Baseplate BChl *a* Subantenna as a Universal Interface between BChl *c/d/e* Subantenna and Plasma Membrane BChl *a* Subantenna in Photosynthetic Green Bacteria

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This work continues the cycle of studies of the strategy of efficient functioning of natural light-harvesting antennae, in particular, inhomogeneous superantennae of green bacteria, consisting of several homogeneous subantennae. In our recent paper [1], mathematical modeling of the dynamics of excitation energy transfer (EET) in inhomogeneous superantenna of the photosynthetic green bacterium from *Oscillochloridaceae* family allowed us to determine the theoretically optimal spectral composition of homogeneous subantennae, which showed the importance of optimal interfacing of their energy levels for efficient and stable functioning of the entire superantenna as a whole. In particular, we theoretically substantiated the necessity of existence in the *Osc. trichoides* superantenna of an intermediate BChl *a* subantenna (Bx) with the energy level in the range of ~790–800 nm for optimizing energy transfer from the chlorosome B750 subantenna to the membrane B805 subantenna. This conclusion was confirmed experimentally [2]. Here we consider the similar problem for green bacteria from two other families – *Chlorobiaceae* and *Chloroflexaceae*, containing chlorosome BChl *c/d/e* subantennae (with the energy levels in the range of 730–760 nm), BChl *a* subantennae of chlorosome baseplates (Bx) and nearest membrane BChl *a* ones (with the energy levels in the range of 805–810 nm). For *Chlorobiaceae* species the BChl *a* subantenna (Bx) was not visually identified in absorption spectra of isolated chlorosomes up to now. Only for one species from *Chloroflexaceae* family, the chlorosome baseplate (B798) was isolated. We supposed the model 3D superantenna with 1D antenna units and used the Förster's type for the description of EET: B(730–760)→Bx→B(805–810) (denote it as 1→2→3). The probability matrix method was used to simulate EET. When varying the Bx spectral position (λ_x), we computed the time (t, a.u.) of EET 1→2→3 for $0.5 \leq R_{12}/R_{23} \leq 2$ (R_{ij} is the distance between donor i and acceptor j) ; $k_{12}/k_{23}=1$ (k_{ij}, orientational factors) ; $n_{12}/n_{23}=1$ (n_{ij}, refractive indexes of medium). The formal quadruple change in degree

$\gamma \equiv R_{12}/R_{23}$ (at $R_{12}+R_{23}=$const) was chosen to consider possible variations of unknown at present parameters k_{ij}, n_{ij} and R_{ij}. The η value is the ratio:

$$\eta \equiv t(B(730\text{–}760)\rightarrow B(805\text{–}810) / t_{min}(B(730\text{–}760)\rightarrow Bx \rightarrow B(805\text{–}810)$$

The calculations demonstrated that: (1) the direct EET (B(730–760)→B(805–810)) is not optimal because the Bx subantenna introduction allows one to decrease the time of direct EET up to 30 times; (2) each curve $t(\lambda_x)$ demonstrates an individual stable minimum $t_{min}(\lambda_X)$, and all minima $t_{min}(\lambda_X)$ are localized within a rather narrow spectral range, from 775 nm to 801 nm ; i.e., at any value of γ parameter the Bx subantenna allows one to control the entire superantenna efficiency, which is governed by the Bx spectral position λ_X (770 nm < λ_X < 805 nm); (3) for each curve $t(\lambda_x)$ maximal effect of the superantenna structure optimization depends on γ value and varies from $\eta = 5$ (at $\gamma = 0.5$) to $\eta = 30$ (at $\gamma = 1.5$). Our calculations demonstrated that the optimal interfacing of subantennae leads to a stable minimization of EET time within superantenna and, consequently, to a decrease in the energy losses, thereby ensuring the high efficiency and stability of the overall superantenna function. Thus, data obtained in this study, together with the data obtained earlier, have shown that the light-harvesting BChl *a* subantenna of chlorosome baseplate with the energy level of the *Qy* absorption band in the range of 790–800 nm is a universal interface between the peripheral BChl *c/d/e* and the nearest membrane BChl *a* subantennae in all three known families of green photosynthetic bacteria—*Chloroflexaceae, Oscillochloridaceae, and Chlorobiaceae*. This demonstrates the versatility of the basic principles of optimization of the structure of natural antennae. This versatility is principal in terms of the strategy of efficient functioning of superantennae: the basic principles of their organization, being optimal, are retained during the evolution of organisms, despite the fact that the structure and size of subantennae vary significantly.

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2. A. Zobova, A. Taisova, E. Lukashev, N. Fedorova, L. Baratova, and Z. Fetisova. CsmA Protein is Associated with BChl *a* in the Baseplate Subantenna of Chlorosomes of the Photosynthetic Green Filamentous Bacterium *Oscillochloris trichoides* belonging to the Family *Oscillochloridaceae*. J.of Biophysics, Volume 2011, doi:10.1155/2011/860382.