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VITAMIN E AND EPIGENETICS: IMPLICATIONS FOR HEALTH AND DISEASE

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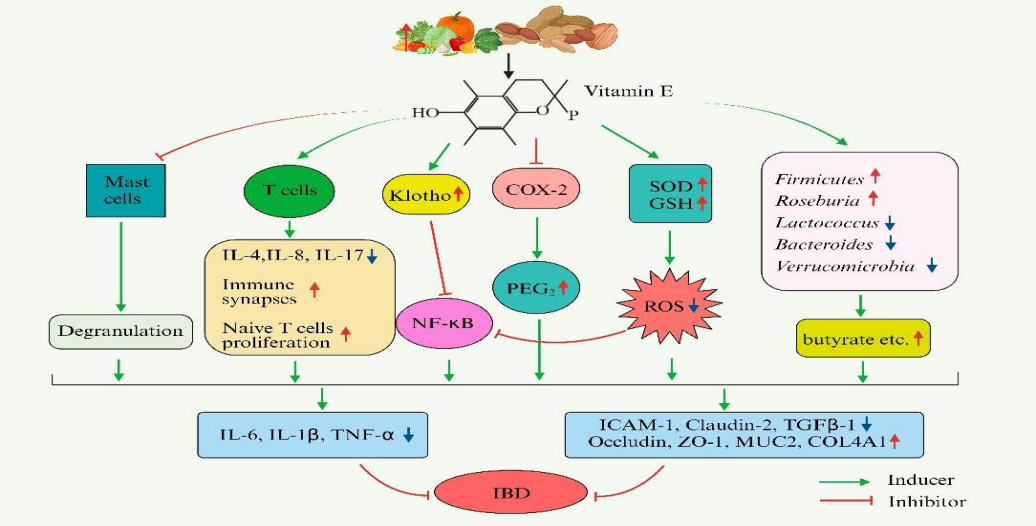
ABSTRACT

Vitamin E is typical component of numerous natural chemicals derived from plants and animals, including tocopherols and tocotrienols (α, β, γ, and δ). The promising results of these studies have made vitamin E a major area of study in the biomedical field, highlighting its additional beneficial properties, such as antibacterial, anti-inflammatory, and anti-cancer properties. The main lipid-soluble element of cells' antioxidant defense mechanism is vitamin E, which is exclusively found in food. Because of its antioxidant effect, it carries out several vital bodily activities. The human body prefers α-tocopherol, even though all eight of the vitamin E-related chemicals that are present in the diet are produced by plants and scavenge peroxyl radicals. Regulatory processes that help to preserve α-tocopherol and eliminate the non-α-tocopherol forms are crucial to vitamin E's biological activity. The biological significance of vitamin E and its uses in food packaging and cosmetics are well documented in the literature, and there are numerous reviews available. Our goal in this review is to highlight the most recent research on how vitamin E-rich antioxidant supplements affect exercise and athletic performance. This review's main goal is to clarify the molecular processes underlying AMD is a progressive and permanent degeneration of central vision that may be treated by vitamin E signaling pathways. The primary causes of cardiovascular issues are inflammation and the oxidation of the body's low-density lipoproteins. Future research should focus on pinpointing the precise genes or signaling pathways that vitamin E affects. Studies should concentrate on the impact of maternal vitamin E consumption on children's health and risk of disease, since vitamin E may influence fetal development through epigenetic programming.

KEYWORD:- Tocopherol, Vitamin E, Health, Antioxidants.

Graphical Abstract



INTRODUCTION

- Brief overview of vitamin E's historical significance and its role as an antioxidant.

As fat oxidizes and free radical reactions spread, vitamin E, a strong chain-breaking antioxidant, prevents the creation of reactive oxygen species molecules.[1]

Although its concentration ratio may be as low as one molecule per 2,000 phospholipid molecules, it is mainly found in the membranes of cells and organelles, where it can have the greatest protective effect.[2] The tocopheroxyl radicals that are produced can either: (1) oxidize other lipids; (2) undergo additional oxidation to produce tocopheryl quinones; (3) compound with an additional tocopheroxyl radical to make non-reactive tocopherol dimers; or (4) be reduced to tocopherol by other antioxidants.[3]

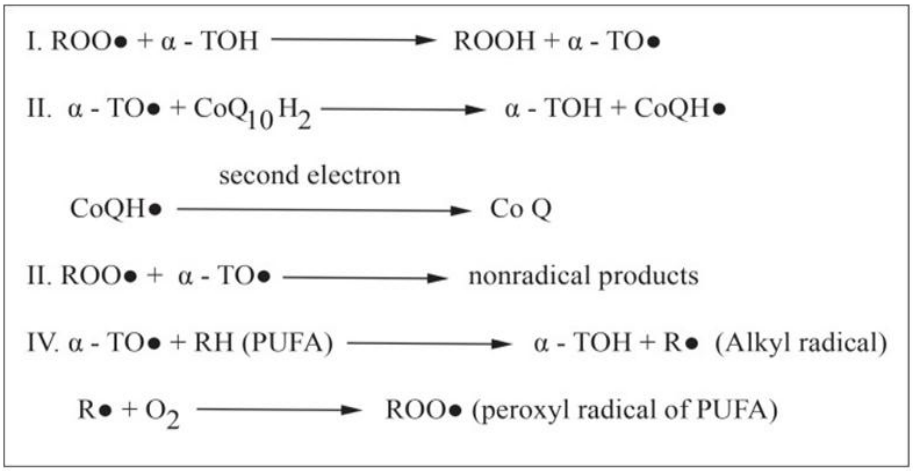


Figure 1

Vitamin E can be found as a dietary supplement, added to other foods, and found naturally in some foods. Vitamin E is the collective designation for a class of fat-soluble compounds having special antioxidant qualities.[4] Antioxidants protect cells from the damaging effects of free radicals, which are molecules with an unshared electron. Free radicals damage cells and may have a role in the emergence of cancer and heart disease.[5] As fat oxidizes, vitamin E, a fat-soluble antioxidant, prevents the production of reactive oxygen species (ROS). In vitro studies of cells, cell signaling, gene expression regulation, and other metabolic processes have shown that vitamin E contributes to immunological function in addition to its antioxidant properties.[6'7]

Benefits of vitamin e

1. May reduce markers of oxidative stress and strengthen defenses against it.
2. May reduce heart disease risk factors
3. People with non-alcoholic fatty liver disease (NAFLD) might benefit.
4. Could aid in dysmenorrhea management
5. Could improve the health of the skin
6. Could improve mental well-being
7. Could be advantageous for senior citizens
8. Could enhance lung function

- Introduce the concept of epigenetics and its importance in gene expression regulation.

In contrast to mutations, epigenetics studies heritable variations in gene expression that are not brought on by alterations in the DNA sequence. The primary epigenetic mechanisms are DNA methylation, chromatin changes, non-coding RNA, and loss of imprinting.[8] Epigenetics has been defined as 'the study of mitotically (and potentially meiotically) heritable alterations alters the expression of genes that are not brought on by variations in the DNA sequence.[12] Twelve Whatever the precise definition, the epigenetic mechanisms that consistently modify patterns of gene expression (and the fact that epigenetic changes can be passed down from mother to daughter cells (mitotic inheritance) and between generations (meiotic inheritance) is a significant characteristic.[9] Furthermore, the pathophysiology of many diseases, and especially cancers, has been demonstrated to include the epigenetic regulation of gene expression.[10,11] Cytosine methylation, post-translational modification of histone proteins and chromatin remodeling, and RNA-based processes are thought to represent some of these pathways. Transcription, translation, and subsequent protein modification—often followed by protein synthesis and/or transmission of the changes upon cell division—transfer genetic information from the archival copy of DNA to short-lived messenger RNA.[13]

- Highlight the potential link between vitamin E and epigenetic modifications.

Vitamin E is widely known for being a strong antioxidant that protects against oxidative damage. When vitamin E isomer tocotrienol-rich fragment (TRF) was administered to rats, their swimming performance improved was given orally because it increased blood lactate levels while maintaining glycogen levels.[104] In this review, we aim to highlight the current findings on impact of vitamin E-rich antioxidant supplements on exercise and sport performance. The theoretical underpinnings of how vitamin E may improve performance are still unknown, even though numerous studies suggest that vitamin E intake may have positive impacts on oxidative damage and health status. Clinical

outcome prediction and disease[105] stratification can be achieved by epigenetic changes.[106] Since epigenetic changes are both reversible and somatically heritable, they make excellent candidates for possible pharmacological therapies. In a mechanism like an inverted oncogene addiction, cancer cells may become "addicted" to the aberrantly generated epigenetic landscape and, thus, be more responsive to epigenetic therapy than normal cells. A changed epigenetic landscape is typically the result of several epigenetic abnormalities present in diseased tissue.[107]

- Outline the research questions or objectives of the review.

1. Understanding Mechanisms

Which are the primary epigenetic mechanisms by which vitamin E influences gene expression?

How does vitamin E affect epigenetic indicators such non-coding RNAs, histone alterations, and DNA methylation?

2. Examining Therapeutic Potential and Disease Prevention

How might vitamin E-mediated epigenetic modifications affect the onset or avoidance of specific diseases (including cancer, heart disease, and neurological disorders)?

Can vitamin E supplements be used as a therapeutic intervention to alter epigenetic alterations in disease states?

3. Dose-Response Relationship

What is the dose-response relationship between vitamin E intake and how it affects epigenetic changes?

Are there differences in epigenetic outcomes according to vitamin E's form (e.g., alpha-tocopherol vs. gamma-tocopherol) or intake levels?

4. Implications for Future Research and Clinical Practice

What are the existing gaps in knowledge regarding the function of vitamin E in epigenetic regulation, and what areas require further investigation?

How could insights into vitamin E's epigenetic effects be applied within the framework of clinical practice to support disease prevention, treatment, and personalized health approaches?

5. Population-Specific Impacts

Does Vitamin E's impact within the epigenome vary by factors like age, sex, ethnicity, or genetic background?

Could personalized nutrition strategies based on epigenetic responses to vitamin E be developed for specific population groups?

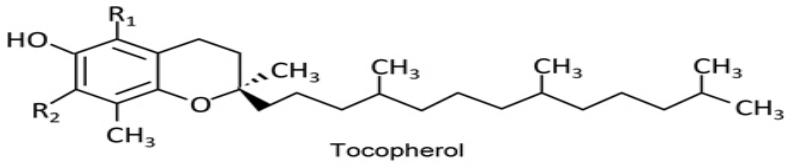
These objectives aim to offer a thorough comprehension of how vitamin E interacts with the epigenome and how these interactions might be leveraged for improved health outcomes.

Vitamin E: A Brief Overview

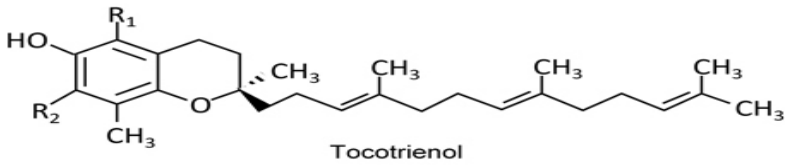
Evans and Bishop discovered and described vitamin E in 1922. It is present in many products that include lipids from both plant and animal sources, including egg yolks, hazelnuts, olive or almond oil, and liver. Tocopherols and tocotrienols are its eight natural forms: α, β, γ, and δ. A 16-carbon lateral chain attached to position 2 of a benzopyran ring essentially separates tocopherols from tocotrienols. The long radical chain's saturation varies significantly between the two isoforms; tocopherols have a fully saturated chain, whereas tocotrienols have an unsaturated one. The amount and location of the methyl group attached to the phenolic ring determined the names of the two homologs.[14,15,16]

- Chemical structure and classification of vitamin E.

Chemical structure of vitamin e



Tocopherol



Tocotrienol

	α	β	γ	δ
R_1	CH_3	CH_3	H	H
R_2	CH_3	H	CH_3	H

Classification of vitamin e

Vitamin e is classified into two main categories: tocopherol and tocotrienols.

1. Tocopherols

- Alpha-tocopherol (The most active form in humans)
- Beta-tocopherol
- Gamma-tocopherol
- Delta-tocopherol

2. Tocotrienols
- Alpha-tocotrienol
- Beta-tocotrienol
- Gamma-tocotrienol
- Delta-tocotrienol

- Dietary sources and absorption of vitamin E

One organic micronutrient that is fat-soluble and contributes to maintaining human health is vitamin E. Soybean, rapeseed, corn germ, sunflower, and wheat germ are some of the vegetable oils that are the primary source of vitamin E humans. It is also found in a number of fruits, vegetables, and nuts, including avocados, almonds, kale, and spinach.[17] In 1922, vitamin E was originally identified as an essential dietary component for rat reproduction.[18] Apart from its conventional function In addition to its antioxidant properties, vitamin E affects gene and protein expression, enzyme function, and signaling cascades.[19,20,21] When vitamin E dissolves in the food's lipid phase, the digestion-absorption process begins. This phase is then emulsified into lipid droplets at the duodenum and stomach levels. Vitamin E metabolism, or breakdown or absorption, does not appear to occur in the stomach. Furthermore, in healthy adults, the efficacy the size of the droplets doesn't seem to have an impact on the subsequent absorption of vitamin E.[22] Ostensibly necessary for the enterocyte to absorb it, vitamin E and the byproducts of fat breakdown in the duodenum combine to form mixed micelles. Mixed micelles can break down hydrophobic molecules and pierce the glycocalyx, the undisturbed water layer, to get close to the brush boundary membrane of the enterocytes. Mixed micelles can break down hydrophobic molecules and pierce the glycocalyx, the undisturbed water layer, to get close to the brush boundary membrane of the enterocytes.[23]

- Physiological functions of vitamin E beyond antioxidant activity.

In recent decades, preclinical research has identified certain non-antioxidant characteristics of vitamin E in addition to its antioxidant role.[58,59,60,61,62] Based on its properties, both independent and dependent on its function as an antioxidant, vitamin E is thought to have an impact on a number of degenerative disease processes, such as obesity, diabetes, cardiovascular illnesses, and neurodegenerative disorders.[59,62,89,90] Several factors, such as endothelial dysfunction, elevated oxidative stress, persistent inflammation, aberrant blood lipid levels, and xenobiotic metabolism, are all linked to the development of cardiovascular events. Vitamin E, especially α-TOH, has been shown in numerous in vitro studies to have positive effects on lipid homeostasis, anti-inflammatory properties, endothelial barrier maintenance, and the inhibition of oxidation of LDL (low-density lipoprotein).[91]

➢ Epigenetics: A Primer

Definition and key pathways of epigenetic changes, including non-coding RNA, histone modifications, and DNA methylation.

Heritable alterations to the genome that influence Gene expression and chromatin structure without changing the DNA sequence are known as epigenetic modifications. These changes may be permanent or temporary, and they may be inherited by subsequent generations.[24]

Epigenetic mechanism

DNA methylation and histone modification are two examples of processes that result in these alterations; they both influence the way genes are expressed without altering the DNA sequence underneath. Furthermore, non-coding RNA sequences have been shown to are essential for controlling gene expression.[25]

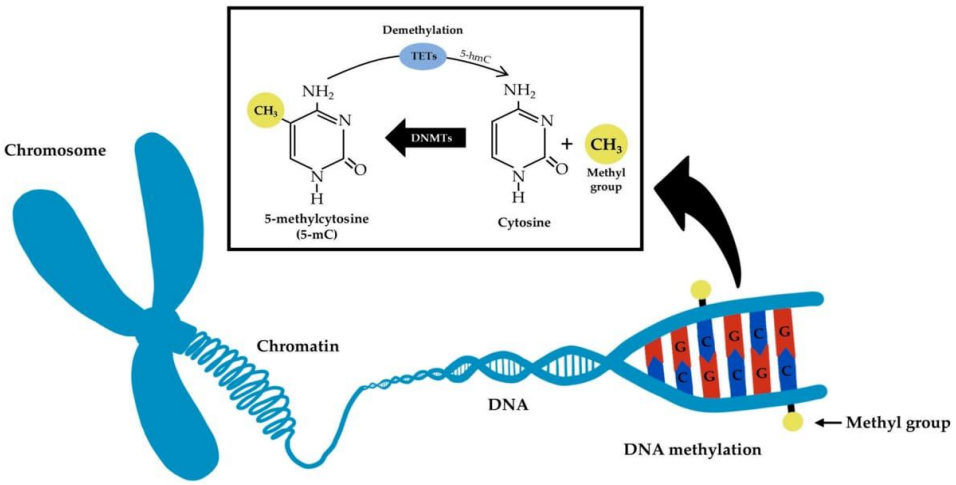


Figure 2

DNA methylation

DNA methyltransferases catalyze the process of DNA methylation, which occurs when a methyl group is added to the DNA base cytosine to generate 5-methylcytosine.[26] Basic cellular functions depend on

housekeeping genes, which normally exhibit a steady level of expression.[27]

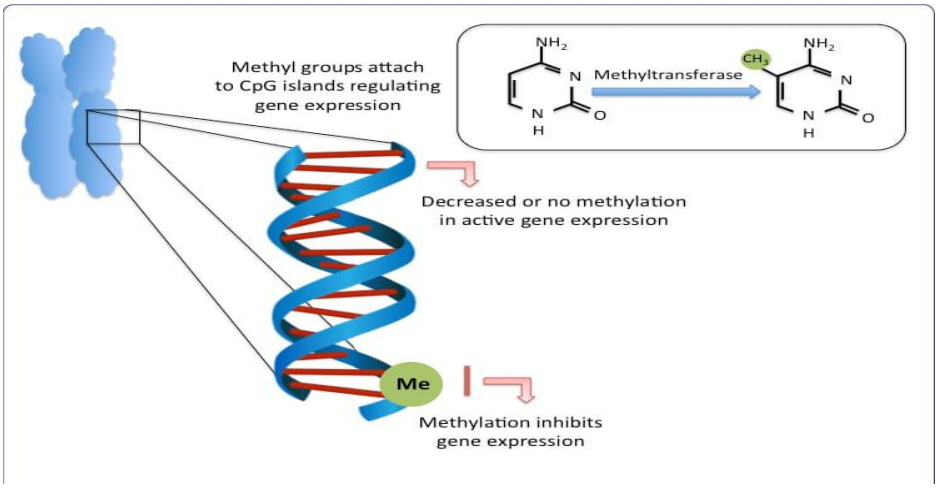


Figure 3.

Histone modification

Variations in the expression of genes are caused by distinct methylation patterns in the genes of different cells.[28] Certain DNA sequences can be recognized by proteins called the transcription factors that can then start DNA transcription. The CpG islands are the target of transcription factors that start the gene expression process. When the sites are unmethylated, they are available for gene transcription and expression. Conversely, methylation of the CpG sites, inhibits transcription factors from attaching to the site, altering gene expression.[29] Without methylation, key developmental processes would not occur, such as genomic imprinting and X-chromosome inactivation, which we address later. Cancer is linked to abnormal DNA methylation. autoimmune diseases, and genetic issues.[30] Histones are negatively charged proteins that bind to the positively charged DNA double helix structure in the cell nucleus to condense the DNA and make it fit inside eukaryotic cells.[31] The histones act as a spool, wrapping the DNA double-helix structure like a thread, to organize and shorten the overall length of the DNA by forming a nucleosome.[32] Histone epigenetic changes alter the chromatin structure by altering the covalent connections inside and between nucleosomes, causing the nucleosome "beads" to be either farther apart, as in either euchromatin or near together, as in heterochromatin.[33]

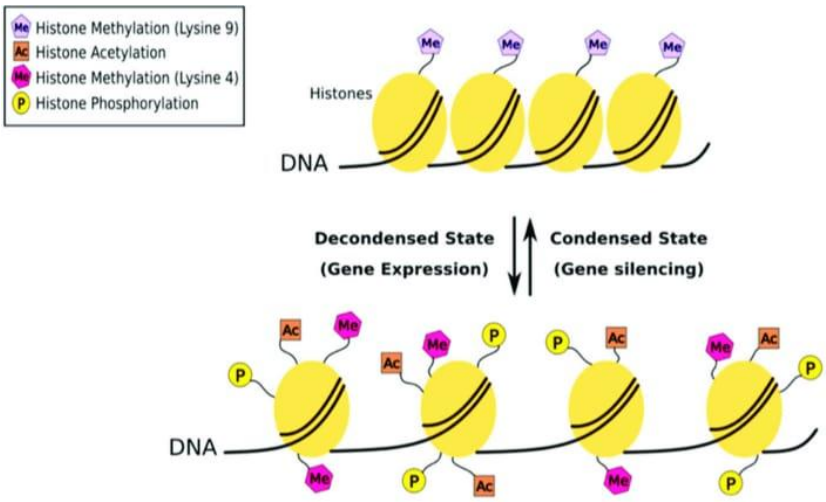


Figure 4.

Acetylation, methylation, or phosphorylation of the amino acids on the histone tails are the most frequent changes to histones.[35,36] Histone-DNA connections can either become stronger or weaker, depending on the type of modification, changing the chromatin structure. Acetylation, for instance, lessens the positive charge on the histone, which makes it more difficult for the histone tail to bind to the DNA's negatively charged phosphate groups.[37] The chromatin is easier to access for gene transcription when there is less interaction between the positive and negative charges. Although it doesn't change the chromatin or the DNA sequence, histone modification modifies the way the DNA is packed, which changes how genes are expressed.[38]

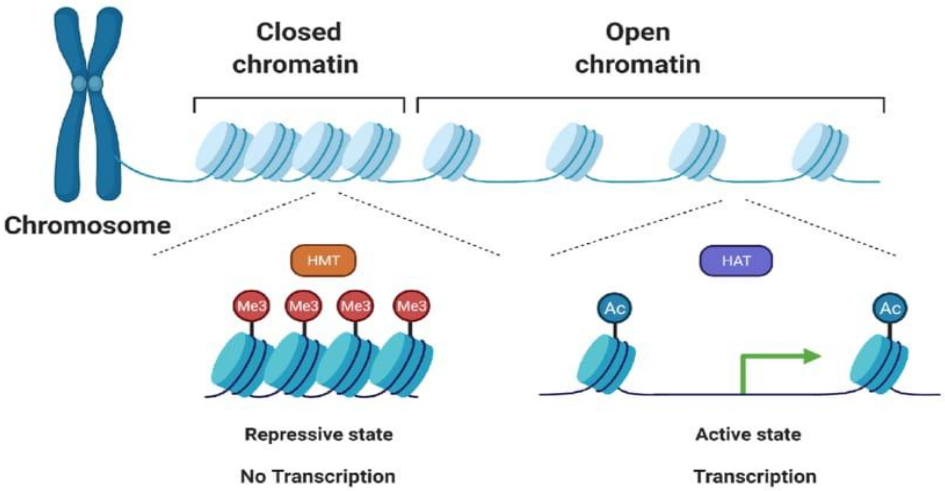


Figure 5

Non-coding RNA

Numerous noncoding RNA types have been discovered by researchers to have a role in the epigenetic control of gene expression.[39] There are two types of noncoding RNAs: short and long. MicroRNAs (miRNA) and short interfering RNAs are examples of short noncoding RNAs (20–25 nucleotide bases).[40] By drawing transcription factors, long noncoding RNAs raise gene expression; by tightening the chromatin structure, they lower gene expression; and by altering transcription, they change gene expression.[41] Although the specific function of noncoding RNAs in the growth of disease is still unknown, scientists have found that cancer, neurological disorders, and fragile X are linked to their elevated expression.[42,43]

- The role of epigenetics in gene expression regulation and disease development.

Incorrect epigenetic marks can result in birth defects, childhood diseases, or symptoms of diseases in other interims of life. Epigenetic mechanisms also regulate development and adaptations during the life of an organism, and their alterations may result in various disorders such as cancer.[44] Epigenetic research is a developing topic. That explores the methods by which gene expression is regulated and inherited through non-genetic means. While genetics traditionally emphasizes the DNA sequence itself as the primary determinant of an organism's traits, epigenetics investigates the chemical modifications and structural changes that occur to DNA and it's this emerging field has revolutionized our understanding by demonstrating the complex interactions between genetic and epigenetic variables in the control of gene expression and inheritance. We will explore the basic ideas and workings of epigenetics, paying particular attention to how it affects heredity and the control of gene expression. We will investigate the enormous effects that epigenetic changes, such as non-coding RNAs, histone alterations, and DNA methylation, can have on cellular function and gene activity. We will investigate how non-coding RNAs, including lengthy RNAs that don't code and microRNAs, function in the regulation of epigenetic associated proteins, influencing gene activity without altering the underlying genetic code. Epigenetic mechanisms are essential to the onset and development of many illnesses. Gene expression dysregulation may result from abnormal epigenetic changes. disruption of cellular processes and contribute to disease pathogenesis. In this section, we will explore the connection between various disease types and epigenetics, emphasizing how epigenetic modifications affect the onset of disease.

- **The Interplay Between Vitamin E and Epigenetics**

- Evidence for vitamin E influence on epigenetic modifications.

A positive energy balance, an abnormal rise in adipose tissue, and health-harming weight gain are all linked to obesity.[45] It is proposed that a number of genetic factors, including single nucleotide polymorphisms, the environment, social standing, dietary habits, metabolism, microbiome, and physical activity, affect how it develops.[46] Energy homeostasis, lipid and glucose metabolism, inflammation, fibrinolysis, coagulation, and blood pressure are all impacted by a variety of bioactive peptides known as adipokines. Among others, they include cytokines such as interleukin-6 (*IL-6*) and tumor necrosis factor α (TNFα), leptin, monocyte chemoattractant protein-1 (MCP-1), plasminogen activator inhibitor-1 (PAI-1), adiponectin, and resistin.[47,48] Base changes, deletions, strand breaks, Examples of DNA damage include chromosome rearrangements and elevated oxygen radical levels that disrupt DNA methylation.[49,50] The DNA mismatch repair (MMR) system includes the repair protein MutL homolog 1 (MLH1).[51,52] Increased mutations in microsatellite sequences, called microsatellite instability (MSI), are associated with anomalies in the MMR system in individuals who have hereditary non-polyposis colorectal cancer and a wide range of other malignancies.[53] Both promoter hypermethylation and genome-wide hypomethylation are brought on by oxidative damage of the DNA.[54]

- Mechanisms through which vitamin E may modulate epigenetic markers.

Ocular health is significantly impacted by nutrition. Certain vitamins can prevent or lower the risk of several eye disorders, such as cataracts, diabetic retinopathy (DR), glaucoma, and age-related macular degeneration (AMD). Finding a balance between free oxygen radicals and antioxidant vitamins E, A, and C may lower the incidence of retinopathy. A powerful antioxidant that is naturally present in food, vitamin E is one of the fat-soluble vitamins that protects the body against free radicals that impair cellular processes.[55]

This review's main goal is to clarify the molecular processes underlying vitamin AMD is a gradual and irreversible degeneration of central vision that may be treated by targeting E signaling pathways. There is currently no cure, although current treatments, including laser therapy and anti-angiogenic medications, Reduce the pace of development. In population-based studies, supplementing with vitamin E has not been shown to improve outcomes.[56] By supplying the hydrogen atom of the hydroxyl group at the chromanol ring, vitamin E, which is also present in membrane bilayers, suppresses the peroxyl radicals.[57] Then, to protect cells from intracellular oxidative stress, antioxidant enzymes like catalase and superoxide dismutase (SOD) are produced.

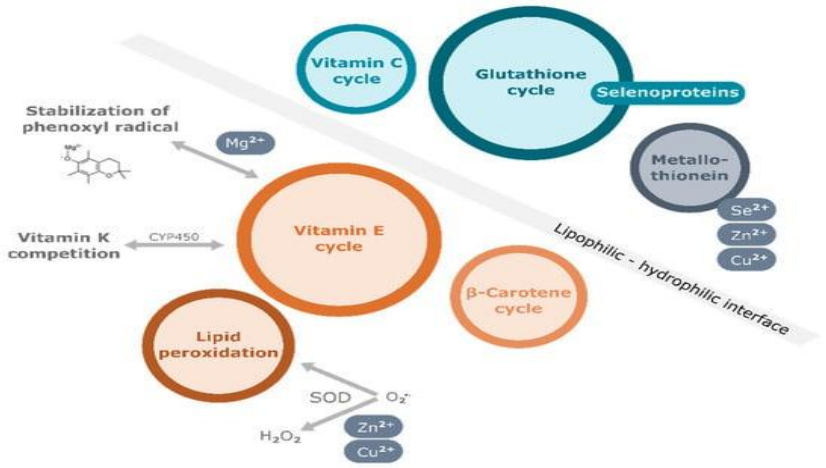


Figure 6.

In the past few decades, preclinical research has also identified a number of vitamin E's non-antioxidant qualities in addition to its antioxidant role.[58,59,60,61,62]

- Potential pathways linking vitamin E to epigenetic changes.

By giving the chromanol ring's phenolic group hydrogen, vitamin E's nonenzymatic antioxidative and radical scavenging properties are a key mechanism.[63] The redox equilibrium is impacted by reactive oxygen species (ROS), a class of metabolic byproducts that are essential for detoxification, host defense, and signaling pathways.[64,65] They are also recognized for controlling growth signals and altering gene expression, which has a major impact on the long-term spread of cancer. Elevated levels of ROS brought on by oxidative stressors, such as external substances like infections, alcohol, and tobacco smoke, or from different inflammatory processes that harm proteins, lipids, and DNA, have been demonstrated to upregulate oncogenes. ROS are what drive inflammation and aging in general.[66,67]

➢ Implications for Health and Disease

The role of vitamin E-mediated epigenetic changes in various diseases (e.g., cardiovascular disease, cancer, neurodegenerative disorders).

- **Cardiovascular disease**

The oxidation of the body's low-density lipoproteins and the resulting inflammation are the main causes of cardiovascular problems.[68] It has been discovered that gamma-tocopherol enhances cardiovascular functions via raising nitrogen oxidation synthesis activity. which produces vessel-relaxing nitric oxide.[69] Researchers have discovered that giving humans a daily dosage of 100 mg of gamma-tocopherol lowers a number of arterial clotting risk factors, including cholesterol and platelet aggregation.[70] Suggesting a combined inhibitory action on platelet. Moreover tocopherols, it was discovered that tocotrienols also restrict 3-hydroxy-3-methylglutaryl-CoA (HMGCoA) reductase, which lowers the quantity of cholesterol that the liver cells generate.[71] On the other hand, vitamin E supplementation has not been shown to have any cardiovascular benefits in the bulk of recent large interventional clinical trials. have instead linked vitamin E use to a markedly elevated risk of a haemorrhagic stroke in the participants.[72] Thus, it was proposed that more research might be necessary to fully comprehend the possible benefits using vitamin E in preventing heart attacks with younger participants.

- **Cancer**

Additionally, vitamin E has anticancer properties. This may be as a result of vitamin E's multiple roles, which include activating heat shock proteins, downregulating

mutant p53 proteins, stimulating the wild-type p53 tumor suppressor gene, and having an anti-angiogenic effect through blocking transforming growth factor alpha.[73] In this context, gamma-tocopherol was discovered to have a more potent growth-inhibiting effect on human prostate cancer cell lines than alpha-tocopherol, while delta-tocopherol has demonstrated inhibitory efficacy against mice mammary cancer cell lines.[74] Jiang et al. demonstrated that, of the many forms of vitamin E, gamma-tocopherol, especially when combined with delta-tocopherol, caused androgen-sensitive prostate cancer cells to undergo apoptosis within three days of therapy, whereas alpha-tocopherol alone did not have the same effect. Despite these findings, the possibility that vitamin E helps prevent cancer is still up for debate. According to findings from the Cancer Institute of New Jersey, gamma- and delta-tocopherols can help prevent lung, colon, prostate, and breast cancers, but alpha-tocopherol has no effect. Additionally, surveys and human studies looking into the connection have revealed that there is typically no positive correlation between vitamin E intake and cancer. Neither the Heart Outcomes Prevention Evaluation—The Ongoing Outcomes (HOPE-TOO) trial nor the WHS study found that taking 400 IU or 600 IU of vitamin E supplements prevented cancer. everyday considerably reduced the chance of developing cancer E.[75,76]

- **Alzheimer's disease**

While beta amyloid protein causes cytotoxicity by a process involving hydrogen peroxide and oxidative stress, which ultimately results in the death of neurons, Alzheimer's disease (AD) is caused by protein oxidation and lipid peroxidation through a free radical mechanism. Hydrogen peroxide can be prevented from generating cytotoxicity by vitamin E.[77] In patients with moderately severe AD, vitamin E may delay the course of the disease, according to the 1997 Alzheimer's Disease Cooperative Study. High doses of vitamin E delayed for several months the patient's decline in ability to complete daily activities and subsequent placement in residential care.[78] In another study, lower levels of plasma antioxidant micronutrients were found in AD patients, suggesting that inadequate antioxidant activity may play a role in the illness. Higher plasma levels of vitamin E in older adults are associated with a decreased risk of AD; this neuroprotective effect is attributed to the combination of many forms of vitamin E, not just alpha tocopherol.[79]

- Potential therapeutic applications of vitamin E targeting epigenetic mechanisms.

Mechanisms known as epigenetic alterations modify a gene's expression without changing the actual DNA sequence.[80, 81] DNA methylation, histone changes, and microRNAs (miRNAs) are significant epigenetic regulators.[82] Epigenetic processes have the characteristic of altering the expression of genes linked to ovarian cancer resistance, onset, and dissemination. The role of epigenetic alteration in the emergence and advancement of chemoresistance in HGSOC will be the main topic of this review.

- DNA Methylation

DNA methylation, a critical epigenetic regulator of gene expression, is catalyzed by the enzyme DNA methyltransferase (DNMT). onto a cytosine ring's fifth carbon to create methyl cytosine.[83,84] Increased methylation of cytosines located in CpG island within the gene's promoter region is knows as hypermethylation and causes binding of proteins to the methylated cytosines within the DNA strand.[85]

- Histone Modification

Histone changes include acetylation, phosphorylation, and methylation, among others. Histone acetylation is the most thoroughly researched alteration in ovarian cancer, not just HGSOC.[86,87] An acetyl group is added to lysine residues in a histone alteration known as histone acetylation.[88]

- Challenges and Limitations in studying the vitamin E-epigenetics connection.

Studying RDEOs presents hurdles not found in genomic research, such as cellular heterogeneity and challenges in collecting the tissue or cell type of interest, due to the specificity of epigenetic markers for each cell type and tissue.[92, 93] When When examining These events provide particular challenges for bulk tissue epigenetic data. The factors that contribute to epigenetic variability in heterogeneous tissues, such as variations in the makeup of distinct cell types, the regulation of epigenetics within a particular cell type, or both, have been addressed using two main strategies.[94,95] To completely comprehend how the sorting process impacts epigenetic profiles, more investigation is required. Additionally, as single cells are being used widely, improvements to the pipelines for experiments and analysis will be required because epigenomic methods degrade data and restrict its interpretability.[92,96] Only modest regeneration has been accomplished thus far, either through the overexpression of TF or the genetic or pharmacological modification of epigenetic modifiers. Furthermore, in an effort to determine which epigenetic modification or modifications few systematic, objective investigations have explicitly examined and connected transcriptional changes and epigenetic modifications, specifically in a peripheral vs. central axonal injury paradigm, despite the possibility that they could remodel CNS neurons in a regenerative state.

Future directions

- Emerging areas of research in vitamin E and epigenetics.

This vitamin is also becoming known as an immuno-homeostatic factor. The immune cell responses Vitamin E supplements have been well-documented, and it has been suggested that they have beneficial effects on the immune system's age-related pathology. A preventative function in the pathophysiology of allergic illness and

the control of lung anaphylaxis are two recently suggested elements of this vitamin's immunoregulatory effect. Long regarded as a cytoprotective agent, the most prevalent form of vitamin E in human tissues may help prevent inflammatory and degenerative processes in the liver when exposed to various xenobiotics, environmental contaminants, and dietary variables. These promising clinical findings point to the necessity of more randomized studies to validate and ultimately elucidate the molecular elements the role that vitamin E plays in both primary and secondary prevention of fatty liver, NASH, and the lipid and inflammatory abnormalities involved. Neuroprotection is another subject of interest in studies on vitamin E. In addition to vitamin E's role as a survival factor for Purkinje neurons needed to prevent AVED. Cardiovascular disease (CVD) is the most common cause of death worldwide.[101] A few global projects, such as the Human Epigenome Project and the International Human Epigenome Consortium (IHEC) Project (HEP) have even been established to catalog the human epigenome and correlate its relation to pathophysiology.[102,103]

- Potential avenues for future investigations.

As a strong lipid-soluble antioxidant that also supports immunological response, anti-inflammatory response, regarding Vitamin E is essential for animal nutrition and the expression of gene control. It functions as an antioxidant, preventing free radicals from oxidatively damaging cell membranes and other lipid-containing structures.[108] As a result, vitamin E is the main chain-breaking antioxidant that stops lipid peroxidation, a physiological role that other endogenous or dietary antioxidants do not perform.[109] A lack of vitamin E might weaken the immune system and raise the vulnerability of animals to infectious diseases.

Vitamin E's function in the relationship between muscles and neurons is yet unclear. Furthermore, no thorough studies have been been done on its function in the reproduction of humans. Rather, most of researchers have concentrated on vitamin E's antioxidant capacity and attempted to explain its different activities using this characteristic. Consequently, it is commonly promoted as helpful in preventing or managing diseases that are allegedly linked to oxidative damage. Consuming supranutritional vitamin E has been shown to help prevent cancer. chronic inflammation, Alzheimer's disease, Parkinson's disease, and cardiovascular illnesses.

- The necessity of more rigorous studies to clarify the clinical consequences and mechanisms.

Thorough cell-based and animal research, as well as in vitro and vivo investigations, the precise processes by which vitamin E influences epigenetic markers, such as DNA methylation, histone changes, and microRNA production, require further research. Identifying the specific genes or signaling pathways that vitamin E influences should be the aim of future study. This could shed light on how vitamin E affects epigenetics in oxidative stress, inflammation, and cellular aging.

Studies should evaluate how vitamin E-mediated epigenetic modifications affect specific diseases. For example, investigating whether vitamin E's impact on Inflammatory pathways or genes that inhibit tumors may aid in the prevention of cancer. Thorough research could find trustworthy epigenetic biomarkers that respond to consumption of vitamin E enabling strategies for evaluating sickness risk and preventing conditions including cancer, Alzheimer's and heart disease. Thorough investigation may reveal trustworthy epigenetic biomarkers that respond to vitamin E consumption, supporting disease risk assessment and preventative care for ailments including cancer, heart disease, and Alzheimer's. Studies should concentrate on the effects of maternal vitamin E intake on the health and disease risk of kids, given that vitamin E can influence lethal development through epigenetic programming. Studies could examine the potential for inheritance of vitamin E-induced epigenetic modifications and the resulting health effects on subsequent generations. Setting these studies as a top priority will aid in the scientific community's understanding of how vitamin E influences the epigenome and its potential to use this understanding to create practical applications for disease prevention and health optimization.

CONCLUSION

Owing to the promising results of these studies, vitamin E is currently the focus of extensive scientific research, highlighting its other noteworthy properties, such as antibacterial, anti-inflammatory, and anti-cancer properties. The biological significance of vitamin E and its uses in food packaging and cosmetics are well-documented in the literature, and there are numerous reviews available. Vitamin E is present in some foods naturally, while it can be acquired as a dietary supplement or added to other meals. Free radicals damage cells and may contribute to the development of heart disease and cancer. Moreover, the epigenetic regulation of gene expression in diseases, and especially cancers, is a crucial factor in the pathophysiology of many illnesses. Depending on its properties, both independent and reliant on its function as an antioxidant, vitamin E is thought to affect the processes of a number of pathological disorders, including diabetes, obesity, heart disease, and neurodegenerative diseases. Researchers have found that a variety of noncoding RNA types contribute to the epigenetic regulation of gene expression. Although there isn't a solution at this time, anti-angiogenic drugs and laser therapy slow down the progression of the disease. There are no benefits to using vitamin E supplements, according to population-based studies. One of the many effects of vitamin E that may be the reason for this is the stimulation of the wild type p53 tumor suppressor gene. This review will focus on how epigenetic changes contribute to the emergence and progression of resistance in HGSOC. It has long been

believed to have cytoprotective qualities and may help prevent inflammatory and degenerative liver processes caused by exposure to different xenobiotics, environmental contaminants, and dietary variables. It is the most common form of vitamin E in human tissues.

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