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A unified concept of enzymes, translocators and receptors: proteins are molecular cognitive devices

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Proteins which function as enzymes, translocators and receptors are molecular engines (1), cyclically transforming various forms of energy and accomplishing mesoscopic work (2). It is misleading to search for analogy between their catalytic performance and the mechanisms of action of low-molecular catalysts of inorganic and organic chemistry, as well as to see in them simple miniatures of macroscopic machines. Any analysis of events at the molecular level should take into consideration thermal motion of molecules and their constituents. In contrast to macroscopic machines, thermal energy can be used by proteins for reversible mesoscopic work under isothermic conditions, and, upon imposing asymmetrical potentials - mainly by cycling nucleotide triphosphate binding and hydrolysis - also for macroscopic work (3). Hence, proteins are Szilard's demons (4).

Proteins have evolved as molecular constructions: native proteins do not reside in global minima of free energy, but persist as traps waiting for their appropriate ligands. They carry embodied evolutionary knowledge. During folding, part of folding energy is being used to align active site dipoles which later serve in catalysis (5), translocation and signal transduction. During interaction with ligands, part of binding energy is being used for stabilization of the transition state in enzymes (6) and for signal transduction in receptors. Proteins can be viewed as molecular rectifiers and amplifiers exploiting the embodied knowledge for mesoscopic and macroscopic work. Their cyclic activity starts with ligand recognition and ends with information erasure. In this view, they can also be designated as molecular cognitive devices.

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