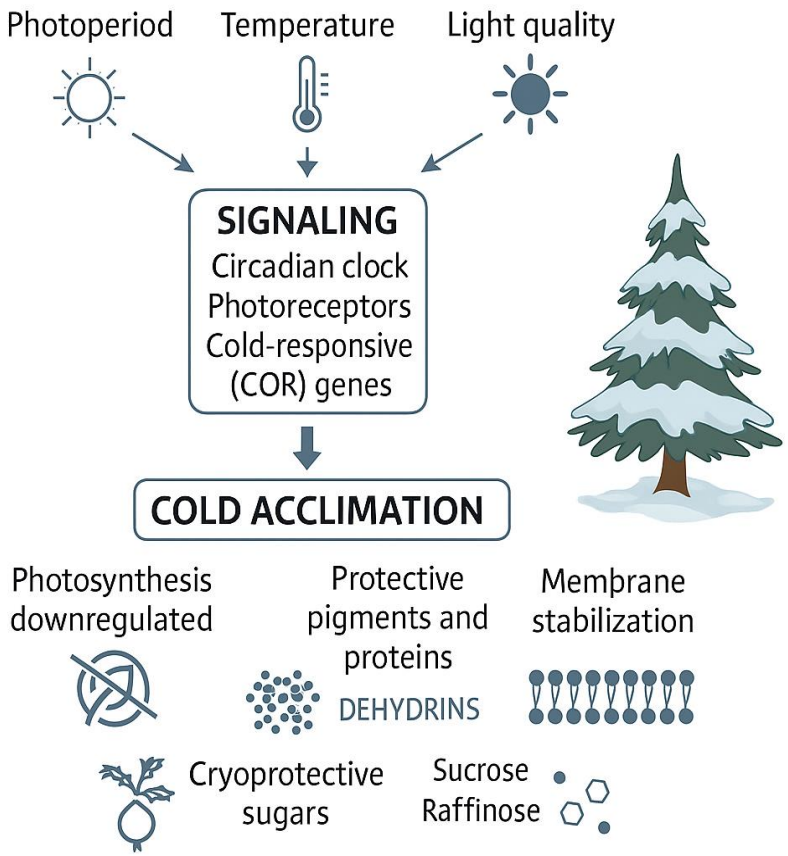

"From Needle to Longevity: Conifer Terpenes as Next-Generation Geroprotectors"

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20.11.25

SilvExpo

Longevity Alliance Baltic

Supplement industry is going to precision

- Conventional supplements are formulations of generic powders and fancy waters that have higher marketing budgets than research and development (R&D) expenditures.
- Today, wellness startups are rejecting unclear claims and mass-market formulas to build genuine health additions and integrations backed by clinical evidence, targeted nutrition, and regulatory compliance.
- This structural reorientation in the nutraceuticals and supplements market is steered by tighter EFSA oversight, consumer awareness, and the economics of credibility.
- As the rules of the ecosystem change, winners will treat supplements less like fast-moving consumer goods and more like science-backed healthcare products.

From Mass-Market To Precision: Rethinking Supplements

- Supplement market is shifting from storytelling to science.
- COVID-19 created a new consumer mindset: people now expect proof, transparency, and clinically validated ingredients.
- Startups that embed science and compliance early have an advantage, while legacy mass players struggle to adapt.
- With rising costs and competition, evidence-based innovation is becoming the only sustainable competitive edge.
- Supplement industry is evolving into a science-driven ecosystem, where trust, data, and real efficacy determine winners.

Supplement Industry Innovation Dilemma: Condition-Specific vs. Multifunctional

- **Condition-Specific:** a supplement that targets a health condition. There are dozens of health conditions that supplements might provide prevention benefits for, such as brain health, healthy aging, beauty from within, heart health, diabetes, menopause, and weight management.
- **Multifunctional:** a supplement that mashes together two or more condition-specific intents that are usually complementary or have adjacency in the consumer's mind. You could at times here industry jargon like "name a condition-specific" plus (i.e. gut health plus or immune health plus).

Longevity (Healthy aging) supplements

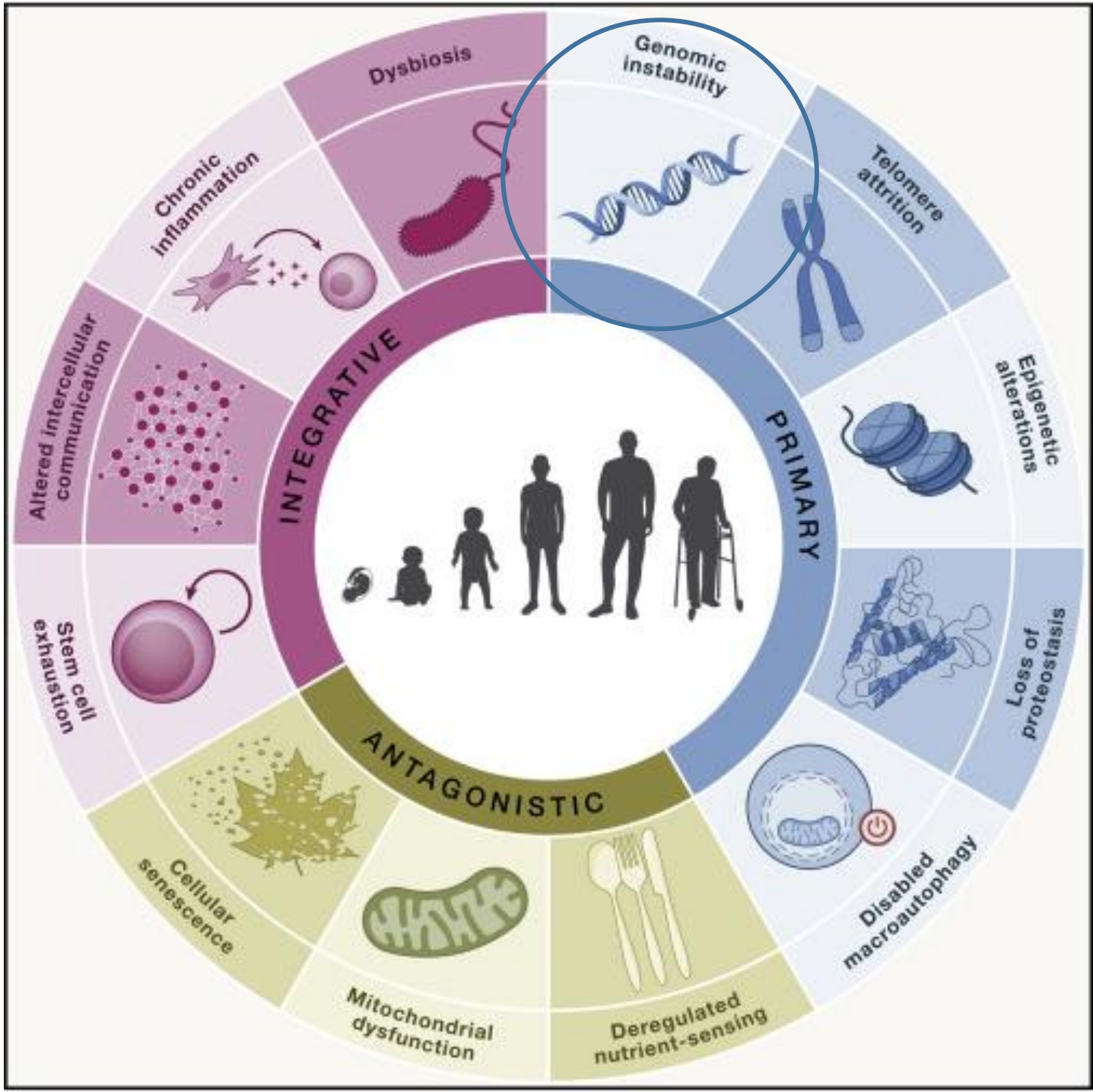
- Longevity supplements represent a fast-growing new category focused on slowing aging at the cellular level, not just improving general wellness.
- These products use science-backed bioactives—such as NAD+ boosters, senolytics, mitochondria-support compounds, and antioxidant terpenes—to target the biological mechanisms of aging.
- Unlike traditional vitamins, longevity supplements are positioned as evidence-driven interventions aimed at extending healthspan, improving metabolic and cognitive resilience, and preventing age-related decline.
- This segment is emerging as a premium, research-first market shaped by advances in biogerontology and rising consumer demand for proactive, science-validated health strategies.

Longevity supplements aim to extend healthspan by addressing the core biological processes that drive aging.
They typically focus on the Hallmarks of Aging identified in geroscience.

Aging is a progressive decline of ability to repair damage.

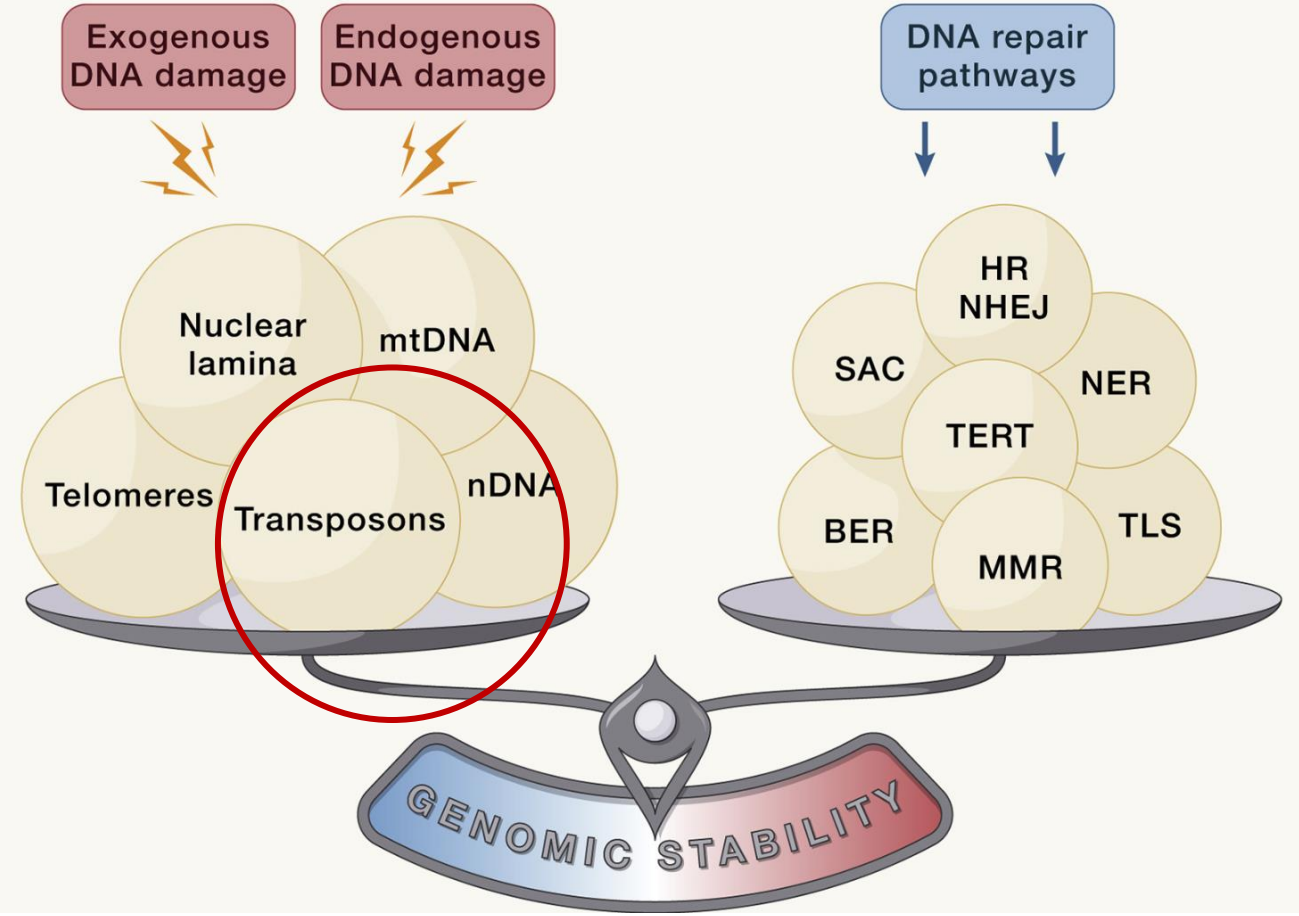
The hallmarks of aging are the types of biochemical changes that occur in all organisms that experience biological aging and lead to a progressive loss of physiological integrity, impaired function and, eventually, death.

Lopez-Otin C et al. 2022



GENOMIC INSTABILITY

Endogenous or exogenous agents cause a variety of DNA lesions that contribute to both normal and pathological aging.



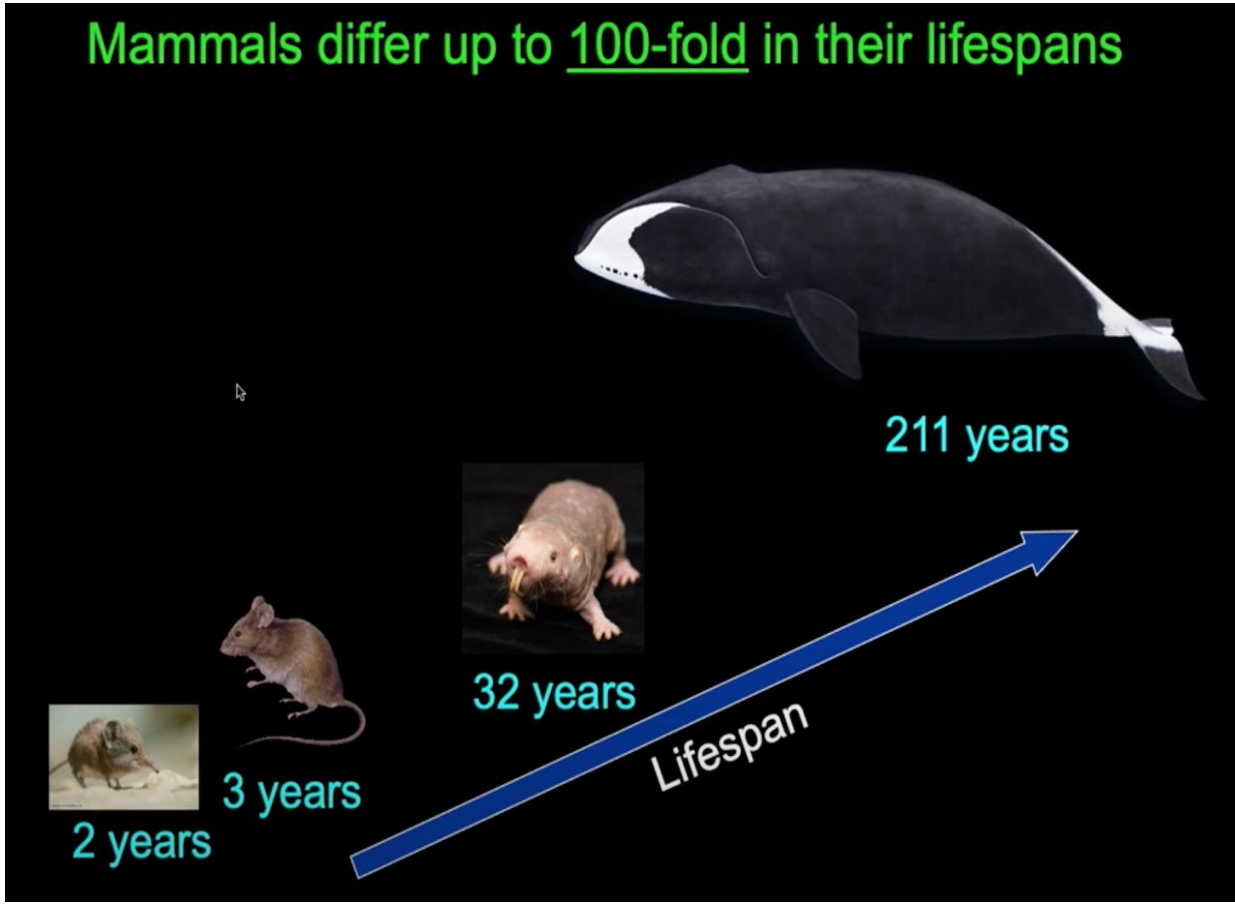
Lesions can by repaired by a variety of mechanisms that lose efficiency with age. Excessive DNA damage, insufficient DNA repair, alterations in nuclear architecture, and telomere attrition favor the aging process. BER, base excision repair; HR, homologous recombination; NER, nucleotide excision repair; NHEJ, non-homologous end joining; MMR, mismatch repair; SAC, spindle assembly checkpoint; TERT, telomerase reverse transcriptase; TLS, *trans*-lesion synthesis.

Source for aging should be in our genome

Across mammals, the pace of aging and species-typical lifespan are strongly shaped by genetics that have been tuned by natural selection—but within a species (e.g., humans), environment and behavior still account for much of the individual variation.

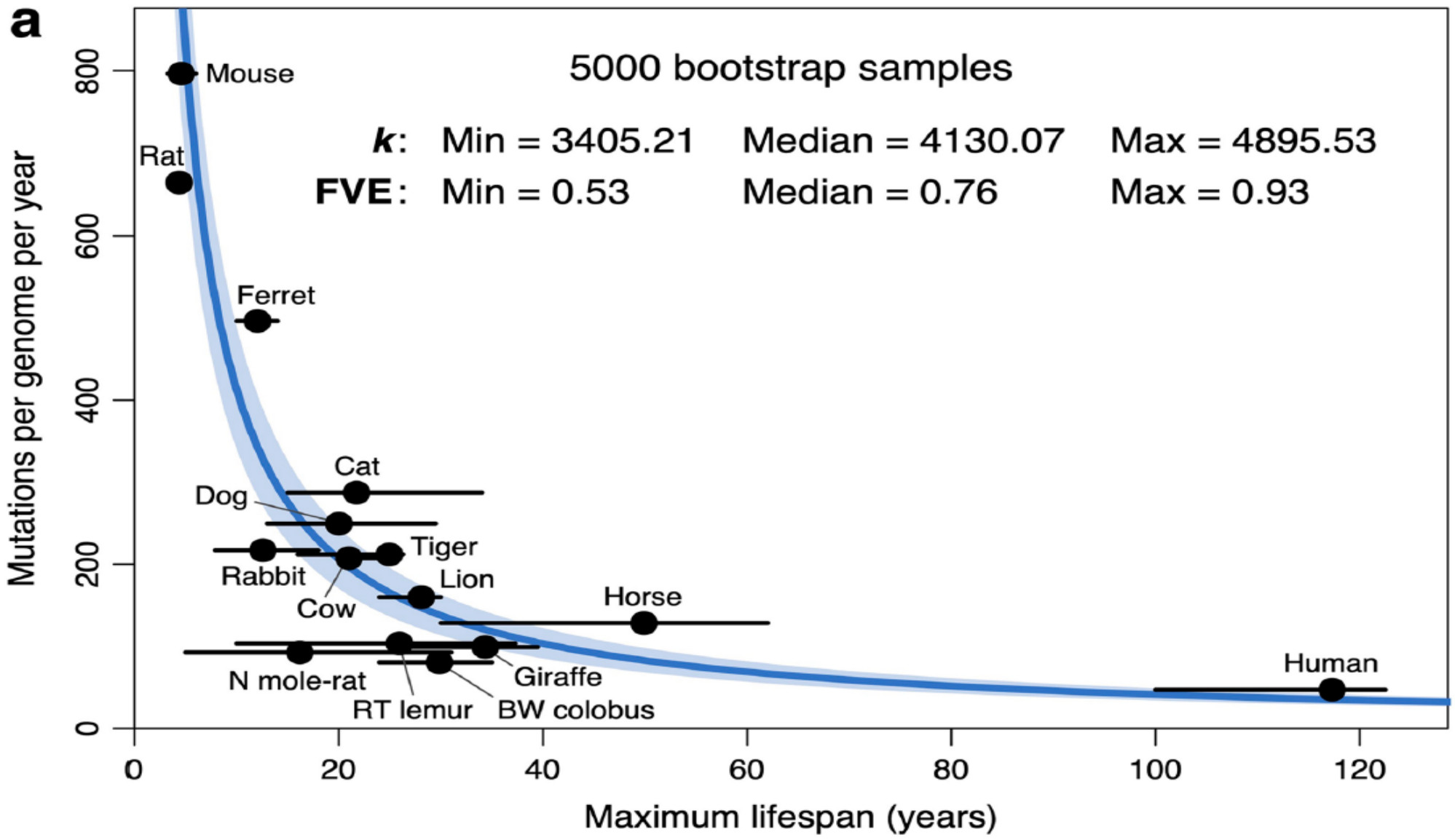
- Universal aging traits in mammals:

1. Genetically determined
2. DNA damage in somatic cells
3. Chronic systemic inflammation



Gorbunova V. et al. 2023

The somatic mutation rate per year varied greatly across species and exhibited a strong inverse relationship with species lifespan



Cagan A, et al. Somatic mutation rates scale with lifespan across mammals. Nature. 2022 Apr;604(7906):517-524. doi: 10.1038/s41586-022-04618-z.

HUMAN GENOME

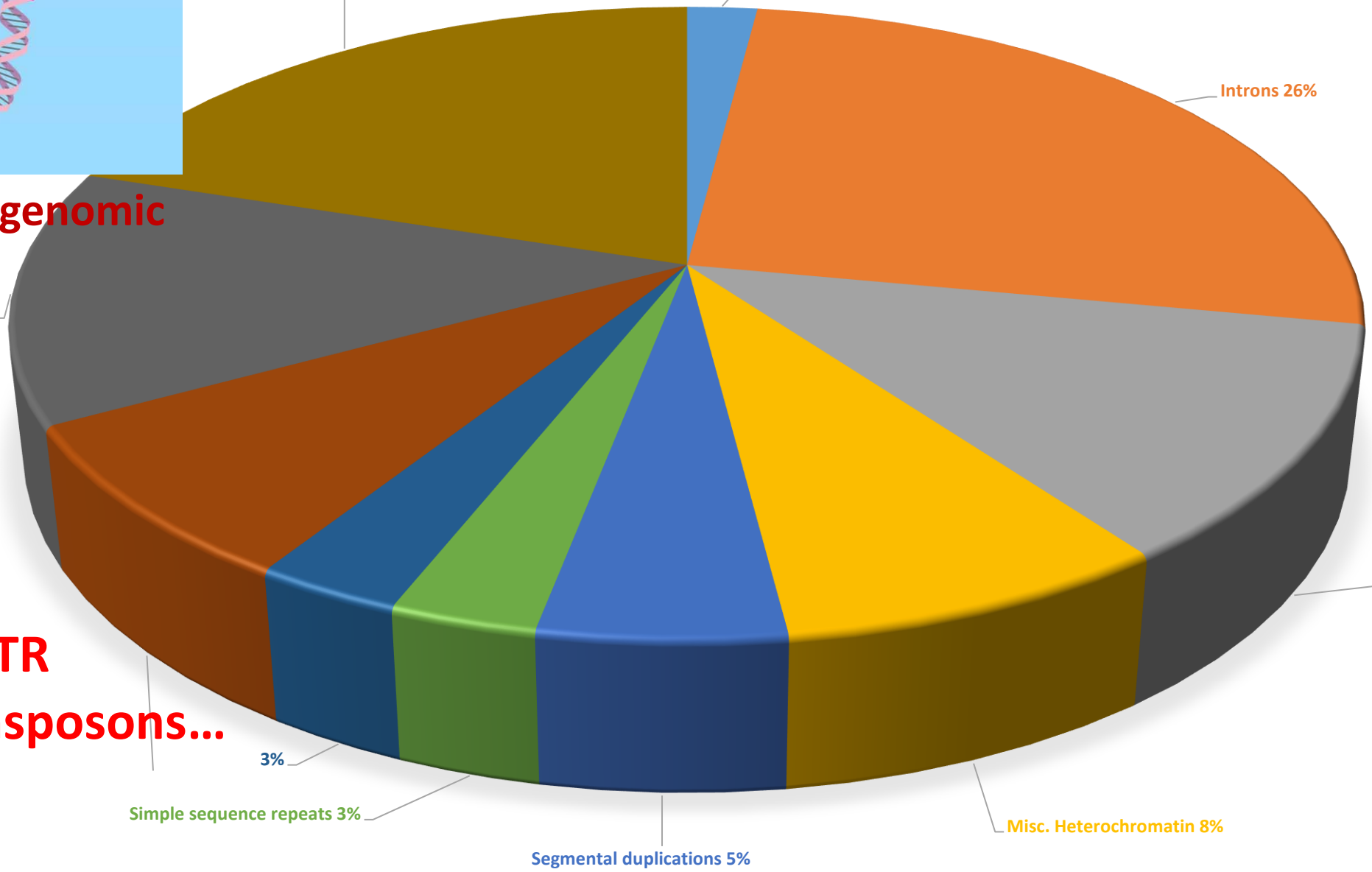
INEs 20%

Protein-coding genes 2%

0.5 million genomic L1 copies

SINEs 13%

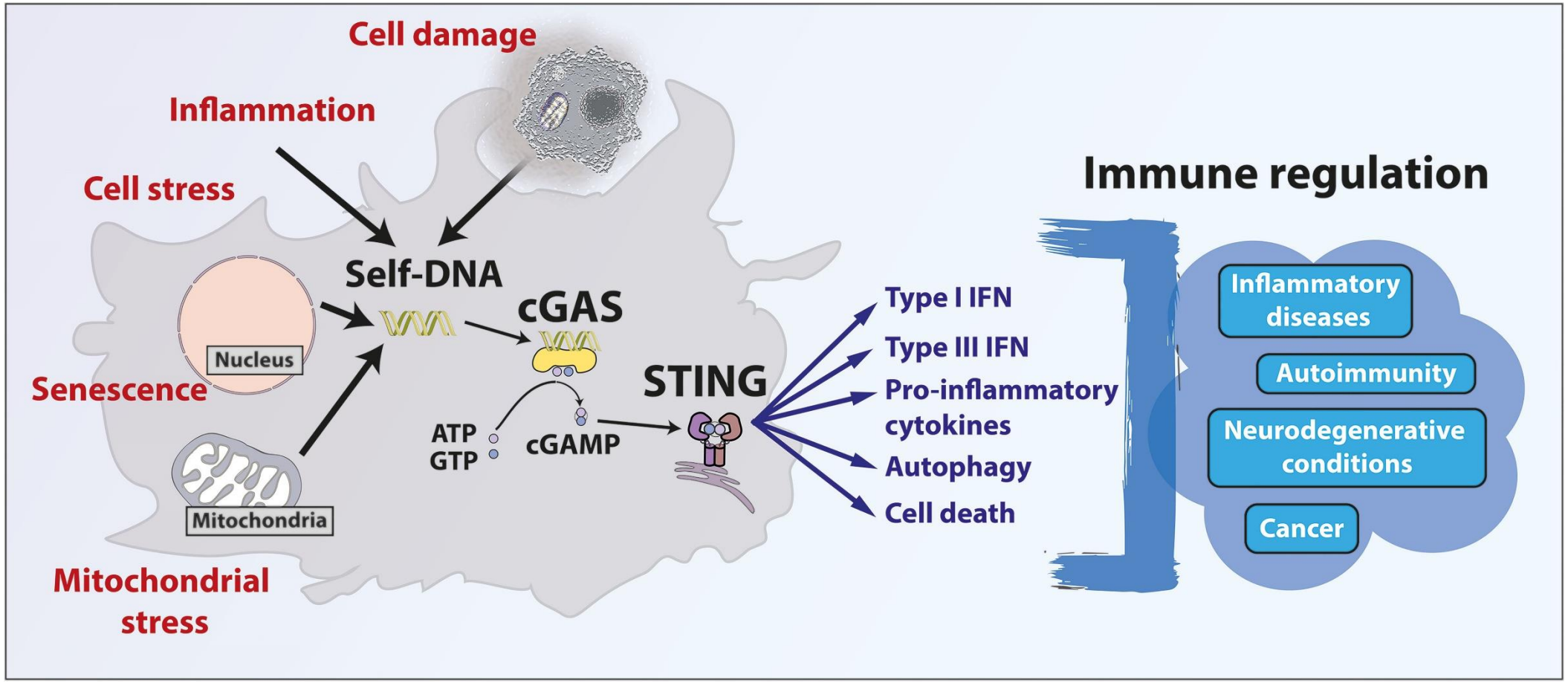
LTR retrotransposons…



Misplaced self-DNA is a aging driver

- Misplaced self-DNA is a potent trigger of immune activation through various DNA sensing machinery.
- Among them, the cGAS/STING pathway has emerged as an important source of type I and type III interferons as well as a critical regulator of cellular processes such as autophagy and programmed cell death.
- Targeting the STING pathway may offer tremendous therapeutic opportunities, not only in response to infection as recently illustrated with SARS-CoV-2 infection, but also in inflammatory conditions and cancer settings.
- In addition, natural and synthetic CDNs are used as adjuvants to enhance protective humoral and CD4+ and CD8+ T cells responses in a STING-dependent manner.

STING, A MASTER REGULATOR OF IMMUNE RESPONSES, REINFORCES ORGANISMAL LONGEVITY AND HOMEOSTASIS



STING Signaling and Sterile Inflammation

Genomic Instability

- **Ingredients:** Antioxidants, polyphenols, spermidine, terpenes
- **Action:** Reduce DNA damage, oxidative stress, and mutation load.

How terpenes help:

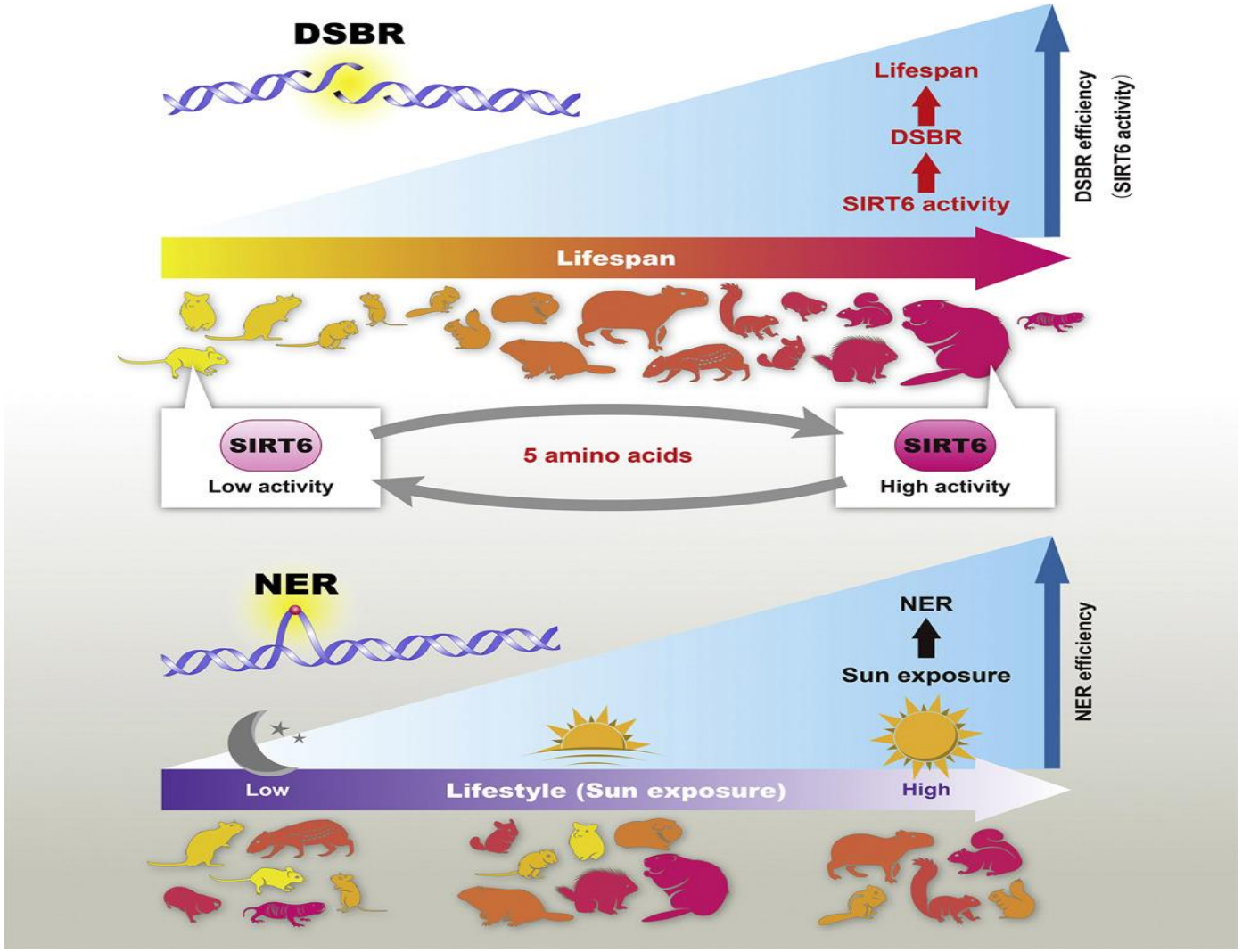
- Strong antioxidant capacity reduces DNA damage from ROS.
- Abietane diterpenes demonstrate DNA-protective effects in stressed cells.
- Fir extract (e.g., Abisil) lowers oxidative injury and stabilizes genome maintenance pathways.

Outcome: Lower mutation load, improved cellular resilience.

References: 1.Effects of Siberian fir terpenes extract Abisil -Lipatova A, Krasnov G, Vorobyov P, Melnikov P, Alekseeva O, Vershinina Y, Brzhozovskiy A, Goliusova D, Maganova F, Zakirova N, Kudryavtseva A, Moskalev A. Effects of Siberian fir terpenes extract Abisil on antioxidant activity, autophagy, transcriptome and proteome of human fibroblasts. Aging (Albany NY). 2021 Aug 24;13(16):20050-20080. doi: 10.18632/aging.203448. Epub 2021 Aug 24. PMID: 34428743; PMCID: PMC8436938.
2.López-Otín et al., "The Hallmarks of Aging." Cell, 2013 / 2023 update.
3.Lagunas-Rangel FA, Bermúdez-Cruz RM. Natural Compounds That Target DNA Repair Pathways and Their Therapeutic Potential to Counteract Cancer Cells. Front Oncol. 2020 Nov 19;10:598174. doi: 10.3389/fonc.2020.598174. PMID: 33330091; PMCID: PMC7710985.

SIRT-6 and DSB repair - could terpens help?

- DNA repair has been hypothesized to be a longevity determinant.
- DNA double-strand breaks (DSB) are the most deleterious type of DNA damage.
- DSB repair, but not NER, coevolves with maximum lifespan (MLS) in rodents
- The activity of SIRT6 in stimulating DSB repair coevolves with MLS in rodent species
- Stronger SIRT6 leads to a longer lifespan
- SIRT6 suppress jumping LINE1 transposons.



Tian X. et al. 2019

Telomere Attrition

- **Ingredients:** Astragalosides, TA-65, omega-3

- **Action:** Support telomere maintenance and cell division stability. Terpenes support telomere maintenece indirectly.

von Zglinicki, T. “Oxidative stress shortens telomeres.” Science, 2002.
Passos, J.F. et al. “Mitochondria and telomeres cooperate in senescence.” Nature Cell Biology, 2007.
Frenck, R.W. et al. “Aging, telomeres, and oxygen free radicals.” PNAS, 1998.

Epigenetic Alterations

- **Ingredients:** Resveratrol, quercetin, butyrate, green needle terpenoids

- **Action:** Modulate epigenetic enzymes (sirtuins, HDACs) to maintain youthful gene expression.

- **Key mechanism:** Terpenes modulate sirtuins and epigenetic regulators.

Bornyl acetate and pine polyphenols influence HDAC/SIRT activity.

Fir terpenes shift gene expression toward youthful metabolic and anti-inflammatory profiles.

- **Outcome:** Restoration of healthy gene-expression patterns.

Reference: Terpenoids as Potential Geroprotectors

Loss of Proteostasis

- **Ingredients:** Spermidine, fisetin, NMN/NAD+, autophagy enhancers

- **Action:** Boost autophagy and reduce toxic protein aggregation.

- **Fir needle terpenes:**

Activate autophagy (documented in Abisil research).

Reduce misfolded proteins and support lysosomal function.

- **Outcome:** Improved cellular "clean-up" and reduced toxic aggregates.

Reference: Effects of Siberian fir terpenes extract Abisil

Deregulated Nutrient Sensing

- **Ingredients:** Metformin-like botanicals, berberine, NMN

- **Action:** Modulate pathways such as mTOR, AMPK, and IGF-1.

- **Conifer terpenes influence mTOR and AMPK signaling:**

β-pinene and limonene increase AMPK activation.

Fir extract improves metabolic stress responses similar to mild caloric-restriction mimetics.

- **Outcome:** Better metabolic flexibility and longevity-linked signaling.

Reference: Terpenoids as Potential Geroprotectors

Mitochondrial Dysfunction

- **Ingredients:** CoQ10, PQQ, NAD+ precursors, fir needle terpenes
- **Action:** Improve energy production, reduce ROS, enhance mitochondrial biogenesis.
- **Pine and fir terpenes (One of the Strongest Effects):**

1. Enhance mitophagy and mitochondrial turnover.
2. Reduce mitochondrial ROS production.
3. Improve membrane potential and ATP efficiency.

- Abisil has shown restoration of mitochondrial structure and function in aging and stressed cells.
- **Outcome:** More youthful, efficient mitochondria.

References: Latkovskis G, Saripo V, Sokolova E, Upite D, Vanaga I, Kletnieks U, Erglis A. Pilot study of safety and efficacy of polyprenols in combination with coenzyme Q10 in patients with statin-induced myopathy. Medicina (Kaunas). 2016;52(3):171-9. doi: 10.1016/j.medici.2016.05.002. Epub 2016 May 30. PMID: 27496187.
Effects of Siberian fir terpenes extract Abisil

Cellular Senescence

- **Ingredients:** Fisetin, quercetin, apigenin, senolytic blends

- **Action:** Clear senescent cells or reduce their inflammatory secretions (SASP).

- **Fir needle terpenoids act on senescence pathways:**

1. Reduce SASP inflammatory secretions.
2. Protect non-senescent cells from entering senescence under stress.
3. Some abietane terpenes show senomorphic effects.

- **Outcome:** Lower biological age load from senescent cells.

Reference: Terpenoids as Potential Geroprotectors

Stem Cell Exhaustion

- **Ingredients:** NAD+ boosters, omega-3, ginsenosides

- **Action:** Promote stem cell renewal and resilience.

- **By reducing oxidative and mitochondrial stress, conifer terpenes:**

1. Improve stem cell niche conditions.
2. Support neural and immune progenitor cell resilience (shown in hippocampal studies).

- **Outcome:** More robust tissue regeneration.

Reference: Hippocampal Memory Enhancing Effects

Altered Intercellular Communication (Inflammaging)

- **Ingredients:** Curcumin, terpenes, omega-3, boswellia

- **Action:** Reduce chronic inflammation and improve immune balance.

- **Terpenes are high-potency anti-inflammatories:**

1. Downregulate NF-κB and cytokines (IL-6, TNF-α).
2. Reduce chronic low-grade inflammation associated with aging.

- **Outcome:** Reduced inflammaging and better immunometabolic balance.

Reference: Terpenoids as Potential Geroprotectors

Disabled Autophagy

- Supplements that enhance autophagy (e.g., spermidine, berberine, terpenoids) restore cellular clean-up processes.

- Fir terpenes directly activate autophagy genes, improving clearance of damaged proteins and organelles.

Reference: Effects of Siberian fir terpenes extract Abisil

Microbiome Dysbiosis

Probiotics, prebiotics, polyphenols improve gut–immune–brain aging axes.

Pine needle extracts:

- Exhibit natural prebiotic effects.
- Support microbiome diversity and reduce gut-derived inflammation.

Rubens J, Kibilds J, Jansons M, Piginka-Vjaceslavova I, Barene I, Daberte I, Liepa L, Malniece A, Rubens A, Starkute V, Zokaityte E, Ruzauskas M, Bartkiene E, Bartkevics V, Pugajeva I. Application of Baltic Pine (Pinus sylvestris) Needle Extract as a Gut Microbiota-Modulating Feed Supplement for Domestic Chickens (Gallus gallus). Plants (Basel). 2023 Jan 8;12(2):297. doi: 10.3390/plants12020297. PMID: 36679012; PMCID: PMC9861901.

Chronic Inflammation

- Anti-inflammatory compounds (e.g., fir terpenes, curcumin) reduce inflammaging at the cytokine level.

- Terpenes are natural immune modulators, calming overactive immune responses.

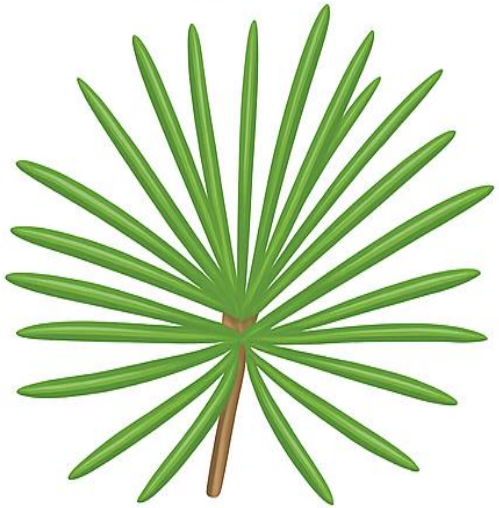
Reference: 1.Terpenoids as Potential Geroprotectors
2.Bespalov V, Sherbakov A, Novik V, Kalinovsky V, Shamsi K, Soultanov V. Conifer Green Needle Complex in Patients with Precancerous Gastric Lesions: An Observational Pilot Study. Evid Based Complement Alternat Med. 2016;2016:3848409. doi: 10.1155/2016/3848409. Epub 2016 Nov 28. PMID: 28003849; PMCID: PMC5149685.

Hypothesis

"Conifer needles survive extreme environmental stress (heat, frost, UV, radiation) for 3–5 years because they contain substances that protect the genome and suppress cellular senescence. ,lk

These substances could also help humans maintain genome stability and extend lifespan."

Needle Longevity

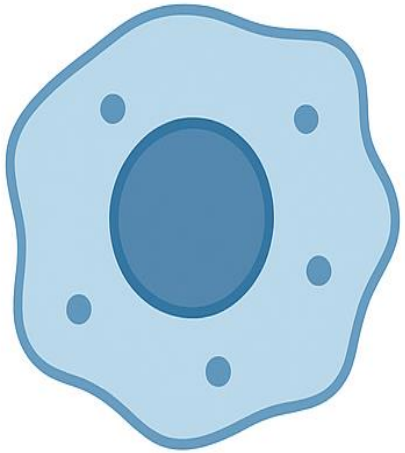


Conifer needles live 3–5 years in harsh environments

Due to genome-protective terpenes

Bioactive terpenes

Human Geroprotection?



- Genomic stability
- Anti-senescence chemistry
- Inflammation control
- Autophagy activation
- Mitochondrial support

This extreme resilience suggests powerful cellular protection systems, including compounds that stabilize:

DNA

Membranes

Mitochondria

Proteins

Redox balance

- **This part of the hypothesis is supported by plant physiology research.**

Cho KS, Lim YR, Lee K, Lee J, Lee JH, Lee IS. Terpenes from Forests and Human Health. Toxicol Res. 2017 Apr;33(2):97-106. doi: 10.5487/TR.2017.33.2.097. Epub 2017 Apr 15. PMID: 28443180; PMCID: PMC5402865.

Proshkina E, Plyusnin S, Babak T, Lashmanova E, Maganova F, Koval L, Platonova E, Shaposhnikov M, Moskalev A. Terpenoids as Potential Geroprotectors. Antioxidants (Basel). 2020 Jun 17;9(6):529. doi: 10.3390/antiox9060529. PMID: 32560451; PMCID: PMC7346221.

Do conifer needles contain genome-protective compounds? — YES, supported by evidence

Studies confirm that fir/pine needle extracts (e.g., Abisil) contain terpenes that:

✓ Reduce oxidative DNA damage

Evidence: *Effects of Siberian fir terpenes extract Abisil shows decreased ROS, lipid peroxidation, and DNA oxidative injury.*

✓ Support genome maintenance pathways

Terpenoids upregulate stress-response genes and stabilise mitochondrial DNA.

Evidence: *Terpenoids as Potential Geroprotectors, Study on the antimutagenic effect of pine needle extractNeedle extrct*

✓ Prevent cellular senescence

Abietane diterpenes suppress SASP-like inflammation and protect cells from stress-induced senescence.

Evidence: *Terpenoids as Potential Geroprotectors, Study on the antimutagenic effect of pine needle extractNeedle extrct*

✓ Strong antioxidant & anti-radiation activity

Highly concentrated terpenes neutralize ROS from UV and cold–heat cycles.

Could these same compounds protect the human genome? — PARTIALLY SUPPORTED

- ✓ **Reduce human cell oxidative DNA damage**
- ✓ **Activate autophagy — a major anti-aging pathway**
- ✓ **Improve mitochondrial function (key to telomere and genome stability)**
- ✓ **Modulate inflammation (NF-κB, IL-6, TNF-α)**

(Inflammation is a major driver of genomic instability)

- ✓ **Protect neural tissue, enhance repair**

These effects support the idea that conifer terpenes could help protect human genome integrity.

Lee JS, Kim HG, Lee HW, Han JM, Lee SK, Kim DW, Saravanakumar A, Son CG. Hippocampal memory enhancing activity of pine needle extract against scopolamine-induced amnesia in a mouse model. Sci Rep. 2015 May 14;5:9651. doi: 10.1038/srep09651. PMID: 25974329; PMCID: PMC4431316.

Could they extend human lifespan? — POSSIBLY, BUT NO DIRECT EVIDENCE YET

To extend lifespan, a compound must:

1. Reduce genome instability
2. Improve proteostasis
3. Support mitochondrial quality
4. Reduce cellular senescence
5. Reduce inflammation

Pine/fir terpenes affect all these pathways, according to studies.

However:

No human lifespan studies exist.

No telomere-length studies exist.

Effects are likely indirect, not direct genome repair.

Hypothesis Testing — Final Verdict

Supported:

- ✓ Needles live long due to stress-protective secondary metabolites
- ✓ These metabolites protect plant DNA and prevent senescence
- ✓ Terpenes show genome-protective and anti-senescence effects in human cells
- ✓ Mechanisms overlap with human aging pathways

Plausible, but not yet proven:

- Terpenes indirectly support telomere and genome stability in humans
- Terpenes may contribute to slower biological aging
- Longevity extension in humans remains untested

Conclusion: Is the hypothesis reasonable?

YES — the hypothesis is biologically plausible and partially supported by experimental evidence.

- Conifer needle longevity is clearly tied to genome-protective terpenes.
- These terpenes show geroprotective effects in human cells.
- They target multiple Hallmarks of Aging.
- They could help maintain genome stability in humans.

But lifespan extension remains unproven.

Testing: “Do terpenes protect the human genome?” (mechanism)

a) Genomics + DNA damage readouts

In cell culture or animal models exposed to stress (oxidative, radiation):

- **Whole-genome or exome sequencing**

o **Compare mutation rates, mutation spectra, structural variants between:**

Control

Stress + placebo

Stress + pine/fir terpenes

- **Multi-omics angle:** Link DNA mutations to changes in expression and metabolism.

If terpene-treated cells accumulate fewer new mutations and show less DNA damage, it’s strong evidence of genome protection, not just antioxidant talk.

Multi-omics aging reviews explicitly highlight genomic instability as a core domain where integrated omics is used to understand aging pathways.

b) Epigenomics: are epigenetic aging patterns “younger”?

- DNA methylation clocks (epigenetic age)
- Histone modification profiling (ChIP-seq / CUT&Tag)

If conifer terpenes:

- Slow down epigenetic age progression
- Reverse age-associated methylation patterns at DNA repair, stress-response and senescence genes

→ that’s strong, quantifiable evidence that they support genome stability over time.

c) Transcriptomics: which genome-defense pathways are turned on?

RNA-seq can show whether terpenes up-regulate genes involved in:

- DNA repair (ATM, ATR, BRCA pathways)
- Antioxidant defense (Nrf2 targets, SODs, GPXs)
- Cell cycle checkpoints
- Senescence and SASP suppression

Multi-omics studies of geroprotectors like rapamycin, metformin, resveratrol already use transcriptomic signatures to map which Hallmarks of Aging are being modulated.

d) Proteomics & phosphoproteomics: functional proof

Proteomics can test:

- **Higher levels of DNA repair proteins**
- Reduced γ-H2AX, 53BP1 foci (double-strand break markers)
- Activation of autophagy and mitophagy proteins (LC3, p62, PINK1/Parkin)
- Lower levels of pro-senescence proteins (p16, p21, SASP factors)

Integrated with genomics/epigenomics, this shows whether the protein machinery that actually protects the genome is being upregulated in a coordinated way.

e) Metabolomics: is the redox/mitochondrial environment “safer” for DNA?

Metabolomics can measure:

- Ratios like GSH/GSSG, NAD^+/NADH
- TCA cycle intermediates, acylcarnitines
- Markers of lipid peroxidation and oxidative stress

Multi-omics work on aging often finds specific metabolic signatures of healthy longevity (e.g. ω-3 PUFAs, SCFAs) and uses them as biomarkers of slower aging.

If terpenes push cells/organisms toward a metabolic profile associated with lower oxidative stress and healthier mitochondria, that supports the idea they indirectly shield the genome.

Microbiome + metabolome integration

Because many nutraceuticals act partly via the gut microbiome, multi-omics can also:

- Track how terpenes reshape gut microbial composition and function.
- Correlate specific microbial changes with metabolomic and epigenetic aging markers.

If certain microbiome shifts consistently associate with improved aging clocks under terpene supplementation, that gives another mechanistic layer.

Multi-omics lets you:

- **Map terpenes → molecular pathways → hallmarks** (genomic stability, epigenetics, proteostasis, mitochondria, senescence, inflammation).
- **Compare terpene signatures to known geroprotectors** (rapamycin, metformin, resveratrol).
- **Quantify changes in biological age** instead of waiting for real lifespan outcomes.

In other words:

Multi-omics gives you a mechanistic “fingerprint” of what pine/fir terpenes are doing to human biology, and tells you whether that fingerprint matches a true longevity pattern rather than just generic antioxidant noise.

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