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TECHNOLOGY

A flavour of the future

Health biomarkers, smart technology and social networks are hastening an era of nutrition tailored to your individual needs but relying on information generated by the crowd.

A man steps out of a health clinic after his monthly nutritional profile. He slides a ring onto his finger and the injection-free technology transmits a read-out of his blood constituents to a central server. Skimming the data sent to his smart phone, he looks at the recommendation for his evening snack — something with a little more selenium: brazil nuts, perhaps. He considers his diet for the coming week — logged with his refrigerator — and confirms an updated home-delivery shopping list. Finally, he tots up his credits for sharing this personal health data with a population-wide genome study—redeemable against the cost of his health insurance and nutritional supplements. It's a familiar sight to his girlfriend. "We're having dinner at my parents' tomorrow. Don't you dare let the FatNav tell you what to eat, or me what to drink."

There are signs that this future is fast approaching. Domestic sleep and weight monitors can transmit results using WiFi; fridges are in development that log what you've eaten; and dinner parties are complicated by food intolerance and fad diets. Already, pin-prick blood test results for diabetes can be uploaded online. Websites such as patientslikeme.org offer tips on drug and nutritional supplement regimens. And at SNPedia.com and DIYGenomics.org, people can share their entire genomic data to pool resources and provide more personal guidance on health issues.

Can all these platforms create genetics-based nutrition advice? Will this affect our definition of health, or the distinction between food and drugs? And how personalized will our diets become?

NOT IN SICKNESS BUT IN HEALTH

Many researchers think that personalized nutrition must begin with a new suite of biomarkers: ones that measure health rather than disease. But what does that mean? "Here we are in the twenty-first century and we don't have a definition of health other than 'the absence of disease'," says Siân Astley, a nutrition researcher at the Institute of Food Research, UK. "Health is about much more."

Astley says that to comprehend what bioactive food compounds are doing we first have to understand what's going on in the body before it becomes ill. "Our difficulty is that the only biomarkers we have are for when the disease process has already started."

'Omics' sciences, such as transcriptomics, proteomics and metabolomics, study many thousands of putative biomarkers in a process called 'extensive phenotyping'. "We now have examples where the protein fingerprint in tissues can indicate precancerous changes long before symptoms appear," says Astley. "The protein fingerprint offers us early diagnosis as well as an insight into potential changes that might be elicited by feeding people a different diet."

Astley also works for the Nutrigenomics Organisation (NuGO), an EU-funded project involving 23 universities and research institutes. NuGO researchers believe that to find these health biomarkers, testing conditions will need a rethink. For example, although we are all in a state of homeostatic equilibrium, the 'normal' levels of metabolites, including glucose, plasma proteins, cytokines and signalling molecules, vary from person to ▶

person. Challenging that state with exercise or new foods, and then measuring changes in metabolites as the body recovers, reveals more about its reaction to bioactive compounds than simply measuring metabolites in a resting state.

THE DEVIL IN THE DETAILS

Extensive phenotyping is a big job and costs big money. Resource-limited researchers have two options: measure many people in lesser detail, or a smaller number in greater detail. Large population studies have more statistical power, but as the ultimate goal is personalized nutrition, an investigation of the individual will provide more in-depth information.

It's a conundrum facing Mike Gibney, director of University College Dublin's Institute of Food and Health. "Too many people in a study smooths out the data and is too expensive in an era when so many measurements are needed," he says. Gibney contends we are in transition towards personalized nutrition and advocates temporarily abandoning the 'individual' mantra. Instead, people should be grouped into broader categories based on biomarkers that indicate, for example, how efficiently different sugars or proteins are metabolized. "I'm taking my research in the direction of clusters," he says. "I believe it's a half-way house." These wider groupings have the advantages of consisting of larger populations and can act as a proof of concept.

"Finally we have the proof in the pudding — genetic variety in dietary advice is relevant."

Results are emerging that support the notion of these clusters. Kenneth Kornman is founder of InterLeukin Genetics (ILG), a Massachusetts-based company developing tests for genes that affect food metabolism based on single nucleotide polymorphisms (SNPs). Kornman recently reanalysed a 2007 study by Christopher Gardner and colleagues at Stanford University. In Gardner's study, 311 women were randomized to four different diets, which varied in the content of carbohydrates. After 12 months, women on the low-carb, high-protein Atkins diet had lost the most weight.

Kornman's reanalysis involved placing 101 of the women (those available for the follow-up study) into one of three groups categorized by three SNPs related to the metabolism of dietary fats and carbohydrates. Women in the 'fat-sensitive' group shared a SNP that meant they gained more weight from a high-fat diet than did women in the 'carbohydrate-sensitive' group, and vice versa. The third group was sensitive to neither fat or carbohydrate. "Our company screened the published evidence on more than 200 SNPs and determined that these three were the only ones that met our criteria," says Kornman. The criteria were that each SNP should have at least three validating clinical studies, should be functional (directly linked to biological or clinical effects) and linked to body weight.

Kornman found that women on a diet that matched their genotype lost two-to-three times more weight than those on an unmatched diet. The study, sponsored by ILG, was presented at the 2010 Joint Conference of the American Heart Association in San Francisco. "The scientists in the audience were shocked," recalls Ben van Ommen, director at the Netherlands Organisation for Applied Scientific Research and NuGO, who had invited Kornman to speak. Kornman, he says, "has been scrutinized by the audience and he's survived. Finally we have the proof in the pudding — genetic variety in dietary advice is relevant".

FOOD TRIBES

Moving towards the more personalized end of the nutrition spectrum will require millions more data points from many diverse groups. One way to collect information from disparate populations is to use crowd-sourcing technologies. Many people who have discovered some or all of their genetic information are sharing or offering it for analysis using websites such as SNPedia, DIYgenomics and Harvard Medical School's Personal Genome Project. As genome testing becomes cheaper, more data will become available to use in this way.

Founders of personal genome information-sharing websites, such as DIYGenomics' Melanie Swan, say they can facilitate this data-gathering process by offering a new way to conduct science that appeals to the subjects. "We aim to give individuals the opportunity to participate in citizen science research studies," says Swan. "The whole point is to experiment and find out what works best for you."

A typical experiment might investigate vitamin supplements and their precursors. Participants would consent to taking regular supplements, pay for their own genetic sequencing test, submit regular tests to an approved laboratory, and upload results to the website. Combining data from all participants paints a picture of the relationship between certain genes and the impact of a vitamin or vitamin precursor on health. DIYGenomics' first study — submitted to a peer-review journal — is a proof-of-concept, extending existing research on gene mutations and vitamin B deficiency. Another study on ageing is designed and set to recruit participants.

This new approach to research blurs the distinction between study organizer and participant. "We all design the study and we all participate. We have our own consenting process too," says Swan, adding that she sees a 'citizen ethicist' version of the Hippocratic oath evolving to accommodate new ways of conducting research.

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Some people see personal genomics as a logical follow-on to social networking and a valuable asset. "There is definitely potential in a citizen science approach," says Marina Levina, a communication researcher at The University of Memphis. Levina, however, adds a few caveats. "Citizen science implies that conventional science has failed us in some ways, whereas I would argue that guidelines and restrictions that perhaps slow down conventional science are there because of valid ethical issues."

There are other potential pitfalls. Genetic testing companies that provide genome-sharing websites have been criticized for offering inconsistent results and flimsy diagnoses regarding genetic propensity to disease. There are signs that the US Food and Drug Administration is moving to clip their wings, perhaps by enforcing tougher regulation. This echoes ongoing changes to regulation of the nutritional supplements industry in the United States and Europe, which is to be treated more like the pharmaceutical industry.

Genes are not the only important considerations when developing tailored nutritional advice. The nascent science of epigenetics, which describes how and when genes are turned on and off in the body, promises to both complicate and frustrate the road to personalized nutrition.

ILG's Kornman says epigenetics is the elephant in the room when it comes to determining optimal diet: "There is growing evidence that prenatal nutrition and environmental effects have a life long and maybe multi-generational effect in terms of fetal development and early childhood nutrition." Even if we can decode the genetic recipe of the diet–health relationship, without a greater knowledge of the epigenetic modifications put in place early in life — or in a mother's or perhaps grandmother's life — this recipe still might not taste right.

What's more, can we ever over-ride our love for sweet, fatty and salty food? "People are perverse about dietary choice," says Tom Sanders, head of nutrition and dietetics at King's College London. "They tend to offset what they perceive as good food with bad food." Put another way, we are bad at eating good food, and good at eating bad food.

Nutrigenomics may well change our definition of health and disease; blur the distinction between food and drugs; between experimenter and experimentee; and demonstrate new models of the scientific method driven by food tribes, citizen scientists and online social networks. The paradox is that as our lifestyles become ever more individualized, it could be the crowd that delivers the best advice for healthy eating. ■

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