An ecophysiological throttle on planetary oxygenation during the Archean

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The evolution of oxygenic photosynthesis created a niche with dramatic potential to transform net energy flow through Earth's biosphere, and ultimately led to the secular oxygenation of the entire ocean-atmosphere system. However, in sunlit environments more primitive forms of photosynthesis, involving reduced species such as Fe^{2+} and H_2, would have competed with Earth's nascent oxygenic biosphere for essential nutrients in surface aqueous environments [1, 2]. Here, we suggest that this competitive landscape among early photosynthetic life would have stifled the proliferation of oxygenic phototrophs and delayed the oxygenation of Earth's ocean-atmosphere system for long timescales. By incorporating experimentally obtained growth parameters from a recently isolated pelagic photoferrotroph into a competitive model for surface ocean photosynthesis, we show that anoxygenic phototrophs represent a very effective bottleneck on nutrient flow to likely cyanobacterial niches when the ocean interior is reducing. However, our model also predicts that such a nutrient throttle on oxygenic productivity may have ultimately represented a positive feedback on biospheric oxygenation once a critical Fe/P threshold was reached in the deep sea.

[1] Johnston et al. (2009) *PNAS*, **106**, 16925-16929.
[2] Jones et al. (2015) *Geology*, **43**, 135-138.