Bone Is Lost in Half a Year and Regained in Ten: “Half-Life” Cannot Be One Number

— At a turnover of **10** % a year the time constant is **10** years and the half-life **6.931472** years, or **83.177662** months, so **0.632121** of the bone present today was laid down within the last decade — the separator is whether the time constant is the same in both directions — [Paper 693]

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— *From thinking to syncing.* —

Abstract

Bone mass is treated as one measurable number. But the speed at which that number moves differs by more than an order between losing and regaining.That “half-life” cannot be one number for one bone is counted here from the balance.No new theorem or law is claimed. First, bone remembers the history of loading with an exponential weight ——at 10 % a year the half-life is 6.931472 years, and 0.632121 of what is there today was laid down within the last decade (Section 2). **Second, the loss in weightlessness cannot come from halting formation alone——against the 0.075 observed in six months, halting formation while resorption runs as usual gives only 0.048771** (Section 2). **Third, so resorption must be accelerating——to reach the observed figure it must run at 1.559231 times its usual rate** (Section 2). **Fourth, and this is the core. The way back has no such acceleration——once loading returns, the deficit closes only at the turnover time constant, taking 6.931472 years to recover half** (Section 3). **Fifth, the asymmetry exceeds an order of magnitude——recovering half takes 13.862944 times as long as the loss took** (Section 3). **Sixth, the separator is whether the time constant is the same in both directions——if it is, “the half-life of bone mass” is one number; if not, no half-life can be quoted without naming a direction** (Section 4). **Keywords**: bone remodelling, time constant, half-life, history of loading, asymmetric response, disuse bone loss.

Scope of this paper (scope note): **No new theorem or law is claimed——bone turnover rates, the loss of bone in weightlessness and the slowness of recovery are all reported (Frost 1987, Martin et al. 1998).Physiology is not treated——the action of osteoclasts and osteoblasts and its hormonal control are not treated; a first-order relaxation is assumed.The figures are not claimed——a turnover of 10 % a year and a loss of 0.075 in six months are representative and differ greatly between sites.Clinical matters are not discussed——the diagnosis of osteoporosis, the action of drugs and prescriptions for exercise or nutrition are not the subject.The acceleration is not explained——the figure of 1.559231 is obtained by inverting a balance, and no physiological cause is offered.Relation to earlier papers**: **Paper 346 showed that for two of the three reaction orders "half-life" is not even a property of the substance——there what broke the single number was the order of the reaction; here it is the direction. The same word fails for two different reasons.**What is added is **obtaining a window of memory from the turnover time constant**, **showing the loss in weightlessness to exceed what halting formation gives, 0.048771 against 0.075**, **inverting that to an acceleration of 1.559231**, **putting the asymmetry with recovery at 13.862944**, and **placing the separator on whether the time constant depends on direction**.

1. Notation and the Question

Setting: **bone is resorbed and formed at a steady rate. Let k be the turnover rate and let the mass relax at first order towards an equilibrium B^{*} set by loading.**

$$\frac{dB}{dt} = -k\,(B - B^{*}), \qquad \tau = \frac{1}{k}, \qquad t_{1/2} = \frac{\ln 2}{k}, \qquad F(t) = 1 - e^{-kt}$$

$F(t)$ is the fraction of the bone present today that was laid down within the last t years. Take $k = 0.10$ per year.

Question: **can "the half-life of bone mass" be written as one number?**

2. Losing

Computation 2.1: **the time constant is 10 years and the half-life 6.931472 years, that is 83.177662 months. The fraction laid down within the last t years follows.**

within the last	fraction replaced
1 year	0.095163
5 years	0.393469
10 years	0.632121
20 years	0.864665

> **Observation 2.2**
>
> bone remembers not the present load but the history of loading, with an exponential weight.The last decade accounts for 0.632121 and the last two for 0.864665——a single measurement is a weighted average of a decade or more of living.

Computation 2.3: six months of weightlessness give an observed loss of 0.075. Halting formation while resorption continues at its usual rate would give only 0.048771.

> **Observation 2.4**
>
> what is missing names a mechanism.To reach the observed figure, resorption must run at 1.559231 times its usual rate——what happens when load is removed is not a pause but an active dismantling, and the difference between two numbers is enough to say so.

3. Regaining

Computation 3.1: once loading returns, the deficit closes at the turnover time constant of 10 years: half in 6.931472 years and nine tenths in 23.025851 years.

> **Observation 3.2**
>
> this is the core: the way back has nothing answering to the acceleration on the way down.Resorption speeds up when load is removed, but formation on return is still capped by the turnover time constant——only one side can move fast.

Computation 3.3: **the 6.931472 years to recover half is 13.862944 times the 0.5 years the loss took; to nine tenths it is 46.051702 times.**

> **Observation 3.4**
>
> **so “the half-life of bone mass” cannot be one number.Downwards it is a scale of months; upwards it is a scale of a decade——quoting a half-life without naming the direction gets the order of magnitude wrong.**

4. The Separator

> **Observation 4.1**
>
> **the separator is whether the time constant is the same in both directions.If it is, one number suffices; if it is not, the quantity describes a history rather than a state——that bone mass is a history is another way of saying that the two directions have different time constants.**

> **Observation 4.2**
>
> **beside Paper 346.Paper 346 showed that for two of the three reaction orders “half-life” is not even a property of the substance——there the single number failed because of the order of the reaction; here because of direction. One word fails for two different reasons.**

> **Observation 4.3**
>
> **what is not said.Physiology and clinical matters are not treated, and the 1.559231 is an inversion of a balance with no cause offered——what is shown is that the two directions differ by more than an order.**

5. Roll Call and Closing

1. **half-life 6.931472 years** (Computation 2.1): **from 10 % a year.**
2. **83.177662 months** (Computation 2.1): **the same number in months.**
3. **last decade 0.632121** (Computation 2.1): **the window of memory.**
4. **last two decades 0.864665** (Computation 2.1): **the weight of history.**

5. **halting gives only 0.048771** (Computation 2.3): **short of observation.**
6. **resorption at 1.559231** (Observation 2.4): **active dismantling.**
7. **half back in 6.931472 years** (Computation 3.1): **the core.**
8. **nine tenths in 23.025851** (Computation 3.1): **longer still.**
9. **a ratio of 13.862944** (Computation 3.3): **the asymmetry.**
10. **same time constant or not** (Observation 4.1): **the separator; Paper 346.**

Closing: **Bone is lost in half a year and regained in ten.At a turnover of 10 % a year the half-life is 6.931472 years and 0.632121 of the bone present today was laid down within the last decade——a single measurement is a weighted average of a decade or more of living.The 0.075 lost in six months of weightlessness cannot come from halting formation, which gives 0.048771; resorption must run at 1.559231 times its usual rate——removing load produces not a pause but an active dismantling.The way back has no such acceleration: recovering half takes 6.931472 years, 13.862944 times as long as the loss.So “the half-life of bone mass” cannot be one number——quoted without a direction, it is out by an order.The separator is whether the time constant is the same in both directions.Placed among the earlier papers——in Paper 346 the single number failed because of reaction order; here because of direction.To be honest——physiology and clinical matters are not treated, and the 1.559231 is an inversion of a balance.**

References

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