Acidithiobacillus ferrooxidans: One of the most tolerant microorganisms to acidic environments

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Introduction. One of the most tolerant microorganisms to acidic environments is *Acidithiobacillus ferrooxidans*, a species of bacteria belonging to the *Acidithiobacillus* genus. These bacteria are known for their remarkable ability to thrive in extremely acidic conditions, often with pH levels as low as 1.0 or even lower. As we will see below, there are several reasons why A. ferrooxidans is considered among the most acid-tolerant microorganisms.

Specialized Metabolism. *A. ferrooxidans* is a chemolithoautotrophic bacterium, meaning it obtains its energy from the oxidation of inorganic compounds (Malik & Hedrich 2022). Specifically, it can oxidize ferrous iron (Fe^{2+}) and elemental sulfur (S^0) to derive energy (Jones & Santini 2023), a process that occurs optimally under acidic conditions (Figure 1).

pH Homeostasis Mechanisms. *A. ferrooxidans* has evolved sophisticated mechanisms to maintain intracellular pH homeostasis in acidic environments (Jung et al 2022). These mechanisms may include the regulation of proton pumps, ion transporters, and pH-sensitive enzymes to prevent cellular damage and maintain metabolic activity.

Biofilm Formation. In acidic environments, *A. ferrooxidans* often forms biofilms, which are structured communities of bacteria encased in a matrix of extracellular polymeric substances (EPS). Biofilm formation provides protection against extreme pH fluctuations and other environmental stresses, allowing the bacteria to thrive in acidic habitats (Vargas-Straube et al 2020).

Genetic Adaptations. *A. ferrooxidans* has undergone genetic adaptations to survive and proliferate in acidic conditions. These adaptations may involve the expression of acid-stable proteins, modifications to cell membrane composition, and the presence of stress response genes that confer tolerance to acidic stress (Sriaporn et al 2021).

Ecological Niche. *A. ferrooxidans* is commonly found in acidic environments such as acid mine drainage, where it plays a crucial role in the biogeochemical cycling of sulfur and iron (Chen et al 2020). Its ability to colonize and dominate these extreme habitats highlights its remarkable acid tolerance and ecological significance.

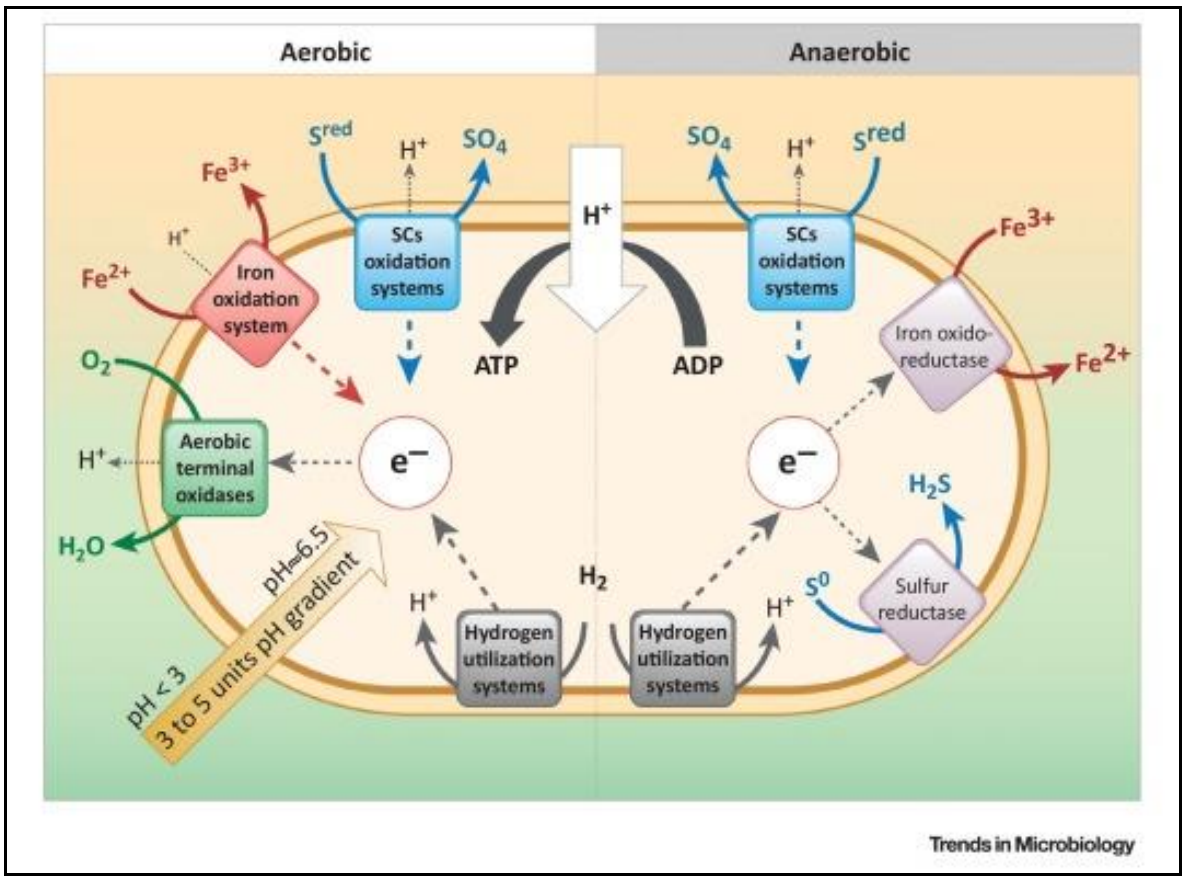

Figure 1. *Acidithiobacillus ferrooxidans* is by far the most widely studied of all extremely acidophilic prokaryotes (source: Quatrini & Johnson 2019).

Conclusions. *Acidithiobacillus ferrooxidans* stands out as one of the most acid-tolerant microorganisms known to science, with adaptations that allow it to thrive in environments characterized by low pH levels and high concentrations of toxic metals and metalloids. Its resilience to acidity makes it a valuable model organism for studying extremophile biology and biotechnological applications in acidic environments.

Conflict of Interest. The author declares that there is no conflict of interest.

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