From nutrigenomics to personalised nutrition

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It is quite clear that food intake is not only about avoiding deficiency diseases but also about optimal health and wellbeing and the prevention of age-related diseases, and that the risks and benefits of dietary choices differ among individuals. The molecular basis explaining food activities and individual responses to food and diets are becoming increasingly understood. To what extent this new body of knowledge, with Genes and Nutrition (Nutrigenomics) in the forceful nucleus of it, will apply to daily life depends on many factors. The European Nutrigenomics Organization (NuGO, a research European network of excellence funded by the European Commission) hosted recently in Palma de Mallorca (Spain) the International Conference “From Nutrigenomics to Personalized Nutrition” to think about these factors. Thanks to important networking efforts, we managed to join together a combination of worldwide relevant scientists and stakeholders in this field to realize where the science of Nutrigenomics is currently, how far we have progressed towards being able to provide personalized nutrition, and what scientific and socio-economic challenges are still ahead.

The bases of our health, wellbeing and longevity are much related to the biochemical diversity of the foods we

eat. Nutrition emerged as a solid science at the end of the last century and acquires predictive capacity as it becomes increasingly based on Biochemistry and Molecular Biology, Genetics, Metabolism and General Physiology in an extended sense. This shift in focus, from classical epidemiology to molecular approaches, is directly related to the realization that the effects of food on health cannot be understood without a deeper comprehension of how nutrients act at the molecular and subcellular level. The holistic perspective offered by the application of post-genomic technologies (metabonomics, proteomics, transcriptomics) combining all available information about food and phenotypes is allowing us to assess in deep and in wide how food interacts with our genes, proteins and metabolism.

It is within this framework that emerges Nutrigenomics, which can be defined as the study of how the information of food and genes interact and the consequences of this two-way interaction. Nutrigenomics is aimed at linking genome research, biotechnology and molecular nutrition research to provide new developments in the field of nutrition and health. Nutrigenomics will provide a greater than ever understanding of food influences in our homeostatic systems, allowing approaches to estimate potential adverse or beneficial effects of foods in precocious phases, before a disease is committed to occur, and to what extent the influence of diet on health depends on the individual genetic makeup. Thus, Nutrigenomics will contribute in designing optimized dietary intervention strategies to restore and improve metabolic homeostasis, improve health and wellbeing and prevent diet-related diseases. Personalized diets that could be uniquely tailored according to the specific demands of a given individual considering his/her genetic background, life-style and history are also included

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here. The speed of penetration of this new science in daily life is expected to come both from the diversity and complexity of food and food practices and from the own complexity of our metabolic systems. Our diet is omnivorous and consists of a variety of plants, animals and derived products, water, as well as fungi, yeasts and a diversity of bacteria. In the past, many food compounds were dismissed because no obvious nutritional roles were known for them. Most foods are a vastly complex and synergistic or non-synergistic mix of several nutrients and many other components, the importance of which is being unveiled step by step. We are exposed to these complex mixtures throughout life and while our biochemical processes extract energy, building blocks and regulators from food to enable us to grow and function properly they are, in addition, not independent on other factors, including physical activity, feeling and emotion, and social and economic factors.

Biological systems can be treated in isolated pieces only for purposes of study and for expository convenience. However, they form a complex and delicate network of feedback loops and interplays that defies simplification. The system that controls body weight is a good example, and very relevant as obesity has become a major health and economic concern in our developed societies. Our bodies are better adapted to avoid weight loss than to combat weight gain, probably because for thousands of years we evolved under conditions of limited food supply. Key elements in the body weight control system are the processes that control feeding behaviour, which determine the sensations of satiety and hunger depending on an interplay between internal signals (such as leptin) and environmental factors, and the processes that control energy efficiency, which can be physiologically regulated making it possible to dissipate part of the energy contained in food as heat instead of accumulating it as fat. Other important elements in this system are the control of adipogenesis, the process by which pre-adipose cells are converted into mature adipocytes, and the control of nutrient partitioning between tissues and metabolic pathways, which greatly conditions the possibilities of adipose tissue growth. Overweight, obesity and related medical complications can occur as a result of genetic or acquired changes in any of these processes. It is increasingly known how different food components act on specific targets in this system that is influenced by a number of genetic variants in more than 400 genes and how the metabolic history affects the predisposition to develop the obesity-associated medical problems. However, obesity, though paradigmatic, is only one example; major challenges for Nutrigenomic research in the next decade are to identify cause/effect relationships between multiple genome variations, diet and other environmental factors, and the main chronic diseases.

Nutrigenomics is rapidly penetrating the markets, as illustrated by a plethora of food products already being advertised on the basis of purported health benefits. The future entry in force and developments of the new European legislation on *nutritional and health claims made on foods* completes the previous initiatives already in place in the other main developed areas of the world to regulate this unstoppable phenomenon. In these legislations, not only the claims on food composition and properties are considered in depth, but also the qualification of food or food-components effects in the borders between food and drugs. Claims on reduction of disease risk are allowed, provided that they are substantiated in compelling scientific evidence. Nutrigenomics and Systems Nutritional Biology are to play an important role here as well. First, one of the main challenges in the assessment of efficacy and safety of food products is the accurate estimation of long-term effects, a lack that could be substantially improved with the development of new feasible models based on Nutrigenomics. Second, the concept of “nutrient profiles”, that initially will be introduced in the daily life and supermarkets based on a few food components only (saturated fat, trans fatty acids, salt/sodium, sugars...), will be progressively extended in the future by taking into account most components and effects with the help of Nutrigenomics. Thus, the emerging controversy between “good and bad foods” versus “good and bad diets” will dissipate. Nutrigenomic claims are foreseen.

Early life feeding may condition late health outcomes. Epidemiological studies over the past 20 years have shown that changes in maternal food intake during fetal growth and feeding during early postnatal development affects susceptibility to cardiovascular disease, obesity, type II diabetes, osteoporosis and other problems and patterns in adult life. As deduced from animal or in vitro studies, differences are caused by the interaction of food components or other environmental factors with our chromosomes allowing the imprinting of metabolic schemes in individuals (epigenetics) that may confer a different susceptibility to alterations later on in life. Defining the early gene–diet interactions of relevance is an important issue within Nutrigenomics.

Current knowledge of gene–diet interactions opens the window to credible, feasible advice that can be given to an individual at the present time to reduce elements of risk associated with food factors. Personalized nutrition is still in its infancy but consumers repetitively report big expectations that genetics will play an important role in their daily lives. Interesting ethical considerations are emerging. There will be a need to implement rigorous and transparent ways to accumulate and manage information while ensuring the protection of the privacy of every individual's information. Another societal consideration

refers to teaching of the new knowledge, which should be introduced in the schools. The trends are toward a better informed, conscious, consumer, thus changing beyond the current situation of a paternalist administration taking care of our uniformly defined “varied and balanced” standard healthy diet.

These and other ideas were discussed in the International Conference held in Palma de Mallorca. This Conference also affirmed our wide objective to continue the search for the answers to unsolved questions, and our

commitment to the challenge that represent the driving forces from nutrigenomics toward personalized nutrition. Big thanks to the NuGO family for all the support in conceiving and preparing the program. Especially outstanding has been the work of all members of the Scientific and Organizing Committee and many thanks also to the local Organizing Committee: without their help this Conference would have not been possible. The excellent initiative of Genes and Nutrition to publish the extended abstracts of this event is particularly recognized.