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Ultrafast dynamics of visual rhodopsin using an X-ray free electron laser

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Mammalian rhodopsin is our light receptor for vision. It belongs to the highly druggable G protein-coupled receptor family. It hosts the retinal chromophore which, like a switch, isomerizes in less than 200 femtoseconds upon photon absorption. This triggers sequential intramolecular changes in rhodopsin, initiating the signalling cascade generating in milliseconds vision events to the brain via the optic nerve. However, the intramolecular events transforming the rhodopsin resting state[1-2] (dark) into the transducin-binding activated state[3-5] (Meta II) are not completely understood.

We experimentally determined ultrafast changes of native bovine rhodopsin at room temperature using time-resolved serial femtosecond crystallography, already successfully used for the proton pump bacteriorhodopsin[6-7], at SACLA and SwissFEL X-ray free electron lasers. Thousands of rhodopsin microcrystals grown in the dark are successively injected in the light of a pump laser and probed after various time-delays using an XFEL. After 1 picosecond, we observe a highly distorted all-trans retinal that has induced changes in its binding pocket while the excess energy of the absorbed 480nm-photon dissipates inside rhodopsin through an anisotropic protein breathing motion towards the extracellular domain. Interestingly, some amino acids known to be key elements later in the transduction of the signal are involved in the ultrafast changes.

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