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Transcriptomic Responses of Bacterial Cells to Sublethal Metal Ion Stress

Jon L. Hobman[1] (✉) · Kaneyoshi Yamamoto[2] · Taku Oshima[3]

[1]School of Biosciences, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK
J.L.Hobman@bham.ac.uk

[2]Department of Advanced Bioscience, Kinki University, Nakamachi 3327-204, 631-8505 Nara, Japan

[3]Department of Bioinformatics and Genomics, Graduate School of Information Science, Nara Institute of Science and Technology, 8916-5 Takayama, Ikoma, 630-0101 Nara, Japan

Abstract Bacterial cellular responses to metal ion stress are often measured as changes in transcription of genes involved in metal ion homeostasis, during detoxification processes or during functioning of efflux systems. Although there has been evidence for other bacterial cellular responses to metal ion stress, a view of what these responses are has been difficult to obtain. Recent measurements from genome-wide transcriptional profiling in bacteria strongly suggests that the effects of metals on cells may be very wide-ranging, and the transcriptomic responses equally wide. This chapter integrates the known biological effects of metal ion stress with data from microarray and other gene regulation studies from different bacteria responding to these stresses. Metal ion stresses elicit responses in metal ion homeostasis, oxidative stress responses, membrane stress responses, amino acid synthesis, and the expression of other metal ion import systems.

1 Introduction

A general definition of bacterial stress is difficult to formulate, but could be described as a perturbation in the cellular physiology or metabolism brought about by external factors, which if sufficiently severe (and not responded to) can result in growth limitation or death. Stress to bacteria can take many forms, some of which (e.g., heat and cold shock, acid, osmotic and oxidative stress) are well known, as are the bacterial responses to them. Metals play an essential role in microbial nutrition, but can also cause stress. Metal ion stress in bacteria can be a result of either excessive or insufficient amounts of essential metal ions being present in the cell, or can be caused by the presence of toxic metal ions in the cell. Therefore, the regulation of expression of genes whose products are specifically involved in uptake, trafficking, and/or removal of metal ions is an essential cellular function. Bacteria have to be able to both sense and respond to limiting and to excess levels of both essential and toxic metals (Moore and Helmann 2005), and appropriately control the