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[info@iuns-icn2017.com](mailto:info@iuns-icn2017.com)

**SAN**  
Sociedad Argentina de Nutrición



# Physiology and psychology underlying food choices

**Adam Drewnowski, PhD**

Director

Center for Public Health Nutrition

UW Center for Obesity Research

Nutritional Sciences Program

Professor of Epidemiology, University of Washington, Seattle, WA, USA

Symposium ID 144/41.

Understanding Dietary Patterns: A step toward devising a global nutrition strategy

UNIVERSITY OF  
WASHINGTON  
**uwcpn**



CENTER FOR PUBLIC  
HEALTH NUTRITION

## Conflict of Interest Disclosure

*The development of nutrient density profiling systems (Naturally Nutrient Rich NNR and NRF9.3) was supported by the NNR Coalition 2004-2009.*

*The present results were not supported by any company.*



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POTATOES  
**GOODNESS**  
UNEARTHED



# Dietary Guidelines for Americans 1980 - 2015



1980



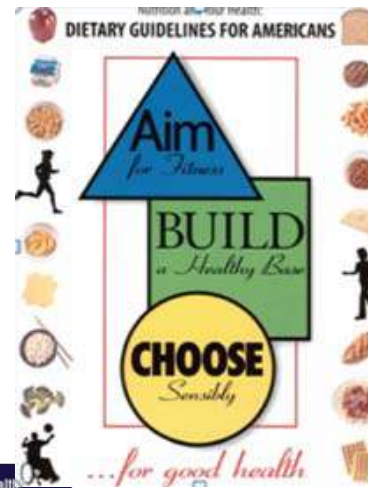
1985



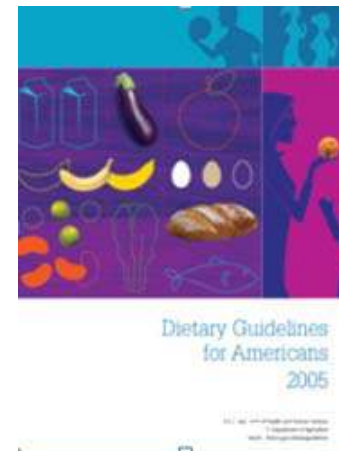
1990



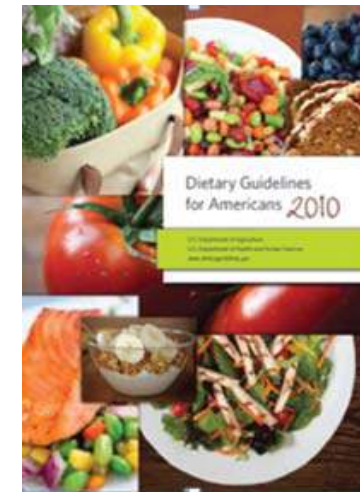
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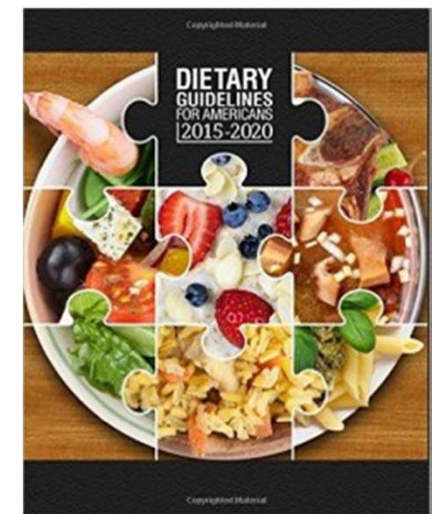
2000



2005



2010

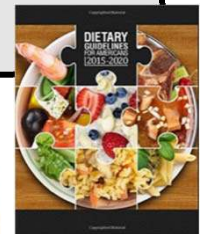
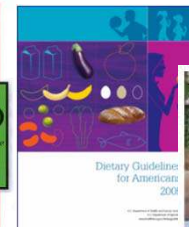
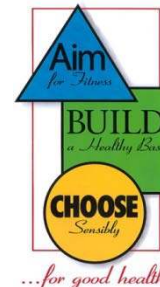
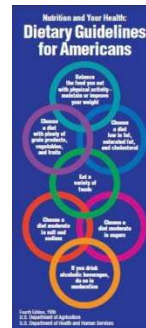
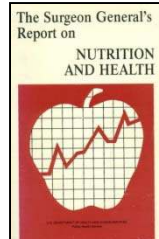
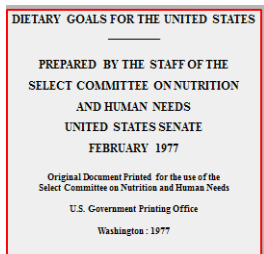


2015



# The 40 year DGAs fat-sugar seesaw

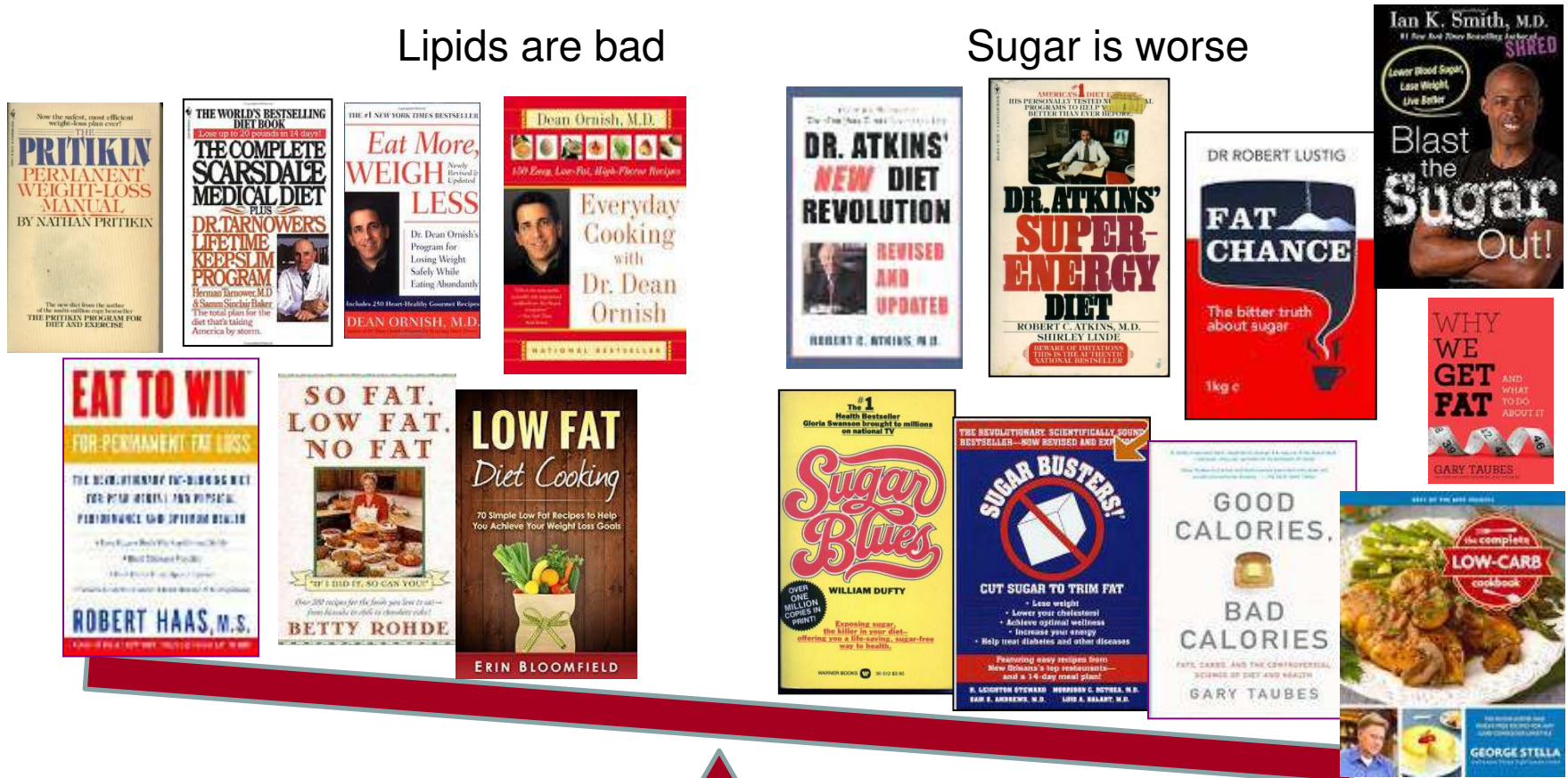
1977	1980	1985	1988	1990	1995	2000	2005	2010	2015
Grains	Variety	Variety	<b>Fat</b>	Variety	Weight	Weight	Variety	Weight	Weight
<b>Fat/chol</b>	Weight	Weight	Weight	Weight	Grains/ FV	Variety	<b>Fat/chol</b>	FV	Sugar
Sugar	<b>Fat</b>	<b>Fat</b>	Grains/f	<b>Fat</b>	<b>Fat</b>	Grains/ FV	Sugar	Sugar	Grains/ FV
Sodium	Grains/f	Grains/f	Sodium	Grains/ FV	Variety	<b>Fat</b>	Sodium	<b>Fat</b>	Sodium
	Sugar	Sugar	Alcohol	Sugar	Sodium	Sugar	Weight	Sodium	<b>Fat</b>
	Sodium	Sodium	Sugar	Sodium	Sugar	Sodium	Alcohol	Grains	Alcohol
	Alcohol	Alcohol		Alcohol	Alcohol	Alcohol			



# The diet books seesaw

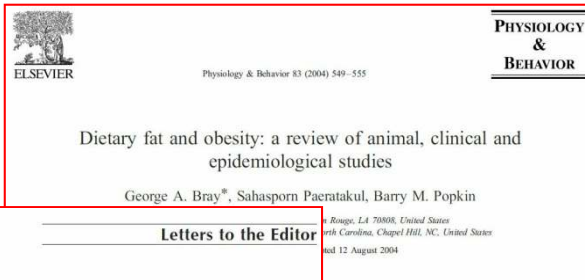
Lipids are bad

Sugar is worse



# The research seesaw

## Fat is bad



**Dietary fat affects obesity rate**

Dear Sir:

Recently, we published an earlier paper published in Determinant of Body Fat paper was also prepared because it was essential

We would expect this because we were looking at the effect of fat while controlling for energy intake, as we showed in the paper.

**Dietary fat intake does affect obesity!**<sup>1–3</sup>

George A. Bray and Barry M. Popkin

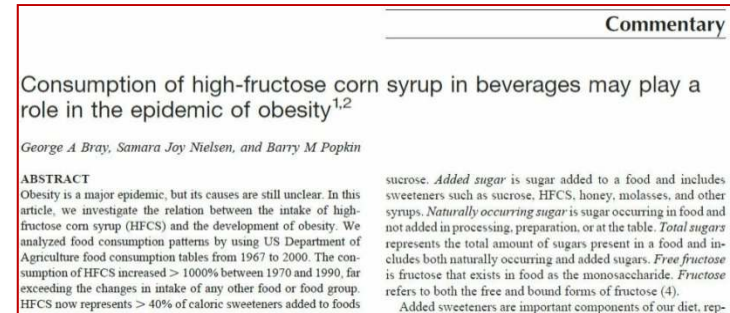
See corresponding editorial on page 1149.

**ABSTRACT** There is a difference of opinion about whether the percentage of dietary fat plays an important role in the rising prevalence of overweight and in its treatment once it has developed. We believe that ample research from animal and clinical studies, from controlled trials, and from epidemiologic and ecologic analyses provides strong evidence that dietary fat plays a role in the development and treatment of obesity. A reduction in fat intake reduces the gap between total energy intake and total energy expenditure and thus is an effective strategy for reducing the present epidemic of obesity worldwide. A review of the results from 28 clinical trials that studied the effects of a reduction in the amount of energy from fat in the diet showed that a reduction of 10% in the proportion of energy from fat was associated with a reduction in weight of 16 g/d. We thus conclude that dietary fat plays a role in the development of obesity. To

sity might increase more rapidly, and that fat intakes may have increased in those segments of society in whom the prevalence of obesity has increased while decreasing in other segments.

Ultimately, obesity is caused by an energy imbalance and the focus on dietary fat intake may have been overemphasized at the expense of total energy intake. This is a critical point when it comes to placing the role of dietary fat intake into its proper context. Total energy balance is what matters most and the focus on dietary fat consumption must be seen through its effects on total energy intake. We are convinced from our review of the literature that if people eat more fat they consume more energy. This is the result of both passive overconsumption and the low thermic effect of fat. Diets with a low energy density are thus associated with greater satiety. In addition, we believe that if people eat less fat they will on average consume less energy.

## Sugar is worse



**Circulation**  
JOURNAL OF THE AMERICAN HEART ASSOCIATION



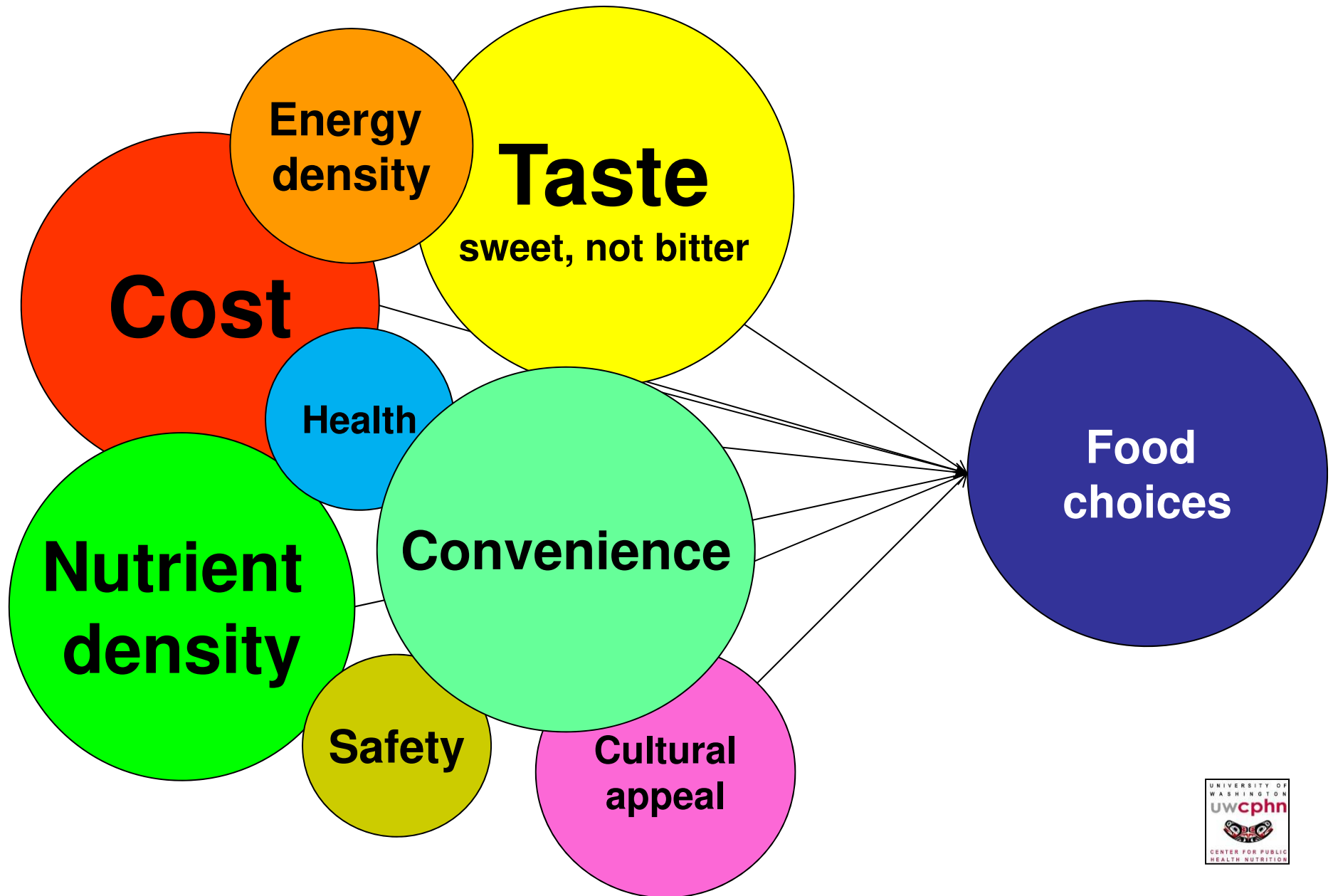
**Sugar-Sweetened Beverages, Obesity, Type 2 Diabetes Mellitus, and Cardiovascular Disease Risk**

Vasanti S. Malik, Barry M. Popkin, George A. Bray, Jean-Pierre Després and Frank B. Hu

Circulation. 2010;121:1356-1364



# Main drivers of food choice





# The formation of dietary patterns:

- Childhood:
  - Sweet taste (not bitter),
  - energy density, familiarity.
- Adolescence:
  - Energy density, variety,
  - attitudes, motivations, peer group.
- Adult life:
  - Taste, cost, convenience,
  - health, variety.





# Classic data: Infants like sweet taste

Facial expressions of 3-day old infants

Steiner, 1977

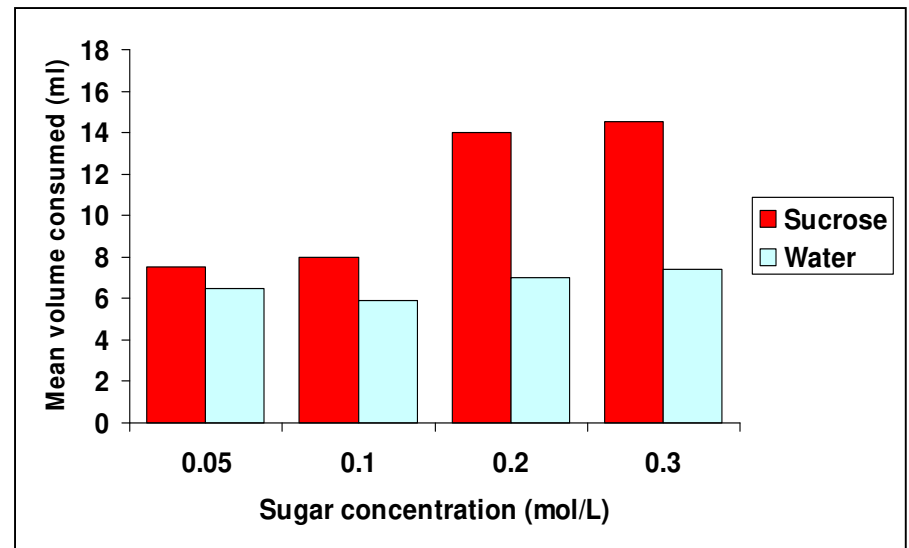


Sweet

Sour

Bitter

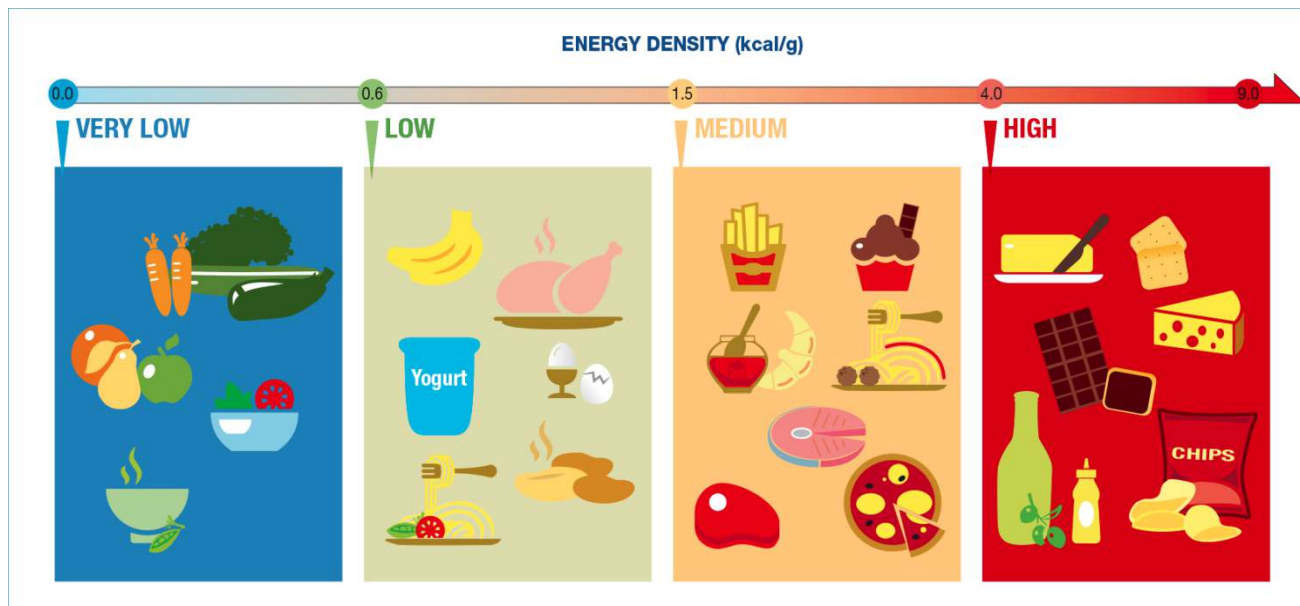
Infants prefer sugary liquids to plain water



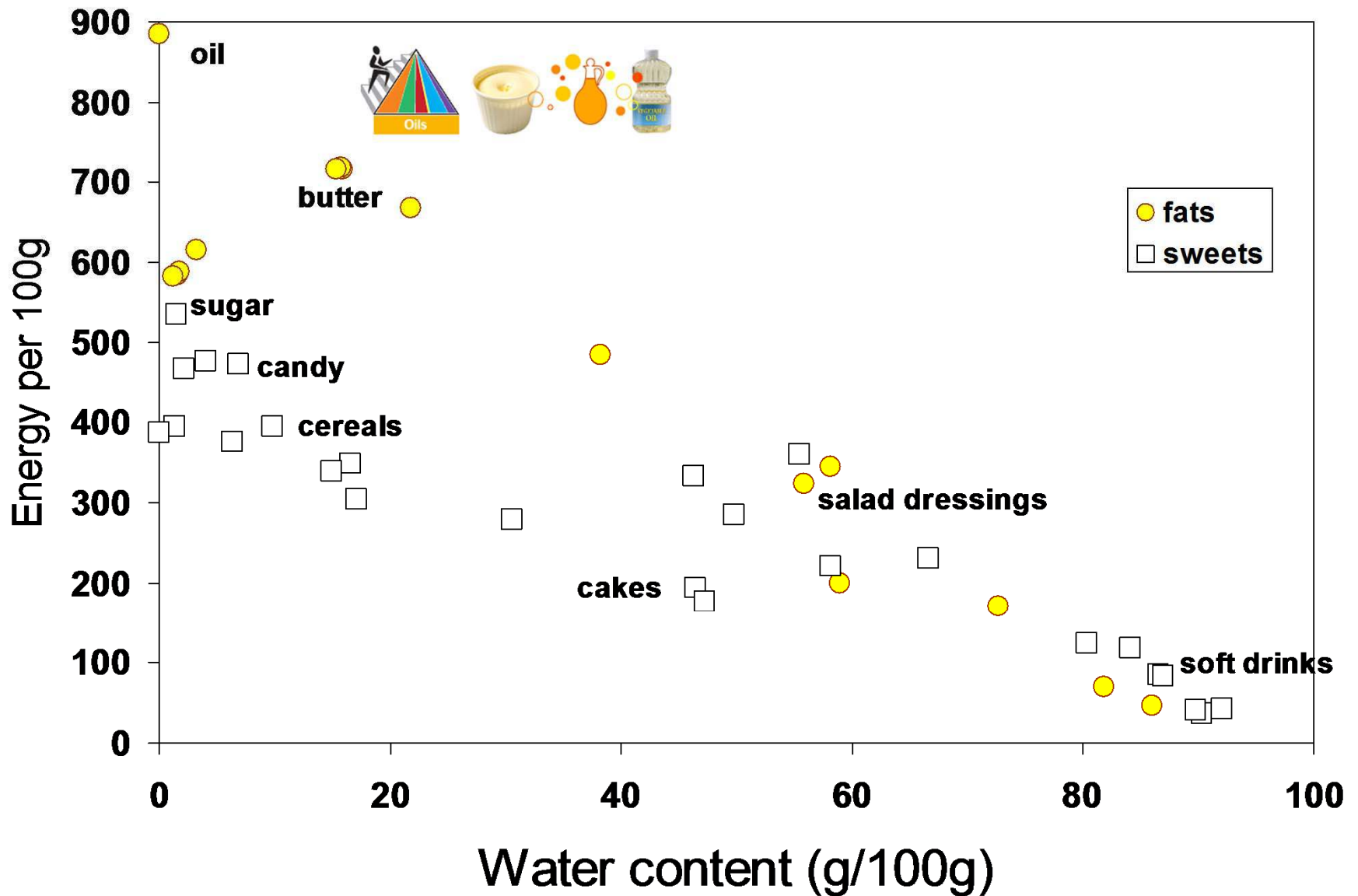
Desor, Maller and Greene, 1978

# Children like energy-dense foods

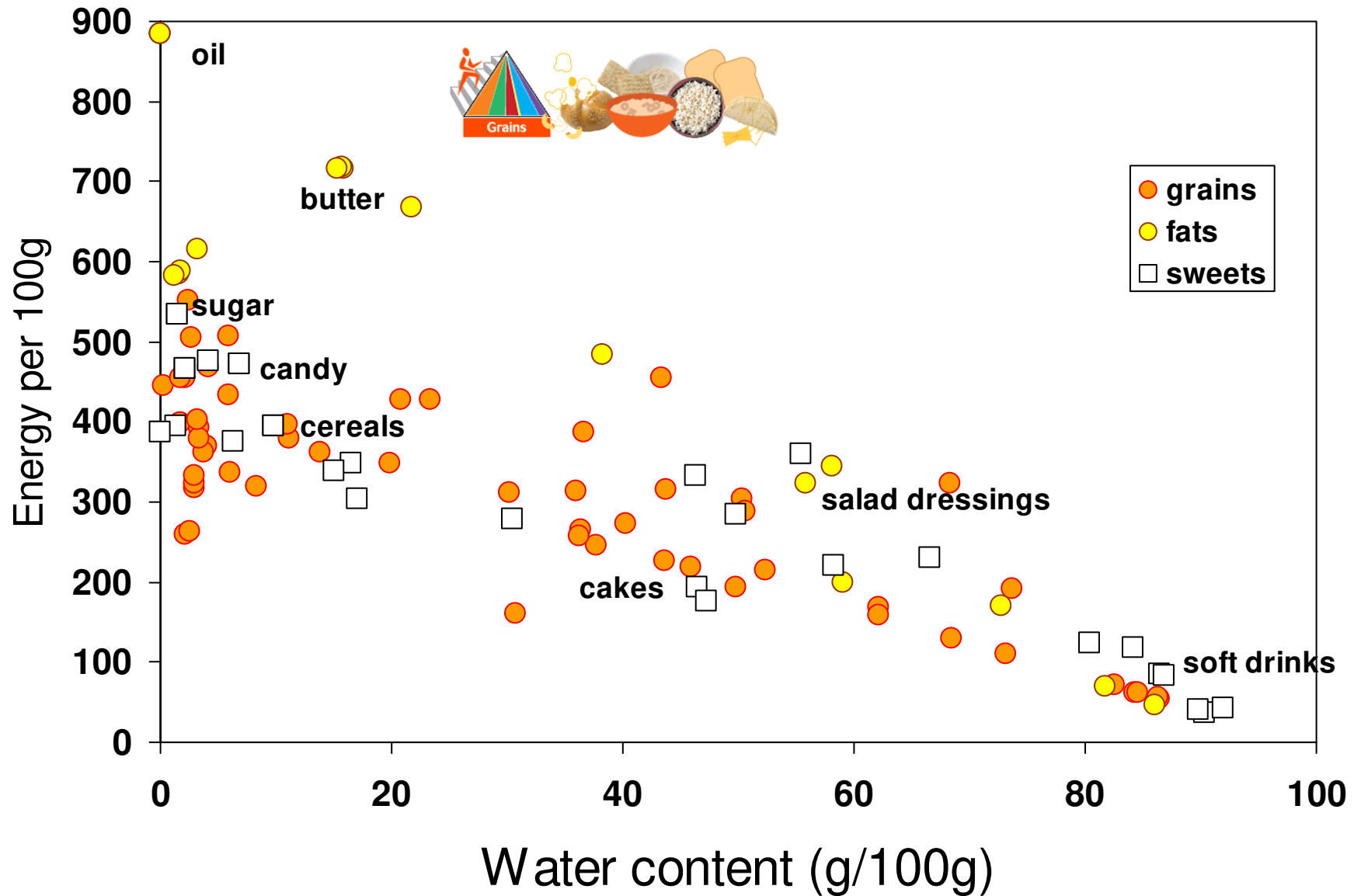
- Energy density (ED) is driven by *water* content.
- Energy-dense foods are *dry*.
- Energy-dense foods can be sweet and fatty.
- Energy-dense foods can be *nutrient-poor*.



# Low water content = high energy density

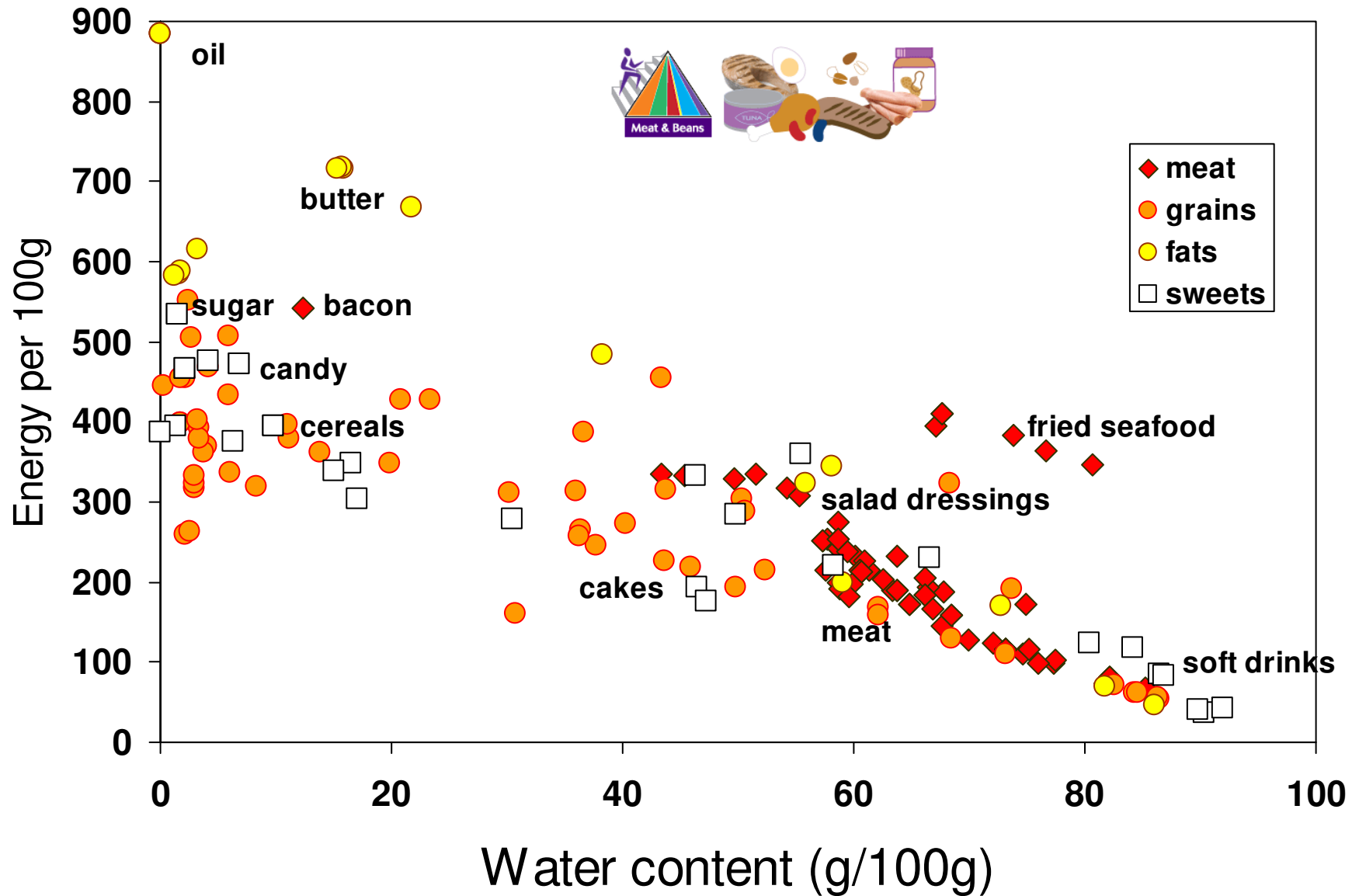


# Low water content = high energy density

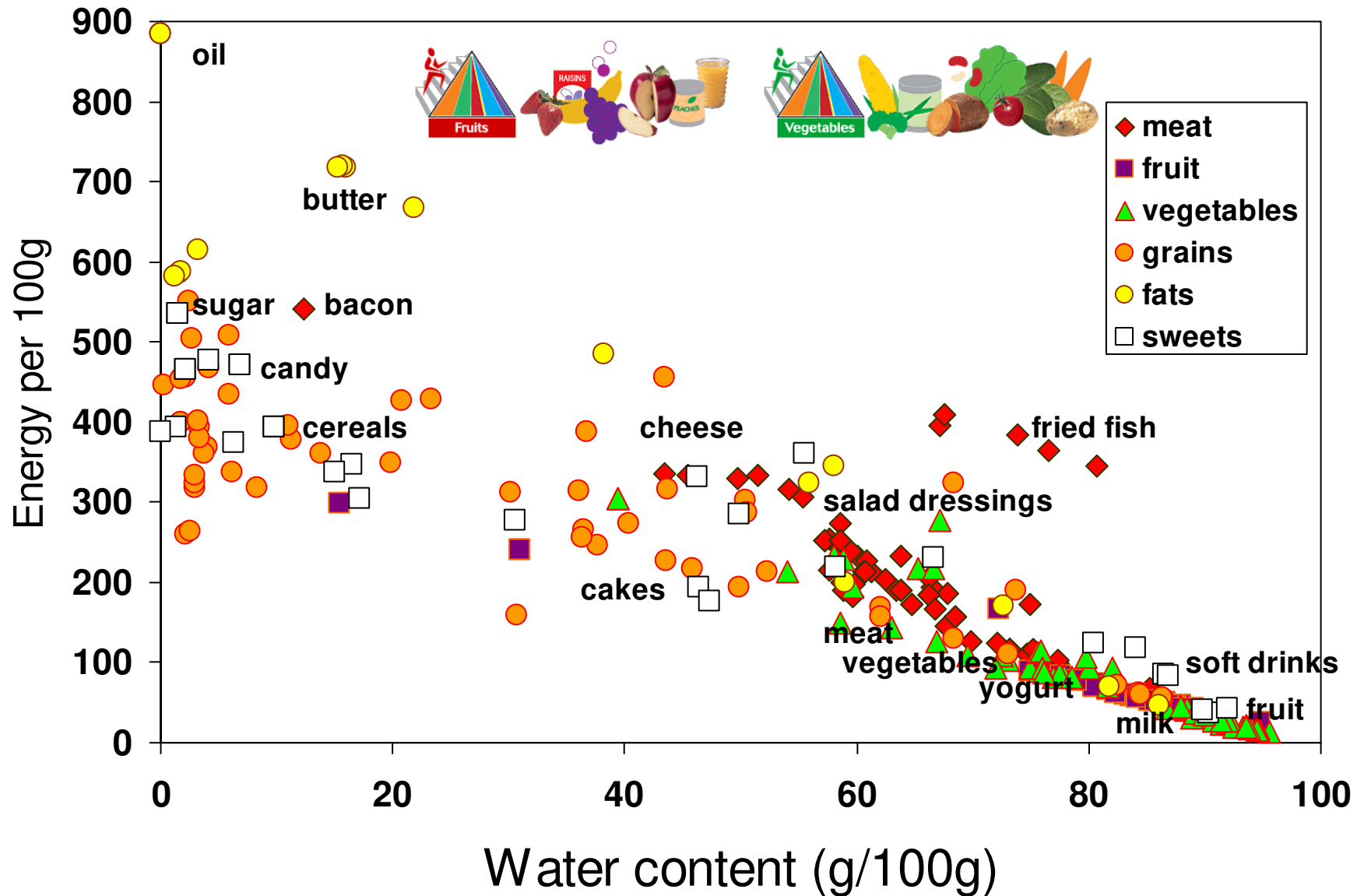




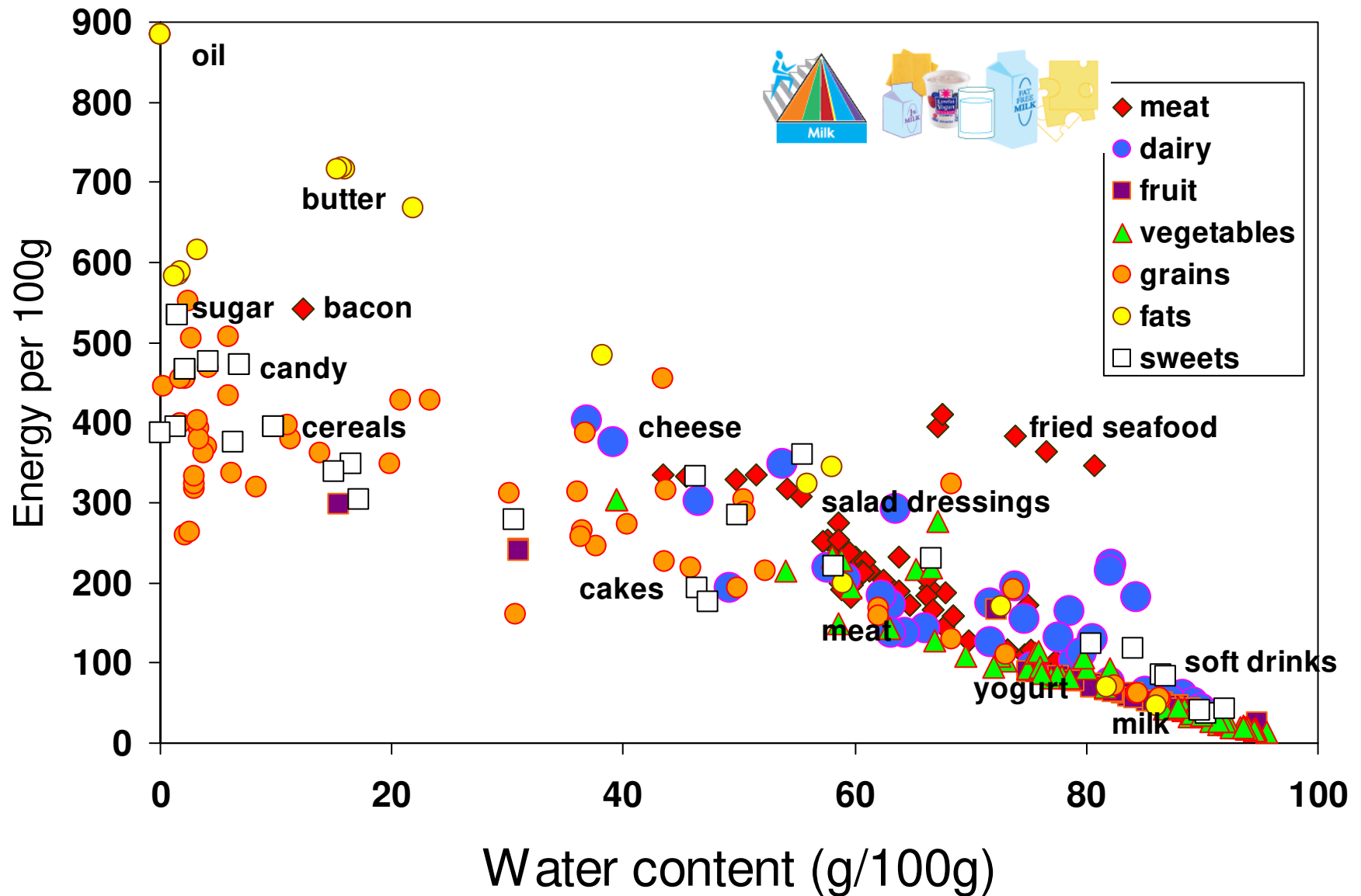
# Low water content = high energy density



# Low water content = high energy density



# Low water content = high energy density



# Children hate bitter taste



- Plant-based phenols, polyphenols (tannins), flavonoids, isoflavones, terpenes and glucosinolates are bitter, acrid, or astringent.
- These compounds impart a bitter taste to plant foods.
- Many of these compounds are toxic – bitter taste is a signal for dietary danger.
- Children hate bitter foods; older people do not mind them (esp. coffee, alcohol).



# The value of culinary science

- Fat, sugar and salt can mask bitter taste.
- Taste illusions
  - Salt makes grapefruit sweeter
  - Parmesan cheese makes red wine sweeter.
  - Broccoli tastes better with butter – or cheese sauce
- Food processing involves the senses and psychology.



# From physiology to psychology and economics

Energy dense foods (grains, sugar, vegetable oils)  
have become very inexpensive

# From foods to food *patterns*: The economics of sugar and fat

Nutrients are expensive. Calories are not.

Low nutrient density, 2000 kcal	High nutrient density, 2000 kcal
<p><b>\$3.52</b></p> 	<p><b>\$36.32</b></p> 

Monsivais, P. and Drewnowski, A. 2007. The Rising Cost of Low-Energy-Density Foods. *Journal of American Dietetic Association* 107:2071-2076.

**JN** THE JOURNAL OF NUTRITION

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**Fat and Sugar: An Economic Analysis<sup>1</sup>**

Adam Drewnowski<sup>2</sup>

Author Affiliations

<sup>1,2</sup>To whom correspondence should be addressed. E-mail: adamdrew@u.washington.edu.

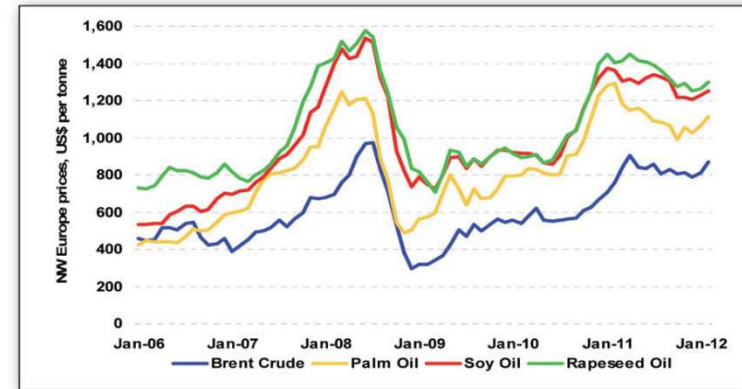
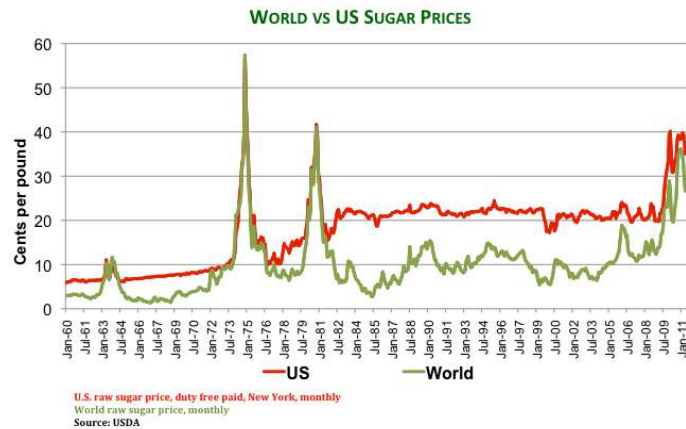


28 g of sugar



34 g of sugar

# Obesity promoting diets driven by low global prices of sugar and fat



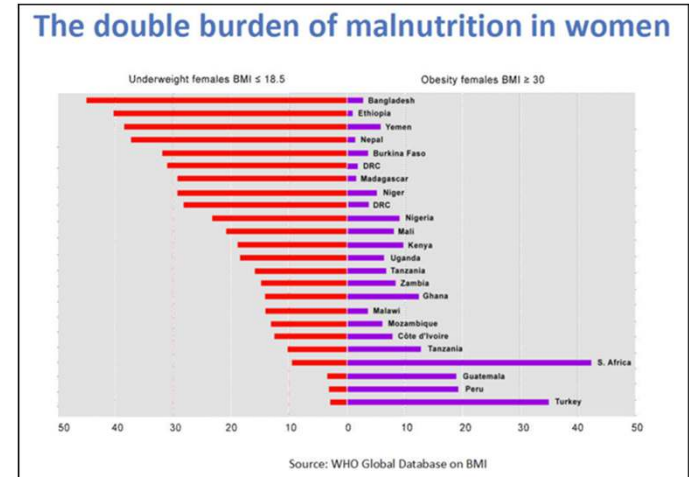
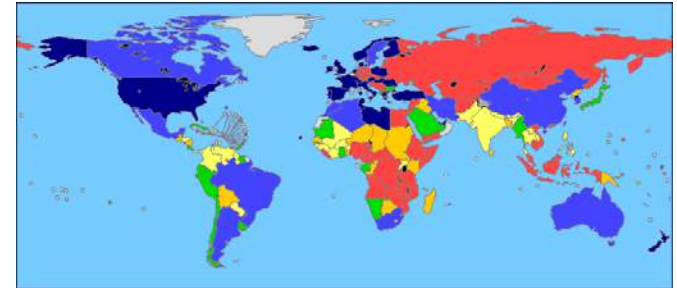
Graph 1: EU vegetable oil prices and Brent crude prices (dollar/tonne).

- World and US prices for sugar and for fats and oils 1961-2011
- Fats and sugars provide 20,000 kcal per dollar
- Nutritionists equate 3,500 kcal with 1 lb of body weight
- The “economic cost” of gaining 1 lb body wt is 12 cents – if the energy comes from added sugar and fat

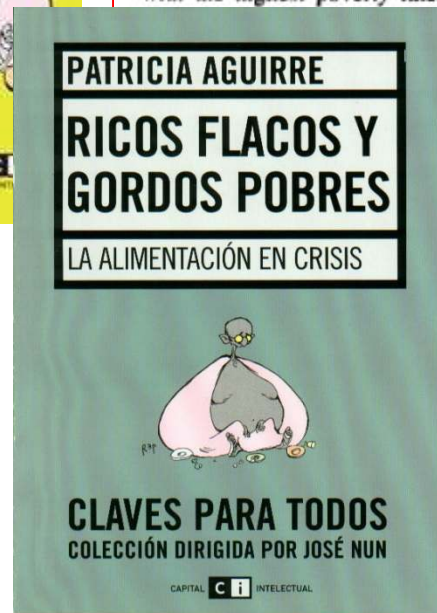
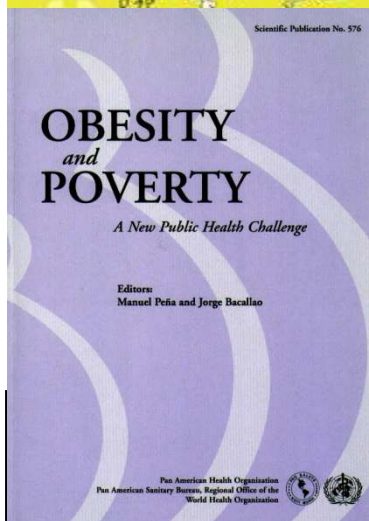
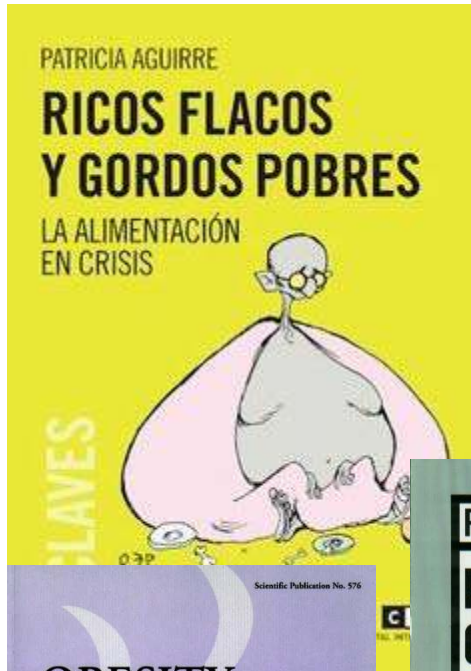


# The global nutrition imbalance

- Human taste preferences run toward energy-dense grains, sugar, and fat
- Calories are cheap; nutrients are not.
- Global diets are becoming energy-dense but also nutrient-poor.
- The global poor suffer from different forms of malnutrition – both undernutrition and overweight.
- Can food processing and food *fortification* help to improve global food patterns?



# Is global obesity caused by low-cost diets?



**Special Article**

## Poverty and obesity: the role of energy density and energy costs<sup>1,2</sup>

*Adam Drewnowski and SE Specter*

**ABSTRACT**  
Many health disparities in the United States are linked to inequalities in education and income. This review focuses on the relation between obesity and diet quality, dietary energy density, and energy costs. Evidence is provided to support the following: First, the highest rates of obesity occur among populations with the highest poverty rates and the least education. Second, between energy density and energy costs, energy-dense foods and fats may represent the most significant risk factors for obesity. Third, the high energy density of these foods is associated with higher energy intake. Fourth, poverty is associated with lower food expenditures and lower-quality diets. Fifth, modeling models leads to the conclusion that a diet similar in composition to the current diet but with lower energy density and energy costs is more affordable. Sixth, such diets are more affordable for populations with high poverty and obesity rates. Seventh, the high energy density of energy-dense foods is a function of the energy density of sugar and fat. The

Public health policies for the prevention of obesity increasingly call for taxes and levies on fats and sweets, both to discourage their consumption and to help promote alternative and healthier food choices (15, 16). Past studies on dietary energy density and energy costs have shown that energy-dense foods are associated with higher energy intake and higher body mass index (BMI). In addition, energy-dense foods are more affordable for populations with high poverty and obesity rates. The high energy density of energy-dense foods is a function of the energy density of sugar and fat. The

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**Tiempo**  
ARGENTINO

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13-08-2012 | entrevista a la doctora en antropología patricia aguirre

### "Nuestra dieta está manejada por empresas"

La especialista cuenta por qué la sociedad, pese a tener disponibilidad excedentaria de alimentos, tiene 1000 millones de desnutridos.

Por: **María Laura Guevara**

En una entrevista exclusiva, la doctora en Antropología, Patricia Aguirre, analiza la comida como reflejo de la vida social y explica los modos de producción y alimentación de la sociedad que pese a tener "disponibilidad excedentaria de alimentos", tiene "mil millones de desnutridos". Además, habla del rol del Estado para recuperar la "soberanía alimentaria" y de la imposición del "gusto pobre" y el "gusto gourmet" para reproducir las desigualdades sociales.

# Linking food, health, and incomes

Poverty and obesity may be linked by the low cost, high reward value, and easy access to energy-dense foods

## Special Article

### Poverty and obesity: the role of energy density and energy costs<sup>1,2</sup>

Adam Drewnowski and SE Specter

#### ABSTRACT

Many health disparities in the United States are linked to inequalities in education and income. This review focuses on the relation between obesity and diet quality, dietary energy density, and energy costs. Evidence is provided to support the following points. First, the highest rates of obesity occur among population groups with the highest poverty rates and the least education. Second, there is an inverse relation between energy density (MJ/kg) and energy cost (\$/MJ), such that energy-dense foods composed of refined grains, added sugars, or fats may represent the lowest-cost option to the consumer. Third, the high energy density and palatability of sweets and fats are associated with higher energy intakes, at least in clinical and laboratory studies. Fourth, poverty and food insecurity are associated with lower food expenditures, low fruit and vegetable consumption, and lower-quality diets. A reduction in diet costs in linear programming models leads to high-fat, energy-dense diets that are similar in composition to those consumed by low-income groups. Such diets are more affordable than are prudent diets based on lean meats, fish, fresh vegetables, and fruit. The association between poverty and obesity may be mediated, in part, by the low cost of energy-dense foods and may be reinforced by the high palatability of sugar and fat. This economic

Public health policies increasingly call for taxes to discourage their consumption and healthier food choices. Antecedents of obesity include sugar and fat as well as (17-19). In contrast, consumption, dietary energy (S/MJ) has not been a chief focus of this report.

#### POVERTY AND OBESITY

Obesity rates in the past 2 decades (20-22 20 y were classified as obese. Overweight is  $> 25$  kg/m<sup>2</sup>, whereas a sharp increase in the number (35) has been observed. There is no question

## Energy density and food costs

Drewnowski and Specter AJCN 2004;79:6-16



The paradox – Saving on food costs leads to energy dense diets  
Energy dense diets permit overeating  
Spend less – eat more





# What is the nutrition transition?

- Low and middle income countries undergoing the **nutrition transition** shift from a traditional diet high in staple grain crops to a dietary pattern with more *animal foods*, more *vegetables and fruit* – but more added **sugars**, and more added **fats**.
- The nutrition transition – the result of economic development - occurs in parallel with demographic, and epidemiologic changes at population level.

**The nutrition transition: New trends in the global diet**  
Adam Drewnowski, Barry M Popkin  
*Nutrition Reviews*; Feb 1997; 55; 2; Health Module  
pg. 31

## Lead Review Article

February 1997: 31–43

### The Nutrition Transition: New Trends in the Global Diet

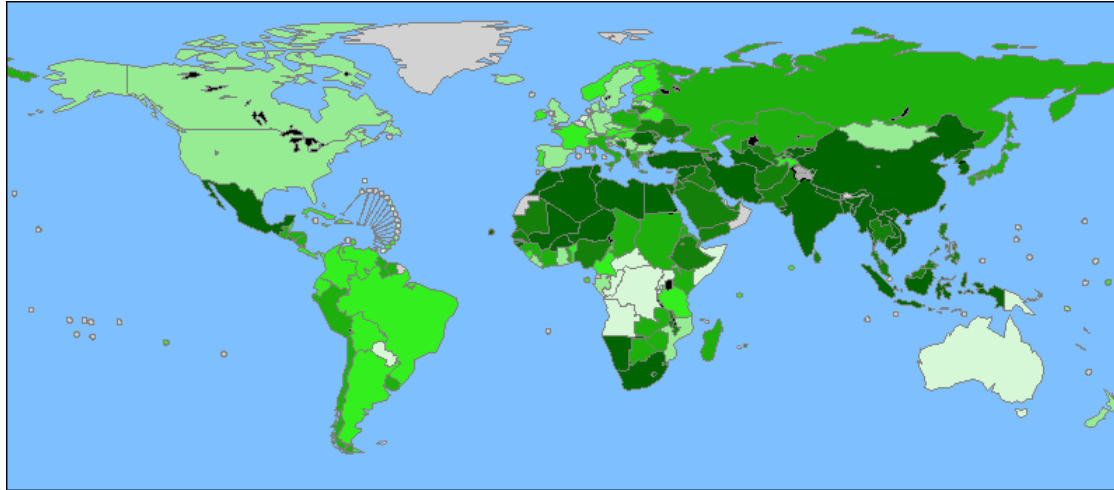
Adam Drewnowski, Ph.D., and Barry M. Popkin, Ph.D.

*Analyses of economic and food availability data for 1962–1994 reveal a major shift in the structure of the global diet marked by an uncoupling of the classic relationship between incomes and fat intakes. Global availability of cheap vegetable oils and fats has resulted in greatly increased fat consumption. Consequently, the amount of fat available at lower levels of income than previously, and urbanization rates where diet structure that diets higher in fats. These shifts in diet structure reflect preferences for more diverse animal products, a human trait, fat intake not by physiological need but by the amount of fat available. Economic development, food security and better health of the nutrition transition and childhood obesity are explored.*

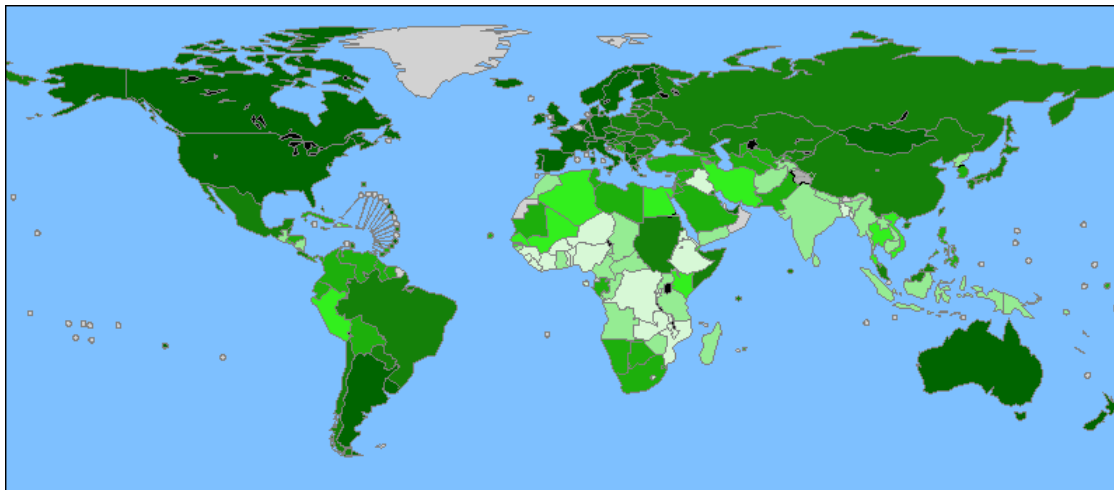
proportion of fats, saturated fats, and sugars.<sup>1-3</sup> These shifts in diet structure accompany demographic shifts associated with higher life expectancy and reduced fertility rates. An associated epidemiologic transition also takes place as patterns of disease shift away from infectious and nutrient deficiency diseases toward higher rates of coronary heart



# The nutrition transition: from cereals to animal foods



Cereals:  
dark green >1400 kcal/d



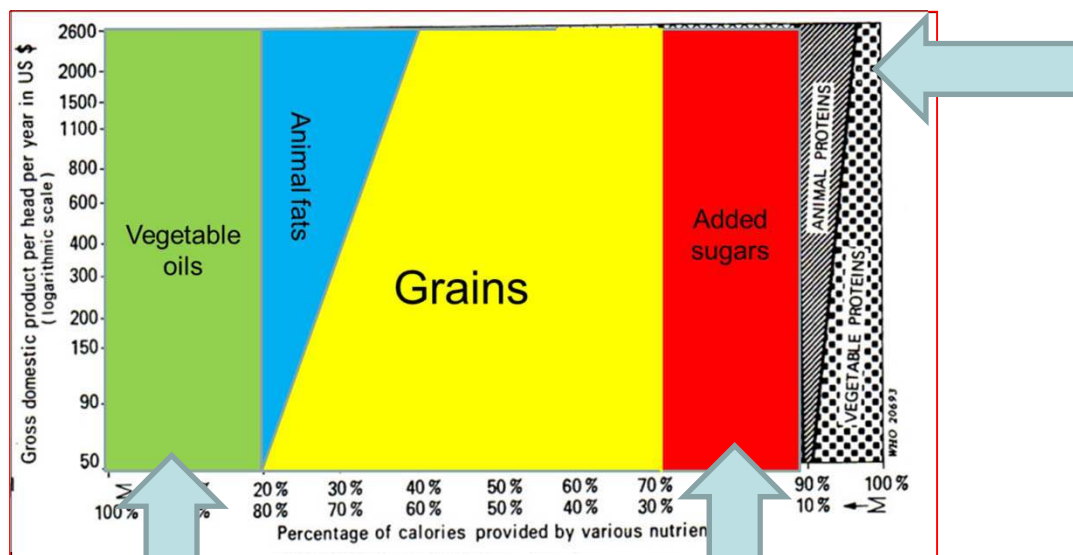
Milk, fish, meat, eggs:  
dark green >700 kcal/d



# Classic relation: GDP and diet quality 1970

FAO 1969/70 - in Nutrition Newsletter, Vol 7, No 3, Jul-Sep 1969 - P. 1-9, 5 Tab., 2 Graphs

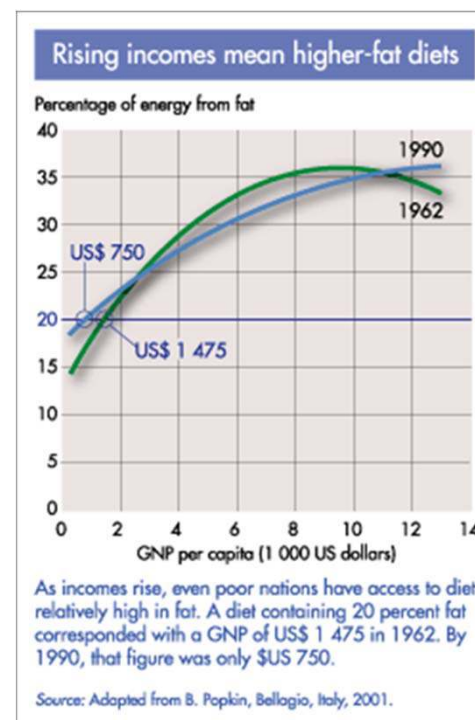
## Uncoupled by 2000



More vegetable oils

More added sugar

Shift to animal protein – but not everywhere

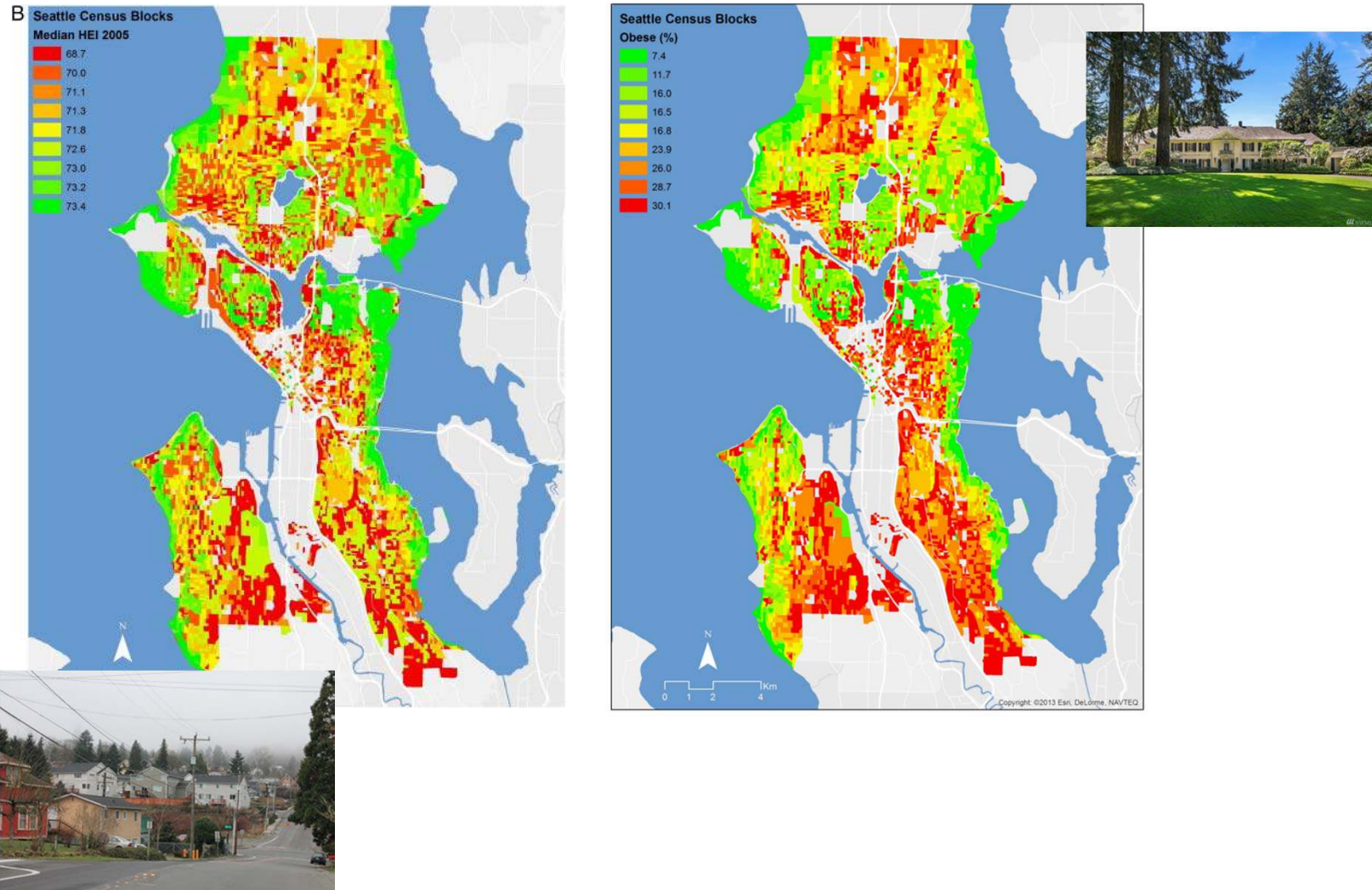


What can we learn from  
*geo-located*  
food patterns and health data?

This is where spatial epidemiology science  
crosses into public policy –  
and food politics!

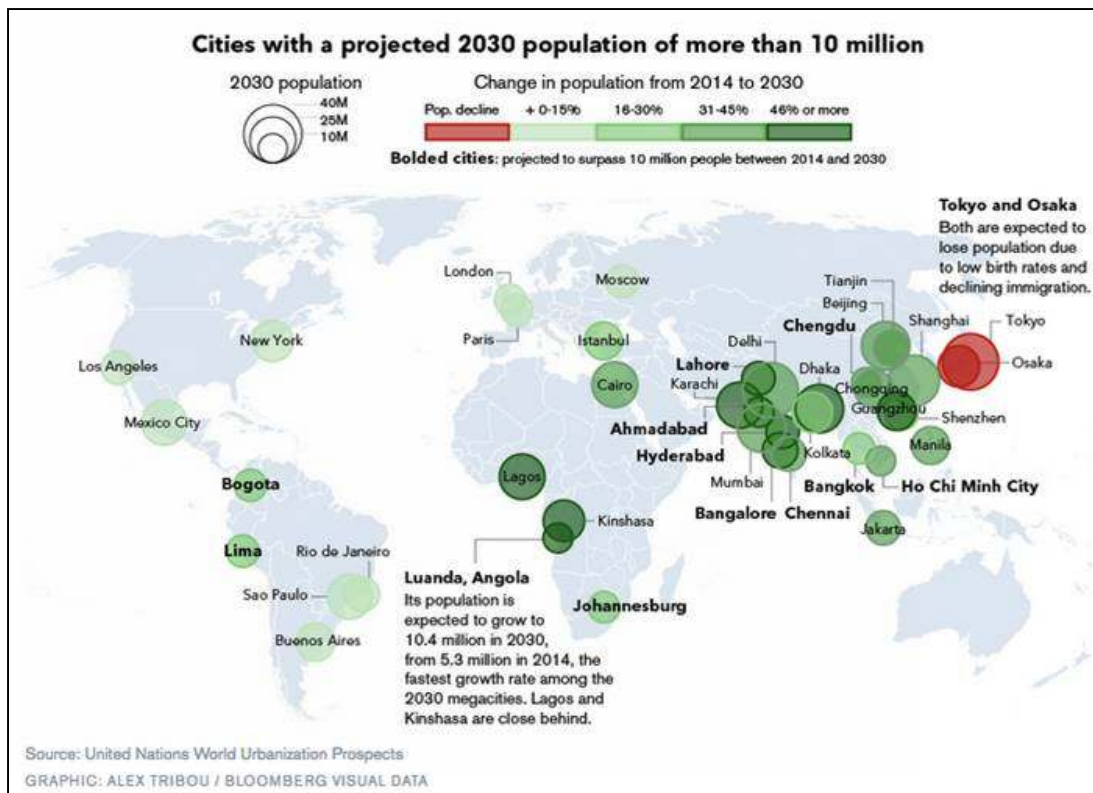
# Spatial nutritional epidemiology:

Heat maps of diet quality (HEI 2010 scores) and obesity by Seattle census block



# Megacities will become future obesity hotspots

Populations will depend on safe, low-cost, energy-dense foods



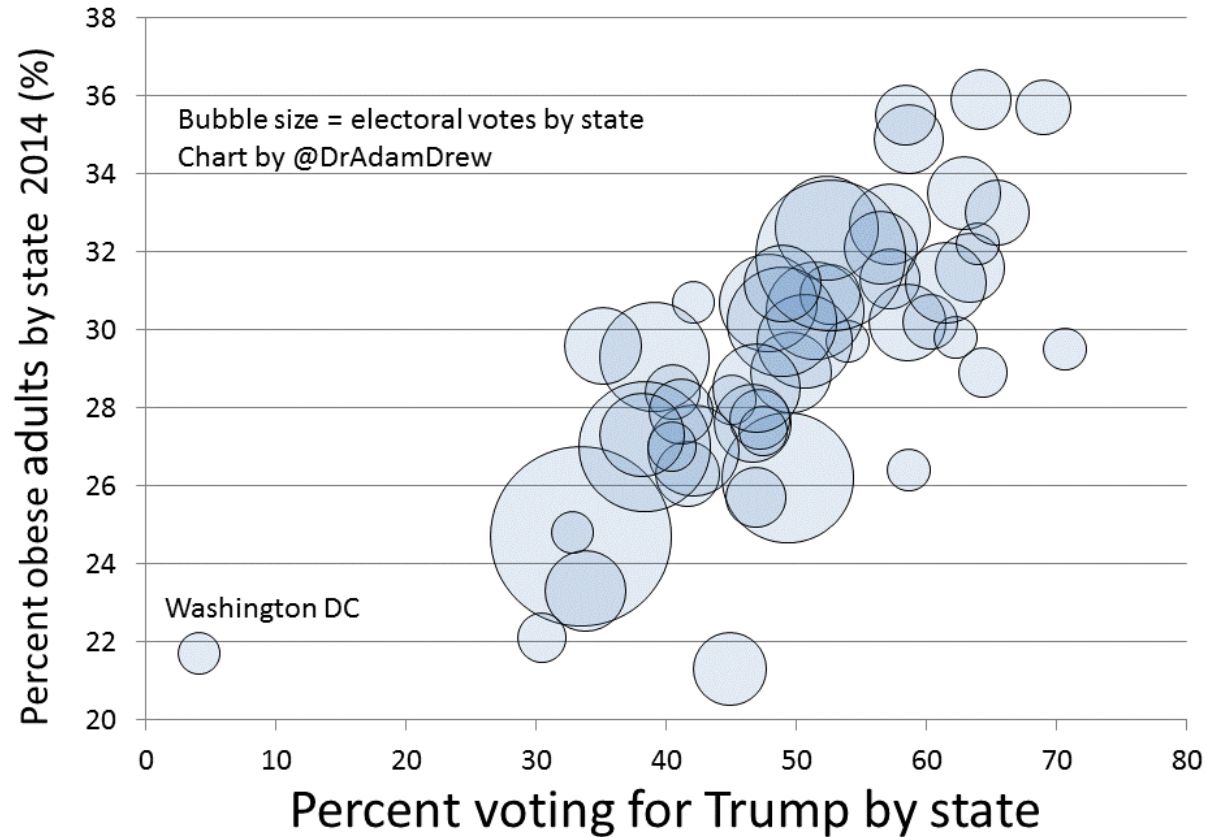
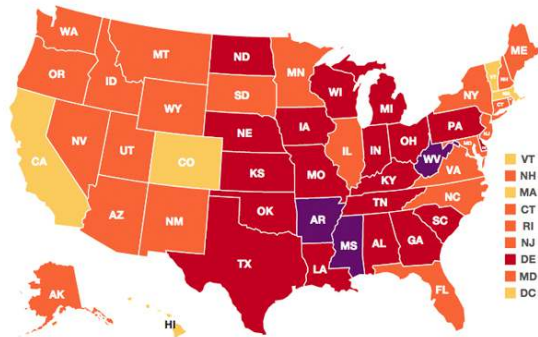
- Assume that 10 million people each consume 2,000 kcal/d.
- Given ED 1.0 kcal/g, then each person needs 2 kg of food daily.
- Then 20,000 tons of food need to be distributed daily.
- But if ED is 4 kcal/g, then each person needs to 0.5 kg/d.
- Distribution drops to 5,000 tons.
- Cost per calorie will also decrease but nutrient density will suffer.

# The search for solutions?

**Adult Obesity Rate by State, 2014**

Percent of obese adults (Body Mass Index of 30+)

0 - 9.9% 10 - 14.9% 15 - 19.9% 20 - 24.9% 25 - 29.9% 30 - 34.9% 35%+



Percent obese 2014 from Centers for Disease Control. Presidential election 2016 votes from ballotpedia.org.



# Time for a paradigm shift



# Time for a paradigm shift

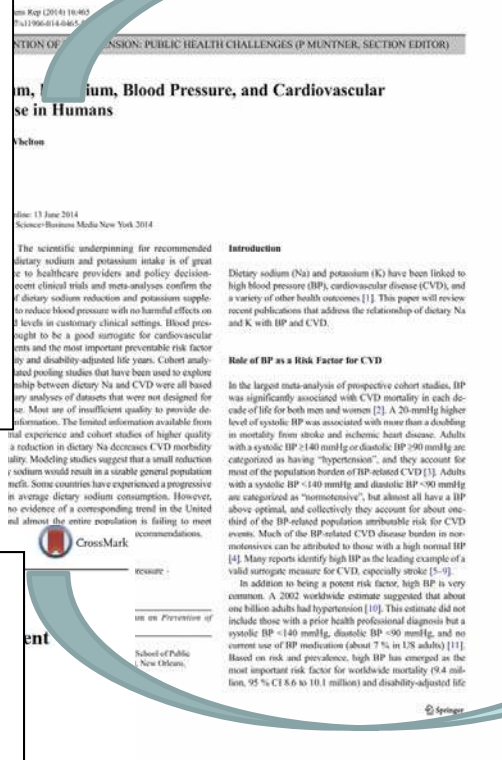
## Socio-demographics

- Diet cost
- Demographics
- Education, incomes
- Culture
- Behavior
- Environment

## Dietary Guidelines

## Food patterns

- Nutrients
- Individual foods
- Dietary ingredients

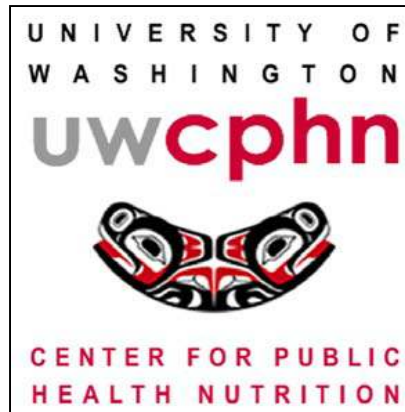


insoluble fibre with incident CVD and all-cause mortality in type 1 diabetic patients. Methods A prospective cohort analysis was performed in 2,108 European type 1 diabetic patients aged 18-70 years who were free of CVD at baseline and enrolled in the EURODIAB Prospective Complications Study (51). Results A complete list of members of the EURODIAB Prospective Complications Study Group is provided in the Electronic Supplementary Material. Conclusions Soluble fibre is associated with lower mortality risk (HR 0.72; 95% CI 0.55, 0.95). This association was stronger for soluble fibre (per 2 g/day, HR 0.66; 95% CI 0.45, 0.97). Similar results were observed for the association with CVD. Interpretation This study suggests that reported fibre intake is not significantly associated with CVD and all-cause mortality.

Eur J Nutr (2016) 55 (Suppl 2):S45-S53

and various health-related sequelae is controversial. Some investigators have argued that excessive sugar consumption is associated with increased risk of obesity, coronary heart disease, diabetes (T2D), metabolic syndrome, non-alcoholic fatty liver disease, and stimulation of reward pathways in the brain potentially causing excessive caloric consumption. These concerns have influenced organizations such as the World Health Organization, the Scientific Advisory Committee on Nutrition in England not to exceed 5% of total energy and the Dietary Guidelines for Americans Advisory Committee 2015 to recommend upper limits of sugar consumption not to exceed 10% of calories. Data

to present data from recent RCTs and findings from recent systematic reviews and meta-analyses related to sugar consumption and its putative health effects. This review evaluates findings from recent randomized controlled trials, systematic reviews and meta-analyses into the relationship of sugar consumption and a range of health-related issues including energy-regulating hormones, obesity, cardiovascular disease, diabetes, and accumulation of liver fat and neurologic responses. Data from these sources do not support linkages between sugar consumption at normal levels within the human diet and various adverse metabolic and health-related effects.



**Thank you**



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