Instrument Development to test Microgravity Biofilm Formation Aboard the International Space Station

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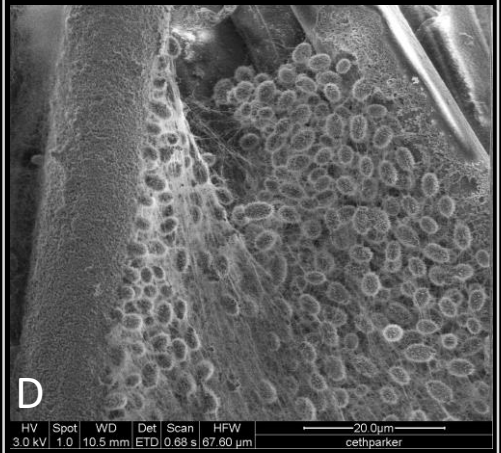
Introduction

- Biofilms pose threats to the crew and life support systems aboard the International space Station (ISS)
- Biofilm mitigation is essential for Moon and Mars missions
- Cultivating ISS Microbes on Earth
- Discovered dual biofilm morphologies in ISS yeast *Rhodotorula mucilaginosa*
- Need to to study under 'ISS' relevant conditions

Biofilms on the ISS

Photos from Mr. Donald Layne Carter, NASAMarshall Space Flight Center

Cultivated at JPL

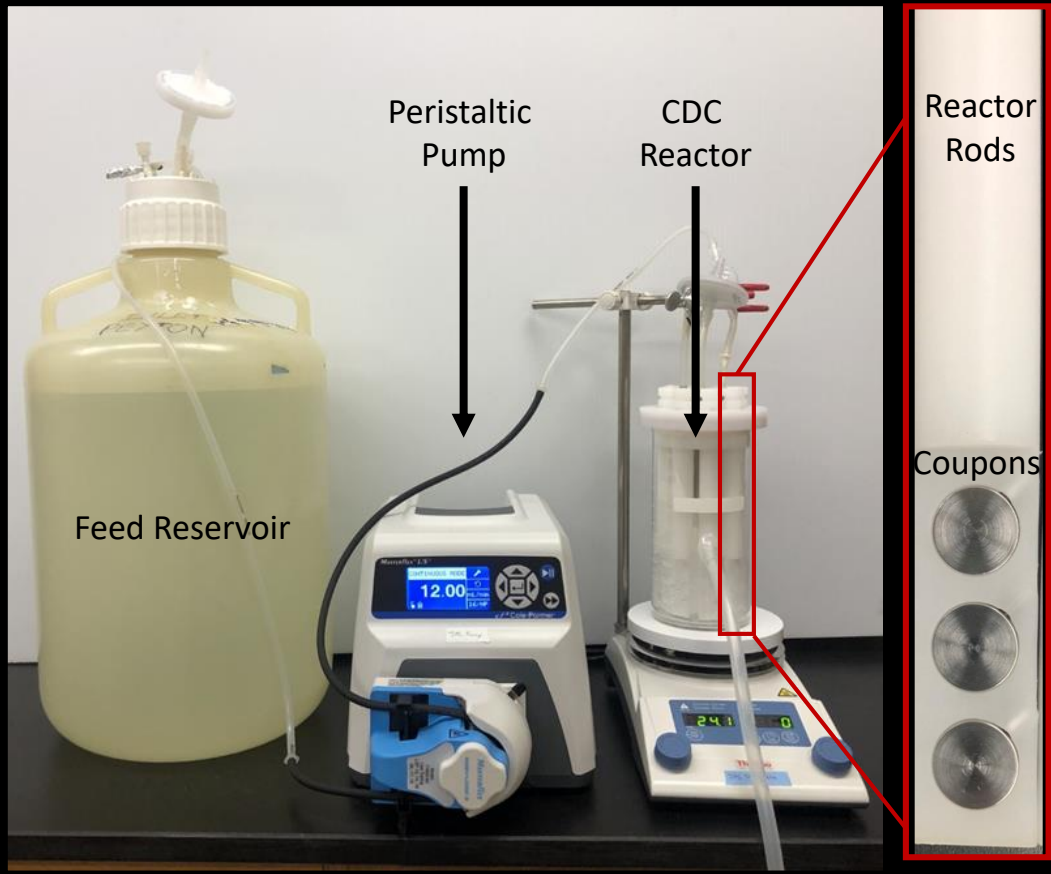


Images from Dr. Ceth Parker, NASA Jet Propulsion Laboratory

Current State of the Art

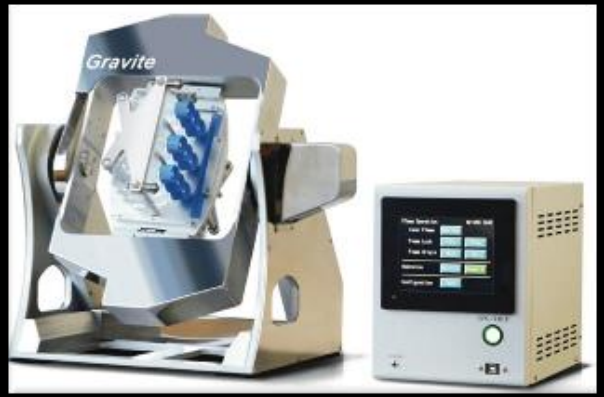
- Centers for Disease Control (CDC) bioreactors
  - State of the art
  - Industry standard
  - Bench top method provides flow regimes
  - However; many draw backs

	CDC Bioreactor
Volume	20 L
Duration	36 H to 4 Days
Power Source	AC 120V power
Weight	~35 kg
Portable/Invertible	No - No

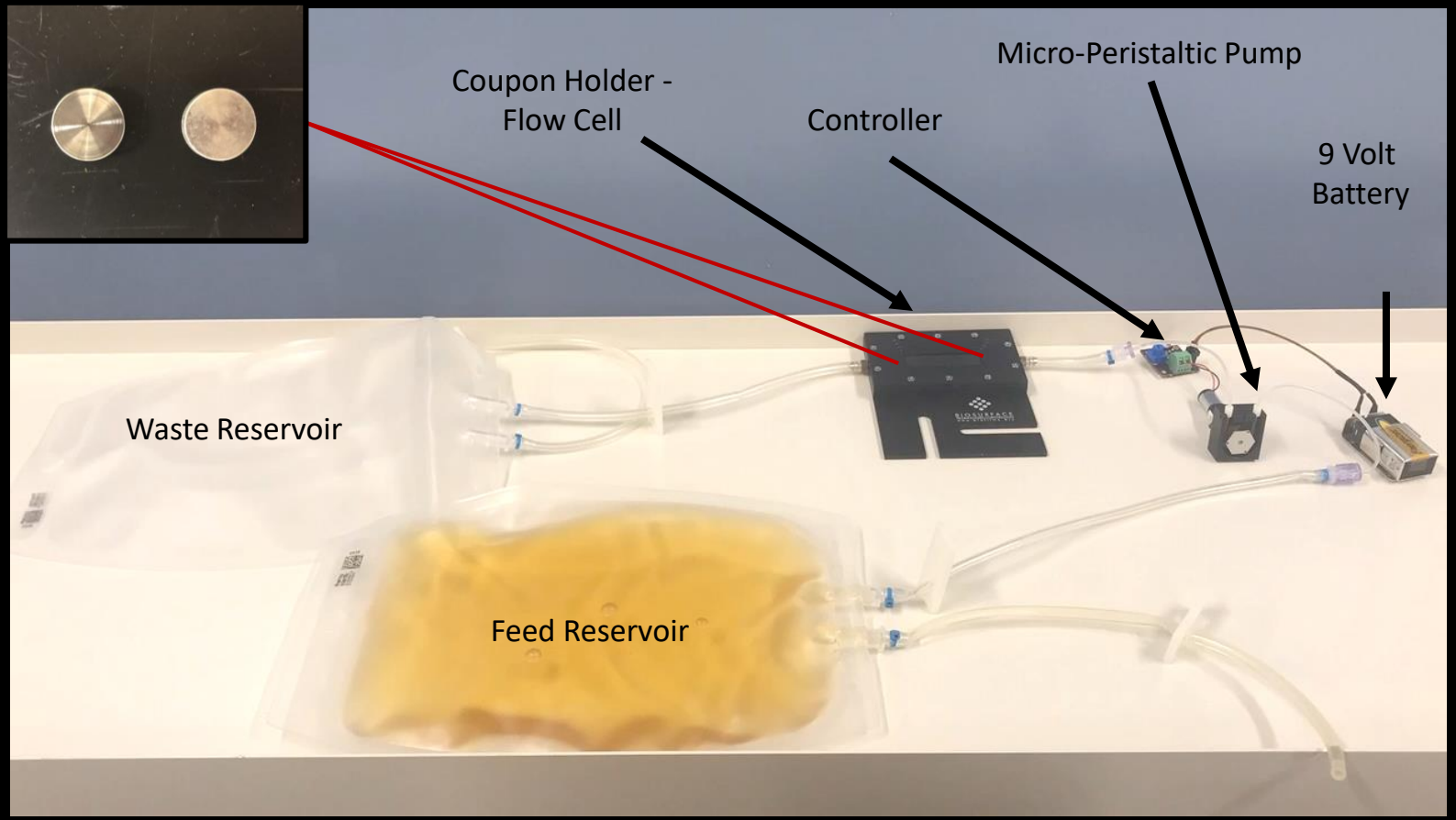


Role of Microgravity (µG) in Biofilm Formation

- Simulated µG Devices (3D Clinostats) allow testing on Earth
  - Samples are inverted while being turned in all directions
- Need to test µG AND flow regimes
- NO current Technology can meet these requirements



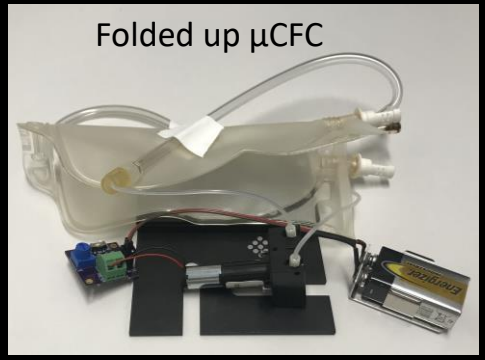
Microgravity Compatible Continuous System Flow Cell (µCFC) for Microbial Growth and Biofilm Analysis



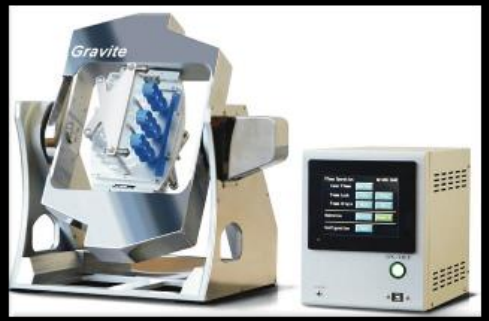
Problem discovery, concept, design, system building, and testing performed by Dr. Ceth Parker; Controller was designed and built by Dr. George Richdale

Accomplishments

	CDC Bioreactor	µCFC
Volume	20 L	0.5 L ✓
Duration	36 H to 4 Days	2 Days to 20 Days ✓
Power Source	AC 120V power	9 Volt Battery ✓
Weight	~35 kg	< 1 kg ✓
Portable/Invertible	No - No	Yes - Yes ✓



- Succeeded
  - Complete Miniaturization
  - Filling the technology gap
    - Can operate on simulated-µG devices
- 1 New Technology Report
- 1 Provisional Patent

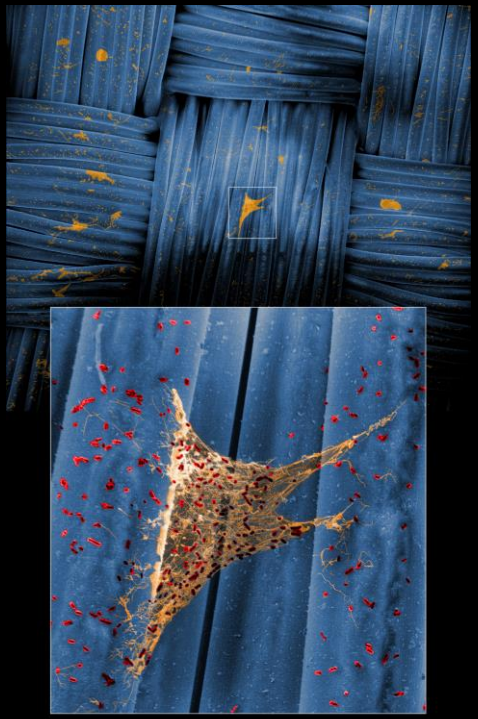


Varied Applications

- Microgravity Associated Research
  - Simulated-µG studies
  - International Space Station studies
  - Cube Sat Studies
  - Antarctic Balloon Studies
- Medical Research
  - Infectious Microorganisms
    - Full sample and waste containment
  - Biofilm growth on Medical Devices
- General Biofilm Studies

Accomplishments and Publications

- Awards
  - 2019 American Society for Gravitational and Space Research conference in Denver, CO., 1st place in Technical Merit for my submitted SEM (Below) .
  - Two JPL Team awards
    - "COVID Surface Testing Team Award"
    - "Outstanding execution of the move and set up of the new B245 Planetary Protection Lab"
- Provisional Patents
  - Microgravity Compatible Continuous Flow Cell (μCFC) System for Microbial Growth and Biofilm Analysis
    - **Ceth Parker**, George Richdale, Kasthuri Venkateswaran CIT-8517-P
- New Technology Reports
  - Microgravity Compatible Continuous Flow Cell (μCFC) System for Microbial Growth and Biofilm Analysis
    - **Ceth Parker**, George Richdale, Kasthuri Venkateswaran JPL NTR ID # 51649
  - Enclosed Miniature-CDC Rods (EMCR) system for Biofilm Analysis in Microgravity Simulators
    - **Ceth Parker**, Kasthuri Venkateswaran JPL NTR ID # 51725
  - Culture Tube Holder for both the Gravite and RPM Microgravity Simulators
    - Jonathan Gleeson, Jeffrey Richards, **Ceth Parker**, Kasthuri Venkateswaran, Ye Zhang: NASA NTR ID # 1596561636
- Select Accepted Publications
  - **Parker CW***, Singh N*, Tighe S*, Blachowicz A, Wood JM, Seuylemezian A, Vaishampayan P, Urbaniak C, Hendrickson R, Laaguiby P, Clark K, Clement BG, O'Hara NB, Couto-Rodriguez M, Bezdan D, Mason M, and Venkateswaran K*. End-to-End Protocol for the Detection of SARS-CoV-2 from Built Environments. mSystems. Accepted. (*Co-First Authorship)
  - Mohan GB*, **Parker CW*,** Urbaniak C*, Singh N, Hood A, Minich J, Knight R, Rucker MA, Venkateswaran K. Microbiome and Metagenome Analyses of a Closed Habitat During Human Occupation. mSystems. 2020;5:1. (*Co-First Authorship)
  - Mhatre SS, Singh NK, Wood JM, **Parker CW**, Venkateswaran K. Description of chloramphenicol resistant Kineococcus rubinsiae sp. nov. isolated from a spacecraft assembly facility. Frontiers in Microbiology. 2020;11:1957.
  - Urbaniak C, Wong S, Tighe S, Arumugam A, Liu B, **Parker CW**, Wood JM, Singh NK, Skorupa D, Peyton B, Jenson R. Validating an automated nucleic acid extraction device for omics in space using whole cell microbial reference standards. Frontiers in Microbiology. 2020;11:1909.



"One Small EPS for Bacteria,
One Giant Biofilm for Bacterial-Kind"

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