Computational Systems Biology: Chapter 4. Biological Foundations of Signal Transduction, Systems Biology and Aberrations in Disease

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Cellular communication is mediated by extracellular stimuli that bind cellular receptors and activate intracellular signaling pathways. Principal biochemical reactions used for signal transduction are protein or lipid phosphorylation, proteolytic cleavage, protein degradation and complex formation mediated by protein-protein interactions. Within the nucleus, signaling pathways regulate transcription factor activity and gene expression. Cells differ in their competence to respond to extracellular stimuli. A deeper understanding of complex biological responses cannot be achieved by traditional approaches but requires the combination of experimental data with mathematical modeling. Following a systems biology approach, data-based mathematical models describing sub-modules of signaling pathways have been established. By combining computer simulations with experimental verification systems properties of signaling pathway including cycling behavior or threshold response could be identified. Yet, to analyze complex growth and maturation processes at a systems level and quantitatively predict the outcome of perturbations further advances in experimental and theoretical methodologies are required.

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