

Metaphors for Biology: Time

If the opening of a voltage-gated K⁺ channel was slowed down to the blink of an eye, how long would other biological phenomena take? Each event (such as a water molecule diffusing the length of an *E. coli* cell) is quantitatively compared against this reference.

Category	Event	Metaphorical Time	Relative to Reference	Order of Magnitude
Reference	Voltage-gated K⁺ channel (inner gate snap open)	100 milliseconds (1 eyeblink)	1x (reference)	10⁰
Molecular Vibrations	Internal vibrations of molecules (H bonds in water)	Billions per second	10,000,000,000x faster	10 ⁻¹⁰
Molecular Motion	Water molecule velocity	6 cm/second	600x faster	10 ⁻³
Diffusion	Water diffuses width of <i>E. coli</i> (1μm)	8 seconds	80x slower	10 ²
Diffusion	Water diffuses width of skin cell (20μm)	1 hour	36,000x slower	10 ⁴
Diffusion	Water diffuses width of human hair (100μm)	1 day	864,000x slower	10 ⁶
Protein Folding	Fastest-folding proteins	20 milliseconds (1/5 eyeblink)	5x faster	10 ⁻¹
Protein Folding	Typical-size proteins (few hundred amino acids)	1 hour to 1 day	36,000-864,000x slower	10 ⁴ to 10 ⁶
Protein Folding	GFP maturation time	Almost 1 year	315,000,000x slower	10 ⁸
Protein Synthesis	Transcription rate (bacterial)	1 base every 3.5 minutes	2,100x slower	10 ³
Protein Synthesis	Typical bacterial gene transcription	~2.5 days	2,160,000x slower	10 ⁶
Protein Synthesis	Human gene transcription (with introns)	~2 months	52,000,000x slower	10 ⁷
Protein Synthesis	Translation rate	1 amino acid every 30 minutes	18,000x slower	10 ⁴
Protein Synthesis	Typical protein translation (few hundred amino acids)	~6 days	5,180,000x slower	10 ⁶
Protein Function	Voltage-gated K ⁺ channel (outer gate uncoiling)	1 second	10x slower	10 ¹
Protein Function	Voltage-gated K ⁺ channel (delay before inner snap)	1 second average	10x slower	10 ¹
Protein Function	Superoxide dismutase (fastest enzyme)	10 reactions/second (0.1 sec each)	1x (same speed)	10 ⁰
Protein Function	ATP synthase rotation (produces 3 ATP)	50 seconds	500x slower	10 ²
Protein Function	<i>E. coli</i> flagellum rotation	30 seconds	300x slower	10 ²
Protein Function	<i>Vibrio alginolyticus</i> flagellum rotation	6 seconds	60x slower	10 ²
Protein Function	Average metabolic enzyme (saturating conditions)	1 molecule every 16 minutes	9,600x slower	10 ⁴
Protein Function	Kinesin motor step (8 nm)	30 seconds	300x slower	10 ²
Protein Lifespans	Shortest-lived yeast proteins	~3 weeks half-life	18,000,000x slower	10 ⁷
Protein Lifespans	Median yeast protein half-life (growing cells)	~300 days	259,000,000x slower	10 ⁸
Protein Lifespans	Longest-lived yeast proteins	>200 years half-life	1,700,000,000,000x slower	10 ¹²
Protein Lifespans	Human fibroblast proteins (non-growing)	20-80 years half-life	173,000,000,000-691,000,000,000x slower	10 ¹¹ to 10 ¹²
Protein Lifespans	Median human fibroblast protein half-life	~65 years	562,000,000,000x slower	10 ¹¹
Protein Lifespans	Ornithine decarboxylase (short-lived human protein)	~75 days half-life	64,800,000x slower	10 ⁷
Protein Lifespans	Collagen (longest-lived human protein)	~1.2 million years	10,000,000,000,000x slower	10 ¹⁶
DNA Replication & Cell Division	DNA polymerase rate (<i>E. coli</i>)	1 base pair every 17 seconds	170x slower	10 ²
DNA Replication & Cell Division	<i>E. coli</i> polymerase processivity	~10 days (before falling off)	8,640,000x slower	10 ⁶
DNA Replication & Cell Division	<i>E. coli</i> division (fast-growing ideal conditions)	7 months	181,000,000x slower	10 ⁸
DNA Replication & Cell Division	Human fibroblast cell division cycle	22 years	190,000,000,000x slower	10 ¹¹
DNA Replication & Cell Division	Fibroblast G1 phase	7.5 years	65,000,000,000x slower	10 ¹⁰
DNA Replication & Cell Division	Fibroblast S phase	10 years	86,400,000,000x slower	10 ¹⁰
DNA Replication & Cell Division	Fibroblast G2 phase	3.5 years	30,200,000,000x slower	10 ¹⁰
DNA Replication & Cell Division	Fibroblast M phase (mitosis)	1 year	8,640,000,000x slower	10 ⁹
DNA Replication & Cell Division	Fruit fly lifespan (lab)	~820 years	7,100,000,000,000x slower	10 ¹²
Neural/Brain Events	Light travel from ruler to eye	Negligible (<1 millisecond)	100x faster	10 ⁻²
Neural/Brain Events	Photoreceptor response (phototransduction)	50 seconds	500x slower	10 ²
Neural/Brain Events	Retinal neurons start responding	1.5 minutes	900x slower	10 ³
Neural/Brain Events	Optic nerve signal travel to brain	1-4 minutes	600-2,400x slower	10 ³
Neural/Brain Events	Visual cortex processing (first awareness)	~15 minutes total	9,000x slower	10 ⁴
Neural/Brain Events	Decision to catch ruler	~6 minutes	3,600x slower	10 ³
Neural/Brain Events	Peripheral nerve signal travel (brain to fingers)	~4 minutes	2,400x slower	10 ³
Neural/Brain Events	Finger muscle movement	~5 minutes	3,000x slower	10 ³
Neural/Brain Events	Total ruler-drop reflex (typical young adult)	~30 minutes	18,000x slower	10 ⁴
Neural/Brain Events	Total ruler-drop reflex (MMA fighter)	~22.5 minutes	13,500x slower	10 ⁴
Neural/Brain Events	Ruler falling through hand (no catch)	41.7 minutes	25,020x slower	10 ⁴
Technology	RAM memory access	10 milliseconds	10x faster	10 ⁻¹
Technology	SSD hard drive access	5 seconds	50x slower	10 ²
Technology	F-22 Raptor jet engine rotation	40 seconds	400x slower	10 ²
Technology	Car engine combustion cycle (cruising)	5 minutes	3,000x slower	10 ³
Technology	LED TV refresh (high refresh rate)	1.4 minutes	840x slower	10 ³
Technology	LED TV refresh (standard)	2.8 minutes	1,680x slower	10 ³
Technology	Video game frame (30 FPS)	5.5 minutes	3,300x slower	10 ³
Technology	Movie frame (24 FPS)	7 minutes	4,200x slower	10 ³
Technology	Analog watch second tick	3 hours	108,000x slower	10 ⁵