

The new nutrition science: sustainability and development

Mark L Wahlqvist*

President, International Union of Nutritional Sciences, and Director, Asia Pacific Health & Nutrition Centre, Monash Asia Institute, 8th Floor Menzies Building, Monash University, Melbourne, Victoria 3800, Australia

Abstract

Objective: To show that nutrition science is anchored in food systems and is influenced by the social, through the environmental to the cosmological, life's connections and rhythms. To indicate that an integrative approach is now becoming possible with advances in food technology, in the understanding of food choice and of human behaviour, and in a preparedness to recognise nutritional inputs in the full sweep of life-long well-being and health outcomes.

Method: An analysis of the much broader understanding of nutritionally related diseases from an ecological perspective, with attention to economic development, beginning with poverty alleviation. Recognition that the biological dimension of nutrition science is undergoing a profound reappraisal; that technologies will allow us to change the course of nutritionally related diseases for the better; and that nutrition science will find partners in information technology and telecommunications, food technology and energy technology.

Conclusion: A new generation of nutrition scientists can help build a new economy that supports development amongst communities, whether close or distant from each other. The opportunities for this kind of development to be realised between Asia, Latin America and Africa are considerable. At all times, however, nutrition scientists must uphold the paramount importance of good governance, conflict resolution and maternal literacy if their work is to achieve its growing potential.



THE NEW
NUTRITION SCIENCE
PROJECT

Keywords

Nutrition science
Technologies
Integrative sustainability
Eco-nutrition
Maternal literacy
Governance
Nutritionally related disease

The linkage of food to survival and health has been as obvious for as long as there has been human consciousness. It is presumptive to say that nutrition science began at any particular point, because systematised observation and prediction of outcomes is both the warp and woof of the human experience, and is in itself science.

We have, at once, narrowed our view of nutrition science (to particular nutrients and diseases) over the last 100 years or so, and made apparently giant strides with nutritional knowledge. But, for all of this progress, planet Earth is on the brink of major climate change, with its implications for food production, and of massive shortage of sustainable energy and safe water. Our science has been good in the particular, but largely blinkered in regard to planetary health and, therefore, the fundamentals of human health.

Reassurance about the future will be possible if nutrition scientists embrace more integrative, even cosmological, methodologies and engage in vigorous and strong partnerships between the various sciences (life, earth, atmospheric, physical and engineering, and molecular sciences), various technologies (power, transport, food, bio-, communication and information technologies) and with altogether other fields of knowledge. Within nutrition, integrative science is necessary at several levels:

with food chemistry and its physical properties, food choice, human behaviour and health outcomes.

Further, nutrition scientists must consider how their findings might contribute to sustainable ecosystems and healthy living environments, on an analogy with the Hippocratic Oath for practitioners of Western medicine. Our science and technology has the capacity to help build and link the health and welfare of communities in more sustainable ways, with good governance, maternal and general literacy, and conflict resolution.

Discussion

Nutrition science distinguishes itself from many other scientific disciplines through its fundamental importance in human development. This is sometimes seen as a weakness insofar as it makes the science less 'pure', but others would argue that the notion that science can be isolated from socio-political and economic drivers and consequences is a delusion, and may be irresponsible. It can, indeed, be said that the best of the old and the future of the new nutrition science depend on the socio-political and economic framework in which it sits, and that the failure to acknowledge this may lead to its demise.

Nutrition science has made giant strides in the last century. But the human population continues to increase, and the global climate is changing, with vast implications. Our science has been good in specific ways, but has ignored and overlooked planetary welfare and thus the basic determinants of human health and well-being. We must now ensure that the practice of our science supports sustainable ecosystems and healthy environments.

Humanistic and cosmological nutrition science

The world's most pressing problem is poverty and associated hunger, and its alleviation is now the first millennium development goal of the United Nations¹. How successfully nutrition science confronts this issue will be a measure of its strength and relevance. Scholars like Dr Ismail Serageldin, Director of the *Bibliotheca Alexandrina* in Egypt, are already saying that 'poverty and hunger will only be reduced if we [academics, scientists and technologists] are passionate about it'. This is not how we have been tutored in our science to date.

Another provocative consideration as we look forward to a more problem-solving nutrition science is how we define the problems in the first place and how we then tackle them. The accepted wisdom of science is Popperian (Karl Popper) hypothesis – testing, rejection and succession². In reality, this rarely happens and is a poor semblance of the creative and innovative dimensions of science, which change the way we think, work and play, and is much more the Kuhnian (Thomas Kuhn) view of 'scientific revolution'³. Many times science stops at the descriptive and mechanistic, as is currently happening in nutrition with the 'poverty [and hunger] trap' and 'obesity and diabetes' rhetoric.

The science (and technology) of and for the future needs to be coupled with passion and compassion, and with the socio-economics of the human condition, and also with aspiration and the arts, and with a planetary, even cosmological, perspective.

One way my colleagues and I have approached this is to invite people to join an on-line club, the Healthy Eating Club (www.healthyeatingclub.org), 'to achieve personal health with a universal outlook'.

I suspect that today's fascination with molecular nutrition, which has emerged from the appreciation of the DNA double helix, will be but a pale shadow when it reaches its own superlative plane comparable to indigenous spiritual art, as we now see emerging with epigenetics and more integrative nutrigenomics⁴⁻⁶. The beauty that nutrition science could be is by no means incompatible with, and may actually be required for, its greatest impact on the human condition.

On this basis it can be said that the issues in food, health and economic development have urgency, requiring a sound ethical basis and a strong sense of

equity. Nutrition science in the future needs to address the broad requirement for human security insofar as it can be achieved by a safe, nutritious and sustainable food supply.

The strategic approach to human security will address:

- Basic human needs.
- Information, communication.
- Mutual understanding and conflict resolution.
- The required science and technology.
- Innovation and entrepreneurial activity.
- Respect, recognition and rewards.
- Holistic development, productivity and sustainability indicators.
- Inter-community partnerships.

Science and technology make a significant, even essential, contribution to a strategy which, at the same time, needs to be broad-based and allow for engagement with the whole food network.

The new nutrition science

The new nutrition science, which has been stated in outline in *The Giessen Declaration*⁷ (www.iuns.org), is and should be integrative, and have strong technology linkages⁸⁻¹⁰.

While much nutrition science to date has been successfully analytic and reductionist, especially in regard to food components and their essentiality or otherwise for human (and other creature) biology, much progress awaits the application of integrative methodology to the outstanding big questions and problems in human and planetary health.

We can expect that with the progression of more integrative nutrition science, more fundamental and lasting solutions will be found to food and health dilemmas, the efficacy and efficiency of programmes will improve, and the perennial risks associated with the food supply will be minimised and acceptably managed.

Integration is required at several levels: with food chemistry and the physical properties of food; with food choice; with human behaviour; and with health outcomes.

Food chemistry and physical properties

Not surprisingly, but not often acknowledged, the biological impact of a food is greater than the sum of its

parts. It begins with the inclination to eat it in the first place, and encompasses the bioavailability of food components and their interaction with each other in the gut, their effects on gut function (including motility and microflora), their effects on splanchnic (notably liver) metabolism, on blood (and lymphatic) transport and on peripheral metabolism.

The corollary is that only a fraction of an essential nutrient's status in an individual is dependent on its absolute intake (which might, for example, for vitamin C, be 30–60% of the variance).

Not only the food chemistry, but also the physical properties of the food are relevant to biological impact. One of the most appreciated areas in which this is in evidence is the 'glycaemic index' of food, the basis of which was developed by Jenkins¹¹ and also Wahlqvist *et al.*¹² in the 1970s. Until that time advice about diet and diabetes (let alone 'chronic disease' prevention) was given only in relation to the macronutrient, carbohydrate.

A revision of our understanding of so-called micronutrients (vitamins and minerals) and medium- to long-term health problems (as opposed to acute or short-term consequences) is also underway. Good examples include those micronutrients (B₆, B₁₂ and folic acid) that determine homocysteine status, and its consequences for arterial and bone health; and vitamin D status, of relevance not only for bone, but also for muscle strength, immune function and cancer suppression (control of cell turnover).

Most recently, there has been a surge in the scope of food chemistry to look at more and more compounds and their isomers which are the basis of taste, smell, colour and texture and which, in turn, may sub-serve a host of human functions¹³. The most canvassed set of functions, but with uncertain and often unproven relevance, is that of anti-oxidation; the chemicals in question include polyphenolics and carotenoids. More broadly, phytonutrients, which may be multifunctional, represent any plant-derived component that has a physiological role in the animal ingesting it, although known macro- and essential micronutrients (vitamins and minerals) are usually excluded from the definition. The vast array of food components and their potential interactions signal a new era of thinking about food and health which can only be tackled by integrative science.

However, that even the broader concept of food chemistry now current, and derivative concepts like the antioxidant capacity of food, remain inadequate alone is increasingly clear. The concept of allostatic load to the human organism, where a host of pathways, hormonal and metabolic, are activated with emotional and physical trauma, and require modulatory responses, raises the question about how this might be met, even partly, by food¹⁴. It should be possible for a number of anti-inflammatory, and not just antioxidant, characteristics of food to be marshalled. This phenomenon may, however, require a lifetime for its full effects to be quantifiable.

Food choice

The first point to acknowledge when considering food choice is that the ability to exert it is dependent not only on availability (which includes questions of sustainability and food choice management), but also on food safety, purchasing power and acceptability (often matters of belief culture and palatability).

Thus, for many people, a narrow range of inexpensive (by local standards) and locally grown foods are what obtains in the diet. A staple like rice, potatoes or maize may be the dominant source of energy and essential nutrients with little in the way of micronutrient-, let alone phytonutrient-, dense food sources. For example, the availability or otherwise of small amounts of animal-derived foods like eggs, fermented milk, poultry or fish, or of pigment fruits and coloured vegetables may be limited, yet have the potential to make a huge difference to health and longevity prospects. Fish is a particularly interesting example, nutritionally, because it is one of the few good sources of several critical factors for human biology – long-chain *n*-3 fatty acids, iodine, calcium, vitamin D and ubiquinone.

The case for a variety of foods, backed by biodiversity, for human health is a strong one⁸, but, regrettably, not achievable by all, and by some food cultures more readily than others. This may be handled by, for example, the Food-Based Dietary Guidelines approach, which takes into account the whole diet, cuisine and food culture^{15,16}.

As demonstrated in the IUNS (International Union of Nutritional Sciences) FHILL (Food Habits in Later Life) studies and the comparison European studies (SENECA) of diet and longevity in later life, the Mediterranean (Cretan) diet of the 1950s and 1960s in aggregate provided dietary superiority (over simple food or nutrients or their simple sum)¹⁷, as did the EPIC (European Prospective Investigation into Cancer and Nutrition) study for Greece¹⁸. The Lyon Heart (and cancer and all-cause mortality) studies also support this view¹⁹. However, food like legumes, (lentils) and fish do provide distinct advantage as particular food categories²⁰. The benefits of fish and legumes are also increasingly clear from disease-specific studies on, for example, cardiovascular disease and the insulin resistance syndrome^{19,21,22}.

Also, by remembering how integral beverages (like water and tea) are to human nutrition and health, food choice will be more relevant and contributory to integrative nutrition science^{23–25}.

Depending on propensity to physical inactivity and over-fatness, especially abdominal obesity, the portion size and energy density of food may also be important considerations in food choice. Social and commercial factors are likely to be of critical relevance in this case, steering food choice in favourable (or unfavourable) directions.

Local *biodiversity* is dependent on the available ecosystem, how replete or depleted it is, and whether it is complemented or compromised by farming, mixed or otherwise. Policy-makers and individuals can promote *food choice in favour of variety* dependent on local biodiversity, on the local or introduced food culture, whether people can move from place to place, and on the extent of food trade. *Human development* may be limited or prosper dependent on the available biodiversity and the extent to which key foods may conserve or compromise it. Accordingly, key foods can be evaluated for their potential to contribute to variety and the required biodiversity, the potential for food to be traded from place of production to place of need, and whether people can or will move or migrate or take knowledge and demands with them when they do move. The broad scenarios that may obtain are shown in Fig. 1.

Human behaviour

Whilst much is now said about nutrigenomics and how our genetic make-up or nutritionally determined gene expression might alter the impact of food intake in our physiology and pathophysiology, it is no less important to consider how our behaviour might do this too. It might, of course, also operate through, or be modified by, genetic factors.

But, more particularly, our levels of physical activity and fitness, social activity and networking, and substance abuse (with tobacco, alcohol, self-medication or illicit drugs) can make food intake and nutritional status mean quite different things.

For example, a given level of body fatness may be associated with a wide range of cardiorespiratory fitness²⁶. Body fatness can, on this account, have quite different consequences on incidence of type 2 diabetes²⁷ and on cardiovascular and all-cause mortality²⁶. Fitness is at least as important as fatness.

Again, those who are socially active, all other things being equal, live longer than those who are socially inactive, according to cohort studies^{28–30}.

In the FHILL (IUNS) studies referred to earlier, cigarette smoking was far and away the most important correctable

in older people’s lives to account for loss of longevity, although an integrative food score was also a powerful predictor of life expectancy amongst the aged³¹.

Health outcomes

Health outcomes will need to be integrative for nutrition and life-long health in regard to disability-adjusted life expectancies³², foetal origins of disease, and how health in later life depends on or is separable from that in early life.

They will also need to recognise integrative gene expression, where examples would be diabetes, non-RNA producing DNA and genome surveillance^{4,5}, and nutrigenomics⁶.

For health outcomes, we need to consider much more about basic causality than that to which we are accustomed in the medical–clinical sciences. Whereas we might, for example, think about the principal causes of road traffic accidents as road design or speed or car design, or driver training, skill, attitudes and health, we might, for driver health, be interested more particularly in alcohol excess; medication side-effects; and sleepiness attributable to time management, work patterns and obstructive sleep apnoea (OSA). And, then, with OSA, we might argue a case for obesity as a contributor.

Diet may be causally important at different levels, both fundamental and intermediate³³. If we consider obesity, we would ask what determines physical inactivity along with excessive and inappropriate food intake – including driving instead of walking and cycling, and situations conducive to inattentive unconstrained eating like watching television. In this way we get back to fundamental causality, which is not just physical inactivity, inappropriate eating and substance abuse – but a society having to generate and expend massive resources on roads and cars, working furiously hard to generate enough taxes (or toll revenues) for roads and to pay individual loans for cars (often the second highest area of expenditure for families in car-oriented societies).

There is a vicious cycle here which includes eating and exercise, but whose outcomes and their consequences are often remote from the day’s consciousness. It is for this reason that, in considering the new nutrition science, with

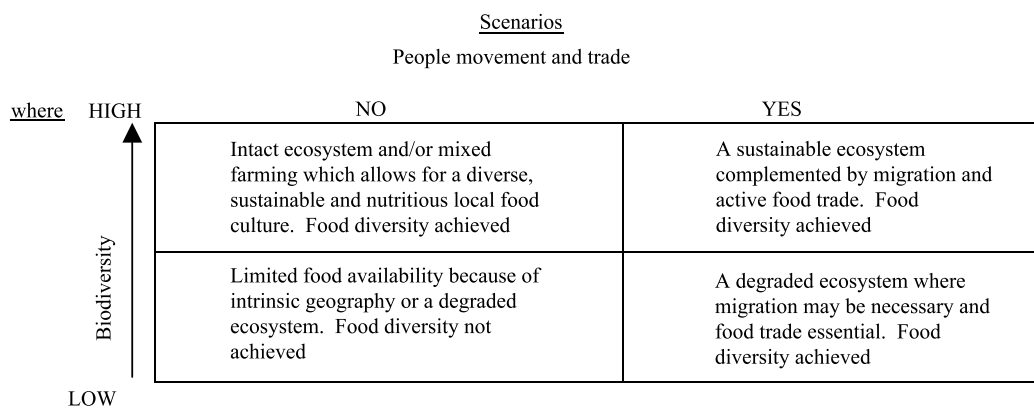


Fig. 1 Scenarios for biodiversity and key foods in human development: people movement and trade. Note that some key foods may be so nutritious (high density of food components) as to reduce the required food variety and biodiversity

its environmental and social as well as biological dimensions, we should also think about econutritional disease as we do for certain diseases in animals for human consumption: for example, Nipah disease³⁴, Newcastle disease³⁵, bovine spongiform encephalopathy³⁶ and influenza virus³⁷. A more thorough examination in this way for most diseases, their causality and their consequences, will yield a socio-environmental biomedical cycle which involves foods and beverages.

Information technology

Information technology (IT) and telecommunications are contributing increasingly to village development. Take, for example, Kuppam in Andhra-Pradesh, where Hewlett Packard is funding IT-linked community information centres, primary health care, agricultural fieldwork, small business development and local government. In less than 3 years, visible economic progress and empowerment of women and families is in evidence (visit by the author in 2004).

The *mobile phone*, an increasingly sophisticated hand-held device, is one of the most promising technologies for small business development, knowledge transfer, and democratisation and good governance (for example, Grameen bank loans for poor women in Bangladesh). Such a device has enormous potential to influence the food system.

Food technology

Food technology is a major contributor to a dependable, safe and secure food supply, to economic development and, at best, to human health. Both traditional and novel food technologies contribute to community development throughout the economically disadvantaged world – India, Southeast Asia, Africa and Latin America.

IUoFST (International Union of Food Science and Technology), with IUNS, has established an on-line training programme in food technology to assist with capacity-building in Africa. This engagement between nutrition science and food technology is essential for healthy diets beyond gatherer-hunter and subsistence agriculture ways of life.

Energy and water technology

The critical situation with dependency on non-renewable energy (oil, gas, coal) and limited water supplies for growing, and more industrialised or deforested communities, is leading to conflict which itself produces poverty and hunger.

Moreover, the whole food network requires both energy and water to sustain it³⁸.

Renewable energy sources are potentially many and varied and include solar energy; wind power; geothermal energy; hot rocks; ocean currents; bio-fuels (vs. food); and controlled nuclear energy (even if controversially). Newer technologies that can allow us to produce renewable

energy (e.g. solar generators) and clean, safe, recycled or desalinated water have immense prospects for improving the human condition – directly and indirectly through conflict minimisation.

Women and technology

We have tended to dismiss the importance of women in technologies relevant to the human condition, but, on reflection, women are 'the founders of technology related to human needs', namely: food-gathering, processing, cooking, storing, feeding; clothing – textiles, manufacturer, design; and information – purveyors of 'communication'. The commercialisation of these technologies has often been in the hands of men, so that the fulfilment of their human potential has tended to fall short.

How to make the new nutrition sustainable

Increasingly, nutrition scientists should envisage their findings being translated into action in ecologically sustainable settings.

For example, the production of fish, more nutritious rice and other grains and root crops, fruits and vegetables are all recommended as especially nourishing: but are they sustainable? It is clear that nutrition policy was not adequately developed in a sustainable way. Thus, for example, despite the increasingly strong case for a regular intake of fish (maybe three 100 g servings per week) in the human diet, only a minority of relatively well-resourced individuals or communities can ever hope to realise this goal. Here there are questions of both sustainability and equity – what is enough and who will get it?

A difficulty we have is the prediction of the point at which new food security crises may supervene, as, for example, with loss of tropical rainforests and desertification. The forest fires in Indonesia in recent times illustrate this point, where the smoke itself can alter the capacity for raindrop formation and, quite quickly, alter rainfall and forest growth. Again, when rains fall, they may quickly wash away the limited topsoil, with consequent desertification. Here fractal and chaos mathematics may be required^{39,40}. This is one of the many examples of a growing need for the sciences to partner each other for food security, individual and planetary health and well-being.

At this stage, we also do not understand enough about biological rhythms and how they might be perturbed in non-sustainable environments. We understand for women, at least, and for farmers, how important lunar monthly cycles are. So, too, for seasons, which have both lunar and solar cycle considerations. What about other more cosmological cycles, and food production and human health? We have scarcely begun our enquiry, but it is bound to be important.

An important point made by Colin Tudge⁴¹ is that it is possible not only to manage agriculture sustainably and economically, but also with food and culture both

attractive and palatable. It is the conjunction and not the contradiction of these matters which has characterised the production of 'peasant food', now finding its way on to the tables of the gastronomists.

Opportunities for the new nutrition science

Opportunities exist for the new nutrition science to help build a new economy, linked to development; operating with inter-community arrangements; and with IT as a driver.

The broad view of human development is not simply fiscal or even health, but as in the United Nations Development Programme's Human Development Index⁴², which refers to education, health and quality of governance.

Further, according to the World Health Organization report on socio-economics and health⁴³: 'Although health is widely understood to be both a central goal and an important outcome of development, the importance of investing in health to promote economic development and poverty reduction has been much less appreciated. Extending the coverage of crucial health services to the world's poor could save millions of lives each year, reduce poverty, spur economic development, and promote global security'.

There is great potential to link the human, economic and ecological development of Africa, Asia and Australia, and it is already happening. It is my view that an African-Asian alliance provides great opportunity for ameliorating the burden of poverty, hunger and disease world-wide, but especially in Africa, as well as within Asian boundaries. The same ought to be possible for Latin America, linked to Asia and Africa, given that the historical linkages to Europe and North America have often failed Meso- and South America.

Solutions for development

The solutions for development rest in partnerships in science and technology (with social science, neurobehavioural science and urban design, for example), good governance, conflict resolution, entrepreneurship and economic development, maternal literacy and in inter-community arrangements.

How should we proceed? There are some tangible and achievable outcomes we can seek. For example, we can establish community networks within and between countries. We can focus on food technology and systems and information technology and systems. We can encourage innovation, knowledge transfer and product trade. We can recruit the Arts (music, performance and visual). We can franchise development concepts with community ownership. We can obtain investment and institutional support. We can progressively address basic needs.

Food security in human development requires location and societal approaches that may interact on the national,

regional, community, generational and gender level. An inter-community strategy is particularly attractive as it can allow internationalisation of locality, telecommunications and information transfer (www.village-life.com) and be 'bottom-up' in response to various 'top-down' approaches.

Conclusion

Health and economic development can proceed more effectively and rapidly together, through a creative and innovative reconceptualisation of nutrition science and related technologies.

A new generation of committed and visionary nutrition scientists and technologists could indeed enable us to deal with poverty and hunger in ecologically sustainable and ethically attractive ways.

References

- 1 United Nations. UN Millennium Development Goals (MDG) [online]. Available at <http://www.un.org/works/millennium/index.html>
- 2 Popper K. *The Logic of Scientific Discovery* (Routledge Classics). London: Routledge, 2002.
- 3 Kuhn T. *The Structure of Scientific Revolutions*. Chicago, IL: The University of Chicago Press, 1996.
- 4 Fenech M. Genome health nutrigenomics: nutrition and the science of optimal genome maintenance. *Asia Pacific Journal of Clinical Nutrition* 2004; **13**(Suppl.): S15.
- 5 Mattick JS. The regulatory architecture of the human genome. *Asia Pacific Journal of Clinical Nutrition* 2004; **13**(Suppl.): S14.
- 6 Simopoulos AP, Ordovas JM, eds. Nutrigenetics and Nutrigenomics [special issue]. *World Review of Nutrition and Dietetics* 2004; **93**.
- 7 The Giessen Declaration. *Public Health Nutrition* 2005; **8**(6A): 783-6.
- 8 Wahlqvist ML, Specht RL. Food variety and biodiversity: econutrition. *Asia Pacific Journal of Clinical Nutrition* 1998; **7**(3/4): 314-9.
- 9 Wahlqvist ML. Eco-nutritional disease or nutrition and chronic disease [foreword]. *Asia Pacific Journal of Clinical Nutrition* 2002; **11**(Suppl.): S753-4.
- 10 Wahlqvist ML. Chronic disease prevention: a life-cycle approach which takes account of the environmental impact and opportunities of food, nutrition and public health policies - the rationale for an eco-nutritional disease nomenclature. *Asia Pacific Journal of Clinical Nutrition* 2002; **11**(Suppl.): S759-62.
- 11 Jenkins DJ. Dietary fibre, diabetes, and hyperlipidemia. Progress and prospects. *Lancet* 1979; **2**(8155): 1287-90.
- 12 Wahlqvist ML, Wilmshurst EG, Murton CR, Richardson EN. The effect of chain length on glucose absorption and the related metabolic response. *American Journal of Clinical Nutrition* 1978; **31**: 1998-2001.
- 13 Nishijo H, Ono T. Food memory: neuronal involvement in food recognition. *Asia Pacific Journal of Clinical Nutrition* 1992; **1**: 3-12.
- 14 ABC Radio National. The Health Report: 4 October 2004 - The end of stress as we know it [online]. Available at <http://www.abc.net.au/rn/talks/8.30/helthrpt/stories/s1211073.htm>
- 15 Darnton-Hill I, Wahlqvist ML, Uauy R. The scientific basis for diet, nutrition and health relationships. In: *Preparation and*

- Use of Food-based Dietary Guidelines*. Report of a Joint Food and Agriculture Organization/World Health Organization Consultation, Nicosia, Cyprus, Geneva: WHO, 1996; 51–92.
- 16 Wahlqvist ML, Savige S, Wattanapenpaiboon N. Cuisine and health: a new initiative for science and technology 'The Zhejiang Report' from Hangzhou. *Asia Pacific Journal of Clinical Nutrition* 2004; **13**(2): 121–4.
 - 17 Trichopoulou A, Kouris-Blazos A, Wahlqvist ML, Gnardellis C, Lagiou P, Polychronopoulos E, *et al.* Diet and overall survival of the elderly. *British Medical Journal* 1995; **311**: 1457–60.
 - 18 Trichopoulos A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. *New England Journal of Medicine* 2003; **348**: 2599–608.
 - 19 de Lorgeril M, Salen P, Martin J-L, Monjaud I, Delaye J, Mamelle N. Mediterranean diet, traditional risk factors, and the rate of cardiovascular complications after myocardial infarction. Final report of the Lyon Diet Heart Study. *Circulation* 1999; **99**: 779–85.
 - 20 Darmadi-Blackberry I, Wahlqvist ML, Kouis-Blazos A, Steen B, Lukito W, Horie Y, *et al.* Legumes: the most important dietary predictor of survival in older people of different ethnicities. *Asia Pacific Journal of Clinical Nutrition* 2004; **13**(2): 217–20.
 - 21 Fung TT, Schulze M, Manson JE, Willett WC, Hu FB. Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Archives of Internal Medicine* 2004; **164**(20): 2235–40.
 - 22 Hu FB, Bronner L, Willett WC, Stampfer MJ, Rexrode KM, Albert CM, *et al.* Fish and omega-3 fatty acid intake and risk of coronary heart disease in women. *Journal of the American Medical Association* 2002; **287**(14): 1815–21.
 - 23 Hegarty VM, May HM, Khaw KT. Tea drinking and bone mineral density in older women. *American Journal of Clinical Nutrition* 2000; **71**(4): 1003–7.
 - 24 Yang CS, Maliakal P, Meng X. Inhibition of carcinogenesis by tea. *Annual Review of Pharmacology and Toxicology* 2002; **42**: 25–54.
 - 25 Zhao W, Chen J. Candidate foods in the Asia-Pacific region for cardiovascular protection: Oriental tea. *Asia Pacific Journal of Clinical Nutrition* 2001; **11**: 138–43.
 - 26 Lee CD, Blair SN, Jackson AS. Cardiorespiratory fitness, body composition, and all-cause and cardiovascular disease mortality in men. *American Journal of Clinical Nutrition* 1999; **69**(3): 373–80.
 - 27 Wei M, Gibbons LW, Mitchell TL, Kampert JB, Lee CD, Blair SN. The association between cardiorespiratory fitness and impaired fasting glucose and type 2 diabetes mellitus in men. *Annals of Internal Medicine* 1999; **130**(2): 89–96.
 - 28 Glass TA, de Leon CM, Marottoli RA, Berkman LF. Population based study of social and productive activities as predictors of survival among elderly Americans. *British Medical Journal* 1999; **319**(7208): 478–83.
 - 29 Isacson A, Hanson BS, Ranstam J, Rastam L, Isacson SO. Social network, social support and the prevalence of neck and low back pain after retirement. A population study of men born in 1914 in Malmo, Sweden. *Scandinavian Journal of Social Medicine* 1995; **23**(1): 17–22.
 - 30 Pekkanen J, Tuomilehto J, Untela A, Vartiainen E, Nissinen A. Social class, health behaviour, and mortality among men and women in eastern Finland. *British Medical Journal* 1995; **311**(7005): 589–93.
 - 31 Wahlqvist ML, Darmadi-Blackberry I, Kouris-Blazos A, Jolley D, Steen B, Lukito W, *et al.* Does diet matter for survival in long-lived cultures? *Asia Pacific Journal of Clinical Nutrition* 2005; **14**(1): 2–6.
 - 32 Mathers CD, Sadana R, Salomon JA, Murray CJL, Lopez AD. Healthy life expectancy in 191 countries, 1999. *Lancet* 2001; **357**: 1685–91.
 - 33 Marin P, Bjorntorp P. Endocrine–metabolic pattern and adipose tissue distribution. *Hormone Research* 1993; **39**(Suppl. 3): 81–5.
 - 34 Tan CT, Wong KT. Nipah encephalitis outbreak in Malaysia. *Annals of the Academy of Medicine* 2003; **32**(1): 112–7.
 - 35 Saif YM, Nestor KE. Increased mortality in turkeys selected for increased body weight following vaccination with a live Newcastle disease virus vaccine. *Avian Diseases* 2002; **46**(2): 505–8.
 - 36 Kamphues J. Animal feeding and feed legislation after the detection of the first indigenous BSE cases in Germany. *Deutsche Tierärztliche Wochenschrift* 2002; **109**(8): 362–7.
 - 37 Beck MA, Handy J, Levander OA. Host nutritional status: the neglected virulence factor. *Trends in Microbiology* 2004; **12**(9): 417–23.
 - 38 Klare MT. The new geography of conflict. *Foreign Affairs* 2001; **80**(3): 49–61.
 - 39 Gleick J. *Chaos: Making A New Science*. London: Penguin Books, 1988.
 - 40 Waldrop MM. *Complexity: The Emerging Science at the Edge of Order and Chaos*. New York: Touchstone, 1992.
 - 41 Tudge C. *So Shall We Reap*. London: Penguin Books, 2003.
 - 42 United Nations Development Programme (UNDP). *Human Development Report 2004. Cultural Liberty in Today's Diverse World*. New York: UNDP, 2004.
 - 43 Sachs J. *Macroeconomics & Health: Investing in Health for Economic Development*. Geneva: World Health Organization, 2001.