

# Bio-Cities

Bio Sensing for Better Urban Development

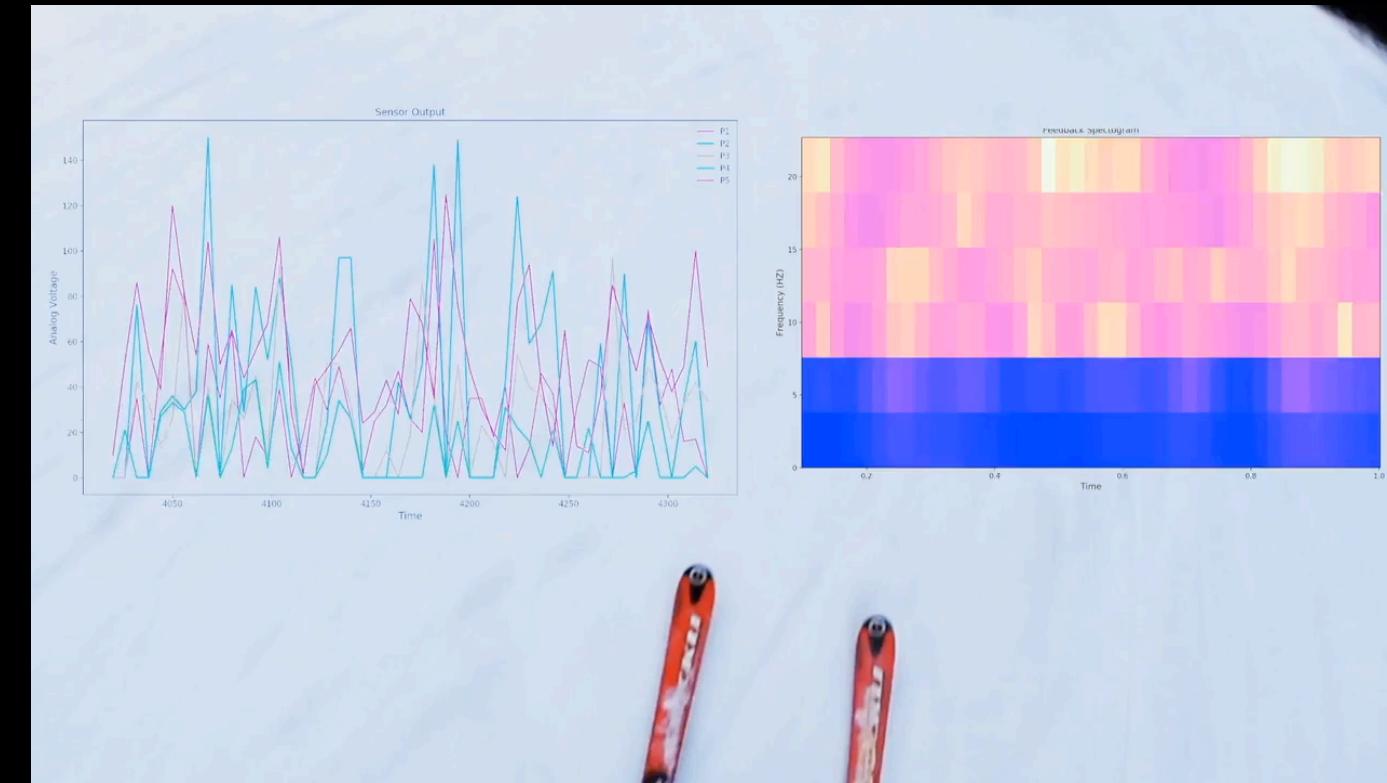
Andres Rico | HTGAA | 2021

# My current sensing adventures...

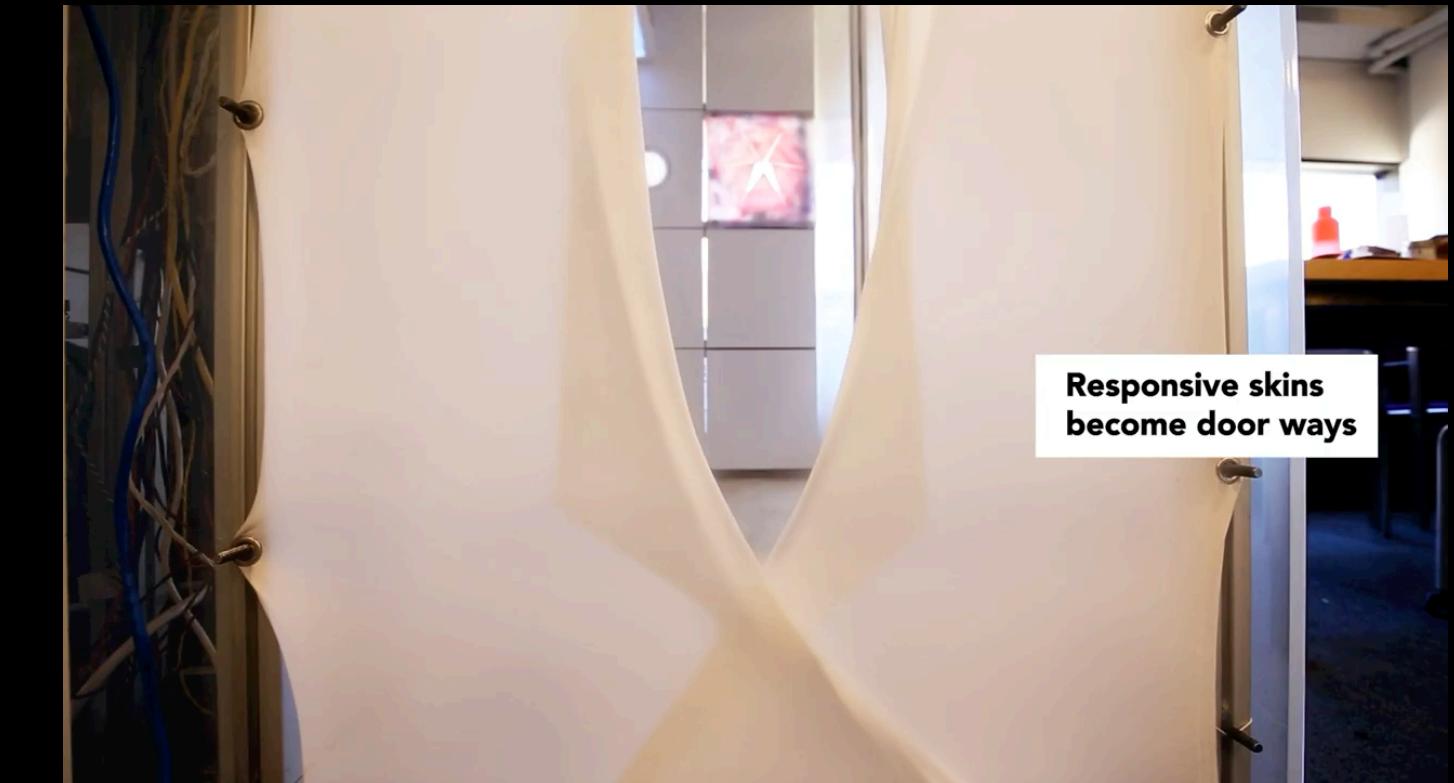
## Sensing at Different City Scales and Environments



Bikes | Mobility [1]



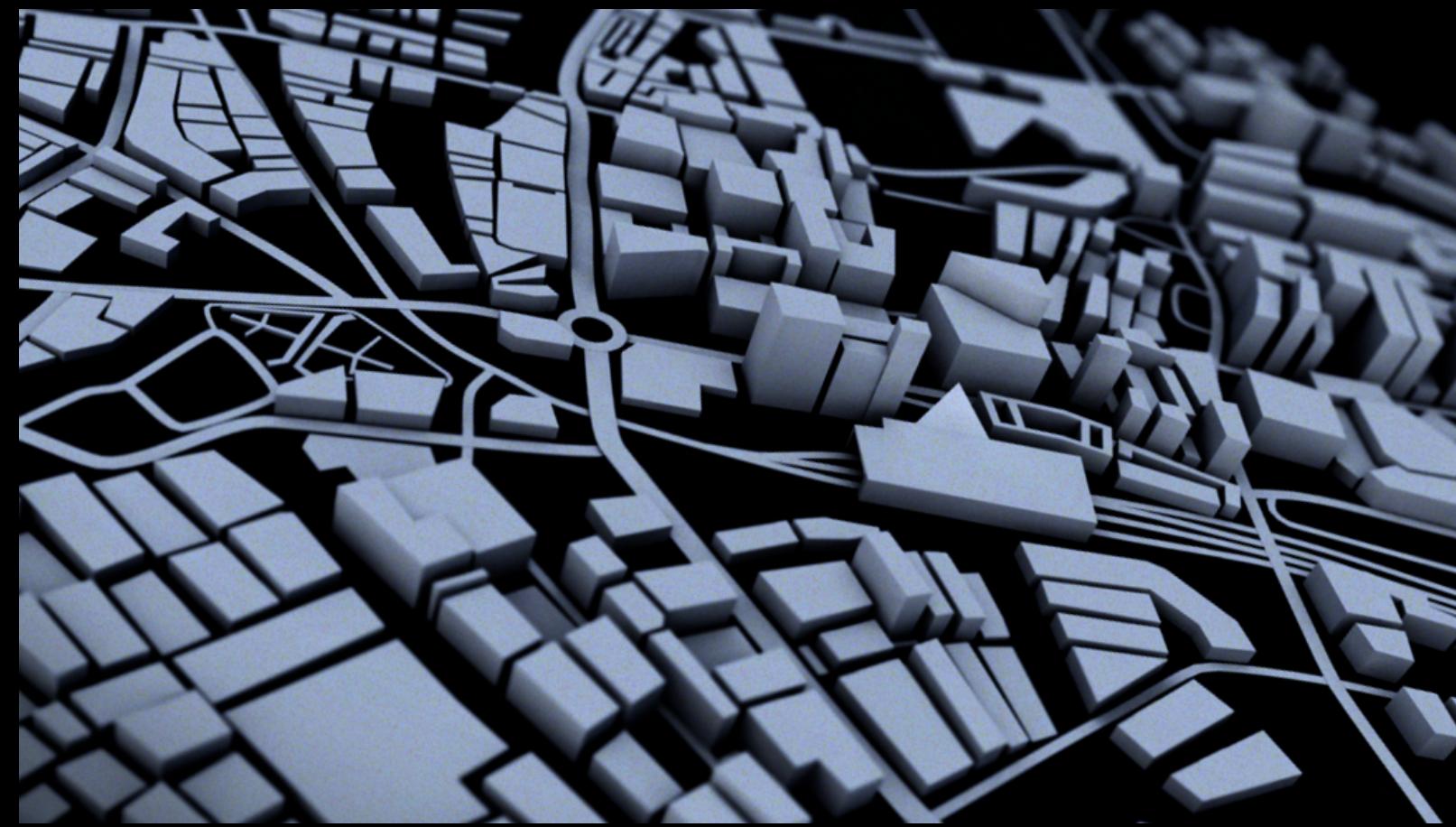
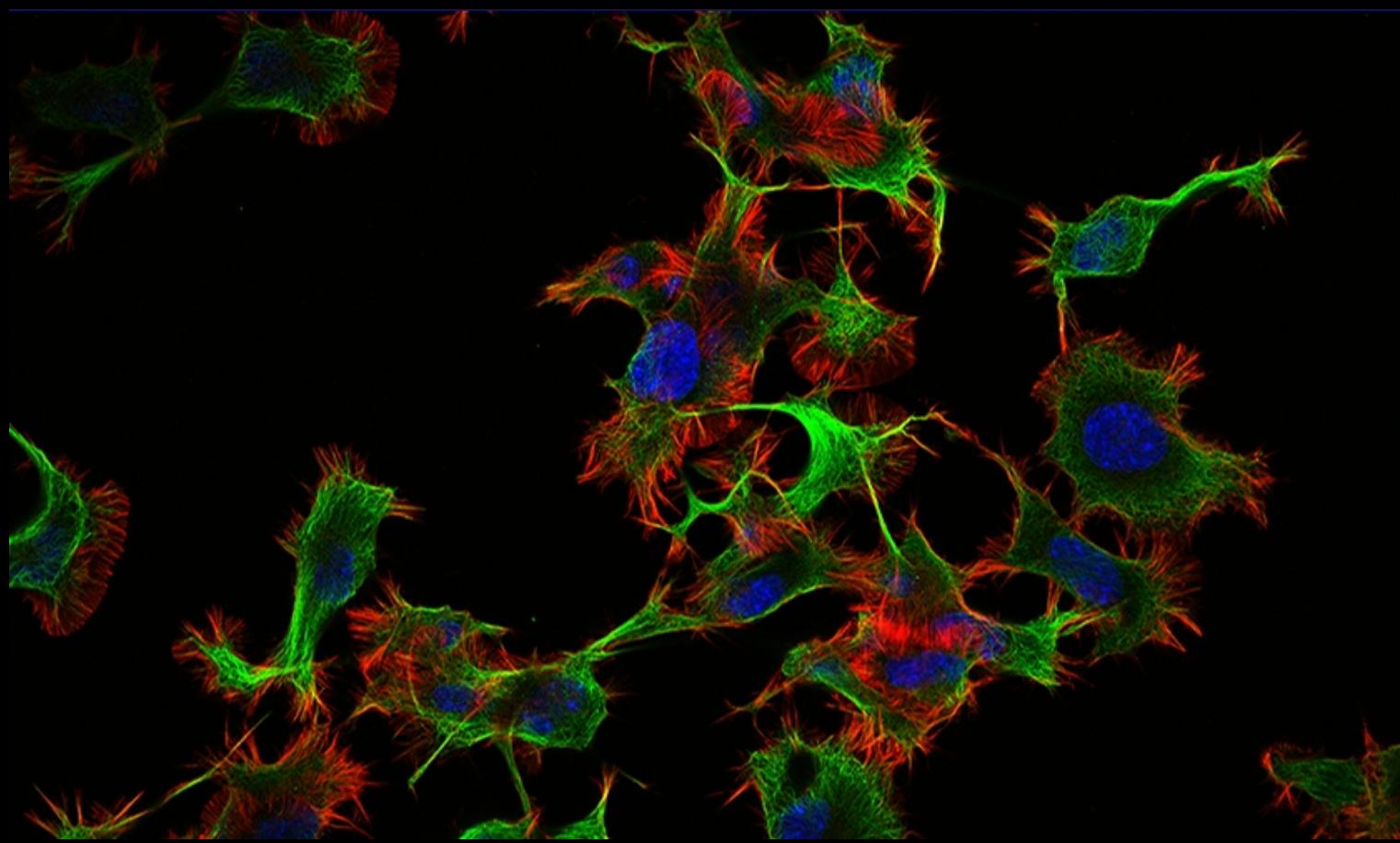
Skis | Environment [2]



Offices | Infrastructure [3]

# Understanding Cities Through Multiple Lenses

## Developing City Imaging Tools



**Biological**



**Social**



**Environmental**



**Physical**



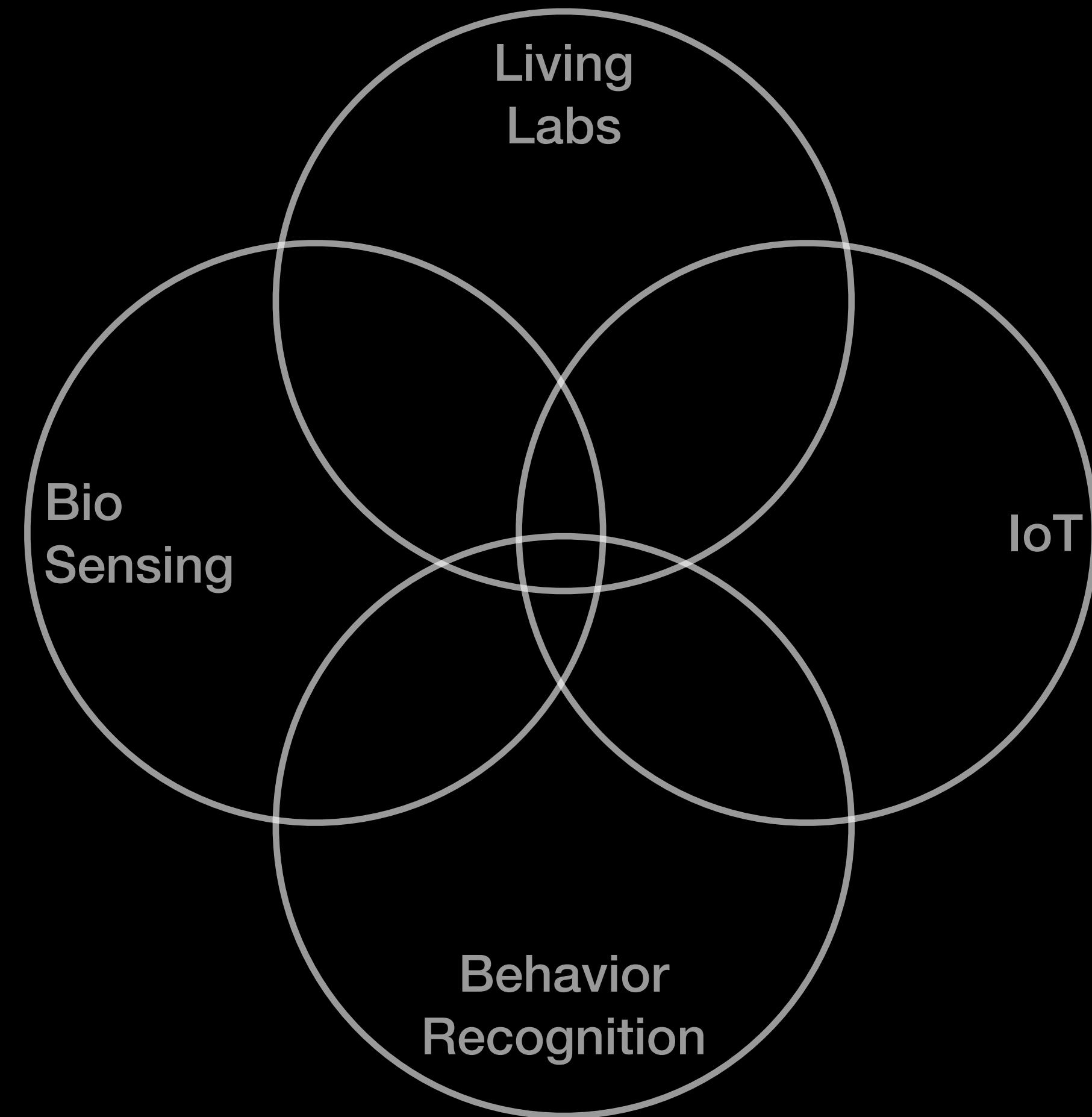
**What can we learn that was previously impossible?  
What can we improve from current sensor  
systems?**



# Aims

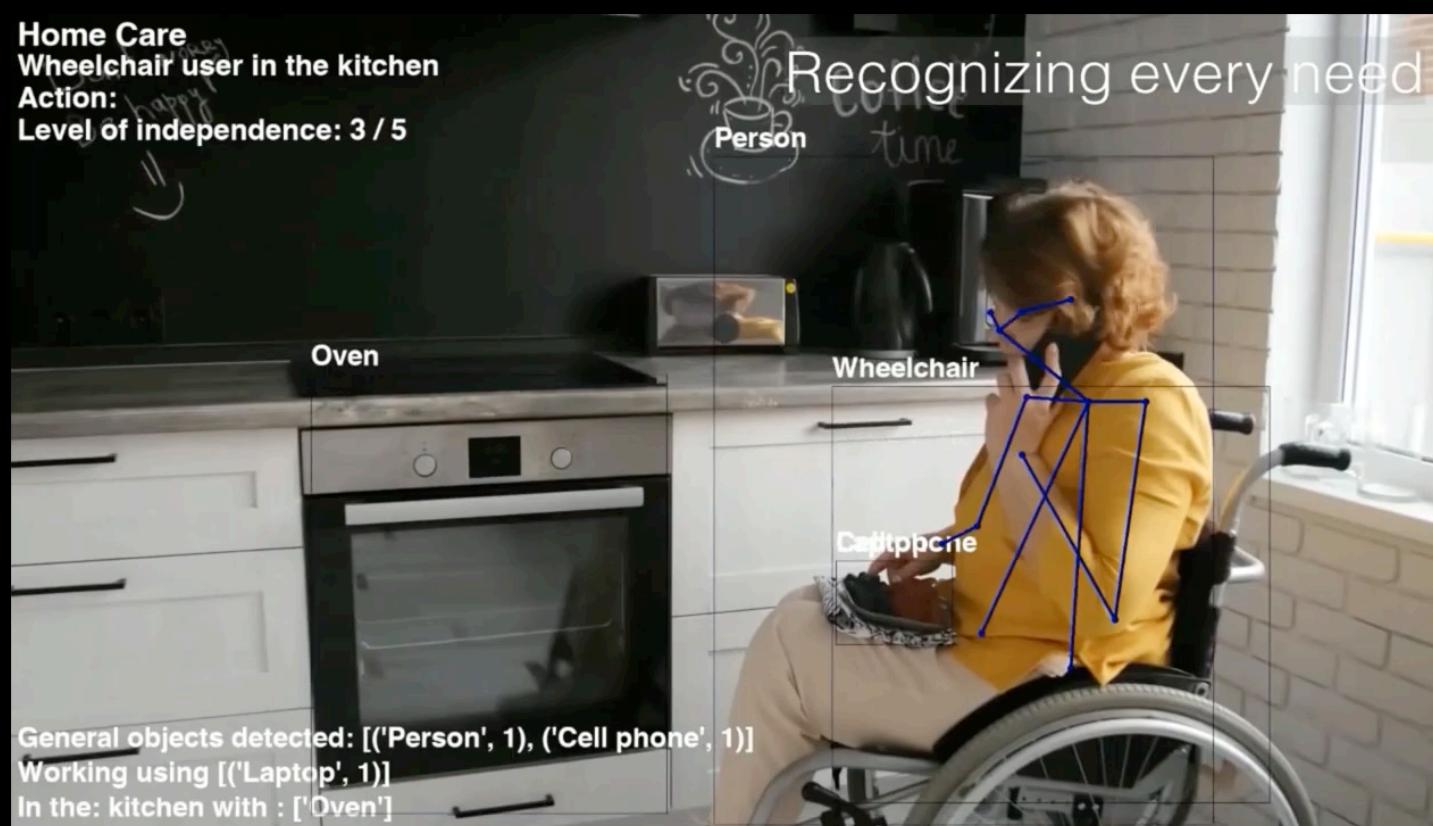
## Intersecting Multiple Fields

1. Implementation of Bio Microphone (**Bio Sensing**)
  - 1.1.Sound Responsive Bacterial Growth
    - 1.1.1. Experiment 1
  - 1.2. Sound Responsive Gene Expression
    - 1.2.1.Experiment 2
    - 1.2.2.Experiment 4
  - 1.3. Bio - Digital Interface
2. Taking Sensors and Experiments Outside of the Lab (**Living Labs**)
  - 2.1. Portable - Low Cost Sensor Incubator Design
  - 2.2. Agar Culture (Time Constrained Field Experiments)
    - 2.2.1. Experiment 3
  - 2.3. Live Culture
3. Sensing in Cities (**City IoT | Behavior Recognition**)
  - 3.1. Vision
  - 3.2.Obstacles

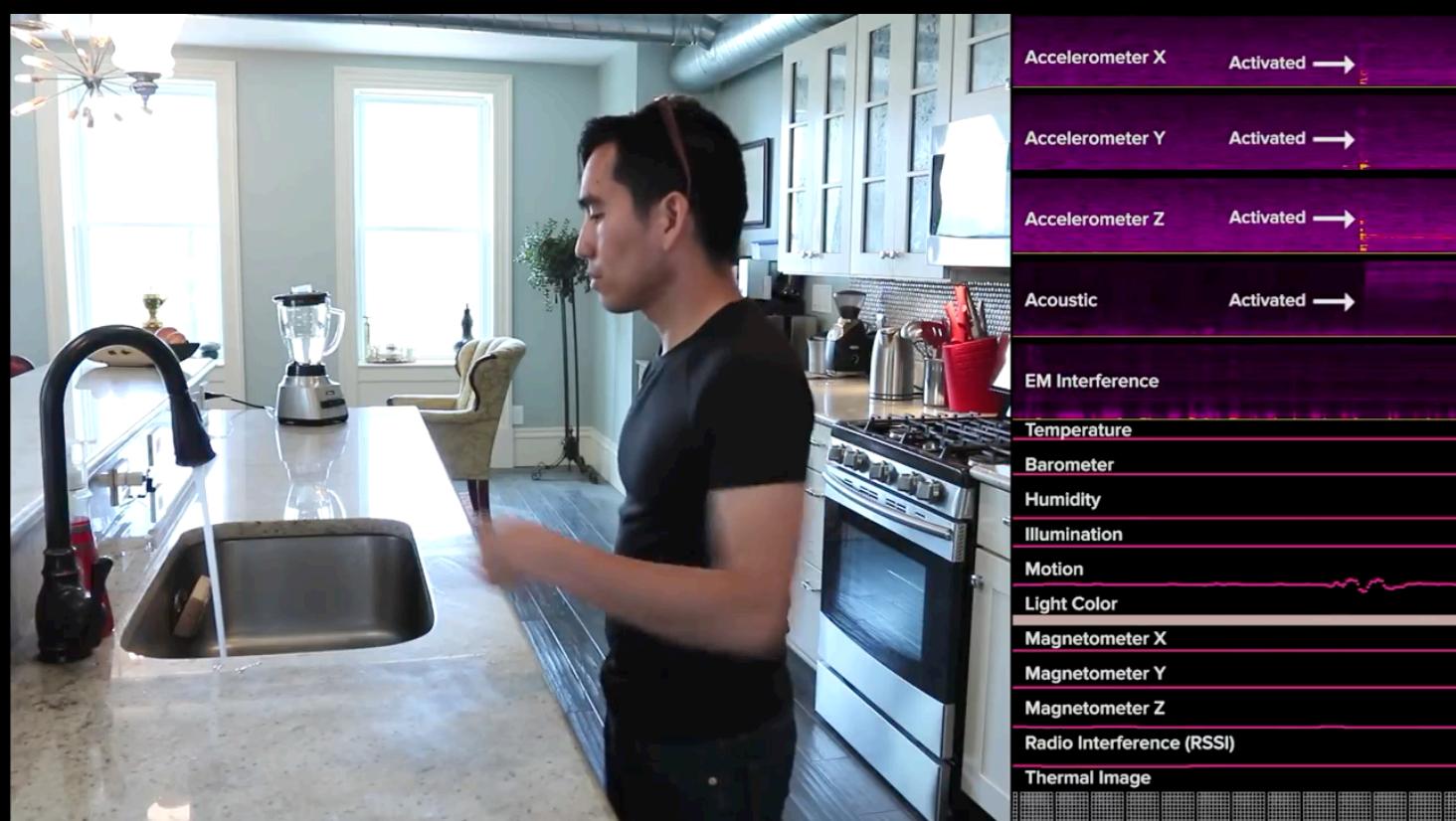


# Aim. 1 Bio Microphone

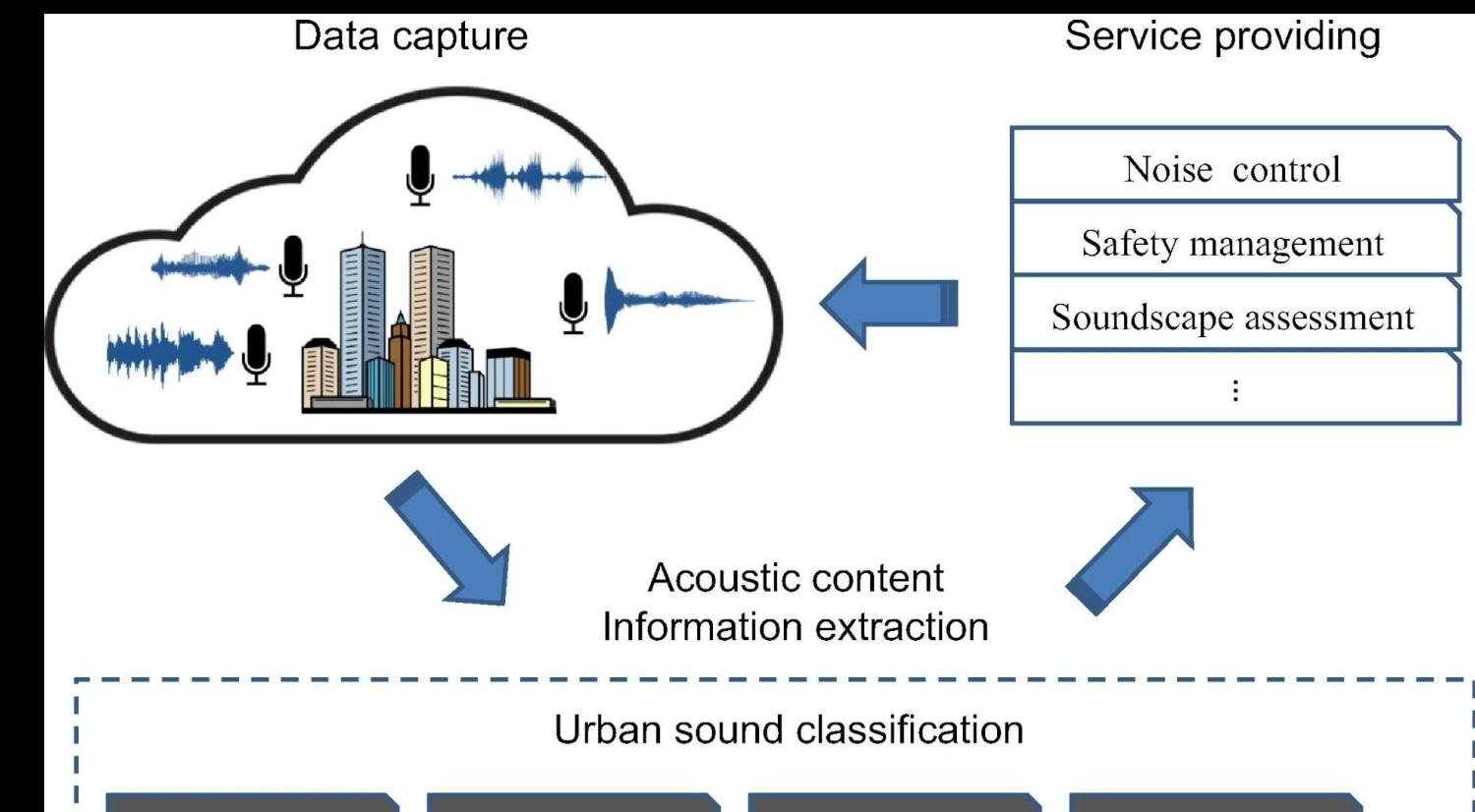
## Motivations & Inspiration



[4]



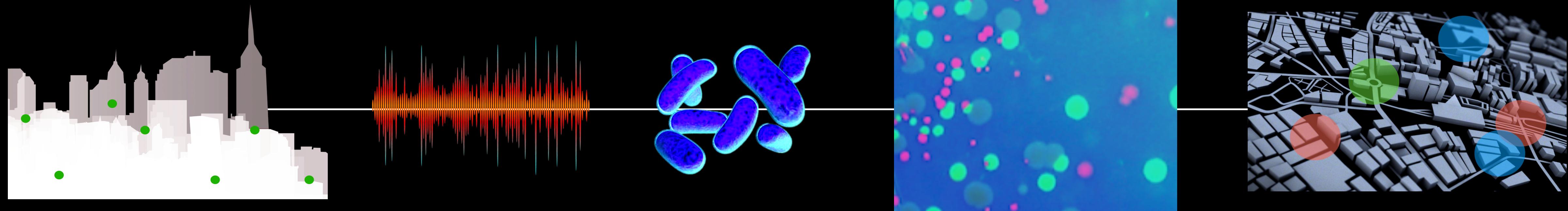
[5]



[6]

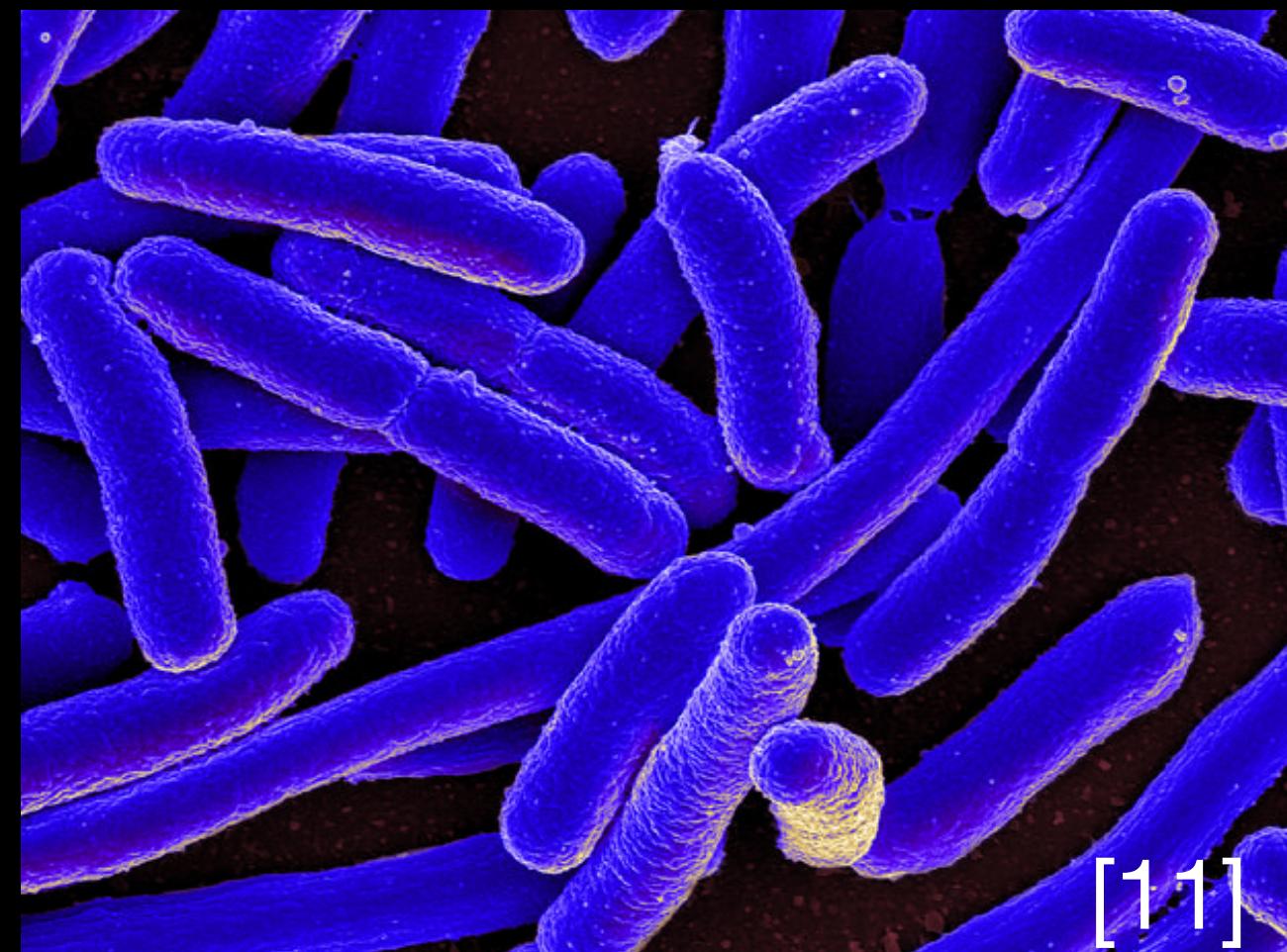
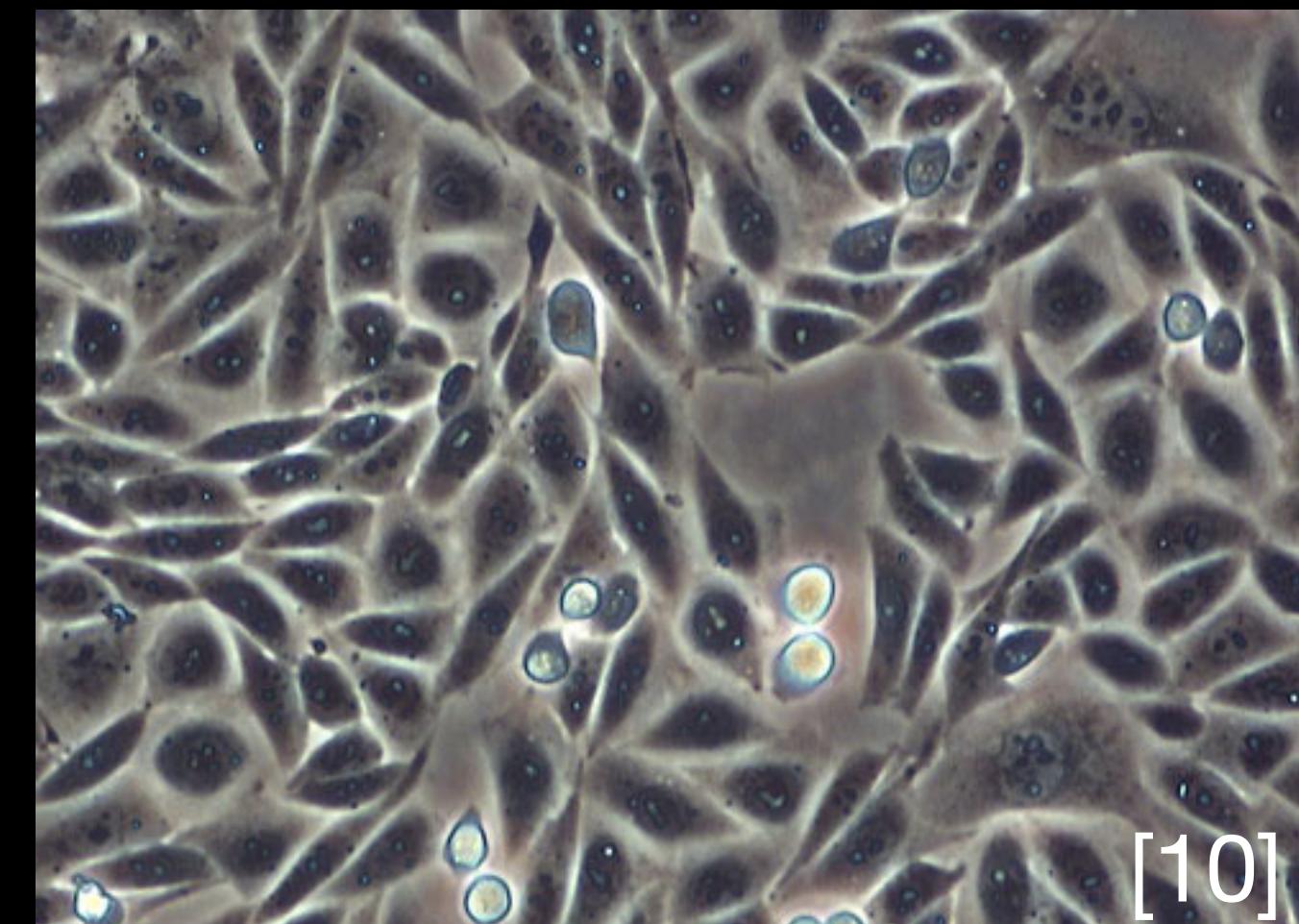
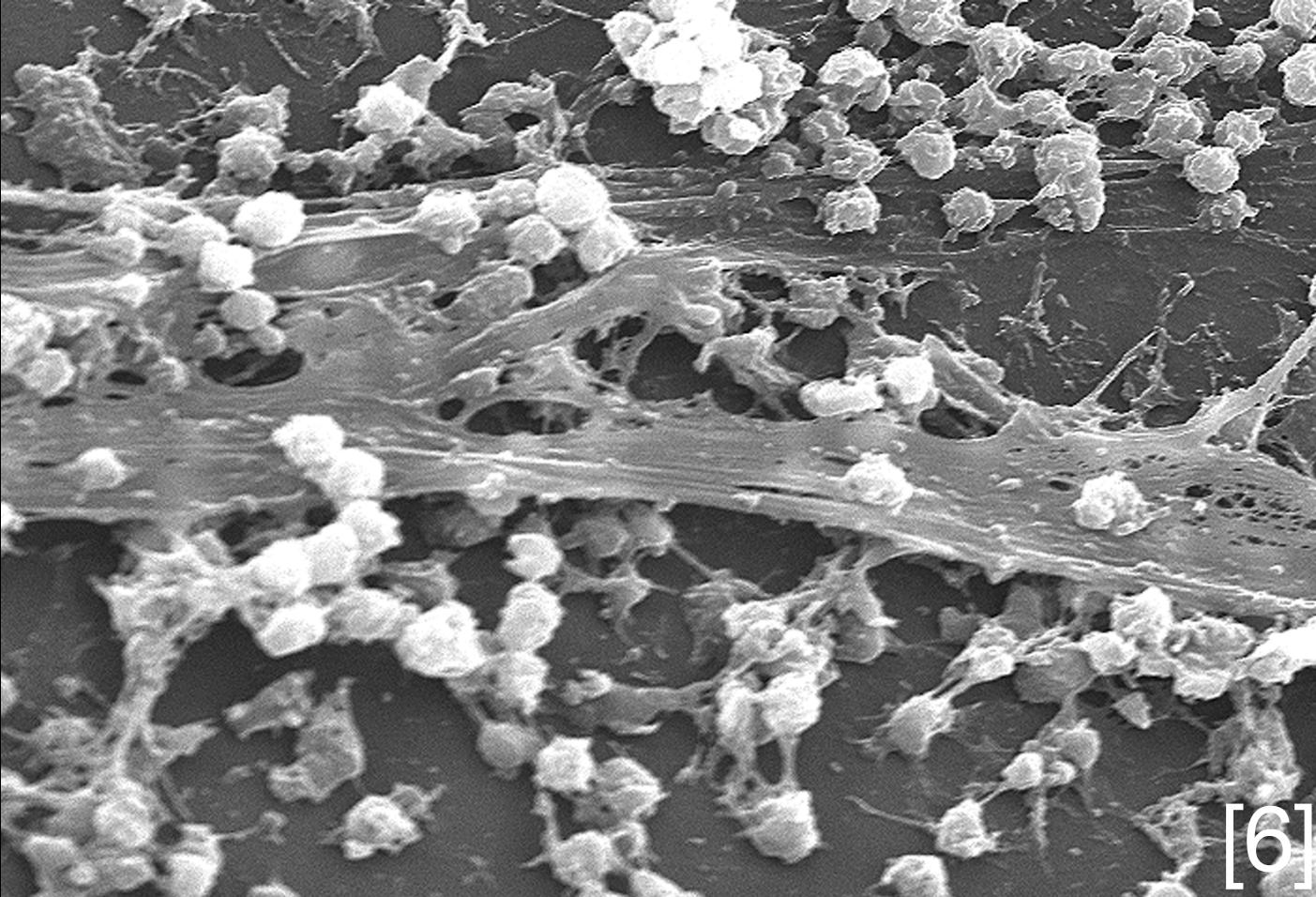
# Aim. 1 Bio Microphone

## System Description



# Sound & Gene Expression

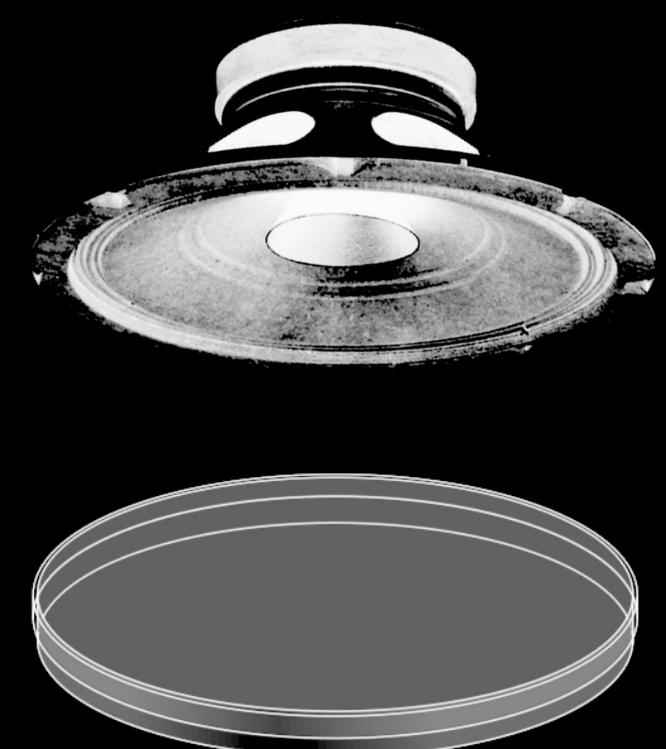
## Some Interesting Publications



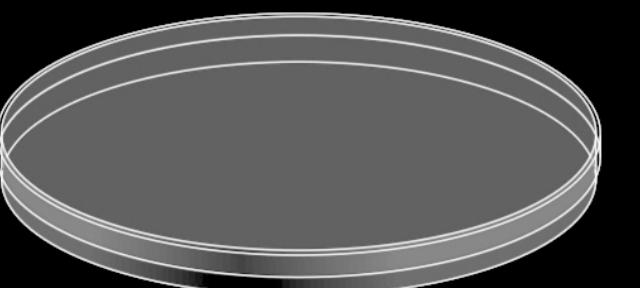
# Experiment 1

## E. Coli Culture - Testing effects of sound on growth

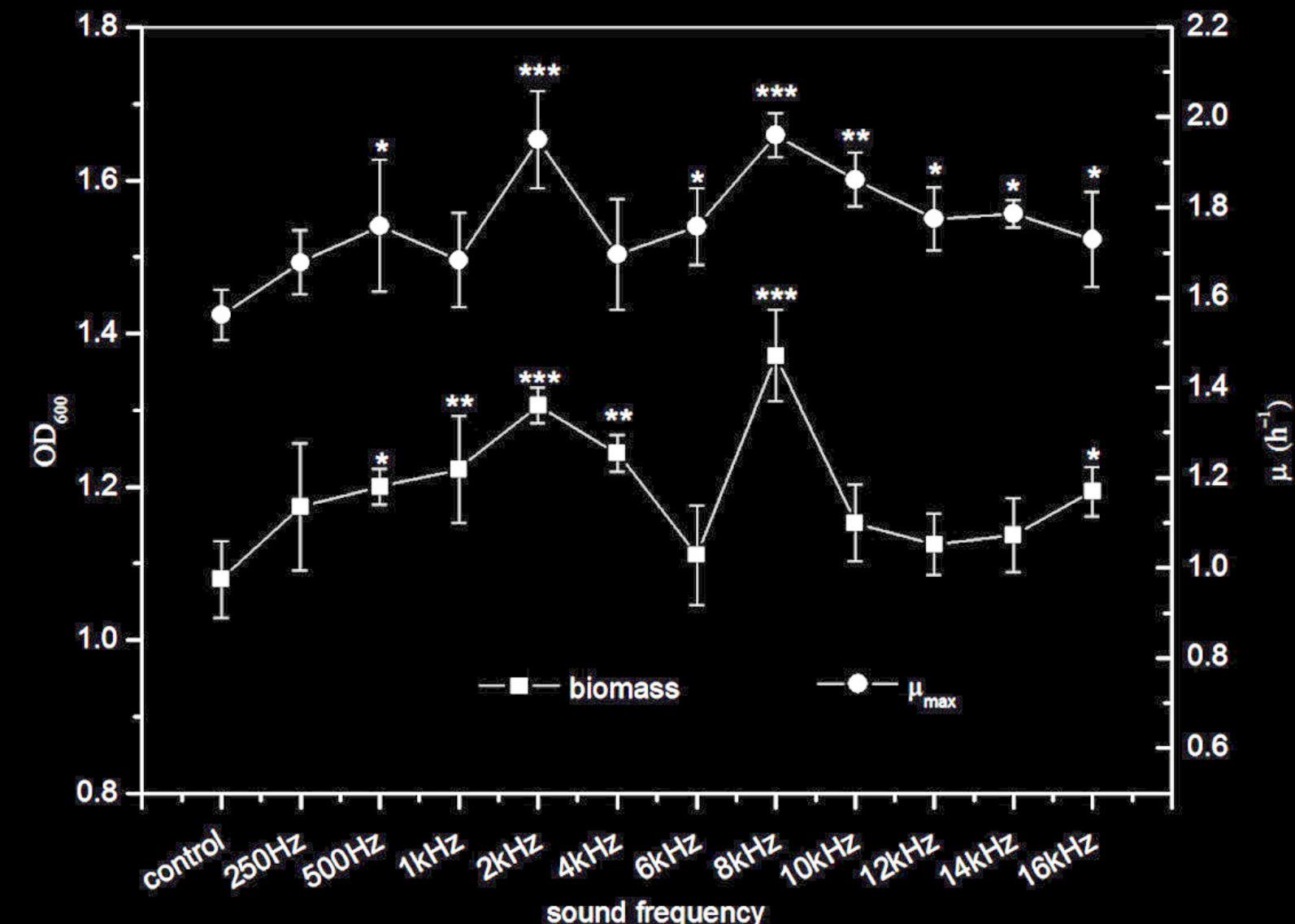
- puc19 E. coli from W4
- Agar Plate
- 8,000Hz 80dB
- Carried Out Within Lab Incubator



Experiment



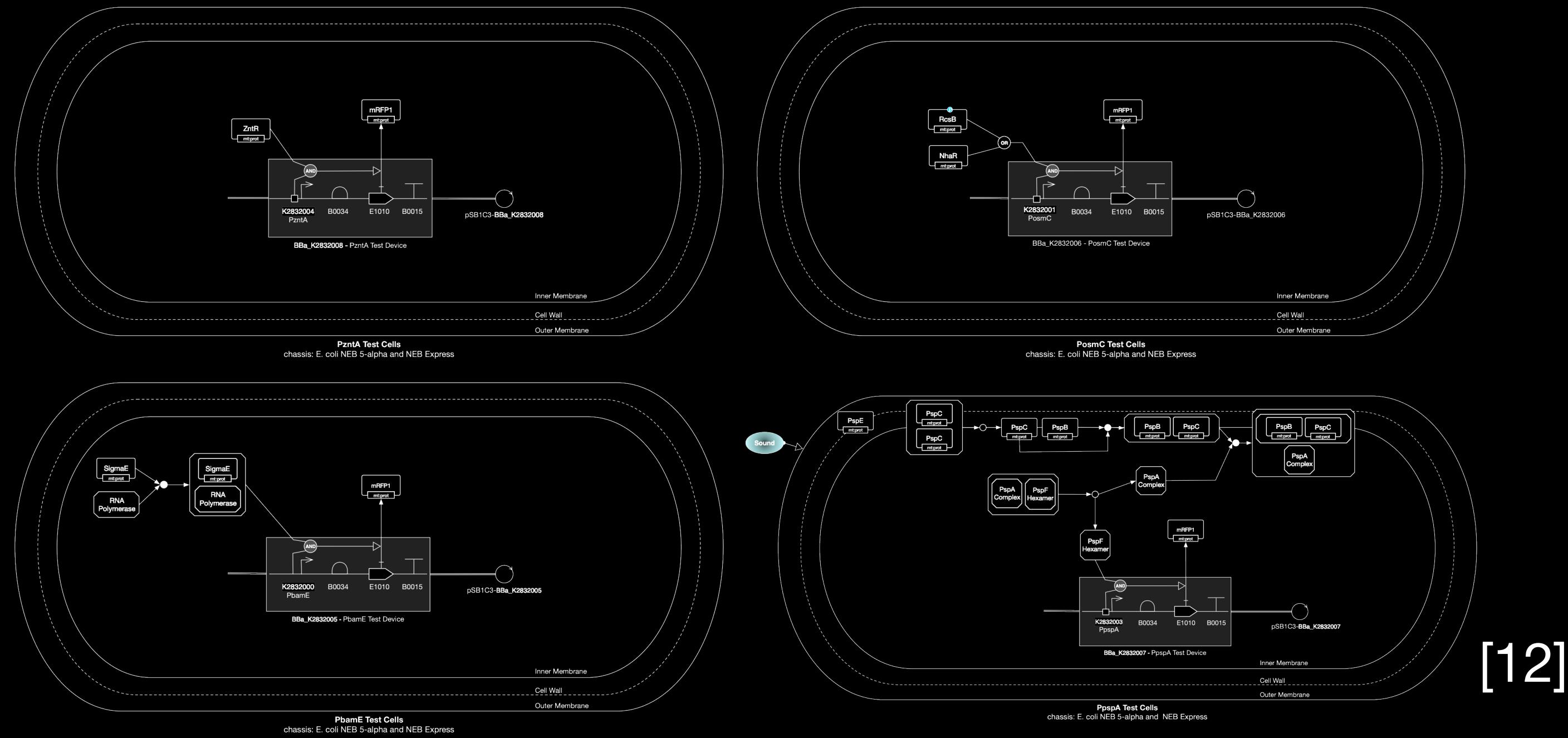
Negative Control



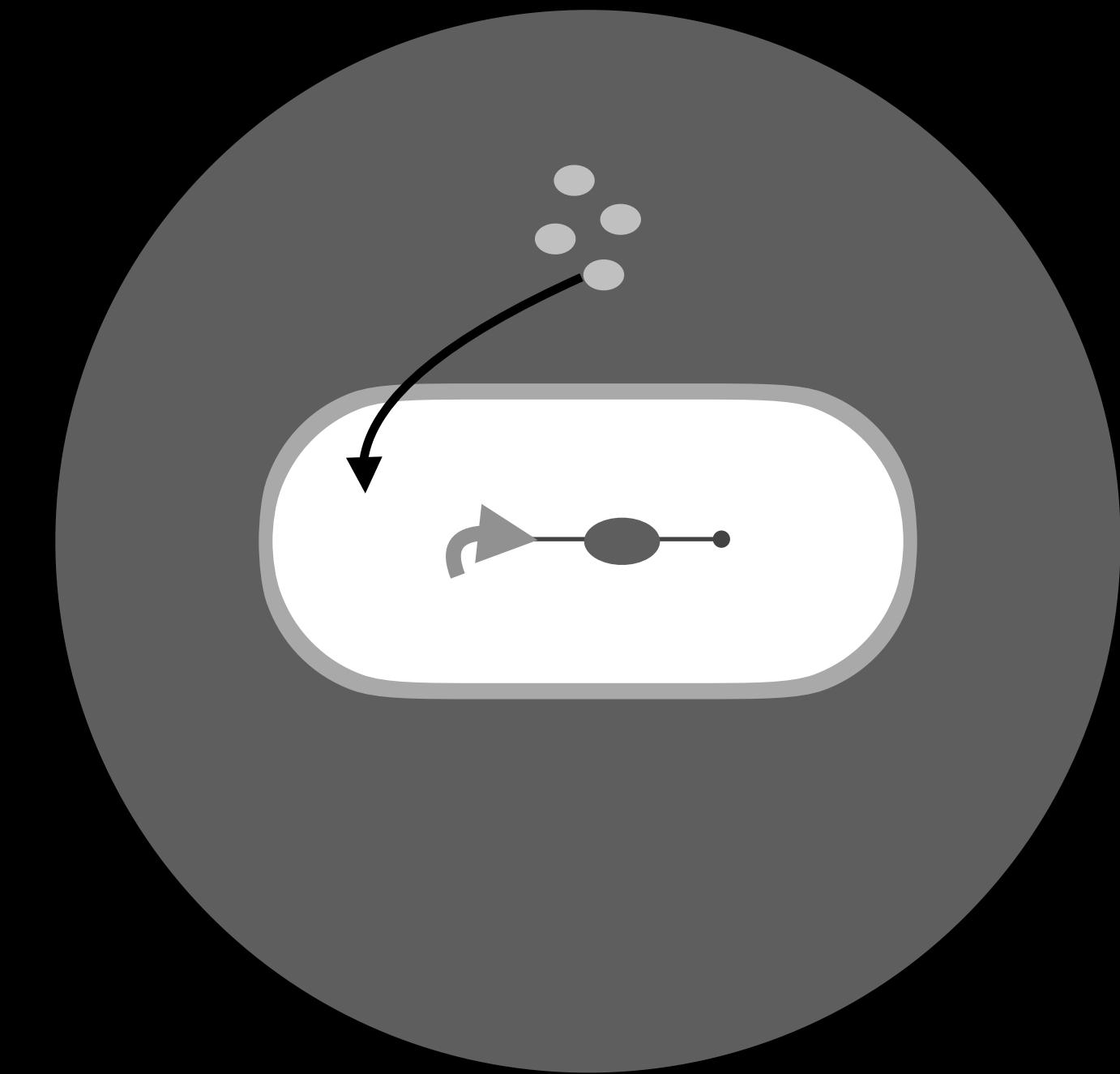
[11]

# Sound Stimulated Gene Expression

## Mechanosensitive Channels for Transduction of Sound



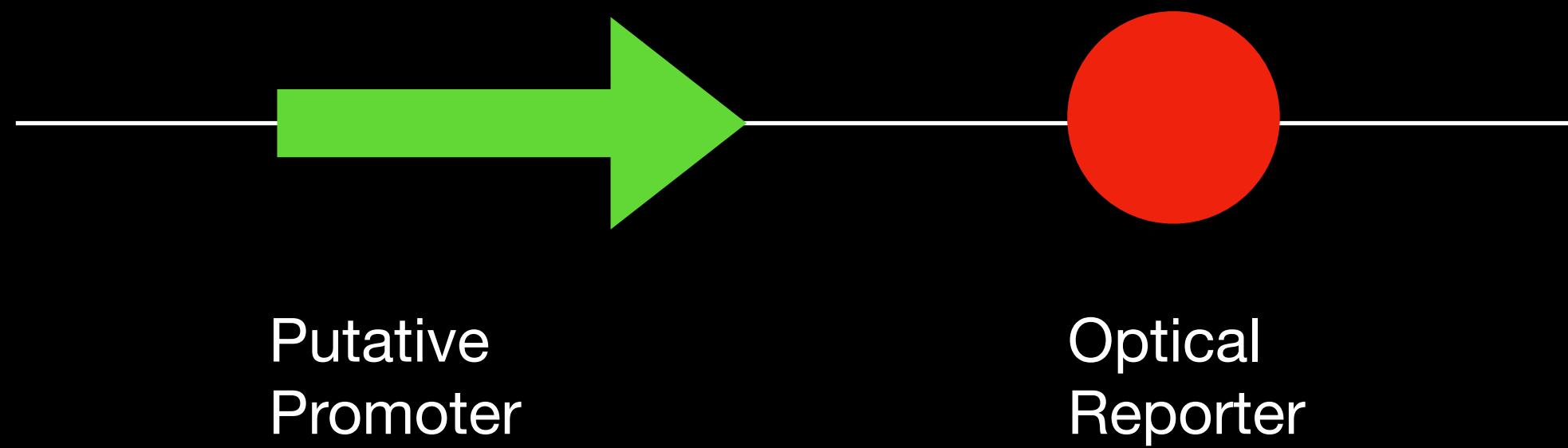
[12]



Maybe for HTGAA 2.0?

# My Basic Gene Design and Test

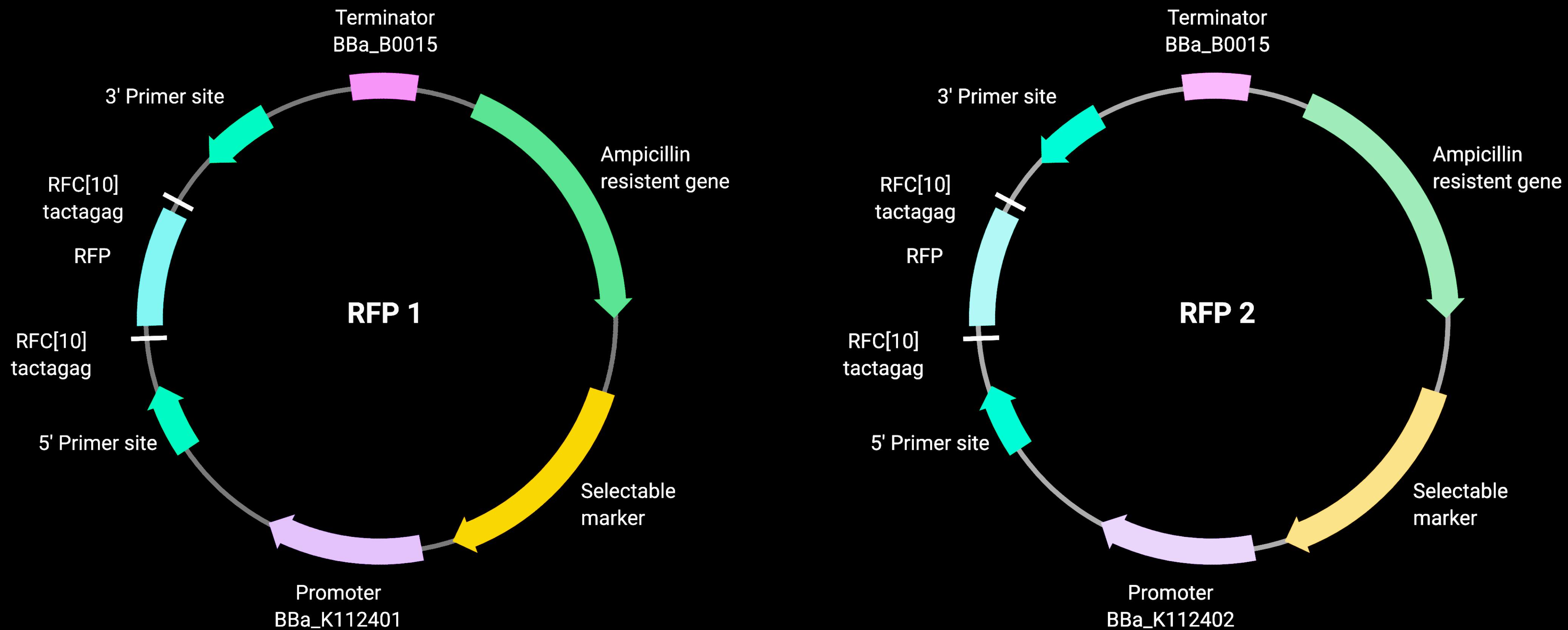
## Upregulation and Downregulation vs Activation



- iGEM 2008 - UC Berkley [13]
- iGEM 2016 - Florida State University [12]

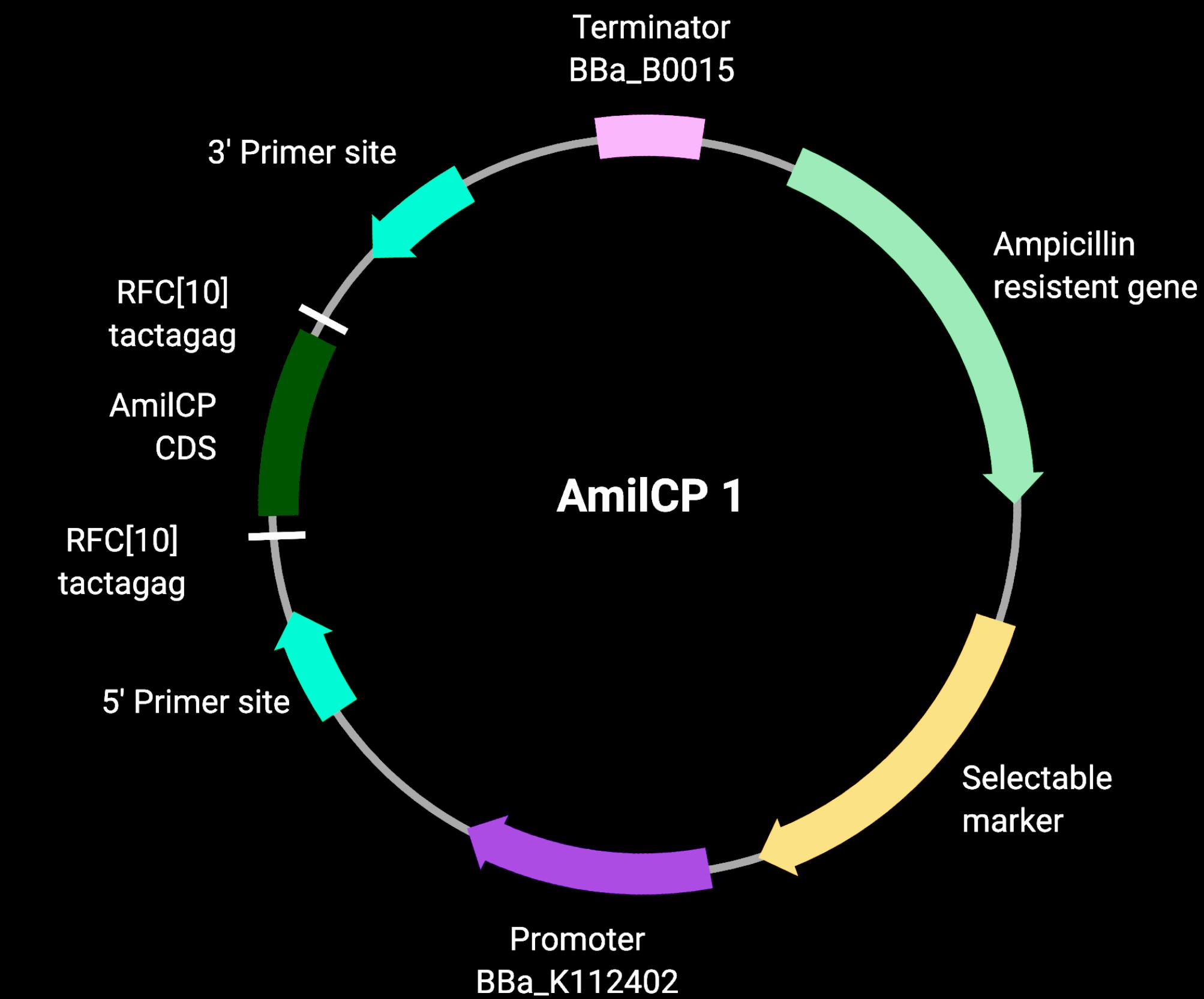
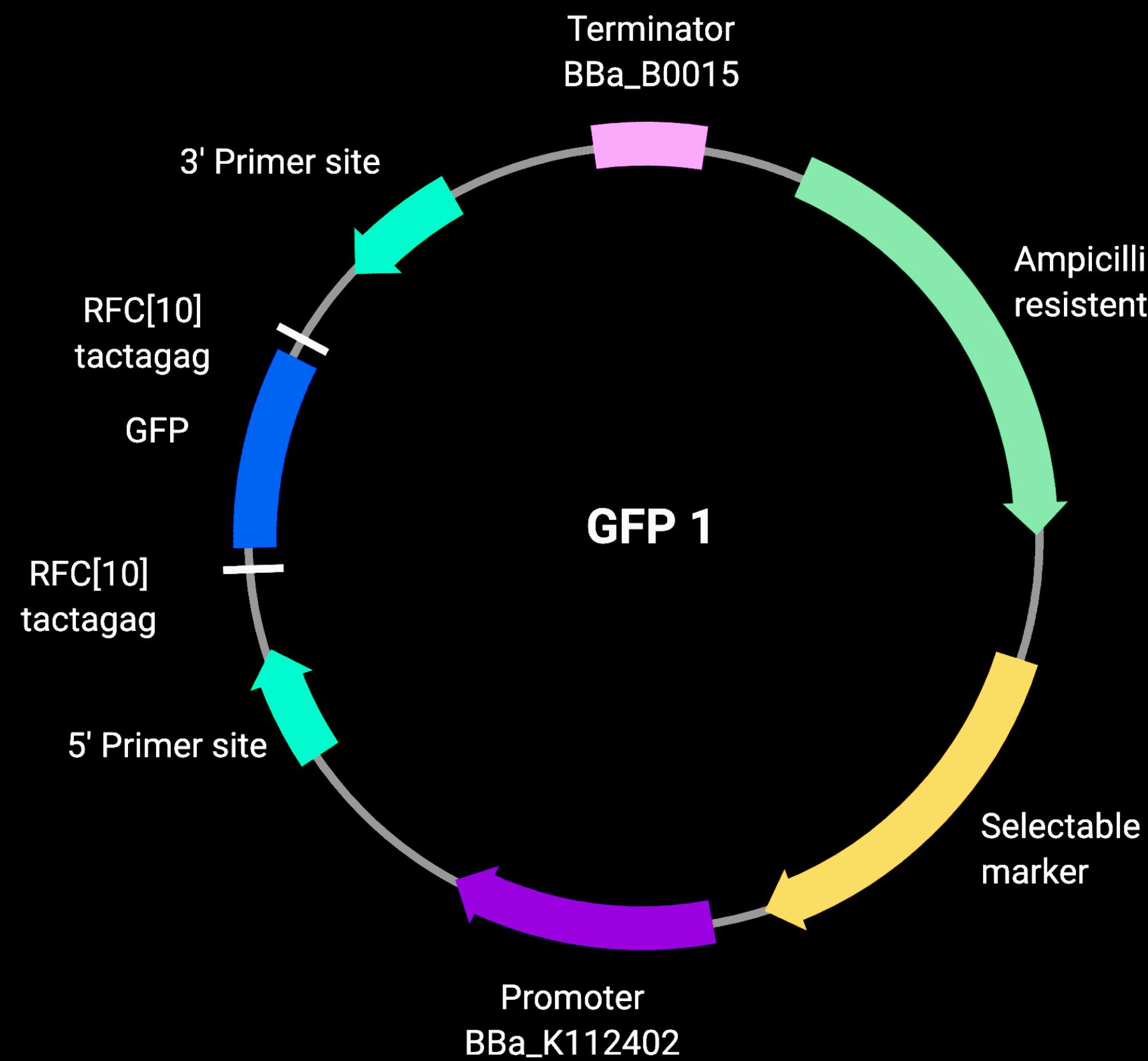
# Plasmid Design

iGem Parts → TWIST Amp Backbone



# Plasmid Design

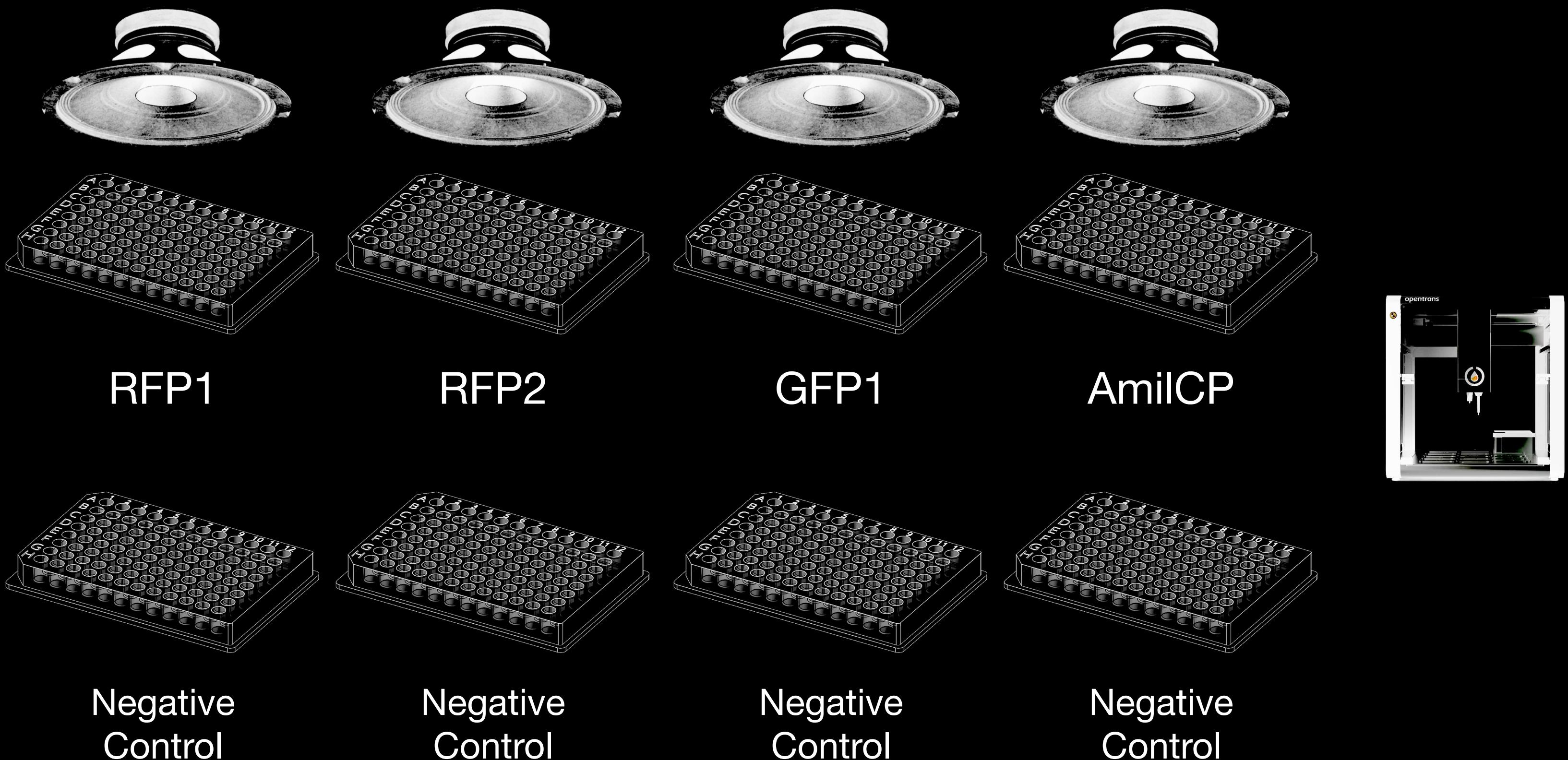
Modified iGem Parts [12] → TWIST Amp Backbone



# Experiment 2

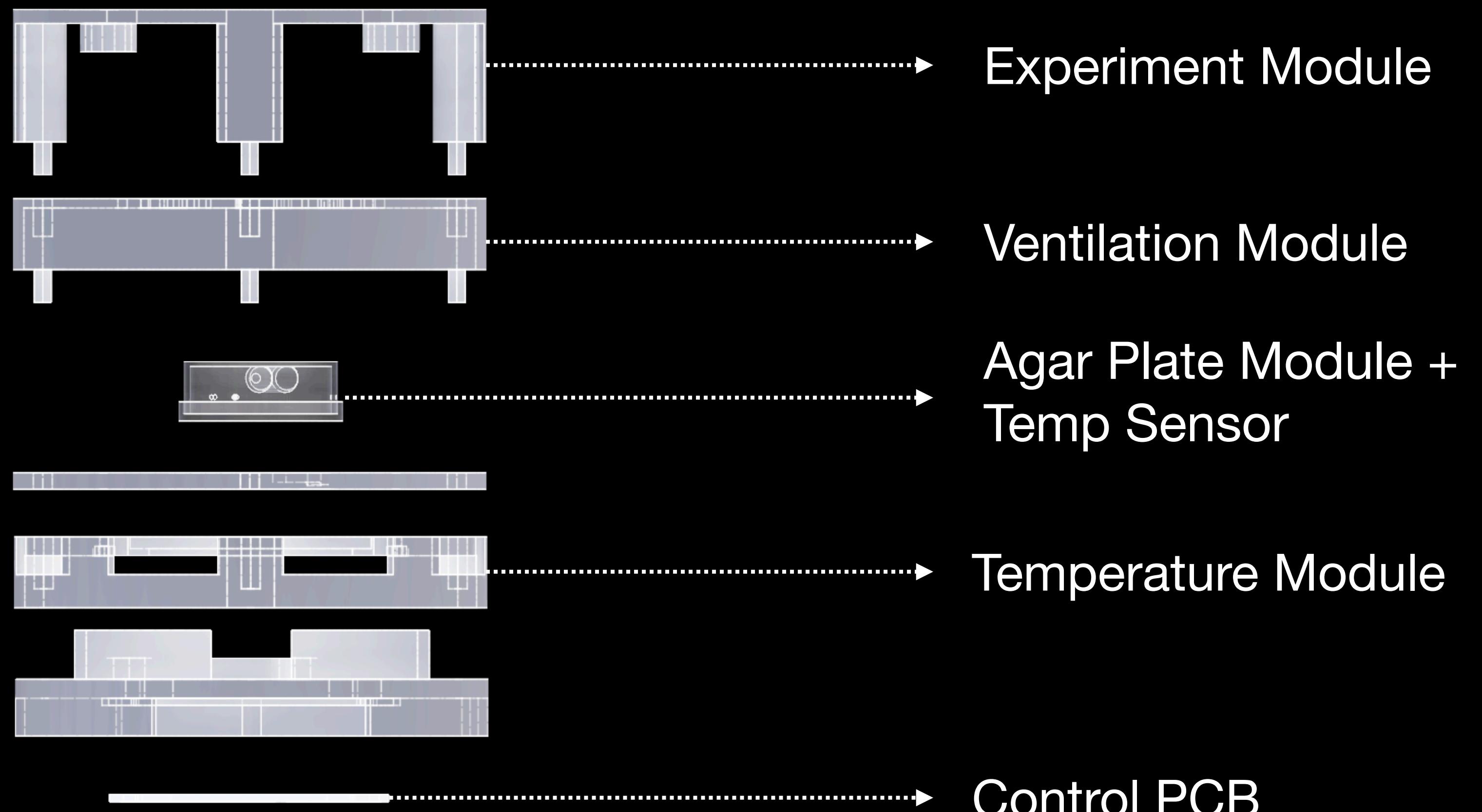
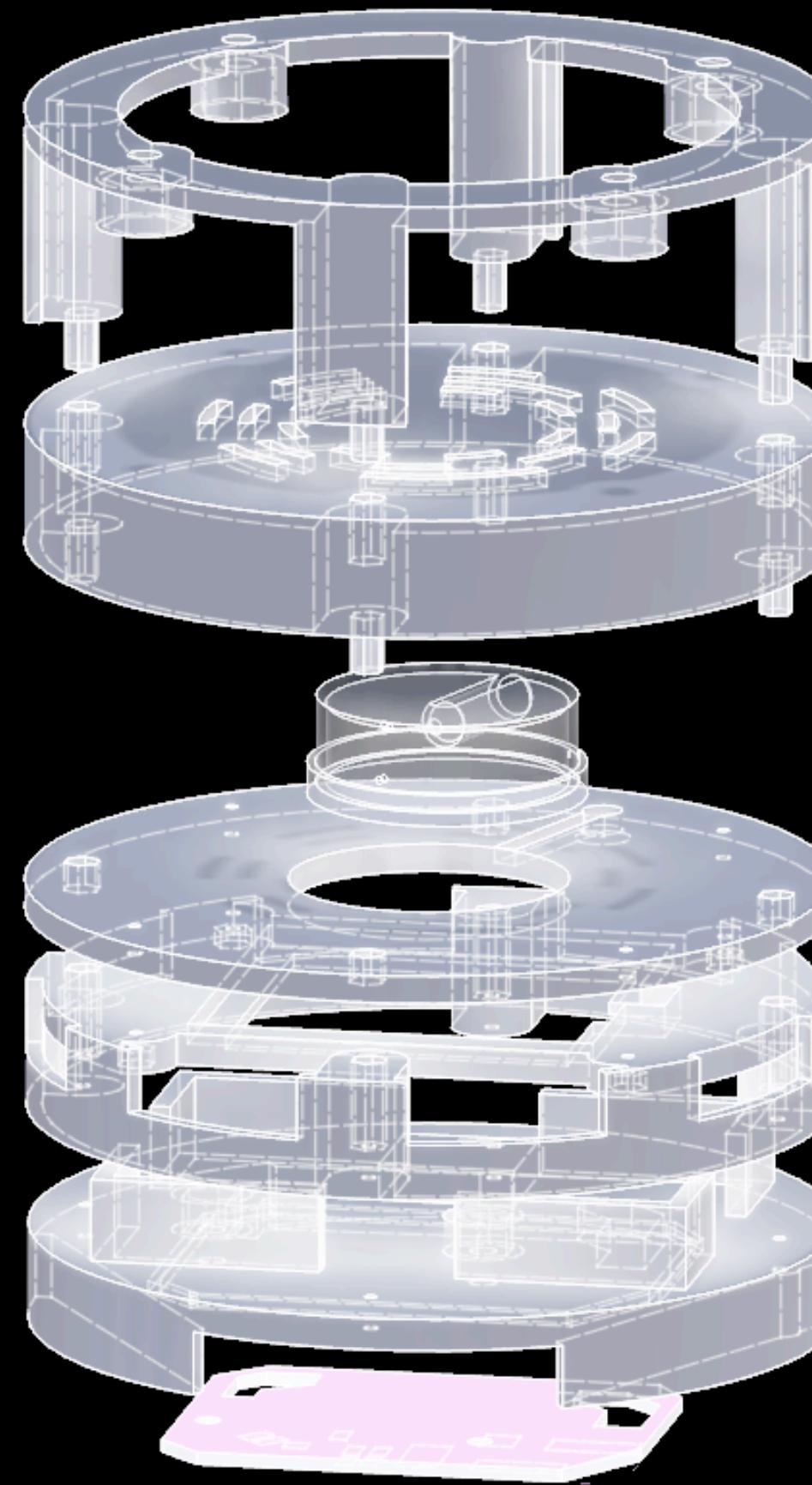
## Testing gene expression stimulated by sound

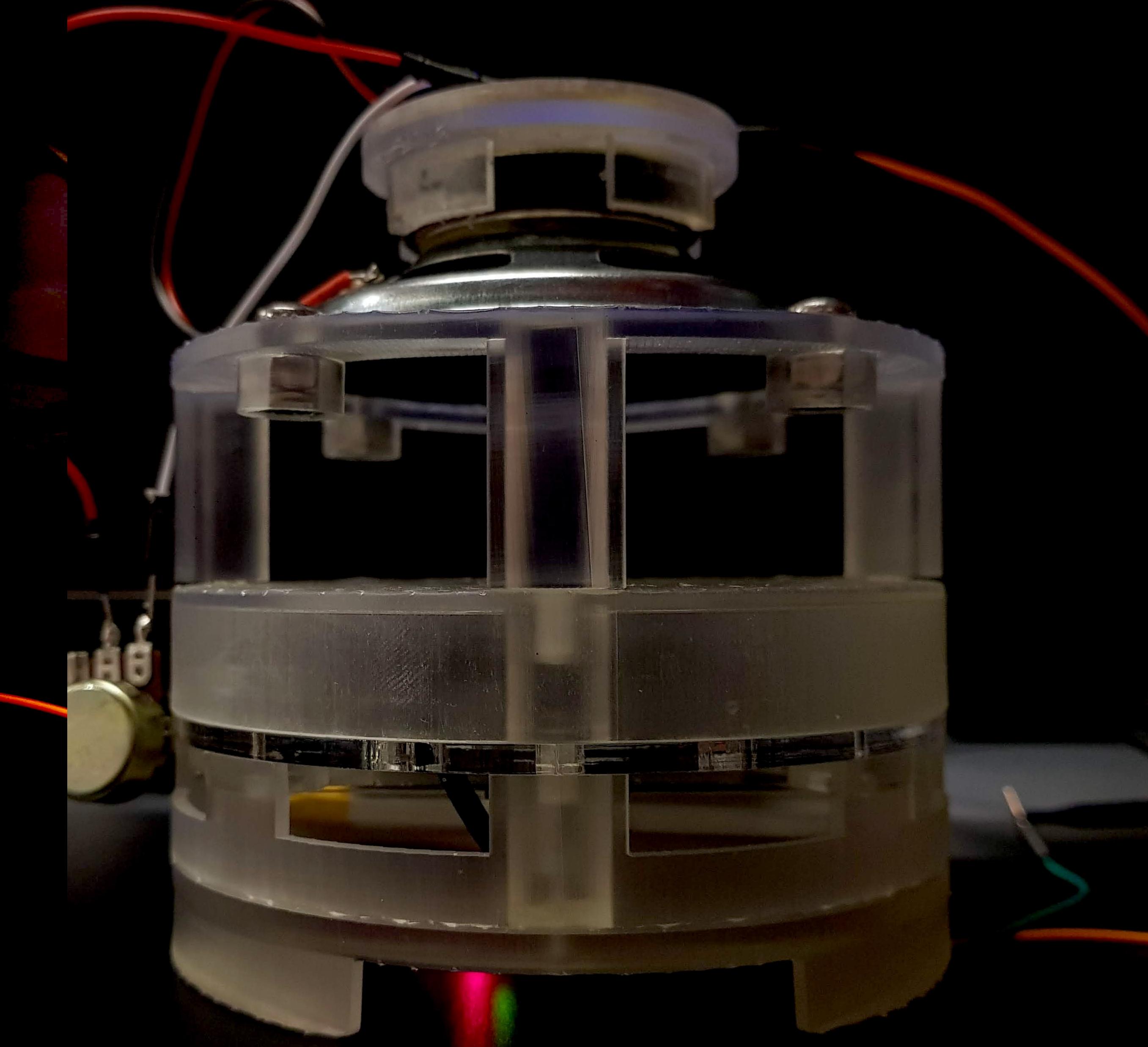
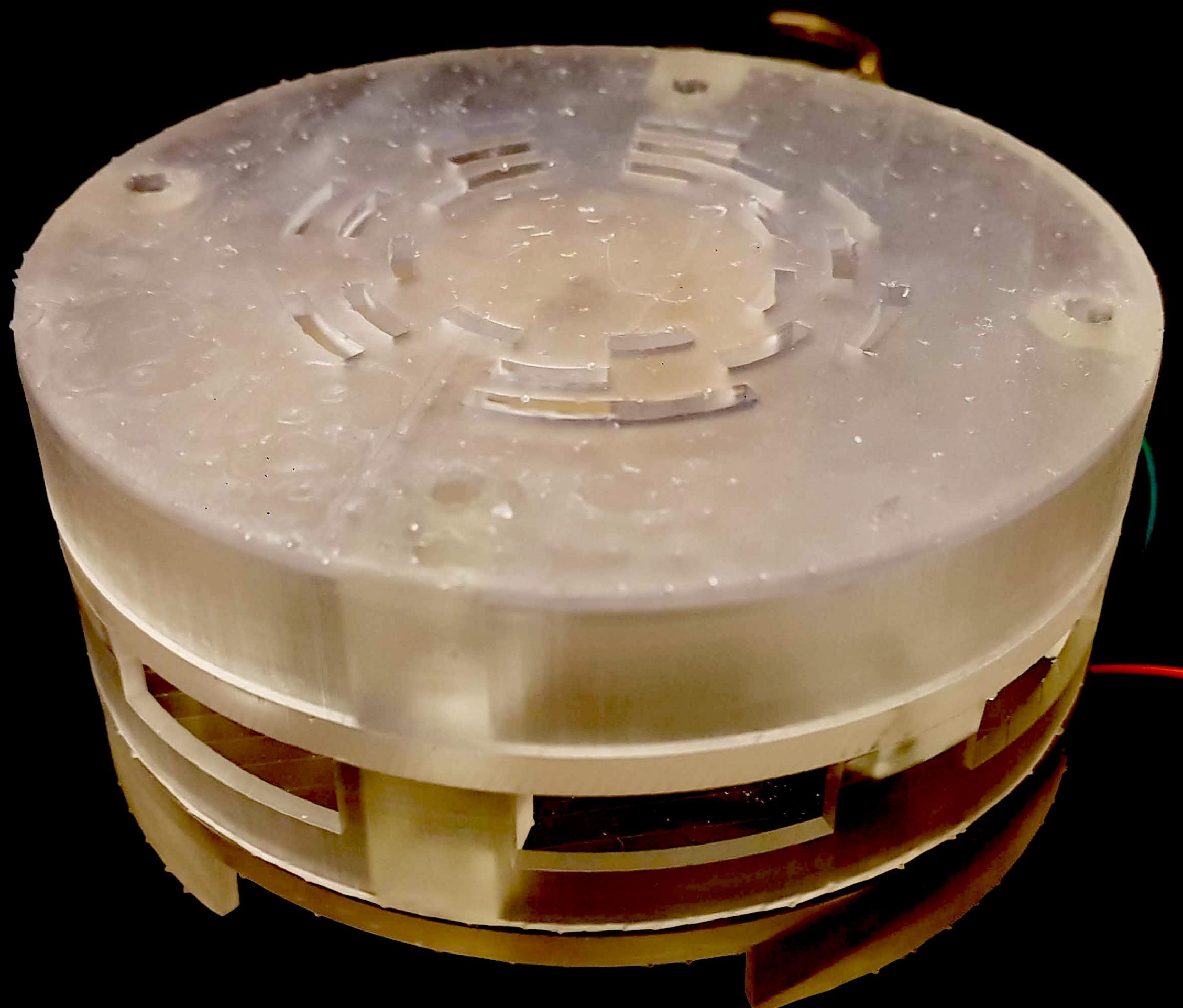
- RFP1 - RFP2 - GFP1 - AMILCP E. coli
- 96 Well Plate [12]
- 8,000Hz 80dB [12]
- Liquid culture and fluorescence spectrometry for analyzing results.



# Aim 2. Taking Bio Sensors and Experiments Out of The Lab

## Designing a Low Cost Modular Bio Sensor Incubator



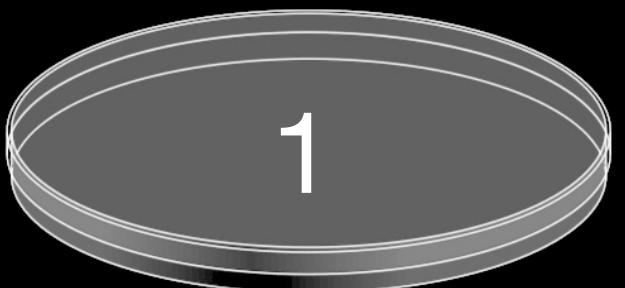


# Experiment 3.1

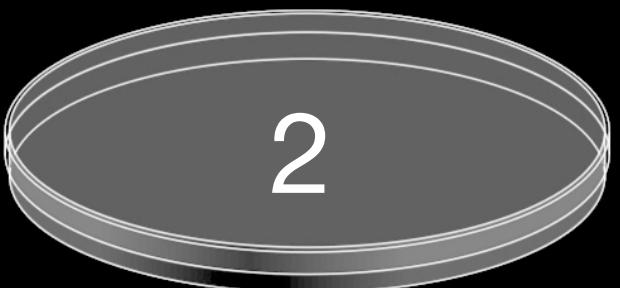
## Bacterial Growth

Incubator			Petri	
Commercial (C)	Andres (A)	Outside (O)	Commercial (C)	Andres (A)

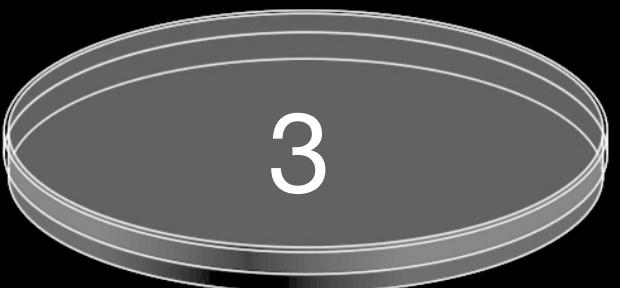
C - C - (+)



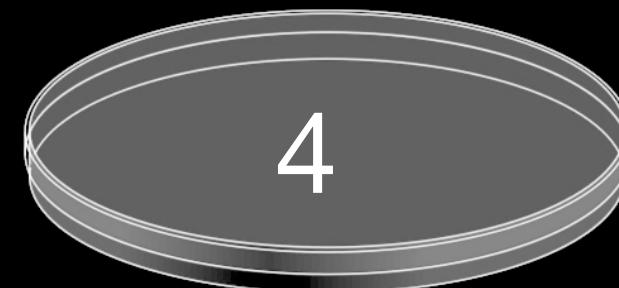
C - A



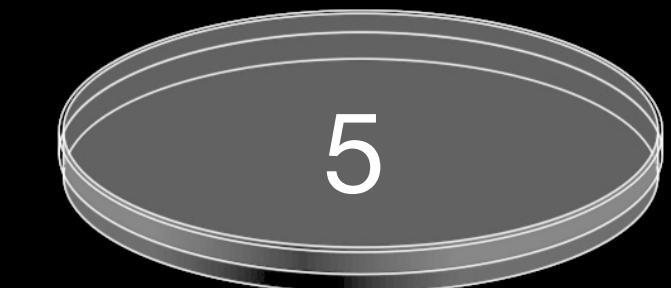
A - A



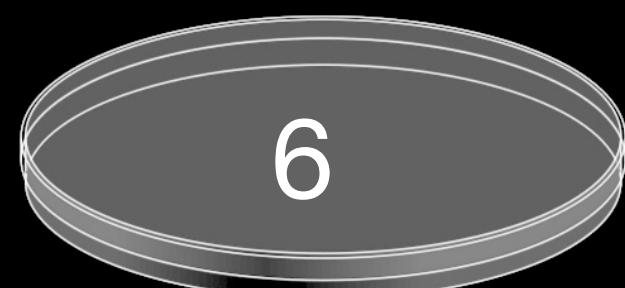
O - A - (-)



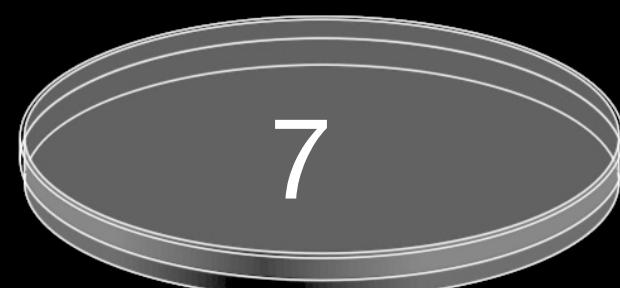
O - C - (-)



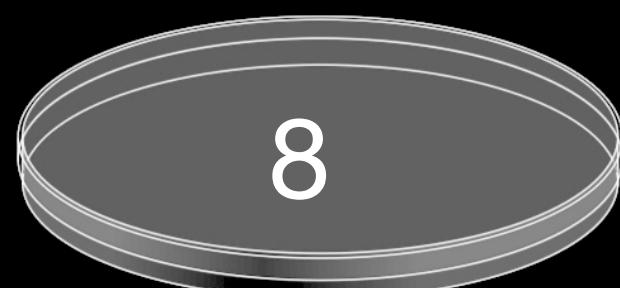
A - C



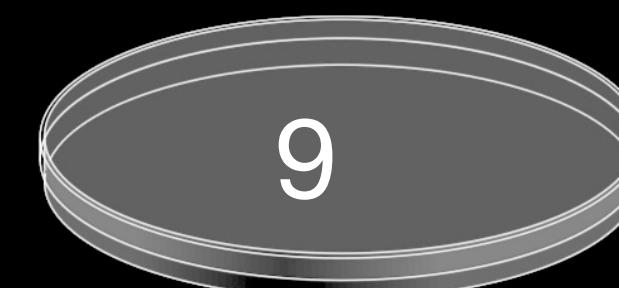
C - C



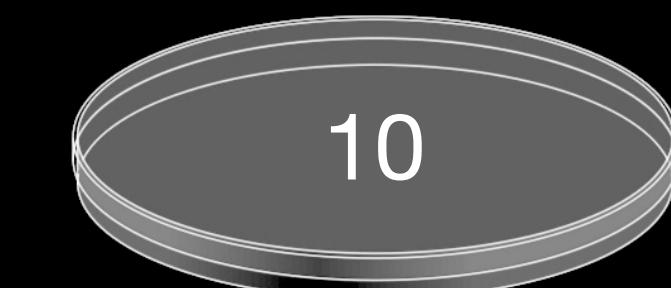
O - C - (-)



C - A



O - A - (-)

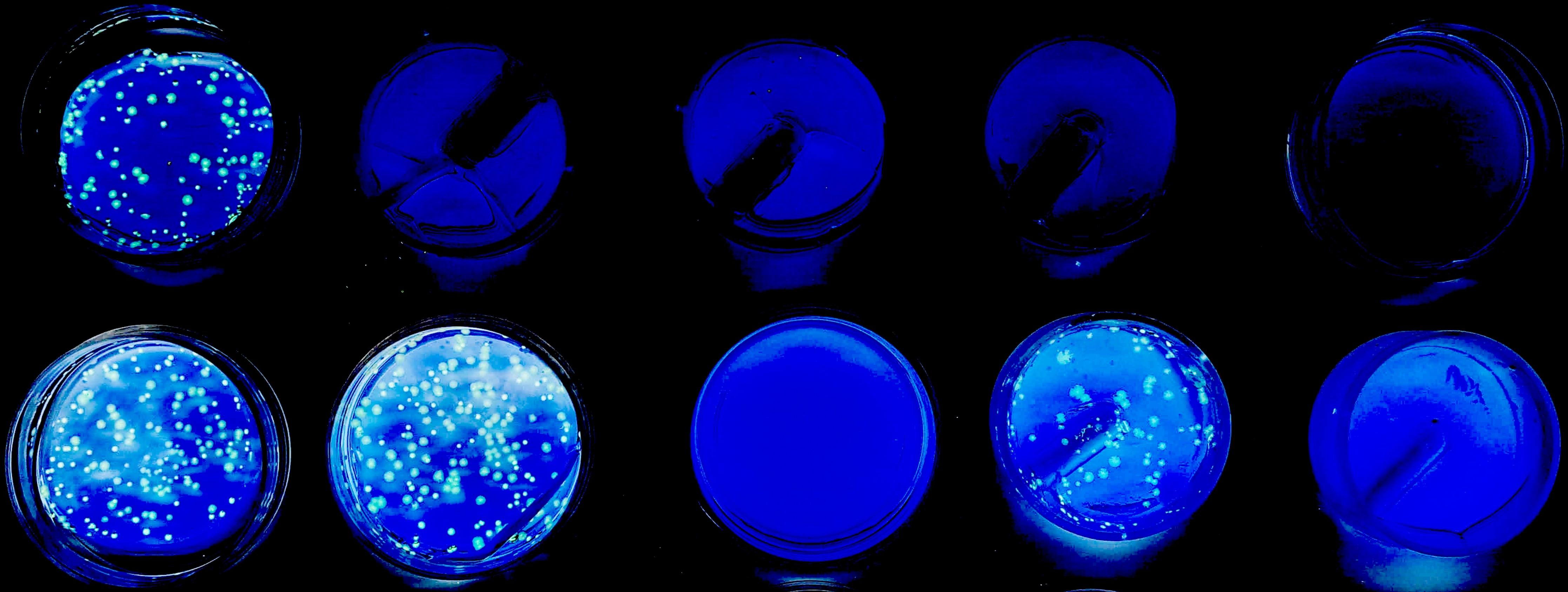


Batch  
1

Batch  
2

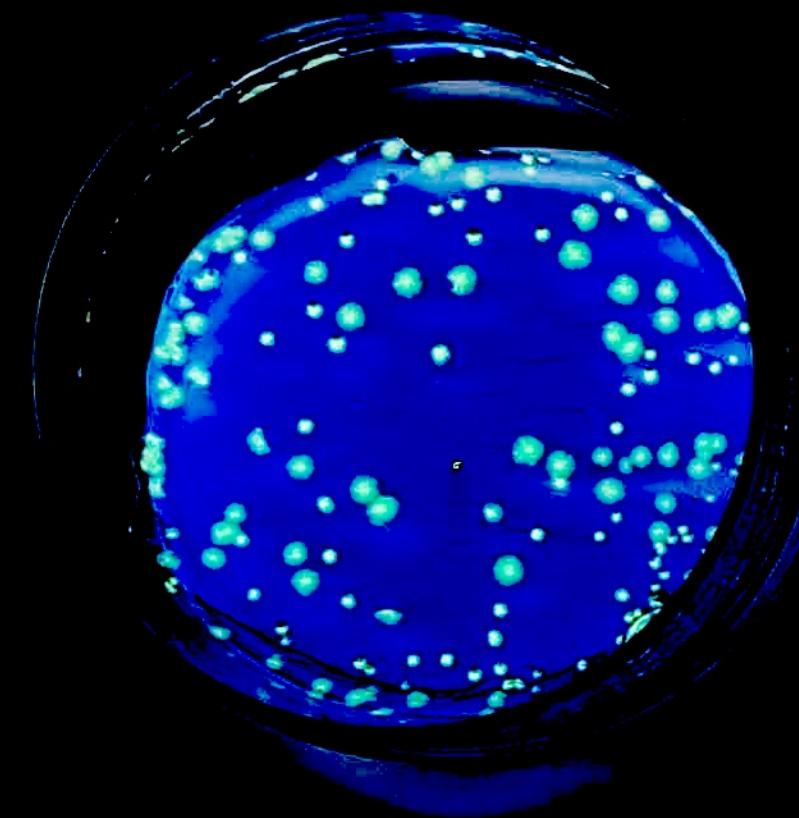
# Experiment 3.1

## Bacterial Growth

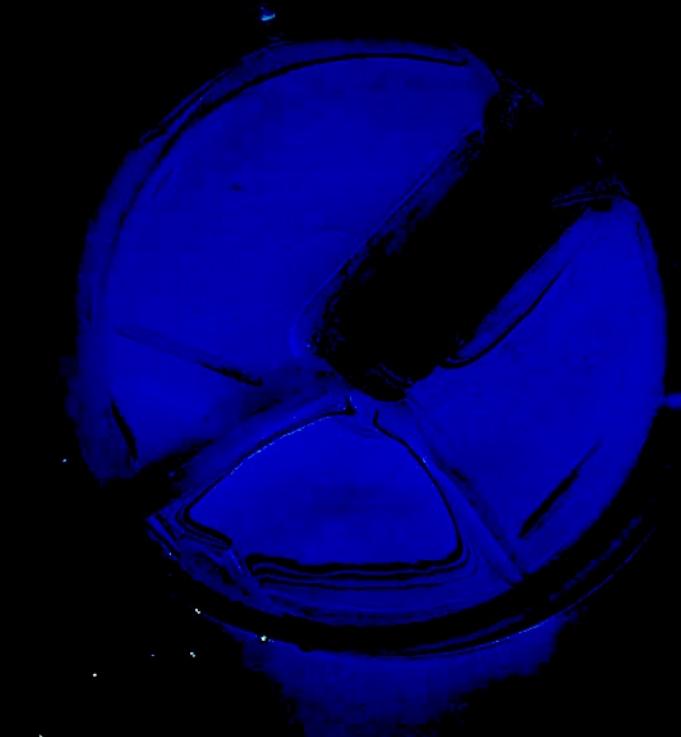


# Experiment 3.1

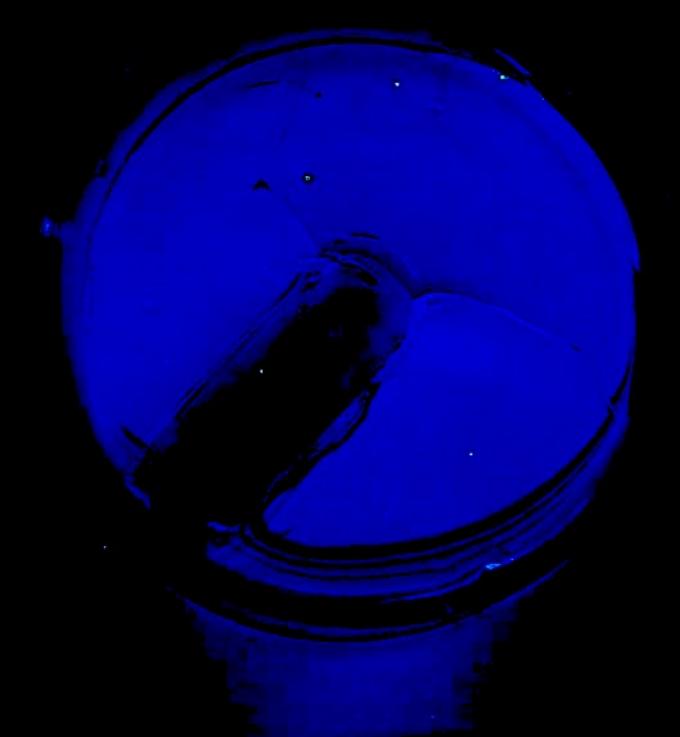
(+) Control



Fail



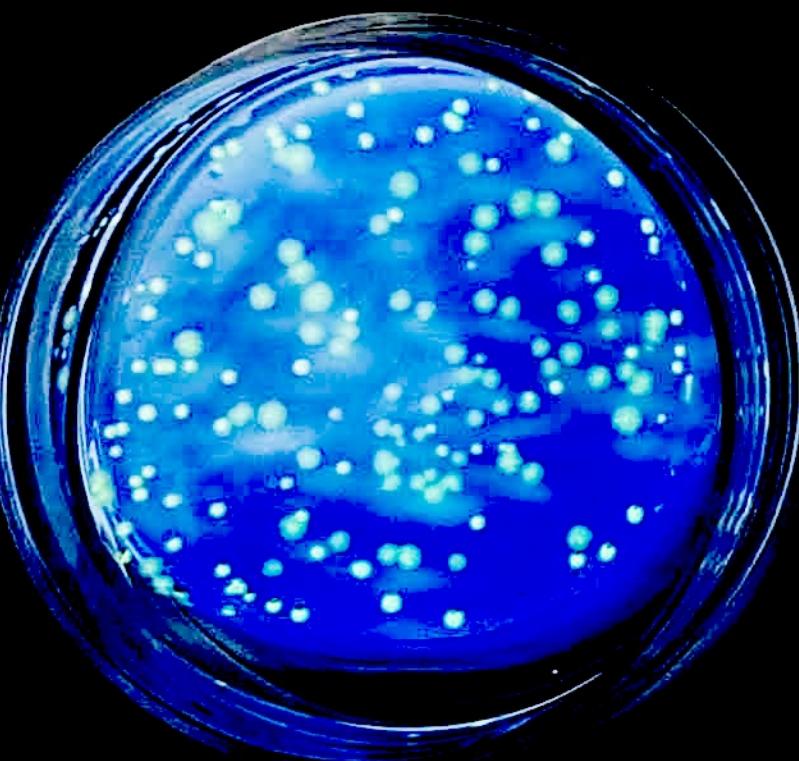
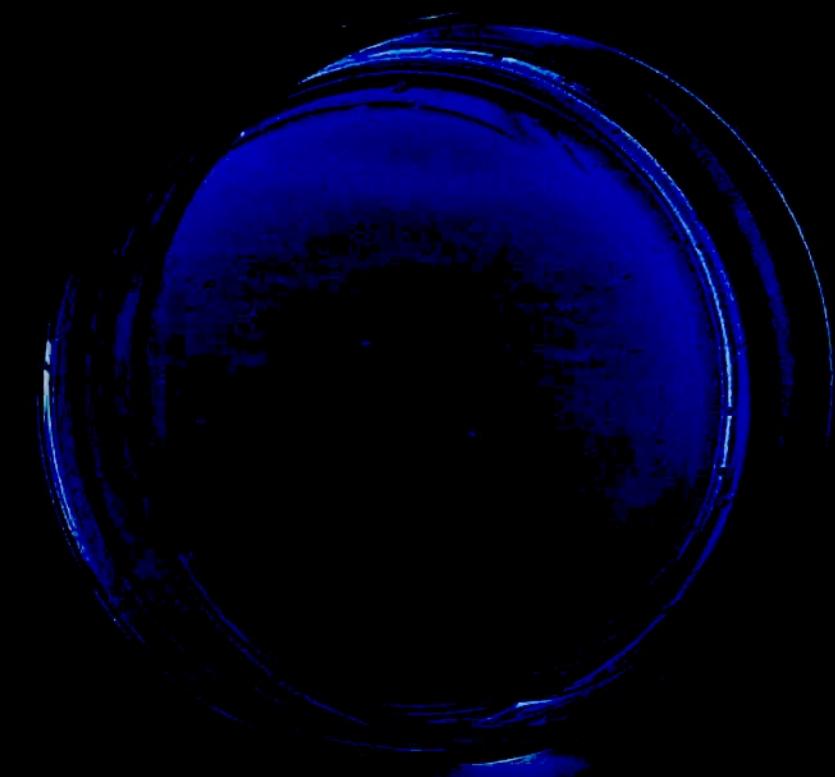
Fail



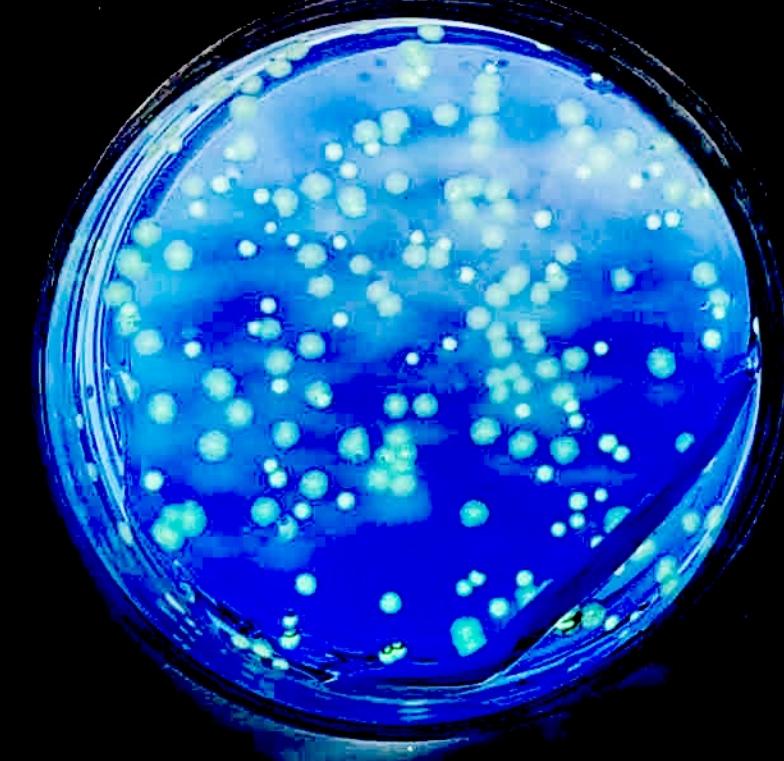
Fail



(-) Control



180 Colonies



196 Colonies  
(+) Control



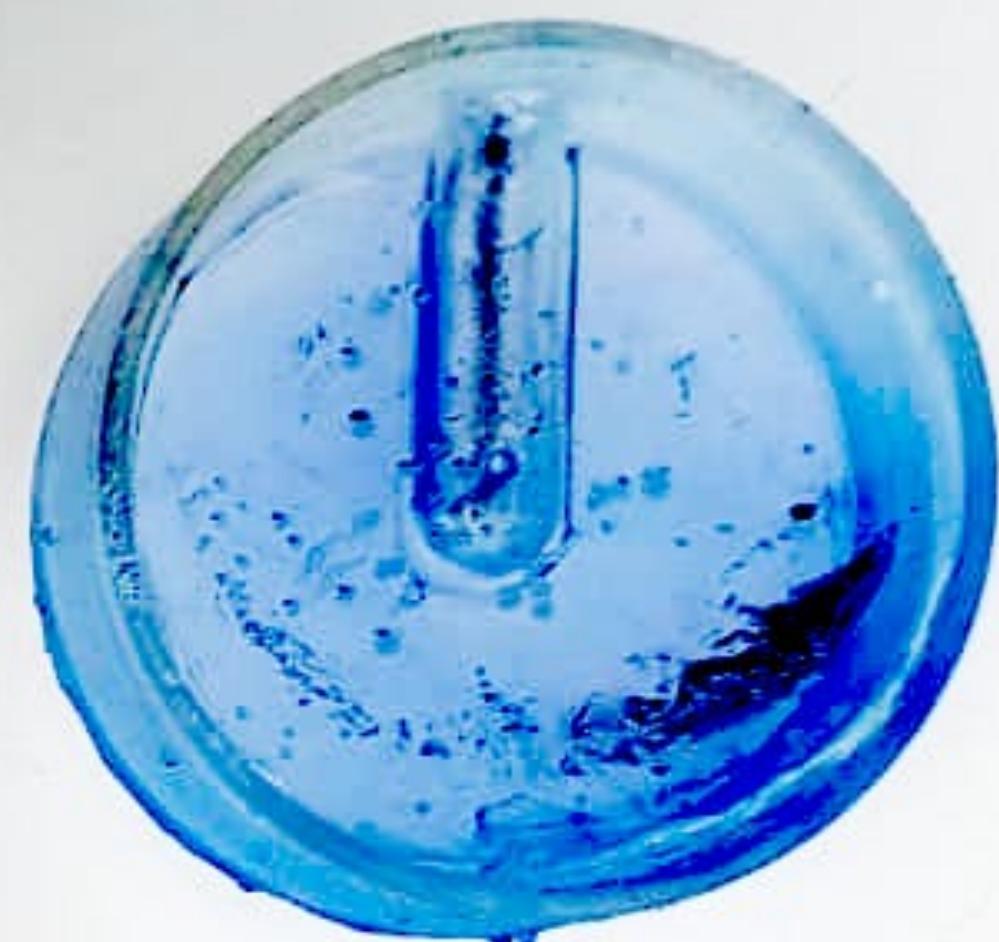
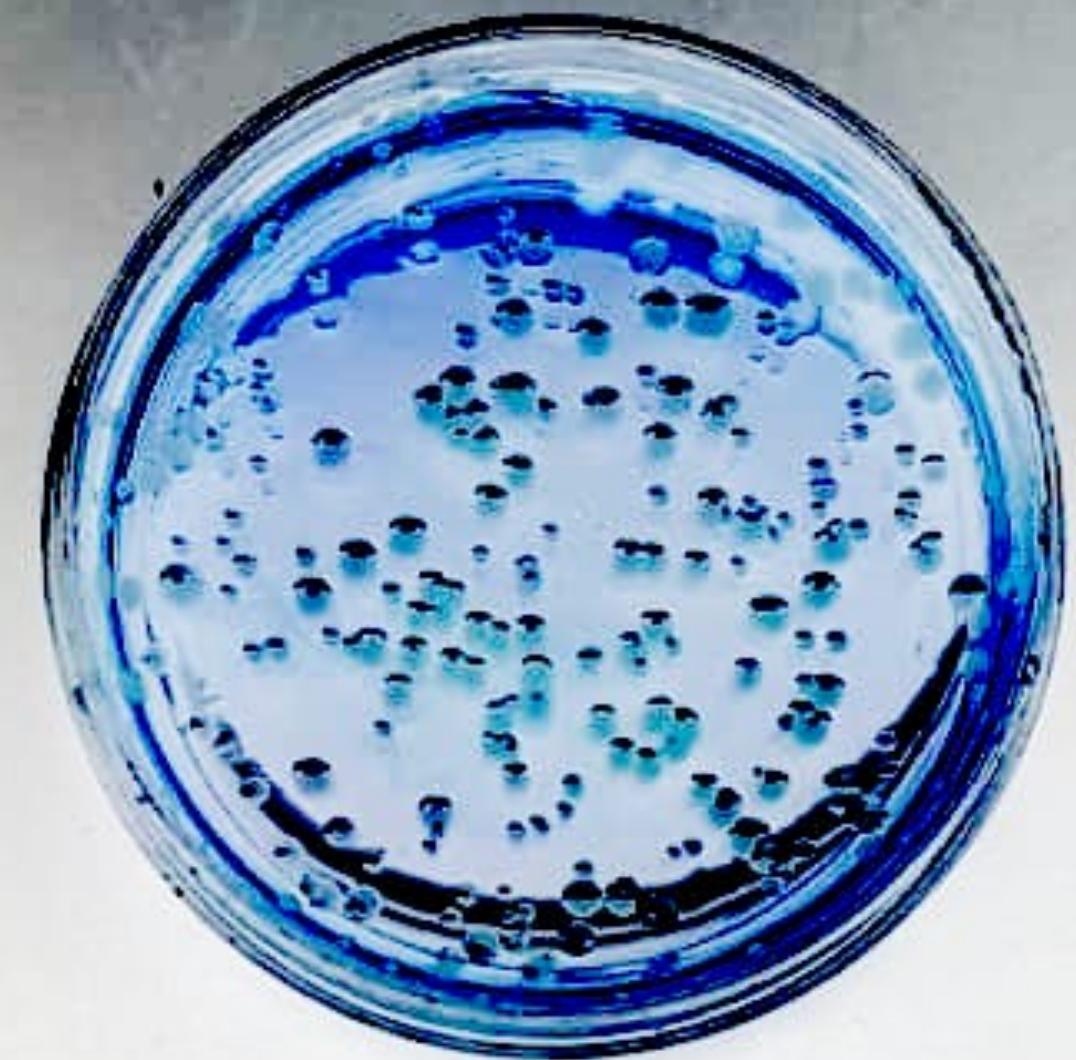
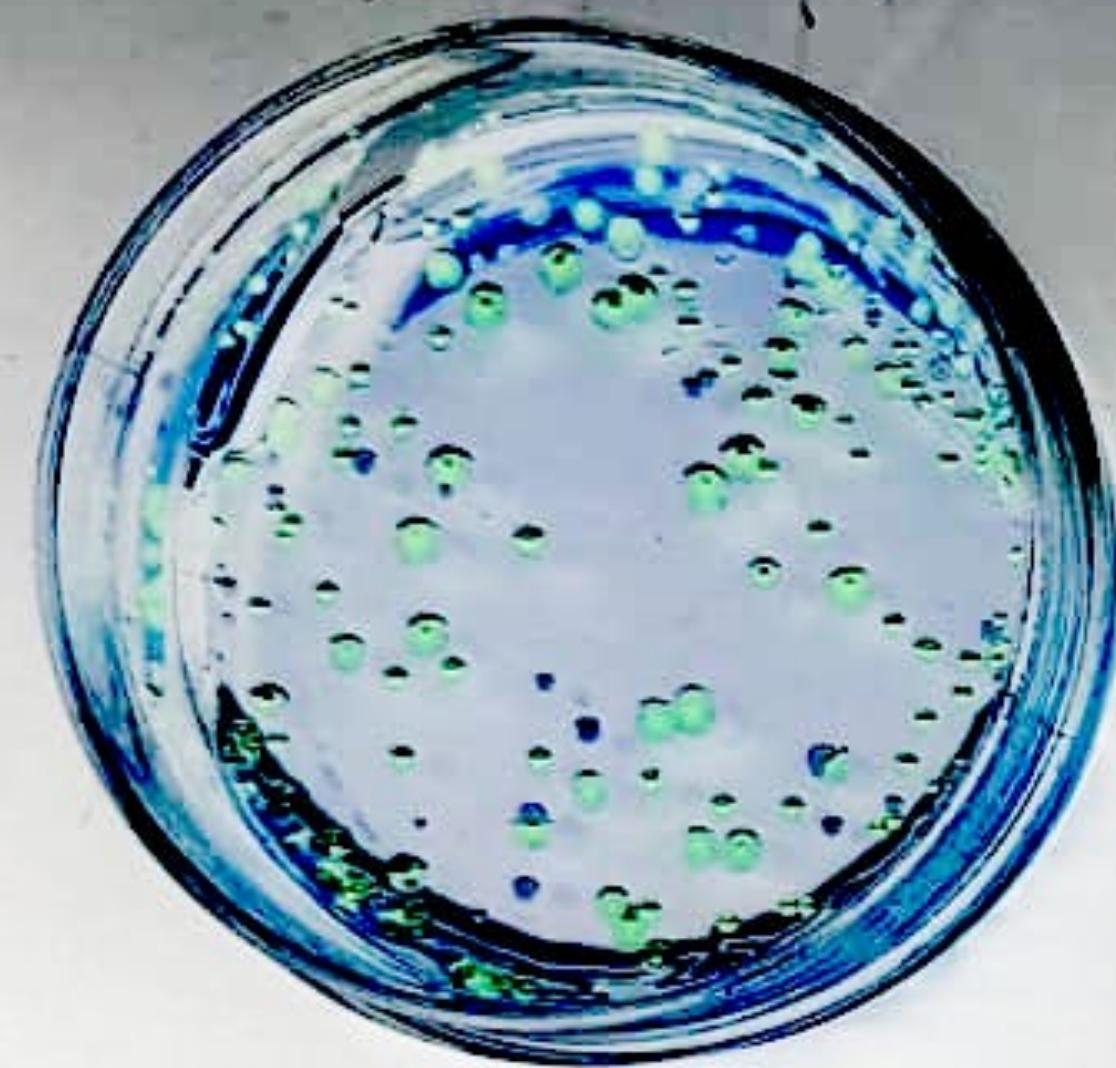
(-) Control

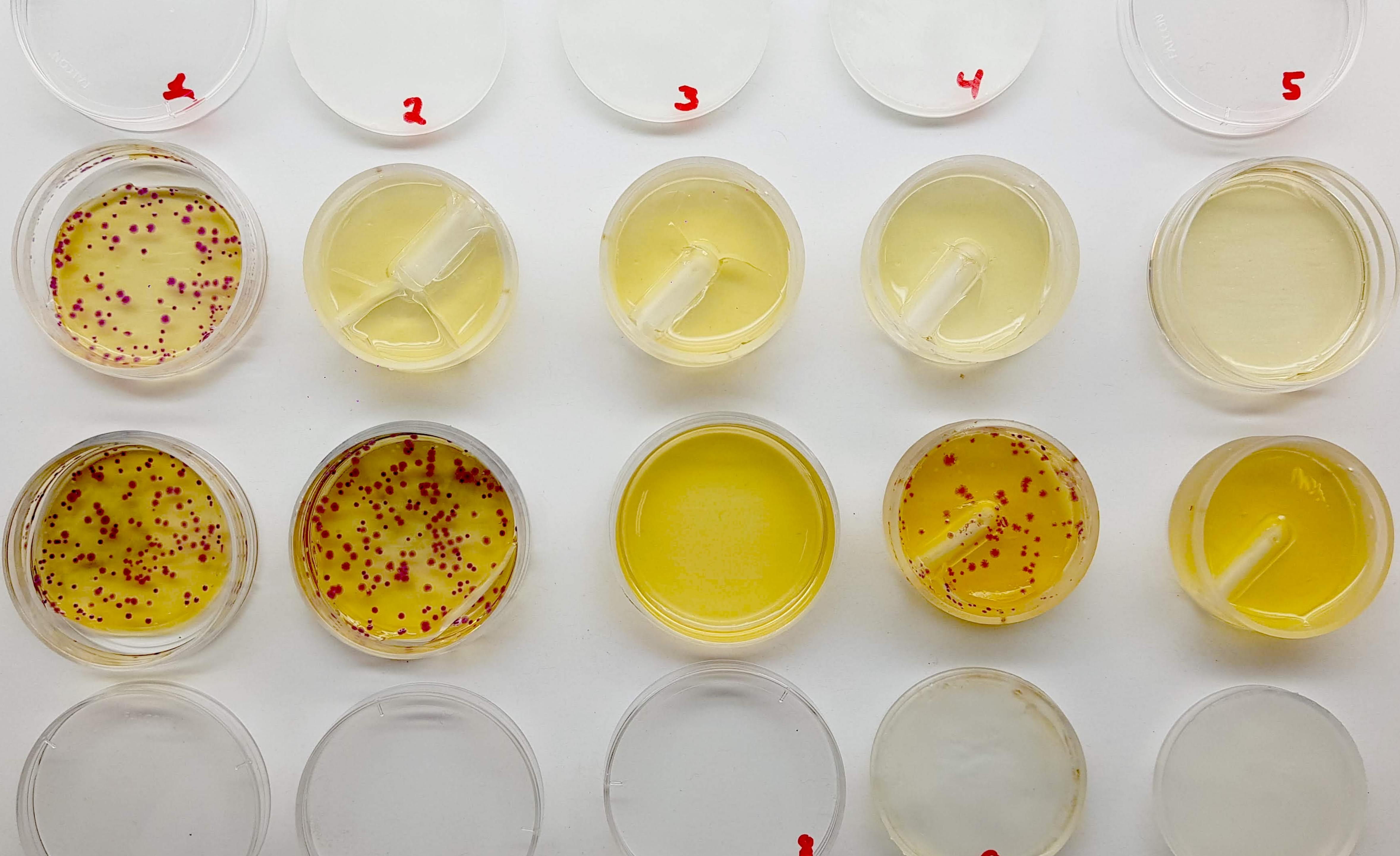


Success



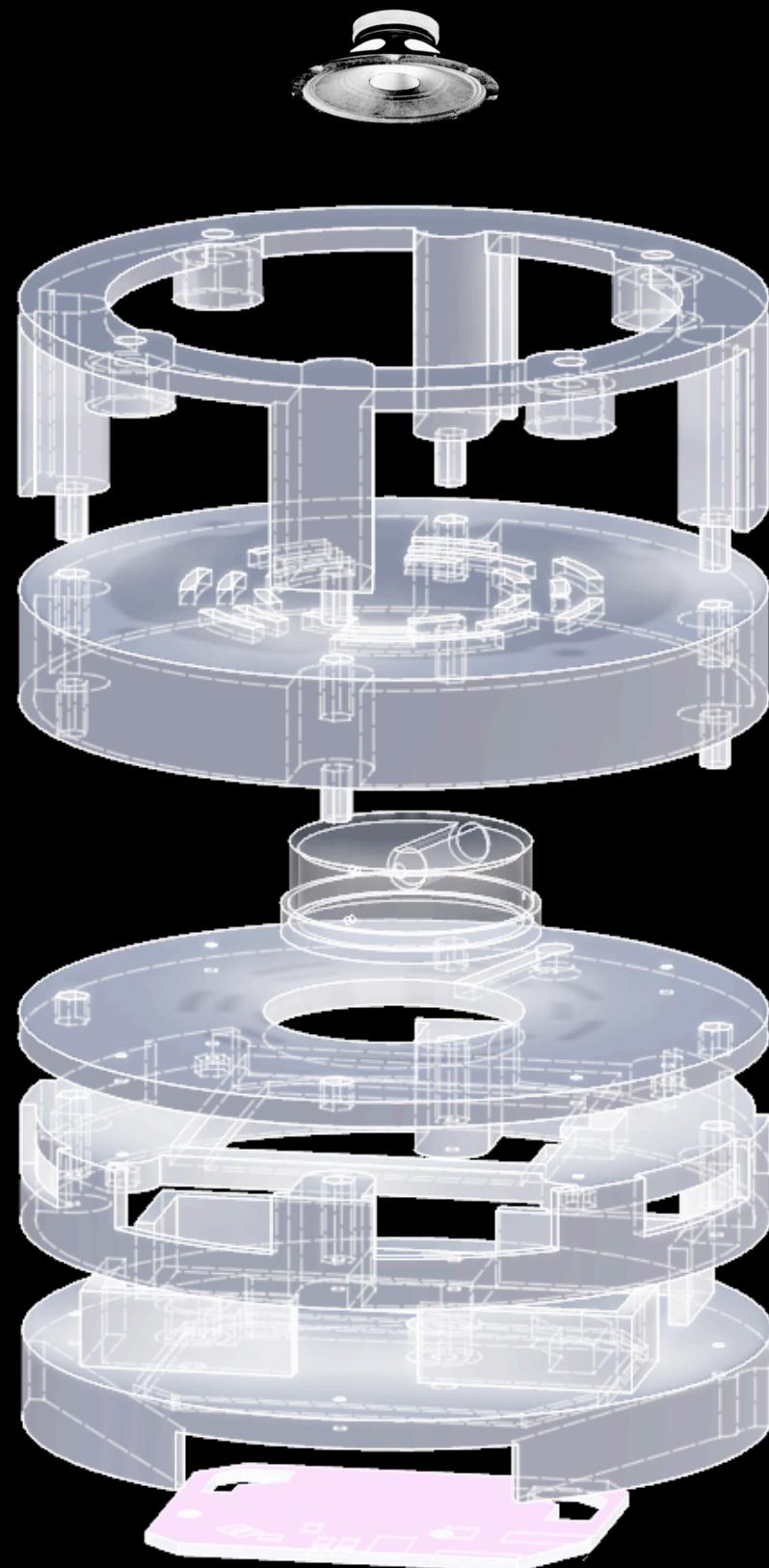
(-) Control



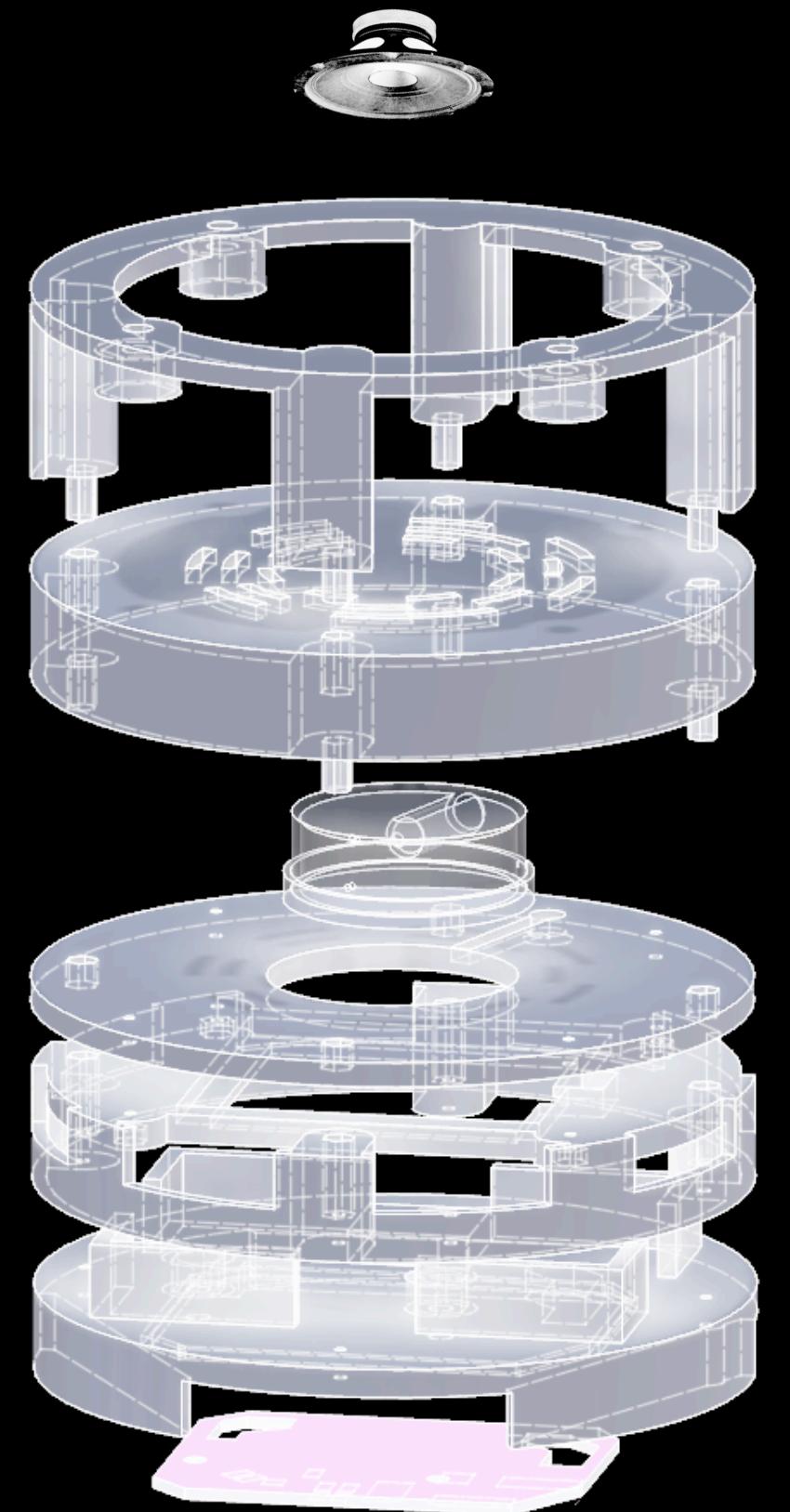


# Experiment 4

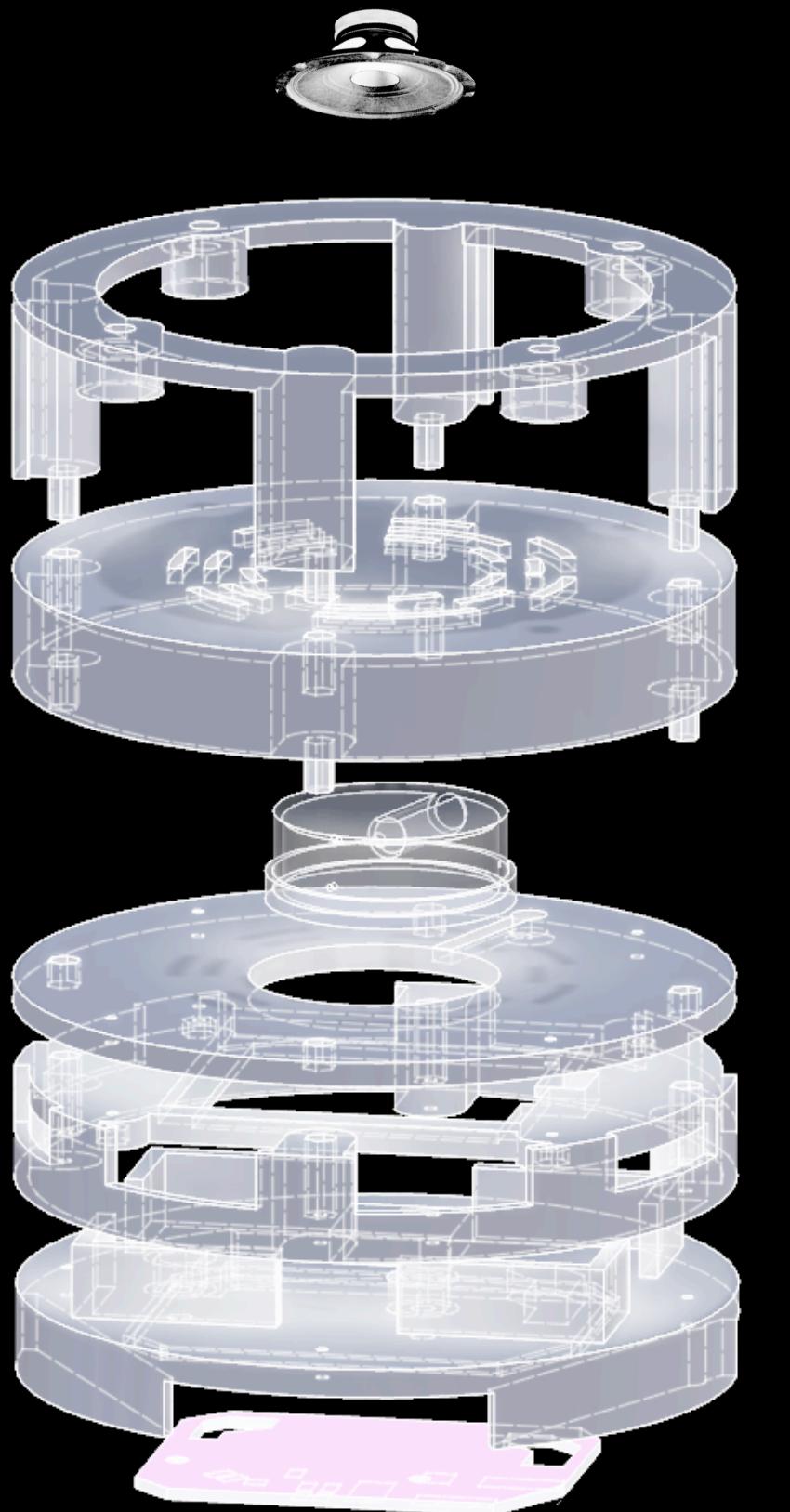
## Sound Stimulated Gene Expression + Incubator



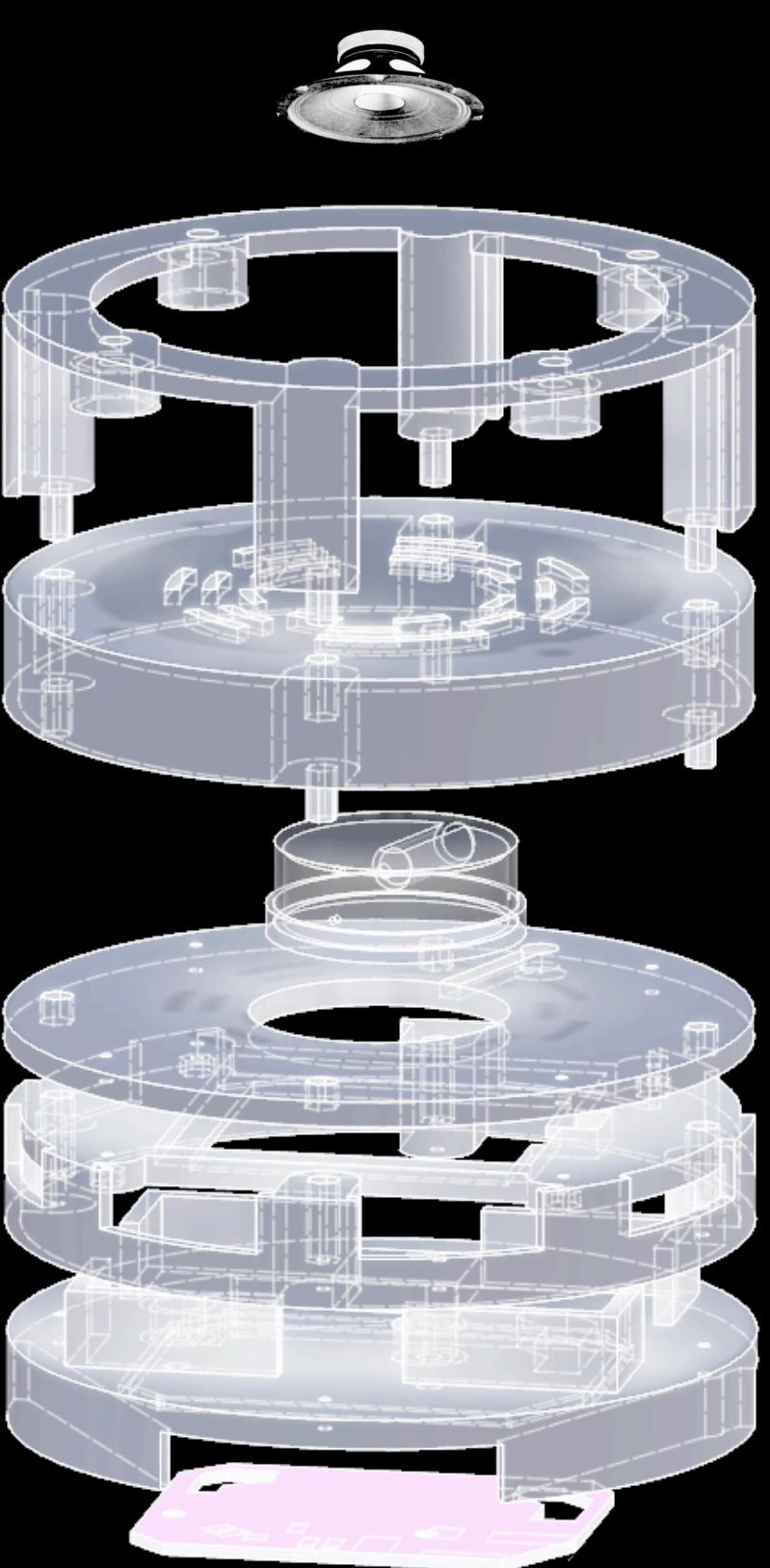
8000Hz - 80dB



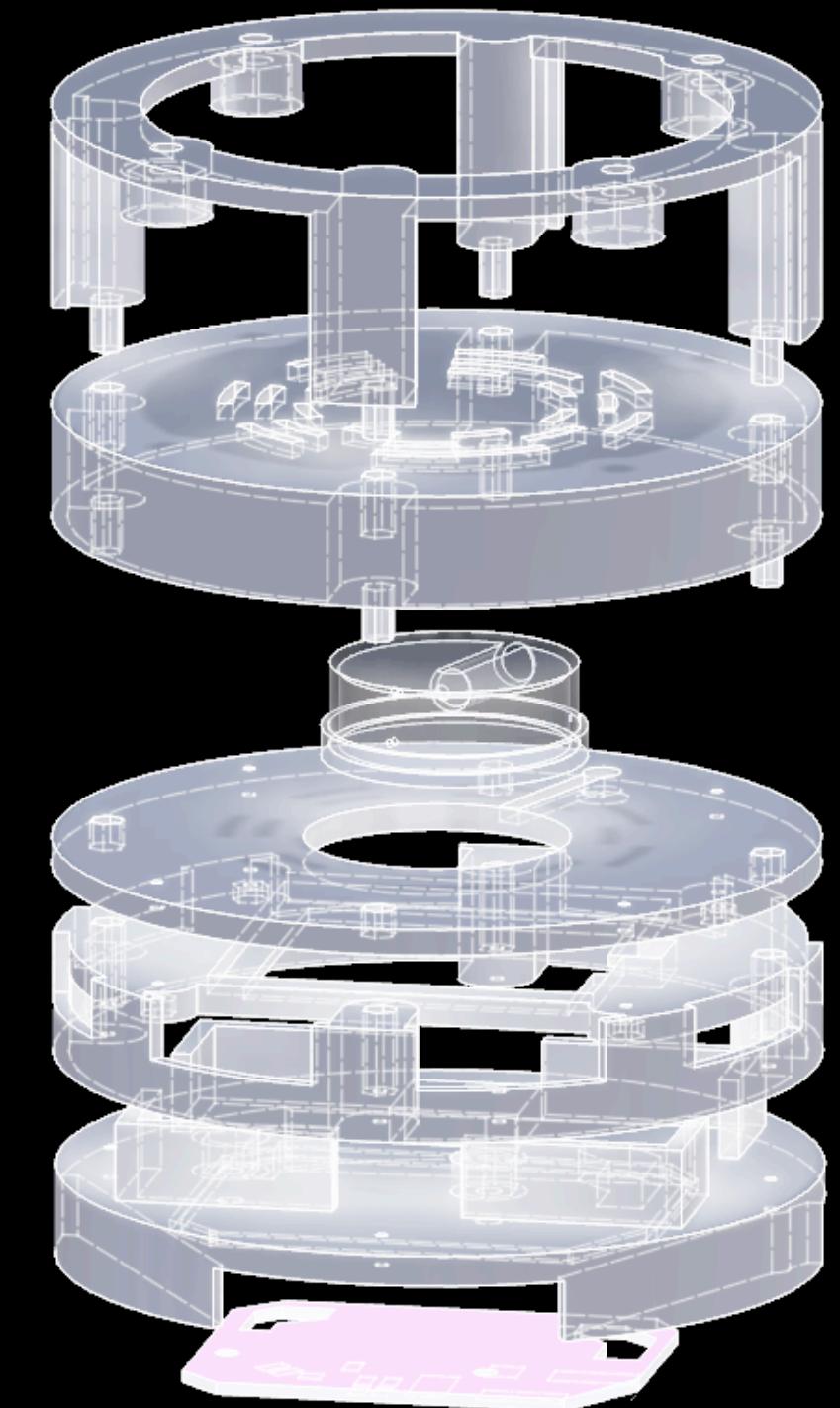
8000Hz - 100dB



2000Hz - 80dB



500Hz - 80dB



Negative  
Control

# Ethics and Possible Negative Societal Impacts

## Analyzing problems that will need solutions for safe deployments

### Device Repurpose

- Using devices for large scale deployment of malign cultures.
- Market incentives misleading applications and benefits of the technology.

### Ecosystem Interaction

- How do we make sure systems interact with nature only in the ways that we expect them to?
- If systems interact in unexpected ways, how do we detect failure and mitigate possible impacts?

### Bio Surveillance Capitalism

- Who owns the data?
- Who makes use of the data?

### Sensor Tampering

- Using molecules to trick sensor readings and mislead decision making.

### Waste Management

- How do communities properly dispose of bio waste and plastic waste coming from the sensor system?

### Open Source Local Community Servers

**Bio resins substituting inorganic resins.**



**Bio Energy harvesting for operation of devices.**

**Only Input membranes as interfaces for allowing molecules to go into systems but never out.**

**Cell Free systems surrounding live cell systems for monitoring of their interaction with the environment.**

# References

- [1] Rico, Andres, Yasushi Sakai, and Kent Larson. "Jettsen: A mobile sensor fusion platform for city knowledge abstraction." *Proceedings of the Future Technologies Conference*. Springer, Cham, 2020.
- [2] Rico, Andres, Carson Smuts, Jason Nawyn, and Kent Larson. "Embedded Piezoelectric Array for Measuring Relative Distributed Forces on Snow Skis". *Proceedings of the Computing Conference*. Springer, Cham, 2021.
- [3] Smuts, Carson, Lucas Cassiano, Chrisoula Kapelonis, Jason Nawyn, Kent Larson and Andres Rico. *Escape Pod*, 2018.
- [4] García, Alejandro, Ryan Zhang, Luis Alonso Pastor, and Kent Larson. *BlindEye*, 2020.
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- [6] Ye, Jiaxing, Takumi Kobayashi, and Masahiro Murakawa. "Urban sound event classification based on local and global features aggregation." *Applied Acoustics* 117 (2017): 246-256.
- [7] Murphy, Mark F., et al. "Acoustic vibration can enhance bacterial biofilm formation." *Journal of bioscience and bioengineering* 122.6 (2016): 765-770.
- [8] Jeong, Mi-Jeong, et al. "Plant gene responses to frequency-specific sound signals." *Molecular breeding* 21.2 (2008): 217-226.
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- [10] Kim, Joo-Yeol, et al. "Sound waves delay tomato fruit ripening by negatively regulating ethylene biosynthesis and signaling genes." *Postharvest Biology and Technology* 110 (2015): 43-50.
- [11] J. Fan. *Cearll's Secret Project Overview*, 2016.
- [12] Acuña-González, Edgar, David Ibarra, and Jorge Benavides. "Effects of sound elements on growth, viability and protein production yield in *Escherichia coli*." *Journal of Chemical Technology & Biotechnology* 94.4 (2019): 1100-1113.
- [13] I. Schlander. *Audiogenetics: Activating Bacteria With Sound*, 2018.

# Thank You!

