Extremophiles

- An **extremophile** is an organism that thrives in **physically or geochemically extreme conditions** that are harmful to most life on Earth.

- In contrast, organisms that live in more **moderate environments** may be termed **mesophiles** or **neutrophiles**.

Characteristics

- In the 1980s and 1990s, biologists found that microbial life has **great flexibility** for surviving in extreme environments that would be completely **inhospitable** to complex organisms.
- There are **viable bacterial spores** that are **40 million years old**.
- Some bacteria were found living in the **Marianas Trench**, the **deepest place** in Earth's oceans.
- A key to extremophile adaptation is their **amino acid composition**, affecting their **protein folding ability** under particular conditions.

Classifications

- There are **many classes of extremophiles** that range all around the globe, each corresponding to the way its environmental niche differs from mesophilic conditions.
- These classifications are **not exclusive**.
- Many extremophiles fall under **multiple categories** and are classified as **polyextremophiles.**

Acidophiles

An organism with optimal growth at **pH levels of 3 or below**

Examples: *Helicobacter pylori, Bacillus* spp, *Clostridium paradoxum*

Alkaliphiles

An organism with optimal growth at **pH levels of 9 or above**

Examples: *Psychrobacter*, Vibrio, *Arthrobacter, Natronobacterium*

Anaerobes

- An organism that **does not require oxygen** for growth such as *Clostridium spp.*, *Spinoloricus cinzia*.

- Two sub-types exist: **facultative anaerobe** and **obligate anaerobe.**

- A **facultative anaerobe** can **tolerate anaerobic and aerobic conditions**; however, an **obligate anaerobe** would die in the presence of **even trace levels of oxygen.**

Cryptoendolith

An organism that lives in **microscopic spaces within rocks**, such as pores between aggregate grains.

These may also be called **endolith**, a term that also includes organisms populating fissures,, and faults filled with groundwater in the deep subsurface.

Examples: Fungi *Ostracoblabe implexis* and *Lithopythium gangliiforme*

Halophile

An organism requiring **at least 0.2M concentrations of salt (NaCl)** for growth.

Examples: *Halobacteriaceae, Dunaliella salina*

Hypolith

An organism that lives **underneath rocks in cold deserts.**

Examples: Some types of *Cyanobacteria*

Lithoautotroph

- An organism (usually bacteria) whose **sole source of carbon is carbon dioxide** and **exergonic inorganic oxidation (chemolithotrophs)** such as *Nitrosomonas europaea*

- These organisms are capable of **deriving energy from reduced mineral compounds like pyrites**, and are active in geochemical cycling and the weathering of parent bedrock to form soil.

Metallotolerant

- Capable of **tolerating high levels of dissolved heavy metals** in solution, such as copper, cadmium, arsenic, and zinc; examples include *Ferroplasma* sp., *Cupriavidus metallidurans.*

Exergonic: release of energy.

Oligotroph

An organism capable of growth in **nutritionally limited** environments.

Examples: *Pelagibacter ubique*

Osmophile

An organism capable of growth in environments with a **high sugar concentration.**

Examples: *Saccharomyces bailii*

Piezophile

Also referred to as **barophile**, is an organism that lives **optimally at high pressures** such as those deep in the ocean or underground common in the deep terrestrial subsurface, as well as in **oceanic trenches**.

High pressures can cause **proteins to fold into themselves.**

Examples: *Halomonas salaria*

Psychrophile/Cryophile

- These are organisms capable of survival, growth or reproduction **at temperatures of -15 °C or lower for extended periods.**

- These are common in **cold soils, permafrost, polar ice, cold ocean water,** and in or under **alpine snowpack**.

- Their proteins have **adapted their amino acid composition** to live in cold conditions.

Examples: *Arthrobacter* sp., *Psychrobacter* sp

Permafrost: Anything which is in frozen state for more than 2 years.

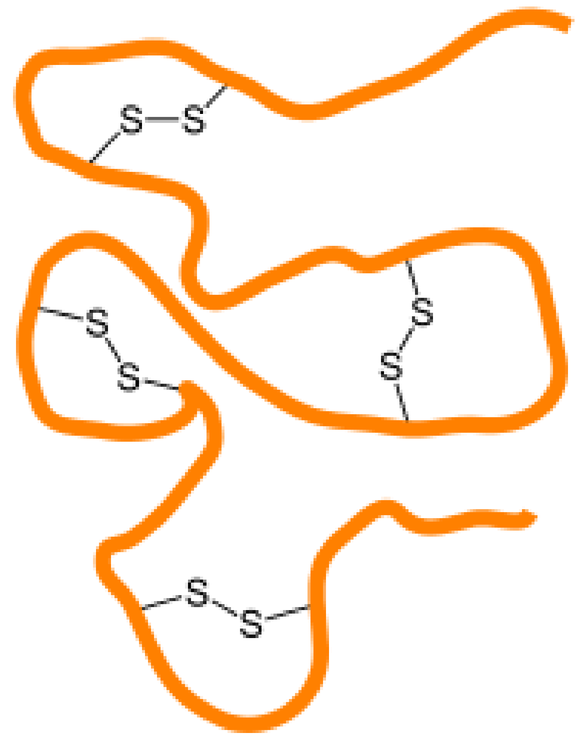
Thermophile

- These are organisms that can thrive at temperatures between **45–122 °C**.
- Normally high temperatures **cause proteins to unfold** and prevent them from functioning but **thermophilic organisms have adapted their proteins** to cope with these conditions.

- They have a **higher amount of cysteine**, which form **disulfide bonds** once the protein has folded.

- These disulfide bonds cause the protein to **fold up tighter and become more rigid.**

- When proteins become more rigid they are **less likely to unfold** due to high temperature.



Examples:

Sulfolobus solfataricus
Sulfolobus acidocaldarius

Thermoacidophile

Combination of **thermophile and acidophile** that prefer temperatures of 70–80 °C and pH between 2 and 3.

Example: *Galdieria sulphuraria*

Xerophile

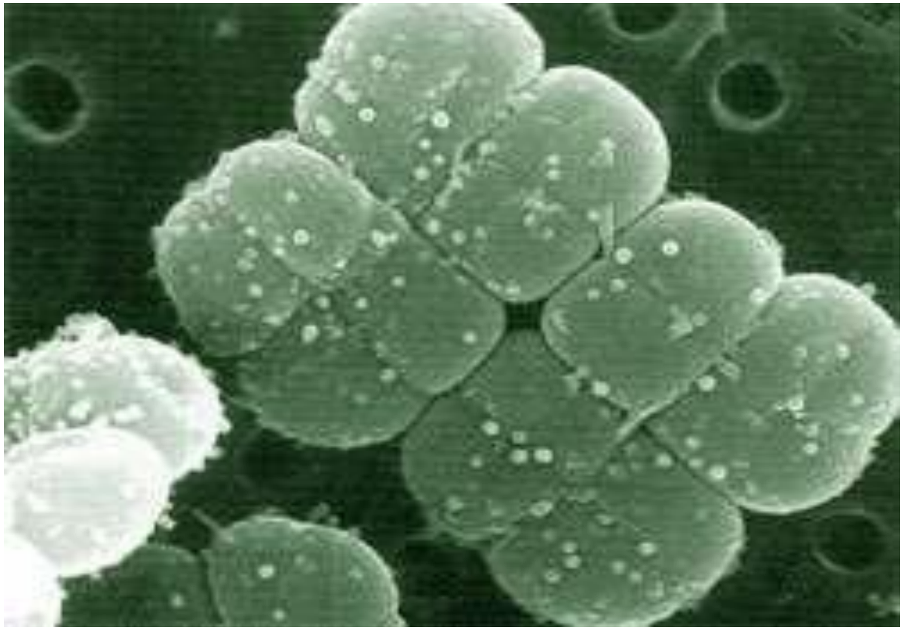
An organism that can grow in **extremely dry, desiccating conditions such as deserts.**

Example: *Trichosporonoides nigrescens*

Radioresistant

Organisms **resistant to high levels of ionizing radiation**, most commonly **ultraviolet radiation**, but also including organisms capable of resisting **nuclear radiation**.

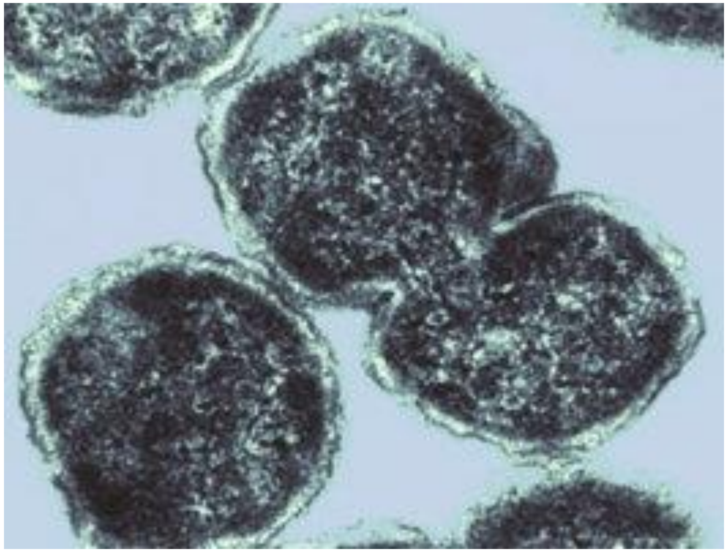
Example: *Deinococcus radiodurans*



Resistance to gravitational force

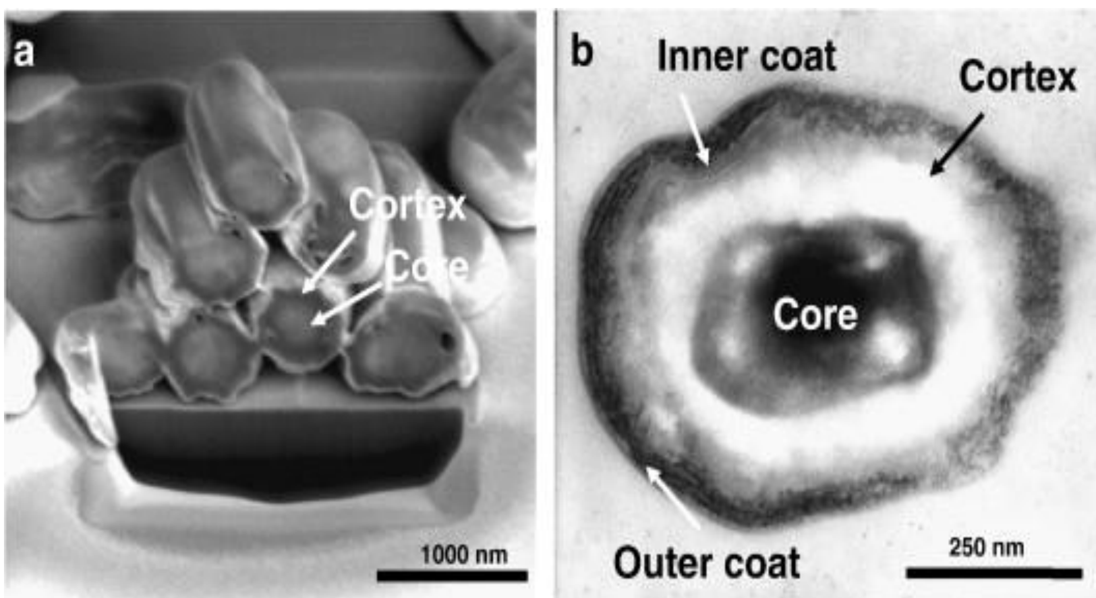
- Recent research carried out on extremophiles in Japan involved a variety of bacteria including *Paracoccus denitrificans* being subject to conditions of **extreme gravity (403,627 g**).

- *Paracoccus denitrificans* displayed **not only survival but also robust cellular growth** under these conditions of hyperacceleration which are usually found only in cosmic environments.



- In 2016, it was reported that **endospores** of *Bacillus subtilis* were able to survive high speed impacts up to **299±28 m/s**, **extreme shock**, and **extreme deceleration**.

- This feature might **allow endospores to survive and to be transferred between planets by traveling within meteorites** or by experiencing atmosphere disruption.



Industrial uses of extremophiles

- The **thermoalkaliphilic catalase**, which initiates the breakdown of hydrogen peroxide into oxygen and water, was isolated from an organism, *Thermus brockianus*.

- The catalase operates over a temperature range from **30 °C to over 94 °C and a pH range from 6–10.**

- This catalase is **extremely stable** compared to other catalases at high temperatures and pH.

- This catalase has applications for **removal of hydrogen peroxide** in industrial processes such as pulp and paper bleaching, textile bleaching, food pasteurization, and **surface decontamination** of food packaging.

- **DNA modifying enzymes** such as Taq DNA polymerase and some *Bacillu*s enzymes used in **clinical diagnostics** and **starch liquefaction** are produced commercially by several biotechnology companies.


Thank You!