

Life in Extreme Environments; Searching for Life Beyond Earth

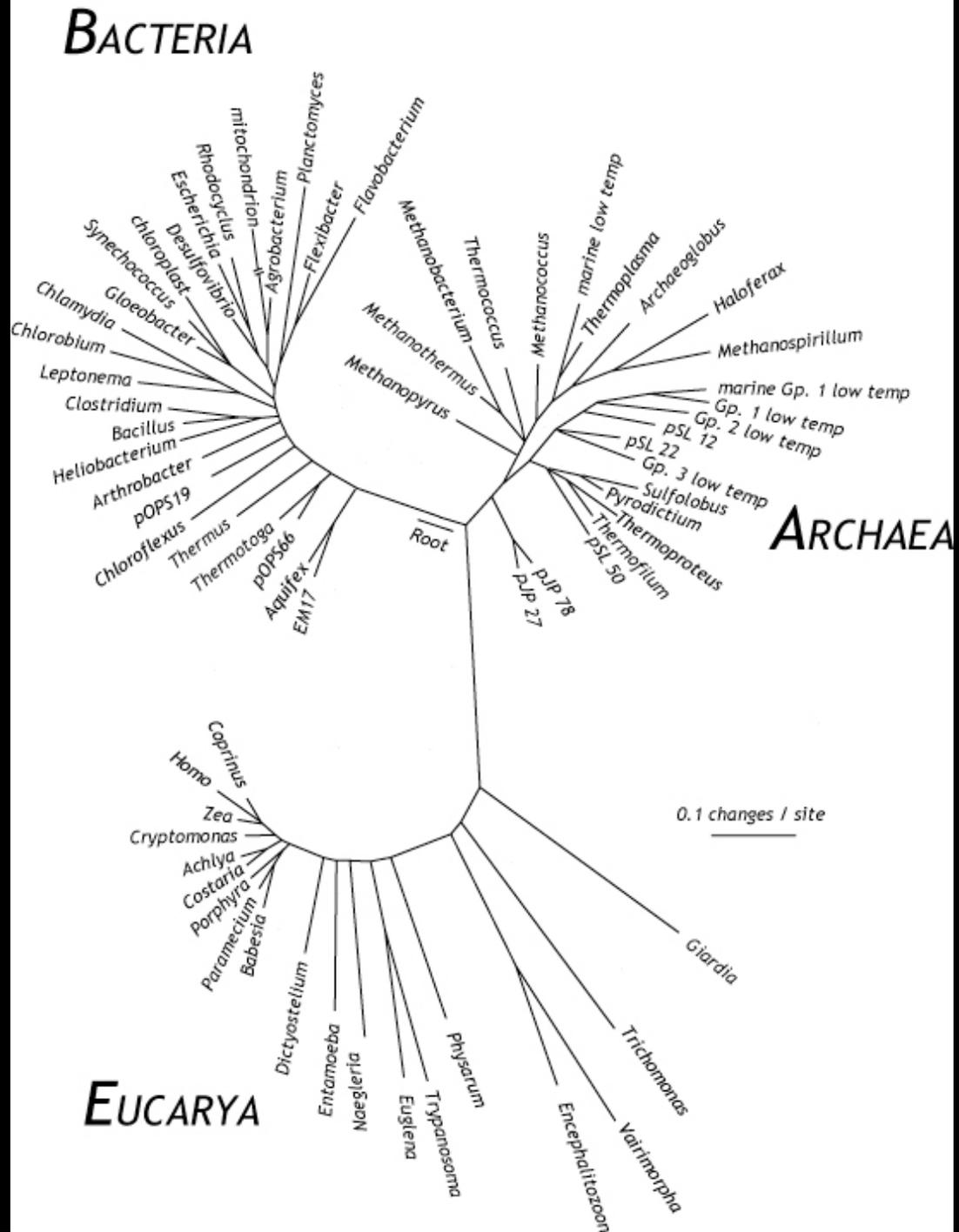
Discussion coordinators:
Dave Des Marais
Tom McCollom



Extending our Concepts of Life

- **Origins on Earth**
 - What environments and evolutionary paths allowed the key components of living system(s) to develop?
 - What evolutionary paths led to the array of attributes shared by all modern organisms?
- **Determinism**
 - Do “nurturing” environments usually lead to life?
 - To what extent do physical and chemical factors cause life elsewhere to resemble our own?
- **Diversity**
 - Does Earth’s biosphere represent a subset of the (much greater?) diversity of life in the universe?
 - What are the ultimate environmental limits of life?

Extreme environments offer insights about the evolution of life



A Definition of Life

Life is the harnessing of free energy

to sustain and perpetuate, by molecular replication and evolution, a high density of information

in the form of complex molecules

and functionally-related larger structures

Biosignature Categories

Cellular and extracellular morphologies

“Biomarker” molecular structures

- Biofabrics: microscale biogenic rock textures

- Community-level structures, e.g., stromatolites

- “Biomarker” minerals

- Biogenic stable isotope patterns

- Light from inhabited extrasolar planets

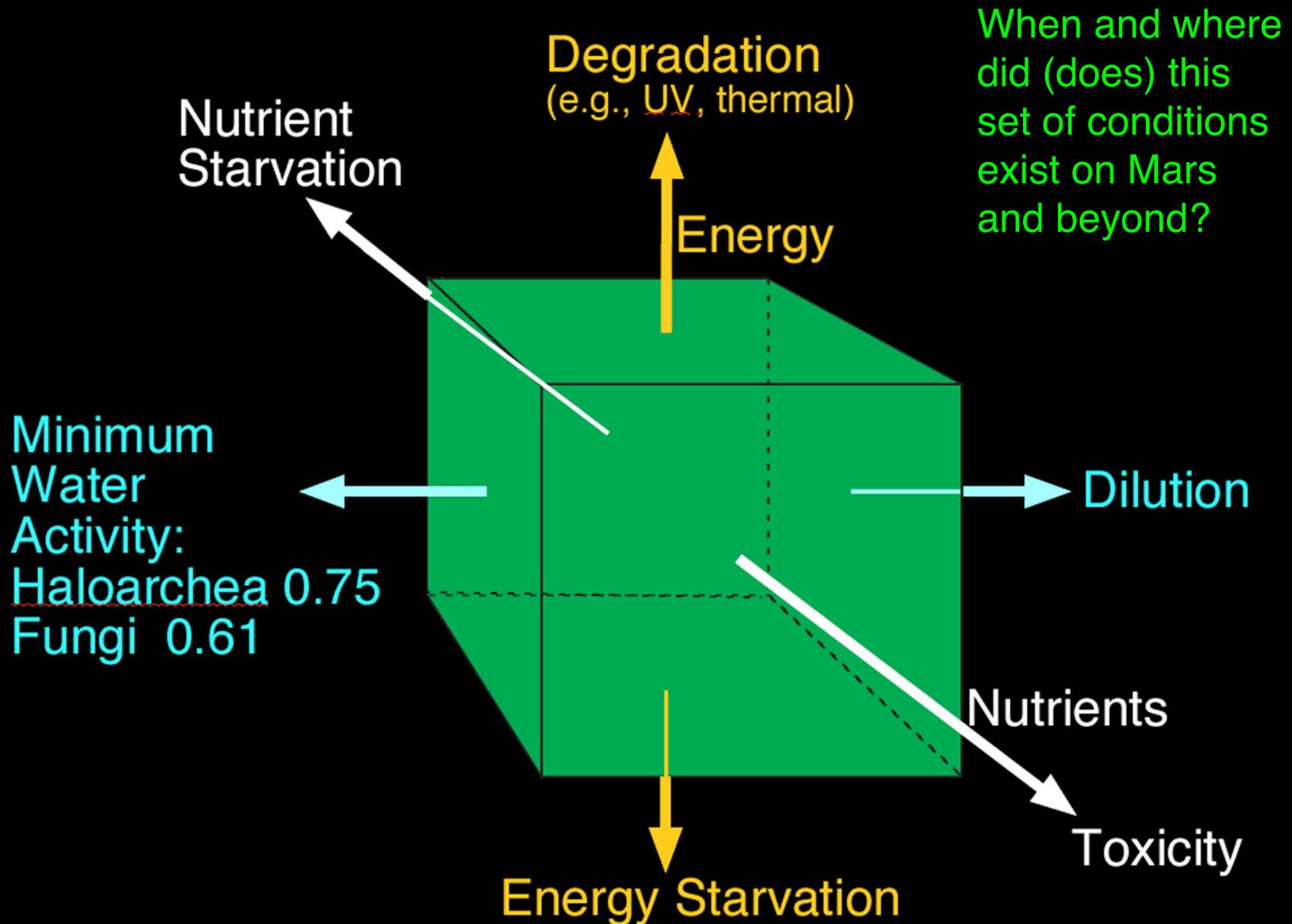
Requirements for (our) Life

(Tori Hoehler)

- Source of Energy
- Source of Carbon
- Source of Electrons
- Water
- Nutrients
- Preserve the Functional Complexity!

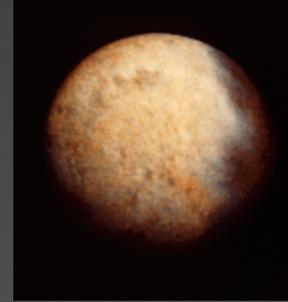
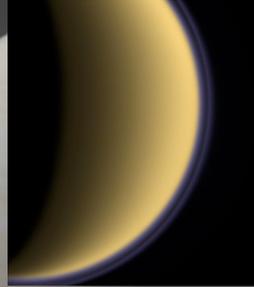
Microbiologists classify organisms based on how they fulfill these needs

Range of Conditions that Sustains Life

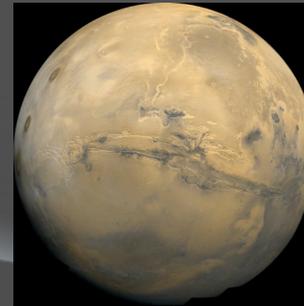


The big "H"--Habitability

Habitability in planetary environments



How does a planetary system become habitable?



Habitability in the architecture of planetary systems

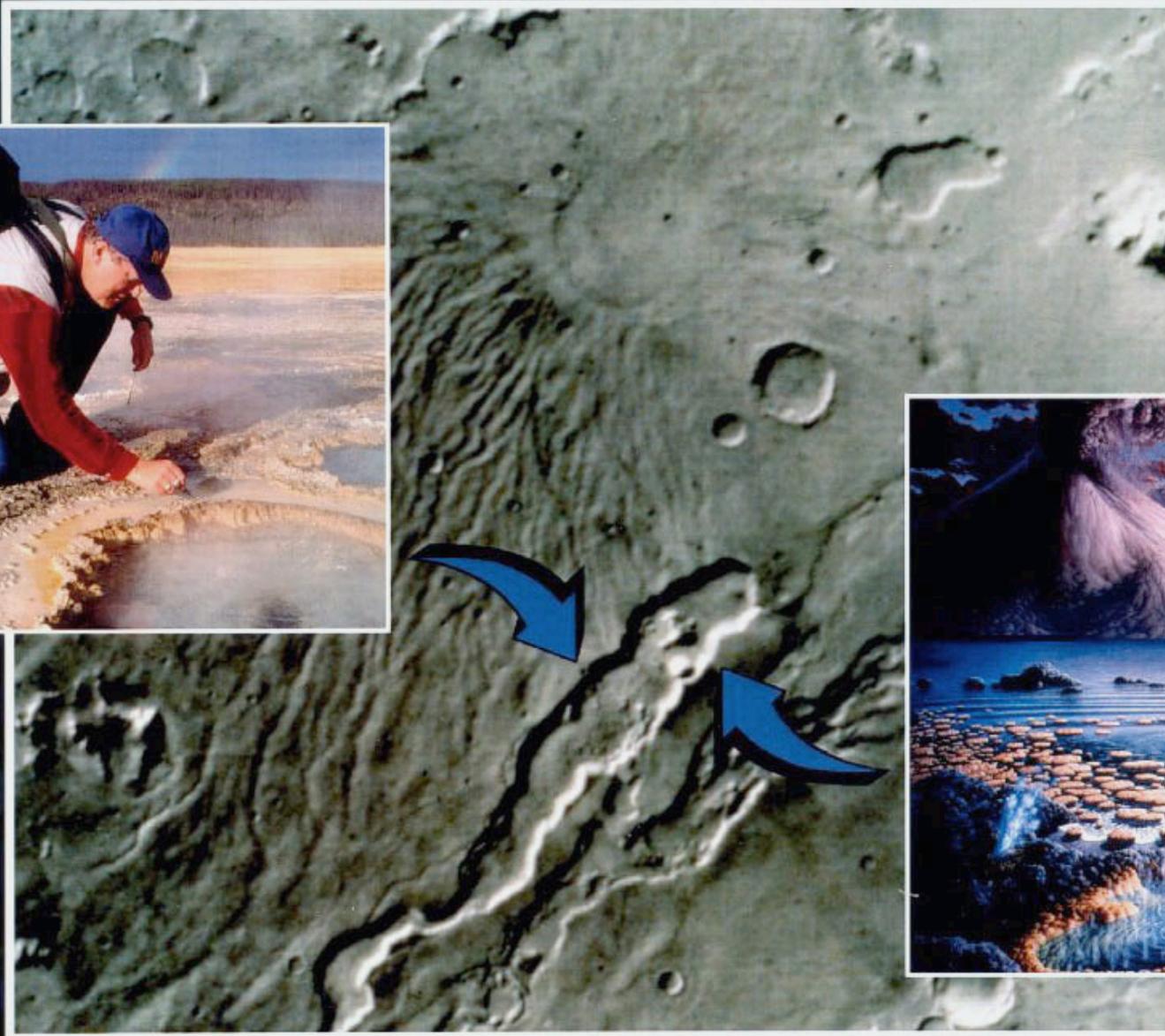
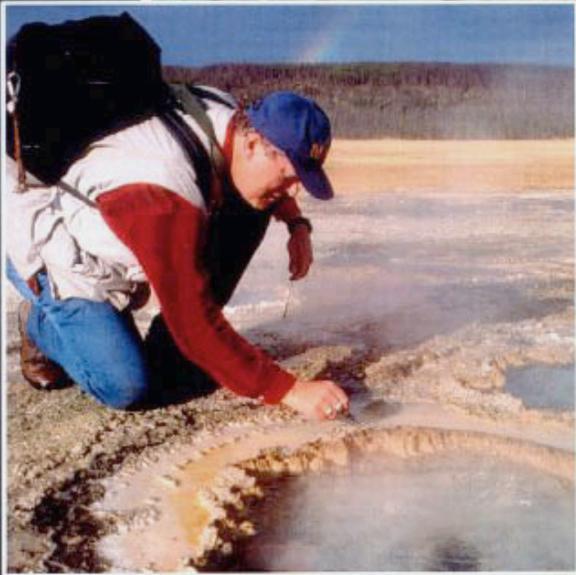
Conditions That Could Sustain Life on Mars: Changes Over the Eons



Des Marais

Life in Hot Springs: Yellowstone. Ancient Earth. Mars?

Prepared
by
S. Chang



End

Features of All Living Systems on Earth

- Cellularity: To define and retain cytoplasm content
- Cells require between 50 & 90 wt. % water to function
- Covalently-bonded C, H, O, N & P compounds dominate, but trace elements (e.g., transition metals) crucial
- Small number of molecules that, as a set, universally comprise most of cell mass
- Most of cell mass consists of carbohydrates, lipids, nucleic acids and proteins
- Energy flow involves formation or hydrolysis of phosphate bonds, usually ATP

Features of All Living Systems on Earth

- Universal core network of biochemical reactions: intermediary metabolism (glycolysis, TCA cycle, etc.)
- Biochemical information is structural, not dynamic (e.g., cells taken to 0 K can recover completely)
- Sustained life is the property of an ecosystem, rather than an individual cell or species
- Universal lipid bilayer structure; cell walls optional
- In replication, info. flows from DNA to RNA to proteins
- Other universal key molecules in replication include ribozymes, t-RNAs and activating enzymes
- Reactions with appreciable rates are enzyme-catalyzed