# MicroCyclerStars: Brocas (*Candidatus* Brocadia sapporoensis and *Ca.* B. fulgida)

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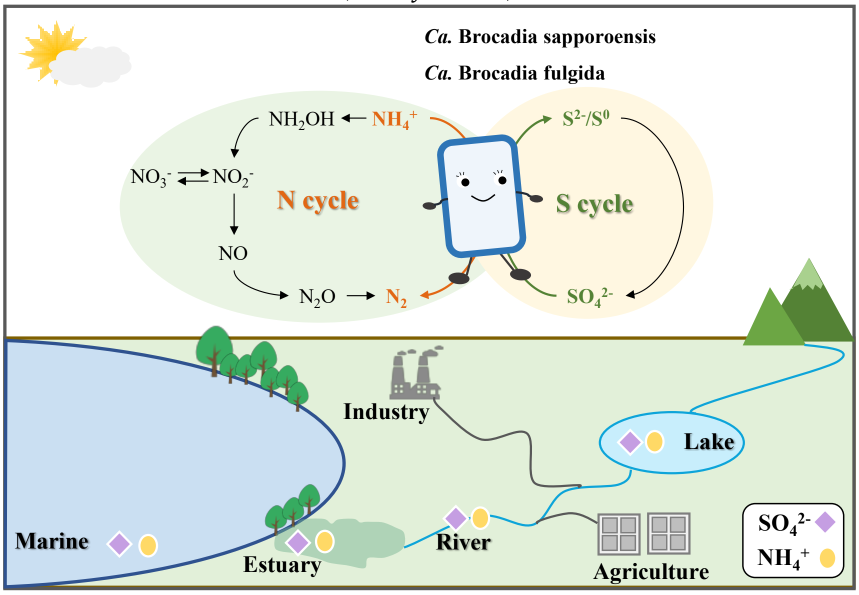


**Claim to fame: Sulfammox – coupling the nitrogen and sulfur cycles**

The biogeochemical sulfur cycle has been crucial to the evolution of life and surface processes. Microbial sulfur cycling is composed of assimilatory and dissimilatory sulfur metabolisms. Dissimilatory sulfur metabolisms change the valence state of sulfur, including sulfur reduction, sulfur oxidation and sulfur disproportionation, provide energy for diverse microbes, play a critical role in regulating the redox state of the surface of the Earth, and influence climate.

The sulfur cycle is intricately linked with nitrogen cycling. Nitrogen is an essential component of all living organisms and the main nutrient limiting life. Although nitrogen is plentiful as nitrogen gas in air, nitrogen gas is not reactive and thus cannot be accessed by most organisms. Only special microbes, called nitrogen fixers, are able to access nitrogen gas and convert it to ammonium, and thence channel it into the biosphere for use by other organisms. These in turn transform ammonium into different nitrogenous compounds, which may serve either as nutrients for growth, or as energy sources. This is the nitrogen cycle, which is almost entirely dependent on reduction-oxidation reactions primarily mediated by microorganisms.

The various biogeochemical cycles are linked like cogwheels. Recently, it was discovered that, under anaerobic conditions (i.e. in environments lacking oxygen), the Earth's nitrogen and sulfur cycles are linked through the metabolic reduction of sulfate coupled to the oxidation of ammonium in a process called Sulfammox. During the Sulfammox process, ammonium and sulfate are converted into nitrogen gas, sulfide, and elemental sulfur. The bacteria responsible for this are Brocas or, to give them their scientific names, *Candidatus* Brocadia sapporoensis and *Ca.* B. fulgida, both of which encode ammonium oxidation and dissimilatory sulfate reduction pathways.

Sulfammox bacteria achieve the reduction of sulfate and sulfite sequentially through a set of enzymes ($SO_4^{2-} \rightarrow SO_3^{2-} \rightarrow S^{2-}$), and oxidize ammonium to hydroxylamine, then hydrazine (a rocket fuel!), and finally to nitrogen gas ($NH_4^+ \rightarrow NH_2OH \rightarrow N_2H_4 \rightarrow N_2$).

Estuary or coastal zones not only receive ammonium but also are subjected to intrusion by seawater. Sulfate concentrations in marine ecosystems and freshwater environments continuously increase owing to the anthropogenic sulfate input from industries, continental weathering (erosion of rocks) and transport by rivers, seawater toilet flushing, and atmospheric sulfur deposits. These ammonium and sulfate inputs possibly provide suitable prerequisites for the Sulfammox process.

Sulfammox bacteria are widely distributed in aquifers, lakeshores, and marine sediment, which contributes significantly to the N- and S-cycles in aquatic ecosystems. Industrial wastewaters in particular may contain high amounts of ammonium and sulfate compounds. Although research on the Sulfammox process is still in its infancy, it is not only a vital activity in nature, but also shows great promise for the biotechnological removal of these compounds from wastewaters.

***The Brocas Sulfammox bacteria are mighty MicroCyclerStars!***