Elucidating the Mechanism of Ras GTPase using Substrate Directed Superimposition

Kosloff M. and **Selinger, Z.**
Department of Biological Chemistry, The Institute of Life Sciences, Hebrew University of Jerusalem

G-proteins are a multi-member family of molecular switches involved in a wide variety of essential cellular processes. Ras is a prominent member of this family due to its ubiquitous role in cell proliferation. Despite their functional diversity, all G-proteins behave as conformational sensors of the bound guanine nucleotide. Depending on whether they are charged with GDP or GTP, they change their conformation and consequently their interaction with other proteins in the signaling cascade. G-proteins charged with GTP are in the 'on' state, capable of acting on their downstream effectors. Hydrolysis of the bound GTP (GTPase) switches the G-protein to the 'off' state, characterized by tightly bound GDP. Working out the details of Ras GTPase mechanism is crucial both for understanding the normal function of the protein and for revealing the reasons why and how mutations that interfere with the GTPase reaction are the cause for diseases such as Cholera or Cancer.

Here we use a novel method, Substrate Directed SuperImposition (SDSI), to analyze the abundant structural data available for the active sites of Ras and other G-proteins in different activation states. We argue that this novel approach for comparative analysis of enzymatic mechanisms enables us to compare many structures simultaneously and without bias and to extract new and striking information about their function. Using SDSI and additional data, we propose a new model for the catalytic mechanism of Ras. We suggest that the rate-limiting step in the GTPase reaction is the correct positioning of the conserved glutamine and arginine. This optimal positioning is necessary for these residues to fulfill their role in creating an electrostatic envelope around the substrate, preferentially stabilizing the transition state.

Using engineered Substrate Assisted Catalysis, a unique enzymatic complementation approach, we obtained experimental evidence supporting our new model. We show the data supporting it and discuss the implications for enzymatic catalysis by Ras and other G-proteins and for future therapeutic approaches.

Relevant reference:

"Substrate assisted catalysis - application to G proteins". Kosloff M., Selinger Z. TiBS, March 2001, 26(3): 161-6.