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Gene-Environment Interactions: Emergence of Knowledge, and Its Successful Translation into Practical Applications

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Researchers have been actively exploring gene-environment interactions for quite some time, and the steady flow of new information is now becoming increasingly actionable. The ultimate value of this research is its "translation" into practical use, which must be done responsibly - that, is, neither too quickly, nor too slowly. Potential applications include gene-environment interactions of all types, including lifestyle factors, nutrigenetics, nutrigenomics, gene expression, epigenetics, pharmacogenetics, and more.

Moving beyond research alone requires informing and engaging health professionals and nutritionists/dietitians, so they will feel both ready and willing to provide guidance to their patients and clients. Engaging members of the public will also be necessary for enabling the teamwork that is critical for the successful and appropriate application of this important new field of science.

An impressive body of information already appears in the literature. Hundreds of thousands of articles relevant to human genetics and related omics have been posted on the PubMed database [1] since completion of the Human Genome Project. To help cope with this avalanche of information, one online database [2] has already indexed about 1 million of those PubMed citations using a controlled vocabulary of standardized terminology.

Inconsistent terminology in the literature is one of the biggest challenges for the entire spectrum of potential users, from researchers to ordinary members of the public. For instance, a single nucleotide polymorphism (SNP) may sometimes be described by its nucleotide substitution (e.g., 677C-T for the MTHFR gene), or by its corresponding amino acid substitution (Ala222Val, or A222V), or by its reference SNP number (rs1801133). Traditional online resources for identifying synonyms for both genes and gene variants include the HUGO Gene Nomenclature database at genenames.org, or the OMIM database at ncbi.nlm.nih.gov/omim, or the dbSNP database at ncbi.nlm.nih.gov/snp.

Importantly, standardized terminology can be used to greatly facilitate the identification of genes and gene variants which are mentioned in PubMed. Use of standardized terminology allows database users to define and create their own index (alphabetical listing of subtopics) "on-the-fly" for any given topic, or for any given combination of topics [2].

Although automated tools for clinical decision support are constantly being pursued, it is unlikely that automation will ever completely replace the need for individualized attention from professionals. Moreover, in order to effectively utilize the "evidence base" for either nutrition or medicine, one of the most basic needs is the ability to recognize within the literature the multiple synonyms for genes and gene variants used by different authors. Standardized-terminology databases can cross-reference synonyms, and can list those synonyms within indexes to help readers of articles find the relevant terms that they might not otherwise recognize.

Moving beyond generalizations that may be true for populations only, individualized advice (or personalized guidance) also requires knowing something about the genetics of the individual. Although family history can be helpful, genetic testing is becoming progressively less expensive, and ever more useful, including both physician-supervised and direct-to-consumer genetic testing. The usefulness of the

latter is illustrated by the SNPTips add-on for Firefox browsers [3]. In addition, personal genome testing is also rapidly emerging, is increasingly affordable, and will be progressively more valuable in months and years to come, where nearly 3 billion nucleotide base pairs are tested, compared to about 1 million as found on the 23andMe test panel, or even far fewer on most other genetic test panels.

With so much information becoming accessible, it now becomes increasingly important to inform and engage health professionals about the growing body of knowledge. Professionals can now easily browse links to thousands of selected high-interest PubMed articles [2]. For nutritionists and dietitians, a remarkable listing of selected articles with brief, characterizing descriptions can be found on the International Society of Nutrigenetics/Nutrigenomics website [4]. The listing illustrates the broad range of opportunities for translational applications, with emphasis on gene-nutrient interactions, but also includes links to some genetics-related PubMed articles of general interest. General-interest examples include lifestyle choices such as exercise, genetics education, public engagement, translational research, genetic testing, genetic counseling, genetic privacy, longevity, epigenetics, gene expression, metabolomics and individualized medicine, to name a few. Health conditions which are spotlighted include cardiovascular diseases, neoplasms, diabetes, inflammation, Alzheimer disease, obesity, metabolic syndrome, diabetes, and many others. Risk modifiers which are discussed include dietary fats (including omega-3), various plant preparations, antioxidants, dietary supplements (especially vitamin D), curcumin, the Mediterranean diet, functional foods, magnesium, and more. Gene variants are mentioned, including those found in the following genes: PPARG, VDR, MTHFR, TNF, IL6, FTO, etc.

With so much information being published, an "information gap" is beginning to emerge between what researchers know, and what's known by members of the public [5]. Informing and engaging the public as well as professionals is important so they can actively work together in order to make better-informed choices. Members of the public include students, educators, journalists, and companies. Members of the public are central to both the purpose and the ultimate utilization of the emerging research knowledge about genetics. Students are members of the public; educators educate the public; journalists inform the public; companies develop products and services for the public; professionals recommend and/or deliver both services and products to the public; and even researchers strive to discover new information that's useful to the public.

Involving students is one of the best ways for any new technology to gain familiarity and acceptance for mainstream use. Learning about genetics requires building a working vocabulary of otherwise unfamiliar terms, much like learning a new spoken language, or even the language of mathematics.

Although university students are obvious candidates for educational efforts, another suitable group that is usually overlooked is high-school students. These young students are often wondering what exciting opportunities might be available to stimulate their interest in future career opportunities. Provocative and exciting reports about gene-environment interactions are capable of captivating the imaginations of most anyone, and can stimulate interest in science, technology, engineering and math. Knowledge about personal genetics can also be useful to younger students when considering the ethical and social ramifications of genetic testing, as well as for learning to deal with the science itself [6].

Especially because of the growing information gap, journalists have both an opportunity and a responsibility to report on new developments as they occur, including their significance in light of larger trends. The use of standardized terminology makes it much easier for journalists to see what has already been published on any given topic or combination of topics, thereby enabling them to more efficiently assess and describe new scientific reports.

Companies which value innovation can also benefit from the creation of indexes for relevant topic combinations, which reveal otherwise hidden relationships between our genes, health conditions, and potential risk modifiers - not only for treatments and potential prevention, but also for health and performance optimizations. Gene-environment interactions can affect our physical health, our emotions, our behaviors, and our sense of well-being in a holistic, body-mind-spirit dynamic.

In conclusion, valuable tools are already available for studying gene-environment interactions including but not limited to nutrition, and for translating that information into practical uses. Successful implementation will require more education, and active engagement with researchers, health professionals, and members of the public - including students, educators, journalists, and companies.

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