

# Microbes in the Environment Research

# Aqueous Geochemistry and Astrobiology

- **Dr. Elisabeth (Libby) Hausrath**
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- Department of Geoscience
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## Expertise

- Using laboratory experiments, field work, and modeling to interpret water-rock interactions and soil-forming processes on Earth and Mars
- Interpreting the signatures of past aqueous and biological impacts on minerals
- Participating Scientist on the Mars Science Laboratory Curiosity and the Mars2020 rover Perseverance and member of the Network for Life Detection ([NFOLD](#)) Steering Committee..

# Holes made by sampling soil on Mars



Image credit: NASA/JPL-Caltech

<https://mars.nasa.gov/news/9311/nasas-perseverance-rover-gets-the-dirt-on-mars/#:~:text=The%20mission's%20first%20two%20samples,prepare%20for%20future%20missions%20there.>

# Microbial Diversity & Ecology

**Dr. Brian Hedlund**

Professor

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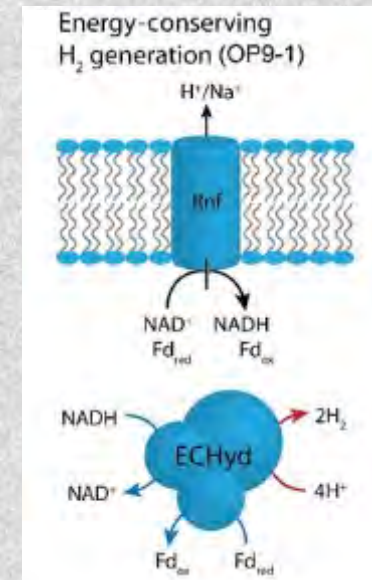
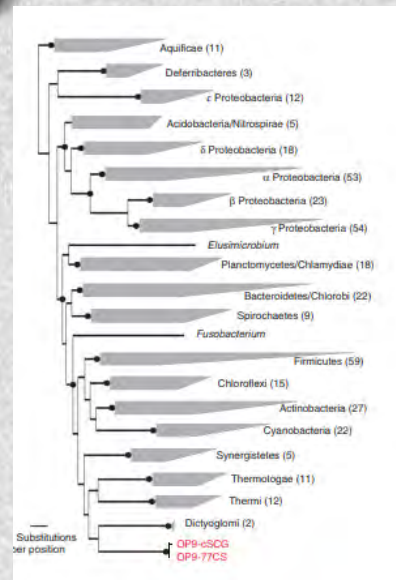
## **Expertise**

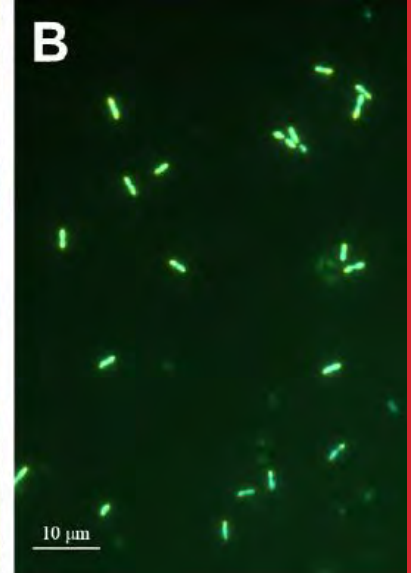
- Microbial diversity exploration
- Cultivation of recalcitrant microorganisms
- Systems biology



## Exploring microbiology's "dark matter"

- Environmental genomics
- Genome-enabled cultivation
- Transcriptomics, proteomics, metabolomics
- Stable-isotope experiments





## Big questions

- What is the function of billions-year-old microbial lineages that have never been cultivated in any lab? Why have they rebuked microbiologists for centuries?
- How can we organize and communicate microbial diversity effectively?
- How does thermal stress affect biology?
- How can we use microbial diversity to solve human problems?

# Geomicrobiology

## **Dr. Aude Picard**

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## **Expertise**

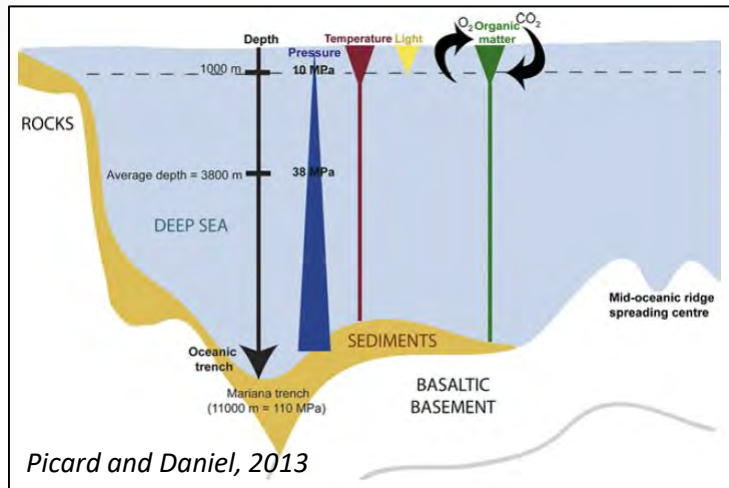
- Anaerobic microbiology
- Microbial physiology
- Biomineralization
- Astrobiology and biosignatures
- Microscopy & spectroscopy

# Microbial life in extreme conditions

## ① Microbial life under high pressure

- What are the pressure limits for microbial life?

High-pressure environments represent the largest habitat for microbial life on Earth



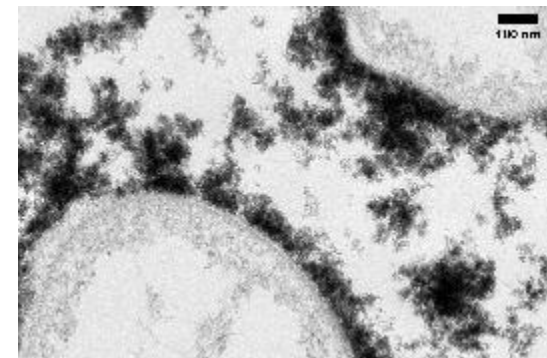
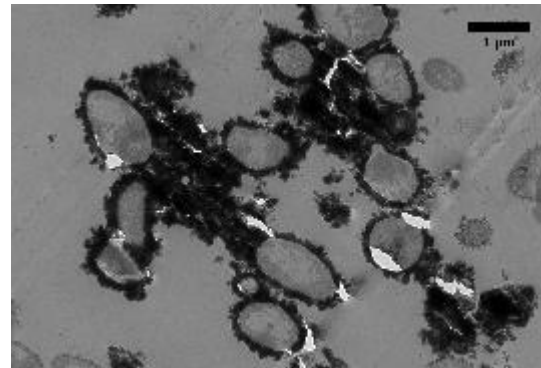
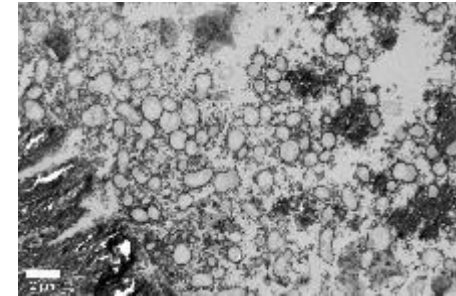
Oceans on icy moons (e.g. Europa) are potential habitats for microbial life in the outer Solar System



## ② Microbe-mineral interactions

- How do bacteria cope with mineral encrustation?
- Do minerals play a role in long-term survival of bacteria?

Transmission electron microscopy images of bacteria encrusted in iron sulfide minerals





# Dryland microbes and soil ecology

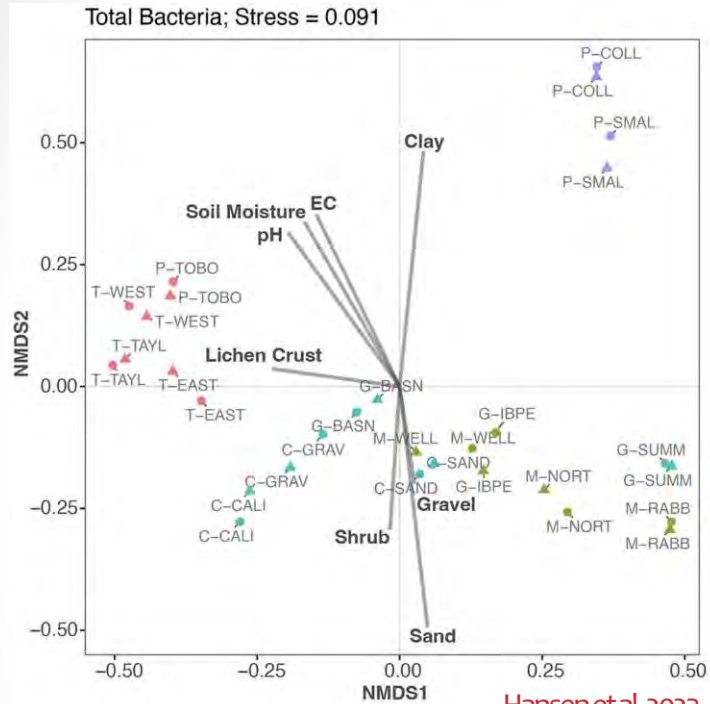
## **Dr. Nicole Pietrasiak**

- Associate Professor of Sustainability in Arid Lands
- School of Life Sciences
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## **Expertise**

- Soil Microbiology and Ecology
- Biological Soil Crusts
- Phycology and Cyanobacteria/Algae Culture Collection
- Soil Science
- Dryland Ecology
- Biogeomorphology

# In our lab we investigate what shapes the diversity, abundance, and distribution of desert microbes



Landscape and soil properties select for unique microbiomes



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DOI: 10.1111/jgs.12887

WHEN IS A LINEAGE A SPECIES? A CASE STUDY IN *MYXOCOPUS* GEN. NOV. (SYNECHOCOCCALES: CYANOBACTERIA) WITH THE DESCRIPTION OF TWO NEW SPECIES FROM THE AMERICAS<sup>1</sup>

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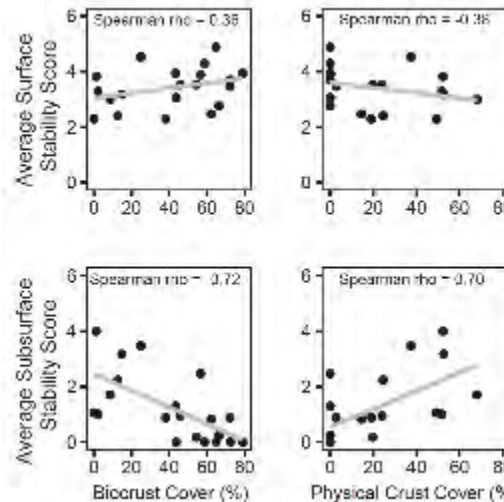
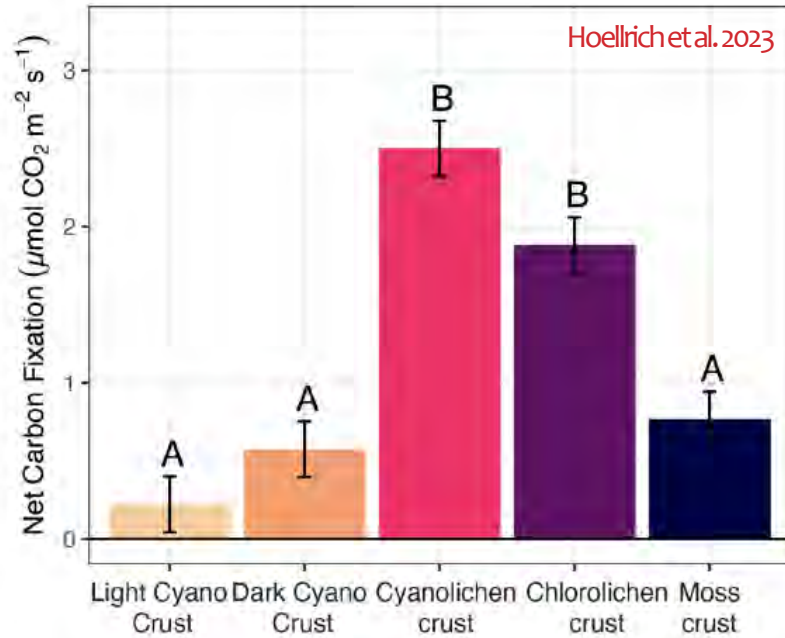
and *Jeffrey R. Johanson*

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We also describe species and genera new to science and society.

# And we identify and quantify the roles microbes play in dryland ecosystem functioning and soil health



Microbes are part of our dryland biodiversity. They prevent soil loss, increase soil fertility, control nutrient cycling, and contribute to carbon sequestration.

Dryland microbes are crucial for maintaining sustainable arid lands.

Stovall et al. 2023

# Extremophiles

## **Dr. James Raymond**

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## **Expertise**

Adaptations to cold environments

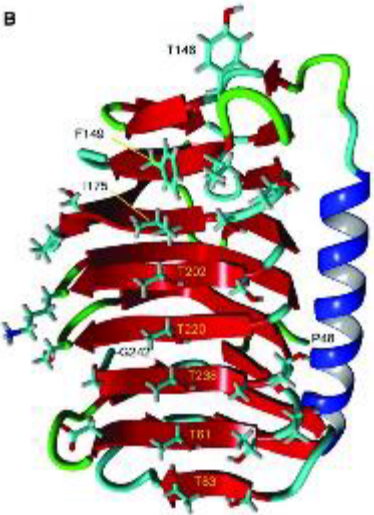
Snow algae

Ice-binding proteins

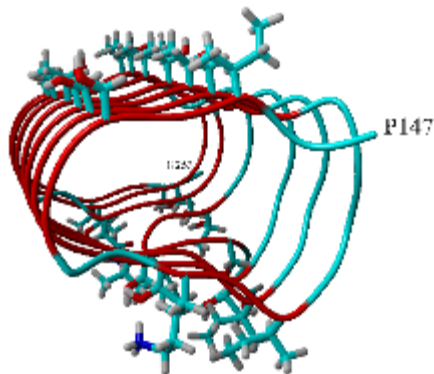
Horizontal gene transfer

# Much of the Earth's surface is exposed to extreme conditions such as freezing, high temperature and hypersalinity.

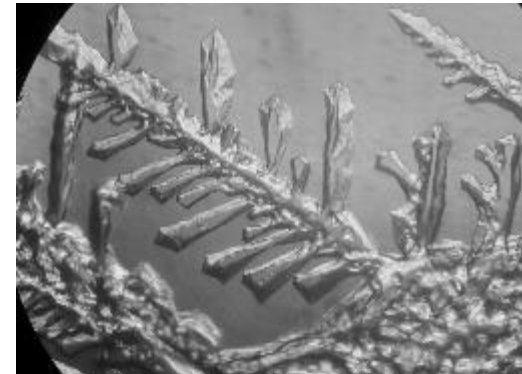
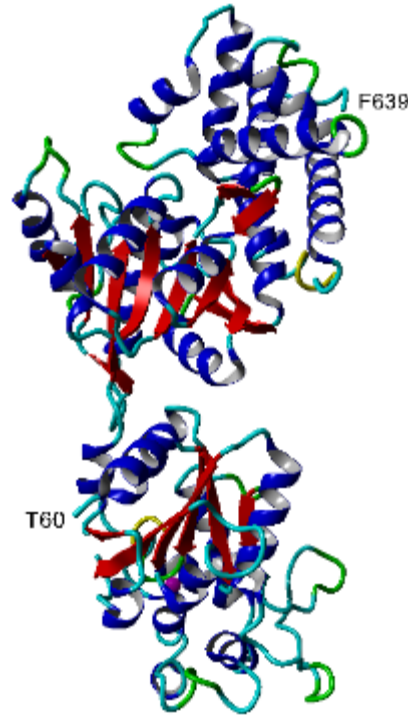
Organisms living in these regions have developed some remarkable adaptations that not only reveal the beauty of Nature, but also may have commercial applications (e.g., low-calorie ice cream) as well as provide clues to the presence of life in other worlds.



Ice-binding proteins. Above, from a snow alga from the Austrian Alps.<sup>1</sup> Below, from a grass growing on the coast of the Arctic Ocean.<sup>2</sup>



An unusual enzyme found only in a few species of algae. This one is from an alga that lives in a saline lake in Antarctica. The alga uses the enzyme to make glycerol so that it can remain in osmotic equilibrium with the lake water.<sup>3</sup>



Demonstration of how many proteins produced by microorganisms affect the growth of ice by binding to its surface. Here, proteins from a polar cyanobacterium distort the growth of a growing ice crystal.

## References

1. Raymond and Remias (2019)
2. Sformo and Raymond (2020) (Submitted)
3. Raymond, Morgan-Kiss and Stahl (2020) (Submitted)

# Bacterial Physiology Research

Dr. Boo Shan Tseng

Assistant Professor

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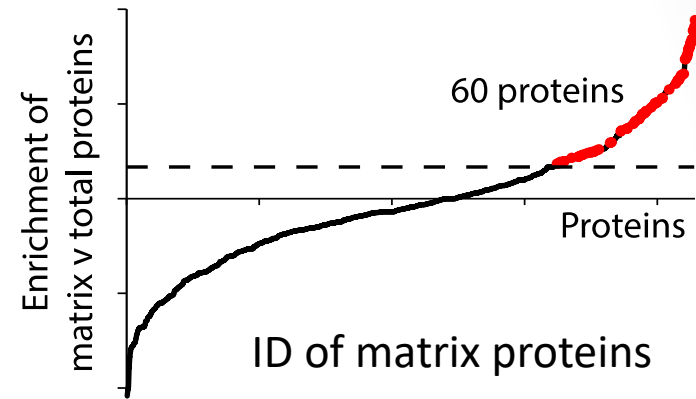
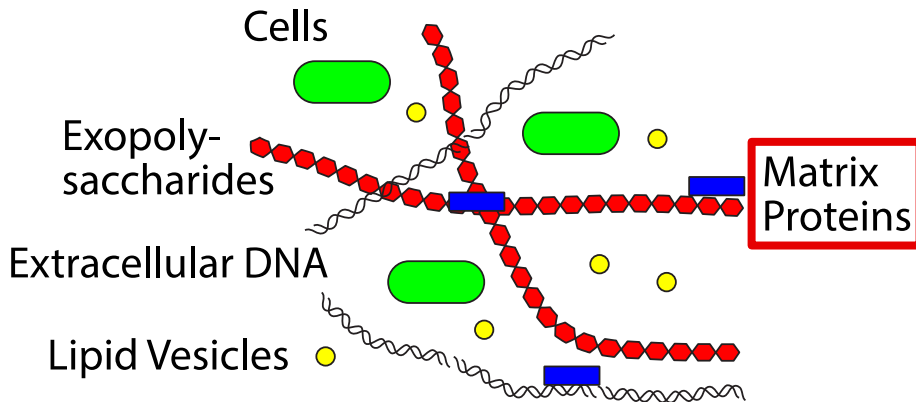
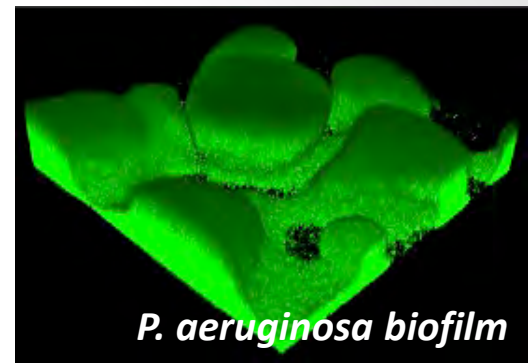
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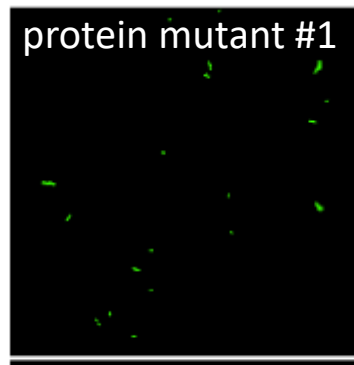
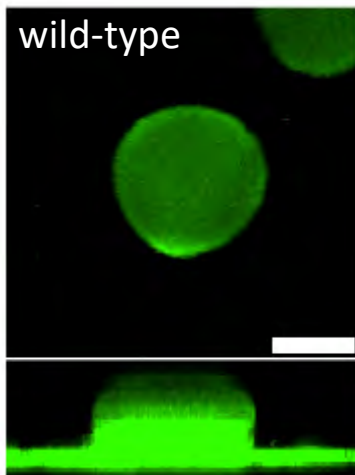
Expertise:

- *Pseudomonas aeruginosa*
- Biofilms
- Bacterial stress response
- Antimicrobial susceptibility
- Cystic fibrosis lung infections

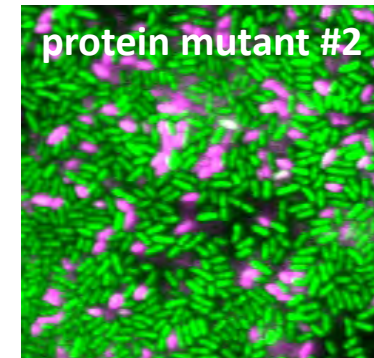
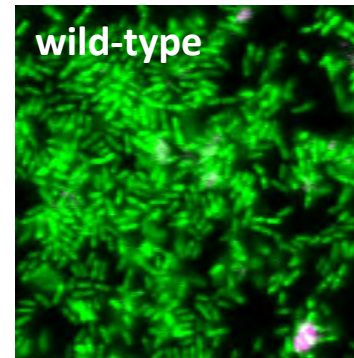
# Identifying the roles of biofilm matrix components



## Functions in biofilm formation

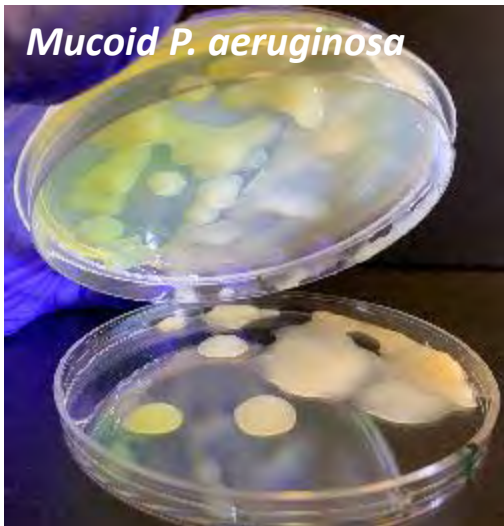


## Functions in antimicrobial susceptibility

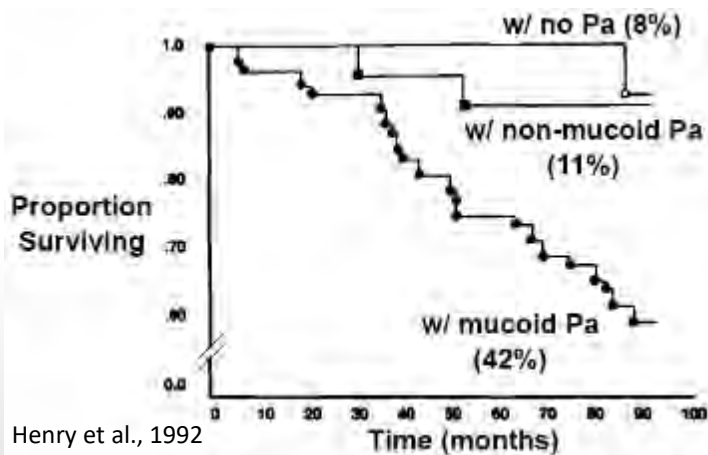


Treated with elastase (green: alive; purple: dead)

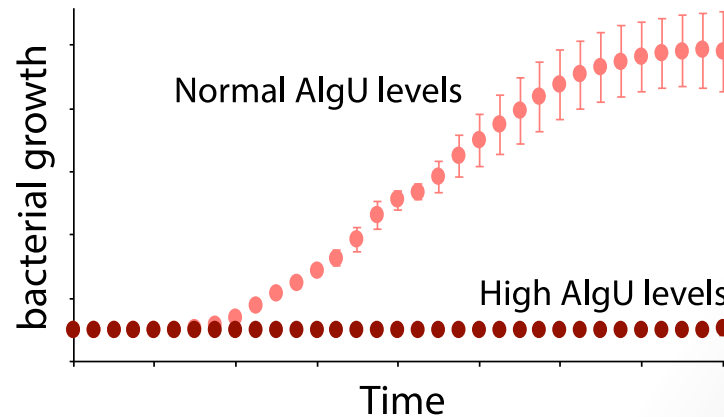
# Mechanism behind the essentiality of bacterial envelope stress inhibitor



- Exopolysaccharide overproducing (e.g. mucoid) bacteria arise during chronic lung infection
- Associated with poor disease outcomes
- Due to mutation in *mucA* gene, which encodes for inhibitor of envelope stress response via AlgU
- BUT *mucA* required for bacterial viability and overproduction of AlgU inhibits growth



In children with cystic fibrosis



Question: why is a gene commonly mutated in clinical isolates required for bacterial viability?