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Omics Technologies: The Most Convincing Tools for a (fully) Individualized Diet?

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Introduction

DNA sequencing is becoming faster and cheaper by the day, and soon enough obtaining one's complete genome will be an act as trivial as buying groceries at the supermarket. It is without surprise that so many start-ups and established brands sell their "do-it-yourself kit" to consumers who get, by means of a simple saliva sample, promises of an individualized diet that fits just as perfectly as Cinderella's shoe, at least from a geno-pheno-typical standpoint. Theoretically, it sounds fantastic. But with the current practices in terms of nutritional genomics, these promises fall short. To provide the best advice possible, one would need

"omics"	Definition	Molecules of interest	Information content	Potential
Nutrigenomics	Study of the effects of foods and food constituents on gene expression	DNA	Genes that influence dietary requirements	Can provide information to optimize nutrition status, and help in prevention of nutrition-related chronic diseases
Transcriptomics	Study of the complete set of RNA transcripts that are produced by the genome	RNA	The study of the mRNA	May prevent adverse health effects resulting from toxic agents
Proteomics	Large-scale study of the set of proteins produced in an organism	Proteins	The study of proteins	Improve disease diagnosis and therapeutic monitoring; provides information about protein disease biomarkers
Metabolomics	Large-scale study of metabolites within cells or organisms	Metabolites (sugars, amino acids, lipids, hormones)	Examines changes in biochemical homeostasis from acute illnesses	Can identify precise biomarkers and current biochemical activity and state of cells

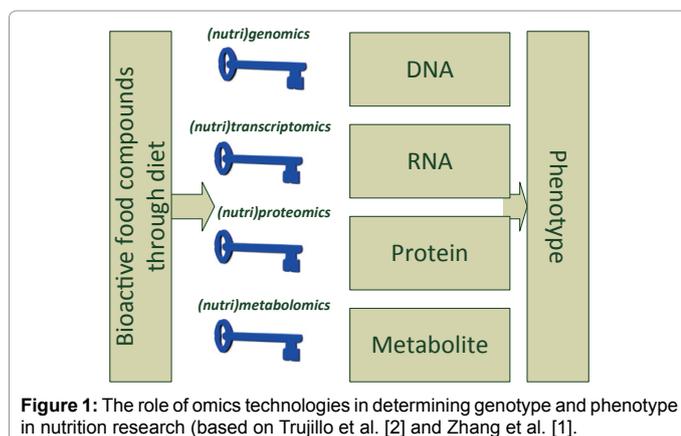**Table 1:** Definition of "omics- " technologies (based on Livingstone et al. [3]).

Figure 1: The role of omics technologies in determining genotype and phenotype in nutrition research (based on Trujillo et al. [2] and Zhang et al. [1]).

a holistic approach to the person, and what helps us gain these insights are the so-called omics technologies, a complex and broad range of applications to analyze the genes, mRNA, proteins and metabolites of our body. At the pace to which the field of nutrigenomics advances, the use of genetics testing is a foreseeable addition to the services offered in dietetics counseling. This article aims at shedding some light on the intriguing omics disciplines and provides an overview of their potential applications to dietetics counseling.

Omics technologies, including genomics, transcriptomics, proteomics and metabolomics, generate large amounts of data from gene sequence and expression to protein and metabolite patterns (Table 1). These technologies have great potential to be applied in applications such as the ones assessing the degree of involvement of genetics in the onset of obesity, as well as the development of incredibly personalized treatments (Figure 1). The goal of these omics technologies is to identify the molecular signatures of dietary nutrients leading to a specific phenotype, and to make dietary recommendations for individualized health maintenance and disease prevention [1]. In the field of research in nutrition and dietetics, these breakthroughs are in their infancy. The aim of this article is to provide an overview of the omics technologies and their potential application to the dietetics field.

Genomics and Transcriptomics

Nutrients have the capacity to alter the metabolic pathway by regulating the expression of genes and translation of proteins, which ultimately results in different health status in each individual based on the genotype [1]. Genomics is the sequencing and analysis of the genome, an organism's complete set of deoxyribonucleic acid (DNA); human chromosomes contain about 3 billion base pairs, organized into 20,000 to 25,000 genes. The expression of many genes can quickly be analyzed in a single reaction with the help of DNA microarrays. For example, they can detect the most common type of genetic variation among people, single nucleotide polymorphisms (SNPs), in which one nucleotide is substituted for another. Transcriptomics study the transcriptome, the entire set of DNA transcript, called mRNA (messenger RNA) expressed by an organism. Comparing the transcriptomes can help identify when and where genes are switched on and off in cells in response to different treatments. Bioactive food components including vitamins, minerals, phytochemicals, and macronutrients can regulate gene expression and therefore influence biological processes, for example by altering

metabolism, cell growth, and differentiation, and thus influence the disease process [2].

Proteomics

The proteome is defined as the set of all expressed proteins in a cell, tissue or organism that can be derived by translation of genes. Proteomics aim to understand proteins' cellular processes by studying their pathways and abundances, as well as their modifications, along with protein-protein interactions. The most commonly applied techniques are mass spectrometry (MS)-based techniques and gel-based techniques such as electrophoresis. As with transcriptomics, proteomic analysis provides a point-in-time snapshot of protein expression, notably in relation to dietary interventions. To assess the impact of diet on the proteome, multiple exposures will be needed to predict who might respond and over which period of time to dietary change [2]. One of the main challenges is the proteome's increased degree of complexity compared to the genome. However, the proteome has most certainly a great potential for biomarker discovery as proteins often play a role in disease and disease response, some protein disease biomarkers already available being CA125 and alpha-fetoprotein [3,4].

Metabolomics

Metabolomics can be defined as the large-scale study of metabolites in cells, tissues, or organisms. Metabolomics is a powerful application as compared to the other omics technologies, because of the relatively small amount of molecules compared to genes, mRNA and proteins. In addition, metabolites represent the end product within a most current state and biochemical activity of cells or tissues. Although the metabolome contains the smallest domain (~5000 metabolites), it includes many diverse biological molecules, which reflects its physical and chemical complexity as compared to the other above-mentioned technologies [4]. There are unique challenges for metabolomics in human nutrition. In general, metabolism is dynamic, and it is not easy to link metabolites back to specific genes/proteins. Moreover, it is intricate to fully understand the separate effects of food supplements, drugs, stress, physical activity, age, gender, or colonic flora [1]. As metabolites represent a large set of biomarkers at a given time, pattern comparison along the time axis yields a major potential to measure changes over a time slot and opens therefore an additional dimension to diagnosis of metabolic diseases, of metabolic capacity, and even of detections of abusive intake of medicines and nutrients (e.g. doping in sports).

Experimental Designs Using Omics Technologies

The purpose of the investigation governs what type of sample should be used. In terms of biomarker discovery, plasma is the obvious candidate, as the ultimate goal is usually a blood test. However, biomarkers could occur in low abundance and be massively diluted in the circulation [4]. The higher their lipophilia, the more likely they are concentrated in deeper compartments and only slowly liberated into the central compartment. If excretion is faster than liberation from deeper compartments, no sufficient plasma level will be obtained and such a metabolite cannot be detected. In such a case, other biological samples harvested by biopsy are needed. Rigorous reproducible standard operating procedures are necessary to ensure that samples are collected, stored and transported in a standardized manner [4]. Sample preparation for omics experiments is imperative and should be reproducible [4]. Mass spectrometry is the main technology used in proteomics and metabolomics analyses. In the mass spectrometer, ions are created from neutral proteins, peptides or metabolites by chemical ionization or electron impact, which are then separated according to their mass-to-charge ratio (m/z) and detected to create a mass spectrum, which is characteristic of the molecular mass and/or structure [4].

Omics Research in Nutrition and Dietetics

Transcriptomics, proteomics, and metabolomics are rapidly advancing technologies that provide a novel perspective in nutrition research, including a better understanding of how dietary habits affect our genotype and phenotype. The main goal of omics-based nutrition research is to understand the relationships between diet and disease and diet and health, and finally to translate these experimental findings into clinical practice, such that recommendations can be made for personalized nutrition or individualized diet [1]. Unraveling nutrigenomic, proteomic, and metabolomic patterns that arise from the ingestion of foods or their bioactive food components is likely to provide insights into a tailored, individualized approach to diet and health [2]. The individual biochemical variability is dictated by genetic variation, environmental factors, and dietary habits linked to cultures and lifestyle. Because of this biochemical variability, different individuals generate different responses to a specific dietary intervention. The future of nutrition research and dietetics counseling should integrate various omics technologies approaches, to measure and predict biological responses of individuals to nutritional modulations [1]. The use of these new technologies will provide needed insights into molecular targets for specific bioactive food components and how they influence individual phenotypes [2]. Dietetics professionals should recognize that their patients' response to dietary intervention will most certainly depend on their genetic background and they can use this information to promote health and prevent disease [2].

Conclusions

The fine-tuning of the omics technologies is ongoing. With time, these applications will prove invaluable for human nutrition research. It is expected that these high-throughput omics approaches will provide invaluable data with high validity that will help develop personalized nutrition plans and optimized dietary recommendation to prevent a plethora of chronic conditions, including type 2 diabetes and obesity. It is of uttermost importance that the registered dietitians, as well as their clients, are sensitized to these approaches and understand the interaction between genetics and nutrition.

References

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