TRACE ELEMENTS

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Nutrition, Epigenetics and Hair Tissue Mineral Analysis (HTMA)

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Encyclopedia Britannica defines epigenetics as “the study of the chemical modification of specific genes or gene-associated proteins of an organism. Epigenetic modifications can define how the genetic information is expressed and used by cells. The term epigenetics came into general use in the early 1940s, when British embryologist Conrad Waddington used it to describe the interactions between genes and gene products, which direct development and give rise to an organism's phenotype (observable characteristics). Since then, information revealed by epigenetics studies has revolutionized the fields of genetics and developmental biology. Specifically, researchers have uncovered a range of possible chemical modifications to deoxyribonucleic acid (DNA) and to proteins called histones that associate tightly with DNA in the nucleus. These modifications can determine when or even if a given gene is expressed in a cell or organism.” (Encyclopedia Britannica, 2008)

To simplify, genes contained in DNA are copied and inherited across generations and are provided by both parents. This produces traits such as eye color, height, weight, blood type etc. DNA is passed on to new cells during development and also when they are reproduced within the body. Epigenetics is the study of how inherited traits are modified or changed by influences other than a change to the DNA sequence. The genome is the genetic material contained within the cells and the epigenome is involved in regulating gene expression. In other words, non-genetic or inherited factors can cause genes to express themselves differently by modifying or changing their expression by activation or silencing of specific genes through abnormal methylation processes.

Epigenetic Expression

Epigenetics affect genetic expression in the embryo by activating and deactivating genes to guide the differentiation of stem cells to form specialized cells, such as heart cells, muscle, nerve, skin cells etc. Following birth there are more and more influences that act upon the genome. These include; environmental factors, hormones, stress and nutrition. The nutritional influence begins in utero and is affected by the nutritional status and environment of the mother. Even the mother’s emotional status can influence the developing fetus. Inheritable epigenetic changes in gene expression unlike genetic mutations of DNA sequences, are responsive to environmental influences.

Nutrigenomics and Nutrigenetics

The effect of diet on epigenetic expression is being studied extensively. The combination of studying nutrition and epigenetic expression has resulted in a field of research termed nutrigenomics. Nutrigenomics is described as a branch of nutritional genomics and is the study of the effects of food constituents on gene expression. Nutrigenetics is a term used to study the individual genetic variation or response to the environment, diet or nutrients based upon single nucleotide polymorphisms (SNP) within the genome that indicate individual phenotypic differences.(Mutch, 2005) Both fields are actually striving to be able to recognize individual nutritional needs so that a personalized nutritional approach can be implemented for the treatment and prevention of disease.

Toxic and Heavy Metal Exposure Early In Life May Promote Disease Later in Life Via Epigenetics

It is well known that nutrient mineral deficiency can impair neurological development. Iron deficiency is a good example. However, it is also known that iron excess can impair neurological development. Some transitional nutrients can cause later-life health disturbances when deficient in the diet, but in excess can be just as harmful. These include iron, copper, manganese and zinc as well as others. Heavy metals such as lead, cadmium, mercury, and arsenic are also neurotoxins and when present early in life can contribute to impaired neuro-development and detrimental health effects later in life and have been called the “fetal origins of disease.” Suggesting that early environmental metal exposure can program later life gene expression, or fetal programming. Although DNA methylation is the most studied of the epigenetic process that regulated gene silencing, studies have shown the relationship of mineral imbalance and neurological function as seen in hair tissue mineral analysis tests. Hair concentrations of cadmium compared to reference groups were found to be higher in children with mental retardation, learning disabilities, dyslexia and lower IQ. (Wright, 2007) Sanders, et al explored the effect of cadmium exposure in mothers and their newborns. Cadmium is known to cross the placental barrier from the mother to the fetus and impacts development. The study showed the adverse effect of cadmium on DNA methylation in both the maternal and fetal DNA.(Sanders 2013)

The Effects of Long-Term Nutritional Deficiencies and Disease

National nutritional recommendations and policies are based primarily on preventing short latency or short-term deficiency disease. Examples of short-term nutritional disease include vitamin C deficiency and scurvy, niacin deficiency and beriberi, iodine deficiency and goiter, and vitamin D deficiency and rickets. It is now recognized that the long-term, inadequate intake of many nutrients lead to several major chronic diseases in industrialized nations and may take years to manifest. Nutritional needs necessary to prevent these chronic disease conditions are higher than the requirements necessary to prevent the effects of short-term deficiency conditions. Therefore, Heaney concluded, "recommendations based solely on preventing the index diseases are no longer biologically defensible." (Heaney, R.P. 2003)

Vitamin Supplementation Could Help 2 Billion Kids

An article that appeared as a headline in USA Today, 3/24/2004 illustrates the importance of nutritional balance early in life. The article stated the critical importance of proper nutrients for children to reach their full physical and intellectual potential. Cutberto Garza, director of the Food and Nutrition program of the U. N. University stated "When a child needs iron or vitamin A or iodine, she needs it now. And if she doesn't get it, then you're going to pay for the rest of her life. But, if you meet that need, the positive outcomes are absolutely glorious."

It is well known that nutritional deficiencies begin to develop long before signs and symptoms manifests. This is true of nutritional imbalances as well. The positive or negative impact of nutritional status begins even before conception with the nutritional status of the mother.

Hair Mineral Patterns, Reproduction and Environmental Endocrine Disruptors

It is known that chemicals from the environment can impact fertility. It is also believed that heavy metals such as mercury as well as the status of some nutrient minerals can impact fertility and reproduction in humans. A report by Dickerson, et al, studied the hair mineral concentrations in women with fertility problems who underwent in vitro fertilization treatment and investigated treatment outcomes. Mercury, zinc and selenium were analyzed. Hair mercury revealed a negative correlation with oocyte yield and follicle number following ovarian stimulation. The hair zinc and selenium correlated positively with oocyte yield after ovarian stimulation. Their data found that mercury had a deleterious impact while zinc and selenium showed a positive impact in the ovarian response to gonadotropin therapy for in vitro fertilization. The researchers found that minerals such as zinc and selenium may be important for reproductive outcomes and are reflective of long-term environmental exposure and dietary status. Their study concluded that HTMA offers a method of investigating the impact of long term exposure to endocrine disruptors and nutritional status on reproductive outcomes. (Dickerson, et.al. 2011).

Metabolomics and Nutritional Assessment

A paper was presented at a symposium of Experimental Biology on improving human nutrition through genomics, proteomics and biotechnologies, and was related to nutritional research related to the future of diet and health. This paper addressed concerns that all humans are not the same in respect to their response to diet. Some individuals may gain weight on a particular diet and others may lose weight on the same diet. This emphasizes the need to approach nutritional needs of individuals based upon their genetic and metabolic needs rather than try to place everyone under one simplistic umbrella. In quoting the authors, "it is clear that diversity of the human population is a nutritional reality. Once this diversity is realized, it becomes imperative that the problems of metabolic regulation, and their causes and interventions, will need to be personalized in order to be addressed and finally solved," it is obvious that individual metabolic assessment and a targeted nutritional approach is much more important than generalized nutritional recommendations. (German, et al. 2003)

Personalized Nutrition and Hair Tissue Mineral Analysis (HTMA)

DNA methylation is probably the most understood mechanism in epigenetic research. Acetylation, ubiquitination and phosphorylation are also known to modify the genome. The methylation process requires over a dozen essential nutrients, including minerals such as zinc, magnesium, copper, selenium and vitamins such as B12, folate, choline, vitamin C, B2, niacin and others. Not only is the status of each nutrient important, but the interrelationship between these nutrients are important for normal methylation reactions.

The HTMA can be considered one of the most economical tests in providing results of a wide number of nutritional elements and their interrelationships. It also provides information about an individual’s nutritional status relative to the presence of heavy metals from the environment. In addition, it can also be considered an excellent tool for developing personalized nutritional recommendations that are known to impact the epigenome. The use of HTMA can greatly aid the clinician in recognizing long-term nutritional imbalances and impending deficiencies of nutrients that lead to chronic disease.

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