

E. coli by numbers

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1 General

- Avogadro's constant = $6.022 \times 10^{23} = 6 \times 10^{23}$
- Total protein density $\approx 2 \sim 4 \times 10^6$ proteins/ μm^3
- Mean diameter of protein $\approx 4 \sim 5$ nm
- 1 base pair volume ≈ 1 nm³
- time scale for transitions between protein states (active/inactive) = $1 \sim 100$ μs
- time scale for transcription factor binding to DNA site ≈ 1 s
- mutation rate $\approx 1 \times 10^{-8} \sim 1 \times 10^{-10}$ /bp/replication

2 *E. coli*

2.1 Physical Specification

- cell volume = $0.3 \sim 3$ μm^3
- cell dimension = $2 \mu\text{m} \times 1 \mu\text{m} \times 1 \mu\text{m}$ (rod shape)
- total weight $\approx 9.5 \times 10^{-13}$ g
- total dry weight $\approx 2.8 \times 10^{-13}$ g (30% of total mass, where 70% of it being water)

2.2 Chemical Composition

- water $\approx 2 \times 10^{10} \approx 70\%$ of total weight
- inorganic ion $\approx 1 \times 10^8 \approx 4\%$ of dry weight (≈ 20 species)
- monomeric metabolites $\approx 4\%$ of dry weight (≈ 500 species)
- polysaccharides $\approx 6\%$ of dry weight (≈ 5 species)
- lipids $\approx 5 \times 10^7 \approx 10\%$ of dry weight (≈ 20 species)
- DNA / cell $\approx 4.6 \times 10^6$ bp $\approx 3\%$ of dry weight
- RNA / cell $\approx 2 \times 10^3 \approx 20\%$ of dry weight
- proteins / cell $\approx 3 \times 10^6 \approx 55\%$ of dry weight
- RNA polymerases / cell $\approx 2 \times 10^3$
- ribosomes / cell $\approx 1 \times 10^4$

2.3 Genetic Info

- Genome size ≈ 4.6 Mbp
- # of protein coding genes ≈ 4300
- Regulator binding site length = $10 \sim 20$ bp
- Promoter length ≈ 100 bp
- Gene length ≈ 1000 bp

2.4 Dynamics

- Transcription rate < 1 min (80 nts/s)
- Translation rate < 1 min (20 aa/s)
- mRNA life time ≈ 3 min
- Protein life time ≈ 1 hr
- Minimal doubling time ≈ 20 min

2.5 Molecular Kinetics

- Diffusion time of protein across cell ≈ 0.01 s
- Diffusion time of small molecule across cell ≈ 0.001 s
- Time scale for equilibrium binding of small molecule to protein = $1 \sim 1000$ ms ($1\mu\text{M} \sim 1\text{nM}$ affinity)

3 *E. coli* Metabolite Concentration

3.1 Glucose Metabolism

Metabolite	mol L^{-1} (= M)	# of molecules [†]
ATP	9.60×10^{-3}	5.8×10^6
ADP	5.60×10^{-4}	3.4×10^5
NAD ⁺	2.60×10^{-3}	1.6×10^6
NADH	8.30×10^{-5}	5.0×10^4
FAD	1.70×10^{-4}	1.0×10^5
Hexose-P (F6P, G6P, G1P)	8.80×10^{-3}	5.3×10^6
Citrate	2.00×10^{-3}	1.2×10^6
Fumarate	1.20×10^{-4}	7.2×10^4
Coenzyme A	1.40×10^{-3}	8.4×10^5
Acetyl-CoA	6.10×10^{-4}	3.7×10^5
α -Ketoglutarate	4.40×10^{-4}	2.6×10^5
Succinate	5.70×10^{-4}	3.4×10^5
Succinyl-CoA	2.30×10^{-4}	1.4×10^5
Malate	1.70×10^{-3}	1.0×10^6

[†] in $1 \mu\text{m}^3$ volume of *E. coli*

3.2 Nucleotides

Metabolite	mol L^{-1} (= M)	# of molecules [†]
ATP	9.60×10^{-3}	5.8×10^6
UTP	8.30×10^{-3}	5.0×10^6
GTP	4.90×10^{-3}	3.0×10^6
CTP	2.70×10^{-3}	1.6×10^6
ADP	5.60×10^{-4}	3.4×10^5
UDP	1.80×10^{-3}	1.1×10^6
GDP	6.80×10^{-4}	4.1×10^5
dATP	1.60×10^{-5}	9.6×10^3
dTTP	4.60×10^{-3}	2.8×10^6
dCTP	3.50×10^{-5}	2.1×10^4
dTDP	3.80×10^{-4}	2.3×10^5
CMP	3.60×10^{-4}	2.2×10^5
AMP	2.80×10^{-4}	1.7×10^5
GMP	2.40×10^{-5}	1.4×10^4
dAMP	8.80×10^{-6}	5.3×10^3
dGMP	5.10×10^{-5}	3.1×10^4
Cyclic AMP	3.50×10^{-5}	2.1×10^4
Guanosine	1.60×10^{-6}	9.6×10^2
Adenine	1.50×10^{-6}	9.0×10^2
Adenosine	1.30×10^{-7}	7.8×10^1
Cytosine	1.40×10^{-5}	8.4×10^3
Guanine	1.90×10^{-4}	1.1×10^5
NADP+	2.10×10^{-6}	1.3×10^3
NADPH	1.20×10^{-4}	7.2×10^4

[†] in $1 \mu\text{m}^3$ volume of *E. coli*

3.3 Amino acids

Metabolite	mol L^{-1} (= M)	# of molecules [†]
Glutamate	9.60×10^{-2}	5.8×10^7
Aspartate	4.20×10^{-3}	2.5×10^6
Valine	4.00×10^{-3}	2.4×10^6
Glutamine	3.80×10^{-3}	2.3×10^6
Alanine	2.60×10^{-3}	1.6×10^6
Arginine	5.70×10^{-4}	3.4×10^5
Asparagine	5.10×10^{-4}	3.1×10^5
Lysine	4.10×10^{-4}	2.5×10^5
Proline	3.90×10^{-4}	2.3×10^5
Isoleucine + Leucine	3.00×10^{-4}	1.8×10^5
Threonine	1.80×10^{-4}	1.1×10^5
Methionine	1.50×10^{-4}	9.0×10^4
Serine	6.80×10^{-5}	4.1×10^4
Histidine	6.80×10^{-5}	4.1×10^4
Tyrosine	2.90×10^{-5}	1.7×10^4
Phenylalanine	1.80×10^{-5}	1.1×10^4
Tryptophan	1.20×10^{-5}	7.2×10^3
Cytidine	2.60×10^{-6}	1.6×10^3

[†] in $1 \mu\text{m}^3$ volume of *E. coli*

4 Reference

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