Precision Longevity

Precision Longevity

From the universal protocol to individual calibration

Kilian Füg

Published by Singular

2026

ISBN: 979-10-987013-1-3

Legal deposit: 2026 — Bibliothèque nationale de France

First edition

Published by Singular

To those closest to me.

"Life is the set of functions that resist death."

— Xavier Bichat

Physiological Researches on Life and Death, 1800

Contents

Preface **18**
The five-part method . . . 18
Editorial method . . . 19
Who this book is for . . . 19
Medical disclaimer . . . 20

Part I. The paradigm **21**

Chapter 1. The end of the universal protocol **22**
Why we age, and why it is not inevitable . . . 22
Healthspan, lifespan and the marginal decade . . . 23
The fourteen hallmarks of aging . . . 24
The measurable failure of the universal protocol . . . 25
Toward precision longevity . . . 27
Conclusion: reading your terrain . . . 28

Chapter 2. Precision: reading your terrain **29**
The terrain: three families of data . . . 29
Main panel: blood biomarkers . . . 29
Extended panel: blood biomarkers . . . 30
Extended panel: non-blood biomarkers . . . 31
Extended panel: stratification (Lp(a)) . . . 31
Extended panel: emerging biomarkers . . . 31
Functional markers . . . 32
Biological ages . . . 32
What genetics says and does not say . . . 33
The pace of measurement . . . 34
Conclusion . . . 35

Chapter 3. Hormesis: the good stress **36**
The inverted-U curve: universality of the principle . . . 36
Paradigmatic case: vitamin D . . . 37
The hormetic variables of longevity . . . 39
Sleep . . . 39
Fasting . . . 39
Physical exercise . . . 40
Thermal stress . . . 40
Hormetic supplements . . . 40
Calibrating within the hormetic zone . . . 40
The gardener's discipline . . . 41

Part II. The diagnosis **42**

Chapter 4. The essential biomarkers and their meaning **43**
Lipid profile: ApoB rather than LDL-C . . . 43

Lp(a): a signal of genetic stratification . . . 44
Omega-3 Index: calibration of membrane saturation . . . 45
ApoB/ApoA1 ratio and particle number . . . 45
Intermediate cardiovascular markers . . . 46
CAC score (Coronary Artery Calcium Score) . . . 46
Carotid IMT (Intima-Media Thickness) . . . 47
NT-proBNP . . . 47
Operational synthesis of the intermediate cardiovascular markers . . . 47
Glycemic control: HbA1c, HOMA-IR, fasting glucose . . . 48
Postprandial glycemic variability: CGM . . . 48
Vitamin status: vitamin D, B12, B9, P5P, homocysteine . . . 49
Vitamin D: the divergence between the clinical threshold and the Healthspan target . . . 49
Vitamin B12: total status and active fraction . . . 50
Pyridoxal-5'-phosphate (P5P): the active form of vitamin B6 . . . 52
Minerals and their balance: Mg, Zn, Cu, Cu/Zn ratio, Se . . . 53
Serum magnesium: availability and detection of excess . . . 53
Copper/zinc ratio: an integrative mineral-inflammatory marker . . . 53
Selenium: the narrow window . . . 54
Iron metabolism and oxygenation: ferritin, TSAT, hemoglobin, MCV . . . 54
Ferritin and TSAT: store, transport and inflammatory signal . . . 54
Hemoglobin, MCV and platelets: oxygenation and hematological terrain . . . 55
Renal filtration: cystatin C, combined eGFR, UACR . . . 55
Cystatin C and combined eGFR: renal function corrected for the muscular bias . . . 55
UACR: early glomerular detection . . . 56
Liver function: ALT, GGT, ALP, Albumin . . . 57
ALT and GGT: early metabolic sentinels . . . 57
Alkaline phosphatase (ALP): a hepatobiliary and bone sentinel . . . 57
Albumin: a nutritional and inflammatory reserve . . . 58
Thyroid function: TSH . . . 59
Sex hormones and the somatotropic axis . . . 60
Total, free testosterone and SHBG (men) . . . 60
Estradiol, progesterone and FSH (women) . . . 61
IGF-1: the paradox of the somatotropic axis . . . 61
HPA profile and allostatic load . . . 62
Salivary cortisol diurnal slope . . . 62
Chronic inflammation: hs-CRP and integrative reading . . . 63
NLR: an emerging marker of the inflammatory panel . . . 64
Emerging markers and the frontier . . . 64
Conclusion: from panel to profile . . . 65

Chapter 5. Biological profiles **66**
Biological sex: female and male . . . 66
The female profile: cycle, pregnancy, menopause . . . 66
The male profile: progressive andropause, androgenic axis, prostate screening . . . 67
Age: the inflections . . . 69
Chronotype and chronobiology . . . 69
Life contexts . . . 70
Cognitive and leadership load . . . 70
Declared chronic condition . . . 71
Convalescence after an acute event . . . 71

Conclusion: from profile to method . . . 71

Chapter 6. The N=1 protocol **72**
Why N=1 . . . 72
The method: five steps of the N=1 cycle . . . 73
Step 1. The baseline measurement . . . 74
Step 2. The isolation of the lever . . . 74
Step 3. The intervention in the hormetic zone . . . 75
Step 4. The retest within the relevant kinetics . . . 75
Step 5. The documented decision . . . 76
The methodological pitfalls . . . 76
The tools of N=1 . . . 77
The method laid down, on to the application . . . 78

Part III. The doses **79**

Chapter 7. Sleep: regularity as a dose **80**
Regularity as the primary dose . . . 80
Duration: the inverted-U curve of sleep . . . 82
Depth: the thermal engineering of sleep . . . 83
Environment and pre-sleep . . . 85
Obstructive sleep apnea: a pathological signal to screen for before calibrating . . . 86
Mapping of OSA . . . 86
Screening: STOP-BANG and the architecture of the tools . . . 87
Management levers and post-CPAP convalescence . . . 87
Why screen before the cycle . . . 88
The sleep N=1: protocol and markers . . . 88
Level of evidence of the sleep levers . . . 89
Conclusion: from sleep to the meal . . . 90

Chapter 8. Nutrition: glycemic curves, hormetic fasting, ratios **91**
The three macronutrient pillars . . . 91
The particular case of sodium: a recently documented U-shaped curve . . . 93
The individual glycemic curve . . . 93
Sweeteners: no blanket ban, N=1 calibration by profile . . . 95
Hormetic fasting . . . 97
Prolonged fasting and the Fasting-Mimicking Diet . . . 98
Omega-6/3 ratios, microbiota and chronic inflammation . . . 99
Hydration, dietary exposome and the alcohol myth . . . 101
Microplastics: the accumulated biological body of evidence . . . 101
Filtration: what works, what works less well . . . 102
PFAS, contact surfaces and concrete calibration . . . 102
Cooking: inert materials and the thermal stability of oils . . . 103
The myth of alcohol as a health ally . . . 104
Coffee and green tea: documented mortality levers . . . 104
Comparative mapping of dietary patterns . . . 106
The N=1 of nutrition: protocol and markers . . . 107
Level of evidence of the nutritional levers . . . 108
Conclusion: from fuel to engine . . . 109

Chapter 9. Exercise in Zone 2 **111**

Zone 2: mitohormesis applied . . . 111
VO_2 max: the cardinal functional marker . . . 113
Resistance training: the absolute priority . . . 114
Sarcopenia: 1% of muscle mass lost per year from the age of 40 . . . 114
Grip strength as a systemic proxy . . . 114
RT as a predictor of mortality independent of cardio . . . 115
Reversibility documented in 70-90-year-old profiles . . . 116
Stability as an axis distinct from RT and cardio . . . 116
RT as neuroprotection . . . 117
Creatine as a cellular metabolic facilitator . . . 118
Functional catalog for the marginal decade . . . 119
HIIT and the hormetic limit . . . 119
The integrated week: 80/20 quantified across five axes . . . 120
Blood pressure: Healthspan zone and trajectory . . . 120
The sport N=1: protocol and markers . . . 122
Level of evidence of the effort modalities . . . 123
Conclusion: from engine to cofactors . . . 124

Chapter 10. Supplements: the inverted-U curve applied **125**
The taxonomy: essentials against geroprotectors . . . 125
The essentials: four families, four kinetics . . . 126
Fat-soluble vitamins: D3 and K2-MK7 . . . 126
Water-soluble vitamins: C and the one-carbon cycle B6+B9+B12+TMG . . . 127
Structuring minerals: from bisglycinate to intra-family antagonisms . . . 128
Essential fatty acids: omega-3 EPA+DHA . . . 129
The geroprotectors: six families, six levels of evidence . . . 130
NAD+ and mitochondrial metabolites: NR, Ca-AKG, PQQ . . . 130
Creatine and structuring amino acids . . . 131
Selected phytonutrients: targeted inflammation and antioxidation . . . 132
Glycans and extracellular matrix: glucosamine, hyaluronic, trehalose . . . 133
Bioactive peptides: hydrolyzed collagens type I, type III and undenatured type II . . . 134
Medicinal mushrooms: reishi and maitake . . . 134
Targeted microbiota: galacto-oligosaccharides . . . 135
Bioavailability and forms . . . 135
Interactions and antagonisms . . . 135
Resveratrol as the paradigmatic case of exclusion . . . 136
Evidence matrix of the bioactives . . . 136
Conclusion: from cofactors to endogenous defenses . . . 138

Chapter 11. The exclusion filter **139**
The three selection filters . . . 139
Filter 1: insufficient bioavailability . . . 140
Filter 2: insufficient human clinical evidence . . . 141
Filter 3: unfavorable benefit-to-risk ratio . . . 142
The method is dynamic: what science will illuminate next . . . 144
Level of evidence of the exclusions . . . 145
Conclusion: from the filter to the interactions between bioactives . . . 146

Chapter 12. Interactions: synergies and antagonisms **147**
Mineral antagonisms and transporter competitions . . . 147

Vitamin and cofactor synergies . . . 149
Drug-nutrient interactions . . . 150
The N=1 of interactions: protocol and markers . . . 152
Level of evidence of the interactions . . . 153
Conclusion: from biochemical neighborhoods to exposure levers . . . 155

Chapter 13. Thermal stress: sauna, cold, light **156**
The sauna: a documented dose-response peak . . . 156
Cold exposure: protocol and limits . . . 158
Red and infrared light . . . 159
The thermal-stress N=1: protocol and markers . . . 160
Level of evidence of the thermal stressors . . . 161
Conclusion: from external stress to chronic internal stress . . . 162

Chapter 14. Chronic stress: the grammar of psychosocial exhaustion **163**
From hormesis to exhaustion: allostatic load . . . 163
Social isolation: an independent mortality factor of documented amplitude . . . 165
Occupational stress and the effect of life events . . . 166
Meaning, engagement and adherence as a meta-protocol variable . . . 167
Cognitive engagement and cognitive reserve . . . 168
The psychosocial N=1: markers and calibration . . . 170
Vagal breathing and HRV biofeedback . . . 171
Level of evidence of the allostatic-load markers . . . 171
Conclusion: from the lever to the tempo . . . 173

Part IV. The integration **174**

Chapter 15. Chronobiology: timing > dose **175**
The central clock and the peripheral clocks . . . 175
The timing of the levers: sleep, nutrition, exercise, supplementation . . . 176
Sleep and regularity of waking . . . 177
Exercise and chronotype . . . 177
Desynchronization and biological cost . . . 178
The chronobiological N=1: markers and protocol . . . 179
Level of evidence for the timing of the levers . . . 180
Circadian phase: integrative architecture . . . 182
Conclusion: from the daily tempo to the long rhythms . . . 182

Chapter 16. Individual cycles: menstrual, seasonal, aging **183**
The menstrual cycle: four biological phases . . . 183
The seasonal cycles . . . 185
The aging cycles by decades . . . 186
The cyclic N=1: an adaptive protocol . . . 187
Conclusion: from the theoretical frame to operational practice . . . 188

Part V. The practice **189**

Chapter 17. Protocols by profile **190**
The endurance athlete . . . 190
The active sedentary . . . 191
The inactive sedentary . . . 192

Perimenopause and postmenopause . . . 193
The post-cancer profile . . . 194
Optimal longevity . . . 195
Conclusion: from the template to the individual cycle . . . 196

Chapter 18. Bodily interfaces: skin, hair, dental, visual, auditory **198**
Skin: photoprotection, barrier, matrix regeneration . . . 198
Hair: androgenetic alopecia and greying . . . 200
Androgenetic alopecia . . . 200
Greying . . . 201
Dental: protocol, measures, oral-systemic axis . . . 201
Visual: retinal photoprotection, microcirculation, screening . . . 203
Typology of age-related visual disorders . . . 203
Screening: periodic examination and OCT imaging . . . 203
Nutritional calibration levers . . . 203
Boundary . . . 204
Auditory: presbycusis, dementia and early equipping . . . 204
A survey of presbycusis . . . 204
The Lancet Commission 2024 and the ACHIEVE trial . . . 204
Screening: pure-tone audiogram and clinical boundary . . . 205
Levers: early equipping, protection, nutritional calibration . . . 205
Synthesis: hearing, cognition and allostatic load . . . 205
Level of evidence of the bodily-interface levers . . . 205
Conclusion: from the local to the advanced systemic . . . 207

Chapter 19. Advanced therapies and the speculative frontier **208**
Longevity pharmacology: six drug classes under surveillance . . . 208
Senolytics and markers of cellular senescence . . . 209
Systemic bioactive peptides . . . 210
Cell therapies, parabiosis and blood donation . . . 211
Gene therapy and partial epigenetic reprogramming . . . 212
Epigenetic clocks and the discernment of biological age . . . 213
The microbiota of centenarians . . . 214
Personalized early oncological detection . . . 215
Mapping of oncological risk in longevity . . . 215
Organized screening validated in the general population . . . 215
Multi-cancer detection by circulating tumor DNA . . . 216
Personalized screening according to family history . . . 216
Adult vaccinations in longevity . . . 217
Framing: adult vaccination as a mortality lever . . . 217
Shingles and Shingrix . . . 217
Pneumococcus . . . 217
Annual influenza . . . 218
Respiratory syncytial virus . . . 218
COVID-19 . . . 218
Cognitive peripheries and final discernment . . . 218
Psychedelics and neuroplasticity . . . 218
Translational maturity matrix . . . 219
Conclusion: the discipline of discernment at the biomedical horizon . . . 221

Chapter 20. When to do nothing **222**
The hormetic ceiling: why *more* becomes *too much* . . . 222
Biological latency: why measuring too often lies . . . 223
The *deload*: recovery as an active lever . . . 224
N=1 wisdom: knowing when to stop . . . 225
Conclusion: precision longevity as a held discipline . . . 227

Afterword **228**
The genesis of Singular . . . 228
Acknowledgments . . . 228
What comes next . . . 229

Appendix. Reference circadian architecture: the timeline of an aligned day **230**
Phase 1. Morning activation (photic signal, post-waking cortisol peak) . . . 230
Phase 2. Daytime performance (morning insulin sensitivity, central thermal peak) . . . 230
Phase 3. Downward regulation (cortisol descent, melatonin rise) . . . 231
Closing note . . . 231

Glossary **232**
AGEs *(medical term)* . . . 232
AHI *(acronym)* . . . 232
Albumin *(Ch 4)* . . . 232
ALP *(alkaline phosphatase, Ch 4)* . . . 232
Allostasis / Homeostasis *(medical terms, Ch 14)* . . . 232
Allostatic load *(Ch 14)* . . . 232
AREDS2 *(clinical study)* . . . 233
ATBC *(clinical study)* . . . 233
Autophagy / Mitophagy *(medical terms)* . . . 233
Biological age *(Ch 2)* . . . 233
Biological feedback loop *(Ch 2)* . . . 233
Biological latency *(Ch 20)* . . . 233
Biological profile *(Ch 5)* . . . 234
Biological terrain *(Ch 2)* . . . 234
Blood pressure (BP) *(extended functional marker, Ch 9)* . . . 234
CAC score *(acronym)* . . . 234
Calibration *(Ch 1)* . . . 234
CARET *(clinical study)* . . . 235
Cellular senescence *(medical term, Ch 19)* . . . 235
CGM *(acronym, Ch 4 and Ch 8)* . . . 235
Chronotype *(Ch 5)* . . . 235
Circadian phase *(Ch 15)* . . . 235
Complementary synergy *(Ch 12)* . . . 235
DLMO *(acronym)* . . . 236
DNA methylation *(medical term)* . . . 236
DunedinPACE *(acronym)* . . . 236
Emerging frontier *(Ch 19)* . . . 236
Estradiol, progesterone and FSH *(female hormone panel, Ch 4 and Ch 17)* . . . 236
EWGSOP2 *(acronym)* . . . 236
FeAST *(clinical study)* . . . 236
Hallmarks of Aging *(Ch 1)* . . . 237

Healthspan vs Lifespan *(Ch 1)* . . . 237
Heat shock proteins *(medical term)* . . . 237
Holo-TC *(holotranscobalamin, Ch 4)* . . . 237
HOMA-IR *(acronym)* . . . 237
Hormesis *(Ch 3)* . . . 237
Hormetic zone *(Ch 3)* . . . 238
HRV *(acronym, extended functional marker, Ch 2)* . . . 238
IGF-1 *(Insulin-like Growth Factor 1, Ch 4 and Ch 17)* . . . 238
IMT *(acronym)* . . . 238
Inflammaging *(medical term, Ch 4)* . . . 238
Isolated lever *(Ch 6)* . . . 238
KIHD *(clinical study)* . . . 239
Level of evidence *(Ch 6)* . . . 239
Lp(a) *(lipoprotein(a), Ch 2 and Ch 4)* . . . 239
Marginal Decade *(Ch 1)* . . . 239
MCTQ *(acronym)* . . . 239
MISS *(clinical study)* . . . 239
Mitohormesis *(Ch 9)* . . . 240
N=1 *(Ch 6)* . . . 240
NHS / NHS II *(clinical studies)* . . . 240
NLST *(clinical study)* . . . 240
Novel Food *(EU regulatory category, Ch 11)* . . . 240
Nutritional antagonism *(Ch 12)* . . . 240
OCT *(acronym)* . . . 241
Odds ratio *(statistical term)* . . . 241
Omega-3 Index *(OmegaCheck, Ch 4 and Ch 10)* . . . 241
P5P *(pyridoxal-5'-phosphate, Ch 4)* . . . 241
Photobiomodulation *(medical term, Ch 13)* . . . 241
Precision Longevity *(Ch 1)* . . . 241
PURE *(clinical study)* . . . 242
RCV *(acronym, Ch 20)* . . . 242
Rectangularization of the survival curve *(Ch 1)* . . . 242
Regularity (of sleep) *(Ch 7)* . . . 242
Resting heart rate (RHR) *(extended functional marker, Ch 2)* . . . 242
Salivary cortisol diurnal slope *(Ch 4 and Ch 14)* . . . 242
Sarcopenia *(medical term)* . . . 243
SASP *(acronym, Ch 19)* . . . 243
SCAPIS *(clinical study)* . . . 243
SELECT *(clinical study)* . . . 243
Self-experimentation *(Ch 6)* . . . 243
SRI *(acronym, extended functional marker, Ch 2 and Ch 7)* . . . 243
SWAN *(clinical study)* . . . 243
TAME *(clinical study)* . . . 244
Thermal stress *(Ch 13)* . . . 244
Total testosterone, free testosterone and SHBG *(male hormone panel, Ch 4 and Ch 17)* . . . 244
TRE *(acronym)* . . . 244
UACR *(Urinary Albumin/Creatinine Ratio, Ch 4)* . . . 244
U-shaped curve *(Ch 3)* . . . 244
VITAL *(clinical study)* . . . 245
Vitamin B12 *(serum total cobalamin, Ch 4)* . . . 245

Alphabetical index **246**
Reading note . . . 246

Section 1. Bioactives **247**

Section 2. Biomarkers **248**
2.A. Main panel (31 blood biomarkers) . . . 248
2.B. Extended panel: blood biomarkers (8 markers) . . . 248
2.C. Extended panel: non-blood biomarkers (3 markers) . . . 248
2.D. Extended panel: stratification (Lp(a)) . . . 249
2.E. Extended panel: emerging and frontier . . . 249
2.F. Extended functional markers . . . 249

Bibliographie **250**

Preface

Longevity is won through the individual calibration of hormetic doses on a measured biological terrain, more than through the accumulation of universal protocols. This thesis structures the book you hold in your hands. It commands its architecture, its voice and its method.

For four decades, the optimized-health industry has been selling the illusion of an optimal protocol for everyone, calibrated on population averages that correspond to no real individual. Multivitamins, eight hours of sleep, ten thousand steps a day, five portions of fruit and vegetables: so many figures whose collective usefulness masks their individual inadequacy. At identical intake, two people do not convert the same dose into biological effect. At identical behavior, two organisms do not follow the same trajectory. Biology resists the average, and that is precisely where individual adjustment begins.

The paradigm has reversed over the past fifteen years or so. Threshold medicine, which asks whether a patient lies on one side or the other of a boundary, brilliantly managed the acute conditions of the twentieth century. But it remains structurally blind to the slow trajectories that lead to the threshold. For longevity, what counts is the slope rather than the threshold: its direction, the speed at which it is traveled, the room for maneuver it leaves for early intervention. Another instrument was required. It came from the convergence of several currents. The systems medicine of Leroy Hood and the Medicine 3.0 of Peter Attia laid down the logic of longitudinal follow-up. The cellular mapping of the Hallmarks of Aging formalized by Carlos López-Otín identified the intervention levers. The dose-response grammar of hormesis, refounded by Edward Calabrese, fixed the shape of the therapeutic window. The experimental economy of N=1, standardized in 2015 by the CONSORT extension for single-subject trials, supplied the protocol of self-observation. Each contributed a piece. We articulate them into a single, operational, falsifiable discipline: precision longevity.

I sign this book under my own name, but the authority expressed within it is collective, and clinical in nature above all. I am an engineer. Fifteen years spent designing highly technical banking architectures trained me in a particular discipline: the calibration of complex systems at the level of the individual, not of the average. It is that discipline I transpose here to the biological field. My signature commits my editorial responsibility for the method, but the clinical substance is not mine. This work of synthesis was conducted collectively by the scientific teams of Singular, a precision-longevity laboratory of which I am the founder. For the medical, pharmacological and nutritional substance, I do not arbitrate by authority: the only true standard remains the evidence, that of the researchers and clinicians who authored the nearly five hundred primary studies on which this book rests. My reading angle is deliberately that of the systems engineer: I architect biological data rather than produce it. The book assumes this perspective and makes it its method: precision longevity demands a logic of data integration that completes the excellence of traditional research without replacing it. No clinician holds, alone, the full breadth of contemporary longevity; only the rigorous aggregation of the world's literature allows one to approach it.

The five-part method

The book unfolds in five movements. The first lays down the conceptual frame (the end of the universal protocol, the reading of the biological terrain, the hormetic dose-response grammar). The second operationalizes this reading through a structuring blood panel, a biological-profile grid and a falsifiable N=1 method. The third applies the hormetic grammar to the fundamental levers of daily life. The fourth steps out of the lever-by-lever logic to treat the system as an orchestra (chronobiology, interactions, superimposed cycles). The fifth crystallizes the whole into six operational profiles, opens the emerging frontier of advanced therapies, and closes on the discipline of calibrated inaction.

Throughout the chapters you will cross a weave of pivotal concepts formalized at their first occurrence and then reused without redefinition: *calibration*, *hormesis*, *inverted-U curve*, *N=1*, *circadian phase*, *emerging frontier*, *biological latency*, and others. This definition strategy makes it possible to treat each concept in depth once and to articulate it with the others later on. The glossary at the end of the book gathers the list with the associated chapters.

Editorial method

We lay claim to a density of references unusual for the format. Across the whole, the chapters mobilize nearly five hundred primary PubMed or DOI references. This density answers to the very nature of the subject. Longevity is a field where speculation circulates freely, where study citations are frequently imprecise, where bibliographic hallucinations spread unchecked. Every quantified claim in the book points to a verifiable primary source, whose PubMed identifier allows direct consultation in a few clicks.

The style places the fact first, the study at the foot of the page. The cohort of 800 individuals fitted with continuous glucose monitors does not appear as "according to a recent study": it appears as the datum itself, cited by its number, its method, its year, and the primary reference that underpins it. A few signature studies recur by name because they structure paradigmatic inflections of the literature: the VITAL telomere trial of 2025, the Finnish KIHD cohort on the sauna, the SELECT trial on vitamin E, the regular-sleep analysis of the UK Biobank by Windred 2024, Lehallier's study of the proteomic waves. The rest remains in the background, cited with rigor but without narrative amplification.

You will find no brand mention in the body of the twenty chapters. We hold to this rule strictly, out of consistency with the chosen format. The book is neither a product manifesto nor a commercial journey disguised as a book of authority. Singular is named in this preface, for obvious editorial reasons, and in the afterword for readers who would like to take the reading further. The method belongs to the shared scientific conversation.

We name and discuss several contemporary methodological anti-models, when their example illuminates the contrast with serious calibration. Bryan Johnson and his Blueprint protocol, Liz Parrish and the gene-therapy program of BioViva, the company Ambrosia and its trade in young plasma are named in Chapter 19, within the frame of the emerging frontier. This transparency seems necessary to us. Biomedical tourism, very-high-risk undocumented self-experimentation, the confusion between a regulated clinical trial and a commercial offering, are drifts the reader must be able to identify without detour.

Who this book is for

This book is addressed to apparently healthy adults who wish to understand the logic of precision longevity before practicing it. It assumes a basic scientific curiosity, without requiring prior medical or biological training. The technical concepts are defined at their first occurrence, and the references allow the demanding reader to trace back to the primary sources.

Nor is it a substitute for clinical medicine. It is not addressed to the reader looking for a turnkey universal protocol, applicable without individual measurement or validation cycle, nor to the one who would want to short-circuit the medical follow-up of an active condition, a pregnancy, or an ongoing course of medication. For those situations, the precision calibration described here is not sufficient: it presupposes a coherent framework of care, which it completes but does not replace. Chapter 7 opens Part III with a reinforced warning that recalls this principle; it applies to all the practical chapters that follow.

If you are a health professional (functional physician, naturopath, pharmacist, dietitian, strength and conditioning coach), this book is for you too. It gathers into one operational frame elements scattered across the specialized literature, and it proposes a method of adjustment you will be able to transpose to your own practice. Several sections of Part II and Part IV were written with this dual audience in mind.

A final remark before handing over to Chapter 1. The method described here is demanding: it is built through repeated adjustments and patient observation, with no shortcut and no promise of spectacular results within a few weeks, and it does not erase the inequalities of access to biological measurement. We own that, and we mean to describe honestly the conditions of its practice.

Medical disclaimer

This book presents a scientific and methodological framework relating to longevity. It does not constitute medical advice, a diagnosis, a prescription or a treatment, and it is not a substitute for consulting a qualified health professional.

The biomarkers, assays, protocols and molecules mentioned in these pages fall within nutritional and behavioral well-being. The food supplements discussed are foodstuffs intended to complement a normal diet; they are not intended to diagnose, treat, cure or prevent any disease. Any individual application requires a prior medical evaluation, particularly in the case of an active condition, pregnancy or breastfeeding, concomitant medication, significant personal or family history, or any established health condition.

In case of doubt, of a new or persistent symptom, of a change to an existing treatment, or of any question relating to your health, consult your physician.

For the Singular collective authorship,

Kilian Füg — founder

June 2026

Part I. The paradigm

Three chapters lay down the intellectual frame of the book. Chapter 1 buries the universal promise and formulates precision longevity. Chapter 2 introduces the reading of the individual biological terrain as a methodological prerequisite. Chapter 3 maps hormesis, the dose-response grammar that governs the operational chapters to follow.

Chapter 1. The end of the universal protocol

The universal longevity protocol is a statistical fiction: no dose, no frequency, no bioactive acts identically on two individuals. The health industry nonetheless keeps selling what biology refutes at every measurement. Multivitamins represent a global market worth more than fifty billion dollars a year, built around the implicit assumption that the nutritional needs of a population of eight billion human beings can be summed up in a single tablet identical for everyone. The scientific literature of the past twenty years makes that assumption untenable.

Vitamin D requirements, glycemic responses to the same food, the absorbed fraction of a dose of iron: three variables that matter for health, and three orders of magnitude of variability from one individual to the next. The quantified demonstration of each will occupy a dedicated section further on. The conclusion is already mechanical: standardized prescription is, by construction, sub-optimal.

This book begins by burying the universal promise. It proposes another logic: individual *calibration*. We will call *calibration* the act of dosing a lever (nutrient, sleep, exercise, thermal exposure, and so on) to the specificity of a measured biological terrain, rather than to a statistical average.

A longevity strategy aims to add years of full life rather than raw years, and that distinction carries heavy consequences. Living ten more years in a state of progressive decline is no biological success. Biological success consists in maintaining high physical and cognitive performance for as long as possible, followed by a brief and late drop-off. That is what epidemiologists call rectangularization of the survival curve. It is the legitimate ambition of the twenty-first century.

The chapter is organized in five movements. The prior question, why we age and why that process belongs to a biological rationality rather than an act of faith, grounds the precision investment. The inadequacy of threshold medicine when faced with the demands of chronic longevity leads to the scientific framework of the mechanisms of cellular aging, the fourteen marks formalized by López-Otín and Kroemer. That framework makes the four measurable failures of the universal protocol intelligible: variability, bioavailability, dose-response, individual biology. From there emerges the need for a third path, which we will call *precision longevity*.

Why we age, and why it is not inevitable

Aging results from identified biological processes whose amplitude escapes genetic determinism by 75 to 80%, and a substantial fraction of which depends on modifiable variables, which anchors longevity in a discipline of engineering rather than in a programmed inevitability.

That claim is not self-evident. Common sense, and several centuries of medical literature, long treated aging as an inescapable drift, a background against which pathologies settle without it being, in itself, an object of intervention. Modern biology has shifted that boundary, without closing the debate on the exact nature of the phenomenon. Three readings coexist in the contemporary literature; what they converge on counts for more than what separates them.

The first reading is evolutionary. It holds that aging is a by-product of natural selection, which optimizes the capacity to pass on one's genes early in life, without exerting any compensatory pressure beyond the window of fertility. The theory of *antagonistic pleiotropy* formalized this in the classical literature: a gene favoring early reproduction may degrade later tissue function without selection acting against it. The *disposable soma* theory completed the argument: the organism allocates its resources to reproduction rather than to somatic maintenance, because unlimited maintenance has no evolutionary return. This reading explains why aging *exists* in sexed multicellular species, without describing its cellular mechanisms.

The second reading, mechanistic, addresses the way aging operates, short of the question of its existence. It groups into fourteen cellular and systemic marks the set of processes identified at the molecular scale. This taxonomy, formalized by

López-Otín and colleagues and then extended in 2025 by López-Otín and Kroemer, is the subject of broad consensus because it organizes without arbitrating: it describes the fourteen levers on which aging runs, while leaving open the question of whether it is programmed or undergone[1].

A third reading, more recent and more contested, proposes that the unifying cause of aging is a progressive loss of epigenetic information: the aged cell still knows its functions, but the regulation of gene expression blurs with the accumulation of stress and repairs. This hypothesis, defended in particular by David Sinclair, has not yet been demonstrated in humans on the basis of the results obtained in animals. Its structural reach nevertheless remains real: if the young information is preserved in the aged cell, then it can, in principle, be re-expressed. The preliminary work on partial cellular reprogramming, which we will return to in Chapter 19, gives this line of inquiry an experimental animal footing[2].

This book is ambitious about what it is possible to do, modest about the great questions of substance. The three readings converge on one decisive point: none supports the model of a closed biological inevitability. The evolutionary reading gives a historical reason for aging without making it an immutable program. The mechanistic reading maps identifiable levers. As for the third, it suggests that at least part of the drift is reversible.

The empirical argument for modifiability is harder. It depends on no particular theory. The heritable share of human longevity sits around 20 to 25%, established by the analysis of 2,872 pairs of Danish twins born between 1870 and 1900 and since confirmed in other populations[3]. The remaining 75 to 80% are not all steered by the individual: they combine modifiable behaviors (nutrition, sleep, exercise, chemical exposure, psychosocial stress) and a stochastic share, tied to chance and not individually controllable. The fraction genuinely actionable within that non-heritable envelope is enough to ground a discipline of precision. A randomized pilot trial conducted in 2021 in 43 men aged 50 to 72 under an 8-week multimodal protocol documented a 3.23-year reduction in epigenetic age, estimated from DNA methylation marks, compared with the control group[4]. Three years in eight weeks, in a cohort admittedly small and calling for replication, but on a marker that biology long held to be unidirectional.

If aging responds to interventions on its identified levers, then it belongs to a steerable process and not to a received fate. If the calibration of those levers shifts the markers of biological age within measurable windows, then individual precision investment has an expected biological return rather than a speculative one. This reversal of perspective promises neither immortality nor even full mastery of aging. It holds that, at an equivalent input of discipline, two trajectories diverge, and that this divergence can be measured.

It remains to specify in which direction this discipline should be exercised. The temporal window of action matters, and the objective bears as much on maintained function as on years added. The distinction between *lifespan* and *healthspan*, set out below, makes it possible to quantify that shift.

Healthspan, lifespan and the marginal decade

In the West, life expectancy has almost doubled since 1900, but healthy life expectancy has not followed the same pace. A person born in 1900 could expect to live about 45 years. A person born today exceeds 82. This spectacular progress is one of the great public-health victories in history. It nonetheless masks a problem that has become central in the epidemiological literature.

The *Global Burden of Disease Study 2021*, which analyzed 371 conditions across 204 countries over three decades, documents this gap with precision. The rise in total life expectancy was not accompanied by an equivalent rise in healthy functional life expectancy (HALE, for *Healthy Life Expectancy*)[5]. The gap has widened over the past twenty years. A growing portion of the years gained is lived with functional limitation: loss of mobility, cognitive decline, multimorbidity, that is, the coexistence of several chronic conditions in a single individual.

Let us set the canonical definitions before going further. *Healthspan* denotes the span of life in good functional health, that is, the period during which an individual retains physical and cognitive capacities at a level that defines an autonomous active life. *Lifespan* denotes total life duration, from the day of birth to the day of death. Rectangularization of the survival

curve aims to bring these two durations closer: at the limit, to ensure that the terminal decline is compressed into the shortest possible window at the end of life, rather than spread over fifteen or twenty years.

This ambition is not new. It was formalized scientifically in 1980 by James Fries in the *New England Journal of Medicine*, under the concept of *compression of morbidity*: shortening the phase of terminal decline instead of spreading it over years[6]. Fries proposed that the curve of human biological function could be deliberately modified by interventions on lifestyle, medical follow-up and environment, so that a high plateau is maintained until a late drop-off instead of sloping into progressive decline. The proposition was considered speculative at the time. It has since been broadly supported, even if the debate between compression, expansion and dynamic equilibrium of morbidity remains open.

We will call *Marginal Decade* the final period of life during which limitations, loss of autonomy and the accelerated degradation of quality of life accumulate. Statistically, this decade is almost always present in one form or another. The compression of morbidity consists in pushing it back or shortening it. Any serious longevity strategy is evaluated on this metric: how many years pushed back on the marginal decade, how many additional years of maintained function.

The room for action on this marginal decade is real. The majority of what separates two end-of-life trajectories is built in repeated behaviors, and what is built can, by method, be calibrated. A substantial part of your biological trajectory is thus played out in your repeated decisions on identifiable levers, not only in your genes or your family fate.

Twentieth-century mainstream medicine is not equipped to exploit this margin. Its diagnostic architecture rests on thresholds. Your LDL cholesterol, the lipid fraction associated with cardiovascular risk, is at 1.89 g/L: you are categorized as normal. It rises to 1.92 g/L: you change category, management is initiated. This threshold logic is effective for acute conditions. It remains blind to the slow trajectories that lead to the threshold. The pertinent question becomes: in which direction is your biology moving, and can that trajectory be modified today?

This reorientation is the pivot of the book. It presupposes another object of analysis: no longer the declared pathological state, but the underlying biological mechanism that produces that state years before it manifests. This mechanism, contemporary science has identified fourteen faces of it.

The fourteen hallmarks of aging

For a long time, "aging" was a word more than a scientific object. Three decades of cellular gerontology have broken it down into fourteen distinct biological mechanisms, identifiable, measurable, and (the cardinal point) modifiable.

The reference scientific framework was formalized by Carlos López-Otín and colleagues in a series of articles published in the journal *Cell*: nine marks in 2013, twelve in an expanded revision in 2023[7], then fourteen in 2025 with the addition of the extracellular matrix and psychosocial isolation, under the banner of precision geromedicine[8]. This taxonomy groups the biological processes of aging into fourteen marks (the *hallmarks*), spread across three functional families: the primary marks, causes of cellular damage; the antagonistic marks, stress responses that become deleterious over time; the integrative marks, systemic consequences at the scale of the organism.

Let us define the *Hallmarks of Aging* as the fourteen cellular and systemic marks that constitute the operational framework of the intervention levers in longevity. They are what structure the entire architecture of this book. Sleep, nutrition, sport, supplements, thermal exposure, chronobiology: each pillar treated in the following parts acts on one or more of these marks, which turns a catalog of levers into an ordered system: none acts on "aging in general", a concept too vague to be actionable, but each on precise and measurable mechanisms.

The five primary marks describe the cellular damage accumulated over time. Genomic instability: the breaks and alterations of DNA that accumulate as cells divide and as the repair mechanisms degrade. Telomere erosion: the protective ends of the chromosomes shorten at each division, until they compromise chromosomal stability. Epigenetic alterations: the chemical marks that regulate gene expression are modified with age and progressively reprogram cellular function. Two mechanisms carry them: DNA methylation, which switches a gene off or on without modifying its sequence, and the modification of histones, those proteins around which DNA winds, which changes its accessibility to the reading machinery. Loss of proteostasis: the balance between synthesis, folding and degradation of proteins degrades, leading to the accumulation of

toxic protein aggregates. Defective autophagy: the cellular system for recycling damaged components (autophagy, literally "self-eating") loses efficiency, letting intracellular waste accumulate.

The three antagonistic marks describe biological responses that are initially protective, but that become counterproductive in the long run. Deregulated nutrient sensing: the signaling pathways that detect caloric intake become less precise and disrupt the balance between cellular growth and maintenance. Three main actors carry this signal. mTOR (*mechanistic target of rapamycin*) commands cellular growth in the presence of nutrients. AMPK (*AMP-activated protein kinase*) answers it in energy shortage by activating economy mode. The insulin pathway translates carbohydrate intake into a storage signal. Mitochondrial dysfunction: the cellular power plants (the mitochondria) produce less ATP, their fuel, and more reactive oxygen species (the ROS), oxidizing molecules that damage internal structures as they accumulate, which feeds a vicious circle of cellular wear. Cellular senescence: certain cells stop dividing while remaining alive, and secrete an inflammatory cocktail that degrades the surrounding tissues.

The six integrative marks, finally, describe the systemic consequences that manifest at the scale of the whole organism. Stem-cell exhaustion: the capacity for tissue regeneration dwindles. Altered intercellular communication: the hormonal and neuronal signals that orchestrate physiological balance become less precise. Chronic low-grade inflammation (*inflammaging*): a background inflammatory state that persists without any identifiable infectious cause and silently degrades the tissues. Dysbiosis: the imbalance of the intestinal and skin microbiota that disrupts digestion, immunity and communication with the central nervous system. Alteration of the extracellular matrix: the weave of collagen and elastic fibers that supports the tissues stiffens and degrades with age. Psychosocial isolation: the deficit of social connection and the chronic psychic load inscribe themselves in the biology of aging and weigh, independently of the other factors, on the mortality trajectory.

This framework is no academic curiosity. It is the operational language of modern longevity. Deep sleep activates cerebral autophagy and regulates inflammation. Intermittent fasting modulates the mTOR pathway and stimulates mitophagy (the specific recycling of failing mitochondria). Zone 2 training, a moderate aerobic intensity where conversation remains possible, improves mitochondrial function and intercellular communication. Antioxidant bioactives support genomic stability and mitochondrial function. Circadian regularity, the stability of biological rhythms over the 24-hour cycle, synchronizes the peripheral clocks and limits the deregulation of nutrient sensing.

Every lever this book is going to calibrate, chapter after chapter, falls within this taxonomy. That is what makes calibration possible.

A practical difficulty nevertheless persists: once the levers are identified, it still remains to determine which to calibrate, at what dose, at what moment, for which individual. The standard answer, one tablet for everyone, is precisely what biology refutes.

The measurable failure of the universal protocol

A single tablet for billions of organisms: stated baldly, the multivitamin hypothesis collapses on its own. This biological aberration rests on four structural failures that can be quantified, each reproduced in large-scale randomized trials.

The first bears on ignored between-individual variability. When a manufacturer formulates a multivitamin, it relies on the Recommended Daily Allowances (RDA), also called Nutrient Reference Values. These values are single blanket benchmarks, fixed for a general population assumed homogeneous and not for an individual. They ignore precise age, sex, physical activity, body composition, actual diet, sun exposure, genetic polymorphisms (natural variations in the DNA sequence between individuals). Above all, they ignore individual dispersion. And that dispersion can be considerable. Vitamin D status illustrates the point with brutal clarity: at identical intake, the circulating concentrations of 25-hydroxyvitamin D vary by a factor of 1 to 10 between two individuals[9]. Skin pigmentation, latitude of residence, body mass index, polymorphism of the VDR receptor (*Vitamin D Receptor*): each of these parameters shifts the equation by several orders of magnitude. The NRV for vitamin D, fixed at 5 µg per day, is therefore either insufficient or excessive for almost every individual; the reference intake covering 97.5% of the population is estimated at around 15 µg, three times as much. It is optimal for no one in particular.

This variability of absorption is not played out only between bodies. It is also played out upstream, in the molecular form ingested (this is the second failure, ignored bioavailability). The dose displayed on a supplement label reflects the quantity ingested, never the quantity absorbed. Between ingestion and absorption lie gastric dissolution, transport across the intestinal barrier and hepatic passage. The molecular form of a bioactive determines the efficiency of each of these steps. The gaps are not marginal: they reach an order of magnitude. A clinical trial in infants with a high iron requirement compared two forms of this mineral. The bioavailability of iron bisglycinate came to 90.9%. That of ferrous sulfate, present in the majority of low-end formulas, came to 26.7%[10]. The same figure announced on the label, 14 mg of elemental iron, thus delivers, in one case, the equivalent of 12.7 mg absorbed, and in the other, the equivalent of 3.7 mg absorbed. The ratio is more than three to one. The same gap of form is found for magnesium, vitamin B12 and vitamin B9 (oxide, cyanocobalamin and folic acid against their better-assimilated forms). Displaying a dose without specifying the molecular form produces a figure compliant with the regulation but devoid of verifiable biological meaning.

The third failure inverts the intuition of the previous section. Once the dose is absorbed, the implicit premise of the multivitamin remains that an additional intake is, by default, beneficial or neutral. This premise is false for the fat-soluble vitamins. Unlike most water-soluble vitamins (group B, vitamin C), mostly eliminated by the urinary route in case of excess, the fat-soluble ones (A, D, E, K) accumulate in the liver and the adipose tissues. Pyridoxine (vitamin B6) is the exception on the water-soluble side: at high chronic dose, it can cause a sensory neuropathy (damage to the peripheral nerves of sensation), which earns it an explicit safety upper limit. For the fat-soluble vitamins, chronic excess is not inert: it is deleterious. The SELECT trial, conducted in 35,533 healthy men, compared vitamin E supplementation (400 IU per day) with a placebo. Long-term follow-up documented a significant increase in the risk of prostate cancer in the supplemented group[11]. A dose presented as preventive proved harmful at the scale of a cohort of several tens of thousands of men. The lesson is clear. More is not better. For the fat-soluble nutrients, the dose-response relationship follows a U-shaped curve, where too low an intake and an excess both degrade the expected benefit. The optimal window is measured individually, case by case. We will return to this central principle of hormesis in Chapter 3.

To these three sources of error is added individual biology itself, ignored by any standardized prescription. A cohort of 800 individuals fitted with continuous glucose monitors for a week, over 46,898 standardized meals, established that, for an identical food, glycemic responses vary radically from one individual to the next[12]. The same slice of bread can raise blood glucose modestly in one subject and brutally in another. The explanatory factors are numerous: composition of the intestinal microbiota, insulin sensitivity, metabolic profile, dietary history. None of these factors is captured by general dietary recommendations.

These four failures are not independent. They add up. A standardized supplement that ignores between-individual variability, that chooses poorly bioavailable forms, that applies a uniform dose and that presupposes a homogeneous biological response, mechanically accumulates the sources of error. The final product is, in the majority of cases, biologically inert, deleterious for an unfavorable minority, sub-optimal for the rest. The probability that it is genuinely suited to a particular individual, by statistical chance, is low.

The supplementation industry has built its economic model on the aggregation of this inefficiency. It sells tablets to tens of millions of people by betting on the absence of individual measurement that would reveal the gap between the promise and the real effect. This absence of measurement is the Achilles heel of the model. As soon as an individual measures their own biological status (blood concentrations, lipid biomarkers, inflammatory markers), the gap becomes visible. And the gap is, in the majority of cases, considerable.

The multivitamin is not the only one in the dock. Any nutritional or behavioral prescription that ignores the individual terrain shares these four breakdowns. So it is with the universal recommendations of eight hours of sleep, of five portions of fruit and vegetables, of ten thousand steps a day, of seven to nine hours in bed. These figures remain exact but incomplete: they describe an average that matches no real individual. The pertinent question refines “how many hours to sleep” into “how many hours to sleep for you, at your age, with your chronotype, in your context of stress, at this season”. The same question applies to every lever. And the answer requires a substrate of measurement.

Toward precision longevity

Three methodological principles are enough to carry the whole of precision longevity. Here they are in their condensed version, before the rest of the book unfolds them.

The most fundamental principle is that no optimal dose is either zero or infinite: the beneficial effect lodges in a narrow and individual window, which is measured rather than guessed. This is hormesis, whose U-shaped curve will be formally defined in Chapter 3. Operationally, this principle governs all the calibrations of Part III, from sleep to supplements by way of sport.

To this principle of dose is added a second one that concerns the subject rather than the substance: biology does not average. What statistics call "the average" has no individual biological reality. The cohort on individual glycemic responses demonstrated it for nutrition[13]. The studies on sleep confirm it for chronobiology. The meta-analyses on supplementation confirm it for bioactives. The methodological consequence is that personal calibration requires a rigorous protocol of self-observation: measure an initial state, intervene on a single lever at a time, measure again, adjust. This protocol, which epidemiologists call the N=1 experiment, will be developed in Chapter 6. It is the practical tool of precision longevity.

The third principle is more economical: a limited number of structuring markers covers the majority of decisions. The method deployed in this book identifies a few essential biomarkers: vitamin D, ferritin, magnesium, vitamin B12, hs-CRP (high-sensitivity C-reactive protein). On their own, these markers cover a decisive share of nutritional calibration decisions. The operational sequence does not change: measure, interpret, calibrate, retest over three to six months. The rigor lies in the sequence and in the quality of the markers chosen, beyond their number alone. Chapter 4 will return to these markers one by one.

These three principles are interdependent. Without the inverted-U curve, calibration has no window. Without N=1, it has no validation. And without the biomarkers, it has no substrate on which to act. Together, they define an operational discipline. This discipline does not present itself as an absolute novelty. It belongs to a well-identified intellectual lineage.

The historical pivot is known. The concept of *P4* medicine (*Predictive, Preventive, Personalized, Participatory*) was formalized in 2012 in a reference article in *New Biotechnology* by Leroy Hood and Mauricio Flores[14]. This formalization was not speculative: it drew on three decades of convergent progress in systems biology, in genomics, in the longitudinal analysis of biomarkers. Peter Attia, in *Outlive*, popularized the notion of Medicine 3.0 that derives directly from it: a proactive, longitudinal and personalized medicine, which acts on trajectories well before the biomarkers cross the diagnostic thresholds of classical medicine. The operational application to the nutritional field was synthesized in a reference article in the *BMJ* in 2018, which lays the methodological foundations of personalized nutrition grounded in individual biology rather than population averages[15].

Precision longevity is the convergence of these two currents. It inherits from the medical framework (Hood, Attia) the logic of longitudinal follow-up and early intervention. It inherits from the nutritional framework the logic of individual calibration grounded in biomarkers. It adds the rigor of the hormetic dose-response, which turns each lever into a narrow-window variable calibrated individually.

This is the framework within which precision longevity is set. The reading of the available data suggests that the majority of the inefficiencies of supplementation and of general recommendations stems from a single structural cause: the absence of calibration. When calibration is rigorous (biomarkers measured, bioavailable forms selected, doses adjusted to the individual terrain, retests planned), results become traceable and reproducible.

This book is a manual of calibration rather than a catalog of doses: it teaches how to measure, interpret and adjust. It offers a methodological framework to turn each reader into an analyst of their own biological terrain. This shift, from the prescriptive toward the analytical, conditions everything that follows: it calls for a concrete object, the terrain to be read, which the next chapter is going to define.

Conclusion: reading your terrain

If the universal fails, the bespoke requires a substrate. Calibration cannot be guessed by introspection nor deduced from the average of a population. It requires an objective, repeated, comparable measurement, anchored in precise biological markers. This substrate is your individual biological terrain. It is the object of the next chapter.

Reading your biological terrain is the founding act of precision longevity, the precondition of all the others. As long as the terrain is not read, any intervention is a supposition. Once the terrain is read, each intervention becomes a measurable, adjustable, falsifiable test. Supplementation then belongs to a practice of engineering, governed by measurement and not by belief. Sleep shifts from the status of an average recommendation to that of an individual variable calibrated on your chronotype, your mental load, your season. Exercise moves from the step counter toward a graded protocol, suited to your VO_2 max, your maximum oxygen consumption under effort, and to your mitochondrial capacity to produce energy aerobically in a sustained way.

The sequence of the book follows this logic. Chapter 2 presents your biological terrain and the three families of data that describe it; Chapter 4 will then develop the essential biomarkers marker by marker. Chapter 3 introduces hormesis as a universal dose-response framework applicable to every lever. The following chapters work this framework through pillar by pillar.

The end of the universal protocol is a liberation: it makes you the actor of your own biology. To exercise that power to act, you have to begin by looking. That is the subject of the next chapter.