# Nutrigenomics: Redox Regulation and Epigenomics

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Nutrigenomics explores how dietary components modulate gene expression through interactions with the genome and epigenome. Among the most biologically active dietary molecules is vitamin D , which, through its active metabolite 1α,25-dihydroxyvitamin D , binds the vitamin D receptor (VDR), a nuclear, ligand-inducible transcription factor expressed in most human tissues. VDR modulates chromatin accessibility at thousands of genomic loci, leading to tissue-specific up- or downregulation of gene expression. A proof-of-principle in vivo intervention demonstrated that high-dose vitamin D supplementation rapidly affects gene expression in peripheral blood mononuclear cells (PBMCs), including key redox-regulatory genes such as PRDX1, TXNRD1, SOD2, and SELENOS. These genes are involved in antioxidant defense and the selenium micronutrient network, underscoring the immediate impact of nutritional signals on redox homeostasis.

Beyond vitamin D, many nutrient-driven gene-environment interactions are redox-sensitive and epigenetically mediated. The cellular redox state, reflected by factors such as the NAD /NADH ratio or vitamin C levels, influences histone acetylation and DNA methylation patterns, shaping both transient and long-lasting epigenomic changes. Such modifications not only affect cellular function but may persist over time, contributing to health trajectories or disease risk, and even influencing transgenerational inheritance.

Dietary signals are continuously integrated by the epigenome throughout life, from conception to aging. While these mechanisms maintain homeostasis under healthy conditions, maladaptive responses to persistent dietary imbalances, such as those observed in obesity, can drive chronic diseases including type 2 diabetes and cancer. In my lecture, I will discuss how nutrigenomics bridges nutrition, redox biology, and epigenetics. Vitamin D will serve as a paradigmatic example to illustrate how nutrition-derived signals dynamically regulate immune function and oxidative stress responses at the systems level, providing insights into precision nutrition strategies for health maintenance and disease prevention.