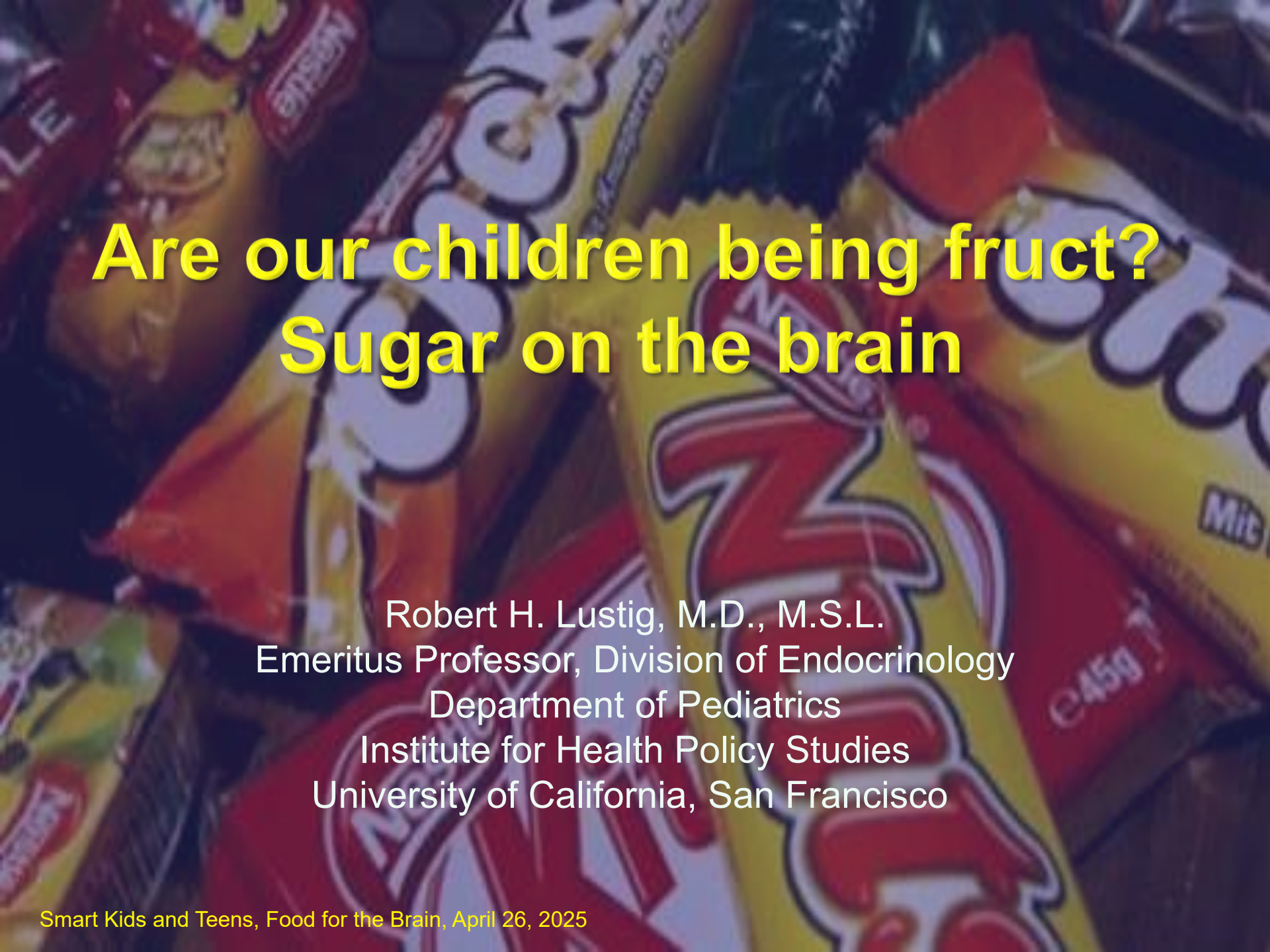
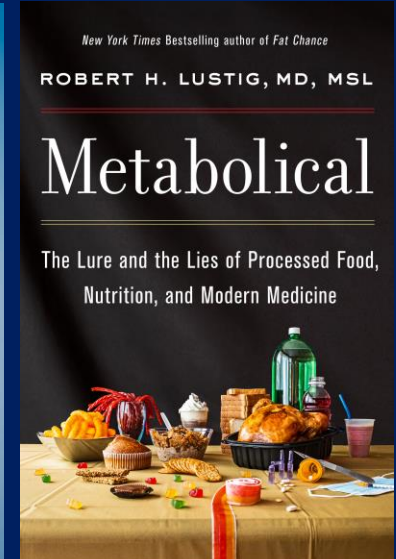
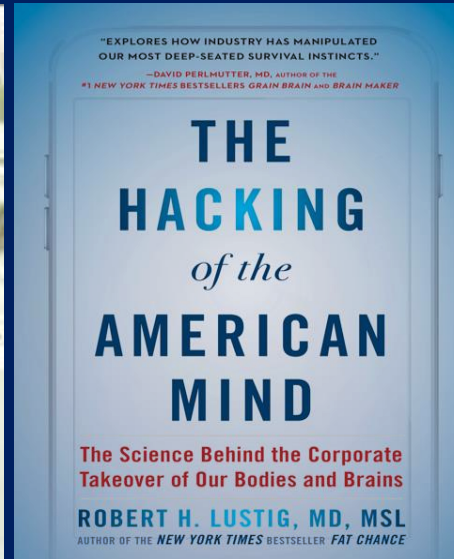
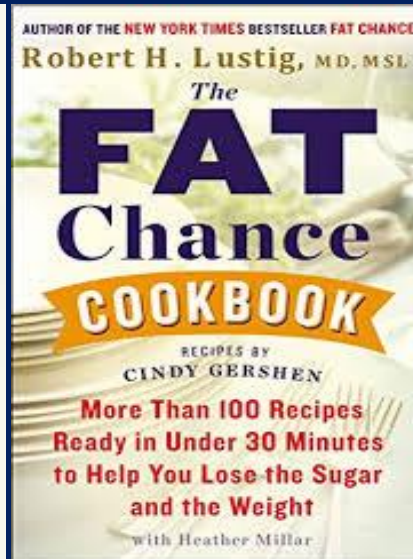
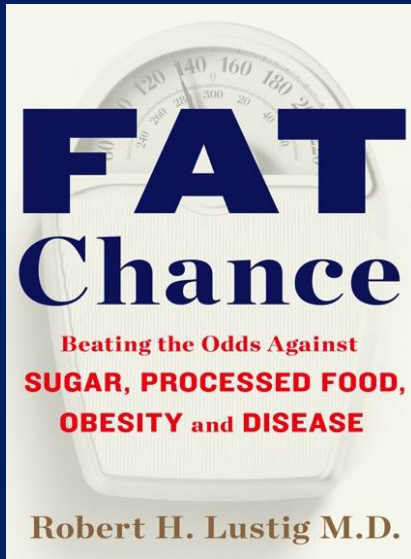




Are our children being fruct? Sugar on the brain

Robert H. Lustig, M.D., M.S.L.
Emeritus Professor, Division of Endocrinology
Department of Pediatrics
Institute for Health Policy Studies
University of California, San Francisco

Disclosures



Chief Medical Officer:

BioLumen
Ireneo Health
Perfact

Paid Advisor:

Simplex Health
Myka Labs
Levels Health

Unpaid Advisor:

Kuwaiti Danish Dairy
Blue Oak Nutraceuticals

I will not be speaking about any of these companies or products

Sugar

56% of the food sold in America is ultraprocessed food
Accounts for 62% of the sugar in the American diet
And 67% of the sugar in kids' diets

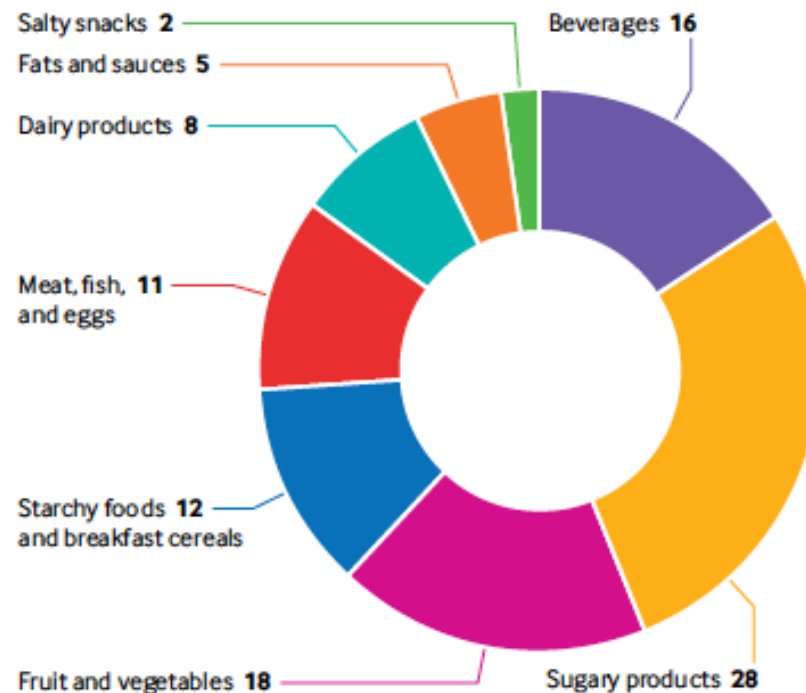


Fig 2 | Relative contribution (%) of each food group to consumption of ultra-processed food in diet

SUGAR IN CHILDREN'S CEREALS: POPULAR BRANDS PACK MORE SUGAR THAN SNACK CAKES AND COOKIES



10 Worst Children's Cereals

Based on percent sugar by weight

	Percent sugar by weight
1 Kellogg's Honey Smacks	55.6%
2 Post Golden Crisp	51.9%
3 Kellogg's Froot Loops Marshmallow	48.3%
4 Quaker Oats Cap'n Crunch's OOPS! All Berries	46.9%
5 Quaker Oats Cap'n Crunch Original	44.4%
6 Quaker Oats Oh!s	44.4%
7 Kellogg's Smorz	43.3%
8 Kellogg's Apple Jacks	42.9%
9 Quaker Oats Cap'n Crunch's Crunch Berries	42.3%
10 Kellogg's Froot Loops Original	41.4%

Source: EWG analysis of nutrition labels for 84 children's cereals.



ENVIRONMENTAL
WORKING
GROUP



Courtesy of
M. Lustig



Courtesy of
M. Lustig

Sugar is the 'alcohol of the child', yet we let it dominate the breakfast table

Robert Lustig

US edition ▾
**The
Guardian**

With kids consuming half their sugar quota first thing, it's no wonder they're getting diabetes and liver disease. We have to fight corporate interests



'On average, cereal contains a whopping 12g of sugar, all added, in a typical serving.' Photograph: Stockbyte/Rex Features

Wednesday 4 January 2017 08.31 EST

The change in our global food supply

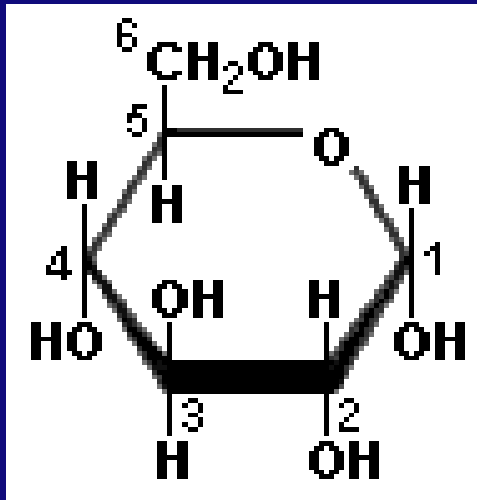
Addition of fructose

- palatability (esp. with decreased fat)
- browning agent

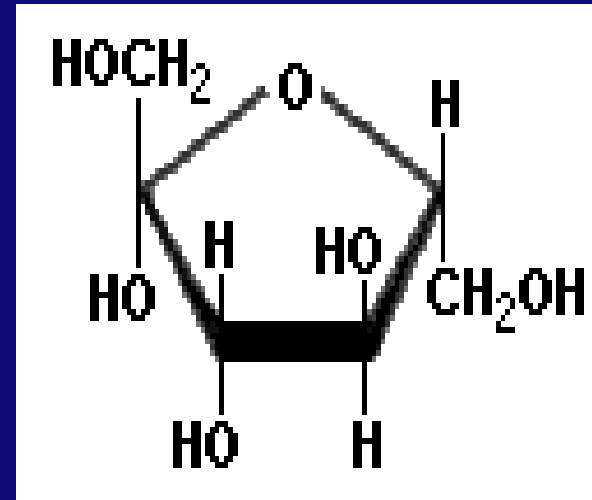
Removal of fiber

- shelf life
- freezing

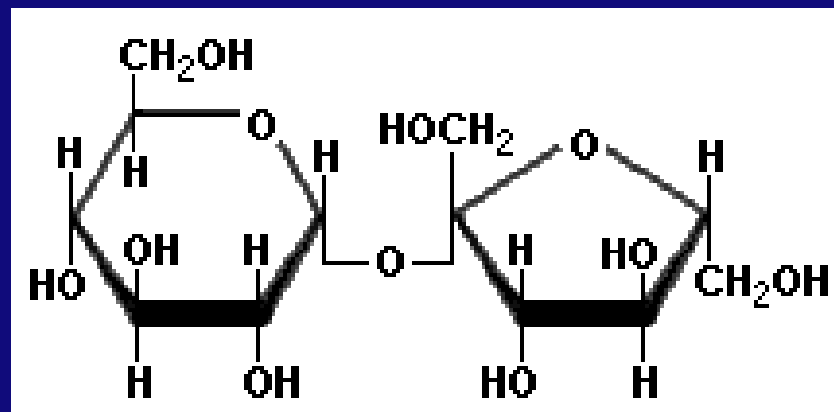
**High Fructose Corn Syrup is 42-55% Fructose;
Sucrose is 50% Fructose**



Glucose



Fructose



Sucrose

Fructose is not glucose

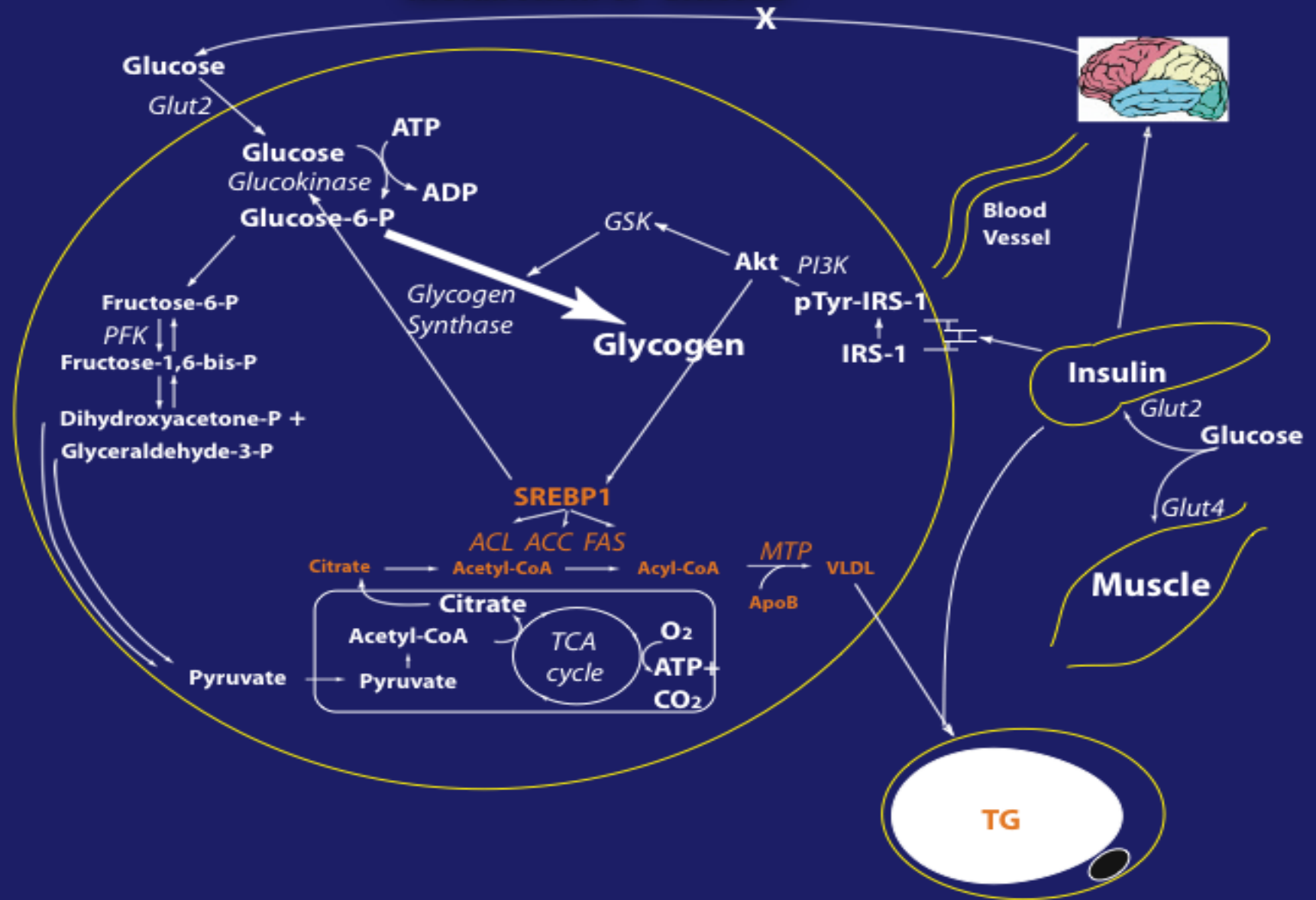
- Fructose is 7 times more likely than glucose to form Advanced Glycation End-Products (AGE' s)
- Fructose does not suppress ghrelin
- Acute fructose does not stimulate insulin (or leptin)
- Hepatic fructose metabolism is different in liver and brain
- **Chronic fructose exposure promotes the metabolic syndrome, including brain manifestations**

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
Johnson et al. Am J Clin Nutr 2007
Rutledge and Adeli, Nutr Rev, 2007
Brown et al. Int. J. Obes, 2008

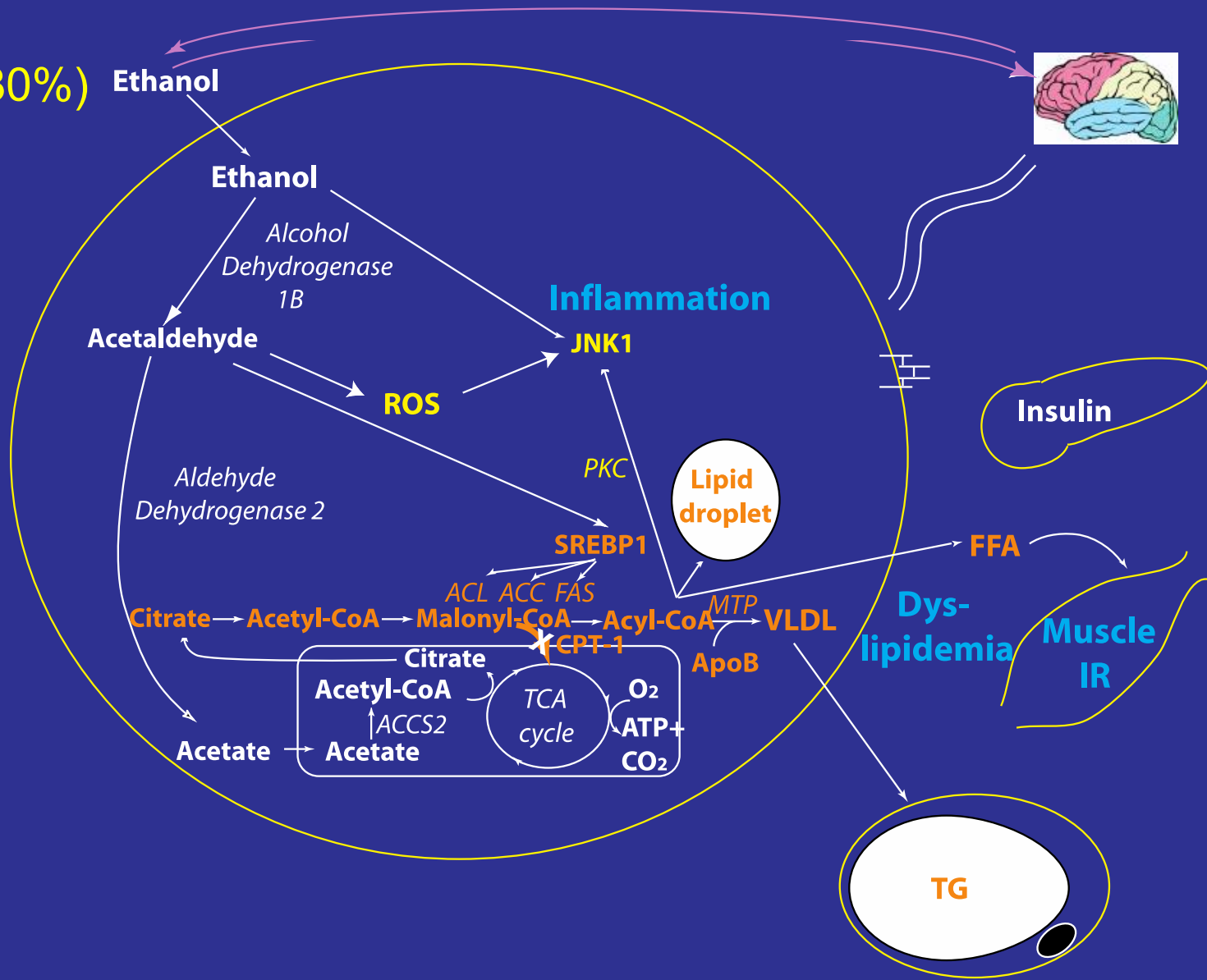
Liver

Metabolism of Glucose



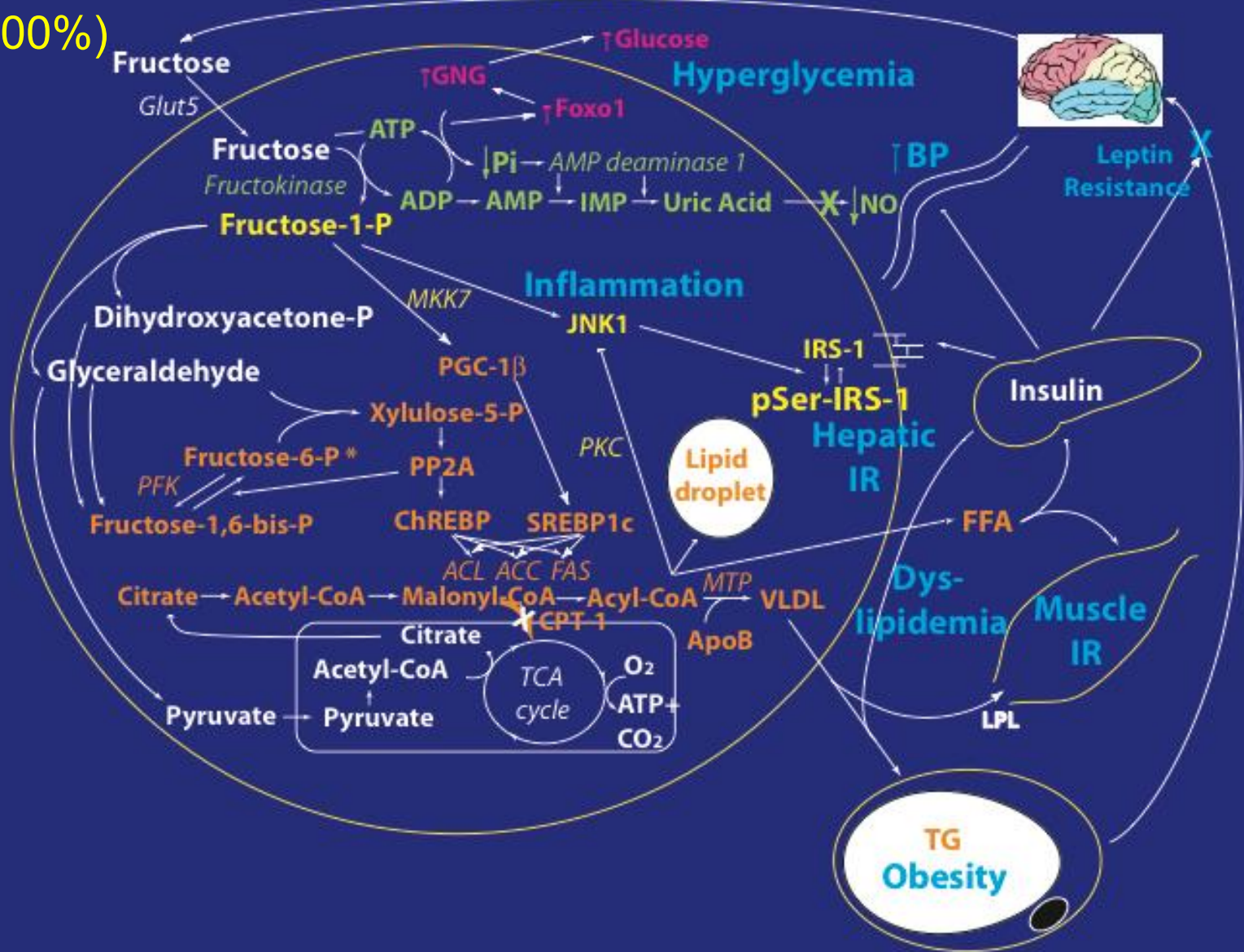
Metabolism of Ethanol

(80%) Ethanol



Detrimental Effects of Fructose

(100%)



Sugar effects on the brain: mechanisms

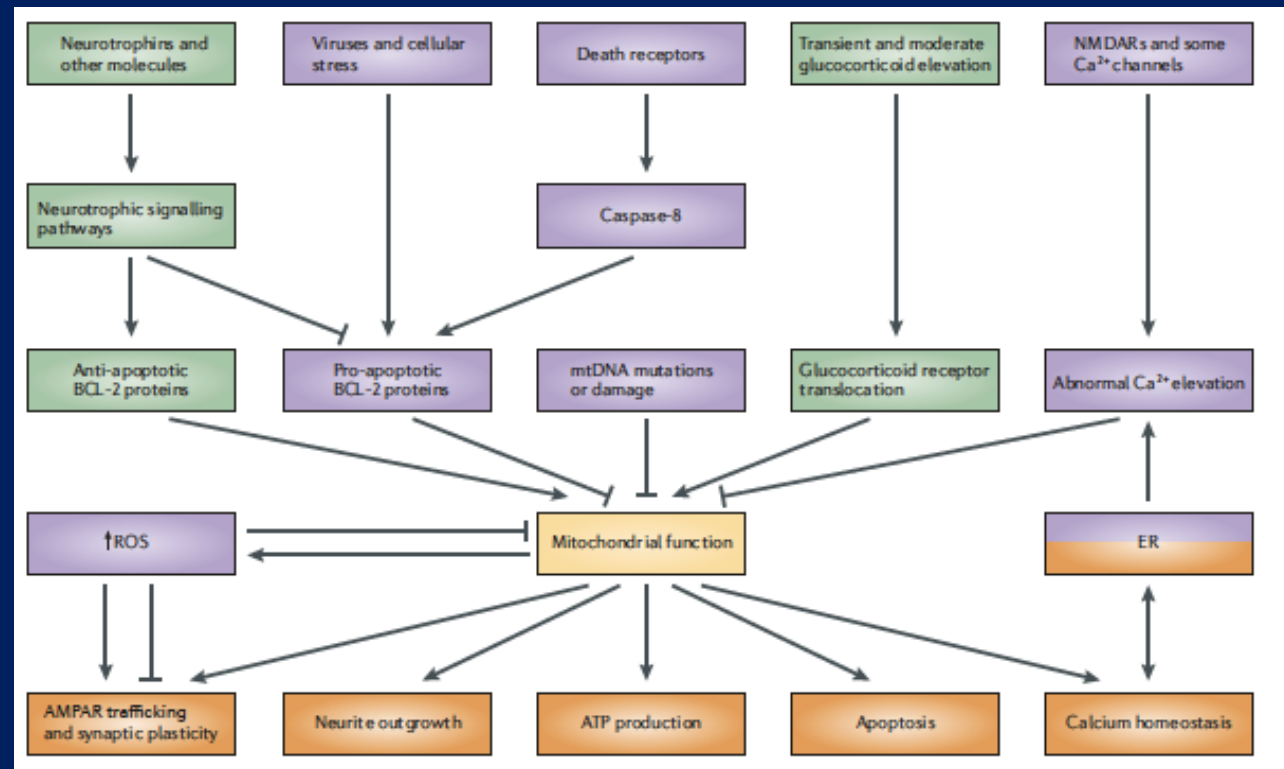
- alter CNS energy metabolism (e.g. mitochondria)
- alter CNS neurotransmission (e.g. glutamate)
- alter CNS trophic factors (e.g. leptin, BDNF)
- alter CNS exposures (e.g. toxins, infections (*Strep.*)
- addiction (dopamine)

1. CNS energy metabolism: Mitochondrial dysfunction

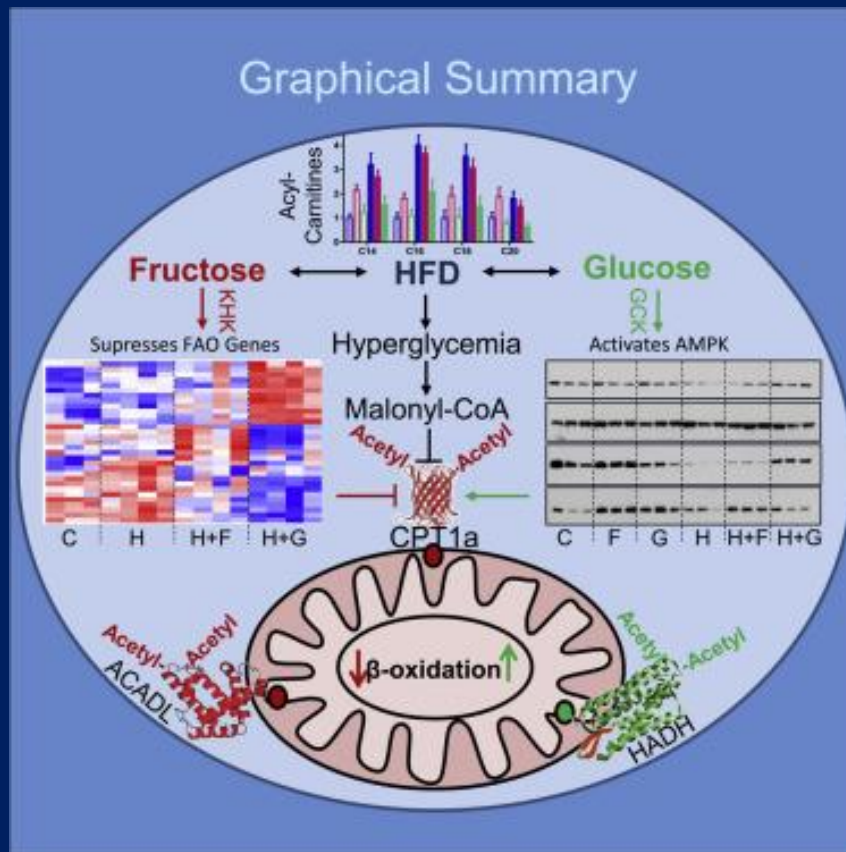
REVIEWS

Impaired mitochondrial function in psychiatric disorders

Husseini Manji¹, Tadafumi Kato², Nicholas A. Di Prospero¹, Seth Ness¹,
M. Flint Beal², Michael Krams¹ and Guang Chen¹



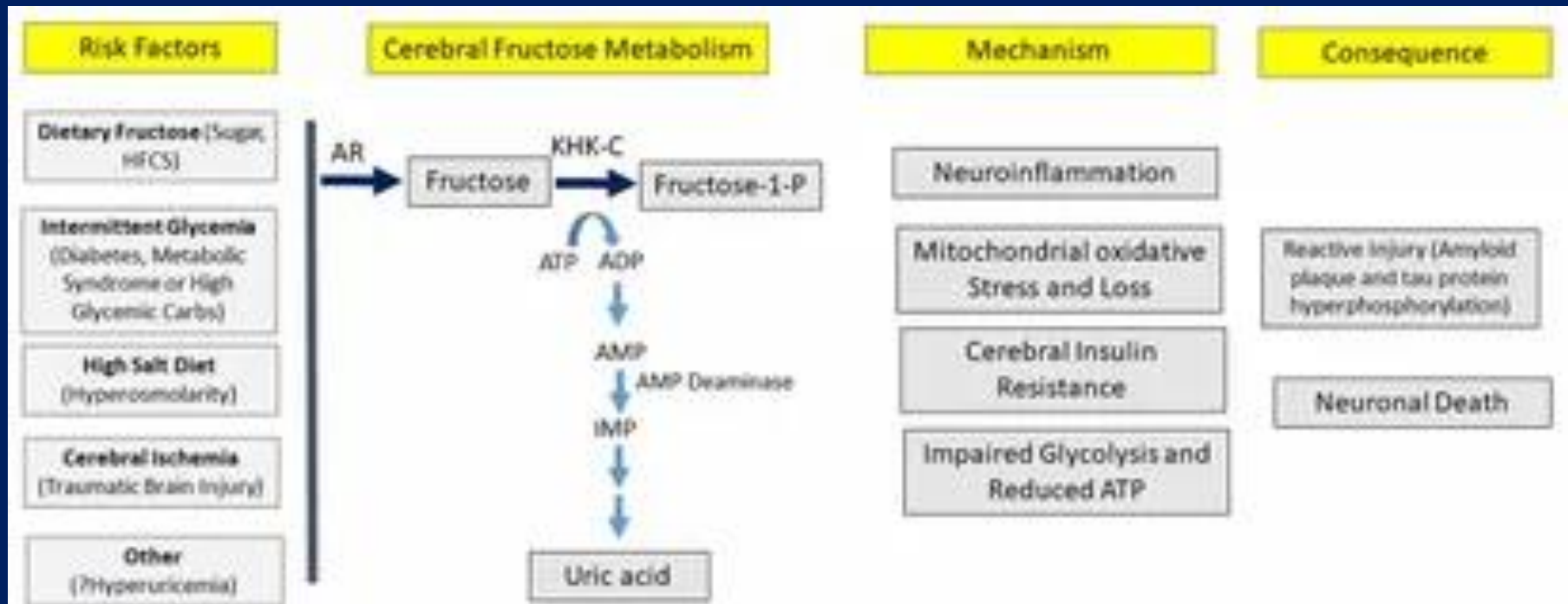
Fructose reduces liver mitochondrial function, while glucose stimulates it



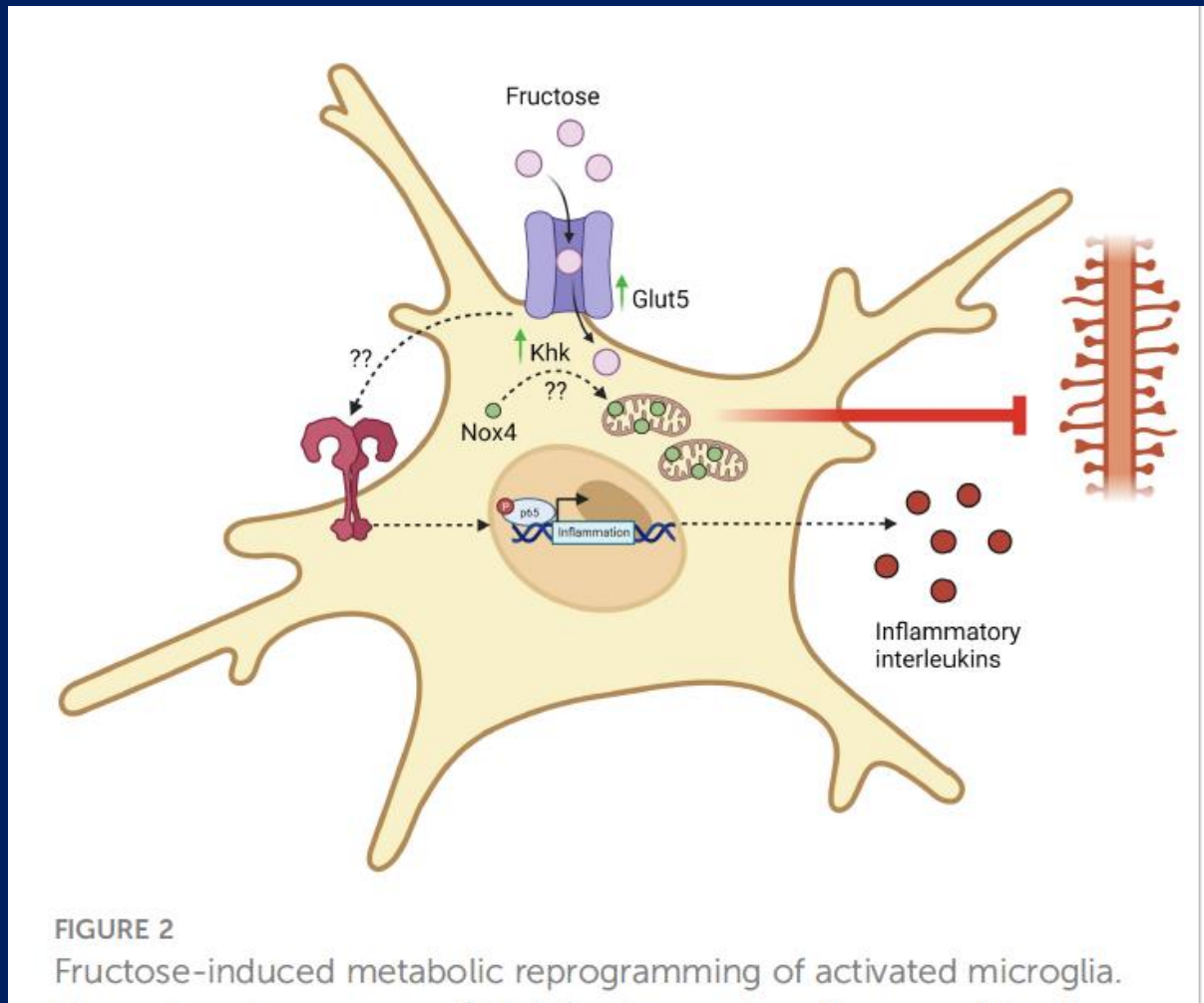
"The most important takeaway of this study is that high fructose in the diet is bad," says Dr. Kahn. "It's not bad because it's more calories, but because it has effects on liver metabolism to make it worse at burning fat. As a result, adding fructose to the diet makes the liver store more fat, and this is bad for the liver and bad for whole body metabolism."

Dr. C. Ronald Kahn,
CEO, Joslin Diabetes Center

Fructose and neuroinflammation in astrocytes and microglia

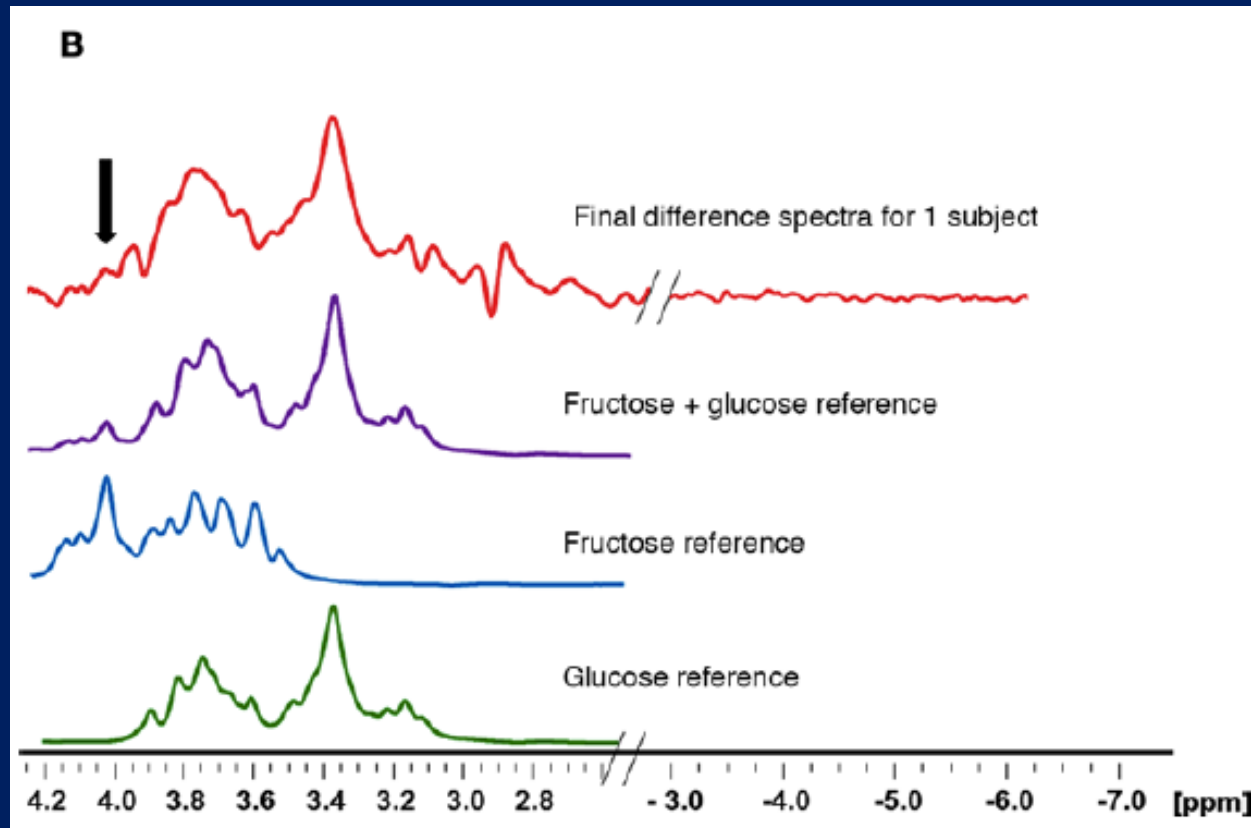


Fructose induces reprogramming of microglia from M2 (anti-) to M1 (pro-inflammatory)

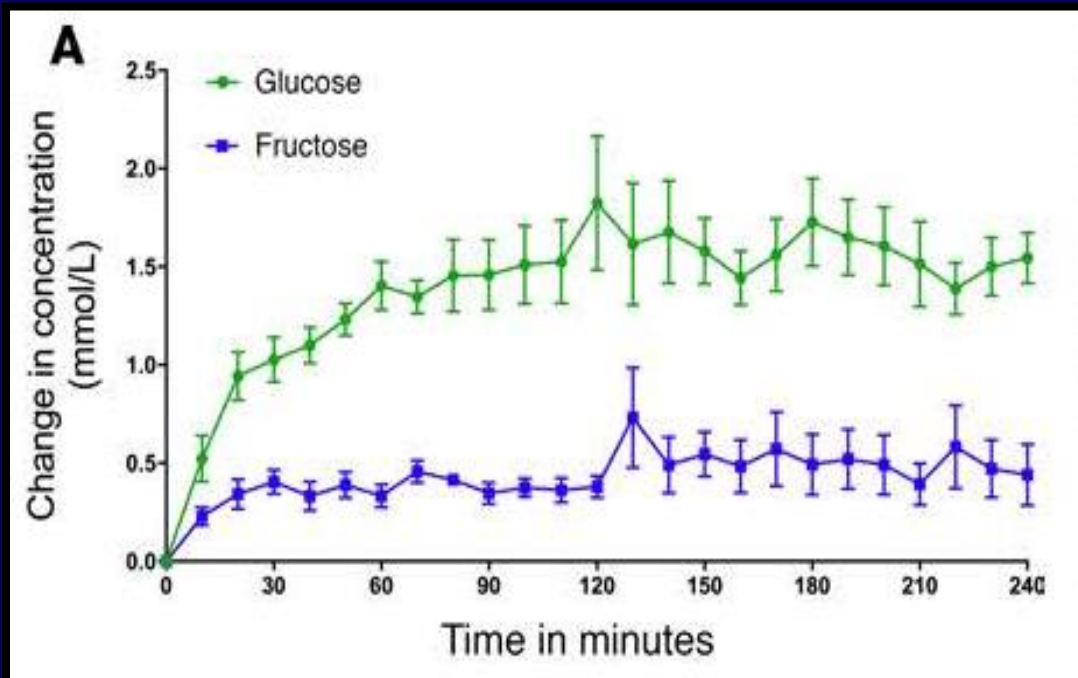


2. CNS Neurotransmission: Glutamate—Glutamine—GABA

**In vivo magnetic resonance spectra in humans after infusion
of glucose or fructose:
The human brain turns glucose into fructose**

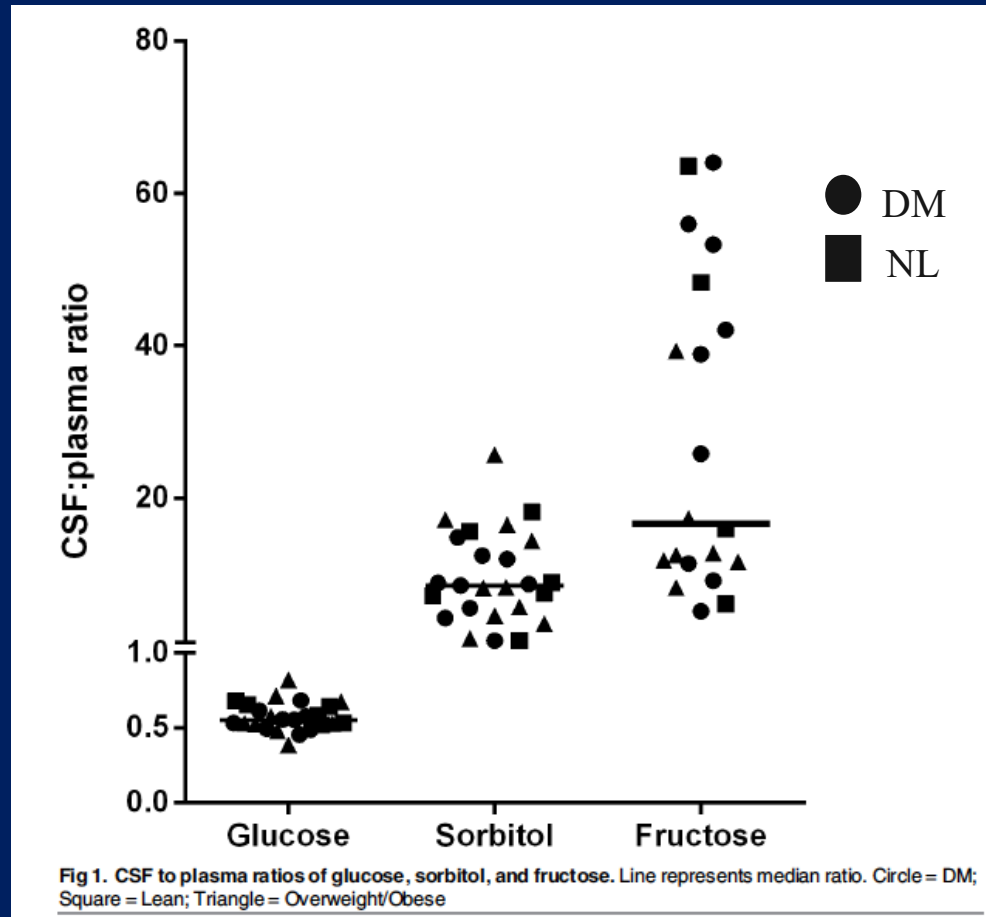


Fructose is Made in the in Brain in Response to Hyperglycemia

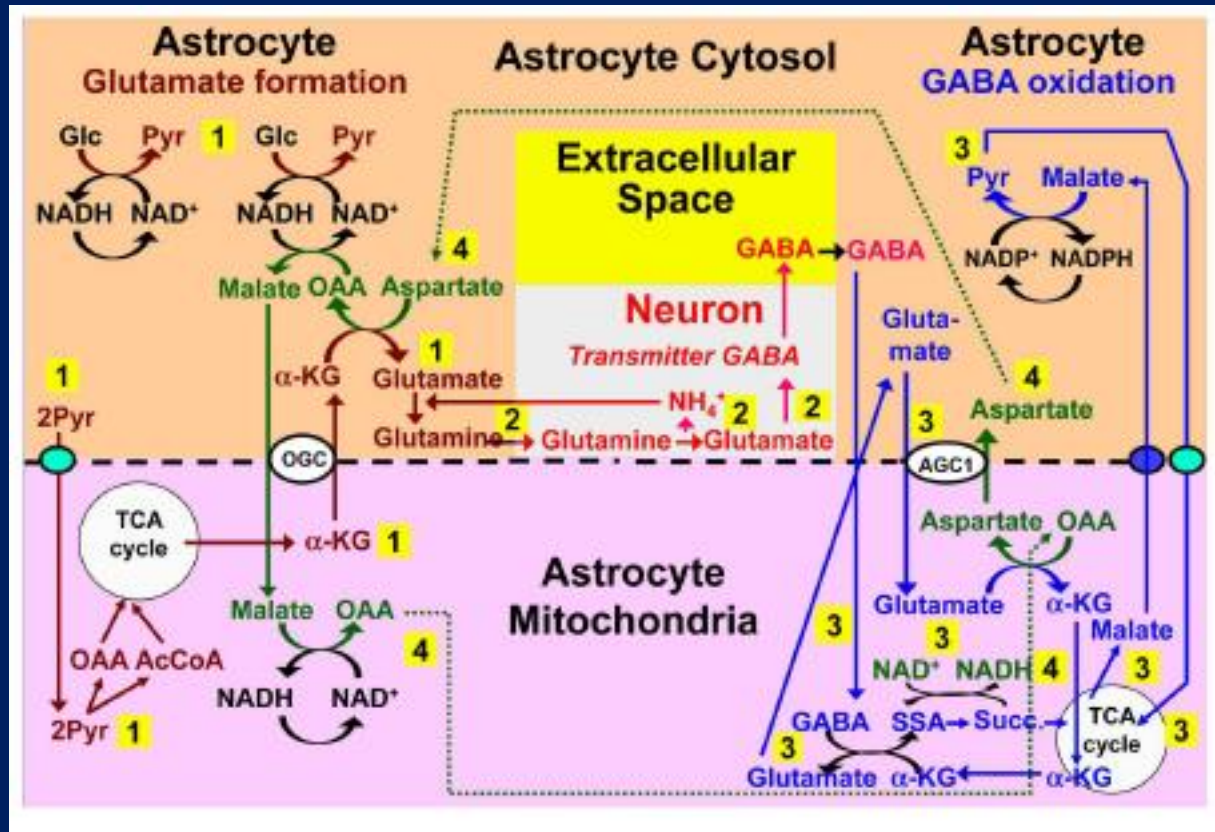


**Blood glucose
raised to 220
mg/dl (12mM) for
4 hrs**

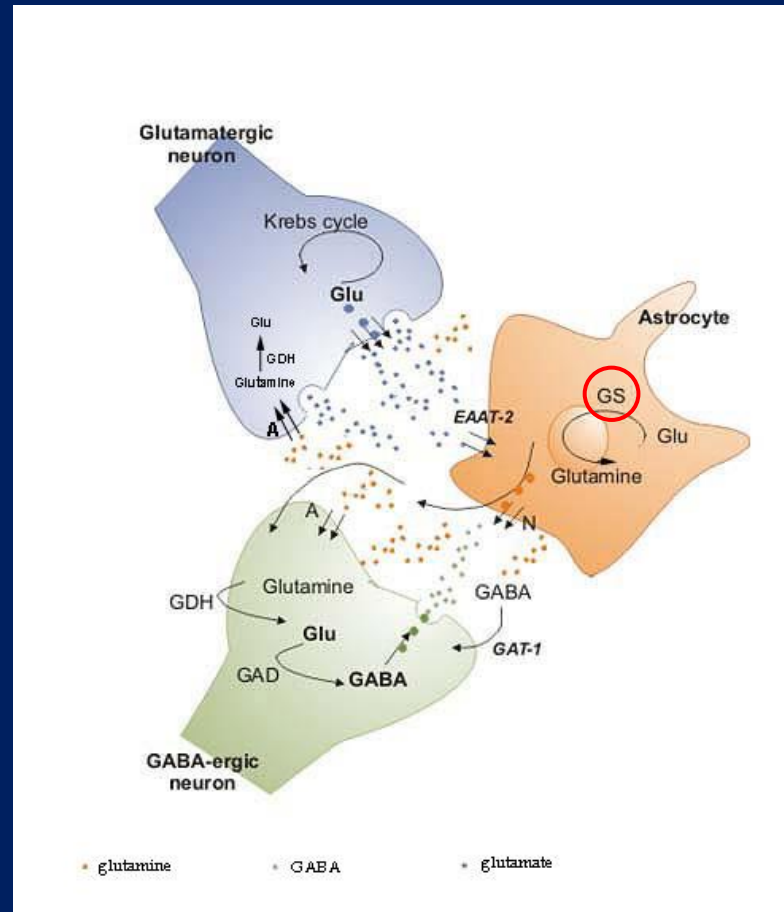
CSF: blood ratio of glucose or fructose due to the insulin resistance of pregnancy



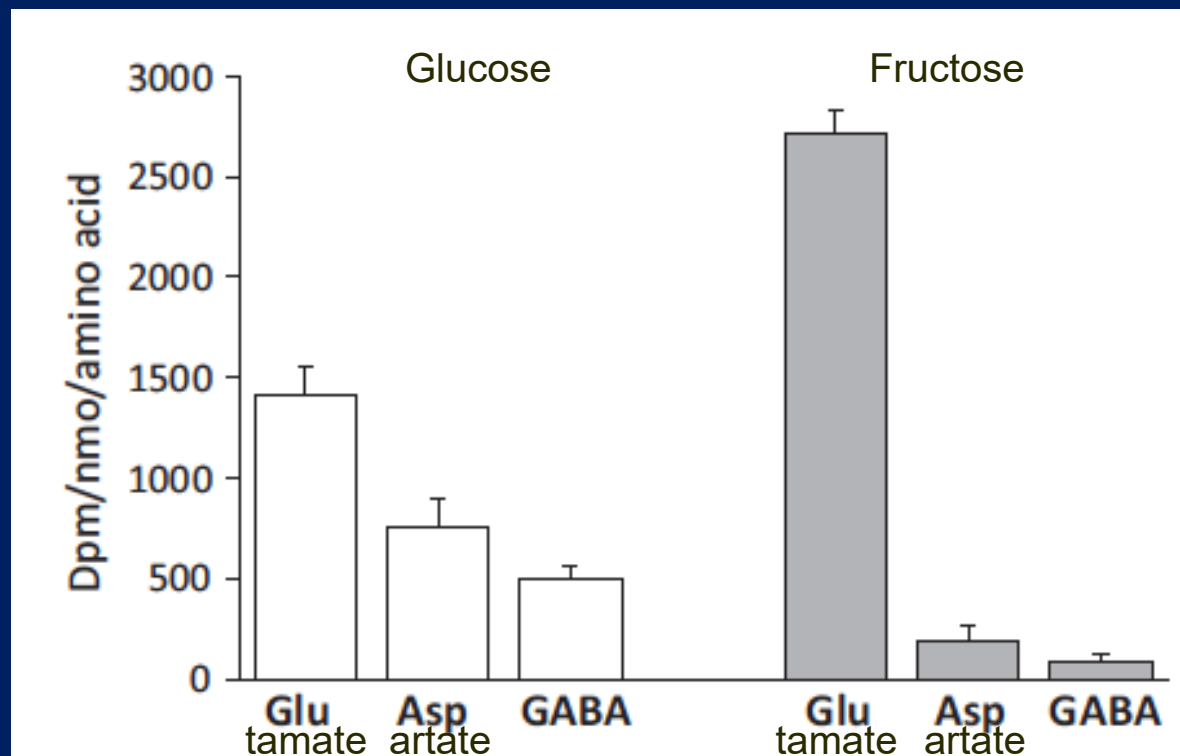
Glutamine synthetase — Glutamate to glutamine cycle in astrocytes



The relation between glutaminergic and GABA-ergic neurons is glutamine synthetase in astrocytes



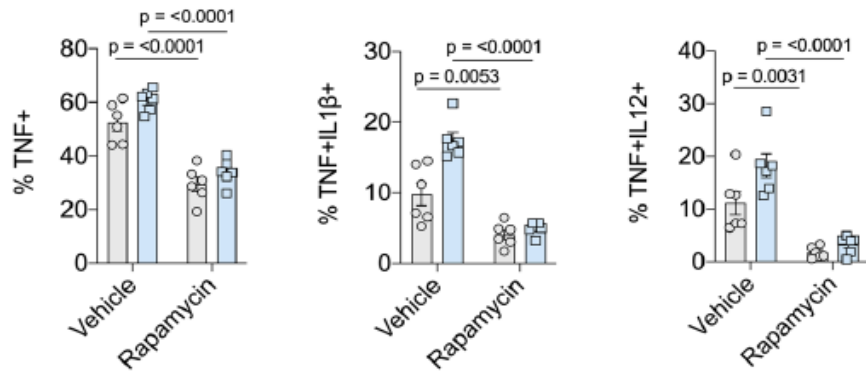
Incubation of rat cortical synaptosomes with glucose or fructose



Hassel et al. J Neurochem 133:572, 2015

Fructose inhibits glutamine synthetase in immune cells

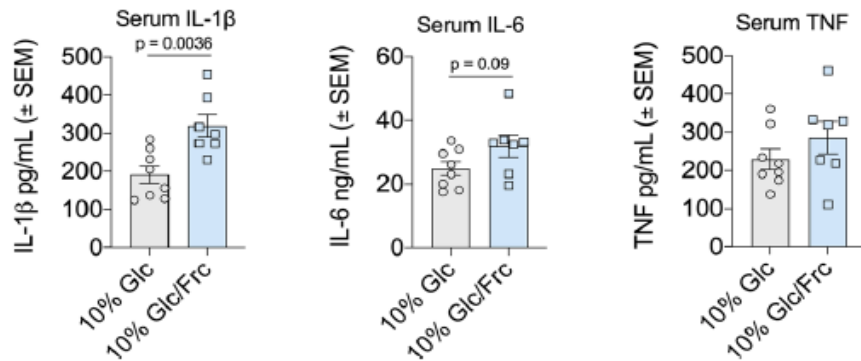
G



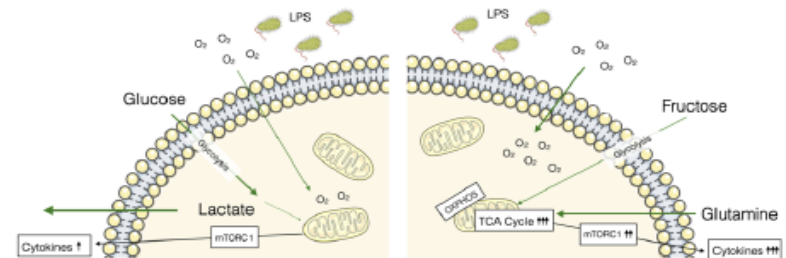
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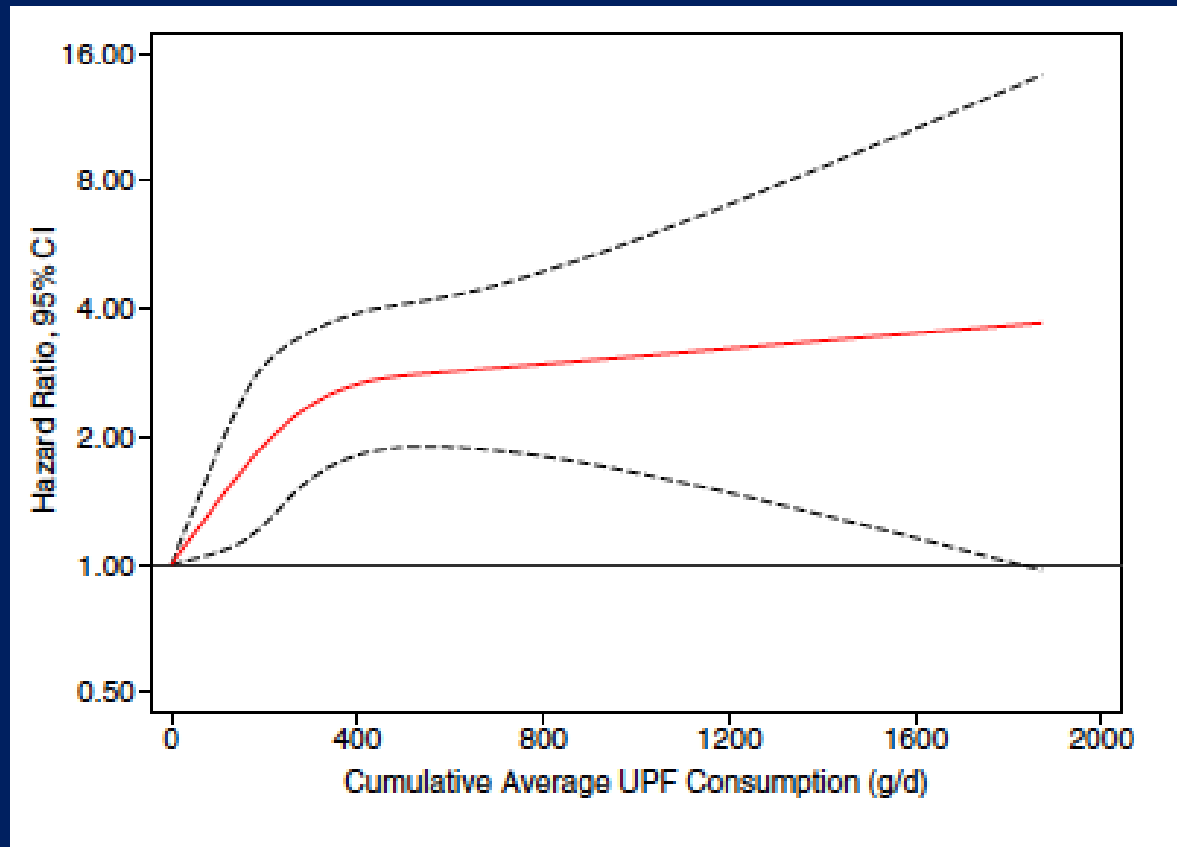


J



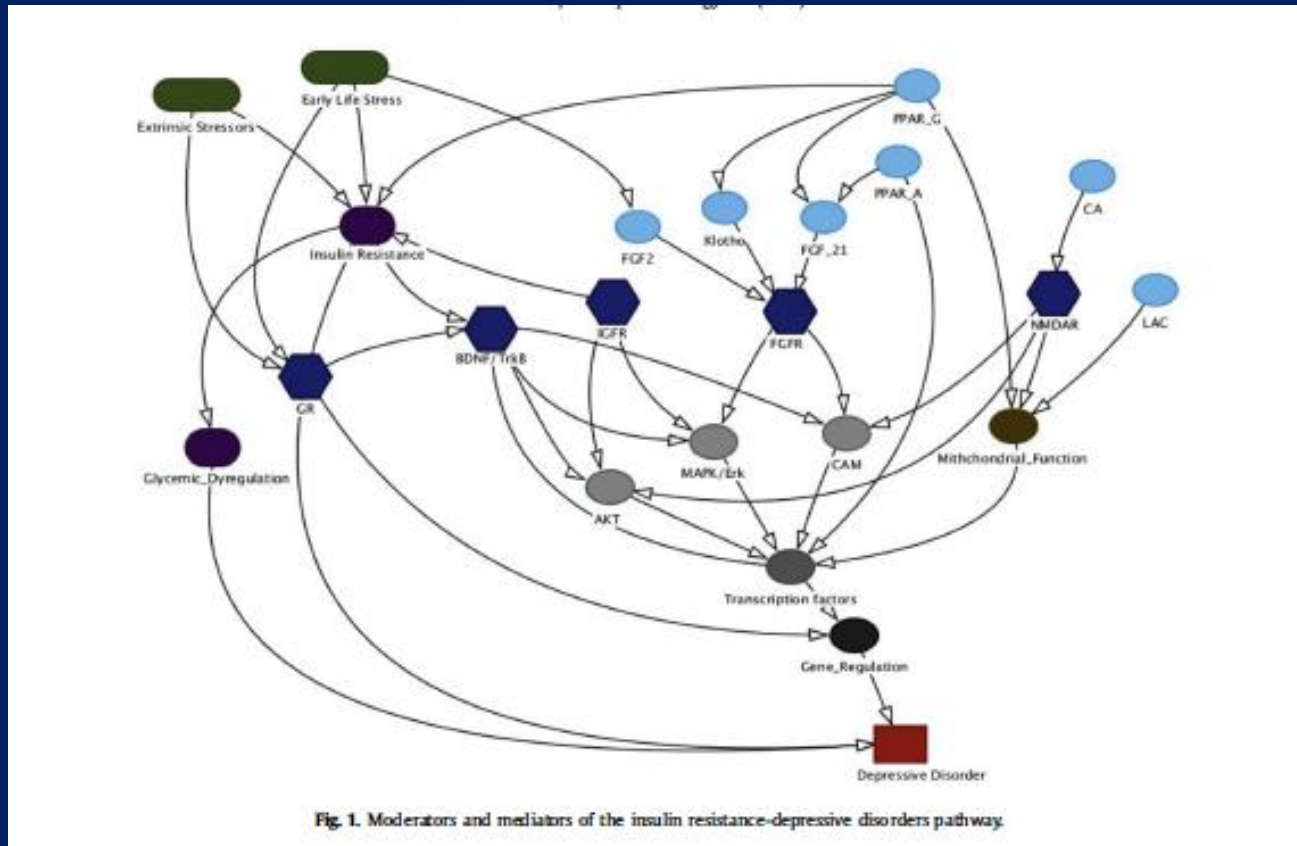
3. CNS Trophic effects: Insulin—Leptin—BDNF

Ultra-processed food consumption correlates with depression



Gomez-Ronoso et al. Eur J Nutrition 2019 doi:10.1007/s00394-019-01970-1

Insulin resistance is a driver of depression



Watson et al. Neuropharmacology 136:327, 2018

Insulin blocks leptin signaling in the brain

Leptin causes neurons to branch and connect

Lee, Ann. NY Acad Sci 1243:15, 2011

Leptin regulates neural and glial protein levels

Ahima et al. Endocrinology 140:2755, 1999

Leptin corrects cognitive defects in patients with leptin deficiency

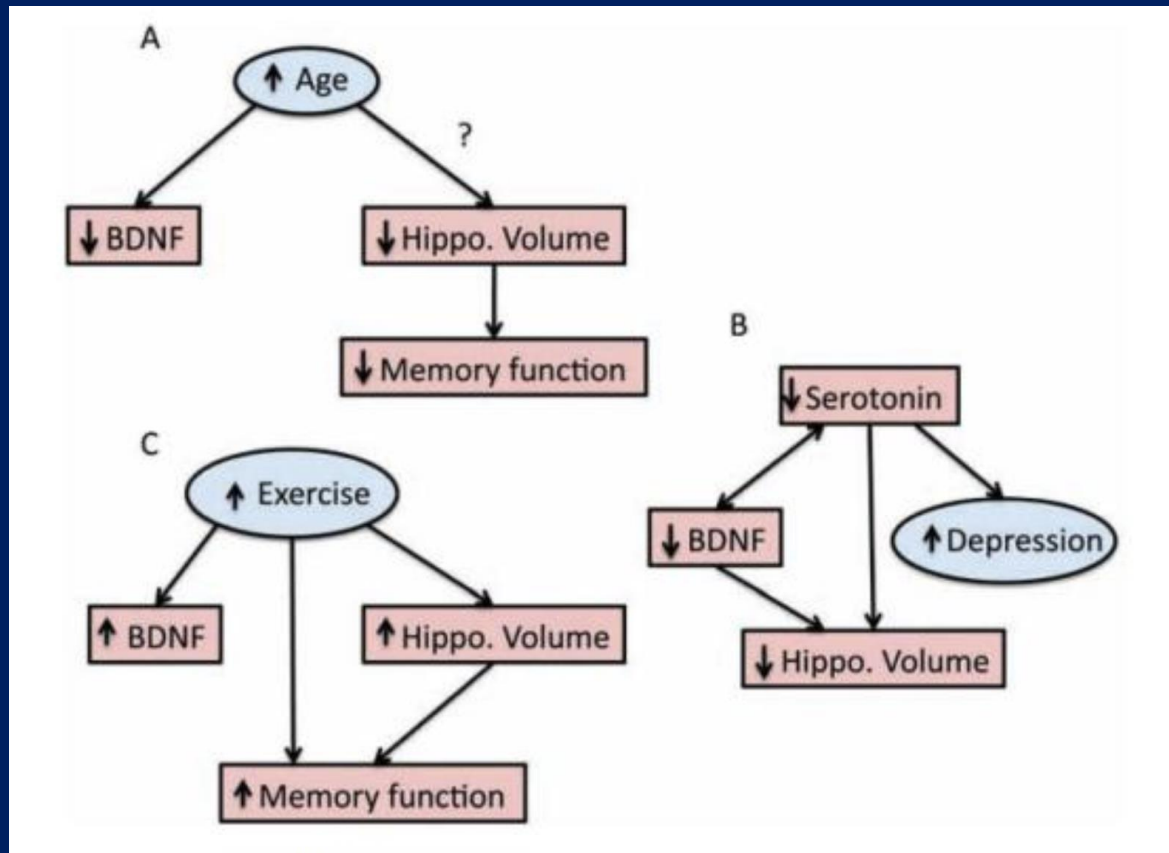
Paz-Filho et al. PLoS One 3:e3098, 2008

**Sugar causes insulin resistance, and
insulin resistance causes leptin resistance**

Lim et al., Nat Rev Gastro Hepatol 7:251, 2010

Lustig, Nat Rev Endocrinol Metab 2:447, 2006

Exercise, BDNF, and depression

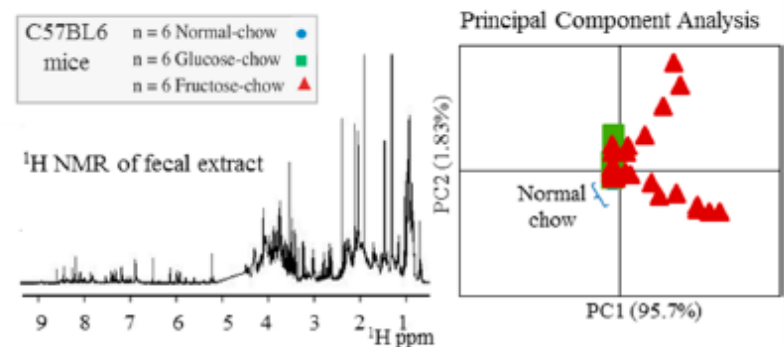


4. CNS exposures: Gut microbiome

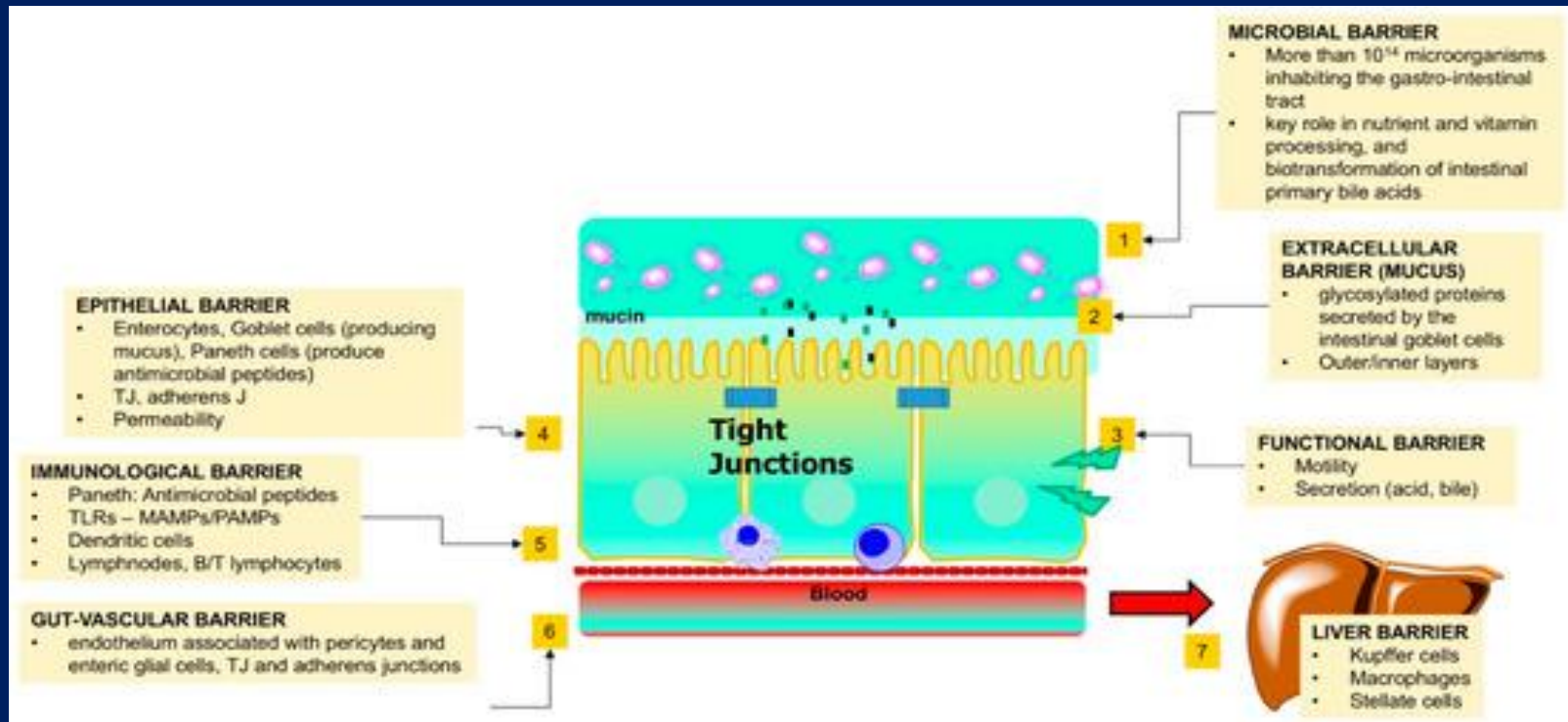
Fructose affects the gut microbiome too

ABSTRACT: Increased sugar intake is implicated in Type-2 diabetes and fatty liver disease; however, the mechanisms through which glucose and fructose promote these conditions are unclear. We hypothesize that alterations in intestinal metabolite and microbiota profiles specific to each mono-saccharide are involved. Two groups of six adult C57BL/6 mice were fed for 10-weeks with diets with glucose (G) or fructose (F) as sole carbohydrates, and a third group was fed with a normal chow carbohydrate mixture (N). Fecal metabolites were profiled by nuclear magnetic resonance (NMR) and microbial composition by real-time polymerase chain reaction (qPCR). Although N, G and F mice exhibited similar weight gains (with slight slower gains for F) and glucose tolerance, multivariate analysis of NMR data indicated that F mice were separated from N and G, with decreased butyrate and glutamate and increased fructose, succinate, taurine, tyrosine, and xylose. The different sugar diets also resulted in distinct intestinal microbiota profiles. That associated with fructose seemed to hold more potential to induce host metabolic disturbances compared to glucose, mainly by promoting bile acid deconjugation and taurine release and compromising intestinal barrier integrity. This may reflect the noted nonquantitative intestinal fructose absorption hence increasing its availability for microbial metabolism, a subject for further investigation.

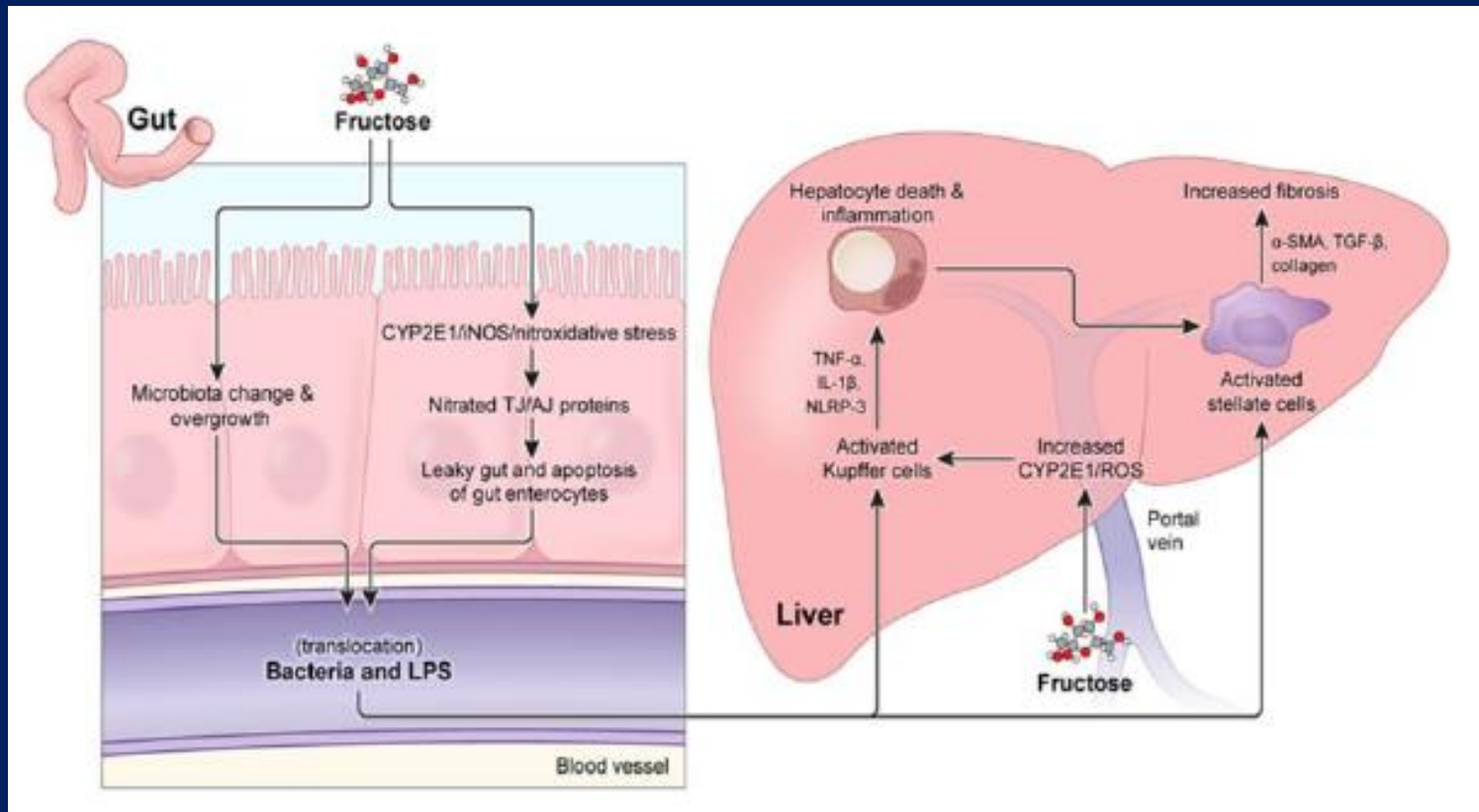
KEYWORDS: *Fructose absorption, short-chain fatty acids, metabolic profiling, metabolomics, intestinal microbiota*



Tight junctions keep bad stuff out



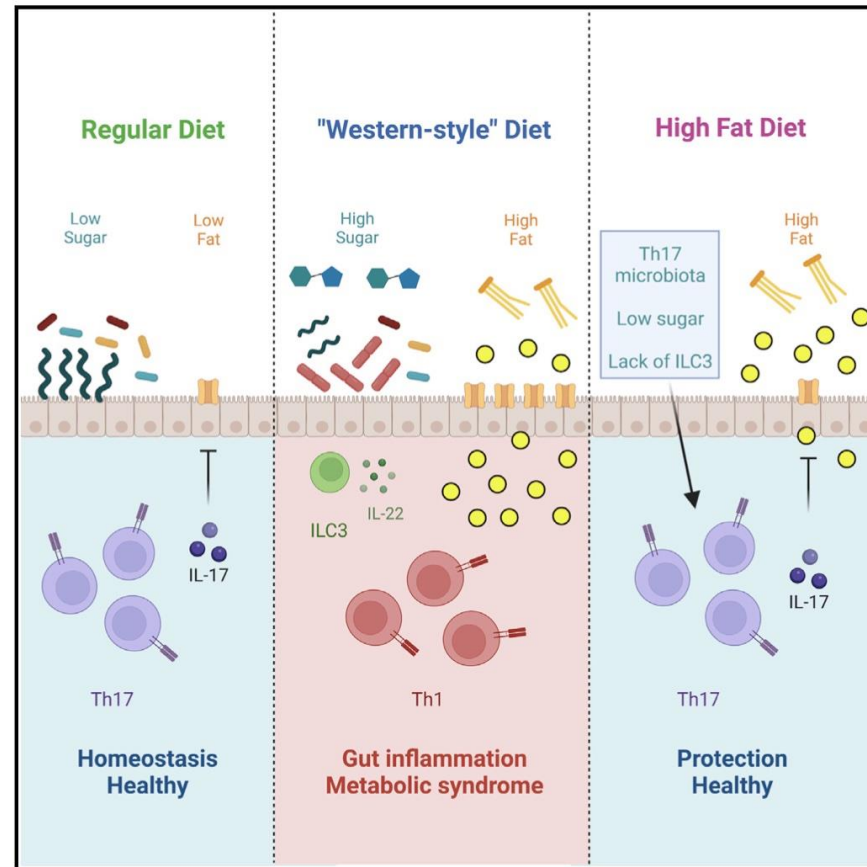
Fructose disrupts tight junctions, and lets bad stuff in



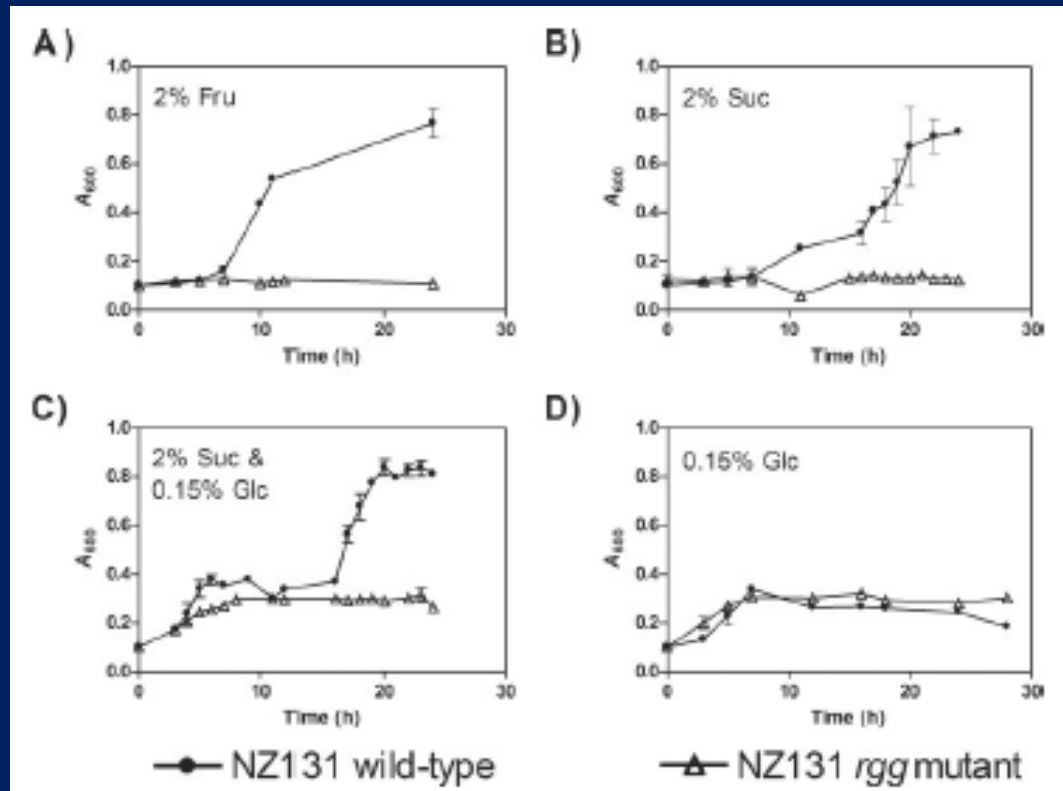
Cho et al. Hepatology 2019 Apr 8. doi: 10.1002/hep.30652.

Sugar alters Th17 barrier in the intestine

Graphical abstract



Group A *Streptococcus* grow better with fructose than glucose



GAS responsible for psych disease:

- 1) Sydenham's chorea
- 2) PANDAS
OCD
tic disorders
adult personality dis.
mood disorder

5. Addiction

Junk food addiction may be clue to obesity: study



(Reuters) March 28, 2010 - Bingeing on high-calorie foods may be as addictive as cocaine or nicotine, and could cause compulsive eating and obesity, according to a study published on Sunday.

Is Fast Food Addictive?

Andrea K. Garber^{*,1} and Robert H. Lustig²

¹*Division of Adolescent Medicine, University of California San Francisco, San Francisco, CA. 94143, USA*

²*Division of Pediatric Endocrinology, University of California San Francisco, USA*

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NHG.COM AUGUST 2014

NATIONAL GEOGRAPHIC

SUGAR

WHY WE CAN'T RESIST IT



The Surprising Life of Lions 38

Can Lions Be Good? 52

Underwater Secrets of the Maya 68

Painted Elephants of India 126

Sugar and opioids



**Sweet-Ease increases endogenous opioids to reduce pain,
Even in neonates**

RESEARCH ARTICLE

Dissociable Behavioral, Physiological and Neural Effects of Acute Glucose and Fructose Ingestion: A Pilot Study

Bettina Karin Wölnerhanssen^{1☯*}, Anne Christin Meyer-Gerspach^{1☯}, André Schmidt^{2,3}, Nina Zimak¹, Ralph Peterli⁴, Christoph Beglinger¹, Stefan Borgwardt^{2,3}

1 Department of Gastroenterology, University Hospital of Basel, Basel, Switzerland, **2** Medical Image Analysis Center, University Hospital of Basel, Basel, Switzerland, **3** Department of Psychiatry, University Hospital of Basel, Basel, Switzerland, **4** Department of Surgery, St. Clara Hospital, Basel, Switzerland

No satiety or fullness with fructose compared with glucose
No insulin rise with fructose compared with glucose

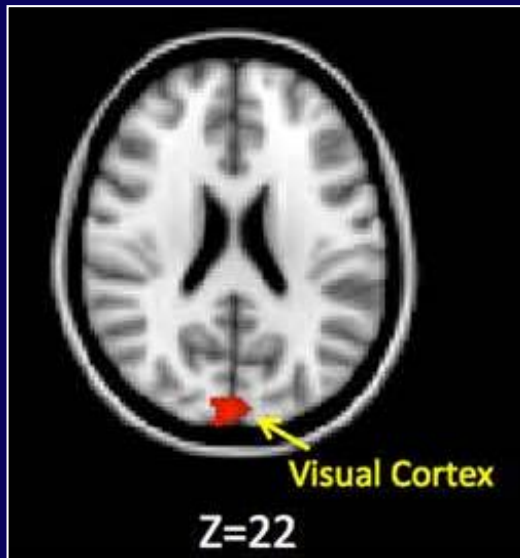
fMRI:

Glucose: caudate, putamen, precuneus, lingual gyrus

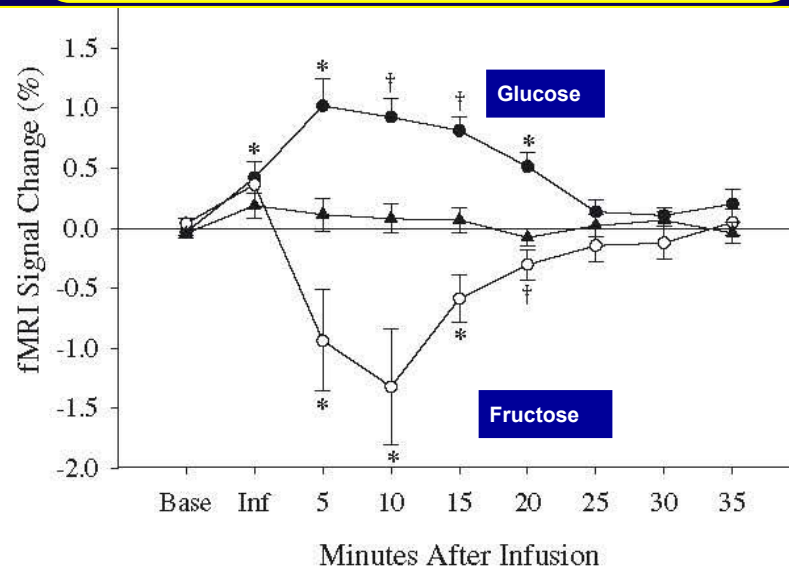
Fructose: amygdala, hippocampus, parahippocampus, orbitofrontal cortex
precentral gyrus

Fructose Increases Hunger, Desire for Food, Increases Visual Cues, Reduces Will Power, and Reduces Recent Memory

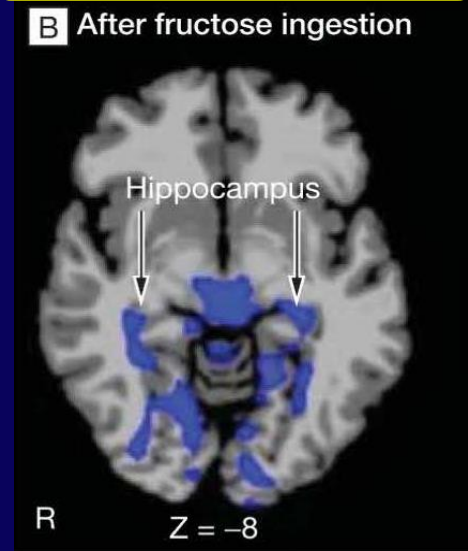
Fructose Increases Visual Cortex Activity To Food Cues With More Hunger And Desire For Food



Fructose Decreases Cortical Activity Involved In Self Control (Glucose Does Opposite)



Fructose Decreases Blood Flow To Hippocampus



Ultraprocessed food promotes tolerance and withdrawal

Current Addiction Reports

<https://doi.org/10.1007/s40429-022-00425-8>

FOOD ADDICTION (E SCHULTE, SECTION EDITOR)



Preliminary Evidence that Tolerance and Withdrawal Occur in Response to Ultra-processed Foods

Lindsey Parnarouskis¹ · Ashley N. Gearhardt¹

Accepted: 28 June 2022

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Adults

Depression

SCIENTIFIC REPORTS



OPEN

Sugar intake from sweet food and beverages, common mental disorder and depression: prospective findings from the Whitehall II study

Anika Knüppel , Martin J. Shipley, Clare H. Llewellyn & Eric J. Brunner

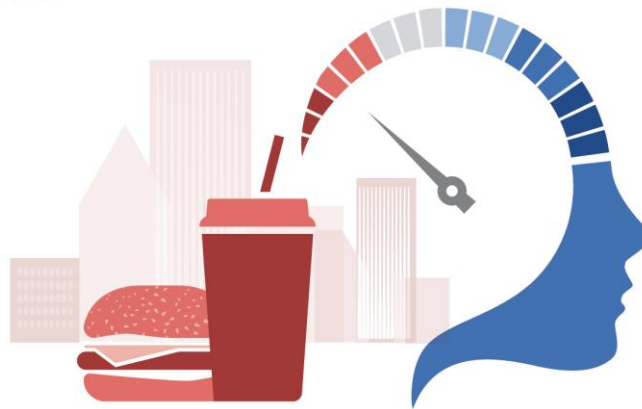
Intake of sweet food, beverages and added sugars has been linked with depressive symptoms in several

Received: 21 November 2016

Accepted: 1 June 2017

Published online: 27 July 2017

Mental Health: Ultraprocessed food and depression



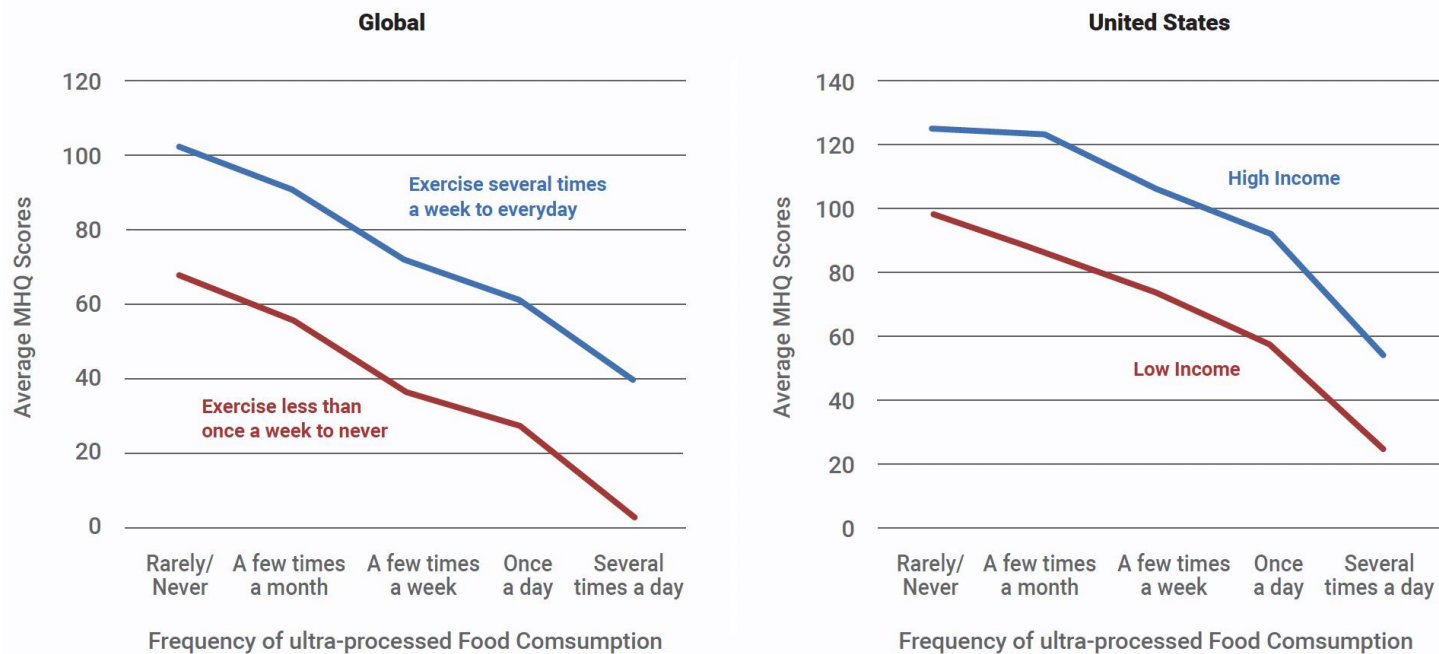
Ultra-processed food
consumption and mental
wellbeing outcomes

Rapid Report // September 2023

Global Mind Project (n = 227,000)

Figure 3: Impact of ultra-processed food consumption for different levels of exercise and income

Relationship between MHQ scores and frequency of ultra-processed food consumptions for individuals who (i) exercise several times a week (blue line) or less than once a week to never (red line) for the global sample (left) and (ii) for those who are low income (<\$40,000 annually; red line) versus high income (>\$100,000 annually; blue line) for respondents in the United States (right)



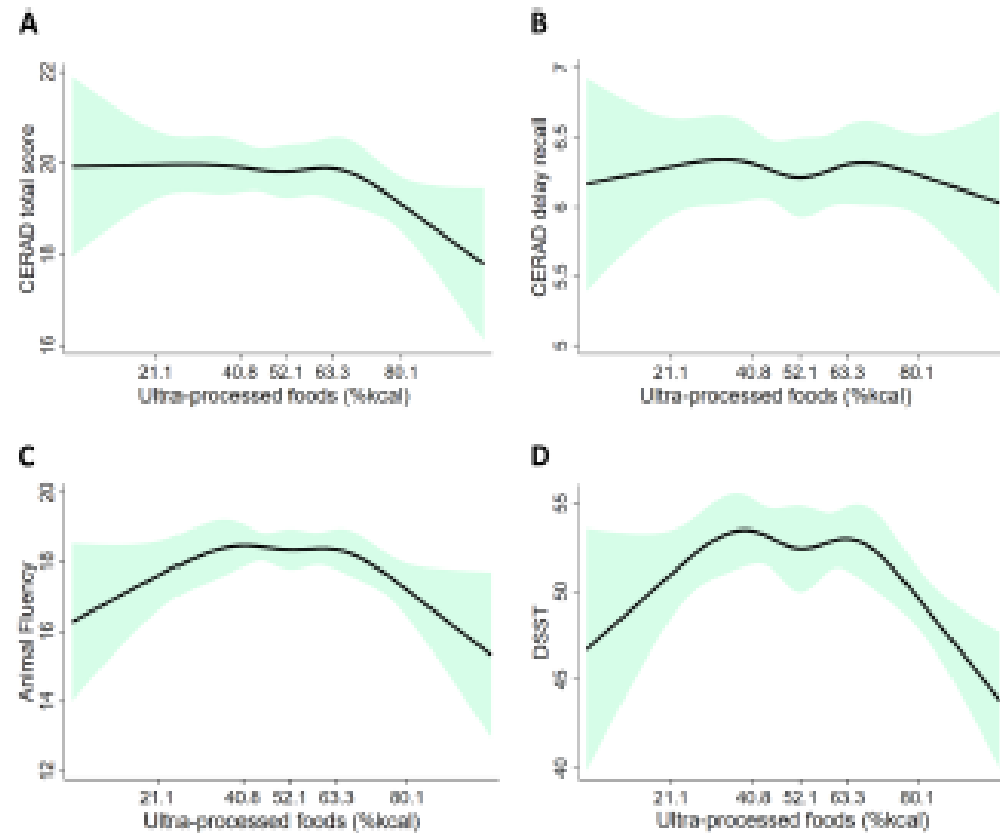
Cognitive Decline

22 Symptoms of Carbohydrate-Associated Reversible Brain (CARB) syndrome

1. Craving sweet and starchy food.
2. Excessive hunger.
3. Excessive mental & physical fatigue.
4. Difficulty concentrating and focusing.
5. Poor impulse control.
6. Depressed affect.
7. Excessive anxiety.
8. Excessive mood swings.
9. Insomnia.
10. Diminished sensory filtering.
11. Low self esteem.
12. Low self-image.
13. Diminished cognitive functioning.
14. Loss of empathy.
15. Chronic diffuse pain.
16. Diminished short term memory.
17. Internal restlessness, racing thoughts.
18. Poor listening skills.
19. Obsessive-compulsive tendencies.
20. Intestinal symptoms.
21. Increased communication lag time.
22. Consciously thinking about food & eating.

Ultraprocessed food inhibits cognition in older adults

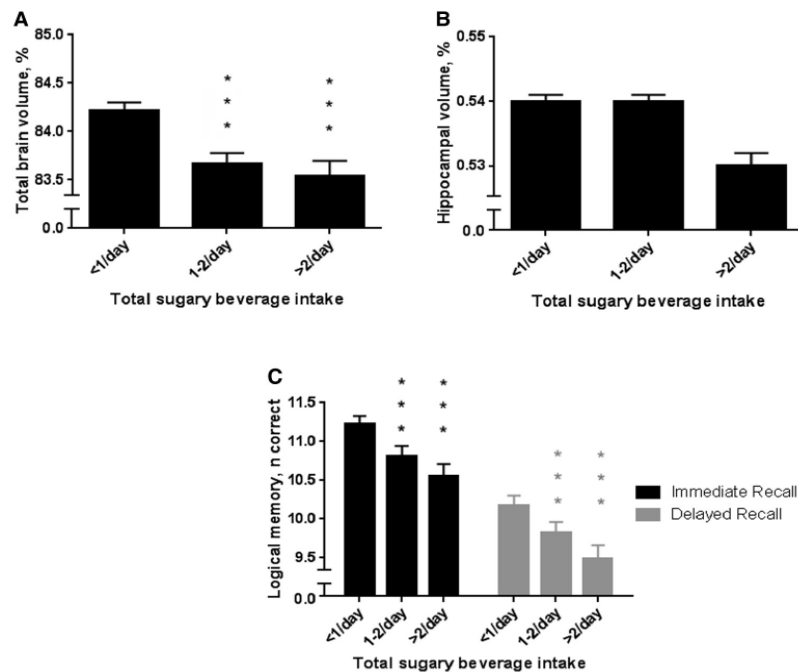
Fig. 1 The relationship between dietary UPF (as % of total energy intake) and cognitive test scores: **a** CERAD total ($P=0.308$); **b** CERAD delayed recall ($P=0.859$); **c** animal fluency ($P=0.010$); **d** digit Symbol Substitution test (DSST) ($P=0.005$). Green area represents the 95% confidence intervals. UPF ultra-processed food, %kcal % of total energy intake



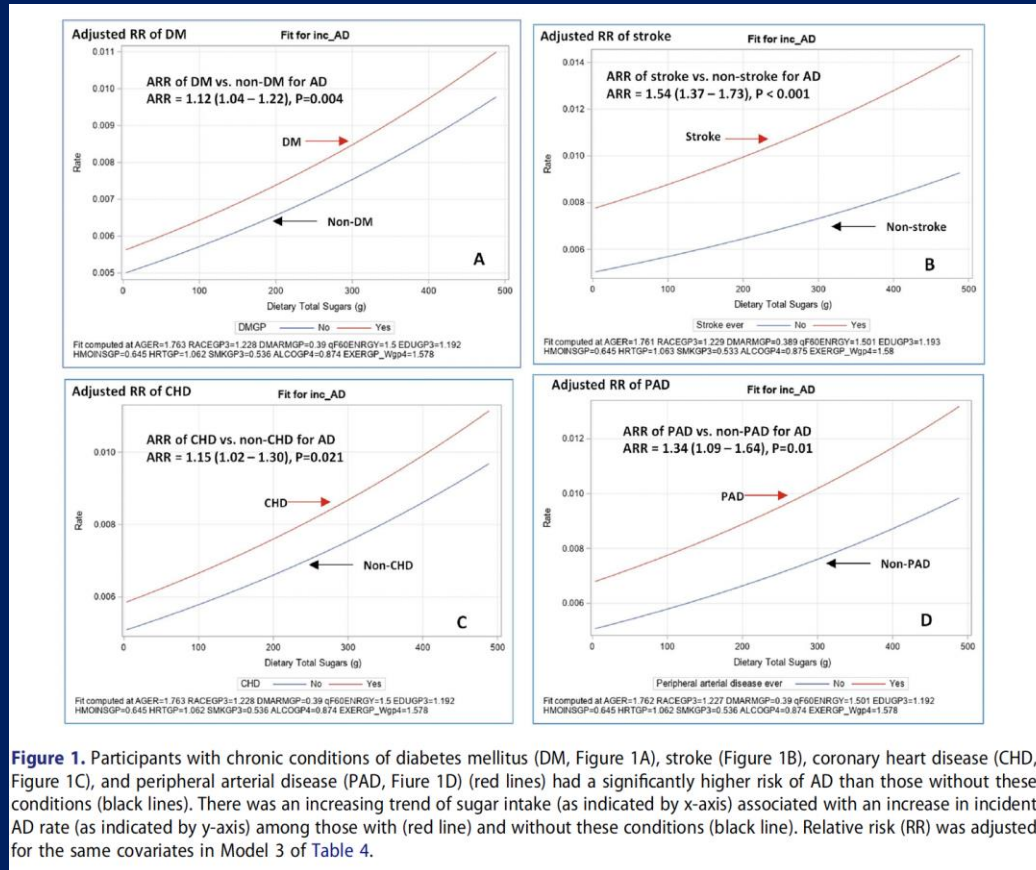
Featured Article

Sugary beverage intake and preclinical Alzheimer's disease in the community

Matthew P. Pase^{a,b,c,*}, Jayandra J. Himali^{a,b,d}, Paul F. Jacques^{b,e}, Charles DeCarli^{b,f},
Claudia L. Satizabal^{a,b}, Hugo Aparicio^{a,b}, Ramachandran S. Vasan^{b,g,h}, Alexa S. Beiser^{a,b,d},
Sudha Seshadri^{a,b}



Sugar consumption correlates with dementia, as well as other systemic diseases



Does sugar cause dementia?

Obesity is associated with dementia

Luchsinger et al. J Alz Dis Assoc Dis 2011

Obesity is associated with altered neural projections c/w dementia

Bouret et al. Cell Metab 7:179, 2008

Sugar generates insulin resistance and hyperinsulinemia

Seneff et al. Eur J Int Med 22:134, 2011

Insulin resistance and high insulin levels are associated with dementia

Craft et al. Nat Rev Neurol 8:360, 2012

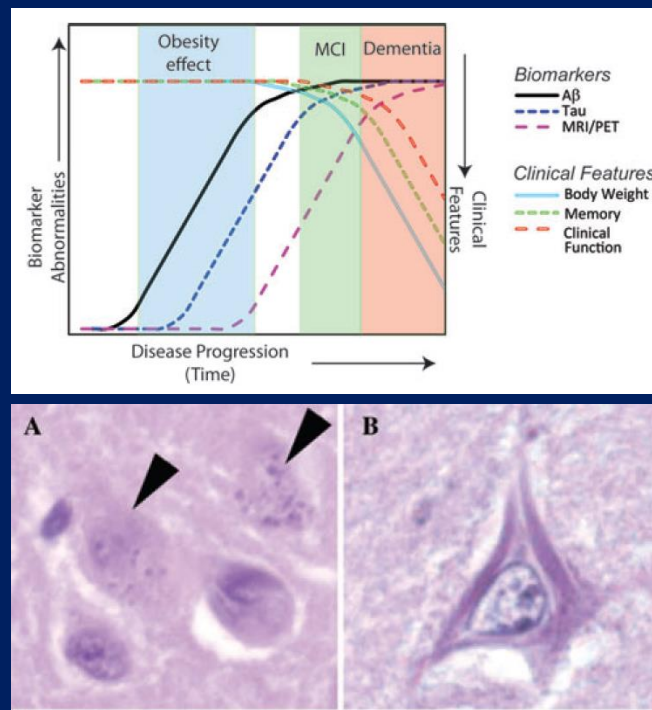
Western Diet correlates with dementia

Barberger-Gateau et al. Neurology 69:1921, 2007

Fat or sugar both cause obesity in rats, but only sugar caused cognitive decline

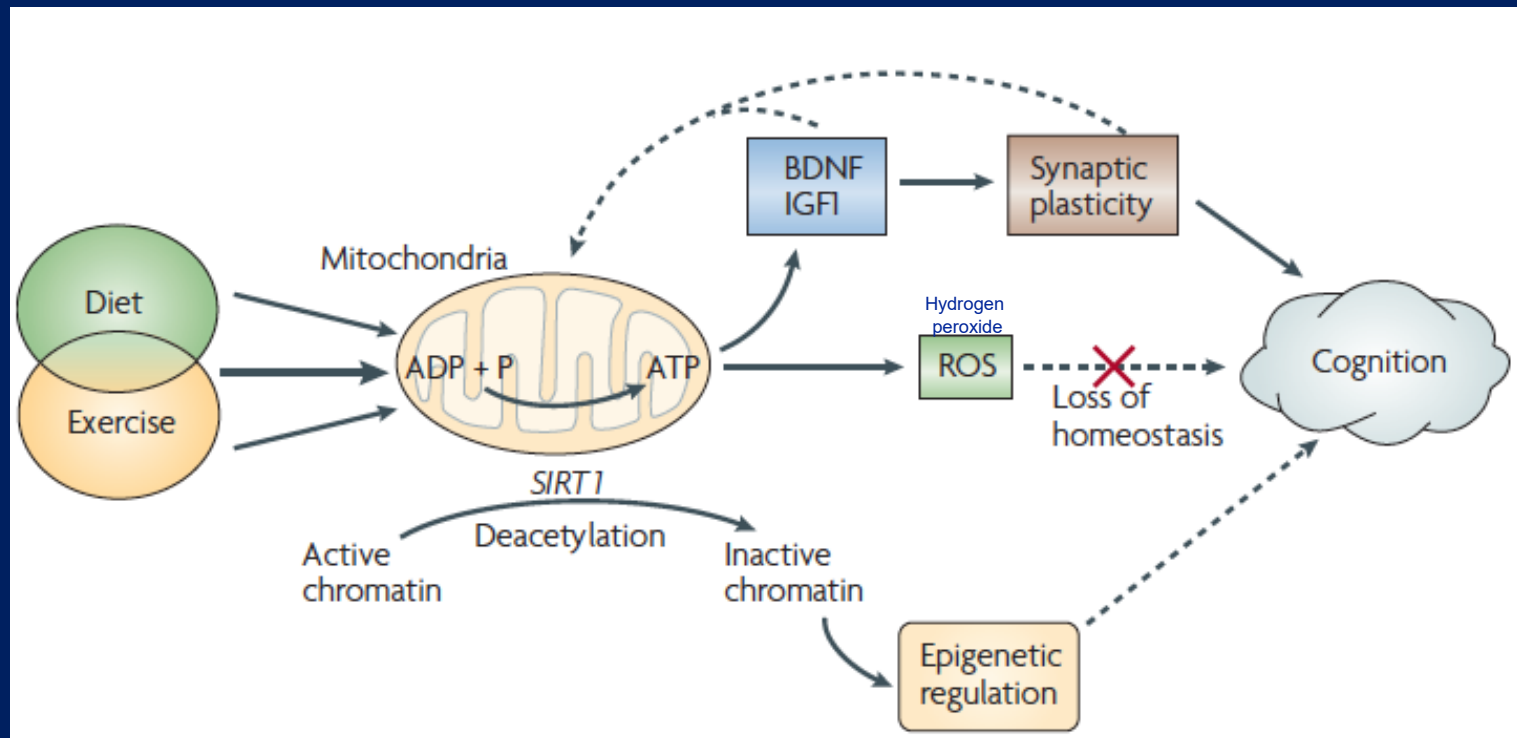
Jurdak et al. Nutr Neurosci 11:48, 2008

Causative data in animals; but to date no direct associative or causative data in humans



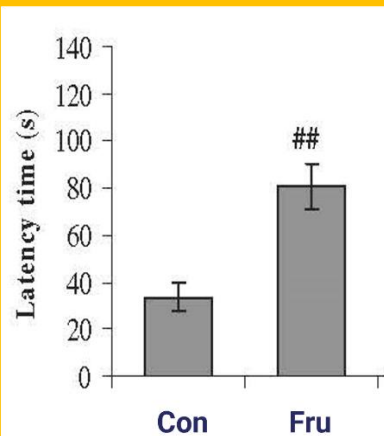
Stephan et al. J Gerontol 65:809, 2010

Anything that increases ROS production can damage cells and result in cognitive decline

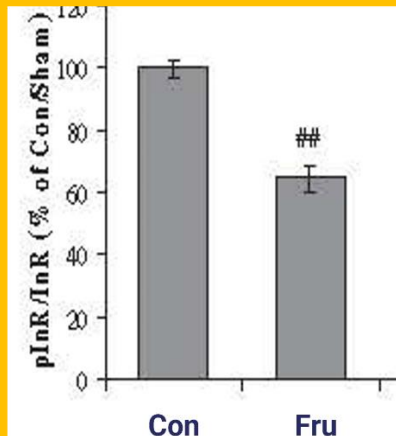


Effect of Dietary Fructose on the Rat Brain

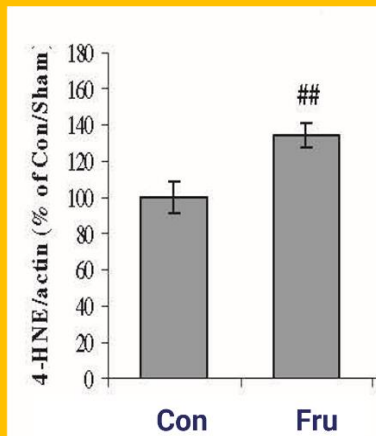
Time to Traverse a Maze (8 wks)



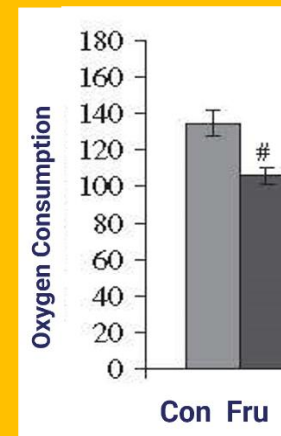
Hippocampal Insulin Signaling



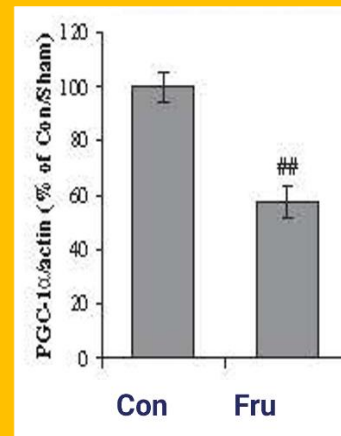
Hippocampal Oxidative Stress



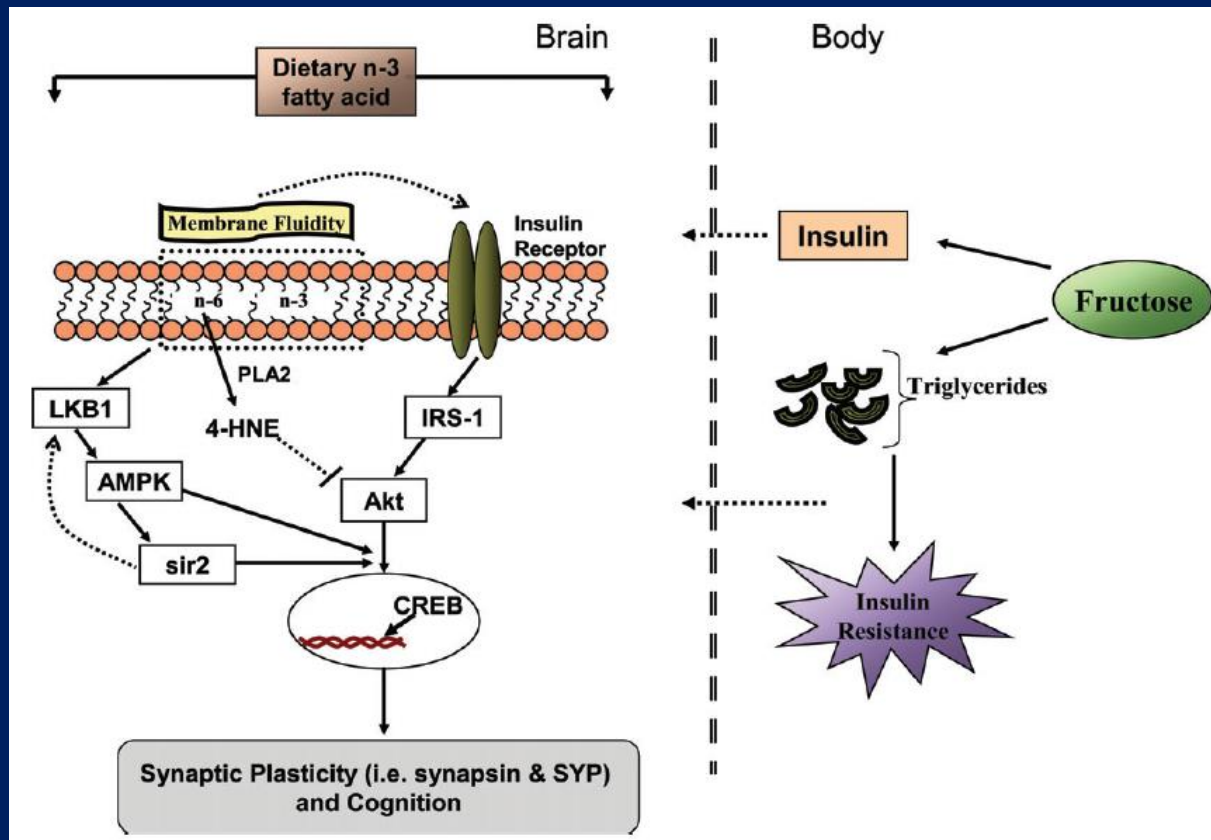
Mitochondrial ATP



Mitochondria Regeneration

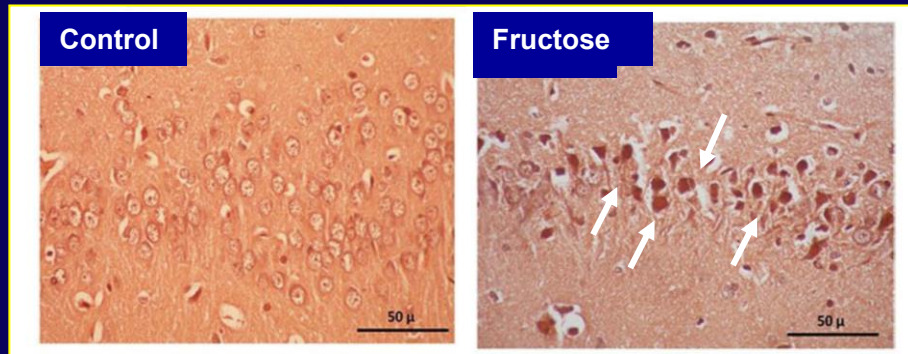


Insulin resistance, especially in the absence of omega-3's, means lack of neuron signaling

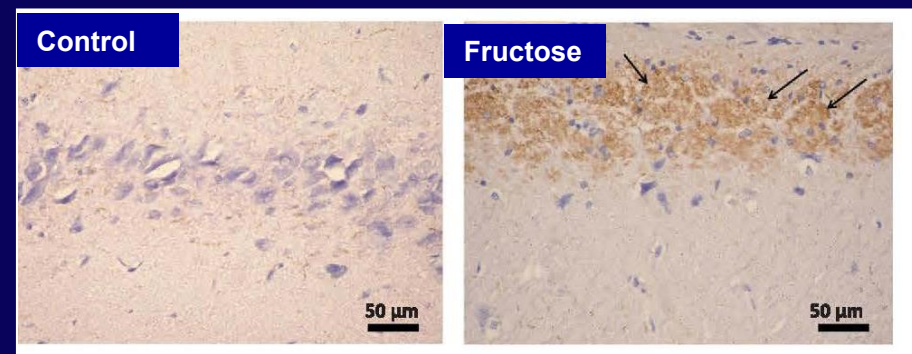


Dietary Fructose Increases Amyloid and Tau Protein in the Brain of Rats

Amyloid (Congo Red Positive)

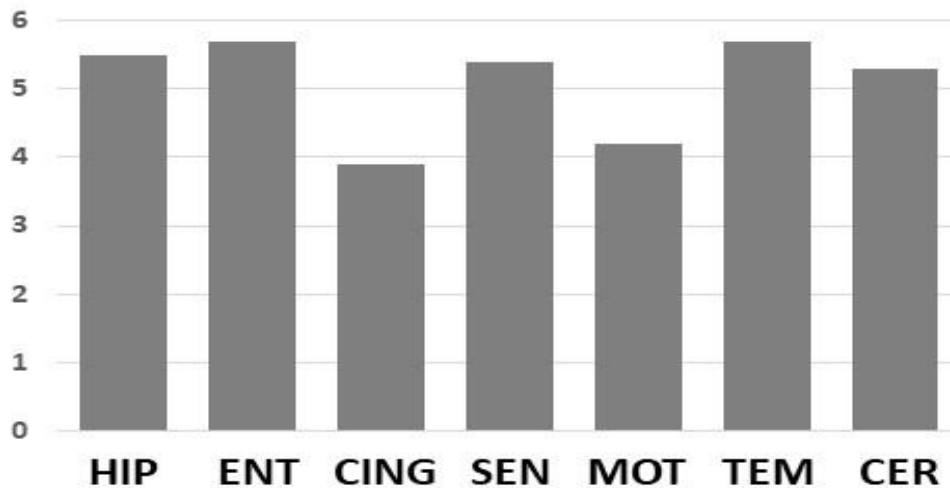


Tau Protein (Brown Stain)

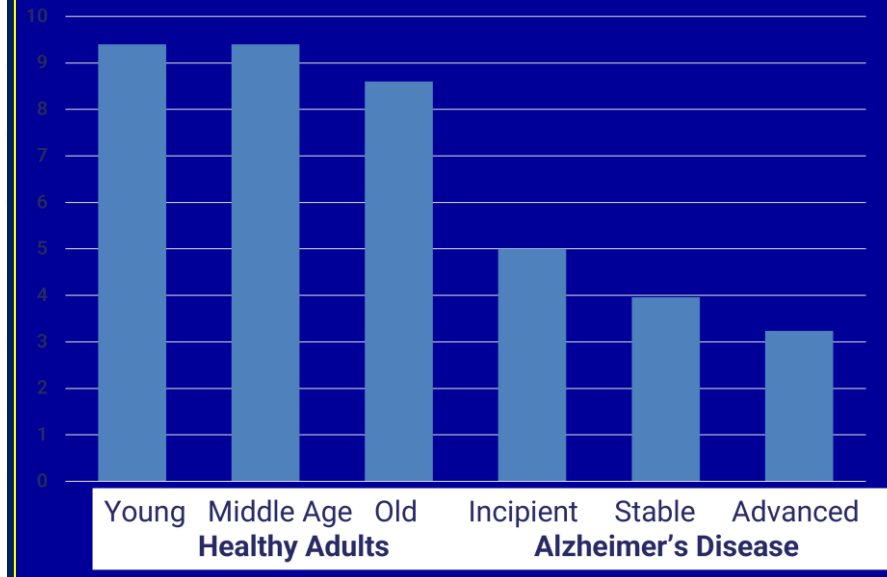


High Fructose Levels and Low ATP in the Brains of Alzheimer's Patients

Fructose Levels (Fold-Increase)



CALCULATED BRAIN ATP FORMATION



Kids

Reduced hippocampus but more CSF in adolescents with metabolic syndrome

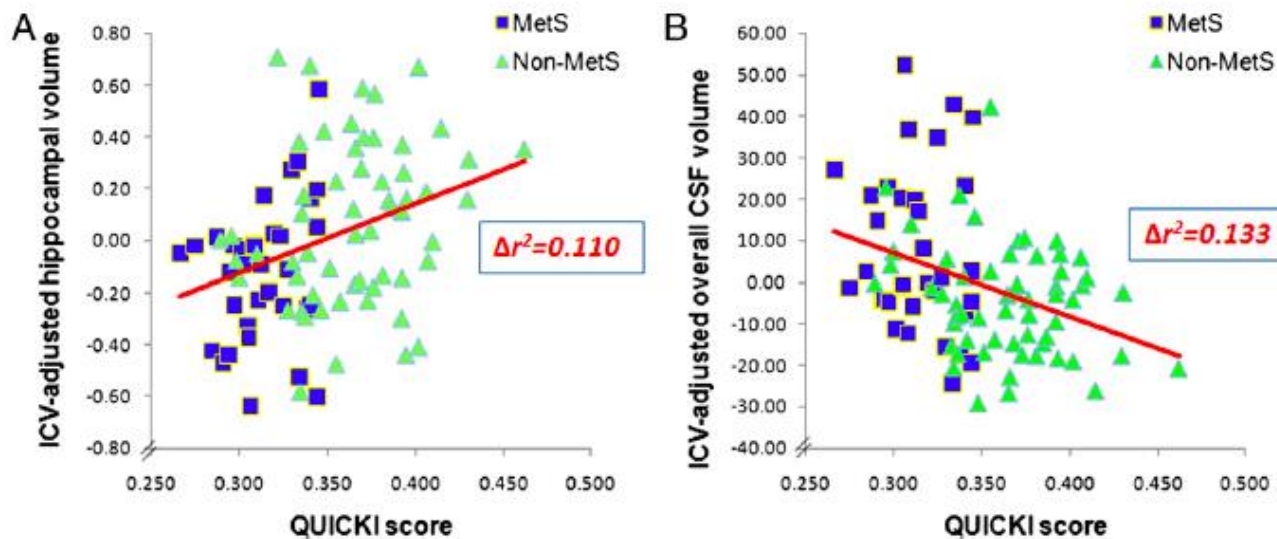


FIGURE 3

Lower QUICKI scores (more IR) were associated with smaller ICV-adjusted hippocampal volumes ($n = 91$) (A) and larger ICV-adjusted overall CSF volumes ($n = 92$) (B).

Reduced prefrontal cortical function in adolescents with metabolic syndrome

Table 2. Domain scores by MetS classification group.

	No MetS (n = 204)	MetS (n = 84)	<i>p</i>	Effect Size (<i>r</i>)
Memory	100.88 (13.86)	97.94 (15.55)	0.195	0.08
Processing Speed	100.57 (13.46)	100.64 (13.14)	0.774	0.03
Executive Function	101.47 (14.34)	96.97 (15.43)	0.020	0.15
Reaction Time	100.39 (13.89)	101.03 (12.81)	0.790	0.02
Complex Attention	103.93 (10.17)	101.32 (11.25)	0.109	0.11
Cognitive Flexibility	101.61 (14.20)	96.53 (16.00)	0.020	0.15
Verbal Memory	100.68 (14.07)	98.18 (15.19)	0.225	0.07
Visual Memory	100.18 (14.92)	99.21 (14.41)	0.674	0.03

The 'Twinkie Defense':

Relationship between carbonated non-diet soft drinks and violence perpetration among Boston high school students

Adolescents who drank more than five cans of soft drinks per week (30%):

- more likely to have carried a weapon
- violent with peers, family members and dates.
- even after controlling for gender, age, race, BMI, sleep, tobacco use, alcohol use, and family dinners.



Long-Term Overconsumption of Sugar Starting at Adolescence Produces Persistent Hyperactivity and Neurocognitive Deficits in Adulthood

Kate Beecher¹, Ignatius Alvarez Cooper², Joshua Wang¹, Shaun B. Walters³, Fatemeh Chehrehasa^{2†}, Selena E. Bartlett^{1†} and Arnauld Belmer^{1*†}*

Soft Drinks Consumption Is Associated with Behavior Problems in 5-Year-Olds

Shakira F. Suglia, ScD¹, Sara Solnick, PhD², and David Hemenway, PhD³

Babies

Children's health

Ultra-processed babies: are toddler snacks one of the great food scandals of our time?

Bee Wilson

Sat 15 Mar 2025 06:00 EDT

Share

396



Illustration: Justin Metz/The Guardian

For time-poor parents, straws, sticks, pouches and powders can seem like a quick, convenient and even healthy option. But these oversweetened, mushy foods are creating a generation of choosy consumers whose teeth are already rotting

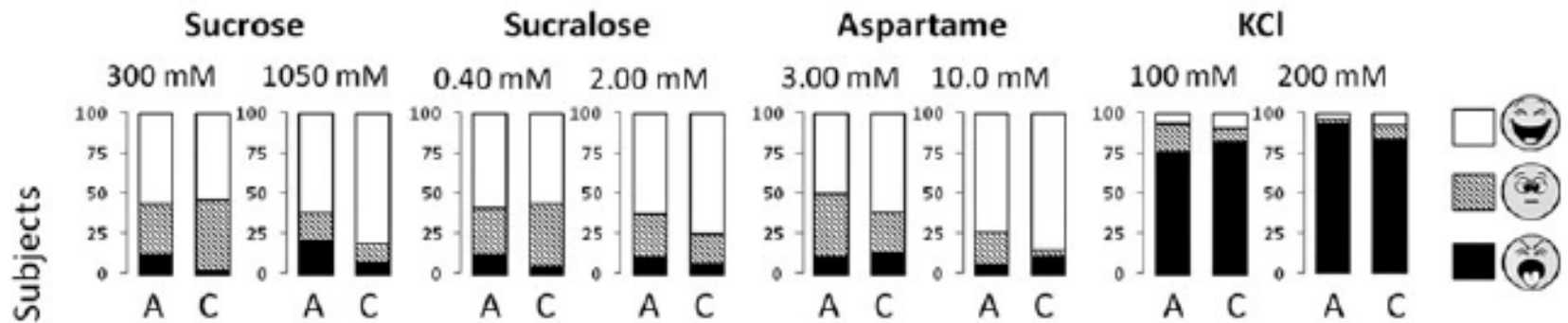
What to feed your baby instead

Advertisement

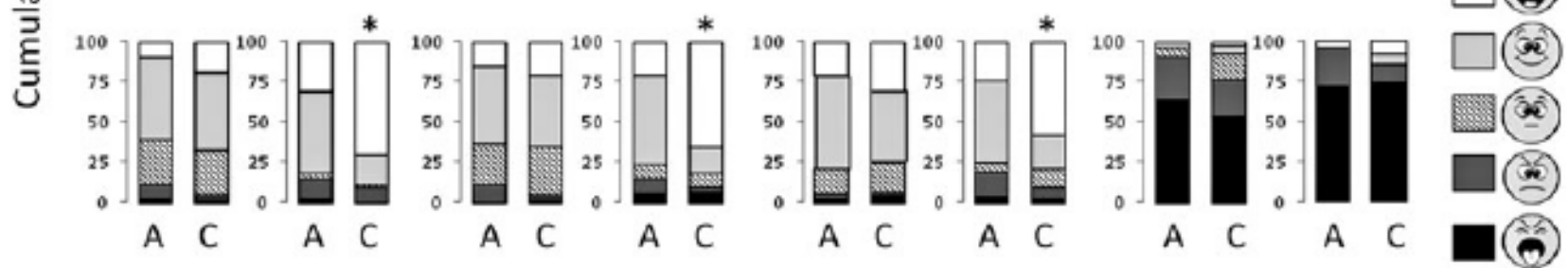


Young children prefer sweet

a 3-point scale



b 5-point scale



Commercial infant foods and health claims

Table 6. High sodium or high sugar content among products with different claims ¹.

	<i>n</i>	High sodium (>130mg)	<i>p</i> value	<i>n</i>	High sugar (>10%)	<i>p</i> value
Total	363	85 (23.4)		237	129 (54.4)	
Food claim						
Composition claim						
Yes	320	66 (20.6)	0.001	224	122 (54.5)	0.965
No	43	19 (44.2)		13	7 (53.8)	
Nutrition claim						
Yes	151	34 (22.5)	0.733	131	68 (51.9)	0.386
No	212	51 (24.1)		106	61 (57.5)	
Health claim						
Yes	182	61 (33.5)	<0.001***	146	68 (46.6)	0.002**
No	181	24 (13.3)		91	61 (67.0)	
Salt related claim						
No added salt						
Yes	19	0 (0.0)	0.013*			
No	344	85 (24.7)				
No added seasoning						
Yes	78	4 (5.1)	<0.001***			
No	285	81 (28.4)				
Sugar claim						
No added sugar						
Yes				48	35 (72.9)	0.004**
No				189	94 (49.7)	

¹ Data are presented as the number (percentage).

**p* < 0.05;

***p* < 0.01;

****p* < 0.001 by chi-square test.

Could this be the reason for obesity in 6-month olds?

INGREDIENTS (Powder) ((U) Pareve*)

43.2% Corn syrup solids,
14.6% soy protein isolate,
11.5% high oleic safflower oil,
10.3% sugar (sucrose),
8.4% soy oil,
8.1% coconut oil



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INGREDIENTS (Powder) ((U) Pareve*)

43.2% Corn syrup solids,
14.6% soy protein isolate,
11.5% high oleic safflower oil,
10.3% sugar (sucrose),
8.4% soy oil,
8.1% coconut oil

Coca-Cola: 10.5% sucrose (fiberless)
Milk shake: 4% sucrose (fiberless)
Breast Milk: 7.1% lactose (fiberless),
no sucrose, **EXCEPT:**

100 MI Milk Shake

Nutrition Facts

Serving Size	100 ml
Amount Per Serving	
Calories	129
% Daily Values*	
Total Fat 4.68g	6%
Saturated Fat 2.835g	14%
Trans Fat -	
Polyunsaturated Fat 0.212g	
Monounsaturated Fat 1.286g	
Cholesterol 15mg	5%
Sodium 65mg	3%
Total Carbohydrate 19.24g	7%
Dietary Fiber 0.9g	3%
Sugars 16.57g	
Protein 6.66g	
Vitamin D -	
Calcium 101mg	8%
Iron 0.33mg	2%
Potassium 165mg	4%
Vitamin A 47mcg	5%
Vitamin C 0.2mg	0%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Last updated: 21 Aug 07 07:33 AM
Source: [FatSecret Platform API](#)



PREPARATION OF MIXTURE BABY FEEDING ON WOODEN BACKGROUND.
GETTY IMAGES

Nestlé Adds Sugar to Baby Milk and Cereal in Poorer Nations

The report calls out Nestlé's "double standard" for adding sugar to baby food products in developing countries.

ARMANI SYED

APR 17, 2024 9:16 AM PDT

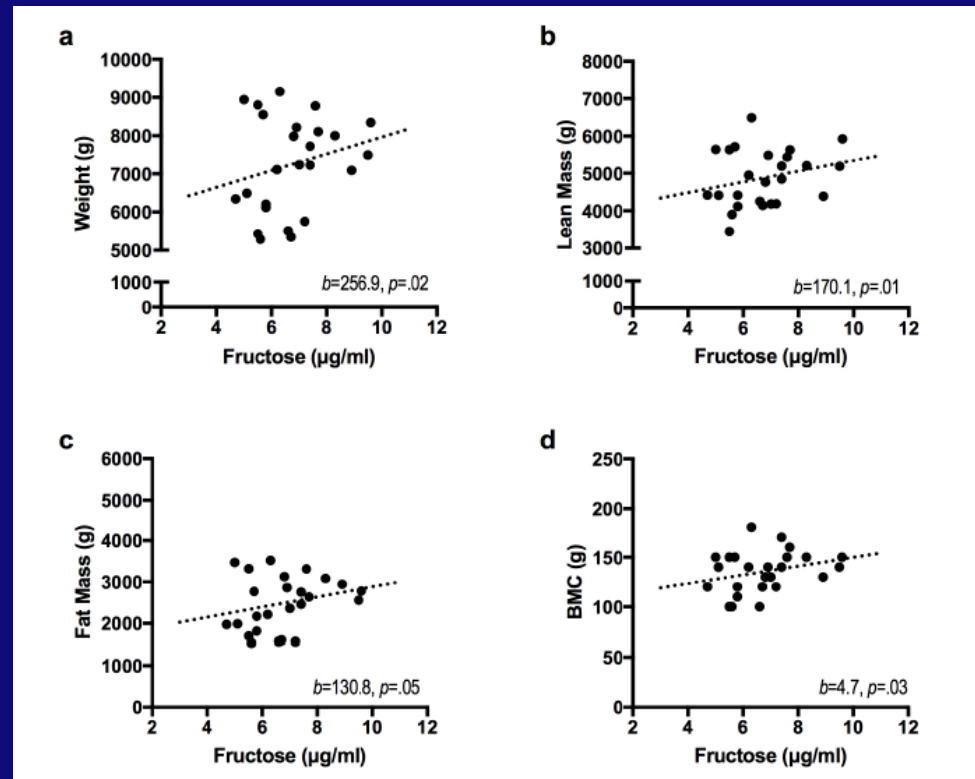
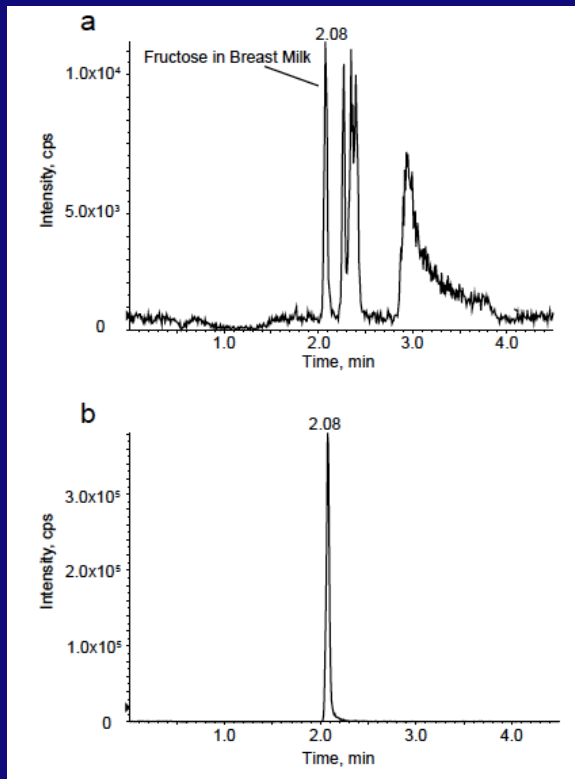
ARMANI SYED IS A WORLD AFFAIRS REPORTER AT TIME. SHE COVERS GLOBAL AFFAIRS, WITH A FOCUS ON THE SWANA REGION, ARTS AND CULTURE, AND ROYAL INSTITUTIONS.

Added sugar content of the same Cerelac wheat product in different countries

Country	Grammes per portion	
Thailand		6,0 g
Ethiopia		5,2 g
South Africa		4,0 g
Pakistan		2,7 g
India		2,2 g
Bangladesh		1,6 g
United Kingdom		0,0 g
Germany		0,0 g

Source: Public Eye and IBFAN (2024) • Analysis of the nutritional information appearing on the products, or, when the added sugar content is not declared, results of laboratory analyses.

Fructose in breast milk predicts weight and fat mass at 6 mos of age



Fetuses

Endocrine Updates
Series Editor: Shlomo Melmed

Robert H. Lustig *Editor*

Obesity Before Birth

Maternal and Prenatal Influences on the Offspring

Obesity obeys the First Law of Thermodynamics. The routine assumption is that obesity is the result of a mismatch between calories in and calories out; in other words, the result of two divergent behaviors. However, there is mounting evidence that biochemical forces can drive obligate weight gain, and that the observed behaviors of increased energy intake and decreased energy expenditure are secondary to these processes. Furthermore, many of these biochemical forces are determined in utero; resulting in a developmental drive toward obesity and disease in later life. Four distinct prenatal forces have thus far been identified: 1) genetics; 2) epigenetics; 3) developmental programming; and 4) environmental obesogens. This volume explores the evidence for each of these in detail in human and animal models, and attempts to provide a cohesive analysis of the biochemical bases of obesity.

This volume will appeal to geneticists, developmental biologists, endocrinologists, epidemiologists, toxicologists, obstetrician/gynecologists, nutritionists, veterinary scientists, animal husbandry researchers, domestic species researchers, and obesity researchers and practitioners.

This very timely volume provides an in-depth scholarly overview of a critical challenge facing our society—the obesity epidemic. Dr. Robert H. Lustig is a highly respected expert author to address the fundamental contribution of preprogrammed genetic disorders leading to obesity, as well as the role of very early environmental influences. The chapters range from classic genetic mechanistic understanding through intra-uterine epigenetic influences, factors determining developmental programming, and the new clinical science of perinatal obesogens.

Obesity Before Birth: Maternal and prenatal influences on the offspring, brings easily accessible, cutting edge information to geneticists, pediatricians, endocrinologists, as well as those clinicians and scientists pursuing the complex yet elusive causes of childhood obesity and related disorders.

Shlomo Melmed, M.D. Series Editor

Internal Medicine



► springer.com

Lustig
Ed.



Obesity Before Birth

Endocrine Updates
Series Editor: Shlomo Melmed

Robert H. Lustig *Editor*

Obesity Before Birth

Maternal and Prenatal Influences on the Offspring

 Springer

Postulated effect of maternal fructose consumption on the offspring

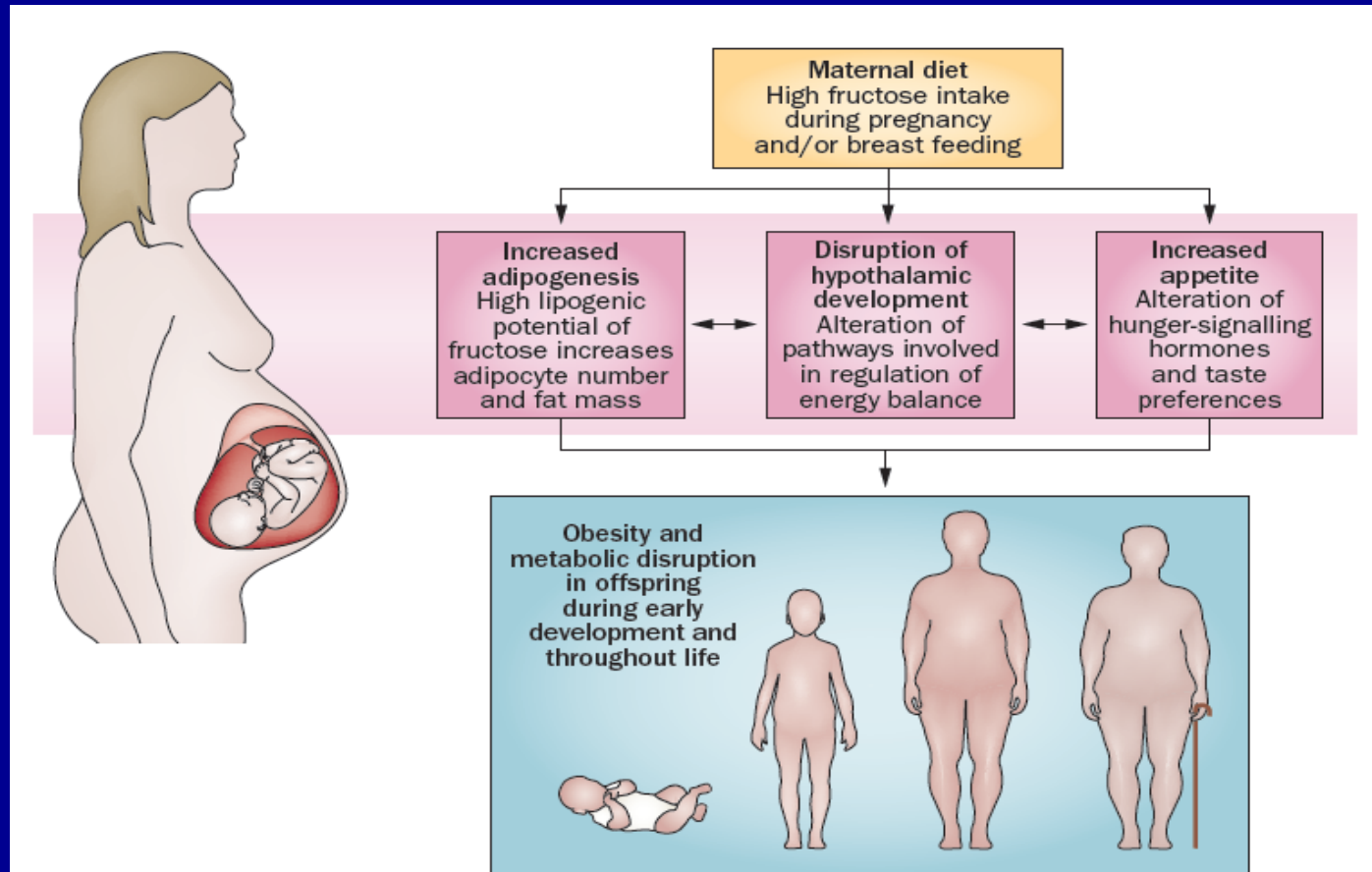
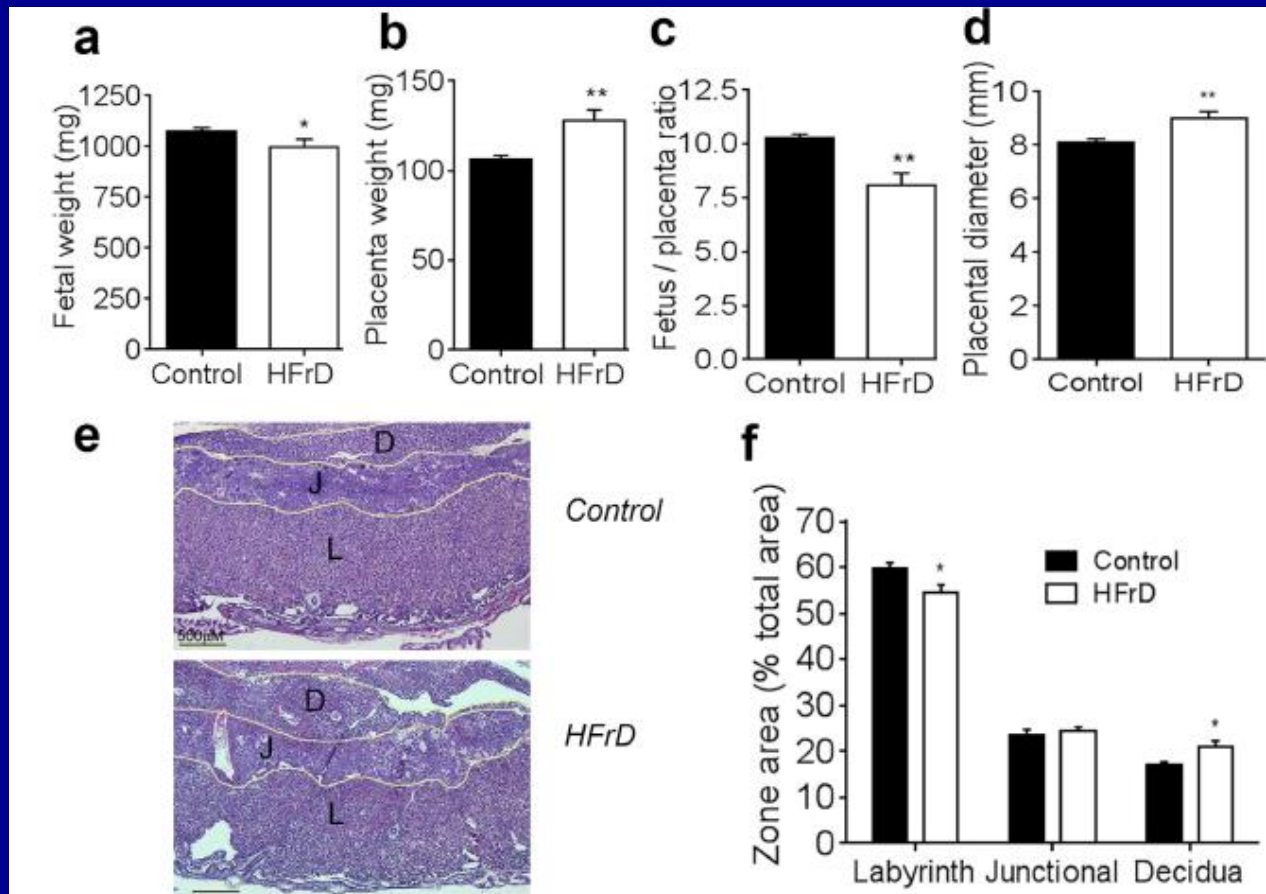
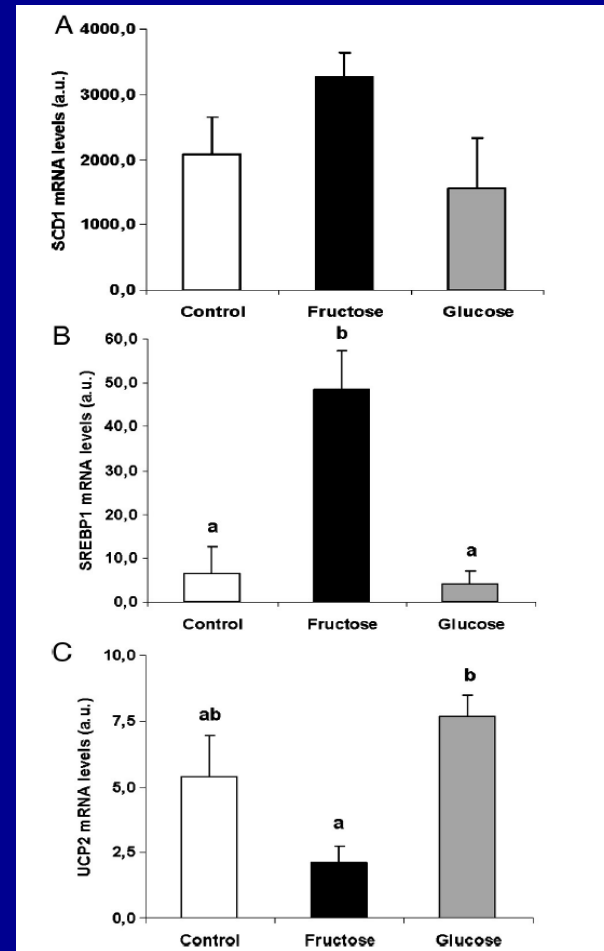
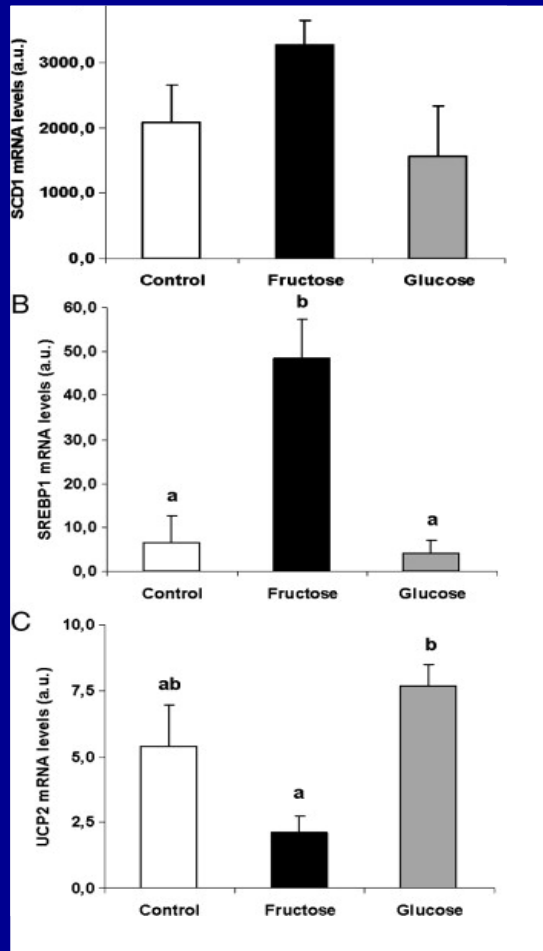


Figure 1 | Links between obesity and fructose exposure during critical developmental periods. High levels of exposure to fructose during gestation and infancy influence the development of adipose tissue, hypothalamic signalling and appetite regulation. In turn, these changes promote long-term obesity, metabolic dysfunction and disease.

Experimental maternal fructose ingestion: effects on the placenta



Experimental maternal fructose ingestion: effects on the offspring



Sugar and epigenetics

Table 3. Overall Unadjusted and Adjusted Associations Between Dietary Exposure and GrimAge2

Dietary exposure	β (95% CI)	
	Unadjusted (n = 342) ^a	Adjusted (n = 325) ^b
Alternate Mediterranean diet score	-0.62 (-0.91 to -0.34) ^c	-0.41 (-0.69 to -0.13) ^c
Alternate Healthy Eating Index -2010 score	-0.10 (-0.13 to -0.06) ^c	-0.05 (-0.08 to -0.01) ^c
Epigenetic Nutrient Index score	-0.19 (-0.29 to -0.08) ^c	-0.17 (-0.29 to -0.06) ^c
Added sugar, g	0.02 (0.01 to 0.04) ^c	0.02 (0.01 to 0.04) ^c

Essential Nutrients, Added Sugar Intake, and Epigenetic Age in Midlife Black and White Women NIMHD Social Epigenomics Program

Dorothy T. Chiu, PhD; Elissa June Hamlat, PhD; Joshua Zhang, PhD; Elissa S. Epel, PhD; Barbara A. Laraia, PhD, MPH, RD

Table 4. Overall Adjusted Associations for Diet Quality Scores and Added Sugar With GrimAge2 Where Dietary Exposures Are Combined Among 325 Participants

Dietary exposure model ^a	Adjusted β (95% CI) ^b
Model 1: aMED and added sugar	
aMED score	-0.29 (-0.58 to -0.00) ^c
Added sugar, g	0.02 (0.00 to 0.03) ^c
Model 2: AHEI-2010 and added sugar	
AHEI score	-0.03 (-0.07 to 0.01)
Added sugar, g	0.02 (0.00 to 0.03) ^c
Model 3: ENI and added sugar	
ENI score	-0.12 (-0.25 to 0.01)
Added sugar, g	0.02 (0.00 to 0.03) ^c

Abbreviations: AHEI-2010, Alternate Healthy Eating Index 2010; aMED, Alternate Mediterranean Diet; ENI, Epigenetic Nutrient Index.

HOME > NEWS > ALL NEWS > BRITAIN'S POSTWAR SUGAR CRAZE CONFIRMS HARMS OF SWEET DIETS IN EARLY LIFE

NEWS | BIOLOGY

Britain's postwar sugar craze confirms harms of sweet diets in early life

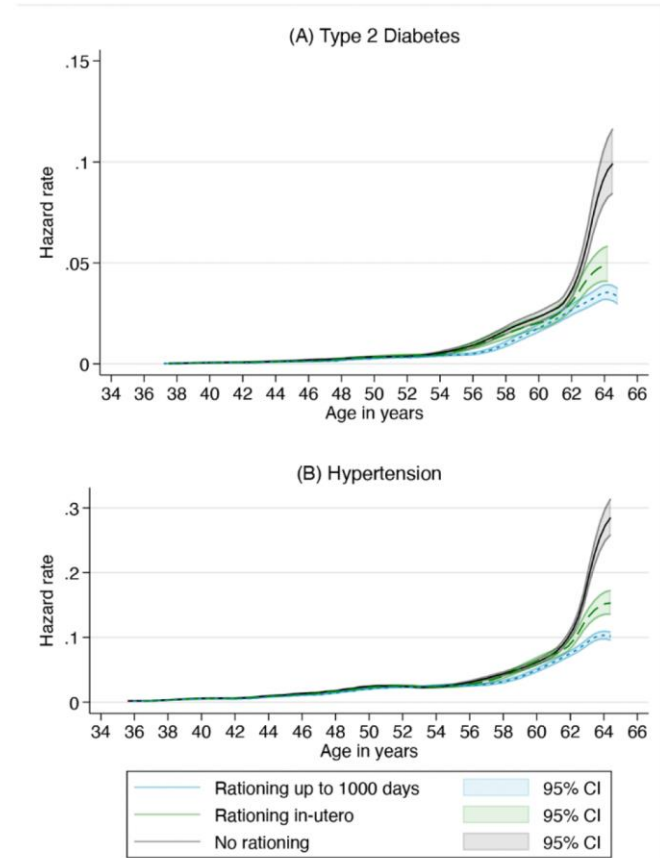
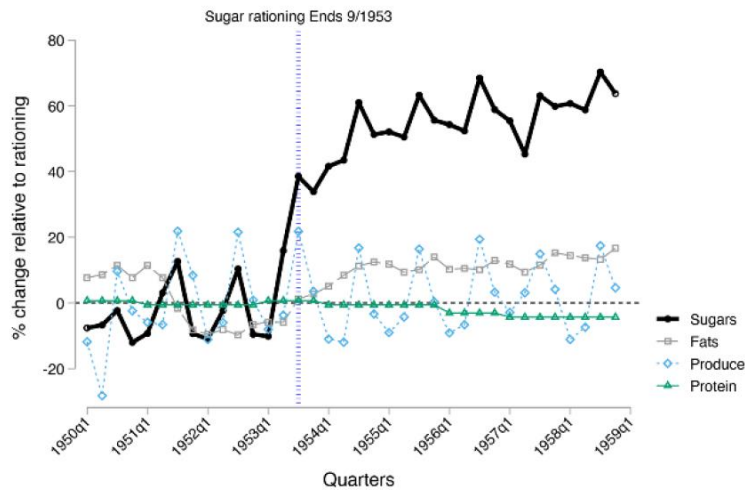
End of sugar rationing boosted diabetes, hypertension rates years later

31 OCT 2024 • 2:00 PM ET • BY [CATHERINE OFFORD](#)



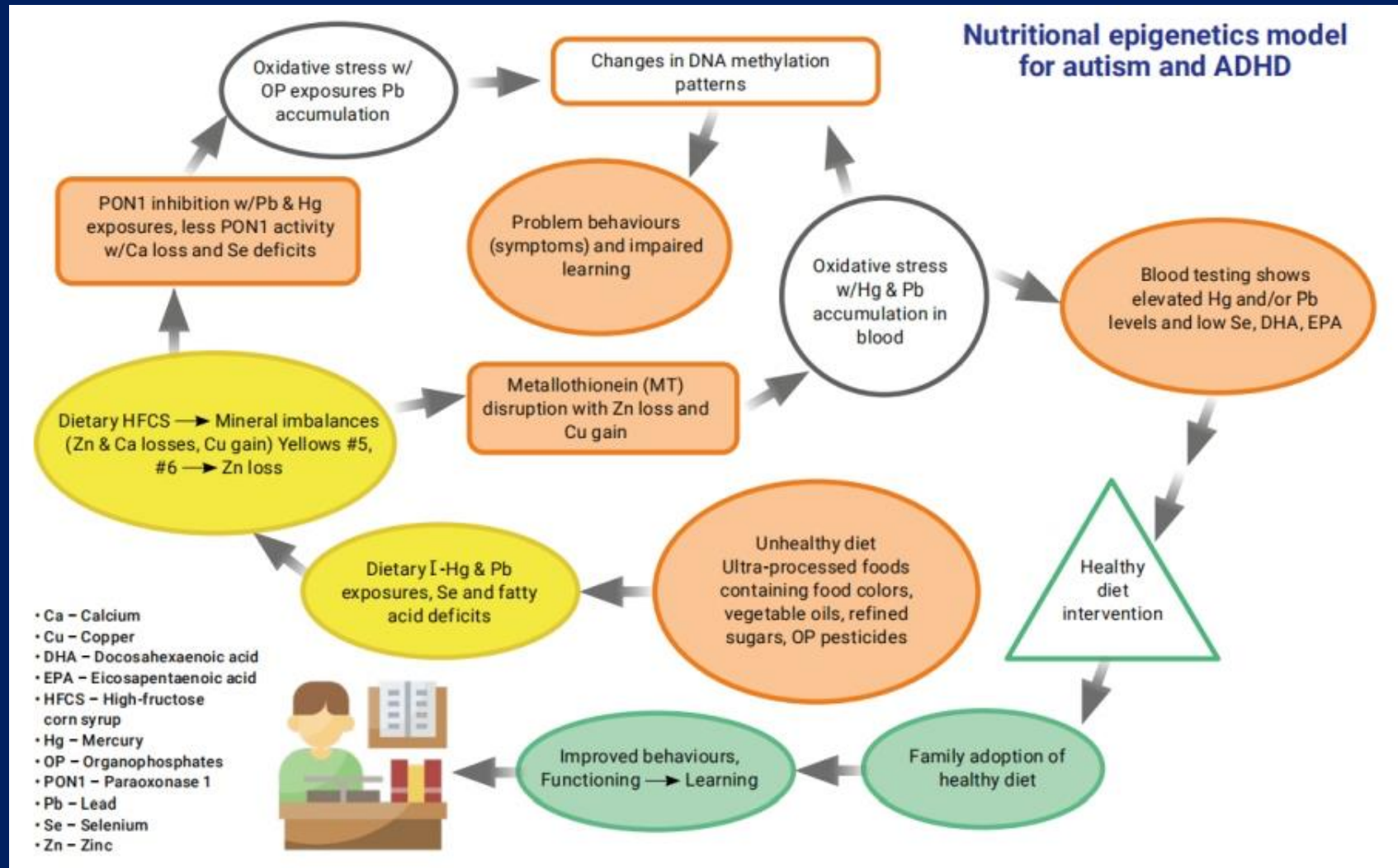
UK sugar rationing ended in 1953— offspring born after rationing with higher diabetes and hypertension

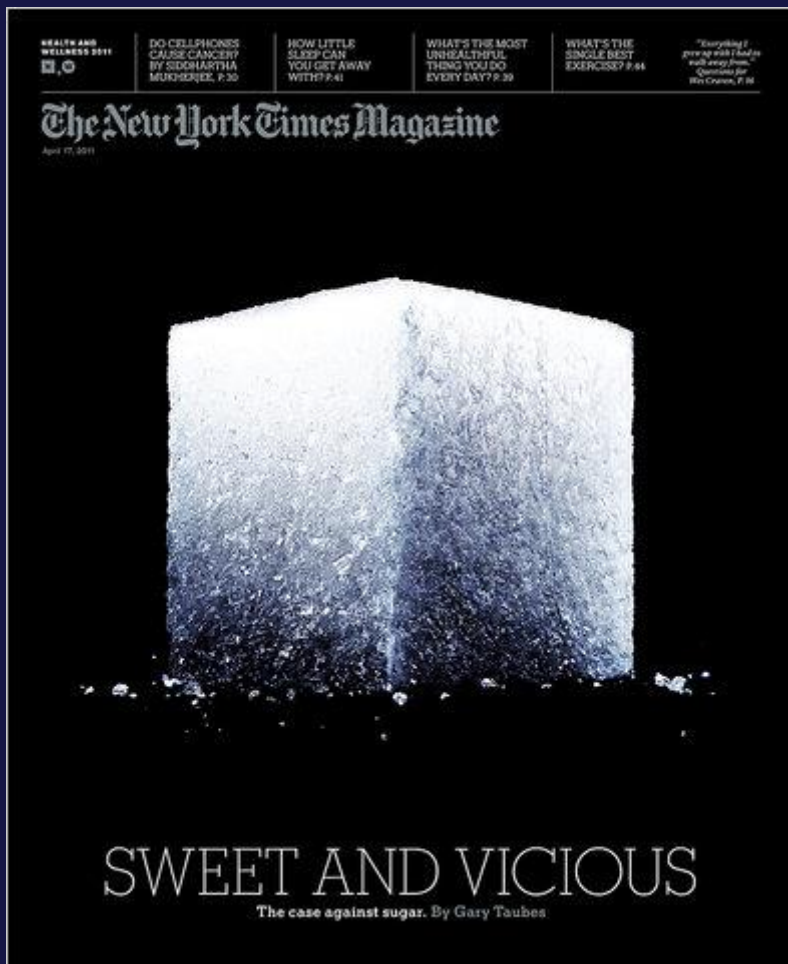
A) Percent changes in intake of sugars and other food groups relative to diet during rationing



Gracner et al., Science 10.1126/science.adn5421, 2024

Untested hypothesis: fructose alters epigenetics to alter prenatal brain development





New York Times,
April 17, 2011

Nature 487:27-29,
Feb 1, 2012

COMMENT

ECOLOGY Komodo dragons and elephants could reduce fire risk in Australia **p.30**

NEUROSCIENCE The source of the self is in the brain's wiring, not individual neurons **p.31**

LITERATURE How Charles Dickens drew on science, but left room for wonder **p.32**

OBITUARY Philip Lawley and the discovery that DNA damage can cause cancer **p.36**



The toxic truth about sugar

Added sweeteners pose dangers to health that justify controlling them like alcohol, argue Robert H. Lustig, Laura A. Schmidt and Claire D. Brindis.

Summary

- Fructose, the sweet molecule of sugar, is preferentially turned into liver fat
- That fat precipitates in the liver, leading to insulin resistance and NAFLD
- Fructose also generates advanced glycation endproducts, which inhibit mitochondrial function
- Fructose effects gut permeability, inflammation, and autoimmunity
- Fructose (and insulin) affect the brain, leading to addiction, depression, dementia, cognitive decline, and irritability
- Kids' and baby food are oversweetened on purpose
- Maternal fructose ingestion can cross into breast milk, and possibly increase infant weight gain and body fat
- Fructose can also cross the placenta, leading to placental insufficiency, and induction of fat-making enzymes in the fetus, and possibly epigenetic changes that could lead to long-term brain alterations