# Mathematical issues in visual transduction

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Visual transduction is the process by which photons of light are converted into electrical signals. A highly amplified biochemical cascade is generated in the retinal rod outer segment (ROS) upon absorption of a photon by a G-protein-coupled receptor, thus initiating diffusion of second messengers in the highly-organized cytoplasm of the ROS, to produce a suppression of electrical current flowing into the ROS.

Single photon responses (SPRs) are expected to be inherently variable because the lifetime of a single activated receptor is highly variable, such as the time to decay of a radioactive particle. However, electrophysiological measurements reveal a surprisingly low variability, which is essential for reliably detecting the absorption of single photons. The problem, what mechanism confers the high reproducibility of SPRs, is still open.

A model of the transduction process is presented, accounting for the nanostructure of the ROS. It is based on the theories of homogenization and concentrated capacity and permits a mathematical and numerical analysis of the various interacting components of the process. The model provides an explanation of the reproducibility of SPRs and is applicable to other signaling systems regulated by G-protein-coupled receptors.