Sugar — the bitter truth

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Department of Pediatrics
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• No disclosures
Obesity has been part of the human condition since there were humans.

But something’s happened—
How did the world get so obese?
And how so fast?
Fat for Life?
Six Million Kids Are Seriously Overweight. What Families Can Do.
By Geoffrey Cowley & Sharon Begley
The First Law of Thermodynamics

The total energy inside a closed system remains constant.
The First Law of Thermodynamics

The total energy inside a closed system remains constant.

Two interpretations:
The First Law of Thermodynamics
The First Law of Thermodynamics

Calories In
The First Law of Thermodynamics

Calories
Out

Calories
In
The First Law of Thermodynamics
The First Law of Thermodynamics

Weight Gain

Calories In

Calories Out

Obesity is the result of two aberrant behaviors
Children 2-17 yrs, CSFII (USDA) 1989-91 vs. 1994-95
http://www.usda.gov/cnpp/FENR%20V11N3/fenrv11n3p44.PDF

↑ 275 kcal in teen boys
Fat Intake: Grams

↑ 5 g (45 cal) in teen boys

Children 2-17 yrs, CSFII (USDA) 1989-91 vs. 1994-95
Secular trends in specific food intake 1989-1996

Prevalence of Obesity Compared to Percent Calories from Fat Among US Adults

- Calories from fat
- Obesity prevalence

Year:
- 1960
- 1970
- 1980
- 1990
- 2000

Percent:
- 0
- 10
- 20
- 30
- 40
- 50
- 60
Carbohydrate Intake: Grams

Children 2-17 yrs, CSFII (USDA) 1989-91 vs. 1994-95

↑ 57 g (228 cal) in teen boys
Secular trends in specific food intake 1989-1996

Beverage Intake

Children 2-17 yrs, CSFII (USDA) 1989-91 vs. 1994-95

- 41% increase in soft drinks
- 35% increase in fruit drinks
Beverage Intake

Children 2-17 yrs, CSFII (USDA) 1989-91 vs. 1994-95

One can of soda/day = 150 cal x 365 d/yr ÷ 3500 cal/lb = 15.6 lbs/yr!
High Fructose Corn Syrup

Current US annual consumption of HFCS

- 63 pounds per person
High Fructose Corn Syrup is 42-55% Fructose; Sucrose is 50% Fructose
10 Most Obese States

> 30% obese
10 Most Obese States

- > 30% obese

10 Laziest States

- < 63% active
10 Most Obese States

- Oklahoma (OK)
- Mississippi (MS)
- West Virginia (WV)
- South Carolina (SC)
- Tennessee (TN)
- Alabama (AL)
- Arkansas (AR)
- Louisiana (LA)
- Kentucky (KY)
- Florida (FL)

> 30% obese

10 Laziest States

- New York (NY)
- New Jersey (NJ)
- Pennsylvania (PA)
- Massachusetts (MA)
- Rhode Island (RI)
- Virginia (VA)
- Maryland (MD)
- District of Columbia (DC)
- Vermont (VT)
- Connecticut (CT)

< 63% active

Adult Diabetes Rate
10 Most Obese States

- > 30% obese

10 Laziest States

- < 63% active

Adult Diabetes Rate

Soda Per Capita
The “birth” of the cola wars

For a better start in life
start COLA earlier!

How soon is too soon?

Not soon enough. Laboratory tests over the last few years have proven that babies who start drinking soda during that early formative period have a much higher chance of gaining acceptance and “fitting in” during those awkward pre-teen and teen years. So, do yourself a favor. Do your child a favor. Start them on a strict regimen of sodas and other sugary carbonated beverages right now, for a lifetime of guaranteed happiness.

The Soda Pop Board of America
1515 W. Hart Ave. - Chicago, ILL.

Why we have the youngest customers in the business

Nothing does it like Seven-Up!
Drinks are on us!

Publix is rewarding top grades with free apple juice and soda. Students, we salute your thirst for knowledge!

Limit one reward per student per grading period. Offer good through February 28, 2011.
Prevalence of diabetes, 2010
Secular trend in fructose consumption

Natural consumption of fruits and vegetables
• 15 gm/day

Prior to WWII (estimated):
• 16-24 gm/day

1977-1978 (USDA Nationwide Food Consumption Survey):
• 37 gm/day (8% of total caloric intake)

1994 (NHANES III):
• 54.7 gm/day (10.2% of total caloric intake)

Adolescents:
• 72.8 gm/day (12.1% of total caloric intake)
• 25% consumed at least 15% of calories from fructose

The perfect storm from three political winds
The perfect storm from three political winds

1. Richard Nixon and USDA Secretary Earl Butz (1973)
   - food should never be an issue in a presidential election
Percent of Gross National Product spent on food, by country

*Source: U.S. Department of Agriculture*

Time Magazine, Feb 28, 2011
The perfect storm from three political winds

1. Richard Nixon and USDA Secretary Earl Butz (1973)
   • food should never be an issue in a presidential election

2. The advent of High Fructose Corn Syrup
   • invented in 1966 in Japan
   • introduced to the American market in 1975
Influence of corn sweeteners on the price of sugar

U.S. Producer Price Index:
- Raw cane sugar
- Refined beet sugar
- Corn sweeteners

International price of refined sugar:
- London price
- U.S. price

U.S. Retail Price:
- Refined sugar
- HFCS-42

U.S. Department of Agriculture
Annual Per Capita Availability of Sugar and HFCS Adjusted for Loss

USDA Food Disappearance Data

Source: USDA, Economic Research Service, Sweetener Yearbook, Tables 51 and 52

*Estimated annual per capita sugar consumption calculated by adjusting sugar deliveries for domestic food and beverage use for food losses.

**Estimated annual per capita HFCS consumption calculated by adjusting HFCS deliveries for domestic food and beverage use for food losses.
Juice is sucrose:
Change in BMI z-score in lower socioeconomic status children versus number of fruit juice servings per day
ANNUAL PER CAPITA AVAILABILITY OF SUGAR AND HFCS ADJUSTED FOR LOSS

USDA FOOD DISAPPEARANCE DATA

TOTAL HFCS & SUGAR

MOST FRUCTOSE ITEMS

SUGAR*

HFCS**

JUICE

YEAR


POUNDS PER YEAR

0 10 20 30 40 50 60 70 80 90 100

Source: USDA, Economic Research Service, Sweetener Yearbook, Tables 51 and 52

*Estimated annual per capita sugar consumption calculated by adjusting sugar deliveries for domestic food and beverage use for food losses.

**Estimated annual per capita HFCS consumption calculated by adjusting HFCS deliveries for domestic food and beverage use for food losses.
The perfect storm from three political winds

1. Richard Nixon and USDA Secretary Earl Butz (1973)
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2. The advent of High Fructose Corn Syrup
   • invented in 1966 in Japan
   • introduced to the American market in 1975

3. The USDA, AMA, and AHA call for dietary fat reduction
   • Early 1970’s: discovery of LDL
   • Mid 1970’s: Dietary fat raises LDL (A ➔ B)
   • Late 1970’s: LDL correlated with CVD (B ➔ C)
   • 1982: If A ➔ B, and B ➔ C, then A ➔ C, therefore no A, no C
The macronutrient wars 1970-1980

John Yudkin

Pure, White and Deadly

Viking
1972, 1986
Seven Countries
Correlation of CHD with dietary fat

![Graph showing correlation between CHD deaths per 1000 and percent calories from fat.](image-url)
The fact that the incidence rate of coronary heart disease was significantly correlated with the average percentage of calories from sucrose in the diets is explained by the intercorrelation of sucrose with saturated fat. Partial correlation analysis shows that with saturated fat constant there was no significant correlation between dietary sucrose and the incidence of coronary heart disease. Comparisons of coronary death rates with estimates of national diets in international statistics indicate a strong direct relationship with saturated fat.
### The lipoprotein continuum

<table>
<thead>
<tr>
<th>VLDL</th>
<th>IDL</th>
<th>LDL&lt;sub&gt;A&lt;/sub&gt; large buoyant</th>
<th>PATTERN “A”</th>
<th>HDL</th>
</tr>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
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<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
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</table>

<table>
<thead>
<tr>
<th>LDL&lt;sub&gt;A-B&lt;/sub&gt; intermediate</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image6.png" alt="Image" /></td>
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</table>

<table>
<thead>
<tr>
<th>PATTERN “B”</th>
<th>LDL&lt;sub&gt;B&lt;/sub&gt; small dense</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
</tbody>
</table>

“Total LDL” won’t tell you particle number - There’s more LDL<sub>B</sub> than LDL<sub>A</sub> at the same total concentration
TG and HDL change with LDL sizing

Rizzo and Berneis, Quart J Med 99:1, 2006
LDL particle size is responsive to dietary CHO

The low-fat craze

The content of low-fat home-cooked food can be controlled

But low-fat processed food means substitution with carbohydrate

Which carbohydrate?

Either

- High fructose corn syrup (55% fructose)
- Sucrose (50% fructose)

e.g. Nabisco Snackwells® Oreos
(—2g fat, +13g CHO (+4g sugars))
Adulteration of our food supply

Addition of fructose
- palatability (esp. with decreased fat)
- browning agent

Removal of fiber
- shelf life
- freezing

Substitution of trans-fats
- hardening agent, shelf life
- now being removed due to CVD risk
Fructose is not glucose

- Fructose is 7 times more likely than glucose to form Advanced Glycation End-Products (AGE’s)
- Fructose does not suppress ghrelin
- Acute fructose does not stimulate insulin (or leptin)
- Hepatic fructose metabolism is different
- Chronic fructose exposure promotes the Metabolic Syndrome

Elliot et al. Am J Clin Nutr, 2002
Bray et al. Am J Clin Nutr, 2004
Teff et al. J Clin Endocrinol Metab, 2004
Gaby, Alt Med Rev, 2005

Le and Tappy, Curr Opin Clin Nutr Metab Care, 2006
Wei et al. J Nutr Biochem, 2006
Rutledge and Adeli, Nutr Rev, 2007
Ethanol is a carbohydrate
Ethanol is a carbohydrate

CH₃-CH₂-OH
Ethanol is a carbohydrate

CH₃-CH₂-OH

But ethanol is also a toxin
Acute ethanol exposure

- CNS depression
- Vasodilatation, decreased BP
- Hypothermia
- Tachycardia
- Myocardial depression
- Variable pupillary responses
- Respiratory depression
- Diuresis
- Hypoglycemia
- Loss of fine motor control

Acute fructose exposure
Metabolism of Ethanol

96 calories
Ethanol (80%)

Stomach and intestine first pass effect 10%
Kidney, muscle, and brain 10%
24 calories
Metabolism of Ethanol
Metabolism of Ethanol

- Ethanol
  - Alcohol Dehydrogenase 1B
  - Acetaldehyde
    - Aldehyde Dehydrogenase 2
  - ROS
  - Acetate
Metabolism of Ethanol

- Ethanol
  - Alcohol Dehydrogenase 1B
  - Acetaldehyde
    - ROS
    - Aldehyde Dehydrogenase 2
- SREBP1
  - ACL ACC FAS
  - Citrate
    - Acetyl-CoA
      - Acyl-CoA
      - VLDL
      - MTP
      - ApoB
  - TCA cycle
    - O2
    - ATP
    - CO2
- Insulin
  - Acetate
    - ACCS2
Metabolism of Ethanol

- Ethanol
  - Alcohol Dehydrogenase 1B
  - Aldehyde Dehydrogenase 2
- Acetaldehyde
  - ROS
- Ethanol
  - SREBP1
  - FFA
  - Dyslipidemia
  - Muscle IR
  - VLDL
  - ApoB
  - MTP
  - TCA cycle
  - O2
  - ATP
  - Acetyl-CoA
  - ACCS2
  - Acetate
  - Citrate
  - Acetyl-CoA
  - Acyl-CoA
  - TG
Metabolism of Ethanol

- Ethanol
  - Alcohol Dehydrogenase 1B
  - Acetaldehyde
  - ROS
  - Aldehyde Dehydrogenase 2

- Citrate → Acetyl-CoA → Acyl-CoA
  - SREBP1
  - ACL ACC FAS
  - MTP
  - VLDL
  - ApoB
  - TCA cycle
  - O2 ATP + CO2

- Acetate
  - ACCS2

- Lipid droplet
  - FFA
  - Dyslipidemia
  - Muscle IR

- TG
Detrimental Effects of Fructose

Fructose
100%

60 kcal
(+ 12 kcal glucose)

48 kcal

Insulin

TG
Detrimental Effects of Fructose

Fructose

Glut5

Fructose

Insulin

TG
Detrimental Effects of Fructose

- Fructose
- Glut5
- Fructose
- Fructokinase
- Fructose-1-P
- ATP
- ADP
- Pi
- TG
- Insulin
Detrimental Effects of Fructose

Fructose
Fructokinase
Fructose-1-P

ATP

ADP

AMP

AMP deaminase 1

Pi

IMP

Uric Acid

X

NO

BP

Insulin

TG
Relations between fructose, uric acid and hypertension in NHANES IV adolescents

Relations between fructose, uric acid and hypertension in NHANES IV adolescents

$P = 0.0495$
Detrimental Effects of Fructose

Fructose

Fructose-1-P

Fructokinase

ATP

ADP

AMP

AMP deaminase 1

Pi

IMP

Uric Acid

X

NO

BP

Insulin

TG

Glyceraldehyde

Pyruvate

Dihydroxyacetone-P
Detrimental Effects of Fructose

Fructose
- Glut5
- Fructokinase
- Fructose-1-P

ATP → ADP → AMP → IMP → Uric Acid → X

Dihydroxyacetone-P
Glyceraldehyde
- Xylulose-5-P
- Fructose-6-P*
- PFK
- Fructose-1,6-bis-P

Pyruvate → Citrate → Acetyl-CoA → Pyruvate

TCA cycle

O2 → ATP + CO2

Insulin

BP ↑

TG
Detrimental Effects of Fructose

Fructose
- **Glut5**
- Fructokinase
- Fructose-1-P
  - ATP → ADP → AMP → IMP → Uric Acid → X → NO
- Dihydroxyacetone-P
- Glyceraldehyde
  - Xylulose-5-P
- Fructose-6-P (*PFK*)
- Fructose-1,6-bis-P

Pyruvate
- Citrate
- Acetyl-CoA
- **TCA cycle**
- **O2**, **ATP**, **CO2**

Insulin

BP

TGl
Fructose increases de novo lipogenesis in normal adults

Fructose increases de novo lipogenesis, triglycerides and free fatty acids in normal adults

Faeh and Schwarz, Diabetes 54:1907, 2005
Detrimental Effects of Fructose

Fructose
- Glut5

Fructose
- Fructokinase

Fructose-1-P

ATP

\[ \text{Fructose} \rightarrow \text{ATP} \rightarrow \text{ADP} \rightarrow \text{AMP} \rightarrow \text{IMP} \rightarrow \text{Uric Acid} \rightarrow X \rightarrow \text{NO} \]

Dihydroxyacetone-P

Glyceraldehyde

Xylulose-5-P

Fructose-6-P *

PP2A

Fructose-1,6-bis-P

ChREBP

ACL

ACC

FAS

MTP

VLDL

ApoB

TCA cycle

Citrate

Acetyl-CoA

Acyl-CoA

O2

ATP

CO2

Pyruvate

TCA cycle

TG

Dyslipidemia

Insulin

BP
Associations between sugar sweetened beverage consumption and ALT in obese children

- Caucasian (n = 163)
  - $r = 0.20$
  - $P = 0.015$

- African American (n = 89)
  - $r = 0.22$
  - $P = 0.049$

Valente et al. (unpublished)
Detrimental Effects of Fructose

Fructose

- Glut5
- Fructokinase
- Fructose-1-P

Dihydroxyacetone-P

Glyceraldehyde

- Xylulose-5-P
- Fructose-6-P *
- PFK
- Fructose-1,6-bis-P

Pyruvate

Pyruvate

ATP

Pi

AMP deaminase 1

ADP

AMP

IMP

Uric Acid

X

NO

BP

Insulin

FFA

Dyslipidemia

Muscle IR

Muscle IR

Lipid droplet

FFA

MTP

VLDL

ApoB

Acyl-CoA

Acetyl-CoA

TCA cycle

Citrate

O2

ATP

CO2

TG
Detrimental Effects of Fructose

1. Fructose enters the cell via Glut5.
2. Fructose is converted to Fructose-1-P by fructokinase.
3. Fructose-1-P is converted to ATP and ADP.
4. ATP is converted to AMP by AMP deaminase 1.
5. AMP is converted to IMP and uric acid.
6. Uric acid is converted to X and NO.
7. BP increases due to inflammation.
8. Inflammation activates MKK7, which activates JNK1.
9. JNK1 phosphorylates PP2A, activating ChREBP.
10. ChREBP activates FAS, ACC, and ACL.
11. Acetyl-CoA and acyl-CoA are converted to citrate.
12. Citrate enters the TCA cycle.
13. TCA cycle produces ATP.
14. ATP and CO2 are produced.
15. Muscle IR and dyslipidemia lead to increased FFA and TG.
16. Insulin resistance leads to increased FFA and TG.
17. Lipid droplet formation leads to lipodystrophy.

Key Pathways:
- Fructose metabolism
- Inflammation
- TCA cycle
- Lipid metabolism
- Insulin resistance
Detrimental Effects of Fructose

Fructose
- Glut5
  - Fructose
  - Fructokinase
  - Fructose-1-P

Fructose-1-P
- ATP
- ADP
- AMP
- AMP deaminase 1
- Pi
- IMP
- Uric Acid
- X
- NO

Inflammation
- MKK7
- JNK1
- Tyr-IRS-1
- IRS-1
- IRS-1
- P Ser-IRS-1
- Hepatic IR
- Insulin
- FFA
- Dyslipidemia
- Muscle IR

Hyperinsulinemia
- BP

Lipid droplet
- TCA cycle
- Citrate
- Acetyl-CoA
- Acyl-CoA
- VLDL
- MTP
- ApoB
- TG
Detrimental Effects of Fructose

- Fructose
  - Fructokinase
  - Fructose-1-P
- Dihydroxyacetone-P
- Glyceraldehyde
- Xylulose-5-P
- Fructose-6-P
- PFK
- Fructose-1,6-bis-P
- PP2A
- ChREBP
- SREBP1
- Citrate
- Acetyl-CoA
- TCA cycle
- Oxygen
- ATP
- CO₂
- Pyruvate

Inflammation
- JNK1
- MKK7
- pSer-IRS-1
- pTyr-IRS-1
- IRS-1
- Hepatic IR
- Muscle IR

Hyper-insulinemia
- Inflammation
- Insulin
- FFA
- Dyslipidemia
- TG

Hyperglycemia
- TCA cycle
- ATP
- CO₂

Lipid droplet

BP:
- Blood Pressure
Detrimental Effects of Fructose

- Fructose
- ATP
- Pi
- AMP deaminase 1
- ADP
- AMP
- IMP
- Uric Acid
- X
- NO
- BP
- Hyperinsulinemia
- Infliximab
- JNK1
- MKK7
- MKP7
- pTyr-IRS-1
- IRS-1
- pSer-IRS-1
- Hepatic IR
- FFA
- Dyslipidemia
- Muscle IR
- TG Obesity
- TCA cycle
- Acetyl-CoA
- Pyruvate
- Citrate
Detrimental Effects of Fructose

- Fructose
  - Fructokinase
  - Fructose-1-P
  - Dihydroxyacetone-P
  - Glyceraldehyde
  - Xylulose-5-P
  - Fructose-6-P
  - PFK
  - Fructose-1,6-bis-P
- ATP → ADP → AMP → IMP → Uric Acid → NO
- MKK7 → JNK1 → pTyr-IRS-1
- SREBP1 → ChREBP → Acetyl-CoA → Acyl-CoA → VLDL
- Citrate → Acetyl-CoA → TCA cycle
- TCA cycle: O₂ → ATP → CO₂
- Lipid droplet
- Hyperinsulinemia → FFA → Dyslipidemia
- Hepatic IR → IR
- Muscle IR
- TG Obesity
Protein Glycation and the Metabolic Syndrome
The furan ring of fructose is more unstable, so at equilibrium, fructose exists in the linear form.
The Amadori Reaction

Hemoglobin

\[ \text{NH}_2 \]
\[ \text{CHO} \]
\[ \text{H-\text{C-OH}} \]
\[ \text{HO-C-H} \]
\[ \text{H-\text{C-OH}} \]
\[ \text{H-\text{C-OH}} \]
\[ \text{CH}_2\text{OH} \]

Glucose

\[ \text{HO-C-H} \]
\[ \text{H-\text{C-OH}} \]
\[ \text{H-\text{C-OH}} \]
\[ \text{CH}_2\text{OH} \]

(Schiff base)

Hemoglobin \(_{A_{1c}}\)

\[ \text{NH} \]
\[ \text{H-C-H} \]
\[ \text{H-C-O} \]
\[ \text{HO-C-H} \]
\[ \text{H-C-OH} \]
\[ \text{H-C-OH} \]
\[ \text{CH}_2\text{OH} \]

(Amadori product)
Generation of reactive oxygen species by carbohydrate
Non-enzymatic glycation: fructose >> glucose

Fructose and glycation \textit{in vitro}

<table>
<thead>
<tr>
<th></th>
<th>Rate (mM/hr)</th>
<th>Carbonyl (%)</th>
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<tbody>
<tr>
<td>Glucose</td>
<td>0.6</td>
<td>0.002</td>
</tr>
<tr>
<td>Galactose</td>
<td>2.8</td>
<td>0.02</td>
</tr>
<tr>
<td>Fructose</td>
<td>4.5</td>
<td>0.7</td>
</tr>
</tbody>
</table>


Bunn and Higgins, Science 213:222, 1981
Serum fructose levels after 75 gm (300 kcal) oral bolus

Serum fructose levels after 75 gm (300 kcal) oral bolus

Hepatocyte death *in vitro* upon fructose exposure (after generation of $\text{H}_2\text{O}_2$)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ED$_{50}$</th>
<th>ED$_{50}$ (with $\text{H}_2\text{O}_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fructose</td>
<td>1.5 ± 0.13 M</td>
<td>12 ± 2 mM</td>
</tr>
<tr>
<td>Glucose</td>
<td>&gt;1.5 M</td>
<td>1.5 M</td>
</tr>
<tr>
<td>Glycoaldehyde</td>
<td>20 ± 2 mM</td>
<td>0.5 ± 0.1 mM</td>
</tr>
<tr>
<td>Glyoxal</td>
<td>5 ± 0.5 mM</td>
<td>0.02 ± 0.002 mM</td>
</tr>
</tbody>
</table>

Prevented by addition of:
- antioxidant vitamins ($\text{VitB}_1$, $\text{VitB}_6$, $\text{VitC}$)
- P450 inhibitors
- hydroxyl radical and carbonyl scavengers
- heavy metal chelators
Chronic ethanol exposure

- Hematologic disorders
- Electrolyte abnormalities
- Hypertension
- Cardiac dilatation
- Cardiomyopathy
- Dyslipidemia
- Pancreatitis
- Malnutrition
- Obesity
- Hepatic dysfunction (ASH)
- Fetal alcohol syndrome
- Addiction
<table>
<thead>
<tr>
<th>Chronic ethanol exposure</th>
<th>Chronic fructose exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hematologic disorders</td>
<td>• Hypertension</td>
</tr>
<tr>
<td>• Electrolyte abnormalities</td>
<td>• Myocardial infarction</td>
</tr>
<tr>
<td>• Hypertension</td>
<td>• Dyslipidemia</td>
</tr>
<tr>
<td>• Cardiac dilatation</td>
<td>• Pancreatitis (2º dyslipidemia)</td>
</tr>
<tr>
<td>• Cardiomyopathy</td>
<td></td>
</tr>
<tr>
<td>• Dyslipidemia</td>
<td>• Obesity</td>
</tr>
<tr>
<td>• Pancreatitis</td>
<td>• Hepatic dysfunction (NASH)</td>
</tr>
<tr>
<td>• Malnutrition</td>
<td>• Fetal insulin resistance</td>
</tr>
<tr>
<td>• Obesity</td>
<td>• Habituation, if not addiction</td>
</tr>
<tr>
<td>• Hepatic dysfunction (ASH)</td>
<td></td>
</tr>
<tr>
<td>• Fetal alcohol syndrome</td>
<td></td>
</tr>
<tr>
<td>• Addiction</td>
<td></td>
</tr>
</tbody>
</table>
### What’s the difference?

<table>
<thead>
<tr>
<th></th>
<th>Coca-Cola Classic</th>
<th>Schlitz Pop Top</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong></td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td><strong>Percent CHO</strong></td>
<td>10.5% (sucrose)</td>
<td>3.6% (alcohol)</td>
</tr>
<tr>
<td><strong>Calories from</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fructose</td>
<td>75 (4.1 kcal/gm)</td>
<td></td>
</tr>
<tr>
<td>other carbs</td>
<td>75 (glucose)</td>
<td>60 (maltose)</td>
</tr>
<tr>
<td>alcohol</td>
<td></td>
<td>90 (7 kcal/gm)</td>
</tr>
<tr>
<td><strong>1st pass GI metabolism</strong></td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Calories reaching liver</strong></td>
<td>90</td>
<td>92</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Calories</th>
<th>150</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent CHO</td>
<td>10.5% (sucrose)</td>
<td>3.6% (alcohol)</td>
</tr>
<tr>
<td>Calories from</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fructose</td>
<td>75 (4.1 kcal/gm)</td>
<td></td>
</tr>
<tr>
<td>other carbs</td>
<td>75 (glucose)</td>
<td>60 (maltose)</td>
</tr>
<tr>
<td>alcohol</td>
<td></td>
<td>90 (7 kcal/gm)</td>
</tr>
<tr>
<td>1st pass Gl metabolism</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>Calories reaching liver</td>
<td>90</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>Calories</td>
<td>Percent CHO</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>10.5% (sucrose)</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>3.6% (alcohol)</td>
</tr>
</tbody>
</table>

**What’s the difference?**
Recognition at the American Heart Association

AHA Scientific Statement

Dietary Sugars Intake and Cardiovascular Health
A Scientific Statement From the American Heart Association

Rachel K. Johnson, PhD, MPH, RD, Chair; Lawrence J. Appel, MD, MPH, FAHA; Michael Brands, PhD, FAHA; Barbara V. Howard, PhD, FAHA; Michael Lefevre, PhD, FAHA; Robert H. Lustig, MD; Frank Sacks, MD, FAHA; Lyn M. Steffen, PhD, MPH, RD, FAHA; Judith Wylie-Rosett, EdD, RD; on behalf of the American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention

Recommends reduction in sugar intake from 22 tsp/day to 9 tsp/day (males) and 6 tsp/day (females)
The First Law of Thermodynamics
The First Law of Thermodynamics

Obligate weight gain

Weight Gain
The First Law of Thermodynamics

Obligate weight gain

Calories Out

Weight Gain
The First Law of Thermodynamics

Obligate weight gain

Calories In

Calories Out

Weight Gain
The First Law of Thermodynamics

The two aberrant behaviors are a result of our biochemistry. Our biochemistry is a result of our environment.
Collaborators

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