Summary

Anoxygenic phototrophic sulfur bacteria flourish where light reaches sulfidic water layers or sediments. Their often dense communities have continuously attracted the attention of microbiologists. Although the major fraction of the existing diversity of phototrophic sulfur bacteria remains to be explored, ecophysiological studies have revealed a number of selective factors which govern the growth and the survival of phototrophic sulfur bacteria in the environment. Some novel aspects of the ecology of phototrophic sulfur bacteria have become apparent recently. Representing the most extremely low-light adapted photosynthetic organisms known to date, a brown-colored *Chlorobium* strain colonizes the chemocline of the Black Sea and is capable of maintaining a stable population at 0.0007% of surface light intensity. Besides the light intensity, the spectral composition of ambient light is a selective factor for the composition of anoxygenic phototrophic communities. A strong competition for infrared light occurs in laminated microbial benthic mats where phototrophic sulfur bacteria occupy their niches according to their long wavelength absorption properties. During evolution this apparently has led to the formation of a novel type of pigment-protein complex which was recently detected in a benthic *Chromatiaceae* species. Thirdly, the capability to establish a highly specialized symbiosis with motile Proteobacteria enabled some species of green sulfur bacteria to acquire motility. In these phototrophic consortia, a rapid
signal transfer exists between the two partners and permits a scotophobic response toward light required by the immotile green sulfur bacterial epibiont. The isolation and characterization of dominant species of phototrophic sulfur bacteria and an improved understanding of their particular niche has also implications for the interpretation of molecular fossils of these bacteria which have been detected in sedimentary rocks of all geological eras and interpreted as evidence for the existence of extended oceanic anoxia in the past.

I. Introduction

Anoxygenic phototrophic sulfur bacteria occur where light reaches anoxic layers in the water column or aquatic sediments. Since the antiquity, colored waters or sediments occurring in various natural environments were described by natural scientists. First observations of blood-red lakes and swamps were reported from the Nile area. Red coloration of a crater lake near Rome was described by Pliny in 208 BC and reddish waters were observed at the seashore near Venice in the year 586 AD (Kondratieva 1965).

The first to describe unicellular motile phototrophic sulfur bacteria was Ch. G. Ehrenberg (1883), who discovered dense accumulations of purple sulfur bacteria, then named Monas okenii (now Chromatium okenii) at the sediment surface of a small polluted pond near Jena in Eastern Germany. Since then, dense communities of purple and green sulfur bacteria (Fig. 1) have continuously attracted the attention of microbiologists due to their conspicuous reddish, green or brown coloration and have stimulated numerous investigations of their environments, their morphology, physiology as well as repeated cultivation attempts (e.g., Winogradsky, 1887; Engelmann, 1988; Bavendamm, 1924; van Niel, 1931).

Earlier investigations of the community composition and physiology of these bacteria included measurements of relevant environmental parameters and physiological rates in situ (e.g., Sorokin, 1970). Elaborate cultivation techniques were developed based upon the insights into their ecological niches (Pfennig, 1993). More recently, a suite of culture-independent molecular methods have been established and permitted novel insights into the ecophysiology and population biology of phototrophic sulfur bacteria.

The current chapter will focus on the ecology of purple sulfur bacteria (members of the Chromatiaceae and Ectothiorhodospiraceae) and the green sulfur bacteria (Chlorobiaceae). Besides providing a condensed view on the ecology of these groups, novel aspects are addressed including extreme low-light adaptation, low maintenance energy requirements, the formation of symbioses in phototrophic consortia and, finally, the analysis of fossil phototrophic communities.

II. Habitats and Natural Populations of Phototrophic Sulfur Bacteria

A. Ecological Niches

1. Light Quantity and Quality

Typically, accumulations of phototrophic sulfur bacteria have been observed between 2 and 20 m, rarely down to 30 m depth in pelagic environments (Montesinos et al., 1983; Guerrero et al., 1987b; Gorlenko, 1988; van Gemerden and Mas, 1995; Herbert et al., 2005). In such environments, values for the light transmission to populations of phototrophic sulfur bacteria range from 0.015 to 10% (Parkin and Brock, 1980a; van Gemerden and Mas, 1995). Chromatiaceae so far have been found in chemocline environments down to depths of ≤20 m. The tight correlation between anoxygenic photosynthesis and the available irradiance suggests that light is the main environmental variable controlling the activity of phototrophic sulfur bacteria.

Since the accumulation of phototrophic sulfur bacterial cells results in an increased self-shading, they can only extend over a limited vertical distance, which is reciprocally related to the amount of biomass present. Accordingly, the densest pelagic communities of

Abbreviations: Bchl bacteriochlorophyll