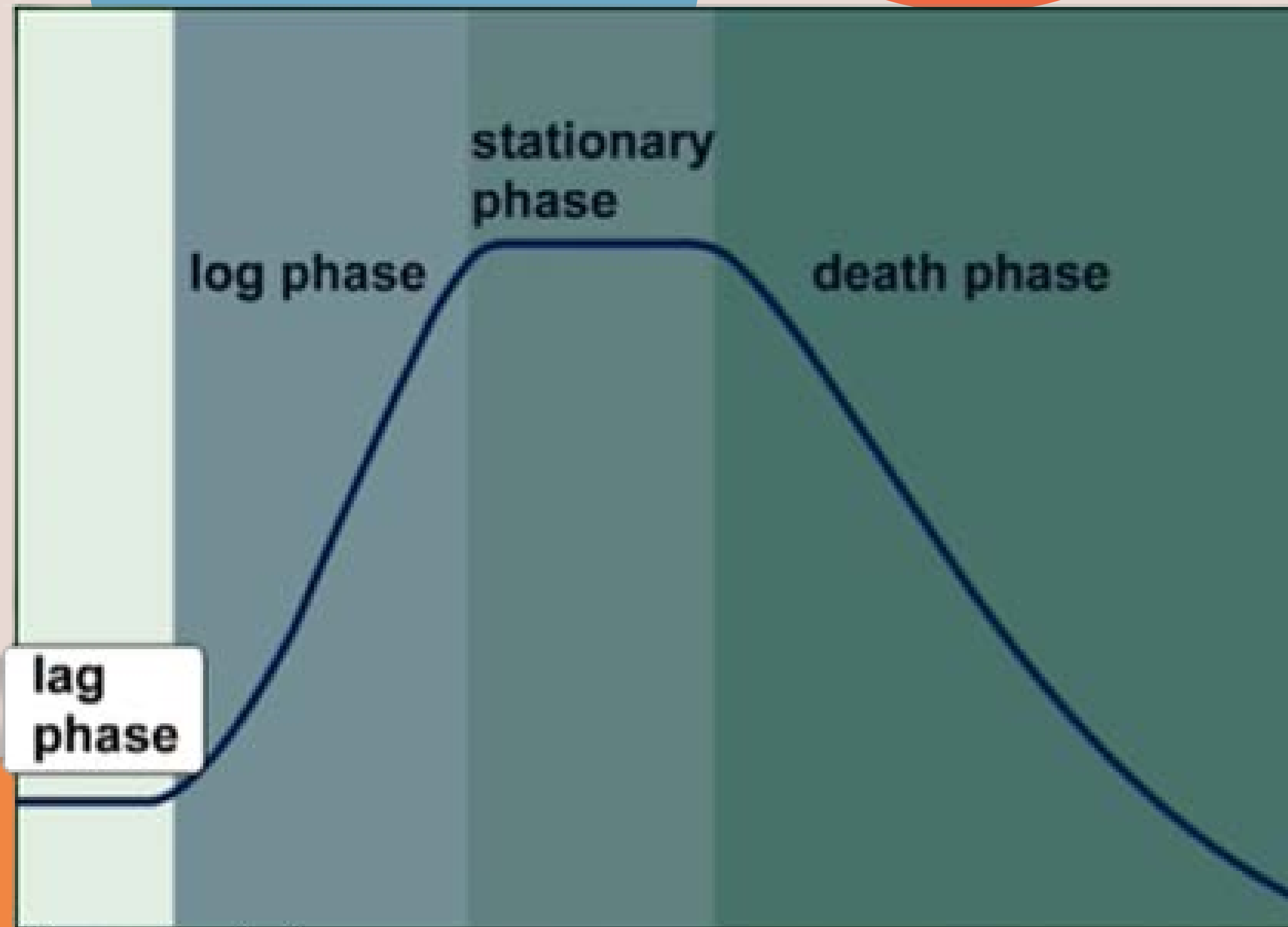
## **3. Environmental and clinical applications**

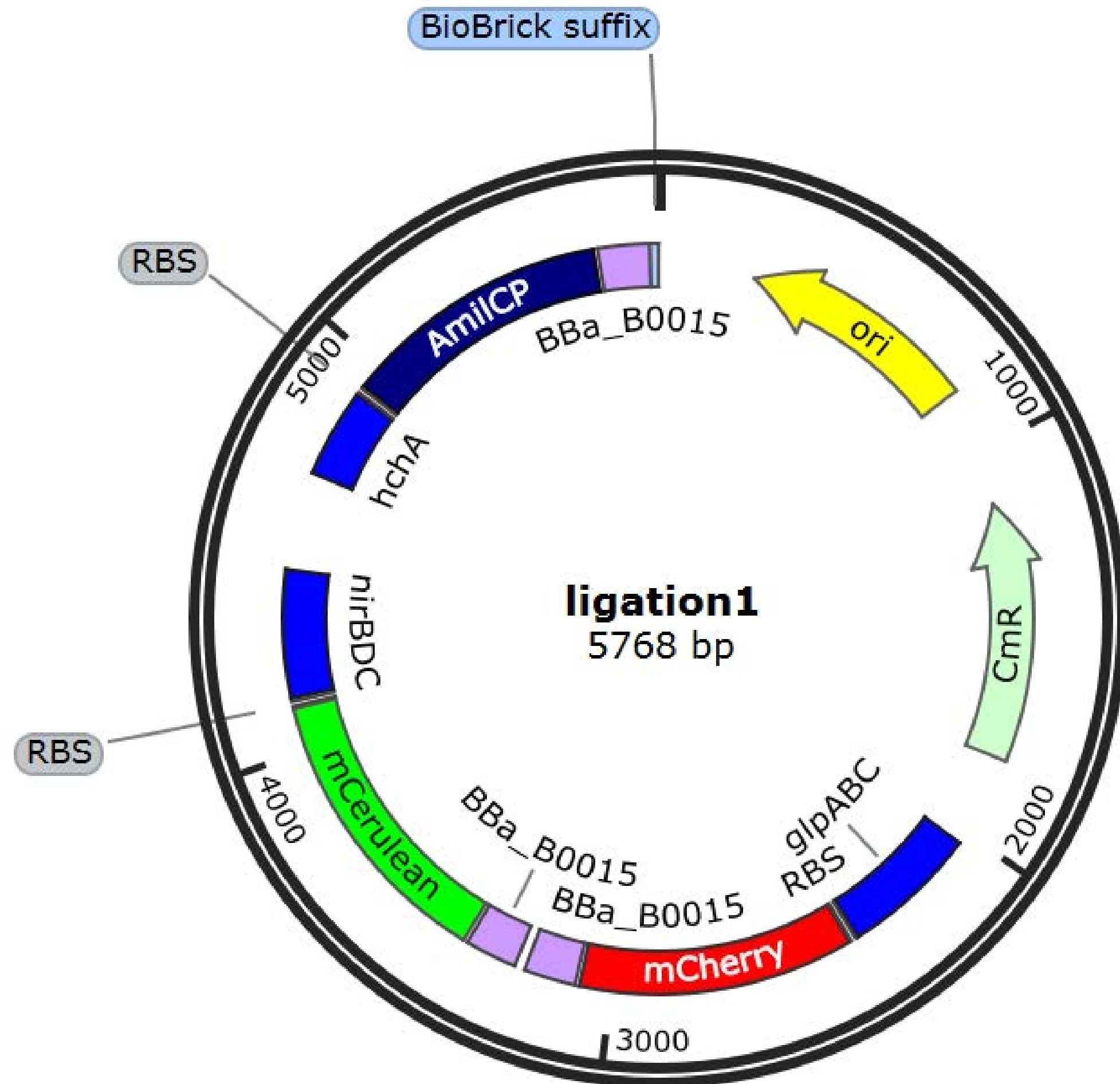
- Serve as an auxiliary tool for drug screening in clinical environments
- Determine whether bacteria is resistant or susceptible to specific environmental conditions

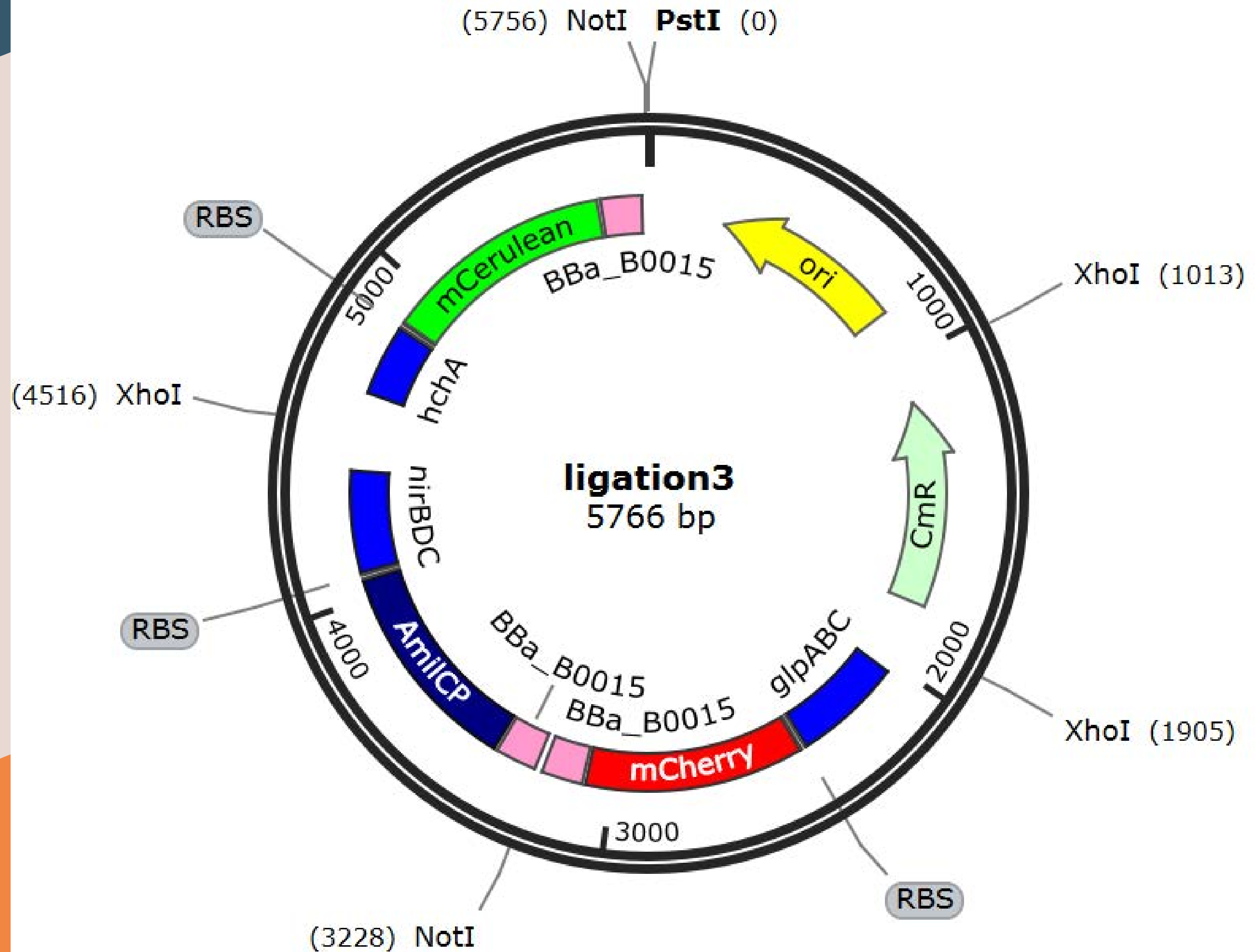
**GROUP 1**

**WET LAB**













**GROUP 2**

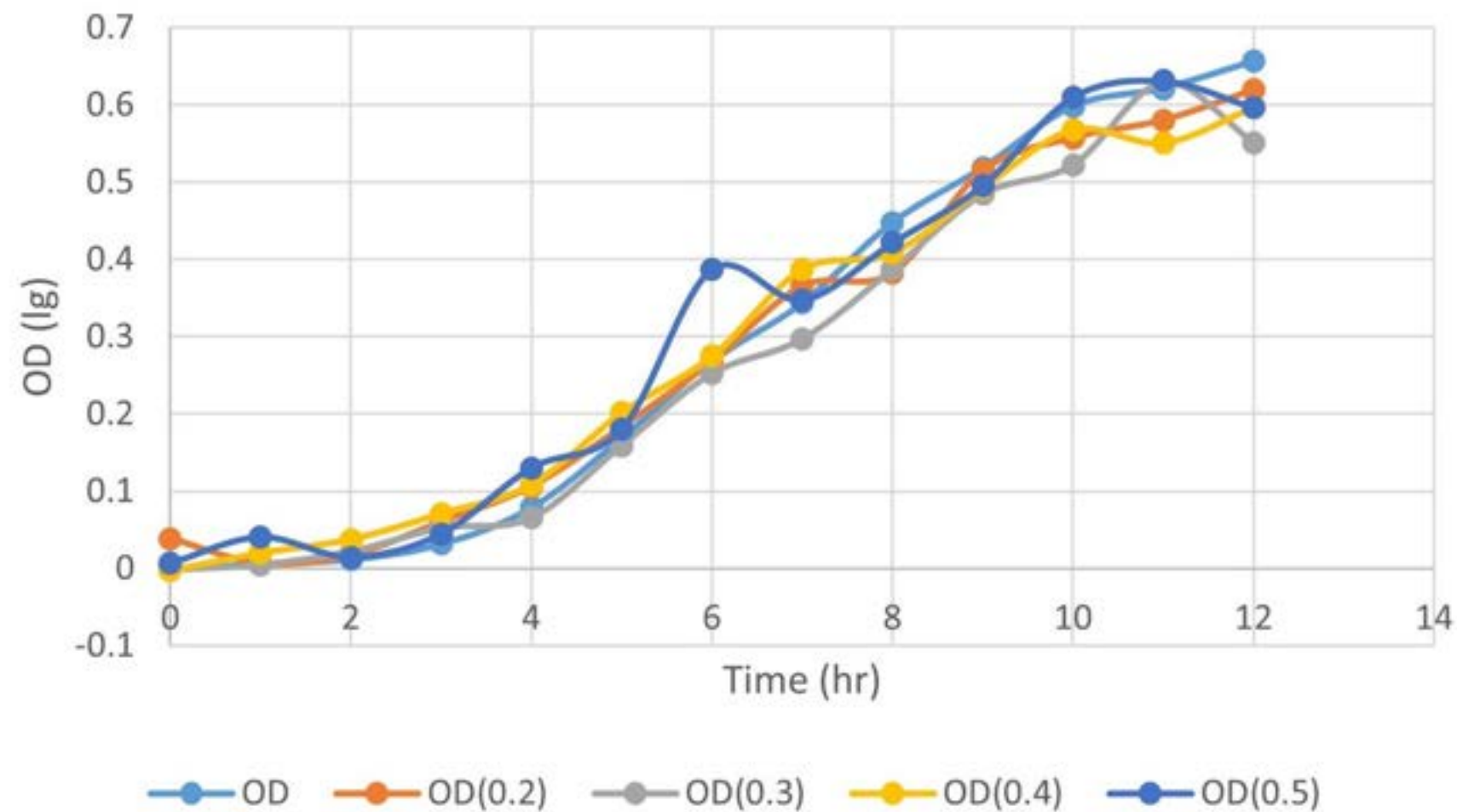
**DRY LAB**



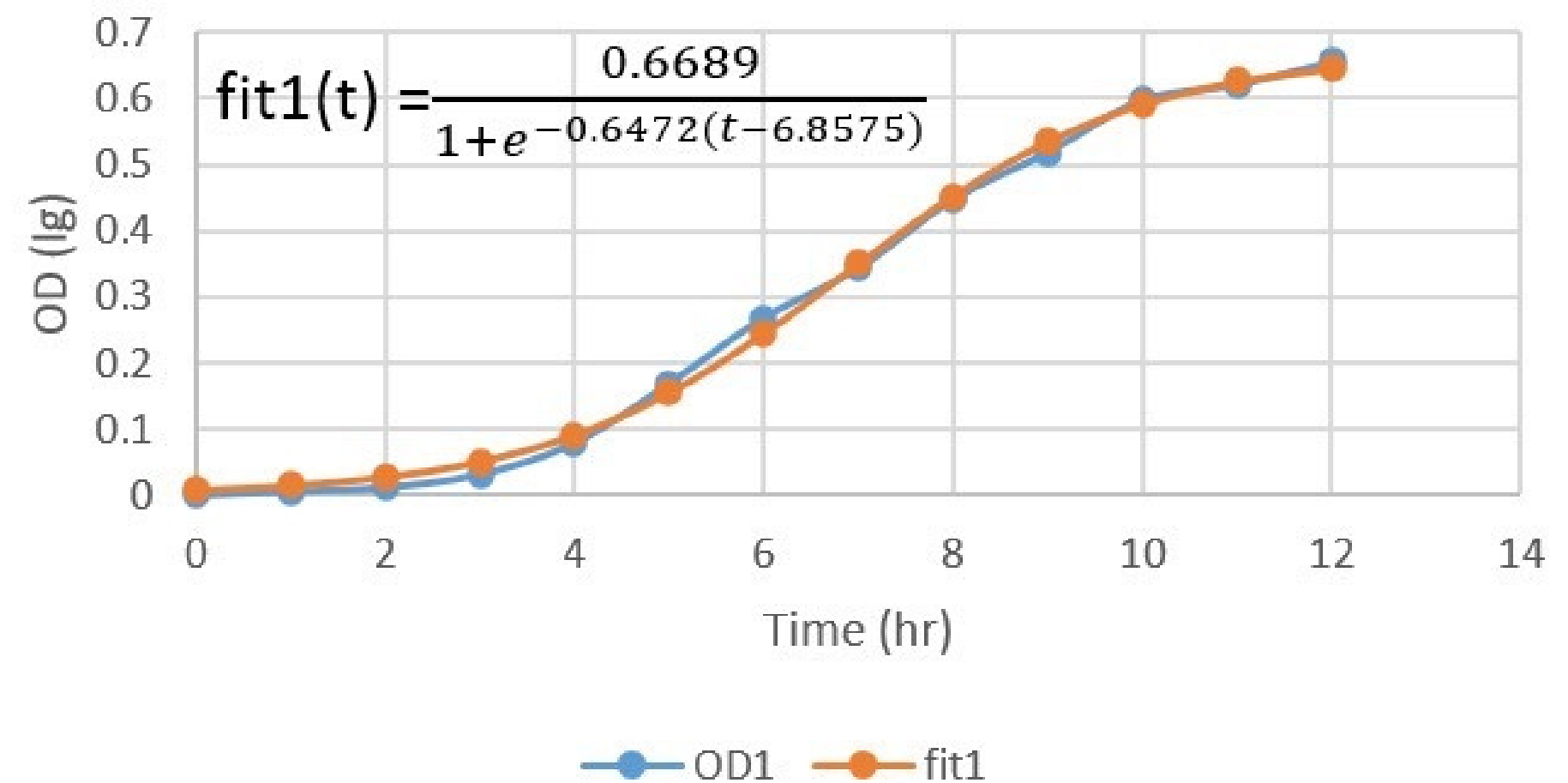
# MODELING

Example: Modeling the growth curve under different harvest timepoint of bacterial culture

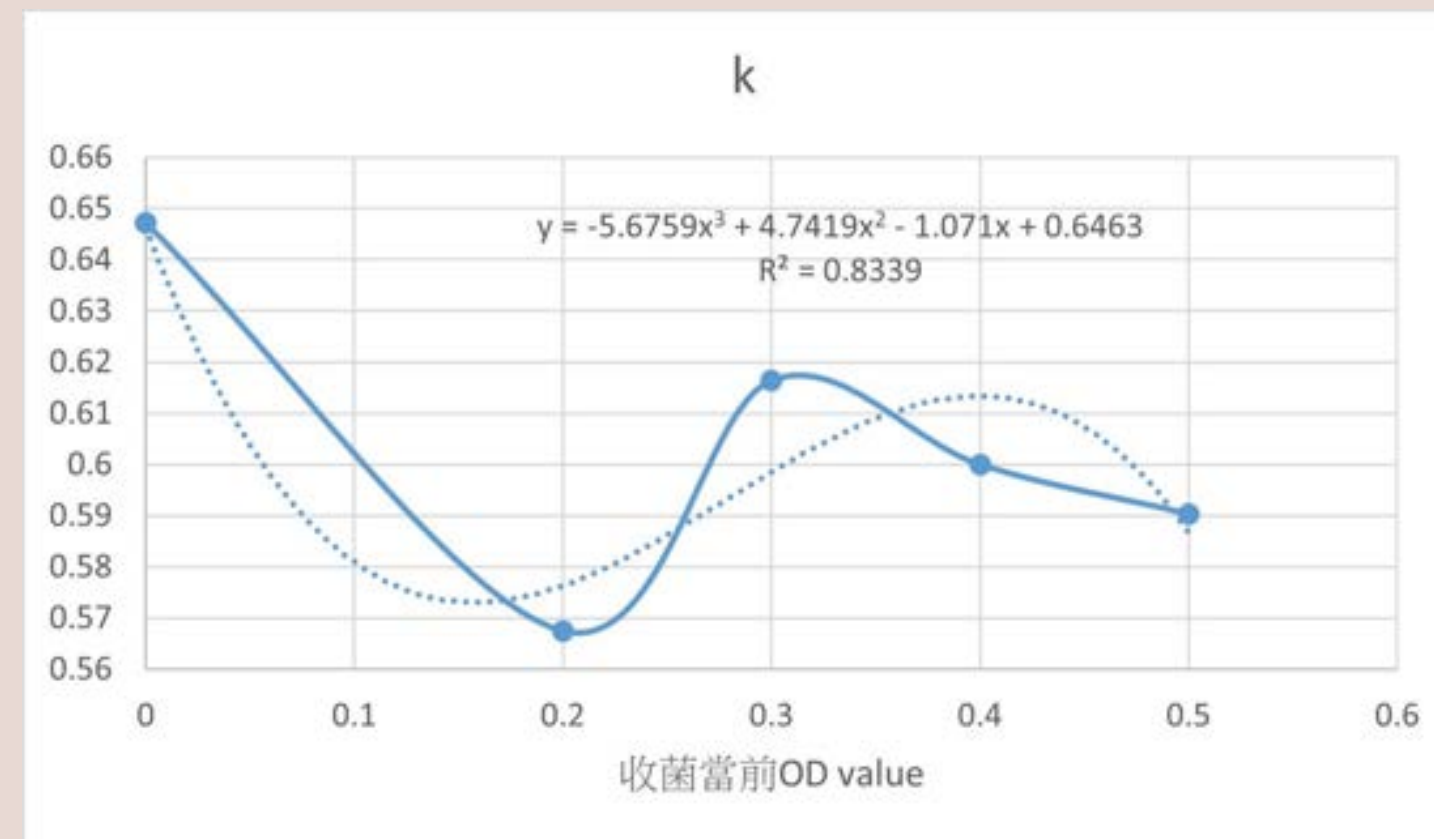
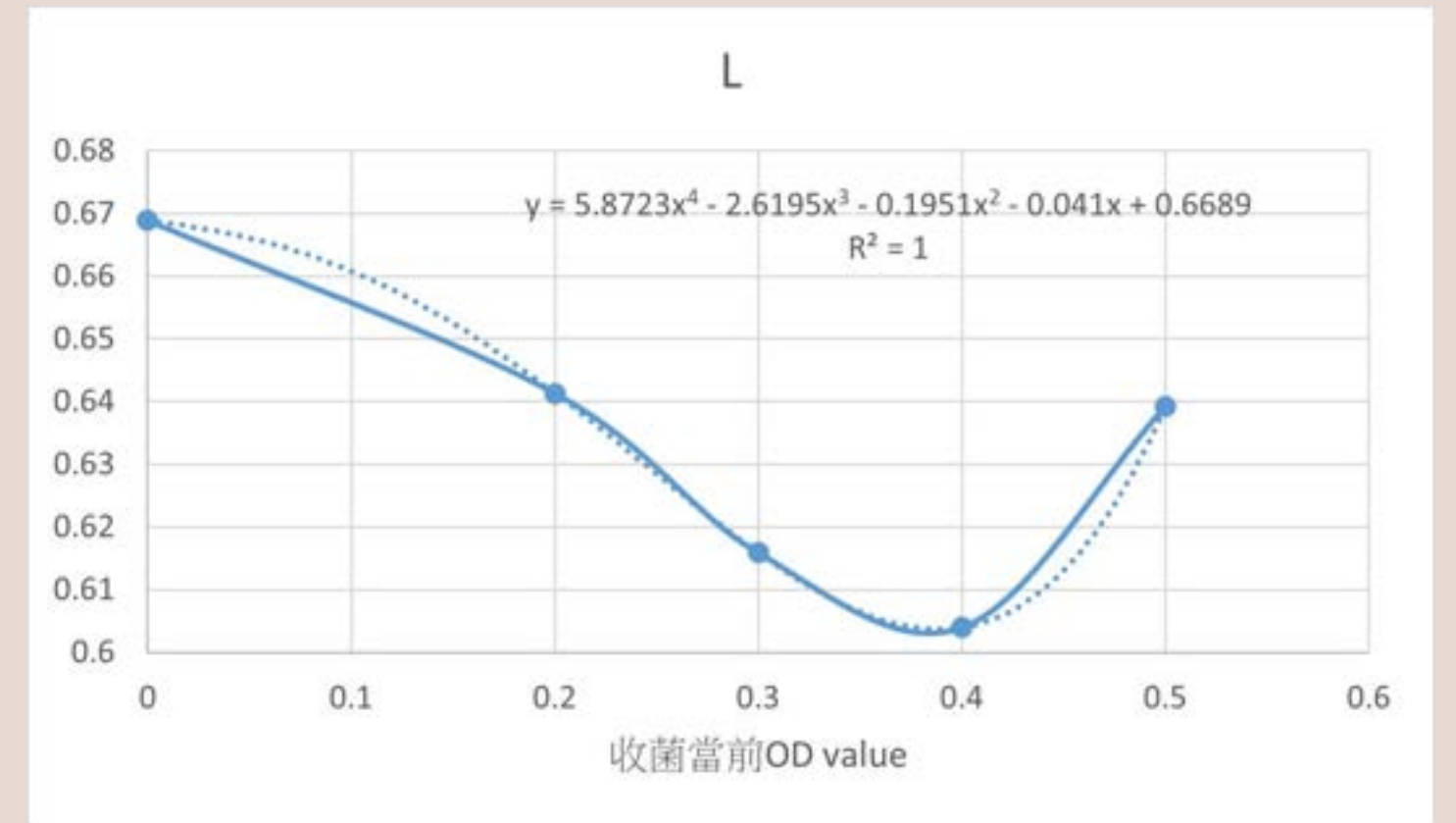
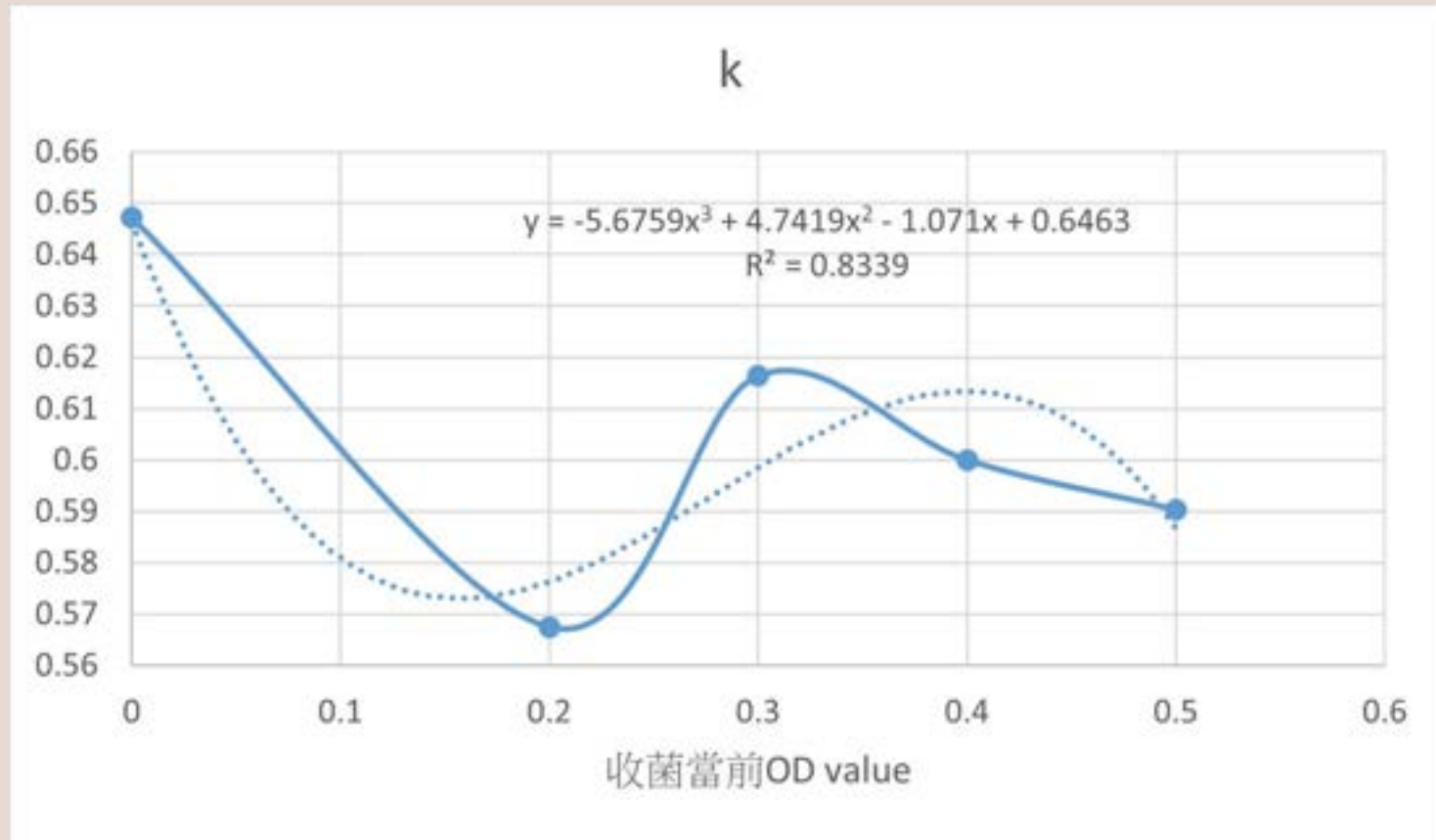
OD-Time (total)



OD-Time (case1)

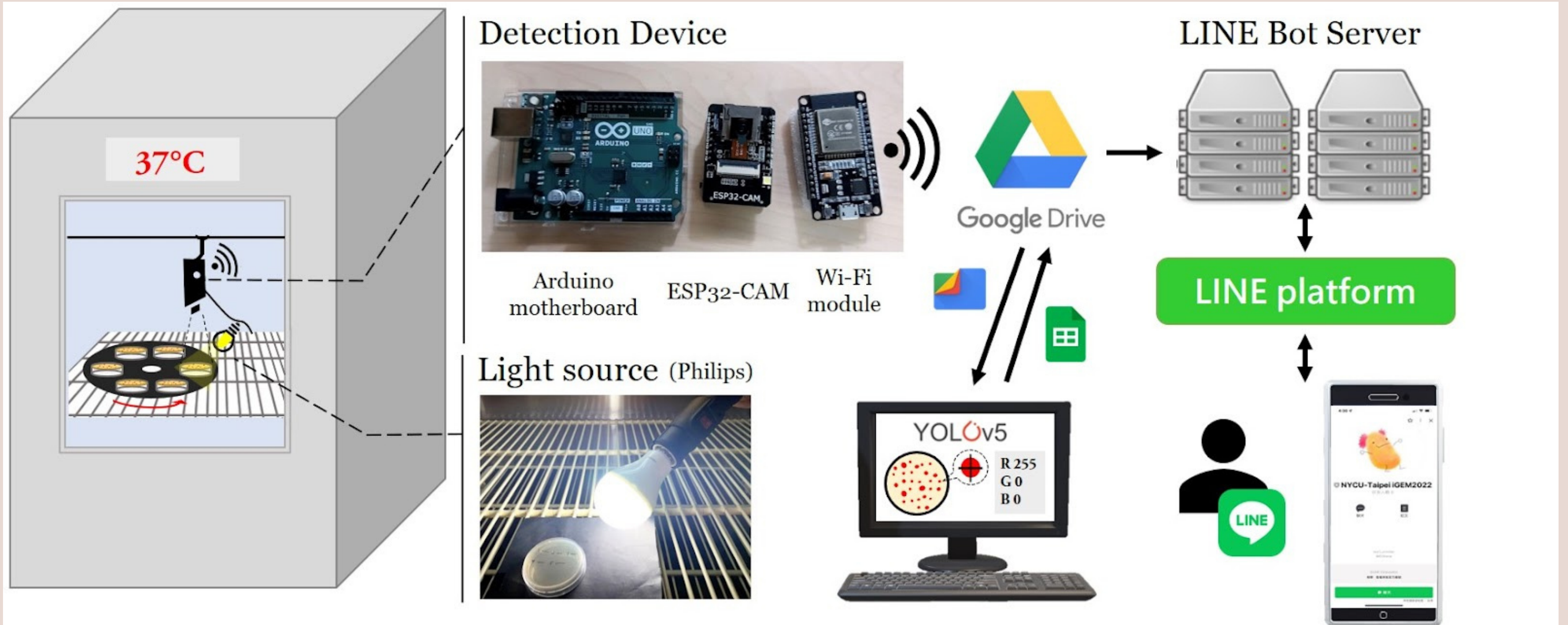


# MODELING





# OUR DEVICE



Camera detects colonies on agar plate

Image collection by Arduino and data transmission to Google Drive through Wi-Fi

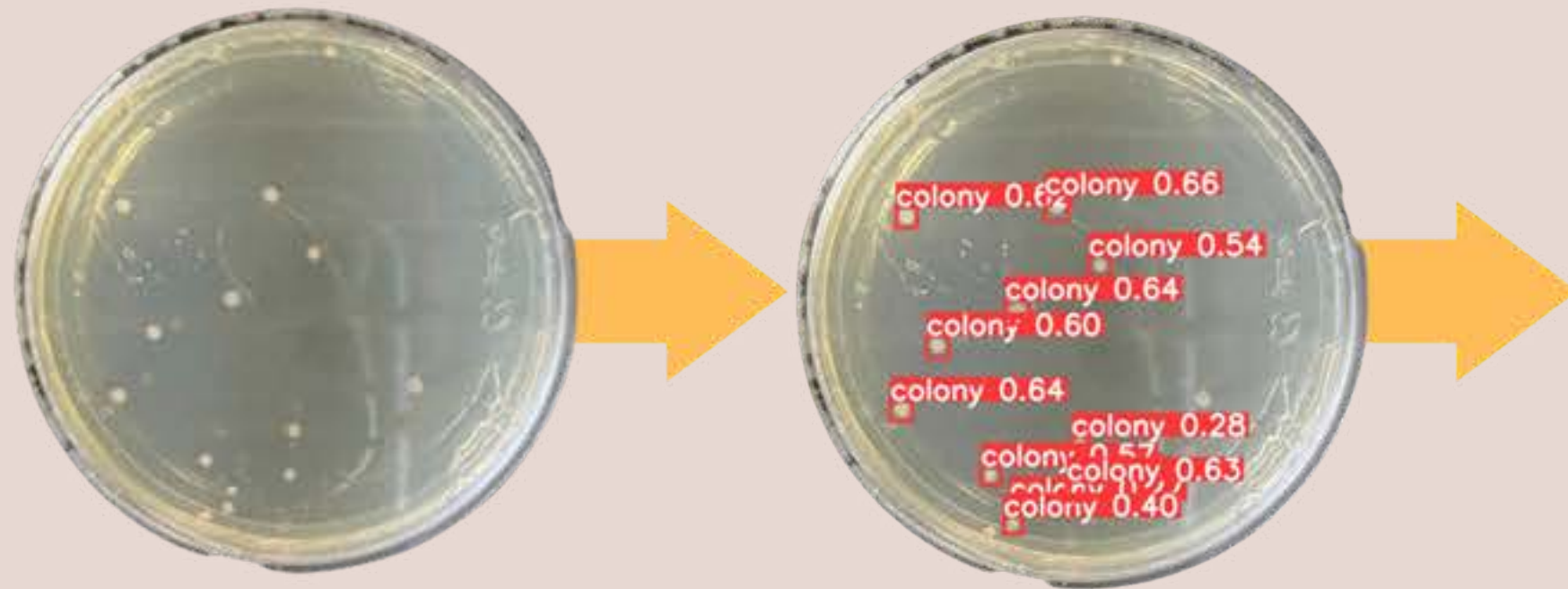
Object detection using YOLOv5 & OpenCV

Upload statistics onto Google Cloud

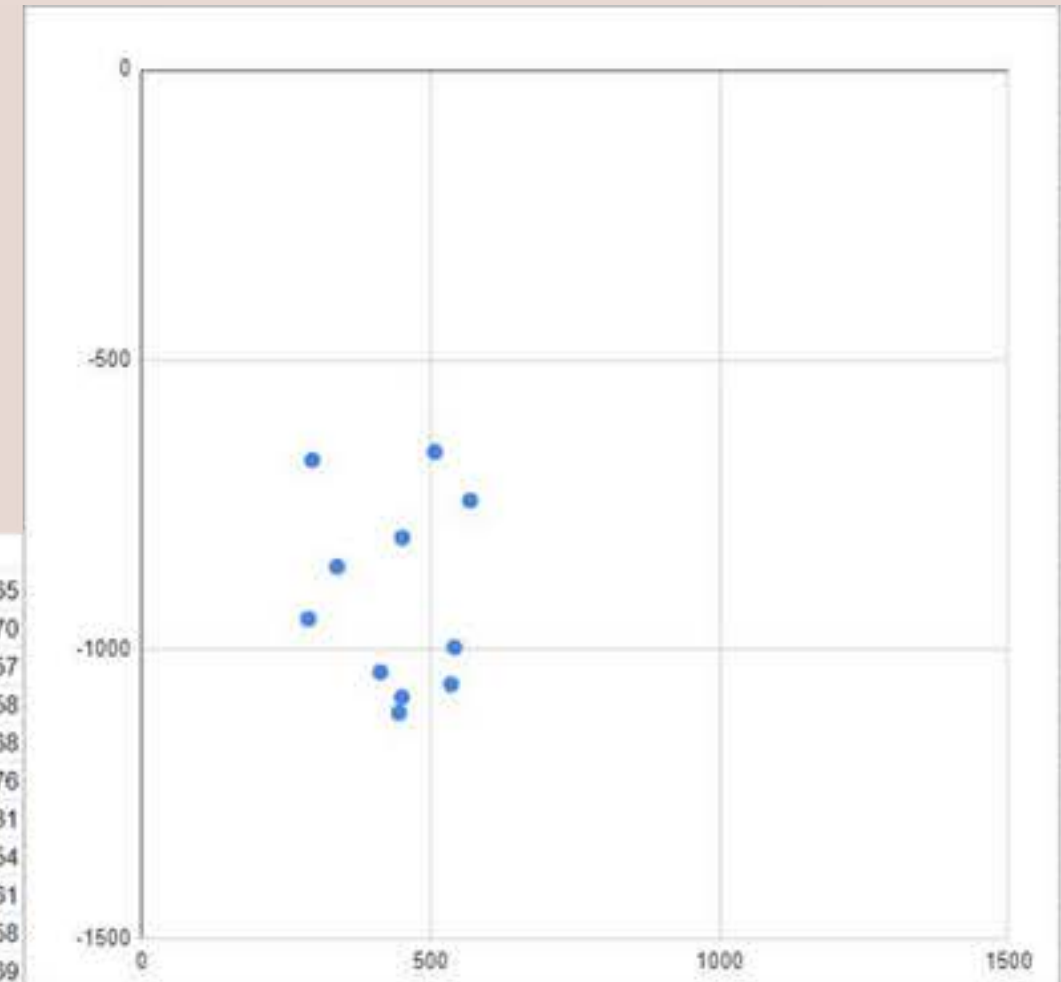
Data output to client terminal using LINE bot

# COLONY DETECTION

- Center coordinate and RGB value of colonies are detected by YOLOv5 and OpenCV
- Data is transmitted onto Google sheet



X中心座標	Y中心座標	R	G	B
507	-659	206	192	165
288	-947	215	202	170
451	-807	193	181	157
535	-1060	195	185	158
295	-673	214	204	168
338	-857	211	201	176
413	-1039	222	208	181
568	-743	200	185	154
445	-1109	210	194	161
541	-998	199	185	158
450	-1082	210	196	169







**GROUP 3**

**HUMAN PRACTICES**



# WHAT WE DID FOR HUMAN PRACTICES



## BACKGROUND RESEARCH

Expert consultation  
Biotech company  
product questionnaire



## COLLABORATION

2022 ARS  
HKUST  
WEGO\_Taipei  
Taiwan Synbio Alliance



## EDUCATION & COMMUNICATION

Taipei Ameican School  
Street Symposium  
Instagram Post



# BACKGROUND RESEARCH

## E.color

Precise and Automatic Detection of Cellular Status  
for Basic and Medical Applications

2022 NYCU-Taipei iGEM team



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### [2022 iGEM NYCU\_Taipei] Product Questionnaire

Greetings!

We are **NYCU-Taipei** from Taiwan, one of the participating teams in the **2022 International Genetically Engineered Machine Competition (iGEM)**. In this competition, we apply synthetic biology to solve real life issues, and design products that are convenient and applicable to

## [國立陽明交通大學 iGEM團隊-產品調查 問卷]

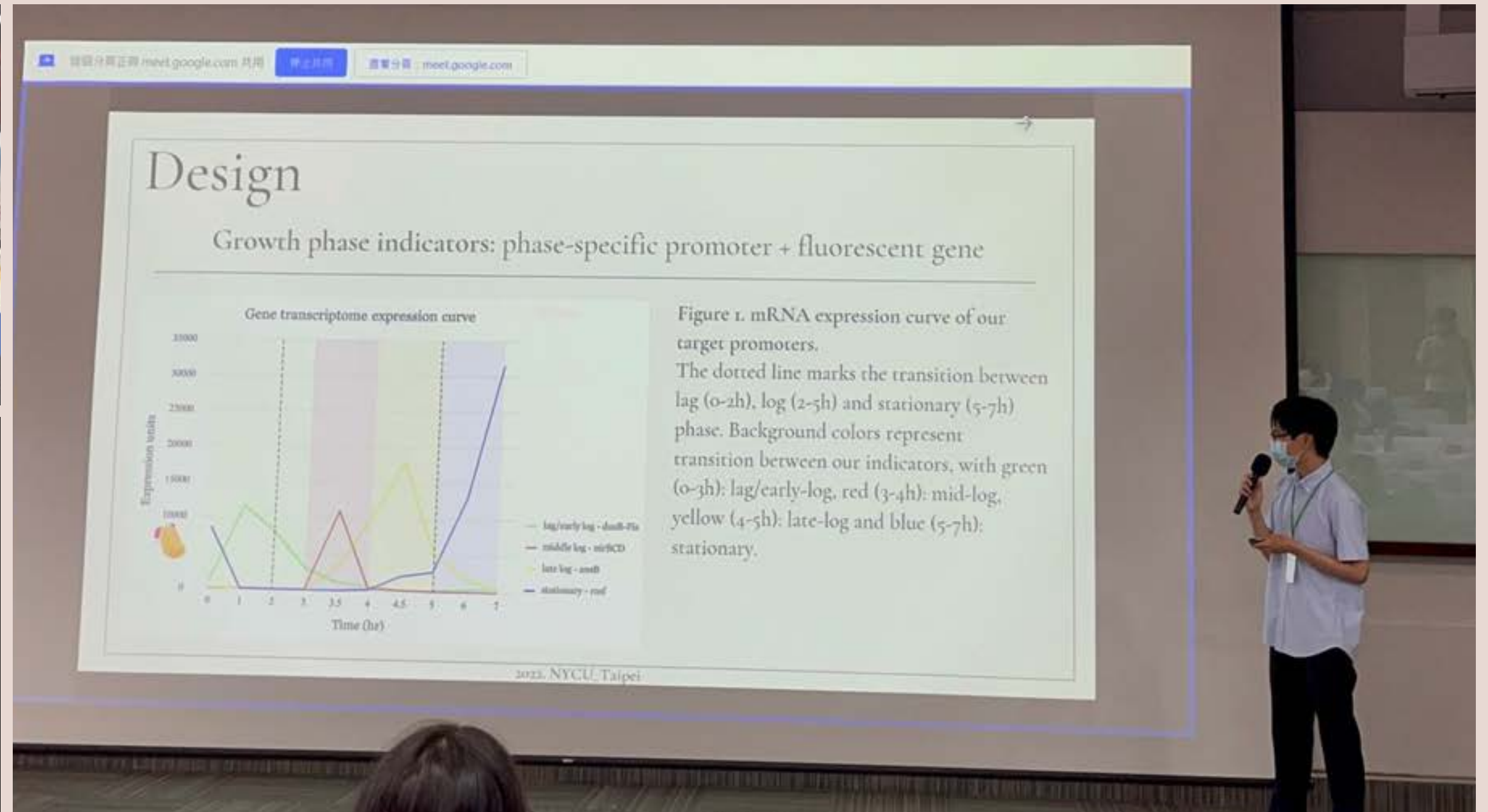
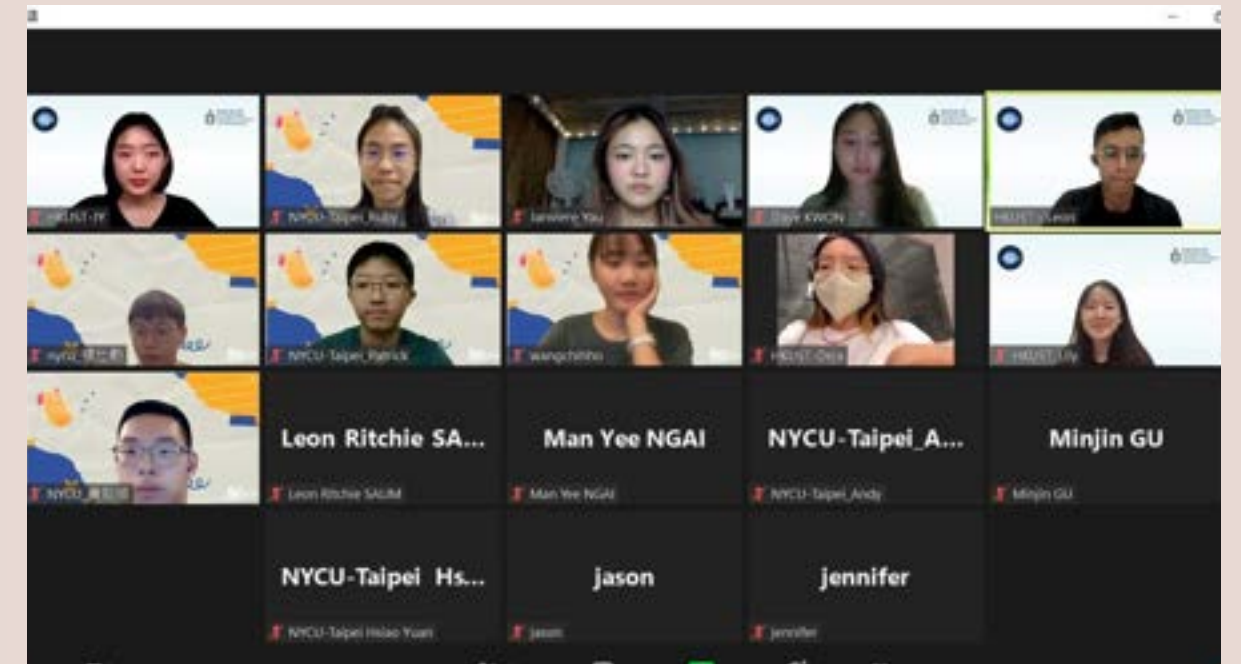
親愛的研究者 您好,

我們是陽明交通大學 iGEM 團隊 **NYCU-Taipei**, 今年將代表學校參加國際遺傳工程機器設計競賽 (International Genetically Engineered Machine Competition, iGEM)。我們希望能運用合成生物學 (synthetic biology) 解決當今社會所面臨的問題, 並設計出便利且應用價值高的產品。

我們的 project 結合基因工程與硬體設計, 開發出一套能「利用螢光自動化辨識細菌生長狀態」的工具 (fluorescent growth status indicator)。使用者可以透過我們的LINE Bot 遠端追蹤細菌的生長, 並藉由菌落顏色、大小及數量對應其生長階段。



# COLLABORATION






# COMMUNICATION & EDUCATION



Fluotato teaches: Episode 1


## Growth characteristics of E. coli



fluo

fluo 2022 10/20, Tokyo


All organisms are able to **grow**, **reproduce**, and **adapt** to their surrounding environments.



Bacteria, one of the fastest reproducing organisms, grows at an astonishing rate when there are plenty of nutrients. Gradually, the **growth rate decreases** when **nutrients are insufficient** to meet the demand of the increasing population. When **growth rate = death rate**, the **cell population remains constant**.

fluo 2022 10/20, Tokyo

For a better understanding, let's draw out the **growth curve** of our model organism, *Escherichia coli* (E. coli)!



The growth curve can be divided into four main stages: **lag**, **log**, **stationary** and **death** phase.

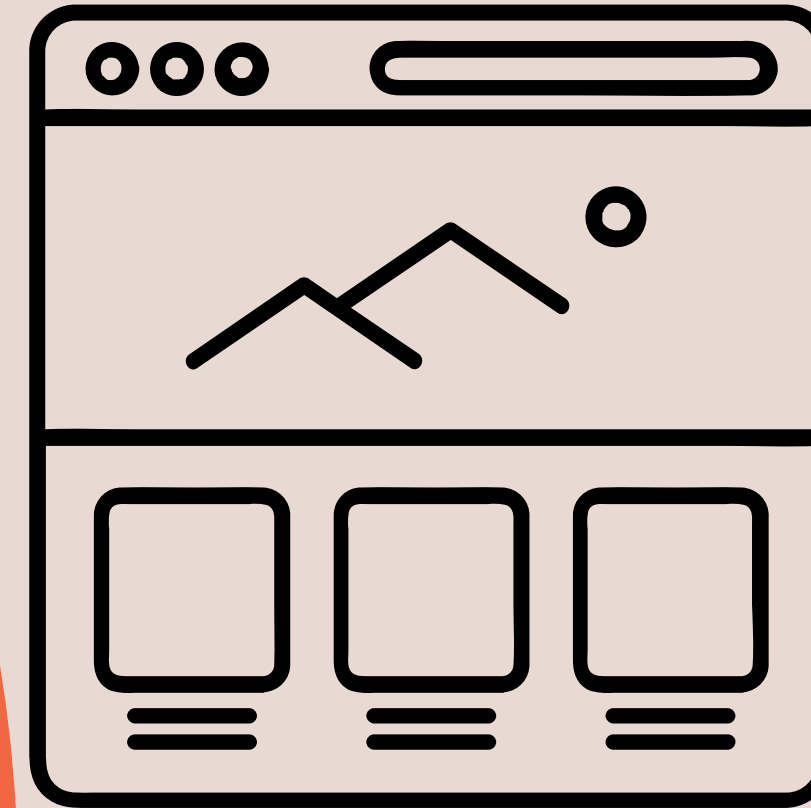
fluo 2022 10/20, Tokyo





**GROUP 4**

**WIKI**





**OUR WIKI**

<https://2022.igem.wiki/nycu-taipei/>

# Method





START



# Step one

**Edit  
IGEM Templates**

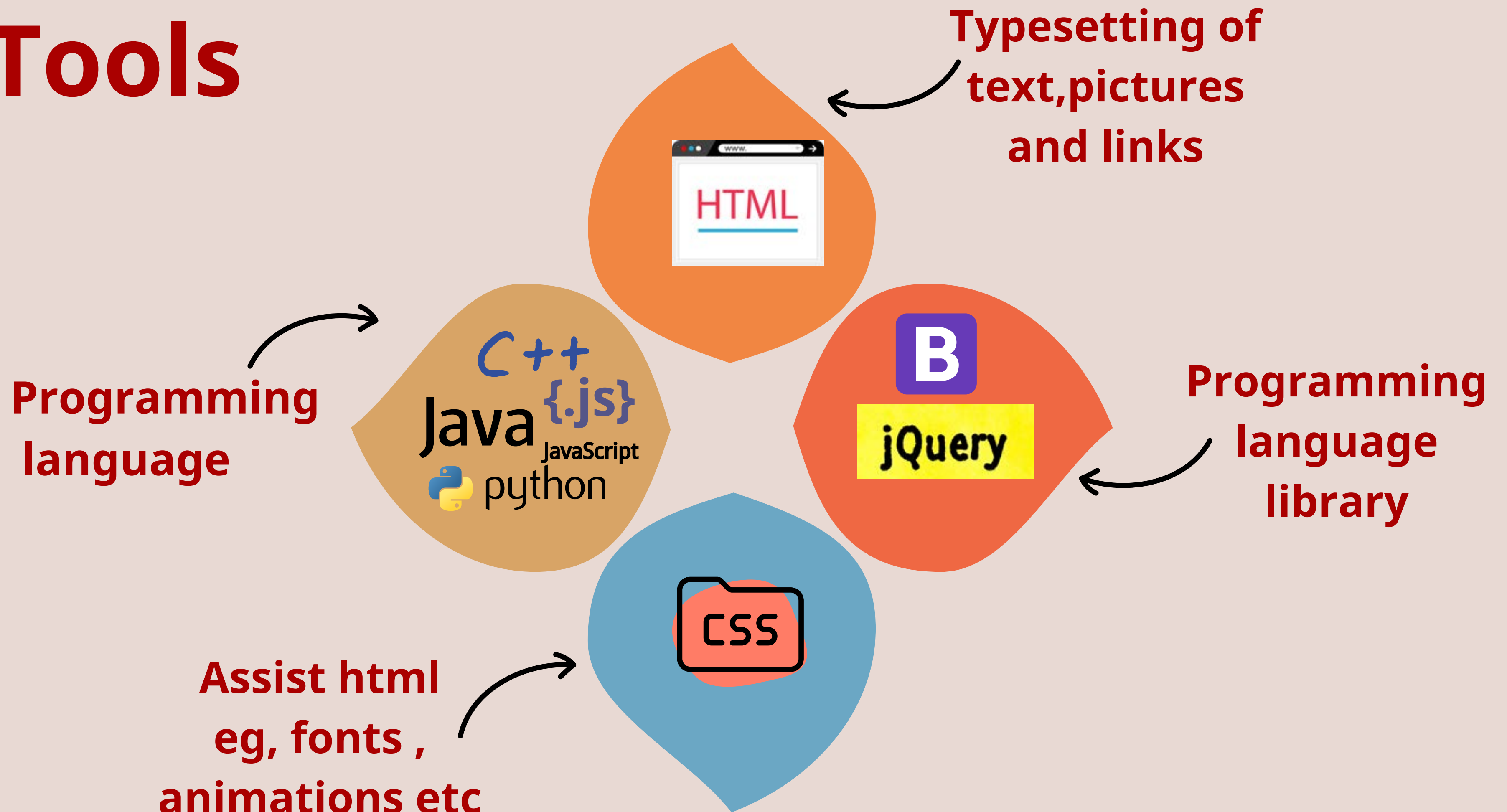


# Step two

**Create your own style**



# Tools



# IMPORTANCE



**Communication**



**Schedule**



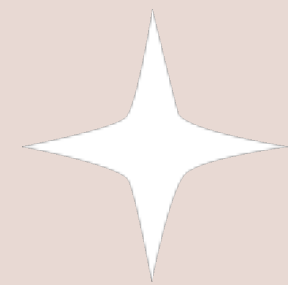
**Reference**

**How your  
team  
wants to  
present**

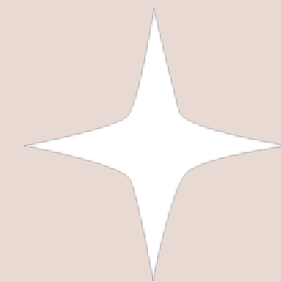
**Start before  
your lab  
experiments**

**Learn from  
works of  
other teams  
or your  
seniors**

# WIKI ON PROGRESS



Loading ...



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The background is a light beige color. It features several large, semi-transparent circles in orange, blue, and yellow. There are also three white, four-pointed stars scattered across the background. The text "THANK YOU FOR LISTENING !" is centered in a bold, dark blue, serif font.

**THANK YOU FOR LISTENING !**