Extremophiles

Alice Chen

Schedule

3:05 - 3:35 Presentation

3:35 - 4:00 Research

4:00 - 4:25 Present findings + Fill out our table

4:25 - 4:35 Break

4:35 - 4:40 Introduce Skype

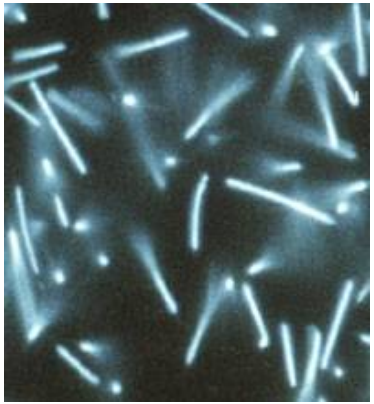
4:40 - 5:00 Group Discussion

5:00 - 5:35 Skype Dr. Carlos Mariscal

Background

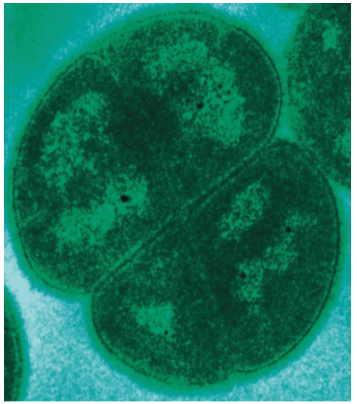
Big Picture:

1. What are the definition and limits of life?
2. What are the molecular mechanisms of adaptation?



http://wishart.biology.ualberta.ca/BacMap/cgi/getSpeciesCard.cgi?accession=NC_003551&ref=index_12.html

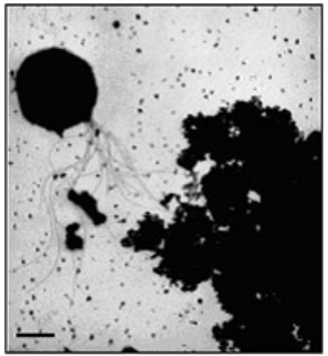
https://en.wikipedia.org/wiki/Upis_ceramboides



https://en.wikipedia.org/wiki/Deinococcus_radiodurans

Paper Summary - Kashefi and Lovley

- Upper temperature limit for life gives us information on origin of life on hot, early Earth and life elsewhere in the universe
- Lots of Fe(III) in hydrothermal vents
- Fe(III) as the final electron acceptor in the ETC was the first form of respiration
- Their experiment -
  - Microorganisms on Fe(III) in water from an active black smoker vent
  - Monitor cell growth and reduction of Fe(III)
- Found strain 121 (Geogemma barossii) from the experiment
  - Grows optimally in a temperature range of 85 to 121℃
  - Uses Fe(III) as electron acceptor



https://microbewiki.kenyon.edu/index.php/Geogemma_barossii

Paper Summary - Rothschild

- Extremophiles help with life outside Earth findings, origin of life hypothesis, biotech industry
- Different types of extremophiles and their mechanisms of adaptation
  - Temperature
  - Pressure
  - Dryness
  - Salinity
  - pH
- Various extreme environments on Earth and in space
  - Deep sea
  - Desserts
  - Snow, ice
  - Mars
  - Space
- Extremophiles have contributed tremendously to many fields: evolutionary biology, molecular biology, chemical synthesis, agriculture, detergents, health, etc.

Adapting Rothschild's Table 1

Extreme Limits and Adaptive Mechanisms of Extremophiles

Extremophile	Limits (Examples)	Mechanisms of Adaptation
Thermophiles		
Psychrophiles		
Halophiles		
Piezophiles (barophiles)		

Table 1 Classification and examples of extremophiles

Environmental parameter	Type	Definition	Examples
Temperature	Hyperthermophile Thermophile Mesophile Psychrophile	Growth >80 °C Growth 60–80 °C 15–60 °C <15 °C	*Pyrolobus fumarii*, 113 °C *Synechococcus lividis* *Homo sapiens* *Psychrobacter*, some insects
Radiation			*Deinococcus radiodurans*
Pressure	Barophile Piezophile	Weight-loving Pressure-loving	Unknown For microbe, 130 MPa
Gravity	Hypergravity Hypogravity	>1*g* <1*g*	None known None known
Vacuum		Tolerates vacuum (space devoid of matter)	Tardigrades, insects, microbes, seeds
Desiccation	Xerophiles	Anhydrobiotic	*Artemia salina*; nematodes, microbes, fungi, lichens
Salinity	Halophile	Salt-loving (2–5 M NaCl)	Halobacteriaceae, *Dunaliella salina*
pH	Alkaliphile Acidophile	pH > 9 low pH-loving	*Natronobacterium*, *Bacillus firmus* OF4, *Spirulina* spp. (all pH 10.5) *Cyanidium caldarium*, *Ferroplasma* sp. (both pH 0)

Rothschild 2001

Thermophiles

- Upper temperature limit of life has been pushed
  - Pyrolobus fumarii (Rothschild 2001)
  - Strain 121 (Kashefi and Lovley 2003)
  - Methanopyrus kandleri (Takai 2008)
  - Possible!
- Extremozyme, proteins that can function in the extreme environments, allow for extremophiles to thrive
- Classification:

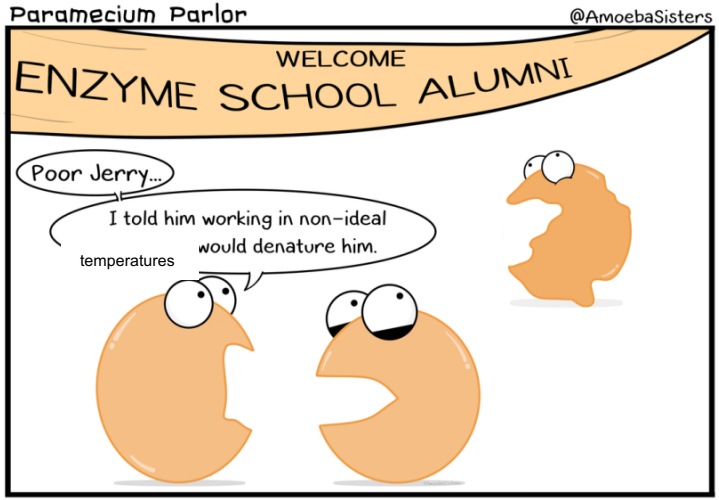
Simply Thermophiles	50–64 °C
Extreme thermophiles	65–79 °C
Hyperthermophiles	>80 °C

Obligate thermophiles	Require high temperature
Facultative thermophiles	Thrive in high and lower temperatures

Thermophiles

In order to adapt to high temperatures,

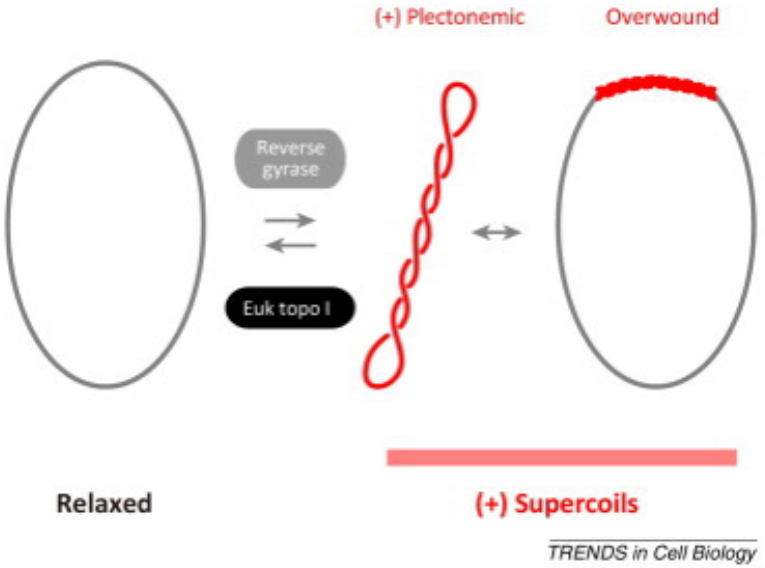
- Membrane fluidity
  - Monolayer better than bilayer
  - Saturated better than unsaturated lipids
- Protein function
  - Charged amino acids form ion pairs
- Cell liquid
  - High pressure
- DNA stability



Thermophiles

Nucleic Acid Stability

- GC content
- Salt screens
- Reverse DNA Gyrase
  - Overwinds DNA
  - Only found in thermophiles
- Extensive methylation of DNA



http://www.sciencedirect.com/science/article/pii/S0962892414001044

Research in Pairs

Extremophile	Limits (Examples)	Mechanisms of Adaptation
1. Thermophiles	122°C with Methanopyrus kandleri	Saturated lipids membrane, ion pairs, reverse DNA gyrase
2. Psychrophiles		
3. Piezophiles (barophiles)		
4. Halophiles		

1. What are the known possible metabolisms in thermophiles?
2. How do various psychrophiles withstand freezing temperatures?
3. What is the current research on the upper pressure limit of life and the mechanisms of adaptation?
4. What is the current research on the upper limit with salinity and the mechanisms of adaptation?

BIO BREAK

Skype: Carlos Mariscal

http://carlosmariscal.com/

- Professor in the Philosophy Department at the University of Nevada
- Member of the Ecology, Evolution, and Conservation Biology Program
- Got his PhD from Duke with Prof. Daniel McShea
- His work and interests -
  - philosophy, biology, astrobiology, microbiology, how philosophy plays its role in those fields
  - life in the Universe, origins of life on Earth
  - journalism
- One of the only philosophers of astrobiology

Group Discussion Questions

1. What do you think extremophiles can tell us about the origin of life hypotheses?
2. If the idea of extremophiles makes life existing elsewhere in space more plausible, how do we discover this life and what do we do when we discover this life?
3. Dr. Mariscal's work on the definition of life

Skype!

Thanks!