Opportunities and Challenges in Nutrigenetics/Nutrigenomics: Building Industry-Academia Partnerships

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The Challenge before Us

Science belongs to society, a public trust that can leverage a wide range of partnerships to achieve shared goals and contribute to the public good. In the context of this article, the word ‘partnership’ is used to characterize a relationship based on shared ethical values, a passion for scientific excellence, and a dedication to training the next generation of nutrition scientists. More specifically, the word partnership is used to denote a relationship built on trust and mutual benefit rather than the legalities of research collaborations and contracts. The challenge is to build such partnerships in an increasingly skeptical world that is hypervigilant in terms of bias, conflict of interest, and private sector funding \cite{1–3}. While not claiming to be the optimal model, DuPont and Pennsylvania State University (Penn State) may rightfully claim to have nurtured a long-standing and productive partnership centered on the molecular nutrition of omega-3 fatty acids, a partnership that is described herein.

Accelerated Learning Curves

A key measure of the success of a partnership is how far each party moves up the learning curves essential to their organizational or institutional goals. As shown in Box 1, DuPont’s association with Penn State enabled them to quickly learn about the complexities of nutripharmacology, the cardiovascular benefits of omega-3 fatty acids, and the specific health benefits of EPA. More importantly, through interactions with the University’s Center of Excellence in Nutrigenomics, they were able to glean strategic insights into the differential nutripharmacology of individual omega-3 fatty acids.
acids such as ALA, EPA and DHA. This learning helped DuPont build the business case for developing the technology to produce ‘designer oils’. Such oils can provide fatty acid mixtures for a spectrum of nutritional products including functional foods, dietary supplements, medical foods and even pharmaceutical agents. In an era of pre-emptive nutrition \[4, 5\], the ability to produce specific mixtures of fatty acids is a key step to enabling personalized nutrition. Figure 1 presents a nutrigenetic/nutrigenomic model of health based on omega-3 fatty acids. While the bottom right side of the model is readily implemented in practice and is applicable to the general population, the upper left side of the model is still unfolding as researchers look to establish

Box 1. Insights gained by DuPont from their partnership with Penn State

- Nutrition is about complex mixtures, not single molecules, the effects of which may be additive and/or synergistic in outcome.
- Omega-3 fatty acids have an extensive nutritional pharmacology; however, not all omega-3 fatty acids are the same.
- Serum EPA correlates with several emerging cardiovascular biomarkers such as vascular cell adhesion molecule, TNF and C-reactive protein.
- There is a nutrigenomic basis for the differential health benefits of individual fatty acids.
- There is an opportunity for biotechnology to provide ‘designer oils’ as novel health products.

Fig. 1. A nutrigenetic/nutrigenomic model of health based on the emerging science of omega-3 fatty acids. While transcriptomic profiling of nutrients has already been reduced to practice in industry, the genetic testing component remains in its infancy.
Box 2. Insights gained by Penn State from their partnership with DuPont

- Drugs and nutrients share considerable commonality in their underlying mechanisms of action.
- Profiling of serum fatty acids and the determination of fatty acid indexes can offer new insights into underlying metabolic events.
- Transcriptional regulation of stearoyl-CoA desaturase may be important in the dietary management of cardiometabolic disorders.
- Biotechnology may be important in providing the omega-3 fatty acids needed to meet emerging dietary recommendations.
- The experience and perspectives of private sector scientists represent a unique mentoring opportunity for students.

Fig. 2. The training of students and the subsequent development of professional networks is one of the high-value activities of academic-industry partnerships. When this occurs in a nutrigenetic/nutrig-enomic paradigm, the future of nutrition science advances in both the public and private sectors.

the impact of different responses of single nucleotide polymorphisms to nutrients, the ethical-legal status of genetic testing is resolved [6] and a business model based on consumer segmentation by genotype is validated.
As shown in Box 2, Penn State’s association with DuPont allowed them to tap into expertise in lipid metabolism and clinical pharmacology resulting in a greater appreciation of the mechanistic overlap between drugs and nutrients, to explore stearoyl-CoA desaturase as a potential target for the dietary management of metabolic syndrome through a DuPont visiting scientist, and to become aware of technological advances in the production of novel and healthier oils. Of particular value to its educational mission, Penn State was also able to offer students and postdoctoral fellows experience-based counseling regarding career opportunities in the private sector.

**Professional Development and Building Networks**

Another measure of partnership success is the extent to which it fosters the development of professional networks. As illustrated in figure 2, the research advisory team of Drs. Kris-Etherton, Vanden Heuvel and Gillies evolved over time into a multidisciplinary training node. Their ‘graduates’ now have positions in government, academia, industry, and even public-interest groups, organizations to which they bring a familiarity with what is possible at the public-private interface.

**Sharing Science**

Publications are unquestionably the currency of science. Herein co-authorship is both a reflection of the strength of the professional relationship and an objective measure of the scientific productivity of the partnership (Box 3). To some, such co-authorship raises the specter of bias, conflict of interest and suspect science; however, best-practice policies throughout the publication process from author disclosure, editorial oversight, and professional guidelines on public-private relationships provide powerful counterpoint to such concerns (Box 4) [7–10].

**Anatomy of a Partnership Model in Molecular Nutrition**

The DuPont-Penn State experience is illustrated in a simple partnership model in figure 3. In sector A on molecular nutrition, there are two special comments to be made. First, omega-3 fatty acids represent yet another example of a bioactive food that is both a nutrient and a drug (other examples being folate, niacin and vitamin A), and underscore the need to bring greater resolution to the ‘nutrient-drug’ debate [11, 12]. In this regard, nutrigenetics/nutrigenomics has an important role to play in providing a molecular foundation for this dialogue. Second, the partnership was ever mindful of the risks associated with involving students in product development. In sector B on how academia can leverage industrial partners, it should be mentioned that the
relationship evolved over time based on mutual interest in cardiovascular research, common membership in professional societies such as the American Society of Nutrition, the American Heart Association and the National Lipid Association, and a fundamental commitment to student education. Sector C offers a number of ways in which industry can grow the partnership from a relationship between two scientists to a relationship between two organizations. It should be noted that in this sector there is always the possibility of ‘duality of interest’ as companies move to manage their industry-academic networks in an open innovation model [13]. A duality of interest occurs when declared or undeclared ulterior motives are present even though such motives are not contrary to the interests of the partnership [14]. A duality of interest is not the same thing as conflict of interest, nor is it, a priori, a negative element in a partnership. To the contrary, in a world of leveraged networks, it’s quite valuable. The nuanced distinction between conflict of interest and duality of interest is an example of the need for a better vocabulary to describe the relational elements of partnerships. Finally, sector D presents a spectrum of increasingly complex legal arrangements that can exist between industry and academia. Such arrangements fall outside the scope

Box 3. Co-authored publications from DuPont and Penn State

of the present discussion, other than to note that they all incur a higher liability in terms of conflict of interest and scientific bias, and they are easy prey for the skeptics of industry-academia relations. What is important in sector D is to realize how quickly problems, or the perception thereof, can arise even in the simplest of business relationships. This said, there is clearly a time and place for industry-academic relationships and they can be ethically managed to ensure scientific integrity. The value and importance of such relations is underscored by the existence of the NIH Clinical and Translational Science Awards (CTSA) consortium that has as one of its specific goals 'to stimulate alliances in medical research and research training by identifying opportunities for collaboration among the CTSA members and private-sector organizations’ [15]. It is noteworthy that in a recent survey of researchers doing translational science (c.f. nutrigenomics), 61.3% reported ties to industry and believed these ties contributed to their most important scientific work [16]. The key to navigating sector D is to know your relational coordinates. As illustrated in figure 4, one's position is constantly changing regardless of the source of research funding. Thus, the first step is to be aware where you are, the second step is to know how to behave. None of this

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<th>Box 4. ILSI provides ‘guiding principles’ for how industry and academia can interact in an open and transparent way. In a nutrigenomic paradigm there is a special need to expand these guidelines to keep pace with the molecular science and to protect consumer rights.</th>
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<tr>
<td><strong>ILSI’s Guiding Principles</strong></td>
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<td>1. Conduct or sponsor research that is factual, transparent, and designed objectively and according to accepted principles of scientific inquiry.</td>
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<td>2. Require control of both study and design research itself to remain with scientific investigators.</td>
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<td>3. Not offer or accept remuneration geared to the outcome of a research project.</td>
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<td>4. Ensure, before the commencement of studies, that there is a written agreement that the investigative team has the freedom and obligation to attempt to publish the findings within some specified time frame.</td>
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<td>5. Require, in publications and conference presentations, full signed disclosure of all financial interests.</td>
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<td>6. Not participate in undisclosed paid authorship arrangements in industry-sponsored publications or presentations.</td>
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<td>7. Guarantee accessibility to all data and control of statistical analysis by investigators and appropriate auditors/reviewers.</td>
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<td>8. Require that academic researchers, when they work in contract research organizations or act as contract researchers, make clear statements of their affiliations; and require that such researchers publish only under the auspices of the contract research organization.</td>
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<td><strong>Some Next Steps</strong></td>
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<td>• Update the dialogue within the emerging nutrigenomic paradigm.</td>
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<td>• Address issues such as intellectual property in the broader context of genetic tests and nutrigenomic claims.</td>
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<td>• Provide GELS training with attention to key issues of confidentiality, access and privacy.</td>
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is new territory; on the other hand, the landscape is perhaps more challenging for nutrigenetic/nutrigenomic partnerships. This stems from the over-arching complexity of GELS (Genomics Ethics Law and Society) and the relative lack of GELS training and experience of nutrition scientists and food companies. Given the pressure to seek a return on investment in nutrigenetic/nutrigenomic research and development, coupled with the realities of low-margin food products sold in a competitive, consumer-centric market, ethical quandaries can quickly surface. For this reason, industry scientists need their academic colleagues not only to build the scientific foundation

Fig. 3. Partnerships are multifaceted relationships as illustrated in this model. Sector A illustrates how basic research can quickly transition into applied research and product development. Sector B illustrates the different ways in which industry scientists can contribute to university activities. Sector C illustrates the various ways industry and academia can work together in defined relationships. Sector D emphasizes the risk of conflict of interest and duality of interest that can occur as industry and academia combine their resources to work on common projects.
of molecular nutrition, but also to vet the credibility and value of industry-academic partnerships. In this regard, industry’s investment in nutrigenetic/nutrigenomic partnerships is not only strategic, it is essential for the future of personalized nutrition.

**Final Thoughts**

There is nothing complicated about building partnerships, it’s like playing together in a sandbox. All kids are welcome, but everyone is expected to find their own space, respect the space of others, and to share their toys. Scientists in the nutrigenetic/nutrigenomic sandbox need to:

- build partnerships on the basis of shared values;
- share limited resources;
- hold an open dialogue about scientific bias, conflicts of interest and duality of interest and be sure to engage younger scientists in the conversation;
- institutionalize the emerging guiding principles for funding food science and nutrition research, improve them with respect to issues of intellectual property, and frame them in the modern context of nutrigenetics/nutrigenomics.

**Disclosures**

Dr. Gillies is employed by DuPont and holds an Adjunct Professorship in the Department of Nutritional Sciences at the Pennsylvania State University.

Dr. Kris-Etherton is a Distinguished Professor in the Department of Nutritional Sciences at the Pennsylvania State University and a consultant to DuPont on a study investigating the effects of omega-3 fatty acids in humans.
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