EXPLORATORY MATHEMATICAL REPORT

Collective Perceptual Trace Theory

A formal model of accumulated observation, shared beliefs, information compression, and the limits of a proposed influence on reality

$$\mathscr{A}_R(T) = \int_{t_0}^{T} N(t)\, n\, f_h\, q_R(t)\, \mathrm{d}t$$

Research questions

How large is humanity's accumulated perceptual trace? At what rate could it consolidate? Does it connect quantitatively to entropy, information-energy limits, or gravity? And what would be required to test the stronger hypothesis of reality generation?

8 November 2026

Research-style synthesis of the discussion and quantitative verification

Executive abstract

A proposed **Collective Perceptual Trace Theory (CPTT)** models the repeated perception of a phenomenon by human observers as an accumulating trace. Memories, cultural transmission, and scientific codification convert this stream into progressively stable shared representations. The motivating example is pre-Newtonian human experience of gravity, contrasted with a hypothetical civilization that intensively investigates anti-gravity.

The simplest trace functional is an integral over population, neuronal count, and an assumed sampling rate. Under the original illustrative inputs, the pre-1687 count is 3.44×10^{30} *neuron-snapshot units*. A reproducible reconstruction using published population anchors instead gives 3.78×10^{30}, a 9.6% difference. Neither value is Shannon information, a measured entropy, or a critical physical threshold.

A memory-decay equation supplies an equilibrium and a characteristic relaxation time. Known thermodynamics provides valid comparisons through Boltzmann's constant and Landauer's erasure bound. The numerical model, however, does *not* derive Newton's G, Planck's $\hbar$, or any demonstrated influence of beliefs on physical laws. The report makes this distinction explicit, and provides falsifiable experimental directions.

> **Scientific status.** The counting and dynamical equations below constitute a mathematically defined *exploratory model*. The claim that concentrated collective attention directly changes physical laws is a separate, *unverified hypothesis*. No successful numerical matching to a fundamental constant has been found.

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1 Motivation and scope

Every observer forms incomplete internal descriptions of a world they encounter. Repetition generates familiarity; communication, writing, photography, measurement, and 3D representations move parts of those descriptions into external media. A civilization can compress millions of disparate experiences into predictive formal laws. Newton's formulation of universal gravitation is an emblematic example: it unified terrestrial and celestial motion in a compact structure rather than merely restating many separate experiences [1].

The proposed theory has **two distinct levels**: (A) collective *representation* of physical reality and (B) collective *modification* of physical reality. A can be developed using standard mathematics and evaluated using psychological, historical, and information-science data. B requires a new physical interaction and independent experimental evidence.

What the theory calls a "trace"

A trace is a modeled record of perceptual activity directed at a target proposition or phenomenon R: for example, "objects fall toward the ground", "gravity is universal", or "a method of levitation could exist". It may be represented in an individual brain, a photograph, a scientific paper, or a cultural institution. Such representations can cause substantial social and technological changes. Their existence does not by itself establish the corresponding physical or supernatural claim.

Ideas concerning a deity, anti-gravity, or new forces therefore receive the same *formal treatment as hypotheses or beliefs*, not automatic certification as physical facts. Ancient experiences of falling objects also should not be equated with conscious recognition of Newton's inverse-square law.

Knowledge as compression

In minimum-description-length (MDL) language, a useful model lowers the length needed to encode the model plus the unexplained observations [7]:

$$L(\text{model}) + L(\text{data} \mid \text{model}) < L(\text{raw data}). \tag{1}$$

The inequality is a criterion to evaluate on particular data and models, not a guarantee that every elegant formula is true. Newton's law, in its domain of validity,

$$F = G\frac{m_1 m_2}{r^2}, \tag{2}$$

is a paradigmatic compact, predictive description. Later theories, including general relativity, refine its domain and interpretation.

2 The central mathematical model

Perfect accumulation

Define

$$\boxed{\mathscr{A}_R(T) = \int_{t_0}^{T} N(t)\, n\, f_h\, q_R(t)\, \mathrm{d}t.} \tag{3}$$

Symbol	Unit	Interpretation
$\mathscr{A}_R(T)$	count	Accumulated modeled neuron-snapshot units by time T
$N(t)$	persons	Number of observers at time t
n	neurons/person	Reference neural population per observer
f_h	s^{-1}	Assumed snapshot frequency, conventionally one per heartbeat
$q_R(t)$	dimensionless	Effective fraction of modeled activity assigned to R, from 0 to 1
t_0, T	time	Chosen observational interval

The formula integrates an *activity proxy*; it is not a measured number of thoughts. The one-heartbeat clock is imposed for simplicity, not a claim that perception is discretized by heartbeats. An all-neuron adult-brain count is also an approximation, particularly problematic for historical populations including children. Setting $q_R = 1$ is a mathematical upper-activity convention, not a realistic description of human cognition.

Flow and historical average

$$\Phi_R(t) = \frac{\mathrm{d}\mathscr{A}_R}{\mathrm{d}t} = n f_h N(t) q_R(t), \tag{4}$$

$$\overline{\Phi}_R = \frac{\mathscr{A}_R(T) - \mathscr{A}_R(t_0)}{T - t_0}. \tag{5}$$

Φ_R has units of modeled snapshot-count per second. It is *not* a thermodynamic entropy flow ($\mathrm{J\,K^{-1}\,s^{-1}}$), nor an independently validated information rate (bits/s).

Individual memories and correlated evidence

If one person revisits the same observation daily, raw trace counts increase. Independent evidential content need not. Under a simplified equicorrelation model with m observations and common correlation $\rho \in [0, 1]$, their effective independent sample size is

$$m_{\mathrm{eff}} = \frac{m}{1 + (m-1)\rho}. \tag{6}$$

When $\rho = 0$, $m_{\mathrm{eff}} = m$; when $\rho = 1$, $m_{\mathrm{eff}} = 1$. **Perfect retention is not perfect independence.** This distinction prevents repeated belief statements being mistaken for billions of independent physical measurements.

3 Historical gravity example: a numerical audit

Choose $t_0 = 50{,}000$ BCE and $T = 1687$ CE, the year of the *Principia* [1]. The starting date is a modeling boundary, not the beginning of consciousness. Use $n = 86 \times 10^9$ as a modern adult reference [3]; $f_h = 1\,\mathrm{s}^{-1}$; and $q_G = 1$ as a maximally simplified gravity-related allocation.

Original first-pass estimate

The initial discussion used $P_0 = 1.269 \times 10^{12}$ historical person-years. Under $1\,\mathrm{yr} = 31{,}557{,}600\,\mathrm{s}$:

$$\begin{aligned} \mathscr{A}_G^{(0)} &= P_0(31{,}557{,}600)(86 \times 10^9) \\ &\simeq \boxed{3.44 \times 10^{30}\ \text{neuron-snapshots}}; \end{aligned} \tag{7}$$

$$\overline{\Phi}_G^{(0)} \simeq 2.11 \times 10^{18}\ \mathrm{s}^{-1}. \tag{8}$$

The initial number of approximately 87.7 billion births between 50,000 BCE and 1687 is consistent in order of magnitude with the Population Reference Bureau's approximate historical tally, after excluding births before the chosen start date [2]. *Births are not person-years*: computing total exposure requires the population integrated over time.

Reproducible population reconstruction

The Population Reference Bureau supplies illustrative population anchors: 2 million (50,000 BCE), 5 million (8,000 BCE), 300 million (1 CE), 450 million (1200), 500 million (1650), and 795 million (1750) [2]. Interpolate *log-linearly* between each anchor:

$$N(t) = N_a \exp\!\left(\frac{t-a}{b-a} \ln \frac{N_b}{N_a}\right), \quad a \leqslant t \leqslant b. \tag{9}$$

Then $P = \int_{t_0}^{1687} N(t)\mathrm{d}t = 1.3913 \times 10^{12}$ person-years, giving

$$\boxed{\mathscr{A}_G^{\text{revised}} \simeq 3.78 \times 10^{30}; \qquad \overline{\Phi}_G^{\text{revised}} \simeq 2.31 \times 10^{18}\ \mathrm{s}^{-1}.} \tag{10}$$

The revised trace is 9.6% above the original because of the population-time reconstruction. Neither count is

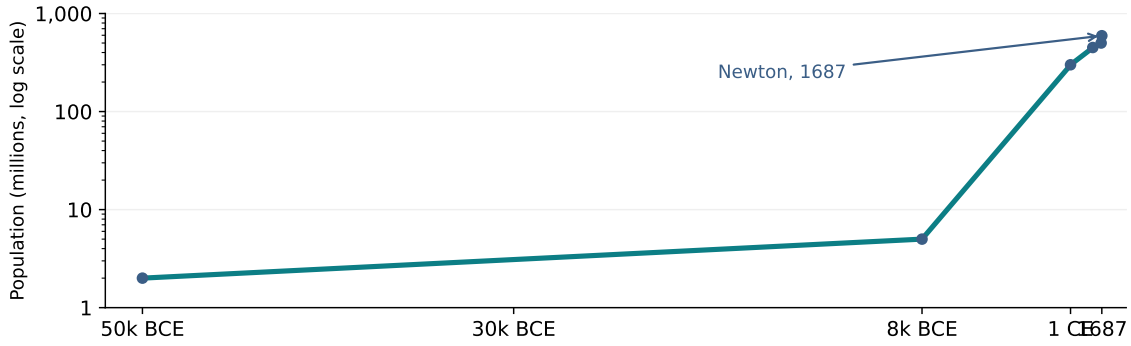


Figure 1: *Population reconstruction from published anchors. Interpolation is a modeling choice; prehistoric data have very large uncertainty.*

an empirically observed entropy constant.

4 Counterfactual anti-gravity scenario

The thought experiment directs a contemporary $N_c = 8 \times 10^9$ observers toward an anti-gravity concept. Use the past gravity trace as a *chosen comparison target*, $\mathscr{A}_*$, without assuming that reaching it creates a new force. With fixed N_c, n, f_h and q, no decay implies

$$\mathscr{A}_{\text{anti}}(t) = N_c n f_h q t, \qquad \boxed{t_* = \frac{\mathscr{A}_*}{N_c n f_h q}}. \tag{11}$$

For $q = 1$, the original trace is matched after ≈ 159 years; the revised PRB-based trace after ≈ 174 years. At $q = 0.1$, these comparison times become about 1,590 and 1,739 years. These are conditional arithmetic scales, **not lower bounds on discovering or altering gravity**.

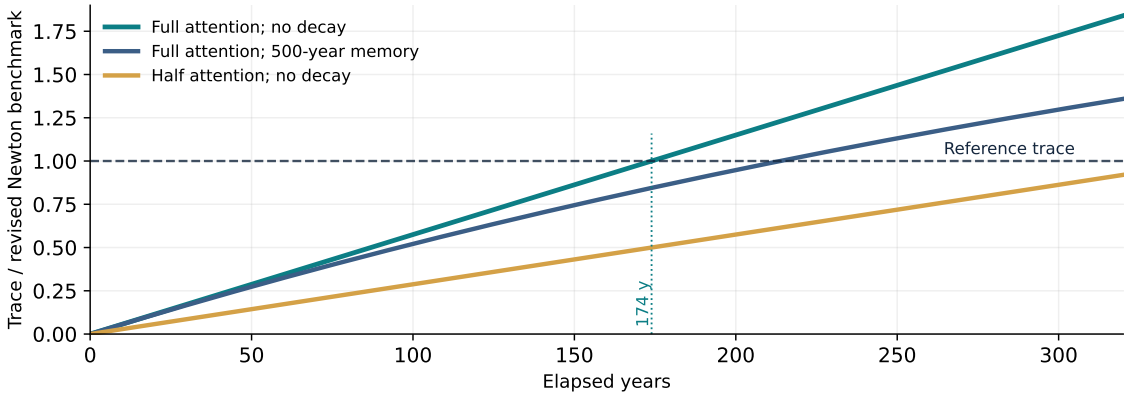


Figure 2: *Counterfactual accumulation relative to the revised historical target. Fixed population and simplified attention factors; the blue curve adds a 500-year decay time.*

> **Why the counterfactual is limited.** A billion people repeating "gravity does not exist" would create evidence that the *belief* is widespread, not evidence that gravitational acceleration had vanished. Collective effort can nonetheless change the physical world indirectly by inspiring experiments, technologies, institutions, and discoveries. Direct modification of G by belief has not been established.

5 Memory, equilibrium, and consolidation

Finite memory lifetime

Add an effective decay rate $\gamma = 1/\tau$ to the influx $J_R(t) = nf_h N(t) q_R(t)$:

$$\boxed{\frac{\mathrm{d}\mathscr{A}_R}{\mathrm{d}t} = J_R(t) - \frac{\mathscr{A}_R(t)}{\tau}.} \tag{12}$$

For constant input J and zero initial trace,

$$\mathscr{A}(t) = J\tau\left(1 - e^{-t/\tau}\right), \quad \mathscr{A}_{\mathrm{eq}} = J\tau, \quad \kappa = \frac{1}{\tau}. \tag{13}$$

κ is a relaxation constant with units s^{-1}, but its value would depend on the population, content, institutions, and retention medium. It is not a universal physical constant. The time to reach 95% of the equilibrium is $t_{95} = -\tau \ln 0.05 \approx 3\tau$.

With $\tau \to \infty$, the model has no forgetting and, under ongoing input, *no finite trace equilibrium*. The original assumption of perfect accumulation therefore yields continuing growth rather than equilibration. With $\tau = 500$ years, full contemporary modeled attention reaches the *revised* historical benchmark in about 214 years. With $\tau = 50$ years it never does because the equilibrium lies below that benchmark.

A separate, saturating consolidation index

An idea can become collectively normalized even while repetitions accumulate. Choose a phenomenological index

$$\boxed{C_R(t) = 1 - \exp\left(-\frac{\mathscr{A}_R(t)}{\mathscr{A}_*}\right).} \tag{14}$$

At $\mathscr{A}_R = \mathscr{A}_*$, $C_R = 1 - e^{-1} \simeq 63.2\%$. The 63.2% is a *feature of our chosen exponential function*, not a discovered cognitive threshold. Combining the decay law and saturation in one expression gives the general

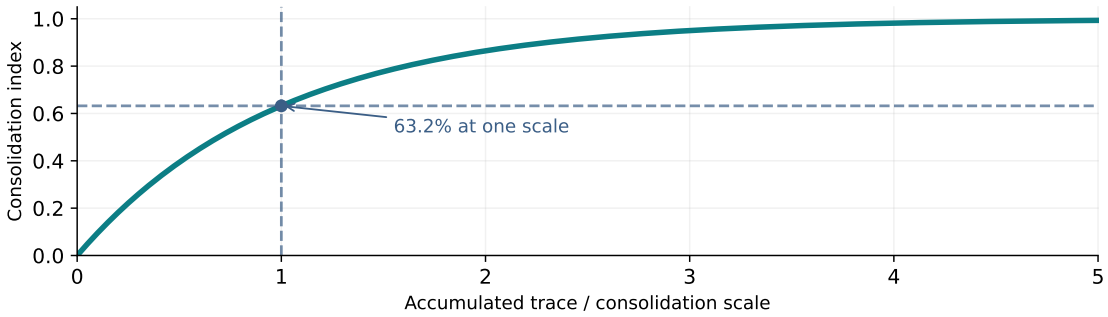


Figure 3: *Hypothetical consolidation saturation. Different functional forms fit different cognitive and cultural processes.*

nonconstant-input model:

$$\boxed{C_R(t) = 1 - \exp\left[-\frac{nf_h}{\mathscr{A}_*}\int_{t_0}^{t} N(s) q_R(s) e^{-(t-s)/\tau}\,\mathrm{d}s\right].} \tag{15}$$

6 Actual energy and entropy comparisons

Brain metabolic energy

A typical awake adult brain uses on the order of 10–20 watts; 20 W is the simplifying reference used here [4]. The historical expenditure proxy is

$$E_{\text{brain}} = P_{\text{brain}} \int_{t_0}^{1687} N(t)\mathrm{d}t. \tag{16}$$

Using 20 W and the earlier person-year estimate gives $E^{(0)} \simeq 8.01 \times 10^{20}\,\text{J}$; the revised person-year reconstruction gives $E^{\text{revised}} \simeq 8.78 \times 10^{20}\,\text{J}$. These represent whole-brain metabolic budgets under an implausibly uniform adult reference; they are not energy specifically expended on gravity.

Landauer limit: information versus heat

Boltzmann's constant k_B relates entropy to physical energy scales. For one logically irreversible classical-bit erasure in an ideal thermal environment at temperature T, Landauer's lower bound is [5]

$$E_{\text{erase,bit}} \geqslant k_B T \ln 2. \tag{17}$$

At $T = 310\,\text{K}$, $k_B T \ln 2 \simeq 2.97 \times 10^{-21}\,\text{J}$ per erased bit. *Only if* we arbitrarily map one modeled neuron-snapshot to one independently erased bit, the original trace would have a minimum erasure-energy equivalent of $\approx 1.02 \times 10^{10}\,\text{J}$. The ratio to the earlier metabolic budget is about 7.84×10^{10}. For the revised numbers the same ratio results because both numerator and denominator scale with person-years.

This ratio is not a fundamental constant. It largely reflects the reference assumption of 20 W distributed across 86 billion neurons at one counted snapshot per second; each neural event involves far more than one logical operation, and perception is not erasure.

A real thermodynamic entropy rate

With 8×10^9 adult-equivalent brains at 20 W, the total illustrative thermal power is $1.6 \times 10^{11}\,\text{W}$. If that heat is delivered to a reservoir near 310 K, the receiving reservoir's entropy rate is approximately

$$\dot{S}_{\text{heat}} \simeq \frac{P}{T} = \frac{1.6 \times 10^{11}}{310} \simeq \boxed{5.16 \times 10^8\,\text{J}\,\text{K}^{-1}\text{s}^{-1}}. \tag{18}$$

Dividing P by $k_B T \ln 2$ gives $\approx 5.39 \times 10^{31}$ minimum-erasure-*equivalent* bits/s. Neither number is a direct measure of conscious information, beliefs, or an intrinsic entropy of humanity.

7 Comparison with fundamental constants

Quantity	Reference value	Relation to CPTT
k_B	1.380649×10^{-23} J/K	Rigorous role in thermodynamic entropy and erasure [6]
$\hbar$	$1.054571817 \times 10^{-34}$ J s	No predicted or dimensionally natural match [6]
G	6.67430×10^{-11} $m^3kg^{-1}s^{-2}$	Cannot be derived from a dimensionless count and its rate [6]
t_P	5.391×10^{-44} s	No justified link with one-heartbeat snapshots [6]
κ	Model dependent, s^{-1}	Effective memory relaxation rate, not universal

A dimensional check is essential. A neural-event count has no inherent meters, kilograms, or joule-seconds. Multiplying and dividing unrelated quantities until a number resembles G or $\hbar$ cannot constitute a derivation.

For example, the adult per-neuron reference energy per one-second snapshot is approximately 2.33×10^{-10} J. If one *further assumes* its duration is 1 s, the constructed action is 2.33×10^{-10} J s, or $2.21 \times 10^{24}\hbar$. This is neither a match nor an invariant; changing the assumed interval changes it.

Genuine connections between entropy and gravitation

Black-hole thermodynamics gives the Bekenstein–Hawking relation [8,9]:

$$\boxed{S_{\mathrm{BH}} = \frac{k_B c^3 A}{4G\hbar}.} \tag{19}$$

It connects horizon area, gravity, quantum physics and thermodynamic entropy. Ted Jacobson derived Einstein's field equation from thermodynamic conditions on local spacetime horizons [10]. Erik Verlinde proposed a contested entropic-gravity scenario involving the heuristic entropic-force relation [11]

$$F = T\frac{\partial S}{\partial x}. \tag{20}$$

These are *physical* state-counting arguments; they do not identify entropy with the sum of subjective human observations. Equations (19) and (20) do not validate an observer-driven change in G.

> **Result of the constant search.** Thermodynamic constants provide legitimate *unit conversions and physical bounds*; no measured universal "collective-perception entropy constant" or convincing numerical prediction of G or $\hbar$ arises from the present assumptions.

8 What would make reality-generation testable?

The stronger conjecture requires a specified physical mechanism by which a mental or informational variable acts on a measurable physical field. As a deliberately minimal ansatz, define

$$\boxed{G_{\text{eff}}(t) = G_0\Big[1 + \lambda C_R(t)\Big]}. \tag{21}$$

Here λ is a dimensionless hypothetical coupling; C_R is an independently measured collective-consolidation proxy. A nonzero λ is *not established*. A field-theoretic implementation would additionally have to respect established conservation laws and pass astrophysical, laboratory and relativistic constraints.

A stringent test would (i) predefine how C_R is measured without using the outcome, (ii) randomize or compare carefully matched attention conditions, (iii) blind precision gravimetric measurements, (iv) control for temperature, vibration, tides, instrument drift and conventional forces, and (v) preregister statistical analysis and replicate independently. Current high-precision G measurements are challenging enough that instrument systematics and inter-experiment differences require careful assessment [12].

Possible tests at different levels

Hypothesis	Empirically measurable outcome	Status
Cultural consolidation	Idea adoption, agreement, reproduction, memory retention, communication networks	Feasible
Knowledge compression	Model length versus predictive error on held-out observations	Feasible
Information efficiency	Independently retained bits per joule in a specified neural or computing task	Feasible, difficult
Direct gravity coupling	Predeclared change in gravitational measurements correlated with exogenous C_R	Unsupported

A potentially useful quantity for the third row is

$$\Xi_R = \frac{I_{\text{retained,independent}}(R)}{E_{\text{acquisition+maintenance}}} \quad [\text{bits/J}]. \tag{22}$$

Unlike raw neuron-snapshot counting, this ratio could eventually be estimated for experimentally specified learning tasks. It still would not itself measure a change in gravity.

How to interpret religious or cultural examples

A collectively shared theological proposition can produce real buildings, rituals, texts, and institutions. These are physical and social effects of belief-mediated *action*. Such effects do not settle whether the proposition's supernatural referent exists. The mathematical framework must distinguish measuring societal belief from testing the external proposition to avoid circular reasoning.

9 Limitations, falsifiability, and conclusion

Current limitations

- The historical population curve is uncertain, especially across prehistory; the t_0 boundary is arbitrary.
- An average adult neural population does not apply unchanged to children or all historical observers.
- A heartbeat is not a validated neural snapshot clock; q_R has not been operationalized.
- Counted repeated traces may be strongly correlated, so repetition must not be mistaken for independent evidence.
- Thermodynamic entropy (J/K), Shannon information (bits), metabolic energy (J), and raw event counts are distinct quantities.
- The chosen historical Newton reference is not a discovery threshold, and no empirical law links $\mathscr{A}_*$ to fundamental-force changes.
- The relaxation and saturation laws are tractable ansatzes, not fitted observations.

What the calculations establish

The equations are internally consistent *as proxies* once their assumptions are stated. The initial pre-Newton reference trace was 3.44×10^{30} and its population-anchor reconstruction yields 3.78×10^{30} neuron-snapshots. Matching these counts with eight billion modeled observers takes, at the maximum assumed counting rate, approximately 159 or 174 years respectively. A finite-memory model yields a relaxation timescale and an equilibrium. Landauer's bound provides an energy benchmark and P/T gives a genuine thermal entropy rate under specified conditions.

No established constant was derived, no direct causal influence of consciousness on gravitation was demonstrated, and the historical count cannot predict when scientific discoveries must occur. The strong reality-generation claim should remain explicitly hypothetical unless a controlled experiment reveals an effect not accounted for by known physics.

> **Central synthesis.** The well-defined core of CPTT is a theory of *how collective representations accumulate, decay, and compress into shared models*. Its possible extension into a theory of *physical reality modification* is a sharply separate research question requiring a new measurable coupling.

A Calculation ledger and reproducibility

INPUTS COMMON TO BOTH RECONSTRUCTIONS

$$n = 86 \times 10^9 \text{ neurons/person}, \quad f_h = 1\,\text{s}^{-1}, \quad q = 1,$$
$$P_{\text{brain}} = 20\,\text{W}, \quad T = 310\,\text{K}, \quad N_c = 8 \times 10^9,$$
$$\Delta t \approx 51{,}686\ \text{yr}, \quad 1\ \text{yr} = 31{,}557{,}600\ \text{s}.$$

HISTORICAL INPUTS AND OUTPUTS

Quantity	First-pass baseline	Reconstructed population
Person-years	1.269×10^{12}	1.3913×10^{12}
Neuron-snapshot trace	3.444×10^{30}	3.776×10^{30}
Mean count flow (s^{-1})	2.11×10^{18}	2.31×10^{18}
Total modeled brain energy (J)	8.01×10^{20}	8.78×10^{20}
Time to match with 8×10^9 people	159 yr	174 yr
Hypothetical Landauer energy (J)	1.02×10^{10}	1.12×10^{10}

EXACT INTERPOLATION INTEGRAL FOR A POPULATION INTERVAL For anchors $(a, N_a), (b, N_b)$ with positive populations, define $g = \ln(N_b/N_a)/(b-a)$. Then

$$\int_a^b N(t)\,\mathrm{d}t = \begin{cases} \dfrac{N_b - N_a}{g}, & g \neq 0, \\ N_a(b-a), & g = 0. \end{cases} \tag{23}$$

Interpolating from 1650 to 1687 using the 1750 anchor yields $N(1687) \simeq 593.6$ million people. The integrated segments, in billions of person-years, are about 137.51 (50k–8k BCE), 576.48 (8k BCE–1 CE), 443.56 (1–1200), 213.55 (1200–1650), and 20.18 (1650–1687); sum 1,391.29 billion.

DECAY CROSSING CALCULATION For constant $J = N_c n f_h$ and target $\mathscr{A}_*$, the finite-memory crossing time, provided $\mathscr{A}_* < J\tau$, is

$$t_* = -\tau \ln\left(1 - \frac{\mathscr{A}_*}{J\tau}\right). \tag{24}$$

With $\mathscr{A}_* = 3.776 \times 10^{30}$ and $\tau = 500$ years, this is ≈ 213.7 years; with $\tau = 50$ years, the target exceeds equilibrium. The original baseline with $\tau = 500$ years produces about 191 years.

B Sources and source-status notes

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Source-status note. Population history is reconstructed from sparse evidence; constants and physiological reference values have empirical support, while CPTT's snapshot mapping, consolidation function, and hypothetical λ coupling are introduced in this report. All computed values are rounded to emphasize the uncertainty of the assumptions, not measurement precision.