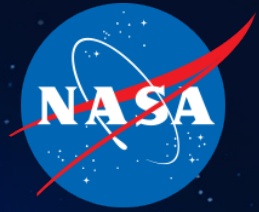




National Aeronautics and  
Space Administration



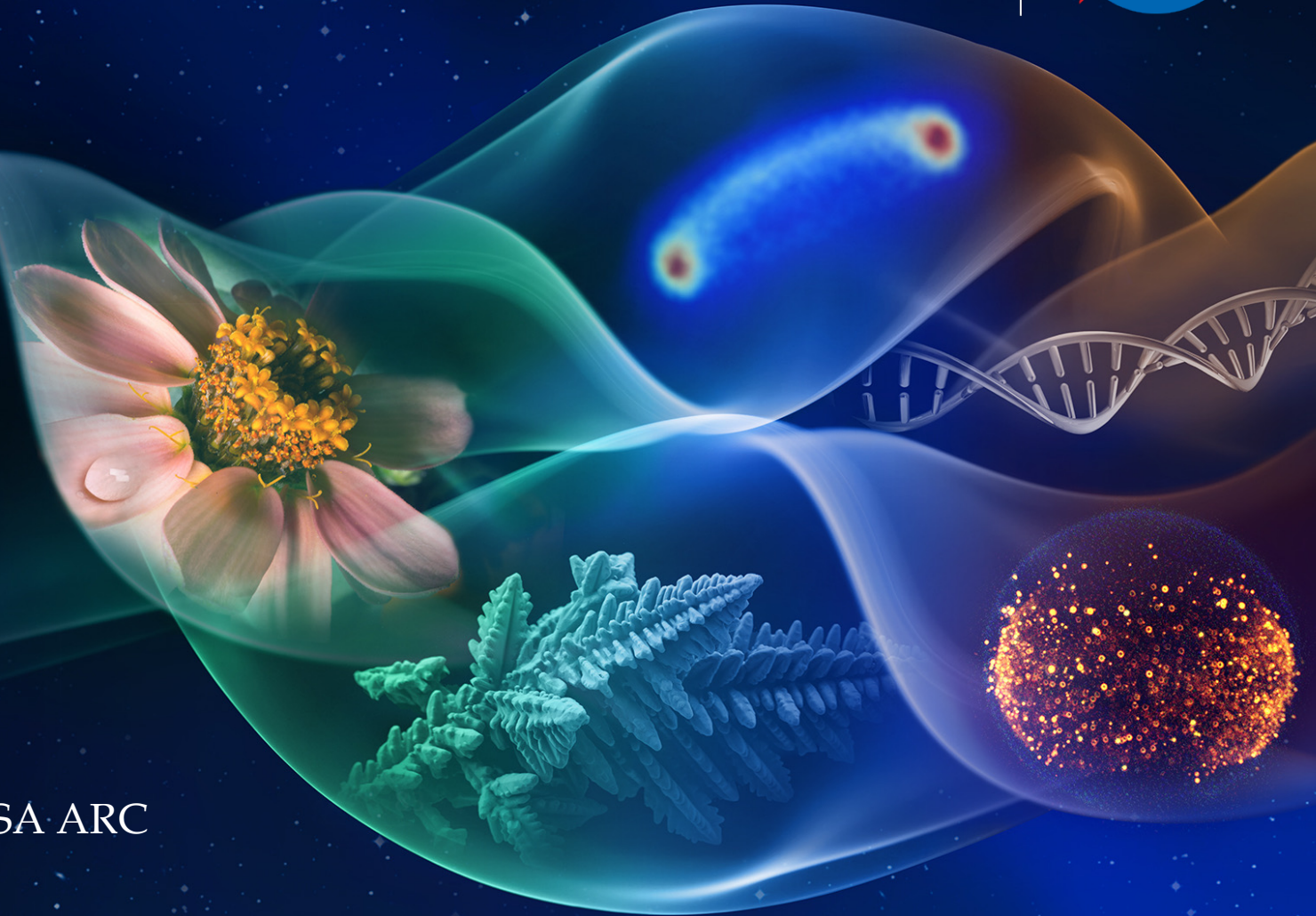
# Human Airway Responses to Lunar Dust Simulants

Katarina Lile

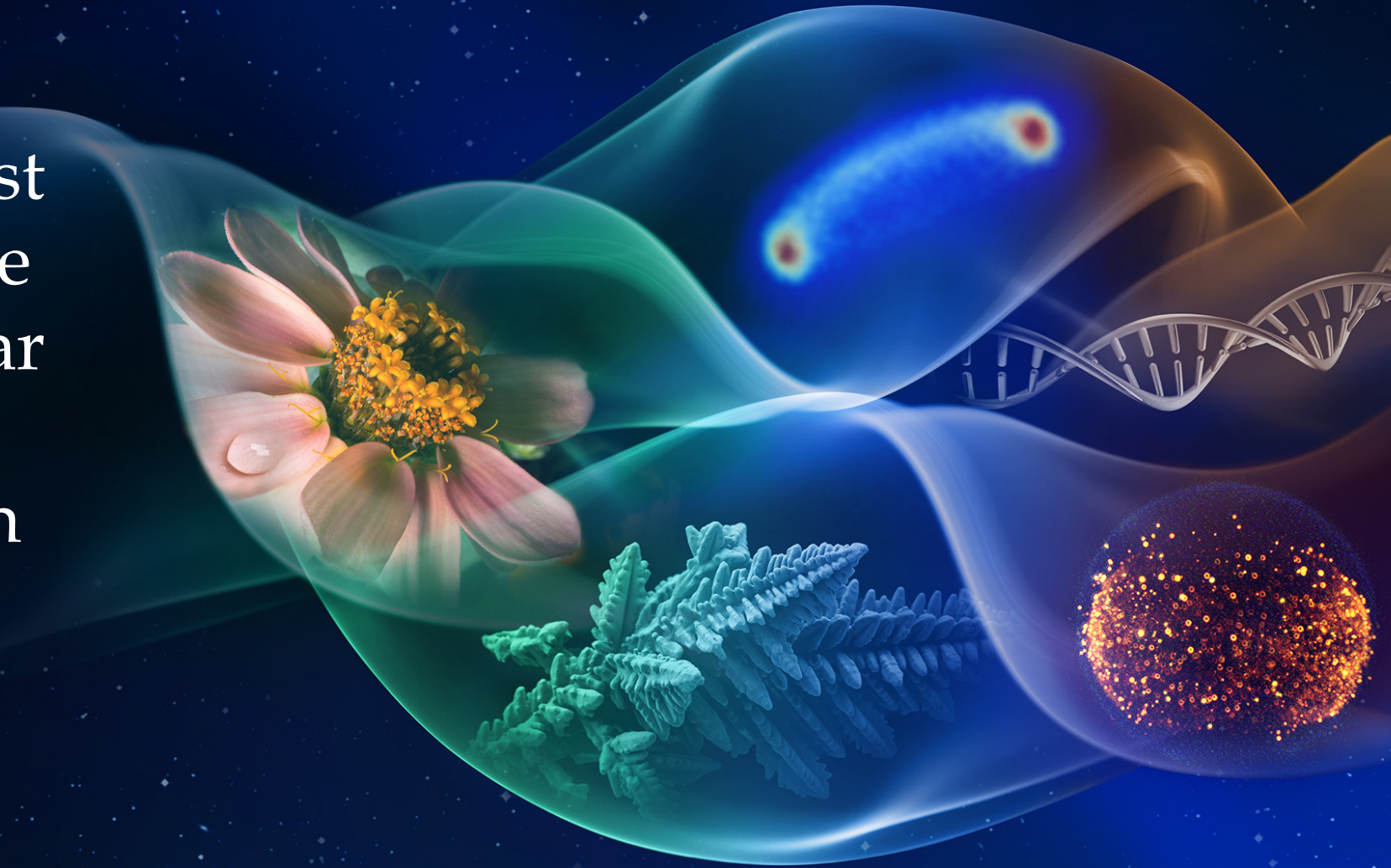
Space Life Sciences Training Program, NASA ARC

University of Vermont

Piyumi Wijsekara, PhD & Egle Cekanaviciute, PhD



How will lunar dust  
simulants effect the  
motility and cellular  
composition of  
engineered human  
airway organoid  
models?



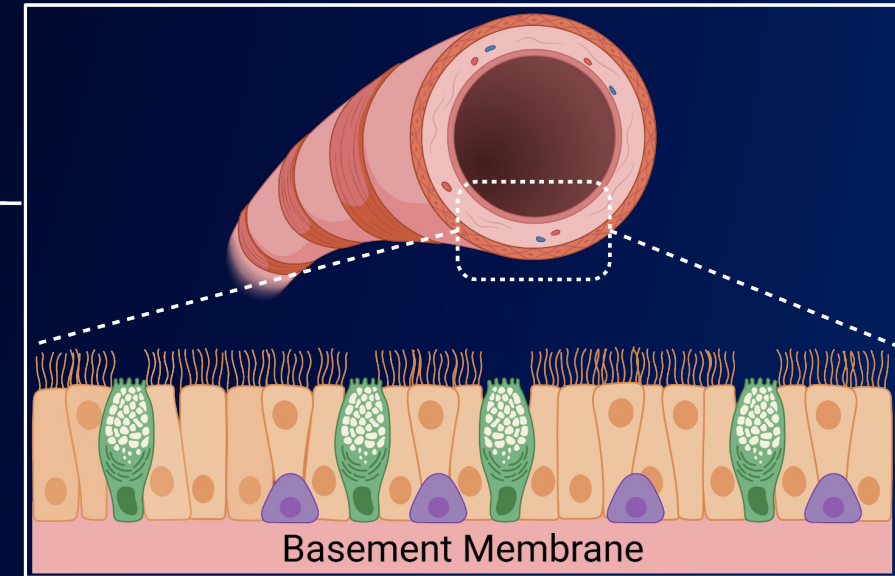
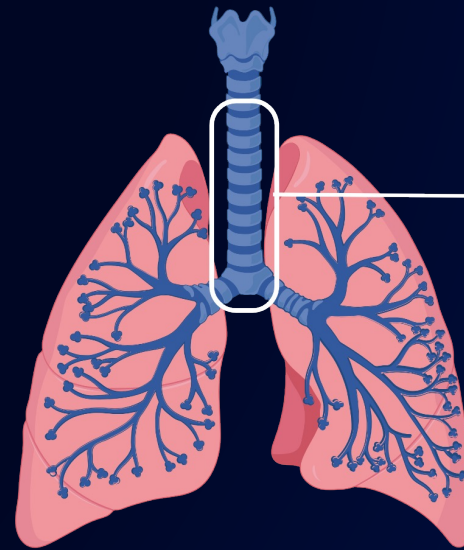
# Motivations

- Unknown effects of space flight stressors limit human space travel
- Generally, space flight stressors result in lung capacity deficiencies
- Lunar dust is a major hazard for lunar missions, yet little is known about its specific effects on the human respiratory system
- Critical insight on risk of chronic lunar dust exposure to the human airway
- Mitigation strategies for astronauts on lunar missions

# Background

Two main units of the lung:  
(i) The airway zone  
(ii) The respiratory zone

Interior pseudostratified columnar epithelium:  
characterized by multi-ciliated cells, goblet cells, and basal stem cells



basal stem cell

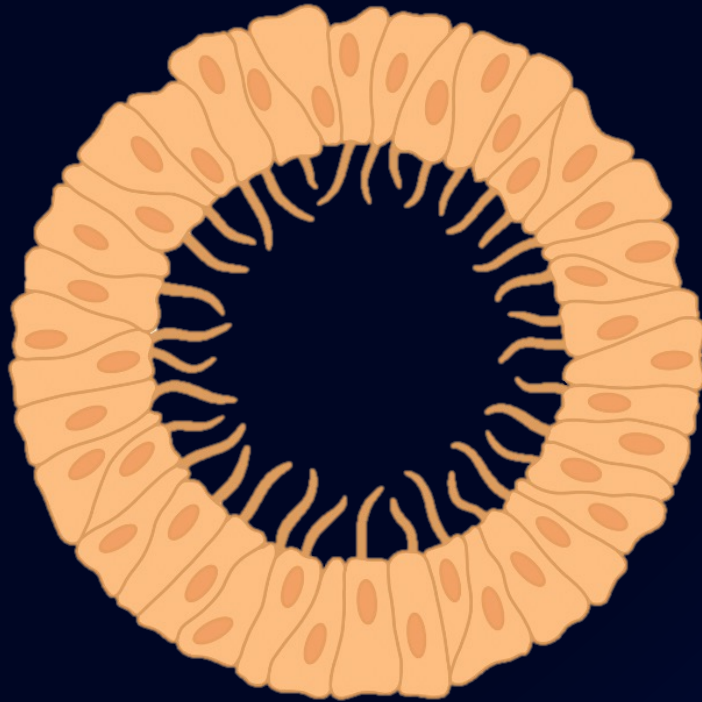


ciliated cell



goblet cell

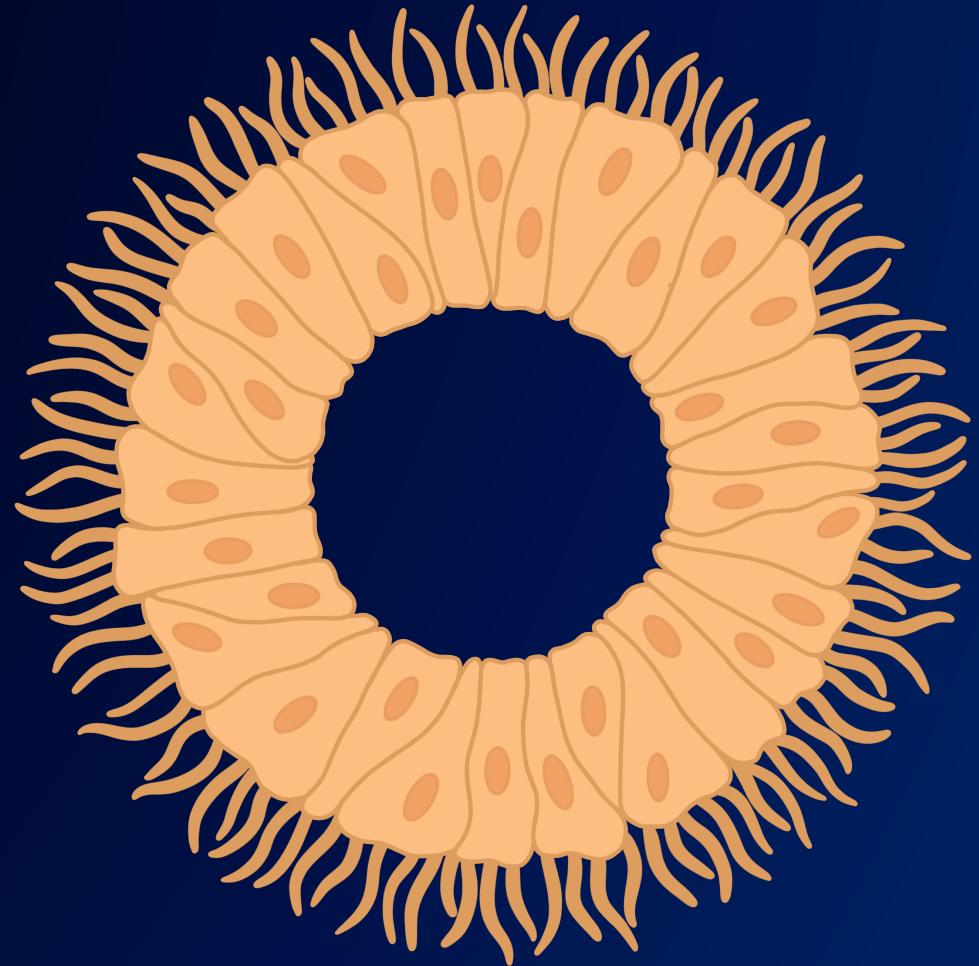
# Background – Airway Organoids



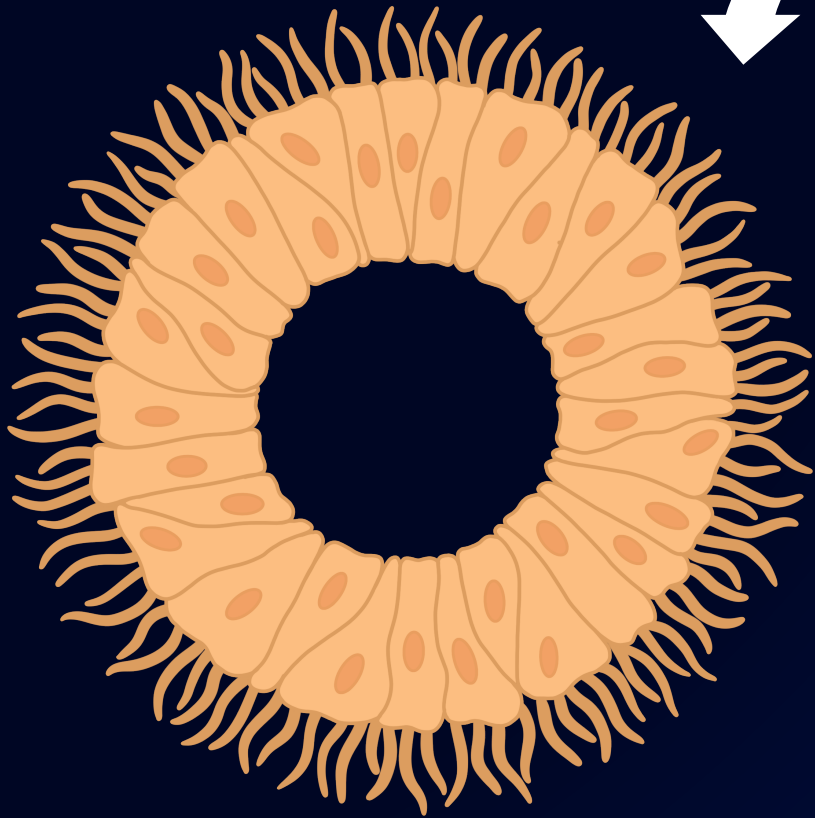
- Spheroids formed from human airway basal stem cells
- Conventional airway organoids have an apical-in epithelial polarity
  - Unable to expose to external environment
  - Build-up of cellular debris within organoid

# Background – Apical-out Airway Organoids

- Differentiated ciliated cells are on the exterior of the organoid
- Mimics the native human airway epithelium more accurately
- Engineered by culturing in an ECM-deprived culture
- Allows for access to apical surface



# Background - Lunar Dust Simulants



Mimic chemical and mineral composition of true lunar dust

# Background – LMS-1

- Formulated by Exolith Labs
- Particle size ranges from <math><0.4\mu\text{m}</math> – 1000 $\mu\text{m}</math>$
- Mimics the lunar maria compared to the lunar highlands



## Mineralogy

As mixed.

| Component         | Wt.% |
|-------------------|------|
| Pyroxene          | 32.8 |
| Glass-rich basalt | 32.0 |
| Anorthosite       | 19.8 |
| Olivine           | 11.1 |
| Ilmenite          | 4.3  |

## Safety

See SDS for details.  
Primary hazard is dust inhalation; wear a respirator in dusty conditions.

## Bulk Chemistry

Relative abundances.  
Measured by XRF.

| Oxide                          | Wt.%        |
|--------------------------------|-------------|
| SiO <sub>2</sub>               | 46.9        |
| TiO <sub>2</sub>               | 3.6         |
| Al <sub>2</sub> O <sub>3</sub> | 12.4        |
| FeO                            | 8.6         |
| MnO                            | 0.2         |
| MgO                            | 16.8        |
| CaO                            | 7.0         |
| Na <sub>2</sub> O              | 1.7         |
| K <sub>2</sub> O               | 0.7         |
| P <sub>2</sub> O <sub>5</sub>  | 0.2         |
| LOI*                           | 0.9         |
| <b>Total**</b>                 | <b>99.0</b> |

\* Loss on ignition

\*\* Excluding volatiles and trace elements

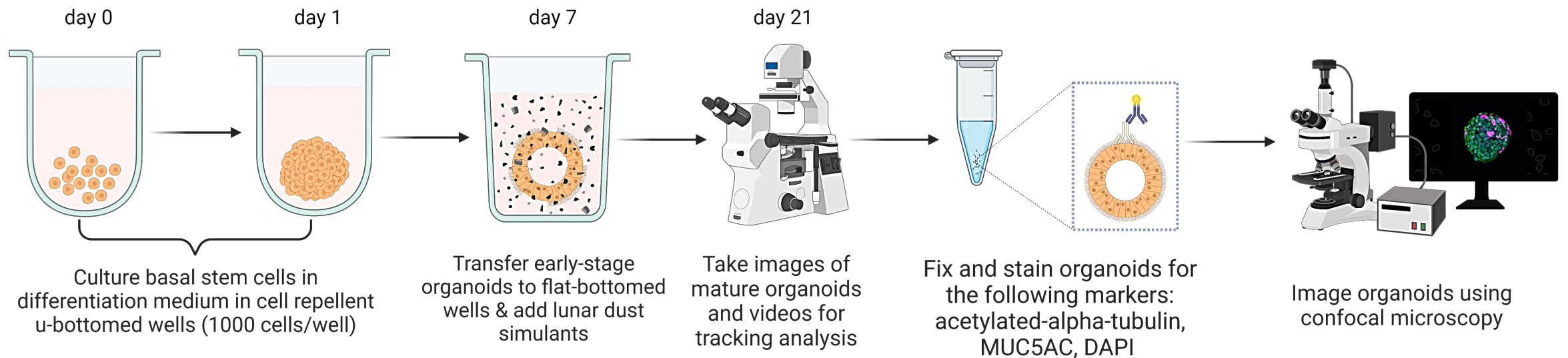
# Background – JSC-1A

- Formulated by Johnson Space Center in the 1990s
- Particle size ranges from <20 $\mu$ m – 5mm
- Primarily glass-rich basaltic ash – Flagstaff, AZ

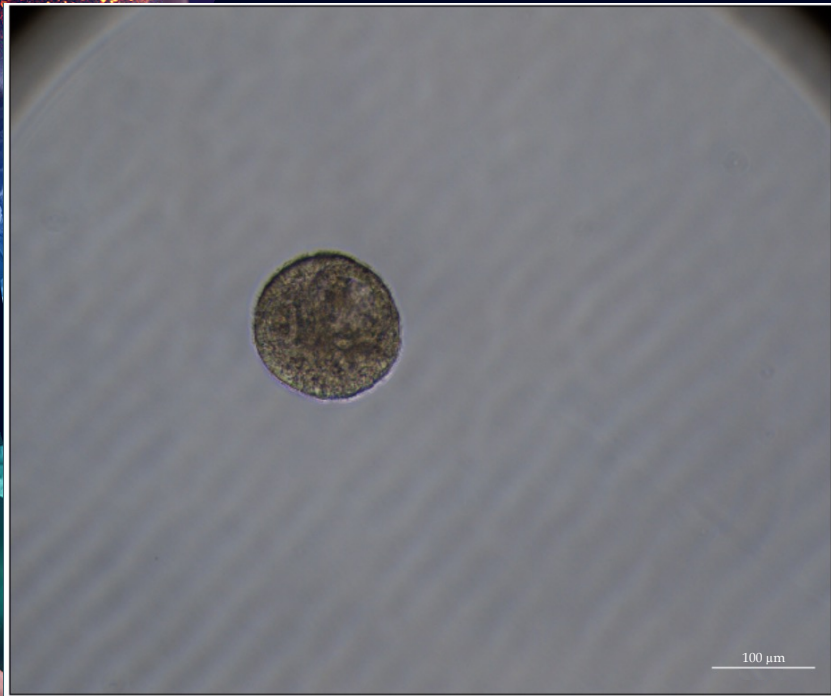


| Oxide                          | Conc. |              | Std. Dev. |      |
|--------------------------------|-------|--------------|-----------|------|
|                                |       | Wt %         |           | Wt % |
| SiO <sub>2</sub>               |       | 47.71        |           | 0.10 |
| TiO <sub>2</sub>               |       | 1.59         |           | 0.01 |
| Al <sub>2</sub> O <sub>3</sub> | 15.02 |              | 0.04      |      |
| Fe <sub>2</sub> O <sub>3</sub> |       | 3.44         |           | 0.03 |
| FeO                            |       | 7.35         |           | 0.05 |
| MgO                            |       | 9.01         |           | 0.09 |
| CaO                            |       | 10.42        |           | 0.03 |
| Na <sub>2</sub> O              | 2.70  |              | 0.03      |      |
| K <sub>2</sub> O               |       | 0.82         |           | 0.02 |
| MnO                            |       | 0.18         |           | 0.00 |
| Cr <sub>2</sub> O <sub>3</sub> |       | 0.04         |           | 0.00 |
| P <sub>2</sub> O <sub>5</sub>  |       | 0.66         |           | 0.01 |
| LOI                            |       | 0.71         |           | 0.05 |
| <b>Total</b>                   |       | <b>99.65</b> |           |      |

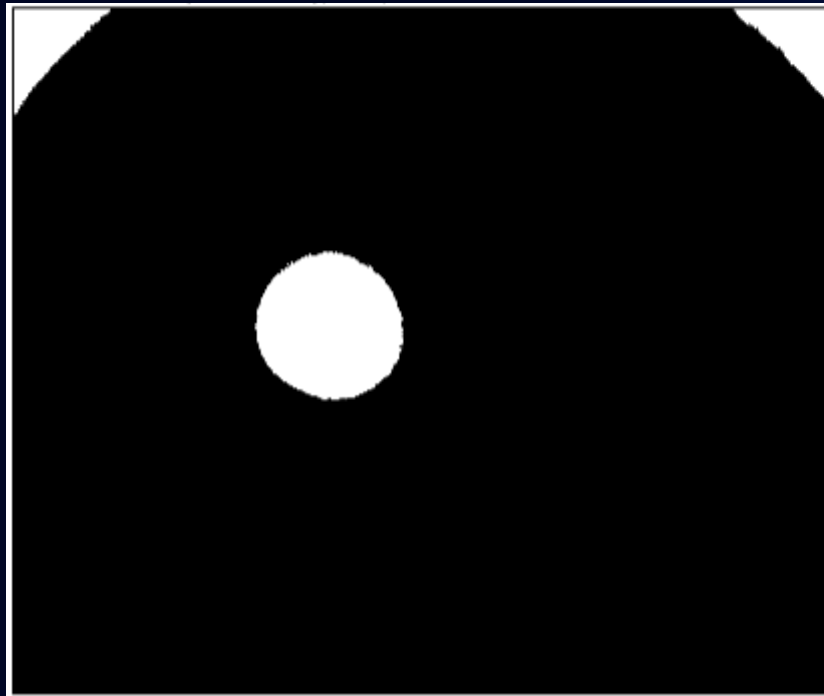
# Methods



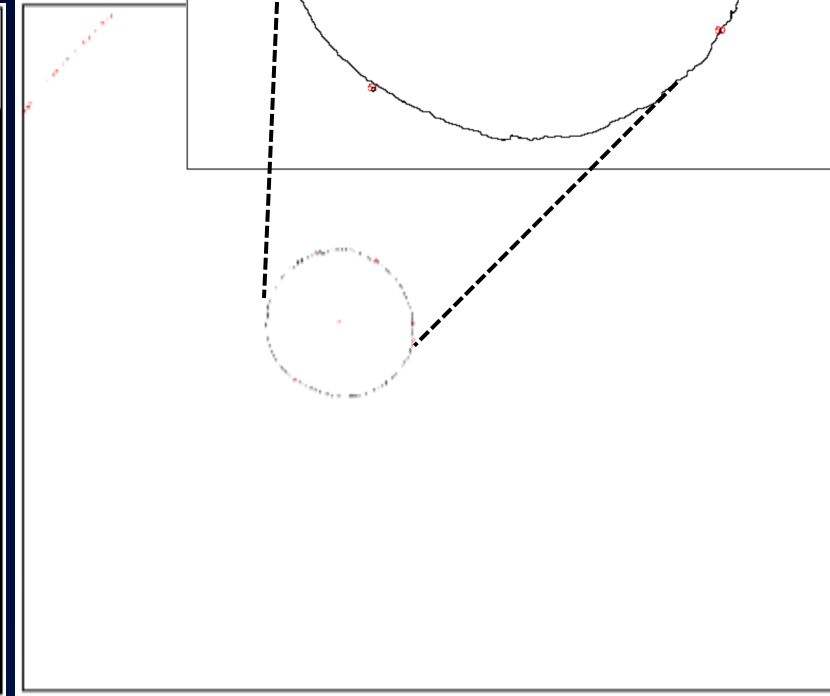
# 20X Size Comparison



Original Image

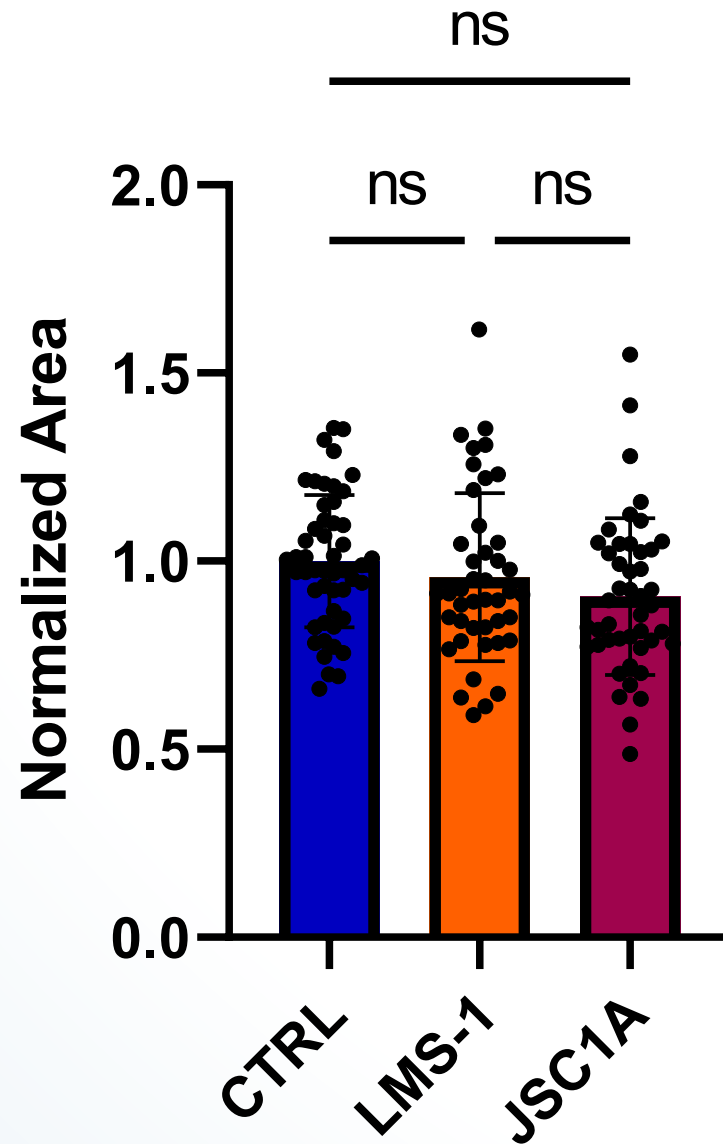


Binary Image



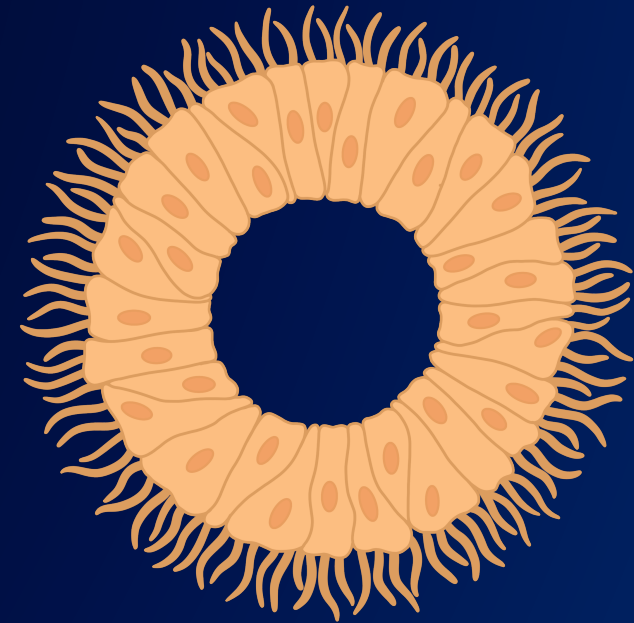
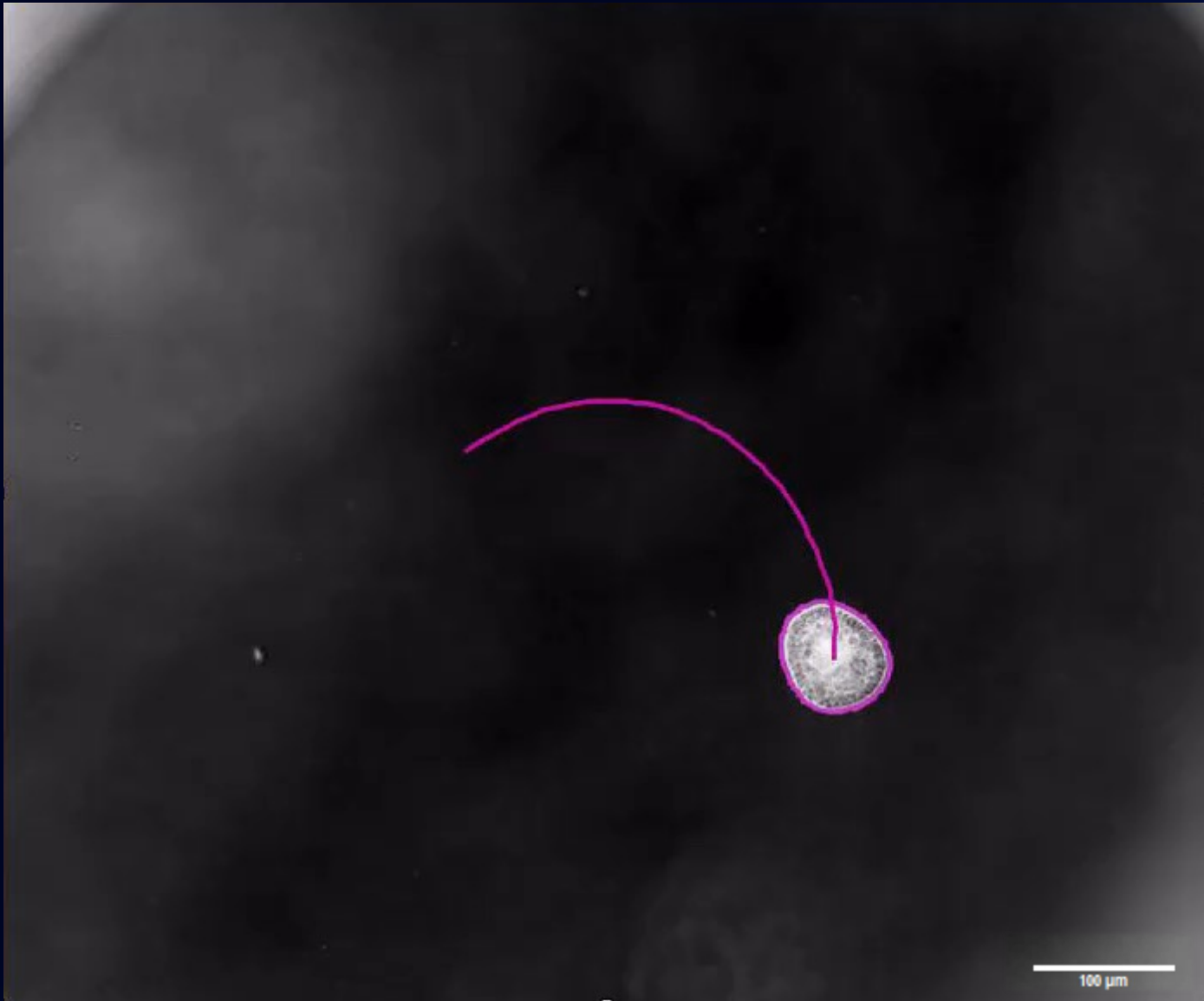
Outline

# 20X Size Comparison

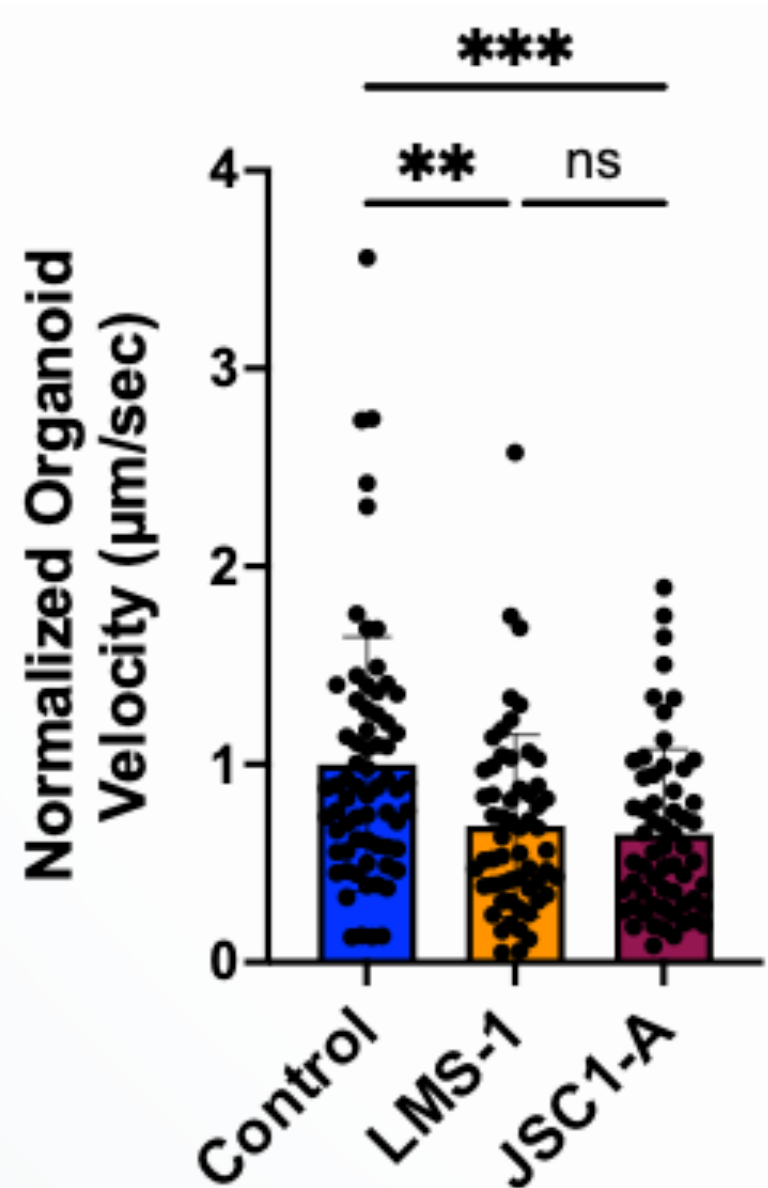


Organoid size comparison - combined & standardized to control

# 2D Locomotion Tracking



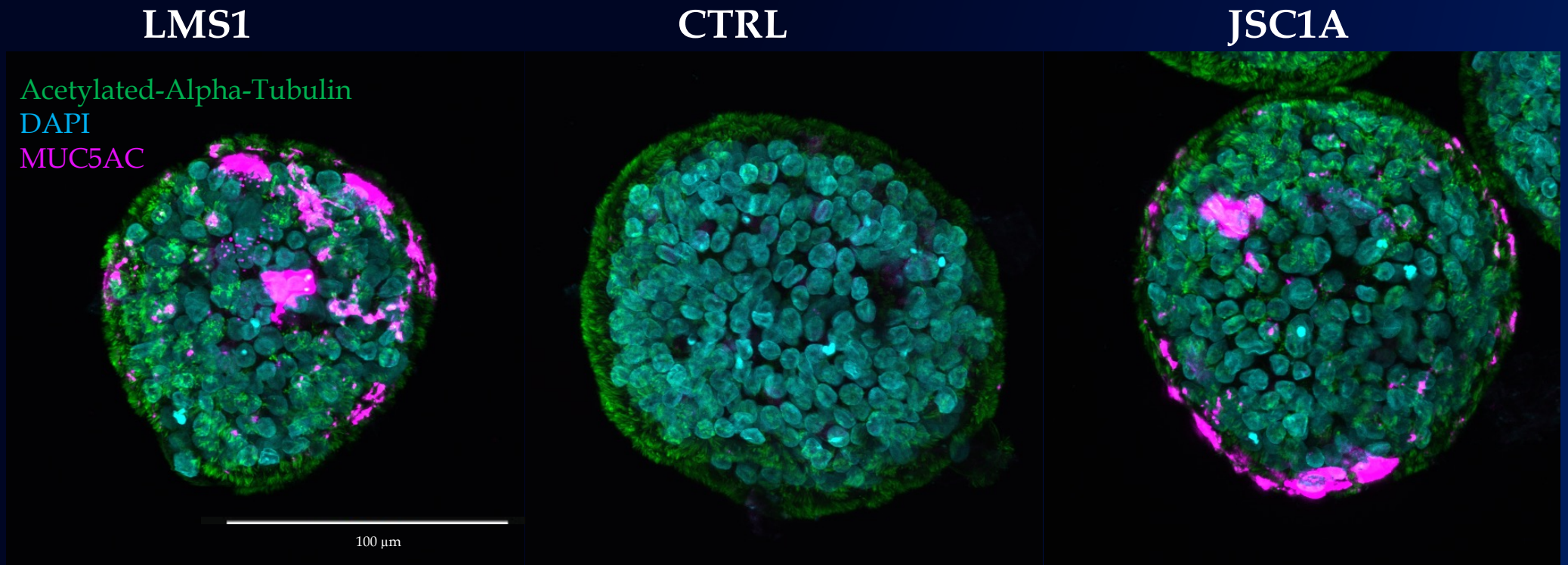
# 2D Locomotion Tracking



Organoid velocity comparison – combined & standardized to control

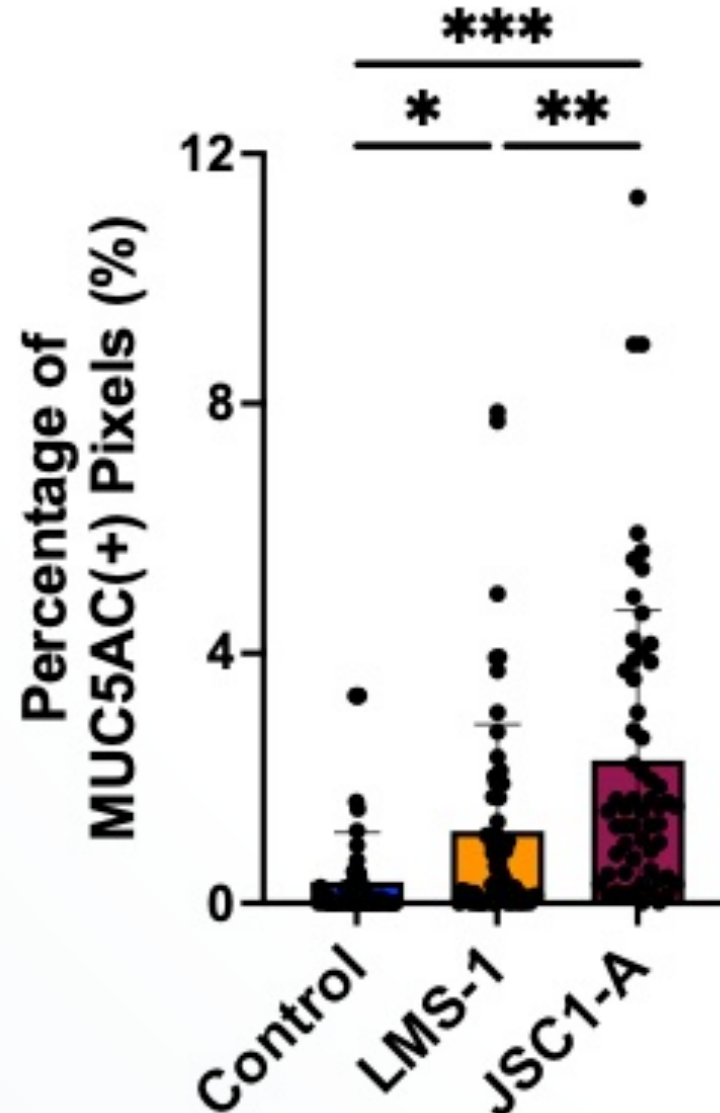
# Cellular Composition – Confocal Microscopy

- Markers: Acetylated-Alpha-Tubulin, DAPI, MUC5AC



- % of pixels with positive presence of MUC5AC

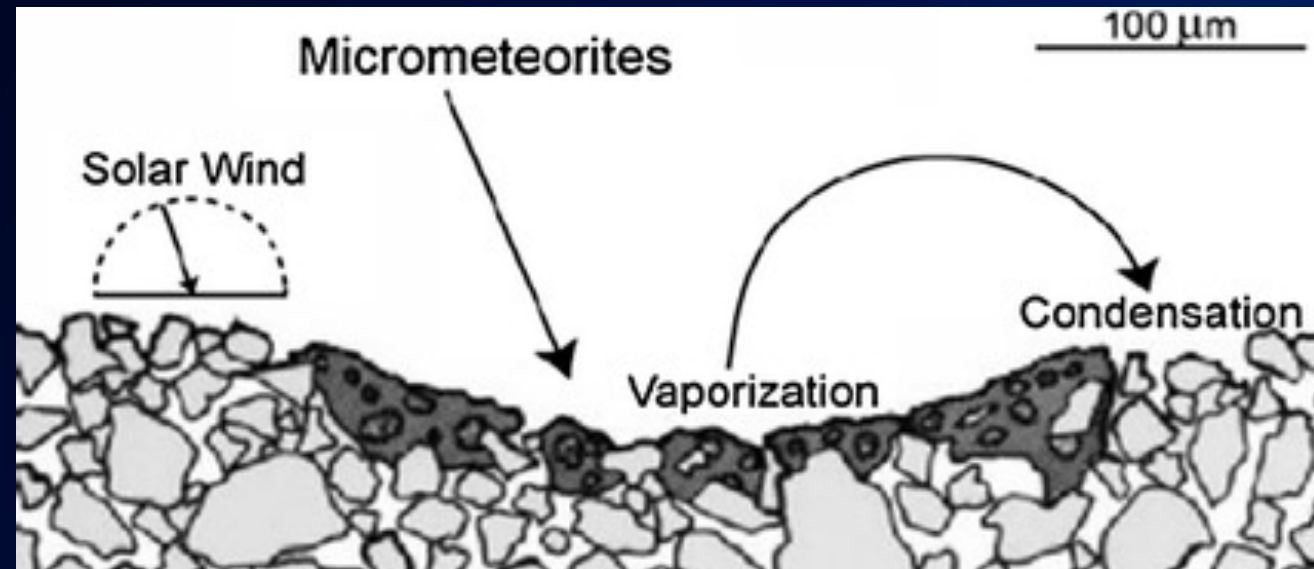
# Cellular Composition - Confocal Microscopy



MUC5AC(+) area  
comparison-  
combined &  
standardized to  
control

# Future Directions

- Lunar simulants + radiation
- Reactivation of lunar dust simulants via grinding and UV exposure
- Nanophase Fe<sup>0</sup> embedded silica-rich glass



# Acknowledgments

- Dr. Piyumi Wijesekara
- Dr. Egle Cekanaviciute
- Dr. Sylvain Costes
- NASA Ames Radiation Biophysics Laboratory
- SLSTP Management and Fellow Research Associates
- NASA SLSTP and NASA Postdoctoral Programs

