Preventing the Epidemic of Mental Ill Health: An Overview

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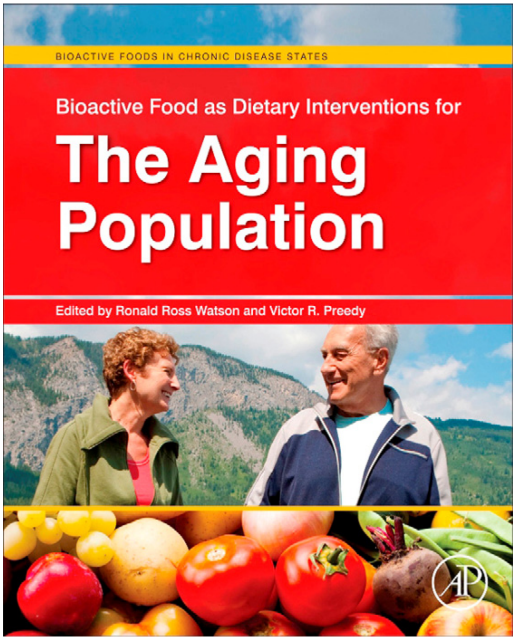

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CHAPTER 14

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ABBREVIATIONS

AA Arachidonic acid
DHA Docosahexaenoic acid
WHO World Health Organization

1. INTRODUCTION

At the end of the seventeenth century, mental ill health was of little significance and was little discussed. At the end of the eighteenth century, it was perceived as probably increasing and was of some concern. At the end of the nineteenth century, it was perceived as an epidemic and was a major concern, and at the end of the twentieth century, it was simply accepted as part of the fabric of life (Torrey and Miller, 2002). Now, in the twenty first century, the cost of brain disorders has overtaken those of any other health burden (Crawford et al., 2009; Wang et al., 2010). The consequences, in terms of mental disability, impose a disproportionately high cost on health services and society because of its life-long impact. For example, in England (a country that is part of the United Kingdom of Great Britain and Northern Ireland), the costs associated with mental health problems were estimated to be £105.2 billion during 2010 (Centre for Mental Health, 2010). It should be noted that £105.2 billion during 2010 was greater than the whole of the funding for England's publicly run National Health Service (NHS); so, it is a huge cost, and during 2010, it was about 9.6% of gross value added (GVA) (Harker, 2012; Office for National Statistics, 2011).

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). Children with the genetic disorder, phenylketonuria, have been protected from

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Figure 14.1 A bowl of steamed mussels, *Mytilus edulis*. Edible bivalves, especially cooked wild bivalves such as mussels, oysters and clams, are some of the most nutritious foods for humans on the planet (Anthony A. Robson ©).

severe mental decline, not from the human genome project, but from nutrition and health management. 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. Eating adequate amounts of foods rich in bioavailable brain nutrients, for example, shellfish[1], such as mussels (Figure 14.1) and oysters (which contain nutrients including protein, docosahexaenoic acid (DHA), arachidonic acid (AA), iodine, iron, copper, zinc, manganese, and selenium as well as a variety of antioxidants including vitamins; see Table 14.1) promotes health and helps prevent diet-induced mental ill health today (e.g., Robson, 2009). This overview highlights the major changes that are urgently needed in order to promote health and help prevent the epidemic of mental ill health (for an overview of preventing non-communicable diseases, see Robson, 2013b). After all, disease prevention, in the long run, is far less costly than treatment.

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

[1] There have been misleading warnings about mercury in seafood. In the absence of a major methylmercury spill into a localized marine environment, selenium in seafood reacts with all the mercury in seafood to produce a safe compound. The actual risks of mercury exposure from the consumption of foods from mercury-contaminated terrestrial and freshwater ecosystems have gone unrecognized for too long (Berry and Ralston, 2008).

Table 14.1 Nutrient Density of Some of the Most Nutritious Brain Foods (Value per 100 g)

	DHA (g)	AA (g)	I[a]	Fe[b] (mg)	Cu (mg)	Zn (mg)	Mn (mg)	Se (μg)	Vitamin A (μg_RAE)	Vitamin B12 (μg)	Vitamin B6 (mg)	Vitamin C (mg)	Vitamin D[a] (μg)	Vitamin Folate (μg)
Oyster meat, wild, cooked (15169)[c]	0.584	0.160	200	11.99	7.569	181.61	0.697	71.6	54	35.02	0.118	6.0	0.14	14
Mussel meat, cooked (15165)[c]	0.506	0.140	160	6.72	0.149	2.67	6.800	89.6	91	24.00	0.100	13.6	0.12	76
Clam meat, cooked (15159)[c]	0.146	0.082	150	27.96	0.688	2.73	1.000	64.0	171	98.89	0.110	22.1	0.12	29
Snapper fish, cooked (15102)	0.273	0.044	40	0.24	0.046	0.44	0.017	49.0	35	3.50	0.460	1.6	0.12	6
Egg, poached (01131)[d]	0.037[e]	0.141	36.6	1.83	0.102	1.10	0.039	31.6	139	1.28	0.121	0	0.67	35
Salmon, Atlantic, cooked (15209)	1.429	0.342	6.5	1.03	0.321	0.82	0.021	46.8	13	3.05	0.944	0	7.4	29
Lamb brain, cooked (17186)	0.590	0.270	4	1.68	0.210	1.36	0.059	12.0	0	9.25	0.110	12.0	0.12	5

Entries retrieved from the USDA National Nutrient Database for Standard Reference, Release 22 (2009) and are identified by a five-digit nutrient database number in parentheses.

[a] Data from the Australian Food, Supplement and Nutrient Database (AUSNUT) 2007 (Available from http://www.foodstandards.gov.au/).

[b] Two billion people, over 30% of the World's population, are anemic, many because of iron deficiency.World Health Organization, 2009. Micronutrient deficiencies: iron deficiency anaemia. http://www.who.int/nutrition/topics/ida/en/print.html.

[c] 100 g provides 100% or more of the adult RDA for iodine. Institute of Medicine, 2001. Dietary reference intakes for vitamin A, vitamin K, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Food and Nutrition Board. National Academy Press, Washington, DC

[d] Vitamin B12 in eggs is poorly absorbed relative to other foods containing B12. Watanabe, F., 2007. Vitamin B-12 sources and bioavailability. Experimental Biology and Medicine 232, 1266–1274

[e] Sum EPA + DPA + DHA = 0.195 g (DPA – docosapentaenoic acid ω-3 is an intermediary between EPA and DHA), in raw eggs from hens on a diet enriched in DHA (Data valid on 8th October 2010 - product: Marks & Spencer plc UK free range omega-3 eggs).

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).

3. GENERAL EFFECTS OF DIET ON THE HUMAN BRAIN

The developing human brain, between 24 and 42 weeks of gestation, is particularly vulnerable to nutritional insults because of the rapid trajectory of several neurological processes, including synapse formation and myelination. Conversely, the young brain is remarkably plastic and, therefore, more amenable to repair after nutrient repletion. On balance, the brain's vulnerability to nutritional insults outweighs its plasticity, not only while the nutrient is in deficit, but also after repletion (Georgieff, 2007). Adverse neurodevelopmental outcomes in children are associated with inadequate maternal consumption of brain nutrients during pregnancy and lactation (e.g., Helland et al., 2003; Hibbeln et al., 2007). Breastfeeding, in comparison to feeding breast milk substitutes such as infant formula, has a wide range of health benefits for mothers and children (e.g., Gartner et al., 2005; Horta et al., 2007). A significant positive effect of breastfeeding on cognitive ability in children has been found over and above the expected positive effect of maternal education (Bartels et al., 2009). The current World Health Organization (WHO) recommendation for breastfeeding is that all infants should be exclusively breastfed for the first 6 months of life, and receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to 2 years of age or beyond (World Health Organization, 2002). The WHO recommendations have been adopted and endorsed by many countries; yet barely one in three infants is exclusively breastfed during the first 6 months of life (World Health Organization, 2010).

Increasing evidence suggests that depression, bipolar disorder, cognitive decline, age-related macular degeneration, Alzheimer's disease, aggression, hostility and antisocial behavior relate to a lack of brain nutrients in the human diet (Crawford et al., 2009). Of course, alcohol and other drug abuse also have deleterious effects on the brain. Furthermore, obesity is common among women of reproductive age. Although obesity alone confers increased disease risk, obesity in pregnancy presents added health problems and increases the incidence of premature births and low birth weight babies (e.g., Rajasingam et al., 2009). There is creditable data that the increase in bipolar disorder has recently been most rapid among children (Moreno et al., 2007). Poor maternal nutrition and living conditions have been causatively linked to low birth weight regardless of socioeconomic status, ethnicity, or smoking habit (Doyle et al., 1989; Rees et al., 2005; Wynn et al., 1994). Low birth weight is the strongest predictor of the risk for chronic ill health, including brain disorders, heart disease, stroke and diabetes along with learning and numeracy difficulties, behavioral problems, low skill level, restricted job opportunities, and crime (e.g., Barker, 2004). As birth weight falls (mostly premature deliveries), the incidence of severe neurodevelopmental disorders rises sharply from about 1 in 1000 live births to over 200 in 1000 live births below 1.5 kg (UK Office for National Statistics data). Yet, non-communicable brain disorders and other degenerative non-communicable diseases 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 (Eaton et al., 2010).

4. THE MOST IMPORTANT BRAIN NUTRIENTS

All brain nutrients are important for neurogenesis and development (the adult human brain contains regions where continuous neurogenesis occurs (van de Berg et al., 2010)), but certain nutrients have greater effects on brain health than do others. Iodine deficiency is the most common cause of preventable brain damage in the World. Iodine deficiency disorders include mental retardation, hypothyroidism, goiter, and varying degrees of other growth and developmental abnormalities (de Benoist et al., 2008). The WHO estimates that over 30% of the world's population (2 billion people) has insufficient iodine intake (de Benoist et al., 2008). The global problem of iodine deficiency primarily affects people not regularly consuming shellfish, fish, seaweed, plants grown in iodine-rich soil, animals fed iodine-rich foods, or iodized table salt. However, plant-based diets rich in staples like cassava or soybeans (the basis of many vegan and vegetarian food products) contain goiterogens, which inhibit iodine absorption (Cunnane et al., 2007). Further, the key minerals needed for brain development and function are more bioavailable from shellfish and fish than from plant-based diets where their absorption is impaired by phytates and other antinutrients.

Fetal protein-energy malnutrition results in intrauterine growth retardation which is associated with a high prevalence of subsequent neurodevelopmental abnormalities characterized by cognitive disabilities (Spinillo et al., 1993). DHA is a potent neurobiological agent that is important for synaptogenesis, membrane function, and myelination. DHA deficiency is associated with many changes in brain function including alterations in learning and memory, auditory and olfactory responses to stimuli, reductions in the size of neurons, changes in nerve growth factor levels, delayed cell migration in the developing brain, and an increase in depressive and aggressive behavior (Crawford et al., 2009). AA is the precursor of a number of different endocannabinoids and eicosanoids which play important roles in the normal homeostasis of brain function (Tassoni et al., 2008). Iron deficiency at any time in life may disrupt metabolic processes and subsequently change cognitive and behavioral functioning. Iron treatment has been found to normalize cognitive function in young women (Murray-Kolb and Beard, 2007). Copper deficiency alters, in particular, the developing cerebellum causing long-term effects on motor function, balance, and coordination (Georgieff, 2007). Manganese deficiency, which may enhance susceptibility to convulsions, appears to affect manganese homeostasis in the brain, probably followed by alteration of neural activity (Takeda, 2003). Selenium mediates its effects on brain and behavior development through thyroid hormone metabolism; folate and choline mediate their effects through one-carbon metabolism, DNA methylation, and neurotransmitter synthesis. Life-long selenium deficiency is associated with lower cognitive function (Gao et al., 2007). Folate deficiency can lead to neurological disorders, such as depression and cognitive impairment (Gomez-Pinilla, 2008). Zinc deficiency alters autonomic nervous system regulation. Severe zinc deficiency during gestation can lead to overt fetal brain malformations, and suboptimal zinc nutrition during gestation can have long-term effects on the offspring's nervous system (Adamo and Oteiza, 2010).

Vitamin A is particularly important during periods of rapid growth, both during pregnancy and in early childhood. Vitamin A derivatives, retinoids, control the differentiation of neurones, and a role has been suggested in memory, sleep, depression, Parkinson's disease, and Alzheimer's disease (Tafti and Ghyselinck, 2007). Furthermore, vitamin A plays a critical role in visual perception and a deficiency causes blindness (Benton, 2008). Impaired cognitive function is associated with the inadequate provision of vitamin B12 throughout life (Benton, 2008).

In many instances, it is likely that a diet deficient in one brain nutrient will be deficient in others. Nutrients do not function in isolation. It is possible that a beneficial response to the supplementation of a single deficient brain nutrient, for example, choline, has not been observed because the functioning of other aspects of a chain of necessary reactions has been inhibited by other deficiencies (Benton, 2008). It is also important to emphasize that consuming diets that are excessively rich or deficient in brain nutrients at any time in life may cause disease or premature death (Church et al., 2009; Georgieff, 2007). Thus, primary prevention of mental ill health starts, crucially, with optimal adult nutrition before the inception of pregnancy, includes breastfeeding and continues throughout the life of the newborn (Robson, 2009). 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).

5. ENERGY DENSITY AND NUTRIENT DENSITY

Human food production should be linked to human nutritional requirements as its first priority (Robson, 2012, 2013a). Thus, the high-energy-density and low nutrient density that characterize the modern diet must be overcome simultaneously (Robson, 2011, 2012, 2013b). 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 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 (c.f. Robson, 2013a). The emphasis 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 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} (c.f. Table 14.2).

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 a 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} (c.f. Norton et al., 2009; Robson, 2012). Nanocellulose is composed of nanosized cellulose fibrils (fiber diameter: 20–100 nm), and 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 (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 from coming into contact with oxygen and other gases. Durethan® KU2-2601 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 a as a nature-based food additive (Chang, et al., 2012; Klemm, et al., 2011).

Table 14.2 Energy Density, Water, Protein, and Carbohydrate Content of a Selection of Foods (Value per 100 g)

	Energy (kcal)	Water (g)	Protein (g)	Carbohydrate (g)
Oil, soybean[a] (04044)[b]	884	0.00	0.00	0.00
Chocolate, dark (19904)[b]	598	1.37	7.79	45.90
Twix® bar, Masterfoods (42183)[b]	550	2.20	7.30	56.00
Potato chips (19811)	536	1.90	7.00	52.90
Oat breakfast bar (43100)[b]	464	4.10	9.80	66.70
Rice cake (42204)	392	5.80	7.10	81.10
Corn pops®, Kellogg's (08068)[b]	378	3.00	3.70	90.00
Bread, white (18069)[b]	266	36.44	7.64	50.61
Ice cream, vanilla (19089)[b]	249	57.20	3.50	22.29
Beef sirloin, roasted (13953)[b]	211	62.63	26.05	0.00
Salmon, Atlantic, farmed, cooked (15237)[b]	206	64.75	22.10	0.00
Chicken meat, roasted (05013)[c]	190	63.79	28.93	0.00
Salmon, Atlantic, wild, cooked (15209)[c]	182	59.62	25.44	0.00
Mussel meat, cooked (15165)[c]	172	61.15	23.80	7.39
Beef brain, cooked (13320)[d]	151	74.86	11.67	1.48
Clam meat, cooked (15159)[d]	148	63.64	25.55	5.13
Egg, poached (01131)	142	75.54	12.52	0.78
Oyster meat, eastern, wild, cooked (15169)[d]	137	70.32	14.10	7.82
Moose meat, wild, roasted (17173)[d]	134	67.83	29.27	0.00
Water buffalo meat, wild, roasted (17161)[d]	131	68.81	26.83	0.00
Shrimp meat, cooked (15151)[d]	99	77.28	20.91	0.00
Pear, raw (09252)[d]	58	83.71	0.38	15.46
Broccoli, cooked (11091)[d]	35	89.25	2.38	7.18
Spinach, boiled (11458)[d]	23	91.21	2.97	3.75
Watercress, raw (11591)[d]	11	95.11	2.30	1.29

Entries retrieved from the USDA National Nutrient Database for Standard Reference, Release 22 (2009) and are identified by a five-digit nutrient database number in parentheses.
[a] Soybean oil provides 20% of all calories in the median USA diet.Gerrior, S., Bente, L., 2002. Nutrient content of the U.S. food supply, 1909–99: a summary report. US Department of Agriculture, Home Economics report no. 55, Washington, DC
[b] High-energy-density >2 kcal g^{-1}.
[c] Medium energy density 2.0–1.6 kcal g^{-1}.
[d] Low-energy-density <1.6 kcal g^{-1}. Ledikwe, J.H., Blanck, H.M., Kettel Khan, L., et al., 2006. Dietary energy density is associated with energy intake and weight status in US adults. American Journal of Clinical Nutrition 83, 1362–1368

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 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 brain nutrition including protein, DHA, AA, iodine, iron, copper, zinc, manganese, and selenium as well as a variety of antioxidants including vitamins (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), such as delivery, solubility, prolonged residence time in the gastrointestinal tract, and efficient absorption through cells (Chen et al., 2006).

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 (both protein and fiber can be produced on a mass scale using aquatic biotechnology) (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). Savoury food and drinks can be sweetened by adding fruit to them or adding calorie-free Purefruit™ (Tate & Lyle) monk fruit (*Siraitia grosvenorii*) extract (Robson, 2013a). 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. ROADMAPPING THE FUTURE

There are 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 mental ill health, 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[2] and it will have to be corrected because of its negative effects on animal welfare and human nutrition (Wang et al., 2010; Ametaj et al., 2010; Daley et al., 2010; Jonsson et al., 2006). Food products and wellness programs that help prevent the causal mechanisms of mental ill-health will be of great benefit to the mankind (Lands, 2009; Robson, 2010b). Emergent technologies can enhance the cleaning and management of lakes, rivers, estuaries, and coastal waters to restore and enhance CO_2 and nitrogen fixation and simultaneously provide more sustainable foods rich in bioavailable brain nutrients, for example, omnivorous shellfish (Robson, 2006), to help prevent the current epidemic of mental ill-health. Emergent technologies will change the 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).

7. CONCLUSION

Mental ill health is an epidemic worldwide because of the combined effect of the modern diet and a sedentary lifestyle (e.g. Robson, 2013b). A low-energy-dense diet rich in bioavailable brain nutrients-plus-exercise is most effective for preventing mental ill-health throughout life. Obesity in pregnancy and poor human nutrition must be tackled head-on. Human food production must be linked to human nutritional requirements as its first priority. High-energy-density and low nutrient density which characterize the modern diet must be overcome simultaneously. Nanocellulose and calorie-free monk fruit extract could be used to lower the energy density of processed foods/drinks, and their bioavailable brain 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

[2] Compare the energy density and protein content of farmed and wild salmon in Table 14.2.

based on the nutritional value of the late Palaeolithic human diet to help prevent mental ill-health and other postprandial insults (Robson, 2009, Robson, 2013b).

REFERENCES

Adamo, A.M., Oteiza, P.I., 2010. Zinc deficiency and neurodevelopment: the case of neurons. BioFactors 36 (2), 117–124 10.1002/biof.91.

Ametaj, B.N., Zebeli, Q., Saleem, F., et al., 2010. Metabolomics reveals unhealthy alterations in rumen metabolism with increased proportion of cereal grain in the diet of dairy cows. Metabolomics 6, 583–594.

Baba, N.H., Sawaya, S., Torbay, N., Habbal, Z., Azar, S., Hashim, S.A., 1999. High protein vs high carbohydrate hypoenergetic diet for the treatment of obese hyperinsulinemic subjects. International Journal of Obesity 23, 1202–1206.

Barker, D.J., 2004. The developmental origins of chronic adult disease. Acta Paediatrica 93, 26–33.

Bartels, M., van Beijsterveldt, C.E.M., Boomsma, D.I., 2009. Breastfeeding, maternal education and cognitive function: a prospective study in twins. Behavior Genetics 39, 616–622.

Benton, D., 2008. Micronutrient status, cognition and behavioral problems in childhood. European Journal of Nutrition 47 (supplement 3), 38–50.

Berry, M.J., Ralston, N.V.C., 2008. Mercury toxicity and the mitigating role of selenium. EcoHealth 5, 456–459.

Brand-Miller, J.C., Holt, S.H.A., 1998. Australian Aboriginal plant foods: a consideration of their nutritional composition and health implications. Nutrition Research Reviews 11, 5–23.

Carmody, R.N., Wrangham, R.W., 2009. The energetic significance of cooking. Journal of Human Evolution 57, 379–391.

Chang, S.-T., Chen, L.-C., Lin, S.-B., Chen, H.-H., 2012. Nano-biomaterials application: Morphology and physical properties of bacterial cellulose/gelatin composites via crosslinking. Food Hydrocolloids 27 (1), 137–144.

Chen, L.W., Appel, L.J., Loria, C., et al., 2009. Reduction in consumption of sugar-sweetened beverages is associated with weight loss: the PREMIER trial. The American Journal of Clinical Nutrition 89, 1299–1306.

Centre for Mental Health, 2010. The Economic and Social Costs of Mental Health Problems in 2009/10. Centre for Mental Health, London. (http://www.centreformentalhealth.org.uk/pdfs/Economic_and_social_costs_2010.pdf)

Chen, L., Remondetto, G.E., Subirade, M., 2006. Food protein-based materials as nutraceutical delivery systems. Trends in Food Science and Technology 17, 272–283.

Church, M.W., Jen, K.-L.C., Jackson, D.A., Adams, B.R., Hotra, J.W., 2009. Abnormal neurological responses in young adult offspring caused by excess omega-3 fatty acid (fish oil) consumption by the mother during pregnancy and lactation. Neurotoxicology and Teratology 31, 26–33.

Cordain, L., Eaton, S.B., Sebastian, A., et al., 2005. Origins and evolution of the Western diet: health implications for the 21st century. The American Journal of Clinical Nutrition 81, 341–354.

Crawford, M.A., Bazinet, R.P., Sinclair, A.J., 2009. Fat intake and CNS functioning: ageing and disease. Annals of Nutrition and Metabolism 55, 202–228.

Crovetti, R., Porrini, M., Santangelo, A., Testolin, G., 1998. The influence of thermic effect of food on satiety. European Journal of Clinical Nutrition 52, 482–488.

Cunnane, S.C., Plourde, M., Stewart, K., Crawford, M.A., 2007. Docosahexaenoic acid and shore-based diets in hominin encephalization: a rebuttal. American Journal of Human Biology 19, 578–581.

de Benoist, B., McLean, E., Andersson, M., Rogers, L., 2008. Iodine deficiency in 2007: global progress since 2003. Food and Nutrition Bulletin 29, 195–202.

Daley, C.A., Abbott, A., Doyle, P.S., Nader, G.A., Larson, S., 2010. A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. Nutrition Journal 9, 10.

Doyle, W., Crawford, M.A., Wynn, A.H.A., Wynn, S.W., 1989. Maternal nutrient intake and birth weight. Journal of Human Nutrition and Dietetics 2, 407–414.

Eaton, S.B., Konner, M., 1985. Paleolithic nutrition – a consideration of its nature and current implications. The New England Journal of Medicine 312, 283–289.
Eaton, S.B., Konner, M.J., Cordain, L., 2010. Diet-dependent acid load, paleolithic nutrition, and evolutionary health promotion. The American Journal of Clinical Nutrition 91, 295–297.
Farhang, B., 2007. Nanotechnology and lipids. Lipid Technology 19, 132–135.
First Data Bank, 2000. Nutritionist v Nutrition Software, Version 2.3. First Data Bank, San Bruno, CA.
Gao, S.J., Jin, Y.L., Hall, K.S., et al., 2007. Selenium level and cognitive function in rural elderly Chinese. American Journal of Epidemiology 165, 955–965.
Gartner, L.M., Morton, J., Lawrence, R.A., et al., 2005. Breastfeeding and the use of human milk. Pediatrics 115, 496–506.
Georgieff, M.K., 2007. Nutrition and the developing brain: nutrient priorities and measurement. The American Journal of Clinical Nutrition 85, 614S–620S.
Gomez-Pinilla, F., 2008. Brain foods: the effects of nutrients on brain function. Nature Reviews. Neuroscience 9, 568–578.
Graveland-Bikker, J.F., De Kruif, C.G., 2006. Unique milk protein based nanotubes: food and nanotechnology meet. Trends in Food Science and Technology 17, 196–203.
Harker, R., 2012. NHS funding and expenditure. House of Commons Library - Standard Note: SN/SG/724. http://www.parliament.uk/business/publications/research/briefing-papers/SN00724.
Harun, R., Singh, M., Forde, G.M., Danquah, M.K., 2010. Bioprocess engineering of microalgae to produce a variety of consumer products. Renewable and Sustainable Energy Reviews 14, 1037–1047.
Helland, I.B., Smith, L., Saarem, K., Saugstad, O.D., Drevon, C.A., 2003. Maternal supplementation with very-long-chain *n*-3 fatty acids during pregnancy and lactation augments children's IQ at 4 years of age. Pediatrics 111, e39–e44.
Hibbeln, J., Davis, J., Steer, C., et al., 2007. Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): an observational cohort study. Lancet 369, 578–585.
Horta, B.L., Bahl, R., Martinés, J.C., Victora, C.G., 2007. Evidence on the long-term effects of breastfeeding: systematic reviews and meta-analysis. World Health Organization, Geneva, Switzerland.
Hsieh, Y.H.P., Ofori, J.A., 2007. Innovations in food technology for health. Asia Pacific Journal of Clinical Nutrition S16, 65–73.
Klemm, D., Kramer, F., Moritz, S., et al., 2011. Nanocelluloses: a new family of nature-based materials. Angewandte Chemie International Edition 50 (24), 5438–5466.
Klemm, D., Schumann, D., Kramer, F., et al. (Eds.), 2006. Nanocelluloses as innovative polymers in research and application. In: Polysaccharides II, vol. 205. Springer, Berlin/Heidelberg.
Johnston, C.S., Tjonn, S.L., Swan, P.D., 2004. High-protein, low-fat diets are effective for weight loss and favorably alter biomarkers in healthy adults. The Journal of Nutrition 134, 586–591.
Jonsson, T., Ahrén, B., Pacini, G., et al., 2006. A Paleolithic diet confers higher insulin sensitivity, lower C-reactive protein and lower blood pressure than a cereal-based diet in domestic pigs. Nutrition and Metabolism 3, 39.
Jones, S., 2009. Genetic 'magic bullet' cures have proven a 'false dawn'. Daily Telegraph. http://www.telegraph.co.uk/science/science-news/5190914/Genetic-magic-bullet-cures-have-proven-a-false-dawn.html (21.04.2009).
Lands, B., 2009. False profits and silent partners in health care. Nutrition and Health 20, 79–89.
Layman, D.K., 2003. The role of leucine in weight loss diets and glucose homeostasis. The Journal of Nutrition 133, 261S–267S.
Ledikwe, J.H., Blanck, H.M., Kettel Khan, L., et al., 2006. Dietary energy density is associated with energy intake and weight status in US adults. The American Journal of Clinical Nutrition 83, 1362–1368.
Liu, L., Liu, C.C., Li, J.L., 2012. Comparison of biochemical composition and nutritional value of Antarctic krill (Euphausia Superb) with several species of shrimps. Advanced Materials Research 361–363, 799–803.
Marsh, D., 2012. Darwin's passionate environmentalism or the dangerous fallacy of the 'All-sufficiency of natural selection' theory. Nutrition and Health 21, 76–90.
Moreno, C., Laje, G., Blanco, C., Jiang, H., Schmidt, A.B., Olfson, M., 2007. National trends in the outpatient diagnosis and treatment of bipolar disorder in youth. Archives of General Psychiatry 64, 1032–1039.

Murray-Kolb, L.E., Beard, J.L., 2007. Iron treatment normalizes cognitive functioning in young women. The American Journal of Clinical Nutrition 85, 778–787.
Neethirajan, S., Jayas, D.S., 2011. Nanotechnology for the food and bioprocessing industries. Food and Bioprocess Technology 4 (1), 39–47.
Norton, J., Fryer, P., Parkinson, J., Cox, P., 2009. Development and characterisation of tempered cocoa butter emulsions containing up to 60% water. Journal of Food Engineering 95 (1), 172–178.
Nurse, J., 2008. Mental health – new horizons after the national service framework. Westminster Health Forum Keynote Seminar 17th July 2008. Westminster Health Forum, London.
Odea, K., 1984. Marked improvement in carbohydrate and lipid-metabolism in diabetic Australian aborigines after temporary reversion to traditional lifestyle. Diabetes 33, 596–603.
Odea, K., Traianedes, K., Ireland, P., et al., 1989. The effects of diet differing in fat, carbohydrate, and fiber on carbohydrate and lipid-metabolism in type-II diabetes. Journal of the American Dietetic Association 89, 1076–1086.
Office for National Statistics (2011) Statistical Bulletin. Regional, sub-regional and local Gross Value Added 2010. http://www.ons.gov.uk/ons/rel/regional-accounts/regional-gross-value-added–income-approach-/december-2010/stb-regional-gva-dec-2011.html.
Ortiz, J., Romero, N., Robert, P., et al., 2006. Dietary fiber, amino acid, fatty acid and tocopherol contents of the edible seaweeds *Ulva lactuca* and *Durvillaea antarctica*. Food Chemistry 99, 98–104.
Pembrey, M.E., Bygren, L.O., Kaati, G., et al., 2006. Sex-specific, male-line transgenerational responses in humans. European Journal of Human Genetics 14, 159–166.
Rajasingam, D., Seed, P.T., Briley, A.L., Shennan, A.H., Poston, L., 2009. A prospective study of pregnancy outcome and biomarkers of oxidative stress in nulliparous obese women. American Journal of Obstetrics and Gynecology 200, 395 e1–9.
Rees, G., Doyle, W., Srivastava, A., Brooke, Z.M., Crawford, M.A., Costeloe, K.L., 2005. The nutrient intakes of mothers of low birth weight babies-a comparison of ethnic groups in East London, UK. Maternal & Child Nutrition 1, 91–99.
Robson, A., 2006. Shellfish view of omega-3 and sustainable fisheries. Nature 444, 1002.
Robson, A.A., 2009. Preventing diet induced disease: bioavailable nutrient-rich, low-energy-dense diets. Nutrition and Health 20, 135–166.
Robson, A.A., 2010a. Creating convenience food based on human nutritional requirements. Azo Nanotechnology 2635, 336–361.
Robson, A.A., 2010b. Nanotechnologies and food: 1st report of session 2009–10. In: House of Lords Papers 22-II 2009–10. Evidence, vol. 2. The Stationery Office, London, pp. 336–361.
Robson, A.A., 2011. Food nanotechnology: water is the key to lowering the energy density of processed foods. Nutrition and Health 20 (3–4), 231–236.
Robson, A. A., 2012. Tackling obesity: can food processing be a solution rather than a problem? Agro Food Industry Hi-Tech 23(2 monographic supplement series: Weight Management), 10–11.
Robson, A.A., 2013a. Chocolate bars based on human nutritional requirements. In: Watson, R.R., Preedy, V.R., Zibadi, S. (Eds.), Chocolate in Health and Nutrition. In: Nutrition and Health, vol. 7. pp. 143–148. Humana Press, New York. DOI http://dx.doi.org/10.1007/978-1-61779-803-0_12.
Robson, A.A., 2013b. Preventing the epidemic of non-communicable diseases: an overview. In: Watson, R.R., Preedy, V.R. (Eds.), Bioactive Food as Dietary Interventions for Liver and Gastrointestinal Disease. Academic Press, San Diego
Seino, Y., Seino, S., Ikeda, M., Matsukura, S., Imura, H., 1983. Beneficial-effects of high protein-diet in treatment of mild diabetes. Human Nutrition. Applied Nutrition 37, 226–230.
Skov, A.R., Toubro, S., Ronn, B., Holm, L., Astrup, A., 1999. Randomized trial on protein vs carbohydrate in ad libitum fat reduced diet for the treatment of obesity. International Journal of Obesity 23, 528–536.
Spinillo, A., Stronati, M., Ometto, A., Fazzin, E., Lauzin, G., Guaschino, S., 1993. Infant neurodevelopmental outcome in pregnancies complicated by gestational hypertension and intrauterine growth-retardation. Journal of Perinatal Medicine 21, 195–203.
Stubbs, R.J., 1998. Appetite, feeding behaviour and energy balance in human subjects. The Proceedings of the Nutrition Society 57, 341–356.
Tafti, M., Ghyselinck, N.B., 2007. Functional implication of the vitamin A signaling pathway in the brain. Archives of Neurology 64, 1706–1711.

Takeda, A., 2003. Manganese action in brain function. Brain Research Reviews 41, 79–87.
Tassoni, D., Kaur, G., Weisinger, R.S., Sinclair, A.J., 2008. The role of eicosanoids in the brain. Asia Pacific Journal of Clinical Nutrition 17 (supplement 1), 220–228.
Tolfree, D., Smith, A., 2009. Roadmapping Emergent Technologies. Matador, Leicester.
Torrey, E.F., Miller, J., 2002. The Invisible Plague: The Rise of Mental Illness from 1750 to the Present. Rutgers University Press, New Jersey.
Van de Berg, D.J., Huitinga, I., Hol, E.M., 2010. Longterm quiescent cells in the aged human subventricular neurogenic system specifically express GFAP-δ. Aging Cell 9 (3), 313–326. http://dx.doi.org/10.1111/j.1474-9726.2010.00556.x.
Veldhorst, M., Smeets, A., Soenen, S., et al., 2008. Protein-induced satiety: effects and mechanisms of different proteins. Physiology and Behavior 94, 300–307.
Wang, Y., Lehane, C., Ghebremeskel, K., Crawford, M.A., 2010. Modern organic and broiler chickens sold for human consumption provide more energy from fat than protein. Public Health Nutrition 13, 400–408.
Westerterp-Plantenga, M.S., Lejeune, M., Nijs, I., van Ooijen, M., Kovacs, E.M.R., 2004. High protein intake sustains weight maintenance after body weight loss in humans. International Journal of Obesity 28, 57–64.
World Health Organization, 2002. Global strategy for infant and young child feeding. Report by the secretariat (A55/15, paragraph 10, page 5) 16 April 2002. World Health Organization, Geneva, Switzerland.
World Health Organization, 2010. Promoting proper feeding for infants and young children. http://www.who.int/nutrition/topics/infantfeeding/en/.
Wynn, S.W., Wynn, A.H.A., Doyle, W., Crawford, M.A., 1994. The association of maternal social class with maternal diet and the dimensions of babies in a population of London Women. Nutrition and Health 9, 303–315.

RELEVANT WEBSITES

http://www.mccarrisonsociety.org.uk/ – The McCarrison Society for Nutrition and 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.