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by Dr. Anthony Robson

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Diet induced disease is epidemic. Worldwide because the changing food system has ignored the nutrient requirements of people. High energy density and low nutrient density which characterise the modern diet must be overcome simultaneously. Overweight and obese people can develop paradoxical nutritional deficiency from eating high energy dense foods with a poor nutrient content[1].

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[2]. A convenience food which is not both low energy dense and high nutrient dense dilutes the diet of the low energy dense foods of high nutrient density that humans should eat: the most nutritious cooked wild plant and animal foods for humans[1, 3-6].

Our ancestral exemplar is the late Palaeolithic diet i.e. a wild plant-to-animal energy intake ratio ~1:1, with fish and shellfish providing a significant proportion of the animal component[7]. However, many foods consumers may consider natural are not due to agriculture, animal husbandry and food processing. Furthermore, the focus on just reducing dietary fat[8,9] 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 I).

Table 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
Chocolate, dark (19904)	6.0	0	119	33	2280	730	0.003	0.4	0
Oat breakfast bar	4.6	0	32	16	1010	600	0	3.5	10

(43100)									
Cheese, cheddar (01009)	4.0	0	7	31	280	7210	0.008	0.7	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)	2.0	0	17	47	220	190	0.015	5.5	0
Beef brain, cooked (13320)[d]	1.5	8550	23	11	120	90	0.101	1.4	105
Clam meat, cooked (15159)[d]	1.5	2840	280	27	180	920	0.989	1.1	221
Egg, poached (01131)[e]	1.4	410	18	11	120	530	0.013	1.2	0
Oyster meat, eastern, wild, cooked (15169)[d]	1.4	11200	120	1816	950	900	0.35	1.2	60
Water buffalo meat, wild, roasted (17161)	1.3	0	21	25	330	150	0.018	4.6	0
Shrimp meat, cooked (15151)[d]	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
Celery, boiled (11144)	0.2	0	4	1	120	420	0	0.9	61

Footnote:

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 anaemic, many due to iron deficiency[10].

[b] Soybean oil provides 20% of all calories in the median USA diet[11].

[c] Fortified with nutrients.

[d] Food with a high natural nutrient content and a low energy density

[e] Vitamin B12 in eggs is poorly absorbed relative to other foods containing B12[12].

Molecular recognition is biology's building strategy and key to nanotechnology: biomolecules e.g. self-assembled, water-filled, edible nanocells and nanotubes that self-organise into more complex structures[13]. Using molecular recognition convenience foods can be created in a more natural, low energy dense way i.e. with high water content [13].

For example, molecular recognition can be used to structure a chocolate biscuit bar (solid convenience food) similar to a celery stalk, to increase its water and fiber content which will substantially lower its energy density (<1.6 kcal g^{-1}). This would allow the same amount of food to feed more people, increasing food security. Celery stalk cells are pressurised with water causing the entire plant to become turgid and stiff.

Food technologists can harness this natural turgor force to produce a firm chocolate bar, biscuit or breakfast cereal with a good bite while looking and tasting the same as before, to aid public acceptance[13]. Water carries flavour with few calories e.g. a cup of tea without milk = 0.01 kcal g^{-1} and taste sensation per mouthful can be improved using the principles of Ultrafine food technology (Eminate Limited, Nottingham, UK); processing food on the nanoscale to increase the surface area that is in contact with taste and smell receptors.

The bioavailable nutrient content including cofactors of convenience foods must mimic and improve on the nutritional value of the most nutritious cooked wild foods for humans and can be increased using existing bioactive nanoencapsulation[13]. Algal 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[14,15]. 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[16].

It is important to consider not only the energy content of the modern diet but also the energetic cost of its assimilation. A reduction in liquid calorie intake has been found to have a stronger effect than a reduction in solid calorie intake on weight loss[17]. Sugar sweetened beverages (SSBs) require little digestion. Glucose and fructose can be directly absorbed into the bloodstream without digestion.

Functional foods are required to simultaneously satisfy the 'sweet tooth' that the modern diet has created, and have a significantly higher energetic assimilation cost compared to today's sugar sweetened foods. This can be achieved by adding protein and fiber to e.g. SSBs, honey, syrup, jam, cereal products and ice cream (Table II)[13].

Table 2. Sugar, protein and fiber content of a selection of sweet foods and drinks (value per 100 grams)

	Sugar (g)	Protein (g)	Fiber (g)
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
Toffee sweets (19383)	63.5	1.1	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)	26.7	0.0	0.0
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

Footnote:

Entries retrieved from the USDA National Nutrient Database for Standard Reference, Release 22 (2009) and a identified by a 5-digit nutrient database number in parentheses. The typical modern diet has a fiber content o g day^{-1}[18] which is considerably lower than the recommended value of 25-38 g day^{-1} [19] or the estimated ance intake of >70 g day^{-1} [20].

Protein has more than three times the thermic effect of either fat or carbohydrate[21] and because it has a greater satiety value than fat or carbohydrate[21,22], a high protein diet (protein and carbohydrate intake both being approximately one third of total energy intake) is of vital importance as a weight-loss strategy for the overweight or obese and for weight maintenance[1,23].

Clinical trials have shown that calorie-restricted, high-protein diets are more effective than are calorie-restricted, high-carbohydrate diets in promoting[24-26] and maintaining[27] weight loss in overweight subjects, while producing less hunger and more satisfaction[28]. Furthermore, high protein diets have been shown to improve metabolic control in patients with type 2 diabetes[29-31]. Some protein based nanotubes are food-grade materials[32] and can increase protein consumption at the expense of lowered carbohydrate.

Cooking has obvious beneficial effects by increasing food safety and improving diet quality[33]. 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 kcal g^{-1} 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 in to the working of these processes and how to manipulate, prevent and/or enhance them for the benefit of mankind. Emergent technologies can and must help correct the food system by creating modern convenience foods on a mass scale that mimic and improve on the nutritional value of the most nutritious cooked wild foods for humans. Thus, helping to prevent mental ill health, heart disease, cancer, obesity and other postprandial insults[1,4].

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