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Regulating gene-expression by mechanical force

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Initiation of transcription is an attractive target for controlling gene expression. Initiation typically involves binding of RNA polymerase to the DNA, followed by a rapid transition into a "closed" complex, and a subsequent transition into the "open" complex in which the DNA is locally melted. Nature makes good use of this target, for example in the form of repressor proteins that bind DNA and inhibit transcription. Here we will show that initiation of transcription is also dependent upon DNA tension and thus may be controlled by force alone, without the need for any accessory proteins. Using a three-bead assay in conjunction with optical tweezers we have shown that transient interactions of T7 RNA polymerase with the DNA promoter site shorten significantly, by up to a factor of $\sim$20, when DNA tension is increased. Experiments in the presence and absence of nucleotides have allowed us to conclude that force is likely to affect the rate constants into and/or out of the open complex, rather than the off-rate from the closed complex.