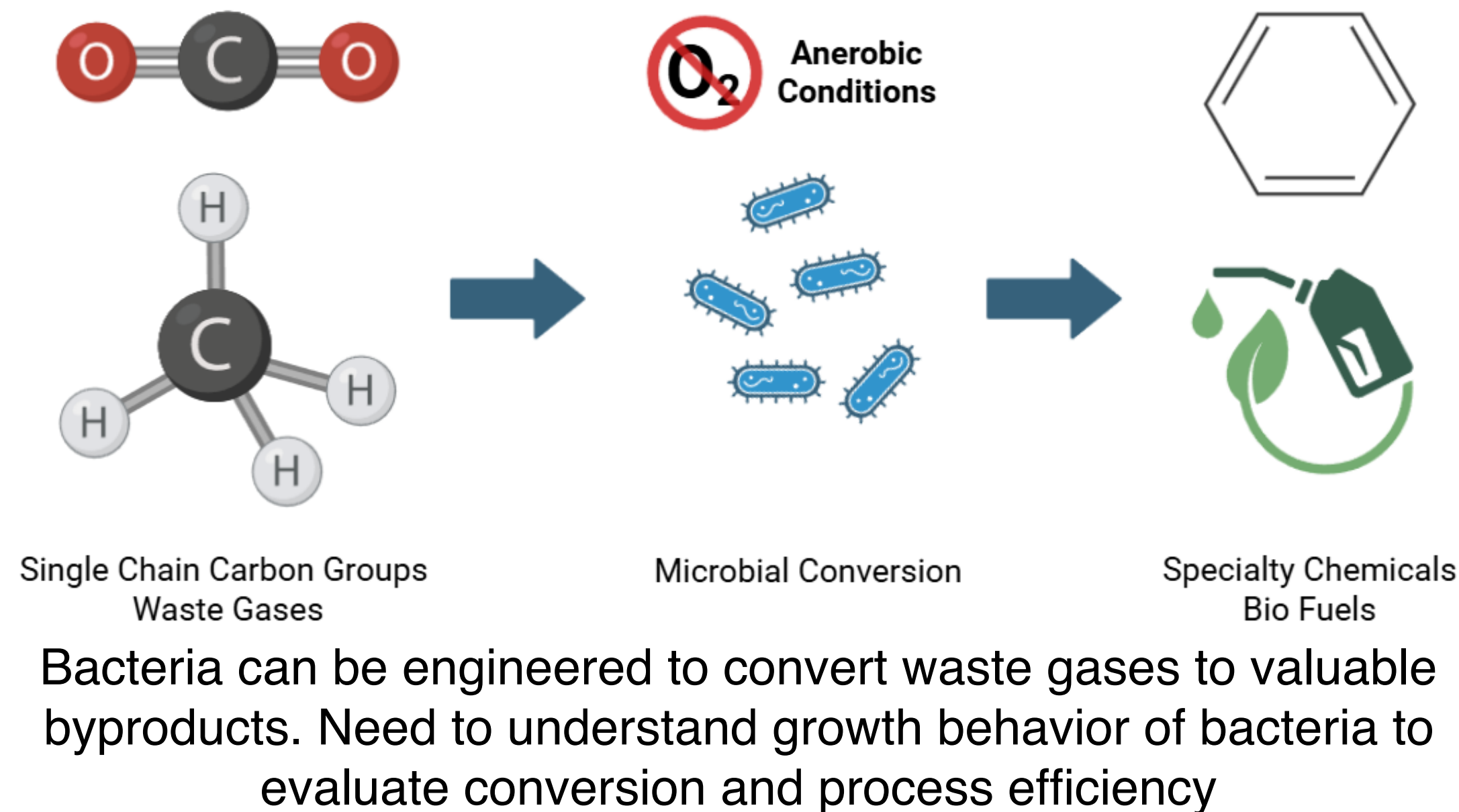# Measuring Anaerobic Bacterial Growth Using a Low-Cost DIY Optical Density Sensor

Kieran Heiberg[1], Diego Alba[1], Ryan Cardiff[2], James Carothers[1, 2]

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Background

Bacteria can be engineered to convert waste gases to valuable byproducts. Need to understand growth behavior of bacteria to evaluate conversion and process efficiency
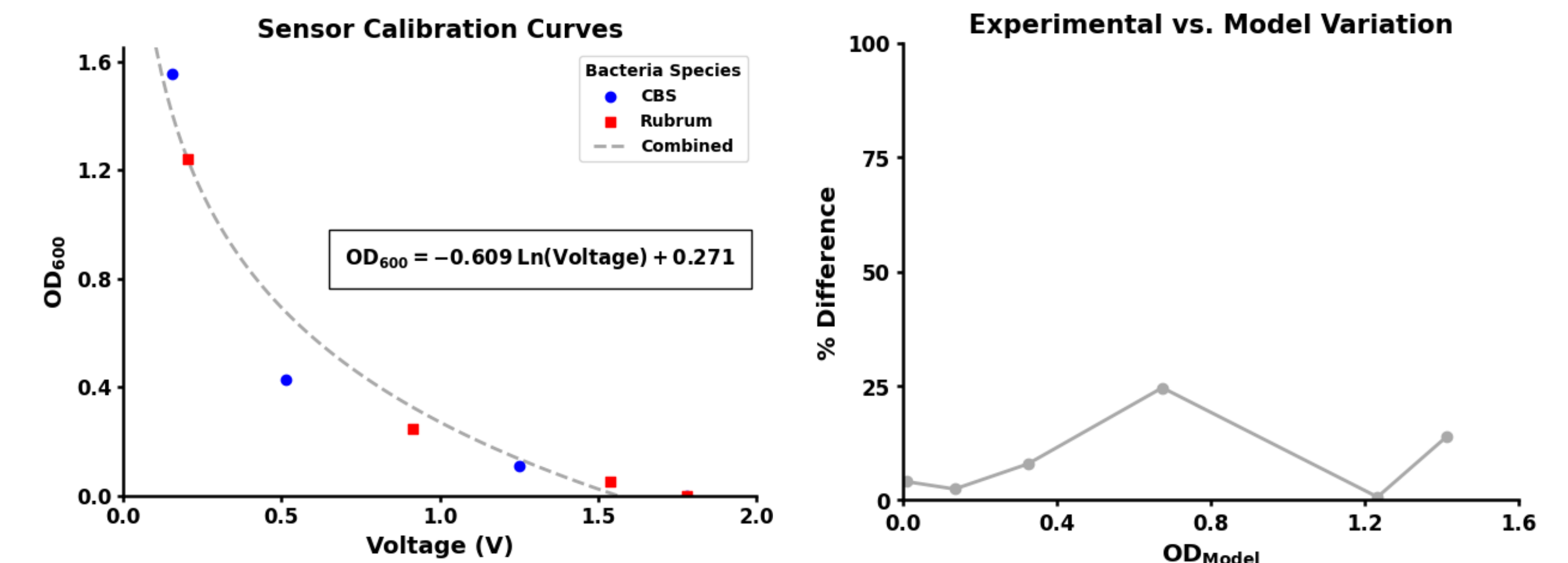
Current State of the Art

Spectrophotometer

Anerobic growth typically tracked using optical density (OD) in Spectrophotometer

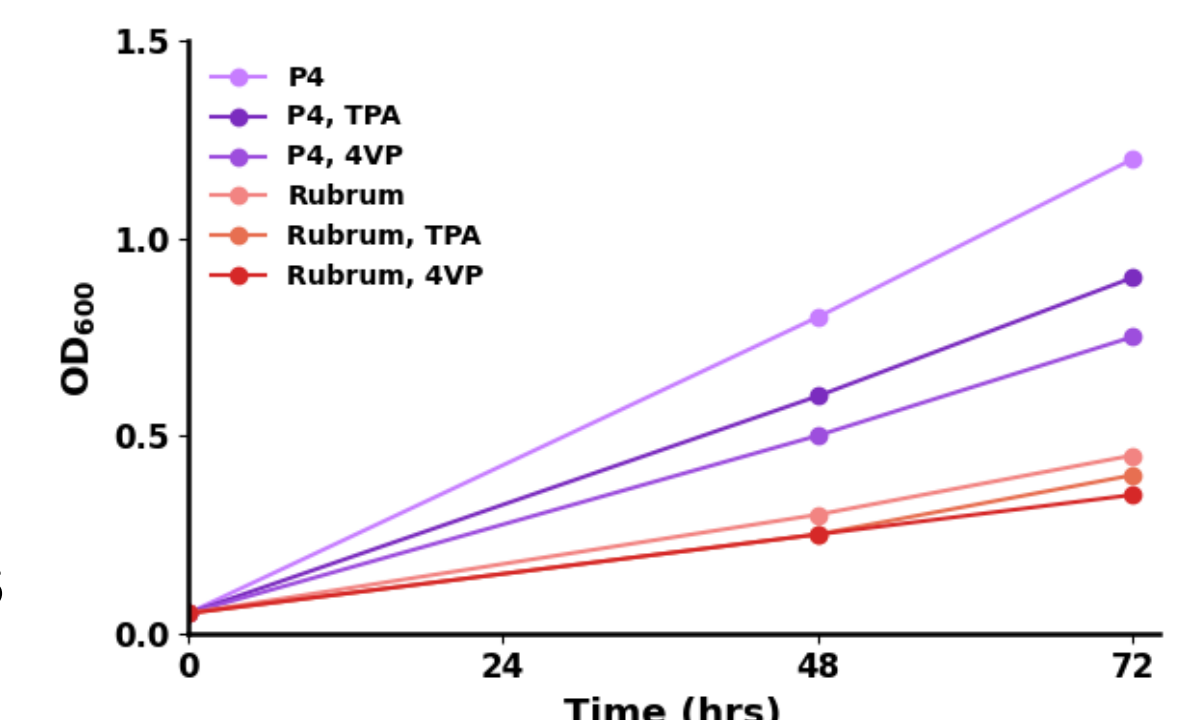- Requires manual sampling
- Large and bulky
- Fixed use cases
- Expensive ($200 - $400)
- Cuvette cost

Functionality

Photosensor produces a voltage value proportional to OD of sample

With 3D printed components and simple electronics, a customizable optical density (OD) sensor can be constructed to cheaply measure anerobic bacteria growth rates

- The sensor design, based on Deutzmann et al. (2022), consists of a 3D-printed sample tube holder with an LED and a photosensor positioned on opposite sides
- The photosensor generates a voltage, which a Python script processes to calculate optical density values for each bacterial species

Benefits

Full sensor set up with data acquisition device (DAQ) in red and sensor in black

Sensor measures OD directly from growth container, removing need for invasive manual sampling and saving time

- Easily reproducible from 3D printing and simple electronics
- Works for anaerobic and aerobic species
- Open-Source and customizable
- Portable
- Low cost

Results

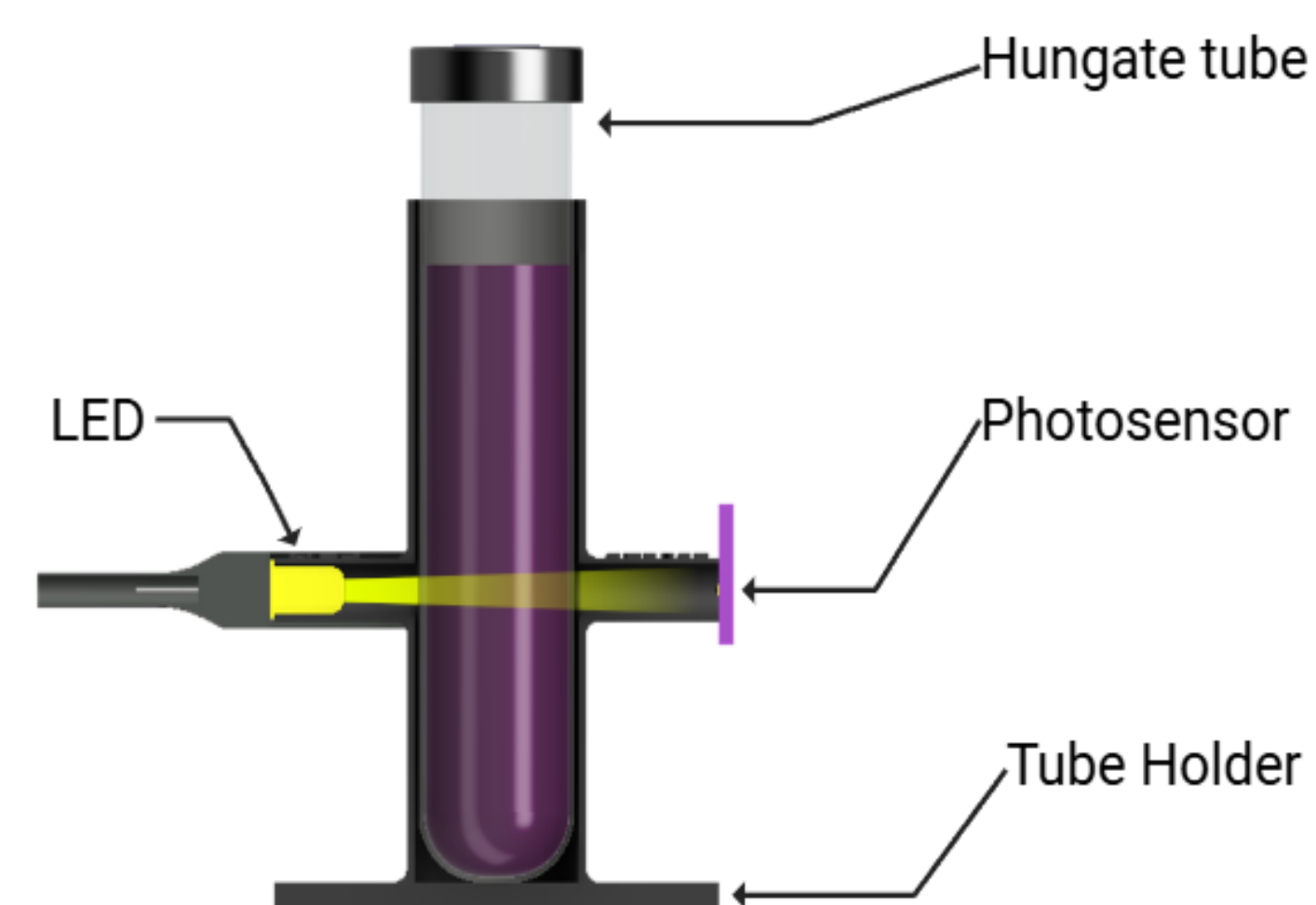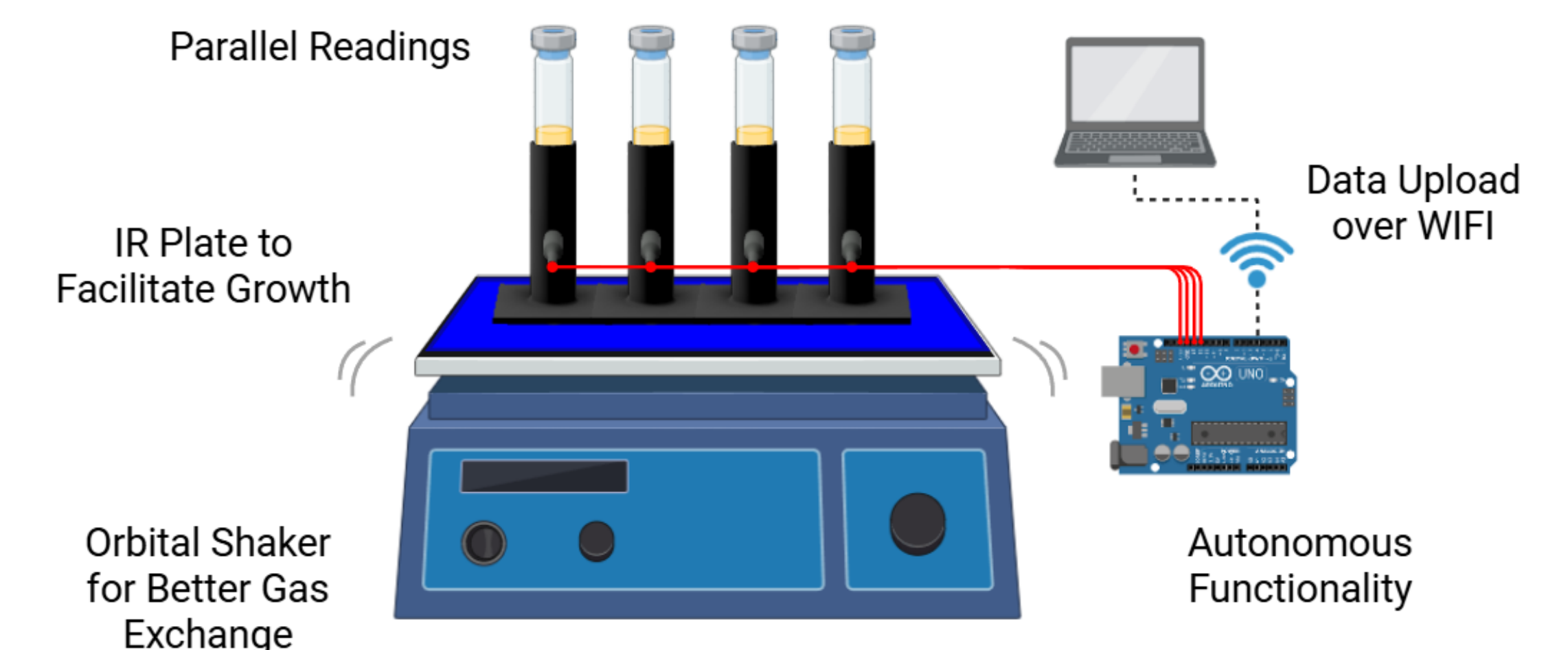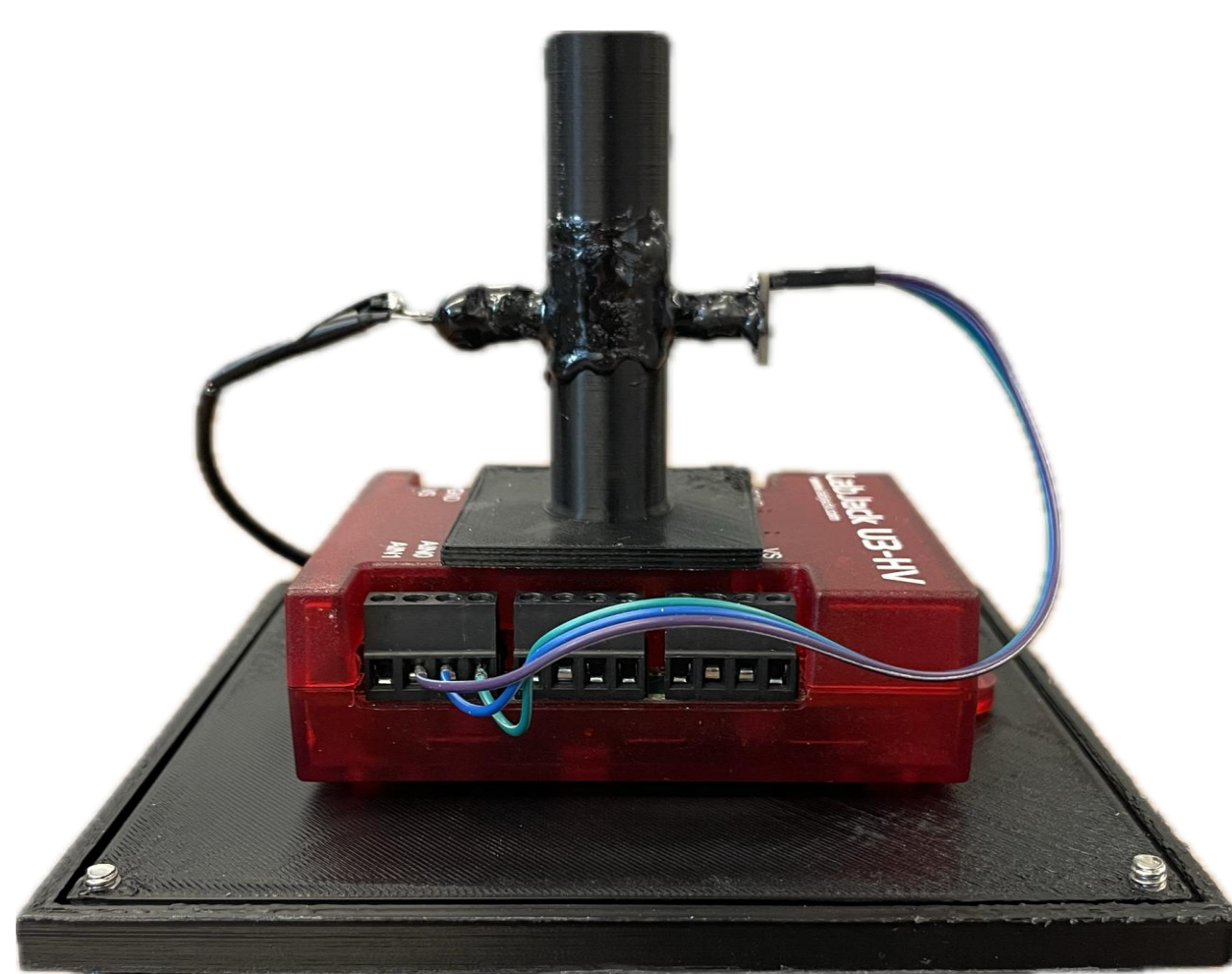$$OD_{600} = -0.609 \ln(\text{Voltage}) + 0.271$$

Calibration curves created to convert sensor output voltage to OD.

- Global conversion equation found but small interspecies variation makes per species equations more precise.
- Sensor has been used for real data tracking of various bacterial species growth for the last 6 months

Future Improvements

Currently upgrading to run via microcontroller. Benefits include multi-sample parallel monitoring, integration with external lab equipment, and autonomous functionality for extended duration experiments
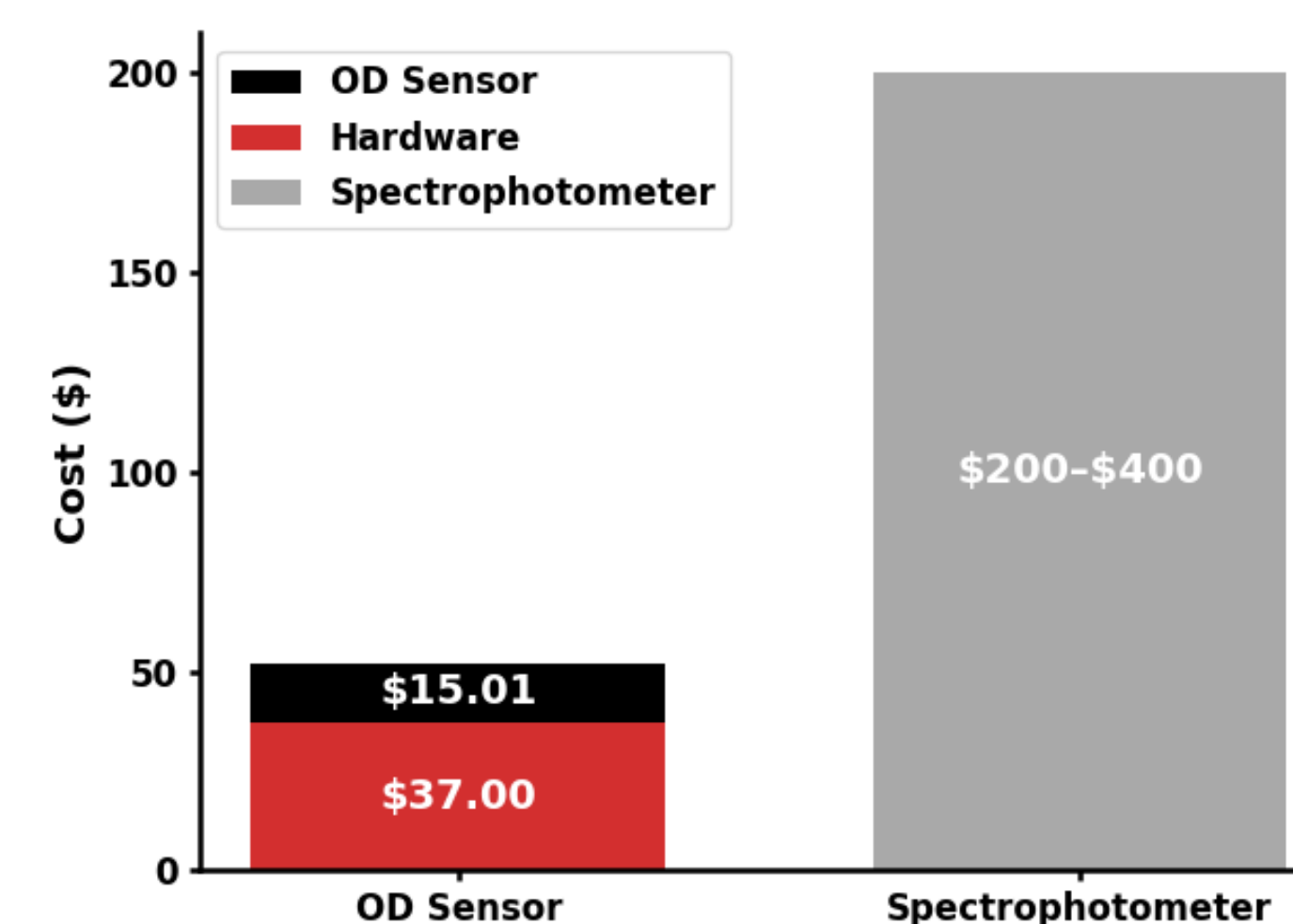
Acknowledgments & References

Deutzmann et al, "Low-Cost Clamp-On Photometers (ClampOD) and Tube Photometers (TubeOD) for Online Cell Density Determination." *Frontiers in Microbiology.* (2022).

Contact