BioNumbers

the database of useful biological numbers

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2010-10-29

BioNumbers is a database of key numbers in molecular and cell biology—the quantitative properties of biological systems of interest to computational, systems and molecular cell biologists.

Cell sizes

Metabolite concentrations

Reaction rates

Generation times

Genome sizes

The number of mitochondria in a cell

Background and Authors:

Biology is becoming increasingly quantitative.

But, there is no handbooks that containing common numbers in biology.

Finding numbers in the vast literature can be an incredibly time consuming and frustrating experience.

1970s, the three-volume Biology Data Book

Ron Milo , at Weizmann Institute in Israel

“In BioNumbers we aim to enable you to find in one minute any common biological number that can be important for your research.”

URL:

http://www.bionumbers.hms.harvard.edu

B10NUMB3R5

THE DATABASE OF USEFUL BIOLOGICAL NUMBERS

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Popular BioNumbers | Recent BioNumbers | Key BioNumbers | Amazing BioNumbers

Find Terms [ ] search ×

e.g., ribosome , p53 , glucose , CO2

Organism (all)

Below are several random BioNumbers. Click a row for more details

Property	Organism	Value	Units	Range	ID	Details
Duration of early induced innate immunity response	Unspecified		hours	4-96	103571	Kenneth M. Murphy, Paul... »
Duration of G1 stage of cell cycle	Bacteria Caulobacter crescentus	~28	min		104922	Laub MT, McAdams HH,... »
Rate of isomerization from closed to open complex (K2) of RNAP and D promoter	Bacteriophage T7	0.024	sec^-1		105136	McClure WR. Rate-limiting... »
Macrophyte oceanic Net Primary Production	Biosphere	1	Pg of Carbon/year		102959	Field CB, Behrenfeld MJ... »
Mid-point and redox potentials for various biological molecules	Generic		N/A	Table link - http://tinyurl.com/5vnsz3	101688	Nicholls, D and Ferguson... »

Organism (all)

(all)

top 15 Organisms

- Bacteria Escherichia coli (967)
- Human Homo sapiens (736)
- Budding yeast Saccharomyces cerevisiae (406)
- Generic (358)
- Biosphere (306)
- Unspecified (221)
- Various (172)
- Rat Rattus norvegicus (167)
- African clawed frog Xenopus laevis (110)
- Mouse Mus musculus (105)
- Plants (102)
- Mammalian tissue culture cell (86)
- Spinach Spinacia oleracea (72)
- bacteria (61)
- Fruit fly Drosophila melanogaster (57)

Alphabetical List

- Acanthamoeba polyphaga Mimivirus (2)

Searching Keyword “Cell cycle”

Property	Organism	Value	Units	Range	ID	Details
Average G1 cell cycle period for haploid daughter cell	Budding yeast Saccharomyces cerevisiae	37	min	+-2	104358	Di Talia S, Skotheim JM... »
Average total cell cycle period for haploid mother cell	Budding yeast Saccharomyces cerevisiae	87	min	±1	104360	Di Talia S, Skotheim JM... »
Duration of each cell cycle phase of HeLa cells cultured in normal gravity and hypergravity	Human Homo sapiens		N/A	Table link - http://tinyurl.com/yks7njp	103805	Kumei Y, Nakajima T, Sato A... »
Average total cell cycle period for haploid daughter cell	Budding yeast Saccharomyces cerevisiae	112	min	±3	104361	Di Talia S, Skotheim JM... »
Average G1 cell cycle period for haploid mother cell	Budding yeast Saccharomyces cerevisiae	15.6	min	±0.5	104359	Di Talia S, Skotheim JM... »
Average cell cycle periods for cells of different ploidy	Budding yeast Saccharomyces cerevisiae		N/A	Table link - http://tinyurl.com/l7maew	104357	Di Talia S, Skotheim JM... »
Cell cycle period for wt haploid daughter cell grown in glycerol-ethanol	Budding yeast Saccharomyces cerevisiae	219	min	+-3	104363	Di Talia S, Skotheim JM... »
Cell cycle period for wt haploid mother cell grown in glycerol-ethanol	Budding yeast Saccharomyces cerevisiae	133	min	+-2	104364	Di Talia S, Skotheim JM... »

ID	104360
Property	Average total cell cycle period for haploid mother cell
Organism	Budding yeast Saccharomyces cerevisiae
Value	87
Range	±1
Units	min
Reference	Di Talia S, Skotheim JM, Bean JM, Siggia ED, Cross FR. The effects of molecular noise and size control on variability in the budding yeast cell cycle. Nature. 2007 Aug 23 448(7156):947-51 Supplementary online material table S7 Table link - http://tinyurl.com/l7maew
Reference PubMed ID	17713537
Entered By	Uri M
Primary Source	
Primary Source PubMed ID	
Measurement Method	Researchers measured times from cytokinesis to budding (G1) and from budding to cytokinesis in haploids, diploids or tetraploids (mothers and daughters), using time-lapse fluorescence microscopy of strains expressing Myo1 tagged with green fluorescent protein (Myo1–GFP). Time lapse fluorescence microscopy is a technique wherein a camera that periodically takes photographs is attached to a microscope, imaging cellular or intracellular activity. GFP (Green Fluorescent Protein), a fluorescing molecule, is often used as a label. In this case GFP was fused (through genetic engineering) to another protein, Myo1, which forms a ring at the daughter cell's bud neck.
Keywords	haploid, cell cycle, generation time, doubling time,
Comments	n=116. Although unspecified the growth media appears to be glucose according to following sentence from p. 16 in supplementary information: "Glycerol/ethanol supports a much slower growth rate than glucose (170 min compared to 100 min doubling time)..." For doubling time of haploid cell from the same article see BNID 101310. See BNID 100270, 101747
Date Added	Jun 17, 2009 10:05 AM
Date Edited	Jul 13, 2010 11:13 AM

B10NUMB3R5

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Browse

A

adenosine triphosphate

ADP

Alanine

amino acid

atp

B

bacteria

base pairs

Blood

brain

C

calcium

calvin cycle

cancer

carbon

carbon cycle

enzyme

erythrocyte

ethanol

expression

eye

F

fluorescent

flux

fumarate

fusion protein

G

gene

gene expression

generation time

genetic material

genome

globular protein

Liver

lysis

M

macromolecule

magnesium

Mammalian tissue culture cell

MAPK cascade

mass

membrane

metabolism

metabolite

metabolome

mitochondria

mRNA

N

net primary production

neuron

Q

quinone

R

Red blood cell

redox

replication

respiration

ribonucleic acid

ribosome

rna

RNA polymerase

RNAP

rrna

rubisco

S

signaling

sodium

Table 1. Database vital statistics

Number of entries	~4500
Number of distinct references	~1000
Number of organisms	~200
Unique visitors per day	~150
Searches performed in BioNumbers per month	~4000

Now entries: ~5300

B1ONUMB3R5

THE DATABASE OF USEFUL BIOLOGICAL NUMBERS

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Resources

Download the BioNumbers database

BioNumbers highlights: Collection of fundamental numbers in molecular biology

BioNumbers description handout: Short description of BioNumbers and a collection of interesting bioNumbers

Specialized BioNumbers collections: Handouts geared to specific communities. For example, a collection focusing on photosynthesis. Please suggest a subject for which you would like to have one.

BioNumbers in the news: Media coverage of BioNumbers .

BioNumbers presentations Introduces the concept and some applications as well as a collection of slides with interesting BioNumbers

Handbooks of BioNumbers: useful book resources .

Basic cell properties comparison table: An updated version of a table in Uri Alon's book Introduction to systems biology.

Quantitative biology problem sets: Aimed at courses teaching biology these questions make use of BioNumbers to develop quantitative reasoning about biological systems. For example: Putting absolute numbers on a sporulation model. Please contribute your ideas for good questions.

More details and future directions for BioNumbers can be found at http://openwetware.org/wiki/BioNumbers.
We welcome all suggestions to improving BioNumbers. Please send suggestions to BioNumbers@gmail.com.

Submit

Enter a new BioNumber to be added to the database.

[click for quick submit]

Property*		The property quantified by the bioNumber. Please be as descriptive as possible.
Organism*	Pick: (select or specify other) Other:	Please use the drop down menu. If correct species is not present, please enter in Other box.
Value Flag	E=equal to	Write value or if a range use range field
Value		No units please! If the Bionumber is a single number, enter in Value box and leave Range/Confidence blank. If the Bionumber is a single value with an associated error or deviation, enter the value in Value and the error or deviation in the Range/Confidence box. If the Bionumber is strictly a range, leave Value blank and enter the range in the Range/Confidence box.
Range/ Confidence		Give range if available. This could be a lower to upper limit, a standard deviation (use +-), confidence interval etc. In the comments please please describe what it is.
Units*		If no units, please type Unitless. Otherwise, use whatever unit is appropriate and/or standard in your field. Please use "u" for micro (ie. ug, um, uL).
Reference*		The reference in which you found the Bionumber: books, reviews, and primary literature are all appropriate.
Reference PubMed ID		Supply Pubmed ID if known
Entered By	huxiaopan	

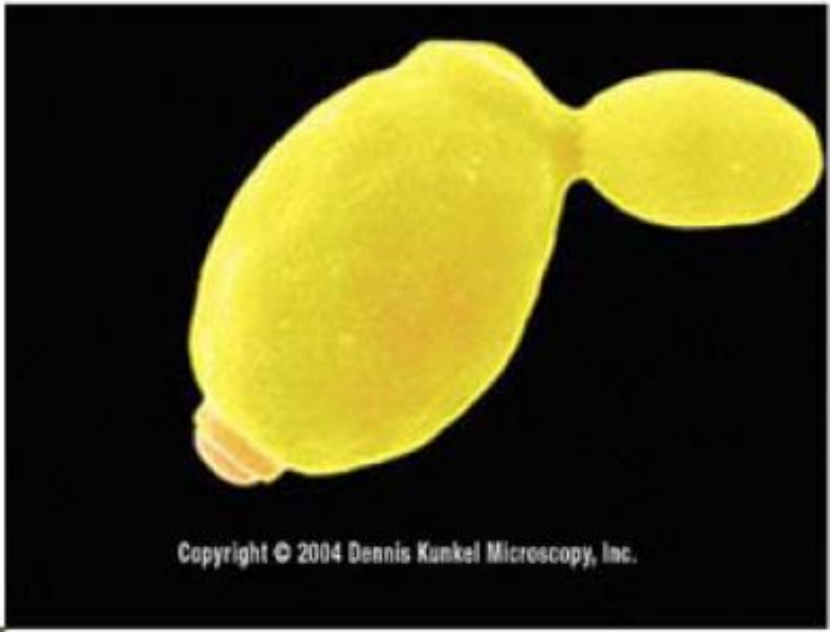
submit reset

Usage:

Some interesting bionumbers:

Property	Organism	Value	Units	Range
Largest protein size - titin	Homo sapiens	33423	aa	
Largest known genome size	Polychaos dubium	6.7e+11	bp	
Cell diameter (largest of any bacteria)	Thiomargarita namibiensis	180	µm	100-750
Volume of egg	Struthio camelus	1338	cm^3	
Number of cells in human body	Homo sapiens	~1e+13		
Number of hairs on human head	Homo sapiens			9-15e+4
Number of hairs in human eyebrows	Homo sapiens	~600		
Ratio between number of bacteria and number of cells in body	Homo sapiens	10		

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%



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

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

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

Cell size

Bacteria (*E. coli*): ≈0.7-1.4 μm diameter, ≈2-4 μm length, ≈0.5-5 μm³ in volume; 10^8-10^9 cell/ml for culture with OD_{600}≈1

Yeast (*S. cerevisiae*): ≈3-6 μm diameter ≈20-160 μm³ in volume

Mammalian cell volume: 100-10,000 μm³; HeLa cell: 500-5000 μm³ (adhering to slide ≈15-30 μm diameter)

Length scales inside cells

Nucleus volume: ≈10% of cell volume

Cell membrane thickness: ≈4-10 nm

"Average" protein diameter: ≈3-6 nm

Base pair: 2 nm (D) x 0.34 nm (H)

Water molecule diameter: ≈0.3 nm

Energetics

Membrane potential ≈70-200 mV → 2-6 k_BT per electron (k_BT ≡ thermal energy)

Free energy (ΔG) of ATP hydrolysis under physiological conditions ≈40-60 kJ/mol → ≈20 k_BT/molecule ATP; ATP molecules required during an *E. coli* cell cycle ≈10-50 × 10^9

ΔG⁰ resulting in order of magnitude ratio between product and reactant concentrations: ≈6 kJ/mol ≈60 meV ≈2 k_BT

Concentration

Concentration of 1 nM: in *E. coli* ≈1 molecule/cell; in HeLa cells ≈1000 molecules/cell

Characteristic concentration for a signaling protein: ≈10 nM-1 μM

Water content: ≈70% by mass; general elemental composition (dry weight) of *E. coli:* ≈$C_4H_7O_2N_1$; Yeast: ≈$C_6H_{10}O_3N_1$

Composition of *E. coli* (dry weight): ≈55% protein, 20% RNA, 10% lipid, 15% other

Protein concentration: ≈100 mg/ml = 3 mM. 10^6-10^7 per *E. coli* (depending on growth rate); Total metabolites (MW < 1 kDa) ≈300 mM

Division, replication, transcription, translation, and degradation rates

at 37°C with a temperature dependence (Q10) of ≈2-3

Cell cycle time (exponential growth in rich media): *E. coli* ≈20-40 min; budding yeast 70-140 min; HeLa human cell line: 15-30 hr

Rate of replication by DNA polymerase: *E. coli* ≈200-1000 bases/s; human ≈40 bases/s. Transcription by RNA polymerase 10-100 bases/s

Translation rate by ribosome: 10-20 aa/s

Degradation rates (proliferating cells): mRNA half life < cell cycle time; protein half life ≳ cell cycle time

Diffusion and catalysis rate

Diffusion coefficient for an "average" protein: in cytoplasm D≈5-15 μm²/s → ≈10 ms to traverse an *E. coli* → ≈10 s to traverse a mammalian HeLa cell; small metabolite in water D≈500 μm²/s

Diffusion-limited on-rate for a protein: ≈10^8-10^9 $s^{-1}M^{-1}$ → for a protein substrate of concentration ≈1 μM the diffusion-limited on-rate is ≈100-1000 s^{-1} thus limiting the catalytic rate k_{cat}

Genome sizes and error rates

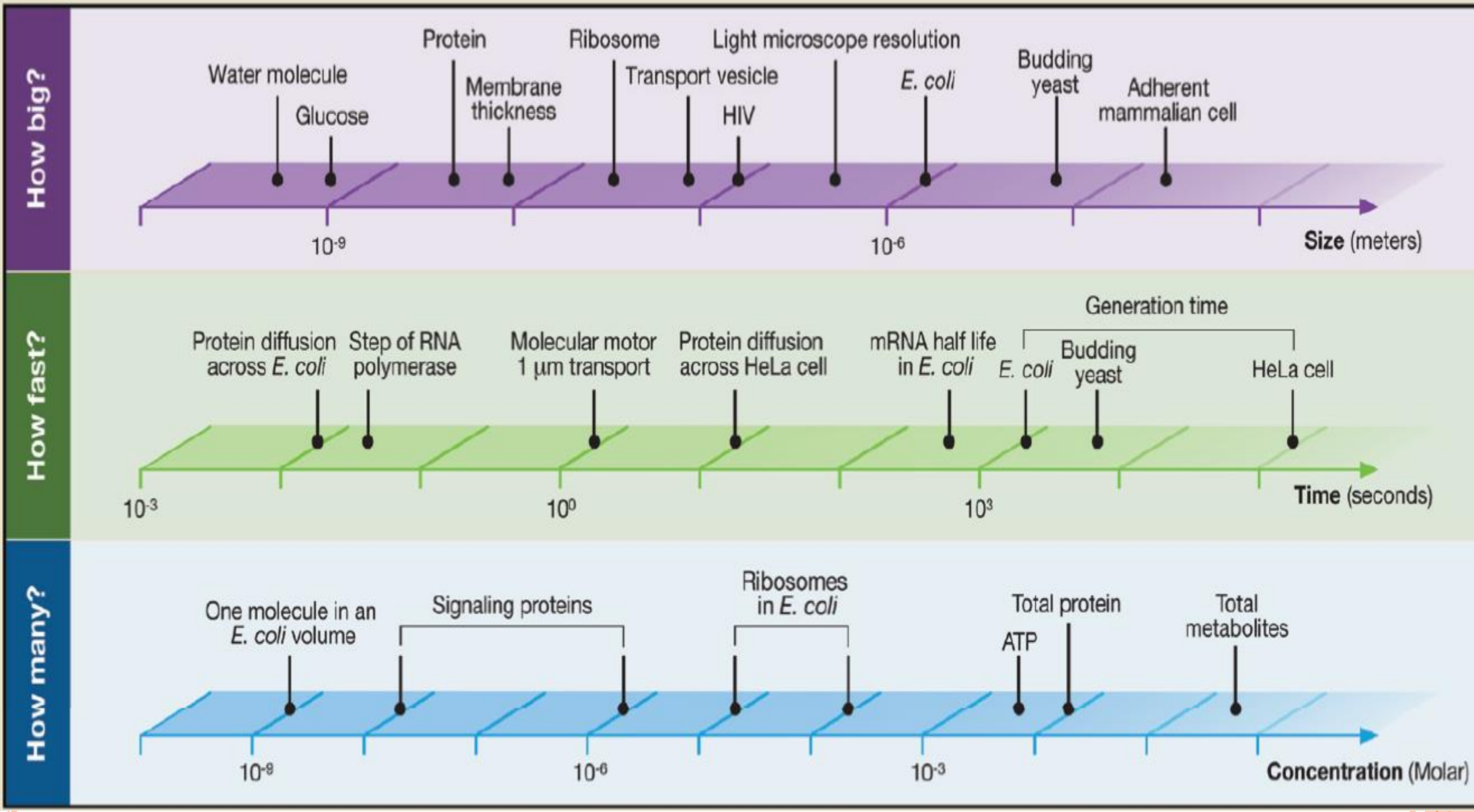
Genome size:

E. coli (enterobacteria) ≈5 Mbp
S. cerevisiae (budding yeast) ≈12 Mbp
C. elegans (nematode) ≈100 Mbp
D. melanogaster (fruit fly) ≈120 Mbp
A. thaliana (plant) ≈120 Mbp
M. musculus (mouse) ≈2.5 Gbp
H. sapiens (human) ≈2.9 Gbp
T. aestivum (wheat) ≈16 Gbp

Number of protein-coding genes: *E. coli* ≈ 4000; *S. cerevisiae* ≈ 6000; *C. elegans, A. thaliana, M. musculus, H. sapiens* ≈ 20,000

Mutation rate in DNA replication: ≈10^{-8}-10^{-10} per bp

Misincorporation rate: transcription ≈10^{-4}-10^{-5} per nucleotide; translation ≈10^{-3}-10^{-4} per amino acid


How big?
Water molecule
Glucose
Protein
Membrane thickness
Ribosome
Transport vesicle
HIV
Light microscope resolution
E. coli
Budding yeast
Adherent mammalian cell
10-9
10-6
Size (meters)
How fast?
Protein diffusion across E. coli
Step of RNA polymerase
Molecular motor 1 µm transport
Protein diffusion across HeLa cell
mRNA half life in E. coli
Generation time
E. coli
Budding yeast
HeLa cell
10-3
100
103
Time (seconds)
How many?
One molecule in an E. coli volume
Signaling proteins
Ribosomes in E. coli
ATP
Total protein
Total metabolites
10-9
10-6
10-3
Concentration (Molar)

In *E.coli*

What limits the maximal rate at which a bacterium can divide?

Generation time: 20 min (why not 2 min?)

Increase the amount of the limiting factor, like the number of nutrient transporters, the number of RNA polymerase complexes.

But ribosome???
Ribosome ~7500 aa, 21aa/sec.

Translating a single copy of all of the ribosomal proteins ~7500/21≈400 sec≈7 min

Rather than relying solely on the limited expertise of our group of curators, the BioNumbers database aims to utilize current information technology to capture the knowledge of the research community as a whole. Unlike a handbook, BioNumbers is dynamic, being continuously updated by curators and by engaged members of the scientific community.

Thanks for your attention!