Transcription and supercoiling : torsion-mediated interaction between adjacent genes

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Abstract

DNA torsional stress is generated by virtually all biomolecular processes involving the double helix, in particular transcription where a significant level of stress propagates over several kilobases. If another promoter is located in this range, this stress may strongly modify its opening properties, and hence facilitate or hinder its transcription. This mechanism implies that transcribed genes distant of a few kilobases are not independent, but coupled by torsional stress, an effect for which we propose the first quantitative and systematic model. In contrast to previously proposed mechanisms of transcriptional interference, the suggested coupling is not mediated by the transcription machineries, but results from the universal mechanical features of the double-helix. The model shows that the effect likely affects prokaryotes as well as eukaryotes, but with different consequences owing to their different basal levels of torsion. It also depends crucially on the relative orientation of the genes, enhancing the expression of eukaryotic divergent pairs while reducing that of prokaryotic convergent ones. To test the in vivo influence of the torsional coupling, we analyze the expression of isolated gene pairs in the Drosophila melanogaster genome. Their orientation and distance dependence is fully consistent with the model, suggesting that torsional gene coupling may constitute a widespread mechanism of (co)regulation in eukaryotes.

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