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Review

Climate change and nutritional biochemistry: emerging risks to growth and development

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Abstract
Climate change represents one of the most significant global challenges, transcending environmental dimensions to directly impact public health and food security. This review explores the complex relationship between climate change and nutritional biochemistry, focusing on the molecular and hormonal mechanisms that control human growth and development. Increased temperatures, altered rainfall patterns, and soil degradation reduce the availability of micronutrients such as iron, zinc, iodine, and essential vitamins, negatively impacting metabolic absorption, hormonal balance, and vital enzyme function. Oxidative stress resulting from harsh climatic conditions also contributes to the accumulation of free radicals, weakens antioxidant defenses, and disrupts growth-related cellular signaling pathways.
Vulnerable groups, particularly children and pregnant women, are most vulnerable to these effects, as micronutrient deficiencies are associated with delayed physical and mental development, impaired immunity, and increased rates of chronic and infectious diseases. Heat stress and malnutrition during pregnancy are also associated with increased rates of preterm birth, low birth weight, and neurodevelopmental disorders.
Evidence from scientific literature and international reports confirms that addressing these risks requires integrated adaptation strategies that include climate-smart agriculture, enhanced crop biofortification programs, and the development of health and nutrition policies targeting the most vulnerable groups. Understanding the interplay between climate, nutrition, and hormones is a fundamental step toward protecting the health of current and future generations in the face of accelerating climate change.

Keywords: *climate change, nutritional biochemistry, growth and development, oxidative stress, hormone*

INTRODUCTION

Climate change represents a comprehensive challenge that has transcended environmental dimensions to become central to the global public health and food security crisis. Climate change, from rising temperatures to altered rainfall patterns and soil degradation, is deeply intertwined with human nutritional biochemistry, including its impact on nutrient bioavailability, metabolism, and hormonal balance essential for healthy growth and development, particularly in vulnerable populations such as children and pregnant women. In addition, the effects of these environmental shifts interfere with the molecular and hormonal pathways that govern human health and can lead to profound biological and psychological changes, including the risk of delayed growth, impaired vital functions, and increased rates of diseases associated with malnutrition and oxidative stress [1].

This research review seeks to provide an in-depth scientific analysis of the relationship between climate change and nutritional biochemistry, focusing on biochemical and hormonal mechanisms, and to clarify emerging challenges that threaten the health and development of current and future generations. The review will also discuss the impact of this shift on children and pregnant women, linking this to molecular data and cellular mechanisms. It will draw extensively on findings recently published in international peer-reviewed scientific journals and reports issued by specialized international organizations.

How does climate change affect the nutritional and hormonal system?

1. Climate change and nutrient bioavailability

The bioavailability of nutrients in soil and plants is a key component of human health, as healthy growth and development depends on the quality of food and its environmental origins. Nutrient cycling is significantly disrupted by climate change, as rising temperatures and altered rainfall patterns alter the transport pathways of nutrients in the ecosystem, as well as the transformation processes within soil, plants, and water [2].

Table 1. Relationship between climatic factors and biochemical changes in nutrients

Climate Factor	Main Biochemical Effect	Potential outputs
Rising Temperatures	Faster decomposition of organic compounds; water evaporation; reduced water content in the soil	Lack of dissolution of mineral elements, decreased plant absorption of iron, zinc and calcium, vitamin damage, and degradation of antioxidants
Changing rainfall pattern	Drought/flood; changes in the distribution of salt and minerals	Soil salinization (nutrient loss problem), soil washing and erosion of its content, poor abundance of nitrate and phosphorus
Deterioration of soil structure	Loss of organic matter, low ionic exchange capacity	Decreasing levels of micronutrients, rising heavy metals, declining productivity of high-bio-value foods
Increased acidity	Deposition of some elements and decreased bioavailability of iron and zinc	Disturbances in the absorption of essential minerals, high incidence of anaemia and micronutrient deficiencies

The above data (table 1) illustrates how climate change disrupts the biochemical composition of plant and animal foods. Some vital nutrients are deposited in an unabsorbable form or dissolved due to acidity or salinity, reducing their effectiveness in supporting vital human functions. The loss or rapid decomposition of organic matter leads to reduced soil fertility and a decrease in the content of essential trace minerals and vitamins in foods [2].

2. Temperature changes and soil deterioration: risks to food chains

Most regions of the world are experiencing an increase in drought conditions and extreme heat waves, leading to accelerated soil degradation, the erosion of organic matter and vitamins (especially B, C, and other heat-sensitive vitamins), and the degradation of soil structure, a phenomenon that reduces the biomass capable of absorbing and storing nutrients.

In addition, soil loss or salinization leads to a quantitative and qualitative decrease in plant proteins and vital nutrients, which directly impacts community health and the mental and physical development of children and young people. Rising temperatures also increase the rate at which plants consume water and nutrients, affecting the plant's internal hormonal balance, leading to the production of defensive secondary compounds, and reducing the overall concentration of nutrients of biological value to humans [1].

3. Changing rainfall patterns and water stress

Irregular rainfall or changes in rainfall patterns, whether in quantity or timing, affect soil moisture, altering the activity of microorganisms responsible for nitrogen conversion (mineralization and nitrification) and the oxidation of organic matter. When soil moisture is low or fluctuates sharply, nitrification rates decline, resulting in reduced nitrate production available to plants. Changes in seasonal rainfall patterns can reduce nitrification and mineralization rates during dry seasons by more than 70%, limiting nitrogen availability to plants [3]. Phosphorus dynamics in soil are influenced by a range of physical and chemical factors, most notably pH, which controls phosphorus solubility and availability to plants. Biogeochemical processes also play a pivotal role in redistributing or fixing phosphorus through its interactions with various soil components. In addition, microbial activity and organic matter oxidation can indirectly influence phosphorus cycles by modifying the soil chemical environment and releasing phosphorus bound to organic or mineral compounds [4]. Disrupted amino acid and micronutrient availability leads to a deficiency in the synthesis of neurotransmitters and protein hormones, a serious factor in learning and growth difficulties in children and adolescents [5].

4. Impact on metabolism and enzyme function

Changes in temperature and humidity have a direct impact on the rate of enzyme reactions within the body, as these processes are extremely sensitive to any thermal or chemical change. For example, basal metabolic rates (BMR) increase under the influence of extreme heat, and the body's requirements for calories and nutrients change. Oxidative stress generated by harsh climates leads to the accumulation of free radicals, which disrupt organic enzymes, break down unsaturated fats and proteins, and affect energy synthesis from nutrients [6].

Also, the effects of climate change on pregnancy and fetus may be mediated by psychological and physiological stressors, including elevated cortisol levels and changes in inflammatory cytokines, which may negatively impact on the long-term health of the fetus and child. Chronic inflammation and altered hormonal environment during pregnancy can alter metabolic pathways, leading to growth and developmental disturbances. Furthermore, exposure to stress before and during pregnancy may program suboptimal metabolic and immune responses, with potential transgenerational effects through genetic and epigenetic mechanisms [7].

5. Hormonal effects of growth under climate stress

The growth-related hormonal system, which includes growth hormone (GH), insulin-like growth factor (IGF-1), and some thyroid and adrenal hormones, is directly affected by climate and nutritional stress. Nutritional scarcity resulting from the deterioration of food chains leads to decreased stimulation of the pituitary gland to secrete growth-promoting hormones, especially in children [8].

Exposure of fetuses or children to malnutrition accompanied by heat stress or dehydration leads to a significant decrease in IGF-1 and growth hormone levels [9], along with disruptions in cortisol (the stress hormone) secretion, which poses a double risk of delayed growth, short stature, and motor and cognitive impairments in the future [10].

Biochemical and molecular effects on human growth and development

1. Micronutrient deficiencies and the risk of growth delay

Micronutrient deficiencies, particularly zinc, iron, and vitamins A and D, are associated with delayed physical growth and neurodevelopment. In addition, children living in climate-affected environments suffer from severe hemoglobin deficiency, decreased collagen and protein synthesis, leading to lower weight and height for age, and increased incidence of inflammatory diseases, respiratory infections, and gastrointestinal infections [11].

Low bioavailability of calcium and vitamin D increases the rate of fractures, osteoporosis, and decreases bone mass in children and adolescents, and leads to reduced muscle and brain development. Infants born to mothers with vitamin D deficiency under hot conditions or with limited exposure to sunlight have been shown to have delayed walking and neuromotor problems [11].

The data from table 2 highlights the central influence of nutrients on body composition and mental abilities. Any disruption in their availability or absorption, due to climatic and environmental factors, is immediately reflected in the rates of diseases that inhibit growth and mental and behavioral problems. This is exacerbated in low-income communities with poor nutritional systems [11].

Table 2. The relationship between essential nutrients and human development

Nutrient	The main vital role	Consequences of shortages under climate pressures
Iron	Hemoglobin Synthesis, Oxygen Transport, Brain Development	Anemia, poor IQ, slow physical and cognitive development
Zinc	Growth Enzymes, Immunity, Tissue Repair	Decreased height, decreased immunity, delayed wound healing
Vitamin A	Vision, immunity, neuronal differentiation	Poor vision, recurrent infections, neurological disorders
Vitamin D	Calcium absorption, bone growth, rickets prevention	Frailty, delayed walking, impaired brain, and motor system development
Iodine	Thyroid hormone synthesis	Impaired mental abilities, goiter, short stature

2. Effects on metabolism and the hormonal system

Elevated temperatures and environmental oxidative stress, coupled with poor nutrition, alter the structure and activity of vital enzymes in the body, such as glutathione reductase, superoxide dismutase, and catalase. These changes lead to the accumulation of oxidized compounds, impaired detoxification, and stress on vital processes, increasing the risk of cancer, heart disease, and metabolic diseases. They are also associated with decreased secretion and production of female and male hormones essential for reproductive and mental development. Disruption of cortisol and thyroid hormone secretion in the body under climatic stress and malnutrition directly affects children's mental capacity, immediate growth rates, and central nervous system maturation, which impacts physical and cognitive outcomes throughout adulthood and adulthood [12].

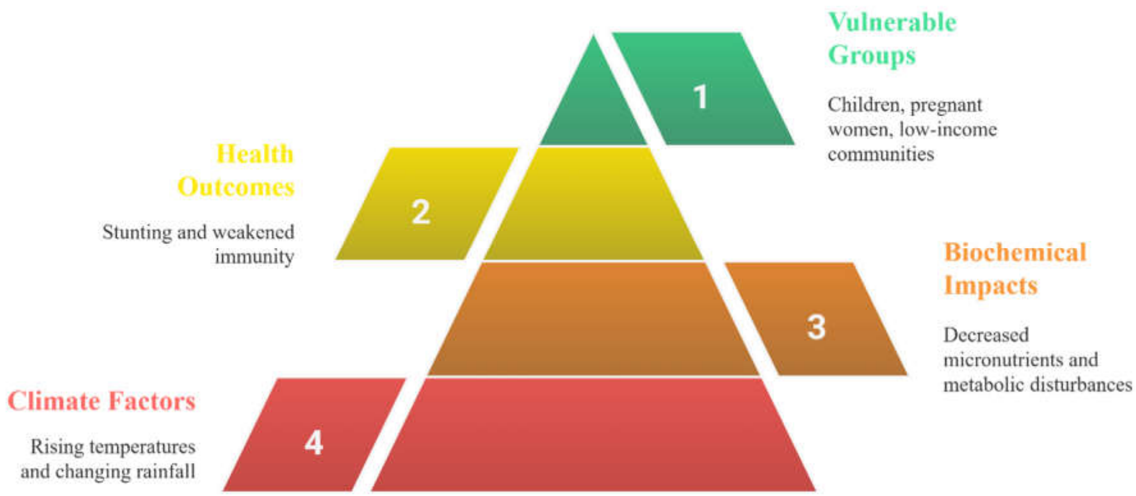

Fig. 1. Conceptual framework illustrating the cascade of climate change impacts from environmental drivers to biochemical disruptions, health outcomes, and vulnerable groups.

Vulnerable populations: children and pregnant women

1. Children: increased risks and impact on biological and cognitive development

Children represent the most vulnerable group to disruptions in environmental and nutritional systems resulting from climate change. This is because childhood is a critical period for bone, muscle, and brain development, and their nutrient requirements are higher compared to their weight compared to adults. Any nutritional deficiency or hormonal imbalance quickly impacts health, learning, behavior, and biological and cognitive development. There is a direct link between nutritional deterioration and climate change, with increased rates of wasting, stunting, weakened immunity, and infectious diseases in areas most vulnerable to drought or flooding [13].

Children with poor micronutrient intake are more susceptible to delayed intelligence, poor academic achievement, and impaired psychomotor development. The risks are not limited to physical aspects; they also include increased rates of anxiety, depression, and behavioral disorders as a direct result of the impact of climate change on the developing nervous system of children, as well as on poor communities lacking sustainable food security [14].

2. Pregnant women: risks to maternal and fetal health

Pregnant women face a compounded risk due to increased nutritional needs, increased sensitivity to heat, and oxidative stress [15]. Exposure to extreme heat stress during pregnancy is associated with increased risks of preterm birth, low birth weight, and stillbirth rates. Potential biological mechanisms such as dehydration and disruption of maternal physiological balance may also negatively impact fetal development. Women in resource-limited settings or those with fragile social and health conditions are more vulnerable to heat waves, highlighting the importance of health equity in the face of climate change [16]. Deficiencies of essential vitamins and minerals (such as iron, zinc, iodine, and vitamin D) in pregnant women lead to complications including premature births, increased neonatal mortality, and impaired intellectual development in infants [17].

Environmental factors such as air pollution, contaminated water, and chemicals impact human health. These factors interact with unhealthy lifestyles such as lack of physical activity and an unbalanced diet to increase the risk of chronic diseases. Malnutrition makes individuals more vulnerable to harmful environmental influences, while improving diet can function as a preventative measure to reduce the health burden resulting from an unfavorable environment, highlighting the close interconnectedness between environment, lifestyle, and nutrition in shaping overall health status [18]. This reflects the importance of providing maternal care in terms of nutrition, climate, and a healthy environment to reduce the cumulative negative impact across generations.

3. Low-income and food security communities

The vulnerability of poor groups and rural areas dependent on subsistence farming is increasing, as the impact of climate change is magnified by limited financial and technical resources, insufficient early warning systems, and inadequate food support. Climate change leads to crop variability, reduced micronutrient content in foods, reduced availability of dairy and animal proteins, and unprecedentedly high food prices, exacerbating the crisis among the poorest population groups and making the cycle of malnutrition more severe and intense with each drought or flood season [19].

Linking molecular and hormonal changes to growth under climate stress

1. Molecular mechanisms: oxidative stress and cellular signaling pathways

Climate stress disrupts the cellular redox balance, increasing levels of free radicals (ROS) and weakening antioxidant defenses such as glutathione, selenium, and superoxide dismutase. These molecular changes lead to damage to proteins, membrane lipids, and DNA within developing cells, linked to increased rates of cell death (apoptosis), impaired neuronal differentiation, and slowed tissue regeneration, particularly in the brain and bones [20].

At the cellular signaling level, severe environmental conditions contribute to the disruption of signaling pathways associated with insulin and growth factors (IGF pathways), leading to short stature, decreased muscle mass, and impaired brain development in infants and children [21].

2. Hormonal mechanisms and physiological adaptation

Climate change and its associated environmental-nutritional factors pose a direct challenge to human growth and development. Temperature changes, air pollution, and erratic rainfall patterns reduce food availability and quality, exacerbating malnutrition and deficiencies in micronutrients such as iron, zinc, and vitamin D. Environmental pollution with heavy metals and organic pollutants also affects nutrient absorption, affecting liver and endocrine function. Under these conditions, the body experiences metabolic and hormonal stress, manifested by increased cortisol secretion, imbalanced thyroid hormones (T3 and T4), and impaired GH/IGF-1 response. This leads to delayed longitudinal and weight growth, decreased muscle and bone mass, and delayed sexual and physical maturation, especially in children during critical stages of fetal development and early childhood. This makes nutritional and preventive interventions an urgent necessity to protect vulnerable groups from these long-term risks [22].

Exposure to heat stress activates the hypothalamic-pituitary-adrenal (HPA) axis, which raises cortisol levels in the body. This increase impacts several vital functions, most notably immune response, metabolic balance, and mood regulation. As a result, susceptibility to psychological disorders such as anxiety and depression increases, especially in environments affected by climate change [23].

Discussion of the most prominent findings in international journals

1. Findings in the field of biochemistry and climate

The relationship between climate change and biochemical disturbances in soil and food, proving that rising temperatures lead to a decrease in protein, essential amino acids, and micronutrient content of foods, particularly in cereals and legumes. The results also confirmed that oxidation-sensitive vitamins—such as vitamins A and C—are significantly affected by storage and exposure to elevated temperatures during dry harvests or floods [24].

2. The impact of climate on health, nutrition, and growth

Climate change poses a direct threat to public health through its impact on nutrition and growth. Extreme climate events such as drought, floods, rising temperatures, and soil degradation reduce agricultural production and the availability of nutrient-rich foods. This increases rates of malnutrition and micronutrient deficiencies, particularly among vulnerable groups such as children, pregnant and lactating women. This is reflected in higher rates of anemia, stunting, delayed physical and cognitive development, and increased susceptibility to chronic diseases linked to malnutrition. The report indicates that these challenges are exacerbated in developing countries due to the fragility of health infrastructure and heavy reliance on traditional agriculture. Addressing them requires integrated adaptation strategies that link environmental, nutritional, and health policies to protect the most vulnerable groups and ensure sustainable human growth [25].

3. Environmental health perspectives and disruption of food security systems

The complex interaction between changing diets—under the influence of climate change—and the increased incidence of foodborne and emerging diseases. They emphasized the need for international public health strategies to strengthen agricultural and food systems against environmental changes, and to integrate biochemical considerations and the special nutritional needs of vulnerable groups into climate adaptation plans [26].

4. Chronic diseases and immunity

Climate change impacts nutrition and public health through increased rates of malnutrition and micronutrient deficiencies due to reduced food availability and deteriorating food quality. Children and pregnant women represent the most vulnerable groups due to their special nutritional needs and biological sensitivities. These changes also contribute to increased risks of chronic diseases and metabolic disorders such as obesity, diabetes, and cardiovascular disease. Furthermore, nutrient deficiencies and malnutrition weaken natural immunity and increase susceptibility to infection [27].

Practical recommendations for adaptation and reducing emerging risks

Considering the dynamic interconnection between climate, nutrition, and hormonal biochemistry, international literature and experience recommend a set of integrated strategies:

- Strengthen crop biofortification programs to increase iron, zinc, iodine, and vitamin A and D levels in staple foods in fragile areas.
- Introduce climate-smart agriculture systems with a focus on soil restoration and improvement, on-farm nutrient cycling, rational water management, and soil erosion control.

- Develop specialized early warning systems to monitor indicators of changes in soil and food quality and guide local communities to adopt sound nutritional behaviors.
- Improving the effectiveness of health and nutrition regulations targeting vulnerable groups, especially children and pregnant women in conflict and environmental disaster zones and developing health policies that recognize the cumulative risks of climate on human structure and development.

Literature search strategy

A comprehensive review of the scientific literature related to climate change, nutritional biochemistry, and their impact on growth and development was conducted using accredited global databases such as PubMed, Scopus, Web of Science, ScienceDirect, and SpringerLink, as well as reports from international organizations such as the World Health Organization (WHO) and the Intergovernmental Panel on Climate Change (IPCC). A set of single and combined keywords in both English and Arabic were used, including climate change, nutrition, micronutrients, growth, endocrine disruption, oxidative stress, child development, and maternal health.

Inclusion criteria included studies published between 2007 and 2025, including original research and scientific reviews published in peer-reviewed journals, in addition to official international reports (WHO, FAO, IPCC). Exclusion criteria included non-peer-reviewed studies, articles focusing on purely agricultural or environmental topics without a connection to health or nutrition, and duplicate or unavailable references in full text. After an initial screening process that resulted in more than 200 articles, 27 primary references representing the most recent and important scientific evidence were selected. These references were comparatively analyzed, focusing on biochemical mechanisms, vulnerable populations, and relevant health recommendations.

CONCLUSIONS

This review of global scientific literature reveals that climate change poses a dual challenge to nutritional biochemistry and human development, both by disrupting the availability of micronutrients and by affecting metabolic pathways, hormones, and the function of vital enzymes. The double impact is particularly pronounced on children and pregnant women, who are more likely to suffer from malnutrition, delayed physical, mental, and cognitive development, and an increase in chronic and infectious diseases.

This crisis requires a radical shift in understanding the relationship between climate, health, and nutrition, and the need to adopt comprehensive adaptive policies that integrate biochemical, environmental, and nutritional considerations, with a focus on protecting the most vulnerable groups. Finally, deepening and renewing research in the context of climate change and the associated environmental chemical and hormonal imbalances represents the most important gateway to understanding the future of humanity and the health of future generations in a world whose climate is changing at an unprecedented pace.

REFERENCES

[1] OWINO, V., KUMWENDA, C., EKESA, B., PARKER, M.E., EWOLDT, L., ROOS, N., LEE, W.T., TOMÉ, D., Front. Clim., **4**, 2022, https://doi.org/10.3389/fclim.2022.941842.

[2] ELBASIOUNY, H., EL-RAMADY, H., ELBEHIRY, F., RAJPUT, V.D., MINKINA, T., MANDZHIEVA, S., Sustainability, **14**, no. 2, 2022, https://doi.org/10.3390/su14020914.

[3] MAO, C., WANG, Y., RAN, J., WANG, C., YANG, Z., YANG, Y., J. Plant Ecol., **18**, no. 3, 2025, https://doi.org/10.1093/jpe/rtaf051.

[4] LIEBERMAN, H.P., VON SPERBER, C., KALLENBACH, C.M., Glob. Change Biol., **31**, no. 7, 2025, https://doi.org/10.1111/gcb.70307.

[5] PRADO, E.L., DEWEY, K.G., Nutr. Rev., **72**, no. 4, 2014, p. 267, https://doi.org/10.1111/nure.12102.

[6] MUHAMMAD, I., STEINBERG, F., LARSEN, J., RUCKER, R.B., FASEB BioAdv., **7**, no. 4, 2025, p. e1487, https://doi.org/10.1096/fba.2024-00140.

[7] OLSON, D.M., METZ, G.A.S., F1000Research, **9**, 2020, p. F1000 Faculty Rev-1222, https://doi.org/10.12688/f1000research.27157.1.
[8] CANOSA, L.F., BERTUCCI, J.I., Front. Endocrinol., **14**, 2023, https://doi.org/10.3389/fendo.2023.1109461.
[9] FAZELI, P.K., KLIBANSKI, A., J. Endocrinol., **220**, no. 3, 2014, p. R57, https://doi.org/10.1530/JOE-13-0477.
[10] BONELL, A., VICEDO-CABRERA, A.M., MOIRANO, G., SONKO, B., JEFFRIES, D., MOORE, S.E., HAINES, A., PRENTICE, A.M., MURRAY, K.A., Lancet Planet. Health, **8**, no. 10, 2024, p. e734, https://doi.org/10.1016/S2542-5196(24)00208-0.
[11] STEVENS, G.A., BEAL, T., MBUYA, M.N.N., LUO, H., NEUFELD, L.M., GLOBAL MICRONUTRIENT DEFICIENCIES RESEARCH GROUP, Lancet Glob. Health, **10**, no. 11, 2022, p. e1590, https://doi.org/10.1016/S2214-109X(22)00367-9.
[12] KHAN, M., MUSHTAQ, M., USMAN, M., RAHMAN, M.A.U., QUAN, G., Adv. Redox Res., **16**, 2025, https://doi.org/10.1016/j.arres.2025.100138.
[13] GEORGIEFF, M.K., RAMEL, S.E., CUSICK, S.E., Acta Paediatr., **107**, no. 8, 2018, p. 1310, https://doi.org/10.1111/apa.14287.
[14] CAMPBELL, S., BRADLEY, H., MULDER, R., HENDERSON, J., DIXON, L., HASLETT, L., RUCKLIDGE, J., Early Hum. Dev., **190**, 2024, https://doi.org/10.1016/j.earlhumdev.2024.105948.
[15] KONKEL, L., Environ. Health Perspect., **127**, no. 10, 2019, p. 102002, https://doi.org/10.1289/EHP6221.
[16] DUMBUYA, S., CHABINGA, R., FEREDE, M.A., SABER, M., J. Water Health, **22**, no. 11, 2024, p. 2113, https://doi.org/10.2166/wh.2024.254.
[17] GERNAND, A.D., SCHULZE, K.J., STEWART, C.P., WEST, K.P. Jr., CHRISTIAN, P., Nat. Rev. Endocrinol., **12**, no. 5, 2016, p. 274, https://doi.org/10.1038/nrendo.2016.37.
[18] CHRISTOFFEL, K.K., WANG, X., BINNS, H.J., Int. J. Environ. Res. Public Health, **9**, no. 4, 2012, p. 1227, https://doi.org/10.3390/ijerph9041227.
[19] MORTON, J.F., Proc. Natl. Acad. Sci. USA, **104**, no. 50, 2007, p. 19680, https://doi.org/10.1073/pnas.0701855104.
[20] MANFUL, C.F., FORDJOUR, E., SUBRAMANIAM, D., SEY, A.A., ABBEY, L., THOMAS, R., Int. J. Mol. Sci., **26**, no. 15, 2025, https://doi.org/10.3390/ijms26157520.
[21] ARAYA, P., KINNING, K.T., COUGHLAN, C., SMITH, K.P., GRANRATH, R.E., ENRIQUEZ-ESTRADA, B.A., WOREK, K., SULLIVAN, K.D., RACHUBINSKI, A.L., WOLTER-WARMERDAM, K., HICKEY, F., GALBRAITH, M.D., POTTER, H., ESPINOSA, J.M., Cell Rep., **41**, no. 13, 2022, https://doi.org/10.1016/j.celrep.2022.111883.
[22] MOHAMMAD, A., MARES, A.C., ALBASIS, A.A., KIWAN, M., SUBBANNA, S., LAWRENCE J.A., WANI, S.A., KHATER, B., ABDI, A., PRIYA, A., ADEMUWAGUN, C.T., MEHTA, K., RAMADAN, N., SOOD, A., GUPTA, H.B., SOOD, A., Endocrinol. Diabetes Metab. J., **8**, no. 3, 2024, p. 1, https://doi.org/10.31038/EDMJ.2024834.
[23] HANNAN, F.M., LEOW, M.K.S., LEE, J.K.W., KOVATS, S., ELAJNAF, T., KENNEDY, S.H., THAKKER, R.V., London Sch. Hyg. Trop. Med., 2024, Available from: https://researchonline.lshtm.ac.uk/id/eprint/4674620/7/Hannan-etal-2024-Endocrine-effects-of-heat-exposure-and-relevance-to-climate-change.pdf.
[24] SEMBA, R.D., ASKARI, S., GIBSON, S., BLOEM, M.W., KRAEMER, K., Adv. Nutr., **13**, no. 1, 2022, p. 80, https://doi.org/10.1093/advances/nmab104.
[25] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), Climate change 2022: summary for all – how climate change is impacting life on Earth, AR6 WGII, 2022, Available from: https://www.ipcc.ch/report/ar6/wg2/downloads/outreach/IPCC_AR6_WGII_SummaryForAll_Impacts.pdf.
[26] TAPKIGEN, J., HARDING, S., PULKKI, J., ATKINS, S., KOIVUSALO, M., BMJ Open, **14**, no. 6, 2024, https://doi.org/10.1136/bmjopen-2023-080241.

[27] YU, Y., LI, H., HU, N.X., WU, X.H., HUANG, X.Y., LIN, H.T., YU, K.L., LI, J.L., Front. Nutr., **11**, 2024, https://doi.org/10.3389/fnut.2024.1470713.

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