



TEACHERS AND RESEARCHERS
EXPLORING AND COLLABORATING

Welcome to a *live* **C-ISE Event!**

With Researcher Elliot Friedman
Terrestrial Methane and Microbiology

Wednesday 4 April 2012

12:00pm AKDT

(1:00 pm PDT, 2:00 pm MDT, 3:00 pm CDT, 4:00 pm EDT)

Slides will be shown here

Exit the presentation

Click to Talk, Unclick to finish talking

Raise your hand to ask a question

Share with emoticons

List of all participants

Chat with one person or the entire group

The screenshot displays the Blackboard Collaborate interface. On the right, a presentation slide titled "Welcome to Blackboard Collaborate" is shown, featuring the ARCUS logo and the text "Arctic Research Consortium of the United States". The slide is labeled "Page 2 - Slide02.jpg". On the left, a control panel is visible with sections for "AUDIO & VIDEO", "PARTICIPANTS", "MAIN ROOM", and "CHAT". The "PARTICIPANTS" list includes Sarah Crowley and Arctic Research Consortium of the US. The "CHAT" section shows a conversation with timestamps. Blue arrows point from text labels on the left to specific UI elements: "Slides will be shown here" points to the presentation area; "Exit the presentation" points to the top right corner of the window; "Click to Talk, Unclick to finish talking" points to the "Talk" button; "Raise your hand to ask a question" points to the hand icon; "Share with emoticons" points to the emoticon icon; "List of all participants" points to the participant list; and "Chat with one person or the entire group" points to the chat window.

Please Note:

- Participants using the telephone can mute/unmute by **pressing *6** on the phone.
- Today's event will be recorded and archived.



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Questions

During the Presentation:

- Type your question in the text chat box

At the End of the Presentation:

- Raise your hand with the “hand button”.
- PolarTREC staff will call on you.
- Speak loud and clear and directly into the phone to ask your question.

Click on the Talk button to speak.

Unclick when you are done.



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Participant Introductions

When called, please state your:

- ✓ Name
- ✓ School / Institution
- ✓ The number of students and adults participating with you in the same location



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What is PolarTREC?

PolarTREC is a professional development experience in which K-12 teachers are paired with researchers for 2-6 week research experiences in the polar regions.

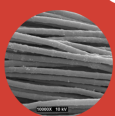
From 2010-2013, nearly 50 teachers from around the United States will join scientists in the Arctic and Antarctica to learn about science, the polar regions, and to share what they have learned with their students and communities.

Terrestrial Methane and Microbiology

Elliot Friedman
PhD Candidate

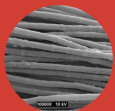
Cornell University, Ithaca, NY

the angenent lab

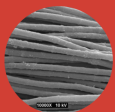
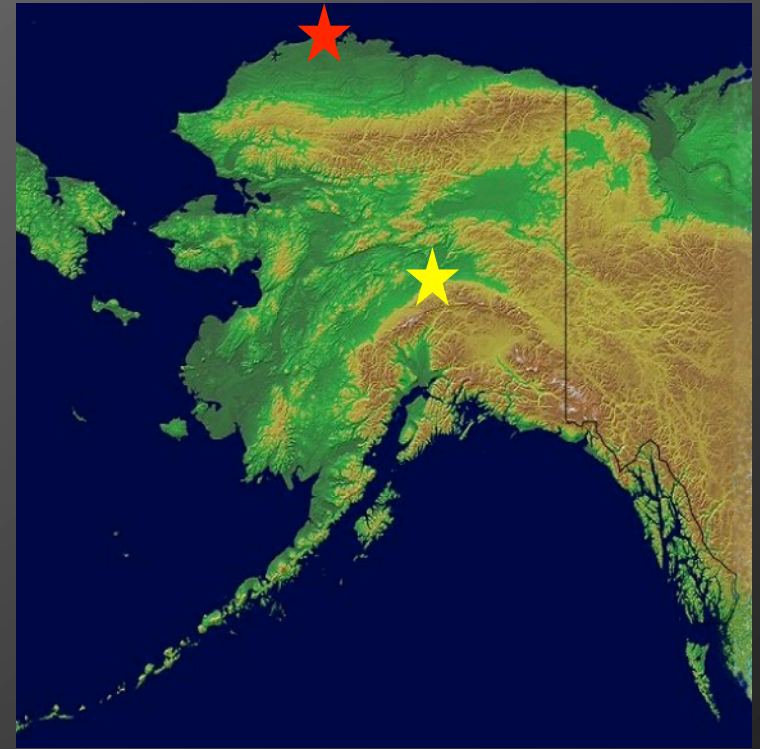


Outline

- Introduction to North Slope
- Overview of biosensor technology
- Barrow Study – Iron as a dominant respiratory process
- Global climate models/methane emissions

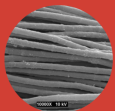


- Barrow, AK
 - Northernmost city in the US
 - 320 mi north of Arctic circle
 - 4,212 people (2010 census)
 - Flat tundra stretches ~200 miles to the south
 - No wind barriers
 - Freezing temperatures ~324 days/year
 - <5 inches of rain equivalent/yr
 - Dark from ~Nov 18th – Jan 22nd
 - Light from ~May 11th – Aug 1st



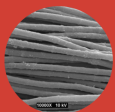
North Slope topography

- Region of Alaska north of the Brooks range
- Above the Arctic Circle
- Sparsely populated
- Only ~5 inches of rain/year
- Lakes and rivers due to very slow evaporation, freeze-thawing, and underlying bedrock
- Polygonized tundra forms as a result of freeze-thaw cycles

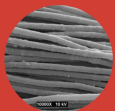
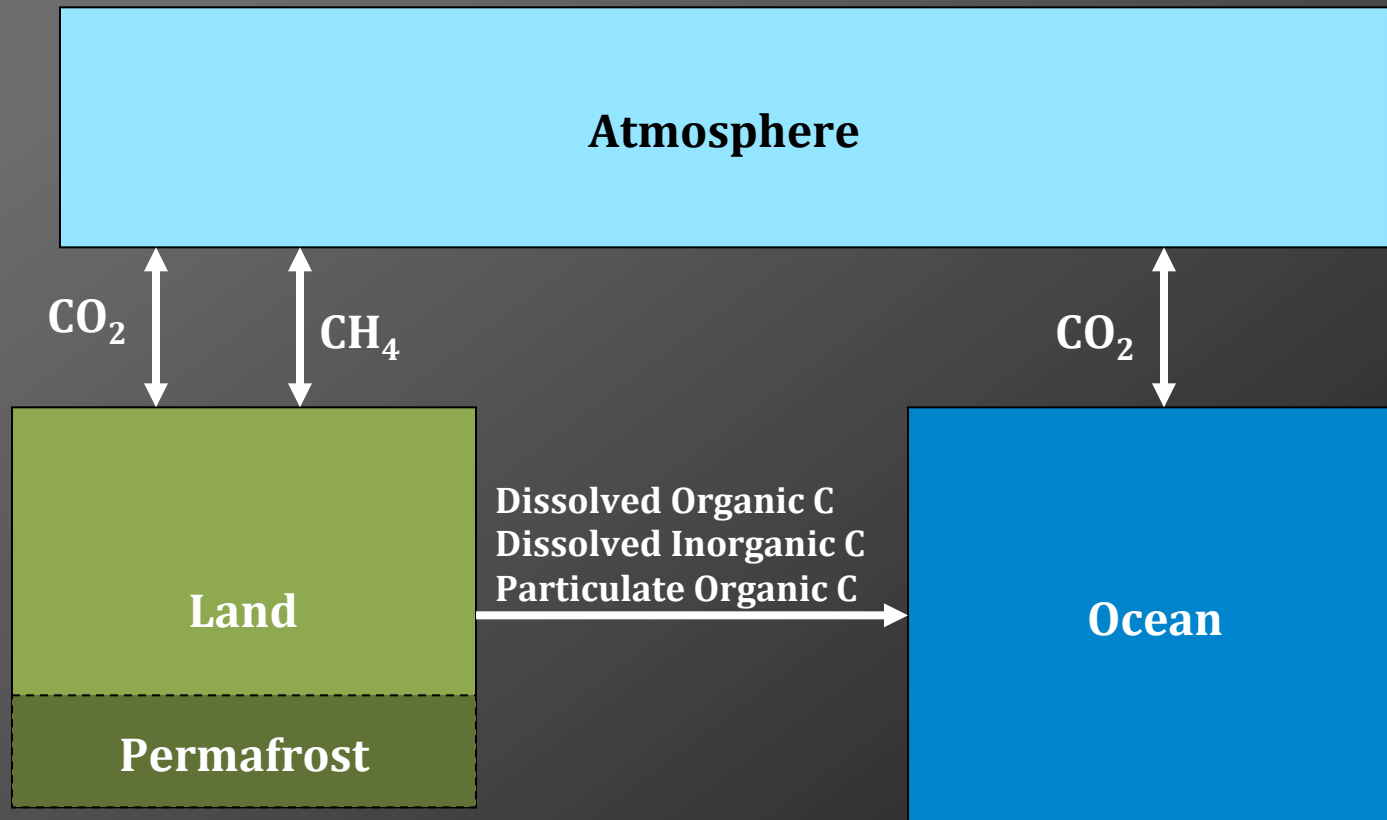


Polar Carbon

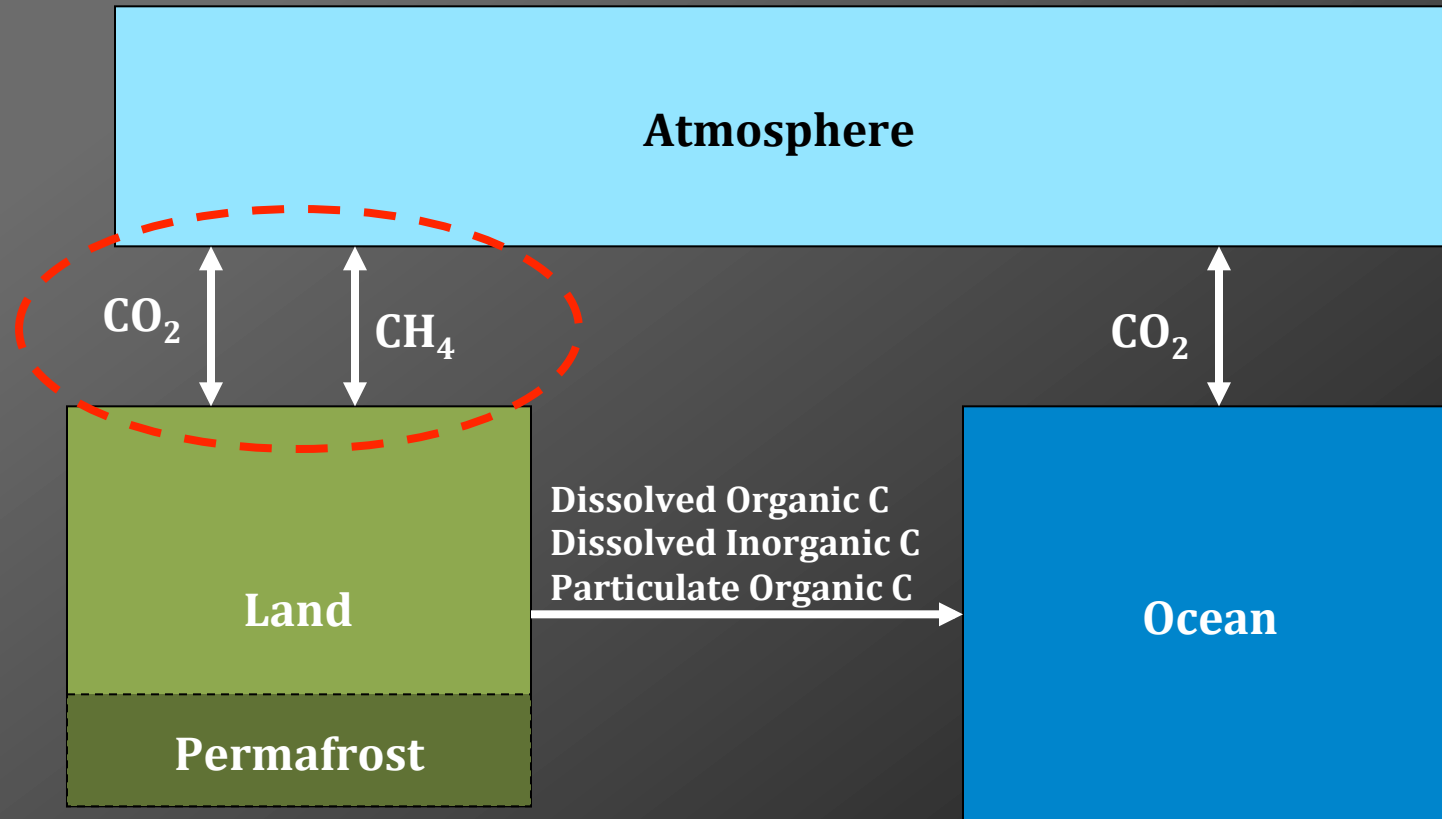
- Northern circumpolar permafrost soil carbon holds ~ 1672 Pg C
 - Up to 60% of global belowground carbon pool
 - Polar regions are more susceptible to climate change
 - What happens to all of this carbon as temperatures warm?
 - Feed forward or 'positive feedback' process



Arctic carbon model

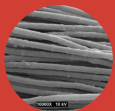


Arctic carbon model



**CH_4 emissions from the Arctic increased
31% from 2003-2007**

the angenent lab

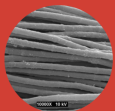
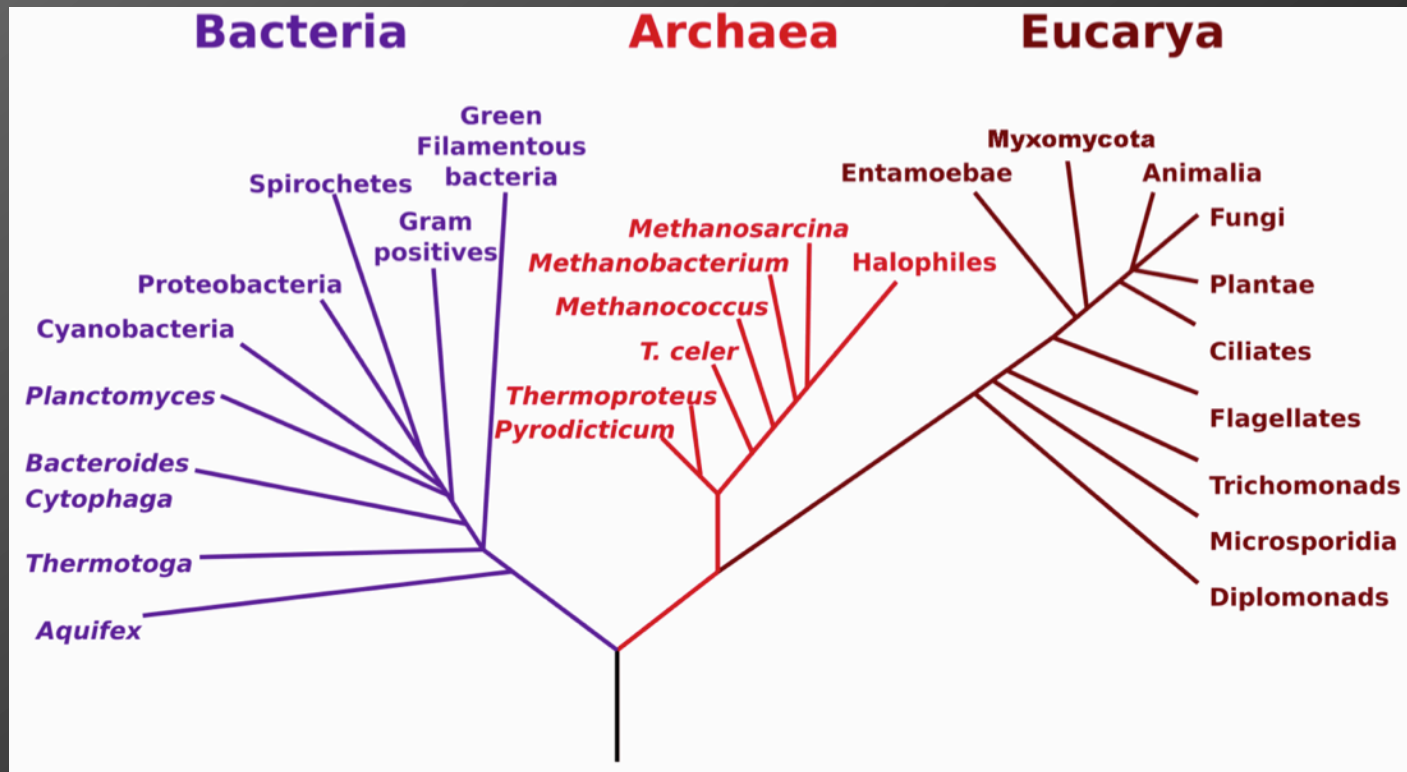


Modified from: McGuire, A.D., Anderson, L.G., Christensen, T.R., Dallimore, S., Guo, L.D., Hayes, D.J., Heimann, M., Lorenson, T.D., Macdonald, R.W., Roulet, N., 2009. Sensitivity of the carbon cycle in the Arctic to climate change. *Ecol. Monogr.* 79(4), 523-555.



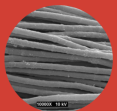
Methane

- 21X climate forcing potential of carbon dioxide
- Formed via methanogenesis – anaerobic degradation of organic matter by methanogenic archaea
- Occurs in natural wetlands and rice patties
- $\frac{1}{4}$ – $\frac{1}{3}$ of soil methane emissions come from wet soils at high latitudes



Microbial Respiration

- Aerobic respiration - O_2 is the terminal electron acceptor
- Anaerobic conditions:
 - Anaerobic respiration – other electron acceptors (NO_3^- , $Mn(IV)$, $Fe(III)$, SO_4^{2-})
 - Methanogenesis
 - Fermentation
- Wide variety of factors can influence which process(es) dominate

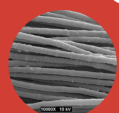


Arctic wetlands

- Drained thaw lake basins formed as a result of climate and freeze-thawing

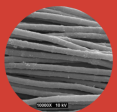


- Anaerobic, lots of carbon – microbial processes are crucial to the carbon balance!
- High amounts of iron [Fe(III)], an alternate electron acceptor
- Fe(III) reduction results in CO_2 emission as opposed to CH_4 from methanogenesis



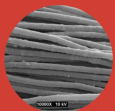
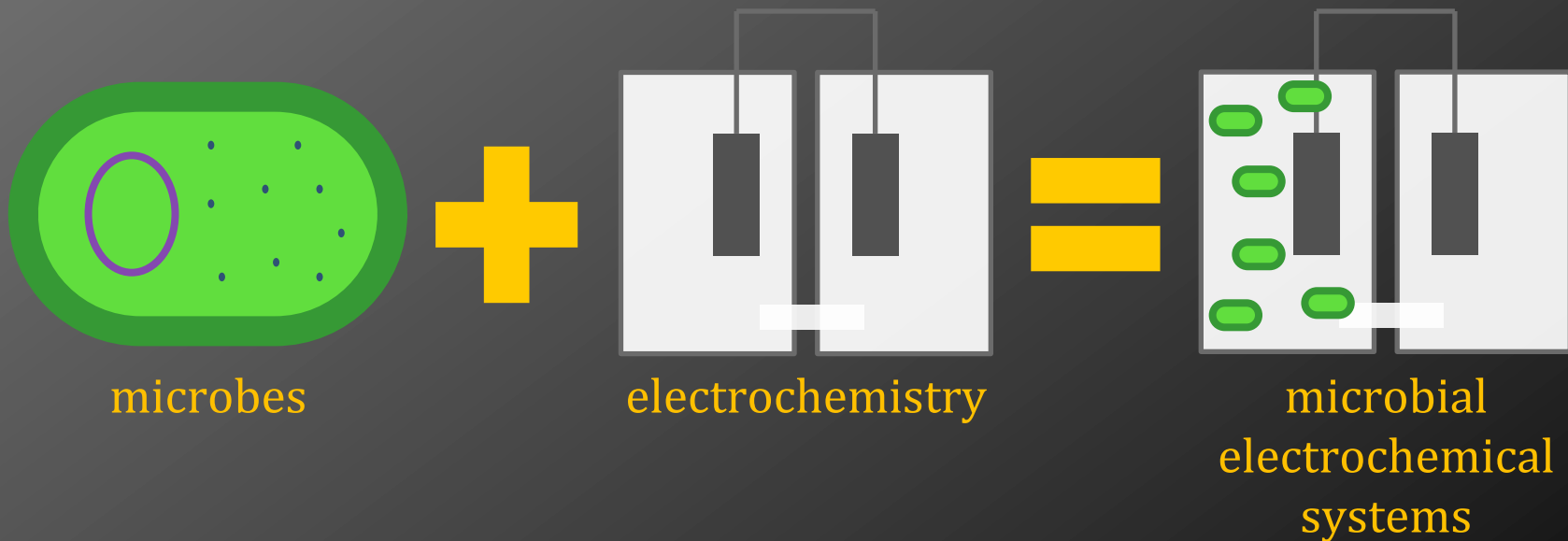
Question

- What is the role of **iron reduction** as a dominant respiratory process in Arctic peat soils?

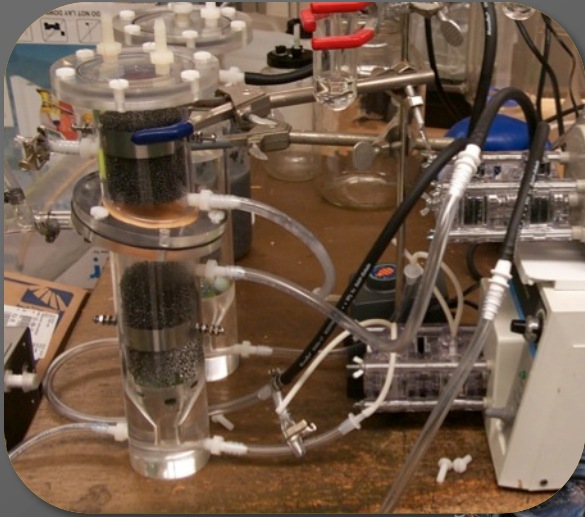


How can we figure out what's happening?

- Microbial electrochemical systems
 - Quantitatively link **microbial metabolism** to **electronic circuitry**



Microbial electrochemical systems: what do they do?



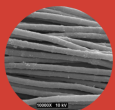
bioenergy



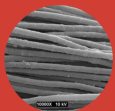
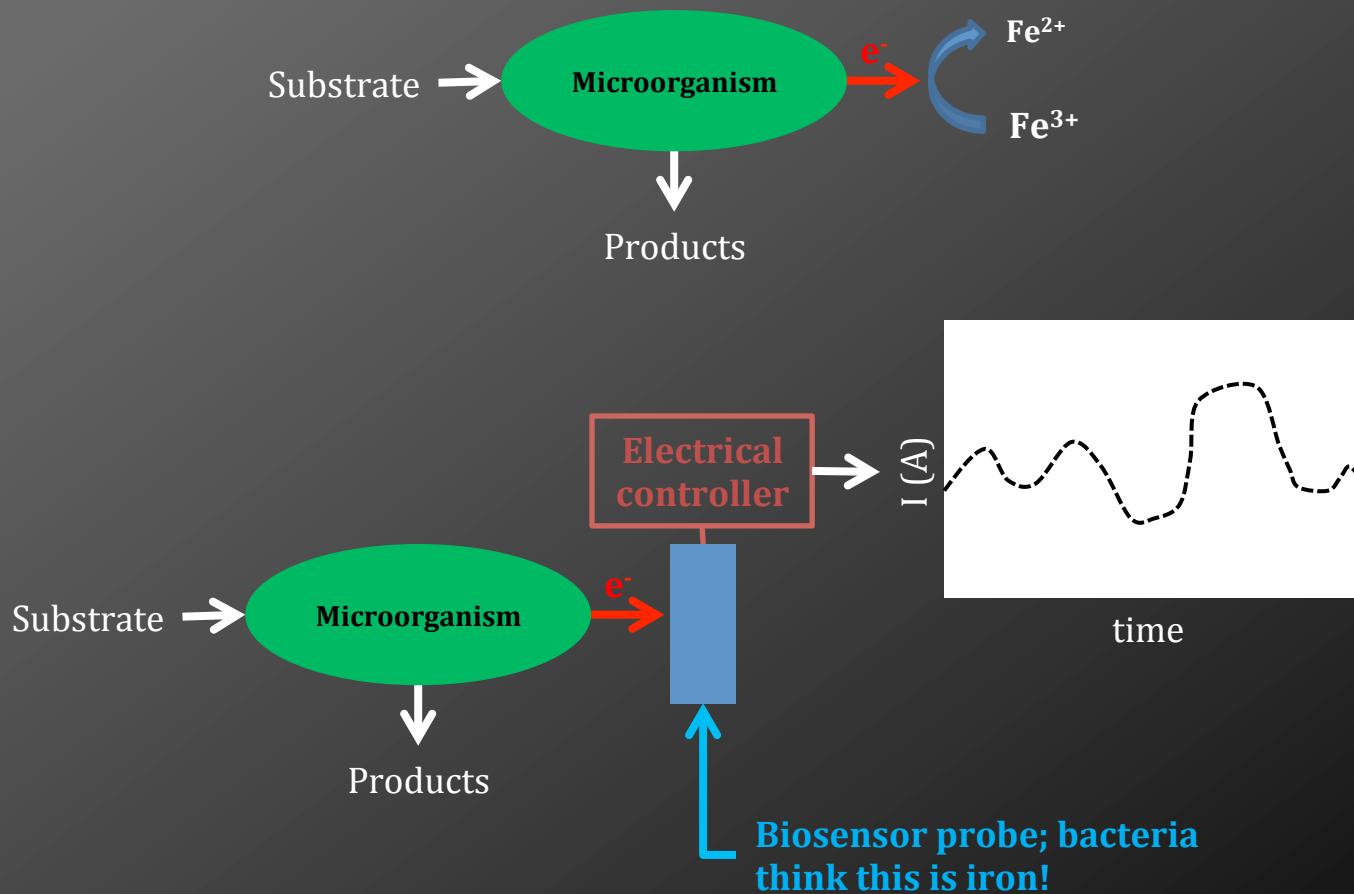
biosensing



biocomputing



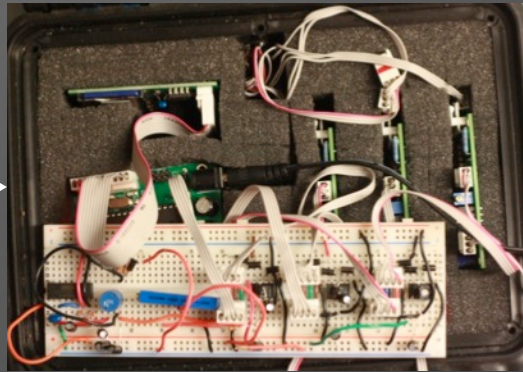
Microbial biosensor



Electrical controller



Prototype



Revisions



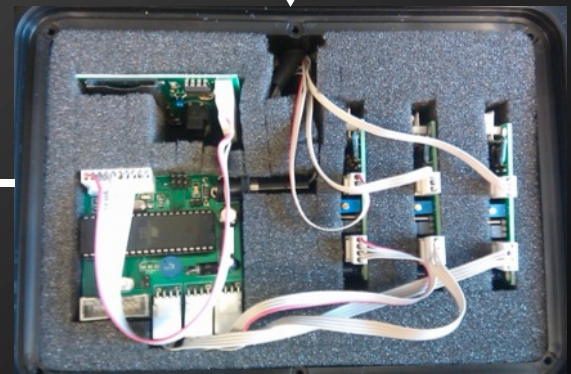
Lab Testing



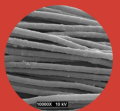
Production



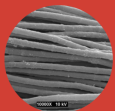
Field Testing



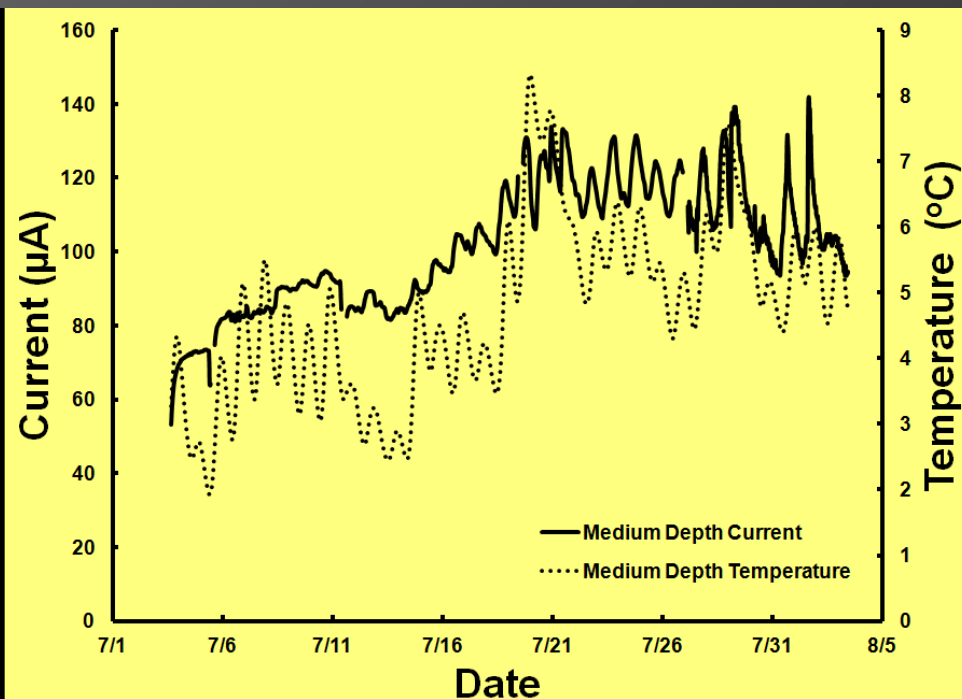
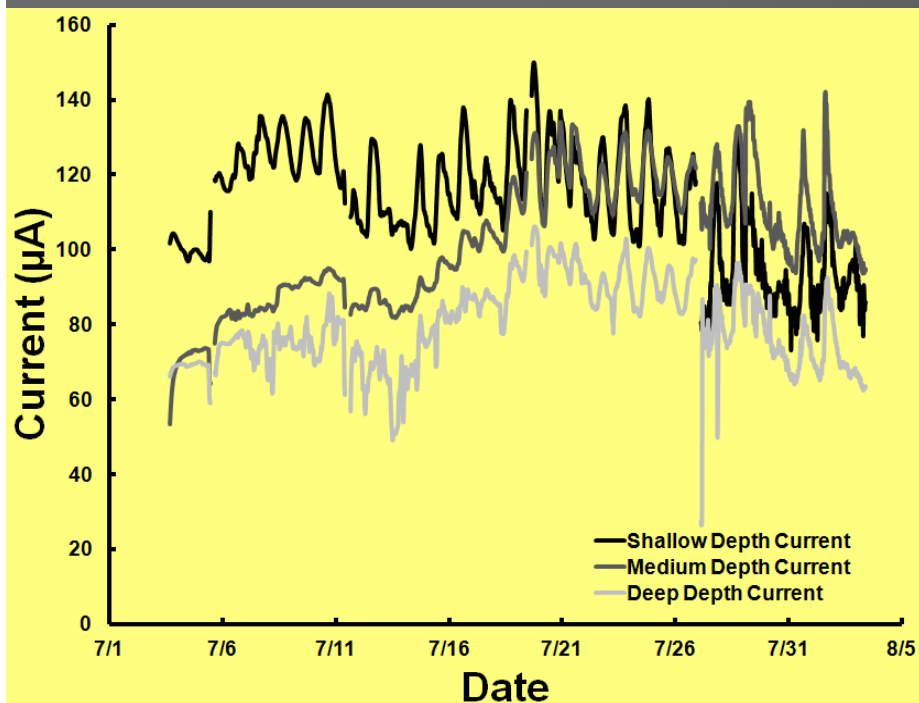
Prototype 2



Field Application

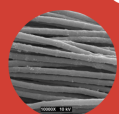


Results



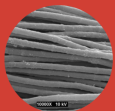
- Daily cycles in microbial activity

- Increase in soil temperature 'awakens' deeper-depth microbes



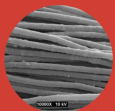
What's next: Field Season 2012

- What is the relationship between **iron reduction** and **methanogenesis**, and how do these processes compete and/or coexist?
- What are the major factors responsible for controlling **microbial dominance**?
- Do **current climate models** accurately predict methane emissions from this site?



Conclusions

- Methane is a major player in the climate change equation
- Arctic soils are an important carbon reservoir, and little is known about how climate change will affect the carbon balance
- Microbes are a crucial component in the carbon cycle
- Large range of methane emissions predicted in current models: site specific studies are necessary to clarify



Acknowledgements

- The Angenent Lab

Miriam Rosenbaum, Alex Lee
Devin Doud, Michaela TerAvest



- Barrow Field Team

Dr. David Lipson, Kim Miller
San Diego State University

Dr. Ted Raab, Eric Slessarev
Stanford University

Jim Miller

Cleveland Heights High School

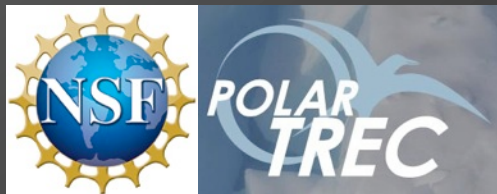
- Logistics

Barrow Arctic Science Consortium (BASC)

CH2M Hill Polar Services

UMIAQ

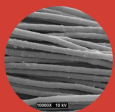
- Funding



Questions?



- Follow our 2012 field season, including PolarTREC teacher Cristina Solis from LA Academy:
<http://www.polartrec.com/expeditions/microbial-activity-in-thawing-arctic-permafrost-2012>
- High school curriculum for building a microbial fuel cell (MFC) – power an LED with bacteria!
<http://angenent.bee.cornell.edu/MFCLab.html>





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Teachers: Join PolarTREC!

www.polartrec.com/about/join

Every teacher can participate in different ways:

- **Following Expeditions**
- **Participate in PolarConnect Events**
- **Join the Polar Education Email List**
- **Take Online Professional Development Courses**
- **Become a PolarTREC Teacher!**



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Upcoming Events

Watch for and register for upcoming events at [www.polartrec.com!](http://www.polartrec.com)

PolarTREC Teacher Amber Lancaster on the Weddell Sea, Antarctica
9 April at 8:30am AKDT [9:30am PDT, 10:30am MDT, 11:30am CDT, 12:30pm EDT]

PolarTREC Teacher John Wood and the Carbon Balance in Tundra expedition
16 April at 12:45 AKDT [1:45pm PDT, 2:45pm MDT, 3:45pm CDT, 4:45pm EDT]



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Thank You!

An archive of the event will be available shortly.
<http://www.polar-trec.com/polar-connect/archive>

