Life and Environment

Microbes in the Environment Research

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Astrobiology and Geomicrobiology

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Expertise

- Geomicrobiology
- Biological impacts on water-rock interactions
- Astrobiology

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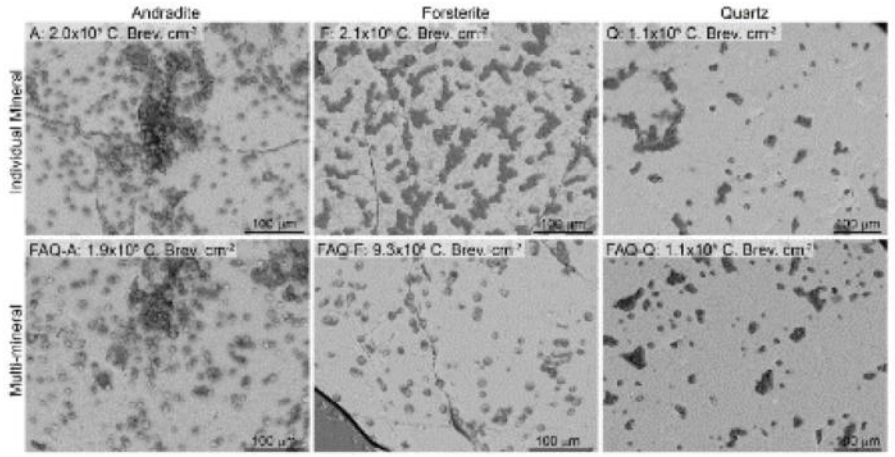
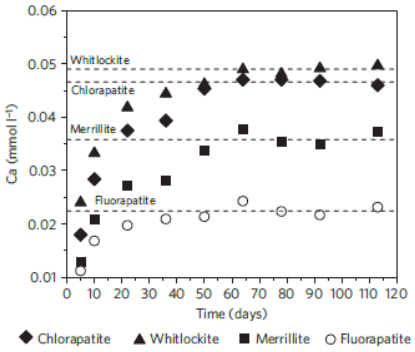
Biological Impacts on water-rock interactions

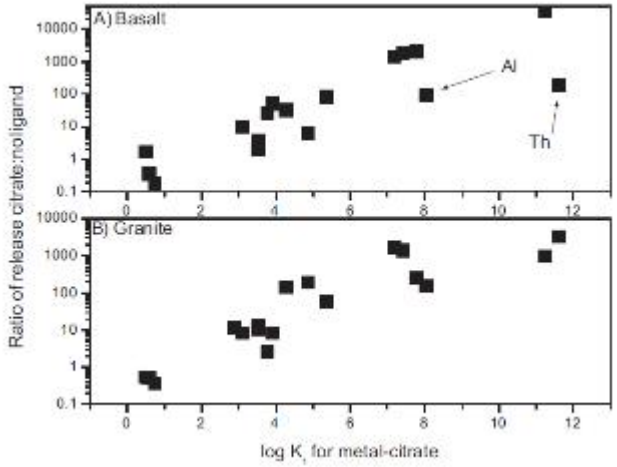
Field studies (e.g. Baumeister et al., 2014)



Laboratory studies (e.g. Phillips-Lander et al., 2020)



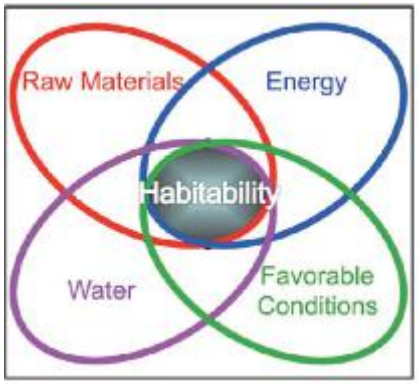
Nutrient release (e.g. Adcock et al.., 2013)



Signatures of biological alteration (e.g. Hausrath et al., 2009)

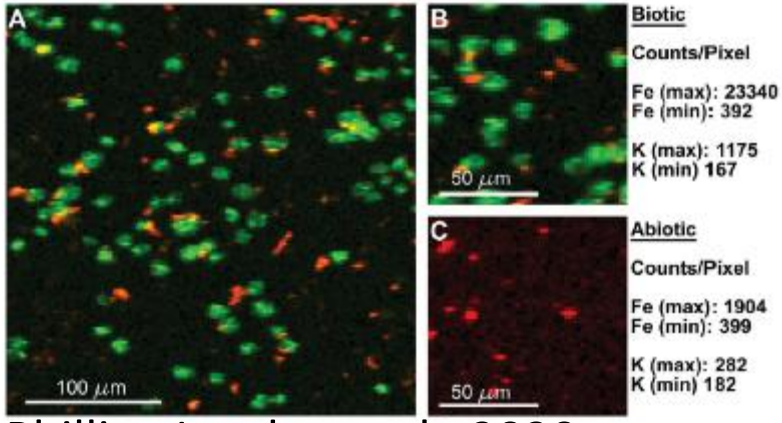
Astrobiology

Habitability



Hays et al., 2017

Potential biosignatures



Phillips-Lander et al., 2020

Mars 2020 and Mars Sample Return

NASA.gov

Microbial Diversity & Ecology

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Expertise

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

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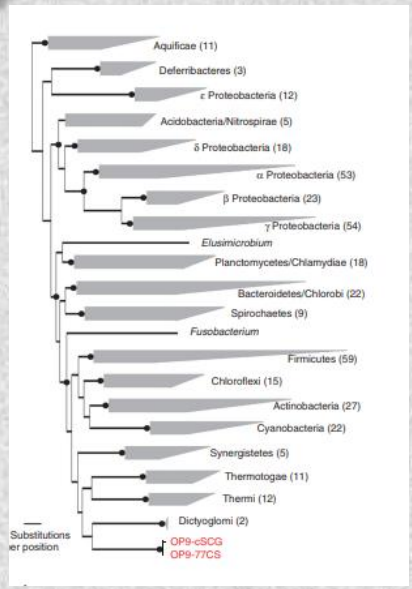
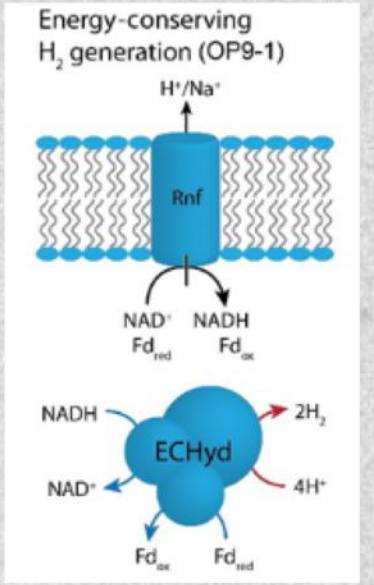
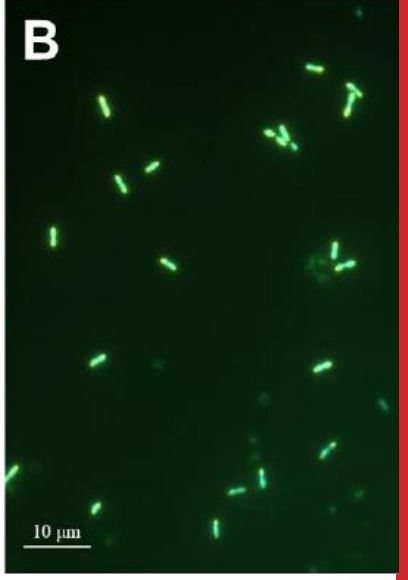
Exploring microbiology's "dark matter"

- 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?

https://hedlund.faculty.unlv.edu/

Geomicrobiology

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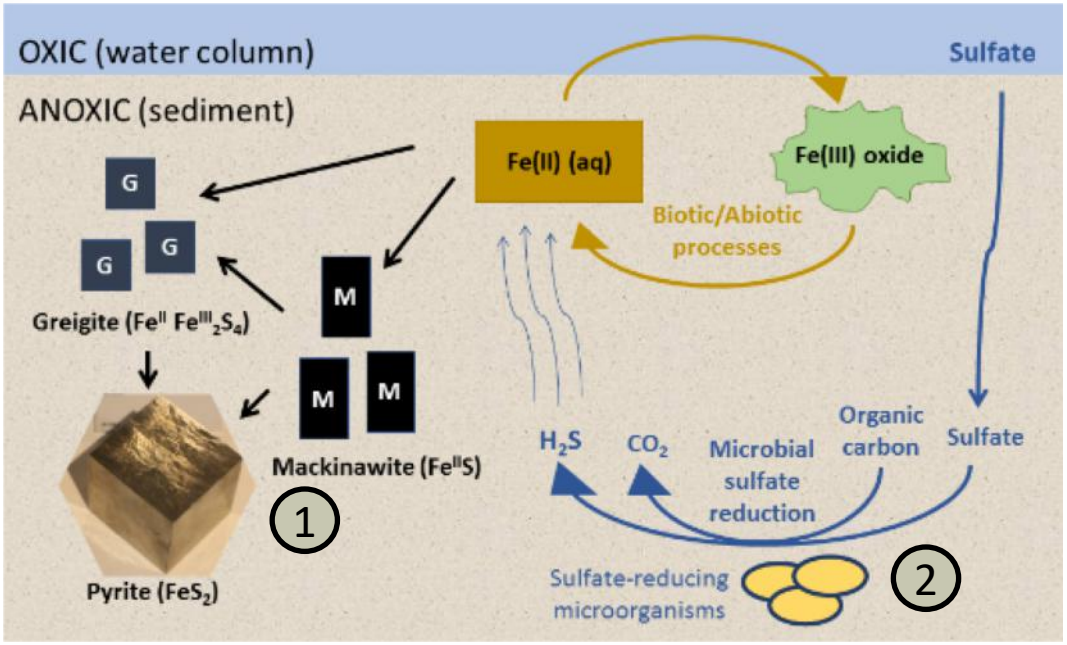
Expertise

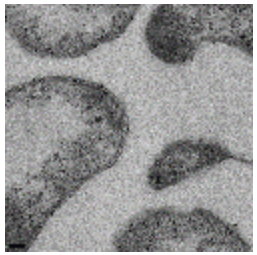
- Anaerobic microbiology
- Biomineralization
- Astrobiology and biosignatures
- Microscopy & spectroscopy

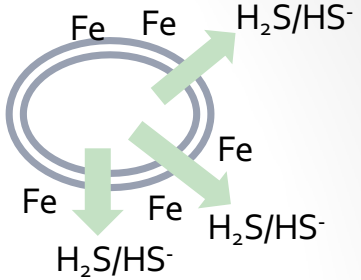
Biogeochemistry of Fe, S and C in anoxic environments

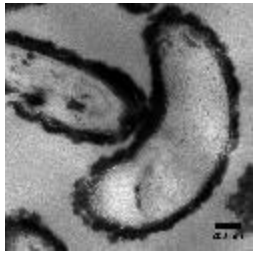
Iron sulfide mineral formation in anoxic environments



2 Microbe-mineral interactions in anoxic environments



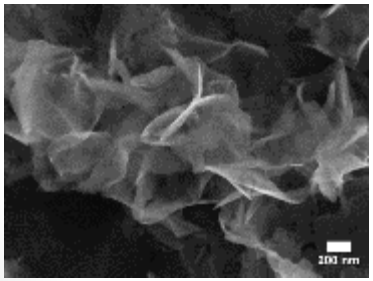




Bacteria become encrusted in Fe-rich environments

- Do minerals play a role in the physiology of bacteria?
- How do bacteria cope with mineral encrustation?

1 Properties of biominerals



Minerals produced with microorganisms have unique physical and chemical properties

- What is the reactivity of biominerals?
- What are the applications of biominerals?

3 Can we use biominerals for the search of life on Mars?

Credits: NASA/JPL-Caltech/MSSS

- Are properties of biominerals unique enough to record life in anoxic environments?

Extremophiles

Dr. James Raymond
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School of Life Sciences
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Expertise

- Adaptations to cold environments
- Snow algae
- Ice-binding proteins
- Horizontal gene transfer

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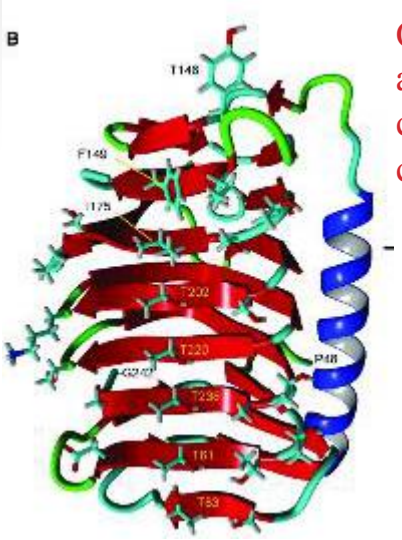
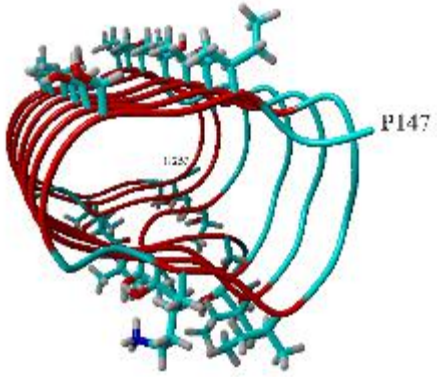
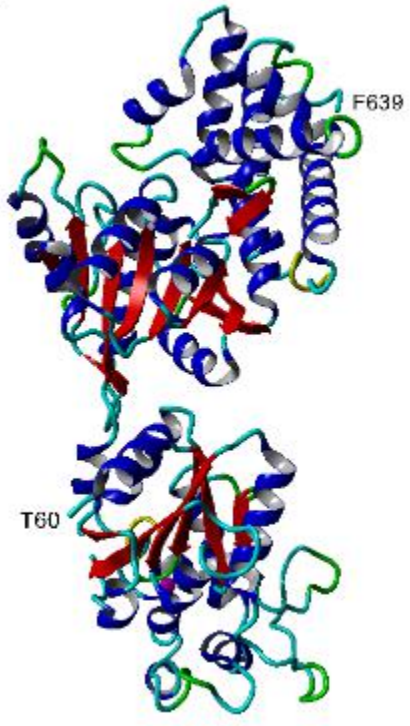
Much of the Earth's surface is exposed to extreme conditions such as freezing, high temperature and hypersalinity.

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.

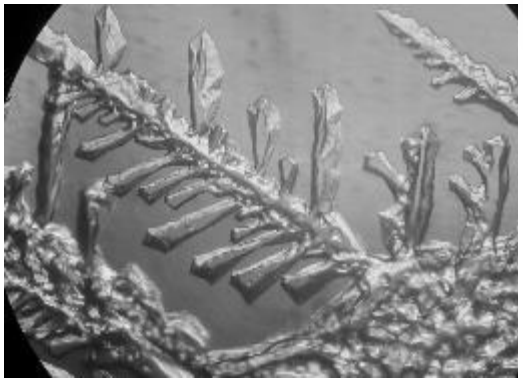


Ice-binding proteins. Above, from a snow alga from the Austrian Alps.[1] Below, from a grass growing on the coast of the Arctic Ocean.[2]





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.[3]



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)

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Bacterial Physiology and Evolution

The Robleto lab studies the effects of Mfd on bacterial cell physiology and evolution

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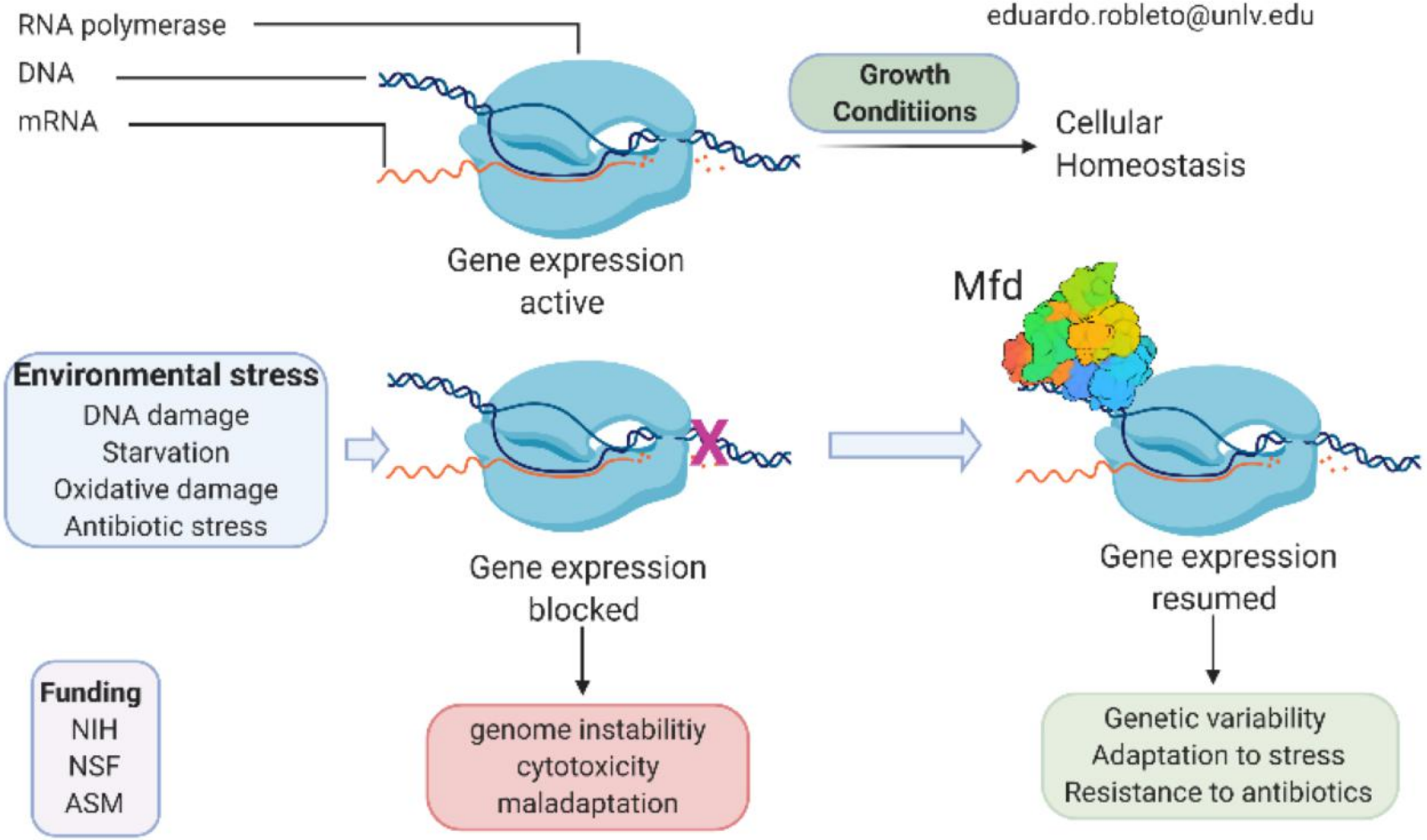

Funding
NIH
NSF
ASM

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Bacterial Physiology Research

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Expertise:

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

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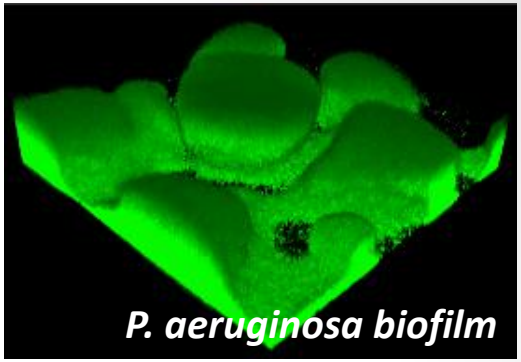
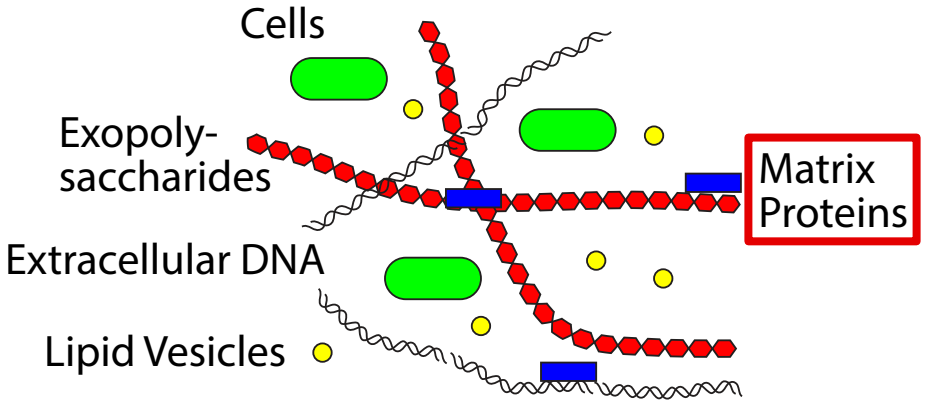
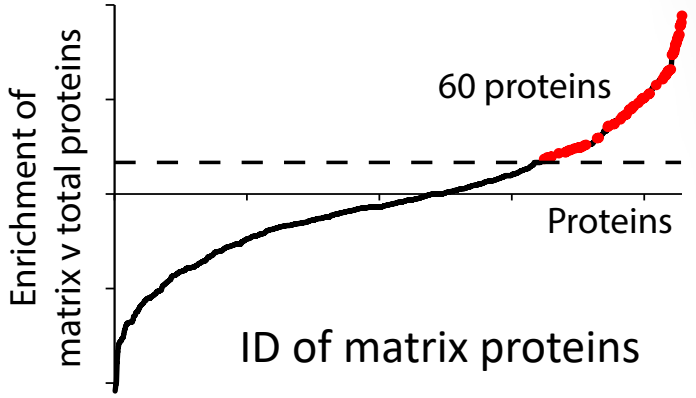
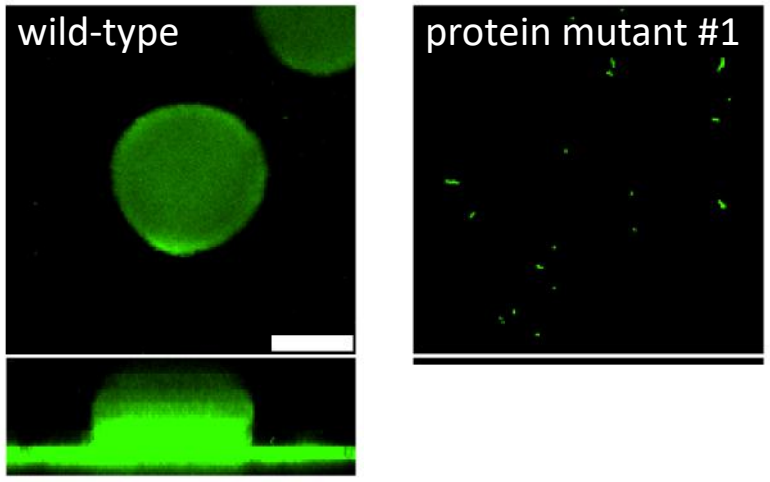
Identifying the roles of biofilm matrix components



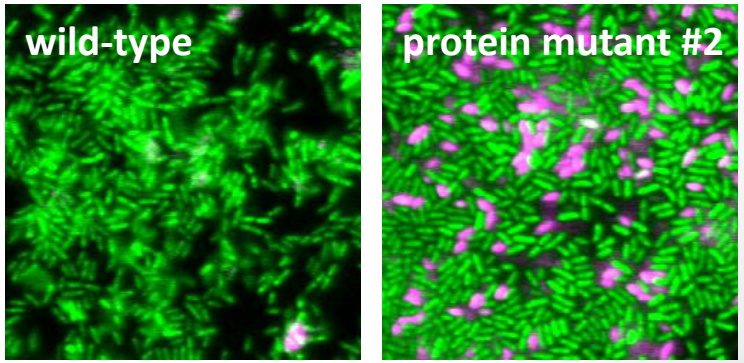




Functions in biofilm formation

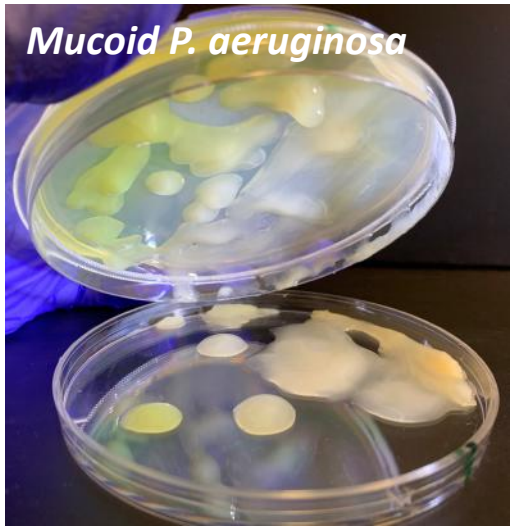


Functions in antimicrobial susceptibility

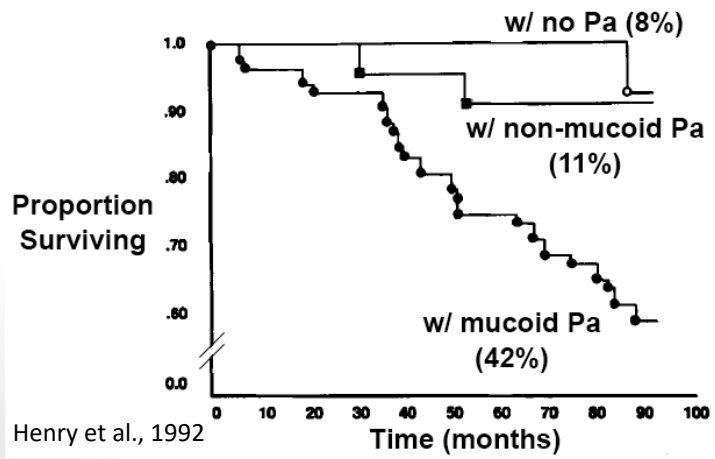


Treated with elastase (green: alive; purple: dead)

Mechanism behind the essentiality of bacterial envelope stress inhibitor

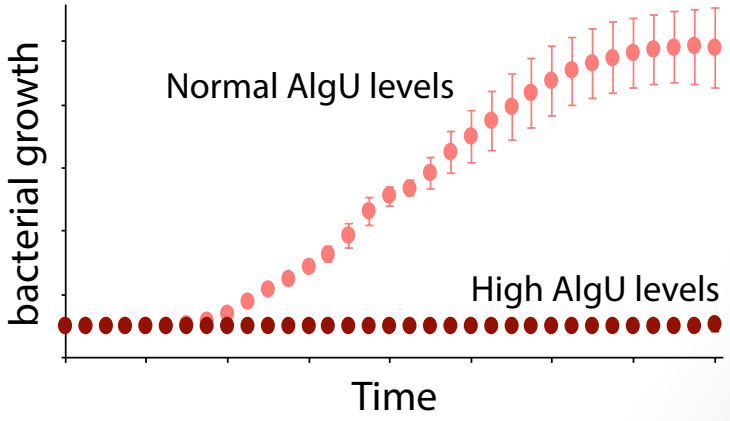


- Exopolysaccharide overproducing (e.g. mucoid) bacteria arise during chronic lung infection
- Associated with poor disease outcomes
- Due to mutation in *mucA* gene, which encodes for inhibitor of envelope stress response via AlgU
- BUT *mucA* required for bacterial viability and overproduction of AlgU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



Henry et al., 1992

In children with cystic fibrosis



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