



THE ROLE OF VITAMINS IN THE HUMAN BODY: MECHANISMS OF ACTION, DEFICIENCY STATES, AND THERAPEUTIC SIGNIFICANCE

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ARTICLE INFO

Received: 8th May 2026

Accepted: 11th May 2026

Online: 20th May 2026

KEYWORDS

ABSTRACT

Vitamins are essential organic compounds required for the normal functioning of the human body and are mainly obtained through food sources. This thesis analyzes the biochemical properties of major vitamins, their mechanisms of action at the cellular level, and their therapeutic significance in modern medicine. In addition, the role of vitamins in metabolic processes, immune regulation, and gene expression is discussed, highlighting their potential in the management of chronic diseases.

INTRODUCTION

The discovery of vitamins became one of the greatest achievements in the history of medicine. It enabled the prevention and treatment of severe diseases such as scurvy, rickets, and pellagra. According to the World Health Organization, more than 2 billion people worldwide currently suffer from micronutrient deficiencies. Therefore, studying the biological and clinical significance of vitamins remains one of the most important directions of modern medicine.

Vitamins are classified into two major groups according to their solubility: fat-soluble vitamins (A, D, E, and K) and water-soluble vitamins (B-complex and vitamin C). Fat-soluble vitamins accumulate in the liver and adipose tissues, providing long-term reserves; however, excessive intake may result in hypervitaminosis. Water-soluble vitamins are not significantly stored in the body and must therefore be consumed regularly through diet.

MECHANISMS OF METABOLIC ACTION

One of the primary biological functions of vitamins is their participation in enzymatic reactions as coenzymes. In particular, B-group vitamins play a critical role in metabolism. Vitamin B1 (thiamine) is a component of the pyruvate dehydrogenase complex involved in carbohydrate metabolism. Vitamin B3 (niacin) functions in the form of NAD⁺ and NADP⁺, participating in numerous oxidation-reduction reactions. Folate (vitamin B9) and vitamin B12 are essential for DNA synthesis and one-carbon metabolism.

Vitamins A and D exert hormone-like effects in the body. They bind to nuclear receptors and regulate gene transcription. The active form of vitamin D, calcitriol, is involved not only in calcium-phosphorus metabolism but also in immune system regulation. Studies have shown that it influences the expression of more than 200 genes. The active metabolite of vitamin A, retinoic acid, controls cellular differentiation and growth.

Vitamins C and E play a major role in the antioxidant defense system of the body. They neutralize free radicals and prevent lipid peroxidation and cellular membrane damage. Therefore, these

vitamins are important in preventing aging processes, cardiovascular diseases, and oxidative stress-related disorders.

CLINICAL SIGNIFICANCE

Vitamin deficiencies may lead to various clinical conditions. Folate deficiency increases the risk of neural tube defects in the fetus, while vitamin D deficiency is associated with rickets, osteoporosis, and weakened immune function. Modern clinical studies demonstrate that vitamins are important not only in the treatment of deficiency states but also in the management of chronic diseases. Large-scale clinical trials such as VITAL and COSMOS have shown the potential of vitamin D and multivitamins in reducing cancer-related mortality in certain cases. Furthermore, advances in nutrigenomics suggest that future vitamin therapy may be individualized according to genetic characteristics. For example, polymorphisms in the MTHFR gene may alter folate metabolism in some individuals.

CONCLUSION

Vitamins are fundamental regulators of human physiology. They play essential roles in metabolism, gene expression, immune responses, and antioxidant protection. In modern medicine, the role of vitamins extends beyond the treatment of classical deficiency diseases toward the identification of subclinical deficiencies and the development of personalized micronutrient therapy. Therefore, further investigation of vitamins and their biological mechanisms remains an important direction in preventive and clinical medicine.

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