

Biological Noise at the level of Cellular Structure

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THE recent explosion of interest in biological noise has largely focused on the role of noise in gene regulatory circuits. We have begun to explore biological noise at the level of cellular structure, using the eukaryotic flagellar length control system as a test-bed. While flagella (also known as cilia) have restricted length distributions and average lengths that depend on the cell type, the mechanisms that regulate the length of cilia and flagella remain unknown. Indeed, length control of flagella represents a tractable, one-dimensional version of the more general problem of organelle size control, which has not yet been solved for any organelle. The unicellular green alga *Chlamydomonas* contains two identical flagella, allowing us to measure both intrinsic and extrinsic noise by separating out the cell-to-cell and within-cell components of length variation. We find that wild-type cells have measurable levels of both types of noise, and we identify mutations that increase both intrinsic and extrinsic noise. What is the functional impact of noise? Using high speed video imaging, we have been able to correlate swimming speed with the lengths of both flagella on a per cell basis, allowing us to define a range of lengths that is compatible with maximum swimming speed. We find that the noise in wild type lengths is precisely tuned to this region of maximal swimming, implying that the length control system has evolved to restrain biological noise at the level of a cellular structure to just an extent appropriate with selective pressures for optimal swimming.