

File S1: Selection of model parameters

Cell volume: Bacterial cell volume varies with growth phase, increasing to $3 \mu\text{m}^3$ during exponential phase but falling to $1 \mu\text{m}^3$ in stationary phase¹. We therefore adopted a value of $1 \mu\text{m}^3$ ($= 10^{-15}$ L) for cell volume during stationary phase. With this value, 1 molecule/cell $= 1.66$ nM.

Total RNA polymerase, σ^{70} , σ^{38} and Rsd per cell: Measured values for total RNA polymerase and sigma factors have varied greatly depending upon cellular growth phase and growth rate. A list of values measured under various conditions is given in². As we are modeling conditions during stationary phase, we have adopted values measured during stationary phase in *E. coli* MG1655 using quantitative western blotting³.

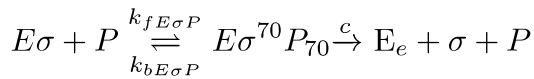
Total 6S RNA per cell: Wassarman and Storz⁴ showed that 6S RNA increases steadily throughout growth and stationary phase, from 1000 molecules/cell in exponential phase to 10,000 molecules/cell in late stationary phase (24 hours). Our data also indicates that the concentration of 6S RNA continues to increase throughout stationary phase. We therefore adopted a value of 8000 molecules/cell ≈ 13000 nM, consistent with an earlier time point in stationary phase.

$K_{E\sigma 70}$, $K_{E\sigma 38}$: Measured values for E- σ dissociation constants have varied greatly with temperature and ionic conditions, although all measurements agree that E- σ^{70} binding is considerably stronger than E- σ^{38} . A list of measured values under various conditions is given in². We have used values measured under high-salt conditions in the presence of glutamate, similar to cellular conditions in stationary phase⁵. However, we have also run the model with values from other studies^{6,7}, and obtained similar results.

K_{6S} : The dissociation constant for *E. coli* 6S RNA and RNA polymerase has not been measured to our knowledge. However, a dissociation constant of 131 nM has been measured for the binding of RNA polymerase and 6S RNA -1 from *Bacillus subtilis*, which is similar in structure and expression pattern to *E. coli* 6S RNA⁸. Increasing or decreasing this parameter by 5-fold does not substantially affect our findings.

Nonspecific binding: *E. coli* has $\sim 4.6 \times 10^6$ base pairs per genome, each of which can potentially be a non-specific binding site. Assuming that stationary phase cells have a single copy of the genome, we adopted this as the number of non-specific DNA binding sites. *In vitro* experiments⁹ under ionic conditions similar to physiological conditions found that the non-specific dissociation constants of E σ^{70} and core were comparable ($10^{-3} - 10^{-4}$ M). We assumed that the non-specific binding affinity of E σ^{38} would be similar to these, and used a value of 10^{-4} M for all non-specific binding.

Promoter binding and transcription: In the *E. coli* genome, it is estimated that ~ 1000 promoters are under the control of E σ^{70} and ~ 200 under E σ^{38} (RegulonDB database). However, not all promoters are active at any time, and many can be bound by both holoenzymes. In particular, the activity of E σ^{70} promoters is strongly reduced during stationary phase. We therefore adopted a value of 200 active promoters/cell for each sigma factor. Promoter binding affinities were chosen to be comparable with values in¹⁰ and¹¹. The promoter clearance rate was also chosen to be comparable with values in² and¹². For simplicity, we have assumed that the sigma factor is released immediately upon initiation, as shown below.



In steady state, this must satisfy the equation:

$$\frac{k_{bE\sigma P} + c}{k_{fE\sigma P}} = K_{E\sigma P}$$

We assumed that the promoter clearance rate is considerably smaller than $k_{bE\sigma P}$ and thus approximated:

$$\frac{k_{bE\sigma P}}{k_{fE\sigma P}} \approx K_{E\sigma P}$$

Transcription Elongation: The rate of elongation by RNA polymerase depends on growth conditions and the transcribed sequence, and is reduced in stationary phase. Proshkin et al.¹³ measured elongation rates of 42 nt s⁻¹ in exponential phase and 21 nt s⁻¹ in stationary phase. Assuming an average operon length of 1000 nt, the transcribing RNA polymerase would be released at a rate of 21/1000 = 0.021 s⁻¹.

References

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