BACTERIAL PHYSIOLOGY

The master template

The organization of the chromosome in bacteria dictates the location of not only transcription but also translation, according to a new paper in *Nature*.

Complex cellular organization was once thought to be the sole domain of eukaryotes, but over the past decade microbiologists have revealed that bacterial cells are also highly organized, containing a dynamic cytoskeleton and

a well-ordered genome.

However, one aspect of bacterial cellular organization that has remained mysterious is the location of protein synthesis. In bacteria, most translation occurs on mature

mRNAs that are thought to be able to diffuse freely in the cell, meaning that protein synthesis should occur at random locations throughout the cell. Until now, it has been extremely difficult to confirm or refute this hypothesis, owing to the technical challenges associated with visualizing mRNA in bacterial cells.

Jacobs-Wagner *et al.* overcame this hurdle using a fluorescent *in situ*

hybridization (FISH) protocol and specially developed image analysis software that allowed the spatial distribution of endogenous mRNAs in wild-type bacterial cells to be quantified. In preliminary experiments, the authors looked at the localization of the abundant *Caulobacter crescentus* *groESL* mRNA using FISH and live-cell assays, and they were able to see that the mRNA was not diffuse throughout the cell but, instead, was present in one or two distinct foci, depending on whether replication had taken place. For quantitative analysis they added a tandem array of 120 *lac* operator sequences (*lacO*₁₂₀) to the 3' ends of the coding regions of interest, which could then be detected using a *lacO*-Cy3 probe. Six *C. crescentus* *lacO*₁₂₀-tagged mRNAs were analysed, and the authors found no evidence for random diffusion; instead, most transcripts remained close to the chromosomal region that contained the encoding gene, which was confirmed by co-visualization of the chromosomal loci. Limited dispersion from the site of transcription was also shown for the *Escherichia coli* β -galactosidase mRNA (*lacZ*; which is processed from the polycistronic *lacZYA*) under native conditions. Mathematical modelling predicted that mRNAs

should be able to diffuse freely throughout the cell; the discrepancy between the distribution predicted by the model and that observed experimentally suggests that there are unknown constraints that limit the diffusion of mRNA in bacterial cells. Analysis of ribosomal mobility in live *C. crescentus* cells revealed that the limited diffusion of mRNA also restricts the movement of actively translating ribosomes.

These results indicate that, rather than occurring randomly, translation in bacteria is restricted to specific locations that are dictated by the limited diffusion of mature transcripts from the location of transcription, which is in turn specified by the position of the chromosomal locus. The chromosome therefore acts as a master template that specifies the spatial localization of transcription and translation. The authors suggest that such an arrangement could contribute to the conservation of gene clustering that is seen in bacterial genomes.

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ORIGINAL RESEARCH PAPER Montero Llopis, P. *et al.* Spatial organization of the flow of genetic information in bacteria. *Nature* **466**, 77–81 (2010)
FURTHER READING Thanbichler, M. & Shapiro, L. Getting organized — how bacterial cells move proteins and DNA. *Nature Rev. Microbiol.* **6**, 28–40 (2008)