Glucose and sucrose for diabetes

From the original article in 2012. Author: Ray Peat.

Diabetes has been known since ancient times as a wasting disease in which sugar was lost in the urine, but more recently the name has been used to describe the presence of more than the normal amount of glucose in the blood, even in the absence of glucose in the urine. Some of the medical ideas regarding the original form of the condition have been applied to the newer form.

Cultural "paradigms" or ideologies are so convenient that people often don't bother to doubt them, and they are sometimes so rigorously enforced that people learn to keep their doubts to themselves. Public concern about diabetes has been growing for decades, but despite the introduction of insulin and other drugs to treat it, and massive campaigns to "improve" eating habits, mortality from diabetes has been increasing during the last 100 years. Diabetes ("type 1") has been increasing even among children (Barat, et al., 2008).

A basic meaning of homeopathic medicine is the support of the organism's ability to heal itself; the essence of allopathy is that the physician fights "a disease" to cure the patient, e.g., by cutting out tumors or killing germs.

Confidence in the organism's essential rationality led the doctors with a homeopathic orientation to see a fever as part of a recuperative process, while their allopathic opponents sometimes saw fever as the essence of the sickness to be cured. Homeopaths concentrated on the nature of the patient; allopaths concentrated on a disease entity in itself, and were likely to ignore the patient's idiosyncrasies and preferences.

Diabetes was named for the excessive urination it causes, and for the sugar in the urine. It was called the sugar disease, and physicians were taught that sugar was the problem. Patients were ordered to avoid sweet foods, and in hospitals they were sometimes locked up to keep them from finding sweets. The practice was derived from ideology, not from any evidence that the treatment helped.

In 1857, M. Piorry in Paris and William Budd in Bristol, England, reasoned that if a patient was losing a pound of sugar every day in 10 liters of urine, and was losing weight very rapidly, and had an intense craving for sugar, it would be reasonable to replace some of the lost sugar, simply because the quick weight loss of diabetes invariably led to death. Keeping patients from eating what they craved seemed both cruel and futile.

After Budd's detailed reports of a woman's progressive recovery over a period of several weeks when he prescribed 8 ounces of sugar every day, along with a normal diet including beef and beef broth, a London physician, Thomas Williams, wrote sarcastically about Budd's metaphysical ideas, and reported his own trial of a diet that he described as similar to Budd's. But after two or three days he decided his patients were getting worse, and stopped the experiment.

Williams' publication was presented as a scientific refutation of Budd's deluded homeopathic ideas, but Budd hadn't explained his experiment as anything more than an attempt to slow the patient's death from wasting which was sure to be the result of losing so much sugar in the urine. The following year Budd described another patient, a young man who had become too weak to work and who was losing weight at an extreme rate. Budd's prescription included 8 ounces of white sugar and 4 ounces of honey every day, and again, instead of increasing the amount of glucose in the urine, the amount decreased quickly as the patient began eating almost as much sugar as was being lost initially, and then as the loss of sugar in the urine decreased, the patient gained weight and recovered his strength.

Drs. Budd and Piorry described patients recovering from an incurable disease, and that has usually been enough to make the medical profession antagonistic. Even when a physician has himself diagnosed diabetes and told a patient that it would be necessary to inject insulin for the rest of his life, if that patient recovers by changing his diet, the physician will typically say that the diagnosis was wrong, because diabetes is incurable.

Twenty-five years ago, some rabbits were made diabetic with a poison that killed their insulin-secreting pancreatic beta-cells, and when some of them recovered from the diabetes after being given supplemental DHEA, it was found that their beta-cells had regenerated. The more recent interest in stem cells has led several research groups to acknowledge that in animals the insulin-producing cells are able to regenerate.

It is now conceivable that there will be an effort to understand the factors that damage the beta-cells, and the factors that allow them to regenerate. The observations of Budd and Piorry would be a good place to start such a reconsideration.

For many years, physicians have been taught that diabetes is either "genetic" or possibly caused by a viral infection, that might trigger an "autoimmune reaction," but the study of cellular respiration and energy metabolism and endocrinology has provided more convincing explanations. The antibodies that are found in the "autoimmune" conditions are evidence of tissue damage, but the damage may have been done by metabolic toxins, with the immune system's involvement being primarily the removal of defective cells.

In the 1940s, Bernardo Houssay found that coconut oil protected animals from poison-induced diabetes, while a lard-based diet failed to protect them. Later, glucose itself was found to protect the pancreatic beta-cells from poisons.

In 1963, P.J. Randle clearly described the inhibition of glucose oxidation by free fatty acids. Later, when lipid emulsions came into use for intravenous feeding in hospitals, it was found that they blocked glucose oxidation, lowered the metabolic rate, suppressed immunity, and increased lipid peroxidation and oxidative stress.

Estrogen and stress are both known to create some of the conditions of diabetes, while increasing fat oxidation and inhibiting glucose oxidation. Emotional stress, overwork, trauma, and infections have been known to initiate diabetes. Estrogen increases free fatty acids and decreases glycogen storage, and when birth control pills were becoming popular, some researchers warned that they might cause diabetes. But the food oil industry and the estrogen industry were satisfied with the medical doctrine that diabetes was caused by eating too much sugar.

If the essence of diabetes is the presence of too much sugar, then it seems reasonable to argue that it is the excess sugar that's responsible for the suffering and death associated with the disease, otherwise, how would the prohibition of sugar in the diet be justified? In fact, the argument is made (e.g., Muggeo, 1998) that it is the hyperglycemia that causes problems such as hypertension, kidney failure, heart failure, neuropathy, blindness, dementia, and gangrene.

As information about the many physiological and biochemical events associated with diabetes has accumulated, the basic doctrine that "sugar causes diabetes" has extended itself to whatever the topic of discussion is**:** "Glucose causes" the death of beta-cells, glucose causes blood vessels to become leaky, glucose causes cells to be unable to absorb glucose, glucose causes the formation of free radicals, glucose impairs immunity and wound healing, but causes inflammation while preventing the "respiratory burst" in which free radicals are produced by cells that cause inflammation, it disturbs enzyme functions, impairs nerve conduction and muscle strength, etc., and it is also addictive, causing people to irrationally seek the very material that is poisoning them.

Tens of thousands of publications describe the pathogenic effects of sugar. To prove their point, they grow cells in a culture dish, and find that when they are exposed to excess glucose, often 5 times the normal amount, they deteriorate. In the artificial conditions of cell culture, the oversupply of glucose causes lactic acid to accumulate, leading to toxic effects. But in the organism, the hyperglycemia is compensating for a sensed deficiency of glucose, a need for more energy.

If diabetes means that cells can't absorb or metabolize glucose, then any cellular function that requires glucose will be impaired, despite the presence of glucose in the blood. It is the intracellular absence of glucose which is problematic, rather than its extracellular excess.

Neuroglycopenia (or neuroglucopenia) or intracellular glycopenia refers to the deficit of glucose in cells. When the brain senses a lack of glucose, nerves are activated to increase the amount of glucose in the blood, to correct the problem. As long as the brain senses the need for more glucose, the regulatory systems will make the adjustments to the blood glucose level.

The antagonism between fat and sugar that Randle described can involve the suppression of sugar oxidation when the concentration of fats in the bloodstream is increased by eating fatty food, or by releasing fats from the tissues by lipolysis, but it can also involve the suppression of fat oxidation by inhibiting the release of fatty acids from the tissues, when a sufficient amount of sugar is eaten.

When a normal person, or even a "type 2 diabetic," is given a large dose of sugar, there is a suppression of lipolysis, and the concentration of free fatty acids in the bloodstream decreases, though the suppression is weaker in the diabetic (Soriguer, et al., 2008). Insulin, released by the sugar, inhibits lipolysis, reducing the supply of fats to the respiring cells.

Free fatty acids suppress mitochondrial respiration (Kamikawa and Yamazaki, 1981), leading to increased glycolysis (producing lactic acid) to maintain cellular energy. The suppression of mitochondrial respiration increases the production of toxic free radicals, and the decreased carbon dioxide makes the proteins more susceptible to attack by free radicals. The lactate produced under the influence of excessive fat metabolism stimulates the release of endorphins, which are lipolytic, releasing more free fatty acids from the tissues. Acting through cytokines such as interleukin-6, lactate shifts the balance toward the catabolic hormones, leading to tissue wasting.

Lactic acid itself, and the longer chain fatty acids, inhibit the regulatory enzyme pyruvate dehydrogenase (which is activated by insulin), reducing the oxidative production of energy. Drugs to activate this enzyme are being studied by the pharmaceutical industry as treatments for diabetes and cancer (for example, DCA, dichloroacetate).

Oxidative damage of proteins is often described as glycation or glycosylation, but it really consists of many addition and crosslinking reactions, most often onto, or between, lysine groups. Carbon dioxide normally associates with lysine groups, so the destructive reactions are favored when carbon dioxide is displaced by lactic acid. The reactive fragments of polyunsaturated fatty acids are much more often the source of the protein-damaging radicals than the carbohydrates are.

The importance of the fats in causing type-2 diabetes is coming to be accepted, for example Li, et al., recently (2008) said "The cellular link between fatty acids and ROS (reactive oxygen species) is essentially the mitochondrion, a key organelle for the control of insulin secretion. Mitochondria are the main source of ROS and are also the primary target of oxidative attacks."

But much earlier (Wright, et al., 1988) it had been demonstrated that a deficiency of the "essential fatty acids" prevents toxin-induced diabetes and greatly increases resistance to inflammation (Lefkowith, et al., 1990). The lack of those so-called "essential fatty acids" also prevents autoimmune diabetes in a strain of diabetic mice (Benhamou, et al., 1995),

Suppressing fatty acid oxidation improves the contraction of the heart muscle and increases the efficiency of oxygen use (Chandler, et al., 2003). Various drugs are being considered for that purpose, but niacinamide is already being used to improve heart function, since it lowers the concentration of free fatty acids.

The antimetabolic and toxic effects of the polyunsaturated fatty acids can account for the "insulin resistance" that characterizes type-2 diabetes, but similar actions in the pancreatic beta-cells can impair or kill those cells, creating a deficiency of insulin, resembling type-1 diabetes.

The suppression of mitochondrial respiration causes increased free radical damage, and the presence of polyunsaturated fatty acids in the suppressed cell increases the rate of fat decomposition and production of toxins.

Increasing the rate of respiration by replacing the fats with glucose reduces the availability of electrons that can trigger lipid peroxidation and produce toxic free radicals, and the shift of fuel also increases the amount of carbon dioxide produced, which can protect the protein amino groups such as lysine from glycation and lipoxidation.

While it's clear that it is the excessive oxidation of fat that damages cells in the "diabetic" state in which cells aren't able to use glucose, it's important to look at some of the situations in which so many researchers are blaming problems on hyperglycemia.

Important problems in diabetes are slow wound healing, excessive permeability or leakiness of blood vessels which allows molecules such as albumin to be extravasated, and the impaired function and survival of pancreatic beta-cells.

During the healing of a wound in a diabetic individual, the local concentration of glucose decreases and then entirely disappears, as healing stops. Applying glucose and insulin topically to the wound, it heals quickly. The very old practice of treating deep wounds with honey or granulated sugar has been studied in controlled situations, including the treatment of diabetic ulcers, infected deep wounds following heart surgery, and wounds of lepers. The treatment eradicates bacterial infections better than some antiseptics, and accelerates healing without scarring, or with minimal scarring. The sugar regulates the communication between cells, and optimizes the synthesis of collagen and extracellular matrix.

An excess of insulin, causing hypoglycemia, can cause blood vessels, for example in the brain and kidneys, to become leaky, and this has been claimed to be an effect of insulin itself. However, the same leakiness can be produced by an analog of glucose that can't be metabolized, so that intracellular glycopenia is produced. The harmful effect that has been ascribed to excessive insulin can be prevented by maintaining an adequate supply of glucose (Uezu and Murakami, 1993), showing that it is the lack of glucose, rather than the excess insulin, that causes the vascular malfunction. Fructose also reduces the leakiness of blood vessels (Plante, et al., 2003). Many of the complications of diabetes are caused by increased vascular leakiness (Simard, et al., 2002).

Sugar can protect the beta-cells from the free fatty acids, apparently in the same ways that it protects the cells of blood vessels, restoring metabolic energy and preventing damage to the mitochondria. Glucose suppresses superoxide formation in beta-cells (Martens, et al., 2005) and apparently in other cells including brain cells. (Isaev, et al., 2008).

The beta-cell protecting effect of glucose is supported by bicarbonate and sodium. Sodium activates cells to produce carbon dioxide, allowing them to regulate calcium, preventing overstimulation and death. For a given amount of energy released, the oxidation of glucose produces more carbon dioxide and uses less oxygen than the oxidation of fatty acids.

The toxic excess of intracellular calcium that damages the insulin-secreting cells in the relative absence of carbon dioxide is analogous to the increased excitation of nerves and muscles that can be produced by hyperventilation.

In every type of tissue, it is the failure to oxidize glucose that produces oxidative stress and cellular damage. Even feeding enough sucrose to cause fat deposition in the liver can protect the liver from oxidative stress (Spolarics and Meyenhofer, 2000), possibly by mechanisms such as those involved in the treatment of alcoholic liver disease with saturated fats.

The active thyroid hormone, T3, protects the heart by supporting the oxidation of glucose (Liu, et al., 1998). The amount of T3 produced by the liver depends mainly on the amount of glucose available.

Animals that have been made diabetic with relatively low doses of the poison streptozotocin can recover functional beta-cells spontaneously, and the rate of recovery is higher in pregnant animals (Hartman, et al., 1989). Pregnancy stabilizes blood sugar at a higher level, and progesterone favors the oxidation of glucose rather than fats.

A recent study suggests that recovery of the pancreas can be very fast. A little glucose was infused for 4 days into rats, keeping the blood glucose level normal, and the mass of beta-cells was found to have increased 2.5 times. Cell division wasn't increased, so apparently the additional glucose was preventing the death of beta-cells, or stimulating the conversion of another type of cell to become insulin-secreting beta-cells (Jetton, et al., 2008).

That study is very important in relation to stem cells in general, because it either means that glandular cells are turning over ("streaming") at a much higher rate than currently recognized in biology and medicine, or it means that (when blood sugar is adequate) stimulated cells are able to recruit neighboring cells to participate in their specialized function. Either way, it shows the great importance of environmental factors in regulating our anatomy and physiology.

"Diabetologists" don't regularly measure their patients' insulin, but they usually make the assumption that insulin is the main factor regulating blood sugar. In one study, it was found that the insulin molecule itself, immunoreactive insulin, accounted for only about 8% of the serum's insulin-like action. The authors of that study believed that potassium was the main other factor in the serum that promoted the disposition of glucose. Since potassium and glucose are both always present in the blood, their effects on each other have usually been ignored.

Cellular activation (by electrical, nervous, chemical, or mechanical stimulation) causes glucose to be absorbed and oxidized, even in the absence of insulin and in otherwise insulin-resistant individuals. I think this local interaction between the need for energy and the production of energy predominates in good health, with insulin and other hormones facilitating the process in times of stress. A variety of local tissue regulators, including GABA and glutamate, probably participate in these interactions, in the brain, endocrine glands, muscles, and other tissues, and are probably involved in the relaxing and analgesic actions of the sugars.

The GABA system (GABA is highly concentrated in the beta-cells) is involved in regulating blood sugar, inhibiting the release of glucagon when glucose isn't needed, and apparently allowing the beta cells to discriminate between amino acids and glucose (Gu, et al., 1993) and acting as a survival and growth factor for neighboring cells (Ligon, et al., 2007).

The damaged beta-cells lose the enzyme (glutamate dehydrogenase) that makes GABA, and their ratio of linoleic acid to saturated and monounsaturated fat increases, a change that corresponds to a decreased metabolism of glucose.

The free intracellular calcium that can become toxic is normally bound safely by well-energized mitochondria, and in the bloodstream it is kept safely complexed with carbon dioxide. The thyroid hormone, producing carbon dioxide, helps to sustain the level of ionized calcium (Lindblom, et al., 2001). In a vitamin D deficiency, or a calcium deficiency, the parathyroid hormone increases, and this hormone can contribute to many inflammatory and degenerative processes, including diabetes. Consuming enough calcium and vitamin D to keep the parathyroid hormone suppressed is important to protect against the degenerative conditions.

When animals were fed an otherwise balanced diet lacking vitamin D, with the addition of either 68% sucrose or 68% starch, the bones of those on the starch diet failed to develop normally, as would be expected with a vitamin D deficiency, and their serum calcium was low. However, the bones of those on the diet with sucrose developed properly, and didn't show evidence of being calcium deficient, though they weren't quite as heavy as those that also received an adequate amount of vitamin D (Artus, 1975). This study suggests that the famous dietetic emphasis on the "complex carbohydrates," i.e., starches, has made an important contribution to the prevalence of osteoporosis, as well as obesity and other degeneration conditions.

Both vitamin D and vitamin K, another important calcium-regulating nutrient, are now known to prevent diabetes. Both of these vitamins require carbon dioxide for disposing of calcium properly, preventing its toxicity. When carbon dioxide is inadequate, for example from simple hyperventilation or from hypothyroidism, calcium is allowed to enter cells, causing inappropriate excitation, sometimes followed by calcification.

Keeping an optimal level of carbon dioxide (for example, when adapted to high altitude) causes calcium to be controlled, resulting in lowered parathyroid hormone, an effect similar to supplementing with calcium, vitamin D, and vitamin K. (E.g., Nicolaidou, et al, 2006.) Glycine, like carbon dioxide, protects proteins against oxidative damage (Lezcano, et al., 2006), so including gelatin (very rich in glycine) in the diet is probably protective.

The contribution of PTH to inflammation and degeneration is just being acknowledged (e.g., Kuwabara, 2008), but the mechanism undoubtedly involves the fact that it is lipolytic, increasing the concentration of free fatty acids that suppress metabolism and interfere with the use of glucose.

When we talk about increasing the metabolic rate, and the benefits it produces, we are comparing the rate of metabolism in the presence of thyroid, sugar, salt, and adequate protein to the "normal" diet, containing smaller amounts of those "stimulating" substances. It would be more accurate if we would speak of the suppressive nature of the habitual diet, in relation to the more optimal diet, which provides more energy for work and adaptation, while minimizing the toxic effects of free radicals.

Feeding animals a normal diet with the addition of Coca-Cola, or with a similar amount of sucrose, has been found to let them increase their calorie intake by 50% without increasing their weight gain (Bukowiecki, et al., 1983). Although plain sucrose can alleviate the metabolic suppression of an average diet, the effect of sugars in the diet is much more likely to be healthful in the long run when they are associated with an abundance of minerals, as in milk and fruit, which provide potassium and calcium and other protective nutrients.

Avoiding the starches such as cereals and beans, and using fruits as a major part of the diet helps to minimize the effects of the polyunsaturated fats.

Celiac disease or gluten sensitivity is associated with diabetes and hypothyroidism. There is a cross reaction between the gluten protein molecule and an enzyme which is expressed under the influence of estrogen. This is another reason for simply avoiding cereal products.

Brewers' yeast has been used traditionally to correct diabetes, and its high content of niacin and other B vitamins and potassium might account for its beneficial effects. However, eating a large quantity of it is likely to cause gas, so some people prefer to extract the soluble nutrients with hot water. Yeast contains a considerable amount of estrogen, and the water extract probably leaves much of that in the insoluble starchy residue. Liver is another rich source of the B vitamins as well as the oily vitamins, but it can suppress thyroid function, so usually one meal a week is enough.

The supplements that most often help to correct diabetes-like conditions are niacinamide, thiamine, thyroid, and progesterone or pregnenolone. Vitamins D and K are clearly protective against developing diabetes, and their effects on many regulatory processes suggest that they would also help to correct existing hyperglycemia.

Drinking coffee seems to be very protective against developing diabetes. Its niacin and magnesium are clearly important, but it is also a rich source of antioxidants, and it helps to maintain normal thyroid and progesterone production. Chocolate is probably protective too, and it is a good source of magnesium and antioxidants.

A recent study (Xia, et al., 2008) showed that inhibition of cholesterol synthesis by beta-cells impairs insulin synthesis, and that replenishing cholesterol restores the insulin secretion. Green tea contains this type of inhibitor, but its use has nevertheless been associated with a reduced risk of diabetes. Caffeine is likely to be the main protective substance in these foods.

Although antioxidants can be protective against diabetes, not all things sold as "antioxidants" are safe; many botannical

"antioxidants" are estrogenic. Hundreds of herbal products can lower blood sugar, but many of them are simply toxic, and the reduction of blood glucose can make some problems worse.

The supplements I mention above--including caffeine--have antiinflammatory, antioxidative and energy-promoting effects. Inflammation, interfering with cellular energy production, is probably the essential feature of the things called diabetes.

Aspirin has a very broad spectrum of antiinflammatory actions, and is increasingly being recommended for preventing complications of diabetes. One of the consequences of inflammation is hyperglycemia, and aspirin helps to correct that (Yuan, et al., 2001), while protecting proteins against oxidative damage (Jafarnejad, et al, 2001).

If Dr. Budd's thinking (and results) had been more widely accepted when his publications appeared, thinking about "diabetes" might have led to earlier investigation of the syndromes of stress and tissue wasting, with insulin being identified as just one of many regulatory substances, and a large amount of useless and harmful activity treating hyperglycemia as the enemy, rather than part of an adaptive reaction, might have been avoided.

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