PROCEEDINGS OF THE 4TH INTERNATIONAL EVOLUTIONARY HEALTH CONFERENCE, 2023

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Foreword

The field of evolutionary health is relatively new, and over the last several decades, has come to signify the interest in the extent of mismatch between factors common in our modern world, and our evolutionary milieu, which is a combination of genetic and environmental interactions that have influenced our development over the course of many thousands, if not hundreds of thousands of years.

We have covered a wide variety of topics during our conferences; this includes, brain function, sleep and light, various components of the diet, aging, cardiovascular disease, exercise, bone health, obesity, vitamin levels, hormonal regulation, inflammation and cancer, with the emphasis on the degree of mismatch between our hominid ancestors and modern humans today. With this most recent conference, we have added topics such as psychological and physical stress, the gut microbiome and the potential role of biomimetics in environmental stressors.

We'd like to thank the Journal of Evolutionary Health for allowing us to publish some of the abstracts from our most recent conference.

INFLUENTIAL FACTORS ON SUN-INDUCED VITAMIN D SYNTHESIS

Pedro Carrera-Bastos

The synthesis of vitamin D in human skin is a sophisticated process, heavily influenced by environmental and biological factors. This essential secosteroid, vital for numerous physiological functions, is synthesized when Ultraviolet B (UVB) radiation penetrates the epidermis. Here, UVB radiation provides the energy required to isomerize 7-dehydrocholesterol into pre-vitamin D3. This compound then undergoes transformation into vitamin D3, which diffuses from the plasma membrane into the extracellular space and enters the dermal capillary bed for transport to the liver.[1,2]

Upon reaching the liver, vitamin D3 undergoes a crucial hydroxylation step at carbon 25 by the enzyme 25-hydroxylase, which may include various cytochrome P-450 enzymes, such as the mitochondrial enzyme CYP27A1 and the microsomal enzymes CYP2J3, CYP2D25, and CYP2R1, with CYP2R1 being particularly significant.[3,4] This process yields calcifediol – 25-hydroxyvitamin D3 (25-OHD3), which, once released into circulation, is transported to various organs and tissues. There, it is converted into its active form, calcitriol – 1α,25-dihydroxyvitamin D3, by the enzyme 25-hydroxyvitamin D 1-α-hydroxylase (CYP27B1).[4] Calcitriol then acts as a ligand for the vitamin D receptor, expressed in various cells, to regulate a multitude of physiological processes.[5,6]

Despite vitamin D's crucial role, widespread insufficiency is evident from global studies.[7] This deficiency can be attributed to factors impacting vitamin D synthesis [1], intake [8–10], and/or metabolism.[4,11] The most influential factors on cutaneous vitamin D synthesis are:

1) Solar Zenith Angle [1]: The angle between the vertical zenith and the sun, as observed from a specific point on Earth's surface, significantly impacts UVB radiation availability. Lower solar zenith angles result in more direct UVB exposure due to a shorter atmospheric path, enhancing vitamin D synthesis. Conversely, higher angles, common during winter above approximately 33° latitude, result in reduced UVB penetration due to increased atmospheric absorption and scattering. Additionally, the angle varies throughout the day, being higher during early morning and late afternoon.

2) Meteorological and Atmospheric Conditions [12]: Cloud cover can drastically reduce UVB radiation, sometimes up to 99%, even during peak summer hours. In contrast, snow can reflect up to 95% of UVB rays. Altitude also plays a role, with a 7% increase in UVB radiation for every kilometer increase in altitude due to the reduction in

atmospheric density, which allows more UVB radiation to penetrate through to the earth's surface.

3) Air Pollution: Pollutants like nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and ozone can absorb UVB radiation within the 280 to 315 nanometer wavelength range, thereby negatively impacting cutaneous vitamin D synthesis.[1]

4) Skin Pigmentation: Human skin pigmentation, primarily determined by melanin, varies significantly across different geographic regions and has evolved as a natural sunscreen to absorb UVB radiation.[13] This variation significantly affects vitamin D synthesis, as darker skin requires longer sun exposure compared to lighter skin to produce equivalent levels of vitamin D.[14]

5) Aging: With age, there's a reduction in the skin's content of 7-dehydrocholesterol, decreasing the efficiency of vitamin D synthesis.[1]

6) Sunlight Exposure: Factors like clothing choice and unintentional avoidance of direct sunlight, such as being behind a window, can significantly impact vitamin D synthesis. For instance, UVB rays cannot penetrate glass, plexiglass or plastic, thus preventing vitamin D production.[1]

7) Sunscreen Use: While sunscreen application can reduce vitamin D synthesis by absorbing or blocking UVB rays, real-life evidence suggests that the impact may be minimal [15], possibly due to incorrect or inconsistent application of sunscreen. However, the effects of sunscreens with very high sun protection factors on vitamin D synthesis are not fully understood and require further investigation.[15]

In light of these factors, it becomes evident that vitamin D synthesis is a complex interplay of environmental, physiological, and lifestyle influences. Understanding these dynamics is crucial for developing strategies to mitigate vitamin D deficiency, which is a growing concern globally due to its extensive health implications. This includes developing public health guidelines for safe sun exposure, considering the use of dietary supplements, and educating the public about the nuances of factors influencing vitamin D synthesis.

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THE IMPORTANCE OF A SHORE-BASED HABITAT IN HUMAN BRAIN EVOLUTION

Stephen C. Cunnane

The human brain confronts two major challenges during its development – (i) meeting a very high energy requirement, and (ii) reliably accessing an adequate dietary source of specific brain-selective nutrients needed for its structure and function. Implicitly, these energetic and nutritional constraints to normal brain development today would also have been constraints on human brain evolution. The energetic constraint was solved in large measure by the evolution in hominins of a unique and significant layer of subcutaneous body fat on the fetus starting during the third trimester of gestation.[1] By providing fatty acids for ketone production that are needed as brain fuel, this fat layer supports the brain's high energy needs well into childhood.

This fat layer also contains an important reserve of the brain selective omega-3 fatty acid – docosahexaenoic acid (DHA), a reserve that was not available in other primates. Foremost amongst the brain selective minerals are iodine and iron, with zinc, copper and selenium also being important. A shore-based diet, i.e., fish, mollusks, crustaceans, frogs, bird's eggs and aquatic plants, provides the richest known dietary sources of brain selective nutrients. Regular access to these foods by the early hominin lineage that evolved into humans would therefore have helped free the nutritional constraint on primate brain development and function. Inadequate dietary supply of brain selective nutrients still has a deleterious impact on human brain development on a global scale today. Iodine and iron deficiencies limit cognitive development in about 1/5 of the world's population and this despite iodine supplementation being widely available for the past century.

The significant adverse impact of these modern-day nutrient deficiencies demonstrates the human brain's ongoing developmental vulnerability, a vulnerability that must also have confronted early hominins. They could only have avoided it by consuming shore-based foods rich in DHA, iron, iodine and other brain-selective nutrients. Indeed, shore-based foods are the richest source of these nutrients. The core of the shore-based paradigm of human brain evolution proposes that sustained access by certain groups of early Homo to freshwater and marine food resources would have helped surmount both the nutritional as well as the energetic constraints on mammalian brain development. [2,3]

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HOW NUTRITION CAN IMPACT MICROBIOME COMPOSITION/PERMEABILITY/IMMUNE RESPONSE TRIANGULATION IN THE GASTROINTESTINAL TRACT DICTATING THE BALANCE BETWEEN HEALTH AND DISEASE

Alessio Fasano

Improved hygiene leading to a reduced exposure to microorganisms have been implicated as one possible cause for the recent ‘epidemic’ of chronic inflammatory diseases (CID) in industrialized countries. That is, the essence of the hygiene hypothesis argues that rising incidence of CID may be, at least in part, the result of lifestyle and environmental changes that have made us too "clean" for our own good.[1]

The gut microbiome consists of more than 100 trillion microorganisms, mostly bacteria. An individual’s gut microbiome is altered by many factors, including internal factors such as placental microbiome transfer from the mother to the fetus and aging, as well as external factors such as nutrient intake and antibiotic use.

It has just recently been recognized that there is a close bidirectional interaction between gut microbiome and our immune system, and this cross talk is dependent on tightly controlled antigen trafficking through modulation of gut permeability. The microbiota, gut permeability and mucosal immune system programming are three reciprocally influenced factors that, together with genetic predisposition and environmental factors, are highly impactful in shifting one’s genetic predisposition to a specific clinical outcome.

This observation led to a revisitation of the possible causes of CID epidemics, suggesting that social, environmental and lifestyle factors (which include infections, physical inactivity, poor diet, environmental and industrial toxicants and psychological stress) may also play key pathogenic roles for these three elements (i.e., the microbiota, gut permeability and mucosal immune system programming).[2] However, these elements need to be interpreted in the contest of multi-omic analyses, which includes genomics, proteomics and metabolomics, to reach metadata informatic levels sufficient to establish their role in CID pathogenesis. This would then help to identify possible diagnostic and therapeutic targets to mitigate the inflammatory processes involved in a multitude of diseases.[3]

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CARDIOVASCULAR RISK ASSESSMENT

Robert Hansen

The Women's Health Study (WHS) demonstrated that diabetes, insulin resistance, as measured by the Lipoprotein Insulin Resistance Score, Metabolic Syndrome, Hypertension, Smoking and obesity carry much greater cardiovascular risk compared to LDL-Cholesterol and total cholesterol.[1] The Lipoprotein Retention Model assumes that endothelial penetration of Lipoprotein particles (LDL and VLDL) is governed by passive filtration, ignoring the issue of endothelial permeability. More recent data demonstrate that high blood sugar (insulin resistance), chronic inflammation, as well as other metabolic factors, interfere with HDL particle protection and enhance endothelial permeability, leading to formation and destabilization of arterial plaque.[2-7] This finding is consistent with the relative risk of various factors studied in the WHS.[1]

Calcium artery score increases as plaque becomes more stable, is easily misinterpreted, and likely to create unnecessary anxiety and possibly lead to unnecessary invasive testing.[8] Likewise, Coronary CT angiography typically overstates degree of obstruction due to "blooming artifact" and does not quantify stable versus unstable-vulnerable plaque.[9] Understanding the difference between cholesterol levels and lipoprotein particle counts, native versus modified lipoproteins, and the factors that govern endothelial penetration by lipoprotein particles is essential for evaluating cardiovascular risk. Chronic inflammation, insulin resistance, blood glucose dysregulation, hypertension, obesity and stress are hubs of multiple converging pathways in an engineering systems approach to understanding atherosclerosis and cardiovascular events. These factors are central to the physiologic maladaptation to modern life as viewed from an evolutionary perspective.[10]

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MALADAPTIVE STRESS RESPONSE: CONSEQUENCES AND RECOVERY

Igor Mitrovic

Physiologic reserve is a spare capacity of a cell, tissue, organ, or organism that is activated when a demand is increased beyond the baseline needed for survival; a theory that was proposed by Strehler and Mildvan in 1960 [1] (also see review by Chhetri et al. [2]). Any stimulus that requires activation of physiologic reserve is a stressor, and the situation in which this occurs is stress. Demand that goes beyond available physiologic reserve results in biological system damage and, ultimately, death.

The brain has evolved as a future predicting device with two key goals: 1) to identify and avoid the actions/situations leading to a threat of damage/death, and 2) to identify and promote actions/situations leading to benefits/survival. Since complex environments result in threats and benefits that are situationally dependent, the brain's capacity to learn to identify/predict the situations that are threats to survival is of paramount importance. This very flexibility that is necessary for survival in complex environments can be the source of stress. Errors in threat assessment caused by aberrant learning result in the activation of physiologic reserve that leads to damage to the organism.[3] These learned threat responses are stored in complex circuits that integrate areas of the central nervous system that regulate cognitive, emotional, and behavioral responses, as well as the classical stress response axes, the autonomic nervous system and hypothalamo-pituitary-adrenal axis. The survival valence of a particular situation dictates, 1) how powerful the activation of these circuits is going to be, 2) how strong the memory of the situation is going to be, and 3) how generalizable the future response is going to be. In other words, the most threatening situations will activate the circuits most powerfully, leading to the strongest memory that is most generalizable. This translates in having very low threshold for identifying a threat based on the similarity between the original experience and the new experience. This kind of processing, while critical for survival, has also created a very intractable problem from the therapeutic standpoint, perhaps best recognized in the phenomenon of posttraumatic stress disorder (PTSD).

Although the understanding of these phenomena at the physiologic and pathophysiologic level is rather recent, therapeutic approaches to these maladaptive states have had elements that have tried to address maladaptive learning through psychotherapeutic, behavioral, as well as pharmacologic approaches. The results, however, have not been not very encouraging. The most likely reasons are that to address the maladaptive stress responses, one must change the maladaptive circuits that encode them. Recent

development in neuroscience suggest that a successful therapy would have to satisfy the following: 1) activate all (or most) elements of circuits that need rewiring as only activated circuits are ready for modification, 2) provide alternative expectation that carries a high positive emotional salience to a specific situation that triggers the maladaptive response (classical extinction learning), 3) the practice/therapy will need to be iterative (emotional learning is implicit and since the most intense threats generalize the most, therapy needs to be iterative to address different conditions and 4) approach must be sufficiently simple/structured to be learned and used in self-therapy in a setting of stress (when the circuits are open and ready for change).

Over the last couple of decades (in parallel to and inspired by the developments in neuroscience), major advancements have been occurring in therapeutic approaches to these problems in both psychotherapeutic and pharmacologic domains. In pharmacologic therapy, psychedelics have been resurrected as the medications with some unique properties to help alter the structure of the stress circuits and reinstate the flexibility of the CNS that has been lost by the maladaptive learning by “locking” the system in a particular response pattern.[3] In the field of psychotherapy, various approaches have been used (from mindfulness through Cognitive Behavioral Therapy). However, most of these approaches do not address the maladaptive circuits across all four points listed above. The one approach that does is Emotional Brain Training (EBT), the therapeutic approach specifically developed to alter the maladaptive circuits across all four points listed above.[4] A proposition of pairing these two approaches for the most efficacious rewiring of maladaptive brain circuits seems like a winning strategy in combating psychopathologies mediated by maladaptive stress responses.

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BIOMIMETICS AND PLANETARY HEALTH

Peter Stenvinkel

Many lack a basic understanding of how closely our health relates to the well-being of animals and nature in what has come to be known as planetary health or "one health". Environmental changes drive the same inflammatory processes that cause us to age faster and suffer from chronic diseases such as obesity, dementia, chronic kidney failure, diabetes, cancer, and cardiovascular disease. Science shows that food that is not good for health is also not good for the climate. One can ask why we are so helpless in the face of the climate threat. Unfortunately, our inability to address insidious threats, learn from our mistakes, and our penchant for short-term financial gain constantly puts a spanner in the works. If carbon dioxide had been a brown and smelly gas, we would certainly have handled the problems differently. Due to the current dire situation, humans are challenged like never before and we must find new solutions.

Many are waiting for a wave of innovation based on a sustainability revolution with ingenious new solutions that reduce man's environmental and climate footprint. Artificial intelligence (AI) may assist us and ensure that data is interpreted objectively and that the right decisions are made more quickly. However, AI is not harmless and needs control. If we are to rely only on our own abilities and AI, several prerequisites for solving the problems are missing. We need to supplement parts where human intelligence and AI are not enough. Here, nature can contribute with its long-term perspective, reuse, diversity, and self-healing ability. However, nature is slowly losing its power due to loss of diversity and climate change. As an example, photosynthesis, the very prerequisite for all life on the planet, is now threatened due to global warming.[1]

Instead of exploiting and destroying the balance that nature painstakingly developed over millions of years, we should learn from ingenious natural solutions and emulate them. The concept of biomimetics is based on the idea that nature always works with optimal efficiency. Regardless of the field of application, biomimetics can become part of a global strategy for responsible development, which aims to establish a sustainable balance between the resources the planet offers and its exploitation. Existing solutions developed in nature can give us many answers and clues to solve the problems with which we urgently need to deal. Solutions created in nature can help us in the fight against chronic lifestyle diseases.[2] Species that live in polluted environments, hot climates, or with a lack of water have developed solutions that protect them against the very diseases that threaten us.[3]

If we are to take a collective approach to the planet's problems, we should make use of the solutions that nature can contribute. We should abandon the current anthropocene organizational

model and instead work more according to a biomimetic model.[3] For example, by changing eating habits with more plant-based foods and less red meat and ultra-processed foods, we could both improve health and reduce emissions of greenhouse gases.[3] If we can combine our own abilities not only with AI, but also with nature's intelligence, our increase our chances of finding solutions to a chaotic planet's health problems. This is an opportunity we must not miss. Although humans are exceptionally good problem solvers, now we need help from nature.

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