(A) Probabilistic Mixed-type Missing (PMM)

Dynamic lineage tracing

Target site

Start (t=0)

Time

End (t=τ)

site k

CTMC with rate $\mathbf{Q}^{(k)}$

Single-cell sequencing

Dropout $\mathbf{\Phi}$

Observed site k

dropout

heritable missing

dropout
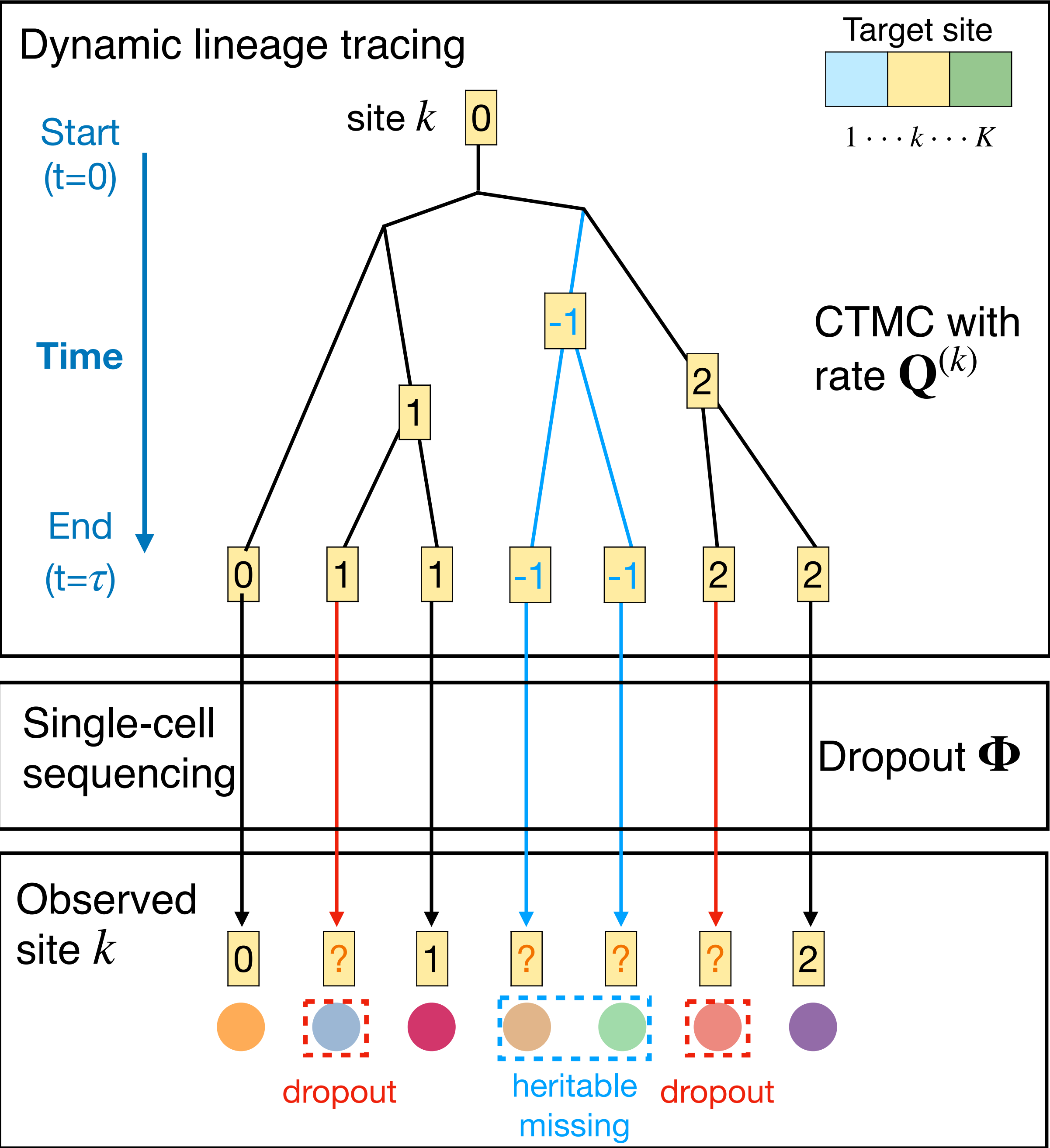
(B) Maximum Likelihood Inference under PMM model

Target site

cells

character matrix $\mathbf{D}$

Input

🐫 **LAML**

$$\max_{T,\mathbf{\Theta}} \mathcal{P}(\mathbf{D}; T, \mathbf{\Theta})$$

Output

(1) Imputed character matrix

Target site

cells

(2) Time-resolved lineage tree

Time

(3) Estimated mutation rate, heritable missing rate, and dropout rate