Plant-based diets are traditional in developing countries: 21st century challenges for better nutrition and health

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The chronic degenerative diseases were virtually unknown in original hunter–gatherer societies. At the dawn of the 21st century, however, they represent the most important public health challenge to populations of both the industrialized, affluent nations of the temperate zones and the low-income developing countries of the tropics. The developing countries most closely reflect the legacy of our traditional foreparents while constituting three-quarters of the world's populace and public health interest. For economic, traditional, religious and cultural reasons, the majority of the dietary fares in the developing world are largely plant based. This is associated with high prevalences of deficiency states in vitamin A, iron, zinc, riboflavin and vitamin B12. Poor linear growth and chronic energy deficiency are concomitant conditions. Conversely, the major chronic diseases have low prevalences among the rural peasantry and tribal groups, with the exception of gastro-esophageal cancer, osteoarthritis and cataract. As a site for intensive research in food and nutritional sciences, Guatemala provides important lessons about the origin and evolvement of a congruent plant-based diet within a food system and which factors of demographic expansion, urbanization, environmental stress and food technology will carry it through the 21st century. We can conclude that, whatever was the 'original' dietary pattern of pre-agricultural humankind, a plant-based diet regimen provides the lowest content of promoters and the highest content of inhibitors of metabolic dysregulation that lead to the major causes of disease and debility in adults over 40 years of age. For developing countries, the challenge is to maintain and reinforce the traditional eating patterns while improving their delivery of micronutrients and obviating any adverse environmental consequences in their traditional preparation patterns. For developed countries, there is an opportunity to find a 'road map' of guidelines to allow correction of current, pathogenic dietary and lifestyle patterns by examining the food-ways of traditional developing societies' cuisines.

Key words: chronic disease prevention, developing countries, food technology, Guatemala, legumes, maize, micronutrient deficiencies, plant-based diets

> The observation is that, for early humans, life was precarious, intense, and short; for 21st century humans, life is more secure, more leisurely, more contemplative, and longer, forcing us to reap the bitter experience of chronic disease along with the sweetness of the foods and comforts that technologic progress has wrought.[1]

Death of living organisms is inevitable — but it is also desirable. In the perspective of global crowding and competition for oxygen and nutrients, if every organism ever to have lived had continued to survive, the biosphere of the earth would have crowded itself out of existence in the early millennia. Death from predation, either by large animals or by minute and microscopic organisms such as helminths, protozoa, bacteria and viruses, is the universal lot of wild and feral animals. For *Homo sapiens*, these same environmental factors were operative for 99% of human evolution. Death was usually acute and fulminant, and came early in the course of the maximal human lifespan. To the extent that death came before the age of reproduction, it did little for the essential survival of the species. To the extent that it came after an individual was able to procreate and reproduce, the thread of the population was continued for yet another generation and the genetic make-up of the survivors was passed along into the genetic pool. What to do about the 'older generation' is not a concern for most animal species, and it was not an issue for humankind until the last few centuries.

The motto of gerontological science has become: 'Add life to years, rather than years to life.' In these two background assertions, we have the crux of the 'evolutionary' (for the species) and the 'personal' (for the individual) aspiration. In the context of evolutionary biology, it is often — and correctly — said that, in Nature, no specific individual's survival matters. It is the survival of the species (and, I would add, the diversification of species) that is important. However, humanism, and the humanitarian philosophies and religions of humankind have placed intrinsic value on the individual.[2] To some extent, this places human concerns outside of the 'natural order'. For better or worse, moreover, the same power of reason that has brought mankind beyond Nature on a philosophical plane allows for *technology*, which carries us beyond Nature on the physical plane as well.

The present Symposium responds to a global challenge of both a growing population and an aging population. The consequence of the former is that they obtain enough to eat, and of the latter that they be fed 'well' enough to maintain good health. The so-called pre-industrialized or developing nations

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constitute the largest segment of the terrestrial population, the fastest growing group, and the regions in which the largest number of adults are surviving to older ages. The challenge of this review is to link the food system issues of these populations that time (and sometimes science) has forgotten, to the challenges of their own demographic, epidemiologic and nutritional transitions, and to place this into the fundamental reality of a global marketplace of both ideas and foodstuffs.[3]

The critical issues

As we are obliged to operate in an unnatural order in the post-technological era, it has become fashionable to speak of 'food systems',[4] in which the human (the tool-bearer) and all of the environmental surroundings are part of a system. In fact, from the time of hunter–gatherer lifestyles, the concept of food systems has been operative. The issues of food and diet have implications for both the production of food for the human diet and the selection, preparation, processing and consumption of these foods. The production issues are the domain of agronomy, ecology and wildlife management sciences. As I have no particular expertise in these areas, the review makes only passing reference to them and to the potential constraints and determinants that exist at the interface of our environment and our food supply. Diet, in contrast, is something we can discuss. Foods and beverages are required to supply all organisms with the hydration, fuel, building blocks and metabolic regulators needed for life. Eating is essential. The downside of feeding is that it can often make us sick, and sometimes kill us. In terms of predation, there was always the chance that what we hunt will turn on us and kill or maim the hunter. Whether plant or animal in origin, food also has the capacity to introduce infectious pathogens or poison us with toxins. It is only recently, however, that technology has allowed us to escape the consequences of the aforementioned eventualities. Nowadays, humans regularly survive to the onset of the age of reproduction — and beyond. As a consequence, a new issue of diet has emerged: that the foods and beverages we eat could condition our health and function in a *chronic* time context.

Table 1 constructs a sequence of contexts of death for the individual. When humans were largely under the sway of evolutionary biology, as with other species, death came early in life from an acute cause: infection, accident, violence. This was true until the 20th century, which dawned with median life expectancies of 30–40 years.[5] The maximal human lifespan has been estimated at 120 years.[6] With the control or conquest of causes of acute death, we have then emerged into the second order. Chronic diseases, which are both debilitating and potentially lethal, have a rising incidence from age 50 years.[7] The consequences of this are troublesome for all aspects of society. The older, vulnerable population experiences the pain, suffering and loss of quality of life. The society as a whole assumes a financial and emotional burden of providing care. We are at this Symposium because of the mounting evidence that chronic illness and functional loss have origins in diet, or at least amelioration through dietary measures. Finally, Fries has introduced the concept of the 'compression of morbidity' in which one's diet, lifestyle and medical care act to keep one free of disease and disability until some catastrophic event produces the final demise.[8] As death is inevitable — and desirable (discussed earlier) — the final context described in Table 1 is where we should be headed.

Table 1. Differential causes of mortality in relation to the preponderant age of death in a society

In early life, with an acute cause
Later in life, from lingering and protracted afflictions
Late in life, from an acute cause

The final critical issue has to do with the overall demographics of the world. As we meet here in Australia, under the auspices of Sanitarium in a meeting entitled 'Nouveau Nutrition: Traditional Foods, Contemporary Science', our patron is a major food producer for the nations of Australia and New Zealand. It is valid that the term 'science' in the mandate of the meeting be related to situations of high conceptual and technological development. 'Traditional', however, harkens to the 75% of the world's population who live in countries that are designated as being 'developing nations'. They are predominantly clustered between the Tropics of Capricorn and Cancer. They express the legacy of the hunter–gatherer and traditional agrarian cultures far more closely than the nations of Europe, North America and Oceania. Poverty is the most important issue for the people of this huge region. Darnton-Hill and Coyne point out the disparities and inequities of access to and availability of food between North and South.[9] Walter concurs, noting that largely vegetarian regimens are consumed in developing countries for economic reasons as often as for preference.[10]

In terms of agronomics, just keeping up with feeding populations of developing countries a diet that is adequate in nutrients and energy looms as a Herculean agricultural and environmental challenge. In terms of public health, feeding such populations a regimen that encourages health and productivity throughout their lifespans has a larger denominator than the corresponding question in the developed world.

Did *Homo sapiens* evolve as a carnivore or a herbivore?

It is truly possible that we (those of us with the means and those who chose to) could eat as did the hunter–gatherer, but none of us could live like hunter–gatherers. In fact, due to this 'technological imperative', we no longer let the people in the remaining foci of traditional society live like hunter–gatherers. The evolutionary consequences of this question are important, but their implications for public health may be even more important. Eaton and Konner can be considered the first to express an interest in 'palaeonutrition', which deals with mobilizing evidence about the pattern of food consumption in prehistory.[11,12] There is universal consensus that fossil records and observations in remote communities in the past two centuries attest to a total absence of contemporary chronic disease in original, hunter–gatherer tribal communities.[13,14] Controversy has arisen, however, as the notion of describing the diet and lifestyle that prevailed in history was sought for purposes of addressing the public health problems of today. One group of scholars feels that most calories were consumed as animal tissues (meat, viscera, eggs, grubs),[15,16] whereas an opposing view holds that edible plants (tree fruits, grass seeds)[14,17,18] were the mainstay of energy intake. If the 'carnivorous evo-

lution' school is correct,[16] then early humans had a more abundant put-through of micronutrients, and may indeed have had requirements for vitamins and minerals that are higher than those delivered by contemporary diets. If the 'herbivorous evolution' school is correct,[14] then what we currently define as micronutrient deficiency may represent the historical norm for the human species. This would tend to reduce anxiety about the consequences of eating plant-based fares, and even raise questions regarding the prudence of systematic fortification and supplementation with micronutrients, as is endorsed by maternal and child health campaigns, worldwide.[19] Reviewing the arguments on both sides, this reviewer inclines toward the notion that animal foods played a much larger part in the diets of hunter–gatherers than they have since the evolution of agriculture.

'Introduction' of plant-based diets into developing countries

With the exception of the few remaining hunter–gatherer tribal groups, the traditional pursuits among rural populations are pastoralists or agrarian peasants. The pastoral lifestyle emerged some 40 000 years ago.[20] Milk, cheeses and yoghurts constitute the foods that are available to herders. They are high in fat, saturated fat and cholesterol. The pastoralist diet would seem to be atherogenic, if not carcinogenic as well. The life of the early herders was as precarious as that of their hunter–gatherer contemporaries. Infectious diseases, predation and tribal violence presented risks of early demise. Living into the age of risk for cardiovascular and malignant diseases was uncommon among the traditional nomadic herders.

The peasant culture arose with the domestication of grass seeds to produce grain crops, which emerged only 10 millennia ago. According to Cordain, who calls cereal grains 'humanity's double-edged sword', wheat and barley were the first grains domesticated 10 000 years ago, followed by rice and corn 7000 years ago, and subsequently millets, sorghum, rye and oats.[21] For the first time in human history, being *settled* in one spot and claiming territory was a premium. Wild game became scarcer by the reclaiming of wilderness lands for farming and became exhausted from hunting in a narrow geographic radius. Cereals or tubers became the major staple of the agrarian age. Today, only 300 edible plant species are used by humans for food, and 17 species constitute 90% of the human food supply of grains, legumes, tubers, vegetables and fruits. In developed countries 31% of energy intake and 30% of protein intake are derived from cereals, whereas in developing countries these respective contributions are 61 and 55%.[22]

It is widely acknowledged in an anthropologic and sociologic domain that the emergence of the Agricultural Era, some 10 000 years ago, was the key to both the expansion of the human population (as it provided a stable and abundant supply of energy) and its differentiation into civilization (as not everyone had to be a food producer in order for the populace to survive).[21] Table 2 summarizes the points made in the present and earlier sections as a series of bullet point principles and the assumptions related to the general dietary evolution of humankind and its contemporary consequences.

Contemporary peasant cultures are direct descendants of the pioneering peasants of 10 millennia past. In many instances, neither the seeds nor the agricultural techniques have changed. Generally, however, plant genetics of the 'Green Revolution' and more mechanized means of cultivation and harvesting have penetrated all corners of the farming world. Hence, it is not the introduction but rather the *maintenance* of the plant-based diet, and the improvement of its nutrient density and balance that represent the challenges for a healthy demographic transition without the classical features of epidemiologic and nutritional transitions. The issue for an antichronic disease diet is not 'changing the diet of a nation' but rather *preserving the diet and dietary preferences* of a nation.

The Mayan 'triad' as a case study

The nature of the Guatemalan diet

The Guatemalan diet has been studied more thoroughly than, perhaps, that of most developing societies. This began with the interest shown by the early Jesuit priests in cataloguing the post-Mayan culture in the decades following the arrival of the Spanish *Conquistadores* in 1524. This was followed by the interest of anthropologists and archaeologists in the 19th century. It was the founding in 1949 of the Institute of Nutrition of Central America and Panama (INCAP) as a research outpost of the Pan American Health Organization under its founding director, Nevin S. Scrimshaw, that provided the privileged situation of exhaustive study of the Guatemalan dietary pattern and its nutritive value and food science challenges. Since the founding of the Center for Studies of Sensory Impairment, Ageing and Metabolism, we have tried to capitalize on the bountiful antecedent studies, and perhaps extend the perspective in the direction of issues of senescence and chronic disease, consonant with the mandate in our title.

The conventional formulation of the Mayan diet, dating back to commentaries in colonial times, is of the 'triad' consisting of maize, beans and squashes.[23] Although, this is an oversimplification, as amply documented by Saenz de Tejada in her treatise on the Mayan and post-Mayan diet, *Descrip-*

Table 2. Principles and assumptions concerning the evolution of human cuisine and dietary practices

1. The nutrient requirements of the human species were determined through evolution, and *Homo sapiens* was a hunter–gatherer through 99% of its evolution. As recently as the last Ice Age, hunters followed a nomadic pursuit of the mammoth and mastodon. The truth in a vigorous academic debate among 'palaeonutritionists' is of importance to judgements we make — and strategies we adopt — for the feeding of a burgeoning global population in the Third millennium.
2. Nutrients were abundant in the muscle and viscera of the hunters' prey, and nutrient requirements reflect those high, customary intakes of nutrients.
3. Life-expectancy was short in hunter cultures, and concerns about the chronic disease consequences of high animal protein intakes would have been disregarded or unknown.
4. Agriculture (the domestication of wild seeds and permanent cultivation of lands) emerged only 10 000 years ago, when humans turned from largely meat eaters (meat to plant ratio is 75 : 25) to plant eaters (meat to plant ratio is 35 : 65).
5. Rural populations of pre-industrialized developing countries are closest to the agricultural (peasant) culture that replaced the hunter–gatherer lifestyle 10 000 years ago.

ción Analítica de los Patrones Alimentarios en Mesoamérica desde los Tiempos Prehistóricos hasta el Presente, con Especial Atención a 'la Triada' (Analytical Description of Dietary Patterns in MesoAmerica from Prehistoric Times to the Present, with Special Reference to 'the Triad'), most reports over the centuries have sustained the observation that the majority of dietary energy can be attributed to corn and legumes. That maize is central to the Mayan legacy is undisputed.[23] The Creation Myth of the Maya-Quiche indigenous group, retold in the anthropological chronicles of this tribe in the *Popul Voh*, relates the belief that the original man was created out of the *masa* (corn dough) of the gods. As such, the contemporary belief is that humans need to consume corn daily as an 'essential nutrient' for the body. This reference is part of the double-meaning title by Guatemala's Nobel Prize laureate, Miguel Angel Asturias, in his classic novel, *Hombres de Maiz* (*Men of Corn*).

Leonardo Mata, in his classic 16-year longitudinal growth study in a rural highland village, *The Children of Santa María Cauqué*, documented up to a 70% contribution of maize to the typical energy intake.[24] The most routine and standard form of consuming maize is as the *tortilla*. Tortillas are flat, pancake-like items, varying in weight from 20 to 50 g,[25] which are prepared with dried corn kernels as the starting ingredient. To begin the traditional tortilla-making process, corn grains are soaked overnight in water to which lime (CaO) has been added. This process produces a softened corn, *nixtamal*, in which the outer husk is loosened from the endosperm. It also imparts calcium to the cereal. The next morning, the dough is milled to remove the husks and create the dough. Traditionally this was performed by milling and stone-grinding by hand. In recent years, electric-powered mills, operated by generators, have sprung up in most villages of any size. Final grinding with the hand implements still occurs, and the soft dough is patted in the hands into the form and thickness required. It is then baked over an open wood fire on a round, slightly concave clay grill called a *comal*. To prevent sticking, more *aqua de cal* (lime-water) containing CaOH is sprinkled on the *comal*. The family's whole day's supply of tortillas will generally be prepared in these predawn hours. Tortillas are consumed at each of the three daily meals, with the soft, fresh hot tortillas eaten in the morning. At midday and evening meals, the tortillas are reheated by toasting over the open flame; crisp, slightly charred forms are consumed. Several varieties of corn (white, yellow, blue) are grown, but white maize predominates.[25] In some parts of the highlands, the dough is wrapped in leaves to produce dense corn cakes (*tamalitos*). Maize *tamales* (leaf-wrapped corn cakes with meat or fowl filling), *atol de elote* (warm, sweet corn gruel), *atol de maiz* or *atol blanco* (seasoned gruel consumed with beans) and *elotes asados* (charcoal broiled corn on the cob) are other vehicles for use of maize in traditional Guatemalan cuisine.

The beans used in Guatemala are varieties of the common bean (*Phaseolus vulgaris*), represented by black (*negros*), red (*colorados*) and white (*blancos*) varieties.[26] Broad beans (*Vicia faba*) and lentils (*Lens* spp.) are also grown and consumed but to a much lesser degree. The preferred legume is the black bean, which is soaked overnight for cleaning and softening, then boiled in earthen crocks. Beans can be served drained and whole (*parados*), or mashed and refried (*voltea-dos*), or combined with their broth as black bean soup (*sopa de frijol*). Legumes are rich in protein, with 23% of the weight of the edible portion of beans being protein.

The squash family items include *güicoy* (*Cucurbita maxima*), *calabaza* (*Cucurbita pepo*), and *güisquil* and *perulero* (*Sechium edule*). The güicoy, in fact, constitutes a family of green-skinned, pumpkin-like squashes ranging from small pale green varieties, with a flesh and taste reminiscent of zucchini, to larger types with a yellow or orange pulp (*güicoy sazón*). Calabaza is the traditional (orange) pumpkin. Güisquil and perulero are prickly green-skinned and smooth white-skinned varieties of the same species. Vitamin C and carotenoids are nutrients contributed in some abundance by squashes. The leaves of the squash plants are among the herbs used in Guatemalan cuisine.[23]

Saenz de Tejada, who is a dissenter from the simplification of the 'triad' concept, wrote a narrative history of food systems in MesoAmerica from prehistoric times.[23] Her own work examined two Mayan-descendant groups and showed that corn was, indeed, central, but that squash and legumes were replaced by other staples. Her principal thesis can be summarized in her own words (translated) in the following excerpt:

> The heterogeneous process of the subsistence agriculture pattern was modified by the Spanish Conquest which, in turn, influenced to varying degrees the natural evolution of the MesoAmerican populations….Despite regional differences, corn has occupied a central place in the economic, nutritional and ritual life of MesoAmerican populations. The complementary foods have been secondary and complementary, and their importance and proportions in the diet have differed among the regions. Hence, the generalized belief that the combination of maize, beans and squashes, known as the 'triad' or 'trinity' of the indigenous MesoAmerican, constituted the basis of subsistence in the region, cannot be accepted conclusively.[23]

Coffee, the leading export crop, and a post-Conquest introduction, is also the major beverage; it is consumed without milk but with heavy helpings of cane sugar. Sugar cane is the second leading export cultivation. Tomatoes and herbs are common garnishes. Soups and stews contain herbs and vegetables as well as squashes, potatoes, rice and noodles. Both bananas and plantain are popular fruits, eaten both raw and cooked. Fried plantains are another source of charred tissue on the Guatemalan menu. Recently, wheat-based breads have begun to intrude on the domain of the tortilla and tamalito,[25] with more urban locality — and the existence of a bakery — being the major determinants.

Dietary variety is of interest in areas where traditional Guatemalan foodways have persisted strongly or are observed less. The number of different foods commonly consumed can be used as a proxy estimation for dietary variety. Using 15-day food frequency questionnaires containing 50 items, which were established through focus-group sessions, a study in a coffee-growing region on the slope of the volcanic ranges in south-central Guatemala, in the region of San Pedro Yepocapa, was used to characterize the intake of preschool children. The survey embraced four sites: a township, a village 1 km away situated across a river, a private plantation 9 km distance over dirt roads, and a collective plantation 16 km distance over dirt roads. It was conducted

once in the rainy season and once in the dry season, and stratified the children for having a maternal-reported diarrheal episode during the interval of reference.[27]

If we focus only on those children whose mothers or caretakers did not report a diarrheal episode in that interval, the food and beverage items (n = 14) reported as consumed over the previous fortnight by over 75% of the participants during the dry season were: tortilla, coffee, tomato, black bean soup, *quilete* (*Solanum nigrum*, a green herb), banana, wheat-flour roll, white bread, black beans, scrambled eggs, pasta, soups, fried eggs and rice. The corresponding selection of foods (n = 10) for the same populace in the rainy season were: tomato, tortilla, *quilete*, banana, coffee, soups, black beans, *atol de elote* (sweet-corn gruel), rice and fried eggs. Consistently, two-thirds of the triad; that is, corn as tortillas and gruel, and beans and bean soup, were represented. If we categorize only the township children as 'urban', 18 items were mentioned by 75% of participants, whereas the other three 'rural' sites had 10 items reaching this proportion of individuals. Combining all children and all seasons, 44 of 50 items in the questionnaire were reported by at least 30% of respondents in the urban area and 29 items in the rural areas.

In a survey among 42 pregnant women in a low-income urban settlement in southern metropolitan Guatemala City, 254 different items were reported in from nine to 14 24-hour recall interviews conducted with each volunteer, but 36 items were common to almost all of the women.[28] Thirty percent (n = 76) of the 254 items were reported on only one occasion among the 706 women-days covered in the study. The mean cumulative number of different food and beverage items reported by each interviewee was 55. By weight, coffee (310 g/woman-day), tortilla (279 g), white bread (67 g), milk (52 g) and sweet rolls (51 g) were the most important. Tortilla contributed 28% of energy, sweet bread 11%, white bread 10%, black beans 3% and beef 2%. All grains together provided 56% of energy and 47% of protein. Eggs and legumes contributed 6% of energy and 12% of protein. Meat products provided 10% of energy and 28% of protein in this urban setting.

A plant-based predominance in the rural Guatemalan diet, as represented by a sample of several hundred adults in the eastern highlands in the Santa Rosa Province, was recently confirmed. The mean contribution of edible plants to total energy intake was 86%. However, the variety of plant species that contributed to this intake was relatively restricted.[29,30]

In rural areas, staple foods (with the exception of sugar and rice) may be cultivated. Itinerant peddlers, roadside vendors and organized markets in the towns exist for the purchase of commodities and perishable fruits and vegetables. As refrigerators are rare, fresh foods must be purchased often and prepared on the same day. The main methods of cooking are boiling, broiling and oven baking, using predominantly firewood in the countryside and propane in the urban areas. Frying is rare except for the preparation of eggs, plantain, and the occasional meat and viscera that is basted in lard. Associated with this is a low fat intake and a small contribution of fat to total energy, almost universally below 20%.[29,30]

Its nutritional and dietary virtues

In the proportion of protein sources of 70 : 30 for maize and beans, the mixture of essential amino acids approaches the quality of protein obtained from eggs or milk through the principle of complementation of essential amino acid.[31] The methionine-poor but lysine-rich legumes complement the lysine-poor but methionine-adequate cereal grain, maize.

A number of nutrients are found in abundance, with consumptions in excess of the recommendations and adequate biological availability. Calcium intakes in Guatemala are rated among the highest in the world,[32] with over 1100 mg consumed daily from the tortilla-based traditional fare. Vitamin C intakes have been found to be generous as well. Tomatoes, potatoes, squashes and bananas provide ample amounts of ascorbic acid along with herbs in stews and seasonal fresh fruits.[29] Moreover, in our early CeSSIAM studies, we found circulating vitamin E levels to be normal or high (NW Solomons, unpubl. data, 1987), as confirmed in a study of elderly residents of the rural village of San Pedro Ayampuc.[33] The corn oil in maize is the likely source of tocopherol in the diet. From that same sample we confirmed that intakes of thiamine, folic acid and vitamin B6, that are adequate to maintain sufficient status, can be presumed to be consumed by the villagers.[33]

Its nutritional and dietary liabilities

Dietary vitamin A is an intrinsic problem within the traditional Mayan diet. Poor in the animal protein sources of preformed vitamin A (retinyl esters), the diet depends on the provitamin A carotenoids to deliver this nutrient. The consumption of green plants is selective and, at times varied, but not large.[34] Moreover, the bioconversion of carotenoids of plant origin is much lower than conventionally assumed.[35]

Central America is a goiter belt, and iodine deficiency disorders were endemic.[36] From the time of the 1965–67 Central American survey, it was recognized that riboflavin (vitamin B2) status was marginal. Low intake of viscera and dairy items relegate the population to a subadequate intake of this nutrient.[37] Dairy products are also a source of vitamin B12. For the same reasons that riboflavin deficiency is rampant, marginal and low vitamin B12 status has been found, based on low concentrations of vitamin B12 in the milk of Guatemalan women.[38]

The intake of iron is not low. Just from the daily ration of 580 g of tortillas, rural women can ingest 8.3 mg of the metal.[39] Iron is present in beans in amounts of 2 mg per 100 g of edible portion. Herbs also contain the mineral. The problem, however, is the low fraction of the iron consumed that is in the form of heme-iron from red meat. Moreover, the iron is consumed with high amounts of calcium, which inhibits absorption of both organic and inorganic iron. The tannins (polyphenols) in coffee, the phytic acid in corn and beans,[40] and the dietary fiber in coarse grains and legumes represent a 'cocktail' of inhibitors of iron bioavailability. Zinc status is compromised in Guatemalan children.[41,42] As with iron, its intake is not low,[39] with 10.7 mg of this nutrient consumed with the tortilla ration, but the same combination of adverse reactions in the diet, and the absence of zinc in flesh tissue, leads to its poor net absorption.[43]

Another liability is that of harmful exposures to infectious pathogens, organic toxins and toxic substances. A study performed at CeSSIAM on the microbiologic characteristics of street foods is illustrative.[44,45] We compared traditional dishes as prepared by street vendors, in low-income homes

and in five-star tourist hotels. Unacceptably high levels of coliform bacteria were cultured from all three sources, without distinction. The typical handling of the corn dough to make the tortilla is a peculiarity of Guatemalan cuisine that might favour fecal–oral transmission of gastrointestinal infections.

Lead glaze has been traditionally used in finishing the clay cooking pots and dishes made by the rural village artisans. Although modern materials of plastics and metals have replaced the heavy and breakable clay pots and bowls, lead is still used in traditional glazing processes. Excessive absorption of lead would be particularly devastating in populations in which there is coexisting iron deficiency, and the enhanced absorption potential for the iron drives hyperabsorption of lead by coadaptation.[46]

Chronic disease prevention by omission

Sodium intake is low in Guatemala because of a series of factors. A low intake of processed foods is one factor. Apparently, much of the added salt for discretionary use as table salt or cooking salt either falls off the item before reaching the mouth in the case of the former, or remains in the cooking juices in the case of the latter. This is the conclusion from a study conducted in a rural hamlet, in which lithium-labeled salt replaced the household supply over a 10-day observation period.[47] This study had a parallel component in Benin, and salt intake among adult women and young boys in Guatemala was half of that documented in West Africa. To the extent that salt-sensitivity is extant in Guatemala, the traditional diet presents little aggravant.

Red meat intake is low. In the Yepocapa area, not a single red meat source was consumed by more than 30% of children in a given fortnight period. In the rural adults of Santa Rosa Province, who were surveyed with an adapted, full-diet food-frequency instrument, the consumption of meat was classified in the times-per-year column, rather than on a daily, weekly or monthly basis.[29] As mentioned already, total fat intake is low. Food tables for the region do not list cholesterol content,[26] but conventional wisdom suggests its intake is minimal as well. For whatever the beneficial consequences of low fat exposure might be in the chronic disease prevention arena, the traditional rural Guatemalan fare is exemplary.

Chronic disease prevention by protective factors

The traditional Guatemalan fare is also favoured by an abundance of substances associated with a lower risk for the gamut of chronic diseases associated with aging. Beans are well recognized hypocholesterolemic agents, and they may also promote antiproliferative effects from hormonal regulation.[48] We can reiterate the high calcium intake from the lime-treated maize tradition. Osteoporosis, hypertension and colon cancer would be among the chronic infirmities mitigated by life-long, major calcium ingestion.

Still debated is the attributable benefit from dietary fiber *per se*, and among its various chemical components.[49] Dietary fiber components are abundant in the Guatemalan diet, beginning with black beans. The legumes are consumed with their skins. The corn for tortillas is lightly milled and retains fiber. Moreover, Malliard-reaction polymers are created on the grill while cooking tortillas, and these behave as fiber.[50] Estimates of total dietary fiber in Guatemalan diets, typical of those consumed in the Central American countryside (beans, tortillas, rice, sweet rolls, vegetables, cheese, eggs), but fed to North American volunteers on a metabolic ward, was 93 g, as analyzed for a 11.9 MJ fare.[51,52] For a composite of the fare consumed in a low-income peri-urban community of Guatemala City by women consuming an average of 8.7 MJ/day,[28] the amount of dietary fiber as analyzed was 27 g. This is a considerable rural-to-urban step down in fiber intake.

Of note, in the former study, Kretsch and co-workers praised the combination of effects of the Guatemalan composite diet in reducing intestinal transit time, increasing the frequency of evacuations, and reducing fecal bile acids and urobilinogen excretion,[52] all putative preventive measures for colon cancer. The consumption of oat bran did not mimic the effect.[52] The definitive and incontrovertible health benefits of a high fiber intake have not been totally resolved.[49] They may vary between populations due to ethnic make-up, exposures and other dietary characteristics.

A diet containing 70% of energy as maize (*Zea mays*) is unique in its capacity to deliver the oxy-carotenoid, zeaxanthin. This component has a specific affinity for the macula (fovea) of the retina. Macular degeneration associated with age (MDA) is a leading cause of visual impairment and blindness in older persons.[53] It is postulated that the greater the density of deposition of this pigment in the fovea, the greater the protection from MDA.[54] In a retrospective survey of consecutive diagnoses of this malady in the ‘Dr Rodolfo Robles V’ Eye and Ear Hospital in Guatemala City, not a single, surname of Mayan origin was recognized in the registry (M. Rodas, pers. comm., 1992), in spite of the fact that 40–50% of the clinic population may be of indigenous ethnic origin. This leads to a hypothesis that a more intense, life-long participation in maize consumption by native Guatemalans protects older individuals of Mayan descent from the development of macular degeneration.

Chronic disease liabilities

Gastric cancer is the ‘original’ cancer. Until the past century, the only site of cancer commonly reported was in the gastroesophageal area. Statistics show that stomach cancer is still the single leading cause of cancer mortality in Guatemala. Diet is intimately related to cancer at this location. Ingestion of carcinogens and formation of such agents is the conceptual framework. In terms of mycotoxins, ever a consideration in a tropical developing nation that stores its grain as seeds rather than as milled flour, contamination with aflatoxin[55] has been recognized and quantified in Guatemala for decades. Fumonisins are mycotoxins from *Fusarium moniliforme*. Meredith *et al.* have recently shown that the toxins derived from that fungus with a predilection for maize are pervasive.[56]

Osteoarthritis, especially of the joints of the lower extremities, seems to be a problem based on functional complaints and the fact that walking a given distance is the only limitation of Activities of Daily Living reported as deficient in free-living Guatemalan elderly.[33] Interestingly, the epidemiologist, Dr Toni Miles, has postulated that conditions that prevent osteoporosis are the same factors that promote degenerative joint disease (T. Miles, pers. comm., 1989). The life-long, heavy weight bearing of carrying loads balanced on

heads, or suspended to head-straps could add stress to the joints of the hips and knees.

Cataracts are also common and of early occurrence in the Guatemalan highlands.[57] The high altitude (highland) dwelling of most of the population, combined with outdoor agricultural pursuits is a recipe for high ultraviolet (UV) exposure of the crystalline lens. Interestingly, we found that older women had greater opacification of the lens than men in the same village.[58] The lack of a sun-visor brim on the headdresses of indigenous women and their exposure to sunlight reflected off the pools of water used to hand wash clothes probably contribute to their differential sensitivity.

What is in the offing to determine whether obesity will reach epidemic proportions in the predominantly indigenous population of Guatemala, as lifestyles become more sedentary, has yet to be investigated. Other Indian populations have been among those at the greatest risk of major obesity, and its consequences, in the Americas. To the extent that short stature is a cofactor in the predisposition to obesity,[59] Guatemala is a particularly vulnerable setting.

Food technology in the Mayan legacy

The emphasis on time savings has spawned industrialized products to provide the traditional corn and bean diet in more ready-to-serve formats. At least three canning companies present refried black beans in canned forms, and several 'tortilla flours' of lime-treated milled corn are in stores. For the low-income population, however, the higher cost does not compensate for the savings in time and labor, and the traditional sources persist.

An interesting offspring of the Mayan diet, however, might be seen in the history of the industrialized product, INCAPARINA**,** which dates to the 1950s when the food technology division of INCAP in Guatemala, under Dr Ricardo Bressani, initiated a series of sequential attempts to formulate a plant-based mixture that would serve both in the treatment and prevention of protein-energy malnutrition.[60] It was the ninth formula (INCAP Vegetable Mixture 9) that became the commercialized product after extensive testing in food technology, animal models and human metabolic and community trials.[61–63] The original formulation had 58 g ground cooked whole corn, 38 g cottonseed flour, 3 g of torula yeast, 1 g of calcium carbonate per 100 g of product, and 4500 IU of vitamin A were added. Its current ingredients are shown in Table 3. It still contains cottonseed meal, but in balanced proportions with soy flour, which is a more costly ingredient. Lysine has been added, and the array of added micronutrients has been expanded enormously, most recently to include zinc as zinc oxide.

The irony of this development is its basis in maize, as the original description of kwashiorkor by Cecily Williams in Ghana (formerly the Gold Coast) was entitled, 'A nutritional disease of childhood associated with a maize diet'.[64] However, by using the principle of complementation of vegetable proteins of grains and legumes, it consisted of a *high quality* plant-origin protein source.

Another lesson can be learned from this process, as food sciences catch up with — and pass by — contemporary practices. In the late 1970s, the formulation of INCAPARINA contained cottonseed meal as one of its ingredients.[65] Cottonseed is a source of gossypol. The animal research conducted over the period of developing INCAPARINA reflects, in retrospect, some concern over the safety of this compound.[65,66] Gossypol has been used in modern Chinese medicine as a male antifertility drug, and this came to light in the Western press in the late 1970s, juxtaposed with INCAPARINA's use. Gossypol's medicinal (anticonceptive) dosage is far greater than the adventitial content in INCAPARINA (and the effect of its chronic consumption from using cottonseed concentrate was never defined), but the historical context is illustrative. This was just following the Vietnam War. An armed insurgency had been raging, replicating the cold war's confrontation. In a Latin country, the fact that this compound acted on male fertility clashed with the machismo mystique of the region, which reaches beyond politics. But, above all, INCAPARINA was a product for children, and the issue was that of (involuntary) fertility control. 'Was there a conspiracy to commit genocide?' became the most radical framing of the question. Were forces working through industrial elites trying to reduce the fecundity of the poorer classes? The genie never got out of the bottle. Denials were made that the exposure to gossypol could influence fertility.

The issue of the cottonseed component played itself out largely in editorials and letters to the editor. The exact impact on sales, if any, of the gossypol controversy is not known. The cotton industry on the Guatemalan Pacific coast had risen in the previous decade, but was already fading due to its low profitability and the environmental contamination that the pesticides used in its production were causing in the coastal waterways. As rapidly as possible, the cottonseed meal contribution was reduced by half, but *not* removed from

Table 3. Ingredients of contemporary commercial incaparina in the Guatemalan diet

Listed ingredients of package labelling		
Maize flour		
Cottonseed flour		
Soy flour		
Lysine		
Calcium carbonate		
Ferrous fumarate		
Zinc oxide		
Riboflavin		
Vitamin B12		
Thiamine mononitrate		
Folic acid		
Butylated hydroxy anisole		
Nutritional information		
Serving size = 18.75 g		
Energy = 70 kcal		
% Daily allowance		
Fat	< 1 g	0%
Saturated fat	0 g	0%
Cholesterol	0 g	0%
Sodium	0 mg	0%
Total carbohydrates	12 g	4%
Dietary fiber	4 g	19%
Sugars	0 g	–
Protein	4 g	–
Lysine	65 mg	–
> 20% of allowance for Vitamin A, niacin, riboflavin, folic acid, thiamine, vitamin B12, iron, zinc.		

the formulation altogether. What is certain is that the principle of nutritious all-vegetable mixtures continued on the food technology agenda at INCAP with the final publication in the series coming in 1967, regarding mixture number 15.[67] By then, more expensive soy proteins were being explored on the legume side, and they were not economically practical in the realities of poor Central Americans.

More recently, a similar issue with INCAPARINA came to light in the international press. With the now estimated one million Guatemalans resident in the United States (and as a testimony to the persistence of food habits), a great demand for INCAPARINA has arisen in the cities of concentration in Chicago and Los Angeles. Relatives are asked to bring bags of the protein mixture when they visit. As the press articles reported, officials of the Animal and Plant Health Inspection Service of the United States Department of Agriculture confiscated consignments of INCAPARINA, which were then analyzed chemically and microbiologically. The aflatoxin levels exceeded the United States safety standards. This prompted child welfare workers in Chicago, as I remember, to raise concerns about the safety of the Central American children from consuming this 'unsafe' product.

Improvement of the nutritional quality of plant-based diets in developing countries

The detrimental effects from an animal-rich diet are well documented in the war on chronic disease.[68] These include: (i) the initiation and promotion of illnesses by consuming foods of animal origin; and (ii) reduced prevention of these maladies by the absence of phytochemical exposures. The common denominator of these two effects points to a largely plant-based diet. The story of the Mayan food legacy in Guatemala illustrates that there are 'cons' to match the 'pros' in traditional plant-based diets. This is common to all cuisines in all climes in the tropical latitudes, and in the emerging temperate nations such as China. A recent report by Guo *et al.* shows just how rapidly the loss of traditional eating patterns can proceed.[69] They analyzed three successive surveys of a multistage cohort of Chinese households in eight diverse provinces. Over a 4-year period, the consumption of grains, especially coarse grains such as maize, sorghum, millet and potatoes, were decreased from 40 to 80 g per day. For the highest income group, meat intake increased by 26 g per capita per day. Fat intake, particularly that of lard, butter and high-fat red meats, as well as edible vegetable oils, increased. Almost 60% of the participants consumed > 30% of their energy as fat by 1993. If we project the adverse health consequences of this change to the aging citizens of this billion-plus population, the urgency of addressing the unhealthy aspects of not continuing with the traditional rural practices becomes immediately evident, and menacing.

The physical bulk of edible plants is a consideration for improving the nutritional status and work efficiency of developing countries that adhere to their original culinary outlines. The fact that carnivores hunt once every day or two, whereas herbivores spend all of their waking time grazing is related to the energy density of the respective foods. One has to consume a huge bulk and volume of edible plants, with their high water and non-fermentable fiber content, to obtain the same energy as contained in a small chunk of animal carcass. Farming and housekeeping in rural peasant conditions requires high energy outputs. In fact, a 'grazing' behavior is probably the norm for the farm family who tend to have snacks to supplement their three principal meals. Moreover, before the total encroachment of farming land on wilderness and before the advent of refrigeration and high-speed transportation, the rural population had a greater access to animal tissue than did the urban poor, because they could supplement their crops with the products of hunting and fishing and could eat (rather than sell) the meat and eggs from their domestic livestock.

To the extent that multiple micronutrient deficiencies arise because of the low nutrient density in edible plants or low bioavailability or restricted ability to utilize nutrients from a plant matrix, measures to increase the intake or uptake are required. The mechanism for combating micronutrient malnutrition is enriching the plant-based diet of a nation through biotechnology, plant-genetics, fertilization, fortification and supplementation in appropriate combinations.[4]

However, given the dichotomization of species interest and individual interest, as introduced earlier, there is a certain validity and legitimacy to notions of micronutrient deficiencies constituting part of the adaption of a tribe to an ecological niche. The most radical form of this argument revolves around the hypothyroidism induced by endemic iodine deficiency.[70,71] The decreased fertility and low energy expenditure of iodine deficiency disorder have been advanced as an adaptation in rain forest regions of Africa for the slow progression of pressure on the environment. Similarly, in regions in which intracellular pathogens are endemic, relative iron deficiency provides relative protection against infection or activation.[72,73] The 'small is healthy' school[74] sees reduced body size, which is mediated by nutrient limitation as part of an adaptation to food insecurity and adverse environmental circumstances. This author has speculated that zinc deficiency might serve an adaptive role, specifically being the mediator of slower growth when environmental adversity requires this adaptation for group survival.[75] With the rise of the world's pandemic of HIV infection, which is disproportionate in developing countries, the issue of moderation in zinc consumption has been raised by the longitudinal observations in a cohort of gay men in the Washington–Baltimore region of the United States in the early days of the epidemic. Those with higher intakes of dietary zinc — and especially those who used zinc supplements — were those who most rapidly progressed to full-blown AIDS[76] and to death from the disease.[77]

The bulkiness of cereals and legumes has been signaled as a particular problem for the period of complementary feeding when the infant moves from exclusive breast-feeding to an exclusive dependency on family foods. Brown *et al.* have analyzed the problem of the viscosity for complementary feeding in the following manner, and recommended broad outlines in their recent WHO–UNICEF monograph:

> …the relatively high concentrations of starch-containing staple foods that are often needed to achieve adequate energy density of porridges may result in final preparations that are too thick, or viscous, for young children to consume in a reasonably short period of time. To reduce the viscosity of these porridges, the amylose and amylopectin fractions of starch must be partially broken down so that they will swell less during

> cooking and thereby retain less water. The most effective method for partial digestion of these starch fractions is by addition of exogenous amylase, which can be obtained by germination of cereal or legume seeds or produced microbiologically.[78]

Concerns about glycemic index in plant-based diets are interesting. In 1981, Jenkins *et al.* introduced a concept of the 'glycemic index' of foods and diet related to the rise in glucose and the insulin response they provoked.[79] This metabolic test has taken on epidemiological contexts in recent years. Brand-Miller suggested that 10 of 11 studies reviewed provided evidence for improved clinical diabetes management using low glycemic index regimens.[80] In terms of the traditional grain diets of developing nations, more coarse grains, including maize, have lower glycemic indices, whereas white rice and potatoes produce major stimulation. Plantain, a standard of tropical diets, has an exceptionally low glycemic index.[81] Contrasting views of the promise of glycemic indices to explain disease occurrence vary from high[82] to modest.[83]

Post-harvest loss and damage adds to the inefficiency of food-systems in plant-based cultures. Consumption by insects and vermin and spoilage are aspects of this process. Fungal overgrowth on stored grains has a potential impact on chronic disease. Aflatoxin has long been associated as a cofactor in hepatic cancer.[84] The mycotoxins from *Fusarium moniliforme* are a more recent concern.[85]

Cooking practices that involve charring of the food over an open flame have been considered to be a concern for gastrointestinal carcinogens.[86] As noted earlier, the health relevance of burnt plant tissue for human carcinogenesis requires greater understanding. Alternative forms of preparing traditional dishes involving less carbonization of the food might need to be devised.

Finally, the microbiological quality of foods prepared in developing countries is an issue. Absence of clean potable water and lack of refrigeration are two intrinsic factors that place developing countries at a disadvantage to their counterparts in the industrialized world. In advance of the infrastructural development that would place piped water into every home spigot and electrical current into every domicile's wall, hygienic education may palliate the situations of risk of infection or intoxication from the foods one eats in the tropics.

The forces *against* the maintenance of the traditional cuisine in developing countries are urbanization, globalization of trade, crop cultivation policies, and environmental and pollution risks from traditional practices. Working for a status quo acts to lock in the disadvantageous aspects of micronutrient deficiencies, microbiological and toxicological safety and selective chronic disease promoters that are currently at play. However, on balance, retarding the movement to less traditional diets while modifying the particular adverse consequences is the challenge for public health nutrition in developing countries. The linking of 'modern' and modernity with traditional foods, as explicit in this Symposium, will go a long way to giving impetus and legitimacy to this effort. 'Why become like them, if we are already ahead of them!' could be the motto for the dietary conservationists' campaign in developing societies.

Restoration of plant-based diets in industrialized countries

There are compelling practical and intellectual reasons for populations in developing countries to maintain a low animal-product diet for both the health benefits that might accrue and the environmental problems that can be avoided. Despite advances in life-expectancy in developing countries, it is still the industrialized countries in which the rates of prevalence of chronic diseases are highest. Obesity is a worldwide epidemic.[87] A recent United Nations report found an equal number of the world's population to have undernutrition and overnutrition in terms of anthropometric classification. It is the developed countries that contribute disproportionately to obesity. Sedentarism is a way of life for the urban middle and upper classes, which benefit from the technological advances in robotics and informatics and work before their computer screens.

Not only does under-expenditure of energy but also overconsumption of calories contribute to the obesity epidemic. What are the factors that promote the consumption of diets rich in fat and in animal-based foods? Hedonic preferences are often cited.[88] Sweet tastes and the flavor of fat are much more appealing to the palate. The prestige factor of animal foods dates back centuries. Why was Sherwood Forest a game preserve of the nobles from which the serfs were excluded from hunting? Hedonism aside, there are political reasons why the notion of 'peasant fare' would be appealing or distasteful. Anderson and Lean, nutrition professionals, comment on the evolution of dietary intake in Scotland:

> Until the nineteenth century the 'traditional' Scottish fare of oats, barley, kail, milk and locally grown produce was the stuff of legends, nurturing a nation of giants wielding claymores and tossing cabers. It has become a long-forgotten menu, superseded, in the course of the past century as shipping and trade boomed, by an abundance of imported wheat for white bread, syrup, treacle and jam from the colonies, and a surfeit of meat from more recent alterations in farming practices.[89]

It is no coincidence that the term 'peasant' in contemporary English usage has become a synonym for 'pauper.' Thorsten Veblen, the Norwegian political economist, applied the term 'conspicuous consumption' to consumer behavior. One way that an elite can differentiate themselves from the lower classes is to indulge themselves in items considered to be of a luxury nature. For those of lesser economic means to avoid the social brand of poverty is to aspire to identify with luxury items above their means. This places a social premium on consumption of sweets and meats beyond the hedonic issues. In addition to these historic sociologic issues, the same constellation of urbanization, globalization of trade, crop cultivation policies and environmental pollution risks, which were discussed earlier, are even more entrenched factors in developed countries.

The first response of humankind in the face of incontrovertible evidence of harm from a hedonic practice is to continue the practice but to find an antidote. This was the situation with tobacco smoking and the efforts to nullify the carcinogenic consequences with beta-carotene. The folly of that approach has recently been recounted by Cooper *et al.*[90] Nevertheless, a similar initial response may be at play across the range of health-seeking behaviors. We want to have our cake and eat it too by taking something *else* (additional) that

will nullify the consequence of what is already producing damage. This explains, in part, the rise in the consumption of dietary supplements as combinations of isolated vitamins and phytochemicals, and herbal and botanical concoctions. The optimistic interpretation of this behavior is that a recognition of the harmful potential of current Western diets has penetrated the consumers. However, they seem willing to wager that continuing their exposure to the 'poison' (the noxious elements in the diet), can be counteracted by self-supplementation with isolated chemicals as the 'antidote'. Borchers *et al.*[91] have made some important observations in this respect:

> It should by now be clear that isolated chemical constituents of plant extracts seldom have the same effect as the complex mixture of bioactive molecules present in whole plant (or plant part) extracts.[91]

Not enough evidence is available on the validity of this approach, but it is my suspicion that it will be no better than that for controlling the negative consequences of the offending diets than were carotenoids for tobacco. At that point, a more comprehensive and integral solution of adopting the *whole* regimen may become the beacon.

The issues of availability, accessibility, dietary habits and preferences interact and intertwine in the goal of consuming a low chronic-disease risk and nutritious diet. We have found it useful to conceive the concept of integral and discrete cuisines as an approach to merging the traditions of developing countries to the health benefits of the developed countries. In fact, CeSSIAM is currently involved in a four-nation, multicentric study entitled 'Concordance with the Provisions of the WCRF/AICR Guidelines on Prevention of Cancer in Northern Europe and MesoAmerica: Comparative Insight for Cancer Risk and its Reduction', involving Scotland, the Netherlands, Mexico and Guatemala, and sponsored by the World Cancer Research Fund (WCRF) of London. The central notion is to compare and contrast the concordance of free-living populations with a set of 14 guidelines laid out in the WCRF publication, *Food, Nutrition and Prevention of Cancer: A Global Perspective*[92] (Table 4). The expressed hypotheses are: (i) that the rural populations will have a consumption pattern more concordant with the plant-based principles of the guidelines; and (ii) that the general fare of the developing countries (Mexico, Guatemala) will be more concordant than that of the developed country sites (UK, Netherlands). Preliminary work with food-frequency data from a rural Guatemalan setting suggests that these hypotheses will be confirmed.[29] Using the results of 269 adults in the Santa Rosa Province, we found that some of the provisions of the WCRF Guidelines could not be assessed. Among those that were assessable, compliance with the provisions of consuming high amounts of carbohydrate and low quantities of fat, red meat and ethanol were fulfilled in most of the population. The diet was largely plant based. When the *Dietary Guidelines for Americans* for the 1995–2000 period[93] were applied to the Guatemalan diets, we found favorable patterns of consumption from the grain, vegetable and fruit group. Red meat consumption was within the recommended limits, but milk-group intakes were low.[30] The Guatemalans were a bit immoderate in their use of sugar, but alcohol consumption was low. More importantly, for developed country strategies, the menus defined in the Yucatan and Guatemalan highlands might contribute specific guidance for the preparation of meals consonant with the principles of cancer avoidance.

There is some promising indication that the notion of embracing exotic cuisines might be viable. Relating to my past Australian experience, I have visited the Sunday brunches in international tourist hotels in Melbourne, in which the Sunday buffet brunch fare includes a selection of the delicacies of the Aboriginal diet. It offers witchetty grubs and a selection of cuts of marsupials along with desert roots and plants. One can go out and 'eat Aboriginal'. Similarly, in the diversity of that cosmopolitan city, there are restaurants with the traditional cuisine of Thailand, Korea, Japan, all regions of China, Greece, Serbia and Croatia among others. For hedonic reasons, however, an emphasis on the meat and animal products of the regions is featured on the menus. Nevertheless, the option to 'eat Chinese', 'eat Korean' and 'eat Serbian', etc., is available. However, the habitual fare of the typical Anglo-Celtic Melburnian appears to be rich in the fried foods of pub fare and the steak and kidney pie, vestiges of the foodways of the seat of the Commonwealth. In an incremental way, it would be preferable for the average Australian to have a constant fare of any of the Asian or Balkan cuisines than the one they are currently choosing.

Table 4. Recommendations for cancer prevention from the World Cancer Research Foundation's guidelines

1. Populations to consume nutritionally adequate and varied diets, based primarily on foods of plant origin.
2. Population average body mass indices (BMI) throughout adult life to be within the range BMI 21–23, in order that individual BMI be maintained between 18.5 and 25.
3. Populations to maintain, throughout life, an active lifestyle equivalent to a physical activity level (PAL) of at least 1.75, with opportunities for vigorous physical activity.
4. Promote year-round consumption of a variety of vegetables and fruits, providing 7% or more of total energy.
5. A variety of starchy or protein-rich foods of plant origin, preferably minimally processed, to provide 45–60% total energy. Refined sugar to provide less than 10% total energy.
6. Consumption of alcohol is not recommended. Excessive consumption of alcohol to be discouraged. For those who drink alcohol, restrict it to less than 5% total energy for men and less than 2.5% total energy for women.
7. If eaten at all, red meat is to provide less than 10% of total energy.
8. Total fats and oils to provide 15% to no more than 30% total energy.
9. Salt from all sources should amount to less than 6 g/day for adults.
10. Store perishable foods in ways that minimize fungal contamination.
11. Perishable food, if not consumed promptly, is to be kept frozen or chilled.
12. Establish and monitor the enforcement of safety limits for food additives, pesticides and their residues, and other chemical contaminants in the food supply
13. When meat and fish are eaten, encourage relatively low-temperature cooking. Do not eat charred food.
14. Community dietary patterns to be consistent with reduction of cancer risk without the use of dietary supplements.

Even when the tasty, congruent plant-based cuisines that reflect the best current evidence on disease prevention are identified, catalogued and placed into recipe books, there still remain a series of barriers to their adoption in industrialized populations. Firstly, the ingredients may be unavailable (or if available, they may be prohibitively expensive and hence unaccessible). Moreover, the use of the ingredients and the nature of the recipes may be unfamiliar to food preparers. Finally, there may be antinutritional chemicals, toxicants or contaminants in these foods that traditional preparation practices have overcome in the course of cultural evolution. These practices must be carried over as the dishes are prepared for 'Western' tables.

If one accepts this premise, then the task of motivators and educators would be to introduce the firm practice of selecting integral cuisines of developing countries. That of food technologists and commercial food companies is to prepare and package the ingredients and preprepared dishes in attractive and economical forms. That of nutritionists and food scientists would be to resolve the aforementioned barriers and address two additional detractors: (i) gastric cancer carcinogenicity; and (ii) low nutrient density and bioavailability. These latter two endeavors are reminiscent of what must also be done in those nations from which the diets are indigenous. I would conjecture that squeezing the time out of current lifestyle schedules to prepare these meals in the home would be an impossible barrier. Free time might be better spent in vigorous and conditioning exercises in one's own home gym or swimming pool to create the demand for energy than in the kitchenette preparing the exotic recipes from equally exotic ingredients. Hence, as anathema to traditional 'dining-room table' family values as it might appear, it will be in restaurants away from home, in catered ready-to-eat foods ordered at home, or in processed foods popped into the microwave ovens at home that will allow the cultural transfer to become a reality in industrialized societies. The restaurant industry and prepared foods industry would be the engines for the availability of the *nouveau* 'concordant' cuisine to the population. Table 5 projects a futuristic weekday menu for principal meals that incorporates the concept of plant-based cuisine borrowed from other cultures.

Summary and future projections

Nothing is inevitable but death and taxes. The cause of death has changed with demographic and epidemiologic transitions. It is no longer primarily decease from an acute cause at an early age, but death from (and with) chronic illnesses in middle and late life. This pattern robs the individuals of independence, function and happiness, and the society of resources spent on health care. The demographics of today are unprecedented in history; never have so many lived to be so mature. Dietary practices are one armament that can possibly be rallied to the quest for longer health during this longer life.

We are fortunate to have such detailed understanding of the traditional diet of MesoAmerica, based on the cultural and culinary evolution of the Mayan civilization. Its basic constitution is one with a low potential to promote — and a high propensity to prevent — the evolution of chronic diseases. It has certain liabilities in terms of the density, bioavailability or both of micronutrients, of environmental hazards in its traditional cropping and preparation, and in exposure to microbiological and toxic hazards associated with the foods as stored and prepared. To preserve and extend its preservation, attention to redressing these disadvantages is paramount.

Three hypotheses about the rate of social, economic and technologic change affecting diets and lifestyle in a country such as Guatemala from 2001 to 2100 are illustrated in Table 6. In many ways, this framework for speculation revolves around the likelihoods of *con*vergence or *di*vergence of food systems and foodways in the future. The first postulation is derived from 'the rich get richer and the poor get poorer' scenario. The second postulation admits to some progress — and rapid change — in the developing nations, but insufficient to catch up with that in the traditionally more affluent regions. The final, and most interesting projection, is a total convergence of conditions across the globe by the end of the present century. Globalization could drive this eventuality. One formulation of this is that 'the rich get richer, and the poor get *much* richer' than they are today. This is the optimistic future scenario. Given the pressure on resources and damage to the environment of a universally *high* standard of consumption, the leveling of all nations may result in some averaging of the *present* status. This would mean that 'the rich get poorer and the poor get richer.'

We can finally revisit the original concepts of this review, which dealt with what favors the survival of species, what favors the well-being of each individual, and the impacts of evolutionary biology and the role of technology. Viewed through a prism aimed at the future, the issues of the origins of human dietaries seem even more academic. Natural selection for the fittest has ceded its way to the management of resources. If the compression of morbidity is indeed the standard for life-long health for each individual, the adoption of lifestyle practices and dietary habits most favorable to avoid-

Table 5. Future household menu

Monday: Indonesian Victuals
Tuesday: Vietnamese Cuisine
Wednesday: MesoAmerican Night
Thursday: Tanzanian Fare
Friday: Moroccan Lite

Table 6. Alternative propositions regarding future trends in the socioeconomic–dietary gap between developing and developed societies

1. That conditions will remain virtually unchanged for yet another century. Consequence: The Guatemalan populations will live in 2099 virtually as they had in 1999, which is similar to where they were in 1899.
2. That development will occur at the rate that it occurred in industrialized and affluent countries during the 20th century. Consequence: The population in Guatemala in 2099 will live as the population of the United States or Australia lived in 1999.
3. That development will occur such that conditions will converge between the developing and developed world. Consequence: The population of Guatemala, the United States and Australia will have the same lifestyle and life-pattern in 2099.

ing chronic disease and functional incapacity with age is a requisite. Plant-based diets, based on traditional practices among rural agricultural societies, but tailored to eliminate their nutritional, microbiological and toxicological liabilities and channeled through industrial processing, seems to be the composite scenario to which the forces point. The principles are the same for populations of what are currently industrialized and emerging societies. The developing countries have a head start, to the extent that they have not lost touch with their traditional rural cuisine. The developed nations have the advantages of being able to mobilize advanced food science and technology to resolve the liabilities of plant-based regimens. The required effort would seem to be to harness dietary practices towards the compression of morbidity[8] so that we can all terminate our lifespans with a healthy, functional and productive life career, followed by a demise from an acute process. For countries such as New Zealand and Australia, motivation and education leading to changes in behavior will be the key.

In an increasing globalized world, all nations are in a syncytial pool and likely to sink or swim together. Getting to know (and share) one another's relative selective advantages — the food heritages of the South and the science and technology of the North — should become the mandate of the community that has come together in a meeting that has had 'traditional' and 'science' in its theme title. However, the bridging of insights about dietary habits practised in developing countries and the principles of edible plants in human dietaries is not exact engineering. The sage words of Dr Betty Jane Burri writing in the journal, *Nutrition*, provide a fitting closure to this essay.

> The typical well-nourished vegetarian appears to have two nutritional advantages over comparable omnivores: lower fat and cholesterol intakes, and higher antioxidant nutrient intakes…[P]eople worldwide are vegetarian or semivegetarian through poverty, and not by choice. Do vegetarian diets derived from poverty and lack of food-choices compare favourably to omnivorous diets under similar structures? Alternatively, will the vegetarian's advantage in antioxidant status disappear when populations with less income, leisure, and education are studied? Only more and different studies will answer these important questions. It is to be hoped that these studies will be done.[94]

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