NUTRIGENOMICS AND THE PROMISE OF PREVENTION: REPRESENTATIONS AND REALITIES

Timothy Caulfield*, Jacob Shelley, Victor Alfonso, and Tania Bubela

Introduction

Nutrigenomics has been called the "next frontier in the postgenomic era."[1] Over the past few years this emerging area has received a considerable amount of attention, both in the popular press and from the scientific community. Viewed as one of the more promising applications of genomics and as being on the cutting edge of nutritional research, one commentator notes, "[i]f you were to sum up the future of nutritional science into a single word, chances are it would be *nutrigenomics*."[2]

Nutrigenomics can be described as the study of the relationship between genes, diet, lifestyle and health.[3] It explores "how diet regulates gene func-

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* Timothy Caulfield, Canada Research Chair in Health Law and Policy, Professor, Faculty of Law and School of Public Health, Research Director, Health Law Institute (HLI), University of Alberta, Edmonton, Alberta. Jacob Shelley is a Researcher, HLI, and graduate student, University of Alberta. Victor Alfonso is a research assistant with the HLI and an LLB student. Tania Bubela is an Assistant Professor in the School of Public Health, University of Alberta. Thanks to Nola Ries, Leia Minaker and David Castle for their assistance and advice. The research was funded by the Advanced Food and Material Network and Genome Canada.

1 Jim Kaput & Raymond L. Rodriguez, "Nutritional genomics: the next frontier in the postgenomic era" (2004) 16 Physiological Genomics 166. See also M.T. Ravi Subbiah, "Nutrigenetics and nutraceuticals: the next wave riding on personalized medicine" (2007) 149 Translational Research 55.

2 Tony Peregrin, "The new frontier of nutrition science: Nutrigenomics" (2001) 101 Journal of the American Dietetic Association 1306 at 1306.

3 A private nutrigenomic testing company, Sciona, states as follows: "Nutritional genomics, 'nutrigenomics' for short, is concerned with the role our genes and our lifestyle choices play in keeping us healthy." See Sciona, "Nutrigenomics," online: mycellf <http://www.mycellf.com/nutrigenomics.aspx>. The science

tion (transcription and translation) and metabolism (i.e., diet – gene interactions)."[4] In other words, nutrigenomics focuses on "understanding how nutrition influences metabolism and maintenance of the internal equilibrium in the body, how this regulation is disturbed in the early phase of a diet-related disease and to what extent the individual genotype contributes to such diseases."[5] Questions nutrigenomics ask include: How do genes impact the way in which individuals metabolize food? What impact does the interaction between lifestyle, genes and nutrition have on disease etiology?[6]

As with other areas of genetics, the rise of nutrigenomics has raised social concerns.[7] Indeed, existing services have been critiqued as unnecessary and misleading.[8] While these social concerns are important, this paper examines the ways in which nutrigenomics is being presented and justified. What are

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journal, *Nature*, defines it thus: "The study of the genome-wide influences of nutrition or dietary components on the transcriptome, proteome and metabolome, of cells, tissues or organisms, at a given time." See Nature Reviews Genetics, "Glossary Terms," online: Nature Reviews Genetics <http://www.nature.com/nrg/journal/v4/n4/glossary/nrg1047.html>.

4 R.M. Elliott & I.T. Johnson, "Nutrigenomics approaches for obesity research" (2007) 8 Obesity Reviews 77 at 77.

5 Michael Muller & Sander Kersten, "Nutrigenomics: goals and strategies" (2003) 4 Nature Reviews Genetics 315 [Muller & Kersten].

6 *Ibid.*

7 See e.g. Vural Ozdemir & Béatrice Godard, "Evidence-based management of nutrigenomics expectations and ELSIs" (2007) 8 Pharmacogenomics 1051; Ruth Chadwick, "Nutrigenomics, individualism, and public health" (2004) 63 Proceedings of the Nutrition Society 161 [Chadwick 2004]; Philip R. Reilly & Ruth M. Debusk, "Ethical and Legal Issues in Nutritional Genomics" (2008) 108 Journal of the American Dietetic Association 36; and Nola M. Ries & Timothy Caulfield, "First Pharmacogenomics, Next Nutrigenomics: Genohype or Genohealthy?" (2006) 46 Jurimetrics 281.

8 See e.g. U.S., Minnesota Department of Health, *Over the Counter Genetic Tests and Nutrition: What We Know Today* (Minneapolis: Minnesota Department of Health, 2005), online: Minnesota Department of Health <http://www.health.state.mn.us/divs/hpcd/genomics/resources/fs/nutrigenomics.html >, where it is suggested that "Nutrigenomic research is a new field of study that holds great promise. However, since we know so little about how diet affects gene function, use of this information may be premature." See also "Firm offers online DNA analysis" *BBC News* (16 November 2007), online: BBC News <http://news.bbc.co.uk/2/hi/science/nature/7098998.stm>; and U.S., Government Account-

the claims to support the rise of the field and how might the representations of nutrigenomics shape its future? In other words, how is nutrigenomics being framed? As Nisbet and Mooney articulate, frames "allow citizens to rapidly identify why an issue matters, who might be responsible, and what should be done."[9] We explore how this emerging field is represented in the public sphere by examining how nutrigenomics is framed in the scientific literature, by research groups, private companies, and the popular press. The representation of nutrigenomics by these dominant stakeholders will likely have important implications for public perceptions, uptake, and, ultimately, viability of this new science.

Interest in Nutrigenomics: The Research Agenda

Over the past few years, there has been a rapid increase in the interest in nutrigenomics as a research topic. It is an area that has been viewed as worthy of public funding, both as a topic of basic scientific inquiry and as a field with health care and commercialization possibilities. From around 2004 forward we see an upsurge of nutrigenomic programs, conferences and funding opportunities.

For example, the European Nutrigenomics Organisation (NuGo,) was established in 2004.[10] Among other things, this multi-national entity aims to train scientists to "use post-genomic technologies in nutrition research" and to "develop and integrate genomic technologies for the benefit of European nutritional science."[11] In the US, there are a number of established university nutrigenomic initiatives, such as the well known program Center of Excellence for Nutritional Genomics at UC Davis – a project with the explicit goal of "promoting the new science of nutritional genomics."[12] The US

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ability Office, *Nutrigenetic Testing: Tests Purchased from Four Web Sites Mislead Consumers* (Washington, D.C.: Government Accountability Office, 2006).

9 Matthew C. Nisbet & Chris Mooney, "Framing Science" *Science* 316:5821 (6 April 2007) 56 at 56.

10 See European Nutrigenomics Organisation, "Nutrigenomics," online: NuGo <http://www.nugo.org/everyone> [NuGo], where it states: "NuGO is funded by the European Commission's Research Directorate General under the Food Quality and Safety Priority of the Sixth Framework Programme for Research and Technological Development."

11 *Ibid.*

12 NCMHD Center of Excellence for Nutrigenomics, "Home," online: NCMHD

Department of Agriculture has several nutrigenomic programs[13] and the US National Institutes of Health has funded a variety of nutrigenomic projects, often through the Nutritional Science Research Group.[14] Many other countries are getting into the nutrigenomic game. For instance, New Zealand has a nutrigenomic organization[15] and in May of 2008, Australia will be hosting the 3rd Asia Pacific Nutrigenomics Conference.[16]

There is also a high level of interest in nutrigenomics here in Canada. Genome Canada, one of the country's primary genomic funding entities, established a Canadian Nutrigenomics Committee to provide advice on the area and has funded an exploratory national workshop.[17] The Advanced Food and Material Network (AFMNet), a federally funded National Centres

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Center of Excellence for Nutrigenomics <http://nutrigenomics.ucdavis.edu/> [UC Davis Center of Excellence for Nutrigenomics]. See also Cornell Institute for Nutritional Genomics (CING), online: Cornell Institute for Nutritional Genomics (CING) <http://www.research.cornell.edu/VPR/CenterDir/CING.html>; and Human Nutrition Research Centre on Aging, "Nutritional Genomics," online: Tufts University <http://hnrc.tufts.edu/1192109687036/HNRCA-Page-hnrca2ws_1192109688473.html>.

13 See e.g. United States Department of Agriculture Agricultural Research Service, "Nutrition, Cardiovascular Health and Genomics," online: USDA <http://www.ars.usda.gov/research/projects/projects.htm?accn_no=409017>.

14 See National Cancer Institute, "Nutritional Science Research Group," online: DCP Division of Cancer Prevention <http://prevention.cancer.gov/programs-resources/groups/ns>. Many of the funded projects "focus on determining how specific genes and/or molecular targets are influenced by either essential or non-essential nutrients."

15 "Nutrigenomics New Zealand is a strategic collaboration between AgResearch, University of Auckland, HortResearch and Crop & Food. With a scientific program addressing the key areas of nutrigenomics the Centre performs high-quality research and knowledge transfer in an international context." Nutrigenomics New Zealand, "Home," online: Nutrigenomics New Zealand <http://www.nutrigenomics.org.nz/> [Nutrigenomics New Zealand].

16 See 3rd Asia Pacific Nutrigenomics Conference 2008: Diet-Gene Interaction in Human Health and Disease, "Home," online: Nutrigenomics 08 <http://www.nutrigenomics.org.au/index.html>.

17 Genome Canada recently had a committee with the mandate of exploring the future research potentials associated with the area of nutrigenomics. Information about the activities of the committee can be obtained from Genome Canada. Genome Canada, online: <http://www.genomecanada.ca>.

of Excellence program, has a number of nutrigenomics projects – including a research initiative that funds our work in the area.[18] There are existing academic Chairs in nutrigenomics and a number of Canadian institutions are recruiting in the area.[19] Memorial University in Newfoundland and Labrador has established the Nutrigenomics Research Interest Group with the mandate "dedicated to promoting the new science of nutritional genomics as well as improving the health of Newfoundlanders."[20]

Of course, the private sector has also entered the game.[21] There has been a recent growth in the number of private genetic testing companies, causing concern about the appropriateness of existing regulatory regimes.[22] Many of these companies offer nutrigenomic testing. To cite just one example, the website "Health and DNA" offers personalized nutritional and lifestyle advice that "lasts a lifetime because your genes are not a fad."[23] Specifically, the company suggests that:

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18 Advanced Foods and Materials Network, "Home," online: afmnet <http://www.afmnet.ca>.

19 For existing CRC in nutrigenomics, see Canada Research Chairs, "Chairholders: Ahmed El-Sohemy," online: Canada Research Chairs <http://www.chairs.gc.ca/web/chairholders/viewprofile_e.asp?id=868&>. University of Manitoba Human Resources Department, "Academic (Vacancy Number: 800-102-07)," online: University of Manitoba Human Resources Department <http://umanitoba.ca/cgi-bin/human_resources/jobs/view.pl?posting_id=77967>.

20 See Nutrigenomics Research Interest Group (NRIG), "Mission," online: NRIG <http://www.med.mun.ca/nrig/pages/02mission.htm> [NRIG].

21 See e.g. Interleukin Genetics, "Gensona Genetic Tests," online: Interleukin Genetics <http://www.ilgenetics.com/content/products-services/gensona.jsp>, where it is noted that "Interleukin Genetics' goal in the nutrigenomics sector is to partner with leaders in the food and nutrition industry to develop nutritional products that extend wellness by first identifying those individuals with specific genetic variations and then to provide products to those persons. These targeted products will be in the form of specially configured nutritional supplements or functional foods."

22 Ailsa Taylor "Urgent regulation needed for direct to public gene tests, say experts" *BioNews* (10 December 2007), online: BioNews <http://www.bionews.org.uk/new.lasso?storyid=3662>.

23 See Genelex, "Nutritional Genetics," online: Health & DNA <http://www.healthanddna.com/nutrigeneticstest.html>. See also GenSpec, "Home," online: GenSpec <http://www.4genspec.com/>, where it is claimed that the company

> Testing examines your personal variations in nineteen genes that scientists have shown play major roles in your body's heart and bone health, detoxification and antioxidant capacity, insulin sensitivity, and tissue repair. Your DNA test results, combined with information from your completed lifestyle questionnaire, result in personalized, realistic steps you can take to improve and maintain your good health.[24]

Themes in Nutrigenomics

While the above list of funding opportunities, nutrigenomic research groups and private companies is hardly comprehensive, it does provide a sense of the tremendous and rapid growth of interest in the area.[25] It also shows the degree to which the value of this emerging area has been accepted by various stakeholders. Indeed, given the amount of investment – in time, money and resources – there seems to be a clear hope that nutrigenomics will bear fruit, from both a health and economic perspective. It is anticipated by some that nutrigenomics will have an economic benefit, especially for those companies that are initially successful in penetrating the nutrigenomics niche market.[26] Although the science of nutrigenomics may be immature, "the business outlook is viewed as encouraging."[27] Moreover, it is thought that

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offers the "the first genetically specific nutritional supplements made just for you."

24 Genelex, *ibid.*

25 While there has been a growth in interest among research funders and within the private sector, the current public demand remains relatively low. "A 2006 United States survey found that only 14% of respondents were aware of nutrigenetic tests (with higher awareness for other types of genetic tests, such as genetic screening in pregnancy) and only a handful (29 individuals, comprising 4% of the sample) had used a nutrigenetic test." Nola M. Ries, "Regulating Nutrigenetic Tests: An International Comparative Analysis" (2008) 16:3 Health Law Review 9 at 10.

26 Timothy Caulfield has previously cautioned that the hype surrounding genetics may lead to "both premature implementation of services and, ultimately, disappointment when expectations are not met." The same remains true with nutrigenomics. Timothy A. Caulfield, "Underwhelmed: hyperbole, regulatory policy and the genetic revolution" (2000) 45 McGill L.J. 437 at 445 [Caulfield 2000].

27 Louise Brown & Frans van der Ouderaa, "Nutritional genomics: good industry applications from farm to fork" (2007) 97 British Journal of Nutrition 1027 at 1033.

nutrigenomics will be "a cost-effective approach to chronic disease, and one that can reduce the nation's healthcare cost."[28] This rise in interest presents a wonderful opportunity to explore how a new area of research is framed. In other words, what is the "public face" of this new field? What are the stated benefits and are the limitations of this field noted and addressed? What themes have emerged?

a) Scientific Literature

We collected 35 review and commentary articles from peer-reviewed scientific journals discussing the public health impact of nutrigenomics. Of these, we collected 27 articles through keyword searches of major databases of academic and scientific publications.[29] In order to ensure comprehensiveness, members of our interdisciplinary team identified the remaining 8 articles. We reviewed articles to identify specific claims made regarding the possible impact of nutrigenomics on public health, and grouped these into main themes.

The main themes in scientific journals were that nutrigenomics would lead to: improved dietary advice; the development of health-promoting supplements;[30] preventative health strategies;[31] and the reduction of health care costs. This last theme is particularly interesting because it is a common justification for supporting new technologies[32] – likely because the idea of paying

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28 Rolanda L. Johnson, Scott M. Williams & Ida J. Spruill, "Genomics, Nutrition, Obesity, and Diabetes" (2006) 38 Journal of Nursing Scholarship 11 at 16.

29 We searched Embase, Medline and EBSCO databases using the following key terms: nutrigenomics, nutritional genomics, nutrigenetics, public health, public policy, regulation, and health policy. We narrowed the search by only examining those articles that were either review or commentary articles.

30 See e.g. Jim Kaput *et al.*, "Application of nutrigenomic concepts to Type 2 diabetes mellitus" (2007) 17 Nutrition, Metabolism and Cardiovascular Diseases 89 at 98, where it is suggested that nutrigenomics will lead to: "Diagnostics, preventive lifestyle guidelines, more efficacious dietary recommendations, health-promoting food supplements, and drugs."

31 Some, for example, suggest that it could be used "to the development of targeted strategies to reduce obesity incidence and severity and the burden of chronic disease at the population level." See e.g. *supra* note 4 at 80.

32 See e.g. Government of Canada, "Pharming the Genome – Implications of Pharmacogenomics for Human Health and Public Policy," online: BioPortal <http://www.biobasics.gc.ca/english/view.asp?x=715&mid=455>, which con-

now, potentially to save greater costs in the future, is a politically palatable rationale. This is especially so for publicly funded health care systems, where cost-effectiveness is a primary policy concern. In the area of nutrigenomics it is believed that the cost savings will come from the reduction of chronic disease. For example, Johnson and colleagues suggest: "Perhaps an overriding benefit still not adequately known in the general population is that this information can be used to prevent disease. Prevention is a cost-effective approach to chronic disease, and one that can reduce the nation's healthcare cost."[33]

In spite of the fact that nutrigenomics will be largely focused on individual dietary advice it is commonly associated with public health. Nutrigenomics is framed as a population health strategy for disease prevention. More than simply managing or treating disease, or the symptoms associated with disease (i.e., post-diagnosis), nutrigenomics will be used to identify susceptibilities to diseases and implement proactive measures to help individuals avoid contracting said disease(s) in the first place.[34] Although it is recognized that the uptake of nutrigenomics as a public health strategy may not be immediate, there is generally an expectation that in the long-term, the field will make an important contribution.[35] As Ordovas and Mooser contend, nutrigenomics will have public health implications because of its "potential to change dietary habits in order to achieve effective disease prevention and therapy."[36] Others have a less tempered expectation, claiming that, "[u]ltimately, nutrigenomics research will lead to development of evidence-based healthful food and lifestyle advice and dietary interventions for contemporary humans."[37]

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cludes that: "the application of pharmacogenomics could reduce adverse drug reactions by up to 25%, saving the health care industry more than $1 billion per year by 2010."

33 *Supra* note 28.

34 Ruth M. DeBusk *et al.*, "Nutritional Genomics in Practice: Where Do We Begin?" (2005) 105 Journal of the American Dietetic Association 589.

35 *Supra* note 5.

36 Jose M. Ordovas & Vincent Mooser, "Nutrigenomics and nutrigenetics" (2004) 15 Current Opinion in Lipidology 101 at 107 [Ordovas & Mooser].

37 Lydia Afman & Michael Muller, "Nutrigenomics: From Molecular Nutrition to Prevention of Disease" (2006) 106 Journal of the American Dietetic Association 569 at 572.

Ghosh and colleagues claim that nutrigenomics will help ameliorate "lifestyle" diseases.[38] Others contend, "[d]iagnostics, preventive lifestyle guidelines, more efficacious dietary recommendations, health-promoting food supplements, and drugs are some of the anticipated end-products of nutrigenomics research."[39] The efficaciousness of nutrigenomics dietary recommendations is perceived to be so strong that some project that parents will test infants at birth for nutrigenetic profiles "in order to intervene before the fetal origins of disease can develop into the later decade realities and so that dietary damage cannot accumulate."[40] Kaput asserts that nutrigenomic information not only harnesses the potential to optimize health and prevent or mitigate chronic diseases, but that "[o]ptimal nutrition may also influence the aging process."[41] Successful aging, made possible with appropriate nutrition, is also a benefit of nutrigenomics highlighted by others.[42]

Although the limitations of the science are recognized, there was generally widespread optimism in the literature surveyed. As Ordovas and Mooser contend, "preliminary evidence strongly suggests that the concept of nutritional genomics should work."[43] Hence the observation by Brand and colleagues that "the integration of genomics into public health research, policy and practice will be one of the most important challenges for our health care systems in the future."[44]

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38 D. Ghosh, M.A. Skinner & W.A. Laing, "Pharmacogenomics and nutrigenomics: synergies and differences" (2007) 61 European Journal of Clinical Nutrition 567 at 570.

39 *Supra* note 30.

40 Lenore Arab, "Individual nutritional recommendations: do we have the measurements to assess risk and make dietary recommendations?" (2004) 63 Proceedings of the Nutrition Society 167 at 172.

41 Jim Kaput, "Decoding the Pyramid: A Systems-Biological Approach to Nutrigenomics" (2005) 1055 Annals of the New York Academy of Sciences 64 at 65.

42 *Supra* note 36 at 101.

43 *Ibid.* at 107.

44 Angela Brand *et al.*, "Getting Ready for the Future: Integration of Genomics into Public Health Research, Policy and Practice in Europe and Globally" (2006) 9 Community Genetics 67 at 68.

b) Research Groups

As noted above, there are a variety of new research groups with a specific focus on nutrigenomics. These groups range from federally funded partnerships with industry (e.g., Nutrigenomics New Zealand)[45] to academic collaborative ventures (e.g., University of California Davis' NCMHD Center of Excellence for Nutritional Genomics)[46] to less formal collections of interdisciplinary teams (e.g., Memorial University's Nutrigenomics Research Interest Group).[47] We identified seven research groups to review using Internet search engines (e.g., Google), supplemented by reference to the various affiliated groups of the authors in the scientific literature identified above. We reviewed how these research groups, which play an important knowledge translation role, framed nutrigenomics.

Often, an explicit mandate of the groups was to promote the field. It is not surprising, then, that the public face of these groups, usually on websites, is optimistic about the social benefits that may accrue from the research.[48] For example, the European group, NuGo, states that nutrigenomics "promises to improve health conditions and to prevent disease, e.g. diabetes, obesity, cardiovascular diseases and cancer."[49] Nutrigenomics New Zealand holds that "nutrigenomics will lead to the development of new foods for individualized health and nutritional benefit."[50] Commercialization is also a strong theme. For example, Germany's BioProfile Nutrigenomics holds that "[n]utrigenomics is a highly innovative and fast-growing interdisciplinary field of research linking genome research, plant biotechnology and molecular nutritional research and offering new applications for medicine and nu-

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45 See e.g. *supra* note 15.

46 UC Davis Center of Excellence for Nutritional Genomics, *supra* note 12, is sponsored by an award from the National Center for Minority Health and Health Disparities (NCMHD) at the National Institutes of Health (NIH).

47 See e.g. *supra* note 20.

48 See e.g. *supra* note 15. The front page of Nutrigenomics New Zealand's website is sub titled: "Tailoring New Zealand foods to match people's genes." It then suggests that "Nutrigenomics will lead to the development of new foods for individualised health and nutritional benefit."

49 European Nutrigenomics Organisation, "Nutrigenomics Facts," online: NuGo <http://www.nugo.org/facts> at para. 1.

50 Nutrigenomics New Zealand, "Tailoring New Zealand foods to match people's genes," online: Nutrigenomics New Zealand <http://www.nutrigenomics.org.nz/> at para. 3.

trition."[51] As a company, BioProfile strives to "expand the industrial application of academic knowledge in the life sciences."[52] Commercialization was a strong theme for most of the groups reviewed,[53] with a few exceptions. For example, the primary mission of the UC Davis Center is to "reduce and ultimately eliminate racial and ethnic health disparities."[54]

Such positive messaging is to be expected as research groups seek to position nutrigenomics within a nation's research agenda and compete for funds, be they public or private. As with the scientific literature, additional frames included the reduction in chronic disease and long term cost savings for the health care system. The UC Davis NCMHD Center of Excellence for Nutritional Genomics, for example, recognizes that nutrigenomics will impact society, having applications that will likely exceed those of the human genome project. "Chronic diseases (and some types of cancer) may be preventable, or at least delayed, by balanced, sensible diets. Knowledge gained from comparing diet/gene interactions in different populations may provide information needed to address the larger problem of global malnutrition and disease."[55] Nutrigenomics New Zealand claims that the information garnered through nutrigenomics "will ultimately lead to the development of completely new, added-value, export-focused, gene-specific foods that will deliver proven health outcomes to consumers."[56] As with the scientific literature, common themes among research groups included

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51 Nutrigenomics Network Berlin-Brandenburg, "BioProfile Nutrigenomics," online: Nutrigenomics Network Berlin-Brandenburg <http://www.nutrigenomik.de/media/downloads/downloads_1/Nutri_Flyer_2005-10.pdf> at 1 [BioProfile].

52 *Ibid*. at 2.

53 *Ibid.* "BioProfile is a development program of the German federal ministry of education and research (BMBF) to expand the industrial application of academic knowledge in the life sciences."

54 *Supra* note 12.

55 NCMHD Center of Excellence for Nutritional Genomics, "Information," online: NCMHD Center of Excellence for Nutritional Genomics <http://nutrigenomics.ucdavis.edu/nutrigenomics/index.cfm?objectid=972D6E14-65B3-C1E7-053774E6C7AF510A> at para. 2.

56 Nutrigenomics New Zealand, "About Us," online: Nutrigenomics New Zealand <http://www.nutrigenomics.org.nz/index/page/26> at para. 5.

the reduction in chronic disease[57] and long term cost savings for the health care system.[58]

c) Private Companies

The number of private companies dealing with genomics has increased dramatically in recent years. The UK Human Genetics Commission report, *More Genes Direct* (2007), identifies 26 companies advertising genetic tests to the public.[59] Six of these companies were explicitly identified in the report as offering nutrigenomic testing (Genetic Health, Genelex, Holistic Heal, Quixtar, Salugen, and Suracell), although more companies are likely offering nutrigenomic testing or are in the process of developing such tests.[60] In addition to examining the websites of the six companies identified as offering nutrigenomic testing, we examined two additional companies offering testing: Genovations and Sciona.

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57 Scott Gottlieb, "Address" (Speech before the Grocery Manufacturers of America Annual Meeting, 30 November 2005), online: U.S. Food and Drug Administration <http://www.fda.gov/oc/speeches/2005/gma1130.html>, where he states: "Nutrigenomics envisions a future in which personalized genetic profiling takes the guesswork out of deciding what you should eat. By adjusting nutrient composition in a person's diet according to genetic profiles, gene-based nutrition planning could one day play a significant role in preventing chronic disease."

58 For example, Geschaftsstelle Kompetenznetze Deutschland states: "Research into the causes of chronic-degenerative diseases has shown that they are partly or entirely related to diet, which means they are preventable in most cases. Statistics have shown that approximately one fourth of costs in the health care system are attributable to such nutrition-related diseases." Germany, Federal Ministry of Education and Research, *Guide to Innovation, Investment and Education in Germany* (Dusseldorf: Federal Ministry of Education and Research, 2003), online: Photonic-Net <www.photonicnet.de/download/innovationsbericht_2003_2004.pdf > at 41.

59 U.K., Human Genetics Commission, *More Genes Direct: A Report on Developments in the Availability, Marketing and Regulation of Genetic Tests Supplied Directly to the Public* (London: Human Genetics Commission, 2007), online: Human Genetics Commission <www.hgc.gov.uk/UploadDocs/DocPub/Document/More%20Genes%20Direct%20-%20final.pdf>.

60 Tania Bubela & Benjamin Taylor, "Nutrigenomics, Mass Media and Commercialization Pressures" (2008) 16:3 Health Law Review 41 (identified fifteen nutrigenomics companies).

The reviewed companies most commonly report offering private testing services, including the provision of nutrigenomic tests and advice. Genovations states that it focuses on testing for genetic variations "influenced by environmental factors" and provides profiles that contain "intervention options based on the patient's genomic pattern."[61] The company also claims to offer "specific risk reduction strategies, including dietary, nutritional, lifestyle, and pharmaceutical interventions."[62] Other companies such as Sciona Inc., through its Mycellf program, are more focused on nutritional and lifestyle advice. Sciona Inc. maintains that it "provides personalized health and nutrition recommendations based on an individual's diet, lifestyle and unique genetic profile."[63] Some companies, such as Holistic Heal, emphasize that the information their tests provide "is not intended to diagnose, treat, cure or prevent disease."[64] Suracell[65] and Salugen[66] included a similar statement in fine print. All three companies, however, allege that their products will help individuals manage their health and well-being.

Naturally, the companies emphasize the potential for disease prevention. Genovations contends that its testing services will "empower physicians and patients to realize … more effective preventive interventions … [and] … improved clinical insight into patients with treatment-resistant 'chronic' conditions."[67] Genelex asserts its recommendations are "practical, effective and proven ways in which to improve your short and long-term health, help

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61 Genova Diagnostics, "Physicians Guide to Clinical Genomics," online: Genovations <http://www.genovations.com/home/clinician_overview.html> at para. 9.

62 *Ibid.*

63 Sciona, *supra* note 3 at para. 1.

64 Holistic Health Consultants, "Comprehensive Methylation Panel with Methylation Pathway Analysis #697," online: Holistic Heal.com <http://www.holisticheal.com/store/product.php?productid=697&cat=124&page=1> at para. 3 [Holistic Heal].

65 Suracell, "How It Works," online: Suracell <http://www.suracell.com/how_it_works/core_nutrition.aspx>.

66 Salugen, "Individualized Medicine," online: salugen <http://www.salugen.com/individualized-medicine.html> [Salugen].

67 Genova Diagnostics, "Genovations is the Advent of Truly Personalized Healthcare," online: Genovations <http://www.genovations.com/home/index.html> at para. 2.

prevent illness, and above all feel better."[68] Sciona's Mycellf program states that "your unique genetic profile is the key to understanding how your body works, including which diet and exercise programs will bring you the results you want and which health and nutrition programs will lead to long-term wellness."[69]

The representations associated with the private companies differ from the scientific literature and research groups in that they emphasize the individual over social benefits, such as the reduction of the burden of chronic disease. Given the nature of the market, this makes sense. Nutrigenomic websites are selling tests to individuals, not health care programs or communities. Recall the claim by Genelex that the advice they offer is not based on dietary fads, but instead on "*your* body's real needs."[70] Salugen attempts to distinguish itself from other companies with a "one-formulation-fits-all approach to wellness" by offering what they term individualized medicine, "a one-formulation-fits-one approach …. [that] delivers precisely what you need to improve your wellness or alleviate your condition."[71] The promise of Holistic Heal is a "personalized map" to help achieve wellness.[72]

Many companies are betting on the long-term benefits of nutrigenomic products. Many companies, like Nestlé and Unilever, have allied with universities to fund nutrigenomics research, while continuing to conduct in-house research and development in order to develop novel food products. Again, this push is focused on perceived individual uptake of the new technologies. While consumer readiness to adopt nutrigenomics is still unknown,[73] the introduction of many products into the market is a continuing success for these corporations. The question remains as to whether the early marketing of nutrigenomic tests will harm the future acceptance of more carefully researched nutrigenomic products by negatively impacting public opinion.

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68 Genelex, "Nutritional Genetics," online: genelex <http://www.healthanddna.com/nutrigeneticstest.html> at para. 15 [Genelex].

69 Sciona, "The Science of You," online: mycellf <http://mycellf.com/index.aspx> at para. 2.

70 *Supra* note 67 at para. 14 [emphasis added].

71 *Supra* note 66 at paras. 1-2.

72 *Supra* note 64 at para. 2.

73 A. Ronteltap *et al.*, "Consumer acceptance of technology-based food innovations: Lessons for the future of nutrigenomics" (2007) 49 Appetite 1.

d) Popular Press

Nutrigenomics has received a reasonable amount of attention in the popular press.[74] We collected media coverage (newspaper articles and radio and television transcripts) on nutrigenomics and grouped the resultant publications into categories.[75] Our search uncovered 89 items to June 2007.[76]

Many media items focused on the commercial nature of the research and the actors involved. Fully one-third of media items referred to nutrigenomics companies but only 8% referenced actual scientific research articles.[77] This is unusual for coverage of medical genetics more generally where media coverage often focuses on research by local researchers published in high profile scientific journals.[78] In contrast, most of the press coverage on nutrigenomics has not been about specific discoveries – although there have been some high profile research findings.[79] Instead, the bulk of the coverage

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74 See *supra* note 60 at 43, where Bubela & Taylor note: "There has been a significant increase in all forms of media coverage of nutrigenomics since 2004."

75 We searched Lexis/Nexis, Factiva and Canadian Newsstand media databases for all media coverage with no date restrictions using the following search string: "nutrigenomic* or nutragenomic* or nutritional genomic* or personalized nutrition or nutragenetic or nutrigenetic or gene food." We then hand-sorted the media coverage into broad categories and eliminated false hits that were not related to nutrigenomics. In addition, we compiled a list of 14 companies through a non-random sampling method using the above search terms coupled with "gene* and test" and "company." We used snowball sampling to augment our list by extracting references to nutrigenomics companies from media articles, policy reports and academic articles. We then repeated our media searches in Lexis/Nexis, Factiva and Canadian Newsstand to search for media articles on nutrigenomics companies with the search string "Company Name" and "gene* and test." Again, these articles were assessed for relevance. *Supra* note 60.

76 These included articles in magazines (2) and newspapers (71) and transcripts from radio (5) and television (11) segments.

77 *Supra* note 60.

78 Tania M. Bubela & Timothy A. Caulfield, "Do the print media 'hype' genetic research? A comparison of newspaper stories and peer-reviewed research papers" (2004) 170 Canadian Medical Association Journal 1399.

79 See e.g. the media coverage of the discovery of the risks associated with coffee consumption: Marilyn C. Cornelis *et al.*, "Coffee, CYP1A2 Genotype, and Risk of Myocardial Infarction" (2006) 295 Journal of the American Medical Association 1135; "Genes may determine caffeine risks: study" *CTV News*

of nutrigenomics is in the form of feature articles about the emerging field, included as part of stories about genetic testing more generally.[80]

Not surprisingly, then, media coverage has been largely optimistic, [81] in part because the main sources of information on nutrigenomics were the companies which provide personal testing services and, in some cases, the entrepreneurial scientists who founded them.[82] Media representations of nutrigenomics emphasized benefits, and despite the lack of empirical evidence, legitimized nutrigenomic testing as providing reliable and valuable health information. Adding to the overall positive framing of nutrigenomics, many items focused on celebrity lifestyles and diets, identifying nutrigenomics as the hottest new diet trend.[83] Other items focused on a move away from a "one-size fits all" diet to a personalized and "revolutionary new change" in dieting.[84] Items emphasized the potential health benefits of personalized dietary advice.[85]

In such stories, nutrigenomics is framed as a field that will revolutionize and personalize dieting. This framing appeals to wealthy and sophisticated consumers who desire "ownership … the feeling that something is tailored to their needs and will overcome their problems."[86] The media coverage clearly targets wealthy, educated consumers who are interested in being trend-setters. The coverage plays on the fears of disease processes and aging in this health-conscious demographic. It emphasizes the obsession of Western culture with individuality through personalized treatment options, possibly to the detriment of public health measures.[87]

(7 March 2006), online: CTV.ca <http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20060307/coffee_genes_060307/20060307?hub=Health>.

80 See e.g. the front page story: Carolyn Abraham, "Would you gaze into a genetic crystal ball?" *Globe and Mail* (31 December 2005) A1.

81 *Supra* note 60 at 45.

82 *Ibid.*

83 *ABC 7 News* (30 November 2005); Hilary E. MacGregor, "Are the clues to diet success in your genes?" *Los Angeles Times* (11 April 2005) F1 at para. 4.

84 *News Weekend* (18 March 2006).

85 See e.g. Tim Cronshaw, "Customised food 'hot'" *The Press* (14 July 2006) 7; Amanda Ursell, "Family matter" *The Sunday Times* (3 September 2006) 38.

86 Jim Dickins, "New clues to the perfect diet – what's good for us in the genes" *Sunday Telegraph* (24 September 2006) 26.

87 *Ibid*. at 46.

On the flip side, because the media reports are often reviews or feature articles on the general area, the risks or limitations of the field have also received limited attention. For example, the *Globe and Mail* had a feature article, entitled "Personal Genetics Tests: Genius or Bogus?" and questioned the value of the emerging testing industry.[88] Likewise, controversies over testing, such as the scathing US Government Accounting Office (GAO) report on the value of nutrigenomic testing received media attention.[89] The GAO created fourteen fictional consumer profiles around two DNA samples and submitted the samples to four nutrigenomics companies. The report concluded that "[t]he results from all the tests GAO purchased mislead consumers by making predictions that are medically unproven and so ambiguous that they do not provide meaningful information to consumers."

This type of polarized story telling – that is, an emphasis on either potential breakthroughs or social controversy – is typical of health care reporting.[90] The media, driven by their own commercial agendas, report on stories that, crudely put, will help sell papers. In genomics, outside of tragedies such as the death of Jesse Gelsinger in a premature gene therapy research trial, a number of studies have shown that the media largely act as an uncritical cheer squad for genomics research.[91] Nutrigenomics appears to be no exception.

Critiquing the Claims

In total, the major sources of the public representations – the science literature, the messaging emanating from relevant research groups, the marketing from testing companies, and the stories in the popular press – have framed nutrigenomics as an emerging field that will lead to a reduction of chronic disease, a lowering of health care costs and healthy lifestyle choices. The tone is largely positive. But, as noted above, not all in the scientific community or in the popular press have been uniformly enthusiastic about nutrigenom-

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88 Hayley Mick, "Personal genetic tests: genius or bogus?" *Globe and Mail* (26 April 2007) L6.

89 Government Accounting Office, *supra* note 8.

90 Roger Highfield, "Selling Science to the Public" *Science* 289:5476 (7 July 2000) 59.

91 See *supra* note 78. See also N.A. Holtzman *et al.*, "The Quality of Media Reports on Discoveries Related to Human Genetic Diseases" (2005) 8 Community Genetics 133.

ics. Even some of the science papers noted above contain statements about the limits.[92] For example, it has been observed that nutrigenomic informed diets may offer little additional benefit when compared to current dietary guidelines, as individual nutrients have a wide-ranging but shallow effect on health.[93] Furthermore, personalized dietary information may be difficult to reconcile with the different nutritional needs of other family members or the general public.[94] Such concerns, however, are moot if nutritious food is not generally available to the public.[95] In all, the current state of nutrigenomics has been described as a "Gordian Knot" that needs to be unraveled, "the solution to which lies as much in ethics as it does in science."[96]

Part of the skepticism lies in the fact that even if nutrigenomic information provided relevant dietary information – and there are those who think we are a long way from having meaningful data[97] – there is doubt that it

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92 See e.g. Hans-Georg Joost *et al.*, "Personalised nutrition: status and perspectives" (2007) 98 British Journal of Nutrition 26 [Joost 2007].

93 See e.g. Manuela M. Bergmann *et al.*, "Bioethics in human nutrigenomics research: European Nutrigenomics Organisation workshop report" (2006) 95 British Journal of Nutrition 1024 at 1025, where they state: "Nutrigenomics research rarely deals with genetic information that would unequivocally determine an individual's health status. In most cases, the genotypic information represents influences that are often no greater than those of lifestyle factors such as diet."

94 Nutrigenomics is often portrayed as the harbinger of personalized nutrition, but this view is highly criticized as impractical. In discussing the difficulty of translating nutrigenomic research into a commercially viable practice, one commentator notes: "although individuals can be distinguished as unique, they most likely will not be treated uniquely." Bart Penders *et al.*, "From individuals to groups: A review of the meaning of 'personalised' in nutrigenomics" (2007) 18 Trends in Food Science and Technology 333 at 337.

95 See: Tim Lang, "Food control or food democracy? Re-engaging nutrition with society and the environment" (2005) 8 Public Health Nutrition 730 at 731, where he states: "Mining the genome may be exciting and brilliant science but it makes for individualized approaches to public health, which will be of little value in the task of tackling the nutrition transition or inequalities or environmental crisis."

96 Peter J. Gillies & Elaine S. Krul, "Using Genetic Variation to Optimize Nutritional Preemption" (2007) 137 Journal of Nutrition 270S at 270S.

97 Consequently, current attempts to derive dietary recommendations based on the genotypes of the few single SCP presently known to be associated with

would be more significant than what we already know about healthy diets.[98] In other words, in order for nutrigenomics to have a broad positive impact, it will need to provide information that is more powerful, from a health promotion perspective, than the information that is already available.

But perhaps more important is the fact that most of the proposed benefits of nutrigenomics require some degree of behavior change by individuals. In large part, nutrigenomics is about the provision of information regarding individual predispositions in the hope that individuals will act on that information.[99] In other words, the reduction in chronic disease and the lowering of health care costs (two of the dominant themes in the framing of nutrigenomics), require individuals to act on nutrigenomic informed advice (be it individual testing or the provision of risk information for a specific, identifiable, sub-population).[100]

Given this reality, we need to consider what available evidence tells us about behaviour change, health and food choices. Will people really change their eating habits in response to nutrigenomic information? Given that answering this basic question is fundamental to the stated goals of nutrigenomics, one would expect it to be a significant part of the nutrigenomic research agenda and a commonly noted limitation. In fact, we found only minimal discussion of this issue in the sources of information we reviewed.[101]

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particular complex diseases appear largely experimental. Recently, such tests have, provocatively, been called 'genetic horoscopes'. See: Gene Russo, "Home health tests are 'genetic horoscopes'" (2006) 442 Nature 497.

98 Jane Brody, "No Gimmicks: Eat Less and Exercise More" *The New York Times* (1 January 2008) F7: "And really, it doesn't matter whether you choose a diet based on your genotype or the phases of the moon, or whether you cut down on sugars and starches or fats. If you consume fewer calories than you need to maintain your current weight, you will lose."

99 To be fair, nutrigenomics also involves the development of supplements and other food products, but these products offer generalized nutritional benefits. In order to maximize the benefits of nutrigenomics, individuals will have to adopt personalized dietary regimens. See *supra* note 92.

100 The need to induce behaviour change has been noted in some of the literature. Indeed, it has been suggested that genetic information might help facilitate change. See, for example, *supra* note 36 at 107. "These approaches will certainly have public health implications because they have the potential to change dietary habits in order to achieve effective disease prevention and therapy."

101 Even recently, criticisms have been general. For example, the Nuffield Trust report, one of the most comprehensive reports on the viability of nutrigenomics,

So, what does available data tell us? While there is little research on the impact of genetic information on diet change (more on that below),[102] we can reflect on the impact genetic information has on behavioural change more generally. Marteau and Lerman note that, similar to any information on risk, genetic risk information could increase or decrease one's motivation to change behaviour, the response being shaped by pre-existing perceptions.[103] Overall, however, they conclude that "[t]he current evidence suggests that providing people with DNA derived information about risks to their health does not increase motivation to change behaviour beyond that achieved with non-genetic information."[104] This conclusion is supported by Carlsten and Burke: "… genetic risk information may be ineffectual in motivating behavior change or potentially may even be harmful by inducing fatalism, feelings of impotency, or loss of willpower . . . . [and thus caution] against 'genocentric views,' which may lead to inappropriate expectations rather than substantive progress towards improving health outcomes."[105]

As such, it is fair to conclude that, to date, there is little data giving support to the notion that genetic information will motivate behaviour change.[106] In fact, some suggest that genetic information may reduce mo-

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only briefly mentions the need to study the impact of the science on individual behavioural change. See: Hilary Burton & Alison Stewart, *Nutrigenomics: Report of a workshop hosted by the Nuffield Trust and organised by the Public Health Genetics Unit on 5 February 2004* (London: Nuffield Trust, 2005) [Nuffield].

102 There has been speculation in the literature that nutrigenomic information may motivate change. See, for example, "It has always been known that success in dieting depends on the dieter's psychological determination to change. But the new research suggests that if a way could be found for individuals to select the right diet for them, it could ease the demands on willpower." J. Laurence, "The right weight-loss plan for the right person: The reality is any diet will do so long as you stick to it" *The Spectator* (11 January 2005) G10.

103 Theresa M. Marteau & Caryn Lerman, "Genetic Risk and Behavioural Change" (2001) 322 British Medical Journal 1056 at 1057.

104 *Ibid*. at 1058.

105 Chris Carlsten & Wylie Burke, "Potential for Genetics to Promote Public Health: Genetics Research on Smoking Suggests Caution About Expectations" (2006) 296 Journal of the American Medical Association 2480 [Carslten & Burke].

106 See Paul Bennett *et al.*, "The Impact of Breast Cancer Genetic Risk Assessment on Intentions to Perform Cancer Surveillance Behaviours" (2007) 16 Journal of Genetic Counseling 617, where they find that women were only slightly more inclined to perform breast cancer surveillance behaviours after a positive

tivation.[107] This has been called "fatalism" – the idea that people will come to view their genetic predispositions as signaling an inevitable course.[108] The concept is expressed well by a Newfoundlander who discovered, as the result of research on the link between heart disease and genetic heritage, that he had a "genetic flaw" predisposing him to heart disease: "This means we are doomed so we might as well live it up. We don't need to quit smoking or change our diets."[109] While the concept of fatalism is inadequately addressed in the nutrigenomics literature, there is some recognition of this issue. For example, Joost and colleagues note: "The possibility cannot be excluded that, in some individuals, knowledge of a genetic predisposition might lead to a fatalistic attitude and a reduced compliance with any intervention."[110]

With this general conclusion about the impact of genetics on behaviour change as a backdrop, it is important to note that one recent study involving obese patients did find that nutrigenomic information was catalytic in maintaining weight loss.[111] The study, which involved patients who had been unsuccessful in previous weight loss attempts, found that the study group provided with nutrigenomic information did "significantly better" than the groups that did not have access to such information.[112] This led the

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genetic diagnosis. Indeed, some researchers, such as Marteau and Lerman, are notoriously skeptical: "Just telling people they are at risk of developing a disease is rarely sufficient to change behaviour. . . Few interventions to induce change have been proved effective, and even these succeed in changing behaviour in only a minority." *Supra* note 103 at 1057.

107 *Ibid.* See also: Victoria Senior, Theresa M. Marteau, & Timothy J. Peters, "Will genetic testing for predisposition for disease result in fatalism? A qualitative study of parents responses to neonatal screening for familial hypercholesterolaemia" (1999) 48 Social Science & Medicine 1857, where it appears that parents who perceive a health risk in their child to have a genetic cause are more likely to act fatalistically.

108 *Supra* note 105 at 2481. See also: A.J. Wright, J. Weinman & T.M. Marteau, "The impact of learning of a genetic predisposition to nicotine dependence: An analogue study" (2003) 12 Tobacco Control 227.

109 Charles Gillis, "'Doomed' Newfoundlanders opt to eat, drink, and be merry" *National Post* (12 April 1999) A1.

110 *Supra* note 92 at 31.

111 Ioannis Arkadianos *et al.*, "Improved weight management using genetic information to personalize a calorie controlled diet," online: (2007) 6:29 Nutrition Journal <http://www.nutritionj.com/content/6/1/29/>.

112 *Ibid.* at 6.

authors to conclude that, "the use of nutrigenetics to improve and optimize a healthy balanced diet in a clinical setting could be an effective aid in long term lifestyle changes leading to sustained weight loss."[113] The results are, no doubt, promising, [114] but given existing data about the impact of genetic information on behaviour, and the fact that this was a highly motivated group in a clinical setting, it is difficult to say whether such data is generalizable to the broader public – which relates more closely to the core claims of the nutrigenomic community. More research is needed to see if such findings will translate into a population health intervention.

Also, it could be argued that success in weight loss, which is observable and quantifiable, differs significantly from abstract notions of prevention of disease susceptibilities and individual health. Eating right and weight loss are not always congruous goals. It is often difficult for individuals of lower socio-economic status to eat nutritiously according to current guidelines, which contributes to health inequity between people of different socio-economic status.[115] Food security is a major concern of public nutrition. Inability to access healthier food choices is correlated with low socioeconomic status.[116] In turn, the poor have higher rates of obesity and cardio-vascular disease.[117] Even if nutrigenomic information were available to the poor, many would be unable to access or afford the food necessary to follow the advice. Recently, this issue has become a growing concern, as food prices

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113 *Ibid.* at 8.

114 Astrid Newell *et al.*, "Addressing the Obesity Epidemic: A Genomics Perspective" (2007) 4 Preventing Chronic Disease A31. "Although scientists hope that personalized health care based on genetic profiling will help people recognize their risk and improve their behavior, additional evidence is needed to support this possibility" at A35. The need to study the effects of nutrigenomic information on individual dietary behaviour was also raised by the Nuffield Trust report, *supra* note 101.

115 Gavin Turrell & Anne M. Kavanagh, "Socio-economic pathways to diet: Modeling the association between socio-economic position and food purchasing behaviour" (2006) 9 Pubic Health Nutrition 375.

116 Elaine M. Power, "Determinants of Healthy Eating Among Low-income Canadians" (2005) 96 Canadian Journal of Public Health S37.

117 S. Paeratakul *et al.*, "The relation of gender, race and socioeconomic status to obesity and obesity comorbidities in a sample of U.S. adults" (2002) 26 International Journal of Obesity 1205.

have climbed dramatically and are projected to continue to climb in the future.[118]

Affluence, however, does not guarantee the ability to adopt nutrigenomics informed diets. As one commentator notes, "the decisions an individual makes about what to eat are arguably much more complex than the decisions about following a doctor's prescription for a pharmaceutical. These decisions are influenced by a greater extent by factors such as anticipated pleasure."[119] As already discussed, it remains unclear whether nutrigenomics will serve as a catalyst for change in dietary behaviour. But addressing the nutritional needs of individuals is more complex than adopting nutrigenomic diets. Combating obesity has been likened to combating climate change, requiring long-term collaboration between governments to create societal change.[120] Without wide environmental and social change, some critics fear that nutrigenomics will only be used by the highly motivated and affluent. Darton-Hill and colleagues perhaps express the criticism best:

> The high costs of the screening and genotype diagnosis of developing novel and functional foods and the poor availability of functional health systems make even the possibility of 'tailored diets' an impossible dream for most populations relying on poorly functioning and poorly resourced health systems. More relevant may be the question asked by Black *et al.* (2003): 'where and why are 10 million children dying every year?' Supposing that this were to happen, what impact would such developments have on public health? Should government, consumers, health care providers and other stakeholders view nutrigenomics as a public health measure?[121]

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118 A recent cover story in *The Economist* states that food prices have increased 75% since 2005: "The end of cheap food" *The Economist* 385:8558 (8 December 2007) 11.

119 Chadwick, *supra* note 7 at 162.

120 U.K., Government Office for Science, *Tackling Obesities: Future Choices – Summary of Key Messages* (London: Department of Innovation Universities and Skills, 2007), online: <http://www.erpho.org.uk/Download/Public/16891/1/obesityKeymessages.pdf>.

121 Ian Darnton-Hill, Barrie Margetts & Richard Deckelbaum, "Public health nutrition and genetics: implications for nutrition policy and promotion" (2004) 63 Proceedings of the Nutrition Society 173 at 182 referring to: Robert E. Black, Saul S. Morris & Jennifer Bryce, "Where and why are 10 million children dying every year?" (2003) 361 Lancet 2226.

The impact of nutrigenomics on health care costs also deserves a mention. Genetic technologies are often hailed as a vehicle for reducing health care costs, increasing system efficiency, promoting population-level health and creating new industry.[122] It is worth noting that there is little evidence that nutrigenomics will have the impact promised on health care costs. At a minimum, we need more evidence regarding the possible health economic impact of this field. For example, Morgan and Hurley claim that:

> [i]n the coming decade, the cost of genetic testing services and the goods and services sold on testing results may become a major cost-driver in the health care system. The bulk of the related expenses may not be the price of the tests themselves, but rather the cost of the products and services that accompany the testing process and that are sold on the basis of test results. Such complementary services include the consultations with health professionals that may proceed and follow testing, as well as ongoing consumption of products and services for the purposes of disease surveillance or prevention.[123]

Conclusion

Nutrigenomics is, no doubt, an exciting emerging field of study. Nutrition is clearly a tremendously important part of public health. Gaining a more complete understanding of the relationship between genes, food and lifestyle in the development of disease is a very worthwhile course, and nutrigenomics has been framed as a science that will be beneficial for population health.

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122 Commission on the Future of Health Care in Canada, *Influences on the "Health Care Technology Cost-Driver"* by Steve Morgan & Jeremiah Hurley (Ottawa: Public Works and Government Services Canada, 2002), online: <http://dsp-psd.pwgsc.gc.ca/Collection/CP32-79-14-2002E.pdf>. The "executive summary" states: "In the coming decade, the cost of genetic testing services and the goods and services sold on testing results may become a major cost-driver in the health care system. The bulk of the related expenses may not be the price of the tests themselves, but rather the cost of the products and services that accompany the testing process and that are sold on the basis of test results. Such complementary services include the consultations with health professionals that may proceed and follow testing, as well as ongoing consumption of products and services for the purposes of disease surveillance or prevention."

123 *Ibid*. at 5.

While it is certainly possible that nutrigenomics may help to motivate particular individuals, there is a paucity of evidence to support claims made by the various stakeholders. For example, better dietary habits may be formed using nutrigenomic information, but it is doubtful that the information itself will cause any significant or meaningful changes in individual behaviours. Although it is not unusual for a new area of research to be presented in a positive light and be associated with high hopes, there remains a danger that this may result in unmet expectations, premature applications and misdirected resources.[124] This, in turn, may serve to undermine public confidence in this fledgling science.

124 *Supra* note 26; Timothy Caulfield, "Popular Media, Biotechnology, and the 'Cycle of Hype'" (2005) 5 Houston Journal of Health Law and Policy 213.