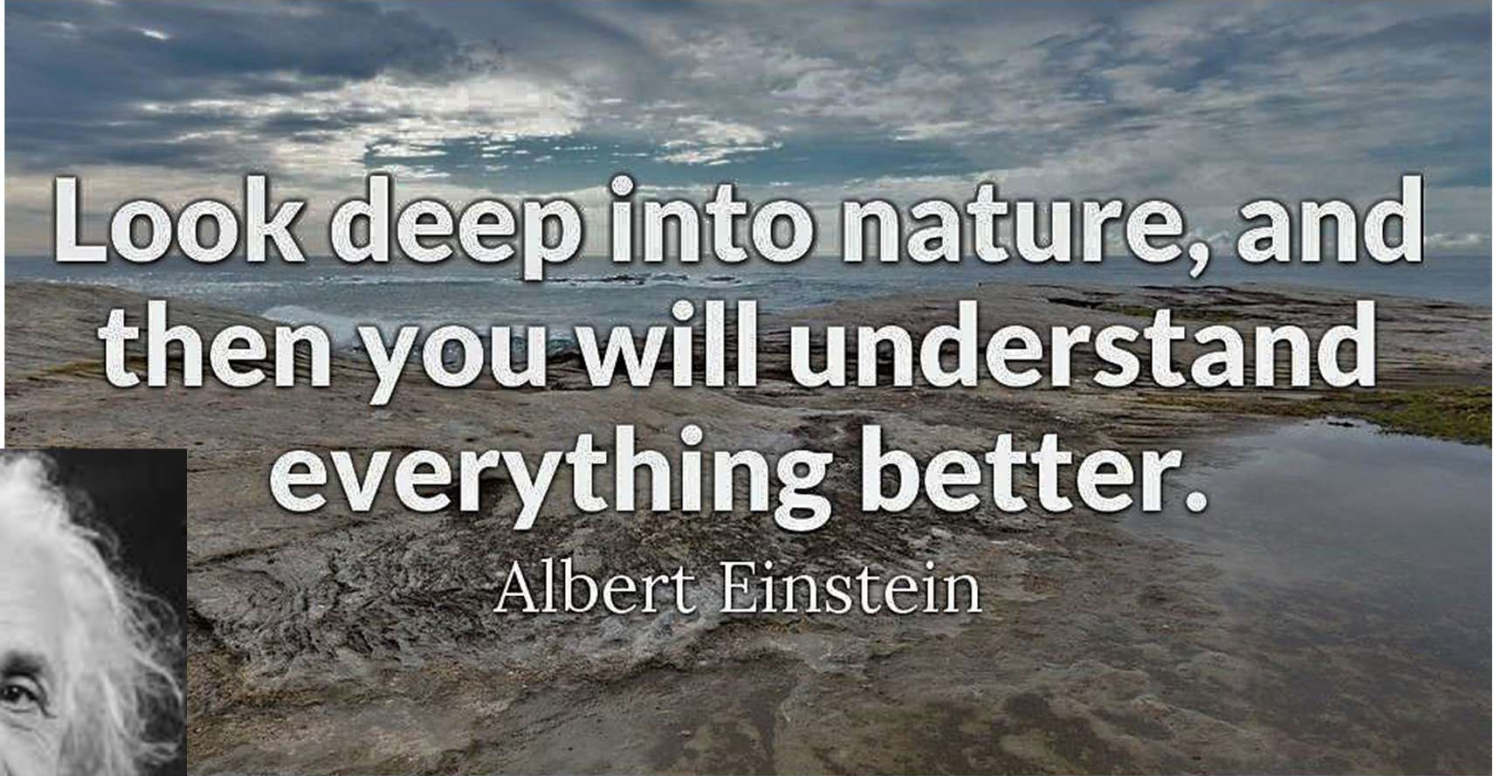


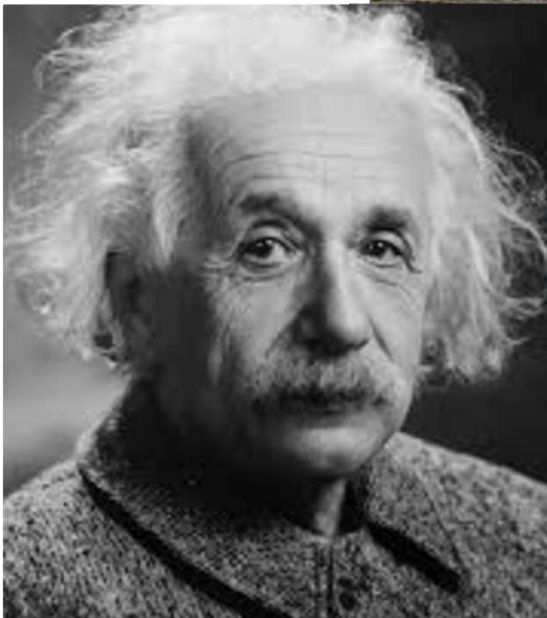


**Karolinska  
Institutet**



**Look deep into nature, and  
then you will understand  
everything better.**

Albert Einstein

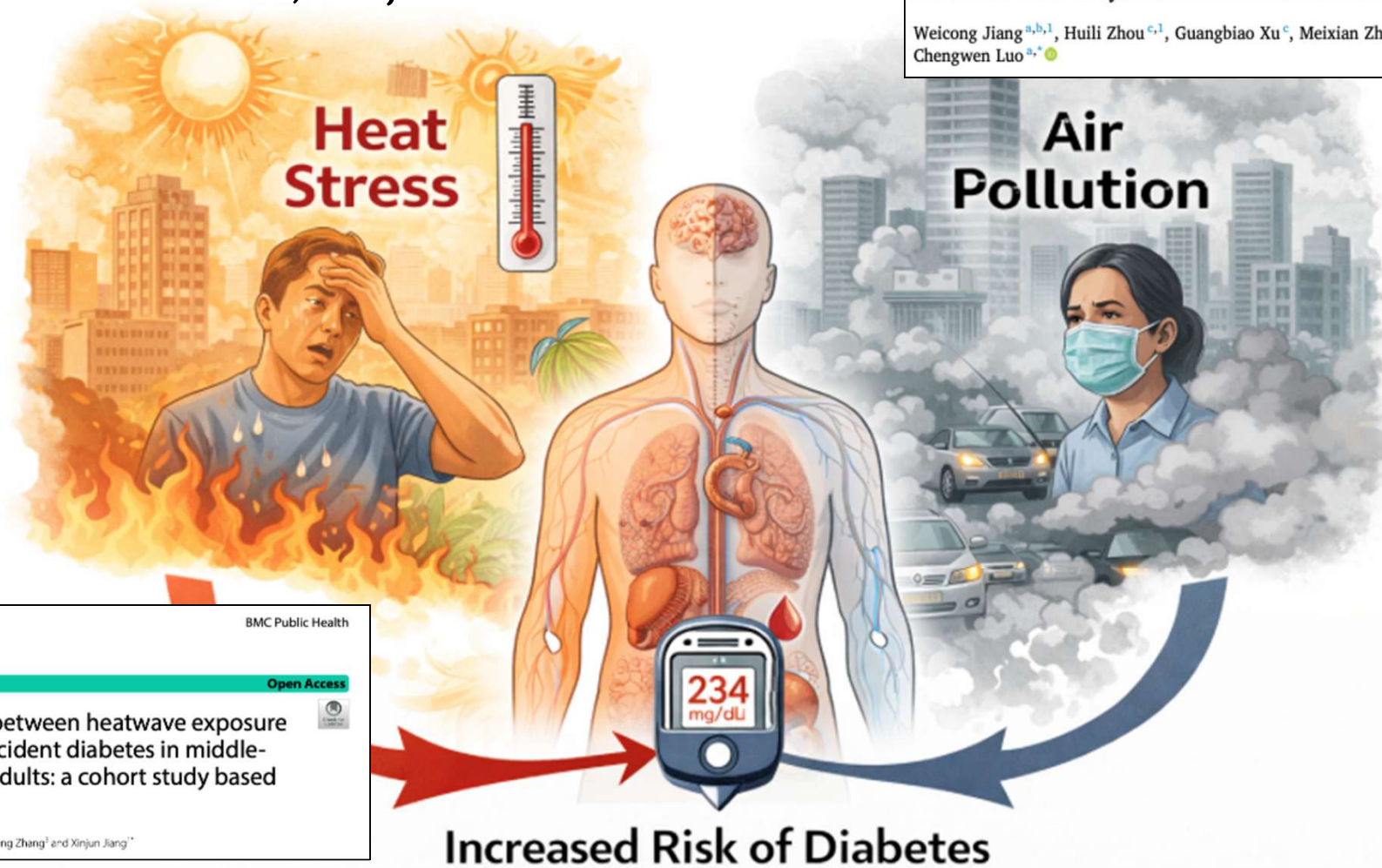


Vad Kan Djuren Lära oss om hur man Undvika  
Komplikationer vid Diabetes?

Peter Stenvinkel



# Typ-2 Diabetes - en Global Epidemi Kopplad till Livsstil, Miljö och Klimat



Review

The association between air pollution and three types of diabetes: An umbrella review of systematic reviews and meta-analyses

Weicong Jiang<sup>a,b,1</sup>, Huili Zhou<sup>c,1</sup>, Guangbiao Xu<sup>c</sup>, Meixian Zhang<sup>a</sup>, Tao-Hsin Tung<sup>a,\*</sup>, Chengwen Luo<sup>a,\*</sup>

Yang et al. BMC Public Health (2024) 24:304  
<https://doi.org/10.1186/s12889-023-26017-5>

BMC Public Health

RESEARCH

Open Access

The association between heatwave exposure and the risk of incident diabetes in middle-aged and older adults: a cohort study based on CHARLS

Wenfei Yang<sup>1,2</sup>, Yan Lin<sup>1</sup>, Caihua Ye<sup>1</sup>, Xiang Zhang<sup>1</sup> and Xinjun Jiang<sup>1\*</sup>

## Water scarcity and conservation and their role in obesity in nature and in humans

Johnson et al.

**Water sources**  
 Drinking water  
 Food  
 Metabolic water

**Water conservation mechanisms**  
 Vasopressin/Vasotocin  
 Reduced evaporative water loss (EWL)  
 Body temperature regulation  
 Metabolic water/fat regulation

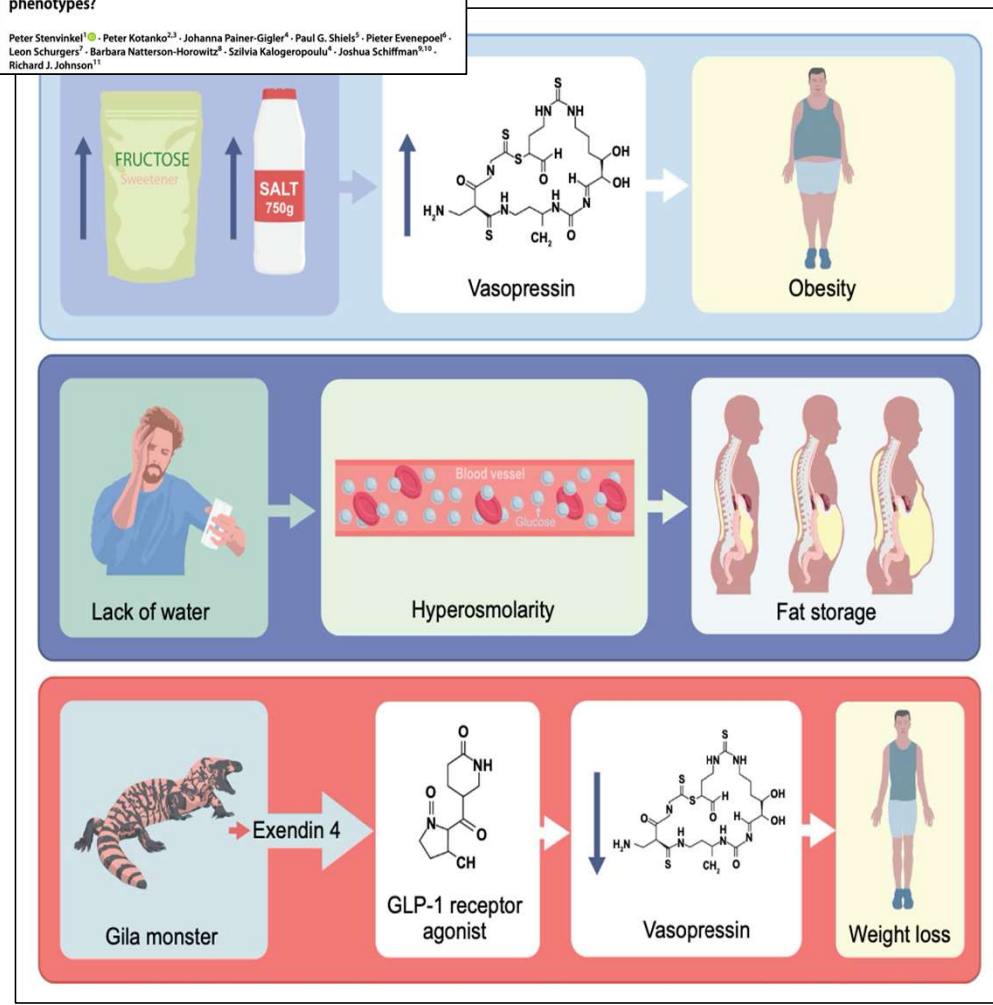
**Species specific adaptations**

Species	Adaptation
Desert mammals	Concentrated urine
Bird	Pre-migratory fat storage
Marine animals	Reduced EWL, low ventilation
Frog/Turtle	Water storage in bladder and skin
Rodent	Daily torpor, water-retaining metabolics

**JIM** Journal of Internal Medicine  
 Founded in 1863

Comparative physiology and biomimetics in metabolic and environmental health: what can we learn from extreme animal phenotypes?  
 Peter Stenvinkel<sup>1</sup>, Peter Kotanko<sup>2,3</sup>, Johanna Painer-Gigler<sup>4</sup>, Paul G. Shiels<sup>5</sup>, Pieter Evenepoel<sup>6</sup>, Leon Schurgers<sup>7</sup>, Barbara Natterson-Horowitz<sup>8</sup>, Szilvia Kalogeropoulou<sup>9</sup>, Joshua Schiffman<sup>4,10</sup>, Richard J. Johnson<sup>1</sup>

Diabetologia feb 2026



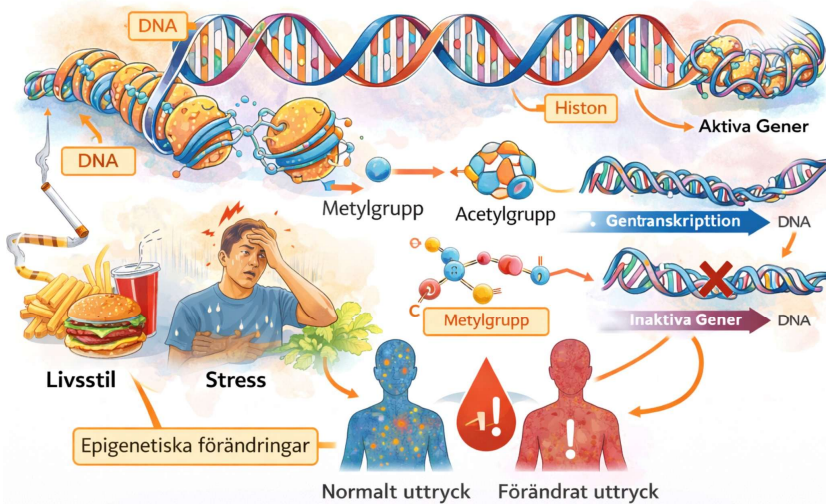
Vi törstar även oss till fetma och typ-2 diabetes

## Comparative physiology and biomimetics in metabolic and environmental health: what can we learn from extreme animal phenotypes?

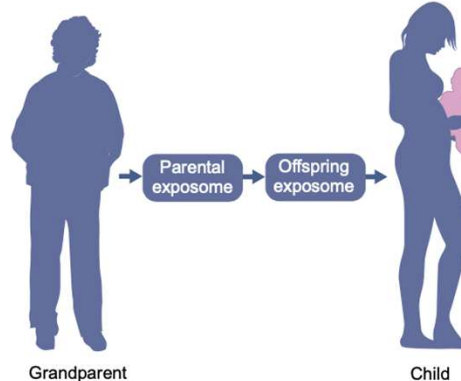
Peter Stenvinkel<sup>1</sup> · Peter Kotanko<sup>2,3</sup> · Johanna Painer-Gigler<sup>4</sup> · Paul G. Shiels<sup>5</sup> · Pieter Evenepoel<sup>6</sup> · Leon Schurgers<sup>7</sup> · Barbara Natterson-Horowitz<sup>8</sup> · Szilvia Kalogeropoulou<sup>4</sup> · Joshua Schiffman<sup>9,10</sup> · Richard J. Johnson<sup>11</sup>

Diabetologia feb 2026

## Epigenetik handlar om hur våra gener slås på och av – utan att själva DNA:t ändras



Lack of clean water Psychosocial stress Ultraprocessed food



nature medicine

Article

<https://doi.org/10.1038/s41591-026-04302-z>

## The exposome of brain aging across 34 countries

Received: 23 July 2025

A list of authors and their affiliations appears at the end of the paper

Accepted: 19 February 2026

Published online: 03 April 2026

Check for updates

The physical and social exposome affects human aging, and brain clocks may track its effects. However, most studies neglect multidomain exposures (physical, social and political) across diverse settings globally and their associations with brain aging. In this study, we characterized the associations between 73 country-level physical and social exposomal factors and multimodal brain age in 18,701 participants from 34 countries (healthy individuals and those with Alzheimer's disease, frontotemporal lobar degeneration or mild cognitive impairment). Exposome effects were assessed using generalized additive models and meta-analytic frameworks. Aggregated exposome models explained up to 15.5-fold more variance than individual exposures (delta Akaike information criterion (ΔAIC): 2.034–3.127). Physical exposome was primarily associated with accelerated structural brain aging (limbic, subcortical and cerebellar regions), whereas social exposome was more strongly associated with functional brain aging (frontotemporal and limbic networks). Exposome burden accounted for 3.3–9.1-fold higher risk of accelerated aging, exceeding effects of clinical diagnoses. Findings were out-of-sample validated in cross-sectional and longitudinal designs, remained consistent across clinical subgroups and persisted after adjustment for demographics, age correction bias, cognition, scanner type and data quality. The exposome accelerates brain aging in health and disease, underscoring the need to address physical, social and political inequities.

Understanding how physical and social environmental factors (for example, pollution, climate change, poverty and political instability) interact to shape health is one of the most pressing and unanswered questions in biomedicine<sup>1</sup>. The exposome encapsulates the cumulative, synergistic effects of diverse environmental exposures that influence the healthspan<sup>2</sup>. A central tenet of exposomics is the nonlinear, system-wide effects on biological functions<sup>3</sup>. These emergent external effects may vary across different geographical contexts, regions and countries. Understanding this framework is particularly salient given that genetic factors in global settings explain only a fraction of variance in healthy aging and neurocognitive disorders<sup>4</sup>. Thus, delayed or accelerated aging patterns may reflect the cumulative biological effects of the exposome.

Physical and social exposures have been linked to accelerated aging across biological and behavioral domains<sup>5</sup>. Omics research has linked exposomal factors to accelerated aging via methylation, organ-based and brain-specific clocks<sup>6,7</sup>. Brain clocks estimate an individual's brain age from neuroimaging data and compare it to their chronological age, providing a framework to assess individual trajectories<sup>8</sup>. The brain age gap (BAG) represents the difference between predicted and chronological brain age, with positive values indicating accelerated aging and negative values indicating delayed aging<sup>9</sup>. The BAG is a sensitive indicator of brain aging and dementia, shaped by disease mechanisms and environmental exposures<sup>10–12</sup>. Some environmental risk factors have been independently associated with greater BAG values in healthy individuals and those with neurocognitive disorders<sup>13</sup>, including Alzheimer's disease (AD), frontotemporal lobar degeneration (FTLD) and mild cognitive impairment (MCI). Despite these advances, the combined effects of the exposome on brain aging remain largely unexplored<sup>14–16</sup>. Most studies isolate a few exposomal factors or assume additive effects<sup>17</sup> and linear models<sup>18</sup>, ignoring the complexity of aggregate-level interactions<sup>19</sup>. The synergistic interplay among diverse physical and social exposures,

✉ e-mail: [herman.hernandez@ucl.ac.uk](mailto:herman.hernandez@ucl.ac.uk); [egustin.baines@ggh.org](mailto:egustin.baines@ggh.org)

Nature Medicine

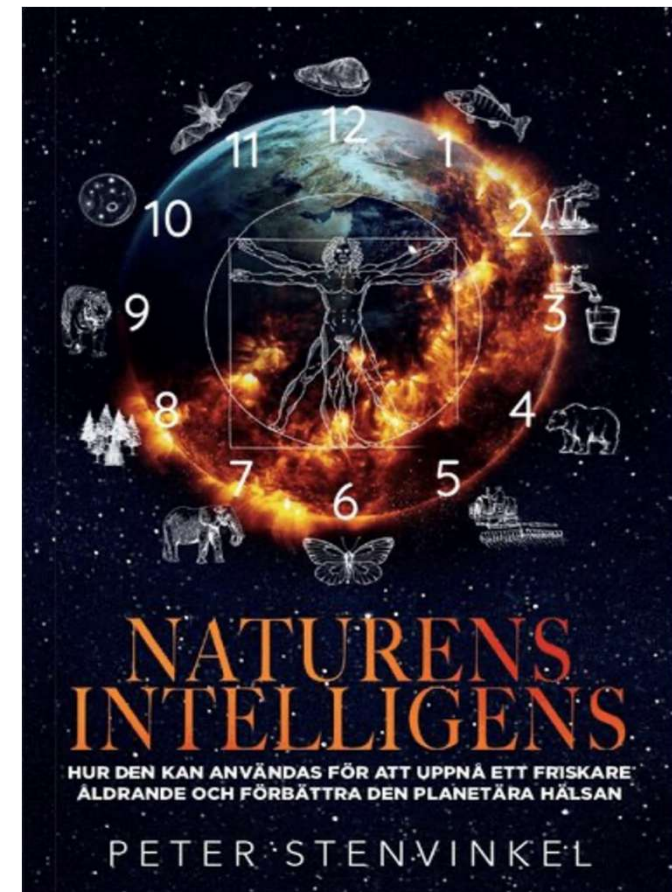
Vår miljö och våra livsvillkor påverkar hur snabbt hjärnan åldras – mer än enskilda riskfaktorer och diagnoser.

# BIOMIMETIK – ATT INSPIRERAS AV NATURENS EGNA SMARTA LÖSNINGAR

Biomimetik – att lära av naturens beprövade strategier – erbjuder ett praktiskt sätt att återkoppla medicinen till biologin



30 april 2026

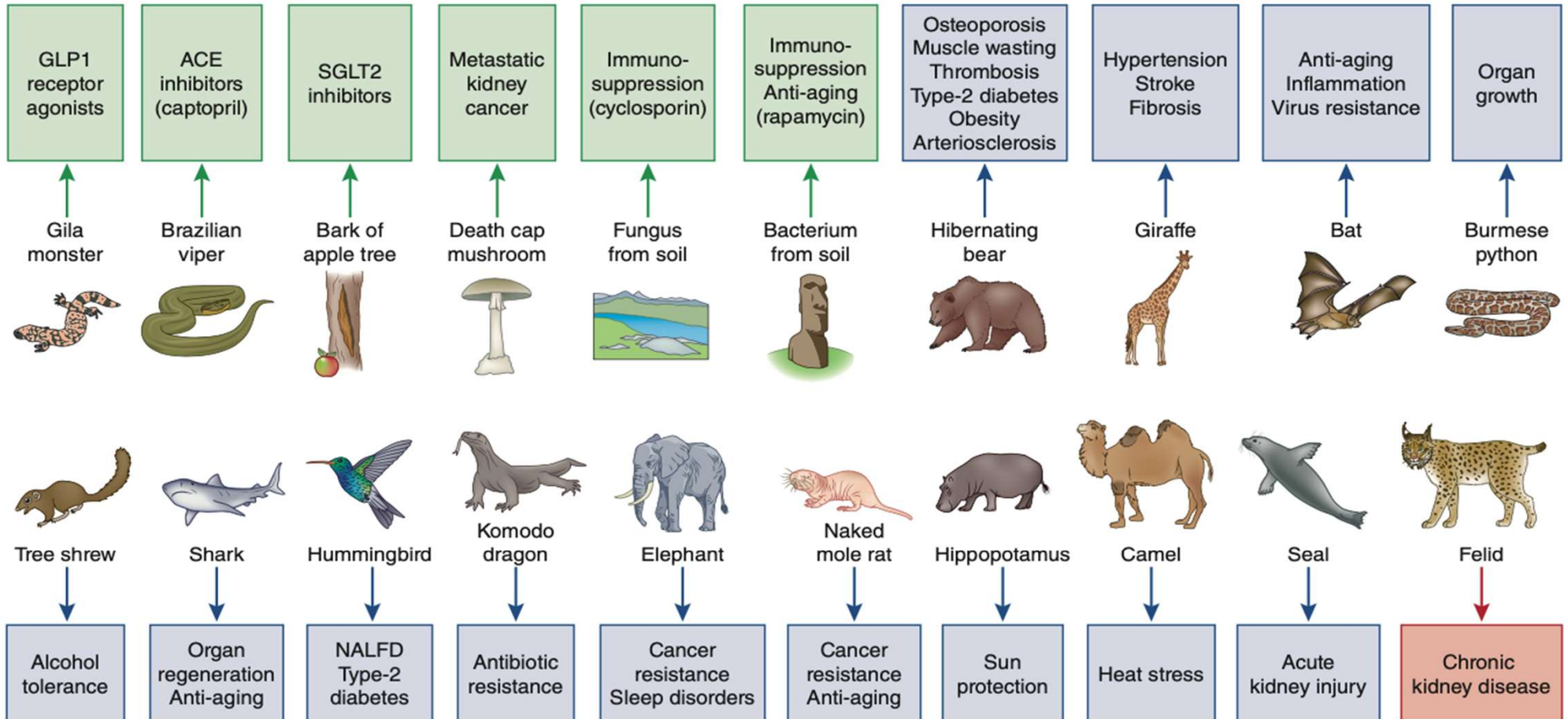


6

# Harnessing Evolution and Biomimetics to Enhance Planetary Health

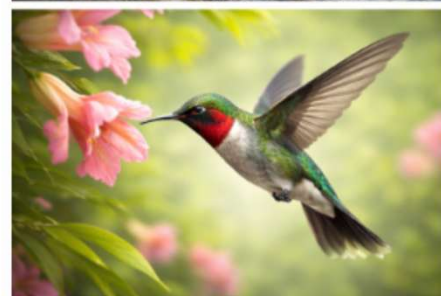
J Am Soc Nephrol 2025  
Kidney Insights

Peter Stenvinkel<sup>1</sup>, Paul G. Shiels<sup>2</sup>, Peter Kotanko<sup>3,4</sup>, Pieter Evenepoel<sup>5</sup>, and Richard J. Johnson<sup>6</sup>



# I Naturen är Insulinresistens Reversibel och Komplikationer Inte Oundvikliga

- **Björnar:** Utvecklar insulinresistens under hibernering men får inte diabetes
- **Sälar:** Lever på fett i månader utan komplikationer
- **Kolibrier:** Extremt högt blodsocker men inga skador av diabetes
- **Delfiner:** Unik, naturlig och reversibel insulinresistens, särskilt under fasta eller sömnliknande tillstånd



## Vinterdvala

Sänkt kroppstemperatur  
Metabol nedreglering



### Metabola anpassningar:

- Viktökning
- Anpassad lipidanvändning
- Reversibel insulinresistens
- Antioxidativa mekanismer
- Sänkt hjärtfrekvens och syreförbrukning

### Fördelar med vinterdvala:

- Förebygger ateroskleros
- Minskar muskelnedbrytning
- Skyddar benhälsa
- Minskar inflammation och oxidativ stress

### Translationell forskning:

- Terapeutisk hypotermi
- Läkemedelsutveckling inspirerad av vinterdvala

Comparative physiology and biomimetics in metabolic and environmental health: what can we learn from extreme animal phenotypes?

Diabetologia Feb 2026

Peter Stenvinkel<sup>1</sup> · Peter Kotanko<sup>2,3</sup> · Johanna Painer-Gigler<sup>4</sup> · Paul G. Shiels<sup>5</sup> · Pieter Evenepoel<sup>6</sup> · Leon Schurgers<sup>7</sup> · Barbara Natterson-Horowitz<sup>8</sup> · Szilvia Kalogeropoulou<sup>4</sup> · Joshua Schiffman<sup>9,10</sup> · Richard J. Johnson<sup>11</sup>

**Hibernating bears (Ursidae): metabolic magicians of definite interest for the nephrologist**

Peter Steenvinkel<sup>1</sup>, Aikesh H. Jani<sup>2</sup> and Richard J. Johnson<sup>3</sup>

<sup>1</sup>Division of Renal Medicine, Department of Clinical Science Intervention and Technology, Karolinska University Hospital, Stockholm, Sweden and <sup>2</sup>Division of Renal Diseases and Hypertension, University of Colorado Denver, Aurora, Colorado, USA

Muscle loss, osteoporosis, and vascular disease are common in subjects with reduced renal function. Despite intensive research of the underlying risk factors and mechanisms driving these phenotypes, we still lack effective treatment strategies for this underserved patient group. Thus, new approaches are needed to identify effective treatments. Biomimetic, i.e., studies of nature's models to solve complicated physiological problems and then translate these hibernating bear (Ursidae) should be of specific interest to remaining aortic and immobile, only to awaken with low blood urea nitrogen levels, healthy lean body mass, strong bones, and without evidence for thrombotic complications. Identifying the mechanisms by which bears prevent the development of anemia, sarcopenia, osteoporosis, and to novel interventions for both prevention and treatment of patients with chronic kidney disease.

*Kidney International* (2012) 82, 207–212. doi:10.1016/j.kint.2012.09.004  
 KEYWORDS: Anorexia; blood urea nitrogen; glycolytic bear; hibernation; muscle mass; osteoporosis; urea

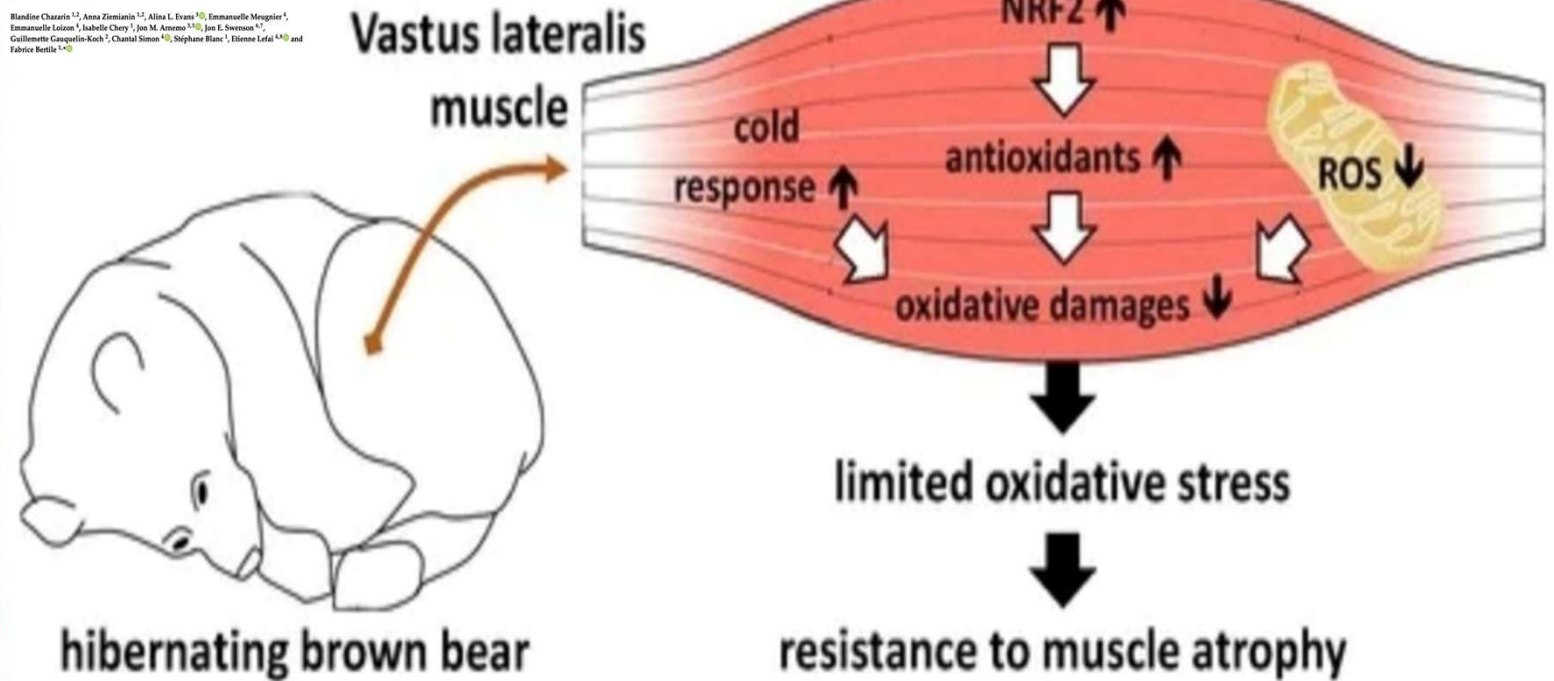
**SURVIVAL AND HIBERNATION IN BEARS**

Black and brown bears, similar to many mammals, undergo hibernation during the winter as a means to protect against periods of food shortage. Whereas true hibernators, such as

Imagine being consulted for a 200-kg individual who has been immobilized for 3 months without food and water, all the time being anuric. After carefully collecting a blood sample, you are surprised to see that despite the subject having a 70% reduction in glomerular filtration rate (GFR) the blood urea nitrogen level is in the low normal range, and into the DEXA scanner, you would be surprised to find that in examination, the bear suddenly awakens and stands up, muscles, bones and teeth. If you have time to think while you rapidly exit from the den, you might ask yourself: what the bear—a true “metabolic marvel”—can teach nephrologists, a process of trial and error to aid the survival of organisms, even under extraordinary circumstances, i.e., nature has learned what really works. “Biomimicry” is the science that takes inspiration from unique designs and processes in nature to solve human problems.<sup>1</sup> We believe that by studying ingenious solutions created by nature nephrologists can learn artificial disease models created by man in mice and rat evolution. Bears figure prominently in the mythology of most native American tribes in which the bear is considered not only a symbol of strength and wisdom but also a “medicine” role in many of native American religious ceremonies. Here, bear, *Ursus americanus* (the brown bear), *Ursus arctos* and the black grizzly bear, *Ursus arctos horribilis*) to protect themselves osteoporosis during hibernation despite prolonged inactivity and anuria (Figure 1). Studies of bear physiology and metabolism may provide new therapeutic directions for the treatment of human renal disease and its complications (Table 1).

**Limited Oxidative Stress Favors Resistance to Skeletal Muscle Atrophy in Hibernating Brown Bears (*Ursus Arctos*)**

Handline Chararín<sup>1,2</sup>, Ana Ziemann<sup>1,2</sup>, Alina L. Evans<sup>1,2</sup>, Emmanuelle Meugnier<sup>1</sup>, Emmanuelle Lefaiver<sup>1</sup>, Isabelle Chery<sup>1</sup>, Joa M. Armento<sup>1,2,3</sup>, Jon E. Swanson<sup>1,2</sup>, Guillemette Cauquelin-Koch<sup>1</sup>, Chantal Simon<sup>1,2</sup>, Stéphane Blanc<sup>1</sup>, Elienne Lefai<sup>1,2,3</sup> and Fabrice Bertie<sup>1,2,3</sup>



hibernating brown bear

resistance to muscle atrophy

# Skillnader i Livslängd mellan Olika Arter Utgör Naturens Eget Experiment i Åldrandets Biologi

## The longest living species

122 yrs



**Human**

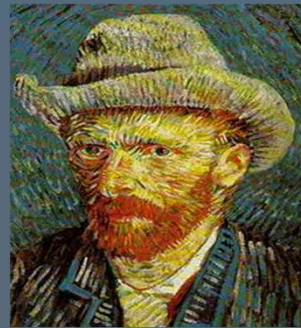
**122.5 years**

The oldest living human was French woman, Jeanne Calment, who died in 1997



Hennes livsvanor.....

- Spelade tennis, simmade och åkte rullskridskor
- Började fäktas när hon var 85 år
- Åt mycket choklad, drack portvin och använde olivolja på all mat
- Slutade röka



# Skillnad i Livslängd Mellan Olika Arter har Utgjort ett Naturligt Experiment i Åldersbiologi

## The longest living species

Human  
**122.5 years**  
The oldest living

### Eye lens radiocarbon reveals centuries of longevity in the Greenland shark (*Somniosus microcephalus*)

Science 2016

Julius Nielsen,<sup>1,2,3,4\*</sup> Rasmus B. Hedeholm,<sup>2</sup> Jan Heinemeier,<sup>5</sup> Peter G. Bushnell,<sup>6</sup> Jørgen S. Christiansen,<sup>4</sup> Jesper Olsen,<sup>5</sup> Christopher Bronk Ramsey,<sup>7</sup> Richard W. Brill,<sup>8,9</sup> Malene Simon,<sup>10</sup> Kirstine F. Steffensen,<sup>1</sup> John F. Steffensen<sup>1</sup>



A Heart That Beats for 500 Years: Age-Related Changes in Cardiac Proteasome Activity, Oxidative Protein Damage and Expression of Heat Shock Proteins, Inflammatory Factors, and Mitochondrial Complexes in *Arctica islandica*, the Longest-Living Noncolonial Animal

Danuta Sosnowska,<sup>1</sup> Chris Richardson,<sup>2</sup> William E. Sonntag,<sup>1</sup> Anna Csiszar,<sup>1,3</sup> Zoltan Ungvari,<sup>1,3</sup> and Iain Ridgway<sup>1,2</sup>

Naturen har redan löst livslängdens gåta många gånger om – utmaningen är att lära oss hur vi på ett säkert sätt kan överföra lösningarna till människor.

- Liten eller ingen predation
- Kall miljö
- Skydd mot inflammation
- Effektiva mitokondrier
- Reparerar/bryter ner skadade proteiner
- Effektiv reparation av skadat DNA

Review Article

### Long-lived animals with negligible senescence: clues for ageing research

Peter Stenvinkel<sup>1</sup> and Paul G. Shiels<sup>2</sup>

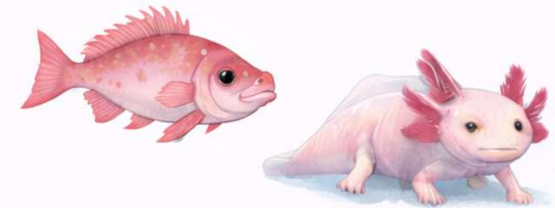
Comparative physiology and biomimetics in metabolic and environmental health: what can we learn from extreme animal phenotypes?  
Diabetologia. 2026;69(2):295-307

Peter Stenvinkel<sup>1</sup>, Peter Kotanko<sup>2,3</sup>, Johanna Painer-Gigler<sup>4</sup>, Paul G. Shiels<sup>3</sup>, Pieter Evenepoel<sup>6</sup>, Leon Schurgers<sup>2</sup>, Barbara Natterson-Horowitz<sup>2</sup>, Szilvia Kalogeropoulou<sup>4</sup>, Joshua Schiffman<sup>5,10</sup>, Richard J. Johnson<sup>1</sup>

Islandsmussla



Kungsfisk



Naken molråtta

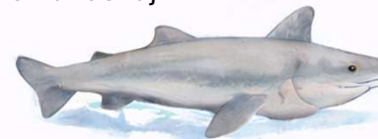


Fladdermus



Axolotl

Grönlandshaj



Elefant



Hydra



Blind grottfisk

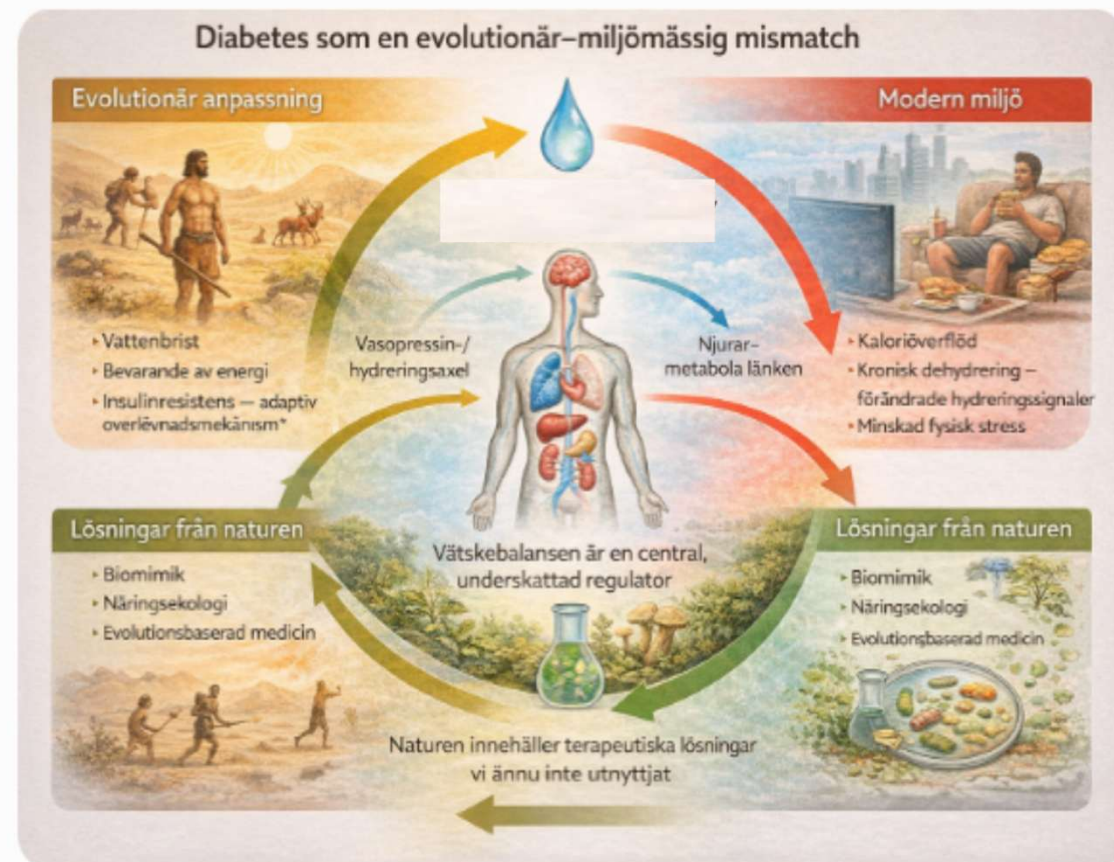


Grönlandsval

# Diabetes är Inte Bara en Sjukdom – det är ett Ekologiskt Fenomen

Samspel mellan  
människa, miljön,  
livsstil och beteenden

- Insulinresistens - en evolutionär överlevnadsmekanism har blivit till en nackdel i dagens miljö
- Vattenbrist, värmestress och luftföroreningar ökar risken för typ-2 diabetes
- I naturen finns många lösningar som vi ännu inte lärt oss använda



Vasopressin är kopplat till ökad glukosproduktion i levern och insulinresistens



*That's all Folks!*