Future Food

Two radical views of 21st Century eating

Michael Heasman
& Colin Tudge

The Caroline Walker Lecture 1999

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Michael Heasman

Michael Heasman is co-founder and Editor of New Nutrition Business, the longest-established international newsletter for healthy eating and functional foods and beverages trends, and Financial Times Food Business. He has 12 year food policy research record having gained his PhD in the Food Policy Research Unit, School of Biomedical Sciences, University of Bradford. He is a frequent contributor to the food industry and academic press, regularly speaking at and chairing food industry conferences on food and health around the world. Dr Heasman is Visiting Research Fellow at the Centre for Food Policy at the Wolfson Institute for Health Sciences, London, and is Affiliate Faculty Member at the Functional Foods for Health Program at the University of Illinois, Chicago, USA. He has held previous research posts at the Universities of Reading, London and Bradford, most recently (1995–1998) as Senior Research Fellow at the Centre for Food Policy. He has published extensively on the subject of food policy and functional foods.

Colin Tudge

Colin Tudge read zoology at Cambridge in the 1960s and then became a journalist, mainly for Farmers' Weekly, New Scientist and BBC Radio 3, but has been freelance since 1990. He has published about a dozen books on food, conservation, evolution and genetics and is now finishing his magnum opus, The Variety of Life - A Survey of All Living Creatures, to be published by OUP in March 2000. Since 1995 he has been Research Fellow at the Centre of Philosophy at the London School of Economics.

The Caroline Walker Trust

The Trust was set up in memory of the nutritionist and campaigner Caroline Walker, who died in 1988. The Trust's mission is the improvement of public health by means of good food - a cause which Caroline made important to everybody in this country. The Trust, which relies on charitable donations, exists to further her work through research and publications.

The functional foods revolution

A new nutrition agenda for a new century

Dr Michael Heasman

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My special thanks go to Caroline Walker. Unlike a number of recent presenters of the Caroline Walker Lecture, Caroline was not a personal friend or close colleague, but she still touched my life. In the mid-1980s I was struggling with my PhD, which was inspired by the 1983 NACNE report, at the Food Policy Research Unit, University of Bradford. Like many PhD students, I had reached a particularly low point in my research. I was really stuck and going nowhere. I had been at a number of meetings and heard Caroline either speak or give other speakers a tough grilling! So I rang her up, told her what I was trying to do and she suggested we should meet. We met up in London and spent the morning discussing food, nutrition and my research. I remember her as inspirational and motivational – our meeting was the kick-start I needed to get going again. So with this lecture, in a small way, I hope I can repay Caroline for her kindness and giving me her time all those years ago. Thanks.

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Michael Heasman
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The functional foods revolution

A new nutrition agenda for a new century

'Functional foods' are changing the face of food and health

It is sometimes easy to forget how scientific knowledge about food and its role in health has its own history. This includes setbacks, apparent leaps forward, continuing challenges and breakthroughs, even fads and fashions and of course, politics. It is an evolving, historically grounded body of knowledge, a true meeting of science and society. For example, it is less than 100 years ago that the international community was first being told about a new discovery, the 'vital amine', and its role in diet and health. Today 'vitamins' (as they became known) are taken for granted as part of our nutritional tool kit, even if their role in the diet is still the subject of intense research and scientific debate.

It is only as recently as the 1950s that studies began in earnest on the relationship between nutrition and degenerative diseases, such as the possible connection between heart disease and dietary intakes of fat. The latter research agenda came to dominate nutrition policy in Western countries from the mid-1970s, but particularly during the1980s and continues today. 'Healthy eating' is that new.

But recent years have seen the unfolding of an equally groundbreaking and new nutrition agenda. In Europe this new agenda is being characterised as 'functional food science'. Functional food science aims to maintain health and improve wellbeing and to create the conditions for disease risk reduction. The targets are the so-called diseases of affluence – notably cardiovascular diseases and certain cancers - but also 'softer' (but important to the sufferers) health concerns such as 'stiff' joints, 'tiredness', physical performance, gut-related problems, allergies and so on. But functional food science also represents one of the more controversial areas of food and health, mainly as the result of what has become a rapid global drive to commercialise and market functional foods, often before the science is substantial or, in the worst cases, has barely started.

What is happening under the banner of functional foods is giving a new, and sometimes worrying, spin to what was at the heart of Caroline Walker's work namely good health through whole fresh food.

To explain this 'spin', in this paper I have tried to limit myself to two main tasks[1]. First, I try to set out what is meant by 'functional foods and beverages' and why this area has

come to dominate the food industry and the food and health agenda. Second, through two detailed market case studies – on the recent introduction of cholesterol-lowering products, and developments in the European dairy industry – how science, corporate ambition and nutrition marketing are mapping out this new area of food and health. In this sense my approach is unusual from previous lectures in that I focus on the food industry rather than a public policy perspective[2].

However, as a final comment I go on to consider some of the public policy issues that functional foods raise. The food industry examples I use are what I term serious developments in functional foods and beverages. As in all food markets, and the functional foods and beverages market is unfortunately no exception, there are products of dubious merit or that are downright misleading. I have chosen not to focus on these since they often detract from the bigger picture that is evolving and which I try to address here.

The functional foods revolution continues to move forward at a rapid pace – for example, at the end of October, the United States Food and Drug Administration approved a 'heart health' claim for soy protein. It is an evolving science and market and will change the way food is marketed in the new millennium.

What are 'functional foods'

But just what are these so-called functional foods? A simple definition put forward by the US Institute of Medicine is: 'Any modified food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains'[3]. But behind such a simple definition lies a vast topic. This embraces global scientific discovery heralding a 'new frontier in nutritional sciences'[4] and regulatory and policy challenges that involve redrawing the boundaries between food and medicine[5]. Not least, food companies around the world are restructuring their operations and spending literally hundreds of millions of dollars to develop and market functional food and beverage products[6]. Functional foods, therefore, serve as a window on the wider topic of food and health and changes within modern global food supply.

While the link between food and health is nothing new, the concept of functional foods only gained widespread recognition during the 1990s. The term 'functional food' was invented in Japan in the 1980s and the Japanese product Fibre Mini – a soft drink containing dietary fibre – is credited with being the world's first functional food and was first launched as recently as 1988. Seeing developments in Japan, some scientists and business consultants in the early 1990s started to actively promote the new trend of

functional foods in the United States and Europe. But even in Japan, the market for functional foods and beverages is still something relatively new. In a survey we undertook of Japanese product launches between 1988 and 1998 we identified some 1,721 'functional' products, however, 725 or 42% of these were introduced in 1997 or 1998, out of the ten year period;this rises to 946 or 55% of all products surveyed if 1996 is included[7].

Within the United States in particular, the concept of functional foods fell upon fertile ground. For example, the term 'designer foods' was coined in 1989 by Dr Herbert Pierson, then director of the National Cancer Institute's $20 million Designer Foods Program, to describe foods which naturally contain or are enriched with nonnutritive, biologically active chemical components of plants (phytochemicals) that are effective in reducing cancer risk. Also in 1989 in the US, Dr Stephen DeFelice, chairman of the Foundation for Innovation in Medicine, invented the term 'nutraceutical', to refer to any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease.

A characteristic of discussions about functional foods/nutraceuticals is over the actual words and definitions used to describe these new food and health developments, especially as companies struggle to make 'health claims' for products. Often 'nutraceutical' is used to describe the bioactive ingredient that can deliver a health benefit and this 'nutraceutical', in turn could be used in a capsule, pill, powder or foods and beverages, thus you get a functional food. However, the terms 'functional food' and 'nutraceutical' are often used to mean the same thing, with a preference in the food industry for the term functional food, while 'nutraceutical' is increasingly being associated with dietary supplements (that is, pills and capsules). You are free to choose your favourite term! The important point, however, is that currently there is no legal definition for functional food or nutraceutical in Europe or the United States.

Functional food', however is a convenient tag, and is used throughout this paper. It does not describe a distinct food category as used by market analysts, such as 'confectionery' or 'snack foods', but is a concept which describes a fast growing range of food industry developments that cuts across traditional food and beverage categories.

Raising the profile of functional foods

In raising awareness about the concept of functional foods, in both Europe and the United States, the International Life Sciences Institute (ILSI) has been instrumental in developing a science based approach to functional foods. But there have been other

pioneers – from individuals to food companies and academia. Notable within the United States has been the Functional Foods for Health Program (FHP) based at the University of Illinois, at Chicago and Urbana-Champaign under the leadership of Dr Clare Hasler and Professor Norman Farnsworth. The program has gained support from a virtual 'who's who' of American companies with an interest in functional foods, illustrating the importance the US food and pharmaceutical industries attach to functional foods. Table 1 lists these current industrial affiliates to the FHP. Another university based initiative is The Nutraceuticals Institute, an alliance of Rutgers, the State University of New Jersey and Saint Joseph's University, Philadelphia, set up under the leadership of founding director, Dr Nancy Childs and Executive Director, Professor Paul LaChance.

Table 1
Industrial Affiliates of the Functional Foods for Health Program, University of Illinois (July 1999)

Ocean Spray; Monsanto; Archer Daniels Midland Company; Cargill; Protein Technologies International; Mead Johnson Nutritional Group; Nestle USA, Inc.; Welch's; McNeil Speciality Products Company; ConAgra, Inc.; Kraft Foods, Inc.; General Mills; Almond Board of California; California Prune Board; Reliv International, Inc.; Hershey Foods Corporation; SunStar, Inc.; Warner Lambert; Tropicana North America; Pulsar/Seminis Vegetable Seed Co.; Ross Products Division; Abbott Labs; National Honey Board; Pharmavite Corporation; Nabisco, Inc.; Novartis Consumer Health; McNeil Consumer Health Care

Source: The Newsletter for the Uni. Of Illinois Functional Foods for Health Program (1999)

In Europe, the functional foods tour de force has been Professor Marcel Roberfroid, based at the Universite Catholique de Louvain, Brussels, Belgium, and past president of the International Life Sciences Institute (ILSI). In addition, in Europe, all the major food research institutes, such as TNO in the Netherlands, VTT Biotechnology and Food Research in Finland and the Institute for Food Research in the UK, have dedicated research programmes or projects on functional foods as do most major food and ingredient companies.

The vision for functional foods

But why is there so much interest in functional foods, especially when no one can agree on a definition? There are three major factors driving the functional foods revolution:

- Behind the functional foods/nutraceuticals revolution, and driving developments, lies a truly ambitious health vision for the developed and developing world
- Food companies have bought-in to what market research describes as a new type of consumer for 'health'
- Shareholder imperatives drive corporate ambition in functional foods. In highly competitive food markets with tight margins and slowly growing food sales, but with shareholder demands for rapid financial growth, functional foods are seen as a way to achieve added value growth and profitability.

A truly ambitious health vision

For the developed world the 'vision' of functional foods, if ever realised (and it is still a big IF), would mean a fundamental change in diet. Functional foods is about manipulating and constructing foods and diets to not just maintain well-being or a 'balanced' diet, but a diet that actively participates in shaping health status. This would be achieved through the enhanced consumption of specific dietary components that have been scientifically tested, including human clinical trials, to demonstrate particular health benefits.

The other fundamental difference in the functional foods revolution from current nutrition, is that such dietary components would be difficult to obtain through a 'normal' modern diet. The example given to illustrate this point is folate acid and the prevention of neural tube defects in babies. Although advocates of functional foods are not suggesting the fortification of foods, it is cited as an example of the principle where a dietary component (folate acid) with a proven health benefit, is difficult to obtain in sufficient quantities through the normal diet to achieve the health benefit. In the case of folate it has been incorporated into general food supply through food fortification. Functional foods, through consumer choice rather than fortification, seek to deliver a recognised health benefit that is difficult to achieve through 'normal' dietary practice.

Therefore, the functional foods revolution, in one sense, is about constructing a future 'unbalanced' diet skewed towards optimum health! Or, in the language of food marketing, the focus is now on supplementing the diet with something 'good', about adding benefits, rather than taking something 'bad' out. 'Bad' in this case meaning dietary components such as fat and sugar. In short, functional foods means there are now 'good' foods in the diet, although this view is challenged by many in the food business (and, strangely there are still no 'bad' foods, only poor diets).

Put simply, therefore, the scientific challenge is all about identifying the individual components of plants and other foods that can both prevent disease and illness, but also

enhance and prolong healthy and active life. It means developing diet-based disease prevention strategies and formulating foods tailored to meet specific health needs. A key goal of functional food science is to understand and target particular 'biomarkers' for disease and illness and the food components that act upon these biomarkers. Stripping away the scientific jargon, this could mean, for example, delaying the ageing process; stopping certain cancers from forming; reducing the risk of diseases such as cardiovascular disease; improving the immune system; maintaining and improving physical and mental functioning; and many more such dietary interventions to 'optimize nutrition'.

Although not addressed in this paper, the functional foods revolution does not stop at the developed world. In developing countries it could mean delivering vaccines through food products such as bananas, or growing rice with high concentrations of vitamin A to help prevent blindness, and other such nutritional interventions.

A fundamental shift in nutrition thinking?

The scientific (and commercial) 'holy grail' is to find the actual component in a food that impacts on human health and the relevant human 'biomarker' it acts upon. Taken to its logical conclusion this is a fundamental shift in the use and application of nutrition science. A recent example serves to illustrate this shift.

In April this year US government researchers, publishing in the prestigious Journal of the American Medical Association (JAMA)[8] , recommended that the US daily allowance for vitamin C should be doubled or tripled in light of increasing evidence of its anti-cancer potential. The authors point out that diets with 200 mg or more of vitamin C from fruits and vegetables are associated with lower cancer risks, especially for cancers of the oral cavity, oesophagus, stomach, colon and lung.

The current US RDA for vitamin C is 60 mg per day and is still based on preventing scurvy, but the researchers from the National Institutes of Health say that since 1989 extensive new biochemical, molecular, epidemiologic and clinical data have become available. The researchers propose a new RDA of 120 mg/d and an 'adequate intake' of 200 mg/d. They suggest an upper limit of 1g per day.

Importantly, the researchers propose that the higher vitamin C intakes should come from eating at least five portions of fruits and vegetables daily. They say five servings of fruit and vegetables appear to be protective. They speculate that fruit and vegetable intake may be associated with lower cancer risk not because of vitamin C alone, but 'perhaps

because of interactions between ascorbate and bioactive compounds in these foods, or because of compounds independent of vitamin C, or because of characteristics of people who eat fruits and vegetables'.

However, in terms of functional food product development, new science like this is being used to develop new products that deliver the 'benefits' of antioxidant vitamins, like vitamin C.

The scope and challenge of functional foods

The scope and scale of the potential for functional foods is staggering. The full spectrum of human disease and illness is under investigation. Table 2, for example, summarises, the areas of scientific enquiry underway in Europe in relation to functional foods. While Table 3 lists some of the actual foods being studied for their functional food/nutraceutical benefits. Functional foods could be targeted at virtually all diet-related disease and ill-health and the whole diets of healthy individuals. It already includes most of the modern food supply from dairy products, grains and cereals, fruits and vegetables, fish and more recently, has been extended to meat.

Table 2
Main areas of scientific investigation in Europe in relation to functional foods

- Human growth and development (especially among infants and young children and during pregnancy)
- Obesity
- Diabetes
- Cancers
- Malnutrition (for example, among the elderly)
- Exercise and diet
- The role of antioxidants in disease prevention (especially vitamins A, C and E, the flavonoids and carotenoids)
- Cardiovascular disease
- Gastrointestinal function and physiology
- Behaviour and psychological functions

Source: Adapted from Bellisle, F. et al. (1998)

Table 3
Functional Foods: Their role in disease prevention and health promotion

Functional Foods from Plant Sources

Oats — Source of cholesterol-lowering soluble fibre

Soy — Thought to play preventative and therapeutic roles in cardiovascular, cancer, osteoporosis, and the alleviation of menopausal symptoms

Flaxseed — Research focus on lignans and their role in human health

Tomatoes — Interest in lycopene, the primary carotenoid found in tomatoes, and its role in cancer risk reduction

Garlic — Wide range of purported health benefits including cancer chemopreventative, antibiotic, anti-hypertensive, and cholesterol-lowering properties

Broccoli and other Cruciferous Vegetables — Epidemiological evidence has associated the frequent consumption of cruciferous vegetables with decreased cancer risk

Citrus fruits — Evidence suggests citrus fruits are protective against a variety of human cancers

Tea — Attention directed to the polyphenolic constituents of tea, particularly green tea

Wine and grapes — Growing evidence that wine, particularly red wine, can reduce risk of cardiovascular disease

Other functional foods

Fish (Omega-3 fatty acids)

Dairy Products (prebiotics and probiotics)

Source: Hasler, (1998) [9]

Functional food science is seen as quite distinct from the medical or pharmaceutical sciences. While part of nutrition science, functional food science is defined as having the objective to maintain health and improve well-being and to create the conditions for disease risk reduction. In contrast, medical and pharmaceutical sciences seek mainly to cure disease[10]. The functional foods vision is only blunted by the extent of scientific understanding still required in many areas to understand the mechanisms behind dietary components and disease prevention.

Functional foods are therefore, about entering new and uncharted territory for much of the food industry. However, a great deal of market activity suggests that many food companies do not grasp this difference and still see functional foods in very much the same light as 'flavour of the month' or the latest line extension and behave accordingly. Using people's fears, worries or concerns about their health and future disease (in a very different way from concerns about too much fat or sugar) and even addressing people's already diagnosed medical conditions, as a basis for product development and the marketing of foods on a wide scale is fundamentally different. For the food industry it calls for a new approach to product innovation, and the marketing and the communication of food and health issues, not least in terms of ethical marketing. It is a challenge that few in the food industry are currently meeting convincingly.

It is perhaps for this reason that even as we talk more generally about 'functional foods' many food companies (and their PR advisers) are now trying to distance themselves and their products from the term (for example one ingredient company told me they are going through all their company literature to make sure the word 'functional' is deleted!). 'Functional foods' in their short life have already attracted a great deal of negative comment. This is mainly because the term is used to embrace the truly awful products together with many that have a solid and peer-reviewed science behind them, and also because of the way regulatory authorities are now looking at these new products.

The new consumer health trend

One reason why I believe the functional foods revolution is unstoppable, is that the world's food businesses have bought-in to what they see as a new consumer relationship with health, which includes attitudes to food. Allied to this, in developed countries, food companies believe the marked demographic changes that will appear over the next 30 years (one generation), in particular an ageing population, will reshape food markets.

Overwhelmingly companies are seeing international consumer research which they believe describes a new type of consumer for 'health', a consumer who is interested in preventative (self-medication) rather than therapeutic health strategies, who appear as empowered and nutritionally aware and are seeking personal control of their own health and well-being. In countries such as the United States, the staggering personal financial costs of healthcare are also a strongly motivating factor.

Health is the 'heavy' trend

Health is seen as the 'heavy' trend in modern food eating. For example, this was one of the main themes developed in a presentation on changing habits of the consumer by Larry Hasson of the French-based international Research Institute on Social Change (RISC) given at the European Food 2000 Seminar in Helsinki in September 1999, an event organised as part of Finland's first ever Presidency of the European Union.

In a complex analysis based on RISC's Anticipating Change in Europe Programme – an annual questionnaire of some 140 socio-cultural questions administered to a

representative population sample of 2,500 in the five main European markets – Mr Hasson described what he calls the different 'logics' of the European food consumer.

The 'mega' trends for food RISC had identified are:

- Pleasure
- Quality (especially for the 50+ age group)
- Innovation
- Compulsion (associated with the young and 'masculine logic')
- Continuity (number of product 'supporters' increases with age, especially after 50)
- Health

Mr Hasson broke the 'health' trend down further into five main areas of consumer concern:

- Expertise (people want diet and nutrition know-how)
- Morals (for example, fat and sugar 'phobias')
- Caring (people want to be pro-active, for themselves and others)
- Compensation (the 'plus' products, for example functional and enriched foods)
- Restriction (the 'less' products, for example, less fat)

It was interesting how the 'health' trend was expressed in different European countries. For example, Mr Hasson explained the French and Italians are Europe's health and nutrition 'experts' and are more attentive to nutritional information. But, on the other hand, the British and Germans are least worried about their health, but buy most 'medical' type products.

It is consumer trends like these that food companies are seeking to exploit through functional foods.

Shareholder imperatives drive corporate ambition in functional foods

While functional foods are changing the face of the nutrition map, we should not lose sight of the background to this development. Functional foods, or more correctly food and health issues, have to be seen in the context of a global food industry faced with falling margins in traditional product markets, an industry driven by the new challenges and economics of shareholder imperatives. This often means massive restructuring and consolidation, along with immense pressure to derive 'value added' in often saturated product markets to drive the double digit growth demanded of financial markets.

The earlier 'healthy eating' revolution of reduced fat, fat free and sugar free pointed the way to the immense gains to be had from food and health trends. Let's not forget, for example, it was as recently as 1983 that the first ever kilogram of the artificial sweetener aspartame was sold in Europe; today the world market for aspartame is close to 14,000 tonnes and the leading company in this area NutraSweet, was recently put up for sale by its parent company Monsanto. The NutraSweet Kelco company, which sells other food ingredient products, had sales of $1 billion in 1998 and Monsanto were putting a price tag of $2 billion on the combined business.

Consumer goods company Procter & Gamble is reported to have spent more than $200 million on developing its fat replacer olestra which finally won US Food and Drug Adminstration approval in 1996 for use in snack products. The fat replacer was taken up by PepsiCo's massive snack division Frito-Lay to produce a fat-free potato crisp called WOW! In 1998 WOW! became America's best-selling new brand earning $347 million in sales, beating other consumer brands from companies such as Gillette, Polaroid and Kodak. Fat-free still is big business.

And it is not just food ingredients, such as sugar and fat substitutes, that offer such big market potential. Healthy eating brands also offer rich rewards. Although no longer the brand star it once was, this lesson is illustrated by Nabisco's SnackWell range of low-fat and fat-free cookies and crackers which achieved US sales of around $500 million within two years of launch. There are many other examples of 'healthy eating' product successes (and failures).

The important point is that many in the food industry now regard functional foods as the next step. This is why the food industry is in a hurry to search the world for the next 'blockbuster' healthy eating ingredient, which it believes this time will be a functional/nutraceutical ingredient.

The challenges around functional foods

Around the world there are already literally thousands of products with supposed health benefits available on the market. This trend in products is accelerating fast. The commercialisation of food and health is taking place on an unprecedented scale, using functional food science as a rapid market stepping stone. Products range from the good, the very bad to the indifferent.

But collectively, they raise a number of critical questions fundamentally different from past 'healthy eating' products. This includes questions about the place of science in product development, on the interpretation of risk and disease and illness, marketing

communications, the regulation of such products and, last but by no means least, the public health implications of such products.

Functional foods/nutraceuticals therefore raise a number of wide-ranging challenges which I summarise under four main headings:

Food industry challenges: how should products be developed and marketed? In the market case studies detailed below I illustrate how the food industry is currently creating functional food markets.

Consumer challenges: while companies are busy market testing functional food concepts, consumers are also 'testing' whether they really need or want such food products. Key concerns are: can the experts be believed; do functional foods do what they say they do; how much and for how long do you have to eat them to get any health benefit; are they affordable and do they taste any good? I have laid out the challenge to consumer policy in a recent article in Consumer Policy Review, published by the Consumers' Association in the UK.

Regulatory and policy challenges: Many functional foods and ingredients fall into 'grey' regulatory areas, not least in what can be said in marketing materials and packaging about their health benefits. Also many food and health policy experts are questioning the relevance of functional foods. Many critics of functional foods are concerned that they represent an unwelcome 'medicalisation' of food supply. The key debate, however, around functional foods remains on the issue of health claims and the regulation of these. For example, it is expected the European Union will have some form of health claim legislation in place in less than two years. But how should authorities regulate to allow consumers to make the informed choices between 'good' and 'bad' functional foods, how should they act as enforcement agencies in this area? There is also the challenge to create an appropriate regulatory environment to stimulate investment and innovation.

Scientific and nutritional challenges: there are new scientific developments in the nutritional sciences that have growing and convincing evidence. What are the implications for nutrition and regulatory policies about food and should recommendations be made to the public? There are other instances where, unfortunately, compelling scientific evidence will not substantiate beliefs in the health benefits of selected foods. The problem at times is where is the dividing line – in other words just how much science is enough and what should be the response to a lack of scientific proof when this is used in the marketing of food products and dietary supplements?

The market for 'functional foods'

To date, functional products on the market still contribute limited revenue in terms of total food sales, but their significance to companies far outweighs their current market values. At this stage of market development, market researchers are often vague about what products or product ranges actually make up 'functional foods'. The best that can be said is that compared to the total food and beverage market, functional foods currently represent a tiny niche. Market estimates are unreliable and should be treated with caution, but as a possible historical benchmark, in 1997, in Europe the functional foods market has been valued at $1.25 billion; in the United States as $14.7 billion; and in Japan as $11 billion. For comparison, the global food market is estimated to be valued at more than $750 billion. Estimates for the size of the functional foods/nutraceuticals market vary considerably. One, for example, suggests by 2010, by value, 25% of European food sales could be 'functional'; while for the US it has even been argued one half of all food sales are already 'nutraceutical'![11]

Over the past two to three years, however, there has been a remarkable market re-positioning by food companies, especially ingredient suppliers, declaring the extent of their commitment and investment to functional foods. This includes companies such as Nestle, Kellogg, Unilever, ConAgra, Nabisco, Quaker, virtually every major European dairy company (sadly this excludes most UK companies since in functional foods as in other areas of innovation they are the laggards of Europe), DuPont, Monsanto and Novartis. Many of these companies have set up 'functional food' or 'human health' divisions to exploit market opportunities.

For example, in the United States The Kellogg Company, always a pioneer in nutritional products, announced in 1997 that it was investing $65 million to provide support for its new functional foods division.

Even the world's global PR agencies, such as Hill & Knowlton which handles the Kellogg and Benecol accounts (see below), are said to be setting up specialist 'functional food' operations to meet the new challenges of food and health communications.

In short, functional foods/nutraceuticals are

- setting public, industry and scientific research agendas
- challenging the regulatory systems governing food and drugs

- raising concerns among consumer advocacy groups and public health professionals around the globe
- creating marketing and business challenges that have already seen soaring share prices and exceptional profits for some companies.

Other companies, however, have already lived to see their functional food efforts disappear down a black hole of consumer indifference, hostile media coverage and regulatory red tape.

Case studies and examples of the marketing of functional foods[12]

In this section I give more detailed accounts of the marketing and business activity on a selection of functional foods. The purpose is two-fold. First to illustrate the global or international perspective on functional foods because what we see in the UK is just the tip of a global industry. Second, is to demonstrate the business importance of functional foods. The focus here is very much on the business, rather than the science, of functional foods. These examples serve to illustrate the big trends in the commercialisation of nutrition and functional foods.

The two areas chosen to illustrate these trends are:

- Cholesterol lowering functional foods (particularly Benecol)
- Probiotics and the European dairy industry - its a bug's life

These examples illustrate the fact that functional foods and nutraceuticals are being targeted at two populations – first, those who have a recognised medical condition, disease and illness and, second, those who are a 'healthy' normal population. This is an important, and often overlooked, distinction to bear in mind.

Cholesterol lowering functional foods

In the food industry in Europe and North America one product in particular has come to symbolise the power and potential of functional foods. Called Benecol, it has now become familiar to UK consumers since its UK launch in March 1999.The Benecol range consists of a regular and reduced fat margarine and two cream cheese-style spreads and all carry the on-pack claim: 'Helps actually lower cholesterol as part of a healthy diet' and are being promoted as: 'a new tool in the dietary management of cholesterol'. The reason this is important in disease prevention is that elevated cholesterol levels in populations have been demonstrated as increasing the risk of heart disease.

Benecol is seen as fundamentally different from other food products with implicit health benefits because the product contains a (functional) ingredient called plant stanol esters (produced from plant sterols as a by-product from wood pulp) that have been demonstrated in human clinical trials using the margarine on a daily basis, to lower elevated levels of total blood cholesterol by more than 10% (14% in the case of 'harmful' LDL cholesterol).

However, Benecol is not a British product and is not even marketed by a British company. Benecol margarine was invented and developed by the until recently relatively unknown Finnish company called Raisio with interests in chemicals, grains, animal feeds and margarine. Benecol margarine was first launched in Finland in 1995. The product sells for roughly four times the price of butter in Finland and now has around a 15% value share and 2.7% volume share of the Finnish margarine market. But its potential outside Finland quickly became recognised and Raisio soon had companies knocking at its door.

The winner was McNeil Consumer Nutritionals, part of the massive United States healthcare company Johnson & Johnson, which secured world-wide licensing rights from Raisio for Benecol in 1998. McNeil are now busy targeting the 200 million plus people in the US and Europe who it is estimated have elevated levels of blood cholesterol and spending a reported $37 million in promoting Benecol world-wide. The UK was McNeil's first country launch for Benecol. This was followed by further country launches, to date, in the United States, the Netherlands and Belgium. Launches in Germany, France, Spain and Austria are also planned.

The interest in Benecol has stirred Unilever, the world's largest margarine maker and the world's third largest food transnational, with sales in 1998 of £50 billion, into action. Unilever has also developed its own cholesterol-lowering margarine, again based on plant sterols, but in this case the active ingredient is sourced from vegetable oils such as soya (which Unilever say is GM-free). In the United States Unilever were able to launch their Benecol competitor, which is called 'Take Control', at the same time as Benecol (in the US, in October, Benecol had a clear market lead with a 70% market share of cholesterol-lowering edible fats according to product trackers Information Resources Inc.). However, in Europe, where the Unilever product will be branded 'Pro-activ', Unilever's plans have been thwarted by regulators. Unilever submitted Pro-activ to review under European Union novel foods regulation (Raisio did not have to do this with Benecol since it was launched before the EU novel foods regulation was introduced) in December last year. However, some Member states have raised

objections to the product which blocked the subsequent launch (Finland was not one of these countries). In particular, the Germans have raised the most serious concerns, asking whether the margarine should be treated as a 'medicine' not a food. At the time of writing the European launch of Pro-activ is still delayed.

In the meantime, Unilever has introduced Pro-activ to the Australian market this summer, where it is sold at four times the price of regular spreads, and in the first seven weeks since launch achieved a 7% value share and 2% volume share of the Australian spreads market. The product was launched in New Zealand in October. At the time of the planned European launch Unilever were also said to be looking to introduce the product in Latin America, starting with Brazil..

Back in the United States, however, McNeil is taking the Benecol cholesterol-lowering concept into new categories. Benecol salad dressings are already on sale and Benecol snack bars are also said to be planned for roll-out by the end of 1999. Other companies, such as Novartis and Monsanto, are also said to have cholesterol-lowering ingredients and products in the pipeline and the product concept of 'cholesterol lowering' is being taken up by a whole host of food competitors – the latest being soy producers who secured a FDA approved health claim for soy protein in relation to heart disease, based on soy protein's potential to lower cholesterol, on October 25th.

The Benecol story illustrates the key factors driving functional foods:

- The new ways nutrition science and 'functional food science' is being commercialised and used to develop food products
- The global character of the marketing and technology
- The focus on making an everyday food product a part of 'disease prevention'
- The regulatory and policy difficulties these products present (for example, in the US McNeil first tried to introduce Benecol under US dietary supplement regulation to enable the company to make stronger health claims, but this move was stopped by the Food and Drug Administration)
- The commercial significance of functional foods to the food industry

This last point is also graphically illustrated by Benecol, because functional food companies are now seen by City money makers as potential goldmines. As the table below illustrates, on the back of Benecol (launched in Finland in November 1995), at one stage Raisio's share price had risen15-fold in three years and foreign ownership in the company increased from under 10% to nearly two-thirds.

Table 4
Raisio's share price and foreign ownership at selected dates 1995-1999

DATE	SHARE PRICE *(Finnish Marks)*	FOREIGN OWNERSHIP *(%)*
March 1995	6.00	8.98
March 1996	15.31	38.31
December 1996	28.84	50.87
December 1997	61.91	57.88
June 1998 (NOTE 1)	94.90	63.84
September 1999	44.42	47.94

(NOTE 1: Share price split adjusted June 26 1998)
Source: Raisio, 1999

While Raisio and Unilever illustrate the development of functional foods targeted at a specific medical condition (elevated blood cholesterol and the possible reduction in the risk of heart disease) it is still the dairy industry throughout Europe that continues to plough its lone furrow of products with 'positive' health benefits for healthy people.

Functional foods and gut health - It's a bug's life!

In Europe, spearheading dairy functional foods have been products that help the health-promoting bacteria that live in the human gut! Functional food science has stimulated a renewed interest in gut health, in particular through the activity of the micro-organisms that live in the gut and make up the gut microflora – the importance of which had become a neglected area in European research.

The way in which diet influences a 'healthy' gut microflora has been of increasing scientific interest over the past decade. When we are first born, the gut contains no microflora (the womb is a sterile environment) and the large-gut microflora is acquired after birth. The species of gut bacteria that develops is largely controlled by the type of diet since it has been shown that the composition of the gut microflora will vary depending if the baby is breast-fed or bottle-fed. After weaning, a pattern that resembles the adult microflora becomes established.

The gastro-intestinal microflora represents an ecosystem of the highest complexity[13]. The gastro-intestinal tract (GIT) of an adult human is estimated to harbour 10^{14} viable bacteria; this equates to about 95% of all cells in the body. It is estimated that the colon

of healthy adults contains about 300 to 400 different cultivable species belonging to more than 190 genera. In general terms, intestinal bacteria may be divided into species that are either harmful or beneficial towards host welfare. Through the process of fermentation, colonic bacteria are able to produce a wide range of compounds that have both this positive and negative effect on gut physiology.

This has led to increased interest in gut bacteria called lactic acid bacteria (LAB) and the concepts of 'probiotics', 'prebiotics' and 'synbiotics'. These are briefly introduced below.

For thousands of years microbial cultures have been used to ferment foods and prepare alcoholic beverages. Food products such as soy sauce and pickles, salami type sausages and dairy products such as yogurt and cheese, as well as alcohol production have relied upon the fermentation properties of lactic acid bacteria (LAB) for their production. But it was only while investigating an industrial problem besetting the alcohol producers of Lille in France, who produced alcohol made from sugar beet, that Louis Pasteur, professor of chemistry at the University of Lille, first identified the role of lactic acid bacteria in fermentation in 1857. It was not until 1965 that the term 'probiotic' was first used to describe beneficial micro-organisms by Lilley and Stillwell. [14]

'Probiotics'

Most prominent in terms of the marketing and product development of functional foods in the dairy industry has been the use of probiotics. Detailed market activity is described below, but to understand the significance of this activity it is crucial to grasp some of the scientific background to probiotics (and prebiotics and synbiotics). The classic definition of probiotics is: 'live microbial feed supplements which beneficially affect the host animal by improving its intestinal microbial balance'[15]. Evidence is accumulating from well-designed, randomised and placebo-controlled double-blind studies that a few well characterised LAB strains have documented probiotic health promoting effects when defined doses are administered [16]

The concept behind increased interest in products containing viable probiotic LAB is the possibility of manipulating the composition of the gut microflora by foods or food ingredients. The aim is to increase the numbers and activities of those microorganisms suggested to possess health promoting properties such as Bifidobacterium and Lactobacillus species.

Table 5 lists some of the areas where probiotic LAB have been investigated and may have a health role, although it should be noted most studies have been conducted on adults and

children with intestinal or other disorders. It is not my purpose here to try to review or comment on the science behind probiotic LAB, other than to highlight the increasing knowledge underlying the importance of the role of intestinal flora in maintaining health and in disease prevention. For example, as Holzapfel et al (1998) conclude:

'Probiotics offer dietary means to support the balance of intestinal flora. They may be used to counteract local immunological dysfunctions, to stabalise the gut muscosal barrier function, to prevent infectious succession of pathogenic microroganisms or to influence intestinal metabolism'

The authors point out, however, that many of the proposed mechanisms have still to be validated in controlled clinical trials.

In terms of the marketing of probiotic products it is important to distinguish between probiotic LAB that have been shown to reach and colonise the human gut and have health promoting benefits and many 'live' or 'bio' yogurts that are on sale in the UK for example, where the LAB is used as a food processing aid. In these cases there usually is limited evidence that the LAB are alive in the product as consumed and/or in sufficient numbers to reach the lower gut, nor that they have any proven human health benefits. For example, in a paper examining the therapeutic potential and survival in yogurt of certain LAB, Kailasapathy and Rybka (1997)[18] cite research from Australia, they say:

'The range of yogurts and dried yogurt preparations available in Australia that contain probiotics is large. However, evaluation by the Dairy Research Laboratory…showed that probiotic organisms are often not at high levels…Strains of bifidobacteria used in some commercial products neither survive product acidity during storage nor gastric transit…It is considered misleading to describe probiotic yogurt as having health promoting properties unless the minimum level of viable cells is present at the expiry date'

In other words, not all probiotics are equal and research will differentiate them. A number of scientifically validated probioitic LAB have been identified and being used to develop functional foods (see below). In terms of food products, it seems a key requirement for probiotic LAB should be their ability to reach the lower gut and to temporarily colonise it. This in turn, depends on what are called the 'colony forming units' (cfu) available, that is the number of health-promoting LAB in the product. Although variable for particular LAB strains, a figure of 10^9 cfu's seems to be a 'gold' standard for product developers to aim for.

Table 5
Areas where probiotics may have a role in human health

Intestinal Disorders :
Diarrhoea (Antibiotic induced, Travellers, Infantile), Constipation, Colitis, Salmonella and Shigella infections, Lactose intolerance, Flatulence

Other Disorders:
Vaginitis, Alcohol-induced liver disease, Cancer, Hypercholesterolaemia

Other Uses:
Stabilization of gut flora, Recolonization of bowel after antibiotic treatment, food allergies, Adjuvant for vaccines

Source: Goldin (1998) [19]

'Prebiotics' and 'Synbiotics'

The concept of 'prebiotics' is an even more modern invention than 'probiotics', being first introduced in a paper by Gibson and Roberfroid as recently as 1995[20]. In this paper they define a prebiotic as: 'a nondigestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health'. By a 'limited number' they mean beneficial bacteria.

To date, while many substances have been suggested as prebiotics the most convincing science and the only recognised prebiotic are ingredients called fructo-oligosaccharides. The most popular in current food use are the chicory fructans - inulin and its enzymatic hydrolysate oligofructose. Prebiotics, such as the range of oligosaccharides, are increasingly regarded as having the properties of other dietary fibres and their subsequent role in human health in this respect continues to be investigated.

A pioneering company in prebiotics derived from chicory is Belgium-based Orafti who have supported an extensive research programme in the health benefits of inulin and oligofructose. In Europe, more than 700 products now contain Orafti's ingredients, although not all necessarily for their prebiotic health benefits.

In the same 1995 paper Gibson and Roberfroid also introduced the concept of 'synbiotics', defining a 'synbiotic' as: 'a mixture of probiotics and prebiotics that beneficially affects the host by improving the survival and implantation of live microbial dietary supplements in the gastro-intestinal tract, by selectively stimulating the growth and/or by activating the metabolism of one or a limited number of health-promoting bacteria, and thus improving host welfare'.

Table 6 illustrates examples of the wide range of probiotic, prebiotic and synbiotic products that have been introduced in Europe. While Table 6 shows many products on the European market are described as 'synbiotic' in that they contain probiotic and prebiotic ingredients, in the strict terms of Gibson and Roberfroid's definition, this is an erroneous (if still convenient) description since the concept of 'synbiotic' still remains to be scientifically validated. By this is meant while the probiotic alone may be demonstrated as beneficial to the host, and the same for the prebiotic alone, there is little scientific evidence that the two act or work together in 'synergy' as suggested by the synbiotic concept. This of course does not negate the individual role of the probiotic and/or prebiotic in the product.

Table 6
Examples of European dairy-based products with a health claim

Company	Product	Countries	Type
Aldi	Bl'AC	Germany	Synbiotic
Aldi	Biotic Plus Oligofructose	Germany/Holland	Synbiotic
Besnier	BA	Many EU countries	Probiotic
Besnier	Jour apres Jour	France	Prebiotic
Candia	Silhouette Plus	France	Prebiotic
Danone	Actimel Casei	Many EU countries	Probiotic
Danone	Actimel Cholesterol Control	Belgium	Synbiotic
Danone	BIO	Many EU countries	Probiotic
Ehrman	DailyFit	Germany	Synbiotic
Emmi	Actifit-Plus	Switzerland	Synbiotic
Migros	ProbioPlus	Switzerland	Synbiotic
MKW	Tuffi Vita	Germany	Probiotic
Mona	Fysiq	Holland	Synbiotic
Muller	ProCult3	Germany	Synbiotic
Nestle	LC1	Many EU countries	Probiotic
Nutricia	Fyos	Belgium	Prebiotic
Sudmilch/ Stassano	Vifit	Many EU countries	Synbiotic
Tonilait	Symbalance	Switzerland	Synbiotic
Yakult	Yakult	Many EU countries	Probiotic

Source: Coussement (1997) [22]

Within European markets, but especially in Northern European countries such as Sweden, Finland, the Netherlands, France, Germany, Belgium, Denmark and the United Kingdom, the 'health of the gut' has already become the major functional foods battleground. In this section I describe the marketing battle lines and the main areas of engagement through a detailed examination of the use of probiotic lactic acid bacteria by dairy companies to deliver products with positive health benefits to consumers.

In a commercial setting a number of probiotic LAB, supported by strong scientific dossiers, are currently driving product development, what we call the 'power probiotic LABs'. Many large dairy companies throughout the world are working on their own 'power' LAB for commercial use.

The 'power' probiotic LAB being successfully marketed internationally and driving product development in Europe, include:

- *Lactobacillus casei Shirota* from Yakult Honsha Co. and marketed in Europe from 1994;
- Nestle's LC1 *(Lactobacillus johnsonii La1)* already available in a number of European countries, but most successfully to date in Germany;
- Danone with their Actimel products using *Lactobacillus casei Imunitass*;
- *Lactobacillus GG* from Finland's largest dairy company Valio and now licensed in 23 countries.
- *Lactobacillus plantarum 299v* from Swedish food research company Probi AB, and being successfully introduced in products by Sweden's second largest dairy Skanemejerier.
- Swedish science-based company BioGaia Biologics and their LAB *Lactobacillus reuturi*

These companies split very neatly between the activities of smaller, innovative pioneering research-based companies and the R & D and marketing muscle of some of the world's largest dairy companies.

The world's most widely studied probiotic over the past 10 years is *Lactobacillus GG* (LGG) which was first isolated in 1985. It was discovered by two American scientists, Sherwood Gorbach and Barry Goldin, but it was Finnish dairy company Valio that spotted the opportunity and secured world-wide commercial rights for LGG and has supported its subsequent scientific and commercial development. The world's first LGG products were the Gefilus range of dairy products and juices, first introduced in Finland in 1990. Since then, Valio have licensed LGG for use by companies in 23 countries.

LGG is a true 'power' probiotic LAB. LGG has been shown to have the ability to:

- Remain alive and active both in food and capsules
- Tolerate conditions in the digestive tract
- Attach to the mucous membrane of the intestine and to bowel mucus, and to boost immune response
- Balance the micro-flora of the digestive tract
- Influence bowel metabolism and to impede the formation of harmful compounds
- To prevent and treat different types of diarrhoea
- Repair mucous membrane damage and the immune barrier of the mucous membrane
- Accelerate recovery from milk allergy and to reduce atopic symptoms

Battle of the little bottles

However, the most high profile development in European functional dairy products has been in the area of fermented milk drinks containing probiotic LAB and sold in tiny, 'daily dose' bottles. However, it is not a European dairy company that has created or pioneered this market, but a Japanese company called Yakult Honsha.

Yakult Honsha is an unusual company which has been developed entirely around the discovery of the probiotic LAB Lactobacillus casei Shirota, named after the discoverer and company founder Dr Minoru Shirota. Dr Shirota, a medical doctor, discovered the bacterium in 1930 and his lifelong philosophy was 'prevention above cure'. It is this same philosophy that still guides Yakult today. The Yakult company was founded in 1955 (and Yakult like many 'functional' foods has therefore been around long before the term 'functional food' was ever thought of!). In 1998 Yakult Honsha had total sales of around £770 million, of which more than half (£425 million) was from milk-based products.

Before entering the European market in 1994 Yakult was on sale in 11 other countries and the company says over 26 million people in the world drink Yakult everyday. Around 500,000 bottles of Yakult a day are consumed in Europe, 120,000 in the UK alone. Earlier this year first Tesco, then Sainsbury's were selling 1 million bottles a month.

Europe's biggest dairy companies took a long time to wake up to the success of the 40-year old Japanese functional fermented milk drink, sold in its 'daily dose' 65ml bottle, but have now begun introducing look-a-likes or 'me-too's' throughout Europe. French-based dairy company Danone was first on the trail, bringing out its Actimel probiotic in a 'daily-dose' package similar to Yakult's in early 1997. Nestle was third into the fray with LC1 Go, a variant on their successful LC1 probiotic yogurt in a package which, like Danone's early versions of Actimel, also bears a striking similarity to Yakult.

Nestle is the world's largest dairy company and one of the world's largest food transnationals with 1998 sales of US$50 billion, so it is perhaps surprising to see their late entry into the 'little bottles' market, since the company has a well researched probiotic. LC1's active ingredient is *Lactobacillus johnsonii La1*, discovered and patented by Nestle's Research Centre in Lausanne with the Pasteur Institute in Paris after four years of research. One of the Lactobacillus acidophilus group, the bacteria counteracts the destructive effects of gastric juices, enriches the natural microflora of the intestine and generally reinforces the body's defence system, according to the company's promotional literature. Nestle Group's Strategic Business Unit in Switzerland decided that, for commercial purposes and packaging, the scientific name of the bacillus should be simplified as Lactobacillus LC1 to avoid consumer confusion.

But the real motivation for LC1Go is a marketing one. Launched in Germany, France, Spain and Italy it is a head-on challenge to Yakult's dominance of the 'daily dose' format and of Danone's aspirations.

In France LC1 is said to make up a large part of both the sales and profit of the Nestle yogurt business. However LC1 is thought to have been losing shelf space in French supermarkets under pressure from Danone's Bio and Actimel brands. In these circumstance Go is a logical counter to Actimel.

LC1Go was also been launched by Nestle in Italy, with a high-budget TV and press advertising campaign. In Italy LC1 Go is targeted at well-educated, high-income consumers aged 25 to 44. Although it was launched throughout Italy, its main concentration is in the more health-concerned north of the country. Sold in 80ml bottles, of which Nestle recommends consumers to drink one a day, it is the first 'daily dose' food product on the Italian market.

However, it is still Yakult that continues to successfully demonstrate that Europe's consumers are ready to accept the blurring of the boundaries between food and 'wellness' implied in the functional foods revolution. Consumers in the Netherlands and Belgium quickly took to the daily dose product, propelling Yakult to a 20%-plus share of the probiotic sector. In the much bigger German and UK markets Yakult is also winning over consumers at the expense of many of their competitors.

But there's more to making a success of a functional food than a claim and a new packaging format. Yakult has demonstrated that a far-reaching education campaign is fundamental to building up the credibility of a functional product - and subsequent market success. Few European companies are prepared to emulate the massive scale of Yakult's European education and sampling programmes.

Small is beautiful for Sweden

In contrast to the companies above, two small research-based Swedish companies, BioGaia and Probi AB, are staking their futures on developing their own particular brands of 'power LAB'. Both BioGaia and Probi, illustrate how innovative science-based companies can start to internationalise a functional ingredient and be at the cutting edge of the functional foods revolution.

Since its foundation in 1990, BioGaia Biologics has invested over $20 million in R&D for their probiotic *LAB Lactobacillus reuteri*, secured worldwide patents on its discoveries and listed its stock on the Swedish stock market. Now the company is looking to capitalise on its investment with the roll-out of its ingredient through licensing deals around the world.

The network of licensees already includes companies such as America's highly innovative and successful Stoneyfield Farms and Switzerland's ToniLait. In the United States, Stoneyfield, which has a strong reputation for its ethical approach to business and has built up a good position for its organic products, have set about communicating the health benefits of *L.reuteri* to American consumers - who have little knowledge of probiotic bacteria - through a major press communication effort.

In February 1999, BioGaia announced two new developments in the commercialisation of *L. reuteri*. Ingman Foods Oy, Finland's second largest dairy company who BioGaia have been working with since 1997 in the Finnish market, launched a range of new functional products containing *L.reuteri* into the Swedish market. The products included R-Orange Juice, R-Yogurt and R-Cottage Cheese. In the same month, BioGaia signed its first licensing agreement within the nutrition business area, when the US-based nutritional supplement company, Nature's Way, decided to add *L. reuteri* to several of the products in its range.

Probi

Probi AB, whose corporate motto is 'First in probiotics', filed the first patent for their 'power LAB' *Lactobacillus plantarum 299v* in 1992. Probi has taken a different approach from that of BioGaia and other dairy companies. This is the result of their LAB technology. Put simply, *L. plantarum 299v* is fermented with oats to form an oat-based 'soup' from which products can be developed, it is not a dairy-based product.

To commercialize its science Probi had to form a partnership with a company which had manufacturing, marketing and the ability to brand and distribute. The partner they chose was Skanemejerier, a $200 million dairy cooperative in Sweden's Skane region, which has committed itself to building up a portfolio of value-added functional foods brands. Functional foods offer companies such as Skanemejerier the opportunity to create higher-margin, branded, added-value business and reduce their dependence on low-margin commodity products such as liquid milk.

ProViva represents an important product innovation. The first product containing L. plantarum 299v was launched in Sweden in 1994. Called Pro Viva it was a genuine and important innovation - the first probiotic juice drink to appear on the European market - and rapidly became a success. Total consumption in the whole of Sweden - which has a population of 8.1 million - is around 9 million litres.

In recent years Skanemejerier has begun the process of rolling the Pro Viva brand out across Europe. Currently Pro Viva is on sale in Poland, Germany, Switzerland, Denmark, Netherlands, Belgium, the UK, Sweden and Finland.

Among developments currently in the Probi pipeline, the company is looking to develop a probiotic sports drink - almost certainly a world-first. Called 'Prestamax', it has already been successfully tested with Swedish sportsmen and women. Described as a 'recovery drink' by Probi, Prestamax contains not only *L. plantarum 299v* but glucose and antioxidant vitamins.

In another innovation using *L. plantarum 299v*, Sia Glass AB, a Swedish ice cream producer, launched what is probably the first-ever commercially-available probiotic ice cream outside Japan. Developments such as these demonstrate how probiotics can be incorporated into the diet in a wide variety of regular foods, not just dairy products.

Other significant developments in functional dairy products

The potential of dairy product to deliver functional foods with 'positive' health benefits is further illustrated by one of the more interesting, to my mind, product launches. Italy's largest dairy company Parmalat took the unusual step of introducing Omega-3 enriched milk in October 1998 – that is, adding healthy fish oils to a dairy-fat based product. 'Plus Omega 3', is the result of several years research by Parmalat in partnership with Swiss pharmaceutical company Roche and Italian universities.

Plus Omega 3, packaged with a heart logo and promoted as 'the milk of life', contains

essential fatty acids derived from fish oils principally found in species from cold northern seas, especially herring, salmon, tuna and mackerel.

While Parmalat had been considering adding these oils to milk for a number of years, the main problem was to extract an oil and add it to a product without the distinctive fishy taste. Finally, Roche was able to supply an odourless oil containing 30% of the essential fatty acids from fish (EPA and DHA). Parmalat's Research Centre also had to solve the problem of the chemical instability of Omega 3 fatty acids, by developing new equipment.

Parmalat is positioning the product as something that health-conscious consumers can substitute for their normal milk and is eager to promote its new product as being of benefit to the population as a whole, and not aimed solely at those at risk of heart disease.

Summary of global functional food market and business activity

The two market case studies given above on cholesterol-lowering products and functional foods in the European dairy industry illustrate a broad trend taking place in functional foods in many markets across the world, from Japan, Australia and New Zealand to North America and in many product categories. By studying these international markets we have summarised in 10 key points the main market and business activity and trends taking place. In an abbreviated form, these are listed below:

Heasman and Mellentin's Top Ten Functional Food Industry Insights

1. Corporate ambition meets 'basic science'

New focus and restructuring of companies to take advantage of nutrition research and development. The increase in activities relating to the global search, innovation and product development of nutrition based products and ingredients and their rapid international market introductions (for example, cholesterol-lowering ingredients and products). Companies looking how to exploit more effectively their own 'basic science' and synergies within their research and product base.

2. Functional foods 'clusters'

Successful developments in functional foods are based on a combination of factors, from public nutrition policy, the public research base (universities, research institutes), industry activity (both collective and collaborative) and creation of consumer acceptance. We see such 'clusters' in both Japan and Finland.

3. Convergence of regulatory activity versus regulatory uncertainty

While there is considerable regulatory uncertainty over where functional foods fit in, and many in the food industry argue this is holding back the market, there has been in our view a remarkable convergence in regulatory activity and co-operation to develop health claims and to accommodate functional foods (which are not recognised as a separate regulatory category). Examples here include the Joint Health Claims Initiative in the UK and the work of the Australian and New Zealand Food Authority on health claims.

4. Functional foods 'makeover'

Some companies are using functional food science and interest in functional foods/nutraceuticals to give their products, sometimes perceived by consumers to have a poor nutritional profile - for example high fat content, too much sugar - what we call a 'functional foods makeover'. The functional foods 'makeover' is to give their products a new positive nutrition profile. Examples include, peanuts in the US and activities of companies such as Kellogg with their K-Sentials cereal 'makeover' in the United States.

5. Foods for general health: dairy industry ploughs lone furrow

As illustrated in the case studies above, there is a clear distinction between developments in functional foods/nutraceuticals aimed at disease/illness prevention or management and products or ingredients targeted at 'healthy' individuals. In the latter area, the European dairy industry collectively leads the world in developing functional products for 'healthy' consumers, although companies like Japanese company Yakult remind us that 'functional foods' have also been around for many decades.

6. Functional foods for disease treatment

Of the products aimed at a recognised medical 'condition', cholesterol-lowering is currently the major area of food product activity in Europe, with Unilever, Raisio/McNeil and Novartis all working in this area. Novartis' AVIVA Life Foods range, expected to debut early next year is expected to fall into the disease treatment category.

7. Blurring the boundaries

Consumers want more information and power over their health. Key trends here are the increasing use of complementary medicines and treatments and growth in markets for dietary supplements. Also important is the promotion of 'health for all' by public authorities which often stresses the link between diet and particular health outcomes (perhaps the medicalisation of food by public health promotion?). Products such as the little bottle 'daily dose' probiotics, have demonstrated that Europe's consumers are ready to accept the blurring of the boundaries between food and 'wellness'.

8. New foods, new communications

Consumer and public interest in functional foods/nutraceuticals is media-led, especially in the US. The onus on the food industry is to find and develop more sophisticated ways of talking to consumers about food and health and their products. Issues such as 'transparency', 'corporate reputation' and 'care' will become even more important if companies are looking for future success.

9. Keeping the 'nutraceutical cowboys' at bay

The health, food and supplement arena is also becoming characterised by 'cowboy' activities and products. This tarnishes the whole area, and we predict this will become a more acute problem in the future. How long is it before there is a 'nutraceutical' disaster (along the lines of a food safety crisis) over some nutraceutical product or supplement. We suggest that 'serious' functional food companies should prepare now to manage such a food and health crisis (see new foods, new communications).

10. Globalisation of food and health

We should never lose sight that the one area where the food industry is integrating and operating globally is increasingly in the area of nutrition, food, diet and health, in particular as represented by trends in functional foods. Companies search the world for the next functional food breakthrough and then look to disseminate innovation, ingredients and products internationally. The globalisation of food and health is seeing

- The rapid diffusion of functional foods technology globally;
- The closing international gap between basic science and commercial development;

The range of challenges facing companies working in this area are being met internationally, from regulatory hurdles to technology and business development. However, in the international context, the voice of public health and policy is not being articulated in the same way around functional foods as the industry agenda. I have seen no research which considers analytically the public health policy implications of such product developments, other than in terms of their regulation and the use of health claims. We have no idea whether functional foods are becoming a global cause for concern or celebration for public health.

Final Comments: Public policy options – embracing the functional food revolution?

I hope I've given you a flavour of the activity in functional foods. The scale, scope and enormity of the functional foods revolution is only just starting to emerge. As with any

new and evolving science and market, the concept of functional foods begs many questions, whether it is over efficacy, over health claims, how products should be regulated, and how these foods fit into the total diet. In addition, consumer advocacy organisations are expressing a number of concerns, for example, the title of a recently published report sums up their perspective: 'Functional Foods – Public Health Boon or 21st Century Quackery?'[24]

The report title also begs the question whether functional foods will contribute to public health goals or simply be seen as addressing a narrow range of individual benefits and effects. A stated objective of functional food science is to contribute to the human, and by implication public, health. There is also a public responsibility of, where appropriate, to provide objective information to consumers the role of diet in health, including new developments. There is also a frustration among a number of food companies who have pioneered research and development in functional foods, that they are unable to communicate effectively to consumers their science-based health findings. Consumers are therefore unable to differentiate between responsible marketing and 'opportunist' companies with little or no scientific integrity.

There are three possible ways forward for public policy in respect to functional foods:

First, to put it simply, is to resist what is happening. There are strong merits to this position, for example, we already have clearly established dietary guidelines for health and these are a long way from being fully implemented – why do we need functional foods. Also many food and dietary supplement manufacturers in the area of functional foods and nutraceuticals seem to find it difficult to undertake responsible and transparent marketing and communications. Tough regulation could be lobbied for to ensure that 'health claims' are only allowed when a pre-determined 'gold' standard of science is achieved.

Second, is a half way house, a wait and see approach, giving a little here (on health claims for example) urging caution in other areas. The danger of this approach is that it will be largely re-active and that it could exaggerate confusion in the public mind. This seems to be the current policy response.

The third approach, is for public policy to wholly embrace the functional foods revolution. Perhaps a radical response, but by this I mean to take the functional foods revolution at its face value. This would mean developing more proactive food and health policy to 'optimise' nutrition in the sense implied by functional food science. For example, as suggested in the commentary earlier, in all but name the food industry is looking to promote 'good' foods, often at the expense of 'bad' foods. Public policy should look to make strong 'health claims' for 'good' foods.

In general terms the heart of the functional food revolution, other than the promotion of healthy gut microflora, is built around the health benefits of plant-based foods. In particular, the chemical (phytochemicals) and other components of plants (essentially fruits and vegetables) that can be further enhanced or isolated to deliver health promoting benefits. Such a position is not at complete odds with existing dietary guidelines and could be seen as complementary and integrated further into 'healthy eating' advice. Essentially it boils down to a plant-based diet that delivers in large quantities the health benefits of fruits, dietary fibres and vegetables. In addition, assuming the food industry is right when it interprets international consumer research, where health is the 'heavy' trend, people want to know more about their health and food and nutrition and how they can help themselves. Public policy will be in-step with consumer trends.

Public policy could also take the functional foods revolution further. The essential cornerstone for embracing the functional foods revolution should be what I call the A+ approach to food and health:

The A+ approach to functional food and health policy

Functional foods should be:

Available – on shelves where people normally go shopping
Affordable – within the means of most people

Available + Affordable = Accessible, for the general population to the benefits of the functional foods revolution.

Finally, functional foods should be:

Acceptable – it doesn't matter what the science may show, if functional foods are not accepted in the minds of consumers, if they don't feel positive about these products and that there is some value for people then the functional foods revolution will fail. Acceptability can be achieved, in part, with good communication.

Public policy should influence and facilitate both Accessibility and Acceptability.

In his 1997 Caroline Walker Lecture, Professor Philip James said the challenge is to engage food companies as allies rather than obstacles to public health. The functional foods revolution could be interpreted as offering such an opportunity on a plate.[25]

Notes and References

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2 A public health perspective in relation to food and globalisation is detailed extensively in Lang, T. and Heasman, M. in Food, Globalisation and Public Health, to be published by Earthscan in February 2000.

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Functional foods and pharmacological impoverishment

And why 'nothing makes sense in biology except in the light of evolution'

Colin Tudge

Functional Foods and Pharmacological Impoverishment

And Why 'Nothing Makes Sense In Biology Except In The Light Of Evolution'

'Functional foods' as I understand the term form a notional category of foods that provide various agents that are presumed to bring some pharmacological benefit, independent of, or in addition to, their value as a source of nutrients or of energy.
But such a notion invokes incredulity. It sounds like yet another foray into the nether-world of mumbo-jumbo and snake-oil. Quite simply, the idea does not seem to make sense. We know that our bodies need proteins and fats (not least because they are largely made of proteins and fats) and carbohydrate largely for energy, plus a mixed bag of 'vitamins' and 'minerals' that seem to embrace about half the periodic table. But why should we need any more than that, unless we happen to be ill, and require some specific drug as an antidote?

Scientists are always insisting (or should always insist) on evidence, but you don't find evidence unless you look for it, and there is no point in looking for evidence unless the notion you want to explore seems likely to lead somewhere. No-one in their right mind would bother to gather evidence for an idea that doesn't seem to make sense in the first place; and if serious biologists feel that functional foods really are in the snake-oil category, then they will shake their heads and keep well away.

But I reckon that when we apply a little evolutionary thinking, we find that the idea behind 'functional foods' makes perfect sense. There is very good reason to suppose that our bodies and minds might indeed benefit from a whole range of materials — found in flowering plants, fungi, and microbes — that do not fall easily into the conventional categories of protein, fat, carbohydrate, and 'vitamin'. Indeed the great Russian-American evolutionary biologist Theodosius Dobzhansky commented in 1973 — it was the title of an essay — that 'Nothing makes sense except in the light of evolution'. This adage applies abundantly to nutritional theory in general, and applies absolutely to the specific category of 'functional foods'.

Until we apply evolutionary thinking, the idea that we might derive some specific benefit from the many odd and various agents contained in various foods makes no sense at all. But when we do apply evolutionary thinking — about the *modus operandi* of natural selection in general, and specifically the evolutionary history of *Homo sapiens* — we find that the idea of functional food makes very good sense. In fact, we begin to see that the implications might spread through all of medicine and into agriculture and cookery, and indeed could influence a great deal more besides — including our attitude to what are now called 'hard drugs'.

The Notion of Co-adaptation

The first premise is that human bodies have been co-evolving alongside other organisms, and adapting to their presence, since long before our ancestors were human. Indeed we should see our physiology — and minds! — as the outcome of three and a half billion years of adaptation to life on Earth, which includes co-adaptation with other organisms. That is, our bodies do not simply reflect the fact that we choose to call ourselves 'human':

- before we were human we were non-human primates
- before we were primates we were non-human mammals
- before that we were non-mammalian vertebrates
- and before that, we were non-vertebrate animals
- and so on all the way back.

Indeed, in our genes, we can still see the tracks of ancestors that were still microbial! (These putative microbial ancestors were not literally like modern bacteria, but were comparable with the existing types in their grade of organisation). We carry all this genetic and physiological baggage around with us.

Specifically, and most importantly: over the past billion years or so we and our ancestors co-evolved in the presence of plants, fungi, and bacteria; and for the past 150 million years ago, the prevailing plants have been flowering plants, alias angiosperms.

Many of those organisms produce agents for their own benefit that we, as consumers, simply cash in on. Thus we make use of the proteins, fats, and carbohydrates that plants produce in seeds for the benefit of their own embryos. Some vitamins, too, were clearly produced originally by plants for their own direct benefit — probably including ascorbic acid, which is an anti-oxidant. Most animals make their own ascorbic acid for the same purpose but we, human beings, do not, and we need to acquire it ready made from our food — which for most people means from plants. Then we call it vitamin C.

But plants, fungi, and bacteria also produce a range of materials that are specifically intended to be toxins — agents intended to prevent us and other animals from eating them. Some of these toxins are merely repellent, like tannins; and others are frankly poisonous. I suggest that the animals in turn have evolved mechanisms that help them -

including us - not merely to cope with the toxins but eventually to make use of them. Indeed, that those erstwhile toxins now form at least part of the miscellaneous list of agents that we now acknowledge as 'vitamins', and - the thesis of this talk - that they include the materials now becoming known as 'functional foods'.

So how does a chemical agent that was originally produced to poison the consumers evolve into an important component of their diet? The point is most clearly illustrated by reference not to a plant toxin but to the gas that every schoolchild knows is essential for minute-by-minute survival: oxygen.

How We Came To Need Oxygen

When our ancestors were still microbes, about two million years ago, they were suddenly subjected to the rudest possible shock. The atmosphere that previously had contained benign and easy gases like ammonia and carbon dioxide, and probably hydrogen cyanide, suddenly began to be laced with oxygen. It was produced by the bacteria that had first invented a new form of photosynthesis: the same form now practised by cyanobacteria (and many other bacteria) and by seaweeds and plants.

Oxygen is extremely lively stuff, and very difficult for living organisms to handle. There would be virtually no free oxygen in the atmosphere if it were not that photosynthetic plants and bacteria pump it out in such vast amounts. It would simply react with other gases and with the continental rocks and disappear.

So what did the ancient organisms do when first assailed with oxygen? Many simply went extinct. Others - (or their descendants) — the kind now known as 'anaerobes' — still exist in marshes and hot springs and other sequestered places. But they are killed if exposed to oxygen.

Some, however, developed mechanisms for coping with oxygen: essentially, detoxifying mechanisms.

Some of these latter organisms (or their descendants) remain with us as 'microaerophiles'. They are not poisoned by small amounts of oxygen, because they can detoxify it. They put molecules in its way which are then oxidised away harmlessly. But the organisms that became the most successful, and went on to inherit the Earth, are the aerobes. They went beyond mere detoxification. For evolution is wonderfully opportunist. Natural selection can make use only of structures, mechanisms, and behaviours that already exist; and (there are thousands of examples) it spectacularly does

make use of what is there, and convert mechanisms that evolved in the face of one particular set of pressures into mechanisms that come to serve quite different functions. (The way that superfluous jaw-bones of synapsid reptiles evolved into the middle-ear bones of mammals is a classic example).

So once natural selection produced a mechanism that could cope with rogue oxygen, it was always likely to go one step further and turn the de-toxification process to more constructive use.

Thus one way to detoxify oxygen is to sacrifice a few surplus sugars: allow the oxygen to react with them, so that they oxidise away into relatively innocuous carbon dioxide (which in simple organisms then dissolves away in the surroundings) and a little water. This detracts the oxygen away from more essential components of the body — notably the structural fats and proteins, which are extremely vulnerable (especially the fats). But the oxidation of sugars releases energy. Aerobes — including us — evolved means to harness that energy. Thus the essentially negative process of detoxification has evolved to become the Earth's most efficient mechanism of respiration, for aerobic respiration releases more energy per gram of fuel — where fuel means sugar — than the various anaerobic mechanisms.

Yet aerobic organisms like us that actually need oxygen to survive also possess various vitamins whose function is to cope with rogue oxygen; and they acquire other de-oxidising materials ready-made in the form of vitamins. Vitamin C is one. I believe that folic acid is another.

Oxygen was produced as 'twere by accident — a by-product of photosynthesis; and when it first appeared in the atmosphere, it surely was the mother of all pollutants. The world's creatures produce many such potentially toxic by-products, including many quasi-metabolised excretory products, produced by the partial oxidation of proteins and nucleic acids. All kinds of nasty toxins can be produced in this way. They also produce a range of noxious agents specifically to repel predators like us.

And, I suggest, the same general kind of co-adaptive processes that enabled our own ancestors to evolve the mechanisms of aerobic respiration out of mechanisms that originally developed to detoxify oxygen, can be seen in the ways in which we cope with other toxins. Agents that plants, fungi, and bacteria produced as noxious by-products — or specifically to stop us from eating them — have now become important or essential to us. First we evolved the means to detoxify those noxious agents and then — out of

the detoxification mechanisms and the toxins themselves — we evolved mechanisms that have become an essential, or at least highly desirable, component of our physiology.

The De-Tox Principle In Action

Most leaves of wild plants are toxic, at least to some extent. They just don't want to be eaten. The animals that do live on the leaves of tropical trees commonly possess spectacular detoxifying mechanisms, including the South American hoatzins, the leaf-eating monkeys and — perhaps most adept of all — the koala, which lives exclusively on eucalyptus leaves which are pure poison, apart from the fibre which is like barbed wire. The livers of dogs are also remarkably good at detoxifying the many foul agents produced by bacteria. They cope marvellously with putrescence.

More broadly, we should envisage an arms race between the plants and fungi that want to avoid being eaten, and the animals — including us — that want to eat them. Arms-race is an extremely important concept in evolution. But of course, the arms race is not finished. Arms-races never are. Some of the agents produced by plants, fungi, and microbes still poison us. Many plants, fungi, and microbes are notoriously toxic, from deadly nightshade through honey agaric to *Clostridium botulinum*. In these instances the plants *et al* are winning.

Some such agents are not particularly good for us, but we or our pre-human ancestors have evolved means to cope with them. In such cases, the arms-race has reached a stalemate.

But, I suggest, we have adapted to a great many of these once toxic agents in the same way we have adapted to oxygen. We have moved a step on beyond mere tolerance; and now we positively need the things that the plants once produced to keep us at arm's length.

Some at least of the miscellaneous class of materials known as 'vitamins', I suggest, are precisely of this kind. They are materials produced by plants for their own purposes (probably including the repulsion of animals) which animals first had to evolve means of coping with — and then came to rely upon.

Why not? These chemically complex agents have all kinds of possibilities. They might in principle be put to all kinds of uses apart from the ones that the plant (or fungus or microbe) first produced them for. It really would not be surprising if the creatures that ate the plants did not explore some of these possible uses. And once the possibilities are explored, the creature becomes reliant; just as we and other animals, as 'aerobic' respirers, have come to depend upon oxygen.

In fact, our reliance upon the rag-bag of agents known as vitamins makes no sense at all unless and until we envisage the scenario of co-adaptation and of arms-race. Vitamins demonstrate Dobzhansky's point exactly: 'Nothing in biology makes sense except in the light of evolution'.

Many agents that we ingest willy-nilly are not so obviously vital for survival, but they are necessary for optimum functioning. This as yet grey category of agents are what are now being called 'functional foods'. In short, if we want to realise our full potential — our genetic potential — then we might well be advised to eat strange things.

I do not mean to imply a criticism, but I offer it as an observation that in fact, evolutionary biologists are the only biologists who seriously ask the question 'Why?' Physiologists this past 100 years or so have conscientiously and very cleverly observed that human beings do need a range of vitamins, and have asked how we can best obtain them. But I have never seen a serious discussion in a book of nutrition or physiology as to why we need vitamins in the first place — why we should have become hooked on particular recondite products from what are sometimes rather recondite organisms. It simply does not make sense: not until we start looking at the generalities of evolution, and the particularities of human evolution.

'Pharmacological Impoverishment'

If this notion is correct — that human beings have evolved a need for a host of recondite plant and microbial products, just as we have evolved a need for oxygen — then the implications could be huge.

For it is extremely unlikely that biologists, through their efforts this past 200 years (which is roughly how long the science of biochemistry has existed), have identified all the agents that plants, fungi, and microbes produce, to which we have adapted; the ones that poison us, the ones that we can cope with, and the ones for which the various mechanisms of our bodies have acquired a definite need.

The agents that would be most difficult to pin down are those that are neither outstandingly toxic, nor absolutely vital for survival. These are the agents that might do us good — that is, are required for optimal functioning — but we can nonetheless get along without. It is difficult to identify any such agent because the effects are liable to be subtle, and variable. It would be extremely difficult to identify all of them because the list is liable to be long and complicated, and there hasn't been time yet. But also — and even more importantly — very few people have looked methodically for such

agents for the simple reason that it did not seem worthwhile. Scientists pursue specific hypotheses; and the particular hypothesis which says that such agents ought to exist, and ought to be worth seeking out, has not to my knowledge been proposed in a plausible form. That is, it has not been spelled out in evolutionary terms.

Instead, modern nutritional theory has grown up with the idea that there are five main categories of food that human beings have to eat: carbohydrates, proteins, fats, the rag-bag of vitamins, and various minerals.

Anything that does not fall obviously into those categories has been assumed effectively to be 'non-food'; although some of the agents in the 'non-food' category have been shown to have specific pharmacological action, and these have been categorised variously as toxins or drugs (with considerable overlap between the two).

In general — as usual — westerners have taken an ambiguous and indeed contradictory view of these non-foods.

On the one hand, puritanism has prevailed: the notion that unless the things that we ingest fall neatly into the carbohydrate-fat-protein-vitamin category, then we should probably do without them. In such a puritanical vein western law in general forbids all psychotropic agents — marijuana, opiates, cocaine, mescaline etc — apart from those that slipped through the net before the law got its act in gear, such as alcohol, caffeine, and nicotine (all of which at various times have been banned by various cults and societies).

On the other hand, we add — cavalierly I would say — a huge range of chemical agents to food that is loosely categorised as 'permitted additives', which are intended to compensate for the fact that food manufacturers have managed to produce food without flavour, and to make it easier to distribute that food to the far corners of the globe.
In other words, on the one hand we have knee-jerk puritanism — the assumption that bodies are better off when they are not assailed with materials that do not readily fall into the conventional categories of 'food'; but on the other we give commercial organisms carte-blanche to lace our food with whatever they choose, provided it has not been shown to cause cancer in mice. In this age of science, commerce rules.

I don't want to talk about additives. Other people can talk about them. But I do want to explore the idea that we actually have some need for — or would in subtle ways benefit from — a whole range of chemical agents, produced by plants, fungi, and microbes, that so far are simply unexplored.

Our present diet is liable to be deficient in such agents for a range of reasons:

- It is based on a narrow range of crops (and livestock) which our Upper Palaeolithic and Neolithic ancestors happened to have available, and developed. Hunting-gathering people have commonly been found to make regular use of scores of different wild plants from a wide range of plant families (and different plant families tend to be pharmacologically distinct; chemistry runs in families) whereas the range of crops regularly eaten by most people in the western world is rather small.
- The post-neolithic diet is largely grain-based; and grains, being the seeds of grasses, are pharmacologically rather bland (see below). Contrast the seeds of, say, legumes or umbellifers.
- Modern crops have been conscientiously selected and bred, over many centuries, largely for yield and for lack of toxicity. Yield is itself largely incompatible with pharmacological variety, since it takes a great deal of energy to produce secondary metabolites (alkaloids etc), and in high-yield crops this energy is diverted into starch and cellulose (which are the principal source of dry mass: ie, effective yield). Lack of toxicity is obvious, and necessary: eg solanaceous crops (tomatoes, potatoes, capsicums) have highly toxic relatives and ancestors; wild parsnip is vicious stuff (like many a wild umbellifer) and so on. But in reducing toxicity we also reduce all pharmacological variety and impact.

Note that the items in the super-market seem extremely varied; but they are all based on a rather narrow range of plants, each of which (apart from the herbs and spices) is pharmacologically blander than its wild counterpart. Variety of brand-name does not imply variety of underlying chemistry.

Putting all the above thoughts together, I reckon (ie, it is at least a worthwhile hypothesis) that human beings (and our pet animals) might well be suffering from Pharmacological Impoverishment'. I lay claim to this expression — first coined in a newspaper article about five years ago — and reckon it has mileage.

Our puritanism tells us that if what we eat does not fall into the easy categories of carbohydrate-fat-protein-vitamins, then it is ipso facto bad (additives aside, of course!). But there is no reason to assume that knee-jerk puritanism is intelligent; that it is truly based upon understanding. Perhaps, instead, this attitude leaves us in a state of pharmacological impoverishment. Perhaps our puritanism is depriving us of a whole range of materials to whose presence our bodies have adapted over the past 3 billion years: the results of co-evolution between our ancestors and the creatures they grew up among.

Suppose, now, that this general hypothesis is right: that the many mechanisms of our bodies are indeed adapted to a range — possibly a huge range — of chemical agents produced by plants, fungi, and microbes that it can survive without (ie, we are not talking simply about the recognised vitamins) but which it nonetheless would benefit from.

Suppose it is the case too — and it undoubtedly is the case — that science has hardly begun to explore this range of agents, at least not in an orderly way, largely because it never occurred to anyone to do so. After all, this hypothesis springs from evolutionary biology; and biochemists and nutritionists are not, for the most part, evolutionary theorists.

If the notion of pharmacological impoverishment is broadly correct, what would be the implications?

Drugs, Cows, And The Concept Of Metanutrition

1. The implication that I happened to think of first is in the field of psychotropic agents: marijuana, opiates, and the rest. In puritanical vein — that is, largely for historical reasons — we assume such agents must be bad for us. Puritanism is an emotional — a moral — stance, but the question of whether drugs are good or bad for us is, in the end, a matter for science. In this instance, however, the emotion leads. Because our moral history tells us that drugs are bad, we do not even look to see whether and to what extent that is the case, and whether in fact the yearning for drugs that some people develop is a manifestation of pharmacological impoverishment.

That is, the specific hypothesis is that our nervous systems evolved in the presence of a range of peculiar materials produced by plants, and functions better in their presence — just as our bodies in general have evolved to function best in the presence of oxygen. Our nervous systems are now deprived of many essential or quasi-essential agents, largely because our diet is no longer based on a range of wild plants. If we followed this hypothesis through, then instead of waging a 'war against drugs' — a war which is, of course, already lost; and serves only to ensure that the Mafiosi are among the world's richest businessmen — then we might begin to gather some sound data about the drugs that are now banned out of hand; and on the basis of that data set the pharmacologists to work, to see if they can tweak the molecules, and produce agents that truly benefit our nervous systems, with a minimum of undesirable side-effects. I don't want to pursue this issue in this context. I just want to point out that our present attitude to psychotropic drugs is at the very least simplistic; that it takes little or no account of what could be the important biological realities; and that policies based on such naivety seem bound to fail, as indeed they are doing, in spectacular style.

2. More broadly — and the real subject of this talk — I suggest that this broad, evolutionary idea of pharmacological impoverishment might lead us to feel that present-day nutritional science, taken in the round, should be seen simply as a first approximation. Yes, it was extremely clever to perceive that human beings (and other animals) need carbohydrates, fats, proteins, and a rag-bag of vitamins, and this wonderful insight has been extremely fruitful.

But life is more complicated than that — precisely because it is evolved; and evolved systems are full of loose ends which would not be the case if they had been designed by teams of engineers from Sony or Ferrari. Of course, living systems are far more intricate and wonderful than anything that any human designer could produce; but nonetheless, because they are evolved, they are also quirky. You cannot second-guess nature. You cannot assume that nature necessarily does the things that human beings might, with their designer's hats on, think are logically necessary. You have to speculate — ask what might be going on — but you also have to do the natural history: observe what actually is going on. Observe and admire. But don't second-guess. And don't presume to override nature with adages based on 17th century puritanism and on 19th and 20th century biochemistry. That just won't do.

In fact I want to suggest that beyond the first approximation of 20th century nutritional theory, we should envisage what might be called 'meta-nutrition': a far more thorough and exhaustive exploration of how the body actually works, and how it actually interacts with all the many thousands of agents that we put down our throats in the form of food and drink — and indeed of all the consequences that might ensue from not consuming all the things we actually need; all the consequences, that is, of pharmacological impoverishment.

In fact, I think it might well be premature to set up a formal university Department of Metanutrition, although if anybody wanted to do so I wouldn't want to get in their way. But in the first instance, I do think that if we do take this evolutionary approach to nutrition seriously then there is a whole range of anecdotes and philosophies and odd pieces of research that ought to be taken more seriously than is generally the case, and brought together and synthesised; and I can think of a range of research projects — though no easy ones! — that ought to be carried out.

For example, it has long seemed to be that animals in general in the wild make far more use of fermented food than seems generally appreciated. Michael Crawford suggested years ago that lions, when they first make a kill, attack the guts and offals of their prey — guts that are far richer, pharmacologically, than the red meat of the muscles. Is this really so? If it is, what do they get out of it?

Similarly, in puritanical vein, we create hygienised Pal and Pedigree Chum for dogs. But when I had a dog I found that if you gave him a bone he invariably, at some stage, buried it. Was this simply a form of storage? I suspect not. I suspect that fermented bones, exposed to the microbes of the soil, contain a range of recondite agents — effectively vitamins — that fresh meat does not. It is at least an interesting hypothesis that animals in general make far more use of natural fermentations than we are aware of.

In anecdotal vein note Keats's observation, in Ode to Autumn, that bees (or was it wasps?) grow drowsy in autumn on the alcoholic fumes of fermenting fruits. It is striking, too, how many animals quickly develop a liking for alcohol — suggesting some predisposition. Laboratory rats prefer their water with a drop of vodka, and elephants notoriously raid the factories where forest people worldwide, out of the gaze of the authorities, attempt to enhance their lives with little illicit poteen. Elephants easily become alcoholics. Incidentally, too, I was told in India by a reliable source that Asian elephants commonly eat carrion. They even dig up the bodies of dead people. To me this suggests, not ghoulishness, but a predilection for concentrated food in general — it saves eating all that vegetation! — and specifically for fermented food, with all its pharmacological richness.

You might argue, of course, that cows and other grazing ruminants clearly do not make use of fermentation, and that — as grazers — they mainly eat grass, by definition. Grass is pharmacologically fairly innocent, as leaves go. As I said, most leaves of most flowering plants are toxic, but grass leaves on the whole are not. Yet grass is among the most successful of modern plants. How come? Because most plants carry their growing tissue at the tips, so that as the plant is eaten the growing tip disappears. Grass throws up its flag leaves well in advance of the growing tips, which remain close to the ground. So unlike virtually all other plants, grass can allow animals to eat it with impunity. Cows and sheep strip off the flag-leaves, but they spare the growing tip. The same is not true of, say, a sprig of mint. In fact, grass quickly succumbs unless it is grazed. If it is not, then it gives way to woodland in warm places, and to sphagnum moss — tundra — in cold places. In fact, over the past 50 million years or so since grass first appeared — and particularly since the Miocene, which began around 25 million years ago — grass and

the grazing animals (particularly though not exclusively ruminants) have co-evolved, each needing the other; and a brilliantly successful co-evolution it has been, too. The only proviso that grass makes is to fill its leaves with silica, which regulates the rate of grazing. There are limits, even for grass. The modern domestic grasses, custom-bred to raise cattle quickly, contain much less silica.

But, you might say, if the recondite pharmacological agents produced by plants are so important to the animals that eats them — undoubtedly abetted by the products of fermentation — how come some of the most successful animals on Earth (the ruminants and other grazers) subsist mainly on grass, which is the pharmacologically the blandest form of wild vegetation?

Answer: they don't. Ruminants have huge stomachs known as rumens which are stuffed with bacteria and protozoans, which ferment the vegetation. They eat grass, but what they actually absorb — what nourishes them — is purely the product of microbial fermentation. Hind-gut digesters, like elephants, horses, and rabbits, do a similar job in their colons. It's because of this propensity that it is, in fact, possible to nourish cattle on human sewage, à la mode Française. Aesthetically of course this is vile, and it shows horrendous and unforgivable contempt for the animals, but it works because the microbes of the rumen are able to steal the nitrogen from the effluent and use it to make amino acids and nucleic acids. It is conventional and acceptable practice to feed cattle on straw supplemented with urea.

Many animals, too, practice coprophagia. Many, like rabbits and gorillas, re-cycle their own dung. Gorillas can be seen to do this in zoos, but the don't do it only in zoos. The behaviour is not innately aberrant. There is evidence that they need the vitamin B12, produced by gut bacteria. Rabbits also recycle. Dogs eat the dung of other species — one reason that human beings have encouraged them to hang around their camps over the past 100,000 years or so. They keep the place clean. Relatively speaking.

My point is, though, that ruminants and other herbivores, even more than us, rely on the products of microbial action; and I do not believe that the chemistry of that action has been exhaustively analysed, nor the effects of that chemistry upon the animal. Here is a rich field for investigation.

In comparable vein, Darwin suggested in a general way that humans do nothing that is not to some extent precedented by animals; and I would find it very surprising indeed if the human predilection for fermented foods — alcohol, cheese and other fermented

milks, and pickles of all kinds, sweet and savoury — did not have deep evolutionary roots, and did not to a significant extent reflect nutritional need. It would simply be extremely unlikely that human beings would have evolved such a predilection de novo over the past two million years or so of specifically human evolution. I think we like chutney in the same way and for the same general reasons that wasps get drunk and dogs like their bones well buried. Our bodies need the products of microbes, and our minds know deep down that this is the case.

In this context, too, we might look again at the many anecdotes which suggest that animals, in the wild, self-dose: that when they are feeling poorly, they seek out herbs. For example, the monkeys at Apeldoorn Primate Centre in Holland are said to seek out parsley and coriander at times when there is other evidence of tummy upset.

We should look again, too, at the many instances of animals strangely extending what we take to be their normal dietary range: at the elephants that eat corpses, and the red deer on a Scottish Island of Rhum which need extra calcium for their antlers and eat the heads off the nesting skuas, and so on. I suspect that for this and many other reasons, the nutrition of wild animals is not as we think it is; and that we can learn from this.

Ah, you will say, but if people living as hunter-gatherers were less impoverished, pharmacologically, than we are, why didn't they live longer? The answer is, of course, that the arms-race with plants and microbes is not over. Our human ancestors would have eaten a great many things that their bodies were truly adapted to — and which we would benefit from — but they also, perforce, consumed more toxins. As for fermentation, there is a very thin line to be trodden between delectation and putrescence, as aficionados of game birds and of exotic cheeses can attest. In fact, of course, people of all cultures enjoy a form of Russian roulette such as who can eat the hottest curry or who can tolerate the rottenest pheasant.

The challenge for the metanutritionists, of course, is to differentiate between the components in which the plants and the microbes still have the upper hand — and so are toxic — and the ones to which we are already adapted, and indeed would benefit from. More broadly, however — and this is the nub of this particular talk — the concept of metanutrition, with the subsidiary concept of pharmacological impoverishment, suggest that we should take a new and broader look at whole areas of human endeavour which, at present, western science at least tends to treat in cavalier fashion — often hostile or at least condescending.

Herbal medicine is one such. Whether or not all the claims traditionally made for nettles or camomile or whatever are correct, it seems to me extremely likely on evolutionary grounds that human beings almost certainly would benefit in many ways from many of the agents contained in such recondite plants, which at present we disregard.

It's clear, too, that western science should take tonics more seriously. Medicines are what people take when they are obviously ill; but people take tonics even when they already feel quite well, in the hope of feeling even better. Western medicine has largely looked down upon tonics. They are widely perceived to be quackery. Partly, I suppose, this is because many alleged tonics are quackery — in the snake-oil category. But puritanism has also crept in; this largely unexamined and I suggest extremely naïve notion that asceticism is innately good, and that the human body is bound to function best when the diet is at its simplest, with nothing included that is not obviously a nutrient. Finally, of course, westerners have tended to look down on the idea of the tonic partly because our medicine is science-based, meaning that it likes hard evidence. But it is always likely to be hard to demonstrate, critically, that intake of some recondite agent produces some subtle but nonetheless worthwhile improvement in general wellbeing. But tonics might be good anyway. Ginseng could well be part of an arms-race that we, at this point in our evolutionary history, happen to be winning.

The evolutionary approach also, of course, has huge implications for 'Functional Foods', which seem to me to include the category of 'nutraceuticals': chemical agents in food that do not simply 'nourish', but have a positive therapeutic or prophylactic effect. The notion that many agents might have such an effect seems to be to be highly plausible; and although it may be premature to claim particular proven benefits for particular foods, this whole sphere is well worth looking at.

So Where Do We Go From Here?

If the notions of metanutrition and pharmacological impoverishment did catch on, what difference would it make?

1. Well, to be very specific, I think it could and should bring about significant changes in our attitude to psychotropic drugs, and with the legal and medical ways in which we deal with what is now a horrendous problem, but probably needn't be — if only our attitudes were different.

2. Secondly, I would hope that in a few decades' time, or at least a century or so, we would see less rigid lines drawn between western, 'orthodox' medicine and various forms of traditional medicine, including the many forms of herbal medicine. Future medicine might be far more eclectic, and in general less cocksure, than at present.

Specifically, many forms of traditional medicine are far more concerned with tonics and palliatives than with specific therapies. Sceptics might suggest that in the absence of vaccines, antibiotics, and aseptic surgery, that is all they can offer. But you can be too sceptical. There surely is vast scope for the apothecary.

3. I would hope and expect that the recent trends in the western diet — increasing reliance on just few plant types, increasing blandness, all tricked out with a crude pharmacopoeia of additives — might be reversed. We might indeed revert to a more 'primitive' diet — meaning, in particular, one in which we treat ourselves to a far greater range of the kinds of materials that nature has to offer, which our ancestors evolved to cope with. In detail, this means more spices, more herbs, more plants in general, and among meat, more offals.

Future plant breeders might accordingly become more subtle — extending their range of desiderata beyond the present obsession with yield, appearance, and shelf-life. We need pharmacological variety without frank toxicity.

4. Finally, to develop the science of metanutrition, and reap its putative benefits, will require science and technology of a very high order. But we need, as a society — indeed as members of the human species — to ensure that the necessary science and technology do not simply become the property of particular companies, making fortunes for particular groups of shareholders. One of the outstanding tasks for the 21st century is to ensure that science and technology in all contexts become what the political philosopher Ivan Illich called 'tools for conviviality'.

In short, there are exciting times ahead. The 19th and 20th centuries brought us Nutritional Science Phase I; and the 21st century should bring us Nutritional Science Phase II — that is, to Metanutrition: markedly more sophisticated both in scientific content and in political context than we have been used to. Functional foods could be the vehicle that carries us into the new age. Who would have thought it?

Colin Tudge, November 1999

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