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Crystal structure of the light-harvesting-reaction center core complex from a thermophilic photosynthetic bacterium

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Introduction

In purple photosynthetic bacteria, the light energy is absorbed by two types of light-harvesting complexes (LH1, LH2), and then is transferred efficiently to the reaction center (RC) where the primary charge separation takes place across the membrane and a cyclic electron transport chain occurs. The LH1 complex is located intimately around the RC with a fixed stoichiometric ratio to form the so-called core complex (LH1-RC). LH1 is a large oligomer of a basic structural unit composed of a heterodimer of two small integral membrane polypeptides (α and β, ca. 6 kDa) associated with bacteriochlorophyll (BChl) and carotenoid molecules. *Thermochromatium* (*Tch.*) *tepidum* is a thermophilic purple sulfur photosynthetic bacterium originally isolated from a hot spring in Yellowstone National Park. It grows anaerobically at optimum temperatures of 48 – 50 ºC with an upper limit of 58 ºC, and contains an unusual LH1 complex that absorbs maximally around 917 nm (Q_y transition). In a series of investigations, we found that the *Tch. tepidum* LH1 is highly stable at room temperature, and calcium ions are involved in both the enhanced thermal stability and the large red shift of the LH1 Q_y transition[1, 2].

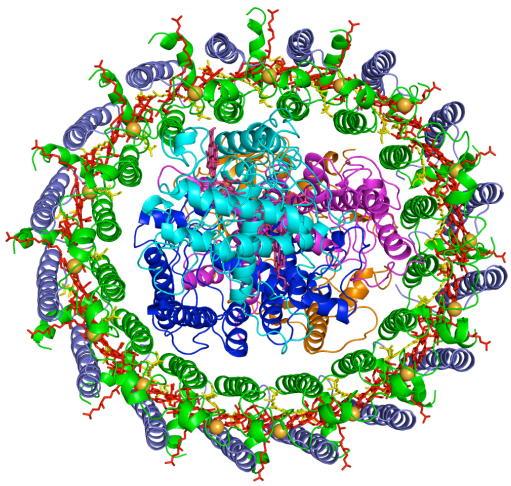
We have determined the crystal structure of LH1-RC from *Tch. tepidum*[3]. The structural features provide insights into the mechanism of its high thermostabilities and spectroscopic properties.

Materials and Methods

Crystallization of the native *Tch. tepidum* LH1-RC complex was performed using sitting-drop vapor-diffusion method at 20 ˚C. The protein solution was mixed with the same volume of precipitant solution (20 mM Tris-HCl, pH 7.5, 3 mM DPC, 50 mM $CaCl_2$, 16% w/v PEG3000).

Results and Discussion

The LH1 subunits are uniformly distributed around the RC forming a closed and slightly elliptical cylinder composed of 16 pairs of helical αβ-polypeptides, 32 BChls *a*, 16 spirilloxanthins and 16 Ca^{2+} ions (see the figure). The pigment and Ca^{2+} stoichiometries are consistent with those determined by biochemical analysis [1]. Similar to LH2, the double-layered cylinder of LH1 has the α-polypeptides located inside and the β-



polypeptides outside with the amino (N) termini on the cytoplasmic side. The long and short dimensions are 107Å and 99Å (distance between the centers of the opposite helices) for the outer ring, and 77Å and 69Å for the inner ring, respectively.

The RC is accommodated in the LH1 ellipsoid and fits the shape of the inner ring with the L- and M-subunits aligned along the long axis. Overall structure of the RC in the LH1-RC complex is similar to that of the RC-only complex. Relatively large differences are found for the membrane-surface attached H-subunit and the membrane extruded C-subunit. All cofactors reported in the RC-only structure are identified, including the 15-*cis*-spirilloxanthin, menaquinone and phytol chains of BChls *a* and bacteriopheophytins (BPhe) *a*. The head group of newly identified ubiquinone is located at the same position (Q_B site) with the same orientation as those in *Blc. viridis* and *Rb. sphaeroides* RCs. Contrary to expectations, most of the transmembrane regions in RC are not specifically interacting with the LH1 polypeptides.

References

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