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Is Sugar Really Toxic? Sifting through the Evidence

By Ferris Jabr | July 15, 2013

Credit: Lauri Andler (Phantom), via Wikimedia Commons

Our very first experience of exceptional sweetness—a dollop of buttercream frosting on a parent's finger; a spoonful of strawberry ice cream instead of the usual puréed carrots—is a gustatory revelation that generally slips into the lacuna of early childhood. Sometimes, however, the moment of original sweetness is preserved. A YouTube video from February 2011 begins with baby Olivia staring at the camera, her face fixed in rapture and a trickle of vanilla ice cream on her cheek. When her brother Daniel brings the ice cream cone near her once more, she flaps her arms and arches her whole body to reach it.

Considering that our cells depend on sugar for energy, it makes sense that we evolved an innate love for sweetness. How much sugar we consume, however—as well as how it enters the body and where we get it from in the first place—has changed dramatically over time. Before agriculture, our ancestors presumably did not have much control over the sugars in their diet, which must have come from whatever plants and animals were available in a given place and season. Around 6,000 BC, people in New Guinea began to grow sugarcane, chewing and sucking on the stalks to drink the sweet juice within. Sugarcane cultivation spread to India, where by 500 BC people had learned to turn bowls of the tropical grass's juice into crude crystals. From there sugar traveled with migrants and monks to China, Persia, northern Africa and eventually to Europe in the 11th century.

For more than 400 years, sugar remained a luxury in Europe—an exotic spice—until manufacturing became efficient enough to make "white gold" much more affordable. Christopher Columbus brought sugarcane to the New World in 1493 and in the 16th and 17th centuries European powers established sugarcane plantations in the West Indies and South America. Sugar consumption in England increased by 1,500 percent between the 18th and 19th centuries. By the mid 19th century, Europeans and Americans had come to regard refined sugar as a necessity. Today, we add sugar in one form or another to the majority of processed foods we eat—everything from bread, cereals, crunchy snacks and desserts to soft drinks, juices, salad dressings and sauces—and we are not too stingy about using it to sweeten many raw and whole foods as well.

By consuming so much sugar we are not just demonstrating weak willpower and indulging our sweet tooth—we are in fact poisoning ourselves according to a group of doctors, nutritionists and biologists, one of the most prominent members of which is Robert Lustig of the University of California, San Francisco, famous for his viral YouTube video "Sugar: The Bitter Truth." A few journalists, such as Gary Taubes and Mark Bittman, have reached similar conclusions. Sugar, they argue, poses far greater dangers than cavities and love handles; it is a toxin that harms our organs and disrupts the body's usual hormonal cycles. Excessive consumption of sugar, they say, is one of the primary causes of the obesity epidemic and metabolic disorders like diabetes, as well as a culprit of cardiovascular disease. More than one-third of American adults and approximately 12.5 million children and adolescents in the U.S. are obese. In 1980, 5.6 million Americans were diagnosed with diabetes; in 2011 more than 20 million Americans had the illness.

The argument that sugar is a toxin depends on some technical details about the different ways the human body gets energy from different types of sugar. Today, Americans eat most of their sugar in two main forms: table sugar and high-fructose corn syrup. A molecule of table sugar, or sucrose, is a bond between one glucose molecule and one

fructose molecule—two simple sugars with the same chemical formula, but slightly different atomic structures. In the 1960s, new technology allowed the U.S. corn industry to cheaply convert corn-derived glucose intro fructose and produce high fructose corn syrup, which—despite its name—is almost equal parts free-floating fructose and glucose: 55 percent fructose, 42 percent glucose and three percent other sugars. Because fructose is about twice as sweet as glucose, an inexpensive syrup mixing the two was an appealing alternative to sucrose from sugarcane and beets.

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Regardless of where the sugar we eat comes from, our cells are interested in dealing with fructose and glucose, not the bulkier sucrose. Enzymes in the intestine split sucrose into fructose and glucose within seconds, so as far as the human body is concerned sucrose and high-fructose corn syrup are equivalent. The same is not true for their constituent molecules. Glucose travels through the bloodstream to all of our tissues, because every cell readily converts glucose into energy. In contrast, liver cells are one of the few types of cells that can convert fructose to energy, which puts the onus of metabolizing fructose almost entirely on one organ. The liver accomplishes this primarily by turning fructose into glucose and lactate. Eating exceptionally large amounts of fructose taxes the liver: it spends so much energy turning fructose into other molecules that it may not have much energy left for all its other functions. A consequence of this energy depletion is production of uric acid, which research has linked to gout, kidney stones and high blood pressure.

The human body strictly regulates the amount of glucose in the blood. Glucose stimulates the pancreas to secrete the hormone insulin, which helps remove excess glucose from blood, and bolsters production of the hormone leptin, which suppresses hunger. Fructose does not trigger insulin production and appears to raise levels of the hormone grehlin, which keeps us hungry. Some researchers have suggested that large amounts of fructose encourage people to eat more than they need. In studies with animals and people by Kimber Stanhope of the University of California Davis and other researchers, excess fructose consumption has increased fat production, especially in the liver, and raised levels of circulating triglycerides, which are a risk factor for clogged arteries and cardiovascular disease. Some research has linked a fatty liver to insulin resistance—a condition in which cells become far less responsive to insulin than usual, exhausting the pancreas until it loses the ability to properly regulate blood glucose levels. Richard Johnson of the University of Colorado Denver has proposed that uric acid produced by fructose metabolism also promotes insulin resistance. In turn insulin resistance is thought to be a major contributor to obesity and Type 2 diabetes; the three disorders often occur together.

Because fructose metabolism seems to kick off a chain reaction of potentially harmful chemical changes inside the body, Lustig, Taubes and others have singled out fructose as the rotten apple of the sugar family. When they talk about sugar as a toxin, they mean fructose specifically. In the last few years, however, prominent biochemists and nutrition experts have challenged the idea that fructose is a threat to our health and have argued that replacing fructose with glucose or other sugars would solve nothing. First, as fructose expert John White points out, fructose consumption has been declining for more than a decade, but rates of obesity continued to rise during the same period. Of course, coinciding trends alone do not definitively demonstrate anything. A more compelling criticism is that concern about fructose is based primarily on studies in which rodents and people consumed huge amounts of the molecule—up to 300 grams of fructose each day, which is nearly equivalent to the total sugar in eight cans of Coke—or a diet in which the vast majority of sugars were pure fructose. The reality is that most people consume far less fructose than used in such studies and rarely eat fructose without glucose.

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On average, people in America and Europe eat between 100 and 150 grams of sugar each day, about half of which is fructose. It's difficult to find a regional diet or individual food that contains only glucose or only fructose. Virtually all plants have glucose, fructose and sucrose—not just one or another of these sugars. Although some fruits, such as apples and pears, have three times as much fructose as glucose, most of the fruits and veggies we eat are more balanced. Pineapples, blueberries, peaches, carrots, corn and cabbage, for example, all have about a 1:1 ratio of the two sugars. In his *New York Times Magazine* article, Taubes claims that "fructose...is what distinguishes sugar from other carbohydrate-rich foods like bread or potatoes that break down upon digestion to glucose alone." This is not really true. Although potatoes and white bread are full of starch—long chains of glucose molecules—they also have fructose and sucrose. Similarly, Lustig has claimed that the Japanese diet promotes weight loss because it is

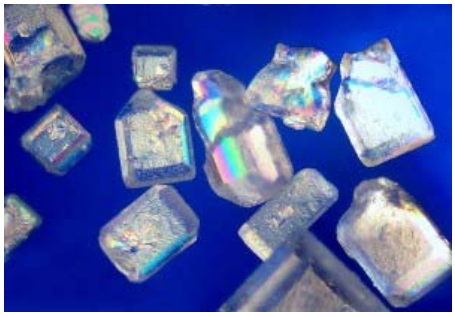
fructose-free, but the Japanese consume plenty of sugar—about 83 grams a day on average—including fructose in fruit, sweetened beverages and the country's many meticulously crafted confectioneries. High-fructose corn syrup was developed and patented in part by Japanese researcher Yoshiyuki Takasaki in the 1960s and '70s.

Not only do many worrying fructose studies use unrealistic doses of the sugar unaccompanied by glucose, it also turns out that the rodents researchers have studied metabolize fructose in a very different way than people do—far more different than originally anticipated. Studies that have traced fructose's fantastic voyage through the human body suggest that the liver converts as much as 50 percent of fructose into glucose, around 30 percent of fructose into lactate and less than one percent into fats. In contrast, mice and rats turn more than 50 percent of fructose into fats, so experiments with these animals would exaggerate the significance of fructose's proposed detriments for humans, especially clogged arteries, fatty livers and insulin resistance.

In a series of meta-analyses examining dozens of human studies, John Sievenpiper of St. Michael's Hospital in Toronto and his colleagues found no harmful effects of typical fructose consumption on body weight, blood pressure or uric acid production. In a 2011 study, Sam Sun—a nutrition scientist at Archer Daniels Midland, a major food processing corporation—and his colleagues analyzed data about sugar consumption collected from more than 25,000 Americans between 1999 and 2006. Their analysis confirmed that people almost never eat fructose by itself and that for more than 97 percent of people fructose contributes less daily energy than other sugars. They did not find any positive associations between fructose consumption and levels of trigylcerides, cholesterol or uric acid, nor any significant link to waist circumference or body mass index (BMI). And in a recent *BMC Biology* Q&A, renowned sugar expert Luc Tappy of the University of Lausanne writes: "Given the substantial consumption of fructose in our diet, mainly from sweetened beverages, sweet snacks, and cereal products with added sugar, and the fact that fructose is an entirely dispensable nutrient, it appears sound to limit consumption of sugar as part of any weight loss program and in individuals at high risk of developing metabolic diseases. There is no evidence, however, that fructose is the sole, or even the main factor in the development of these diseases, nor that it is deleterious to everybody."

To properly understand fructose metabolism, we must also consider in what form we consume the sugar, as explained in a recent paper by David Ludwig, Director of the New Balance Foundation Obesity Prevention Center of Boston Children's Hospital and a professor at Harvard. Drinking a soda or binging on ice cream floods our intestines and liver with large amounts of loose fructose. In contrast, the fructose in an apple does not reach the liver all at once. All the fiber in the fruit—such as cellulose that only our gut bacteria can break down—considerably slows digestion. Our enzymes must first tear apart the apple's cells to reach the sugars sequestered within. "It's not just about the fiber in food, but also its very structure," Ludwig says. "You could add Metamucil to Coca Cola and not get any benefit." In a small but intriguing study, 17 adults in South Africa ate primarily fruit—about 20 servings with approximately 200 grams of total fructose each day—for 24 weeks and did not gain weight, develop high blood pressure or imbalance their insulin and lipid levels.

To strengthen his argument, Ludwig turns to the glycemic index, a measure of how quickly food raises levels of glucose in the blood. Pure glucose and starchy foods such as Taubes's example of the potato have a high glycemix index; fructose has a very low one. If fructose is uniquely responsible for obesity and diabetes and glucose is benign, then high glycemic index diets should not be associated with metabolic disorders—yet they are. A small percentage of the world population may in fact consume so much fructose that they endanger their health because of the difficulties the body encounters in converting the molecule to energy. But the available evidence to date suggests that, for most people, typical amounts of dietary fructose are not toxic.



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Even if Lustig is wrong to call fructose poisonous and saddle it with all the blame for obesity and diabetes, his most fundamental directive is sound: eat less sugar. Why? Because super sugary, energy-dense foods with little nutritional value are one of the main ways we consume more calories than we need, albeit not the only way. It might be hard to swallow, but the fact is that many of our favorite desserts, snacks, cereals and especially our beloved sweet beverages inundate the body with far more sugar than it can efficiently metabolize. Milkshakes, smoothies, sodas, energy drinks and even unsweetened fruit juices all contain large amounts of free-floating sugars instantly absorbed by our digestive system.

Avoiding sugar is not a panacea, though. A healthy diet is about so much more than refusing that second sugar cube and keeping the cookies out of reach or hidden in the cupboard. What about all the excess fat in our diet, so much of which is paired with sugar and contributes to heart disease? What about

bad cholesterol and salt? “If someone is gaining weight, they should look to sugars as a place to cut back,” says Sievenpiper, “but there’s a misguided belief that if we just go after sugars we will fix obesity—obesity is more complex than that. Clinically, there are some people who come in drinking way too much soda and sweet beverages, but most people are just overconsuming in general.” Then there’s all the stuff we really should eat more of: whole grains; fruits and veggies; fish; lean protein. But wait, we can’t stop there: a balanced diet is only one component of a healthy lifestyle. We need to exercise too—to get our hearts pumping, strengthen our muscles and bones and maintain flexibility. Exercising, favoring whole foods over processed ones and eating less overall sounds too obvious, too simplistic, but it is actually a far more nuanced approach to good health than vilifying a single molecule in our diet—an approach that fits the data. Americans have continued to consume more and more total calories each year—average daily intake increased by 530 calories between 1970 and 2000—while simultaneously becoming less and less physically active. Here’s the true bitter truth: Yes, most of us should make an effort to eat less sugar—but if we are really committed to staying healthy, we’ll have to do a lot more than that.

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