Serine/threonine/tyrosine phosphorylation regulates DNA binding of bacterial transcriptional regulators

Reversible phosphorylation of bacterial transcriptional regulators (TRs) belonging to the family of two-component systems (TCSs) is a well-established mechanism for regulating gene expression. Recent evidence points to the fact that reversible phosphorylation of bacterial TRs on other types of residue, i.e. serine, threonine, tyrosine and cysteine, is also quite common. The phosphorylation of the ester type (phospho-serine/threonine/tyrosine) is more stable than the aspartate phosphorylation of TCSs. The kinases which catalyse these phosphorylation events (Hanks-type serine/threonine protein kinases and bacterial protein tyrosine kinases) are also much more promiscuous than the TCS kinases, i.e. each of them can phosphorylate several substrate proteins. As a consequence, the dynamics and topology of the signal transduction networks depending on these kinases differ significantly from the TCSs. Here, we present an overview of different classes of bacterial TR phosphorylated and regulated by serine/threonine and tyrosine kinases. Particular attention is given to examples when serine/threonine and tyrosine kinases interact with TCSs, phosphorylating either the histidine kinases or the response regulators. We argue that these promiscuous kinases connect several signal transduction pathways and serve the role of signal integration.