Useful fundamental numbers in molecular biology

B10NUMB3R5
THE DATABASE OF USEFUL BIOLOGICAL NUMBERS

The numbers quoted here were extracted from the literature. They should only serve as "rule of thumb" values. Consult the full references to learn about the specific system under study, growth conditions, measurement method etc. Full references at: www.bioNumbers.org

Cell sizes:
Bacteria (e.coli): ~1μm diameter, 2μm length, ~1μm^3 in volume; 10^9cells/ml in an overnight culture (OD600~1)
Yeast (Saccharomyces cerevisiae): ~5 μm diameter, ~50 μm^3 in volume
Mammalian (HELA) cell - ~2,000 μm^3 in volume, adherent cell on a slide ~20 μm diameter → ~100,000 cells in a confluent well of a 96 multiwell plate

Organelles and cell constituents:
Mammalian cell nucleus ~10 micron diameter
Mitochondria ~1-2 micron length, ~0.2-0.7 micron diameter
Chloroplast ~4 micron length, ~1 micron diameter
Cell membrane ~5-10 nm, "average" protein ~2nm, water molecule ~0.2nm

Concentrations
Absolute numbers "rule of thumb": concentration of 1 nM in a cell the volume of e.coli is ~ 1molecule/cell → 1 μM~ 1000 molecules/bacterial (e.coli) cell; 2,000,000 molecules/mammalian (HELA) cell.
Characteristic concentration for a signaling protein ~10 nM-1μM
Water content: ~50-70% of cell. General elemental composition dry mass: $C:H_{1.77}:O_{0.49}:N_{0.24}$
Composition of dry weight of an e.coli: ~55% protein, 20% RNA, 10% Lipids, 15% others.
Number of proteins in an e.coli cell $3\text{-}10*10^6$ (depending on growth rate)

Energetics
ΔG needed to achieve an order of magnitude ratio of concentrations: ~6 kJ/mole = ~2 kT = ~60 meV
Energetic contribution of a hydrogen bond: ~6-24 kJ/mole → 1-4 orders of magnitude concentration change
ΔG of ATP hydrolysis under physiological conditions ~50 kJ/mole → ~20 kT

Diffusion and catalysis rate
Diffusion coefficient for a protein in the cytoplasm D~5-50 μm^2/sec → ~10 millisec to reach from one end of an e.coli to the other, ~10 sec to traverse a mammalian (HELA) cell. D(metabolite) ~500 μm^2/sec.
Diffusion limited on-rate for a characteristic protein $\sim 10^8\text{-}10^9$ 1/sec/Molar → for a protein substrate of concentration ~1μM the diffusion limited on rate is ~10-100 Hz thus giving a limit on the catalytic rate K_{cat}

Replication, transcription, translation rates
Rate of DNA replication by DNA polymerase ~1000 bp/sec → ~ 60 minutes to replicate whole e.coli genome. To achieve faster growth rates requires simultaneous internal replication forks.
Rate of transcription by RNA polymerase ~80 bp/sec
Rate of translation by the ribosome ~20 aa/sec

Mutation and error rates
Mutation rate in DNA replication $\sim 10^{-9}$ per bp in e.coli
Error rate in translation $\sim 10^{-4}$ per amino-acid

Please send corrections and ideas for more bioNumbers to bioNumbers@gmail.com

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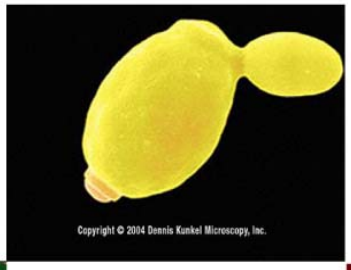
ATP to make one cell: ~55 billion
Volume occupied by RNA: 6%
Number of tRNA/cell: ~200,000
Speed: 50 µm/sec
Ribosomes: 6,800 - 72,000
Proteins: ~3.6×10^6
Translation rate: 12 - 21 aa/sec
Volume occupied by water: 70%



Generation time: 4 days
Cells in an adult male: 1031
Number of genes: 20,621
Eggs laid during lifetime: 300
Size of Genome: 100Mbp
Life span: 2-3 weeks
Run speed at 20°C: 0.13mm/sec
Cells in hatched larvae: 556

Median haploid volume: 42 μm^3
Number of ribosomes: ~200,000
Nucleus volume: 7% of cell
mRNA out of total RNA: 5%
mRNA in cell: 15,000
Kcat of Pyruvate kinase: 71,400/min
Cell diameter: ~5µm
RNA to DNA ratio: 50

Total number of taste buds: 10,000
Cell divisions in a life-time: 10^{17}
Abundance of p53 per cell: ~160,000
Average brain weight: ~1350g
Hairs on the head: 90,000-150,00
Diameter of erythrocytes: 7.5µm
Weight of skin: 4.1 Kg
Average time between blinks: 2.8 Sec

See a collection of useful fundamental numbers in molecular biology on other side of page

BioNumbers (bioNumbers.org) is the database of useful biological numbers. It aims to enable you to find in one minute any common biological number important for your research, such as the rate of translation of the ribosome, concentrations of metabolites or the number of bacteria in your gut. You will find full references, comments and related numbers that are useful. Check it out at: www.bioNumbers.hms.harvard.edu.

Please send suggestions and comments: ron_milo@hms.harvard.edu