Chapter 5

Ecology of Thermophilic Anoxygenic Phototrophs

Richard W. Castenholz

Biology Department, University of Oregon, Eugene, OR 97403-1210, USA

Beverly K. Pierson

Biology Department, University of Puget Sound, Tacoma, WA 98416-0320, USA

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Summary

It is apparent that very few species of anoxygenic phototrophs occur or grow at high temperatures, particularly when compared to species numbers for thermophilic Archaea and non-photosynthetic Bacteria. *Chloroflexus* spp. are the most thermotolerant (up to ~70 °C), but none are in the hyperthermophilic category.

Recognizing that there may be some endemic populations of anoxygenic phototrophic bacteria that have not been dispersed among geographically disparate geothermal sites, the major factors affecting the distribution of these bacteria are temperature, pH, and concentration of sulfide. Oxygen may have an effect on the vertical distribution and the diel vertical migration of some species within mats. Facultative aerobic metabolism appears to be a property of many of the anoxygenic phototrophs (but not *Chlorobium* or *Heliobacillus*) in these dynamic habitats. Light quantity and quality are affected by the diversity of pigmentation within the vertically stratified communities and adaptation to low photon fluence rates is a necessity for many species.
I. Introduction

A. Definition of Thermophily

The terms thermophily and thermotolerance in phototrophic prokaryotes should encompass a different range of temperatures than those used to define thermophily in non-phototrophic organisms, both archaea (Archaea) and eubacteria (Bacteria). Some contemporary biologists have proposed a high temperature environment for the origin of life and support this in part by pointing to the existence of living hyperthermophilic ‘bacteria’ that, according to parsimonious 16S rRNA sequence analyses, branch early in both eubacterial and archaeabacterial phylogenetic ‘trees.’ Chlorophyll-based photosynthesis occurs only in branches of the eubacterial tree (which includes chloroplasts). Phototrophic bacteria do not exist above 73–74 °C, a relatively low temperature when compared to extreme hyperthermophilic non-phototrophic prokaryotes, such as *Thermotoga* and *Aquifex* which branch off early (Olsen et al., 1994). Thus, if chlorophyll-based photosynthesis has a monophyletic origin and appeared early (as indicated by the *Chloroflexus* branch) it did not evolve at extreme temperatures (i.e. >75 °C) unless subsequent loss of caldoactive photosynthesis has occurred through extinctions. Diversity in the upper temperature range for photosynthesis (63–73 °C) is limited, although it is possible that many genotypes (or species) of the highest temperature form of the cyanobacterium *Synechococcus* sp. exist. A relatively large number of species, genera, and higher categories of phototrophic bacteria inhabit waters between 53 and 63 °C. In addition, the highest temperature phototrophs known today (i.e. *Synechococcus* sp. and *Chloroflexus aurantiacus*) have not adapted fully to the upper several degrees of their temperature range (Meeks and Castenholz, 1971; Pierson and Castenholz, 1974a; Castenholz, 1984b, 1988; Table 1). Species determinations have not been made from populations in most hot spring areas, so with the limitation of only morphology, pigmentation, and temperature tolerance comparisons, all will be referred to simply as *Chloroflexus.*

Recently Hanada et al. (1993) have isolated a new species of *Chloroflexus* from Japanese hot springs. Although quite similar to *Cf. aurantiacus* physio-