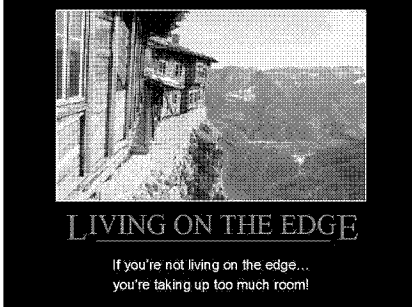


Friday, October 15
Extreme Life



Extreme Life
Key Concepts

- 1) Extremophiles are organisms that are adapted to extreme environments.
- 2) Different classes of extremophiles can tolerate heat, cold, salt, acid, & radiation.
- 3) Studying extreme life on Earth helps us to understand the possibilities of life elsewhere.

Extremophiles are organisms adapted to living in environments with extreme properties.

Extremely hot, cold, salty, acidic, dry, etc.

Most extremophiles are prokaryotes; some are eukaryotes, including simple animals.

They may provide 1/3 to 1/2 of Earth's biomass.



Extreme heat is bad for most living things.

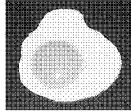
Heat decreases the solubility of CO₂ and O₂ in water.



Heat degrades chlorophyll, stopping photosynthesis.



Heat denatures proteins, causing them to stop working.



Thermophiles thrive at high temperatures (> 45°C or 113°F)

Thermophiles are found in hot springs & deep-sea volcanic vents.

They have enzymes & proteins that work at high temperatures.

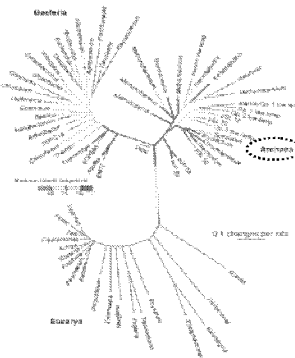


Were thermophiles the first life on Earth??

The earliest organisms were prokaryotes (archaea, more precisely).

Prokaryotes are heat-tolerant.

Deep-sea vents were isolated from harsh conditions on the surface.

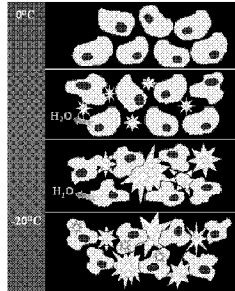


Extreme cold is bad for most living things.

Freezing damages cells.

Cold increases viscosity, slowing the flow of nutrients & wastes.

Proteins & enzymes get stiff, slowing their function.

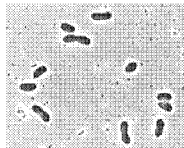
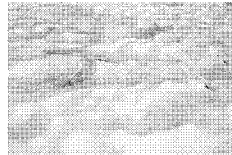


Psychrophiles thrive at low temperatures (< 15°C or 59°F)

Psychrophiles are found in ice, snow, soil, & deep oceans.

They have exceptionally flexible enzymes & proteins.

Some are photosynthetic eukaryotes ("snow algae").

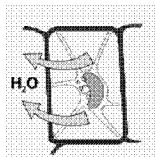


Desulfotomaculum gelida

Extreme salinity (lots of salt) is bad for most living things.

Salt water desiccates cells (draws out water).

Salt promotes protein aggregation, disrupting function.

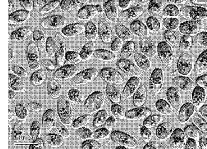


Halophiles thrive in high concentrations of salt.

Halophiles can live in water with 10× the saltiness of the ocean (Dead Sea, Great Salt Lake).



Extra potassium ions inside the cell prevent desiccation.



Dunaliella salina

The acidity of a solution is measured by its pH.

Low pH solutions are **acidic**.

High pH solutions are **alkaline**.

High acidity is bad for most living things; it destroys proteins & DNA.

pH=1 Stomach Acid

pH=3 Orange Juice

pH=5 Black Coffee

pH=7 Pure Water

pH=9 Baking Soda

pH=11 Windex

pH=13 Bleach

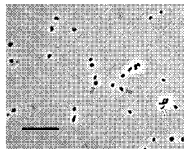
Acidophiles thrive in highly acidic environments (pH < 2).

Acidophiles can live in stomach acid & pools of acidic mine drainage.



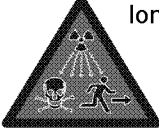
Some neutralize the acids in their cell interiors.

Others have evolved acid-resistant proteins.



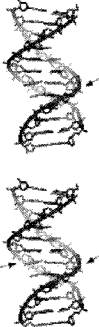
Ferropasma acidarmanus

Ionizing radiation is bad for most living things.



DNA is susceptible to radiation damage:
 Minor damage → self-repair
 Lethal damage → cell death
 Non-lethal damage → mutation

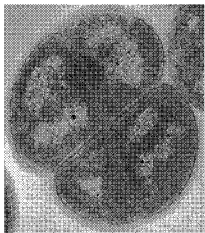
Radiation dose = Energy absorbed per kg
 Medical X-ray: ~0.002 joule/kg.
 10 joules/kg is lethal to humans.
 60 joules/kg kills *E. coli* bacteria.



Radioresistant organisms thrive after high doses of ionizing radiation.

Deinococcus radiodurans can survive doses of 5000 joules/kg.

It has ultra-efficient DNA repair plus multiple copies of its genome.



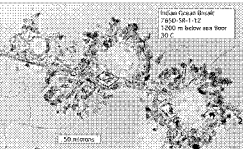
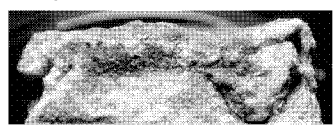
Deinococcus radiodurans

Endoliths are organisms that live inside rocks.

Endoliths have been found as far as 3 km below ground.

Most are chemoautotrophs.

They reproduce about once a century.

The total mass of endoliths could exceed the mass of all surface life!

Studying extreme life on Earth helps in understanding the possibilities of life elsewhere.

The existence of extremophiles extends the range of life-friendly environments.

The first living things on Earth may have been extremophiles by today's criteria.

No organisms are known that can live without liquid water.



Monday's Lecture:

The Origin of Life

Next Week's Reading:

Chapter 6

Problem Set #1 due Monday.
