Requirements for Autonomous DNA Replication:

Understanding Information Transmission Fidelity in Templated Copying

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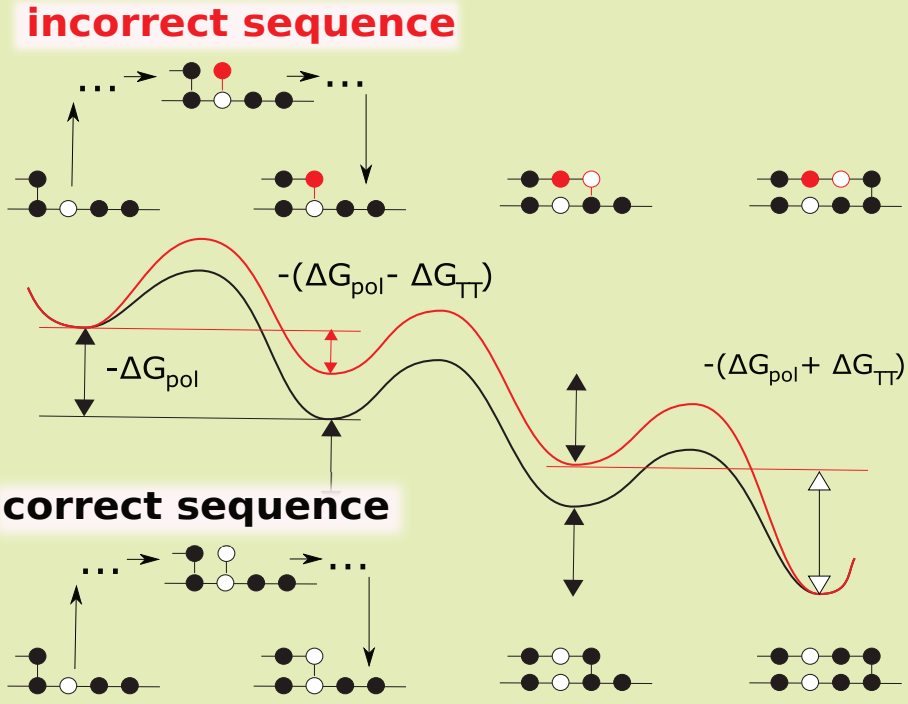
Polymer Copying Model



adapted from J. M. Poulton, P. R. ten Wolde, and T. E. Ouldridge, Proc National Acad Sci **116**, 201808775 (2019).

- Polymer copying is essential for living systems, think of replication, transcription, translation...
- Polymer copying happens far out of equilibrium, requires energy
- We have **developed a method** that allows using microscopic models for templated copying to study copying accuracy/ efficiency tradeoffs

Abstract Process of Sequence Copying

Information Theory

Mutual Information

$$I = H(\mathcal{X}) - H(\mathcal{X}|\mathcal{S})$$

Output Entropy

$$H(\mathcal{X}) = k_B \ln N_{\mathcal{X}}$$

Conditional Entropy

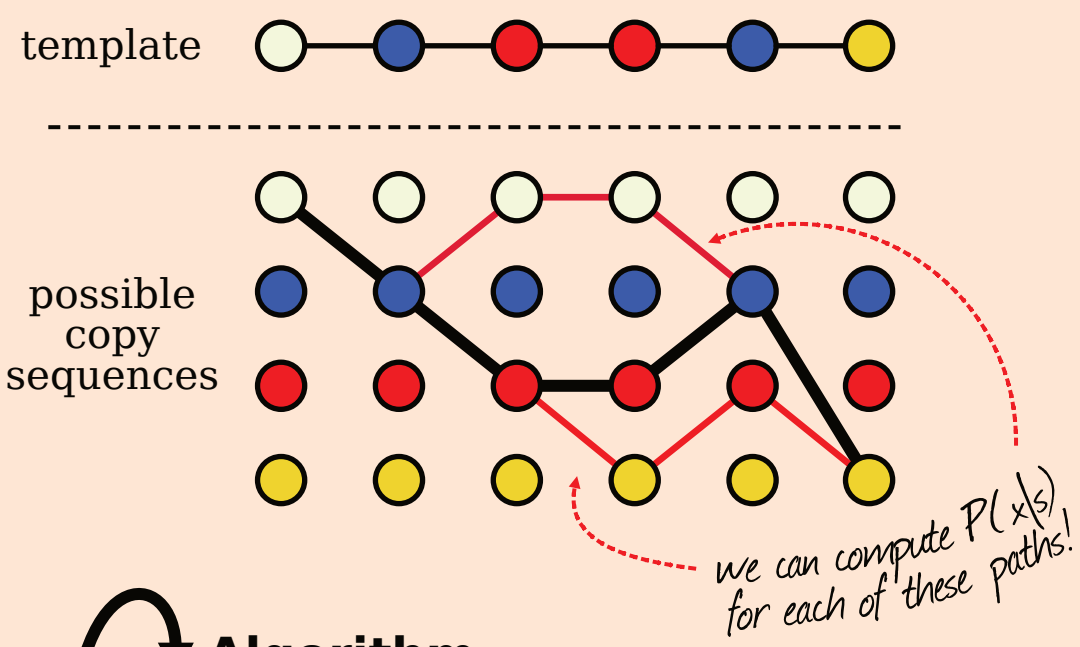
$$H(\mathcal{X}|\mathcal{S}) = k_B \left\langle \ln \frac{1}{P(x|s)} \right\rangle$$

#possible sequences

prob. to get copy sequence x from template s

- Copying a polymer sequence can be understood as a biochemical information processing operation
- Hence, we can use the generic framework of **Information Theory** to analyze polymer copying
- To understand the fidelity of the entire process, we want to compute the **mutual information (MI)** between template and copy *sequences*

A new algorithmic approach



Algorithm

1. generate random template
2. simulate many copy processes
3. average sequence probabilities

- We have developed a **new algorithm to compute the MI** for general discrete stochastic models
- In the algorithm we use the stochastic model to compute the **exact path probabilities** (sequence probability) of simulated copies