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Cell Division Control in E. coli

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The coordination of cell growth and division is a long-standing problem in biology. In particular, the mechanisms that ensure size homeostasis and, at the same time, adapt cell growth and size to the environment have been the subject of intense research. However, the answers were traditionally hindered by limited statistics on single cells. Contemporary experimental techniques overcome this problem, but this progress must be combined with new theoretical tools to approach the data. Focusing on E. coli, we introduced a quantitative method for estimating the variables controlling the division rate from dynamic data, and used it to build a minimal stochastic model of cell growth and division. Combining this method with large-scale microscopy experiments, classic quantitative laws relating cell size, doubling time and growth rate of bacterial populations in different nutrient conditions can be revisited at the single cell level. The main result is the emergence of a combination of universality and individuality in the growth-division laws of single E. coli cells. These two apparently contrasting behaviors emerge naturally from the condition-dependent modulation of the division control mechanism, thus actually representing two sides of the same coin. Finally, the simultaneous observation of cell growth and DNA replication dynamics allowed us to pinpoint replication initiation and cell division as the two main "checkpoints" for size control. This opens the way to more detailed models of the process, and to rigorous tests of molecular cell-cycle descriptions.

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