Accepted Manuscript

Stress-free microbes lack vitality

John E. Hallsworth

PII: S1878-6146(18)30064-3

DOI: 10.1016/j.funbio.2018.04.003

Reference: FUNBIO 918

To appear in: *Fungal Biology*

Please cite this article as: Hallsworth, J.E., Stress-free microbes lack vitality, *Fungal Biology* (2018), doi: 10.1016/j.funbio.2018.04.003.

Stress-free microbes lack vitality

John E. Hallsworth[1]

[1]*Institute for Global Food Security, School of Biological Sciences, Medical Biology Centre, Queen's University Belfast, Belfast, BT9 7BL, Northern Ireland*.

E-mail address: j.hallsworth@qub.ac.uk

Abstract

Stress is an inextricable aspect of life, and stress biology has been a field of intensive study over the last 200-300 years. In human psychology, we consider a stress-free condition to be one of relaxation or happiness, yet with respect to microbial cells we do not have a concept that describes being non-stressed. Stresses within, and stress tolerance of, microbial systems lie at the crux of critical global challenges, such as optimising soil- and plant-health and crop yields; reducing food spoilage; bioremediation of polluted environments; effective biological control and biofuel production; gaining insight into aging processes in humans; and understanding astrobiology. There is no consensus on how to measure cellular stress, or even how we define it. 'Stress' implies that physical forces act on the microbial system in such a way that impairs its ability to function. Ironically, however, a cell that exhibits optimal growth has reduced energy generation, is less resilient to change, and can have poor competitive ability. Furthermore, rapid growth is associated with a high level of oxidative damage and compromised vitality of the system. Stresses induced by temperature, pH, water activity, chaotropicity, reactive oxygen species, dehydration-rehydration cycles, ionizing radiation, changes in turgor and other mechanical forces are well-known. However, we have limited understanding of the complex and dynamic stresses that typically occur in microbial habitats or industrial systems, and how these impact the biophysics, cellular biology and evolutionary trajectories of microbes. There is also a paucity of information on precisely why the cellular system ultimately fails under extremes of stress. It is debatable whether any microbe can ever be completely stress-free. However, cells that exhibit optimal rates of biotic activity are likely to exhibit low ecological fitness compared with those that are moderately stressed; in other words, stress can enhance microbial vitality, vigour and resilience. 'Stress' is sometimes applied mistakenly to describe the effects of toxic substances that have target site-specific modes-of-action (e.g. antibiotics) rather than inducing stress *per se*. Whereas terms such as 'rapid-growth stress', 'nutrient stress' and other forms of 'biotic stress' span a range of logical categories, their modes-of-action do usually involve a biophysical component. Stress can impact all levels of biology (from biomacromolecules to ecosystems), is a potent driver for evolutionary processes and - it could be argued - is an inherent property of life itself. The published articles that follow include a number of unprecedented findings and were compiled for this special issue on *Biology of Fungal Systems under Stress*. Collectively, they are testament to the breadth and importance of the stress-biology field.

Keywords: habitability and astrobiology; halophiles, xerophiles, extremophiles; hurdle technology; osmotic, oxidative, acid- and heat stress; protein-stabilization proteins; *Saccharomyces cerevisiae*

Running title: Stress-free microbes lack vitality