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MOLECULAR MECHANISMS OF ENZYME ACTIVITY REGULATION IN LIVING CELLS

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Abstract: Enzymes regulate nearly all biochemical reactions in living cells and ensure metabolic stability. Their activity is controlled by genetic, molecular, and environmental mechanisms. This study analyzes major mechanisms of enzyme regulation, including allosteric modulation, covalent modification, feedback inhibition, and gene expression control. The findings show that enzyme regulation maintains cellular homeostasis, adapts metabolism to changing conditions, and prevents metabolic imbalance.

Keywords: enzymes, regulation, metabolism, allosteric control, cellular biochemistry

Introduction

Enzymes are biological catalysts that accelerate chemical reactions without being consumed. Their activity must be precisely regulated to match cellular demands. Metabolic pathways require coordination between substrate availability, energy status, and regulatory signals. Failure of enzyme regulation may lead to metabolic disorders, oxidative stress, and impaired cellular function.

Materials and Methods

A review of biochemical and molecular biology literature was conducted. Mechanisms of enzyme activation and inhibition were analyzed, including allosteric regulation, phosphorylation, proteolytic activation, feedback control, and transcriptional regulation. Examples from carbohydrate, lipid, and protein metabolism were included.

Results

Allosteric regulation allowed rapid adjustment of enzyme activity through binding of activators or inhibitors. Covalent modification, especially phosphorylation, played an important role in signal-dependent metabolic control. Feedback inhibition prevented excessive accumulation of metabolic products. Gene expression regulation provided long-term control of enzyme concentration.

Discussion

Enzyme regulation is essential for cellular adaptation. Rapid mechanisms respond to immediate metabolic changes, while gene-level control supports long-term adaptation. Integrated regulation improves metabolic efficiency and protects cells from harmful accumulation of intermediates. Understanding enzyme regulation is important for medicine, biotechnology, and pharmacology.

Conclusion

Enzyme activity is regulated through multiple coordinated mechanisms. Allosteric control, covalent modification, feedback inhibition, and gene expression regulation maintain metabolic balance and cellular homeostasis. These mechanisms are fundamental for understanding cellular biochemistry and disease pathogenesis.

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