Together is better than alone: Modulating transcription elongation efficiency through RNA polymerase group dynamics

Sangjin Kim[1, 2] and Christine Jacobs-Wagner[1]

Transcription by RNA polymerases (RNAPs) is essential for cellular life. Here, we provide in vitro and in vivo evidence that co-transcribing RNAPs display either collaborative or antagonistic group dynamics over long distances through transcription-induced DNA supercoiling. Our findings suggest a model in which RNAPs assist each other's motion by relieving torsional stress, largely independently of promoter strength and thus RNAP density, as long as cancellation between positive and negative DNA supercoils can be achieved. Promoter repression reduces the apparent speed and processivity of RNAPs over two kilobases downstream of the promoter due to accumulated negative DNA supercoils, quickly arresting the synthesis of proteins that are no longer needed. Antagonistic RNAP dynamics can also be intergenic such that transcription of a highly-expressed gene can dampen the transcription elongation rate of a divergently-transcribed gene. Our findings may be broadly applicable given that transcription on topologically-constrained DNA is the norm across genes and organisms.

[1]Microbial Sciences Institute, Yale University, Howard Hughes Medical Institute. Other address information. E-mail: christine.jacobs-wagner@yale.edu
[2]Current address: Department of Physics, University of Illinois at Urbana-Champaign.