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The new nutrition science project

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Abstract

Objective: To show that nutrition science, with its application to food and nutrition policy, now needs a new conceptual framework. This will incorporate nutrition in its current definition as principally a biological science, now including nutritional aspects of genomics. It will also create new governing and guiding principles; specify a new definition; and add social and environmental dimensions and domains.
Method: A narrative review of nutrition science, its successes and achievements, and its dilemmas, paradoxes, shortcomings, dissonances and challenges. Reference is made to 16 associated papers. Equal use is made of continuous text and of boxed texts that extend the review and give salient examples.
Results: Recent and current interrelated electronic and genomic discoveries and linked sequential demographic, nutritional and epidemiological shifts, in the context of associated and interlinked global social, cultural, environmental, economic, political and other developments, altogether amount to a world in revolution, requiring all disciplines including that of nutrition science to make comparably radical responses.
Conclusion: Nutrition in principle and practice should be a biological and also an environmental and social science. This new broad integrated structure brings much recent and current progressive work into the centre of nutrition science, and in some ways is a renewal of the period when nutrition science had its greatest impact. It amounts to a map charting well-known and also new worlds. The new nutrition science is concerned with personal and population health, and also with planetary health – the welfare and future of the whole physical and living world of which humans are a part. In this way the discipline will make a greater contribution to the preservation, maintenance, development and sustenance of life on Earth, appropriate for the twenty-first century.

Keywords
Conceptual framework of nutrition
Principles of nutrition
Ethical principles of nutrition
Ecological principles of nutrition
Evolution and nutrition
History and nutrition
Life-course approach to nutrition
Biotechnology and nutrition
Genomics and nutrition
Human rights and nutrition
Definition of nutrition
Dimensions of nutrition
Biological dimension of nutrition
Environmental dimension of nutrition
Social dimension of nutrition
Causes of health and disease
Scientific revolutions
Systems theory and nutrition

The New Nutrition Science project, of which this and associated papers[1–16] are an initial part, is work in progress. The project, as developed so far, proposes new principles to govern and guide nutrition science and its application to food and nutrition policy, and a new definition that takes into account extended dimensions and domains. The purpose is to give the science maximum relevance and usefulness in addressing the challenges and opportunities of the twenty-first century. Taken together, this is groundwork for a new general theory of nutrition science.

Introduction

We have now entered a new era of human history. We are moving out of the period in which human activity has been mainly concerned with exploitation, production and consumption, into a new period in which our main concerns are and will remain ones of preservation, conservation and sustenance. This is inescapable, and has the greatest significance for those human activities with the greatest impact on the living and natural world. The implications for all sciences and technologies are profound.

There is in any case imperative need for nutrition science to gain a new definition, new governing and guiding principles, and extended dimensions and domains. The science, with its application to food and nutrition policy, is already breaking out of its original physiological, biochemical and medical frame, and is extending into other dimensions and domains; but it has not yet gained the overall conceptual framework needed by all sciences and indeed by all structured and sustained human activity.

An integrated science

The new nutrition will remain a biological science, now exploring the new domain of genomics, with a broader biological base, and will also be a social and environmental science, with all three dimensions integrated

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The world now is transformed from that mapped by nineteenth and early twentieth century theories and principles. The discovery of new worlds begins by becoming open to new ideas. As from the last decades of the twentieth century, the linked political, financial and electronic revolutions known as 'globalisation', together with bioscientific and biotechnological discoveries, and demographic, nutritional and epidemiological trends, all together make a new world that needs new maps. Nutrition therefore now needs a new conceptual framework, as a biological and also an environmental and social science, able to analyse and assess all relevant determinants of well-being and disease, and to take effective action. The new nutrition science will follow ethical and ecological principles, respect history, tradition and culture, affirm human rights, and be committed to the creation and maintenance of policies and programmes designed to preserve and protect the human, living and physical world all together. *The New Nutrition Science project* is work in progress to these ends.

together. These concepts, of broadening and integration, should be inseparable: the whole is greater than the sum of its parts.

The prospect includes accelerated evolution of nutrition, enabling it to respond more effectively to recent and current aspects of this electronic age, to give it increased depth and range as a biological science linked with other sciences.

The prospect also amounts to a revolution of the science. This is because taken together, the principles, dimensions and domains proposed here, including those of evolution itself and ecology, as well as those of economics, equity and ethics, change the science from one centred on humans, to one centred on the ecosphere of which humans are a part[4].

In these ways, the reformulated nutrition will regain the importance, influence and impact the science enjoyed in its first period between the mid-nineteenth and mid-twentieth century[3], by addressing the most important challenges and opportunities of the twenty-first century.

Need for new maps

The proposals made in *The New Nutrition Science project* amount to an outline of a map of both old and new territory. An analogy from recent human history is the discovery of the New World of the Americas by European explorers, with all that meant and still means for our understanding of our place in nature and in the cosmos. Just as the discovery by Europeans of the Americas half a millennium ago created the pressure that caused new maps to be drawn and a new cosmology to be accepted, the task now for nutrition science is to make a new map based on principles that fit the world now and for the future.

Discovery, exploration and settling of new worlds begin by being open to extraordinary ideas. With nutrition science, this will involve, with the adoption of ethical and ecological principles, the incorporation of disciplines conventionally seen to be outside its scope, attention to history, tradition and culture, acceptance that health is more than absence of physical disease, and commitment to policies and programmes designed to protect the whole human, living and physical world. The meaning and purpose of nutrition will be renewed as a result of this collaborative adventure.

Background

The theory and practice of nutrition science is certainly to do with the health of humans and animals in the service of humans. The well-being of populations in both rich and poor countries has owed much to the practice of the science in its modern form since its beginnings in the mid-nineteenth century (albeit in different proportions) and will continue to do so.

Fundamental public health measures including the securing of supply of adequate, varied food and safe water at population level, whether or not these have been the result of evidence from nutrition science[7], have greatly reduced infant and childhood mortality, increased resistance to infection, improved good health throughout life, and greatly increased the average human lifespan[17,18]. This vital work, a living legacy of the public health movement whose initial great achievements transformed the health of the first industrialised countries, continues at international, national and local levels throughout the world[19,20]. For these achievements alone, nutrition science has a proud place in the history of human health, welfare and development.

The biochemical frame

Nutrition is now conventionally seen as a biological (or 'life') science, principally working within a physiological,

biochemical, medical and now genomic frame, applied clinically or on behalf of communities and populations. This is shown in recent and current descriptions and definitions of the science[2]. A current textbook statement is: 'Nutrition has as its core the physiology and biochemistry of human metabolism'[21]. So its dominant practitioners have been and still mostly are people trained as physiologists, biochemists and physicians, who may see nutrition as a branch of their original discipline. Dietetics, the predecessor discipline, has been relegated largely to paramedical and other auxiliary practice, although some people originally trained as dietitians become nutrition scientists.

This process began with the foundation of nutrition as a biochemical science, as developed and consolidated in Germany by Justus von Liebig at the University of Giessen in the first half of the nineteenth century and then later in Munich, following the work of Antoine Lavoisier and others[22]. 'Family trees' showing the lineage of von Liebig as a leader and teacher descend to many distinguished and influential biochemists in Europe, the USA and the UK, including Max von Pettenkofer, August Kekulé, Carl von Voit, Max Rubner, Paul Ehrlich, Wilbur Atwater and Hans Krebs; among living nutrition scientists the physician and biochemist John Waterlow, and through him (because of his own leadership and teaching) many currently active leading nutrition scientists and food and nutrition policy-makers[23,24].

In the USA the biochemist Elmer McCollum, a founder and populariser of what he termed 'the newer knowledge of nutrition', concluded in his history of the science[25]: 'The primary objectives set by pioneers... [were] to discover what, in terms of chemical substances, constituted an adequate diet for man and domestic animals'. Looking forward, he stated: 'The essential nutrients are the most important units with which biochemists in every segment of the science' (he includes physiology, botany, zoology, bacteriology, embryology, genetics, immunology and virology) 'deal in extending knowledge of the phenomena of life'.

In the UK the physician Robert McCance, with Elsie Widdowson and assistants, compiled for the Medical Research Council *The Chemical Composition of Foods*, published in 1940. In later editions the word 'chemical' was dropped, as it became accepted that 'composition' meant chemical composition. 'McCance and Widdowson' has – itself or adapted – become a prime reference for teachers and students of nutrition, and its practitioners in government, industry, civil society and journalism, throughout the world. The introduction to the first edition begins: 'A knowledge of the chemical composition of foods is the first essential in the dietary treatment of disease or in any quantitative study of human nutrition'[26]. The statement is repeated in the most recent valedictory edition, published by the Royal Society of Chemistry in 2002[27].

Discussion

The 'classical' biochemical approach to nutrition is reductionist: it reduces food to its chemical constituents. Descriptively, it examines the effects of nutrients on physiology, metabolism and pathology. Prescriptively, it uses this knowledge with the intention of improving individual or population health. It has in turn shaped the disciplines of physiology, biochemistry, medicine and also public health in their nutritional aspects, as subjects of scientific study and in their applications as food and nutrition policy and practice. It has largely determined the teaching and practice of nutrition, starting in the mid-nineteenth century and continuing up to now. It has also influenced what theories and practices are accepted, and what are regarded as ancillary, marginal, irrelevant, spurious or fraudulent.

Historical and current achievements

The framing of what is now the conventional science of nutrition has an historical context. The medical and other biological sciences are part of the dominant human enterprise of the last five centuries, originated in Europe, whose achievement has been the use of science and technology to explore, dominate and control the living and physical world[28]. Nutrition scientists trained as physiologists, biochemists and physicians have designed and applied the technical blueprints showing governments and industry how best to feed institutional, urban and national populations. In the period between the mid-nineteenth and mid-twentieth century they gained great influence as figurative or literal 'powers behind the throne'[3,29].

Since the mid-nineteenth century and to date, the practice of 'classical' nutrition science has had great impact on public health. Some of its achievements are:

- Beginning in the mid-nineteenth century, with identification of protein as the 'master' nutrient and emphasis on animal foods, policies initiated by governments and industry as advised by nutrition scientists have increased the vigour of young people and the average size of much of humanity.
- At the beginning of the twentieth century, nutrition scientists identified by experiment various chemical micro-constituents of food, the lack of which are among the nutritional cause of the epidemics of deficiency diseases that then ravaged most impoverished industrial populations.
- In the first half of the twentieth century, the biochemistry of some vitamins and other nutrients became understood, and policies emphasising nourishing energy-dense foods better prepared young people as factory workers and soldiers, and influenced the outcome of both twentieth-century world wars.

In the second half of the twentieth century and in particular in its last two decades, the influence of nutrition

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Box 1 – The New Nutrition Science project: so what is new?

The Giessen Declaration[1] begins by stating: 'We acknowledge the work already done by institutions, organisations and individuals in Africa, Asia, Europe and the Americas that are already addressing the issues, challenges and resolutions set out here'. *The New Nutrition Science project* is not alone.

Traditional practice

In the past, much teaching on dietetics and nutrition did not draw lines between people, society and the environment. The separation of areas of study and practice is a feature of the modern period of history beginning in Europe around the seventeenth century. 'Complementary' naturopathic systems that do not isolate the individual are now common; as are traditional Chinese, Indian and other approaches that express philosophies of humans in society and nature. In Germany the philosophy of nature associated with Johann Wolfgang von Goethe, with its doctrines of co-responsibility and connaturality of humans with the living and physical world, is taught in universities and applied to nutrition[2].

Modern practice

As from the 1970s, some of the most influential books on nutrition and food and nutrition policy have had their impact because they integrate social and environmental with biological factors.

For the lay as well as the professional reader, the radical analyses made by Susan George in *How the Other Half Dies*[3] of the political determinants of world hunger and malnutrition rely on information compiled by the Food and Agriculture Organization of the United Nations, the World Bank and other official sources. Francis Moore Lappé's revelation in *Diet for a Small Planet*[4], that it takes over 20 times as much fossil fuel to produce a given amount of protein from industrially reared cattle than from cereals and legumes, comes from research carried out by David and Marcia Pimentel of Cornell University. Alan Berg in *The Nutrition Factor*[5], writing for the professional reader, identifies malnutrition as a consequence and also a cause of failure of countries to develop, costs the value of breastmilk, points out that formula feeding of infants increases dependency on imports and foreign aid, and identifies construction of the Indian national railway system as the main contributor to famine relief; he then became nutrition advisor to the World Bank.

Cornell University in upstate New York, founded in the late nineteenth century to promote scientific beef and dairy production, has always been involved with food and nutrition and their social and other implications. Its training is not separated into academic subjects, but brings different disciplines to bear on problems and their solutions (Garza C, personal communication).

As in other departments of nutrition, students at the University of Vienna are able to study relevant aspects of behavioural, social, educational and environmental sciences[6]. The Justus-Liebig University in Giessen, Germany, has within its institute of nutrition a department of nutrition ecology, dealing with the local and global impacts of food production, processing, trade and consumption, using systems theory methods[7,8].

Many other examples could be given of integrated nutrition science. Mark Wahlqvist, President of the International Union of Nutritional Sciences, is a champion of econutrition, believing that an ecological approach may be 'the most critical conjunction of all the sciences for human survival, health and well-being'[9].

The name *The New Nutrition Science project* was agreed in the knowledge that *The Old Nutrition Science project* or *The Continued Nutrition Science project* might be appropriate! The concepts of revival and renewal are certainly apt. What is new, as this paper outlines, is first the circumstances of the world and of nutrition science now in the twenty-first century; and second the need to bring together in common cause at this right time, the pioneers inside and outside the profession who are working in the social and environmental as well as the biological dimensions.

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scientists on international and national public policy and public affairs has waned[3]. But some of their achievements have been and remain remarkably important. For example:

- Beginning in the mid-twentieth century, calculations of global undernutrition, deficiency diseases and starvation made by nutrition scientists have enabled a global enterprise whereby impoverished populations are supplied with staple foods, 'fortified' foods and nutritional supplements.
- In the later part of the twentieth century, governments and industry responded to advice that diets high in saturated fats are a major cause of coronary heart disease. Food systems in high-income countries now supply less hard fats, and incidence of coronary heart disease has dropped dramatically.

Historical and current achievements continue to have their impact, and many[13,14], though not all[30], remain relevant and vital now. But what legacies are we who now are involved with nutrition liable to leave to our grandchildren and their grandchildren? We cannot assume responsibility for everything that happens in the world that is relevant to our own line of work. But how will those writing in the twenty-second century judge what we thought, said and did?

Mentioning the gorilla

There is a parable that speaks to us about the state of nutrition science now. The parable is about a gorilla in a room full of people. *Nobody mentions the gorilla*.

Why? Some people think that everybody else knows why the gorilla is there. Some believe that gorillas are found only in zoos and African jungles. Many are too shy or sophisticated to be the first to mention the gorilla. Some have nothing to say about gorillas, or else think that gorillas are not their business. Some suppose that the gorilla is a puzzle to which they do not know the answer. Some think it is a joke stuffed gorilla. Some would prefer to say nothing about the gorilla until it has been measured and weighed, when they will know what it means and what to do about it. Some are frightened that if they mention the gorilla it will kill them. Some are nervous not about the gorilla but its implications: if this is true, what else is true? Many hope that the gorilla is an illusion, or else that if they say nothing it will go away. So *nobody mentions the gorilla*.

As stated, the purpose of *The New Nutrition Science project* is to specify new principles, a new definition, and new dimensions and domains for nutrition science. Also as stated, the purpose of this is to enable nutrition science to fulfil its potential in the twenty-first century.

But there would be no purpose in such upheaval if nutrition science was now in the mainstream with its work charted, and its status respected by governments and industry and also civil society, in the general belief in its demonstrated beneficial influence in public affairs and public life, as was so between the mid-nineteenth and the mid-twentieth century[3]. In this case all that would be needed would be accretion and assimilation of new specialities, the use of new information and techniques, and their use according to existing principles and practices.

Now, to mention the gorilla. Nutrition scientists now are uncomfortably aware that the science is in crisis, in the Chinese sense of a time of danger and also of opportunity. In this sense a crisis is not intrinsically bad or good, but is a state of being in which a decision must be taken, to go one way or another. In the case of nutrition science, the choice is to remain principally a biological science; or, while retaining its biological identity, to become transformed. *The New Nutrition Science project* advocates the second path. This is because *nutrition science will be able effectively to address the relevant challenges and opportunities of the twenty-first century only as an integrated biological, social and environmental science*.

Ideas come first

It is conventional for articles in scientific journals to proceed from the particular to the general, following the inductive method first elaborated by Francis Bacon[31]. This paper proceeds from the general to the particular, following the deductive method preferred by most modern thinkers on scientific method. As the epigraph of Karl Popper's masterwork states: 'Theories are nets: only he who casts will catch'[32].

All progress in science, and in all human affairs, begins with theories, or simply ideas. These can be tested, but do not materialise as a result of the mere accumulation of information[33]. One of the ideas in this paper derives from the observation that the world in which we live now is transformed from that in which nutrition science was formulated and developed and had its great impact. Therefore, to expect 'classical' nutrition to be successful in this century would be rather like insisting that all transport needs can be met by canals and locomotives, or that Newtonian physics still has all the answers, or – perhaps a closer analogy – that Ptolemaic cosmology remains an adequate fit with observed reality after the European discovery of the Americas.

This new world now

An even-handed overview of the state of the world now is the three-volume *The Information Age*, compiled and written by the Catalan polymath Manuel Castells[34], in collaboration with many colleagues. He concludes: 'A new world is taking shape at this turn of the millennium. It originated in... the information technology revolution; the economic crisis of both capitalism and statism and their subsequent restructuring; and the blooming of social

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Box 2 – Personal, social and environmental health: competence and responsibility

The Giessen Declaration[1] states: 'The biological dimension should therefore be one of the three dimensions of nutrition science. The other two dimensions are social and environmental'. This has implications for the teaching and practice of the science.

Individual ideology

The biological dimension of a science relates to individuals, and populations seen as aggregations of individuals. Conventional clinical nutrition is descriptive, concerned with the interactions of food and its constituents with biological systems in laboratory and clinical settings, and as applied uses this knowledge prescriptively in hospitals, health-care centres and community settings. It assumes that all individuals of agreed types will respond in the same way, so that (for example) nutritional requirements for 'standard' women aged 18–50 years can be specified.

Taking humans out of all but the biological context limits the competence and responsibility of the nutrition professional, to that between doctor and patient, or investigators and subjects. Nutrition scientists working in the current frame make suitably tailored dietary recommendations designed to inform and educate the general public. Correspondingly, the types of recommendation they will make, directed at individuals or aggregations of individuals, will specify nutritional – which is to say biological – factors believed to affect health and disease, and assume that the people to whom they are directed are able freely to follow such advice or to ignore it, just as a patient may refuse to have an operation or to take the medicine.

In cultures focused on individuals and on freedom of choice, of which the most influential is that of the USA, this approach is dominant. Recommendations aimed at people as individuals or aggregates are most likely to have effect when the targets for advice are relatively able and willing to act as they personally wish. Whether this is how most humans usually behave in any type of society is debatable.

Social consciousness

Health professionals trained in social and environmental dimensions have a different attitude. They see the people they work with as being within a family and community, and within society and its environment. Such group consciousness was universal until the rise of religion centred on the individual conscience[2], and in most traditional cultures people, including leaders and teachers, naturally think this way[3].

In the social dimension it becomes evident that choice is constrained for many reasons. Impoverished communities are likely not to have the resources to change their ways of life; this is part of what being impoverished means[4]. But individual choice is not only constrained by lack of resources. Hindus and vegans will not follow advice to eat meat, for example. In any society, whose institutions include government, industry, communities and families, it is generally only privileged and also isolated people who take decisions by themselves.

Socially trained nutrition scientists consider the impact of their work in and on society. In giving advice and making recommendations, they have a sense of the deeper determinants of dietary patterns, and will naturally address policy-makers whose decisions shape food systems and supplies.

The environmental dimension includes physical and living resources, including the nature, state and quality of the global 'commons' – air, land, water. Here relevant policies and practices can be affected by individuals or indeed families and communities only as citizens. Professionals aware of the impact of environmental factors on nutrition and public health see it as a central part of their responsibility to advise those whose decisions shape the environment, whether United Nations and other international agency officials, transnational industry executives, or national government politicians and civil servants.

Politics and policy

This all implies enlarged competence and responsibility. In its application to food and nutrition policy and practice, nutrition science is inevitably political, meaning bound up with issues of public policy. This does not mean that nutrition scientists should pretend to be politicians. It does mean that their expert advice to politicians and civil servants should include relevant social and environmental considerations.

By accepting its wider responsibilities, nutrition science as a whole therefore becomes part of the theory and practice of population health in a broad sense of the term, with its laboratory and clinical aspects as means to that end.

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cultural movements, such as libertarianism, human rights, feminism, and environmentalism'. The interactions between these developments, and the reactions to them, have created a new dominant social structure (which he terms 'the network society'); a new economy ('the information/global economy') and a new culture ('the culture of real virtuality')[35]. He sees, as do other big-picture thinkers now focused on aspects of global affairs such as civilisation[36], economics[37], agriculture[38] and public health[39], that we are now living in the middle of a revolution.

Records of our times written at the beginning of the twenty-second century are indeed likely to say that our period of history was one of revolutionary developments and changes, and that the transition we are living through was comparable to that which moved the medieval to the modern period in European history. It may require some imagination to see this now. From now on the rate of change may slow down, or it may accelerate. We also cannot tell whether, as a result of these changes, the world will become a worse or better place. As professionals, we can decide whether or not to make a difference.

Nutrition scientists have their own responsibility. Much depends on attitude. The Indian plant geneticist MS Swaminathan, a man of sunny disposition, likes to quote the eighteenth-century French philosopher Jean-Marie Condorcet: 'People have a duty to those who are not yet born. That duty is not merely to give them existence but to give them happiness'. It is apt that the Marquis Condorcet was the originator of the theory of population attributed to Thomas Malthus but, as Dr Swaminathan is, he was an optimist: he saw the solution, in birth control.

The conditions for transformation

Why should nutrition science transform its nature? No science, and indeed no developed form of human activity, changes radically unless a series of factors are in play. The first is positive: the perception that the discipline will become transformed in effectiveness by itself taking a new shape. The second is negative and the obverse: the perception that without transformation, the ordinary practice of the discipline is becoming less and less relevant or useful. A third factor is a critical mass of energetic, effective and influential people in and out of the discipline already working outside its conventional frame, and beginning to converge and agree its new shape, which can also be called a new narrative or story[40]. This paper argues that these three factors apply to nutrition science. A fourth factor is the articulation, expression and communication of this new theory, which as work in progress is the intention of *The New Nutrition Science project*; and then its increasing use, because it is found to be more attractive, interesting, powerful, inclusive, relevant and valuable; which remains to be seen.

All transformations, personal or professional, are typically preceded by a period of discomfort and confusion in which paradoxes and dissonances become increasingly apparent and troublesome. The accumulation of such disturbances is like tremors preceding an earthquake. These may culminate in a dramatic phenomenon: this may be experienced with the senses, like the images of famine in Ethopia that galvanised the Band Aid initiatives, or with the mind, like the results of the studies of cigarette smoking and lung cancer in physicians that irreversibly changed the public mood about smoking.

As long as the conceptual framework and the methods or tools of any science are seen to work well, or more or less well enough, it will not change. ('If it ain't broke, don't fix it'.)

The historian and philosopher of science Thomas Kuhn observes: 'Science moves fastest and penetrates most deeply through confident employment of these tools. . . As in manufacture so in science – retooling is an extravagance to be reserved for the occasion that demands it. The significance of crises is the indication they provide that an occasion for retooling has arrived'[41].

One mistake Thomas Kuhn makes is to identify crises as negative. He formulated his ideas at a time and place when the science of physics, in which he was originally trained, was preoccupied by the consequences of the development of nuclear power, so this is not surprising[42]. However, a critical period of time, or indeed an exact moment (a 'tipping point') that is a catalyst for transformation, is just as likely to be positive in nature. Such an epiphany was the photograph of 'spaceship earth' taken at the time of the moon landings, that helped to inspire the first Earth Summit in Rio de Janeiro in 1992, now an emblem of the environmental movement, which at that time became transformed in scope, purpose and effectiveness.

Transformation can come from an initial position of strength and optimism, or from an initial position of weakness and pessimism. Positive energy is more effective. A Zulu concept is expressed in the word 'Indaba', meaning 'a coming together to make an agreement on an important matter'. *The New Nutrition Science project* is an Indaba, and proposes the resolution to the current crisis of nutrition.

Genomics. Transformation from strength

Change is always good for some, bad for others. In early 2001 the initial results of the sequencing of the human genome were published[43,44]. The then Director-General of the World Health Organization (WHO) stated in response: 'It is clear that the science of genomics holds tremendous potential for improving health globally'[45].

In his last book Peter Medawar reflected on how far science can and should go, and on the responsibilities of scientists. He wrote: 'Science's greatest glory is also,

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Box 3 – This era: evolution and revolution

The Giessen Declaration[1] states: 'The world is now experiencing a general period of accelerating social, technological and environmental changes'. Altogether these are revolutionary.

Correspondingly, the transformation of nutrition into a biological and also a social and environmental science is an evolution of the science, and is also revolutionary. Evolution implies orderly progress towards a more complex whole. Revolution can mean progress in a forward and also circular direction, as shown by a wheel, and upwards also, as shown by a spiral; this is one of the senses meant here. In modern history it refers to rejection of, revolt against and overthrow of an established order: this is not what is meant here!

In public affairs, revolutions are sometimes bloody, sometimes peaceful. Similarly in science, revolutions may be ones in which old systems of ideas break *down*; or in which they may break *through* to a new order that adjusts the old order and incorporates it within a more developed synthesis[2]. It is the second sense in which the new nutrition is revolutionary, in ways parallel with the change from Ptolemaic to Copernican–Keplerian cosmology.

Exploration of new worlds

The story of this change in cosmology, and the reasons for it, is instructive. Defining icons of medieval Europe are official maps of the known world shown as a flat surface centred on Jerusalem. But by the early fifteenth century, European leaders and explorers were well aware that there was a wider world outside official confines.

In 1409 Pope Alexander V obtained a Latin translation of Ptolemy's long-overlooked and ignored *Geographia*, showing the world as round, and setting out the principles of latitude and also longitude. Ptolemaic cosmology was a revolutionary breakthrough. In 1428 Prince Henry 'the Navigator' in Portugal obtained a world map probably of Arab or Chinese origin, showing the capes of Patagonia and of South Africa, and large islands to the west of Europe and Africa, probably including Puerto Rico. Christopher Columbus, Bartolomeu Diaz, Vasco de Gama, Amerigo Vespucci, Fernando Magellan and other captains probably sailed with such maps, and knew roughly where they were going[3,4].

European discovery and exploration of the New World of the Americas created a new need. The longer the voyages into new waters, the more the Ptolemaic cosmology did not fit with observations. It generated too many paradoxes and anomalies. The need to make sense of the existence and implications of the Americas created the context for the new general theory of Nicolaus Copernicus set out in his *On the Revolutions of the Heavenly Spheres*, which, as modified by Johannes Kepler, became accepted as true because it has turned out to be a better frame for a wider world[5].

The move from Ptolemaic to Copernican–Keplerian cosmology was evolutionary, proceeding by gradual development, reshaping accepted knowledge much of which remained useful. What made it revolutionary in the most disturbing sense, and led to the confrontation between Cardinal Roberto Bellarmine and Galileo Galilei[6], was that the new cosmology changed thinking about the place of humans in the scheme of things. Before, humans made in the image of God were at the centre of the universe. After, planet Earth was one of others in a heliocentric universe within one galaxy.

The new nutrition science is revolutionary for the same reason. As a biological science, nutrition is centred on humans. As a social and environmental as well as biological science, nutrition is centred on the ecosphere and biosphere of which we humans are one part. Human nutrition as a biological science is not rejected or overthrown, but rather made more relevant and effective and incorporated into a larger whole.

That said, the new nutrition science is not centred on *Homo sapiens*, any more than the universe has planet Earth as its centre. Writing at a time before feminism, a philosopher has said: 'Since Copernicus, it has been evident that Man does not have the cosmic importance that he formerly arrogated to himself. No man who has failed to assimilate this fact has a right to call his philosophy scientific'[7].

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unhappily, its greatest threat... In the world of science anything that is possible in principle can be done if the intention to do it is sufficiently resolute and long sustained. This places on scientists a moral obligation which, considered as a profession, they are only just beginning to grapple with'[46]. What nuclear energy has been for physics and antimicrobial drugs have been for pharmacology, genomics is for biology.

Big biotechnological Science

Genomics, the theory and practice of recombinant DNA biotechnology, is now used in agriculture, food, nutrition and health on a massive scale. By 2001 more than 50 million hectares, two-thirds of the USA, had been planted with crops with recombined genes, including almost half the world's soya beans which, since they are mostly grown to feed to cattle, are substrate for meat production. Sales of genetically modified seeds have been forecast at over $US 5.5 billion for 2005[47], and of crops $US 25 billion by 2010[48].

Nutrigenomics. Determine your lifespan?

Nutrigenomics is the application of genomics to create genetically modified 'nutraceuticals' or 'functional foods' whose nutritional profiles are changed so that their manufacturers can make health claims of protection against specific diseases. In rich countries these are resisted by civil society organisations and regarded cautiously by regulatory authorities for safety and other reasons. On a global basis 'golden rice', genetically modified to contain more carotenoids, is one example of biotechnology projected in the service of the poor: a cover story of *Time* magazine in 2000 featured 'golden rice' with the headline: 'This rice could save a million kids a year'[48].

A view expressed in a paper associated with this paper is: 'We are now at the threshold of a new era in which humans may in fact design their food supply to modify their life course and possibly their own evolution. The choices we make in the coming years may have profound influences in the future of humankind'[14]. This refers to nutrigenomics at an individual and family level. Tests of blood pressure and blood cholesterol are now widely available. A nutrigenomic test available from a private practitioner can, it is said, map individual optimum nutrient requirements, so that consumers can then shop for the exact foods genetically modified to meet their needs. On a rough-and-ready basis this is already the practice of private nutritional consultants who prescribe nutritional supplements and 'functional' foods such as 'probiotic' yoghurts, as well as offering naturopathic advice.

Proteomics. Cure for cancer?

Proteomics is one or two steps beyond. Interviewed at the end of 1998[49], Richard Klausner, then director of the US National Cancer Institute (NCI), envisioned proteomics, the application of genomics to protein, as the solution to cancer. 'Nothing is too Star Trekkie', he said. He explained that NCI scientists were planning cancer detectors to be injected into people that would seek out and destroy cancers and pre-cancers, somewhat like computer virus detectors. 'We're working on it with NASA', he explained. 'It's really exciting. If we can think of stellar probes where the signal-to-noise ratio is much, much greater, we're going to be able to find a cancer cell in the human body'.

It would be unwise to scoff. Television was science fiction in 1925, as were personal computers in 1950 and mobile telephones in 1975. True, proteomic therapy is not likely to be offered by any taxpayer-funded health service; and there seems little chance that it would be marketed at a price affordable by the poor as well as the rich. But almost anything is possible. Who would have guessed 50 or even 25 years ago that fisherfolk in Tamil Nadu would, in the first years of the twenty-first century, be downloading images from space satellites that track fish shoals?

Biology is not enough (1)

Jared Diamond observes: '[A]dvances in technology just increase our ability to do things, which may either be for the better or for the worse'[36]. Like nuclear physics, and for rather similar reasons, genomic biology troubles many reasonable people. Some of its uses now seem to be out of control. Released into the environment, a 'rogue' gene sequence conceivably might transmit devastating disease in plants, animals or humans. The general effect of application of genomics so far may well be to increase social inequalities, and perhaps also to distract attention from fundamental causes of health and disease. Farmers without money or credit to buy seeds are forced off their land. The patenting of genetically modified life forms is seen by some to be a new form of imperialist plunder. The dismissal by scientific establishment bodies of concerns about genomics is troublesome. There is reason to doubt announcements that genomics are a meaningful response to world poverty. And so on: 'The promise of genetically modified (GM) food species, while potentially great, remains clouded by unresolved uncertainties about the genetic, nutritional and ecological consequences'[4].

Everything that is known, all the speculations, and all the concerns, are all reasons why genomics in all its aspects should not remain within the frame of biological science. Its dangers are magnified as long as its social and environmental dimensions are not seen as at least equally significant, and all the more so when scientists who work with genomics are impatient with or indifferent to the full implications of their work. There is good reason to fear narrow vision. If judgement of the benefits of genomic technologies is limited to assessment of their biological efficacy, without paying equal attention to their ethical, ecological, economic and other implications, the possibility of catastrophe is real. There are many parallel examples, two being the introduction of the rabbit to

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Box 4 – Integrated nutrition scientist: MS Swaminathan

The Giessen Declaration[1] states: 'The overall principles that should guide nutrition science are ethical in nature. Its principles should also be guided by the philosophies of co-responsibility and sustainability... and by understanding of evolution, history and ecology'. One scientist whose life and work embodies this approach is the plant geneticist MS Swaminathan.

Following Gandhi

The MS Swaminathan Research Foundation (MSSRF) in Chennai (former Madras), India, founded with money from the first World Food Prize awarded to Dr Swaminathan in 1987, was host to the 30th session of the United Nations Standing Committee on Nutrition in 2003. Two years later he and his staff and volunteers were working with the farmers and fishermen whose livelihoods had been devastated by the tsunami that had swept over the littoral of Tamil Nadu. He was prepared: the MSSRF has a resource centre anticipating a general rise in the level of the world's oceans as a result of climate change, whose programmes include protection and replacement of the mangrove wetlands that are natural barriers against flooding[2,3].

His ethical, social and political principles in general, and as applied to rural reconstruction and development, are those of Mahatma Gandhi, including that of *antyodaya*: 'Self-realisation is impossible without service of, and identification with, the poorest'. His first great ambition, inspired in the late 1940 s by meeting the founding president of the republic Jawaharlal Nehru, was to work to make India self-sufficient in food production. Speaking of the mid-1960 s he said: 'Importing food was like importing unemployment... We were supporting farmers in other countries'.

He became known as the father of the 'green revolution' after successfully advocating the 'dwarf' hybrid strains of wheat developed in Mexico. The Indian government declared agricultural self-sufficiency in 1971. The great increase in cereal production in India, Pakistan and other countries has increased the inequity between capitalised and subsistence farmers and driven millions of rural families off the land into lives of urban squalor; however, a critic of industrialised agriculture reckons that: 'In 1960 s Asia the new technology, and the science behind it, was necessary'[4].

Empowering farmers

MS Swaminathan also accepts genomics applied to agriculture, with its troublesome aspects[5]. At the 17th International Congress of Nutrition held in Vienna in 2001 he spoke with enthusiasm about prospects for low-income countries of 'designer' genetically modified rice and potatoes, as well as crops bred conventionally[6]. He has faith in an 'ever-green revolution' involving horticulture as well as grains, saying: 'An integrated approach to Mendelian and molecular breeding is likely to make a food-based approach to nutrition even more effective in the future'.

The issue of genetic modification of crops and food in countries like India is controversial. Some see it as a new form of capitalist plunder[7]; others as a technology that is here to stay, has risks, and that should be beneficial. Much depends on thinking through the social and environmental implications of new technology[8].

The MSSRF does not have its own experimental farms. Its development of agriculture is in the villages of Tamil Nadu themselves. Many of the leading farmers and workers in its bio-villages project in Pondicherry are women. The project does not accept external funding. Every village has a community centre and pays for workers operating computers using Tamil fonts, networked to obtain and use news about market prices, weather conditions, and best practice. Satellite images downloaded from the local US Navy's website show the village fishermen the movement of shoals. In celebrating the initiative and energy of peasant farmers given the opportunity to become self-sufficient, Dr Swaminathan calls agriculture 'applied ecology', saying: 'Anybody who is interested in agriculture, not only today but also for the future, has to think of the conservation of nature and natural resources'.

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Australia and the feeding of the remains of sheep to cows in England.

Put positively, the chances of genomics being of real and lasting benefit to humanity are vitally increased once it is defined and practised as an environmental and social as well as a biological science. The new identity will itself be a start. And then: 'The genetic modification of food species... should be a co-operative public–private partnership, with agreed environmental, social and public health objectives. Priority should be given to nutritional needs in food-insecure populations'[4]. Given the vast impetus accorded to biotechnology by the richest transnational industries, lightly regulated by national governments and international agencies, this is easier said than done. But progress always begins with a good idea.

Public health. Transformation from weakness

The world of nutrition and population health is very different from that of genomics. The United Nations (UN) and other international agencies regularly produce reports on global health as affected by food and nutrition. Such bodies tend to emphasise the scale of their work, and their reports may begin and end optimistically. But their stories are of woe and lamentation.

Immoral malnutrition

In the early 1990 s, at the end of a world conference called by the Food and Agriculture Organization in Rome, UN member nations stated: '[W]e are especially distressed by the high prevalence and increasing numbers of malnourished children under five years in parts of Africa, Asia and Latin America'[19]. Here 'malnutrition' is used in the conventional sense, to mean deficiency of food in general or of various nutrients, which also increases vulnerability to common infections especially in childhood. A total of 2000 million people, mostly women and children, were deficient in one or more micronutrients. A total of 780 million people in poor countries were chronically short of food. Food-related chronic diseases were increasing in impoverished as well as rich countries. A message was: 'Hunger and malnutrition are unacceptable in a world that has both the knowledge and the resources to end this human catastrophe'[19].

In the year 2000 the UN Standing Committee on Nutrition (then the UN Administrative Committee on Coordination/Sub-committee on Nutrition, ACC/SCN) produced its fourth report on the world nutrition situation[50]. This emphasised foetal undernutrition, stunting, underweight and micronutrient deficiencies. The ill-effects of population displacement and the challenge of economic globalisation were mentioned. Stunting was decreasing, obesity was increasing. A message was: 'The size of the malnutrition problem is still vast... and progress in most regions is all too slow'.

The Commission on the Nutrition Challenges of the 21st Century was mandated by the UN ACC/SCN to find out why hunger and malnutrition was still so prevalent 'despite all the impressive agreements and world summits of the past decade'. Its report was also published in 2000[20]. The Commission assessed the problems. A total of 790 million people in poor countries had inadequate access to food. Iron-deficiency anaemia was pandemic. Zinc deficiency had emerged. The incidence of vitamin A and iodine deficiencies was decreasing, as was underweight in pre-school children. However, in 2020 one billion stunted children will grow up with impaired physical and mental development. Obesity was escalating. Poor countries were afflicted by a double burden of infectious and deficiency diseases of childhood, and chronic diseases later in life. A World Bank vice-president was quoted: 'The burden of malnutrition is completely unacceptable by any standards of decency. We must do something right now'. The general tone of the report was distressed.

Access to adequate nutritious food was impeded by shortage of water, soil degradation, decline in crop diversity and fish stocks, climate change, rushed urbanisation, and war. Poor countries were vulnerable to fluctuations in global money markets. Hope was seen in biotechnology. A message was: 'The persistence of malnutrition, especially among children and mothers, in this world of plenty is immoral'.

Staggering chronic diseases

In 2003 WHO produced a new report on diet, nutrition and the prevention of chronic diseases[51]. This updated a previous report published in 1990[52]. It confirmed the finding of *The Bellagio Declaration* of 2001, which states: 'Phenomenal social and economic changes, on a scale and at a speed unprecedented in history, have resulted in an epidemic of nutrition-related chronic diseases that must be contained'[53]. Since 1990 rates of chronic diseases had soared in middle- and low-income countries. Cardiovascular diseases had become more common in China and India than all high-income countries put together. In some countries obesity had doubled or tripled in recent decades. Obesity increases the likelihood of diabetes, high blood pressure, heart disease, diseases of the liver, kidney, gallbladder, nervous and musculoskeletal systems, and some common cancers, and obese people are often depressed[51]. With reference to poorer countries, a message was: 'The public health implications of this phenomenon are staggering'.

Did this mean that rates of deficiency and infectious diseases were decreasing? Relatively if not absolutely yes, in most countries outside sub-Saharan Africa. But every year nearly a quarter of all babies were born very small, a condition identified as due to intrauterine growth retardation; over 6 million malnourished children under the age of 5 were dying and 250 million were short of vitamin A; iodine deficiency, the greatest single cause of brain damage, afflicted over 700 million people; and over 2000 million people were estimated to have iron-deficiency

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Box 5 – Integrated nutrition: infant and young child feeding

The Giessen Declaration[1] states that nutrition science should be guided by the life-course approach 'and by understanding of evolution, history and ecology'. With breastfeeding, so it now is.

US and UN commitment

Examples of integrated policy are the current United Nations (UN) global strategy on infant and young child feeding[2], and that of the US Department of Health and Human Services (DHHS)[3] which admit evidence from many disciplines.

'Breast-fed infants, compared with formula-fed infants, produce enhanced immune responses to polio, tetanus, diphtheria, and common respiratory infections. Recent research also suggests that breast-feeding reduces the risk of chronic diseases among children, including diabetes, inflammatory bowel disease, allergies and asthma, and childhood cancer'. This is from the US DHHS Blueprint and the US Surgeon General, at the time of its publication in 2000[3,4]. The Blueprint cites more evidence of life-course benefits: breastfed children are less likely to be overweight and obese, are more intelligent and learn faster; and mothers who breastfeed may be less likely to suffer cancer of the breast and ovary.

The UN Global Strategy, published in 2004, states that: 'Mothers and babies form an inseparable biological and social unit; the health and nutrition of one group cannot be divorced from… the other'. Both policy documents stress the social and economic benefits of breastfeeding. The Blueprint calls for action: 'Increasing the rates of breastfeeding is a compelling public health goal'.

Growth and health

The UN Global Strategy recommends exclusive breastfeeding for 6 months 'to achieve optimal growth, development and health' and that breastfeeding should continue up to and beyond 2 years of age. Achieved after long hard debates[5], this is supported by a literature review finding that exclusive breastfeeding continues to protect against infections until and after infants are 6 months old[6].

How does this square with fears of 'growth faltering'? All over the world the health of infants and young children is gauged by regular weighing, checked against standard growth charts. These are issued by UN agencies, and endorsed by national governments and non-government organisations. If the weight shows a trend towards the lower recommended weight-for-age, the mother is likely to be told to switch to *ad lib* formula feed, higher in protein, and/or relatively energy-dense complementary foods. However, what in 2005 were still current standards are based on studies undertaken up to half a century ago, of the growth of children in the USA mostly fed formulas and weaned early. Meaning, mothers are told that their children are 'failing to thrive' because of not 'achieving' the weights of children in a country where rates of childhood obesity are close to the highest in the world.

In an equally impressive example of joined-up solution-orientated nutrition science in action, new UN standards are due to be issued at the end of 2005, based on the growth patterns of exclusively breastfed children[7,8], who flourish with much less energy from food[9]. The scientists responsible for the new standards affirm that the healthy rate of human growth is that with which the human species is evolved: 'This new policy takes the breast-fed infant as the biological "norm"… Policy implications and public perceptions should shift dramatically when the reference for normal growth and development is based on the breast-fed infant'[10].

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anaemia. Life expectancy was increasing, but more people were living with disease for more of their lives.

The obesity and diabetes shock

In 2004, a report on obesity was published by the UK House of Commons Health Committee[54]. In 25 years obesity had increased almost fourfold, and around two-thirds of people in the UK were overweight or obese; the economic cost was estimated to be £6.6–7.4 billion a year. A report published by UBS Warburg in 2002 stated that in the USA 300 000 deaths a year were causally related to obesity, costing $US 70 billion a year[55]. Obese people on average have 9 years' less life expectancy. Referring to diabetes, a message was: 'Should the gloomier scenarios... turn out to be true, the sight of amputees will become much more common in the streets of Britain [and] there will be many more blind people'[54].

The most remarkable figures are for childhood obesity and early-life diabetes. In some parts of the USA, half the new diagnoses of what has been termed 'adult-onset diabetes', until recently almost unknown in early life, were in adolescents[56]. UBS Warburg[55] stated that in the previous 20 years diagnoses of diabetes at the Boston Children's Hospital had increased 10-fold. Its report, produced as a service to industry, pointed out that class actions taken out on behalf of consumers against manufacturers of energy-dense, fatty, sugary and/or salty products were already a reality in the USA, and that the costs to industry of legal actions in the cases of cigarettes and asbestos together had so far amounted to over $US 600 billion. A message was: 'There are risks associated with obesity that have not yet been factored into share prices'.

This does not mean that childhood obesity and diabetes is a public health catastrophe only in rich countries[51]. In July 2005 the UN System Standing Committee on Nutrition (UN SCN) decided (not decided) that the theme for its 2006 session will be the 'double burden' of deficiencies, infectious diseases and also obesity, diabetes and other chronic diseases, in middle- and low-income countries. Special attention will be given to the increase in childhood obesity in impoverished countries, which contributes to 'an immense and growing global public health problem'[57,58].

In the scientific community, the emergence of early-life obesity and diabetes was not anticipated, and much discussion to date has mostly consisted of amazed description, as if the phenomenon is a volcanic eruption or a disaster of war. The revelation is so shocking that it may prove to be a 'tipping point' for transformation of the science.

The big bad news

Consolidated estimates for the prevalence of all types of disease whose immediate sole, main or partial nutritional cause is inadequate, monotonous, unbalanced or generally unhealthy food, with trends over time, have not been compiled. Such figures would be rather rough and ready, and those for micronutrient deficiencies could be exaggerated[59]. But broad global assessments of numbers of people (not proportions of the global population) suffering from diseases of all types of malnutrition, including of deficiency, imbalance and superfluity, are bleak.

- Food insecurity and undernutrition, even hunger and starvation, and some specific nutritional deficiencies are decreasing slowly and erratically.
- Infectious diseases, vulnerability to which is affected by nutritional status, are also decreasing only slowly outside Africa; in Africa they are increasing.
- Those most vulnerable to all types of food-related disease are impoverished populations who do not have access to, or money for, medical treatment.
- Obesity, diabetes, cardiovascular diseases, various cancers and other diseases altogether are increasing, most of all now in middle-income countries.
- The staggering rise of obesity and diabetes in children and young people, with predictable consequences in later life, is a pandemic now out of control.

It is commonly stated in reports such as those cited here that linked underlying causes of diseases whose immediate causes are nutritional, including chronic diseases like obesity, are deprivation, impoverishment and crowding. Here the story is also bleak:

- The number and proportion of impoverished communities in low-income countries, and within high- and middle-income countries, continue to rise.
- The number of countries increasingly dependent on foreign aid, trade, loans and other interventions, and unable to support themselves, continues to rise.
- The world's population continues to rise, and the production and consumption of energy and other physical and living resources continue to accelerate.

Why is all this so? Why are there now more impoverished people in the world? Why are the governments of middle- and low-income countries increasingly unable to become independent? Why is use of non-renewable energy continuing to rise exponentially? Questions like these are disturbing. It is tempting to say in response, for example, that while we can all act as citizens and not just as consumers, and buy locally produced or fairly traded food[11], nutrition scientists cannot be expected to solve the world's external debt problem. True; but this is not what is proposed here.

It is unconscionable to be unconscious of the fundamental reasons for the rates and trends of all types of malnutrition in the world. This is also inadvisable, because when politicians and other policy-makers become ready to address the big issues, they will not be influenced by those who don't know the questions and so don't have any answers. Accurate analysis and assessment of any problem is an essential prerequisite of effective

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Box 6 – Disintegrated nutrition: fish and seafood

The Giessen Declaration[1] states: 'For the first time in human experience, the overall size and the economic activity of humankind exceeds the capacity of the planet to supply, replenish and absorb'. One example is fish and seafood.

The price and the cost of fish

Nutrition scientists who make recommendations meant to improve health are becoming uneasily aware of dissonance with environmental implications. Thus, the World Health Organization's 2003 report on prevention of chronic diseases[2] recommends fish as protective against heart disease and stroke, but says this 'needs to be balanced against concerns for sustainability of marine stocks and the potential depletion of this important marine source of high quality nutritious food'; meaning, the more fish eaten the less fish there are to eat. No solution is suggested.

Environmental scientists are more forthright. The UK Royal Commission on Environmental Pollution warns that the oceans and seas are being mined at an unsustainable rate[3]. Fish stocks could diminish irreversibly. Intensive aquaculture is not a solution because farmed fish feed is made from fish. Inasmuch as fish are protective foods because of their omega-3 fatty acid content, the Commission suggests that dietary recommendations should specify other sources, such as seeds and nuts.

The tsunami and shrimp farming

Ecologists say that abuse of the living and physical world has a karmic effect. A recent case is the Asian tsunami at the end of 2004. The deaths of many of the 200 000 and more people swept away by the great wave were not just a natural catastrophe.

Coral reefs and mangrove wetlands protect against the force of the ocean. The reefs and mangroves that circle the mostly 'undeveloped' Andaman and Nicobar Islands buffered impact of the waves; there, relatively few communities were destroyed[4]. Mangroves, anchored in mud in estuarine ecosystems, once made up almost a quarter of the littoral of South East Asia. For fishing communities, mangroves are 'sea cradles' protecting hatchlings from predators and providing safe mooring. Husbanded mangrove ecosystems provide stocks of fish for local consumption; part of traditional food systems and a source of communal livelihoods.

Throughout Asia reefs and mangroves continue to be dynamited and bulldozed. Already more than half these natural commons are now gone. Thailand once had 380 000 hectares of mangroves; by 2000 over 250 000 hectares had been destroyed[5]. Some people gain; most lose. Local fishing communities are pushed out. Many of the people who died in December 2004 were unnaturally close to the ocean.

This environmental devastation is the result of construction of tourist resorts and capitalised industries. The biggest single destroyer of Asia's coastal wetlands is shrimp farming. In 2000 Thailand exported 300 000 tonnes of shrimps and prawns, Indonesia plus India another 150 000 tonnes. Close to half the annual Asian total of over half a million tonnes is imported by the USA, with an annual market valued in 2000 at around $US 10 billion[5]. Shrimps and prawns are marketed as tasty and also as low in fat, high in many nutrients, and so (apart from dietary cholesterol) very nourishing.

Like estuarine fish, shrimps mature in a mixture of fresh and salt water. Intensive breeding of shrimps creates a polluted 'footprint' about 100 times the size of any 'farm'. Every tonne of shrimp produced kills 20 tonnes of fish[4]. One reason is the fish used as feed. Another reason is that 'factory' conditions involve constant use of antimicrobials and other chemical inputs. The farmers abandon the poisoned earth every few years, move on and destroy more mangroves. Much of the coastline of the Aceh province of Indonesia was already devastated by shrimp 'ponds' looking like bomb craters before the tsunami struck, with more destructive force than if the mangroves had been preserved.

The right price for food includes the cost of preservation and development of human, living and physical resources. The right price protects life as well as livelihoods; and in the case of the tsunami, not only the lives of Asian farmers and fishers, but also of rich people whose experience of catastrophe is usually only what they see on television. The cost of shrimps is much higher than their price. Food and nutrition policies need to be based on the evidence not only of human biology but also of ecological impact.

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action. You can know where you are going, only if you know where you are.

Reasons for health and disease

The question 'What is disease?' is not fully answered by a description of its pathology. A better question is: 'Why is disease?'

This question has been asked and answered well in the past. Thus, as recorded by René Dubos[60], the German epidemiologist Rudolf Virchow was asked by the Prussian government in 1847 to investigate an epidemic of typhus in Upper Silesia. He concluded that the underlying cause was a year of hard rain and bitter cold that had made poor people starve, huddle together and incubate the disease that then, as an ecological nemesis, had spread to the wealthier classes whose representatives had commissioned his research. He then founded the journal *Medical Reform*, with the purposes of identifying poverty as the breeder of disease and of encouraging physicians to support reforms that would create healthy societies.

His philosophy was a foundation of the public health movement of the nineteenth century. He saw disease as a 'disturbance of culture'[61], and epidemics as warning signs against which the progress of states and civilisations can be judged. That is to say, mass diseases are symptoms of deeper pathology. This applies not just to infections but to all forms of disease.

A challenge for public health nutritionists now is to identify the 'disturbances of culture' driving the epidemics of disease whose immediate causes include inadequate, unbalanced or excessive diets: and most of all, of those epidemics projected to get worse.

The authors of four papers associated with this paper identify four such basic pathogenic driving forces[4–7,38,39,47,62–64]. These social and environmental phenomena themselves have political, economic and commercial drivers. They are all interlinked, and history shows they are all examples of types of human activity that, if continued for long enough on a great enough scale, contribute to the collapse of civilisations[36]. These are: degradation of vast tracts of land, most of all by the industrial production of animals[65]; mass migration of rural populations into already crowded cities[66]; saturation of markets by fast food and drink companies[67]; and depletion of the planet's living and physical resources[68]. There are more. Such phenomena need to be seen systematically. Their dimensions are not sensibly separated; they are all environmentally and socially and biologically pathogenic.

Biology is not enough (2)

In its genomic aspect, nutrition as a biological science is strong; within biological confines public health nutrition is weak. Strong or weak, the answer is the same: the future for nutrition is also as a social and environmental science. Once the science incorporates ethical and ecological principles and includes domains like human rights, rural livelihoods, biodiversity and land use, it will be able to assess, analyse and also act effectively. Until then, whether as an academic or practical discipline, nutrition science can expect to have only a somewhat superficial impact on public health, such as lawyers have on crime, or motor mechanics on car crashes.

The Giessen Declaration[15] summarises what, particularly since the last two decades of the twentieth century, amounts to a linked series of general challenges facing all scientists and all citizens. On the one hand: 'This twenty-first century in many respects shows prospects of opportunity and prosperity for the minority that enjoys stable entitlements including physical and financial security, adequate, nourishing and safe food, safe water supplies, and good education and health'.

But on the other hand: 'The majority is not so fortunate. Most people in the world could in future be better off in some and possibly even most respects than they are now. But they are afflicted and threatened by interrelated deprivations that make social and individual life difficult and sometimes impossible. These include loss of amenities and skills; loss of traditional farming and food cultures; loss of land, property and independence; vulnerability to unemployment, dislocation, and other impoverishments; precipitate urbanisation; social, economic and political inequities and turmoil; poor governance, and conflicts and wars of many types'.

Challenges for nutrition science

Below are some of the questions now increasingly being asked by and also of nutrition scientists, with a sense of urgency and anxiety. They are uncommon topics for themes of conferences or presentations within scientific meetings. But they are in the air. Here they are phrased in the form of 'how?' questions. There are also plenty of 'what?' and 'why?' questions to be asked.

- How can the science maintain its prestige and justify its existence, when global rates of classical malnutrition are decreasing slowly or erratically?
- How can the science claim to prevent food-related diseases, when global rates of childhood obesity and diabetes in young people are now rocketing?
- How can genomics be a global solution to diseases caused by unhealthy foods, when most people have no access to sophisticated health care?
- How can the benefits of local fresh agricultural produce be advocated, when governments are shifting their rural populations into big cities?
- How can consumers enjoy cheap nutritious food, while producers especially in middle- and low-income countries also sustain equitable livelihoods?
- How can traditional ways of life survive the invasion of

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Box 7 – Well-being and disease: causes and action

The Giessen Declaration[1] states that nutrition science can successfully address the challenges of the twenty-first century 'only by means of integrated biological, social and environmental approaches'. This entails addressing fundamental causes of well-being and disease.

Types of cause

Modern medicine is uncomfortable with concepts like causation, used in work that involves broad judgements, such as law[2]. Physicians tend to use terms like 'aetiological factor'. On death certificates, as on records of mortality, they equate cause with a pathological event, saying that death was caused by (say) a cerebrovascular event (a stroke). Or they equate cause with disease, saying that death was caused by hypertension (high blood pressure), leading to the haemorrhage. Physicians and surgeons say what they see. This language is descriptive and restricted: it addresses 'how?' but not 'why?'

Nutrition scientists go a stage deeper and look for nutritional factors. They may say that high blood pressure and stroke is caused in part by diets typically high in salt, and may recommend that people consume less 'risk factors' like salt, usually by individual choice supported with information and education.

'Why' questions are asked when people are seen in context. In a social context, to say that a death is caused by a cerebrovascular event, or by over-consumption of salt, is like saying that a death is caused by a bullet penetrating a brain. While in a sense true, this not useful outside the autopsy room or laboratory, where relevant questions include: who bought the gun, who fired it, and why?[2] Immediate or 'proximal' causes are never the whole story.

Types of action

Identification of environmental and social determinants of well-being and disease involves thinking of production and food systems rather than consumption and individual diets. A series of 'why?' questions may be asked, as in a court of law; and then concepts of cause and of responsibility become bound up with one another.

Deciding how far such questions should go, depends on deciding what type of proposed action may be most effective. Thus high rates of death in infancy in low-income countries can be said to be caused by malnutrition, infection or inadequate breast-feeding, or (going deeper) lack of medical care, famine, fragile food systems, impoverishment or the practices of transnational baby food companies, or (deeper yet) expropriation, dislocation, corruption, warlords or the effects of colonialism, and now of economic globalisation[3]. Any or all of these factors may be causative, meaning any or all may in some degree be responsible[4].

The question 'so what?' then needs asking and addressing, so that assessment and analysis can generate meaningful actions. These can be gauged in different ways, including cost, time, scale, and number of lives improved and saved. The concept of 'effective cause' is useful, with its implication of effective action. Thus, with alcohol, fiscal, legal and regulatory policies, including high taxes and restriction of availability, advertising and promotion, are known to work[5]. This implies that effective causes, or driving forces, of high rates of death from diseases of which alcohol is the immediate cause, include absence of such policies. Similarly, in the case of high infant death rates, the relative effectiveness of artificial baby milk container labelling can be weighed with that of regulations controlling the marketing practices of infant formula manufacturers.

In situations where prompt action is clearly needed, such as sudden pandemic childhood obesity and early-life diabetes, action may rationally follow a decision on the 'John Snow' principle that the burden of proof is on those who propose no action.

Nutrition scientists should address social and environmental causes of well-being and disease, as well as immediate biological causes. Indeed, when United Nations and other reports state, as they do, that food and nutrition policies should be equitable and sustainable, they imply the need to understand social and environmental determinants. This implies professional competence to work outside clinical contexts, with international agencies, governments, industry and civil society organisations.

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highly concentrated, capitalised, advertised and promoted brands?
- How can poor countries protect their traditional food systems, when their food supplies are overwhelmed by imported surpluses from rich countries?
- How can food and nutrition security for practically all communities in southern Africa be sustained, when the region is devastated by HIV/AIDS?
- How can policies to prevent in childhood food insecurity be harmonised with those designed to prevent chronic diseases through the course of life?
- How can consumption of red meat and animal fat decrease, when global food trade regulations have the effect of increasing their production and supply?
- How can the production and consumption of more fish be recommended, when it is known that fish stocks are a threatened food resource?
- How can the human right to adequate nutritious food be achieved in countries devastated by wars and by food trade and aid used as an instrument of power?

Key phrases in this text include 'the course of life', 'childhood obesity', 'equitable livelihoods', 'traditional ways of life/food systems', 'sustained food security', 'global food trade regulations', 'threatened food resource' and 'the human right to adequate nutritious food'.

Framed as principally a biological science, nutrition cannot adequately answer questions like these, because it cannot fully address them. The social and environmental driving forces of what are now the vast political, economic, demographic, nutritional and epidemiological developments and changes referred to in such questions, are beyond its scope.

Following the example of environmental science in the last two decades, such questions need to be addressed, as central to the professional calling of nutrition. This can be done, and is fulfilling. As mentioned, advances in the principles and practice of infant and young child feeding are an example of integrated nutrition science in effective action. César Victora of the University of Pelotas in Brazil was one of the group of nutritional epidemiologists responsible for the literature review on which the WHO strategy recommendation on exclusive breastfeeding for 6 months, now part of the UN global strategy, relies[69,70]. Speaking to representatives of the International Baby Milk Action Coalition he said: 'For 15 years we have been accumulating evidence on the benefits of exclusive breastfeeding, and this has at last led to a change in global policy. The scientist's greatest frustration is when our studies do not result in changes in the real world'[71].

Reasons not to change

Looking to the future, five attitudes are more or less content with conventional nutrition science.

- *Defensive*. Nutrition is correctly identified as principally a physiological, biochemical and medical science; other approaches are at most ancillary.
- *Proprietorial*. Only those formally qualified in the discipline as now taught may legitimately engage in nutrition science and its applications.
- *Aggressive*. A 'firewall' is needed between the 'classic' and other dimensions, and in particular between descriptive science and prescriptive policy.
- *Dismissive*. Nutrition may well be both a discipline in itself and also a meeting ground of related disciplines, and so what?
- *Acquisitive*. The science can accrete other specialisms and sub-specialisms without any major stated change in its nature and purpose.

All of these positions have some merit and validity. All are implicit in the way that the science has developed since the mid-twentieth century. Some are implicit in many major reports on food, nutrition and public health published since the 1960s[19,20,50–52,72]. None of these positions is advocated in this paper.

Moves towards integration

Moreover, there are now plenty of signs that the profession of nutrition is already moving towards becoming a more ambitious and integrated enterprise, while retaining its biological dimension. Examples are given in boxed texts in this paper. Thus:

- Towards the end of the twentieth century, teams working outside and inside the profession converged in the view that the origins of obesity and other chronic diseases are in early life and begin in the womb[73,74], and that exclusive breastfeeding protects good health throughout life for child and mother[69,75].
- In the last decade of the twentieth century, in response to the production and consumption-driven approaches co-created by conventional nutrition science now magnified by global food trade policies, a rights and entitlements approach began to be developed that does not fit in the conventional frame[37,76].
- At the beginning of the twenty-first century, integrated thinking on nutrition and food policy is converging on the view that the big issues are outside any conventional frame, and include those of evolution, resources, ecology, the environment, economics, trade, politics and ethics[1–16,30,38,39,47].
- Thus, study of underlying and basic determinants of obesity has identified the 'obesogenic environment' needing elimination by fiscal, regulatory and other political and economic instruments including food trade laws, regulations on marketing to children, and urban planning[56,77,78].

A striking feature of these initiatives is that they are collaborations. Most involve scientists, inside and outside the profession of nutrition however defined, working with international and UN agencies and government ministries,

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Box 8 – Integrated nutrition: the rights approach

The Giessen Declaration[1] states that the main principles of nutrition science should be ethical in nature, and 'be guided by the philosophies of co-responsibility and … by the … human rights approach'. This approach is already being taken by scientists working within the United Nations (UN) system and in national governments.

Human rights

The human right to adequate food and nutrition, an ethical principle with constitutional and legal implications, is in part derived from the Universal Declaration of Human Rights and similar UN statements, like that which 'reaffirms the right of everyone to have access to safe and nutritious food'[2]. It is being developed in various fields of food and nutrition policy[3,4]. The approach perceives people less as objects, patients or consumers, more as subjects, agents and citizens.

The executive summary of the Commission on the Nutrition Challenges of the 21st Century begins: 'To live a life without malnutrition is a fundamental human right'[5]. The human rights approach is also part of the UN global strategy on infant and young child feeding, which is 'based on respect, protection, facilitation and fulfilment of accepted human rights principles'[6].

The human right to adequate food and nutrition was the theme of the 32nd annual session of the UN Standing Committee on Nutrition (SCN) held in 2005 in Brasília. Case studies from Bolivia, Mozambique, Angola and Brazil were presented, examining food and nutrition aspects of programmes using the human rights principle[7].

A rights-based approach to food and nutrition within any country involves the making and changing of laws, regulations and codes, and requires collaboration among various ministries[8]. In Brazil, the rights dimension is being integrated into the national *Fome Zero* (Zero Hunger) programme, which includes government-supported mobilisation of civil society organisations through the Brazilian National Food and Nutrition Security Council (CONSEA)[9].

Co-responsibility

Another ethical principle affirmed in *The Giessen Declaration* is that of co-responsibility with other humans, which may also be with animals, the whole living world, and the physical world.

An example of co-responsibility in action is preference for plant-based diets, not just because these are more healthy, but because food systems mainly made up of plants use less resources, have a lesser impact on the environment, are more protective of rural livelihoods, and because on a global basis animal-based food systems are unlikely to be sustainable[10,11].

The principle of co-responsibility may also involve belief in the rights of animals. Vegetarians and vegans eat no flesh, or no food of animal origin, usually not only for environmental reasons, but also because they believe that animals have rights violated by slaughter, or else perceive modern methods of industrial animal production as outrageous[12]. As far as human health is concerned, consciousness of co-responsibility might affect the impact of nutrition on physical health. It is likely to have most relevance to the types of well-being and health that distinguish humans from animals.

The concept of co-responsibility makes nutrition a social science if the shared responsibility is with other humans; and an environmental science also, if the principle includes responsibility to the living and physical world.

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with non-government organisations with academic, profession or civil society bases, and with constructive diplomatic relationships with industry, as for example is normal practice for scientific teams concerned with climate change.

In this process, civil society organisations are essential[7,30]. The best of these have become increasingly radical, and their campaigns combine thorough scientific and situation analysis, formidable networking skills and impressive contacts in the media, as has been done in the environmental field by Greenpeace and Friends of the Earth.

What about the teaching of nutrition science? A current textbook envisions 'a second renaissance' of nutrition, and sees the original biological model being expanded 'to include the study of all other external environmental factors that determine what and how much food and nutrients are available on a global level. These studies are underpinned by social, behavioural, economic, agricultural and political sciences'[79].

The International Congress on Nutrition, held every 4 years under the aegis of the International Union of Nutritional Sciences (IUNS), is designed to present the latest thinking in nutrition science. The themes of the plenary presentations for the 18th Congress in Durban, South Africa, in September 2005[80], suggest a science on the move. Six of its themes might fit into the current physiological, biochemical and medical frame of nutrition as a biological science. These are: responding to the HIV/AIDS pandemic with evidence-based nutrition interventions; global strategies to prevent non-communicable diseases; evidence-based nutrition; nutrigenomics; assessment of scientific support for food claims; and polyphenols and health.

The other five presentations are outside a biological frame. These (as well as *The New Nutrition Science project*) are on poverty and food and nutrition security; econutrition; the nutrition of children as investment in human capital; and nutrition in transition.

Looking forward, Ricardo Uauy, IUNS president 2005–2009, in his draft vision and mission for the IUNS and the world's nutrition science community[14], states: 'The challenge… for this century and immediately, for the remaining years of this first decade, is to integrate biological, social and environmental dimensions… This implies an overall ethical framework, awareness of evolution and history, and application of broad principles including those of human rights and the sustained protection of human, living and physical resources. In turn, this requires that our profession becomes more aware of and sensitive to global social and environmental changes and their impact on the nutrition and health of humankind'.

What is to come is a conceptual framework: the general theory of the science of nutrition designed to meet the opportunities and challenges of the twenty-first century and to act effectively in helping to make a better world. The creation of such a philosophy is the purpose of *The New Nutrition Science project*, within which this and associated papers are a beginning.

Conclusion

Features, papers, reports and books about nutrition and health are being published every day. Those concerned only with advising individuals what to eat may simply summarise current recommendations, select corresponding foods from tables of chemical composition, and add some recipes. But these days, most serious professional advice, and indeed much journalism, considers not just the physical health of single or aggregated individuals, but also issues such as sustainability and equity.

Being connected

This is not because writers and readers have suddenly become virtuous. One effect of the electronic revolution is that it is easy to make connections that previously were obscure. We are all able to be ecologists now. Adolescents anywhere in the world with access to television and the Internet can work out for themselves that the sons of farmers driven off the land often become destitute, desperate and dangerous. Anybody can see that the human population is getting fat, just by walking down the street, and can see why, by taking a look at what is on offer in the shops and on television and the Internet. Perhaps most people are unconscious, but it is always the conscious minority who create transformations. And as soon as equity and sustainability are part of the equation, nutrition is bound to include the social and environmental dimensions.

The big issues that press on us now, as citizens and professionals, are mostly not secrets. They are apparent to everybody who watches television and reads newspapers. They are high on the policy agenda of powerful governments and UN and other international agencies, despite some attempts to remain oblivious. Many are part of one great issue. The necessary shift in thought and action is from exploitation, production and consumption, to preservation, conservation and sustenance. This is not a matter of choice. We are overdrawing the planet's resources. The only argument is by how much. Now we have to invest.

Nutrition science is already working in social and environmental dimensions as well as in the conventional biological dimension. This progressive work needs integration into a new conceptual framework. The science as a whole now needs new principles to govern and guide its theory and practice, and a new definition, as well as wider dimensions and domains. These will transform the structure and scope of textbooks, curricula, reports, conferences and other academic frames. They will also enable application of the science to efficient and effective food and nutrition policies and programmes in all settings,

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Box 9 – Tools for transformation: the systems approach

The Giessen Declaration[1] states: 'Those now concerned with the future of the world at all levels, from local to global, generally agree that their overriding shared priority is to protect human, living and physical resources all together, in order to enable the long-term sustenance of life on Earth and the happiness of humankind. Nutrition science is one vital means to this end'. But how? This complex task can be accomplished, but not step by step: only all together, by use of systems methods.

Not the parts but the whole

Systems methods (and also field and complexity theories and practices) are tools for developments of the type proposed by *The New Nutrition Science project*. They examine big pictures as a whole: '[T]he totality of co-existing facts that are conceived of as mutually independent'[2].

Key phrases in systems theories are: 'The whole is greater the sum of the parts' and: 'Everything is connected'. They study the principles inherent in complex and related structures in time and space. In the early twentieth century they sprang out of quantum physics, were adopted in the branch of psychology known as *Gestalt*, the German word for 'figure' or 'whole form'[3], and were then developed in and for other sciences[4].

Systems methods are not well expressed by words on paper because language (at least, alphabetic language) is linear, and systems, like stories, pictures and music, have more than two dimensions[5]. Practitioners rely more on interactive working groups and computer networking. Systems theories and methods were developed by biological, social and computer scientists[6,7] and then by the creators of the electronic revolution[8,9]. Practitioners say they model the human brain and all living systems, and that feedback spirals between computer systems and their networked users enable humans to fulfil their potential.

Applied to government, industry and other organisations, systems methods are used as tools to identify the nature of organisations and to work with and manage change. One of their applications are 'vision' and 'mission' statements, types of definition designed to determine the dimensions and principles of organisations and identify their purposes, and thus to create, channel and drive energy. Many governments and corporation leaders are now trained by systems practitioners, some of whom are influenced by the fusion of Eastern and Western thinking in the Californian crucible of the 'human potential movement'.

The biological sciences have in general become increasingly reductionist in their approach; that is, more and more concerned with description and analysis of static, separate, minute parts of organisms removed from space and time, in conditions designed to approximate to those of a laboratory. Like any ecological concept, the practice of systems theory is subversive of such techniques. It implies for example that the recombination of genetic sequences, an enterprise based on a linear concept, must by the spiral nature of gene systems be inherently unpredictable and therefore dangerous.

The need for dynamic principles

The way forward for nutrition indicated by systems thinking is first by means of agreeing its principles, definition, dimensions and domains. This work is best done by interdisciplinary teams, addressing big questions and issues, such as 'how can human food systems and nutritional health be reconciled with the sustenance of the living and physical world throughout the twenty-first century?' Progress is then made by a spiral process of planning, action, evaluation, then revised plan, action, evaluation... and so on[10,11].

Thus, the spiral symbol used for *The New Nutrition Science project*. As the medieval mathematician Leonardo of Pisa, known as Fibonacci, suggested[12], and as proposed by current systems analysts: 'A spiral vortex best depicts the emergence of human systems as they evolve through levels of increasing complexity'[13].

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local to global, with the general purpose of making the world a better place for the foreseeable future.

The time has come

What will our successors at the beginning of the twenty-second century, very well aware of how precious and threatened are the planet's resources, think of nutrition science and scientists of previous generations? If it seemed to them that at the beginning of the twenty-first century the profession became increasingly more remote from public affairs and generally less able to make any difference for the better in the world, they surely would be perplexed. Whereas if history taught them that in the first decade of this century, just before it would have been too late, nutrition professionals reformulated their science, gave it new relevance and impetus, and played a leading part in effective protection and preservation of personal, population and planetary health for present and future generations, they surely would feel that we had done our best and had done well.

Declaration

The authors developed the conceptual framework of this paper jointly. The text is also the result of iterations between the authors and other authors of papers published in this issue of Public Health Nutrition, *referenced below, and also reflects discussions and findings of the Giessen workshop whose conclusions are stated in* The Giessen Declaration. *Thanks are also due to Catherine Geissler and Boyd Swinburn. Initial drafts were prepared by Geoffrey Cannon; subsequent drafts were worked on by Claus Leitzmann and Geoffrey Cannon. Thanks are given to those who have influenced the thinking of this paper, and associated papers written by the authors, in the general introductions preceding this paper.*

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