Ron Milo: Number of mRNA molecules within one *E. coli* cell?

Step	**Variable (units)**	**Calculation**	**Result**
Cell size	V_{cell}	Length: 1 µm, 10^{-6} m = 10^{-18} m^3	10^{-18} m^3
Cell mass	M_{cell}	V_{cell} x density = 10^{-18} m^3 x 1 kg/l (1.08 kg/l E. coli) multiply by 1 = 10^3 l/1 m^3) = 10^{-15} kg = 10^{-12} g = 1 pg Atom mass Dalton D (1 H atom) , with N_a = 6.022 10^{23} => 6.022 10^{23} Da / 1 g M_{cell} = 10^{-12} g * ($6 \cdot 10^{23}$ Da / 1g) = $6 \cdot 10^{11}$ Da	$6 \cdot 10^{11}$ Da
Protein mass / cell	$M_{protein}$	Cell: water 70%, DNA, RNA, lipids, proteins (half of the cell's dry weight) $M_{cell} \cdot 0.15 = 6 \cdot 10^{11} \cdot 0.15$ Da = 10^{11} Da	10^{11} Da
Protein number	$N_{protein}$	Average length: 300 aa, 110 Da/ aa 300 aa x 100 Da/aa = 30 000 Da = 30 kDa (average protein mass) number of proteins per cell / protein mass = 10^{11} Da / $3 \cdot 10^4$ Da = $3 \cdot 10^6$ proteins/cell	$3 \cdot 10^6$ proteins
		What could go wrong (sensitivity analysis): cell volume cubic 5 fold larger size under good conditions than in resting state => number of proteins: $3 \cdot 10^6$ proteins per μm^3	
Protein production rate	$R1 = N_{protein} / \tau$	cell cycle: within this time the cell doubles and needs twice the amount of the protein 20 min (max) to 1 h (could be much slower…), τ = 3000 seconds / 1h $R = N_{protein} / \tau = 3 \cdot 10^6 / 3 \cdot 10^3$ s = 10^3 proteins / (cell s)	10^3 proteins per s
Proteins / mRNA	$R2 = N_{protein}$ / (RNA s)	Velocity (ribosome) $V_{ribosome}$ = 10 aa/s = 30 nucleotide / s 30 nucleotide ribosome footprint => max 1 protein / (RNA s)	1 - 0.1 proteins per RNA per s
mRNAs/cell	N_{mRNA}	*N*(RNA/cell) = R1 (protein) / R2 (protein/RNA) = 10^3 protein/s // 1 to 0.1 protein / (RNA s) = 10^3-10^4 mRNA/cell	10^3-10^4 mRNA/cell
mRNAs/human cell		different cell size (1000x) and cell cycle (20x) = $V_{human}/V_{E.coli}$ // $\tau_{human} / \tau_{Ecoli}$ = $3 \cdot 10^3$ * 1000/20 = 10^5 mRNA / human cell (human cell 1000 - 4000 x larger, yeast 40x larger)	10^5 mRNA / human cell