Extremophile bacteria

Why in news?

The recent research studies shows that extremophile bacteria can survive not only in extreme environments but also in microwaves.

What are extremophile microbes?

- **Microbes** - They are microorganisms, tiny living organisms , that are *too small to be seen with the naked eye.*
- **Microbes Type** – Protozoa, bacteria, fungi and microscopic animal and plant viruses, viroids and also prions that are proteinacious infectious agents.
- **Single or Multi cell** - Microorganisms may be single-celled like bacteria, some algae and protozoa, or multicellular, such as many algae and fungi.
- **Global Initiatives** - Many global initiatives are currently trying to map, organise, and understand this diversity.
- **Earth Microbiome Project -** It was founded in 2010 to sequence 200,000 genetic samples and assemble 500,000 microbial genomes.
- **Earth Biogenome Project** - To sequence the genomes of all of the planet's eukaryotic organisms to create one of the largest and most comprehensive maps of organisms
- **Habitats** - They live in all types of environment, ranging from ice cold climate to hot springs; and deserts to marshy lands.
- They are also found inside the bodies of animals including humans.
- Some microorganisms grow on other organisms while others exist freely.
- **Extremophiles** – Microbes that live in extreme natural conditions are called extremophiles.
- They have been found in
    - Hydrothermal and volcanic vents
    - Permafrost
    - Dark lakes buried kilometres under polar ice caps
    - Acid mines
    - Around nuclear waste storage sites.
    - Exteriors of spacecraft

        Deinococcus radiodurans, an earth-born bacteria, could survive in outer space for more than three years, stuck to the outside of the International Space Station

- There are different types of extremophiles adapted to live in different extreme conditions.

Extremophiles Types	Description	Examples
Thermophiles	These organisms live in extremely hot environments, such as hot springs or deep-sea hydrothermal vents.	Thermus aquaticus and Pyrococcus furiosus.
Psychrophiles	These microbes thrive in extremely cold environments, such as polar ice caps and deep oceans.	Psychrobacter cryohalolentis.
Acidophiles	Acid-loving microorganisms that grow in highly acidic environments with pH levels below 3.	Ferroplasma acidarmanus and Acidithiobacillus ferrooxidans.
Alkaliphiles	These organisms prefer basic or alkaline environments with a pH above 9. They are often found in soda lakes.	Alkalimonas universalis and Bacillus alcalophilus.
Halophiles	Salt-loving microbes that thrive in high-salt environments, such as salt mines and salt flats.	Halobacterium salinarum and Halococcus salinarius.
Barophiles	These organisms live under extreme pressure, such as in the deep sea.	Halomonas salaria and Deepleogaster formosus.
Xerophiles	These microbes can survive in extremely dry conditions, such as deserts. They have adaptations to conserve water and manage desiccation.	Bacillus spores and Clostridium species.

- **Radiation Resistant Extremophiles** - Microbes that are resistant to radiation, desiccation, and high temperatures have been found in domestic microwaves and research facilities.

What are the adaptations of extremophiles microbes?

- Microbes adapt to extreme environments by incorporating unique *biological and biochemical processes*.
- **Proteins and Enzymes-** Their proteins and enzymes are often *more stable and functional under extreme conditions*, such as high temperatures or acidic pH.
- **Extremozymes** - These organisms use unique enzymes, called extremozymes, which allow them to survive and function in harsh conditions.
- For example, thermophiles have heat-stable enzymes that are useful in industrial processes (e.g., PCR).
- **Cell Membranes-** They have *unique membrane lipids that maintain fluidity and integrity* under extreme temperatures or pressures.

- **DNA Repair Mechanisms-** Extremophiles have *specialized mechanisms to repair DNA damage* caused by extreme conditions, such as high radiation or desiccation.

What are their significance in science and industry?

- Understanding extremophiles could lead to advances in synthetic biology, disease resistance, and bioremediation.
- They offer potential for new medications and industrial applications.
- **Enzyme development** - Extremophiles produce enzymes and proteins that remain stable and active under extreme conditions.
- These enzymes are used in industries like *detergents, biofuels, and pharmaceuticals.*
- **Example** - Heat-resistant enzymes like Taq DNA polymerase from Thermus aquaticus bacteria from a hot spring at Yellowstone National Park , is used in Polymerase Chain Reaction(PCR).
- **Bioremediation** - Radiation Extremophiles are useful in bioremediation of toxic waste.
- **Exoplanet search** - Helps in understanding life in extreme environments, both on Earth and potentially on other planets.
- **Medicine**- Extremophiles' unique proteins and metabolic pathways aid in creating new treatments and drugs, including antibiotics and other therapeutics.
- **Genetic Research**- Extremophiles' unique genetic adaptations offer insights into *gene regulation and stress responses, advancing genetic engineering.*
- Understanding them can help in creating synthetic biological systems that can augment the immune system.
- **Agriculture-** Extremophiles can be used to develop crops that are more resistant to extreme conditions, helping *improve food security in challenging environments.*

References

1. The Hindu | Extremophile bacteria

2. Biolablest | Extremophiles

3. Britannica | Extremophile