Chapter 16

Structure and Organization of Purple Bacterial Antenna Complexes

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This chapter presents a comprehensive overview of what is currently known about the structure of purple bacterial antenna complexes, with special emphasis upon modeling their three-dimensional structure and intramembrane organization.

Purple bacterial antenna complexes can be grouped into two major types, the ‘core’ B875-type which forms a close association with the reaction centers and the ‘variable’ B800-850- or B800-820-type. Both these types of complex are constructed on a similar modular principle and are oligomers of \( \alpha \) and \( \beta \)-apoproteins. These antenna apoproteins have been sequenced from a range of species and form a rather homologous group of proteins. The light-absorbing pigments, BCHl and carotenoids, are non-covalently bound to these apoproteins.

As is described below, in a few cases these antenna complexes have been crystallized and structure determinations are under way. However, in the absence of three-dimensional structural information a great deal can be deduced by a comparison of their primary structures. The main part of this chapter illustrates the type of models for antenna structure that can be constructed by a detailed analysis of the conserved structural elements which can be seen by such an examination of the database of antenna apoprotein primary structures.

I. Structure and Function of Antenna Complexes from Purple Bacteria

A. The Purple Bacterial Photosynthetic Unit

The major light-absorbing pigments in purple bacteria are the bacteriochlorophylls (\( a \) and \( b \)) and the carotenoids. These pigments are non-covalently attached to two types of integral membrane proteins forming on the one hand the photochemical reaction centers and on the other the light-harvesting or antenna complexes (Hawthornthwaite and Cogdell, 1991; Zuber and Brunisholz, 1991). The majority of these pigments perform a light-harvesting role and serve to funnel absorbed solar radiation to a specialized few which form the reaction center. The combination of antenna complexes with a reaction center constitutes the photosynthetic unit (PSU). For most commonly studied purple bacteria the size of the PSU is variable. Usually, however, it is in the range of between 20 and 200 BCHl \( \alpha \) molecules per reaction center (Aagaard and Sistrom, 1972). This arrangement of reaction centers surrounded by an antenna system ensures that each reaction center is kept well supplied with incoming solar energy and effectively increases their cross-sectional area for photon capture. The detailed structure and function of the reaction center is described in section V of this volume. The rest of this contribution will concentrate upon the antenna complexes.

B. Intracytoplasmic Membranes

In the purple bacteria the PSU is located in the intracytoplasmic membranes. Most species can survive either by respiration or photosynthesis. In the presence of oxygen, the cells tend to be unpigmented and have a smooth cell membrane. When they become anaerobic, they switch photosynthetic mode and the photosynthetic apparatus develops de novo. During this changeover, the cells...