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The food matrix: Is it time to rethink how we evaluate the health effects of food?

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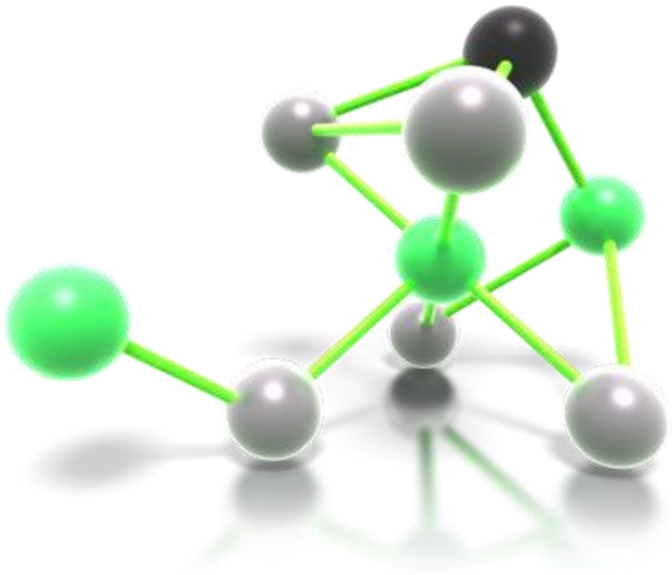
- Background – holistic and reductionist approaches to nutrition research
- The food matrix
- The dairy matrix
- Conclusion

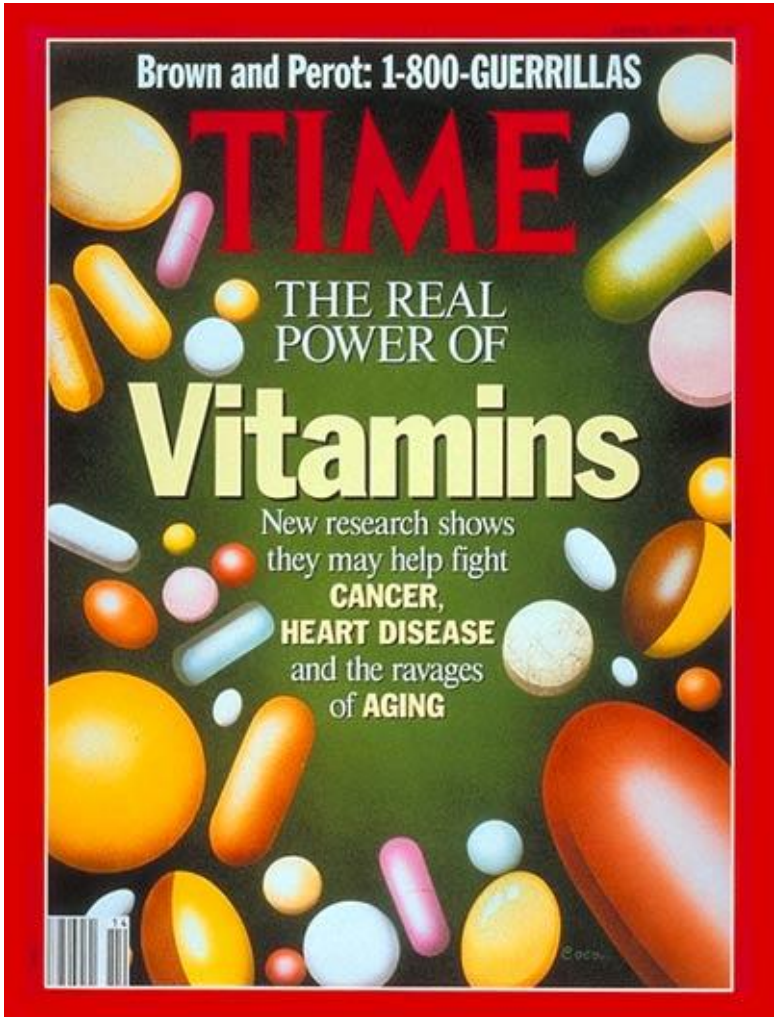


Early nutrition research

- **Earliest nutrition research** focused on the role of ***individual nutrients*** in relation to maintenance of health and prevention of disease – termed a **'reductionist' approach**
- **Responsible for many of the major advances in nutrition science, e.g:**
  - eradication of vitamin deficiencies
  - discovery of the role of folic acid in closure of the neural tube
  - establishing RDAs/DRVs

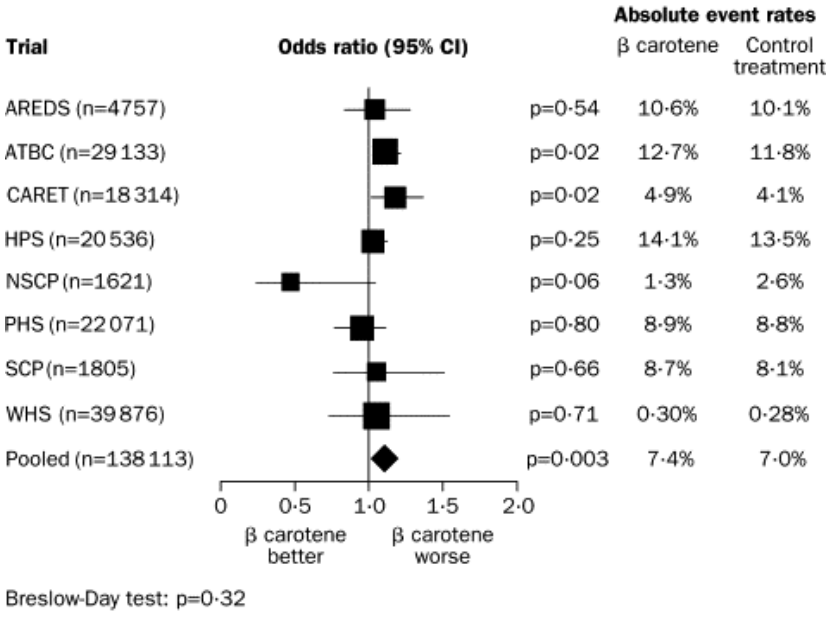
The '90s – the promise of antioxidants….

6 April 1992

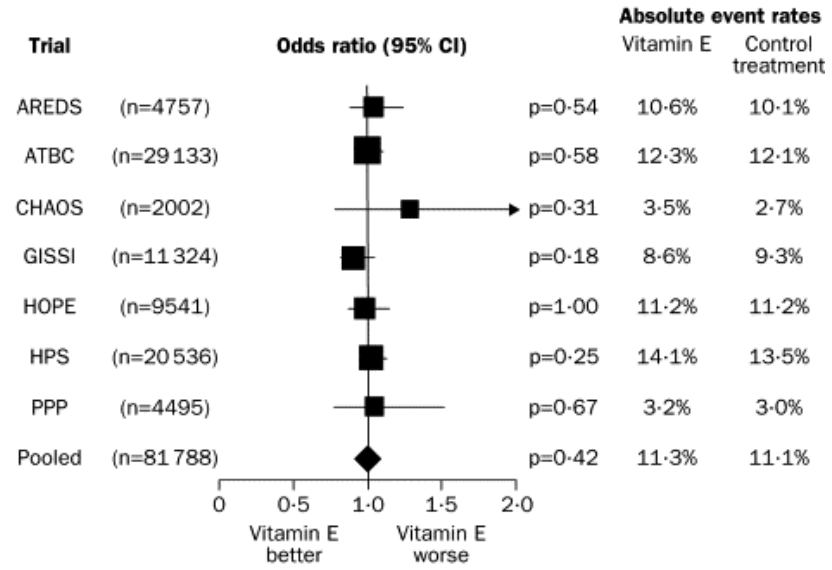


http://content.time.com/time/covers/0,16641,19920406,00.html

Antioxidant supplementation and CVD – ten years on…..



Breslow-Day test: p=0·32



Breslow-Day test: p=0·63

β-carotene

Vitamin E

No effect of antioxidant supplementation on CVD endpoints

Vivekananthan et al., 2003 Lancet. 2003 Jun 14;361(9374):2017-23. Use of antioxidant vitamins for the prevention of cardiovascular disease: meta-analysis of randomised trials.

Why did clinical trials show no effect of antioxidant supplementation?

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Trial design	Dose Duration of treatment Initial antioxidant levels Dietary intake Extent and distribution of existing atherosclerosis
Antioxidants used	**Do single antioxidants behave differently out with the food matrix e.g. whole fruit and vegetables more effective?**
Confounding	Other lifestyle behaviours, e.g. high intake of antioxidants associated with physical activity, smoking and social class; unmeasured confounding

Supplements and chronic disease – there is no magic bullet……

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"the effect on diseases with long latency periods of pharmacological doses of specific micronutrients over a few years in middle-aged adults is a different scenario from physiological doses of the same micronutrients provided as part of a balanced diet on a lifelong basis, starting in childhood."

Forman D(1), Altman D. Vitamins to prevent cancer: supplementary problems. Lancet. 2004 Oct 2-8;364(9441):1193-4.

Reductionist approach - limitations

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- **Possible limitations**:
  - Discrepancy between observational and clinical trials
  - Public association of a food with only one nutrient

e.g:
Milk + calcium
Oranges + vitamin C
Cheese + saturated fat

Fardet & Rock, Adv Nutr 2014;5:430-446

Reductionist approach - limitations

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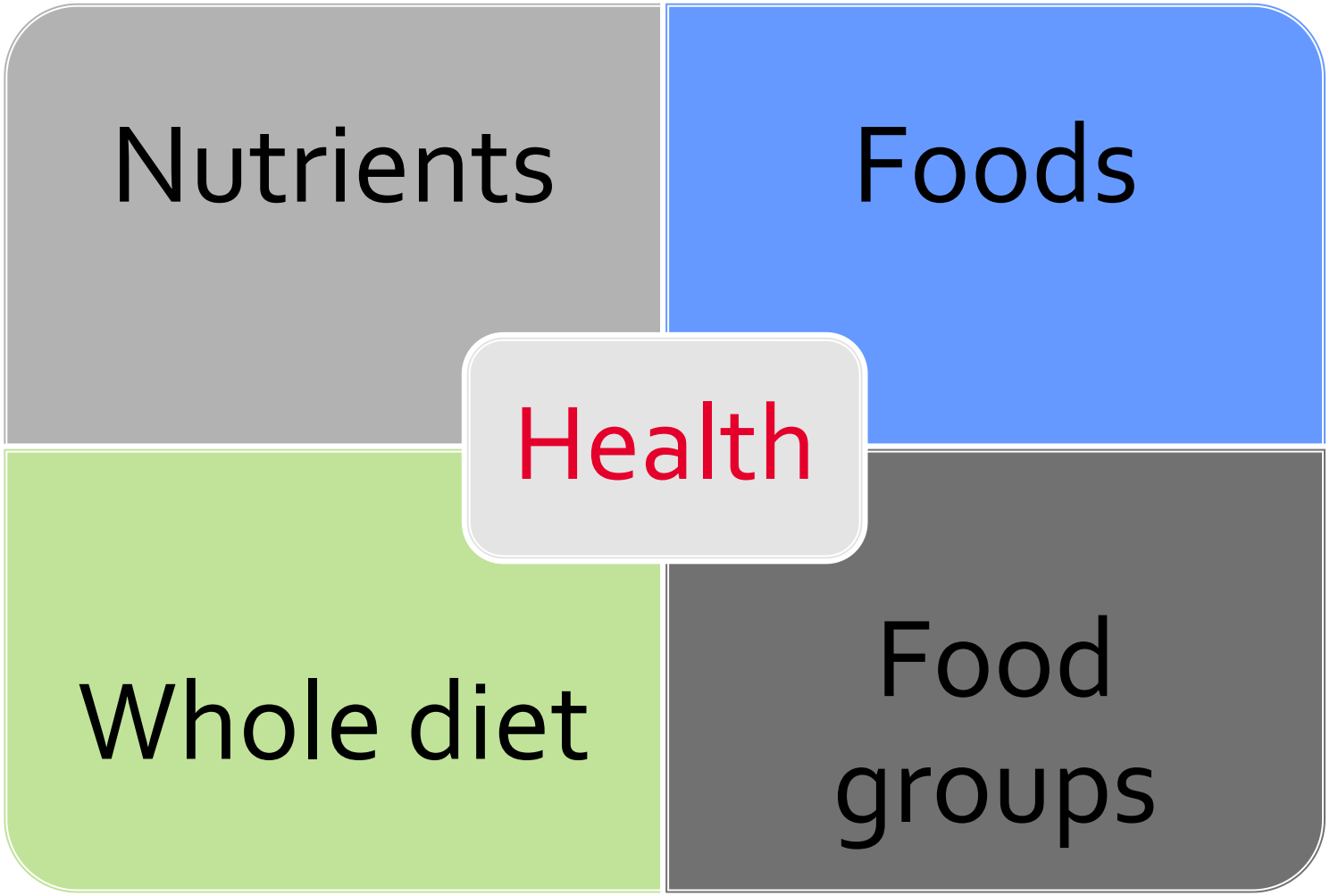
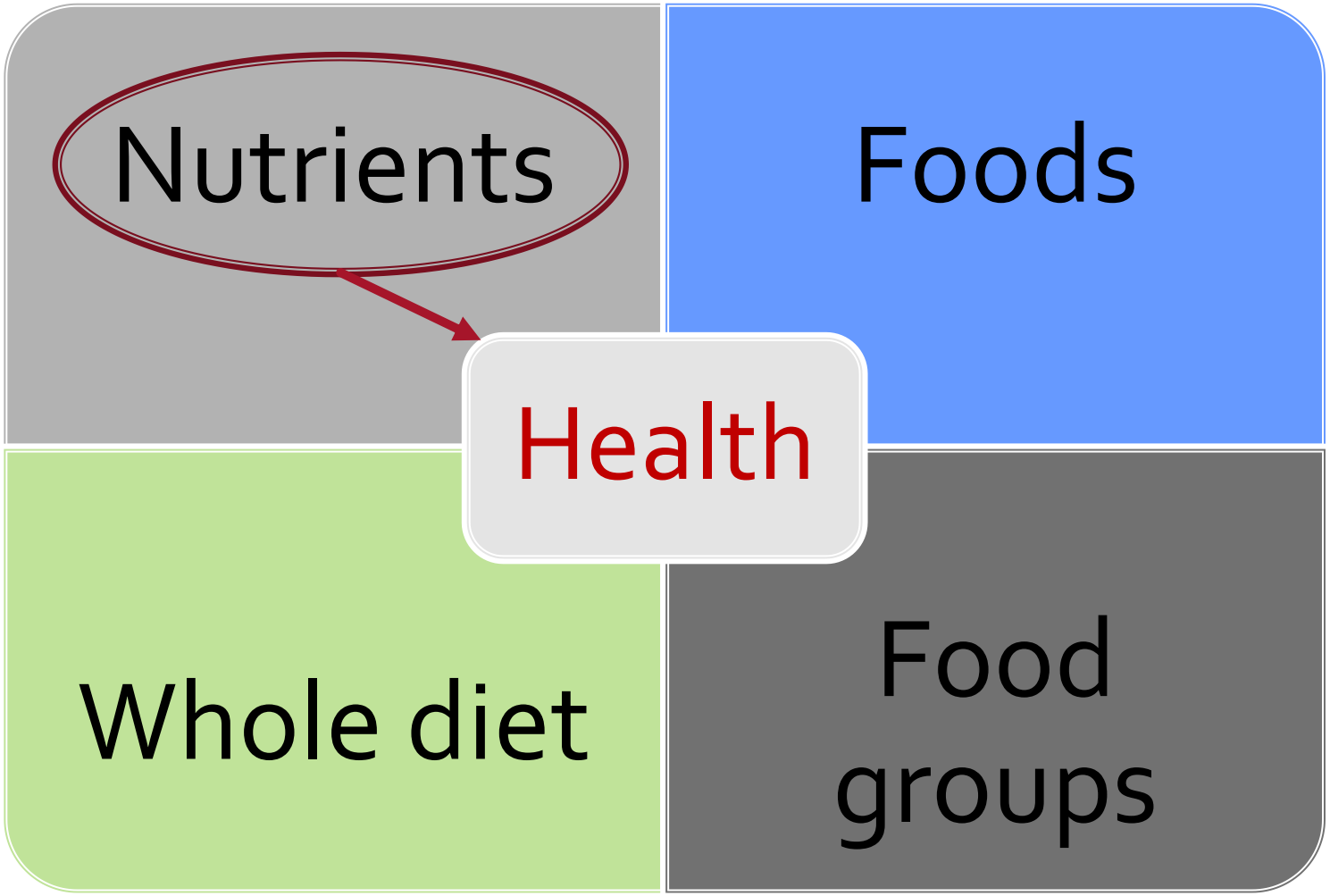
- **Possible limitations**:
  - Discrepancy between observational and clinical trials
  - Public association of a food with only one nutrient
  - **Oversimplification of nutrition** – leading to classification of some foods as 'super foods' because of one piece of information about its nutrient content and some foods demonised for the same reason

Fardet & Rock, Adv Nutr 2014;5:430-446

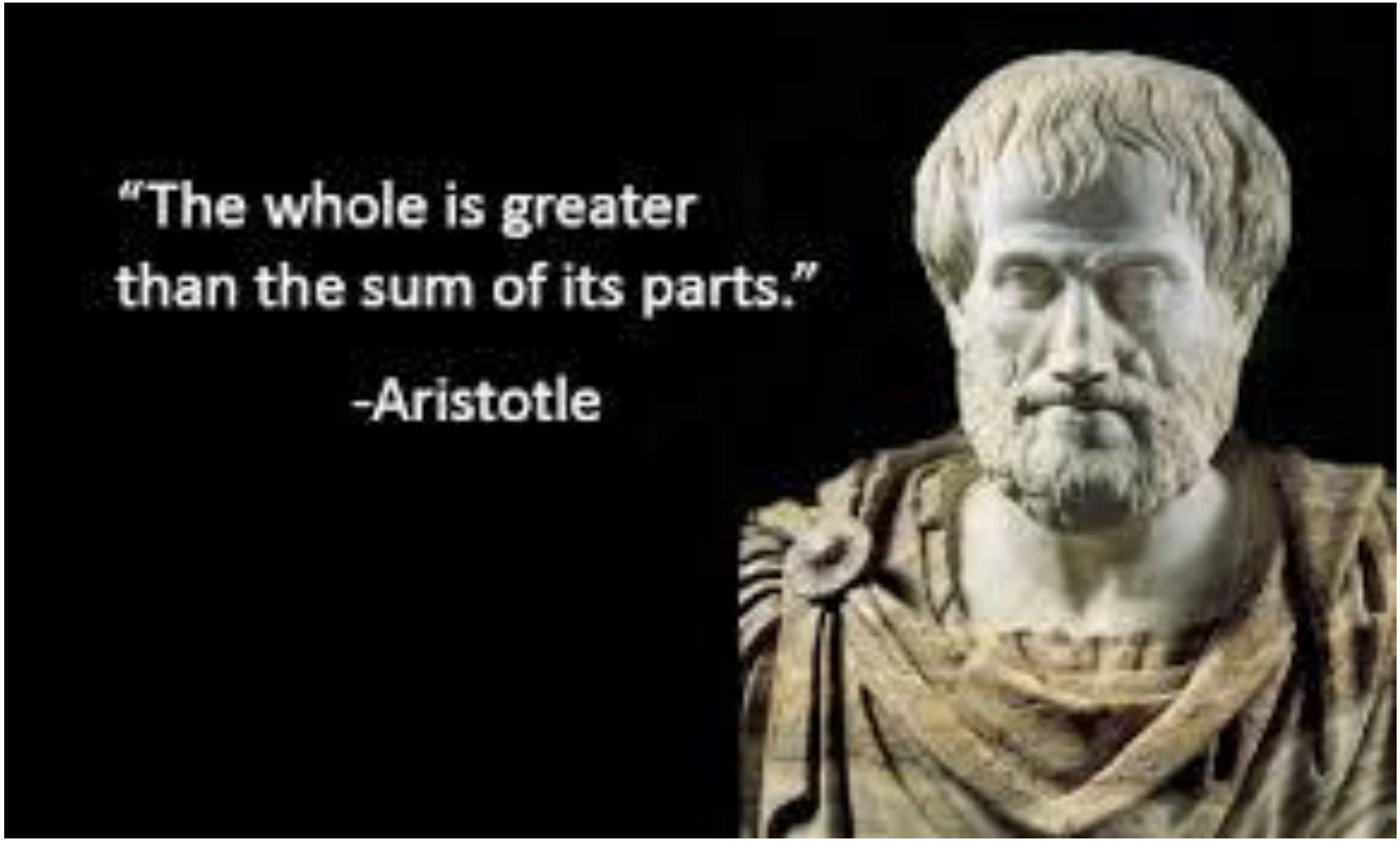

Nutrients
Foods
Health
Whole diet
Food groups


Nutrients
Foods
Health
Whole diet
Food groups

Recent nutrition research

- **Earliest nutrition research** focused on **a reductionist approach…….**
- **More recently**, approaches that seek to understand the unique features of **foods, food groups and whole dietary patterns** have emerged as a ***complementary*** approach to advancing nutrition science - **a more holistic stance**

Holistic approaches acknowledge that:



What is the food matrix?

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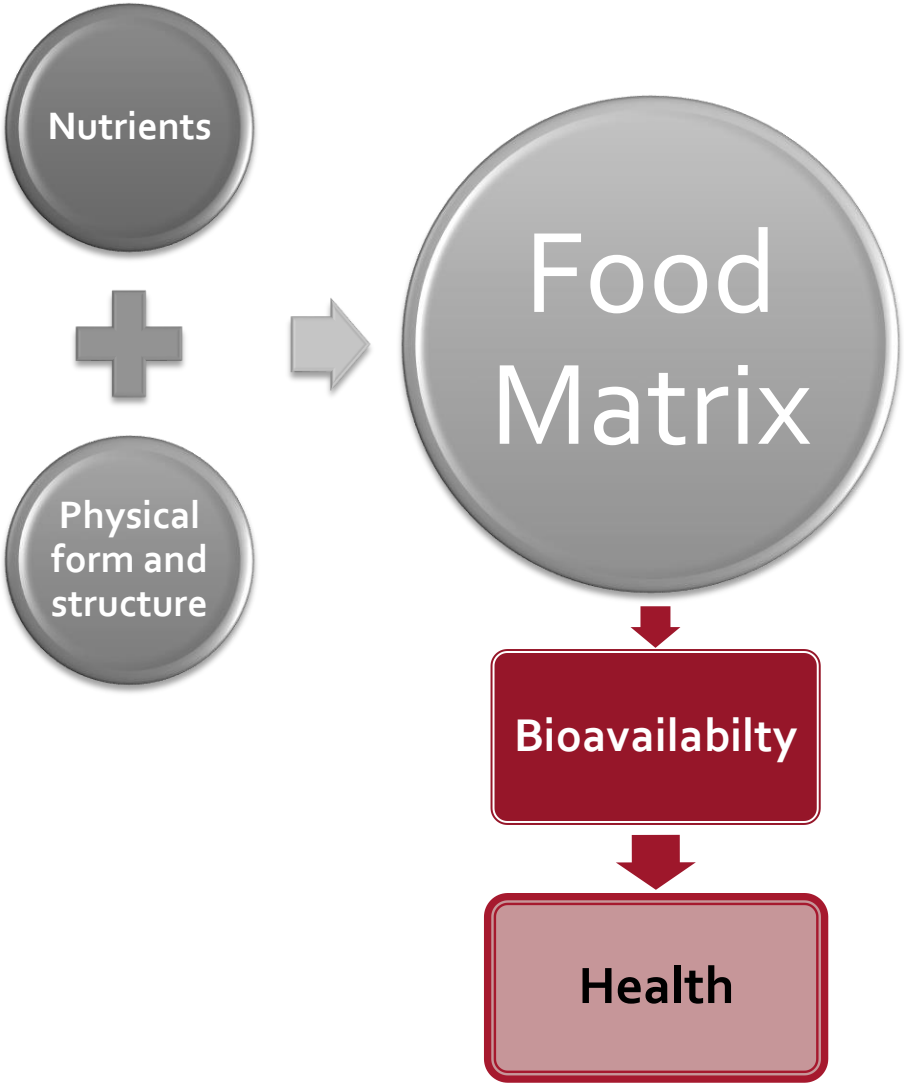
Foods consist of a large number of nutrients that are contained in a complex physical structure.
The nature of the food structure and the nutrients therein (i.e., the food matrix) will determine the nutrient digestion and absorption, thereby altering the overall nutritional and health properties of the food.



The food matrix – affects nutrient bioavailability

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Carotenoids in carrots - present in either crystalline form or bound to proteins, within chromoplasts - disruption of the cell wall is needed to release them.

Bioavailability (the fraction of the ingested nutrient that is available for absorption and for metabolic processes) of carotenoids in carrots prepared in a number of different ways:

Form of carrots	Total carotenoids recovered
Raw, bitesize chunks	3%
Cooked, bitesize chunks	6%
Pulped, raw	21%
Pulped, cooked with rapeseed oil	39%

Hedren E, Diaz V, Svanberg U. Eur J Clin Nutr 2002;56:425-430

Almonds

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Nuts are an energy dense food

So incorporating them into the diet is likely to be associated with weight gain?

Observational and RCTs consistently demonstrate that nut consumption is not associated with weight gain.....why?

Discrepancy between the Atwater factor predicted and empirically measured energy values of almonds[1–4]

Janet A Novotny, Sarah K Gebauer, and David J Baer

Am J Clin Nutr 2012;96:296-301

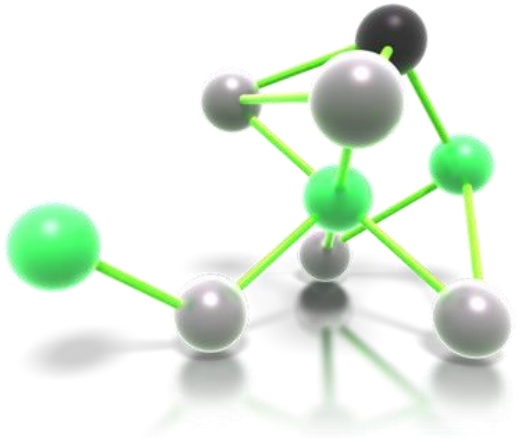
Digestibility of fat from whole nuts may be lower than that for other foods:

- Estimated energy content almonds 170 kcal/ 28g serving .
- The energy content of almonds in the human diet was found to be 129 kcal/ 28g serving.
- The Atwater factors, when applied to almonds, resulted in a 32% overestimation of their measured energy content.

The dairy matrix

Dairy matrix hypothesis

The health effects of dairy foods are a function of the interaction between the physical structure of the food and the nutrient and bioactive constituents within it, meaning that the whole is greater than the sum of the parts.



Dairy products are not all the same….

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TABLE 2
Bioactive components and supramolecular structures in different dairy products[1]

	Calcium, mg/100 g	Phosphorus, mg/100 g	MFGM,[2] mg/100 g	Protein,[3] g/100 g, type	Fermented	Fat structure[4]	Protein network
Cheese[5] (25% fat)	659	510	150	23.2, Casein	Yes	MFG/aggregates/free fat	Solid/viscoelastic
Milk (skimmed, 0.5% fat)	124	97	15	3.5, Whey/casein	No	Tiny native MFG/potential MFGM fragments	Liquid
Milk (whole, 3.5% fat)	116	93	35	3.4, Whey/casein	No	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Liquid
Yogurt (1.5% fat)	136	99	15	4.1, Whey/casein	Yes	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Gel/viscoelastic
Cream (38% fat)	67	57	200	2, —	No	Native MFG or homogenized milk fat droplets/potential MFGM fragments	Liquid
Butter	15	24	—	<1, —	No/yes[6]	Continuous fat phase (water-in-oil emulsion)/MFGM-residue traces	—

[1] All values are approximate amounts. MFG, milk-fat globule; MFGM, milk-fat globule membrane.
[2] General estimation on the basis of Dewettinck et al. (11) and Conway et al. (12).
[3] According to food-composition tables from The Technical University of Denmark (13).
[4] General estimation on the basis of Michalski (14) and Michalski et al. (15) and references therein.
[5] Semihard Danbo type, as a point example among many different cheese types.
[6] Depends on the production method used. With indirect biological acidification, starter culture is added to the butter after churning.

Thorning et al; 2017, Am J Clin Nutr.
Whole dairy matrix or single nutrients in assessment of health effects: current evidence and knowledge gaps

A heterogeneous food group.....

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Milk

- Fat
- Protein

Cheese

- Bacterial cultures
- Ripening/aging
- Fat
- Protein

Yogurt

- Bacterial cultures
- Fat
- Sugar

A heterogeneous food group.....

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Milk

Fat

Protein

Cheese

Bacterial cultures

Ripening/aging

Fat

Protein

Yogurt

Bacterial cultures

Fat

Sugar

PLUS

- Variations in physical structure – e.g. liquid, gel, solid……

One approach to studying the effect of the dairy matrix

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Dairy food

Vs

A constituent of dairy – calcium, vit D, fat

Weight management

Dairy matrix effect - Weight

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Nutrition, Metabolism & Cardiovascular Diseases (2011) 21, 499–503

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/nmcd

Nutrition, Metabolism & Cardiovascular Diseases

Comparison of the effects of cows' milk, fortified soy milk, and calcium supplement on weight and fat loss in premenopausal overweight and obese women

Sh Faghih [a], A.R. Abadi [b], M. Hedayati [c], S.M. Kimiagar [a,*]

[a] *Department of Nutrition, Faculty of Nutrition Sciences and Food Technology, Arghavan Ave, Farahzadi Bulv, Tehran, Iran*
[b] *Department of Statistics, Faculty of Medicine, Evin, Tehran, Iran*
[c] *Obesity Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences,*

Faghih et al, 2011

- 100 healthy overweight/obese pre-menopausal women
- Randomised, 8 weeks, calorie-deficit diets:
  - Control diet – 500 kcal/d deficit
  - Calcium supplemented diet – 800 mg/d + 500kcal/d deficit
  - Milk diet – 3 servings/d + 500 Kcal/d deficit
  - Soy milk – 3 servings calcium fortified soy milk + 500 kcal/d deficit

Faghih et al, 2011

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Control	Soy milk	Ca supplement	Milk diet
2.87 ± 1.55 kg (3.8%)	3.46 ± 1.28 Kg (4.3%) (0.59 kg)	3.89 ± 2.40 kg (4.8%) (1.02 kg)	4.43± 1.93 kg* (5.8%) (1.56 kg)**

- Weight reductions after 8 weeks:
- **No significant differences** in changes in body weight and BMI between the soy milk or Ca suppl & control.
- *Reductions in weight and BMI were **significantly greater in the milk group compared to controls**.
- **Greatest changes were seen in high dairy group - **% weight loss in milk group was significantly greater than in soy milk group and controls.**

Bone health

Dairy matrix effect - Bone

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Am J Clin Nutr 2005;82:1115–26.

See corresponding CME exam on page 1147.

Effects of calcium, dairy product, and vitamin D supplementation on bone mass accrual and body composition in 10–12-y-old girls: a 2-y randomized trial[1–3]

Sulin Cheng, Arja Lyytikäinen, Heikki Kröger, Christel Lamberg-Allardt, Markku Alén, Arvo Koistinen, Qing Ju Wang, Miia Suuriniemi, Harri Suominen, Anitta Mahonen, Patrick HF Nicholson, Kaisa K Ivaska, Riitta Korpela, Claes Ohlsson, Kalervo H Väänänen, and Frances Tylavsky

ABSTRACT

Background: Little is known about the relative effectiveness of calcium supplementation from food or pills with or without vitamin D supplementation for bone mass accrual during the rapid growth period.

Objective: The purpose was to examine the effects of both food-based and pill supplements of calcium and vitamin D on bone mass

Calcium metabolism during childhood is complex, and the degree of positive calcium balance necessary to achieve maximum peak bone mass is not known. Recent studies have shown that calcium intake and skeletal modeling determine calcium balance during growth and that childhood is a time of high calcium requirements (1, 2). Calcium supplementation intervention studies in children have shown that daily supplementation

Cheng et al, 2005

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Cheese	Ca supplement	Ca + D supplement	Placebo

- N=195 healthy girls, habitual calcium <900mg/d
- **Cheese group** – significantly **higher percentage change in cortical thickness of tibia** than placebo *or* calcium *or* calcium + vitamin D group.
- Cheese group - also **higher whole-body bone mineral density** than placebo when compliance >50%.
- Cheese more beneficial for bone mass accrual than the use of Ca supplement.

Dairy matrix effect - Bone

The American Journal of Clinical Nutrition

Changes in biochemical indexes of bone metabolism and bone mineral density after a 12-mo dietary intervention program: the Postmenopausal Health Study[1–3]

Yannis Manios, George Moschonis, George Trovas, and George P Lyritis

ABSTRACT

Background: In southern Europe, calcium supplementation alone is a common practice for osteoporosis prevention.

Objective: We examined whether calcium supplementation could be as effective in achieving favorable bone mass changes in postmenopausal women as is a holistic dietary approach including dairy products fortified with calcium and vitamin D_3.

Design: A sample of 101 postmenopausal women were randomly assigned to a dairy intervention group ($n = 39$) who received daily ≈1200 mg Ca and 7.5 μg vitamin D_3 via fortified dairy products and attended biweekly nutrition education sessions; a calcium-supplemented group ($n = 26$) who received a total of 1200 mg Ca/d; and a control group ($n = 36$).

Results: The increases observed in serum concentrations of insulin-like growth factor I were greater in the dairy intervention group than in the 2 other groups, especially during the first 5 mo of intervention ($P = 0.034$). The decreases and increases observed during 5 and 12 mo, respectively, in serum 25-hydroxyvitamin D_3 were significant in all groups ($P = 0.050$). Serum parathyroid hormone increased only in the control group, and serum type 1 collagen cross-linked C-telopeptide decreased only in the dairy intervention group during both 5 and 12 mo of intervention ($P = 0.035$ and 0.047, respectively).

Greece has increased significantly: from 1977 to 1992, age-adjusted incidence in Greek persons aged >50 y increased by 80.9% (2).

The adequate intake of certain nutrients that are essential for bone metabolism, such as calcium and vitamin D, plays an important role in maintaining bone mass. With increasing age, however, both dietary calcium intake and intestinal calcium absorption decrease (3). Furthermore, in the elderly, serum concentrations of 25-hydroxyvitamin D_3 [25(OH)D_3] decline, mostly because of decreased sunlight (ultraviolet B irradiation) exposure, which leads to a limited capacity for cutaneous vitamin D synthesis (4). Combined with low dietary intake of vitamin D from staple foods, especially in countries without mandatory fortification policy (5), these factors contribute to lower concentrations of 25(OH)D_3 and consequently to accelerated bone loss and greater risk of bone fracture (6, 7). It has been reported that meeting daily dietary requirements of calcium and vitamin D produces a significant reduction in the incidence of bone fracture (8, 9).

Although low bone mineral density (BMD) has been identified as one of the stronger predictors of future bone fracture, the serum concentrations of several biomarkers of bone remodeling

Manios et al, 2007

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Dairy group

Ca supplement

Control

n=101 postmenopausal women

12 months

Am J Clin Nutr 2007; 86:781-9

Manios et al, 2007

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Dairy group

Ca supplement

Control

Dairy group – after 12 months - favourable changes in biochemical indexes of bone remodelling, calciotrophic hormones and in pelvis, total spine and total-body BMD were observed.

No favourable changes in either biochemical indexes or BMD in the **Ca supplement group.**

Am J Clin Nutr 2007; 86:781-9

Manios et al, 2005

"…..it has been suggested that the effect of dairy products on bone health may be greater than can be accounted for by any single constituent and that milk ingredients as a whole may be more effective than the sum of their individuals parts."

Dietary guidelines.....

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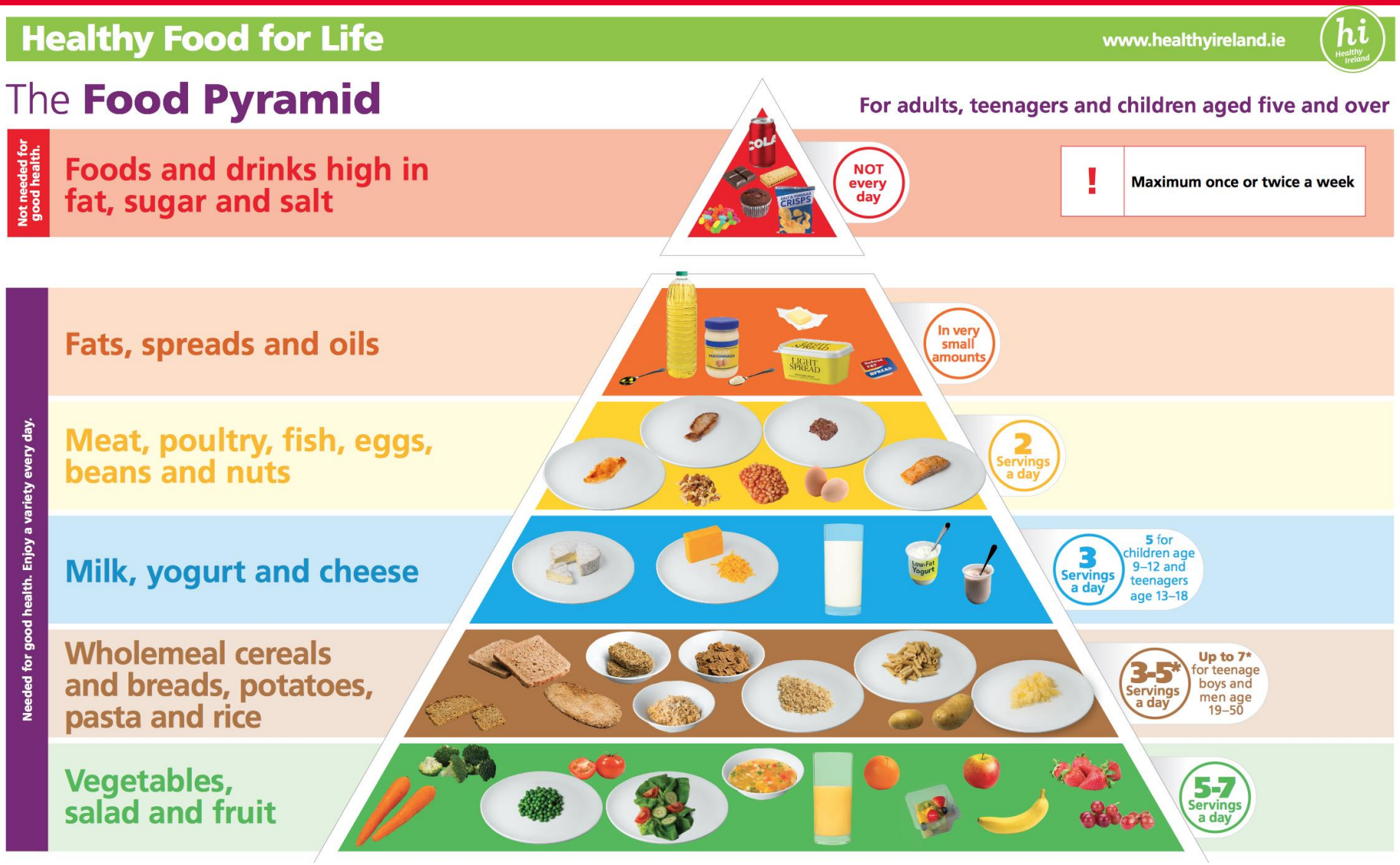

Is it time to rethink how we evaluate the health effects of food? **Yes**

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- Foods are complex **mixtures of nutrients** sitting within **unique physical structures**.
- **Foods and whole dietary patterns** have beneficial effects on health **that aren't seen with supplements**.
- Giving individual nutrients as supplements **cannot mimic the effects of the food matrix**.
- We also cannot assume that **taking a nutrient out of *one* food matrix and putting it into *another* food matrix** will result in the same health effects.
- **Consider all types of evidence** when formulating dietary guidelines - not considering food matrix effects **could result in reduced intake of foods that are important for preventing disease and improving health.**

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THANK YOU