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Cell differentiation in bacterial biofilms

It has been long understood that isogenic (genetically identical) cells in complex living organisms can perform different, but co-ordinated roles. This is called cell differentiation and until recently, it was thought that this behaviour was restricted to multi-cellular organisms. However, through recent technical advances it has been shown that simple, single-celled organisms such as bacteria, also display cell differentiation and so to some extent can behave as "multi-cellular collectives". It has been postulated that this within-species variation may be essential for survival in a changing environment.

One of the most striking examples of bacterial cell differentiation is within a *biofilm*: a multicellular sessile community of bacteria encased within a self-produced polymeric matrix. It is thought that over 90% of bacterial colonies in the natural environment exist in this form. Biofilms are important in all sectors of our economy with examples ranging from human health (e.g. they form the basis of chronic infections) to bioremediation (e.g. they are required for the effective treatment of sewage). The Gram positive bacterium *Bacillus subtilis* is extensively used in an industrial context to produce enzymes for cleaning products and has growing potential as an alternative and environmentally friendly pesticide. It has recently been shown that within biofilms of *B. subtilis*, only a subpopulation of the isogenic cells produce the extracellular matrix which surrounds all of the cells, while a different subset retain their flagella (and therefore remain motile) and a further subset will undergo sporulation. We discuss a regulatory network that may shed some light on component processes in cell differentiation in *B. subtilis*. In particular we focus on the phosphorylation of the response regulator DegU and its control of cell fate, detailing how a non-unimodal distribution of "on" cells within a population does not necessarily come from a classical bistability in the underlying dynamics of the regulatory network.