SELF-REPLICATION IN LIVING SYSTEMS

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ANNOTATION: *This article provides an overview of self-replication in living systems and the essential roles of vitamins in biological processes. The first part discusses how self-replication occurs at different biological levels—from molecules like DNA to entire organisms—and highlights the role of metabolism in enabling these processes. The second part focuses on water-soluble vitamins such as B1, B2, and PP, explaining their biological functions, deficiency symptoms, and daily requirements. The paper emphasizes the importance of vitamins in maintaining metabolic balance, energy production, and overall health.*

Keywords: *self-replication, metabolism, anabolism, catabolism, DNA replication, organelles, vitamins, thiamine (B1), riboflavin (B2), niacin (PP), deficiency, biological functions, energy production.*

The biological processes occurring in the human body are in constant motion, ensuring the continuity of vital activity. Among these processes, metabolism holds a special place. Metabolism occurs in two main phases — anabolism and catabolism. Anabolism is the process in which complex compounds are synthesized, supporting the renewal and growth of cells and tissues. In contrast, catabolism involves the breakdown of complex substances into simpler compounds, releasing energy. These two processes remain in balance to ensure the normal functioning of a living organism.

Organisms, as open systems, possess the capability for self-replication, meaning they can reproduce or copy themselves. This ability for self-replication in living systems is also referred to as reproduction. This process occurs at all levels

of biological organization. Through reproduction, not only whole organisms but also cells and cell organelles (such as mitochondria, plastids, etc.) can divide and resemble their original states.

Primary self-replication is observed at the molecular level. Specifically, during the replication of DNA as an informational molecule, two daughter molecules are formed that are exact copies of the parent molecule.

However, DNA replication requires the presence of numerous enzymes. Since enzymes are proteins, the genes encoding them must also exist. Furthermore, the presence of certain primary molecules is essential—molecules that may not always be present in food or may quickly degrade in the digestive system. In such cases, these substances must be synthesized within the cell itself, implying that metabolism must be present. All of this indicates that DNA self-replication is the most fundamental stage of self-replication.

Following this, organelles replicate themselves — this represents the second stage of self-replication, which then leads to the third stage: cell replication.

Thus, individual cells of multicellular organisms are self-replicating systems, and the entire multicellular organism is an even higher-level self-replicating system. Populations, species, biogeocenoses, and the biosphere are self-replicating systems of increasing complexity. The simplest self-replicating organisms on Earth are bacteria: their genome contains about 5,000 genes, while the human genome contains about 50,000 genes.

Therefore, as a result of metabolism, nutrients obtained from food are transformed into the cell's own substances and structures, and additionally, the organism is supplied with energy to perform external work. Self-replication — the creation of copies of oneself — is a fundamental property of living organisms that distinguishes them from the material exchange of non-living nature.

VITAMINS

Vitamins are designated by capital letters or by the names of diseases caused by their deficiency or by their chemical names. The modern classification of vitamins is not yet complete; it is based on physical and chemical properties (especially solubility), chemical nature, and alphabetic designation.

1. Vitamins are classified into water-soluble and fat-soluble:
2. Water-soluble vitamins:
3. Vitamin B1 – Antineuritic, thiamine
4. Vitamin B2 – Growth vitamin, riboflavin
5. Vitamin B6 – Antidermatitis, adermine, pyridoxine
6. Vitamin B12 – Antianemic, cobalamin
7. Vitamin PP – Antipellagra, niacin, nicotinamide
8. Vitamin B9 – Antianemic, folic acid
9. Vitamin B5 – Antidermatitis, pantothenic acid
10. Vitamin H – Antiseborrheic, bacterial and yeast growth factor, biotin
11. Vitamin C – Capillary stabilizer, ascorbic acid

Vitamin B1

Vitamin B1 (thiamine, antineuritic) was the first vitamin to be isolated in crystalline form by K. Funk in 1912. It was later synthesized chemically. Thiamine is so named because its molecule contains an amino group and sulfur. It consists of a pyrimidine and thiazole ring connected by a methylene bridge. Thiamine deficiency leads to a widespread disease in Asia and Indochina — beriberi. Symptoms of vitamin B1 deficiency include: disruption of gastrointestinal motor and secretory functions; memory loss; hallucinations; changes in cardiovascular activity; damage to the peripheral nervous system; and eventually, paralysis.

Biological role: In the form of TPP (thiamine pyrophosphate), vitamin B1 is part of the pyruvate and alpha-ketoglutarate dehydrogenase complexes, as well as

transketolase. TPP serves as a coenzyme for these enzyme complexes in mitochondria, playing a role in the oxidation of carbohydrates and amino acids and energy production.

Transketolase is important in the pentose phosphate pathway, where it produces NADPH and ribose-5-phosphate. These compounds are essential in the synthesis of fatty acids, steroids, nucleotides, nucleic acids, and detoxification processes. Disruption of these pathways affects overall metabolism.

Sources and daily requirement: Found abundantly in yeast, whole grain bread, rice, peas, beans, bran, liver, kidneys, and brain. Daily requirement: 1.2–2.2 mg

Vitamin B2

Vitamin B2 (riboflavin) was synthesized by R. Kuhn in 1935. Its solutions are yellow-orange. The molecule is based on the heterocyclic compound isoalloxazine, with a five-carbon sugar alcohol ribitol attached at the 9th position.
Symptoms of deficiency: Growth retardation, hair loss (alopecia), inflammation of the tongue and lips, cracking of mouth corners, keratitis, cataracts, general muscle and heart muscle weakness.

Biological role: As FMN and FAD, it forms part of flavin coenzymes involved in electron and proton transfer in the respiratory chain and in the oxidation of pyruvate, succinate, alpha-ketoglutarate, alpha-glycerophosphate, and fatty acids.

Sources and daily requirement: Found in all animal tissues and plants, especially in whole grain bread, cereals, eggs, milk, meat, and fresh vegetables. Daily requirement: 1.7 mg

Vitamin PP (Niacin, Nicotinic acid, Nicotinamide)
Isolated from liver extract by K. Elvehjem in 1937. Nicotinic acid belongs to the pyridine group and contains a carboxyl group (unlike nicotinamide which has an amide group).

Symptoms of deficiency: The main symptom is pellagra, which involves dermatitis, gastrointestinal disturbances (diarrhea), and central nervous system changes (dementia).

Biological role: Vitamin PP is part of the NAD and NADP coenzymes in many dehydrogenases involved in oxidation-reduction reactions. These coenzymes are essential for proton and electron transfer, biosynthetic processes, and act as allosteric regulators in enzymes.

Sources and daily requirement: Widely found in both plant and animal organisms. Main sources include rice, bread, potatoes, meat, liver, kidneys, carrots, and more. Daily requirement: 18 mg

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