Preventing the Epidemic of Non-Communicable Diseases: An Overview

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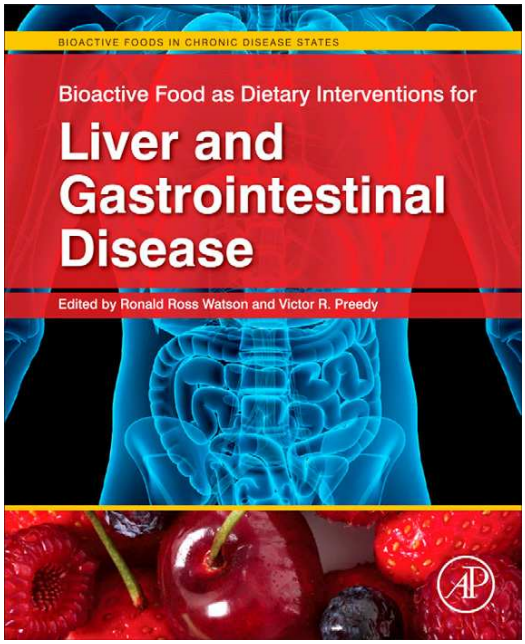

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CHAPTER 25

Preventing the Epidemic of Non-Communicable Diseases: An Overview

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ABBREVIATIONS

AA Arachidonic acid
ALA Alpha-linolenic acid
DHA Docosahexaenoic acid
EPA Eicosapentaenoic acid

1. INTRODUCTION TO THE WORLD'S BIGGEST PROBLEM

In the twentieth century, science and technology brought about phenomenal change. Huge advances were made in all branches of medicine, diagnostics, drugs and drug delivery, gene therapies, etc. Yet, now in the twenty-first century, there is a global epidemic of non-communicable diseases (Robson, 2009). Leading scientist Professor Steve Jones said the hope that genetic research could provide a cure for a host of common diseases (genetic disorders are rare) has proved to be a false dawn and that we have wandered into a blind alley and it might be better that we come out of it and start again. In most cases, hundreds of genes are responsible, and often they have less effect than other factors such as diet, lifestyle, and the environment (Jones, 2009). The gene code for the coagulation factors in humans is much the same as it is for the puffer fish, *Fugu rubripes*, whose genome dates back 450 million years (Jiang and Doolittle, 2003). The rise in death from heart disease – coagulation of the blood – was not caused by the unchanged genes but by a bad diet operating on ancient genes (Edward G. D. Tuddenham, Professor of Haemophilia at University College London, personal communication). The view of diet being a major driver of health and disease dates back to Sir Robert McCarrison's studies in India early last century. This overview highlights the major changes to the modern human diet that are urgently needed in order to promote health and help prevent the global epidemic of non-communicable diseases.

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2. HUMAN DIET

Agriculture introduced foods as staples for which the human genome had little evolutionary experience. More importantly, food processing procedures were developed, particularly following the Industrial Revolution, which allowed for quantitative and qualitative food and nutrient combinations that had not previously been encountered over the course of human evolution. Cooking oils, cereals, dairy products, refined sugars, fatty meats, alcohol, NaCl salt, and combinations of these foods fundamentally altered several key nutritional characteristics of ancestral human diets and ultimately had far-reaching effects on health and well-being. As these foods gradually displaced the minimally processed, but often cooked, wild foods in human diets, they adversely affected the following dietary indicators: (1) fatty acid composition, (2) energy density, (3) macronutrient composition, (4) micronutrient density, (5) acid–base balance, (6) sodium (as NaCl)–potassium ratio, and (7) fiber content (Cordain et al., 2005; Robson, 2009). Wild foods known to be consumed by hunter–gatherers have higher nutrient concentrations than their domesticated counterparts (Brand-Miller and Holt, 1998; Eaton and Konner, 1985), including the muscle meat of wild animals (First Data Bank, 2000). Humans may have started consuming cereal grains (e.g., wheat, rice, and maize) tens of thousands or more years ago, but the human immune, digestive, and endocrine systems have not yet fully adapted to cereals, which provide 56% of humanity's food energy and 50% of its protein (Cordain, 1999). Cereal grains are truly humanity's double-edged sword (Cordain, 1999). For without them, our species would likely have never evolved the complex cultural and technological innovations which allowed our departure from the hunter–gatherer niche. However, because of the dissonance between human evolutionary nutritional requirements and the nutrient content of these domesticated grasses, many of the world's people suffer disease and dysfunction directly attributable to the consumption of cereals (Cordain, 1999).

3. EPIDEMIC OF NON-COMMUNICABLE DISEASES

Diet, lifestyle and environment do not just affect a person's health, they also determine the health of their children and possibly the health of their grandchildren (Marsh, 2012; Pembrey et al., 2006). Fifty seven million deaths occurred globally in 2008, of those deaths, 36 million – almost two thirds – were caused by non-communicable diseases. Non-communicable diseases are caused, to a large extent, by an unhealthy diet, insufficient physical activity, and drug (e.g., tobacco and alcohol) abuse (World Health Organization, 2011a). Non-communicable diseases are a substantial economic burden today and are predicted to cost the world economy in the region of US $47 trillion over the next 20 years, pushing millions of people below the poverty line (Bloom et al., 2011). Non-communicable inflammatory diseases, for example, cardiovascular diseases and

non-communicable mental ill health (Robson 2013b) are global epidemics and when combined, they typically afflict 50–65% of the population in modern societies. Cardiovascular diseases are the number one cause of death globally (17.3 million people died from cardiovascular diseases in 2008, representing 30% of all deaths), and it is projected that by 2030, almost 23.6 million people per year will die from cardiovascular diseases, mainly from heart disease and stroke (World Health Organization, 2011b). As predicted in 1972 (Crawford and Crawford, 1972), brain disorders have followed the rise in cardiovascular disease, and the cost of brain disorders has now overtaken those of any other health burden (Crawford et al., 2009; Robson, 2013b; Wang et al., 2010). The reason for linking heart disease and brain disorders is that during early development, the brain relies heavily on a pre-existing and efficient placental vascular and fetal cardiovascular system. The fetal brain uses 70% of the energy transferred to the fetus from the placenta. The placenta itself is a rapidly growing vascular system which needs to be in place ahead of the fetal brain growth spurt of the last trimester. Hence, healthy brain development is very much dependent on a good cardiovascular circulation. Put simply, if the cardiovascular system is under attack in an adult from poor nutrition, the brain in the next generation(s) is likely to suffer (Crawford et al., 2009; cf. Marsh, 2012; Pembrey et al., 2006). The top predicted causes of death and disability worldwide for 2020 (ischemic heart disease and unipolar major depression) and the top three causes in developed regions (ischemic heart disease, cerebrovascular disease, and unipolar major depression) (Murray and Lopez, 1997) have common denominators in adverse nutrition and are related and relevant to both neurogenesis and neurodegeneration (Crawford et al., 2009).

Cancer is a leading cause of death worldwide and accounted for 7.6 million deaths (around 13% of all deaths) in 2008, and deaths attributable to cancer are projected to continue rising (World Health Organization, 2012a). An estimated one-third of all cancer deaths are because of nutritional and lifestyle factors (Danaei et al., 2005). Diet-induced inflammation leads to insulin resistance and type 2 diabetes (Solinas et al., 2007), and taking into account deaths in which diabetes was a contributory condition (heart disease or kidney failure), approximately 2.9 million deaths in 2005 were attributable to diabetes (World Health Organization, 2008). Type 2 diabetes is rapidly becoming a disease of children and adolescents. In 2000, it was estimated that 30% of boys and 40% of girls born in the United States were at risk of being diagnosed with type 2 diabetes at some point in their lives (Institute of Medicine, 2005b). Globally, in 2010, more than 40 million children under the age of 5 years were overweight; in 2008 more than 1.4 billion adults, age 20 years and older, were overweight and of these over 200 million men and nearly 300 million women were obese (World Health Organization, 2012b). In 2006 (World Health Organization, 2006), the World Health Organization estimated that by 2015, approximately 2.3 billion adults would be overweight and more than 700 million would be obese (Figure 25.1) – these

Figure 25.1 An obese person eating high-energy-dense processed food. It is an inescapable fact that consuming more calories than is needed results in weight gain, even if there is genetic variation between one person and the next (Anthony A. Robson ©).

statistics may be underestimated (see obesity statistics above). Once considered a problem only in high-income countries (World Bank classification: http://data.worldbank.org/about/country-classifications), the prevalence of overweight and obese people is now dramatically on the rise in low- and middle-income countries, particularly in urban settings where exercise is optional and high-energy-dense (>2 kcal g^{-1} – Ledikwe et al., 2006) fast food is now plentiful (Figure 25.2). Yet, inflammatory diseases and brain disorders are rare or nonexistent in hunter–gatherers eating a late Paleolithic diet, that is, a low-energy-dense diet with a wild plant-to-animal energy intake ratio ~1:1, with fish and shellfish providing a significant proportion of the animal component (see Eaton et al., 2010).

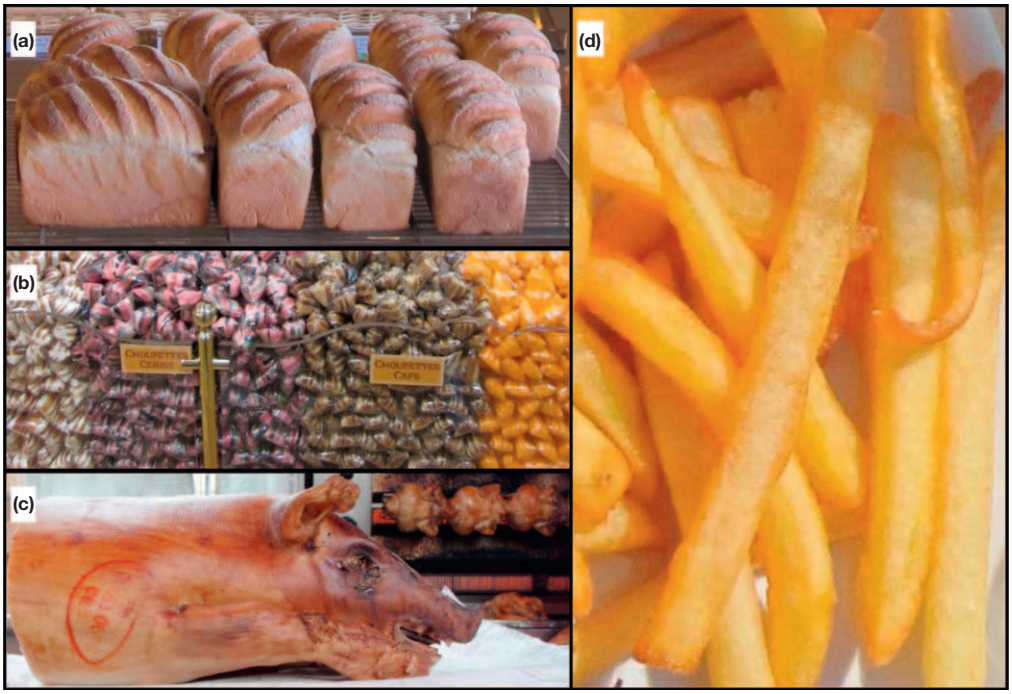

Figure 25.2 Examples of widely consumed modern foods with both a high-energy-density and a low-nutrient-density: (a) bread, (b) boiled sweets, (c) domesticated pig and chicken intensively reared on an unnatural diet that is both high-energy-dense and a low-nutrient-dense, and (d) French fries (Anthony A. Robson ©).

4. INFLAMMATION

Uncontrolled excessive production of proinflammatory mediators over prolonged periods of time is associated with heart attacks, thrombotic stroke, arrhythmia, arthritis, asthma, headaches, dysmenorrhea (menstrual cramps), inflammation, cancer, and osteoporosis (Samuelsson, 1979). The cardioprotective effects of anti-inflammatory DHA and EPA have been recognized for over 50 years, with the low incidence of mortality from cardiovascular disease in Eskimos consuming a diet rich in DHA and EPA (e.g., Makhoul et al., 2010; Sinclair, 1956). Inflammatory diseases all seem linked to a lack of anti-inflammatory agents in the diet and excess food energy (the positive imbalance between energy intake and energy expenditure). The close interaction between ω-3 (including DHA and EPA) and ω-6 fatty acids (including gamma-linolenic acid (18:3, n-6), dihomo-gamma-linolenic acid (20:3, n-6), and AA (20:4, n-6)) on the ability to modify inflammatory markers, production of prostacyclin, prostaglandin E_1, prostaglandin I_3, lipoxins, resolvins, neuroprotectins, nitric oxide, and nitrolipids, and the

action of aspirin,[1] statins,[2] glitazones,[3] and nitroglycerin[4] on essential fatty acid metabolism and nitric oxide explains the relationship between both various fatty acids and excess food energy and cardiovascular disease (Lands, 2008; Robson, 2009).

According to the review by Griffin (2008), the totality of evidence for the positive effects of DHA and EPA on various outcomes of cardiovascular disease is almost incontrovertible. It should be noted that the primary prevention of cardiovascular (inflammatory) disease starts, crucially, with optimal adult nutrition before the inception of pregnancy and continues throughout the life of the newborn and includes consuming not only more DHA and EPA but also their cofactors. For their physiological/beneficial actions, DHA and EPA need many cofactors, not currently present in DHA and EPA capsules, such as folic acid, vitamin B12, vitamin B6, vitamin C, tetrahydrobiopterin (BH_4), zinc, magnesium, calcium, L-arginine and small amounts of selenium, and vitamin E) (Robson, 2009). It is important to note that if DHA and EPA undergo oxidation, it attenuates their beneficial effects (Turner et al., 2006). Bioactive packaging made from nanomaterials can control the oxidation of foodstuffs (Sozer and Kokini, 2009). Further, the excessive consumption of anything may cause disease or premature death, including DHA and EPA (e.g., Church et al., 2009).

Tumor cells undergo apoptosis (programmed cell death) on exposure to DHA and EPA because of an increase in intracellular free radical generation and the formation of lipid peroxides (Das, 2008). However, most epidemiological cohort studies have found no association between DHA and EPA intake and cancer risk (e.g., MacLean et al., 2006). But inverse associations with breast cancer have been reported in Chinese and Japanese women having DHA and EPA intakes up to 40 times greater than Western intakes (e.g., Gago-Dominguez et al., 2003; Wakai et al., 2005).

Increasing human consumption of DHA and EPA and their cofactors, and eating less food energy per meal to lower transient short-lived meal-induced oxidative stress (e.g., Libby, 2002) inflammation, proliferation, and impaired nitric oxide (e.g., Lands, 2008), ultimately could have far-reaching effects on health and well-being. Evidence gleaned over more than three decades now indicates that virtually all so-called diseases of civilization arise from a complex interaction of multiple nutritional factors directly linked to the replacement of ancestral foods by the excessive consumption of Neolithic and Industrial era foods, along with other environmental agents and genetic susceptibility (Robson, 2009).

[1] Non-steroidal anti-inflammatory drugs, such as aspirin and ibuprofen are cyclooxygenase enzyme inhibitors which block excessive inflammatory actions – primarily linked to a low absolute amount of ALA, DHA and EPA in the diet (see – Goyens et al., 2006; Griffin, 2008; Liou and Innis, 2009; Friesen and Innis, 2010). Our estimated ancestral exemplar is an intake 5–6 g DHA + EPA per day (Eaton et al., 2010).

[2] HMG-CoA reductase inhibitors – linked to excess food energy.

[3] Peroxisome proliferator-activated receptor agonists – linked to excess food energy.

[4] A vasodilator – linked to excess food energy.

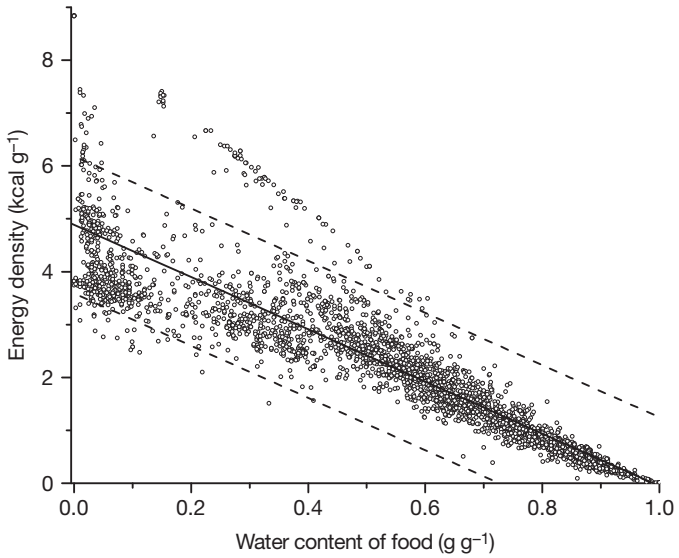

Figure 25.3 Relationship between energy density and water content based on all* food items present in the Australian Food, Supplement and Nutrient Database (AUSNUT, 2007) (energy density $= -4.942 \times$ water content $+ 4.889$, $F_{1,3843} = 16566.17$, $P < 0.001$, $R^2 = 0.81$). The best-fit regression line (solid line) and 95% prediction intervals (broken lines) are included. *All foods and beverages listed in the database (available from http://www.foodstandards.gov.au/) were included for analysis unless the item was listed in a state that was not normally consumed (e.g., powdered foods that need reconstitution). In total, 3536 individual foods (including raw and cooked foods) and 309 beverages were included in the analysis.

5. ENERGY DENSITY AND NUTRIENT DENSITY

Human food production should be linked to human nutritional requirements as its first priority (Robson, 2012). Thus, the high-energy-density and low-nutrient-density that characterize the modern diet must be overcome simultaneously (Robson, 2011, 2012). People can develop paradoxical nutritional deficiency from eating high-energy-dense foods with a poor nutrient content (Robson, 2009). The finding that people with a low-energy-dense diet (<1.6 kcal g^{-1}) have the lowest total intakes of energy, even though they consume the greatest amount of food, has important implications for promoting compliance with a healthy diet (Ledikwe et al., 2006). A farmed and/or processed food that is not both low-energy-dense and of high-nutrient-density (Figure 25.3, Table 25.1) is of poor dietary quality compared to the low-energy-dense foods of high-nutrient-density that humans should eat: the most nutritious cooked wild plant and animal foods for humans (Eaton et al., 2010; Robson, 2006, 2010a, 2011).

Processed low fat foods can have a deleteriously high-energy-density (cf. Robson, 2013a). The focus on just reducing dietary fat (Farhang 2007; Hsieh and Ofori 2007), must be refocused on reducing the positive imbalance between the intake and the expenditure of food

Table 25.1 Energy Density and Nutrient Density of a Selection of Foods (Value per gram)

	Energy (kcal)	DHA + EPA (μg)	Fe[a] (μg)	Zn (μg)	Mg (μg)	Ca (μg)	Vitamin (μg)		
							B12	B6	C
Oil, soybean[b] (04044)	8.8	0	1	<1	0	0	0	0	0
Nut, Brazil nut (12078)	6.6	0	24	41	3760	1600	0	1.0	7
Chocolate, dark (19904)	6.0	0	119	33	2280	730	0.003	0.4	0
Twix® bar, Masterfoods (42183)	5.5	0	13	9	460	1300	0.003	0.4	10
Oat breakfast bar (43100)	4.6	0	32	16	1010	600	0	3.5	10
Cheese, cheddar (01009)	4.0	0	7	31	280	7210	0.008	0.7	0
Mayonnaise, regular (04018)	3.9	0	2	2	20	140	0.002	0.2	0
Special K®, Kellogg's (08067)[c]	3.8	0	270	29	620	300	0.195	64	677
Mayonnaise, light (04641)	3.2	0	3.2	2	20	80	0	0	0
Bread, white (18069)[c]	2.7	0	37	7	230	1510	0	0.8	0
Beef sirloin, roasted (13953)	2.1	0	17	47	220	190	0.015	5.5	0
Chicken meat, roasted (05013)[d]	1.9	500	12	21	250	150	0.003	4.7	0
Beef brain, cooked (13320)[e]	1.5	8550	23	11	120	90	0.101	1.4	105
Clam meat, cooked (15159)[e]	1.5	2840	280	27	180	920	0.989	1.1	221
Egg, poached (01131)[f]	1.4	410	18	11	120	530	0.013	1.2	0
Oyster meat, eastern, wild, cooked (15169)[e]	1.4	11200	120	1816	950	900	0.35	1.2	60
Moose meat, wild, roasted (17173)	1.3	0	42	37	240	60	0.063	3.7	50
Water buffalo meat, wild, roasted (17161)	1.3	0	21	25	330	150	0.018	4.6	0
Shrimp meat, cooked (15151)[e]	1.0	3150	31	16	340	390	0.015	1.3	22
Banana, raw (09040)	0.9	0	3	2	270	50	0	3.7	87

Continued

Table 25.1 Energy Density and Nutrient Density of a Selection of Foods (Value per gram)—cont'd

	Energy (kcal)	DHA + EPA (μg)	Fe (μg)	Zn (μg)	Mg (μg)	Ca (μg)	Vitamin (μg)		
							B12	B6	C
Mayonnaise, extra light (42193)	0.8	0	1	1	20	60	0	0	0
Spinach, boiled (11458)	0.2	0	36	8	870	1360	0	2.4	98
Celery, boiled (11144)	0.2	0	4	1	120	420	0	0.9	61

Entries retrieved from the USDA National Nutrient Database for Standard Reference, Release 22 (2009) and are identified by a 5-digit nutrient database number in parentheses.
[a] Two billion people, over 30% of the world's population are anemic, many because of iron deficiency (World Health Organization, 2009).
[b] Soybean oil provides 20% of all calories in the median US diet (Gerrior and Bente, 2002).
[c] Fortified with nutrients.
[d] Intensively reared chicken: if one takes DHA as the limiting nutrient for the assessment of quality, then to obtain the same amount of DHA today as can be obtained from one wild chicken, one would need to eat six intensively reared chickens – ingesting somewhere in the region of 9000 kcal (Wang et al., 2010).
[e] Food with a high natural nutrient content and a low-energy-density.
[f] Vitamin B12 in eggs is poorly absorbed relative to other foods containing B12 (Watanabe, 2007).

energy. Low-fat, high-carbohydrate cereal-based products are often of high-energy-density. For example, a Masterfoods Twix® chocolate biscuit bar: 56% carbohydrate and 2.2% water – = 5.5 kcal g^{-1}, Kellogg's Special K®: 71% carbohydrate and 3% water = 3.8 kcal g^{-1}, white bread: 51% carbohydrate and 36% water = 2.7 kcal g^{-1}, while roasted wild water buffalo meat: 0% carbohydrate and 69% water = 1.3 kcal g^{-1}, shrimp meat cooked in moist heat: 0% carbohydrate and 77% water = 1.0 kcal g^{-1} and boiled celery: 4% carbohydrate and 94% water = 0.2 kcal g^{-1} (cf. Figure 25.3 and Table 25.1).

Processed food products of plant origin such as chocolate bars, biscuits, fruit bars, and cereal bars have a high-energy-density principally because they have low water content (Robson, 2011, 2012, 2013a). Self-assembled, water-filled, edible nanotubes that self-organize into a more complex structure, possibly a 3D network of nanocellulose, could be incorporated into many processed foods to lower their energy density to <1.6 kcal g^{-1} (Robson, 2012; cf. Norton et al., 2009). Nanocellulose is composed of nanosized cellulose fibrils (fiber diameter: 20–100 nm), has a water content of up to 99% and the same molecular formula as plant cellulose (Klemm et al., 2006). The water inside the nanosized cellulose fibrils could contain flavor with few calories, for example, a cup of tea without milk = 0.01 kcal g^{-1}. The shape and supramolecular structure of the nanocellulose can be regulated directly during biosynthesis to produce fleeces, films/patches, spheres, and tubes (Klemm et al., 2011). Other edible materials can strongly adhere to the surface and the inside of nanocellulose structures such as fleeces to form edible composites (Chang et al., 2012). Taste sensation per mouthful could be improved by adding flavoring substances processed on the nanoscale

Figure 25.4 Oysters, *Ostrea edulis*, for sale at a French market. Oysters, especially cooked wild oysters, are both low-energy-dense and some of the most nutritious foods for humans on the planet. However, they lack the fiber found in plants (Anthony A. Robson ©).

(increased surface area in contact with taste and smell receptors) to edible composites (Ultrafine food technology: Eminate Limited, Nottingham, United Kingdom). Durethan® KU2-2601 packaging film produced by Bayer Polymers, Germany, is a nanocomposite film enriched with silicate nanoparticles which is designed to prevent the contents from drying out and prevent the contents coming into contact with oxygen and other gases. Durethan® KU 2-2601 can prevent food spoilage (Neethirajan and Jayas, 2011) and thus the water content of dehydrated plant-based food products can be increased without reducing product shelf life. Therefore, nanocellulose is expected to be widely used as a nature-based food additive (Chang, et al., 2012; Klemm, et al., 2011).

The bioavailable nutrient content including cofactors of processed foods should be based on the nutritional value of the most nutritious cooked wild foods for humans (Figure 25.4) and can be increased using existing bioactive encapsulation (Robson, 2010a, 2011). Aquatic biotechnology can provide the food industry with sufficient amounts of all the nutrients needed for mass scale optimal human nutrition including protein, DHA, EPA, AA, vitamins, minerals, and fiber (Harun et al., 2010; Liu et al., 2012; Ortiz et al., 2006). Reducing particle size using nanotechnology can further improve the properties of bioactive compounds (e.g., DHA and EPA), such as delivery, solubility, prolonged residence time in the gastrointestinal tract, and efficient absorption through cells (Chen et al., 2006).

Table 25.2 Sugar, Protein, and Fiber Content of a Selection of Sweet Foods and Drinks (Value per 100 g)

	Sugar (g)	Protein (g)	Fiber (g)
Granulated sugar (19335)	99.8	0.0	0.0
Brown sugar (19334)	97.0	0.1	0.0
Honey (19296)	82.1	0.3	0.2
Vanilla fudge (19103)	79.8	1.1	0.0
Chewing gum (19163)	66.1	0.0	2.4[a]
Toffee sweets (19383)	63.5	1.1	0.0
Boiled sweets (19107)	62.9	0.0	0.0
Maple syrup (19353)	59.5	0.0	0.0
Marshmallows (19116)	57.6	1.8	0.1
Jellies (19300)	51.2	0.2	1.0
Apricot preserve (19719)	43.4	0.7	0.3
Creme de menthe drink (14034)	41.6	0.0	0.0
Kellogg's Frosted Flakes® (08069)	38.7	4.3	1.8
High-fructose corn syrup (19351)	26.4	0.0	0.0
Pina colada drink (14017)	22.3	0.4	0.3
Chocolate milkshake (01110)	20.9	3.1	0.3
Vanilla ice cream (19089)	20.7	3.5	0.0
Cola drink (14148)	10.6	0.0	0.0
Red Bull® drink (14154)	10.1	0.3	0.0

Entries retrieved from the USDA National Nutrient Database for Standard Reference, Release 22 (2009) and are identified by a 5-digit nutrient database number in parentheses.
[a] The fiber in the chewing gum is not usually ingested.

A reduction in liquid calorie intake has been found to have a greater effect on weight loss than a reduction in solid calorie intake (Chen et al., 2009). Sugar-sweetened beverages (SSBs) require little digestion. Glucose and fructose can be directly absorbed into the bloodstream without digestion. Reducing the energy density of processed foods, including SSBs, and simultaneously increasing the cost of their assimilation makes them more akin to foods consumed by late Palaeolithic humans. The energetic cost of the assimilation of processed foods can be increased by increasing their protein and fiber content (Table 25.2) (Eaton et al., 2010; Robson, 2010a, 2011). Protein has more than three times the thermic effect of either fat or carbohydrate (Crovetti et al., 1998), and protein has a greater satiety value than fat or carbohydrate (Crovetti et al., 1998; Stubbs, 1998). A high-protein diet (protein and carbohydrate intake both being approximately one-third of total energy intake; Eaton et al., 2010) is of vital importance as a weight-loss strategy for the overweight or obese and for weight maintenance (Robson, 2009; Veldhorst et al., 2008). Clinical trials have shown that calorie-restricted, high-protein diets are more effective than are calorie-restricted, high-carbohydrate diets in promoting (Baba et al., 1999; Layman, 2003; Skov et al., 1999) and maintaining (Westerterp-Plantenga et al., 2004) weight loss in overweight subjects, while producing less hunger and more satisfaction (Johnston

et al., 2004). Furthermore, high-protein diets have been shown to improve metabolic control in patients with type 2 diabetes (Odea, 1984; Odea et al., 1989; Seino et al., 1983). Food-grade protein-based nanotubes (Graveland-Bikker and De Kruif, 2006) may be used to increase the protein content of processed foods that are currently high in fat or high in carbohydrate. Functional foods and drinks are required to simultaneously satisfy the human 'sweet tooth' and almost completely remove added sugars such as glucose, fructose, and sucrose from the diet (Eaton et al., 2010). Savory foods and drinks can be sweetened by adding fruit to them or adding calorie-free PUREFRUIT™ (Tate & Lyle) monk fruit (*Siraitia grosvenorii*) extract (Robson, 2012, 2013a, 2013b). PUREFRUIT™ is approximately 200 times sweeter than sugar and has exceptional stability.

Cooking has obvious beneficial effects by increasing food safety and improving diet quality (Carmody and Wrangham, 2009). However, cooking can reduce the water content of a high-energy-dense processed food and, thus, further increase its deleteriously high-energy-density, especially if it is cooked twice. For example, toasting whole-wheat bread increases its energy density from 2.5 to 3.1 kcal g^{-1} as water content decreases by 14% (data calculated from USDA National Nutrient Database for Standard Reference). Nanoscale science and technology are now enabling us to understand many natural and unnatural processes. Studying nanostructures at the cell and DNA level gives us insight into the working of these processes and how to manipulate, prevent, and/or enhance them for the benefit of mankind.

6. ACID–BASE BALANCE, NACL SALT, AND FIBER CONTENT OF THE DIET

The late Paleolithic diet was net base yielding because of very little cereal consumption (Eaton et al., 2010). The modern diet is too acidic (Cordain et al., 2005); that includes hunter-gather diets such as that of the traditional Eskimo, whose net endogenous acid production is acidic because of very little fruit and vegetable consumption (Eaton et al., 2010). The known health benefits of a net base-yielding diet include preventing and treating osteoporosis (Bushinsky, 1996; Sebastian et al., 1994), age-related muscle wasting (Frassetto et al., 1997), calcium kidney stones (Pak et al., 1985; Preminger et al., 1985), hypertension (Morris et al., 1999; Sharma et al., 1990), exercise-induced asthma (Mickleborough et al., 2001), and the progression of age- and disease-related chronic renal insufficiency (Alpern and Sakhaee, 1997). Adding sufficient amounts of potassium bicarbonate to cereals and cereal-based products will make them net base-yielding foods.

The addition of manufactured NaCl salt to the food supply and the displacement of traditional potassium-rich foods by foods introduced during the Neolithic and Industrial periods caused a 400% decline in potassium intake while simultaneously initiating a 400% increase in sodium ingestion (Cordain, 2002; Eaton and Konner, 1985). The potassium concentrations in vegetables are four and twelve times those in milk and whole grains, respectively, whereas in fruit, the potassium concentration is two and five times that in milk

and whole grains, respectively (First Data Bank, 2000). The inversion of potassium and sodium concentrations in hominin diets had no evolutionary precedent and now plays an integral role in eliciting and contributing to numerous non-communicable diseases (Cordain et al., 2005). Diets low in potassium and high in NaCl salt may partially or directly underlie or exacerbate a variety of maladies and chronic illnesses, including hypertension, stroke, kidney stones, osteoporosis, gastrointestinal tract cancers, asthma, exercise-induced asthma, insomnia, air sickness, high-altitude sickness, and Meniere's syndrome (ear ringing) (Cordain et al., 2005; Robson, 2009).

The more NaCl salt one uses, the more one needs it in all kinds of foods (e.g., bread, potatoes, and cheese) because of the damaging effect of NaCl salt on taste buds, which may be irreversible in older people but is normally recoverable within a couple of months on a low NaCl salt diet (Joossens and Geboers, 1981). Not adding NaCl salt to (processed) food and the biofortification of cereals and dairy products with potassium bicarbonate will help alleviate the current sodium–potassium imbalance in the human diet (and the deleterious acid–base effect (net endogenous acid production): acidic).

The typical modern diet has a fiber content of 15.1 g day^{-1} (U.S. Department of Agriculture, 2008) which is considerably lower than the recommended value of 25–38 g day^{-1} (Institute of Medicine, 2005a) or the estimated ancestral intake of >70 g day^{-1} (Eaton et al., 2010). Refined sugars, cooking oils, dairy products, and alcohol are devoid of fiber and constitute an average of 48.2% of the energy in a typical modern diet (Cordain et al., 2005). Furthermore, fiber-depleted, refined grains represent 85% of the grains consumed in a typical modern diet, and because they contain 400% less fiber than whole grains (on an energy basis), they further dilute the total dietary fiber intake (Cordain et al., 2005). Fresh fruit typically contains twice the amount of fiber in whole grains on an energy basis, and nonstarchy vegetables contain almost eight times the amount of fiber in whole grains on an energy basis (First Data Bank, 2000). Fruit and vegetables known to be consumed by hunter–gatherers contain considerably more fiber than their domestic counterparts (Brand-Miller and Holt, 1998). Diets low in dietary fiber may underlie or exacerbate constipation, appendicitis, hemorrhoids, deep vein thrombosis, varicose veins, diverticulitis, hiatal hernia, and gastroesophageal reflux (Trowell, 1985). Dietary fiber can be added to processed foods, for example, chocolate (Robson, 2013a), milk, cheese, ice cream, refined cereals, and white bread, to increase the fiber content of the modern diet (Robson, 2009, 2012).

7. ROADMAPPING THE FUTURE

There are already more humans on Earth than can be sustained by the natural world. Thus, the nutritional value of processed and farmed foods will be increasingly based on the nutritional value of the late Paleolithic human diet to help prevent diet-induced disease because unbiased observers agree that nutritional advice from conventional sources,

whether based on epidemiologic or mechanistic findings, has not affected complex degenerative disease incidence/prevalence as much as hoped (Eaton et al., 2010). Furthermore, modern animal husbandry caused the rise in the production of high-fat meat with a low-nutrient-density and it will have to be corrected because of its negative effects on animal welfare and human nutrition (Ametaj et al., 2010; Daley et al., 2010; Jonsson et al., 2006; Wang et al., 2010). Functional food products and wellness programs that help prevent the causal mechanisms of non-communicable diseases will be of great benefit to mankind (Lands, 2009; Robson, 2010b). However, the consumption of the most nutritious cooked wild foods for humans, for example, omnivorous shellfish (Robson, 2006), should be encouraged, and emergent technologies will probably enhance the production, utilization, and food safety of this nutritious resource. Emergent technologies will change society beyond anything that has gone before. This should, but not with any certainty, eventually slow down the spiraling increase in healthcare costs (Tolfree and Smith, 2009).

8. CONCLUSION

Non-communicable disease is a situation out of control. The causes are preventable. Non-communicable disease is a global epidemic because of the combined effect of the modern diet (including drug abuse) and a sedentary lifestyle (Robson 2013b). Human food production must be linked to human nutritional requirements as its first priority. A low-energy-dense, drug-free diet rich in bioavailable nutrients-plus-exercise is most effective for preventing non-communicable disease throughout life. High-energy-density and low-nutrient-density which characterize the modern diet must be overcome simultaneously. Drug abuse must be made socially unacceptable. Nanocellulose and calorie-free monk fruit extract could be used to lower the energy density of processed foods/drinks, and their bioavailable nutrient content including cofactors can be increased using bioactive encapsulation. Aquatic biotechnology can provide all the nutrients needed to make processed foods really nutritious. In conclusion, the nutritional value of processed and farmed foods should be based on the nutritional value of the late Palaeolithic human diet to help prevent cardiovascular disease, mental ill health, cancer, obesity, and other postprandial insults (Robson, 2009, 2012, 2013a, 2013b).

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RELEVANT WEBSITES

http://www.mccarrisonsociety.org.uk/ – The McCarrison Society for Nutrition & Health.
http://www.mother-and-child.org/ – The Mother and Child Foundation. Working for good health in mothers and children
http://www.who.int/en/ – World Health Organization.