Astrobiology

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Duke University
BIO 590S

Schedule

3:05 - 3:35 Presentation

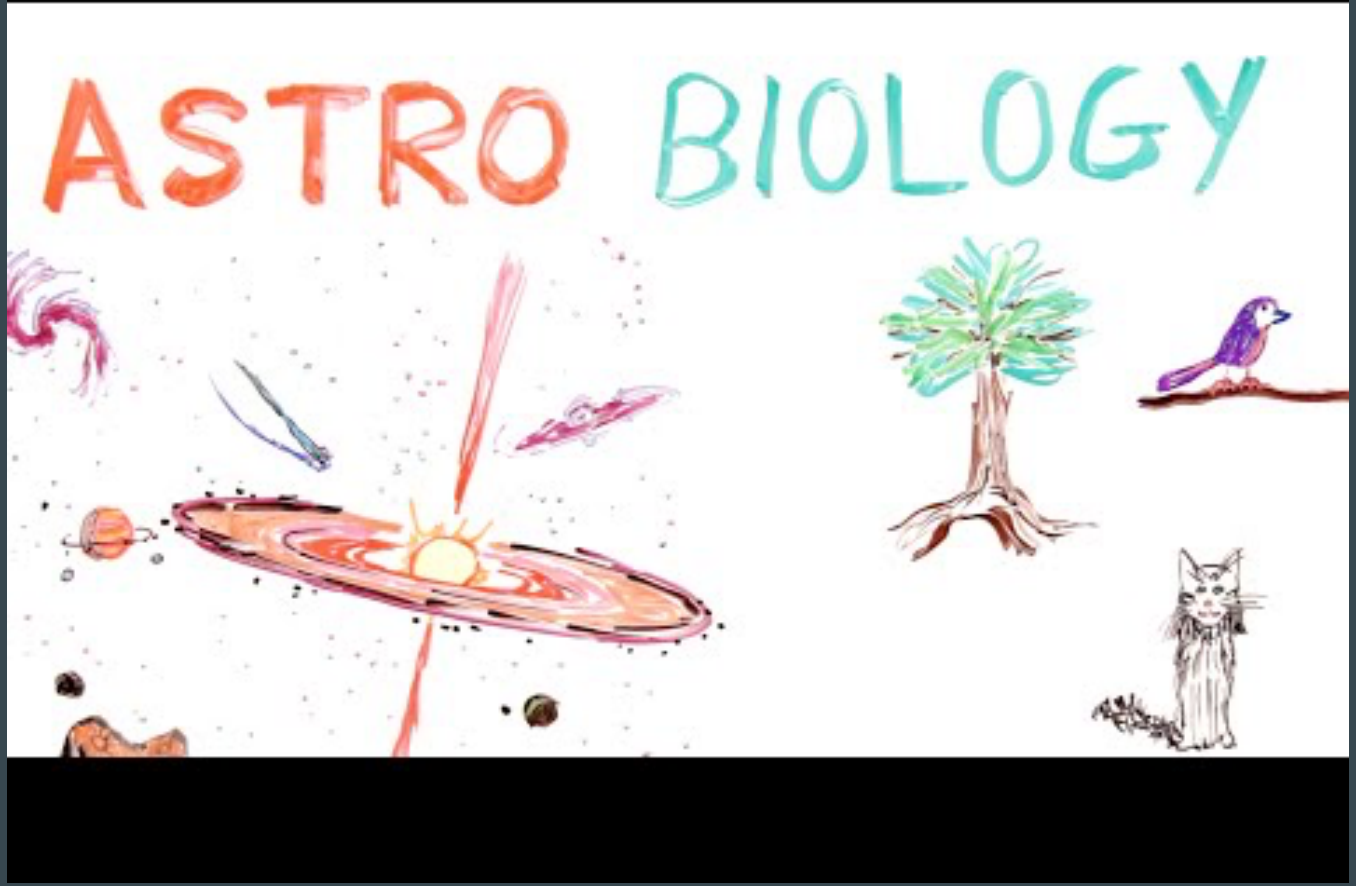
3:35 - 4:00 Group Research

4:00 - 4:30 Present Findings

4:30 - 4:40 Break

4:40 - 5:00 Class Evaluations

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


ASTRO BIOLOGY

Key Questions in Astrobiology

What are the building blocks of life?

Where and how did Earth obtain the essential ingredients for life?

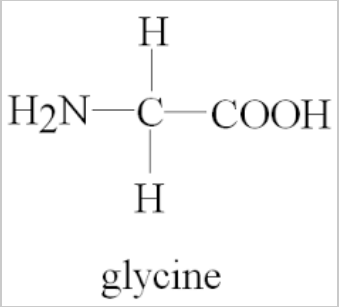
Is Earth the only planet with the necessary ingredient and conditions for life?

Is it possible that life exists elsewhere based on elements other than carbon and a system different than DNA?

Nova Episode

Key Ingredients for Life:

- Organic Molecules: Carbon, hydrogen, oxygen, etc.
- Liquid (i.e. water): Medium in which basic organic molecules can mix and interact
- Energy (i.e. sun): To power internal processes required for life



Planetary Formation

- Repeated impacts from space debris, creating heat to produce oceans of magma
- Steam resulting from impacts later create water that forms the oceans

Cosmic Bodies (asteroids, comets, meteorites)

- Icy comets contain glycine
- Late heavy bombardment (evident from impact craters) may have delivered building blocks of life to Earth

Other plantetary bodies with the ingredients for life

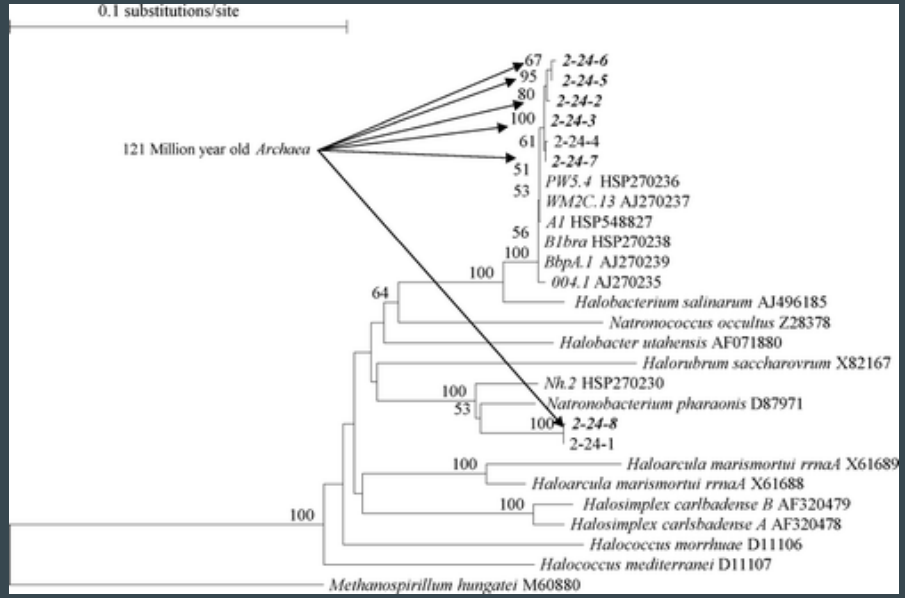
- The moons of Jupiter (Io, Europa) contain building block necessary for life

Vreeland et al 2007

Six living strains from genera *Halobacterium* and *Natronobacterium* were isolated from Cretaceous era primary salt crystals, implicating mechanisms of long-term survival for some microbes

Results:

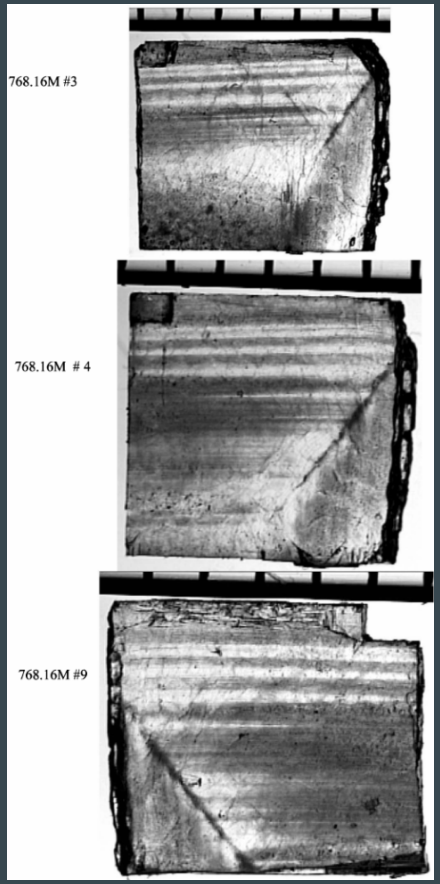
- Six living strains from genera *Halobacterium* and *Natronobacterium* (5 strains and 1 strain, respectively) collected from 4/56 crystal samples
- Age: Aptian Period (121 - 112.2 MYA)
- Characteristics: Archaea, Non-Sporing



Vreeland et al 2007

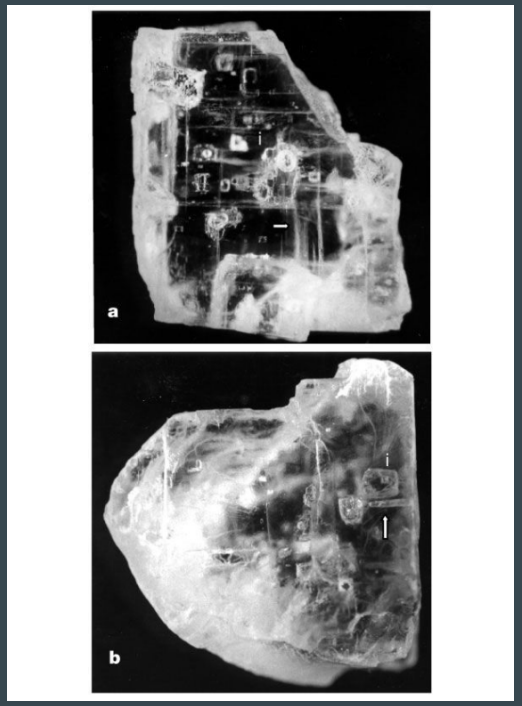
Discussion:

- Reveal geochemical environment that foster survival
- Implications for long-term survival of microbes
- Necessitate investigation on more ancient environments for older organisms
- Lack of selective pressure implies extreme genetic stability of microbes
- What is the survival potential of microorganisms from salt on different planets?



Vreeland et al 2007

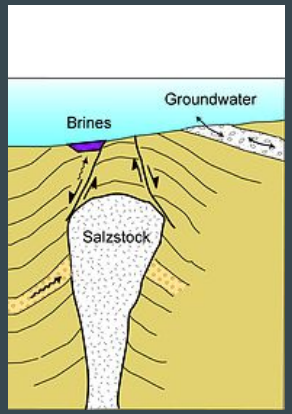
Contamination Concerns



Vreeland et al 2000

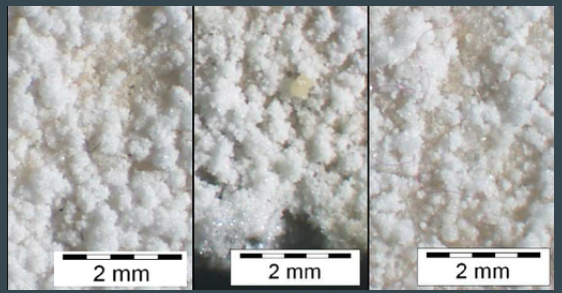
Flowing Brine

vs



Rock Salt

Gonçalves et al 2000



Van Dover 2000

Salt Efflorescence

Goordial et al 2016

The combination of severe cold, aridity, and oligotrophic permafrost soils of the McMurdo Valleys in Antarctica severely limit microbial activity and survival.

Results:

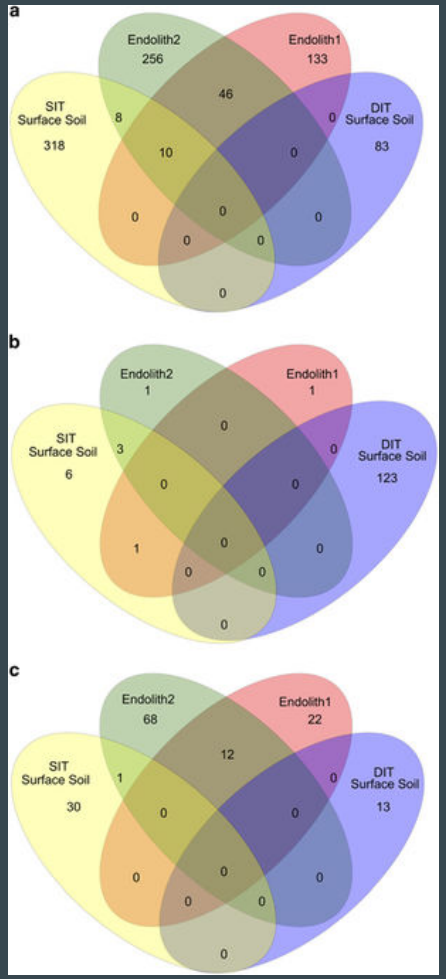
- Mean Temperature -23.5 °C to -26.5 °C, Soil samples highly oligotrophic
- Only 6 heterotrophic isolates on over 1000 agar plates in 2 years
- Of the culturable isolates, required liquid enrichment indicating dormancy or damage

Isolate	Environment of closest BLAST match	% Similarity	Temp. growth range (°C)[a]	Salinity growth range (% NaCl)	Isolation media	Enrichment step before isolation	Sample	GenBank accession number
Rhodococcus sp. (Bacteria)	Cloud water (1465 m), France (HQ256820.1)	97%	−5–30	0– 7	R2A, 5 °C	0.1% $Na_4P_2O_7$, 2 weeks	IT-12, 37–42 cm	KM279631
Methylobacterium sp. (Bacteria)	Moss phyllosphere (NR_117561.1)	96%	5– 30	0–5	TSA+5% NaCl	TSA+5% NaCl, 2 weeks	IT-5, 5–10 cm	KM279632
Rhodotorula sp. (Fungi)	Lake Vostok accretion ice, Antarctica (EU108797.1)	99%	−10–30	0–15	R2A, 5 °C	0.1% $Na_4P_2O_7$, 2 weeks	IT-12, 37–42 cm	KM279633
Sphingomonas sp. (Bacteria)	Surface Soil, South Korea (NR_043171.1)	95%	5–25	0–5	R2A	TSA+5% NaCl, 2 weeks	IT-12, 12–15 cm	KM279634
Unidentified *Chaetothyriales*[b] (Fungi)	University Valley sandstone endolith collected 1980/81 (GU250317.1)	99%	0–25	ND	1:10 TSA, 5 °C, 50 days; 1:2 R2A, TSA, 5 °C, 40 days	No enrichment	IT-12, surface soil; IT-5, 5–10 cm	KM279635
Bacillus sp. (Bacteria)	Taibai mountain, China (KJ589539)	99%	ND–25	ND	R2A, anaerobic conditions	Perchlorate-reducing media	IT-5, 5–10 cm	KM279636

Goordial et al 2007

Discussion:

- Places limits on the possibilities of life in cold and arid environment due to inability to metabolize and grow
- Combination of lack of water, cold, and oligotrophy severely constrain survival
- Microbes found may not be fully cold-adapted, but instead a transient phase
- Life is currently limited to lithic habitats
- Dry permafrost is commonplace in northern polar regions of Mars



Goordial et al 2007

Break-up and Discuss!

How might radiation-resistant microbes alter our beliefs about the mechanisms of panspermia? Just how irradiating is outer space?

How feasible would it be to have a life-form based around liquid methane instead of liquid water? What about other liquid compounds? What adaptations for life might be necessary in these situations?

How are astrobiological exploration missions kept completely sanitary and free of spores or extremely durable microbes/extremophiles? What past examples of accidental contamination are there?

What is the viability of biomolecules over the timeframe suggested by the Vreeland et al paper? What mechanisms are there for long-term stabilization of DNA to prevent breakdown over time?

Break + Class Evaluations

Guest Speaker: Carlos Marsical

Assistant Professor of Philisophy at the University of Nevade, Reno
Ph.D, Philisophy, Duke University, 2014
M.A., Philisophy, Duke University, 2012
B.A., Journalism & Mass Communication, New Mexico State University, 2006

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