Role of Hydrogen Bonds and Packing in the Assembly and Stability of Helical Membrane Proteins

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The functional assembly and stability of helical membrane proteins is governed by weak inter-helical interactions in a manner still not clearly understood. To study this process, we utilize photosynthetic reaction centers (PRCs) as a model system. PRCs are among the most structurally studied family of membrane proteins enabling *in silico* sequence and structural comparison of this diverse group of hetero-dimer pigment-protein complexes. In vivo support to such analysis is gained by well-established methods for genetic manipulation accompanied by electron-transfer measurements that probe functional stability changes in local environments of the complex.

Multiple structural alignment (MUSTA algorithm) was performed on the different PRC structures: bacterial RC, photosystem I RC and photosystem II RC (PSII-RC). A structural tree was established for the family including a common core to all PRCs – a family lacking sequence identity. Grouping of different amino-acids (AAs) found in this core demonstrated a cluster of 'high-packing' AAs (term defined via the occluded surface algorithm by Eilers *et al*, PNAS 97:5796-5801, 2000), including Gly, Ala, Ser, Thr and Cys found in the 4-helix-bundle center of the complex. Multiple sequence alignment between different RCs confirmed a conserved GxxxG helix-helix packing motif as well as other conserved high-packing motifs in this region. In a search for stabilizing interactions within the packing motifs, inter-subunit hydrogen bond (H-bond) analysis was conducted on each one of the RC structures. A single inter-subunit H-bond was found in the membranous region of each of the RCs.

The role of H-bonds was further studied by combinatorial mutagenesis of the residue donating the putative inter-subunit H-bond in PSII-RC, followed by temperature-dependent biophysical characterization of the mutants (O. Kerner, I. Samish, D. Kaftan, H. Kless & A. Scherz, In preparation). Interestingly, while wild type residue, Ser, and mutants having Cys and Thr in this position showed remarkable stability, incorporation of residues which cannot donate a H-bond, markedly destabilised the complex. Correlation between protein stability (measured by $\Delta G^{\ddagger}_{QaQb}$) and packing values for membrane proteins was high (R^2=0.9) for AAs that contain a polar or charged moiety, and low (R^2=0.06) for AAs that do not contain such a functional group.

Hence, H-bond capacity combined with packing values correlates with membrane protein assembly and stability, enabling deduction of new rules for modeling and design. Future work will include mutagenesis of other AAs involved in electrostatic interactions, molecular dynamics simulation of the mutants at high temperatures, and analysis of additional protein structures.