One Step Closer to Mars with Aquaponics:

Cultivating Citizen Science in K12 Schools

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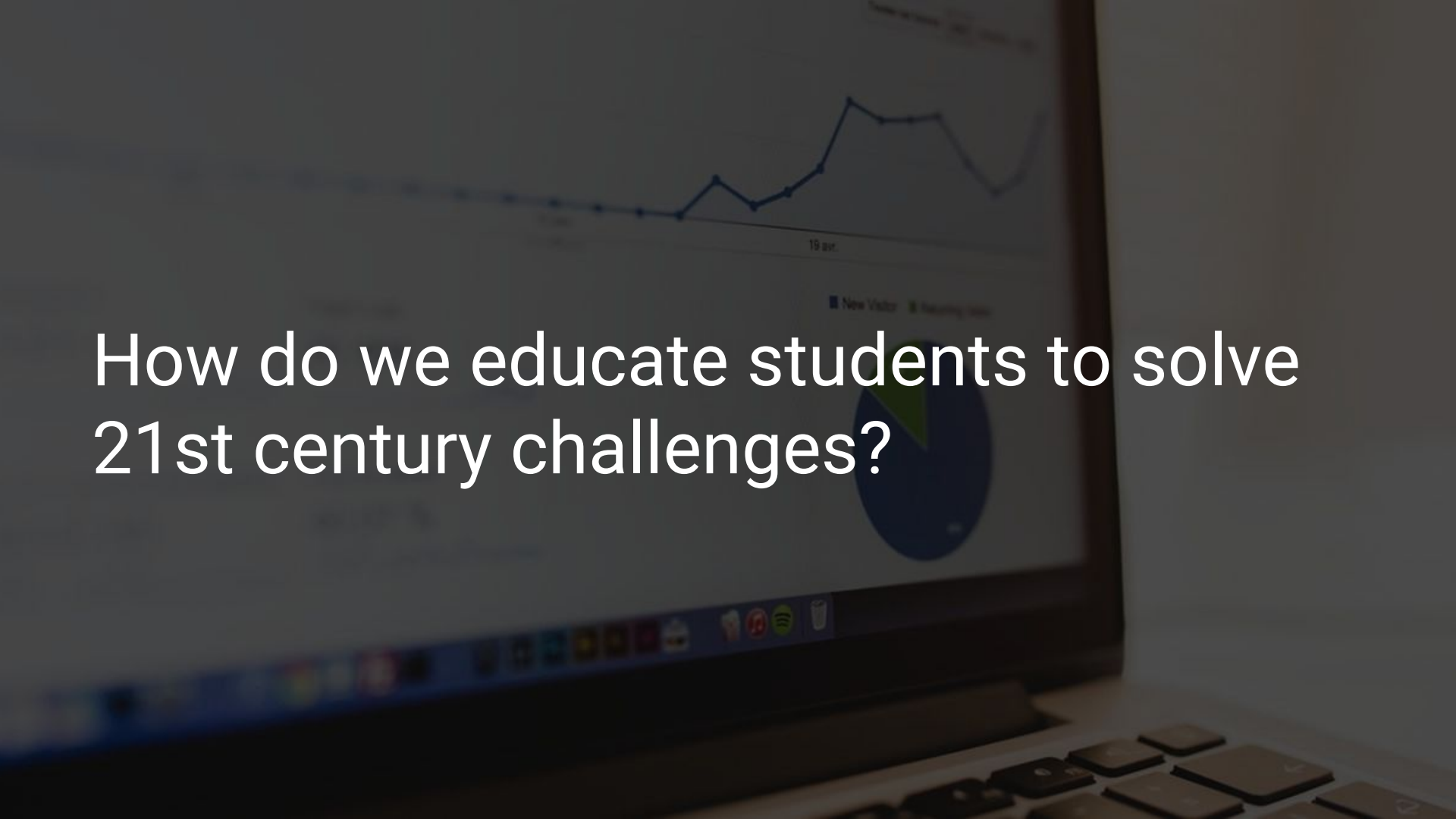
We could not have completed this work without the 50 other students and staff at Meadow Park Middle School

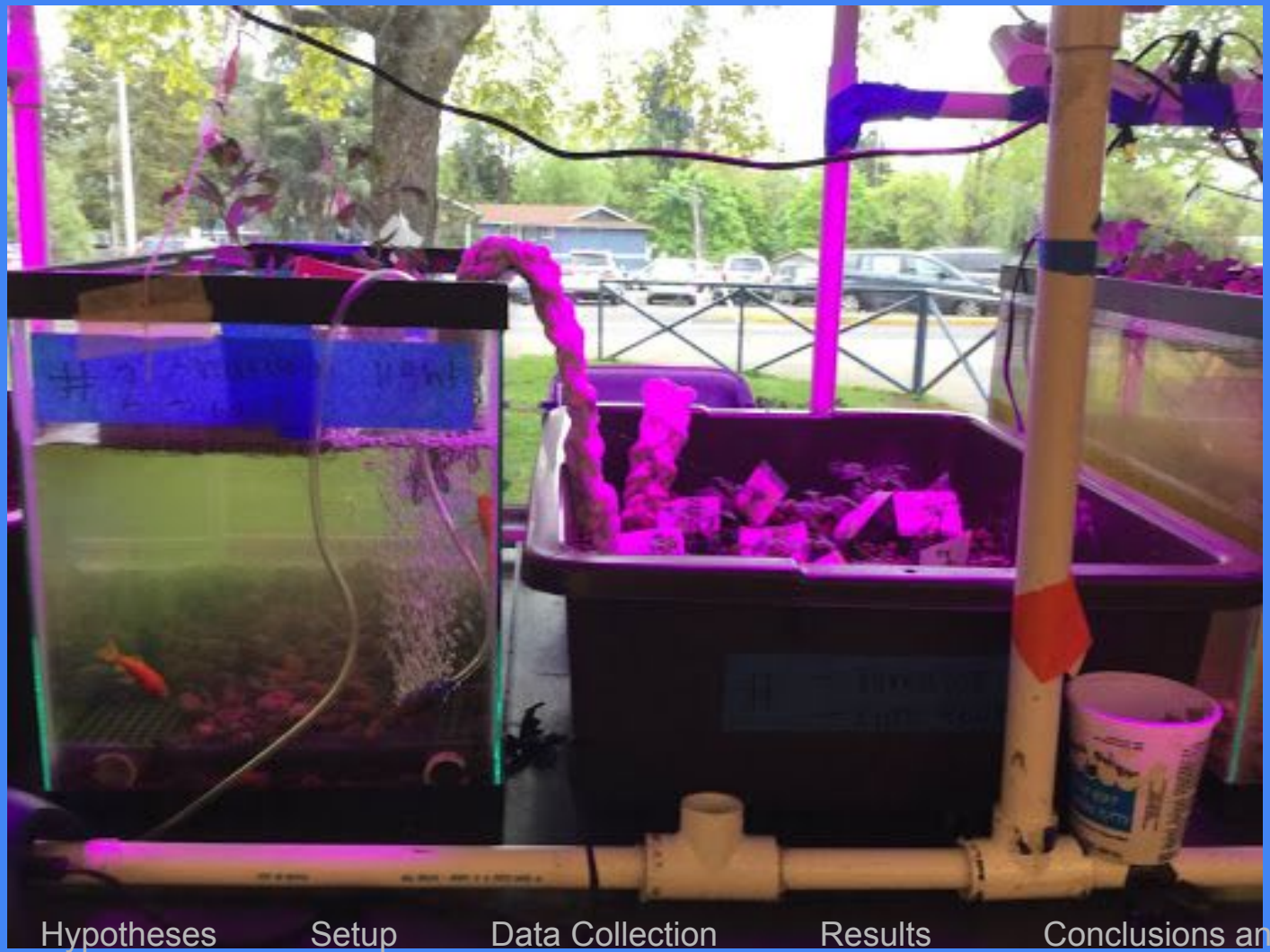


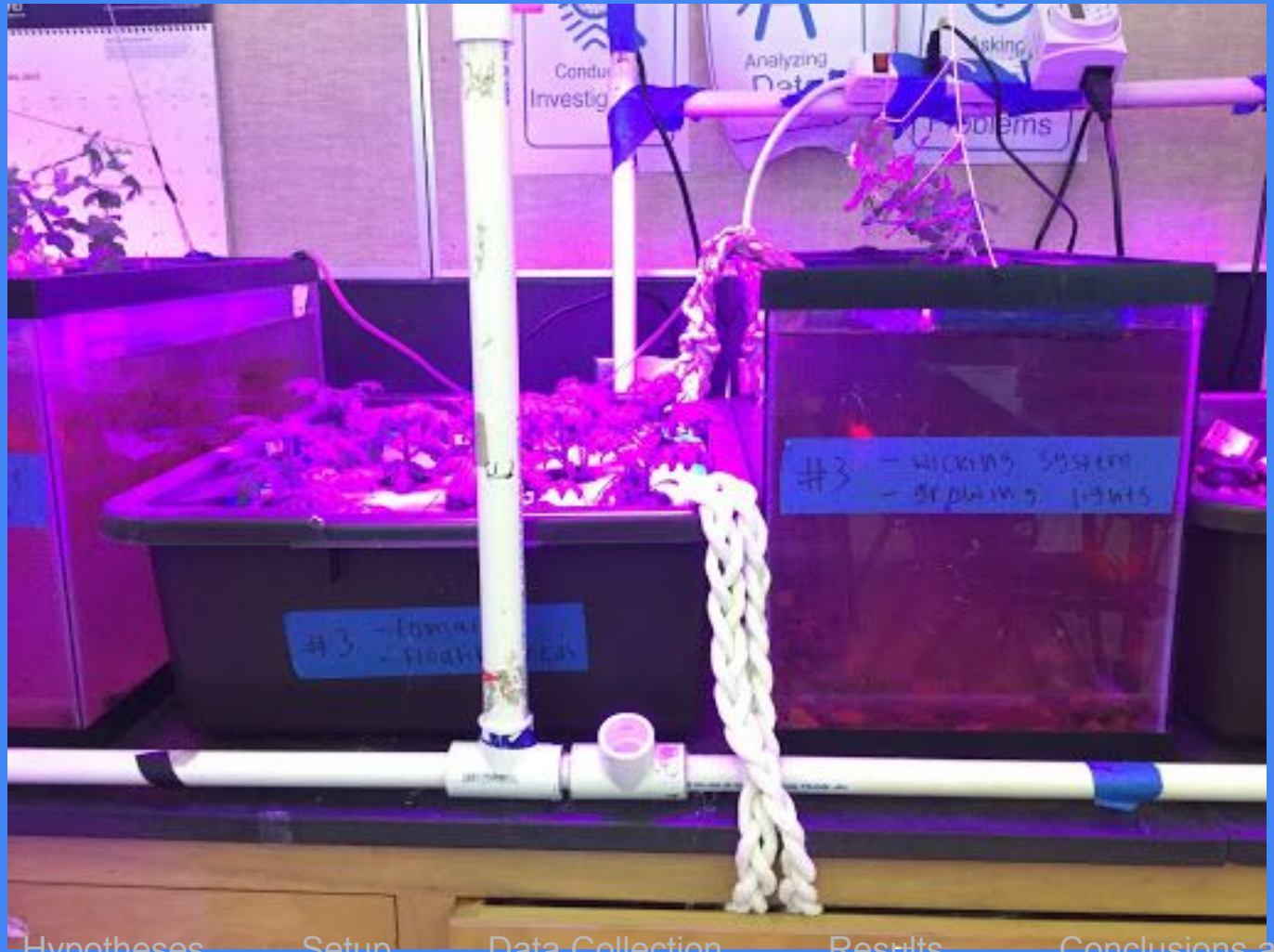
How do we educate students to solve 21st century challenges?

How do we create the most efficient aquaponics system with microbes that promote stable plant and fish growth with steady nutrient cycles?

From the ground up, we engineered, maintained and analyzed 10 aquaponics systems.

- We engineered 10 different small scale aquaponic system
- We received funding from NASA, and funded the rest on our own
- Each system experimented with different variables
- We performed daily tasks
- We Analyzed and concluded our data
- Sent our genomics data to NASA, and ongoing analysis

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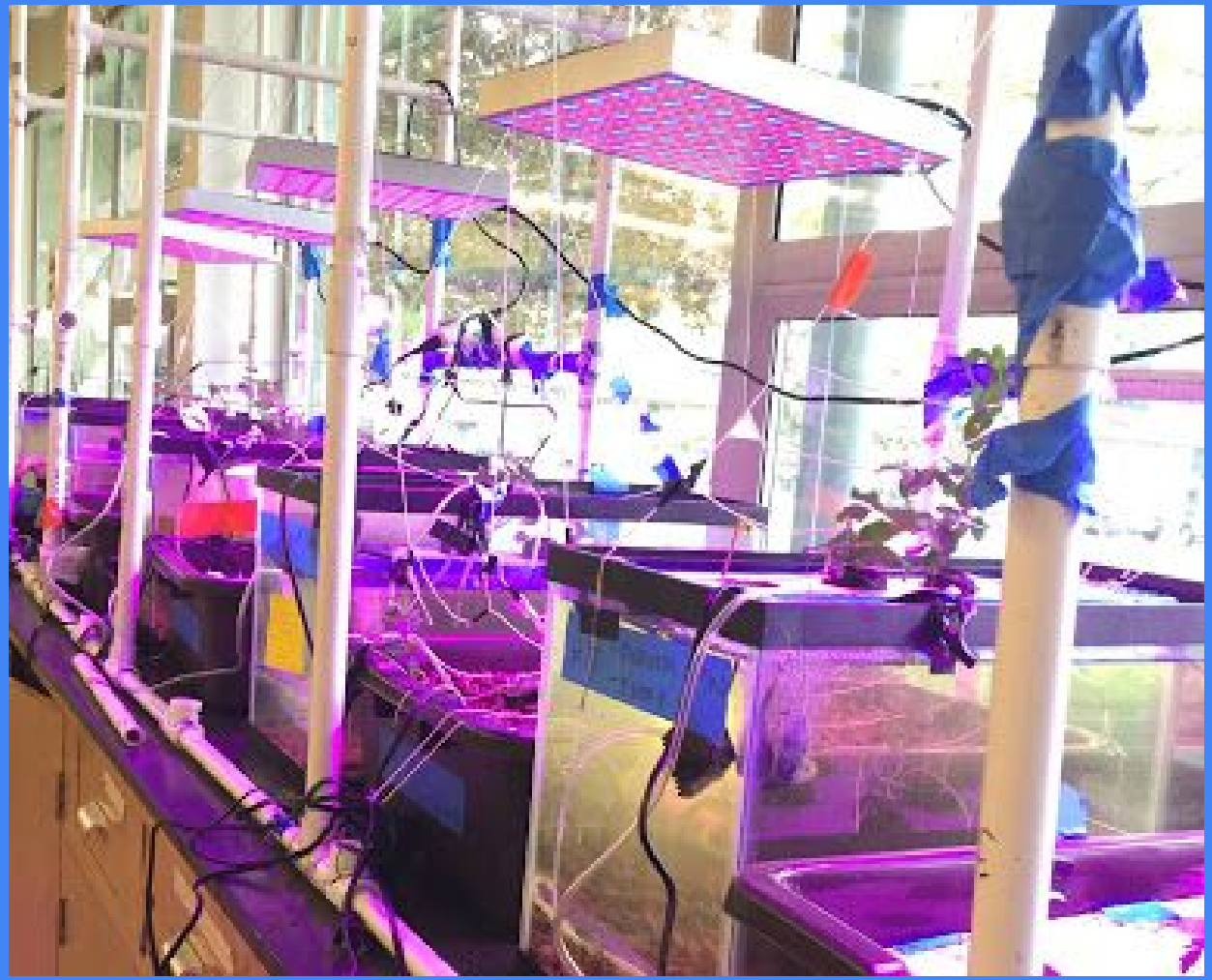
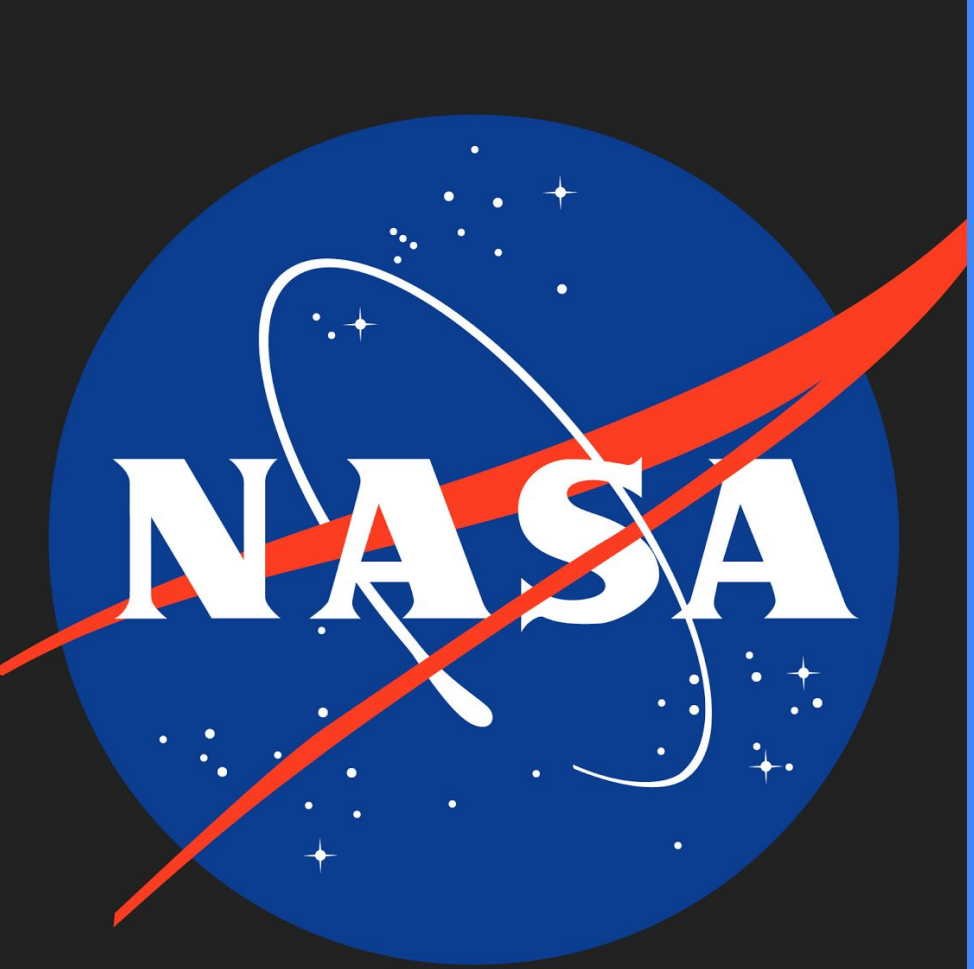
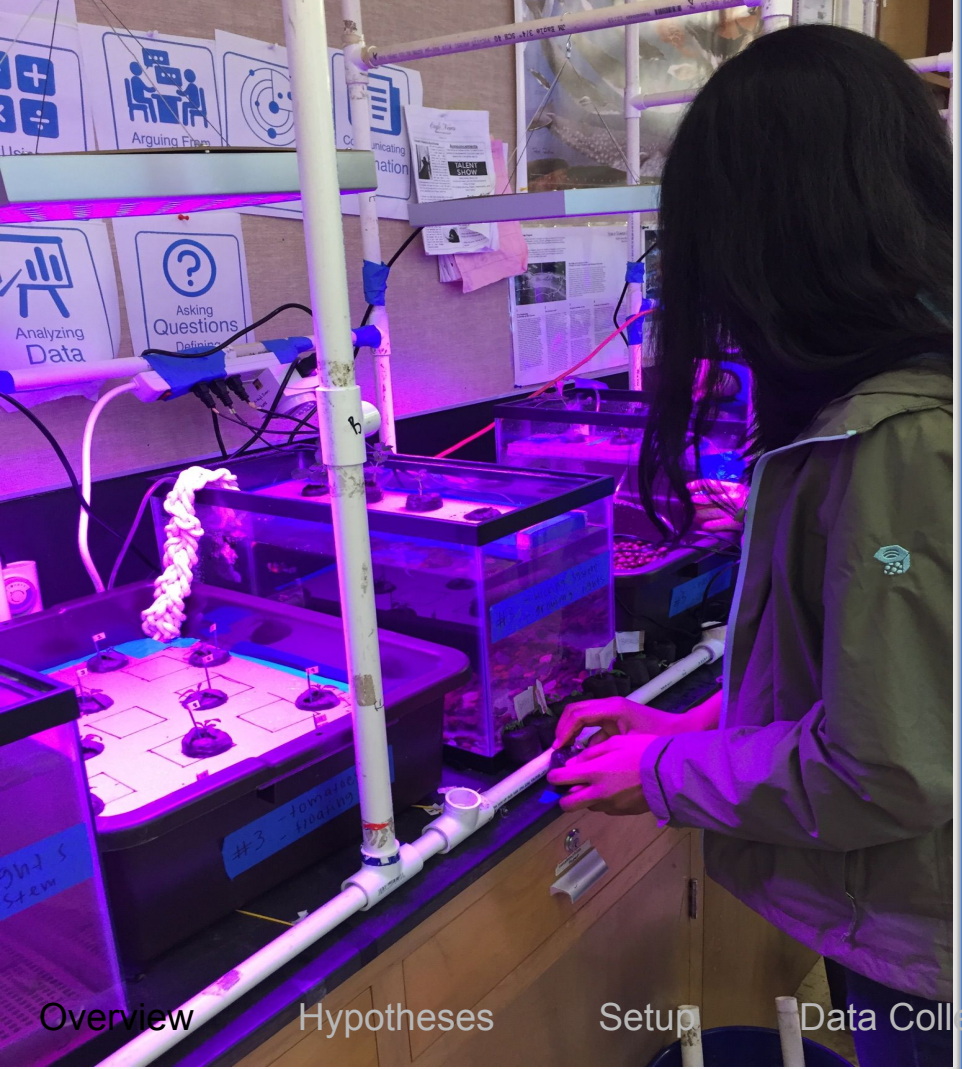


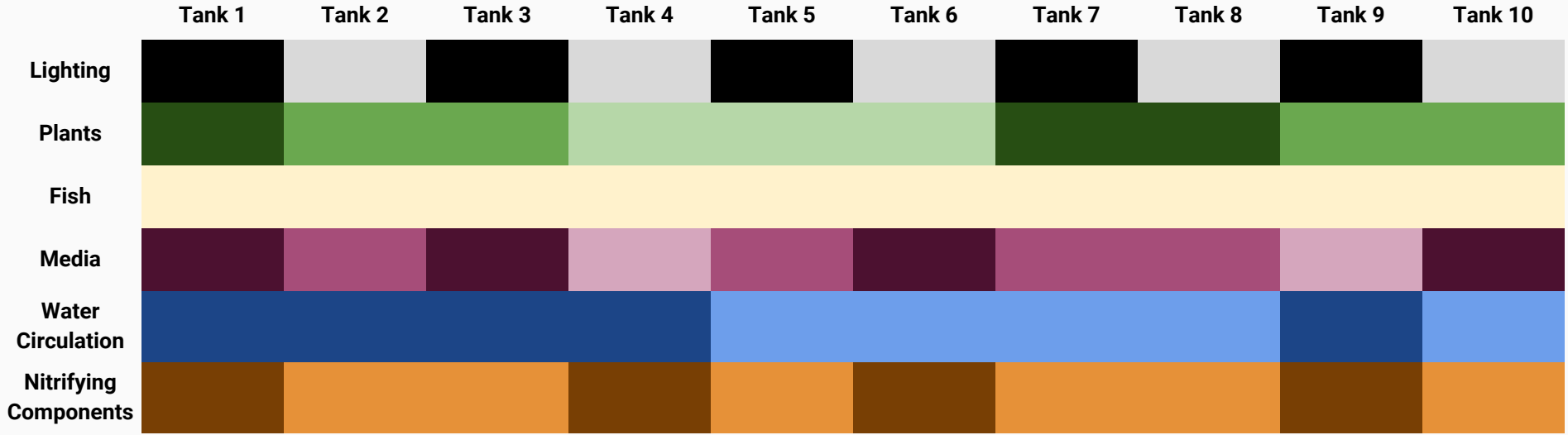


- Food production is key to long term space travel, aquaponics is one possible design solution
- To develop the most efficient/most plant bearing system
- Large scale citizen science



- Over 55 middle school student
- More possible replication than in most labs in the same time frame
- Faster, and great data
- Citizen Science in our schools
- Follows Curriculum for students
- Unique Experience and Exposure for Students

We tested as many independent variables as possible in our 10 tank system to give ourselves a wide foundation to build upon in future experiments.



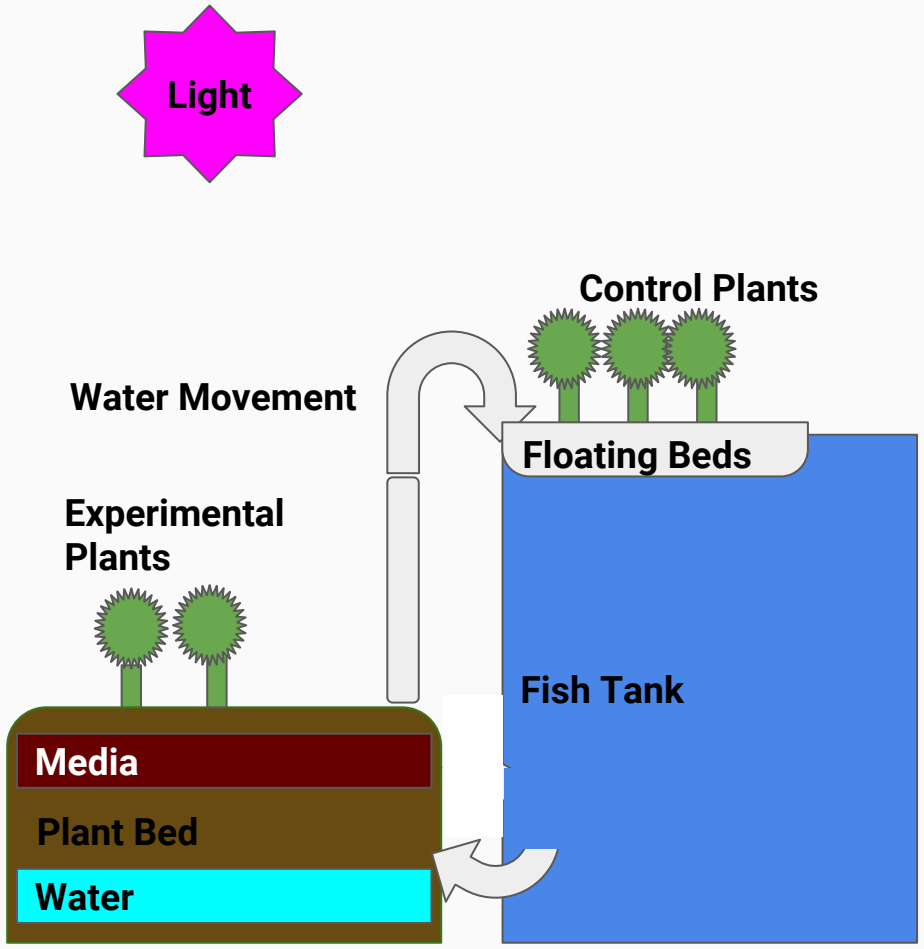
Lighting:	Artificial	Natural and Artificial	
Plants:	Peas	Tomatoes	Basil
Fish:	Goldfish		
Media:	Coconut Husks	Clay Pellets	Floating beds

Water Circulation:	Wicks	Pumps
Nitrifying Components:	Collected Gravel	Commercial Inoculant & Storebought Gravel

Experimental Setup

Three major structures:

- 10 gallon fish tank
  - Fancy and Comet Goldfish
  - Positive control plant group
- Plant bed
  - Experimental Plant Group
  - Media (three treatments)
- Light
  - PVC pipe structure

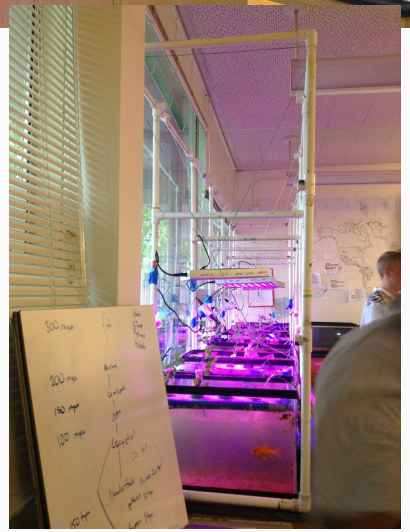


Lighting

Artificial :

- Erligpowht 45W LED Red Blue Hanging Light for Indoor Plants

Natural and Artificial



Plants

Basil

Tiny Tim Tomatoes

Peas

Fish

First: Fancy Goldfish

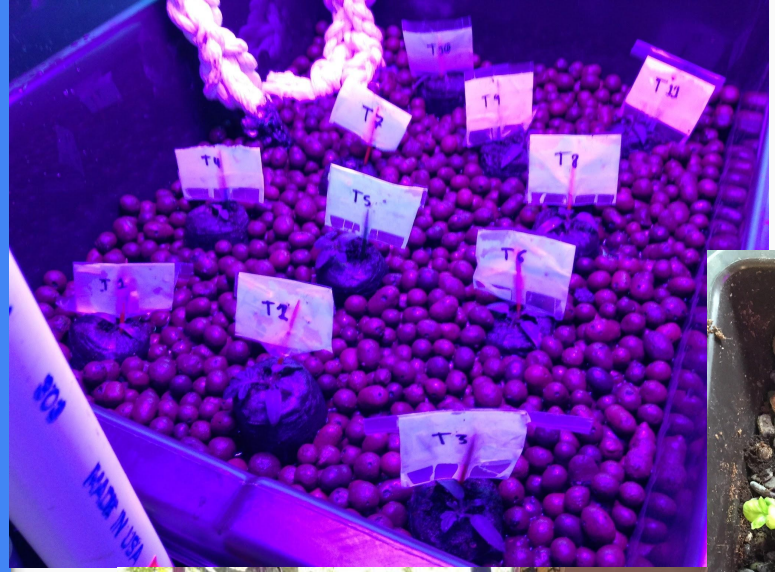
Second: Comet Goldfish

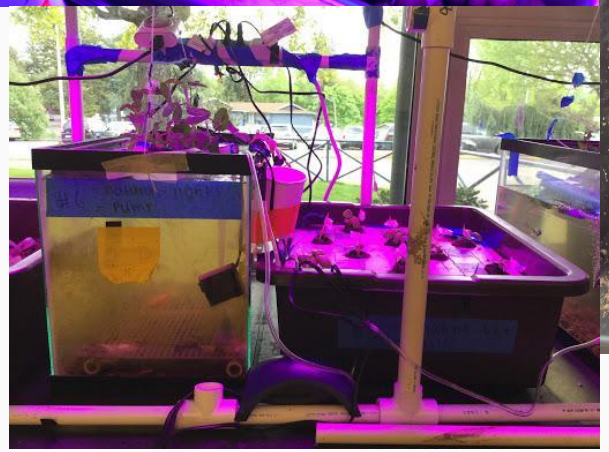
Media

Coconut Husks

8-16 mm Clay Pellets

Floating Beds (branded as insulation material)

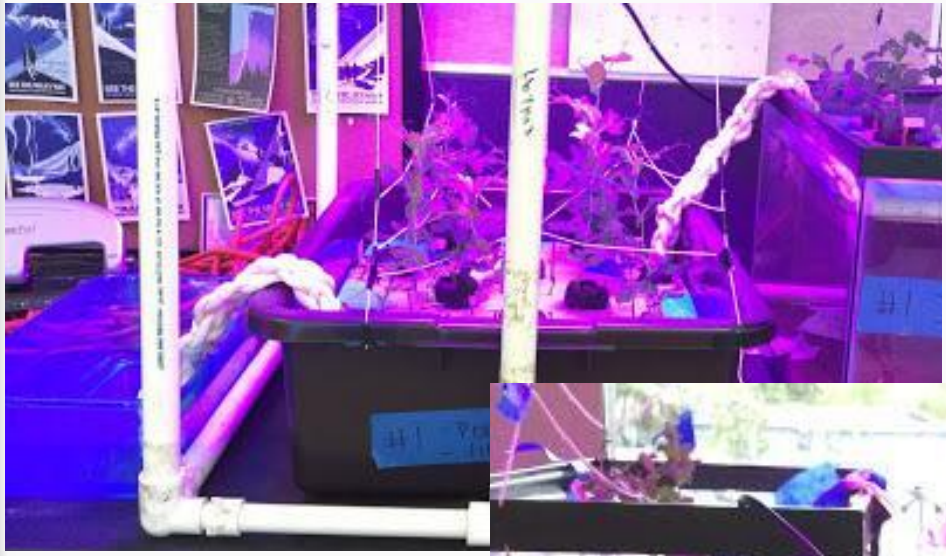


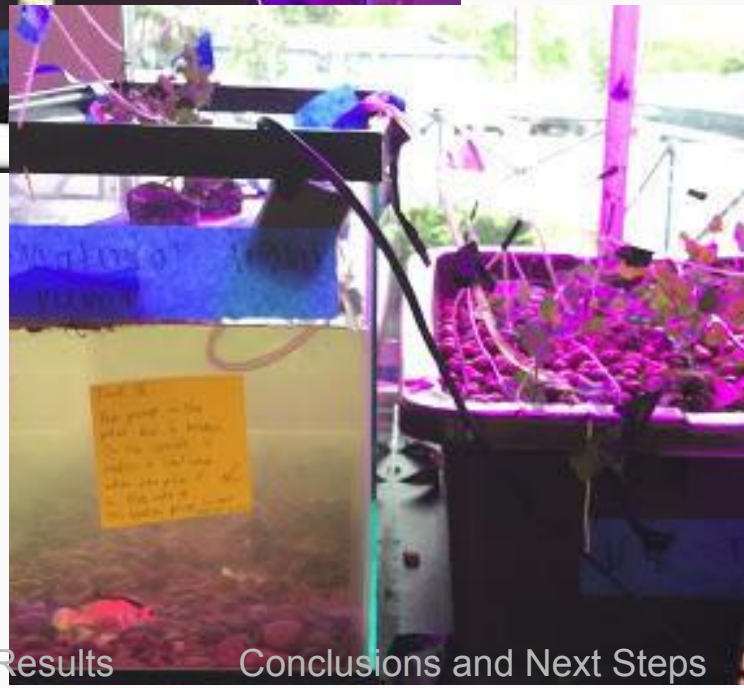


Water Circulation

Wicks (braids of twisted polypropylene rope)

Pumps (300L submersible water pump)

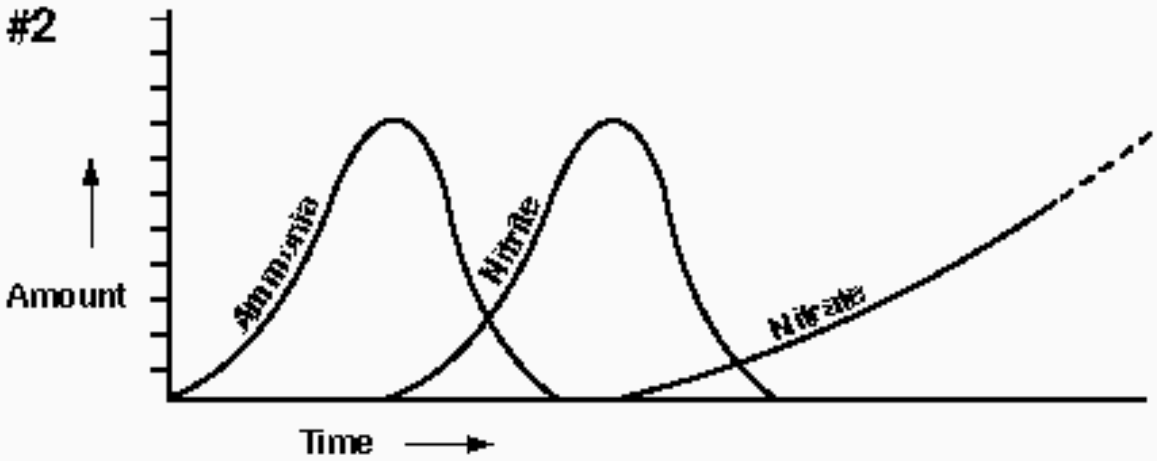




Nitrifying Component

- Nitrate cycle is one of the most important factors in an aquaponics system.

- This is the cycle we expected to see based on previous research in similar topics.



Tanks + Floating Beds + Fish

- 5 tanks on each side
- Floating beds made of styrofoam, with holes and mesh for plants
- 2 fancy goldfish, regular later

Material Beds + Pumps

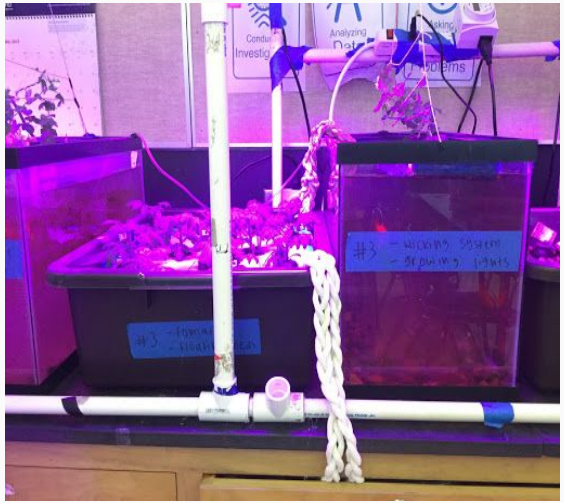
- 13 inch brown Tupperware bins with 15 plants each
- Pump cycling system for 5 tanks
- Plant roots filtered the water

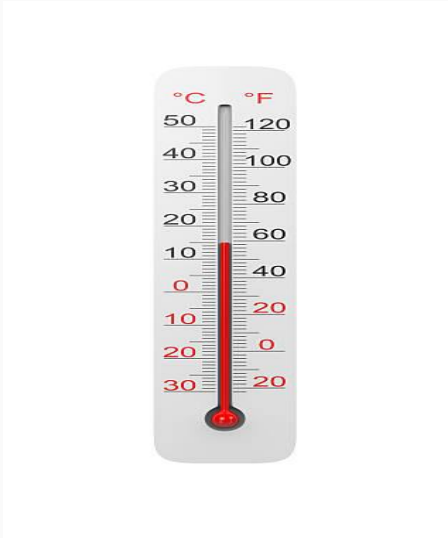
Wicks + Lights

- Polypropylene rope for wicks in 5 of the tanks
- PVC pipes for lights, plugged in to metal string to the adapters
- Lights were pink and blue
- Large amounts of masking tape

We measured the components of the aquaponics system consistently over the course of 10 weeks

- Nutrient Analysis
- Plant growth
- Water quality
- Temperature
- Every two days





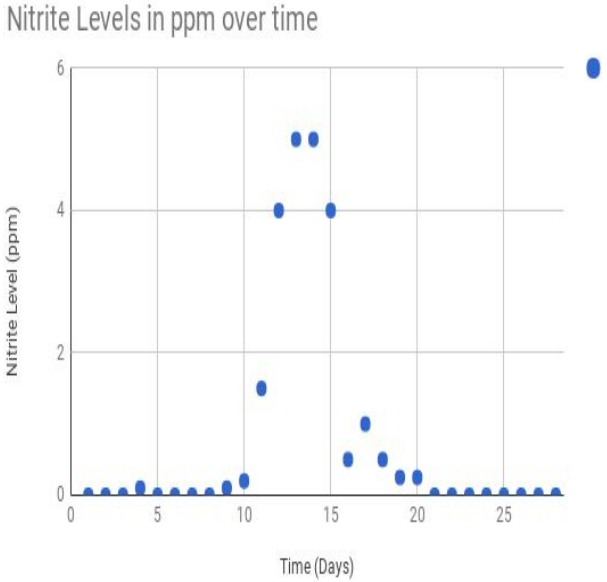
We measured the nutrients in our system

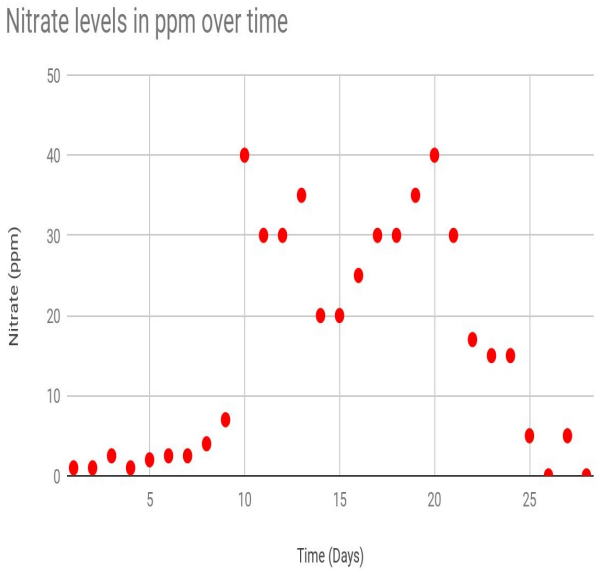
- Nitrate
- Nitrite
- Ammonia
- pH

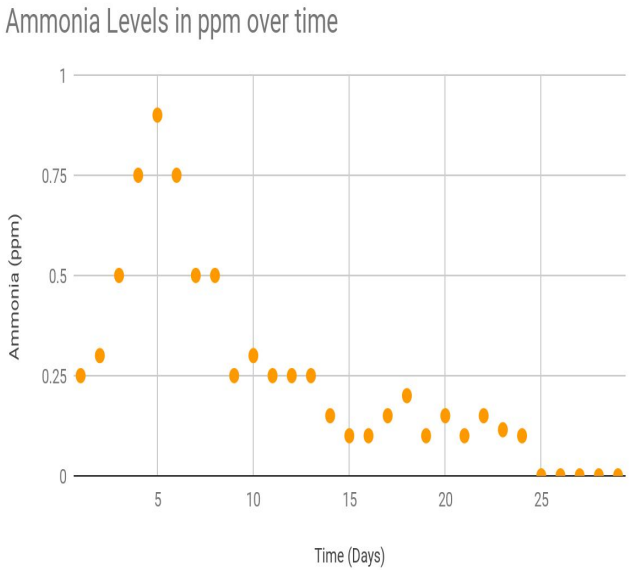
We measured plant growth and temperature

- Twice a week
- Measured root and stem separately
- Thermometer for temperature
- To see whether our system is working

We were able to create a curve which showed cycling of nutrients

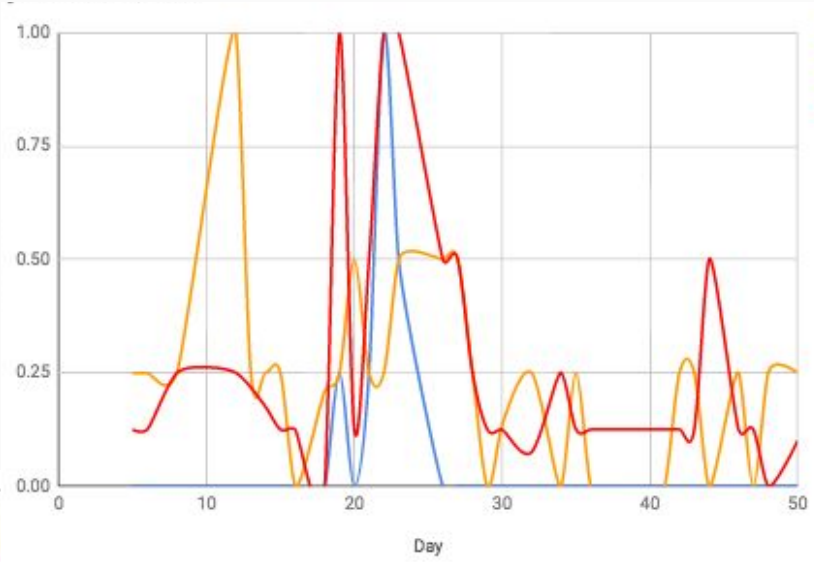


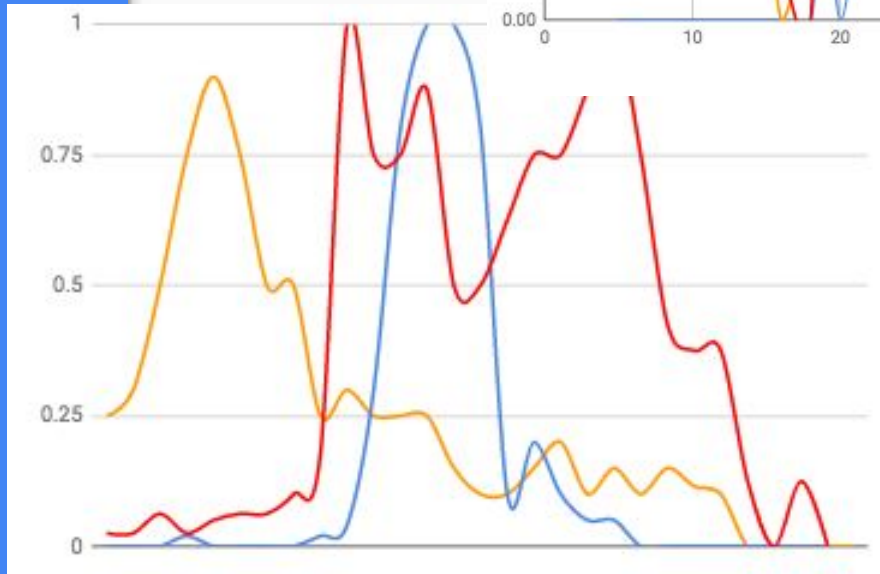




Several tanks succeeded in cycling their nutrients

- Ammonia spike followed by nitrite and nitrate spike
- Inconsistencies because of water changes and ammonia input





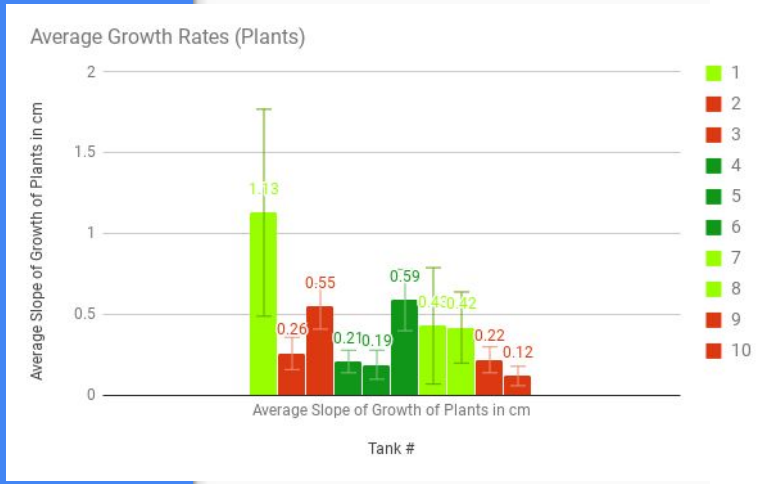
Ammonia

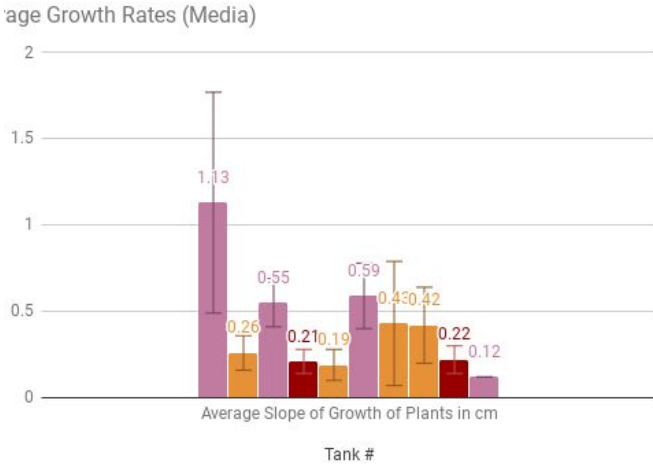
Nitrite

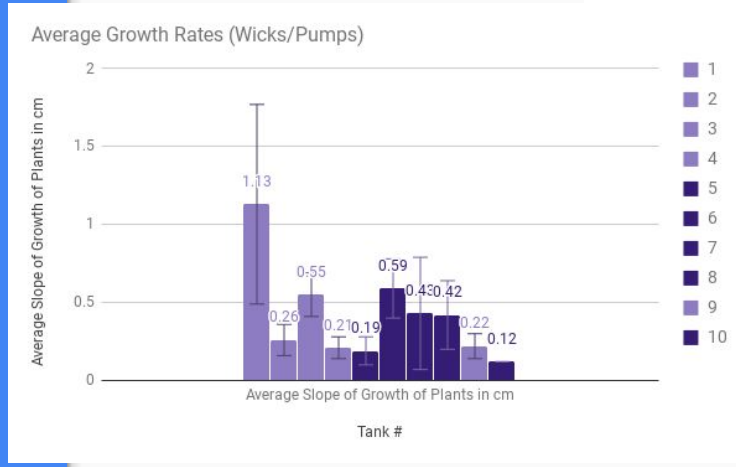
Nitrate

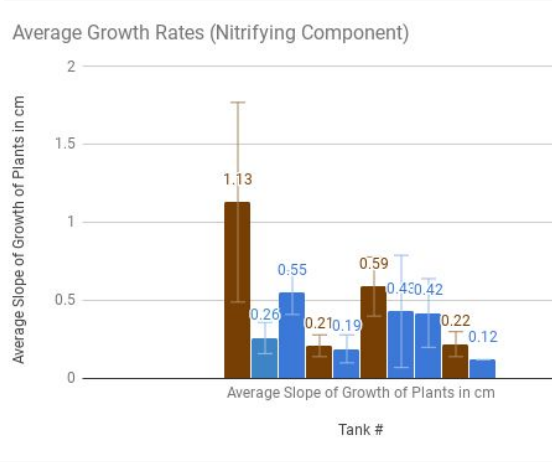
Plant Growth

- Not enough data to find correlation between nutrient levels and plant growth rate
- Plant growth affected primarily by human and outside factors not variable matrix







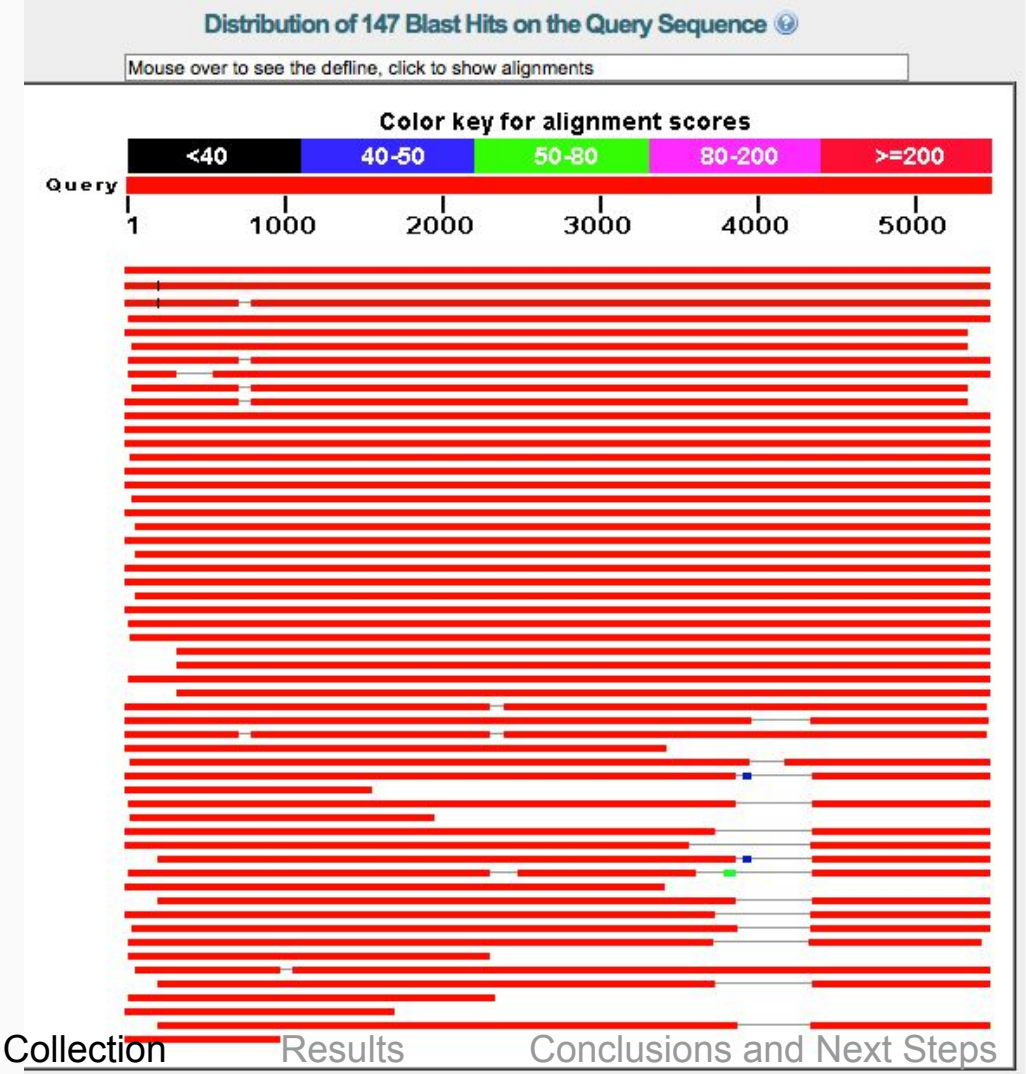


Next Steps

- This data represents time 3, we have two other time points to look at community shifts over the experiment
- Incredibly rich data
- Questions for future aquaponics students
- Data analysis for hypotheses to be tested in next experiment
- MinION on ISS

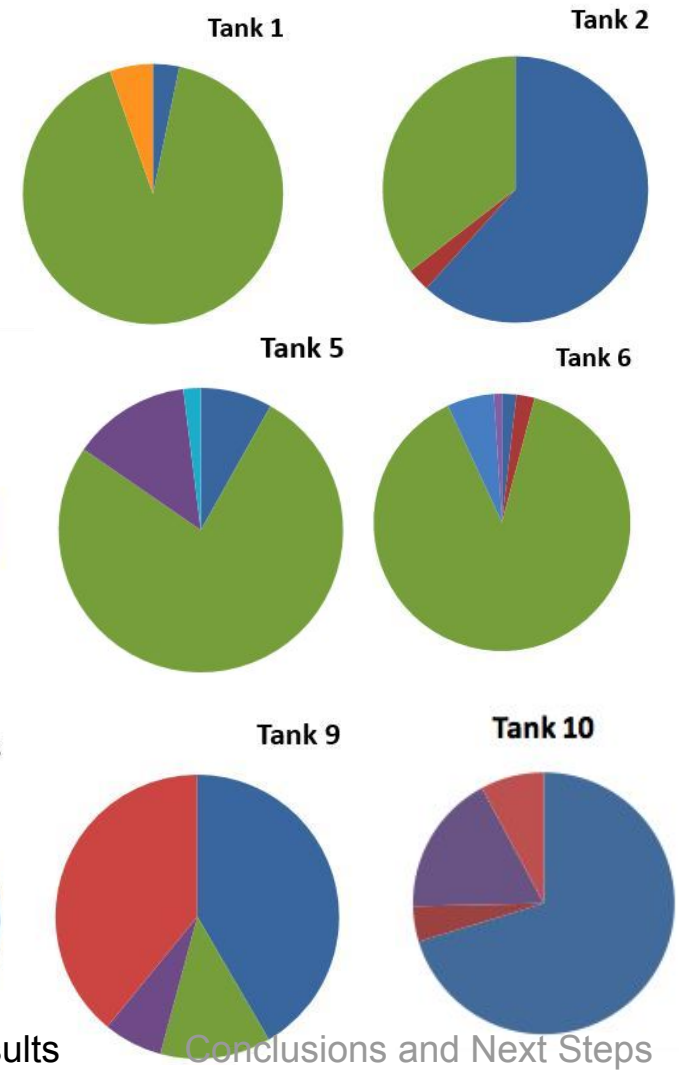
We used the MinION platform

- 16S rRNA sequences
- Identified using BLAST algorithm through the EPI2ME platform
- Primary biological sequence information



- Alphaproteobacteria
- Bacilli
- Betaproteobacteria
- Chitinophagia
- Closttridia
- Cytophagia
- Deltaproteobacteria
- Gammaproteobacteria
- Negativicutes
- Plantctomycetia
- Sphingobacteria

Each pie chart represents 100,000 species of bacteria found in each tank



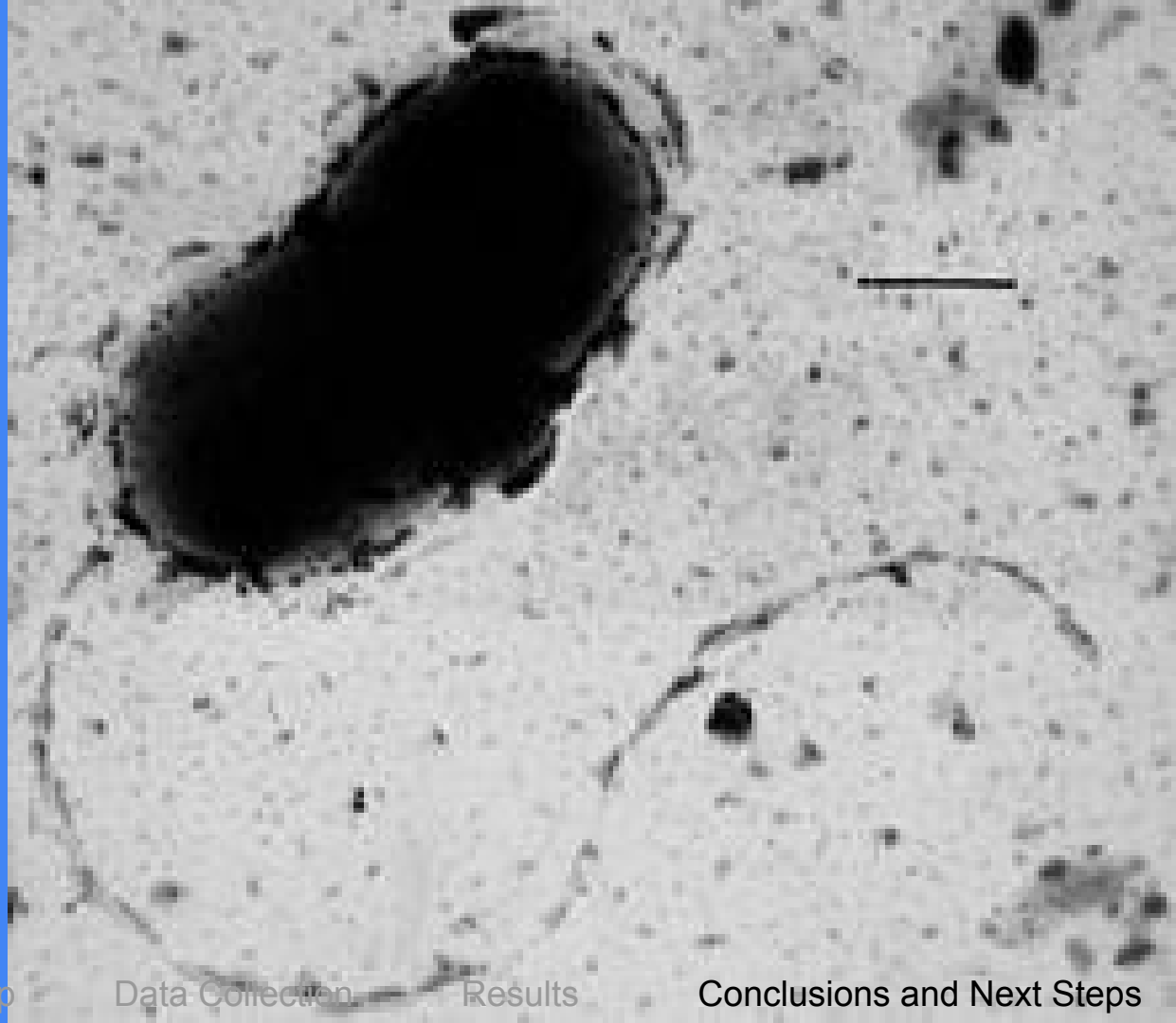
Next Steps: working to test correlations between species shown in the pie charts and the variable matrix

Lighting:	Artificial	Natural and Artificial	
Plants:	Peas	Tomatoes	Basil
Fish:	Goldfish		
Media:	Coconut Husks	Clay Pellets	Floating beds

Water Circulation:	Wicks	Pumps
Nitrifying Components:	Collected Gravel	Commercial Inoculant & Storebought Gravel

Deltaproteobacteria in Tank 6

- Myxospore forming bacteria
- Found uniquely in tank 6

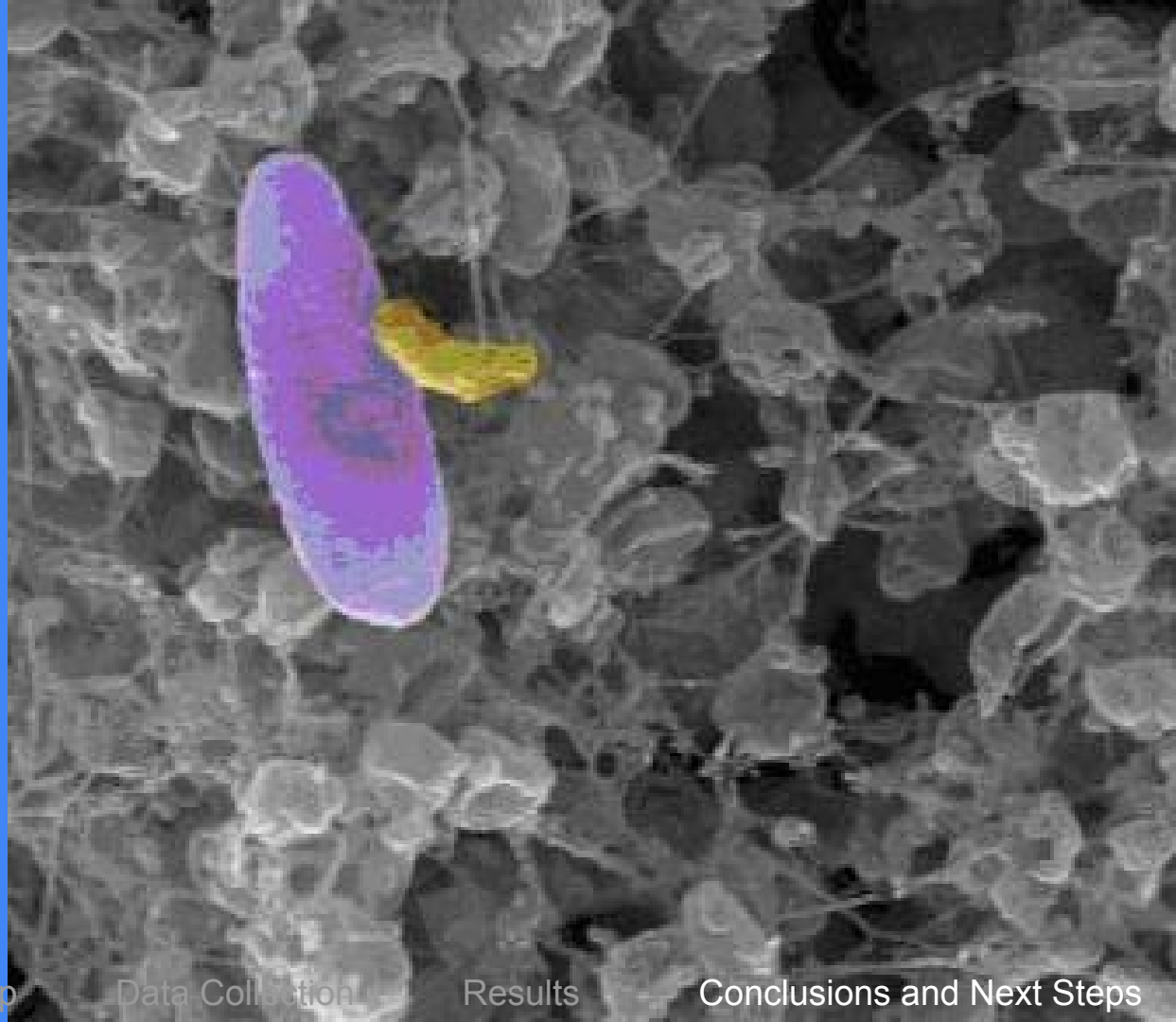


High percentage of Betaproteobacteria in the gravel tanks

- Possibly due to naturally occurring nitrifiers

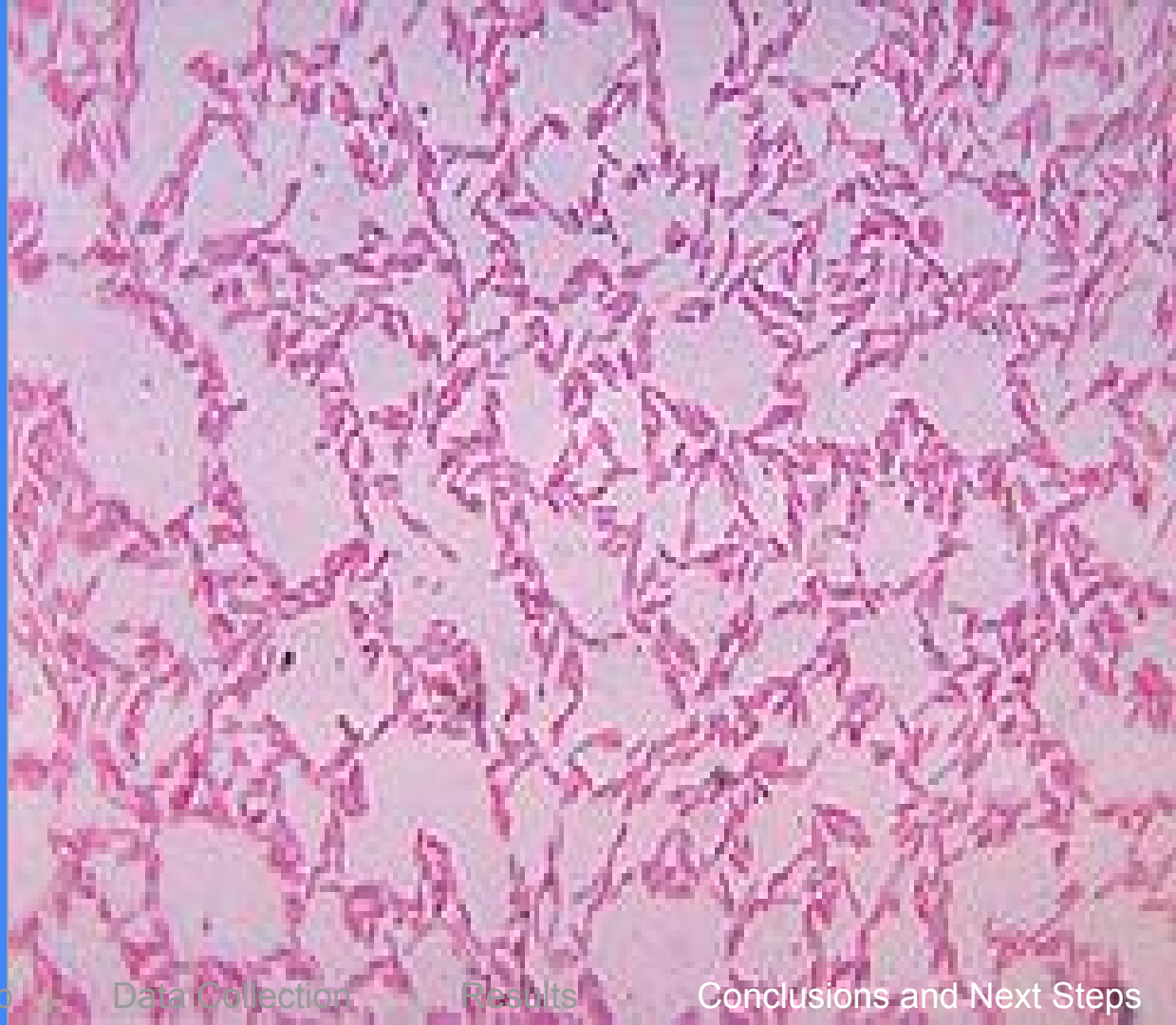
Vampirovibrio chlorellavorus

- Chlorella-eating bacteria
- One of few predatory bacteria



Sphingnobacteria

- Present uniquely in tank 5



Azosprillum

- Nitrogen-fixing bacteria
- Plant-growth promoting bacteria
- Rizobacter, Erzasprillum

Questions?

For more info, see: **https://tinyurl.com/y7689rex**

Fish Mortality

- Affected by temp rather than nutrient levels
- Outside temperature spike led to fish death
- Tanks with natural light had lower mortality rate