Three level signal transduction cascades lead to reliable switches

Dieter Armbruster [1], *Jon Young* [1], *John Nagy* [2]
[1]School of Mathematical and Statistical Sciences, Arizona State University, Tempe, AZ, USA
[2]Department of Life Sciences, Scottsdale Community College, Scottsdale, AZ, USA

Signaling cascades proliferate signals received on the cell membrane to the nucleus. While noise filtering, ultra- sensitive switches, and signal amplification have all been shown to be features of such signaling cascades, it is not understood why cascades typically show three or four layers. Using singular perturbation theory Michaelis-Menten type equations are derived for open enzymatic systems. Cascading these equations we demonstrate that the output signal as a function of time becomes a sigmoidal switch with the addition of more layers. Furthermore, it is shown that the switching time will speed up to a point, after which more layers become superfluous. It is shown that three layers create a reliable sigmoidal response progress curve from a wide variety of time-dependent signaling inputs arriving at the cell membrane, suggesting the evolutionary benefit of the observed cascades.