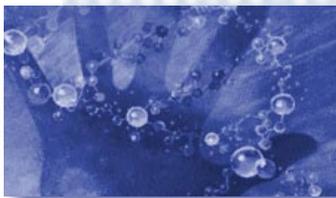


The Future of Nutrigenomics

From the Lab
to the Dining Room



INSTITUTE FOR THE FUTURE

New Consumer, New Genetics
Health Horizons Program

March 2005 | SR-889

124 University Avenue, 2nd Floor
Palo Alto, CA 94301
650.854.6322 | www.iff.org

The Future of Nutrigenomics

From the Lab
to the Dining Room

INSTITUTE FOR THE FUTURE

New Consumer, New Genetics
Health Horizons Program

March 2005 | SR-889



650.854.6322 | www.iff.org

ABOUT THE ...

INSTITUTE FOR THE FUTURE

The Institute for the Future is an independent, nonprofit strategic research group with over 35 years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design process, innovation, and social dilemmas. Our research generates the **foresight** needed to create **insights** that lead to **action**. Our research spans a broad territory of deeply transformative trends, from health and health care to technology, the workplace, and human identity. The Institute for the Future is based in Palo Alto, CA.

Acknowledgments

Author: Diane Oliver

Contributors: Rod Falcon, Katherine Haynes Sanstad, Bern Shen, and Leah Spalding

Editor: Charles Grosel

Creative Director: Jean Hagan

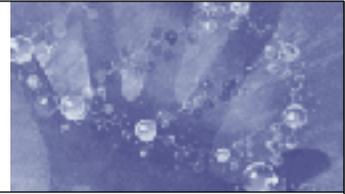
Production and
Graphic Design: Robin Bogott

Contents

List of Figures and Tables	iv
Chapter 1 Introduction.....	1
Chapter 2 Advances in Nutritional Science.....	5
Chapter 3 Personalization of Nutritional Recommendations	14
Chapter 4 Getting the Products to Market	23
Sidebar: Genetic Testing: One Consumer's Experience	35
Chapter 5 Nutrigenomics Will Attract Consumers	40
Chapter 6 Business Implications for Personalized Nutrition	56

List of Figures and Tables

Figure 2-1	Scientists Seek to Navigate Metabolic Superhighways	7
Table 3-1	Majority of Americans Are Overweight	15
Figure 4-1	Diabetes Prevalence Suggests Gene-Diet-Disease Interaction	25
Figure 4-2	Growth of In-Vitro Diagnostics Will Meet Growing Demand	27
Figure 5-1	Awareness of Nutrigenomics Lags Behind Genomics	41
Figure 5-2	Consumers Are Interested in a Personalized Nutrition Test	42
Table 5-1	Consumers Say They Would Pay for Genetic Tests	42
Figure 5-3	Consumers Willing to Pay for Personalized Nutrition Benefits	43
Figure 5-4	Distribution of Consumers Along the CNI	44
Table 5-2	Questions for the 2004 CNI	44
Table 5-3	Demographic Differences Across the CNI Groups	45
Table 5-4	Members of High CNI Groups Are More Likely to Have Chronic and Serious Illnesses	46
Table 5-5	Behavior Identifies High CNI Consumers	47
Figure 5-5	High CNI Consumers Already Do What's Required for Personalized Nutrition	48
Figure 5-6	Very High CNI Consumers Particularly Interested in Personalized Nutrition Tests	49
Figure 5-7	Physicians Bridge the Gap Between Nutrition and Science	50
Figure 5-8	A Small, Vocal Minority May Oppose Nutrigenomics Testing	53



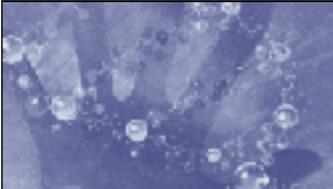
The dramatic scientific advances of the Human Genome Project—the mapping of the entire human genome—are revolutionizing the way we think about health, illness, and disease prevention. Not only do advances in genomics increase our understanding of the inherited basis of disease, allow us to develop new drugs with specific molecular targets, and help us to understand why drugs are more effective or more toxic in people with certain genetic characteristics, they also promise to revolutionize our understanding of nutrition and how people differ in their response to nutrients. This is the study of nutrigenomics, and the purview of the Institute for the Future’s (IFTF) New Consumer, New Genetics (NCNG) Program.

As we defined it in the first report of this series, *The Future of Nutrition: Consumers Engage with Science* (2000, SR-731), nutrigenomics is “the study of the relationship between what we eat and how our genes function, and thus how healthy we are.” The study of nutrigenomics is aiming to achieve “personalized nutrition:” the recommendation of foods and supplements based on a person’s genetic profile. Many pioneers in nutrigenomics, including Nancy Fogg-Johnson, who coined the term, argue that nutrigenomics will bring revolutionary changes to health and nutrition—to both how we prevent and treat disease and how food is grown, processed, and made. As with all such revolutions, however, there are questions: When will the scientific breakthroughs reach the marketplace, and in what form will they appear?

To answer these questions, IFTF’s NCNG Program explored the implications of nutrigenomics for a whole range of players—consumers, the biotech companies doing the research, health care stakeholders (practitioners and payers), genetic-testing companies, pharmaceutical companies, food manufacturers, grocery stores, and other retail outlets. In particular, NCNG was designed to analyze the potential market for nutrigenomic products: genetic testing and recommendations based on these tests, programs for changing nutrition, and the production and sales of foods and supplements that meet these recommendations.

In the first NCNG report, *The Future of Nutrition: Consumers Engage with Science*, we discussed the advances in the basic science of nutrigenomics, how the structure of the food industries would likely create barriers to the creation of a nutrigenomics market, and the key role that the more empowered, more information-savvy consumers will play in the adoption and spread of nutrigenomic products (both genetic tests and foods and supplements). To forecast the likely size of the market in a decade’s time, we designed the Consumer Nutrition Index (CNI), which arranges consumers on a spectrum based on their interest in nutrition information and their likelihood of changing behaviors based on that information. With this metric, we determined that by 2010 or so, about 33% of the consumer marketplace is likely to be open to buying some kind of nutrigenomic product. We analyzed the early implications and strategies for players all along the food supply chain.

In the second report, *From Nutrigenomic Science to Personalized Nutrition: The Market in 2010* (2003, SR-793), we looked more deeply at the whole enterprise of nutrigenomics by first examining the bioethical ramifications of the science, including the question of when scientific information is ready to be acted on, issues concerning the use and misuse of genetic information, the role of the informed consumer in adopting cutting-edge science, and how intel-



1. Introduction

lectual property laws might effect development. Given the real debate about such issues, we discussed the likely regulatory responses by the government. Will nutrigenomic products be regulated like food, like dietary supplements, or like drugs? Does the current regulatory system have a real answer for the nutrigenomic revolution? How will regulation affect the expansion of the market?



To some degree, the answers to these questions depend on the demand for the products in the first place, and the demand for such products depends, of course, on consumers. In this report, we re-examine the role of consumers in the nutrigenomic marketplace and refine our measurement tool, the CNI. Since very few nutrigenomics products exist today, we continue to use information about nutrigenomics as a way to measure the potential market for such products. Our conclusion: we stick by our forecast from the first and second reports. About one-third of the consumer market will be open to “personalized nutrition:” that is, a sizable segment of consumers will be open to making day-to-day decisions about what to eat based on their particular genetic makeup.

The likely size and strength of this market has a host of implications for stakeholders not only along the food chain (food producers, food packagers, and grocery stores) but for those in health care (pharmacies, diagnostic-testing companies, health care providers, insurers, and nutrition advisors), science (research labs), and health information providers such as journals, magazines, newspapers, and newsletters. Because the market is just beginning to take shape, and the roles of these various players aren’t yet fully defined, it is likely many players will turn to partnerships to target particular market segments.

Which brings us to the third report for NCNG—*The Future of Nutrigenomics: From the Lab to the Dining Room* (SR-889). To see where the market is today, this report revisits many the issues discussed in the first two reports. It is a distillation of the insights we’ve gathered over the four years of this project—a look at where the science and markets are, and where they could be in 10–15 years.

A RECAP AND A LOOK FORWARD: WHERE IS NUTRIGENOMICS HEADED?

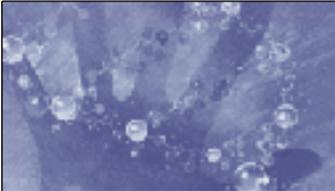
For years, nutritional recommendations have been developed with a one-size-fits-all approach. Yet we know that differences among individuals in gene sequence, gene expression, and consequently the

proteins that mediate most cellular functions will lead to differences in how these individuals respond to food. When people eat, proteins are required in a series of molecular processes related to food breakdown, absorption, transport, interactions with molecular targets, and excretion. Since the function of these proteins can vary from person to person, the response to the original food is not the same in everybody: one size does not fit all.

A basic understanding of processes at the cellular and molecular level provides us a vision of what genomics can contribute to the field of nutrition: the ability to develop nutritional recommendations and nutritional products specifically targeted for an individual, given the individual's genotype—that is, personalized nutrition. Since we believe that an individual's genetic makeup influences his or her response to diet—and growing scientific evidence suggests that diet can in turn influence gene expression patterns—a clear understanding of gene–diet interactions is an essential step in achieving this kind of personalized nutrition.

A variety of players must participate to fulfill this vision. At the discovery end of the value chain, which is where most of the emphasis in the field is today, society relies on nutritional scientists to advance our understanding of food and nutrition, and on molecular biologists and genomics experts to decipher the meaning of the human genome. Scientists from these disciplines, interacting and sharing their methodologies, will generate new discoveries in the nascent field of nutrigenomics.

As the field advances, leaders in health care, professional societies, and government agencies will sift through the scientific evidence and develop nutritional recommendations for the public that can be tailored according to an individual's genetic makeup and state of health or disease. This aspect of the market is just beginning to be developed, with companies such as Sciona and Genelex offering diagnostic testing and dietary recommendations. Corporate leaders in the food, supplement, and nutraceuticals industries and innovators at diagnostic-testing companies will analyze market potential and identify opportunities to develop new products. The promise of this aspect of the market is just beginning to be explored. We think the likely timeframe for the dissemination of these products is closer to 15 years than five, a slight upward revision of our earlier estimates.



1. Introduction

The nutrigenomics marketplace cannot be fully realized without a willing consumer. It is consumers who must undergo genetic testing after all, who must access nutritional recommendations based on such testing, and who must change their behaviors accordingly. In many cases, the consumers will not only have to participate in the diagnostic process, they will have to seek it out and pay for it, too. Consumers, who will make decisions about food, supplements, and diagnostic tests, must be convinced of the value proposition of nutrigenomics—that is, that the health benefits of nutrigenomics are real, that the products are desirable and cost-effective, that the professionals they consult are experts, and that it is worth risking loss of privacy and changing their behaviors to try something new.

For all of this to happen, consumers will need to receive complex information in forms they find useful. The nutrigenomic market today is focused less on foods that will be “prescribed” in response to genetic testing than about dissemination of nutrigenomic information, development and marketing of diagnostics testing, and segmenting customers. The actual tailoring of food and supplement products to specific genomic market segments will follow only after these issues are at least partially resolved.

To analyze the factors required for nutrigenomics to become a reality, we consider four categories of activities in Chapters 2 to 5: (1) advances in nutrition science, (2) the personalization of nutritional recommendations, (3) getting the products to market, and (4) the likely consumer responses to nutrigenomics. In Chapter 6, we present the business implications of these developments for a range of players. Between Chapters 4 and 5, we include a sidebar describing one consumer’s actual experience with genetic testing and dietary recommendations.

We use this basic framework to describe steps that must occur for a nutrigenomics market to evolve. As we discuss the framework, we consider the drivers and barriers to advancement in each of the four areas for the next 10–15 years. A look at these activities, drivers, and barriers will reveal what it will take to move nutrigenomics from the lab to the dining room.



The explosion of knowledge about the human body at the molecular, cellular, and systems levels offers a surfeit of data that must be pieced together for us to gain a deep understanding of the intricacies of how the body works, what can go wrong, and how physiologic processes can be optimized by efforts under our own control. We take for granted that we need to eat regularly because we get hungry, and we have been told for years (often conflictingly) what we should and should not eat to be healthy. But what happens to each molecule of a mouthwatering steak, a tart apple, a piece of freshly baked bread, or our favorite candy bar as it encounters every cell, enzyme, transporter, and receptor in its path?

Scientists seek to catalog not only all *genes* in the *genome*, but given biology’s “central dogma” that “DNA makes mRNA makes protein” they also want to catalog all mRNA transcripts in the transcriptome. Translation of mRNA into proteins leads in turn to ensembles of proteins in the *proteome* and of *metabolites* in the metabolome. The interrelationships of all the molecules and processes can be organized into complex displays of dynamic metabolic pathways (see Figure 2–1 on page 7). A wealth of knowledge is emerging that enables us to map these pathways and understand the crucial roles that nutrients play in them.

Understanding metabolic pathways and physiologic processes is key to understanding nutrition, and much of the work can and must be done *in vitro*, that is, in a laboratory, to isolate and study interesting parts of the pathways. However, individual nutrients and metabolic pathways are part of an interdependent network in the human body, and theories that emerge from basic science must be tested in human populations in order to yield practical results that affect diet and health—in order to move from the lab to the dining room.

DRIVERS OF ADVANCES IN NUTRITION SCIENCE

Advances in nutrigenomics and the understanding of gene–disease–nutrient interactions will result from the combination of several disciplines:

- The “omics”—genomics, proteomics, and metabolomics; that is, the study of collections of genes, proteins, and metabolic pathways
- Epidemiology, food science, and clinical trials
- Advances in laboratory methods and computing technologies

THE “OMICS”

The Human Genome Project—the mapping of the human genome—was a massive scientific undertaking and one of the seminal achievements of science at the millennium. The project was expected to take 15 years and cost \$3 billion (FY 1991 dollars) to complete; in the end, it finished about two years ahead of schedule and under budget (\$2.7 billion [FY 1991 dollars]).

This historic effort left a rich legacy, laying the groundwork for biomedical discovery in the 21st century. The Human Genome Project produced analytic tools for assessing the genome, and holistic ways of looking at genes and their functions. It also suggested



2. Advances in Nutrition Science

DEFINITIONS

chromosome: the self-replicating genetic structures of cells containing the cellular DNA that bears in its nucleotide sequence the linear array of genes

DNA: the molecule that encodes genetic information in the nucleus of cells. It plays a primary role in determining the structure, function, and behavior of the cell

genome: the total set of genes carried by a cell

mRNA (messenger RNA): single-stranded RNA molecule that is synthesized from the DNA template, and that in turn specifies the amino acid sequence of one or more proteins

metabolite: any substance produced or used during metabolism (digestion)

metabolome: the set of all metabolites in a human

proteome: proteins expressed by a cell or organ at a particular time and under specific conditions

transcriptome: the full complement of activated genes, mRNAs, or transcripts in a particular tissue at a particular time

a research agenda for the next decade. In the issue of *Nature* that coincided with the completion of the Human Genome Project (April 24, 2003), the National Human Genome Research Institute (NHGRI) laid out a vision for future genomics research. Building on the gains of the Human Genome Project, the NHGRI recommended that researchers work toward: (1) new tools to allow discovery of the hereditary contributions of common diseases, such as diabetes, heart disease, and mental illness; (2) new methods for the early detection of diseases; (3) new technologies that can sequence the entire genome of any person for less than \$1,000; and (4) wider access to tools and technologies of “chemical genomics” to improve the understanding of biological pathways and accelerate drug discovery.

Progress in all four of these areas will have significant implications for nutrigenomics. First, common diseases such as diabetes and coronary artery disease are clearly diet related, and they will be an important focus of genomics researchers in coming years. Genomics research will also increasingly incorporate the study of cancer, since there is expanding evidence for the importance of diet in some forms of cancer. Second, the development of new methods for early detection of disease will lead to increased emphasis on disease prevention, including long-term nutritional interventions. Third, new tools that make it possible to sequence individual genomes at low cost will enable increasing numbers of people to obtain information about their own gene sequences—the first step in creating a marketplace for personalized nutrition. Finally, as scientists develop new tools and technologies to improve our understanding of biological pathways, there will be an explosion of knowledge around targets for potential drugs or nutrients.

Epidemiology, Food Science, and Clinical Trials

Translating advances in the “omics” to actual nutritional treatments for people will depend on understanding patterns of disease and potential nutritional targets from large-population studies, development of nutritional products or interventions, and validation of treatments in clinical trials.

Epidemiologists identify correlations between nutrition, behavior, and health outcomes from analysis of large data sets. They are already setting the stage for nutrigenomics research through population-based studies such as the National Health and Nutrition Examination Survey

(NHANES), which is run by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC). In anticipation of advances in genetic research, the NHANES III program started collecting lymphocytes from survey participants in the 1991–1994 survey period. Specimens from approximately 7,300 participants are currently available to researchers who want to obtain genetic information and correlate genetic data with the nutritional data in the survey. Samples were distributed to researchers whose projects were approved in 2003, and studies are ongoing. This treasure trove of data will drive nutrigenomics correlational studies over the next five years.

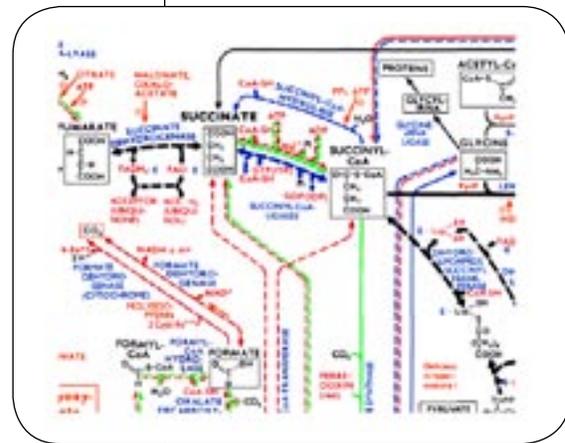
Once food scientists create nutritional products to address the gene–diet correlations uncovered by epidemiological studies such as NHANES, clinical researchers will conduct studies in groups of patients to evaluate the effectiveness of dietary interventions in people with particular disease states. Clinical trials of nutritional interventions may be even more challenging than those for pharmaceuticals in some ways; although the safety of most foods is not an issue, proving efficacy may take very large studies since the effects of nutrients may be more subtle than many drugs, or masked by the inherent complexity of food. However, nutrigenomic approaches may mitigate this problem, just as pharmacogenomic approaches promise to reduce the size and expense of drug trials by more selectively defining the patient populations of interest.

Taken together, these research methodologies drive progress by generating the correlational, experimental, and model-based data needed to guide randomized controlled clinical trials among humans who are distinguished by genotype.

Advances in Laboratory Methods and Information Technologies

Although advances in life sciences may not quite exhibit “Moore’s Law” kinetics, during the 1990s, parallel advancements in automated sequencing, computational power, and algorithm development converged to allow progress to occur at a much faster pace than before. High-throughput techniques now allow for sequencing of hundreds of thousands of DNA fragments in a short period of time, genotyping in facilities that can produce over 7,500 genotypes per day, large-scale identification of proteins using mass

Figure 2–1
Scientists Seek to Navigate
Metabolic Superhighways



Source: Swiss Institute of Bioinformatics, Expert Protein Analysis System (ExPASy).



2. Advances in Nutrition Science

spectrometry, and analysis of expression of thousands of genes at one time using microarrays.

To deal with these vast quantities of biological data, bioinformaticians have developed computational tools to archive, annotate, query, and retrieve the information. Although bioinformatics began with the actual sequencing of the genes, it now not only generates sequence data, but also uses pattern recognition and data-mining tools to uncover relationships among large data sets, and uses simulation and modeling tools to explain the complex interactions of genomes, nutrition, and health at both the cellular and systems levels. Computational methods now enable us to predict gene function, identify regulatory regions in the genome that govern gene expression, and analyze statistically the massive volumes of data that result from genomics studies. Increasingly sophisticated techniques help us to understand the effects of genetics and diet on health that are essential for identifying targets for clinical trials.

Another key advance is more distributed access to data. The advent of the World Wide Web changed the way that biologists search for scientific information and post their research results. Databases, such as GenBank, LocusLink, Human Gene Mutation Database, SwissProt, and Protein Databank provide a wealth of publicly accessible data, and continue to grow. Shared databases containing large quantities of microarray gene-expression data are emerging as well. Similarly, text-based resources such as PubMed, Online Mendelian Inheritance in Man, and online biomedical journals are readily available via the Internet, and boost the speed with which knowledge can be shared among scientists.

Not long ago, each of these databases had to be searched through a separate interface. Now, however, there are Web sites that provide a single entry point to many of them. These databases are available to scientists across disciplines and around the globe, and are enabling nutrigenomics scientists to benefit from work done by scientists in other subfields of genomics.

FORECAST: THE POWER AND SPECIFICITY OF THE SCIENTIFIC TOOLKIT WILL INCREASE

The road to identifying nutrition-related gene function and regulation will be paved by advances that result from studies conducted in wet-bench laboratories, those done in human populations, and those that employ computational methods and modeling. This wave of advances will in turn accelerate further advances, and ultimately the premarket approval of test kits or health claims for new food products or supplements.

Epidemiologic Studies Will Yield Correlational Data on Nutrigenomics

As mentioned above for NHANES, population studies will increasingly include both genetic and dietary information that will provide us with insight into their interactions. Given that samples of genetic material collected through the NHANES III were distributed to researchers in 2003, we anticipate that studies will begin to yield results on the correlation of specific genes with diet and illness by 2010. Another study of diet, genotype, and health outcomes is the Health ABC (Dynamics of Health, Aging, and Body Composition) conducted by the National Institute on Aging of the National Institutes of Health. The goal of this program is to identify the clinical conditions caused by the changing body composition of older people and their impacts on health, and we should likewise expect market-relevant insights in the next decade.

Computational Approaches Will Sharpen Focus and Speed Hypothesis Testing

In the next decade, we will see new assays that push the boundaries on sensitivity and specificity. We will see microarrays that can recognize hundreds of thousands of single nucleotide polymorphisms on a single gene chip—and those that are highly targeted to optimize statistical analysis of a particular locus. However, the new challenge will be to elucidate the details of metabolic pathways and gene-expression regulatory processes, and to figure out how all the pieces contribute to the interlinked processes throughout the human body. This will require continued increases in computer-processing power, data-storage capacity, and network capacity. Advanced data-visualization techniques and pattern-discovery algorithms running on highly parallel or grid computers will step up the pace of discovery.



2. Advances in Nutrition Science

Clinical Trials Will Be the Gold Standard, but Will Not Answer Every Question

Large-scale clinical trials are the gold standard of clinical research, but due to time and cost constraints, we will never be able to conduct clinical trials to answer all the questions we have about gene–diet interactions and prove that certain diets and foods improve health outcomes in the setting of specific genotypes. However, certain disease areas will be more likely to attract the attention of clinical researchers: chronic diseases such as diabetes, hypertension, coronary heart disease, asthma, osteoporosis, and cancer. Diet-related clinical studies are beginning to appear in the mainstream medical literature and will become more prevalent and sophisticated during the next ten years.



In the absence of clinical trials to answer research questions definitively and to provide clear data on “doses” of nutrients that should be taken in a given diet, a combination of evidence from epidemiologic studies, small clinical studies, and accepted scientific theories will provide sufficient data to influence nutritional recommendations, though this is certainly one of the ethical questions considered in the second NCNG report: When is scientific information ready to be acted on?

BARRIERS TO ADVANCES IN NUTRITION SCIENCE

Despite great hope and opportunity, challenges to progress in moving from the lab to the dining room remain. Barriers to understanding gene–diet interactions and progress in nutrigenomics research include:

- The complexity of nutrigenomic science
- The limitation of animal studies in understanding gene–diet–disease interactions in humans
- The difficulty of implementing human studies
- Decline in the growth of funding for genomics research
- Intellectual property issues
- Complexity of nutrigenomic science

Nutrigenomic science is complex in and of itself. Scientific advances rely on the ability to replicate findings. Yet the results of studies that assess the association of genes with disease as well as those that evaluate microarrays are often difficult to reproduce.

Association studies may show that a gene is associated with a disease, but this doesn't necessarily demonstrate causality because that population may share a particular gene for another unrelated reason. When the association study is done in a different population, the association does not hold up. In microarray studies, the results are highly dependent on assay conditions, and may give different results when run in different laboratories, despite efforts to control conditions in a standard way. Also, different statistical techniques that purport to do the same thing—such as cluster genes that are expressed similarly—may generate different clusters. Finally, nutritional studies do not always give consistent results because a substance being investigated is generally not pure—it is part of a food that contains many ingredients, and part of a diet that contains many foods.

Limitation of Animal Studies

While animal studies will offer essential insights into the dynamics of nutrigenomics, they can provide only an approximation of human responses to dietary variations. Conclusions drawn from mouse and other animal studies will generate useful hypotheses and analytic approaches, but must be followed by well-designed human studies if diagnostic tests and interventions are to be accepted by the government and medical establishment and find their way to consumers. This is due not only to interspecies differences in biochemistry, but also to the prominent, perhaps even dominant, roles that volition and behavior play in human nutrition.

Difficulty in Implementing Human Studies

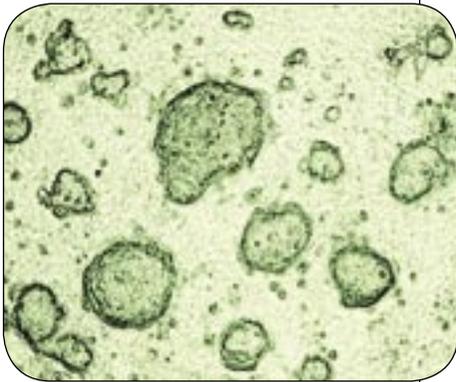
Human studies pose scientific and practical impediments to the advancement of our understanding of gene–nutrient–disease interactions. First of all, the outcome of diet-related disease takes a long time to manifest and so does the outcome of diet-related treatments. We know that the impact of dietary habits may not be seen for many years. Longitudinal studies must have a very long time horizon, or they risk stopping short of the hypothesized outcome. Second, many diet-related health outcomes are multifactorial, and it can be quite difficult to control for physical activity, mood, or other experimental confounders in such studies. In addition, the effects of a particular dietary intervention may be difficult to detect or may be insignificant due to finely tuned, highly evolved homeostatic mechanisms of the human body. Lastly, as those who have tried to change their own diets know, nutritional studies in humans are difficult to conduct because



2. Advances in Nutrition Science

controlling diet in large populations for periods of time sufficient to see an effect is challenging. All of these factors combine to make human research costly, time consuming, and not entirely conclusive.

Human trials are also rife with ethical considerations that must be addressed. The U.S. federal government is well aware of this and sets aside 3–5% of its total genomics research budget, which totaled \$437 million in 2003, for the study of ethical, legal, and social issues. What does a genetic testing company do if it uncovers a predisposition to disease that, if known, would make it impossible for an individual to get insurance coverage? How does the company both allow individuals to benefit from knowledge of potential interventions to prevent or treat disease and protect their privacy? Methods for rigorously protecting human research participants are still being perfected.



Funding for Genomics Research

After years of double-digit increases in public funding for genomics research under the auspices of the Human Genome Project, federal spending grew by less than 1% in 2003. While this reflects the completion of the genome project, it is also consistent with the slowed growth in NIH funding in general that has attended the rising deficits in the U.S. budget and the slowing economy.

The Human Genome Project was a Herculean effort that required heavy up-front investment; however, there is every reason to believe that additional and sizeable investments will be required of the public and private sectors to delve deeper into the complex, multi-gene interactions that produce and prevent illness. Slowed investment will moderate the pace of scientific discovery in the next 3–5 years even if the economy recovers. Given substantial state budget deficits and staggering projected shortfalls in federal programs such as Medicare and Social Security, the future of funding for nutrigenomic research is far from ensured.

Intellectual Property Issues

The question here is, to what extent should discoveries in genomics in general and nutrigenomics in particular be subject to patent? As we discussed in our second report, some biotech and pharmaceutical firms are seeking to patent research procedures, sequencing information, and even genes themselves. The laws are even fuzzier for nutrigenomics, since most nutrients are found in naturally occurring foods,

which by law cannot be patented, though testing procedures and special supplements can be.

There are two big issues.

The first is that intellectual property protections can sometimes limit the purview of other researchers. Trying to patent their intellectual property is natural for businesses, of course, since the goal of most businesses is to make money, and protecting intellectual property is a good way to get a jump on the marketplace. But if companies restrict access to certain procedures and substances, they may slow progress in the field in general.

The second issue is that the way intellectual property is currently structured, targeted, patentable drugs offer bigger payoffs to the companies (mostly pharmaceuticals) that have the resources to do the really big science. This may ultimately keep these important scientific resources from studying nutrigenomics in an expansive way, since the results of the research will be more difficult to patent and in the end may not be as lucrative as the more targeted drugs. This, too, may slow the development of nutrigenomics and thus the markets that could arise from it.

FROM THE LAB TO PERSONALIZED NUTRITION

Advancing the science of nutrigenomics is the first step toward moving nutrigenomics from the lab to the dining room and achieving personalized nutrition recommendations for consumers. How will the recommendations for personal nutrition based on the science of nutrigenomics be implemented in the marketplace? We discuss this in the next chapter.



3 Personalization of Nutritional Recommendations

Advances in nutrition standards arise from both scientific evidence and socioeconomic influences. In the next decade, nutrigenomics will add to the scientific knowledge aimed at improving health, but in the United States, it will play out within a complex social, economic, regulatory, and health care environment. The fruits of nutrigenomic research will come in the form of recommendations for personalized nutrition.

DRIVERS OF PERSONALIZED NUTRITION RECOMMENDATIONS

The dynamics of illness and health management will drive the development of personalized nutrition recommendations in the next 5–10 years as new knowledge of the genome and nutrition is applied to major chronic health problems by both the public and private sectors. Three drivers will play significant roles:

- The epidemic of overweight and obese people in the United States
- The evolution of government-based nutritional guidance from “one size fits all” to “one size fits most”
- The system for disseminating clinical guidelines

The Epidemic of Overweight and Obese People in the United States

Although the general public has been interested in diets and weight-loss strategies for years, the growing epidemic of obesity and diabetes is forcing greater attention by providers, payers, and employers on the health impact of dietary choices. As of 2000, 64% of American adults and 15% of children ages 6–19 were estimated to be overweight or obese (see Table 3–1).

According to the CDC, poor diet and physical inactivity account for one in six deaths, behind only tobacco. Obesity also exacts a high economic cost, on the order of \$75 billion per year, or about

\$175 paid by every person in the United States. Furthermore, obesity-related illnesses such as cancer, diabetes, heart disease, and stroke together account for nearly two out of three deaths in the United States, and cost \$690 billion dollars in direct and indirect costs per year.

These huge direct and downstream costs in disease burden and lost productivity is particularly worrisome given the long-term economic uncertainties of Medicare, Social Security, and other safety nets. As a result, obesity is increasingly viewed as a high-priority public health problem, and the government and other stakeholders are under growing pressure to find solutions and create incentives for the public to adopt better behaviors concerning diet and exercise.

Evolution of Government Nutritional Guidance to “One Size Fits Most”

The nature of nutritional recommendations in the United States has evolved over the years. They have moved from the goal of preventing deficiencies to the goal of avoiding excess.

After the United States emerged from the Great Depression and World War II in 1946, the United States Department of Agriculture (USDA) developed minimum daily requirements (MDR) to advise people on what they needed to eat to stay relatively healthy. As food became more plentiful, the USDA shifted its focus to recommended daily allowance (RDA) in 1976, and later to the daily reference intake (DRI) in 1996. With awareness of diet-related diseases, the USDA emphasized avoiding excesses

and ensuring that people get specific ingredients that may have protective value. As nutritional studies have become more prevalent in the medical literature, more specific information about diet has become available for people with particular clinical conditions.

Every five years since 1980, the Department of Health and Human Services (HHS) and the USDA have jointly published a document entitled *Nutrition and Your Health: Dietary Guidelines for Americans*. All federal food and nutrition programs follow the advice in these guidelines.

The first version of the Dietary Guidelines in 1980 was 11 pages long; by 1995, the document had expanded to 48 pages and included the well-known Food Pyramid. The latest edition was released in January 2005, and reflects the growing understanding of the affects of diet on health.

In 1980, *The Dietary Guidelines for Americans* was deliberately geared toward healthy Americans, and people with special needs were not considered. By 2004, however, there was an explicit effort to include individuals on the Dietary Guidelines Advisory Committee who could represent minorities, women, and persons with disabilities. This process of formulating dietary guidelines acknowledged that the HHS and USDA serve diverse groups, and that the needs of these groups are not necessarily all the same.



Table 3-1
Majority of Americans Are Overweight
(Age-adjusted* prevalence [percent] of overweight and obesity among U.S. adults, age 20–74 years)

	NHANES II (1976–80) (n=11,207)	NHANES III (1988–94) (n=14,468)	NHANES (1999–2000) (n=3,601)
Overweight or obese (BMI > 25.0)	47	56	64
Obese (BMI >30.0)	15	23	31

*Age-adjusted by the direct method to the year 2000 U.S. Census Bureau estimates using the age groups 20–39, 40–59, and 60–74 years.

Source: National Health and Nutrition Examination Survey (NHANES), National Center for Health Statistics.



3. Personalization of Nutritional Recommendations

With each revision, new scientific evidence is incorporated, and the public is given an opportunity to give comments to the advisory committee. Academic and scientific groups play important roles, but industrial groups are also extremely influential. Controversy reigns as different interest groups push, promote, and lobby their views. For example, in 2004, organizations such as the National Dairy Council, the Grocery Manufacturers of America, the National Restaurant Association, the International Fresh-Cut Produce Association, and the Salt Institute submitted their arguments to the advisory committee, as did organizations such as the Society for Nutrition Education, the American Institute for Cancer Research, the American Society for Clinical Nutrition, and the American Dietetic Association. Increased stakeholder participation means that, although dietary guidelines grow more complex with each scientific advance, they often lack hard and fast prohibitions against the foods produced by key stakeholders.

Nonetheless, the 2004 and 2005 guidelines include several recommendations for specific groups of people: women of childbearing age, people over age 50, and elderly people with dark skin and those exposed to insufficient UVB radiation. Gender distinctions are made in certain cases, such as in defining moderate alcohol intake as one drink per day for women and two drinks per day for men. Occasionally, people from particular disease, racial, or age groups are acknowledged as having special needs, as in a statement that hypertensive individuals, African Americans, and middle- and older-aged adults will benefit from reducing their salt intake below the usual recommended amount of 2,300 mg of sodium per day. In this way, the seeds have been planted for the Dietary Guidelines to recognize different subgroups of people, not only because nutrition science allows greater specificity, but also because our political philosophy is to represent different people's interests equitably.

Despite the inclusion of group-specific guidance, the bulk of the recommendations are still written as universal recommendations, without recognizing people with particular conditions. For example, the USDA Food Guide Pyramid suggests 2–3 servings from the milk group daily; yet, a person with lactose intolerance may be unwilling to follow this advice. Thus, U.S. dietary guidelines have moved from “one size fits *all*” to “one size fits *most*.”

While science and political philosophy drive the U.S. government toward greater specificity in its dietary guidelines, the need to provide

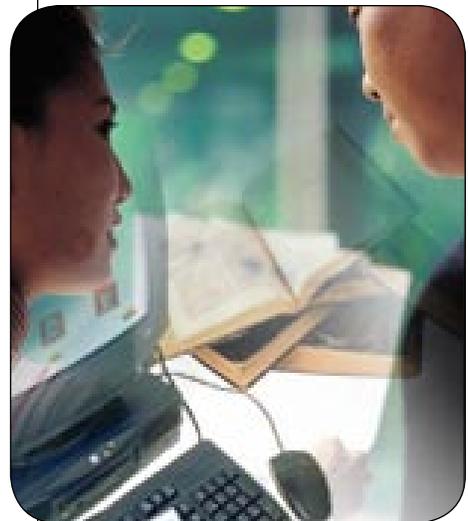
direction for the vast majority of healthy Americans means that clinicians and individuals have more choices and more complex tools for constructing healthy diets. As the science of nutrigenomics advances, they will have even more tools to use and more choices to make. Because group-specific dietary guidelines have an official place in the information chain that informs clinical practice, the structure is in place to move closer to recommendations for personalized nutrition.

The System for Disseminating Clinical Guidelines Is Primed for Nutrigenomics

Although initially criticized for being part of a trend toward “cook-book medicine,” clinical practice guidelines developed by reputable organizations have gained acceptance among physicians since the early 1990s. There are several reasons for this: practitioners increasingly realize they cannot stay abreast of the knowledge explosion in medicine, they’ve gradually become educated about the value of meta-analyses and aggregated evidence over personal experience, and, since the expansion of the managed care industry in the 1990s, there has been growing pressure to standardize care and to measure and report clinical quality.

Clinical guidelines used by medical professionals are typically disease specific, and thus, personalization of nutritional advice is generally based on the treatment of disease. For example, the American Academy of Family Physicians, American Dietetic Association, and Nutrition Screening Initiative have produced nutritional guidelines that are specific for people with cancer, chronic obstructive pulmonary disease, congestive heart failure, coronary heart disease, dementia, diabetes mellitus, hypertension, and osteoporosis; the National Kidney Foundation provides nutrition guidelines for people with chronic renal failure; and the National Cholesterol Education Program specifies nutritional recommendations for individuals with hypercholesterolemia and heart disease.

Because of the disease-specific nature of most guidelines, only a fraction of clinical practice guidelines currently relate to nutrition per se. However, the infrastructure already devoted to the dissemination of guidelines will facilitate distribution of nutrigenomics guidelines as support data become available. As science links nutrition to disease prevention and management, and the government includes nutrigenomics-based recommendations in its guidelines, these recommenda-





3. Personalization of Nutritional Recommendations



tions will find their way into the pipeline of the clinical guidelines for diet-linked conditions that medical professional organizations generate. Since physicians still play a large role in many patients' health beliefs and practices, and since they are most likely to adopt and recommend practices that are advocated by their own specialty organizations, the movement of nutrigenomics into clinical guidelines will be an important enabler of gene-linked dietary recommendations for both clinicians and their patients.

Indeed, Nancy Fogg-Johnson thinks it likely that the first wave of nutrigenomic foods will consist of “medical foods” prescribed by doctors. According to the Senior Health Web site, a medical food is prescribed by a physician when a patient needs special nutrients in order to manage a disease or health condition. The label must clearly state that the product is intended to be used to manage a specific medical disorder or condition. An example is a food used by persons with phenylketonuria, that is, foods free of the amino acid phenylalanine.

Once established, nutrigenomic guidelines will be increasingly accessible to providers and patients alike. Clinical guidelines are maintained online (e.g., National Guidelines Clearing House at <http://www.guideline.gov>), and are only a few clicks away when an urgent need for information arises.

FORECAST: PERSONALIZED NUTRITION RECOMMENDATIONS WILL ENTER MEDICINE

As the science of nutrigenomics advances, scientists will be able to make more particular recommendations about nutrition to individuals based on their genetic profile. Clinical guidelines will include more information about such recommendations, government nutritional guidelines will become more disease specific, and as evidence of the relationship between genes, diet, and the prevention of disease grows more solid, payers will encourage doctors to include personalized nutrition recommendations in their practices.

Clinical Guidelines Will Include More Nutritional Information

Because nutrition has historically been viewed as ancillary to “real medicine,” physicians have generally been undereducated and underinterested in how diet can affect health. Their lack of interest has probably been reinforced by the “noise” generated by the poor qual-

ity of evidence cited in most lay-press accounts of easy solutions to weight loss, magic bullets to prevent dreaded diseases, and research results that fly in the face of long-accepted beliefs.

However, advances in nutritional science will yield results that increasingly convince the medical profession that specific dietary interventions can improve clinical outcomes. Nutritional recommendations developed by respected authorities already exist for people with diabetes, high cholesterol, hypertension, lactose intolerance, celiac sprue, pregnancy, and other conditions. More specific understanding of metabolic pathways and pathophysiologic mechanisms will extend the range and detail of further guidelines in terms of target populations, specific nutrients, and risk–benefit estimates. Nutritional recommendations will be more clearly targeted toward disease prevention or delay of chronic diseases and, as we accumulate data from long-term studies, nutritional interventions will become increasingly important as ways to manage both health and disease.

Unlike the U.S. government’s dietary guidelines, there is no specific timeline for release of clinical practice guidelines by professional health care organizations; they are governed largely by the pace of discovery and sociopolitical drivers. A small clinical study with a short-term outcome could take less than a year, but large studies with long-term outcomes can take many years. Production of guidelines by expert consensus could take months or several years, depending on scope and degree of controversy.

Government-Based Nutritional Guidelines Will Become More Disease Specific

Dietary Guidelines for Americans will continue to be updated every five years in compliance with Public Law 101-445 passed by Congress in 1990, which formally directs HHS and USDA to collaborate and issue the guidelines on that schedule.

With growing interest in chronic disease, and pressure to bring in new data from research studies, the government-based guidelines will include more disease-specific information, both for disease prevention and for slowing disease progression. The 2004 Advisory Committee recommends that future research include clinical trials to determine effects of diet on body mass index, lipid metabolism, cardiovascular disease, type 2 diabetes, cancer, and osteoporosis; to compare calcium salts to calcium in milk on bone health, insulin resistance, blood pres-



3. Personalization of Nutritional Recommendations

sure, and weight management; and to conduct trials that assess the effects of salt intake on clinical outcomes other than blood pressure. Over the next ten years, research will address many of the unanswered questions that puzzle us today. The results from a subset of these studies will be included in upcoming recommendations.

However, there is a tradeoff between keeping guidelines simple and easy to communicate to the public and expanding the guidelines to include the latest research. Research in the next ten years will allow us to stratify the population into subgroups that are at greater or lesser risk for particular diseases. It will be possible to predict risk based on genetic testing and tests for biomarkers and to make nutritional recommendations accordingly. Yet, the complexity of such information will make it impossible to include the details in national dietary guidelines for widespread dissemination among the lay public. Simplicity will win for the national dietary guidelines, but more detailed recommendations will be available to the public through other channels, such as mainstream health care providers, alternative-medicine providers, health plans, commercial weight-management services such as Weight Watchers, and industries promoting personalized nutrition products. The key, here, as we discussed in our first report, is to get the information to the consumers in the way they best understand it.

Payer Support for Personalized Nutrition Will Grow

As personalized nutrition recommendations are validated by science and adopted by key government and professional organizations, federal policy makers and funding agencies will be willing to address the relationships between nutrition and chronic disease prevention more directly. As the financial burden of diet-related disease breaks the health care budget, traditional payers, including insurance companies, large employers, and the government, will encourage personalized nutrition products and services that deliver evidence-based, cost-effective ways of reducing the burden of disease. Early indicators of this trend include the recent decisions by Blue Cross Blue Shield of North Carolina and Medicare to consider reimbursement for both medical and surgical treatments for obesity.

BARRIERS TO DEVELOPMENT OF PERSONALIZED NUTRITION RECOMMENDATIONS

Although in general we can expect recommendations for personalized nutrition to become a more prominent way of keeping people healthy, it's important to note several potential barriers.

- The public will continue to be confused
- The health care establishment is and will continue to be slow to change practice standards
- Greater genetic specificity raises the specter of moral dilemmas

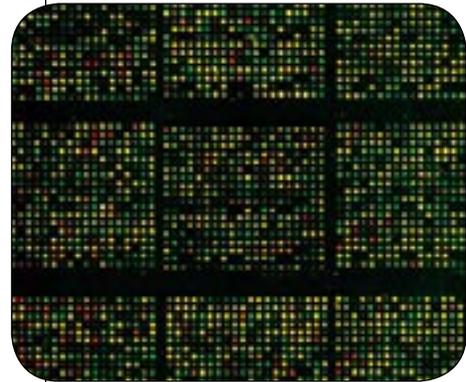
The Public Will Continue to Be Confused

The public generally believes that nutritional advice is constantly changing, contradictory, and confusing. One day eggs are good for you, the next they're bad for you, and the day after that they're good for you again. The same goes for nuts or bread or red meat.

Much of this confusion stems from efforts by the food and supplement industries to promote new products and to defend their current markets. The danger is that, as people have greater awareness and access to guidelines promoted by the government, by health care providers, and by health plans, they will continue to be significantly influenced by advertising and "infomercials." Nutrigenomics will not lessen this confusion; indeed, this confusion may stymie the acceptance of science-based, nutrigenomics-driven personalized nutrition. Thus, it will be essential for those who want to promote consumer acceptance of nutrigenomics to reduce this confusion by offering very simple messages through a variety of consumer channels.

The Health Care Establishment Is Slow to Change

In nutrigenomics, much will turn on how long it will take specific nutrigenomics-driven recommendations to be sanctioned by professional organizations. To come up with specific recommendations for specific groups of people, studies must be done in a range of subpopulations: men and women, young and old, healthy and ill, and those of different genotypes. Without these studies, recommendations will not follow. And even when successful studies are completed, clinical practice can still be slow to change. Organizations led by members of the medical profession tend to be conservative. Delays in professional acceptance of new guidelines will slow the progress of personalized nutritional recommendations based on the findings of nutrigenomics.





3. Personalization of Nutritional Recommendations

Genetic Specificity Will Raise Moral Dilemmas

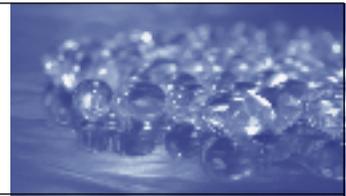
Because certain genetic patterns cluster in specific ethnic or racial groups, there are likely to be differences in response to diet that are correlated with ethnic or racial identity. We already know that, in the United States, diet-related conditions like diabetes disproportionately affect African Americans, Latinos, and Native Americans—groups that have historically been socially and economically disadvantaged. Nutrigenomics studies may be just the tool to help us understand the disproportionate burden of disease. However, race and ethnicity are sensitive topics, and the studies may never be done because of moral concerns and fears of discrimination. Federal policy makers may be reluctant to make recommendations based on personal characteristics that are directly or indirectly targeted to particular racial and ethnic groups.

TRANSLATING NUTRIGENOMICS SCIENCE TO THE GLOBAL MARKETPLACE

Nutrigenomic science will, of course, emanate from leading scientific institutions the world over and have a worldwide affect. While in this chapter we have considered the influence of nutrigenomic science on personalized nutrition in the unique cultural, medical, and regulatory environment of the United States, its influence will be felt and responded to differently across the globe as many societies attempt to address the rising incidence of diet-related disease.

The dynamic interplay of drivers and barriers is likely to affect the pace at which nutrition science advances to the point where recommendations for personalized nutrition can be made. But once that happens, there is yet another hurdle to jump: translating the recommendations for personalized nutrition based on nutrigenomic science into viable products for the marketplace. As Indra Mehrotra writes in his article, “A Perspective on Developing and Marketing Food Products to Meet Individual Needs of Population Segments” (*Comprehensive Reviews in Food Science and Food Safety*, Vol. 3, 2004), we’re still in the discovery phase of the science of nutrigenomics. The next step is orders of magnitude more complex, involving stakeholders all along the health and food chain: scientists and genetics labs, health care providers and payers, food product manufacturers, and grocery stores. What are the products going to be? Who is going to get them to marketplace?

Getting the Products to Market **4**



Two types of products are critical to building the nutrigenomics market: diagnostic tests and nutritional products. While diagnostic tests work to assess the predisposition to and presence of disease, nutritional products, including food, supplements, and nutraceuticals, are designed to prevent, treat, or slow the progression of disease. Together, diagnostic tests and nutritional products make it possible to bring nutrigenomics to consumers.

Currently, however, the marketplace for nutrigenomics is more science than food. Most players in the industry are working on the basic science, which translates in the marketplace into diagnostic tests. For nutrigenomics to truly make an impact in the marketplace, the science must be translated into real nutritional products that can be used to fulfill the recommendations for personalized nutrition discussed in the previous chapter.

In this chapter, we identify what drives the development of diagnostic tests and nutritional products, take a look at where they are now, forecast their evolution over the next 15 years, and explore the barriers that stand in the way of their diffusion.

DIAGNOSTIC TESTS ASSESS RISKS AND PROMISE EARLIER INTERVENTION

A number of diagnostic tests from companies such as Sciona and Genelex, can supply the individual physiological data needed to personalize nutritional recommendations. Tests of both genes and biomarkers promise greater specificity that could prove instrumental in preventing and managing disease with nutrients.

Diagnostic Tests Screen for and Monitor Disease

Genetic tests come in a variety of forms. Tests that analyze the sequence of DNA in genes can determine whether there is a substitution, deletion, insertion, or a segment of DNA that is repeated too many times. If a gene variant is significant and causes disease, it is often called a mutation, but many gene variants either

have no significance, or may simply be variations in the population that result in differences in non-disease-related personal characteristics. Many tests analyze one gene at a time (e.g., by polymerase chain reaction [PCR]), but other tests analyze a whole set of genes (e.g., by microarrays).

When a gene is expressed, it is transcribed into RNA, and certain tests measure RNA instead of DNA. Other tests measure the output of the next step in gene expression, when RNA is translated into proteins; the levels of specific proteins in various tissues or body fluids can be a valuable marker for disease states. Still other tests measure the breakdown products of these proteins. Finally, certain genetic tests assess entire chromosomes, such as in Down syndrome, where there are three copies of chromosome 21 instead of the usual two. Thus, genetic tests may measure the genome, the transcriptome, the proteome, the metabolome, or the chromosomes.

Whatever the type of test, questions of sensitivity, specificity, predictive value, and cost-effectiveness arise. False positives can bring on unnecessary anxiety, medical risks, and costs, while false negatives can delay needed treatment. Low predictive value due to unfavorable underlying population characteristics and low cost-effectiveness raise questions of opportunity costs and alternative deployment of scarce resources. In other words, if the test doesn't work well, nobody's going to want to pay for it.



4. Getting the Products to Market

Nutrigenomic Diagnostic Tests Target Pathways for Nutritional Intervention

If a nutritional recommendation is appropriate for people with a particular genotype or genetic profile, then it may be useful to perform a genetic test to determine whether or not a person belongs to that group. If a biomarker or other diagnostic test is suitable for monitoring progress, then that test can be done initially at baseline, and repeated at intervals after the nutritional recommendation is followed.

Consider the example of the MTHFR gene, which is associated with elevated levels of homocysteine in the blood. Elevated levels of homocysteine have been shown to be an independent risk factor for heart attack. There are multiple reasons why a person might have elevated levels of homocysteine, including vitamin B12 deficiency, folate deficiency, vitamin B6 deficiency, kidney failure, alcoholism, and hypothyroidism, but the reason that has captured the attention of the nutrigenomics community is a polymorphism in the 5,10-methyltetrahydrofolate reductase gene (MTHFR). At position 277 in the gene, most people have a C (cytosine), whereas other people have a T (thymine). This variant allele (referred to as C277T) is fairly common in the population. A subset of people has two copies of the variant, and those that have two copies have mildly elevated levels of homocysteine. (People have two copies of each gene because one copy comes from each parent.)

A person who is homozygous for this polymorphism is likely to have mildly elevated levels of homocysteine, and therefore has a risk factor for heart disease. From a meta-analysis of 12 trials, we know that treatment with folate and vitamin B12 will lower homocysteine levels. In fact, we even have information on dose response. However, what we do not know is what we are most interested in: Does treatment with folate and vitamin B12 reduce the risk of heart disease and stroke? Clinical trials are underway, but will not be completed until late 2005 or 2006.

If treatment with folate and vitamin B12 does prove to be an effective preventive measure in people with this polymorphism, then the genetic test could be used initially to identify people at risk, and the biomarker test for homocysteine could be used subsequently to monitor how well the nutritional intervention is going.

At present, the American Heart Association advises against general screening for hyperhomocysteinemia, and the U.S. Preventive Services Task Force states that there is insufficient evidence to recommend vitamin supplements to prevent cardiovascular disease. However, even without definitive evidence, physicians might order tests for homocysteine levels in high-risk patients and offer folate and vitamin B12 therapy, because such treatment is unlikely to cause harm. Testing for MTHFR for cardiovascular purposes is currently extremely uncommon in the medical setting, but the test is available to consumers on direct-to-consumer services, such as Sciona.

DRIVERS THAT WILL BRING DIAGNOSTIC TESTS AND NUTRITIONAL PRODUCTS TO MARKET

The diffusion of diagnostic tests for nutrigenomics interventions and the development of products and services to respond to nutrigenomic data will be driven by:

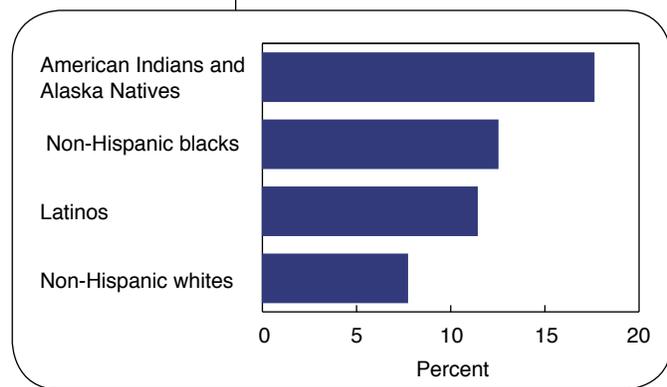
- Rising prevalence of diet-related diseases coupled with increasing public awareness of their toll
- Technological advances that make nutrigenomic tests viable

These drivers create both a compelling need to understand gene–diet–disease interactions and the means to do so.

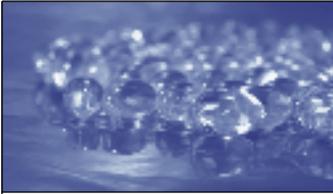
Rise of Diet-Related Disease Drives Nutrigenomic Interventions

One look at headlines in the United States, and you will know that obesity is on the rise. With it has come the increase of other diet-related conditions, type 2 diabetes chief among them. This is a disease that is long term, subject to numerous complications, and time-consuming to manage. Its prevalence increased 76% among people aged 30 and above between 1990 and 1998. The American Diabetes Association states that 6.3% of the U.S. population has diabetes. Just over 8% of adults 20 and older have diabetes and 18% of people over 60 do. Prevalence and incidence vary by racial and/or ethnic group, with diabetes on the rise among American Indian and Alaska Natives, Latinos, and African Americans, who are significantly more likely than non-Latino white counterparts to have been diagnosed with diabetes (see Figure 4–1).

Figure 4–1
Diabetes Prevalence Suggests Gene–Diet–Disease Interaction
(Percent of population age 20 and older with diabetes by race/ethnicity, United States 2002)



Source: 1999–2001 National Health Interview Survey and 1999–2000 National Health and Nutrition Examination Survey estimates projected to the year 2002.



4. Getting the Products to Market

Patients with diet-related diseases such as diabetes bear the direct burden of these diseases, and they will likely bear more of the economic burden in the next decades as payers, employers, and federal programs such as Medicare shift cost and risk to consumers. Providers are on the front line of the diabetes epidemic, and employers and payers are waking up to the consequent workplace and economic impacts. For example, according to the American Diabetes Association, on average people with diabetes between age 18 and 64 lose 8.3 days of work a year compared to 1.7 days for people without.

The correlation of diet-related disease with race and ethnicity coupled with the increasing incidence of diabetes—the risk of which is both hereditary and behavioral—makes the understanding of gene–diet–disease interactions critical. Failure to do so is costly in both money and human suffering. The American Diabetes Association estimated that direct and indirect costs of diabetes totaled \$132 billion in 2002. The burden of diet-related disease, especially when it appears to be influenced by genetic susceptibility, will drive researchers to understand how specific groups of people respond to different foods and to develop nutritional recommendations to inhibit susceptibility.

Technological Advances Make Nutrigenomic Tests Viable

Advances in PCR methodologies and microarray techniques and the application of these methods to newly discovered genes and clinical applications are pushing growth in the market for genetic tests. The majority of genetic tests currently performed in the clinical environment are prenatal tests that screen for abnormalities in the fetus, but physicians are using an increasing number of genetic tests to help determine appropriate treatment for diseases of patients seen in their offices. Although microarrays are currently used almost exclusively in scientific research, they hold promise for clinical purposes as well. In 2003, Affymetrix—a leading company in microarray technology—began a partnership with Roche Pharmaceuticals to develop the first microarray chip to be marketed for clinical diagnostic purposes: a pharmacogenomics microarray chip that will allow physicians to adjust medications in patients.

As the *in vitro* diagnostic market for genetic testing matures and clinicians gain experience with genetic testing, the idea of testing for genes that are significant for nutrigenomics will no longer seem futuristic. There is increasing demand for diagnostic tests, including

genetic tests, and a highly capable diagnostics industry is rising to the challenge. In the United States, the in vitro diagnostics industry was valued at approximately \$11.9 billion in 2003, and the market is expected to grow at 6% per year through 2007 (see Figure 4–2). The growth of diagnostics overall and genetic testing in general will facilitate the growth of nutrigenomic testing in particular.

FORECAST: DEVELOPMENT AND USE OF NUTRIGENOMICS TESTING WILL EXPAND

By 2015, nutrigenomics testing and personalized nutrition will occur in a world in which genotyping to assess risk for certain chronic diseases will be common, and the link between some of those diseases and diet will be known. Although evidence linking genotype to specific nutrients may still be in its early stages, the medical community will have recognized the clear potential of nutrigenomics, and many consumers, particularly if they're bearing more cost and risk for their own health, will be willing to undergo genetic testing in order to modify their diets, as long as those choices are perceived as cost-effective and not harmful.

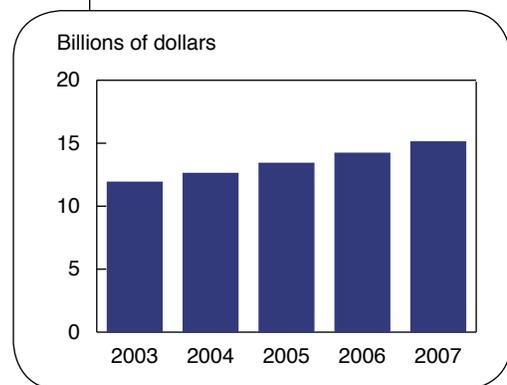
Application of Diagnostic Tests for Nutrigenomics Will Grow

Advances in technology will improve our ability to diagnose disease, to identify risk factors for disease, to predict the efficacy and toxicity of therapies, and to monitor disease and health status. Growth in the diagnostics industry, overall, will spur growth for genetic tests and other diagnostic tests important for nutrigenomics, and direct-to-consumer marketing of diagnostic tests will be common.

Regulators and the medical establishment will push test producers to offer trustworthy information and counseling to consumers along with the tests themselves.

An example of a nutrigenomics test panel that is currently available via direct-to-consumer marketing comprises 18 genetic tests. A consumer can currently obtain his or her genotype for each of these genetic tests, although actual clinical studies that demonstrate reduced risk for disease or better health outcomes for particular diets associated with these genotypes are mostly lacking. By 2015, the evidence for or against improved outcomes for dietary interventions based on these genotypes will be much further along, and there will be an expanded number of genes on test lists such as these.

Figure 4–2
Growth of In-Vitro Diagnostics Will Meet Growing Demand
(Billions of dollars)



Source: Freedonia Group, 2003.



4. Getting the Products to Market

Demand for Nutrigenomics-Based Interventions Will Grow

With substantial current and looming state and federal program deficits and health costs likely to overtake profits at many companies, employers and insurers will continue to embrace interventions that can be shown to reduce the cost of medical care. For diagnostic tests, success will turn on whether they provide information of greater value than tests currently available (e.g., family history), whether the information they yield is likely to dictate interventions that would not have been attempted using existing diagnostics, and whether the resulting interventions have proven efficacy.

Given these conditions, consumer awareness and demand for such tests and interventions will also grow, as we discuss in the next chapter.

Nutritional Products Will Be Tools of Nutrigenomic Intervention

Once a robust hypothesis about gene–nutrient interaction and a diagnostic test to assess predisposition to or existence of diet-related disease are available, nutritional products will become an important set of interventions. In fact, both nutritional products, like foods and dietary supplements, and nutritional services, like nutritional plans and counseling, will be used to promote health and to prevent disease based on genetic predisposition.

To be sure, the pharmaceutical industry has long been a primary source of medical treatments, and it will continue to be an engine of innovation. However, several factors favor the increased use of dietary treatment modalities for genetic-based diagnoses. Specifically, the near-term prospects of traditional pharmaceutical companies is somewhat clouded by the imminent expiration of a significant number of drug patents, the transition to business models in which biotech firms serve as an important discovery funnel is uncertain, post-market surveillance for unexpected adverse effects (e.g., Vioxx) is increasing, and FDA approvals in the future may require a demonstration of cost-effectiveness. On the demand side, many of the 45 million Americans without health insurance are looking for alternatives to costly pharmaceuticals and indeed alternatives to the traditional health care system altogether, and nutrition-related interventions are often a part of complementary medical regimens.

BARRIERS TO DIFFUSION OF DIAGNOSTIC TESTING AND NUTRITIONAL PRODUCTS

Although we've reviewed several drivers likely to encourage the adoption of nutrigenomic interventions, there will be significant scientific and social roadblocks along the way that make the realization of nutrigenomics-based personal nutrition a long-term endeavor—15 years rather than five, a slight upward revision from our first two reports.

Four factors will inhibit the diffusion of diagnostic testing and, by extension, of nutritional products that seek to directly respond to the results of such tests.

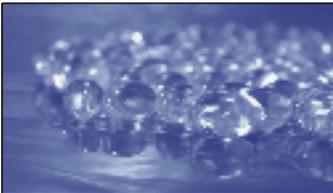
- Scientific, medical, and professional organizations that seek to discourage genetic testing outside the medical profession
- The need to establish clear health-outcome benefits and possible cost-effectiveness to get buy-in from physicians and health insurers
- Cumbersome federal regulatory processes
- Unresolved issues regarding regulatory oversight of genetic testing

Medical and Professional Establishments Discourage Outside Testing

The American Society of Clinical Oncology (ASCO) produced a policy statement in 2003 on genetic testing, published in the *Journal of Clinical Oncology*. The society's recommendations state indications for cancer susceptibility testing, clarify the details of informed consent, and strongly recommend that genetic testing be done only when paired with pre- and post-test counseling. ASCO believes that none of the genetic tests for cancer susceptibility currently available are appropriate for screening asymptomatic individuals in the general population.

ASCO is far more cautious in its views on genetic testing than are companies who offer nutrigenomic testing to consumers on the Web. Web-based companies currently offer very little of what ASCO recommends in the way of support and counseling services, even though they offer nutritional advice to reduce cancer risk based on genetic





4. Getting the Products to Market

testing. If these tests and services become more widespread, we can expect that professional groups related to a variety of diseases will escalate these concerns.

Need to Demonstrate Clear Benefits to Secure Buy-in from Physicians and Insurers

In general, doctors will adopt and insurance companies will pay for only new diagnostic tests that can demonstrate advantages over existing screening modalities. These advantages can be in the form of functionality (e.g., MRI compared to CT for soft-tissue imaging), convenience (e.g., point-of-care tests such as urine dipsticks), speed (e.g., rapid strep or cardiac enzyme tests), risk (e.g., Doppler ultrasound for certain vascular conditions rather than angiography), or cost. Without either these provable advantages or the buy-in of the professional and governmental organizations that establish and disseminate clinical guidelines, neither tests nor nutrigenomics-driven nutritional recommendations will gain a foothold.

Of course, getting that evidence is contingent upon navigating a field of regulatory hurdles.

Slow Progress Through the Federal Regulatory Process

The regulatory process to which both diagnostic tests and nutritional products are subject will be an important barrier to the diffusion of nutrigenomics products and services.

The time it takes to get a diagnostic test to market or a food or supplement with a health claim to market is significantly affected by the length of time it takes to get the new product over regulatory hurdles. For the diagnostics market, there are two main channels for regulatory approval: (1) laboratory certification by CLIA (Clinical Laboratory Improvement Amendments) and (2) in vitro diagnostic test approval by the FDA. For foods and supplements, there is the option of making a *health claim*, which requires FDA approval, or a *structure function claim*, which does not require pre-marketing approval.

Laboratory Approval

Laboratory approval diagnostic testing is done in clinical laboratories, which are regulated under the 1988 CLIA law, administered by the Centers for Medicare and Medicaid Services (CMS). CLIA emphasizes the quality of the laboratory, including education, training, and

experience of the laboratory director; proper functioning of laboratory tests; accurate identification and confidentiality of specimens; proficiency testing; and quality control, assessment, and improvement practices.

While CLIA certification means that the laboratory fulfills its quality requirements, it conveys little about the test itself.

FDA Pre-Market Approval for Test Kits

In contrast, tests that go through the FDA pre-market approval process are reviewed for performance, safety, and efficacy. The FDA approves or clears in vitro diagnostic tests as it does other medical devices. The emphasis is on the *test*, rather than on the laboratory. Such tests are sold as kits, and are used in multiple laboratories. Sponsors who seek FDA approval or clearance must submit scientific evidence to the FDA for review. If the link between clinical performance and analytical performance is not well established, the FDA may require information on sensitivity and specificity of the test, and sometimes positive and negative predictive values.

For home diagnostic tests, the FDA requires three additional criteria to be met: (1) the test must perform well in the hands of a lay person, (2) the risks and benefits must be fully addressed as part of the analysis of safety and effectiveness, and (3) the consumer must be able to understand the label. The FDA encourages submissions to include consumer studies that demonstrate safety and efficacy.

Nutritional Product Makers Who Want to Make Health Claims

Diagnostic tests are not the only nutrigenomics products affected by the barrier of regulation. Nutritional products have to jump through regulatory hurdles, too. Which hurdles they jump depend on what kind of claims they want to make on their packaging and in sales literature: the bolder the claim, the higher the hurdle.

If a food or supplement company wants to make a health claim (statement that a relationship exists between a food, food component, or dietary supplement ingredient and the reduction in risk of a disease or health-related condition), there are three ways that a company can fulfill FDA regulations: (1) based on “significant scientific agreement,” (2) based on an “authoritative statement,” or (3) based on a qualified health claim.



4. Getting the Products to Market

In the first approach, the company can submit a health-claim petition to the FDA and demonstrate that the nutrient/disease relationship is well established and that there is “significant scientific agreement.” This approach is based on the FDA’s definition of significant scientific agreement.

In the second approach, the company can notify the FDA of a health claim based on an “authoritative statement” from a scientific body of the U.S. government or the National Academy of Sciences. This approach is currently available for foods only, not for dietary supplements.

The third approach requires the company to submit a “qualified health claim” petition to the FDA, which the FDA then makes available for public review and comment. A qualified health claim does not have to meet the “significant scientific agreement” standard because a qualified health claim recognizes that the evidence is not conclusive. However, a significant amount of supporting scientific information is required for the petition.

Producers Don’t Have to Make Health Claims

If a company is marketing a dietary supplement, it can choose not to make a health claim that links the product to a disease. Instead it can make a “structure/function” claim and follow the rules of the Dietary Supplement and Health and Education Act of 1994 (DSHEA). Structure/function claims are statements that “describe the role of a nutrient or dietary ingredient intended to affect the structure or function in humans or that characterize the documented mechanism by which a nutrient or dietary ingredient acts to maintain such structure or function.”

Getting FDA approval on the basis of a structure/function claim is a faster process than getting approval for a health claim. To use a structure/function claim, (1) the company must have substantiation that the claims are truthful and not misleading, (2) the company must notify the FDA within 30 days of marketing the product of the claim, and (3) the product must have a disclaimer that says: “This statement has not been evaluated by the FDA. This product is not intended to diagnose, treat, cure, or prevent any disease.” An example of a structure/function claim is “calcium builds strong bones.” Dietary supplements under DSHEA do not need pre-market approval by the FDA for safety or effectiveness.

Time Matters

Time is of the essence in bringing products and services to market. The FDA may take up to 180 days to review the scientific submission for a diagnostic test and to make its determination. If approval is denied, the applicant may petition for reconsideration within 30 days. However, there is significant variability in the length of time it takes for the FDA to approve or deny a submission. From the FDA's point of view, the length of time depends on the quality of the submission. A high-quality submission goes through quickly. For example, the test for Factor V Leiden took 30 days to approve, but other tests have taken years.

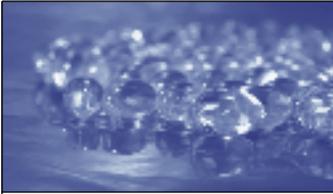
The time-consuming and costly part is the preparation of the submission to the FDA. Collecting compelling scientific evidence of safety and efficacy may require a comprehensive analysis of the literature, and/or years of primary research studies for investigators to collect new data, thus slowing the flow of product to market. On the other hand, companies do want to make sure they get it right—they may only have one chance to succeed.

Delay in Establishing Regulatory Oversight on Genetic Testing

Nearly all genetic tests that are currently available are in-house tests or so-called “home brews.” If a test is performed only at a single site and is not marketed to multiple laboratories, then *no approval by the FDA is necessary*, and CLIA certification of the laboratory is sufficient. This lack of oversight on the tests themselves has raised questions and controversy over these kinds of home-brew tests.

The concern is three-fold: (1) the genetic test may be a low-quality test whose results are not reliable, due to errors associated with the sample or the assay, (2) the results of the test may be misinterpreted, and (3) claims about why the test is useful may be misleading. If an appropriately trained health-care professional is involved in the testing process, then that professional can take responsibility for selecting reputable laboratories, interpreting test results properly, and providing accurate information to the patient about why the test is useful. However, if a company markets a genetic test directly to the consumer, then the information the consumer receives and understands will be variable. Although health-care professionals and consumers could both be misled, the professional is more likely to have the knowledge





4. Getting the Products to Market

and resources available to sort through the confusion and uncertainties of genetic testing. The consumer may not even know what he or she does not know. Thus, the biggest concern has been over direct-to-consumer marketing and selling of genetic tests. This concern slows getting products to market.

The question is—how much governmental oversight should there be for genetic tests and services, and whose role should that oversight be? The FTC has broad jurisdiction over false advertisements for drugs, devices, and services, but can do little without the FDA on the matter of quality assurance for genetic testing. The FDA is responsible for implementing the Food Drug and Cosmetic Act of 1938, but the act does not stipulate how to oversee genetic testing. The FDA has not taken a clear stand on what its authority is in terms of protecting the health and safety of the public on this issue, and companies may be reluctant to invest in products or have difficulty planning strategy without knowing the answers to these critical questions.

THE MISSING PARTNER IN MOVING FROM THE LAB TO THE DINING ROOM

The consumer, of course, is the missing partner essential for bringing nutrigenomics products into the dining room. Even if consumers don't pay for diagnostic tests, they must undergo them. And they will, no doubt, be the primary buyers of the personalized nutritional products and services recommended based on the tests. In the next chapter, we turn to consumers to understand what drives their participation in or abstinence from the market in nutrigenomics tests and nutritional products. First we treat you to a glimpse of the consumer perspective on today's nutrigenomics testing experience.



GENETIC TESTING: ONE CONSUMER'S EXPERIENCE

The promise of nutrigenomics is to deliver personalized nutrition recommendations that allow individuals to eat the right foods in the right amounts for their genetic makeup so that they can improve their health and prevent and treat diseases. IFTF set out to find out what information consumers can get now through genetic testing, and how useful they perceive that information in generating personalized nutrition plans. This is what we learned from our interview with Francisco Rodriguez.

Q | What prompted you to take the nutrigenomic test?

I was simply open to this sort of test and information after I was diagnosed with hypertension five months ago. After ruling out high stress situations like divorce or a job change, my primary care doctor initiated a whirlwind of specialist visits, tests, and procedures, all aimed at uncovering the physical cause of my hypertension. All physical causes were ruled out, and it was going to take four prescription drugs to control it. As a result, I was more open to this test and learning about my health than ever before. I believed the nutrigenomic tests would provide me with additional options at a time when it was becoming clear to me and my doctors that I would need to take prescription drugs indefinitely or radically change my lifestyle. The genetic test seemed like a good addition to various strategies I was exploring to achieve better health—prescription drugs, exercise with a fitness trainer, nutritionist consults, finding and processing information on hypertension, the DASH diet. Also, the idea of personalized nutrition was attractive. The information out there is fragmented—and the potential for overload is high—and it is difficult to know where to start. Equipped with the results of the nutrigenomic test, I expected to have the information to make the best food and nutrition choices to manage my health.

Q | What was involved in getting the nutrigenomic test, how much was it, and what service was included?

Genelex sent me a test kit, including a brochure, a questionnaire about my diet and food intake, some instruments to take inner cheek samples, and a return envelope. Once I got the kit, I combed through the Genelex Web site—again—for any red flags, additional information on the genes they include in the test, and more about their privacy policies to confirm, at least in my mind, that this was a good decision. I learned that the test focuses on gene variations that may call for a change in diet or lifestyle and does not include any genes that do not interact with your nutrition or lifestyle. The test is not a screen for inherited disorders or inherited predispositions to disease. And according to its privacy policy, everything is kept strictly confidential. In fact, Genelex de-identifies the material sent in so that a person's identity is separate from the genetic material that undergoes evaluation. I was also surprised to learn about the full range of genetic tests the company offers: paternity, forensic, nutrition, ancestry, and drug reaction. Wanting to learn more about their nutrition counseling services, I called Genelex. The call took me

CONSUMER:

Francisco Rodriguez
Professional, Market Research
Single, Male, 35
Healthy, but overweight
Managing hypertension with prescription medication

Insurance: Aetna HMO

Health Providers: primary care physician and specialist: nephrology

COMPANY:

Genelex





GENETIC TESTING: ONE CONSUMER'S EXPERIENCE

into a maze of options and I was finally routed to the paternity-test lab where a random person answered the phone. My call surprised him, since he is used to discussing case numbers and not talking to actual customers. My questions were answered, but it became clear to me that its primary business is paternity tests. The nutrigenomic panel and other tests are offered but these are a much smaller portion of its overall business.

I delayed sending back the test kit for several weeks and decided to talk about the test with as many people as I could to see how they reacted and get their opinions. Most of the people I talked to were work colleagues and family members. Most people found the idea of nutrigenomic testing novel and cool and some thought it too risky to trust anyone with your genetic information despite the utility of the information for health management and cited worst-case scenarios such as my health insurance company obtaining the results and the loss of my health insurance coverage. Nothing I heard convinced me not to take the test. I was also highly motivated to eat better and improve my health, and I thought the test would help me do that.



In the end, I was satisfied with Genelex's privacy policy and took the samples. The cost was \$500 and included a telephone consultation with a nutritionist to interpret my test results.

Q | How long was the wait for the results and how did you feel about the tests while you were waiting?

The wait was about six weeks. I called Genelex after about three weeks and asked about expediting my test results. It turned out the test kit and sample had been processed the week before and was just sent to an external lab. No wonder it was taking so long. I did not realize the process would involve companies other than Genelex. Genelex told me that it could not expedite the test results and told me the process was essential to ensure my privacy. The answers convinced me that the wait was necessary, but I still think things should move faster to leverage the customer's enthusiasm and attention on their health. I was anxious to get the results to include in my own health program planning. I had high expectations to use the information to lose weight, lower my blood pressure, and eventually obviate the need to take prescription medication.

Q | What did you get back from Genelex?

One day I found a DHL package on my front door step. I think I would have preferred a much more discreet package in my mailbox plus a phone call summarizing the results with me directly. The idea of the results lying on my front door step all day made me feel exposed. But the thought soon left my mind, and I rushed inside and began reading the report. The results were impressively presented and bound in an easy-to-read format. The report was organized into several sections including: "Your Personal Lifestyle

Report,” “Your Genetic Results,” “Understanding Your Genes,” “Vitamin and Mineral Guide,” and “FAQs and Quick Reference.”

Q | What are your thoughts about the information itself?

The results and nutrition recommendations that are based on my genetic profile read like common sense. Reading the results, I could not help but begin to question the value of the test itself. The real value lies in personalized nutrition, that is, how genetic information can be used to optimize my nutrition and eating for better health. However, the results felt too general despite the fact that they were generated from my DNA. The results describe whether a variation exists in my genetic profile across 18 different genes tied to areas as diverse as B-vitamin use, inflammation, insulin sensitivity, and antioxidant activity. The results, unfortunately, did not explain the meaning of any variations or the scientific basis for including it in the test.

However, there were a lot of specific recommendations about the kinds of foods and supplements I should take. The test results confirmed good eating habits and identified deficit areas, such as the need to take supplements or eat foods rich in B vitamins. The recommendations were not at the “reduce fat, lower carbs” level, but more like, “Eat more cruciferous vegetables and focus on super foods like broccoli.” The result is that I can eliminate the “program” diets such as Atkins, because now I have a much better idea of what a healthy diet is and what it is not.

Although I was satisfied with all the information Genelex provided prior to the test, I really underestimated the amount of work the results would generate and the kinds of information I

would eventually want to seek out. Like all good health care consumers, I went online to collect more information about each gene in the panel, but was quickly overwhelmed by the complexity of the information and alarmed by some information that tied variations in these genes to disease or predisposition for disease. After a week or so I stopped my quest for more information.

Q | How useful was the information you got from Genelex and why?

Well, I keep coming back to the report and I still believe the information is very useful. It has helped me learn more about food and its various health benefits, something I have always found difficult. It really is a task to figure out whose recommendation is right and, in the end, it’s always a toss up. At least now I have a food manual specific to me. I now have a better sense of what my body needs, and how I can help basic metabolic processes through nutrition and the food I choose to eat. I am still not convinced they needed my genetic profile to create this report. The survey and the questions they asked me about the foods I eat was, perhaps, enough to personalize food and nutrition recommendations.

In addition to the report I think I would have liked a tailored program for weight loss. I also would have liked some tool, program, or Web site that allows me to track my food intake and track how close I am following the recommendations. Also I think I would be open to purchasing supplements or drinks formulated with my personalized needs in mind. I’d like to see products and services that make this information actionable. Right now, I can make the information actionable through nutrition and food choices, but the burden is entirely on me and I’d like a short cut or two.



GENETIC TESTING: ONE CONSUMER'S EXPERIENCE

The value, when I step back and think about it, is the information synthesis. There is too much out there and this did save me a lot of time—despite all the work I did before and after the test.

The key consumer value in this space is *navigation*. A genetic test or a counselor can achieve different levels of synthesis and navigation for the consumer, so anything that reduces the burden of information and can *confirm* that the consumer is making good choices is key.

Q | How was the meeting with the nutritionist?

The meeting with the nutritionist was okay. It was over the phone with a nutritionist based in Los Angeles. I did request someone local but no one was available in Genelex's network in the Bay Area. I went online and tried to prepare as much as possible before the meeting but was overwhelmed with the information online. I would have liked the nutritionist to have acted as a guide or coach using this information. The expectation was that I would ask questions. It could have ended in five minutes if I had nothing to ask. So I asked questions about the genes themselves and wanted to know which genes and results I should pay most attention to. She cited general information about the genes and what they test for—information that can be found on the Web site or in the report.

After about ten minutes of general information and explanations I asked how I compared to other test takers. She told me I had good results based on her previous experience and sessions with other Genelex nutrigenomic test takers. I also asked to hear more about the science that influenced the company to include this particular set of genes in the test. She focused most of her discussion about the science on two genes. The first

is labeled GSTM1, which is tied to antioxidant activity and detoxification. The second gene is labeled PPAR-Y2 and is tied to insulin sensitivity. She cited a study that showed increased susceptibility to lung cancer in smokers with a variation in GSTM1. She also discussed PPAR-Y2 and diabetes and said I did not have a variation in my genetic profile tied to insulin sensitivity. The discussion stayed at a general level, but captured my interest and attention. I thought this discussion was interesting especially in light of the disclaimer that Genelex was not testing for disease predisposition.

Q | What are you doing with the information now?

I am planning on taking it to my doctor, though I suspect she will not be able to use it. The information provided does not necessarily help me lose weight, which is her primary recommendation to me. Rather, this information is great for my overall health. The information is helping me make better food choices and it has confirmed the health benefits of some of my existing patterns and food choices. I believe it is also making me question the food I eat more. I look for raw and natural choices when I can, but am much more aware that my schedule and lifestyle (e.g., long commute) and not lack of information or strategies are the primary barriers to better nutrition. I am taking this information and looking for good food and eating choices along my commute and for more mobile food options in the form of nutrition bars, shakes, and fruit—the ultimate mobile food.

Q | Would you tell a friend to get nutrigenomic testing?

It depends on which friend and what their need is. I think the test and information is useful, but is not ready for everyone. The science is still developing and there is little evidence that a variation in one particular gene actually reveals anything about your health or predisposition to illness

or disease. I think it is a combination of factors (perhaps a range of variations in multiple genes), environment, access to care, and lifestyle that ultimately determine our health. I am sharing the results with my brother. My brother is in perfect health and does not have an immediate need for the information, but I felt obligated to reveal the test results to him.



5 Nutrigenomics Will Attract Consumers

As scientists come to a more robust understanding of gene–diet–disease interactions, the promise of personalized nutrition will become more tangible to consumers. Faced with that promise, a cadre of consumers will be compelled to learn about their genetic make-up and turn to personalized nutrition to improve their health. The question for those who develop nutrigenomics products and services—from screening tests to dietary plans to food products—is whether consumers are motivated enough to take the next step to understand potential benefits of such products and spend the money to purchase them.

IFTF’s Consumer Nutrition Index tells us that about one-third of consumers will be open to personalized nutrition.

DRIVERS OF CONSUMER ACCEPTANCE OF PERSONALIZED NUTRITION

Four forces will drive consumers to participate in the emerging nutrigenomics-driven market for personalized nutrition.

- Consumer interest in personalized nutrition
- The desire to know more about personal health risk and health status
- Consumers’ current focus on food and supplements for health
- The emergence of engaged health consumers who believe that food and supplements can protect or improve health

Consumers Are Already Interested in Personalized Nutrition

The idea of having an eating plan that takes personal characteristics into account is not new. If you go to Weight Watchers, you’ll complete a survey about your health and eating style. Do you like your food in a few large meals or in lots of little meals throughout the day? Are you an emotional eater? Do you like crunchy foods or gooey ones? The goal is to work within the Weight Watchers paradigm of a

reduced-calorie, low-fat, high-fiber diet to come up with a way of eating that you can live with and that allows you to lose weight, improve your health, and maintain your weight loss. One could argue that this is already personalized nutrition. The innovation of nutrigenomics-driven personalized nutrition, of course, lies in the variables used to personalize.

Fully realized nutrigenomics-driven personalized nutrition would allow a level of specificity in personalization never previously achieved. In the best of all possible worlds, it could relieve people of the “burden of empowerment”—having to decide among Atkins, Ornish, and South Beach diets, for example, on the basis of imperfect information. With nutrigenomics, individuals would, instead, get tested to discover their predisposition to diet-related diseases, and then consult with an expert who would help interpret the results, merge them with patient preferences and, if indicated, recommend specific foods or a dietary plan to treat or prevent that disease.

Given the hype surrounding the Human Genome Project, it is no surprise that consumers have heard of *genomics*; fewer, however, know of *nutrigenomics*. In fact, while a survey by Cogent Research found that 79% said they know something about the use of “genetic information to optimize health” (genomics), only 39% say the same thing about “nutritional genetics” (nutrigenomics)—use of genetic information to provide nutritional or dietary recommendations (see Figure 5–1).

If the terms nutritional genetics and nutrigenomics elicit blank stares, the idea of personalized nutrition has a more immediate appeal. It's no surprise; many consumers have been trying to get personalized nutrition for years. Cogent Research estimates that 50–75% of consumers surveyed in 2004 are interested in knowing what disease to focus on and what foods or nutrients address those diseases. Respondents want to know to which conditions they are predisposed, as long as they could do something about them and, while they believe that diet can affect health, they are not sure what to do about diet. Respondents want nutrition plans to prevent disease (56%) and diet-related recommendations for wellness (7%), mental alertness (7%), and stamina (65%).

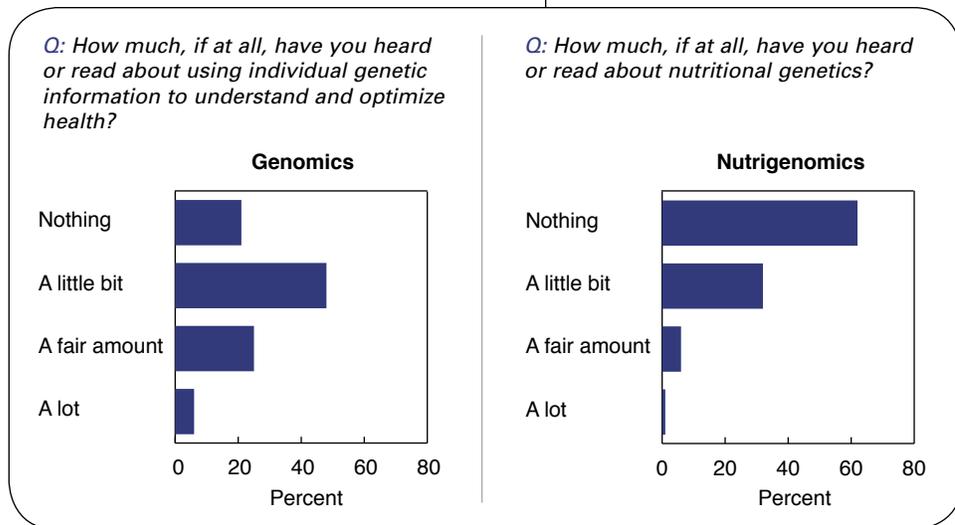
Consumers Want to Know More About Their Health and Health Risks

Consumers want information about themselves and about nutrition that they can trust and act on. They are willing to do their part, as well. In its 2004 American Lifestyles Survey, a national survey of 2,000 adults, IFTF found that 75% of consumers are somewhat or very interested in taking a “personalized nutrition test” that would direct them to the right foods for their own genetic make-up

(See Figure 5–2 on page 42). Forty percent are also willing to share that information with their primary health care providers.

Consumers may also be willing to take and pay for genetic testing. Eighty-one percent of respondents to a 2002 poll conducted by HarrisInteractive say that they are interested in tests for conditions that could be prevented or treated and 49% are interested even if no treatment or prevention were available. Respondents also said that they'd pay for such tests. In fact, they'd be willing to pay as much as \$300 out-of-pocket for genetic testing. Nearly one-quarter of those

Figure 5–1
Awareness of Nutrigenomics Lags Behind Genomics
(Percent responding ... to the following questions)



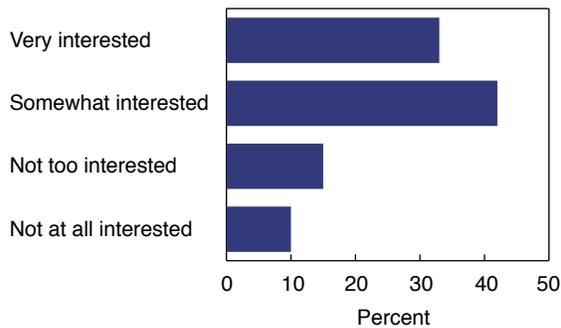
Source: CogentSynicated Genetic Attitudes and Trends Survey (CGAT), November 2003.



5. Nutrigenomics Will Attract Consumers

Figure 5-2
Consumers Are Interested in a
Personalized Nutrition Test
(Percent responding ... to the
following question)

Q: In the future, scientists may develop tests that could use a person's genetic information to determine what exact foods would be most healthy for them. How interested would you be in having such tests done for yourself?



Source: Institute for the Future, 2004
American Lifestyles Survey.

in the lowest income category are willing to pay more than \$400 for such a test, and those with greater household income are willing to pay as much as \$450 for such a test (see Table 5-1). It is notable, however, that more than a quarter of the sample either don't know how much they would pay or did not respond at all.

The caveat for interpreting these measures is that the questions are currently hypothetical for most conditions. Thus, the results of the survey should be taken as an indicator of consumer willingness to consider diagnostic testing when nutrigenomic tests become credible and genetics-based nutritional recommendations are available.

Consumers Are Turning to Food for Health

Existing measures such as the size and growth of the supplement market and the rise of functional food sales indicate that consumers are willing to move beyond medicine and the medical establishment to improve their health. The market for "functional foods" (foods that provide health benefits beyond

Table 5-1
Consumers Say They Would Pay for Genetic Tests
(Percent of base respondents who would pay ... for the genetic test described, by household income)

Q: If you had to pay, yourself, to get such a test for a very serious disease for which there are treatments or other ways to greatly reduce your risk, about how much would you be willing to pay for the test?

Base: Somewhat or very likely to ask for test (81% of all adults) for which a treatment exists

	TOTAL POPULATION	<\$25,000	\$25,000– 49,999	\$50,000– 74,999	≥\$75,999
Nothing	5	8	5	5	-
\$1–\$25	4	6	1	2	5
\$26–\$100	16	18	20	14	11
\$101–\$400	14	15	13	16	15
\$400+	34	23	32	41	49
Not sure/refused	28	29	29	21	19
Median	\$314	\$184	\$222	\$459	\$483

Source: HarrisInteractive, The Harris Poll #26, June 5, 2002.

basic nutrition, such as oatmeal that can reduce cholesterol or orange juice with added calcium) is estimated to be growing at an annual rate of 14%. Nutraingredients.com, a news service specializing in dietary supplements and healthy foods and beverages, expects the functional food market to reach \$32.7 billion in the United States by 2005, up from \$17.6 billion in 2001. Distribution of both dietary supplements and organic foods has also diversified, moving from specialty stores to mainstream grocery chains and food-service enterprises across the nation.

Consistent with IFTF research, these trends suggest that Americans are focusing on food and dietary supplements as means to sustain or improve health. They also indicate that consumers are not only willing to spend money for nutritional benefits, as in the case of supplements, but also to pay a premium for perceived added health benefits even when cheaper alternatives exist, as in the case of organic foods.

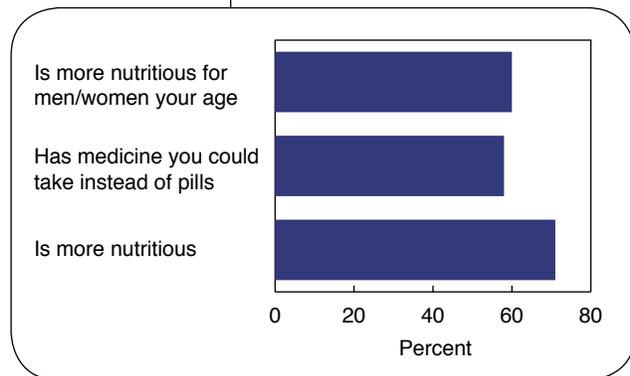
Consumers are also interested in food and supplements that take personalized information into account, and they say they are willing to pay a bit more for them. Data shown in Figure 5-3 indicate that a sizable share of respondents are willing to pay a bit extra for a snack bar that gives additional personalized nutritional or medicinal benefits.

The Emergence of Engaged Consumers Who Turn to Food for Health

Over the last four years, IFTF has used its Consumer Nutrition Index (CNI) to measure the potential market for personalized nutrition products and services. The CNI measures nutrition-related attitudes and behaviors. Both the 2003 Health and Nutrition Online Survey of 1,000 adults and the 2004 American Lifestyles Survey of 2,000 adults included the questions related to the CNI. Each sample is weighted to reflect the age, income, gender, education, health, and health insurance status of the 18-64-year-old population in the United States.

The 2004 version of the CNI is comprised of five questions (see Table 5-2 on page 44). Each question has a response on a scale from 1 to 4, and the CNI is the sum of the responses. Thus the highest score is 20, and the lowest score is 5. Respondents are grouped into similarly

Figure 5-3
Consumers Willing to Pay for Personalized Nutrition Benefits
(Percent of those who eat snack bars that would pay more for a bar that ...)

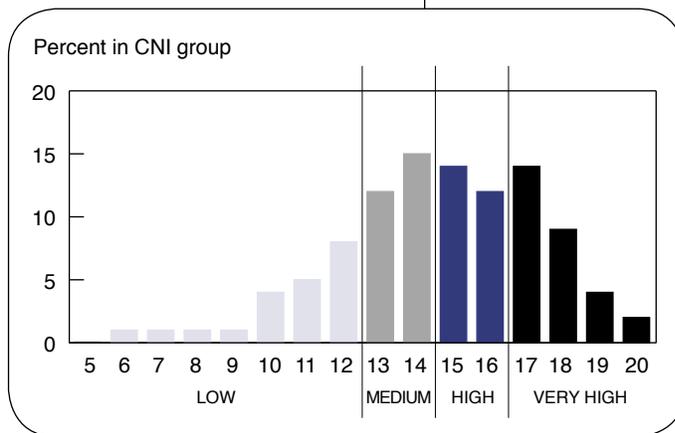


Source: Institute for the Future, 2003 Health and Nutrition Online Survey.



5. Nutrigenomics Will Attract Consumers

Figure 5-4
Distribution of Consumers
Along the CNI
(Percent of consumers in
CNI category)



Source: Institute for the Future, 2003 Health and Nutrition Online and 2004 American Lifestyles Surveys.

sized categories (low to very high) based on CNI score, for data analysis. Figure 5-4 shows the distribution of survey respondents among the CNI scores and categories.

IFTF analyzed the survey data to understand how strongly individuals associate the quality of their diet with their health status. In 2004, IFTF also conducted in-depth, in-home, ethnographic interviews with 25 survey respondents. These interviews focused on the health management strategies survey respondents used. Taken together, the 2003 and 2004 surveys and the ethnographic interviews help to illuminate the extent to which consumers use food as a tool to manage their health, to characterize which consumers are most likely to use food for health, and to identify those who use food to manage their health using both personal characteristics and attitudes/behaviors.

The data suggest that there is a group of consumers that is particularly active in using nutrition to manage health. Those who scored 15 or more on the CNI scale and fell into the High and Very High CNI categories—53%—appear to be active in this way.

Table 5-2
Questions for the 2004 CNI

Questions 1-2:

Responses are on a 4-point scale, ranging from (1) strongly disagree to (4) strongly agree.

1. I always carefully select what I eat to achieve balanced nutrition and a healthy diet.
2. I am always experimenting with new foods that may improve my health.

Questions 3-5:

Responses are on a 4-point scale describing level of importance, with one of the following phrases replacing "...": (1) very unimportant, (2) somewhat unimportant, (3) somewhat important, and (4) very important.

3. Eating healthy foods is ... to my health.
4. Taking vitamins and other supplements is ... to my health.
5. Health benefits are ... to me when I am purchasing food.

Source: Institute for the Future, 2003 Health and Nutrition Online and 2004 American Lifestyles Surveys.

Which Consumers Are Primed for Personalized Nutrition?

Over the last three decades, IFTF has chronicled increasing market fragmentation and found that social mobility makes it increasingly important to evaluate traditional demographic variables in the context of attitude and behaviors. As people of different ethnicities, incomes, and genders shift their places in society, particularly as they gain command of increasingly available streams of information, behavior sometimes defies demographic segmentation.

In IFTF’s NCNG research, attitudes and behaviors have emerged as increasingly important determinants of whether consumers embrace nutrition as a tool for active pursuit of health or not. While women and those with at least some college education are more likely to fall in the High and Very High CNI categories, annual household income and insurance status show no clear trends across CNI categories (see Table 5–3). In fact, although there are differences in scores between demographic groups (women’s mean score is 15.0 versus 14.2 for men, for example), it is health status, information gathering and sharing behaviors, and attitudes about food and health that tell the real story about those most likely to respond to the promise of nutrigenomics.

The link between health status and interest in food as a tool for managing health seems clear. According to the National Center for Chronic Disease Prevention and Health Promotion, conditions like heart disease, cancer, and diabetes account for seven out of every ten



Table 5–3
Demographic Differences Across the CNI Groups
(Percent share of CNI group with the following characteristics)

	LOW	MEDIUM	HIGH	VERY HIGH
Female	39	58	59	62
At least some college	48	52	64	58
Household income	36	40	45	41
Currently insured*	69	78	82	74

* With no coverage gaps over last 12 months

Source: Institute for the Future, 2003 Health and Nutrition Online and 2004 American Lifestyles Surveys.



5. Nutrigenomics Will Attract Consumers

deaths in the United States, so it is not surprising to find that 43% of IFTF's 2004 American Lifestyles survey respondents report they had been told that they had a chronic disease. Since diet has long been recognized as a contributing factor to these conditions, it makes sense that those in the three higher CNI categories are almost twice as likely to report chronic illness as those in the lowest category; people living with illnesses can be expected to have higher engagement with health issues (see Table 5-4).

High CNI Consumers Focus on Food for Health

When it comes to using food to advance health, those in the Very High CNI group are more likely than those in the Low CNI group to review multiple sources of health and nutrition information, including health care providers, retailers, grocery stores, complementary and alternative medicine (CAM) providers, friends and family, and online resources. They are more likely to believe that their physician's primary role is to be an equal partner with them in making decisions (21% versus 10%), and agree that their desire to manage or prevent a health condition is a big factor in determining what foods they eat (88% versus 19%) (see Table 5-5).

High and Very High CNI consumers, who comprise roughly 53% of our sample, are what IFTF calls "engaged health consumers"—in this case, consumers who focus on food for health. Engaged consumers can be "engaged" in a variety of areas, and can come from any demographic group, as their passion for the task at hand is much

Table 5-4
Members of High CNI Groups Are More Likely to Have Chronic and Serious Illnesses
(Percent of CNI group who report the following health conditions)

	LOW	MEDIUM	HIGH	VERY HIGH
Chronic illness	26	42	47	43
Serious illness	8	14	14	25

Source: Institute for the Future, 2004 American Lifestyles Survey.

more important than, say, income or education level. Engaged consumers display three “bellwether behaviors.” They act as their own agents rather than relying primarily on outside authorities. They customize products and services to meet their own needs. And they come together with other consumers to form networks that learn, minimize the risk of trying new things, and rapidly disseminate and gather information. For example, Very High CNI consumers are important sources of information on health within their social networks as well: 44% say others come to them for advice on how to get what they need from doctors and insurance plans, and 64% say their friends and families need their help to understand health and medical issues. They are also more likely to use CAM providers and to get a second opinion about a medical diagnosis or treatment.

As such, the group of consumers we call engaged consumers is already exhibiting the behaviors required of a nutrigenomics market. The question is, how will they come to accept nutrigenomics, and when?

Table 5-5
Behavior Identifies High CNI Consumers
(Percent share of CNI group that endorses each statement)

	LOW	MEDIUM	HIGH	VERY HIGH
Agree that, “My desire to manage or prevent a health condition or illness has a big impact on what foods I eat.”	19	48	66	88
Believe that their physician’s primary role is to be an equal partner with them in decision making	10	16	19	21
People come to me to find out the best way to get things they need from doctors or health-insurance plans	16	23	33	44
My friends or family members sometimes need my help to understand health and medical issues	41	50	56	64
Have gotten a second opinion on a diagnosis or treatment	27	44	49	59
Used CAM in the last 12 months	11	18	26	28

Source: Institute for the Future, 2004 American Lifestyles Survey.



5. Nutrigenomics Will Attract Consumers

FORECAST: ASTUTE CONSUMERS DETERMINE MARKET ACCEPTANCE

The confluence of consumer interest in personalized nutrition, the desire to know more about personal health risks, the focus on food as a route to health, and the emergence of engaged health consumers who focus on food for health presages the formation of a cadre of early adopters who have the potential to influence the nature and growth of the consumer market for personalized nutrition.

High CNI Consumers Will Be Early Adopters of Personalized Nutrition

Consumers who score higher on the CNI scale are likely to be the majority of people who will be receptive to nutrigenomics-driven personalized nutrition. They are more likely to try genetic and other diagnostic tests to facilitate personalized nutrition, and they will tell their friends about their experiences. They are the ones who will believe that eating right prevents disease. They will change their diets in the pursuit of health. In fact, almost 40% of Very High CNI consumers have already changed their diets to improve their health and 73% take supplements daily (see Figure 5-5).

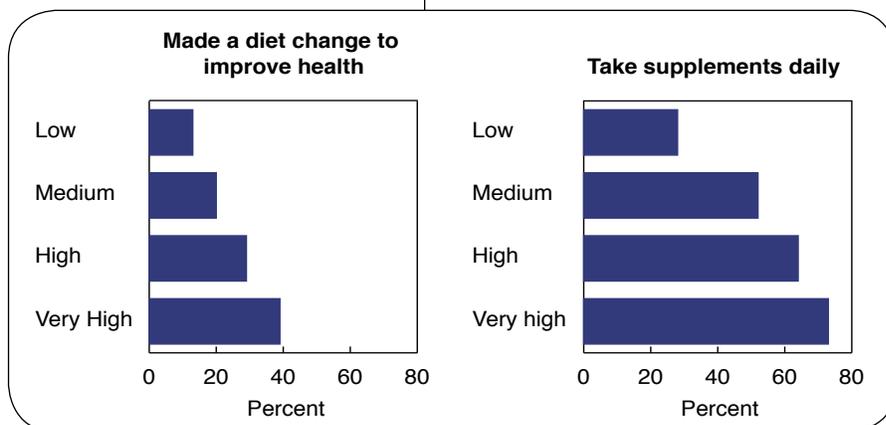
Higher CNI Consumers Will Be Open to Genetic Testing

Higher-scoring CNI consumers are ready for the promise of personalized nutrition. They report more interest in taking genetic tests to facilitate personalized nutrition and are more willing to share that information with health and nutrition professionals than their lower-

scoring counterparts. Fifty-seven percent of Very High CNI consumers report being very interested in genetic testing for personalized nutrition, whereas only 19% of Low CNI consumers do (see Figure 5-6). Those who scored higher on the CNI tended to be more willing to share the information with family members, primary health care providers, and

dieticians or nutritionists, but few people in any group were willing to share such information with health insurance companies or employers.

Figure 5-5
High CNI Consumers Already Do What's Required for Personalized Nutrition
(Percent share of CNI group that ...)



Source: Institute for the Future, 2003 Health and Nutrition Online Survey.

Early Adopters' Experiences Will Influence Rate of Growth

High and Very High CNI consumers will influence their friends and family in areas of health and nutrition. IFTF's 2004 American Lifestyles Survey found that 64% of Very High CNI consumers report that friends and family need their help to understand health and medical issues. In this way, their influence reaches beyond their numbers in the population. And since they will be the first consumers to attempt genetic testing to facilitate personalized nutrition, their formative experiences will matter. If they have good experiences, they will tell their friends and recommend testing. If they have bad experiences, they will tell their friends and family and dissuade them from testing. These engaged health consumers are key nodes in networks of information flow—and right now, the marketplace for nutrigenomics is more about information flow than the sales of actual products.

Positioning Tangible Benefits of Nutrigenomics Products Will Be Key

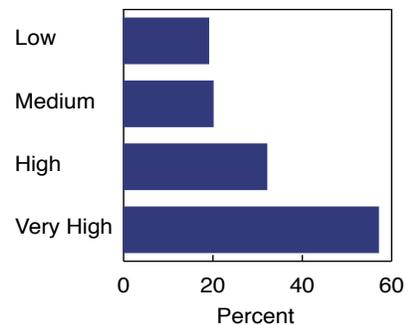
A major challenge for the nutrigenomics field is whether it will be able to simplify the science and communicate tangible product benefits. While scientists revel in the complexity and conceptual elegance of their domain, consumers just want to know whether the results will make them healthier, thinner, or prevent the onset of disease. Cogent Research found that the simpler the sell, the better, when it comes to consumer appeal. It found that the term *personalized nutrition* markedly out-performed *nutrigenomics* and *nutritional genomics*, for example, in both its appeal and relevance to consumers. Very few consumers will be willing to acquire basic knowledge of probability and genetics, and if the message is not simple and clear, they will not be interested.

Trusted Information Sources Will Influence Early Adopters

While the physician is not the consumer's only source of information, he or she is an important source when it comes to health care decisions. When consumers are faced with decisions about screening tests, foods, and supplements that can have an effect on their medical condition (e.g., diabetes), physicians and authoritative medical sources will be important factors in determining whether consumers try nutrigenomics testing or personalized foods. They will often be the translators that help consumers interpret the connections between

Figure 5-6
Very High CNI Consumers
Particularly Interested in
Personalized Nutrition Tests
(Percent that are very interested in
the test described, by CNI group)

Q: In the future, scientists may develop tests that could use a person's genetic information to determine what exact foods would be most healthy for them. How interested would you be in having such tests done on yourself?



Source: Institute for the Future, 2003 Health and Nutrition Online Survey.



5. Nutrigenomics Will Attract Consumers

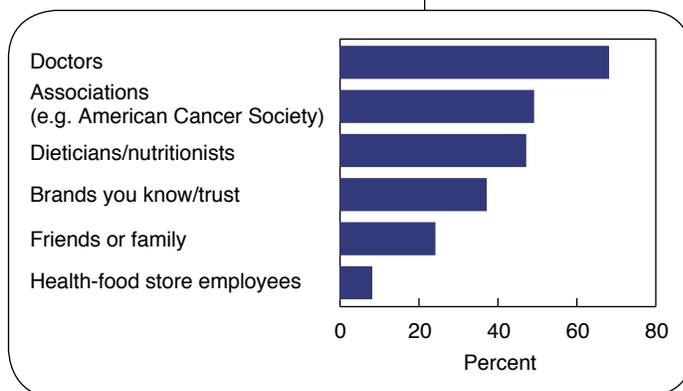
their genetic predisposition to disease and prevention and treatment options. Cogent Research found that doctors, professional associations, and dietitians/nutritionists are important sources of information (see Figure 5-7). We forecast that they will continue to be so, and that the market for nutritional genomics will grow once these professionals see solid scientific evidence in support of nutrigenomics and advise their patients to try it.

BARRIERS TO CONSUMER ADOPTION OF NUTRIGENOMICS-DRIVEN PERSONALIZED NUTRITION

Once scientific understanding of gene–diet interactions has advanced enough to produce personalized nutritional recommendations and receptive consumers have been identified, those who wish to provide products and services for the personalized nutrition market will have to overcome several barriers.

- Nutrigenomic science is still in its infancy
- The cost of genetic testing may be higher than its perceived value
- Support services for interpreting and using results of nutrigenomics tests lag
- The health care establishment is slow to adopt and pay for new practices, and will not recommend those practices in the absence of high-quality outcomes data
- Consumers have ethical concerns about the use of genetic information and about genetic modification
- It is unclear how the industry will be regulated

Figure 5-7
Physicians Bridge the Gap Between
Nutrition and Science
(Percent that list ... as having an
influence on products to consume)



Source: CogentSyndicated
Genetic Attitudes and Trends
Survey (CGAT), November 2003.

Nutrigenomic Science Is in Its Infancy

As discussed earlier in this report, companies offering broad-based nutrigenomics testing can measure many genes or proteins whose functions are interrelated in complex metabolic networks that are incompletely understood and that defy easy explanation to the vast majority of

consumers. Furthermore, there's growing evidence that many nutrients may not be fully effective in isolation from a complex food matrix. Finally, the health effects of many dietary interventions are multiply determined and often occur years or even decades in the future, making controlled clinical trials difficult and costly. Thus, companies leading the charge in genetic screening run the risk of providing information that consumers will not be able to use because no short-term, clear-cut, actionable diet-related recommendations have been determined.

Support Products and Services Lag

Not only is there a limited repertoire of actionable information, but there is also an insufficient marketplace of advisors and tools for consumers to use to build personalized health and nutrition strategies that they can implement. While many tools have been developed in the context of mass-market weight loss programs, they are not currently linked to developers of nutrigenomics tests, and calculating a BMI is much simpler than characterizing a panel of several dozen genetic traits. If nutrigenomics companies are to assist consumers in recognizing and getting the most value out of their products and services (foods and testing), they will need to develop support services or partner with existing dietary programs. If they do not, the experiences of early nutrigenomics consumers may be disappointing and the promise of nutrigenomics tainted with unrealized benefits.

Costs May Be Greater Than the Value of Their Perceived Benefit

Currently, nutrigenomics tests cost between \$400 and \$500 for broad-based analysis (e.g., Cellf). Given the state of the science, these tests may seem like fishing expeditions to consumers and, while some may just want to know their predisposition to diseases, those seeking personalized nutrition want to know what to eat and what not to eat. If tests can't help consumers determine their optimal diet, or if the recommendations are too general, the price may be perceived as too high for the benefit.

The Health Care Establishment Is Slow to Change

As mentioned in Chapter 3, medicine will be slow to change clinical practice while it waits for the scientific evidence supporting nutrigenomics testing to accumulate. Meanwhile, however, the direct-to-consumer market will continue to develop. As a result, consumers



5. Nutrigenomics Will Attract Consumers

may arrive at clinical encounters armed with the results of nutrigenomics tests that physicians are ill prepared and disinclined to interpret. Reluctance on physicians' part will slow the diffusion of nutrigenomics testing within the medical establishment and stands to create a tension between the physician-based, insurance-driven health care system and direct-to-consumer markets. Thus, nutrigenomics testing may go the way of the full-body scan: the direct-to-consumer marketplace leads and the health care system is forced to respond.

For the foreseeable future, consumers will continue to look to insurance companies to pay for most medical procedures, and many will expect genetic testing to be covered. However, like physicians, insurance companies will not be inclined to pay for nutrigenomics testing until compelling evidence accumulates regarding sensitivity, specificity, predictive value, cost-effectiveness, and links to interventions that improve health outcomes and/or reduce costs. It will likely be several years before nutrigenomics-test manufacturers can present the evidence that insurers need to be convinced that a diagnostic test should be covered. For many consumers, this will deter adoption either because they are unable to pay for it themselves or are unwilling to pay for something that payers and providers seem to have so many doubts about.

Ethical Concerns May Hamper Consumer Adoption of Testing

Nutrigenomics-driven personalized nutrition raises the specter of risk for consumers: risk of loss of privacy, risk of loss of employment or insurance if a genetic predisposition to a disease that cannot be prevented is discovered and revealed, and, for some, risk of encroachment on strongly held moral and ethical values regarding working with genetic material in the first place.

It is difficult to gauge the magnitude of influence that ethical concerns will have on consumer adoption of personalized nutrition in the nutrigenomics era. Groups such as GeneWatch, which are protesting genetically modified foods, especially in Europe, are a small but vocal minority. Yet consumers do already have some experience with genetic testing—say for breast cancer risk—in a context in which health benefits are hard to come by and easy to lose. They worry about who has access to the results of genetic tests, and, while they want the benefits of personalized products, they are concerned about the potential negative effects of creating them.

One large concern is how the results of nutrigenomics tests would be stored and shared. Cogent Research found that 51% of its 2004 survey respondents are extremely concerned about how personal genetic information would be stored and who had access to it. Forty one percent of those who are concerned about data storage at all say that the concern would prevent them from having genetic tests. IFTF’s high-scoring CNI consumers are reluctant to share the results of genetic tests with insurance companies or employers, with the only 16% of Very High and 5% of High CNI consumers willing to share results with insurers (2004 American Lifestyles Survey). This implies that consumers fear the misuse of personal information.

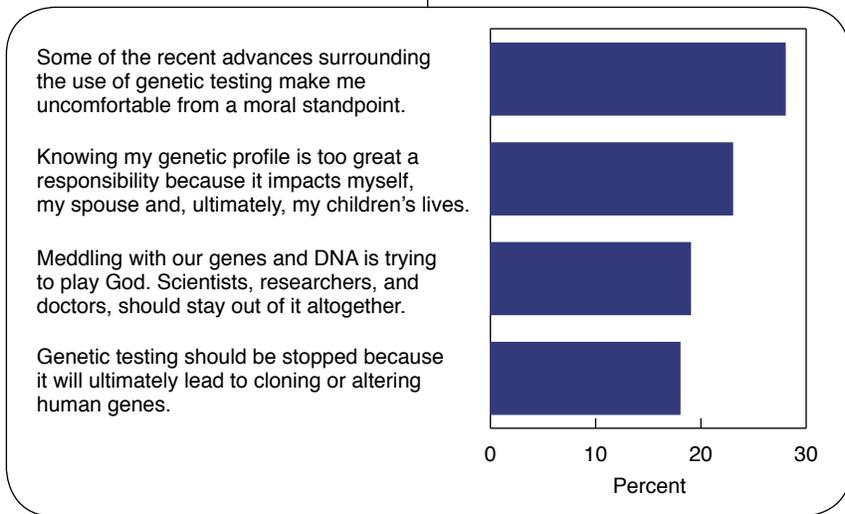
Moral concerns may also slow adoption of nutrigenomics products and services. Cogent Research found a small but vocal minority that opposed nutrigenomics on moral grounds (see Figure 5–8). It found that the notion made some consumers uncomfortable, that some fear the responsibility of having knowledge of genetic predisposition to disease, and that some feel that manipulating genes and DNA is “playing God.”

It Is Unclear How Nutrigenomics Products Will Be Regulated

As we discussed in our second report and Chapter 4 of this report, the regulation of nutrigenomic products and services will influence the expansion of the market. The question is, will the actual products consumers are recommended to take be regulated as food because they involve nutrition, or as drugs because they will be used to prevent and treat disease?

Obviously these are two very different approaches, and will affect the way consumers respond to the market. If nutritional genomic products are regulated as food, companies only have to prove that they are safe to use. If they are regulated as food that makes health claims, however, or, in the extreme case,

Figure 5–8
A Small, Vocal Minority May Oppose Nutrigenomics Testing
(Percent of respondents that somewhat or strongly agree with the following statements)



Source: CogentSyndicated Genetic Attitudes and Trends Survey (CGAT), November 2003.



5. Nutrigenomics Will Attract Consumers

as actual drugs, then companies have the much more arduous task of proving the efficacy of the substances and claims.

This puts companies in a bind. If they advocate the food route, they can get to market faster but they can't be as explicit about what their foods are supposed to do—which belies the purpose of personalized nutrition.

On the other hand, if the companies choose to emphasize the health claims of their products, they have the long and expensive burden of proving those claims. We have already discussed the difficulties of reproducing the results of nutrigenomics research from lab to lab and the difficulty and expense of long-term clinical trials. Such trials will slow the expansion of the nutrigenomics market significantly, and put off many consumers as being just too complicated to deal with.

In fact, nutrigenomics products fall somewhere between food and drugs. Their proper recommendation and use is really a matter of getting the correct and thorough information to the consumers. And perhaps the best and most direct way of doing so is by means of the labels on the products themselves.

Right now, however, what companies can put on their food labels is highly restricted. But the whole notion of nutrigenomics relies on the recommendation of specific foods to prevent or treat specific conditions—if this information can't be included on the label, then where will the consumer find it? Is the government willing to become a clearinghouse for this kind of information? Is the consumer going to be willing to go look for it? The harder it is for the consumer, the more restricted will be the size of potential markets.

We think it is likely that the government will loosen the restrictions on labeling so consumers get more and better information about the food they eat, especially those foods that may be scientifically enhanced to meet their particular genetic requirements. Meanwhile, the current regulatory process is not quite ready to handle these issues. Until some of them are decided, the nutrigenomics marketplace will have a difficult time gaining ground simply because consumers will find it too complex to navigate.

Meanwhile, though the tests themselves fall under the guidelines that regulate laboratories, there are currently no regulations guiding the

support services that are such a critical aspect of nutrigenomics. Until consumers are sure that they can trust these services, this will continue to be a barrier to the expansion of the nutrigenomics market.

NAVIGATING CONSUMER ADOPTION OF PERSONALIZED NUTRITION

Consumer desires and fears and the context in which they access and act on nutrigenomics information and testing holds both opportunities and threats for those who wish to engage consumers in a marketplace of personalized nutrition products and services. In the final chapter, we address implications of our findings and forecasts concerning the nutrigenomics market for product and service providers.



6 Business Implications for Personalized Nutrition

As advances in the sciences of genomics and nutrition converge in the midst of heightened consumer interest in personalized nutrition, businesses must proceed with cautious optimism. Over promising could inhibit the growth of nutrigenomics products and services more than the complexity of mastering gene–diet–disease interactions. The key to capitalizing on growing knowledge and moving nutrigenomics products from the lab to the dining room will be careful targeting, clear and focused product claims, and judicious partnering.

GENETIC-TESTING COMPANIES: TARGET CAREFULLY

Nutrigenomic testing and resultant dietary recommendations for diabetes and heart disease and some cancers will surely be the first out of the box with important implications for individuals and the public and private sectors. Those who produce diagnostic tests will benefit by the existing medical infrastructure if they are patient and methodical in proving that their products provide superior benefit to medical management of these conditions. Why? These conditions—diabetes, heart disease, and, increasingly, obesity—are costing health care payers and employers money. They are causing consumers and their families to suffer. If you can detect predisposition to diseases such as these with huge economic, social, and emotional costs, help forestall them, and/or help clinicians and patients take action to prevent or ameliorate the conditions in a manner superior to available methods, those who set standards for diagnosis and treatment of disease will certainly adopt the new technology and payers will help pay for its adoption.

Genetic-testing companies should target markets where the costs of illness are great and deliver strong evidence of product benefit, including compelling information about cost-effectiveness compared to other available options. It is important to then capitalize on existing channels of distribution. While nutrigenomics testing and recommendations may be a new domain in health care, the mechanisms for expanding nutrigenomics-based medicine don't have to be.

TESTING AND PRODUCT COMPANIES: MAKE CLEAR, FOCUSED CLAIMS IN THE CONSUMER MARKET

The consumer markets in diagnostic tests and nutritional products differ in the challenges they pose. While the diagnostic-test market boldly asks consumers to assume financial and emotional risks, the nutritional products market doesn't. While genetic testing may be new to many consumers, supplements and foods that boast health benefits are familiar. Consumers may well look upon nutrigenomics testing as a way to choose foods more wisely and get tangible results out of their supplements. The advent of nutrigenomics testing may raise the bar for performance of the very nutritional supplements that consumers are willing to ingest without proof of tangible benefit now.

There are risks for companies on both sides of the industry that will emerge from advances in nutrigenomics. The consumers most likely to adopt nutrigenomics testing early are the ones for whom the product benefits must be most compelling—the benefits of the tests themselves and the foods and supplements these tests suggest consumers should eat. Early nutrigenomics adopters will be engaged consumers who not only turn to food for health, but also play key roles in the consumer networks that can damn or laud products and services and determine their trajectory in the marketplace.

To succeed, producers of nutrigenomics products and services will have to be clear and precise in their

claims and deliver on them. Better to promise little and deliver much than to introduce a product with diffuse benefits because consumer expectations—especially those of the early adopters—will be set as much by the multiple sources of information they review as by your product. Careful, even modest positioning, followed by a great consumer experience will be essential. A great consumer experience will be one in which consumers perceive that the information they get is instrumental to their health and in which they will perceive health benefits.

ALL PLAYERS: PARTNER JUDICIOUSLY TO GET SUCCESSFUL PRODUCTS TO MARKET

To succeed in the emergent nutrigenomics industry—a market that includes both industry and consumer channels—businesses including labs and genetic testing companies and product manufacturers will have to strengthen established capacity, build on old connections, and forge new partnerships.

The protocols for testing products and getting through the regulatory process, while well established, will evolve as the science evolves. Developing mature systems for educating professional health care societies and for interacting with regulatory bodies will be of increasing importance. The nutrigenomics market is still as much about the dissemination of information about nutrigenomics as it is about the selling of actual products.

As nutrigenomics science begins to confront the limits of the existing regulatory framework, agencies such as the FDA may face pressure to establish new standards for oversight. While in the near term, this pressure will not be from within the industry—the trend will most surely be toward less regulation in the next five years—external forces may press for greater structure. Companies will have to anticipate new regulatory hurdles and adapt.

The experience of Francisco Rodriguez (see Sidebar to Chapter 4), who underwent nutrigenomic testing to find a way of eating that would improve his health, suggests that the diagnostic-test company could use strong support partners with experience working with consumers to establish eating plans and monitor them. Diagnostic companies don't have to become consumer support companies, but they will have to partner with those who can provide a range of services. They will need to forge these partnerships sooner rather than later because



6. Business Implications for Personalized Nutrition



the highly motivated early adopters will come to nutrigenomics testing not out of idle interest, but because they want to act on the information that nutrigenomic diagnostic testing offers to treat specific health conditions. They will want results.

The best diagnostic companies will provide a total solution to their customers: the diagnostic test that focuses on variables that correlate to diet and can be affected by diet; clear, actionable results and recommendations; and tools to help consumers act upon the recommendations.

There is a possible niche here for intermediary support services—companies that can take the results of a genetic test and walk the consumer through the process of following the recommendations, including the use of food and supplements, whether they are just “normal” foods or foods and supplements specifically designed for genetic predispositions.

ALL PLAYERS: CAPITALIZE ON GLOBAL OPPORTUNITIES

Obesity, diabetes, and heart disease are not only felling those in advanced economies, but also those in developing economies as they embrace the lifestyles of the more developed economies. As countries like China and India leapfrog in their economic development, obesity and diabetes are on the rise in these countries. Nutrigenomics may hold the promise of allowing these economies to sidestep the dietary excess and disease that attend Western-style economic development. The moderate pace of advancement in nutrigenomic science may well allow industry and government the opportunity develop business and public health strategies that deploy nutrigenomics products and services where they are most needed and can bring the greatest economic and health benefits.

Nutrigenomics is, thus, an international venture and those who would compete should keep an eye on the worldwide development of diet-related diseases and apply ingenuity to developing highly resilient and easy-to-use diagnostics for a wide range of settings. Those who would produce foods, supplements, and programs to change eating habits would also do well to think globally as they develop products. Rather than construe the nutrigenomics marketplace as one for the richest consumers, imagine what it would be if its products and services were of use to everyone. What would diagnostic tests look like if they could be widely deployed in India? What would partnerships with local food growers look like if they were to apply to the United States and

China? How does a company like Weight Watchers work with nutrigenomics companies to adapt their programs and services worldwide?

MODERATE ADVANCES IN NUTRIGENOMICS LEAVE TIME FOR STRATEGY DEVELOPMENT

This potential worldwide market in nutrigenomics will develop at a moderate rather than brisk pace. There is time to forge a prudent strategy for both the medical and consumer markets. There is time to ask where to play, with whom to partner, and what to promise. There is the opportunity to build a market, and the great potential to make a difference in the health of people in both developed and developing economies. A strategic advance from the lab to the dining room can, indeed, make the world healthier, but it is more likely to do so on a 15- rather than 10-year horizon.