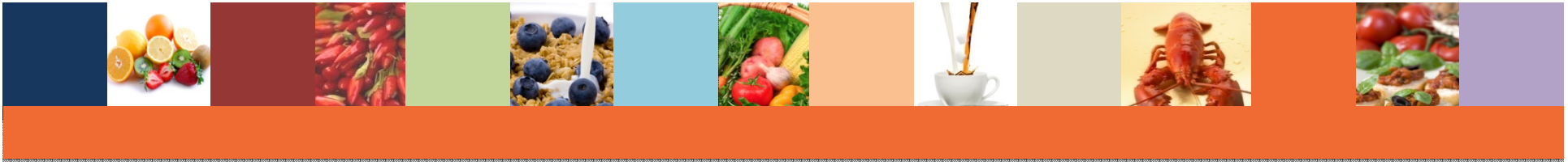




# Evidence reviews of the work of the U.S. Dietary Guidelines Advisory Committee on carbohydrates including sugars

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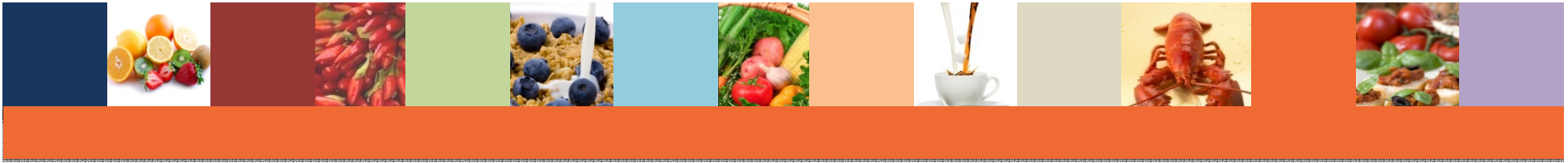
# Outline

- Carbohydrate definitions and categories
- Existing guidance on carbohydrates
- US Dietary Guidelines Advisory Committee (DGAC)
- Description of DGAC process
- Summary of carbohydrate findings in 2010 DGAC



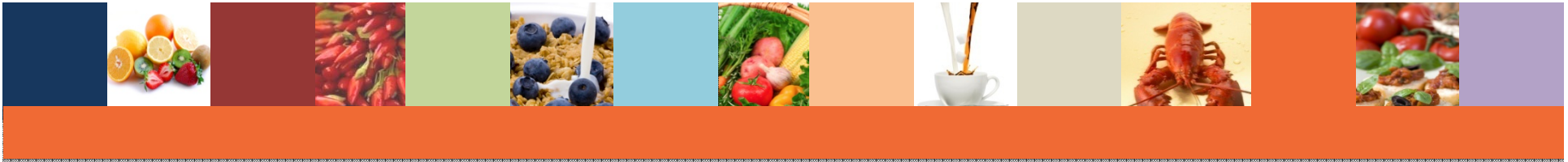
# Does a carbohydrate equal a carbohydrate - No

- Chemical structure – mono, di, polysaccharide
- Digestible vs. non-digestible
- Speed of digestion and absorption – Glycemic index
- Fermentable vs. non-fermentable
- Physical structure – in solution, part of a food, associated substances (protein), part of a seed or grain, particle size



# Of what use are carbohydrates?

- Sweeteners
- Food preservation
- Functional attributes (viscosity, texture, body, browning capacity)
- Energy
- Fermentable substrates – dietary fiber



## How does high fructose corn syrup (HFCS) compare to other sweeteners?

- Usual HFCS is 55% fructose and 45% glucose – very similar to sucrose
- In the US, HFCS consumption higher than refined sugar consumption
- Fructose has a low glycemic index – so drinks and food sweetened with HFCS are low GI, not high GI
- HFCS = “corn sugar”



# Intrinsic vs. Extrinsic sugars

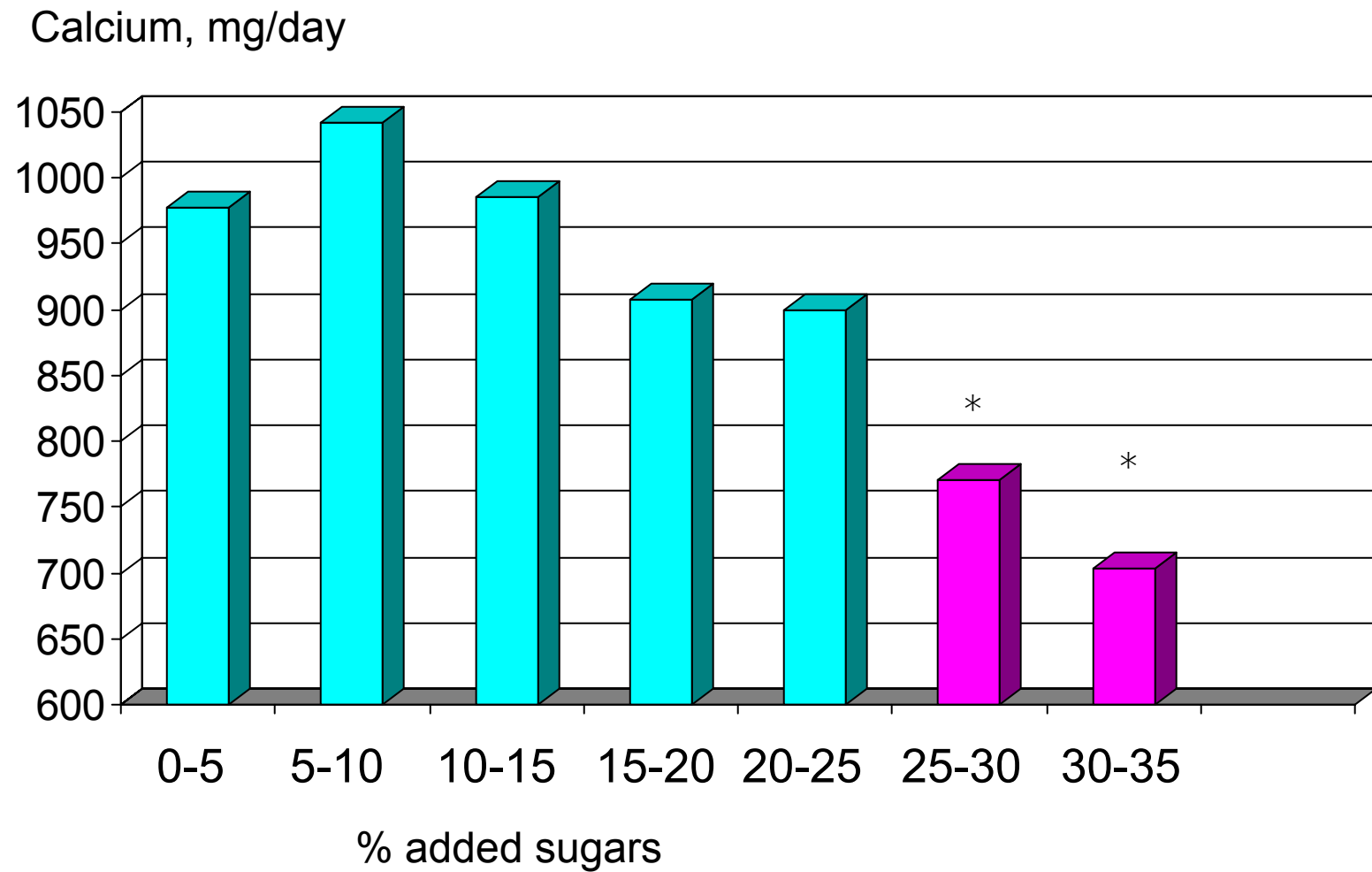
- Intrinsic sugar – sugars that are naturally occurring within a food
- Extrinsic sugars – those added to food  
AKA “added sugar”
- No difference in the molecular structure of sugar molecules, whether they are naturally occurring in the food or added to the food
- No analytical method to differentiate between added sugar and intrinsic sugar



# Recommendation on “added sugar” consumption

- USDA recommendation for “added sugars” : no more than 25% of total kcal
- Major sources include soft drinks, cakes, cookies, pies, fruitades, fruit punch, dairy desserts, and candy.

# Calcium intake in children 4-8 Y as a function of added sugar intake

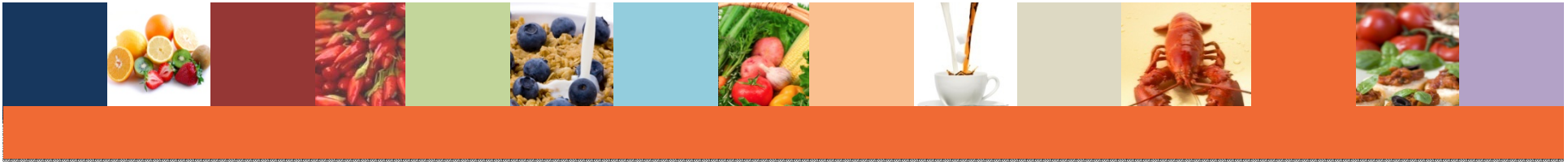






# Consumption of sugars and body weight review

- There is insufficient evidence that an exchange of sugar for non-sugar carbohydrates in the context of a reduced-fat ad libitum diet or energy-restricted diet results in lower body weights
- Observational studies suggest a possible relationship between consumption sugar sweetened beverages (SSB) and body weight, no RCTs
- Insufficient evidence to support a difference between liquid and solid sugar intake in body-weight control
- Van Baak & Astrup. *Obes Rev* 2009;10 Suppl 1:9-23



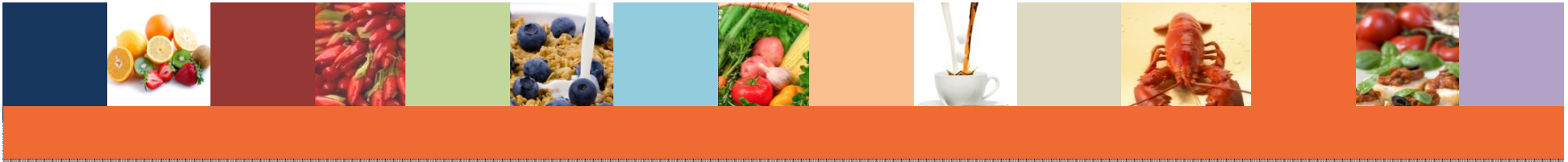
## DRIs in 2002

- Insufficient evidence to set an upper level for sugar intake, based on data available on dental caries, behavior, cancer, risk of obesity and risk of hyperlipidemia
- No clear and consistent association between increased intakes of added sugars and body mass index



## Existing US dietary guidance on carbohydrates

- Dietary Reference Intakes (DRIs) – 2002
- 45 – 65% of calories from carbohydrate
- Added sugar – 25% or less of calories
- Dietary fiber – 38 grams for men, 25 grams for women – 14 g/1000 kcals
- 130 g/day – RDA for carbohydrates



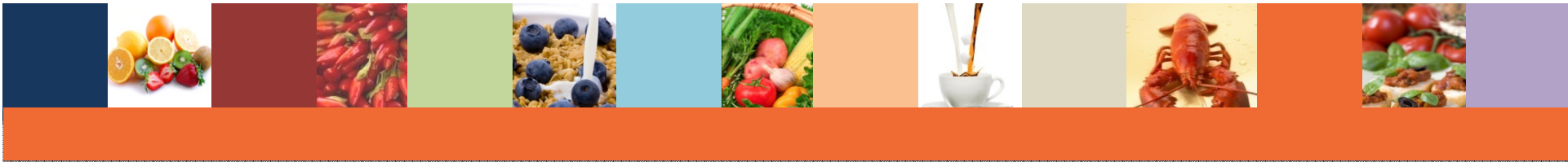
# Carbohydrate guidelines in 2005 Dietary Guidelines

- 45 – 65% of calories from carbohydrate
- Choose carbohydrates wisely
- Choose fiber-rich fruits, vegetables, and whole grains often
- Choose and prepare foods and beverages with little added sugars or caloric sweeteners
- Reduce dental caries by consuming sugar and starch foods less frequently



## *What are the Dietary Guidelines?*

- 1<sup>st</sup> published in 1980
- Federal nutrition policy established jointly by USDA & HHS
- Updated every 5 years
- Provide science-based advice for ages 2 and over to help prevent chronic disease & promote health
- Foundation for Federal nutrition programs, nutrition education programs, and a basis for research gaps and priorities
- Ensure that messages and materials are consistent through-out the Federal government and that government speaks with “one nutrition voice”
- Policy used by educators, health professionals, policy makers – for consumers



# Dietary Guidelines for Americans 1980 - 2005

**Nutrition and Your Health**  
Dietary Guidelines for Americans

- 1 Eat a Variety of Foods** page 4
- 2 Maintain Ideal Weight** page 7
- 3 Avoid Too Much Fat, Saturated Fat, and Cholesterol** page 11
- 4 Eat Foods with Adequate Starch and Fiber** page 13
- 5 Avoid Too Much Sugar** page 15
- 6 Avoid Too Much Sodium** page 17
- 7 If You Drink Alcoholic Beverages, Do So in Moderation** page 19

U.S. Department of Agriculture  
U.S. Department of Health, Education and Welfare

Nutrition and Your Health  
**Dietary Guidelines for Americans**

- 1 Eat a Variety of Foods** page 6
- 2 Maintain Desirable Weight** page 9
- 3 Avoid Too Much Fat, Saturated Fat, and Cholesterol** page 15
- 4 Eat Foods with Adequate Starch and Fiber** page 17
- 5 Avoid Too Much Sugar** page 19
- 6 Avoid Too Much Sodium** page 21
- 7 If You Drink Alcoholic Beverages, Do So in Moderation** page 23

Second Edition, 1985  
U.S. Department of Agriculture  
U.S. Department of Health and Human Services

Nutrition and Your Health:  
**Dietary Guidelines for Americans**

- 1 Balance the food you eat with physical activity—maintain or improve your weight**
- 2 Choose a diet with plenty of grain products, vegetables, and fruits**
- 3 Choose a diet low in fat, saturated fat, and cholesterol**
- 4 Eat a variety of foods**
- 5 Choose a diet moderate in salt and sodium**
- 6 Choose a diet moderate in sugars**
- 7 If you drink alcoholic beverages, do so in moderation**

Fourth Edition, 1995  
U.S. Department of Agriculture  
U.S. Department of Health and Human Services

Nutrition and Your Health:  
**Dietary Guidelines for Americans**

- 1 Eat a variety of foods** page 5
- 2 Maintain healthy weight** page 8
- 3 Choose a diet low in fat, saturated fat, and cholesterol** page 13
- 4 Choose a diet with plenty of vegetables, fruits, and grain products** page 18
- 5 Use sugars only in moderation** page 21
- 6 Use salt and sodium only in moderation** page 23
- 7 If you drink alcoholic beverages, do so in moderation** page 25

Third Edition, 1990  
U.S. Department of Agriculture  
U.S. Department of Health and Human Services

Nutrition and Your Health:  
**DIETARY GUIDELINES FOR AMERICANS**

**Aim for Fitness**

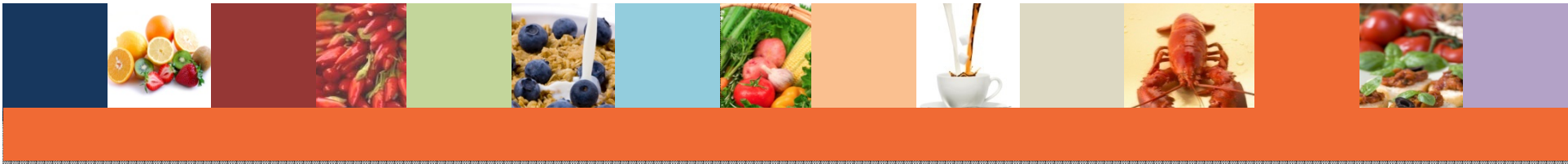
**BUILD a Healthy Base**

**CHOOSE Sensibly**

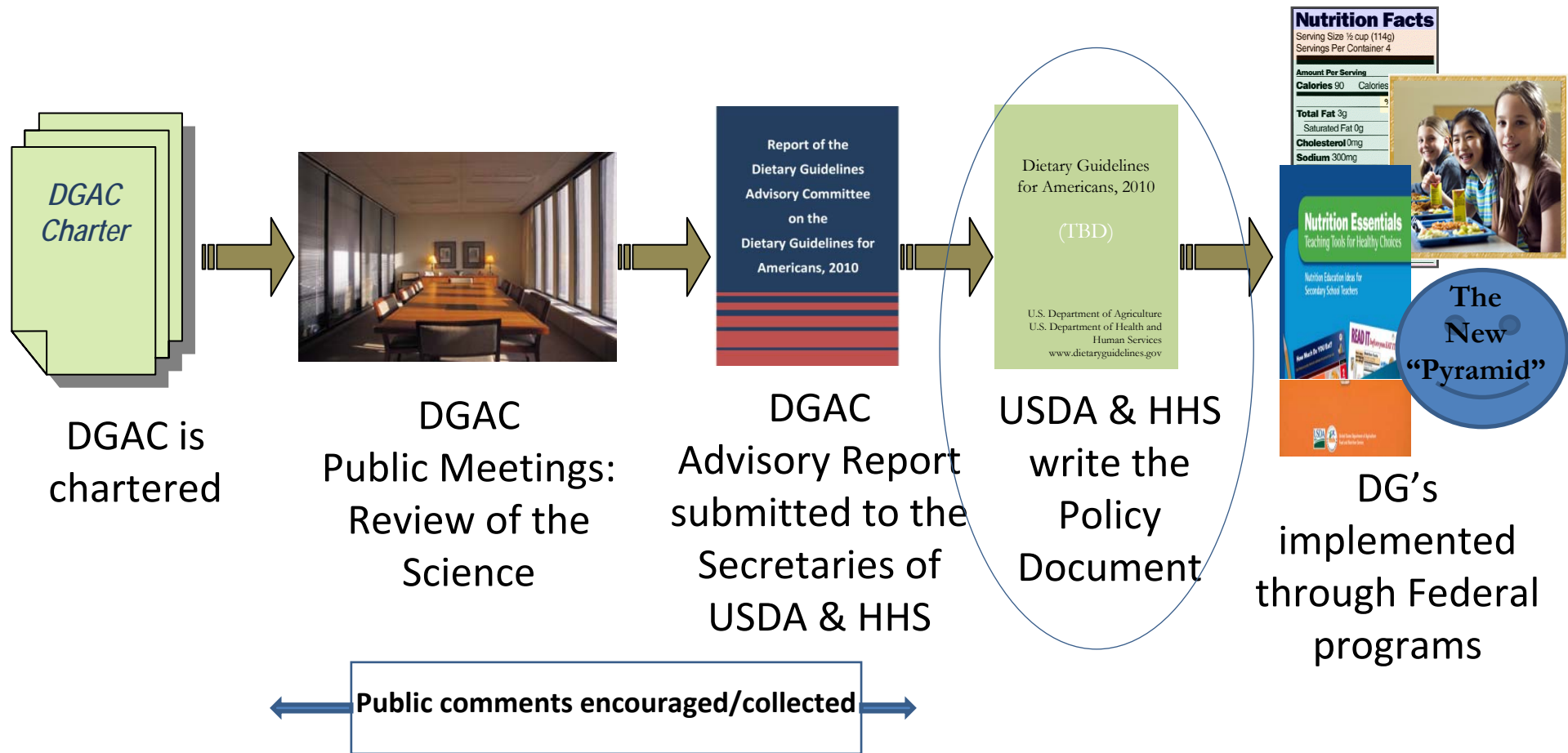
...for good health

**Dietary Guidelines for Americans 2005**

U.S. Department of Health and Human Services  
U.S. Department of Agriculture  
www.health.gov/dietaryguidelines



# Development of Dietary Guidelines Policy



**Evidence-based Methodology Used to Review the Science**



## *Membership of the 2010 Committee*

- 13 members
- Variety and broad range of expertise, e.g.,:
  - Prevention of chronic diseases (e.g., cancer, cardiovascular disease, type 2 diabetes, obesity, and osteoporosis)
  - Energy balance (including physical activity)
  - Epidemiology
  - Food safety and technology
  - General medicine, gerontology, maternal health and pediatrics
  - Nutrient bioavailability, nutrition biochemistry and physiology
  - Nutrition education
  - Evidence review methodology





# ***2010 Dietary Guidelines Advisory Committee***

Chair

Linda Van Horn, PhD, RD

Co-chair

Naomi Fukagawa, MD, PhD

*Topic Subcommittee/Chapter Chairs:*

Energy Balance / Weight  
Management

F. Xavier Pi-Sunyer, MD, MPH

Nutrient Adequacy

Sharon Nickols-Richardson, PhD, RD

Fatty Acids

Thomas Pearson, MD, PhD, MPH

Food Safety & Technology

Roger Clemens, DrPH

Sodium, Potassium, Water

Lawrence Appel, MD, MPH

Carbohydrate & Protein

Joanne Slavin, PhD, RD

Alcohol

Eric Rimm, ScD

*Subspecialties:*

Pediatrics

Christine Williams, MD, MPH

Maternal Nutrition

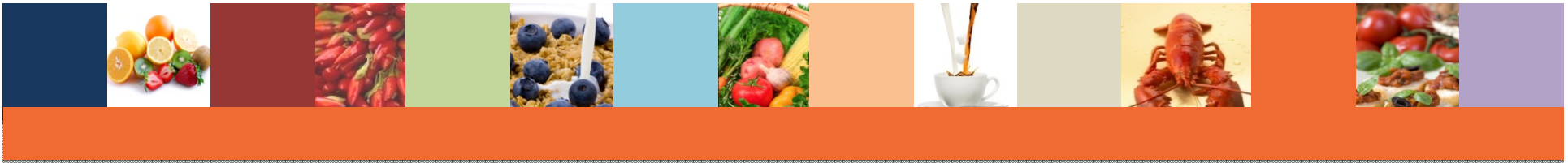
Rafael Pérez-Escamilla, PhD

Behavior / Food Choices

Cheryl Achterberg, PhD

General Nutrition

Miriam Nelson, PhD



## *Evidence Analysis Methodology*

Rigorous

Minimizes bias

Transparent

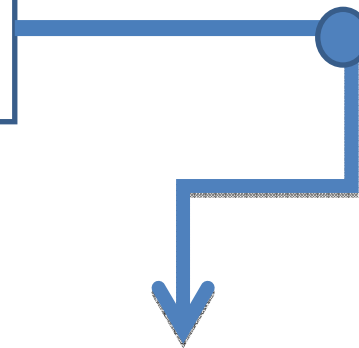
Accessible to stakeholders and

consumers

Defines state of the science

Foundation for updates

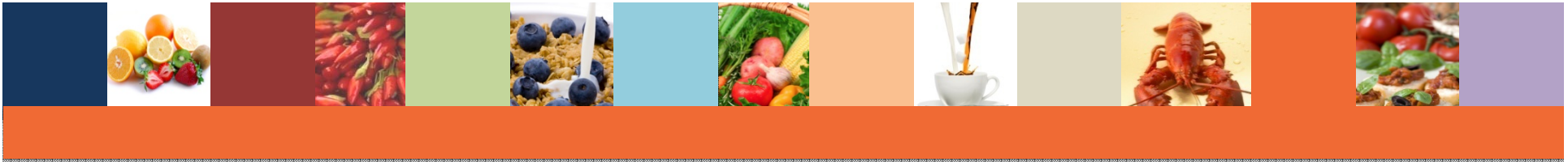
*Answers precise questions • Illuminates research gaps*



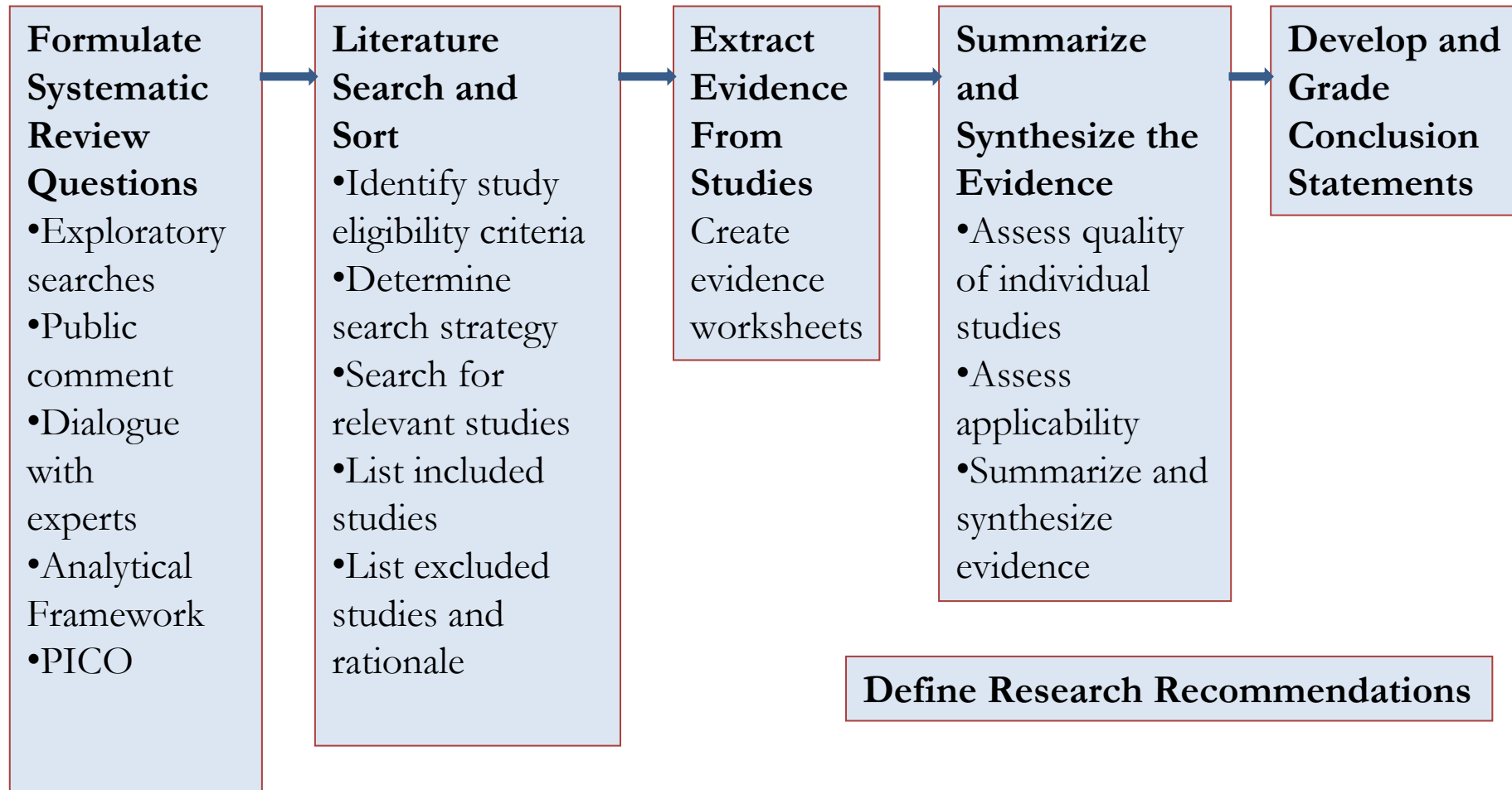


## ***USDA Nutrition Evidence Library***

- Evidence-based systematic review preferred foundation for policy and guidance
- NEL established to synthesize evidence to inform nutrition policy and programs
  - Dietary Guidelines Advisory Committee resource
  - Implementation of *Dietary Guidelines for Americans*
- Ensures compliance with *Data Quality Act*
- Expert workgroup is a critical element in the approach



## NEL Process





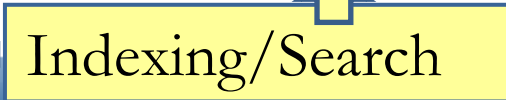
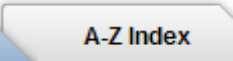
## *General Study Eligibility Criteria*

- Human studies
- Developed countries
- English language
- Peer reviewed journals
- Search and sort plans specified:
  - Age of subjects, study setting, number of subjects per study arm, attrition rate, characteristics of intervention, outcome measures and study design



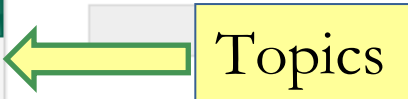
## *Grade Strength of Evidence*

- **Quality**
  - Scientific rigor and validity
  - Consider study design and execution
- **Quantity**
  - Number of studies
  - Number of subjects in studies
- **Consistency of findings across studies**
- **Impact**
  - Importance of studied outcomes
  - Magnitude of effect
- **Generalizability**


[DGAC 2010](#)
[Methodology](#)
[FAQs](#)
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## Topics

- [Alcohol](#) ▶
- [Carbohydrates](#) ▶
- [Energy Balance and Weight Management](#) ▶
- [Fatty Acids and Cholesterol](#) ▶
- [Food Safety and Technology](#) ▶
- [Nutrient Adequacy](#) ▶
- [Protein](#) ▶
- [Sodium, Potassium, and Water](#) ▶



## 2010 Dietary Guidelines Advisory Committee (DGAC) NEL Evidence-Based Systematic Reviews

The NEL website provides a detailed evidence portfolio for each of the 2010 DGAC's systematic reviews. Each evidence portfolio in the NEL contains the systematic review questions, conclusion statements, evidence summaries, search plan and results, and worksheets for each article included in the review. The [2010 DGAC Report](#) summarizes the systematic review findings and provides interpretations and implications related to all aspects of the Committee's Dietary Guidelines review process. To navigate the library:

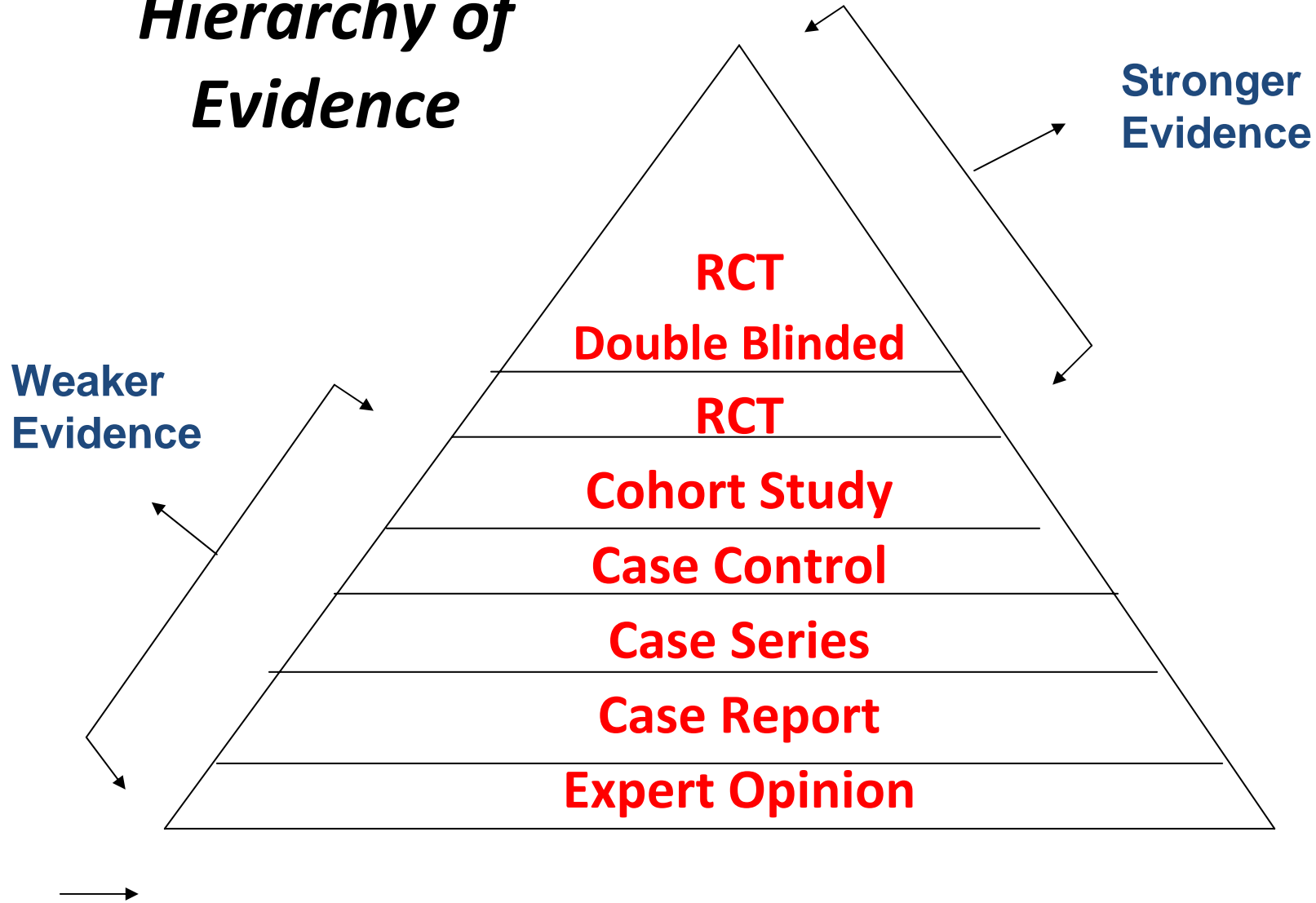
- ▶ Select a topic from the menu on the left to examine the evidence reviewed by the 2010 DGAC.
- ▶ Each topic is divided into subtopics of questions reviewed by the Committee.
- ▶ By clicking on a subtopic you can access:
  - ▶ **Systematic review questions** - Questions formulated by the Committee.
  - ▶ **Conclusion statements** - Concise statements that answer the questions based on the Committee's review of the evidence.
  - ▶ **Evidence summaries** - Synthesis of the articles included in the NEL evidence-based systematic review, including evidence summary paragraphs for each article considered in the review and a summary overview table.
  - ▶ **Search plan and results** - A description of the search parameters and selection criteria used to identify peer-reviewed literature related to the topic of interest. Additionally, the final list of articles included in the review is provided, along with the articles excluded from the review with reasons for exclusion.
  - ▶ **Worksheets** - Comprehensive, templated evidence worksheets which summarize key evidence from each study and document the methodological appraisal of the study quality.

Available at:

[www.NutritionEvidenceLibrary.gov](http://www.NutritionEvidenceLibrary.gov)



# Hierarchy of Evidence







# ***Carbohydrate and Protein Chapters***

Joanne Slavin, PhD, RD – Chair

Cheryl Achterberg, PhD

Xavier Pi-Sunyer, MD, MPH

Linda Van Horn, PhD, RD, LD



# ***What's Different in 2010 DGAC?***

## **Protein:**

- Has its own section**
- Driven by consumer interest in high protein diets for weight loss and health promotion**
- Importance of both protein quantity and protein quality with recommendations to eat fewer calories**
  - DRI – 0.8 g/kg Body Weight/d; no UL; Recommended protein intake range 10 – 35% of kcalories – *low calorie diets should be high protein diets***



# What are the health benefits of dietary fiber?

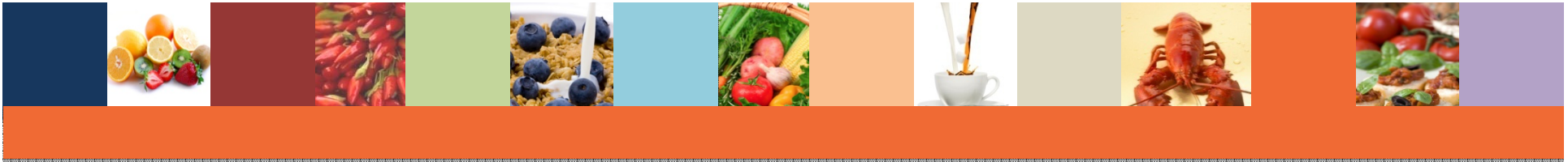
- A moderate body of evidence suggests that dietary fiber from whole foods protects against cardiovascular disease, obesity, and type 2 diabetes and is essential for optimal digestive health



# ***Carbohydrates & Health Outcomes***

## ***Whole Grains***

**What is the relationship between whole grain intake and selected health outcomes?**



## ***Whole Grains - Conclusions***

- **A moderate body of evidence from large prospective cohort trials shows that whole grain intake, which includes cereal fiber, protects against cardiovascular disease.**
- **Consumption of whole grains is associated with a reduced incidence of type 2 diabetes in large prospective cohort studies. (Limited)**
- **Moderate evidence shows that intake of whole grains and grain fiber is associated with lower body weight.**



# ***Vegetables & Fruits***

**What is the relationship between the intake of vegetables and fruits, not including juice, and selected health outcomes?**



## ***Vegetables & Fruits - Conclusions***

- **Consistent evidence suggests at least a moderate inverse relationship between vegetable and fruit consumption with myocardial infarction and stroke, with significantly larger, positive effects noted above five servings of vegetables and fruits per day.**
- **Insufficient evidence is available to assess the relationship between vegetable and fruit intake and blood pressure or serum cholesterol.**



## ***Vegetables & Fruits - Conclusions***

**Evidence for an association between increased vegetable and fruit intake and lower body weight is modest with a trend towards decreased weight gain over 5+ years in middle adulthood; no conclusions can be drawn from the evidence on the efficacy of increased vegetable and fruit consumption in weight loss diets. (Moderate)**





## ***Vegetables & Fruits - Conclusions***

- **Limited and inconsistent evidence suggests an inverse association between total vegetable and fruit consumption and the development of type 2 diabetes.**
- **Evidence also indicates that some types of vegetables and fruits are probably protective against some cancers.**



## ***Glycemic Index & Load***

**What is the relationship between glycemic index (GI) or glycemic load (GL) and selected health outcomes?**



## ***GI & GL - Conclusions***

- **Strong and consistent evidence shows that glycemic index and/or glycemic load are not associated with body weight and do not lead to greater weight loss or better weight maintenance.**
- **Abundant, strong epidemiological evidence demonstrates that there is no association between glycemic index or load and cancer.**



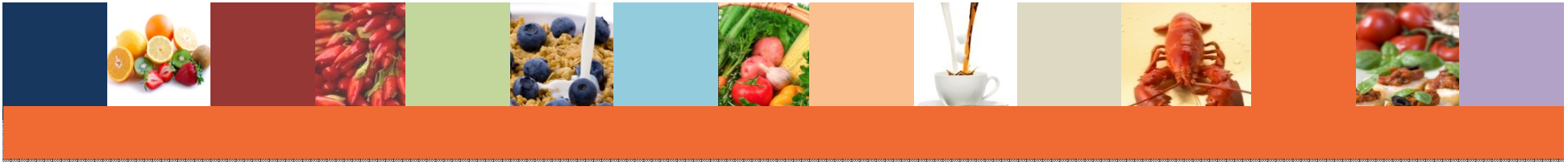
## ***GI & GL - Conclusions***

- **A moderate body of inconsistent evidence supports a relationship between high glycemic index and type 2 diabetes. Strong, convincing evidence shows little association between glycemic load and type 2 diabetes.**
- **Due to limited evidence, no conclusion can be drawn to assess the relationship between either glycemic index or load and cardiovascular disease.**



# 2010 DGAC Report: Added Sugar = SSB

- **Original question: In adults, what is the association between the intake of added sugar, including sugar-sweetened beverages, and energy intake and body weight?**
- Question from 2005 DGAC:
  - What is the significance of added sugars intake to human health?
  - Conclusion: “Compared with individuals who consume small amounts of foods and beverages that are high in added sugars, those who consume large amounts tend to consume more calories but smaller amounts of micronutrients. Although more research is needed, available prospective studies suggest a positive association between the consumption of sugar-sweetened beverages and weight gain. A reduced intake of added sugars (especially sugar-sweetened beverages) may be helpful in achieving recommended intakes of nutrients and in weight control.”
- Strategy for review:
  - Considered literature from 1990-present
  - Ages 19 yrs and older (Childhood Overweight section addresses SSB)
  - Original research articles included in a systematic review were excluded
  - **Cross-sectional studies were excluded**



**Conclusion based on the review of:  
3 systematic reviews, 7 trials, and 4 prospective observational studies**

Study	Systematic Review / Meta-Analysis	Authors Conclusion
<i>Gibson-2008</i> (Neutral-quality)	Systematic review of sugar-sweetened soft drinks (SSD) and body weight, BMI, or adiposity ( <b>44</b> original studies [11 included adults]; 6 review articles)	SSD are a source of energy, but there is little evidence that they are more obesogenic than any other source of energy
<i>Malik-2006</i> (Neutral-quality)	Systematic review of sugar-sweetened beverages (SSBs) and body weight, obesity, or both ( <b>30</b> original studies [9 comparisons with adults])	Epidemiologic and experimental evidence indicates that a greater consumption of SSBs is associated with weight gain and obesity
<i>Vartanian-2007</i> (Positive-quality)	Meta-analysis examined the association between soft drink consumption and nutrition and health outcomes ( <b>88</b> original studies [~30 comparisons were available for soft drinks and energy intake or body weight in adults])	Clear associations of soft drink intake with increased energy intake and body weight were observed

Study	Design: Prospective Observational	SSB	Comparison	Time	Support a relationship between added sugar and energy intake?	Support a relationship between added sugar and body weight?
Palmer-2008 (Neutral-quality)	Prospective cohort of African American women in the U.S. examining change in soft drink intake over time	≥ 1 soft drink/d	≤ 1 soft drink/d	6 yrs	N/A	Yes
Dhingra-2007 (Quality TBD)	Prospective cohort (Framingham Heart Study) examining soft drink intake and obesity	• 1 soft drink/d and • ≥ 2 soft drinks/d	< 1 soft drink/d	4 yrs	N/A	Yes
Chen-2009 (Positive-quality)	Prospective cohort (PREMIER) examining changes in beverage consumption and weight change	Sugar-sweetened beverages	Diet drinks, milk, 100% juice and coffee/tea, alcoholic beverages	18-mo	N/A	Yes
Stokey-2007 (Quality TBD)	Secondary analysis of data from Stanford TO Z intervention examining drinking water as alternative to sweetened-caloric beverages	Sweetened-caloric beverages	Water	2-, 6-, and 12-mo	N/A	Yes

Study	Design: Trials	Added sugar	Comparison	Time	Support a relationship between added sugar and energy intake?	Support a relationship between added sugar and body weight?
Stanhope-2009 (Neutral-quality)	Parallel-arm study with glucose- or fructose-sweetened beverages including both outpatient and inpatient phases	Beverages sweetened with glucose or fructose provided 25% of energy intake		10 wk	N/A	Mixed: Inpatient energy-balanced diet → No Outpatient self-selected diets → Yes
Surwit-1997 (Positive-quality)	Controlled feeding study with high vs. low sucrose weight-loss (hypoenergetic) programs	High-sucrose diet: 43% energy from sucrose	Low-sucrose diet: 4% energy from sucrose	8 wk	N/A	No
Reid-2007 (Quality TBD)	Parallel-arm trial with 4 soft drinks added to daily diet	Regular soft drink	Diet soft drink	4 wk	Yes	No (nonsignificant trend for weight gain)
Raben-1997 (Neutral-quality)	Crossover case-control study with 3 diets (sucrose-, starch-, fat-rich) in normal weight adults	Sucrose-rich diet: 23% energy from sucrose	Starch- and fat-rich diets: Both with 2% energy from sucrose	14 days for each diet	No	No
Flood-2006 (Quality TBD)	Randomized crossover trial with ad lib beverage and lunch	Cola	• Diet cola • Water	1 day (test meal)	Yes	N/A
Soenen-2007 (Neutral-quality)	Crossover trial with preload followed by test meal	Sucrose beverage • HFCS beverage	• Milk • Diet drink	1 day (test meal)	No (higher energy intake with added sugar, but same energy intake as with milk drink)	N/A



# Added Sugar = SSB

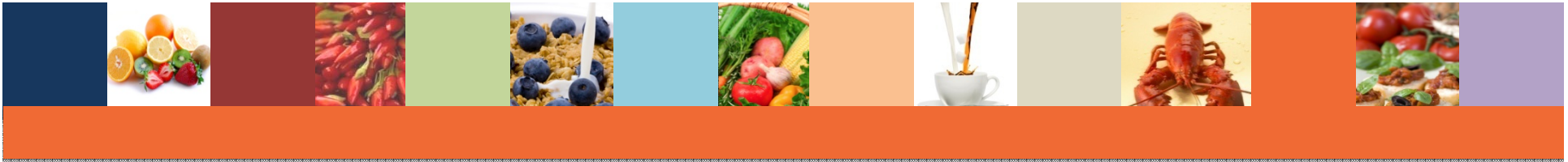
- In adults, what are the associations between intake of sugar-sweetened beverages and energy intake and body weight?
  - Limited evidence shows that intake of sugar-sweetened beverages is linked to higher energy intake in adults.
  - A moderate body of epidemiologic evidence suggests that greater consumption of sugar-sweetened beverages is associated with increased body weight in adults.
  - A moderate body of evidence suggests that under isocaloric controlled conditions, added sugars, including sugar-sweetened beverages, are no more likely to cause weight gain than any other source of energy





# Added Sugar

- Implications:
  - Measurement of “added sugar” in studies is inconsistent making study comparisons difficult – easier to count SSB
  - Comparisons of sucrose, HFCS, and milk show little difference in satiety and energy intake
  - Added sugar not different than other extra calories in the diet for energy intake and body weight



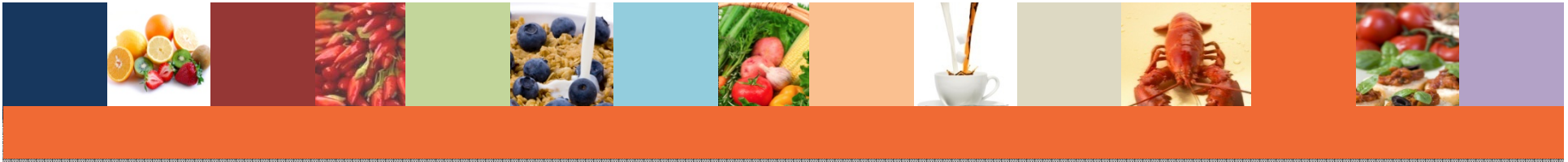
## DGAC: How are non-caloric sweeteners related to energy intake and body weight?

- “Moderate evidence shows that using non-caloric sweeteners will affect energy intake only if they are substituted for higher calorie foods and beverages. A few observational studies reported that individuals who use non-caloric sweeteners are more likely to gain weight or be heavier. This does not mean that non-caloric sweeteners cause weight gain rather that they are more likely to be consumed by overweight and obese individuals.”



# Implications

- “The replacement of sugar-sweetened foods and beverages with sugar-free products should theoretically reduce body weight. Yet many questions remain, as epidemiologic studies show a positive link with use of nonnutritive sweeteners and BMI. Additionally, whether use of low calorie sweeteners is linked to higher intake of other calories in the diet remains a debated question.”



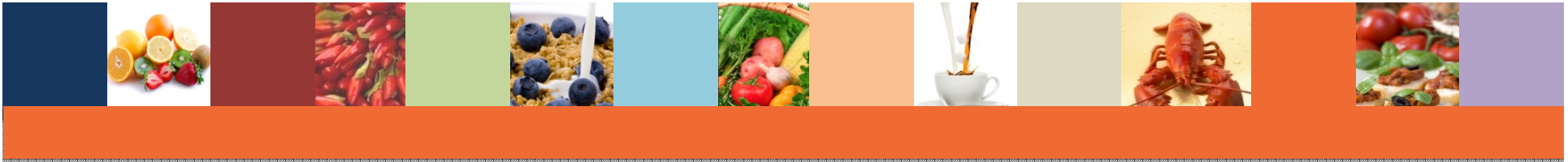
## What is the impact of liquid vs solid foods on energy intake and body weight?

- A limited body of evidence shows conflicting results about whether liquid and solid foods differ in their effects on energy intake and body weight except that liquids in the form of soup may lead to decreased energy intake and body weight



# Implications

- “In general, if total calorie content is held constant, there is little support for any effects on energy intake and body weight due to the calories consumed either as liquid or solid. Some studies suggest that whole foods may be more satiating than liquid foods. Food structure, specifically a whole food (apple, carrots), plays a role in satiety and decreasing food intake at subsequent meals, yet fiber added to a drink is not effective in reducing food intake at subsequent meals. Soup as a preload decreases food intake at a subsequent meal. Thus, Americans are advised to pay attention to the calorie content of the food or beverage consumed, regardless of whether it is a liquid or solid. Calories are the issue in either case.”



# DGAC Carbohydrate chapter summary

- Healthy diets are high in carbohydrate. AMDR for carbohydrates are 45 – 65%. A maximum intake of 25% of added sugars is suggested
- Americans should choose fiber-rich foods such as whole grains, vegetables, fruits, and cooked dry beans and peas as staples in the diet. Dairy products are also a nutrient-dense source of carbohydrates
- Carbohydrates are the primary energy source for active people. Sedentary people, including most Americans, should decrease consumption of caloric carbohydrates to balance energy needs and attain and maintain ideal weight.