Abstract

Water is one of few absolute requirements for life. Consistent with its crucial importance, all living organisms have developed mechanisms for control of their internal water levels. Although water maintenance is a continuous homeostatic process, rapid increases in extracellular osmolarity cause acute dehydration. Cellular dehydration, depending on severity, leads to loss of turgor pressure and, eventually, cellular volume. While dehydration itself needs not be lethal, it prohibits proliferation and disturbs cellular homeostasis. In order to regain water balance, cells produce and accumulate a compatible solute, which results in an uptake of water, again increasing cellular volume, and eventually, turgor pressure. The cellular response to osmotic stress occurs at several levels, and includes metabolic as well as transcriptional changes. Dehydration is perceived at the plasma membrane, and the signal conveyed by the High Osmolarity Glycerol pathway, resulting in extensive transcriptional alterations.

This thesis describes the characterisation of this osmotic stress response, using transcriptome analysis, mutants, different growth conditions and a novel two-dimensional visualisation tool. Furthermore, it describes an in-depth analysis of the High Osmolarity Glycerol pathway employing comparative genomics and the twenty fully sequenced and annotated fungal genomes.

The results show that this regulatory mechanism is highly conserved, as its components are readily identified in all genomes. Yet, they highlight differences in pathway architecture, which shed light on functional differences between components presumed to be redundant. In stark contrast to the critical importance of osmoregulation, as inferred from the high mechanistic conservation, stands the observation that only a minute fraction of the transcriptional response is aimed at components directly involved in water homeostasis. The bulk of the response is general, and shared between virtually all acute stress conditions, including energy depletion. The lack of contingency on specific stress conditions strongly advocates that this response relies on a generic signal. Presumably, this signal is decreased intracellular energy levels, reflecting a metabolic imbalance, from which the cell attempts to recover.