

## Original article

# Nutrition: the new world map

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The map of nutrition, evident in the structure of any course or textbook, derives from theses that framed a science begun in the 1840s, developed until the 1940s, and consolidated until now. Nutritionists now are perplexed as the explorers of half a millennium ago, who continued to use maps that did not fit the wider world they found. Until the 1600s, alternatives to Ptolemaic cosmology remained unthinkable despite its obvious inadequacy, because it was of a universe with the earth, and man made in the divine image, at its centre. Nutritionists now are inhibited for similar reasons. Two determining principles of nutrition science, the identification of health with growth and the belief that animal food is superior to plant food, have a deep origin; they derive from the materialist ideology that asserts a manifest destiny of humans to exploit and consume the living and natural world. In response, a new nutrition is emerging, with a global perspective, whose ideology places humans within nature, and whose theses make a wider frame, able to fit the world as we can discern it now. The new nutrition gives equal value to personal, population and planetary health, with all that implies, including the concept that the world is best perceived as a whole. The Copernican revolution changed the meaning of movement on earth. The new nutrition can change the meaning of life on earth. Now is the time to draw its map.

**Key words:** ecological nutrition, growth and health, nutrition, paradigm shifts in nutrition, population and planetary health.

## Introduction

This and the accompanying article propose that nutrition science should be reformulated, because its principles and practice are now inadequate.<sup>1</sup>

Nutrition science is more important than many nutrition scientists may realise. It is a vast subject. No individual could master all aspects of nutrition. As a chemical and biological science it includes biochemistry, physiology, and medicine. As a social science, it involves economics, epidemiology and anthropology. As a practical science it includes agriculture, food science and dietetics. Its policies and practices affect most areas represented by government departments, including finance, foreign affairs, home affairs, industry, trade, planning, environment, and culture, as well as agriculture and health. Any influential nutritionist is involved in policy, which is to say, politics.

Thus, nutrition science is an ambitious undertaking. Since its beginnings in the middle of the nineteenth century, nutrition scientists have advised governments and industry how best to feed populations, and after the creation of the UN system after World War II, how best to feed the world. It might be thought that the people of countries whose own food systems have evolved in harmony with climate, terrain and culture over hundreds and thousands of years, know how to feed themselves. But in the past 50 years we have been saturated by images of famines, wars, dislocation, poverty and other malign phenomena that cause populations to starve and become helpless. We have come to assume that low-income countries need to be fed by high-income countries.

If a purpose of nutrition science is to maintain and improve health, it can be said that since its beginnings just over 150 years ago, the gap between its fundamental concepts and their impact on the human and living world, between its intentions and their consequences, is so wide that, notwithstanding its many achievements, nutrition science has caused as much harm as good. Any such proposition, likely to seem obviously absurd and outrageous to those who work in the profession within current paradigms, becomes easier to grasp when these paradigms are themselves addressed. Where are the boundaries of nutrition science? Who and what is it meant to benefit? Why is it styled as it is? What are its intentions and its impacts? How far does one go in identifying chains of causes and effects? This article considers questions like these.

As citizens we all know that nutrition is a big issue. For example, popular and scholarly publications are increasingly discussing the proposal that modern food systems that generate energy-dense fatty, sugary, salty food supplies, and involve intensive farming of animals depending on the regular use of drugs, amount to problems that require systemic solutions.<sup>2–5</sup> But usually it requires a big food or bug scandal that threatens government and industry, and

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interests civil society and the media, as happened in the UK in the 1980s and 1990s, to provoke public debate about the normal practice of human, animal or plant nutrition.<sup>6,7</sup> Even so, the general principles of nutrition science that have generated cataclysmic changes in food systems and food supplies during the past 150 years, and are now occurring with accelerated speed throughout the world, remain intact.

When general theories need reformulation, this is usually not so much because they are wrong, but more because they have become a mismatch with observed reality and felt needs. Ptolemaic cosmology worked well enough until the late middle ages, but became increasingly unhelpful when navigators began to discover the new world, and so it became replaced by Copernican cosmology, which worked better. General theories are never true in an exclusive sense. The best they can be is truthful, which is to say, the best frame for the known facts, which in turn fit well within them. As the philosopher of science Thomas Kuhn says, and as Judaism, Christianity and Islam show, 'more than one theoretical construction can be put on a given collection of data'.<sup>8</sup>

Around 500 years ago, too much information did not fit the Ptolemaic construction. It generated too many paradoxes. Its champions, including the established orders, became increasingly defensive. The need to make sense of the existence and implications of the Americas created the context for a new general theory that was a better fit for a wider world. By analogy, too many of the most pressing issues of personal, population and planetary health that should now concern nutrition science, are off its current map. It is now time to draw a new map.

In order to make the argument of this and the accompanying article relatively concrete, four general beliefs that underlie nutrition science are questioned, by means of four examples: the first two in this article, the second two in the accompanying article.

1. Growth means health, or to be more precise, the measure of good human health is babies and children that grow fast, and relatively tall and heavy adults.
2. Science and technology are keys to universal truth, so that policies and practices that work in one context can be imposed always and everywhere.
3. Knowledge means wisdom, meaning that good nutrition policies are generated not by philosophical or ideological convictions, but by technical expertise.
4. The purpose of nutrition science is to maintain and improve human health, it is not concerned with the living and natural world as a whole.

All such general beliefs are by nature and purpose philosophical and political. Thus, the association of growth with health was not invented, but adopted by the first nutrition scientists, who lived in Europe in an age of expansion when it seemed self-evident that bigger was better. This belief is now buttressed by every public statement that assumes that economic growth, meaning more use of money, is proof of progress.

Similarly, the astounding development of machines in the past three centuries has created a thought and felt world

in which science and technology have replaced philosophy and religion. In turn, this has created an idea-free ideology, epitomised by Isaac Newton's comparison of his life's work with that of a beachcomber, in which it is supposed that information has intrinsic value, and that accumulation and organisation of data will of itself generate sound judgements and rational policies.

Furthermore, conventional nutrition science is one small part of the medical and other biological sciences, themselves part of the dominant human enterprise of the past five centuries associated with the European Renaissance, Enlightenment, industrial revolution and colonial expansion, which is the use of science and technology to dominate and control the living and natural world. Radical observations about nutrition science deal with our general, often unconscious assumptions about the dominance of the human species and our purpose here on the planet.

### Method

The map of nutrition science cannot be redrawn in one or two articles; or by means of a conventional approach, with plentiful citation of articles in the field recently published in peer-reviewed journals. Evidence that new paradigms are needed will not be found within the normal practice of any discipline.

New maps are drawn after new territory is brought to light and old territory is seen in a new light. This means teamwork. A new map of nutrition science requires international and multidisciplinary collaboration. International collaboration is needed because many of nutrition science's failures are caused by attempts to impose outdated and unsustainable theories and practices devised by professional elites in high-income countries onto impoverished populations in low-income countries. Multidisciplinary collaboration is needed because the redefinition of nutrition involves the perception of its impact on the whole world.

Meanwhile, here an attempt is made to sketch a fragment of the thinking needed in the construction of a new map of nutrition science, designed as a better fit for the world that we know and the new worlds that we are beginning to discern. The four general beliefs listed previously are discussed, each with one example. I also use my own research and experience, mostly in Britain and Brazil; historical information; and evidence and concepts from other disciplines. Personal touches are included.

### Discussion

What we eat now is generally not a matter of culture, chance or choice. Modern food agriculture and manufacture systems, that determine the supply of food, and therefore what people buy and eat, have been engineered following the development of nutrition science and its use by governments and industry for political and economic purposes.

Food systems have been designed for thousands of years. The modern process began just over 150 years ago. Many of the key decisions that shape modern food systems were made within living memory. Such decisions too often have

been and are based on general beliefs that have outlived their usefulness, and whose review shows that nutrition science itself needs to be reformulated. This and the following article make four assumptions.

1. The nature and quality of food systems are a determining factor of human health and welfare, and also of the whole living and natural world.
2. Since its beginnings, the principles and practice of nutrition science have had a profound impact on world food systems.
3. We can understand the issues that face us now, only by the examination of historical decisions that have shaped the modern world.
4. Nutrition science should consider the human world (personal and population health), and also the whole living and natural world (planetary health).

### **Language**

Language needs watching. Ideology can be embedded in language tendentiously. For example, countries in north America and western Europe, and others, such as, Japan, Australia and New Zealand, are often termed 'developed', and other countries were once termed 'undeveloped' – the word used now is usually 'developing'. What these words really mean, is economically developed or developing. The terms 'developed' and 'developing' are troublesome, as are 'rich' and 'poor', because they imply being and becoming in a good state, because of having and gaining money. Riches and poverty are not just a matter of money. For this reason, I have used the relatively value-free terms 'high-income' and 'low-income'.

Another example of a loaded word is 'America'. The Americas are divided into the countries in the north (including Canada and also Mexico); the central region; and the separate southern subcontinent or perhaps continent. Use of the word 'America' as synonymous with the USA is wrong and unhelpful; for many people in Latin America this is an expression of US expropriation of their identity. For this reason, here the value-free words 'north America' and 'USA' are used.

Nutrition science habitually uses loaded words. For example, 'stunting' and 'wasting' actually mean heights and weights well below agreed norms. All people who are very small and thin are defined as malnourished. Perhaps most are, but obviously some are not, and certainly not simply by definition. For this reason, here the words 'small' and 'thin', which should be value-free, are used. Technical discussion obviously requires precise value-free terminology, such as, body mass indices (BMI).

Other words are used thoughtlessly. For example, reports recommending limitation of some types of fat may nevertheless refer to foods as being 'rich' in saturated fat or *trans* fatty acids, which creates dissonance in the mind of the reader. It is tempting to refer to energy-dense foods as being 'loaded' with added fat and free sugar, and 'rich' in vitamins, but here the value-free words 'high' and 'low' are used.

Concepts as well as words need scrutiny. For example, chronic diseases were once termed diseases of civilisation or of affluence or as Western diseases. These terms are all obviously wrong. They are usually now described as diseases of lifestyle, the implication being that individuals are free to choose whether or not to decrease their risk of chronic disease, which in turn implies that prevention is all about education and information programs aimed at adults. The concept of 'lifestyle' was formulated in the late 1970s at Stanford Research Institute in California as a way to categorise individuals within the USA population so that products and politics could be marketed more effectively. It is an extremely problematic concept applied to disease. The obvious example of why, is diseases for which the risk is increased by regular smoking and drinking of alcohol, both of which are and can be addictive. Also the environmental insults that increase the risk of some chronic diseases have their effect early in life, tooth decay and obesity being the two obvious examples. It is now believed that more serious chronic diseases may well originate early in life and even before birth. It is fanciful to use the word 'lifestyle' to apply to a young child or a foetus. Also, while middle-class people in high-income countries can have lifestyles and may make choices, most communities in the world have little choice but to consume the food they are supplied and have little scope for style. The concept of lifestyle implies that systemic approaches to disease are misplaced. For these reasons, here the unsatisfactory but relatively value-free term 'diseases of environment' is used.

A similar example is use of the term 'diet-related', implying that the relevant focus for attention is at the point of consumption. Here, the broader term 'food-related' is used.

Expert reports and lay accounts habitually target specific foods or dietary constituents as modifiers of disease risk. For example, it is commonly said that vegetables protect against cancer, saturated fat increases the risk of coronary heart disease, and salt increases the risk of hypertension and stroke. This shorthand is misleading because it suggests that some aspects of diet are medicines and others poisons. Apples are not elixirs, sugar is not strychnine. I have used phrases, such as, 'food supplies high in meat'. Again, technical discussion needs precise value-free terminology, for example, the use of ranges of percentages of total energy.

### **General belief 1**

Growth means health, or to be more precise, the measure of good human health is babies and children that grow fast, and relatively tall and heavy adults. For example, protein.

Between the 1950s and the 1980s UN agency policy was to fill the world protein gap, and then to fill the world protein-energy gap. These have been the most publicised and capitalised initiatives ever designed and then redesigned, to conquer world malnutrition. Governments, industry, the health and medical professions, civil society organisations, and the media, citizens and consumers, accepted that the world was short of protein. Populations that were small and

thin were for that reason defined as malnourished. Global trade and aid programs were put in place, and world supplies of food for human consumption still continue to shift towards foods high in protein, which are also often energy-dense and high in fat. Why?

### *What was in the soup?*

The reason is because foods high in protein promote growth. Since its beginnings, nutrition science has preached that good human health requires fast growth in early life. This founding principle of nutrition science has had and still has a profound impact on world food policy.

An example of this thinking is one of the most troublesome episodes in the history of nutrition science, the outcome of which has shaped food manufacture, the supply of food in the shops now, and everyday eating habits. It concerns bread. The story explains why white bread, palatable only if made with plenty of salt and when usually fatty or sugary spreads are added, remains a staple food in Britain, northern America, and many other countries – including Brazil (whose white bread, made from wheat grown in an unsuitable climate and terrain, is particularly disgusting).

After the 1939–1945 war the millers and bakers of Britain pressed the government to give them freedom to produce white bread. This suited their machines, created a product with longer shelf-life, and made them more money, partly because bran was used for animal feed and germ made into a nutritional supplement. However, the prevailing expert opinion at the time, following common sense, was that brown and wholegrain bread not only contain more nutrients than white bread, which of course they do, but are also more nutritious, which seems a reasonable assumption. Certainly, brown or wholegrain bread is preferable and ideally should be a staple food of any population at risk of nutritional deficiency.<sup>9</sup>

The experiment that encouraged the government and the medical establishment to accept that there is no relevant nutritional difference between brown and white bread, was devised by McCance and Widdowson, and carried out on German orphan children between 1946 and 1949. The children were given soups, vegetables, potatoes, milk, supplements of vitamins A, C and D and calcium; and in addition, various types of either brown or white bread.<sup>10</sup>

The results of this experiment enabled McCance and Widdowson, best known as the original chief compilers of *The Composition of Foods*, the British reference book still used worldwide,<sup>11</sup> to conclude that brown and white bread are practically the same in relevance to public health. Why? Because ‘the children in all the groups began to improve at an equal rate’. Meaning? ‘Their heights and weights went up faster than those of American children of comparable ages would have been expected to do . . . at the end of a year there were still no differences between the groups and the children were still gaining weight and height’.

This was of course not surprising. Protein, together with starch, is present in much the same amounts in bread of any type, and the diets of the children were designed to contain

ample amounts of energy and other nutrients. The point made here is not the absurdity of the experiment, but the assumption that growth equals health.

McCance and Widdowson, who in the third-quarter of the twentieth century were among the most influential nutrition scientists in the world, gave the white loaf that remains dominant in Britain, north America, and many other countries, not only commercial license but also scientific credibility, because it was assumed that foods that accelerate the weight and height of children are for that reason, healthy.

This assumption remained unchanged a generation later. In the mid 1980s the British government was faced with an officially commissioned survey that showed that the food supplied to and eaten by British 11–14 years olds included masses of crisps, chips and biscuits and almost no vegetables, and thus was high in fat, sugar and salt and low in nourishment. The then Minister of Health – no doubt so briefed by his technical advisors – said when interviewed on television ‘a report which shows that the children studied are taller and heavier than people expected and the standards that apply, what can be embarrassing about that?’<sup>12</sup>

### *Who won the Vietnam war?*

But is big beautiful? When I was about 9 years old I was taken with a group of other children on a tour of the Tower of London. The guide showed us that we were already almost big enough to fit into some of the suits of armour, and made a joke, implying that our ancestors were toy people. And in his slim youth Henry VIII at 1.83 m tall (6 foot in old measure), was seen as a colossus. This was the first time I wondered what was wrong with being small. Voltaire measured less than 1.50 m, and Napoleon was a few centimetres taller than Dudley Moore. But these were individuals: the suits of armour proved that the European mediaeval ruling classes were generally much smaller than we are. So were people later in history. The average height in high-income countries has increased by around 10 cm in the past 150 years, a phenomenal increase now happening in one or two generations throughout most low-income countries.

Later in my life I attended a conference of paediatric nutritionists, and after listening to half a dozen presentations and discussions, I made myself unpopular. I stood up from the back of the hall and asked the speakers why they all assumed that the measure of child health, was fast growth. I asked if this assumption could be discussed. I can still see everybody in the hall turning round, and looking at me as a congregation might turn to look at somebody who got up in a marriage service to object to the wedding. The chairman of the meeting did not accept my question.

Steady growth is of course a vital measure of child health. Children who really are failing to grow need care and treatment. Stunting and wasting, terms that actually mean height and weight a long way below norms agreed by technical experts, are indeed reliable markers of underlying infection and infestation, and are prevalent in low-income countries.<sup>13</sup> What impressed me though, was the unquestioning association of growth with health, and the lack of

presentation or discussion of child health assessed in any other ways. But paediatricians follow the prevailing paradigm, which is not only that growth is good, but also that within wide limits, the bigger and taller the child, the earlier the age of sexual maturity, and the bigger and taller the adult, the better. Is this so? The answer depends on addressing another question, which is: good for who and what?

Was a condescending attitude to smaller populations, the assumption that to be big is superior and to be small is inferior, one reason why the USA bungled the war in Vietnam? Could the relatively massive north Americans not imagine that the relatively diminutive Vietnamese could outmatch them? So it proved. Human intelligence is not a function of bulk.

### *Just the stuff to give the troops*

But why are we bigger than our ancestors? As every nutritionist knows, this is not an accident. In the nineteenth and first half of the twentieth century, a period of political and economic aggrandisement, when the most powerful European nations had worldwide empires and were also fighting or preparing for wars of national survival, and the most powerful independent nations outside Europe were creating internal empires, growth, in every sense, was self-evidently good.

The first time I recall annoying a physician was when I was 12, at my secondary school, Christ's Hospital, which has a special place in the history of human nutrition. British margarine became 'fortified' with vitamins A and D partly as a result of studies in the 1920s and 1930s done by the school's doctor, George Friend. Like German orphanages, British boys' boarding schools were in those days useful institutions for experiments, because their food supplies could be manipulated without reference to the children or their parents. Dr Friend confirmed an association between consumption of unfortified margarine and limb fracture on the rugby football fields. When butter replaced margarine (which not long before had replaced butter) rates of fracture decreased.<sup>9</sup>

The relevance of this finding to British national security was explained by Jack Drummond just before he became chief scientific advisor to the British wartime Ministry of Food. Referring to the previous European war he stated 'in the last year of the War an exceptionally large number of German infantrymen fractured their arms in throwing stick-bombs . . . it is not unlikely that defects in the bone due to deficiency of vitamin D and perhaps vitamin A as well, might have led to easy fracture'.<sup>9</sup> Thus, an original reason for the 'fortification' of margarine is to make soldiers reliable throwers of stick-bombs. Given the irrelevance of vitamin A to limb strength, an equally good result could of course be obtained by regular exposure to daylight in early life.

Friend had also found that drinking substantial amounts of full-fat milk increased the height and weight of the boys in his care. His and other human studies confirmed the results of experiments on rats. As a result, a 1936 committee

of the League of Nations, predecessor to the United Nations, proposed that 'milk is the nearest approach we have to an ideal food . . . it contains all the materials essential for the growth and maintenance of life in a form readily assimilable by the human body . . . milk should represent a large proportion of the diet of every age'.

John Boyd Orr, who with Jack Drummond was the chief architect of British wartime food and nutrition policy, and who later became the first Director-General of the UN Food and Agriculture Organization, wrote a revealing judgement in 1940: 'except for young children, milk is of course not an essential food. All that is contained in milk could be contained from other sources. But it is so rich in first-class protein, minerals and most of the vitamins, that it is the most valuable and cheapest food available for making good the nutritional deficiencies of the poor'.<sup>14</sup>

School doctors at Christ's Hospital kept unusually detailed records of the health of the boys in their charge. I annoyed the doctor because in the summer term of my first year I decided to experiment on myself, and eat less and exercise more, as a result of which I dropped 6 kg (1 stone in old British measure) by the time of the end-of-term weigh-in. Of all the lines on his graph, mine was the only one pointing in what for him was the wrong direction – down. I had messed up his data!

Health professionals in those days in Britain, cared about the weight and height of children for good reason. The main issue confronting social reformers in the nineteenth and early twentieth century Europe, was the condition of the poor. In Britain, which had suffered the industrial revolution in its crudest and cruellest forms, the peasantry had been effectively destroyed, driven off their land into the new cities and lives of squalor and darkness. The new urban poor were obliged to eat store food, and so became weak and diseased and often stunted and deformed.

A hundred years ago the health of the British population was worse than the health of the population of almost all countries in the world today. A quarter of all children died at birth or in infancy. Rickets was rampant, as were bronchitis, pneumonia, dysentery, typhoid, typhus and cholera.<sup>15,16</sup> Expectation of life in Manchester in the 1880s was 29 years for men and 33 years for women and in 'healthy' areas of England, 51 years for men and 54 years for women<sup>17</sup> An official Committee on Physical Deterioration reporting in 1904 noted that half the men recruited to fight in the Boer War were physically unable to carry arms, and the minimum height for British soldiers was lowered from 5 foot 6 inches to 5 foot (1.67–1.52 m).<sup>9</sup>

The context in which nutrition science developed in the early twentieth century, was the need to breed 'bonny bouncing' babies and healthy children. Animal and human experiments had proved that diets high in protein of animal origin accelerated growth in early life. Protein was identified as the master nutrient, and animal foods high in protein as the master foods. Scientists persuaded politicians that wars were likely to be won and lost on the home front. The findings of research on the growth of animals and humans

were used as the rationale of the first official reports that specified recommended daily amounts of dietary constituents. These in turn were used as the basis for the planning of national and institutional food supplies, in order to grow and maintain big tall strong young people as foot soldiers and factory workers. There was no practical reason to plan further ahead. Four food groups were officially devised by government and industry in Europe and the USA, two of which were meat, and milk and dairy products. 'Just the stuff to give the troops' my mother said in the late 1940s, as she spooned boiled egg into me.

Seen through European eyes, the young men from the USA reared on diets high in milk and meat who came over as soldiers to win the wars in Europe in 1917 and then later in 1941, seemed like young gods, tall, broad, radiating energy and confidence: all the more remarkable, since many of them had much smaller parents and grandparents, who had emigrated to the USA in living memory.

The north Americans were a new breed. The ironic English joke about US soldiers, 'overpaid, over-sexed, and over here' had a nutritional aspect. Age at puberty is a function of body weight and mass, and so the main factor determining age on onset of sexual maturity in populations, is the quantity and nature of food supplies. Even in one generation, diets high in protein and energy can reduce the age of sexual maturity by more than 2 years, from over 14 to under 12.<sup>18</sup> English adolescents did indeed have a reason for resenting the GIs, with more money and more experience of chasing girls.

Then the British began to catch up. Lord Woolton, the wartime Minister of Food, recalled: 'I was charged with the task of feeding a nation . . . I decided to try to develop a food policy based on the scientific knowledge of those engaged in the study of nutrition and biochemistry . . . People began to give as much thought to the consideration of food, as the skilled engineer affords to the feeding of his engines'.<sup>19</sup> The other benefit was bonny bouncing babies.

### *No worries for Dona Silveirinha*

Mothers still worry that their children may be short of protein. In 2001 I spent Christmas with a prosperous family in Fortaleza, a big city on the littoral of the state of Ceará in north-eastern Brazil. The meals were feasts of fresh meat and fish, rice and beans, vegetables and a vast array of fruits, bought in the city markets and cooked by three maids directed by the family matriarch, Dona Silveirinha. One of her sons was vegetarian. She asked me: how could her son get enough protein if he didn't eat meat?

She was worried because she had been taught, as we all were as we grew up, not only that everybody needs lots of protein from foods of animal origin, but also that diets low in animal protein are deficient. Why was she worried? Of course, we know the answer. It is because protein deficiency is still believed to be a massive global public health crisis, and indeed, humans can become deficient in protein, like any other nutrient. But how common actually is deficiency specifically of protein?

In the 1930s, at about the same time that George Friend was experimenting on my predecessors at school in England, Cecily Williams identified a disease of impoverished Ghanaian children as 'kwashiorkor', which in the local language means 'the disease of the first child when the next child is born'.<sup>20</sup> This syndrome, also known as nutritional oedema, had been identified previously in Europe, Asia and Latin America and had been thought to be caused by starvation or multiple deficiencies.<sup>21</sup> However, the diets of these west African children were extremely low in protein, and when they were given a high-protein diet based on cows' milk, they often recovered.

So kwashiorkor became identified as a protein deficiency disease. In 1953 the UN Food and Agriculture Organization (FAO), stated that kwashiorkor was 'the most serious and widespread nutritional disorder known to medical or nutritional science'. Estimates of its prevalence were based on global extrapolations from the original African studies, which in turn formed a basis for official estimates of the global prevalence of malnutrition. 'Closing the protein gap', the elimination of protein deficiency, became the single most important declared policy of world food aid programs.

Shortly before, in 1948, the US National Research Council (NRC) recommended that children aged around 1 year should consume around 15% of energy as protein. This cannot be achieved by food systems whose only staple foods are grains or roots and tubers, legumes and vegetables. The concept of the protein gap implies that the food systems of high-income countries are superior, and those of low-income countries inferior. 'Closing the protein gap' requires trade and aid on a colossal scale, the literal uprooting of traditional plant-based food systems evolved over hundreds and thousands of years, and their replacement by mechanised animal-based food systems.

The scientists at the NRC, and indeed at FAO and the League of Nations, may or may not have been aware of the implication of their recommendations. However, the high-protein policy was enthusiastically promoted by governments and industry in the USA and other high-income countries, whose subsidised dairy farmers were producing vast surpluses of milk, which was then dried and sold to, given to, or dumped on low-income countries.<sup>22,23</sup> The policy was also welcomed by the rulers of low-income countries chasing foreign aid, some of which was sometimes diverted into the private foreign bank accounts of the elites receiving the money.

Then in the 1960s and 1970s the emphasis shifted from protein deficiency to what became named protein-energy deficiency, on the reasonable grounds that children suffering from the kwashiorkor syndrome are also starving. The less advertised reason was that FAO published new estimates of protein requirements for children in 1957 and then in 1971, which were much lower. The new official policy was to close a double gap, the protein-energy gap.<sup>24</sup> Then in the 1990s the policy emphasis shifted again, from protein-energy deficiency to deficiency of specific micronutrients, one of which, vitamin A, is discussed here.<sup>25,26</sup>

Why? Did this mean that the protein gap, and then the protein-energy gap, had been closed? No, it did not. The reason for the successive convulsion of policies that shape world food supplies, was not because world food aid programs had eliminated protein malnutrition or protein-energy malnutrition. Kwashiorkor remains a real disease. But it never was a global epidemic.

Two factors created what became known as 'the great protein fiasco'.<sup>27</sup> First, the belief that babies and young children need high-protein diets, itself derived from the equation of growth with health; and second, more outrage than fiasco, the policy of the USA and other rich countries with milk surpluses to use food trade and aid for profit and as an instrument of political, economic and social control, as they do now.<sup>22,23</sup>

So what causes kwashiorkor, the global epidemic that never was? Current academic thinking has abandoned the idea that it is a single-agent disease. The key causes are probably a vicious cycle of semistarvation diets, and infection and infestation.<sup>21</sup> Gross deficiency of protein may play a part in this. An infant prematurely weaned on to watery porridges or gruels will be deficient in practically all nutrients. Later in young childhood, monotonous and inadequate diets mostly made from non-grain starchy foods including cassava, yams, sweet potatoes and plantains, and perhaps also corn and millet, whose protein content when cooked is under 5% of energy,<sup>11,28</sup> if prepared and eaten together with water and some sugar and oil, with very little if any vegetables, fruits or animal food, might supply as little as 2% of energy from protein.

Bearing in mind that mature breast milk contains about 5% of energy from protein,<sup>11</sup> it makes sense to assume that such diets are deficient in protein, as well as practically all micronutrients. But while it is now known that deficiency of protein in isolation is rare, and that children deficient in protein don't need protein supplementation but nourishing food, the notion that we should all worry about being short of protein lives on in the minds of mothers throughout the world.

When a mother who is breast-feeding is warned that her baby is failing to thrive, because its height and weight are not following the lines on the charts devised by paediatricians and used by health workers, and is also told that her baby needs more protein to grow well, she is likely to take to the bottle. The height and weight of infants and young children is indeed accelerated by infant formula milks, which typically contain almost twice the protein of breast milk; and by cows' milk, which contains well over three times the protein of breast milk,<sup>29</sup> and then by diets high in protein and concentrated in energy.

### **Human artificial fertiliser**

The impact of milk and meat on growth did not surprise scientists in the early twentieth century. The gospel of protein as human growth promoter was first preached in the mid nineteenth century by Baron Justus von Liebig who,

following Lavoisier, saw life in terms of its chemistry, and who created nutrition science as a branch of biochemistry.

In 1840 von Liebig showed that concentrated nitrogen, together with phosphorous and potassium (NPK) accelerates the growth of plants. In 1842, in his great work *The Chemistry of Animals* he extended this discovery to animals and to humans. The culmination of his work at Giessen in Germany, was the isolation of protein, its identification as the master nutrient, and above all, programs for its use to push the growth of plants, animals and humans. He was an evangelist as well as a scientist. For plants, he marketed an artificial fertiliser based on guano found off the coast of Peru. For humans, he patented Liebig's Extract, boiled down from the beef of Argentina, popular in Europe as an elixir of health.

Von Liebig in effect designed the nutritional blueprints from which the mighty meat and dairy industries of the USA as well as Europe were built. The indigenous people and the buffalo on which they depended were exterminated from the central plains of north America, and replaced by white settlers and cows. The Hatch Act of 1887 created what remains USA food and agriculture policy and practice, establishing a series of research stations across the country including what is now Cornell University, dedicated above all to the development of meat, milk and dairy technology. The mechanisation of death by means of slaughterhouses using railways, disassembly lines and refrigeration, made meat and its products cheap food for the masses.<sup>30</sup>

Von Liebig's impact on the modern world is as great as that of Louis Pasteur, for similar reasons. They both promoted the prevailing faith that the living world can be conquered and controlled. Their achievements had a philosophical basis. The drive for growth, which justifies modern 'market' economies that confuse price with value, derives from the materialist ideology developed in Europe since the Reformation, asserting a manifest destiny of humans to rule the living and natural world; and indeed, if fast growth is the aim, the high protein doctrine works. Artificial fertiliser speeds the growth of crops. Farm animals fed on concentrates high in protein achieve slaughter weight faster. Humans grow faster on energy-dense diets high in animal protein.

During the European and world wars between 1870 and 1945, the nations that became most powerful were those with most animal and human fodder. Von Liebig had as great an effect on wars fought by land armies as the inventors of the machine gun and the tank. At home, the centrepiece of the main meal in the USA became the steak, in the UK the roast, and in Eastern Europe the sausage, and now everywhere, the burger.

In its time, going for growth worked. Food supplies high in animal protein and in energy, produce big strong tall young populations. In the circumstances of the early twentieth century this was all that was required. But now, unlike crops and animals, we humans are not harvested or slaughtered when we are first full grown. We live on.

### ***The Tupi-Guarani theory of human nutrition***

How much protein do humans actually need; and does it matter whether protein comes from animal or plant sources?

First, how much protein? Estimates of energy and protein requirements were made by von Liebig. His pupil Carl von Voit recommended consumption of 125 g of protein a day after experiments on a laboratory assistant which, if he was in energy balance on 3000 calories a day, amounts to about 15% of energy. Policies that shaped food supplies more than 100 years later were derived from this kind of thinking.

Later, recommended amounts dropped dramatically, partly because populations became less active, and partly because of increasing awareness of the world outside the laboratory. In 1974 the World Health Organization (WHO) recommended 0.57 g of protein per kilogram of bodyweight per day for men and 0.52 g/kg per day for women.<sup>31</sup> In 1985 FAO and WHO together recommended 0.75 g/kg per day, which included an amount added to be on the safe side. This is roughly 8% of energy.<sup>32,33</sup>

More recent national recommendations are derived from this FAO/WHO report but are for higher amounts.<sup>34,35</sup> Why? Not because they state that people need more protein, but simply because people in high-income countries consume more of it – curiously, around 15% of total energy, about the same as von Voit's laboratory assistant. Expert reports produced for high-income, high animal protein countries, generally assume that consumption well above recommended levels is no problem.

Second, where from? About two-thirds of the protein consumed in most high-income countries is of animal origin. The earlier recommendations are based on protein of animal origin, from milk and eggs. Why, is because the essential amino acids, the constituents of protein needed for human growth and body maintenance, are contained all together in the exact balance needed by humans, only in these foods.

So milk and eggs became identified as what has been termed 'first-class' protein. The explanation given in the official UK *Manual of Nutrition* in its ninth edition in 1985 is: 'most animal proteins (from meat, fish, milk, cheese and eggs) have a high biological value. The reason for this is that man is part of the animal kingdom'.<sup>36</sup> The fifth impression of the tenth edition published in 2001 contains just one political correction: 'the reason for this is that humans are part of the animal kingdom'.<sup>37</sup> The manual does not explain why this concept does not apply to vegetarian species, such as, gorillas, elephants or cows. It can be called the Tupi-Guarani concept of protein metabolism, named after the nations of indigenous Brazilians who habitually barbecued their captives and who, after the Portuguese conquest, became partial to bishop crackling, because its logical conclusion is cannibalism.

Here is the reason why protein of animal origin is still believed to be best. It is assumed that the food systems of high-income countries produce superior people, big and strong, whereas the food systems of low-income countries produce inferior people, small and weak. So like air passengers, humanity is classified: there are the first and

business classes with big seats and lots of choices, and the cramped and envious world travellers.

I thought about this in 1985 when I was in a village street outside Kandy in Sri Lanka. A girl aged maybe 6 years, curious to see the big white visitors, gathered her little brother on her hip, and carrying him, ran laughing maybe 50 m up the road towards us. Later that day at the rest house where we were staying, I watched the grandmother squatting in the garden grinding spices, rhythmically beating them in a stone mortar with a wooden pestle thicker and longer than her arms. The girl and the woman were thin and small, and active and strong. Not a lot of girls and women of their ages in the UK or USA could do what they did, I thought.

This of course is just an anecdote. However, the WHO/FAO report published the same year, confirms that 8% of energy from protein contained in varied diets, is adequate. Not 15%, roughly the amount in cows' milk and as contained in the food supplies of high-income countries; and not protein just from milk and eggs, but from mixed diets. This is because nutrition science made a convulsive adjustment in an attempt to fit the facts outside the laboratory in the real world, and agreed that cereals together with legumes are balanced in protein, as evolved by traditional food systems all round the world, until they are destroyed by colonialism or 'cola-colonialism'.

A group of British researchers then discovered that humans are evolved to adjust either to high-protein diets or to low-protein diets. The implications of this finding are sensational. Joe Millward, a leader of the group, stated in a book published in 2000: 'healthy individuals in overall balance will exhibit an *apparent* protein requirement similar to their intake . . . normal healthy individuals can with time, safely adapt their metabolic demand to match their protein intakes down to levels considerably below the intakes habitually consumed by individuals satisfying energy and micronutrient requirements'.<sup>38</sup>

That is to say, if you measure protein turnover in a burly male laboratory assistant who tucks away half a kilo of wurst every day with his sauerkraut, washed down with a litre of beer, you get a high result for apparent protein needs; whereas if you do the same measurements on Chinese peasants, say, subsisting in a diet of rice and other plant food, you get a low result.

The same group also found that protein from milk and eggs is not used efficiently in the body; and a look through food composition shows that all sorts of foods of plant origin have many mixtures of amino acids.<sup>11</sup> Allowing for any lower availability from plant foods, a figure of 10% from plant-based or vegetarian diets seems reasonable to be on the safe side.<sup>33</sup>

### ***Reactions of fast breeders***

If 8–10% of energy from protein is all we need, what is ideal? How much more of a good thing is best? What seems to be a low-key technical issue becomes revealed as a highly charged political issue. For the next question is: best for what?

If the right policy now is to continue the policies of the past two centuries, and accelerate the growth of babies and children, and achieve sexual maturity and final adult height as early in life as biologically possible, then energy-dense food supplies high in protein of animal origin are best. This perhaps explains why a textbook published in 2001 by the International Life Sciences Institute (ILSI) states that for adolescents, 'protein should account for 12–14% of energy intake', a bit lower than the protein content of cows' milk and of actual consumption of protein in high-income countries.<sup>39,40</sup>

But in our times, and taking a view not only of the human but also of the living and natural world, this policy, which derives from the go for growth paradigm that still drives nutrition science, is catastrophic for a number of reasons, some perhaps more obvious than others.

If the only concern is risk of human disease, one reason is enough. It is this. Food of the type that increases body mass in early life, also increases the risk of chronic diseases, including obesity, diabetes, hypertension, coronary heart disease, and cancer of the breast and other sites, in middle age and later life.<sup>40,41</sup> High-protein food by itself is not likely to be a major cause of chronic disease (except osteoporosis, because high-protein diets cause pathological excretion of calcium); but energy-dense food supplies that promote growth, high in protein of animal origin and also high in fat, are now causing vast epidemics of chronic diseases throughout the middle- and low-income world.<sup>42</sup>

The second reason moves outside normal nutrition science. Age at sexual maturity is, as mentioned, a function of body mass. Most discussion assumes either that the precipitate drop in menarche in the past few generations is either of unknown or complex cause, or else is a good thing, or both. But the same formula that pushes growth in plants and animals, pushes growth and also brings down the age of human menarche.

Food supplies high in protein are in effect, artificial fertiliser used on humans. They extend the years of adolescence, the period of war between immature thoughts and feelings in a matured body, into and even before the first teenage years, when the body is also immature. This means that teenagers spend more of their time acting out their sexual and other hormonal urges and less of their time learning in school. The impact on society is destructive. Rates of premature pregnancy soar, as do rates of failure at school, and the incidence of disruption, violence and even homicide perpetrated by children increases.<sup>43</sup> The impact of premature adolescence on society was a preoccupation of Hugh Trowell in his later years (Trowell H, unpubl. data, 1974).

A notorious disease now generally supposed to be psychopathological in origin may be at least in part caused by premature menarche. The anorexia–bulimia syndrome is the result usually of an adolescent girl trying to stop becoming an adult by means of obsessive starvation, exercise and vomiting. For any child terrified by premature hormonal rushes and sexual development, this is an understandable

while futile attempt to slam an over-accelerated body into reverse.

### ***Breeding human cattle***

The case against energy-dense food supplies high in animal protein is made by Michael Crawford, a researcher who works out of the box of normal nutrition science. Earlier in his career Crawford worked in Africa and then at the Zoological Society in London, and then founded the Institute of Brain Chemistry in London. He has co-written a book on human evolution from a nutritional point of view.<sup>44</sup>

He proposes that *Homo sapiens* is evolved to grow slowly. Hence the long period of gestation of the foetus, and the long time in which infants and young children are helpless, which allows gradual growth of the brain and nervous system, whose solid matter is mostly made up from essential fats. It is not an accident that the protein content of human milk is 5% of energy, far lower than that of animals, and also that the essential fat content of human milk is much higher than that of animals.

Cows and rats are evolved to grow fast, and start to run around soon after birth. Correspondingly, cows' milk contains approximately 15% of energy as protein, and rat's milk contains approximately 40% of energy as protein. Michael Crawford proposes that by using food supplies that include 15% of energy as protein, we are breeding human cattle. As said, this was a wise policy at a time when governments required big strong young people to fight in wars, who if they did not perish in battle would be likely to die young anyway. But not now.

He states that if we think not in terms of nutrition but in terms of food, the crucial aspect of the food supplies of high-income countries is that food of animal origin that is high in protein, is also very high in saturated fat. It is often pointed out that our palaeolithic ancestors ate a lot of animal food and thus a lot of animal protein.<sup>45</sup> No doubt true, although their lifespan was short, and modern research suggests that palaeolithic people were gatherers first and hunters second. But in any case, the meat of wild animals is not energy dense; it is low in fat, and the ratio of essential fats to total fats is very high. With domesticated, intensively reared animals, the reverse is true: they are fat, and their fat is highly saturated. As with animals, the flesh of fish and birds that are reared intensively become increasingly high in fat and saturated fat, whereas in nature, the flesh of birds and fish that fly or swim long distances, and depend on their body stores for nourishment for long periods of time, while being oily, is high in essential fats.

Michael Crawford proposes that human civilisations tend to grow from settlements on sea and ocean estuaries, which before they became polluted, teemed with oily birds, fish and shellfish. By contrast now, he proposes that *Homo* is becoming increasingly less *sapiens*. He also believes that diseases of the brain and nervous system, multiple sclerosis for example, are caused by food supplies that have become artificially low in essential fats, partly because nutrition

science, hand in hand with governments and industry, has pushed human quantity at the expense of human quality.

From a Gaian point of view, the global epidemic of coronary heart disease can be seen as a revenge of cattle on humans. But Michael Crawford's key point, in the context of this article, is that the worst possible thing to do to human populations, is to accelerate their growth in early life. I come back to an earlier question: who won the Vietnam war? The question has a new resonance applied to the events of and after 11 September 2001. Setting aside the moral rights and wrongs of the current global war of civilisations, the thought that the breeding of the people of the USA has made them bigger and fatter and also less intelligent than the people of the Islamic world, is sobering.<sup>46,47</sup>

### *Seeing the big picture*

As soon as we see the big picture, like the amazed explorers who 'discovered' the Americas, Australia and New Zealand not so long ago, we can see that going for growth by means of creating food systems high in animal protein, is a global catastrophe.

Where to start the indictment? It has been well known for more than 30 years that intensive agriculture systems geared to mass production of animals for human consumption are unsustainable. In her book *Diet for a Small Planet*, Francis Moore Lappé cites the work of David and Marcia Pimentel at Cornell University, estimating that while it takes around 3.5 calories of fuel to produce a calorie from human consumption from grains and beans, the figure for milk is 26 calories and for feedlot beef 78 calories.<sup>2</sup> Animal-based food systems use too much energy, they wreck ecosystems, they poison the landscape, they contribute to global warming. There are plenty of books and reports whose theses are generally accepted now, making this case. These should help to determine new recommendations for human protein requirements, because the big question is: required for what?<sup>48</sup>

Until I began to research this article, I did not know that the protein content of human milk expressed in terms of energy, is 5%. Most nutrition scientists I have asked did not know either. Why? One reason is that the nutrition of infants and young children is a separated scientific and medical discipline. Another reason is that textbooks some of which state the fat and carbohydrate content of human milk in terms of percent of energy, curiously do not do the same for protein content.<sup>29,49</sup>

The burden of proof is on anybody who asserts that the reference value for human protein requirements is cows' milk, rather than human milk. The circumstances in which cows' milk was a rational reference for human health are past.

In order to sustain the human race on planet earth, it is necessary to stop going for growth. The rational reference for planning the protein content of global food supplies is not cow milk but human milk. If humans are enabled to grow slowly, as we are evolved to do, and given that growth is fast in infancy and young childhood, with the brain having

special needs for amino acids as well as essential fats, the initial reference point should be the 5% of energy as protein in human milk.

This figure can be adjusted upwards to allow for special needs, such as, infection and infestation in early life, human variability, and difference in amino acid composition in the protein of every type of food system. This might suggest the current WHO/FAO figure of 8%, but as a universal maximum, for all types of food supplies.

In which case, nutrition science is revolutionised, and current world food policy is overturned. Here is why. If, as audaciously suggested in the recent textbook published by ILSI, humans have evolved so that breast milk is deficient in protein,<sup>49</sup> or if policy is to go for accelerated growth and conquer nature, so that the 15% of energy from protein in cows' milk is preferred as a reference, then at a stroke, much of the world's population is short of or deficient in protein. Most people who live outside cities in low-income countries consume 12% or less of energy in the form of protein, almost all from foods of plant origin, whose protein, despite the whoopsies in thinking, is still generally supposed to be 'second-class', or of 'lower biological value'.

The high-protein theory defines most rural people in Africa, Asia, the Middle East and Latin America, whose food systems have evolved to be based on grains and legumes, with some vegetables and fruits and small amounts of animal foods, as malnourished.

However, if the reference is not cow milk but human milk, then traditional indigenous food systems are seen in a new light. The most common staple grains, rice and wheat, and also rye and oats, when cooked or made into breads or pastas, supply 8–10% of energy in the form of protein. Most vegetables, eaten cooked or raw, and most fruits eaten raw, contain at least 8% of energy in the form of protein; and as is well known, legumes (pulses, e.g. beans) contain as much or more protein than meat and fish. With a recommendation of 8% of energy from protein, the only possible risk of protein deficiency on most staple grain-based diets is if the starchy staple is eaten as a watery gruel, or if diets are extremely monotonous; and the issue here is not protein deficiency alone, but poverty and starvation.

What the low-protein principle shows, is when people do not suffer a disease that itself causes deficiency, protein deficiency is almost impossible unless diets are bizarre or else monotonous and watery.

So once again, what at first seems to be a technical issue, is revealed as a political issue. For if human protein requirements are high, and if the best protein is of animal origin, then the world's food systems need to be changed to approximate to those of high-income countries, more meat, more milk, more dairy products, conveniently marketed as cheeseburgers and milkshakes. But if human protein requirements are low, and practically any diet that supplies enough energy also supplies enough protein, then there is nothing wrong with the traditional plant-based food systems of low-income countries, providing they are adequate and varied. Protection and preservation of such food systems should be

a priority of the relevant UN agencies and national governments. But many if not most have already been burgered.

### ***Are we too big?***

So what is the right size for humans? One ecological point is obvious: small people eat less food, and a physically active world population with an average height of say 1.50 m weighing 60 kg in energy balance at 2000 calories, will consume 20% less food compared with a sedentary population with an average height of say 1.75 m weighing 75 kg getting steadily fatter in energy imbalance at 2500 calories. With a world population expanding from 6 billion, that is a lot of food. A world population smaller in size as well as numbers would use natural resources more prudently and leave a better legacy for future generations.

But what about human potential? Severe under-nutrition especially in early life certainly remains a major global public health problem. As already stated, stunting and wasting are reliable markers for infestation, infection, and sustained mental retardation. No doubt, hundreds of millions of children in low-income countries really are malnourished and need help, preferably by methods that are community-driven and do not perpetuate the misery of impoverished populations.<sup>50</sup>

There is nothing intrinsically wrong with being small. A child that is properly fed, not infested or infected, and normally formed and lively, is healthy, whatever its height or weight. Defining malnutrition in terms of 'stunting' and 'wasting', meaning height and weight well below set standards, may be essential in order to get the attention of international agencies and governments and make them understand that small thin children who live in low-income countries are very likely to be starving and diseased. But obviously some small thin children are not actually malnourished. Plenty of small thin people enjoy long, active and healthy lives. Voltaire was not unique.

If human protein requirements are based on the evolution of the human and not of the cow, perhaps hundreds of millions of people in low-income countries now defined as malnourished, can be seen in a new light, as short, light and adequately nourished. Ever since the debate of the 'small but healthy' thesis at the Congress of the International Union of Nutritional Sciences at Brighton in 1985, anybody who suggests that official figures of malnutrition might be over-estimated is generally regarded by the custodians of conventional wisdom, as a crook or an idiot. But in reality, the only question, is how great is the exaggeration.

The obverse of this argument is that many hundreds of millions of people in the world in high-income countries usually perceived as well-nourished can be seen as big or fat and unhealthy. That is to say, right now in 2002, the most urgent and important nutrition crisis in the world, is not that too many people are short and thin, but that too many people are tall or fat.<sup>51</sup>

Protein requirements should spring from a new general principle for nutrition science. They should be derived not from experiments on animals and humans, but from knowledge of

life in the world outside the laboratory, study of long evolved food systems that produce adequate and varied food supplies, awareness of the evolution of *Homo sapiens*, and commitment to sustain not only the human race but also the living and natural world.

### **General belief 2**

Science and technology are keys to universal truth; policies and practices that work in one context can be imposed always and everywhere. For example, vitamin A.

### ***Vitamin A: supplementation and fortification***

After it became obvious that lack of protein in itself was not a major global public health issue, the UN agencies regrouped, although the drive to increase protein in world food supplies still continues. In the 1990s the UN identified deficiencies of specific micronutrients as the most important and urgent global public health priorities.

Infants, children and other vulnerable people who are malnourished are liable to be short of, or deficient, in all sorts of micronutrients, and tinkering with one deficiency while ignoring others can be troublesome. For example, high-dose supplementation of iron, often recommended in pregnancy, is liable to cause zinc deficiency, because iron and zinc compete for use in the body, and zinc deficiency can be as serious as iron deficiency. But the UN agencies and aid organisations decided that the leading nutrient deficiencies are of iron, iodine, and of vitamin A.<sup>52</sup> This remains the official position, and estimates of world malnutrition rely on estimates of the prevalence of these and other specific deficiencies, together with estimates of stunting and wasting,<sup>13,50</sup>

Severe iron deficiency anaemia and iodine deficiency showing as goitre, are indeed serious and common syndromes in many middle- and low-income countries. The best policy is primordial prevention (the creation or preservation of environments that protect against disease) and failing that primary prevention before clinical signs are evident. The same policy applies to vitamin A deficiency. Adequate intakes of vitamin A protect against serious infections of the respiratory and gastrointestinal tracts, and reduce the risk of transmission of HIV infection from mother to child. Thus, vitamin A deficiency is a killer.<sup>50,53-55</sup>

The key message is that babies exclusively breast-fed up to the age of 6 months and whose diet includes breast milk after that age, as now recommended by WHO and endorsed by all member states at the World Health Assembly in 2001,<sup>56,57</sup> are most unlikely to become deficient in vitamin A. What this means, although I have not found this said in any textbook or report, is that vitamin A deficiency in infants and young children is mainly caused by feeding with formula milks and by premature weaning. Partnerships with governments to encourage exclusive breast-feeding of infants and young children should be a primary priority of the relevant UN agencies.

As well as increasing the risk of infections, vitamin A deficiency affects sight, leads to night blindness, and eventually

causes blindness. Reports estimate that in over 75 countries in Africa, Asia and Latin America, between 250 000 and 500 000 preschool children go blind every year because of vitamin A deficiency, and more than 225 million suffer from subclinical deficiency.<sup>53–55</sup> However, a recent report prepared for the UN system that attempts a literature review states that the prevalence of clinical vitamin A deficiency in Asia seems to be ‘quite low’.<sup>50</sup>

The virtual elimination of vitamin A deficiency by the year 2000 was a goal of the 1990 World Summit for Children. In 1998 a consortium of UN and other international agencies launched a global vitamin A initiative.<sup>54</sup> This emphasised the importance of supplementation of diets and fortification of foods, with development of horticulture as an additional long-term approach. Breast-feeding was not given special emphasis.

Textbooks and reports on vitamin A deficiency usually agree that production and consumption of foods naturally rich in vitamin A is important. However, the programs of the UN system and the aid agencies, mostly directed at children, have an emphasis on supplementation with doses of vitamin A at pharmacological levels that can be close to a toxic dose, and fortification of commodities, such as, sugar, fats, oils, milk and monosodium glutamate with vitamin A.<sup>50,58</sup>

The usual reason given for such policies, is that the immediate and urgent need is to treat existing clinical and subclinical disease, particularly in young children. Vitamin A is stored in the liver so a one-stop approach can be efficient and effective, and for researchers has the attraction that it can be conducted by means of controlled trials whose results can be measured. However, the three randomised controlled trials of high-dose supplementation carried out in Africa (Ghana), Asia (China) and Latin America (Peru) summarised in the *Lancet* in 1998, showed that high doses of vitamin A did not make any difference to rates of disease or death in children. Commenting, the review produced for the UN suggested ‘the doses of vitamin A provided may have been too low’.<sup>50</sup>

In any case, supplementation with vitamin A does not touch the underlying causes of deficiency, including inequity and poverty. Worse, a general belief that supplementation programs work, is likely to have the effect of enabling governments to neglect systemic responses to destitution, such as land reform. A report published by FAO and ILSI states that a policy of supplementation ‘fails to recognise the root causes of micronutrient malnutrition’.<sup>59</sup> Cynics would say that the sustained beneficiaries are the pharmaceutical industry, the sugar industry and the international aid business.

Working as I do in Brazil, I decided to look at vitamin A deficiency, at programs designed to prevent this syndrome, and also at foods that are sources of vitamin A.

Vitamin A deficiency is endemic in the north-eastern region of Brazil. This was the centre of the original Portuguese conquest, a land mass bigger than western Europe that the colonisers turned into vast estates for sugar, cotton, cattle and other commodities. After independence from Portugal this area was controlled by *os coronéis*, the rich and power-

ful owners of latifundia who controlled the north-eastern states, a culture of which the books of Gilberto Freyre are an elegy. The native Brazilians were exterminated, or driven off their land. The surviving indigenous people usually now live in reservations far away from their native lands. In the sertão, the arid backlands, some of which is caatinga or semidesert, some cerrado or savannah, the white and mixed race inhabitants, mostly relatively recent migrants, are often as impoverished as people who live in rural areas in Africa. Their children often starve.

The Brazilian Ministry of Health is concerned about deficiency of vitamin A, and of iron and iodine. Brazilian vitamin A deficiency programs are devised and managed by the Pan American Health Organization, the equivalent of the World Health Organization for the Americas. This mostly means high-dose capsules.

### *Let them eat liver*

As every nutrition student and reader of articles on food and health in magazines knows, vitamin A, a fat-soluble vitamin, comes in the form either of retinol, found in foods of animal origin, or else as carotenoids, pigments found in foods of plant origin. Carotenoids or provitamin A are precursors of vitamin A. It is generally accepted that their activity in the body is much lower, meaning that you need anything between 3 and 12 units of carotenoids to have the same effect as 1 unit of retinol. This is allowed for by expressing the vitamin A activity of carotenoids as retinol equivalents (RE).

I used to think that the richest sources of vitamin A are foods of animal origin. Textbooks and reference books give the impression that retinol is the real thing, no doubt because the first research on animals and humans was on retinol, and that carotenoids are inferior, partly because of their lower vitamin A activity.

If what is meant by vitamin A is retinol, animal foods are by definition not just the richest but the only sources of vitamin A: the recent report published for the UN system includes an editing slip, stating that, ‘animal products usually contain more retinol’.<sup>50</sup> The recent textbook published by ILSI wonders if carotenoids are truly essential, and anyway says that: ‘the richest sources of vitamin A are foods of animal origin or spreads enriched with the vitamin’<sup>60</sup> and the report produced for the UN states ‘the main cause of vitamin A deficiency is a low intake of animal products’.<sup>50</sup>

Textbooks, reference books and technical reports are usually compiled in high-income countries whose food supplies were shaped long ago by the nutrition science paradigm and the reasons of state discussed previously. These books are also used as the usual texts in middle- and low-income countries, many of whose common foods have not been analysed.

Modern textbooks usually begin discussion of vitamin A by saying that it is present in a relatively small number of foods.<sup>60,61</sup> The list usually starts with liver, where vitamin A is stored in animal as well as human bodies, and which is very rich in variable amounts of retinol, depending on the species and its own eating pattern. The list also includes

cows' milk, butter, eggs (especially yolk) and cheese. In many countries margarine and also milk is fortified with vitamin A and D, and in some low-income countries sugar is fortified with vitamin A. So the message indeed seems to be: eat animal or fortified foods. The 2001 report comments in rather strange phrasing, 'unfortunately, children in developing countries often receive only small amounts of food that contain animal products'.<sup>50</sup>

Table 1 is a list of foods of animal origin and fortified foods identified as good sources of vitamin A. It is compiled from the Brazilian tables of food composition and from other sources.<sup>28,62,63</sup> The Brazilian values are consistent with those published in high-income countries.<sup>11</sup> The second column of the table shows whether the food is cheap or free for impoverished communities in low-income countries. Vitamin A deficiency is rare in high-income countries, so this seems a reasonable approach. As the table shows, the one such food that is free is human milk. The estimated average daily requirement of 250 µg RE for infants may be rather high, because it takes roughly 400 mL of mature human milk to supply this amount of vitamin A.<sup>64</sup> This suggestion is supported by the fact that colostrum is more than twice as rich in retinol than mature human milk, and so may deliver a surplus to the new-born to be stored in its liver. Cows' milk is as good a source of vitamin A as human milk, but is not cheap or free for impoverished people unless they rear cows for their own use or unless milk is part of an aid program.

The one cheap food is fortified sugar, which indeed might be handed out free. None of the other foods is cheap. The third column lists those foods that are good sources of other nutrients. Sugar and margarine are not, unless energy is counted as a nutrient, the rest are. The next column lists

the RE (measured in µg) in every 100 g of the food. The final column shows which of the foods delivers the estimated average requirement for adults for vitamin A, here taken as 500 µg RE a day in 100 g or, in the case of fats, 15 g.<sup>64</sup> This is an arbitrary measure, for example, people are unlikely to consume 100 g of egg yolk in a day.

What this shows is that animal and fortified foods, apart from sugar, are not particularly good sources of vitamin A, unless the estimates for average requirements are much too high. The obvious exception is liver: one serving of 100 g of liver delivers more than enough retinol for not only a day but for over a week, as indicated by the bold type. However, impoverished people in low-income countries do not eat liver once a week.

So what about foods of plant origin? Typically the textbooks and reference books list some foods of plant origin that contain carotenoids, saying that the most relevant is beta-carotene, which has vitamin A activity with a potency estimated at one-sixth that of retinol. As with plant sources of protein, plant sources of vitamin A are always listed second and presented explicitly or implicitly as inferior.

However, the UK food composition tables show that carrots, after which carotene is named, contain rather more retinol equivalents than any animal food apart from liver, and that many vegetables are fair or good sources of vitamin A.<sup>11</sup> The tables include an intriguing footnote saying that the carotenoid content of vegetables and fruits can be 10 times or more higher than listed. The reason for this variation is not given, except in the case of mangoes, where it is stated that the ripe fruit is highest in carotenoids.

Given this, maybe locally grown vegetables and fruits, picked ripe and eaten fresh, are better sources of vitamin A than produce picked unripe and stored before delivery to

**Table 1.** Foods of animal origin and fortified foods that are good sources of vitamin A\*

Food	Type	Cheap or free†	Source of micronutrients‡	RE/mcg 100 g§	100% + 100 g¶
Sugar (fortified)**	Sugar	YES	NO	1500	YES
Liver	Meat	NO	YES	8500	<b>YES</b>
Liver oil (cod)††	Oil	NO	YES	18 000	<b>YES</b>
Butter	Fat	NO	YES	650	–
Margarine (fortified)	Fat	NO	NO	925	–
Milk (cow)	Milk	NO	YES	50	–
Milk (human)	Milk	YES	YES	60	–
Colostrum (human)	Colostrum	YES	YES	150	–
Eggs (chicken)	Eggs	NO	YES	525	YES
Eggs (yolk)	Eggs	NO	YES	800	YES
Cheese	Dairy	NO	YES	250	–

\*Source: reference 28.

†Cheap or free: meaning low price in shops or readily available.

‡Source of micronutrients: a good source of other micronutrients and bioactive compounds.

§RE/mcg/100 g: retinol equivalents measured in µg contained in 100 g.

¶100% + 100 g. YES means that 100 g (or in the case of fats, 15 g) contains more than 100% of the estimated average daily requirement of vitamin A (500 µg RE). YES in bold means that a portion contains more than the requirement for a week. Note that recommended amounts of vitamin A are higher in the USA, as are the reference nutrient intakes (RNI) in the UK.

\*\*Value for sugar fortification from reference 63.

††Value for cod liver oil and human milk from reference 11. Estimated average daily requirement from reference 64.

shops. If so, then plant foods grown wild or in gardens and smallholdings will be richer (perhaps much richer) in vitamin A than indicated in food composition tables based on analyses of stored foods, and perhaps the plant foods of tropical countries are richer in vitamin A than the plant foods of temperate countries, when picked ripe and eaten fresh.

In supplements of the UK food composition table listing 'immigrant foods', yams and a few other 'exotic' fruits are listed as well as mangoes, as moderate sources of vitamin A.<sup>65</sup> The reports on vitamin A deficiency often suggest that rural people in low-income countries should grow and eat mangoes.<sup>65</sup>

The most significant reference, is to red oil from palm trees. Textbooks usually mention that red palm oil is very high in carotenoids, and one of the two recent textbooks that refer to two Brazilian palm oils, dendê and buriti, states: 'a Brazilian palm fruit, buriti, is the richest plant source of provitamin A'<sup>60</sup> It is also stated that half a teaspoon of red palm oil a day supplies the vitamin A needs of a child.<sup>59,63</sup> and that 77 million hectares of Brazilian land are suitable for palm oil production. Furthermore, trials in India indicate that absorption of vitamin A from the beta-carotene in red palm oil is 90% and its potency is not one-sixth but one-third that of retinol.<sup>66</sup> All this, it seemed to me, is very important information, from the point of view of Brazil, and other tropical countries where palms produce red oil.

#### ***Are plant foods the richest source of vitamin A?***

Why is red palm oil not advocated as the first line of approach to vitamin A deficiency for weaned children? One report said that people don't like the taste or the colour of the oil. Well, I remember that cod liver oil tastes disgusting, but this did not stop the government program manufacturing and distributing it in Britain during the 1939–1945 war, nor did it stop my mother giving it to me.

As for adults, one of the two cities in Brazil whose people consume more than the recommended amounts of vitamin A is Salvador, the capital of the state of Bahia, where dendê oil is habitually used as part of Bahian cuisine.<sup>67</sup> The dendê palm was originally imported to Brazil from Africa by slaves whose descendants give the state its dominant culture. The other city is Rio, also influenced by African culture. So some people like red palm oil. It is high in saturated fats, of a type whose effect on the risk of coronary heart disease is debated; but the amounts needed to prevent vitamin A deficiency are very small.

An article published in the *American Journal of Clinical Nutrition* in 1989 is maybe the only study of buriti and vitamin A deficiency.<sup>68</sup> The buriti palm grows wild in the north, north-eastern and central regions of Brazil. Its vitamin A is almost all beta-carotene. The vitamin A content of the fruit of the palm expressed as retinol equivalents is as high as, or higher than, liver. Buriti is produced on an artisanal basis by country people and consumed as a fresh fruit drink or in the form of sweets.

The study was carried out as follows. Buriti fruits and sweets were bought in the market in São Luiz, the capital of

Maranhão, a north-eastern state, and their chemical composition was analysed by standard methods. Three towns in the interior of Rio Grande do Norte, another north-eastern state, were selected, and 44 children with clinical vitamin A deficiency were included in a case-control study. Mothers were asked to give their children one 12 g buriti sweet a day for 20 days. The sweets contained 1116 µg RE per 100 g. In all cases but one of xerophthalmia, all clinical signs of deficiency vanished. The authors commented that, 'the results justify a greater attention to this natural food source of provitamin A . . . [as] . . . an alternative of intervention to be combined with, or to replace, the massive distribution of vitamin A capsules'.

Indeed, Buriti is cheap or free for *os sertões*, the impoverished people of the backlands of Brazil and if the trials conducted in India for conversion of beta-carotene to vitamin A apply, buriti is richer in vitamin A than liver.

I then decided to take a closer look at the vitamin A content of plant foods. Over the years the Brazilian Ministry of Health and its agencies has collected a lot of information about national food patterns, much of which has until recently been neglected by Brazilian health professionals in favour of data from the USA. The food composition tables commissioned and published by the Brazilian national institute responsible for statistics more than 20 years ago includes compositional analyses of native foods, but is now out of print and not reproduced internationally.<sup>28</sup>

Table 2 lists the vitamin A content of a number of Brazilian foods of plant origin: vegetables, leaves, fruits, nuts, seeds and oils, using the food composition tables and one other source.<sup>69</sup> Table 2 is presented in the same way as Table 1. If the RE of palm oil is not one-sixth but one-third of animal foods, then the values shown in the table should be doubled.

The table shows that there are at least four Brazilian fruits that are extremely rich in vitamin A, in the same range as liver: buriti, dendê, pequi and tucumã. I was not able to find data for three other fruits and their oils, babaçu, macaúba and urucum, said to be rich in vitamin A. Allowing for variation in types and measurements, the oils of buriti, dendê, pequi and tucumã are as rich if not richer in vitamin A than liver or cod liver oil.

So the statement so often made in textbooks and reference books and expert reports, that animal foods are the richest source of vitamin A, is in the case at least of one big tropical country, Brazil, comprehensively wrong. Any suggestion that animal foods are the most available sources of vitamin A may be true in terms of the food supplies of high-income countries but is grotesquely wrong if applied to middle- and low-income countries.

Most of these plant foods grow wild in the rural areas of Brazil. They are free food, much of which, such as couve (a kind of cabbage), mangoes, and sweet potatoes, are commonly cultivated. Leaves of plants are richer in vitamin A, and people might need encouragement to cook and eat the leaves of beetroot, cassava and pumpkin, which are all delicious. Such work is coordinated by community leaders

**Table 2.** Brazilian foods of plant origin that are naturally rich sources of vitamin A\*

Food	Type	Cheap or free†	Source of micronutrients‡	RE/mcg 100 g§	100% + 100 g¶
Abóbora (pumpkin)	Vegetable	YES	YES	350	–
Abóbora (leaves)	Leaf	YES	YES	600	YES
Alfalfa	Leaf	YES	YES	1140	YES
Babaçu (nut)	Fruit, nut	YES	YES	?	LIKELY
Babaçu (oil)	Oil	YES	YES	?	LIKELY
Batata doce (sweet potato)	Root	YES	YES	300	–
Batata doce (leaves)	Leaf	YES	YES	975	YES
Bertalha	Leaf	YES	YES	582	YES
Bettaraba (beetroot)	Root	YES	YES	–	–
Bettaraba (leaves)	Leaf	YES	YES	525	YES
Buriti (palm) (pulp)	Fruit, nut	YES	YES	6000	<b>YES</b>
Buriti (oil) *	Oil	YES	YES	50 000	<b>YES</b>
Caruru	Leaf	YES	YES	530	YES
Cenoura (carrots)	Root	YES	YES	1100	YES
Coentro	Leaf	YES	YES	533	YES
Couve (like cabbage)	Leaf	YES	YES	600	YES
Dendê (red palm) (pulp)	Fruit, nut	YES	YES	10 166	<b>YES</b>
Dendê (oil)	Oil	YES	YES	45 920	<b>YES</b>
Espinafre (spinach)	Leaf	YES	YES	585	YES
Macaúba (palm)	Fruit, nut	YES	YES	?	LIKELY
Macaúba (oil)	Oil	YES	YES	?	LIKELY
Mandioca (cassava)	Root	YES	YES	–	–
Mandioca (leaves)	Leaf	YES	YES	1960	YES
Manga (mango)	Fruit	YES	YES	210	–
Mostarda (mustard)	Leaf	YES	YES	700	YES
Paprika	Vegetable	YES	YES	470	–
Pequi (fruit)	Fruit, nut	YES	YES	20 000	<b>YES</b>
Pequi (oil)	Oil	YES	YES	28 196	<b>YES</b>
Pimenta (pepper)	Vegetable	YES	YES	1356	YES
Pupunha	Fruit	YES	YES	1500	YES
Tucumã (fruit)**	Fruit, nut	YES	YES	6000	<b>YES</b>
Tucumã (oil)**	Oil	YES	YES	31 300	<b>YES</b>
Urucum (fruit)	Fruit, nut	YES	YES	?	LIKELY
Urucum (oil)	Oil	YES	YES	?	LIKELY
Vinagreira	Leaf	YES	YES	689	YES

\*Source: reference 28.

†Cheap or free: meaning low price in shops or readily available.

‡Source of micronutrients: a good source of other micronutrients and bioactive compounds.

§RE/mcg/100 g: retinol equivalents measured in µg contained in 100 g.

¶100% + 100 g. YES means that 100 g (or in the case of fats, 15 g) contains more than 100% of the estimated average daily requirement of vitamin A (500 µg RE). YES in bold means that a portion contains more than the requirement for a week. Note that recommended amounts of vitamin A are higher in the USA, as are the reference nutrient intakes (RNI) in the UK.

\*\*Values for tucumã from reference 69. Estimated average daily requirement from reference 64.

and is carried out in rural areas of Brazil, in one case supported by a State government.<sup>70</sup> The message for Brazil, being prepared by the Ministry of Health in a new program called 'Alimentos do Brasil' (Foods of Brazil) is: 'see, grow, and eat what you already have. Your good health is in the hands of your family and community.'<sup>71</sup> But of course a systemic approach will be needed to recover and transform the agricultural systems of Brazil.

### *Who do we think we are*

The native Brazilians will have known that buriti, pequi, tucumã and urucum and many other native plant foods are effective in prevention and treatment of vitamin A deficiency diseases, which can be seen as originally caused by colonialism.

People who live with nature do not separate food, herbs and medicine. The pequi fruit, and nuts from buriti and other

palms, will have been part of the food culture of the people who originally lived in Brazil where vitamin A deficiency is now endemic, not just because they were there and are edible, but because their special properties would have been discovered. People who live in nature need to see at night.

But the native Brazilians who lived in what are now its northern, north-eastern and central states, were exterminated or else forced off their land, and the people who now live with vitamin A deficiency in these territories are mostly relatively recent migrants from Europe who still have little idea of the riches surrounding them, literally dropping off the trees in their yards and streets. There may now be nobody left alive with detailed direct knowledge of the original food systems of Brazil.

How can we be sure that native people knew the value of the foods they gathered and consumed? Questions like these can be only partially answered by information counted as admissible within currently accepted paradigms because it is primarily not scientific but philosophical in nature. What do we think we are, as humans? We have been brought up to believe in progress, and its prayer that every day in every way, things should get better and better. This implies that primaeval and modern gatherer-hunters, pastoralists and agriculturalists, living with simple technology, are stupid and ignorant. In which case, the idea that ancient humans could know more about some aspects of nutrition than is now known by nutrition scientists, is an absurdity.

If we admit evidence from other disciplines, testimony comes from anthropology. Claude Lévi-Strauss has written, 'extreme familiarity with their biological environment, the passionate attention they pay to it and their precise knowledge of it, has often struck enquirers as an indication of attitudes and preoccupations which distinguish the natives from their white visitors'.<sup>72</sup> He quotes a colleague on Filipino natives: 'many times I have seen a Negrito who, when not being certain of the identification of a particular plant, will taste the fruit, smell the leaves, break and examine the stem, comment upon its habitat, and only after all of this, say whether he did or did not know the plant... Most Negrito men can with ease enumerate names of at least 450 plants... the botanical knowledge of the medicine men and women is astounding.' On agriculture, Lévi-Strauss states that the Aymara Indians of Bolivia, where the potato is native, have cultivated and classified over 250 varieties, growing them at up to 12 000 feet. Of the Navaho he writes that since they 'regard all parts of the universe as essential to well-being, a major problem of religious study is the classification of natural objects', adding that this observation perhaps applies to all native people. and of the Australian aborigine he writes, 'mountains and creeks and springs and water-holes... are the handiwork of ancestors from whom he himself has descended... The whole countryside is his living, age-old family tree'.

Levi-Strauss seems not to have written anything comparable on Brazilian natives, perhaps because the communities he studied for 'Tristes Tropiques' were on the edge of extinction, living far away from their ancestral lands, and the

passages cited here are of botanical and agricultural, not nutritional knowledge. This may indicate the limits of Lévi-Strauss' own knowledge and interests, rather than the people studied. To natives, botany is not an academic subject. Their taxonomical knowledge is a means to a practical end.

In just the same way, the older women who live in the valleys of French Catalonia where I drafted much of this article, know when in the year and where on the mountain to gather plants, which they then prepare as specifics to ward off and to treat trivial and serious ailments. They know the names of the herbs, to explain and pass on knowledge of their uses. Likewise, the Negrito identified plants as a matter of health and indeed of life and death, just as we need to know the meaning of alternating red and green lights.

For a full understanding of nutrition, we should accept that our human ancestors and people who now live with nature, as a rule knew and know more about native foods than we do. This challenges us to think about what knowledge is, and what being human is. In his book *The Pasteurization of France* the philosopher Bruno Latour says that, 'the hunter who covers dozens of square miles and who has learned to recognise hundreds of thousands of signs and marks, is called 'a local'. A cartographer who has learned to recognise a few hundred signs and indices while leaning over a few yards of maps and aerial photographs, is said to be more universal than the hunter and to have a global vision. Which one would be more lost in the territory of the other? Unless we follow the long history that has turned the hunter into a slave and the mapmaker into a master, we can have no answer to this question'.<sup>73</sup>

The burden of proof is on anybody who asserts that the original Brazilians were unaware of the value of plant foods that are rich in carotenoids – and, indeed, unaware of the value of all the native foods of plant and of animal origin that are rich in vitamins and minerals, and in other bioactive compounds whose relevance to human health is not yet understood by modern nutrition science. The same, of course, applies to the original inhabitants of all other parts of the world.

A world network involving national and state and local government, civil society organisations and communities should be set up, guided by native and local communities, in order to discover the true value of tropical foods of plant origin, and to use them as primordial prevention of endemic and epidemic diseases.

The story of vitamin A, plant foods, and buriti, pequi, tucumã and urucum, may become a parable. In order to learn about nutrition, and its value to the human, living and natural world, we have to begin again.

## Conclusion

Nutrition science is based on a number of general principles that, when put into practice, worked in times gone by in a limited context, but in our wider world frustrate its objective to maintain and improve health.

One of these general principles, is that growth means health, or to be more precise, that the measure of good

human health is babies and children that grow fast, and relatively tall and heavy adults. The example given here is protein, which in different forms is used as artificial fertiliser for plants, animals and humans, to achieve rapid growth.

The concept of the superiority of food systems that emphasise protein of animal origin, follows from this general principle. Originally practiced in the most powerful countries, which then developed subsidised agriculture and food systems that produced vast surpluses of meat, milk and their products, the principle worked well when the paramount perceived need was to breed fast-growing plants, animals and people of prime quality in early life, for harvest, slaughter or labour.

However, the main effects of the development of food systems first in high-income countries, but now globalised, with more meat, milk and dairy products, and therefore fat and saturated fat as well as protein, are to produce babies that are too big, children who become sexually mature prematurely, and adults liable to become or remain obese. The penalty of stressing the biology of populations in early life, is epidemic diabetes, hypertension, stroke, osteoporosis, heart disease, cancer and other chronic diseases.

The effects of this policy on the whole living and natural world is even more disastrous, because its practice destroys indigenous food and agriculture systems. The evolved agriculture systems of middle- and low-income countries based on local foods of plant origin that require only low inputs, are ripped up and replaced by capitalised systems producing cheap milky meaty fatty sugary processed foods and drinks of foreign origin. As well as undermining public health these are socially, economically and politically damaging.

Another general principle, is that science and technology are keys to universal truth, so that policies and practices that work in one context can be imposed always and everywhere. The example given here is vitamin A.

The original discovery of the essentiality of retinol has led to promotion of foods of animal origin, relegation of foods of plant origin that are rich sources of carotenoids, promotion of liver and cod liver oil, and fortification of milk and margarine. Emphasis on milk, eggs, butter and fortified foods in high-income countries increases attachment to agriculture systems geared to meat and dairy products, and has no compensating public health value in high-income countries, where vitamin A deficiency is rare.

Vitamin A deficiency is generally agreed to be common in low-income countries. As first-line policy, pharmacological doses of retinol are administered to children mostly in rural areas whose food supplies inevitably contain little food of animal origin, and commodities like sugar are fortified. This mystifying and confusing policy frustrates sustainable recovery or development of systems using indigenous plant foods that are rich sources of carotenoids, and also increases dependence of rural people on urban and foreign elites.

The internal confusions and contradictions of nutrition science as currently defined and practiced can be perceived by examination of its own principles. The argument of this

and the accompanying article is that the general principles of nutrition, and the normal scientific practice they generate, are beyond further modification or repair. They are derived from philosophical, political and scientific paradigms that cannot answer the most important and urgent issues that face us now. Nutrition science is meant to maintain and improve global health. It therefore needs a new map.

### Science

In the late 1970s the polymath Joseph Needham, who devoted his life to reconciliation of eastern and western philosophy, science and civilisation, gave a lecture in Sri Lanka.

In it he referred to, 'two characteristics of our Western civilisation: on the one hand the conviction that the scientific method is the only valid way of understanding and apprehending the universe, and on the other hand the belief that it is quite proper for the results of this science to be applied in a rapacious technology often at the service of private capitalist profit . . . What we can rightly object to is the idea that science is the only valid way of apprehending the universe.'<sup>74</sup>

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