

Nutritional Genomics

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In nutrition, the diet is the sum of food consumed by a person or other organism. Dietary habits are the habitual decisions an individual or culture makes when choosing what foods to eat. Although humans are omnivores, each culture holds some food preferences and some food taboos. Individual dietary choices may be more or less healthy. Proper nutrition requires the proper ingestion and equally important, the absorption of vitamins, minerals and fuel in the form of carbohydrates, proteins and fats. Dietary habits and choices play a significant role in health and mortality. Throughout the 20th century, nutritional science focused on finding vitamins and minerals defining their use and preventing the deficiency diseases that they caused. In order to address the increasing incidence of these diet-related-diseases, the role of diet and nutrition has been and continues to be extensively studied.

Nutritional genomics is a science studying the relationship between human genome, nutrition and health. It can be divided into two disciplines:

Nutrigenomics:

Studies the effect of nutrients on health through altering genome, proteome, metabolome and the resulting changes in physiology.

Nutrigenetics:

Studies the effect of genetic variations on the interaction between diet and health with implications to susceptible subgroups.

97% of the genes known to be associated with human diseases result in *monogenic diseases*, i.e. a mutation in one gene is sufficient to cause the disease. Modifying the dietary intake can prevent some monogenic diseases. One example is phenylketouria a genetic disease characterized by a defective phenylalanine hydroxylase enzyme. In contrast, diseases currently in the world, e.g. obesity, cancer, diabetes and cardiovascular diseases, are *polygenic diseases*, i.e. they arise from

the dysfunction in a cascade of genes and not from a single mutated gene. Dietary intervention to prevent the onset of such diseases is a complex and ambitious goal.

To prevent the development of disease, nutrition research is investigating how nutrition can optimize and maintain cellular, tissue, organ and whole body homeostasis. This requires understanding how nutrients act at the molecular level. The dietary constituents participate in the regulation of gene expression by modulating the activity of transcription factors or through the secretion of hormones that in turn interfere with a transcription factor. As a result, nutrition research has shifted from epidemiology and physiology to molecular biology and genetics and nutrigenomics was born.

Inter-individual differences in genetics or genetic variability, which have an effect on metabolism and on phenotypes were recognized early in nutrition research and such phenotypes were described. With the progress in genetics, biochemical disorders with a high nutritional relevance were linked to a genetic origin. Genetic disorders which cause pathological effects were described.

Nutrigenomics:

Nutrigenomics is the study of molecular relationships between nutrition and the response of genes, with the aim of extrapolating how such subtle changes can affect human health. Nutrigenomics focuses on the effect of nutrients on the genome, proteome and metabolome. By determining the mechanism of the effects of nutrients or the effects of a nutritional regime, Nutrigenomics tries to define the relationship between these specific nutrients and specific nutrient regimes (diets) on human health. Nutrigenomics has been associated with the idea of personalized nutrition based on genotype. While there is hope that nutrigenomics will ultimately enable such personalized dietary advice, it is a science still

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in its infancy and its contribution to public health over the next decade is thought to be minor.

Definitions:

Nutrigenomics is applying the sciences of genomics, transcriptomics, proteomics and metabolomics to human nutrition in order to understand the relationship between nutrition and health. Nutrigenomics is a new science and has several different definitions. Nutrigenomics has been defined as “*the application of high-throughput genomic tools in nutrition research.*” The term high throughput tools in nutrigenomics refers to genetic tools that enable literally millions of genetic screening tests to be conducted at a single time. When such high throughput screening is applied in nutrition research, it allows the examination of how nutrients affect the thousands of genes present in the human genome. Nutrigenomics involves the characterization of gene product and the physiological function and interactions of these products. This includes how nutrients impact on the production and action of specific gene products and how these proteins in turn affect the response to nutrients.

“The Journal of the American Dietetic Association predicts that Nutrigenomics is the “next technological and commercial frontier emerging from genomics.”

Why is nutrigenomics important?:

While some DNA is common to all people, there are variables within genes known as polymorphisms. When they occur they may be responsible for differences in the protein product of that gene, proteins which play key roles in important body processes. Current research has determined how genetic variation affects our body’s ability to utilize nutrients and remove toxins. Your health is a result of how these processes interact with environmental and lifestyle factors such as diet, exercise, stress, smoking and alcohol.

By learning about the specific nature of some genes, you will find out how their variations (polymorphisms) affect the way in which your body manages its nutrition and detoxification processes. By testing for these variations you can learn if these body processes are functioning below their optimum level. Every individual has a predetermined susceptibility to disease based on his or her genetic profile. Now through genetic knowledge you can help offset the health risks they might create.

How do nutrigenomics and genetic research benefit you?:

You and your Genes:

By discovering your own genetic code you can begin

to be pro-active in taking care of your health. It is important that you provide your body with the right balance of nutrients in order for your unique set of enzymes to function at their optimum level. By discovering and understanding the make-up of these specific genes, you can adjust your diet and lifestyle to meet your specific genetic needs and improve your health and well-being.

Research shows that dietary intervention and carefully chosen supplements can compensate for your genes’ predisposed weaknesses and help prevent or cure chronic disease.

You will be able to make lifestyle choices based on information that is specific to you and you alone and create a unique health program. Nutrigenomics creates an opportunity for you to take control of your health like never before. Contained in your DNA is an accurate dietary and supplement prescription which we can translate for your knowledge.

In nutrigenomics, nutrients are seen as signals that tell a specific cell in the body about the diet. The nutrients are detected by a sensor system in the cell. Such a sensory system works like sensory ecology whereby the cell obtains information through the signal, the nutrient, about its environment, which is the diet. The sensory system that interprets information from nutrients about the dietary environment includes transcription factors together with many additional proteins. Once the nutrient interacts with such a sensory system, it changes gene, protein expression and metabolite production in accordance with the level of nutrient it senses. As a result, different diets should elicit different patterns of gene and protein expression and metabolite production. Nutrigenomics seeks to describe the patterns of these effects which have been referred to as *dietary signatures*. Such dietary signatures are examined in specific cells, tissues and organisms and in this way the manner by which nutrition influences homeostasis is investigated. Genes which are affected by differing levels of nutrients need first to be identified and then their regulation is studied. Differences in this regulation as a result of differences in genes between individuals are also studied.

It is hoped that by building up knowledge in this area, nutrigenomics will promote an increased understanding of how nutrition influences metabolic pathways and homeostatic control, which will then be used to prevent the development of chronic diet related diseases such as obesity and type two diabetes. Part of the approach of nutrigenomics involves finding markers of the early phase of diet related diseases; this is the phase at which intervention with nutrition can return the patient to health. As nutrigenomics seeks to understand the effect of

different genetic predispositions in the development of such diseases, once a marker has been found and measured in an individual, the extent to which they are susceptible to the development of that disease will be quantified and personalized dietary recommendation can be given for that person.

The aims of nutrigenomics also includes being able to demonstrate the effect of bioactive food compounds on health and the effect of health foods on health, which should lead to the development of functional food that will keep people healthy according to their individual needs.

Nutrigenetics:

Nutrigenetics is the retrospective analysis of genetic variations among individuals with respect to the interaction between diet and disease. It is an applied science that studies how the genetic makeup of an individual affects the response to diet and the susceptibility to diet-related diseases. This necessitates the identification of gene variants associated with differential responses to nutrients and with higher susceptibility to diet-related diseases. The ultimate goal of nutrigenetics is to provide nutritional recommendations for individuals in what is known as *personalized or individualized nutrition*.

Applications:

A number of genetic variations have been shown to increase the susceptibility to diet-related diseases. These include variants that have been associated with Type 2 diabetes mellitus, obesity, cardiovascular diseases, some autoimmune diseases and cancers. Nutrigenetics aims to study these susceptible genes and provide dietary interventions for individuals at risk of such diseases.

Nutrigenomics is a rapidly emerging science still in its beginning stages. It is uncertain whether the tools to study protein expression and metabolite production have been developed to the point as to enable efficient and reliable measurements. Also once such research has been achieved, it will need to be integrated together in order to produce results and dietary recommendations. All of these technologies are still in the process of development which after a few years will make people enjoy the taste of life in a real sense.

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